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Questions of the small size of non-industrial private forest (NIPF) holdings in Finland are considered and factors affecting their partitioning are analyzed. This work arises out of Finnish forest policy statements in which the small average size of holdings has been seen to have a negative influence on the economics of forestry. A survey of the literature indicates that the size of holdings is an important factor determining the costs of logging and silvicultural operations, while its influence on the timber supply is slight.

The empirical data are based on a sample of 314 holdings collected by interviewing forest owners in the years 1980–86. In 1990–91 the same holdings were resurveyed by means of a postal inquiry and partly by interviewing forest owners. The principal objective in compiling the data is to assist in quantifying ownership factors that influence partitioning among different kinds of NIPF holdings. Thus the mechanism of partitioning were described and a maximum likelihood logistic regression model was constructed using seven independent holding and ownership variables.

One out of four holdings had undergone partitioning in conjunction with a change in ownership, one fifth among family owned holdings and nearly a half among jointly owned holdings. The results of the logistic regression model indicate, for instance, that the odds on partitioning is about three times greater for jointly owned holdings than for family owned ones. Also, the probabilities of partitioning were estimated and the impact of independent dichotomous variables on the probability of partitioning ranged between 0.02 and 0.10. The low value of the Hosmer-Lemeshow test statistic indicates a good fit of the model and the rate of correct classification was estimated to be 88 per cent with a cutoff point of 0.5.

The average size of holdings undergoing ownership changes decreased from 29.9 ha to 28.7 ha over the approximate interval 1983–90. In addition, the transition probability matrix showed that the trends towards smaller size categories mostly involved in the small size categories, less than 20 ha. The results of the study can be used in considering the effects of the small size of holdings for forestry and if the purpose is to influence partitioning through forest or rural policy.

Keywords holding size, forest ownership, private forests, logistic regression, ownership change, forestry behaviour, partitioning, forest policy, Finland.
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Preface

This study of the question of the small size of non-industrial private forest holdings and their partitioning in Finland was begun in the late 1980's with the encouragement of my supervisor Dr. Aarne Reunala, Head of the Helsinki Research Centre of the Finnish Forest Research Institute. The support and guidance of my closest colleagues, Harri Hänninen, Heimo Karppinen, Dr. Jari Kuuluvainen, Dr. Ville Ovaskainen and Esa-Jussi Viitala has been most important throughout the work, and their constructive criticism has greatly increased my skills as a research worker. I am also grateful to Prof. Kalevi Rikkinen of the Department of Geography of the University of Helsinki for his guidance and innovative ideas. Both Dr. Reunala and Prof. Rikkinen also made valuable suggestions at the final stage of preparing the manuscript. Besides, thanks are due to Prof. Seppo Vehkamäki of the Department of Forest Economics of the University of Helsinki for his valuable comments which led to the final revision of the manuscript. The responsibility for any remaining errors is, however, mine alone.

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Helsinki, October 1996

Pekka Ripatti

List of Frequently Used Symbols

Roman symbols

CI	Confidence interval
D	Deviance
$E(Y \mid x)$	Conditional mean
G	Likelihood ratio test statistic
ln	Logit transformation
W	Wald test ratio
x	Value of the independent variable
Y	Outcome variable

Greek symbols

α	Constant term
β	Independent parameter to be estimated
$e^{\beta 1}$	Antilog
$L(\beta)$	Log likelihood
ε	Error term
π	Probability
$\pi / (1 - \pi)$	Odds
G^2	Likelihood goodness-of-fit statistic
HL^2	Hosmer-Lemeshow goodness-of-fit statistic
ψ	Odds ratio

1 Introduction

1.1 Private Forest Ownership

Forest owners in Finland are typically divided into four major categories: private, companies, the state and others. The last-mentioned consist of local authorities, church parishes and other collective bodies. Private forest owners are individuals whose ownership is not integrated with wood processing companies (Statistical Yearbook of Forestry 1995, p. 41). In English speaking countries these private forest owners are referred to as non-industrial private forest (NIPF) owners (e.g. Tansey and Hutchins 1988, p. 43–45), and it is therefore reasonable to use the same concept when speaking of Finnish private forest owners in the present context.

NIPF ownership has long roots in Finland, beginning with the early settlement which spread from the southwestern parts of the country towards the northeast in the late Middle Ages (Rikkinen 1976, p. 15–24). A Forest Decree of 1734 laid down that a distinction was to be made between state other forests, as there was a need to clarify the land taxation system (Helander 1949, p. 33–46). The official demarcation of forests began in the 1770s and has been continued up to the present-day.

As a result of the early settlement, most of the non-industrial private forests are still located on quite good soils and in regions with relatively favourable climatic conditions in the southern part of the country. Consequently, the proportion of the annual increment of the growing stock represented by them is about 75 per cent, even though they account for only 62 per cent of the total forest land (Kuusela and Salminen 1991). Hence, NIPF owners play an important role in Finnish forestry, supplying 70–80 per cent of the domestic roundwood purchased by the Finnish wood processing companies (Tervo 1986, p. 26, Statistical Yearbook of Forestry 1995).

On the other hand, forests have been important for the Finnish population throughout history. In olden times their main roles were as sources of game, firewood and timber for construction purposes, and from the 17th century onwards they provided the raw material for the making of tar and charcoal. The sawn timber industry entered the picture in the 19th century, and the 20th century brought the expansion of sawmills and the pulp and paper industry (Helander 1949). Alongside all this, one must not forget the role of the stumpage incomes obtained by NIPF owners in the economy of rural areas and that of forestry work as a source of livelihood. To take an example, the stumpage incomes of NIPF owners in 1995 amounted to 7756 mill. Finnish marks (Savela 1996).

Since 1917, when Finland gained her independence, the pace of partitioning of NIPF holdings has accelerated continuously, to the extent that the increase has been approx. 20 000 holdings per decade in recent times. Where the first Agricultural Census of 1929–30 placed the number of holdings at 230 000 (Fig. 1), it increased by

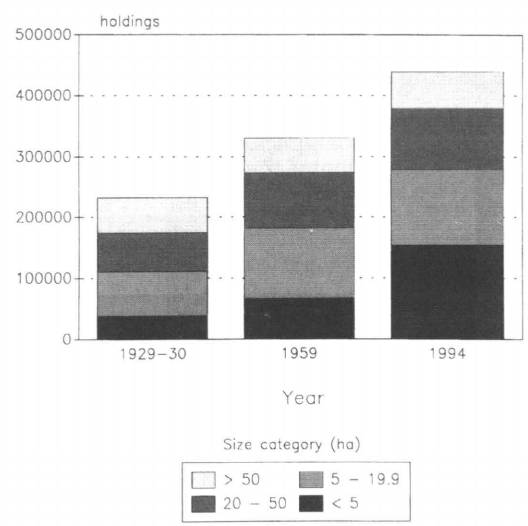


Fig. 1. Trends in numbers of NIPF holdings from 1929–30 to 1994.

100 000 over the next 30 years to reach 330 000. This dramatic increase is mainly explained by the settlement policy pursued after the Second World War, when 140 000 new farms were established (Ilvessalo 1962). Today the farm register maintained by the National Board of Taxation shows the number of holdings of at least 1 ha forest land to be about 440 000. This means that the number has doubled during the independence period. The increase in the number of small holdings of less than 20 ha has accounted for much of this, while the number of large holdings of at least 50 ha has increased only slightly.

While the number of small holdings has increased the trend in the use of the allowable cut has been a declining one. After mid-1960's this can partly be explained by the increase in investment in timber production. Thus the annual increment in the growing stock in the early 1970's, for example, was just under 60 mill. m^3, but it was estimated that 80 mill. m^3 was possible with more intensive silviculture (Kuusela 1974, p. 74). In fact, two decades later the annual increment in the growing stock has reached close to 80 mill. m^3, but the total drain has remained at about 50 mill. m^3 (Statistical Yearbook of Forestry 1995, p. 76). The majority of the unused volume of timber resources lies in non-industrial private forests. It is often claimed that this under-utilization is partly caused by factors such as the small average size of NIPF holdings and trend towards smaller holdings. These questions have been discussed under the heading of "fragmentation problems".

1.2 The Question of the Small Size of NIPF Holdings

Discussion on the small size of NIPF holdings began in Finland as early as the end of 19th century when Blomqvist (1874) worried about weak condition of silviculture in small-scale ownership. Furthermore, it was worried about deforestation in small average size of holdings when the price of timber increases (Gebhard 1897, p. 16–19). Later, Jutila (1924) stated that fragmentation of holdings will complicate silviculture in private forests and also Saari (1928, p. 15) pointed out that small-scale ownership was the least propitious from the viewpoint of practical forestry. The question was then raised again in a new form in the early 1970's (e.g. Metsälön... 1970, Reunala 1974) and has persisted to the present-day (e.g. Metsä 2000 -ohjelman... 1985, Metsien... 1995). The small average size of holdings has been seen to entail many disadvantages for forestry, the major worries having concerned the economics of non-industrial private forestry and the continuity of timber supplies from such forests.

The costs of forest holdings are crucial in determining the profitability of forestry, and the high average unit costs associated with small holdings are the primary obstacle to be overcome in connection with their management and harvesting (Cubbage 1983). The effects of size on average costs are most significant where mechanization is concerned, e.g. modern logging operations (e.g. Doll and Orazen 1978). Apart from the unit costs associated with silviculture and logging, a small average size of holding may complicate timber supply from non-industrial private forests. Some other disadvantages of small average size and the partitioning of holdings are also mentioned in Finnish forest policy statements, such as diminished possibilities to increase timber production. Also effectiveness of means of economic- and forest policy have been seen weakened (Metsä 2000 -ohjelman... 1985, p. 99).

The partitioning process itself similarly has detrimental effects on forestry. The costs of land surveying are high and such operations may take a very long time and may involve the suspension of all management and felling while they are in progress (Kiviniemi 1992). It is also assumed that the partitioning process bestows certain less advantageous characteristics on the holding and its mode of ownership from the viewpoint of timber supply, e.g. ownership with recreational objectives which are associated with small size of forest holdings (Ihalainen 1992, p. 32).

The small average size of holdings and their partitioning can evidently cause problems for the economics of forestry, even though recent empirical studies of the behaviour of NIPF owners indicate that the importance of the size of the holding has been exaggerated (Kuuluvainen 1989). Besides, a large NIPF ownership base can also be seen to promote the spread of information about forests and forestry in our increasingly more urbanised and environment-conscious society. Nevertheless, if small holding size and the partitioning of holdings are thought to impair the economic base of forestry, then the benefits of broad-based NIPF ownership will be of little consequence (Ripatti and Reunala 1989, p. 4).

In fact, some attempts have been made to circumvent this partitioning process, especially in the suggestions concerning the divisions on inheritance put forward in the Report by the Committee on the Size of Woodlot (Metsälön... 1970), most of which were reconsidered in the Forest 2000 -Programme (Metsä 2000 -ohjelma 1985, p. 32–34). It was proposed in this programme, for example, that the partitioning of NIPF holdings into units smaller than 10 hectares should be made illegal, but this has never been implemented in practice.

In addition, there is considerable confusion about the interpretation of concepts related to the size of forest holdings in Finland. The concept of partitioning has been understood in several ways. It means first of all the breaking up of holdings into two or more smaller units. This does not necessarily mean fragmentation, however, as one or more of the units of a partitioned holding may transfer to an individual who already owns forest, so that the final result may even be consolidation. To take a hypothetical example, if a holding is to be partitioned into three units, it may be that two units will be transferred to individuals who are not NIPF owners and one to an existing forest owner. This can be seen in the size distribution of holdings in a relative increase in both small and large holdings and a decrease in that of medium-size holdings. In fact, the above example describes very well the reality of current trends in the size distribution of NIPF holdings in Finland.

Also, estate structure, i.e. the shape and number of forest parcels and their position in relation to each other, is an important point related to the discussion of the size of NIPF holdings (Alho 1968, Häkkilä 1974). There has even been talk of "fragmented forests" or "fragmented holdings" (e.g. Jylhä 1988, Kantee 1988, Kontteli 1988). Research into the forestry behaviour of NIPF owners in the United States has similarly failed to make a clear distinction between ownership size, parcel size and treatment size (Cleaves and Bennett 1995, p. 70). The most common measure of size is nevertheless the area of forest land in the possession of a single owner, although the significance of the area depends, in the first place, on the size of the growing stock on the holding. There is no other measure, however, that can be acceptable as the basis for a theory of size, as all the concepts either attempt to measure size by reference to one resource only or reflect a normative view of resource requirements based on average input-output data (Ritson 1977, p. 205).

1.3 Aim and Outline of This Research

From the point of view of Finnish forest policy, the prevention of partitioning has not achieved the desired results. One reason may be that the forest policy measures have not been accurately targeted, and another that the institutional barriers designed to circumvent the partitioning process are scattered throughout much of what is a highly fragmented system of administration. It is evident that any attempt to influence partitioning via forest policy requires extensive co-operation between separate administrative bodies.

In countries dominated by NIPF ownership, one problem facing forest policy is how to influence the development of the structure of NIPF ownership so that it would meet the goals of national policy as regards to the role of forestry (Riihinen 1986). Therefore, the task of forest policy makers is to collect and unify the fragmented information on the factors influencing partitioning. In order to carry out efficient forest policy, information on holdings and the ownership factors lying behind partitioning and its implications for the size distribution of NIPF holdings must be available as the starting point for preventing partitioning.

The topic of this research is thus derived directly from Finnish forest policy, the aim being to identify those characteristics of holdings and their ownership that influence partitioning by providing a model that can be used as a screening tool for forest policy measures. Such a model is useful as an aid to determining and interpreting the factors that need to be taken into account in order to influence partitioning through forest policy. It is then the task of forest policy makers to employ instruments that blend in with the model (Vehkamäki 1986, p. 7–8). However, before any forest policy measures are taken, it is important to compile and evaluate the results of investigations regarding the economics of forestry and the forestry behaviour of NIPF owners in relation to holding size.

It should be emphasized that although the focus of this research is on the size of NIPF holdings, mostly one aspect, partitioning when holdings change hands, is treated exhaustively. Only passing attention is paid to the mechanism of partitioning and to changes in the size distribution of holdings. The objectives of the work are as follows:

- to review the literature related to forest holding size
- to describe the mechanisms of partitioning between different types of ownership
- to analyse the characteristics of holdings and their owners that affect partitioning
- to describe changes in the size distribution of the holdings.

In an earlier investigation into ownership factors affecting the partitioning of NIPF holdings in Finland (Ripatti 1993), the author employed discriminant analysis, which yielded only the signs of the effects exercised by the variables. The principal objective here was therefore to quantify holding and ownership characteristics that influence partitioning among different kinds of NIPF owners, for which purpose a formal socio-economic micro-model is developed and tested, which describes the structural factors lying behind partitioned holdings. To find an answer to the question why some holdings are partitioned in conjunction with a change of ownership and some not, will be performed. It is concluded that a bivariate approach is needed, implying that logistic regression analysis can be used. Therefore each holding is coded as one (partitioned) or zero (unpartitioned).

The research is explorative in character and due to the lack of longitudinal data, the effects of partitioning on both the average size and the size distribution of holdings are no more than indicative of certain trends. The work advances as follows. A review of the literature on the economics of forest holding size and previous research into partitioning will be presented in Chapter 2, and the frame of reference, including a historical review of forest ownership, property rights relating to forest ownership, structural changes in society and in NIPF ownership and the control system that regulates forest ownership, will be analyzed in Chapter 3. This chapter will conclude with an a priori model for partitioning. The material and methods employed in the research will be explained in the Chapter 4.

The empirical results will be presented in three parts in Chapter 5. First, the mechanism of partitioning will be demonstrated, and secondly, the results of the logistic regression models will be given. Although the subject is of national scope, the supporting empirical results will be drawn from Southern Finland and also the southwestern and southeastern corners of the country. Finally, changes in the size distribution of the holdings will be assessed. The results will be discussed in Chapter 6, and a list of the variables used, the detailed statistics and the outputs from the logistic regression models will be presented in appendices.

2 A Survey of Earlier Research

Most research into forest holding size has been done in countries dominated by NIPF ownership, and the relationship between these two facts is an obvious one. There are a number of studies carried out in Finland (e.g. Metsälön... 1970, Karppinen 1988, Ripatti and Reunala 1989) and in the United States (e.g. Schallau 1965, Row 1978, Straka et al. 1984, Cleaves and Bennett 1995), although holding size is often discussed in general terms. Little research has been paid to these questions in other countries (see Cubbage 1983, Cleaves and Bennett 1994). In this chapter the literature on the economics of forest holding size is cursorily reviewed in section 2.1 and the findings regarding NIPF owners' forestry behaviour in relation to holding size are discussed in section 2.2. Section 2.3 concentrates on research into partitioning.

2.1 Literature on the Economics of Holding Size

Scandinavia

Andersson (1965) used a synthetic model of a 36 000 ha forest on an even-aged 100-year rotation to examine highly mechanized versus conventional forestry methods in Sweden. The analysis included all the costs of managing and operating a forest enterprise for the two alternatives employing parcels varying in size from 11.5 to 360 ha. The variation in the average costs of felling areas ranging from 45 to 360 ha (corresponding to harvests of 1800 m^3 to 14 000 m^3) was less than 5 per cent. When the annual area felled was below 30 to 40 ha (1200 m^3 to 1600 m^3 harvests) costs increased rapidly, especially in the highly mechanized alternative. Andersson noted that if revenues remained constant of the area felled annually, the profit would decrease by as much as the operating costs increased. It should be stressed that though Andersson's study is outdated, it is still, however, trendsetting.

In Finland, the Ad Hoc Committee on the Size of Woodlot (Metsälön... 1970) discussed the problems of a small average size of NIPF holdings and of an unfavourable NIPF estate structure in general terms, but concentrated largely on methods which could help prevent the partitioning of holdings and promote development of the estate structure. The possibilities for increase the average size were also discussed.

Hämäläinen (1973), who compared the contribution profits of small (37 ha) and large (9500 ha) holdings by determining their revenues and expenditures, found stumpage price revenues per hectare to be 6.5–11.1 per cent higher on the large holdings, depending on the length of forest rotation. Furthermore, because of the more rational timber harvesting methods their logging costs operations were also smaller. On the other hand, no administration costs were marked down for the small holdings. All in all, the contribution profit per hectare with the ordinary 70–95 year forest rotation in Finland was usually approximately the same for the small and large holdings. When the forest rotation was shortened the contribution profit of the large holdings become definitely less advantageous, mostly due to their administration costs.

Vesikallio (1974) compared the costs of silvicultural and logging operations in small and large management units in Finland, his empirical results clearly indicating that the smaller the parcel, the greater the cost per unit volume of timber. Later Finnish studies regarding the costs of logging as a function of size of area felled have attained similar results (e.g. Linjala 1986).

In Norway, Noer (1975) evaluated the effect of the size of forest holding on 12 cost and yield factors, using hypothetical parcels 1000 metres long and of four widths, yielding areas of 1, 5, 20 and 50 hectares. Model 100 000 hectare forests composed exclusively of a given parcel size were considered, and the costs of the smaller parcels were compared with those of the largest parcel of three harvest levels. The costs on the 50 ha parcel were usually taken as the basis for comparison, so that the results reflect comparative costs and not the absolute costs for each parcel size. The results indicate, for instance, that even 5 ha parcels entailed costs almost double those affecting the 50 ha parcels. It was only at the level of 20 ha parcels that the costs were broadly similar to those of the 50 ha parcels with only a few exceptions.

The United States

Cubbage (1983) reviewed the theoretical basis for the economics of forest holding size in the United States and the literature on forest economics associated with holding and parcel sizes. Numerous theoretical and applied studies of size exist, but they require modifications to be adopted to forestry practices. The uneconomic aspects of small holding size, reflected in high average unit costs, are thought to be a primary reason for the assumed underproductive nature of NIPF and other small forests.

Small size in itself makes the costs of management and harvesting excessively high as compared with larger industrial and government holdings. In addition, economies of holding size affect the cost of delivering assistance. The difficulties encountered in combining small holdings or parcels may partly determine how readily industrial companies are prepared to develop economic management units and thus may change the location of the industry and its markets. Administrative costs are higher when timber is bought from numerous small parcels rather than a few large ones (Row 1978).

The statistical cost research performed by Wikstrom and Alley (1967) on the control of National Forests of the United States found that the size of the area was the most critical variable affecting management costs, where the management practices examined included slashing, burning, piling, terracing, pruning and thinning. The cost per hectare for all these practices increased rapidly with decreases in the size of the area, particularly for areas smaller than 20 to 25 ha. Likewise, Walbridge (1967) found that for highly capitalized harvest systems careful attention must be paid to the frequency and length of the move. Move distances in excess of 15 kilometers in the case of parcels of less than approximately 600 cubic metres total volume were found to be a significant factor in the total cost of harvesting when mechanized systems were used.

Sutton (1973) discussed several efficiency advantages of small NIPF holdings which might offset their disadvantages. Firstly, their timber can be sold on the free market at any time, depending on the price. The owner can avoid financial loss with only minimal risks by holding on to his timber. Secondly, and most important, owners of small holdings have much more flexible management alternatives and are often the first to accept new techniques. Thirdly, owners of small holdings have low overheads and administration costs and can often use state roads instead of building their own. Lastly, since they have no national or company interests or status to worry them, and since they are spending their own money rather than someone else's, they have every direct incentive to reduce costs.

Row (1973), addressing questions of the economics of holding and parcel sizes, developed an extensive computer simulation model using the synthetic firm approach to analyze financial returns from southern pine timber growing. The simulator package tested the sensitivity of financial returns to the area of the parcel, indicating that the fixed costs entailed in forest management were the primary determinants of the average costs of forestry operations, and that the magnitude of the fixed costs was directly related to the level of mechanization. The effect of planning, administration and inspection on the average fixed costs for each parcel was reduced when several parcels were combined, while conversely, the average fixed costs increased when separate parcels were included in the contract as compared with the same acreage contained in one contiguous parcel. The average area per parcel also influenced the variable costs slightly. Therefore parcels should be contiguous if combining them to reduce costs is to be successful.

Thienpont et al. (1976) surveyed completed logging operations in the Southeast United States to determine whether small parcel sizes had sufficient volumes to amortize both the fixed and variable costs attached to different harvesting systems and still provide a profit. They found that

mechanized systems required at least 10 ha or about 1300 cubic metres make harvesting a viable proposition. Bobtail truck systems dominated the harvesting of small areas or volumes, and if bobtail crews ceased operating, small parcel supplies would not be economic at current levels of pulpwood harvests. The volumes harvested on small parcels were to increase, however, felling might become economic in the future.

Vasievich (1980) developed a set of L-shaped inverse function cost curves that did not approach a minimum until about 450 ha, while Hunter (1980) found a decrease in parcel size statistically significant in reducing stumpage incomes for pulpwood, supporting the hypothesis of higher harvesting costs on small parcels. He did not find this to be the case for sawn timber, however.

Gardner (1981) found that larger parcels have lower average reforestation costs than small ones, but investments in small parcels could return an acceptable yield of 6 per cent when subsidy payments were included in the financial analysis. Even without subsidy payments, most reforestation methods provided adequate returns on small parcels, assuming that no stumpage discounts were applied to the timber crop. Cubbage (1981), using an economic engineering approach, found that large tree length systems, highly mechanized full-tree systems and whole-tree chipping systems incurred high average harvest costs on small parcels of land. Even though such parcels generally had average harvest costs as low as or lower than conventional southern pine short wood harvesting systems, they did not approach their minimum cost level until about 30 to 55 ha, depending on the degree of mechanization and capital investment in the system.

Fox et al. (1989), studying the effect of planning unit size on the implementation of forest plans in north central Arizona using a computer-aided decision support system, found that, although the differences between large and small areas were not dramatic, the results were consistent with the commonly held hypothesis that applying forest plan standards and guidelines to large planning areas is less restrictive than their application to small areas.

Finally, it should be stated that though the above results from the United States are supranational in their main principles, they are not directly generalizable to Finnish conditions due to differences in logging and silvicultural practices and institutions.

2.2 Findings on Forestry Behaviour Related to Holding Size

The size of forest holding has been considered an important background factor in most studies of the forestry behaviour of NIPF owners, and has been used both as an independent variable and as an interaction variable in multi-equation models. In the United States, Binkley (1981), for instance, proposed that the smaller the area of forest land, the smaller the likelihood of timber sales per holding, and Cleaves and Bennett (1995) came to the same conclusion when studying timber harvests by NIPF owners in Oregon. Although the size of forest holding was the main factor explaining timber harvests in cross-tabulations, the authors noted that this was in turn associated with length of ownership, type of ownership, occupation and personal income levels, suggesting that it may subsume subpopulations with different demographic profiles and types of harvesting behaviour.

Cleaves and Bennett (1994) also reviewed 21 investigations carried out in the United States, Canada and Scandinavia concerning the holding size lying behind NIPF owners' forestry behaviour, as well as studying holding size effects on the basis of their own harvesting research concerning Oregon NIPF owners, in which holding size variables were evaluated for their ability to distinguish unit, parcel and holding size. Most of the research did not distinguish these size elements. The term tract, for instance, had been used ambiguously. The samples for the NIPF owner surveys had been drawn either proportionally from the population, on an areal basis or according to participation in given behavioural activities. The second of these approaches is the most sensitive to potential areal effects, as it overrepresents large holdings. Most of the research had used dichotomous choice to describe behaviour, e.g. harvesting or not, and the most common reporting period was five years.

The Oregon research demonstrated that the frequency of timber harvests increases with holding size and decreases with the number of parcels, showing the typical direct relationship between size and timber harvests over five years, i.e. the most commonly reported period. Thus, the major conclusion derived from the 21 reports and the Oregon research was that if one aims to study the size effects of NIPF holdings cautiously, the size variable should be designed to be relative in character, e.g. fellings per hectare over a sufficient length of time (Cleaves and Bennett 1994, p. 205–206).

Most investigations into the timber sales behaviour of NIPF owners in Finland (e.g. Järveläinen 1988) also indicate that the frequency of timber sales and the annual volume felled per hectare increase with holding size, though this association is not necessarily an entirely straightforward one (Karppinen and Hänninen 1990, p. 39). In addition, this factor has some indirect effects on timber sales behaviour, in that high age of the owner, heir-owned holdings and recreational objectives in forest ownership are all associated with lower-than-average holding size. Felling of timber for sale is less prevalent among elderly and recreationalist owners and among heirs than among NIPF owners as a whole (Karppinen and Hänninen 1990, Ihalainen 1992, Kuuluvainen et al. 1996).

Although most investigations indicate that small holding size is detrimental to the timber supply, results indicating only a slight influence have also been obtained, especially in conjunction with multi-equation models (see Dennis 1989, Kuuluvainen 1989, Kuuluvainen and Ovaskainen 1994). In addition, an interesting approach was employed by Hyberg and Holthausen (1989), who used both profit maximizing and utility maximizing models to study the timber management behaviour of NIPF owners. Neither indicated any positive correlations with size of holding.

Apart from affecting commercial felling, a small average size of holding has been found to detract from silvicultural activity. Almost 40 years ago Holopainen (1957, p. 18–19), for instance, suggests that the size of holding seems to be an important factor affecting the silvicultural measures taken, and Järveläinen (1971, p. 16–17) likewise hypothesises that it is a significant factor lying behind silvicultural activity, confirming this with empirical findings. However, recent empirical results based on micro-data from southeastern Finland (Ovaskainen et al. 1994) indicate that voluntary silvicultural operations per hectare, e.g. seedling stand improvements, were greater in the case of smaller holdings (less than 20 ha) than of larger holdings.

Results regarding the investment behaviour of NIPF owners in the USA similarly indicate that a small size of holding discourages investment behaviour (e.g. Webster and Stoltenberg 1958, Marlin 1978, Boyd 1984, Straka et al. 1984, Holmes 1986, Greene and Blatner 1986). Straka et al. (1984, p. 495), for instance, came to a conclusion that this relationship centres on the economies of holding size, diminishing marginal utility, and the NIPF owner's alternative rate of return. Later studies using a logistic regression approach, however (Romm et al. 1987, Royer 1987), indicate that a small size of holding does not significantly influence the probability of forestry investment by NIPF owners.

Owners of small holdings also experience efficiency-related problems such as a lack of liquid investments and poor cash-flow (Glascock 1978), higher risks of loss due to fire, insects or disease (Row 1973), and greater market risks or uncertainty regarding the prices they will receive for their product (U.S. Department... 1978). Federal income tax provisions in the US similarly allow forest owners to offset a large proportion of their costs immediately and to pay only capital gains tax on the proceeds from growth. While these are essentially scale-neutral, they tend to benefit owners of large holdings (Row 1973).

When Thompson and Jones (1981) classified NIPF holdings in eastern Oklahoma into three groups by holding size, they found that forest management objectives varied markedly between the size classes. Owners of small holdings (less than about 25 ha in size) used their forest for timber production less often than did owners of large holdings. In addition, harvesting and stand improvement were minimal among owners of small holdings, who similarly did not appear to be interested in forestry extension programmes. A recent investigation into the forestry extension behaviour of NIPF owners in Finland (Hänninen and Viitala 1994) indicates that owners of small holdings use extension services less than those of large holdings.

Row (1978) enumerates many of the secondary effects of small parcel size that influence the economics of forestry extension. Owners of small parcels, for example, pay less attention to public extension programs. Also, the benefits of chargeable assistance depend on how large an area the assistance concerns, due to the partly fixed costs. From the viewpoint of society as a whole, the effect of assistance is influenced by both the costs of the program and the social value of increased timber availability or other benefits. Even if the values to the public exceed the cost, unit costs are higher in relative terms for owners of small parcels than for owners of large ones.

2.3 Research into Partitioning

Partitioning has been studied using existing statistical sources, e.g. by Karppinen (1988) and by examining the factors affecting it at the holding level, e.g. by Schallau (1965). The first of these approaches involves calculating trends using aggregate data, so that it is impossible in practice to incorporate holding and ownership characteristics into the analysis, whereas the second typically uses data on individuals, i.e. micro-data, and succeeds in relating partitioning or changes in the area of forest land to holding and ownership characteristics. As the present work is concerned with the latter approach, suffice it to say that considerable attention has been paid to the available statistics so far.

The first evaluation of trends in numbers of NIPF holdings was published as long ago as the 1930s (Osara 1935), the material being based on the first Agricultural Census to be held in Finland, that of 1929–30. The work highlights early trends in the number of holdings and changes in settlement policy from the end of the 19th century up to the time of the census.

The Report of the Ad Hoc Committee on the Size of Woodlot (Metsälön... 1970) described the size and estate structure of NIPF holdings and discussed the methods which could help prevent the fragmentation of holdings. It also discussed means of improving the NIPF estate structure, for instance, and of combining the separate parcels of a single holding or enlarging holdings. The most effective way of preventing fragmentation was seen to be the restriction of partitioning by means of special legislation applying to inheritance. Together with the loan system, this was thought capable of influencing the partitioning of holdings. The enlargement of silviculture and logging units, joint ownership and co-operation among NIPF owners were also discussed.

Karppinen (1988) studied trends in the number of NIPF holdings in Finland during this century. The early statistics were based on Agricultural Censuses covering the years from 1929–30 to 1969, and more recent data were from the farm and forest holding register maintained by the National Board of Agriculture. The results suggest that it is quite difficult to derive any reliable conclusions, as there were substantial differences in the definitions of a farm and the forest area belonging to it. Statistics describing trends in the number of NIPF holdings have also been presented by Ripatti and Reunala (1989), who estimated that number of holdings had increased by a good 20 000 each decade since the 1950's and concluded that the annual statistics contained in the farm register maintained by the National Board of Taxation are the most suitable for continuous monitoring.

Kampp and Rikkinen (1973, 1974) used the Archives of the National Board of Survey to determinate changes in the number and ownership of farms in the village of Levanto in southern Finland from the Great Partition of 1787 to the completion of the New Partition in 1916 and on to the period 1916–1973. Four stages in the history of the number of farms can be distinguished: the early settlement period, the early independence period, the resettlement period following the Second World War, and the period of surplus agricultural production from the mid-1960's onwards.

Kupiainen (1991) also studied partitioning by looking into the historical development of a village as a whole and of two individual farms, pointing out that this case study approach can bring out details which cannot be perceived from a statistical analysis. His description of the historical pattern of land ownership was as similar to that of Kampp and Rikkinen.

The first research concentrating particularly on factors affecting the partitioning of NIPF holdings was carried out in the United States (Schallau 1965). This used data on individuals, i.e. micro-data, as will be done here. The material was based on a sample of 334 holdings collected from a county tax register in northern Lower Michigan, and the aim was to develop a regression model to explain the factors affecting the fragmentation of holdings between 1946 and 1962. The most significant factor was change in the area under absentee ownership.

Binkley et al. (1980) also used a county tax register to formulate a model for determining transfers of land holdings in the Adirondack region in the northern part of New York State between 1970 and 1980. The probability of a holding changing ownership was estimated as a function of size and type of ownership. As the authors expected, the logit model showed that large holdings were less likely to change hands than smaller ones, and that the transfer rate was higher among NIPF owners than in other ownership groups.

Like Cleaves and Bennett (1994), Dennis (1992), provides a synthesis of the results of several empirical studies of the forestry behaviour of NIPF owners in the United States, filled out with his own empirical results on trends in the size distribution of forest holdings in Vermont and New Hampshire from 1973 to 1983. Parcelization of NIPF holdings and affluence among owners are included in the scope of the discussion. The overall trend seem to be towards smaller holdings and more affluent owners, which the author regards as likely to be detrimental to both the availability of timber and access for public recreation.

In Finland, Ripatti (1993) used discriminant analysis to examine holding and ownership factors affecting partitioning at the holding level. Ownership changes through inheritance, the area of forest land, use of a holding mainly for recreation etc., under-use of the allowable cut, residence in an urban district and large area of arable land increased the probability of partitioning, while family ownership and permanent residence on the holding reduced it. Only the signs of the effects of these independent variables were given by the analysis, however, but the question of the extent of their influence was considered to be beyond the scope of the research. In addition, changes in the areas of forest contained in NIPF holdings in southeastern Finland were studied by Ripatti (1992). The average gross decrease in the area of forest land was 1.7 ha, while the average gross increase was 1.2 ha during 1986–91. Consequently, the average size of holding decreased from 32.5 ha to 32.0 ha. The main factors affecting the changes in the area of forest land were the inheritance system, resulting in a decrease of 0.7 ha, and reclassification of the forest land, producing an increase of 0.4 ha per holding.

An inventory of NIPF estate structure produced by the National Board of Land Survey (Mustonen 1987, Kantee 1988, Selvitys... 1988) shows both the smallest and the most irregularly shaped estates to exist in Ostrobothnia and the southern and northwestern parts of Finland. Attempts were made to relate the present size and shape of estates to partitioning, but inventories of this kind are based on data from the Basic Map and therefore they cannot relate estate structure to ownership. In any case, use of the Basic Map makes it difficult to distinguish forest land from other land use types on estates.

3 Frame of Reference

3.1 Remarks on the Approach

Arrangements for the transfer of ownership of NIPF holdings are often bound up with many institutional factors, especially the inheritance system and farm legislation, in addition to which social change also has direct and indirect effects on the manner in which such arrangements are carried through. As with other changes in property ownership, the former and subsequent owners of a NIPF holding evaluate its continuity in the light of their own circumstances, although such a transfer may also be a passive process, depending on whether the recipient party wants the holding or not. Such disturbances can be expected to lead to unexpected ownership changes.

An additional feature associated with the theoretical basis for this work can be seen in the conceptual apparatus which guided the frame of reference to be applied. It is assumed that one factor lying behind NIPF ownership change arrangements concerns the differences in present day settlement conditions and the history of settlement between the western and eastern regions of Finland. This means that the analysis of factors affecting NIPF holdings will be linked to the regional variations in the degree of development of NIPF ownership (see Järveläinen 1971).

Since most non-industrial private forests have traditionally belonged to farmers, the development of the farm legislation to a level at which it provides for the prosperity under present-day conditions means that farm husbandry should be taken into consideration. Besides, the average length of ownership is sufficiently long that most of the holdings studied here must have initially been owned by farmers. Also, the fact that NIPF holdings are always located in rural areas whereas an increasing number of owners are coming to reside in urban areas should be taken into consideration. This discrepancy reflects changes in social environment from urban to rural areas which are associated with the characteristics of holdings and their ownership.

No specific theory has been developed to cope with this topic, but the general theory of structural change of society presented by Riihinen (1990) might provide a suitable starting point for the construction of a frame of reference, as it helps us to take changes of social positions and social institutions within various regions into consideration. Structural change itself can be explained in many ways, typically as processes in which parts of regions, actions and society are replaced in a new quality structure. Structural change may also be understood as an adaptation to new external circumstances (see Hjerppe 1988, Pajuoja 1988, Tykkyläinen and Kavilo 1991). Using Riihinen's theory as a basis, however, an additional feature is provided by an overall consideration of the description of the mechanism of social change by means of the theory of cumulative growth and regional differentiation as adapted by Myrdal (1964) and Riihinen (1965).

The idea of the frame of reference is illustrated in Fig. 2. Changes in social position, e.g. occupational structure, and social institutions, e.g. social environment, and also the system controlling the transfer of NIPF ownership, the latter in turn consisting of the inheritance system and farm legislation, are the major elements influencing changes in NIPF ownership. The impact of social change is assumed to accumulate in NIPF ownership, so that it may be described through structural factors inherent in the latter. In addition, social institutions have some direct effects on ownership change arrangements, although these are difficult to demonstrate.

The above framework will serve as a tool for the empirical part of the work, to be presented in this chapter. It should be stressed, however, that the elements of the frame of reference will be discussed separately. The discussion will proceed as follows. First, in order to understand the present-day conditions, a historical review of land ownership and its rights in Finland will be given. Secondly, we will discuss the system controlling the

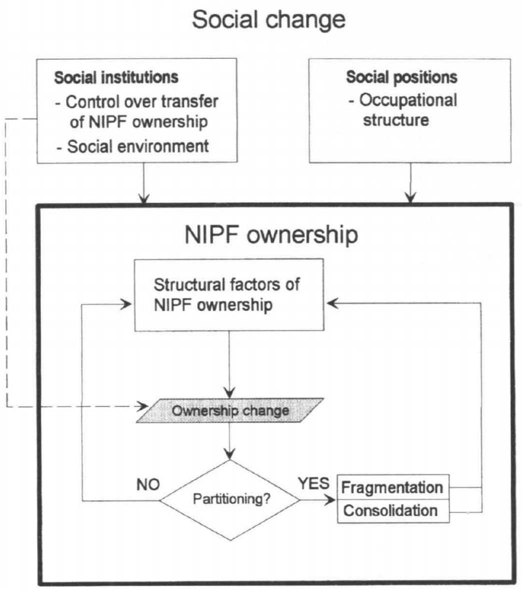


Fig 2. Frame of reference for this research.

transfer of NIPF ownership, after which social and NIPF ownership changes will be described, and finally an a priori model will be formulated.

3.2 A Historical Review of Forest Ownership

The spread of settlement to Finland took the form of the establishment of individual houses (farms) in the hitherto uninhabited interior of the country, which later formed the basis for villages. As villages formed, the adjacent forests were regarded as belonging to them, while the extensive parcels of forest beyond were considered common land, over which newcomers possessed rights of settlement, for instance (Häkkilä 1977, p. 32). The increase in taxation rights over cultivated land and the clarification of such rights is one factor which contributed to the further development of the land division system in the kingdom of Sweden-Finland that existed in that time. The very earliest taxes treated all farms equally, and thus the taxation records for this period serve simply as indications of the number of farms in the village. With the introduction of land division, however, taxation came to be based more and more on the area under cultivation and the size of harvest obtained (Wiiala 1952, p. 190–196, Siuruainen 1978, p. 69).

In 1542, King Gustav Vasa decreed that the rights to all uninhabited land should revert "to God, the King and the Crown of Sweden" (e.g. Haataja 1949, p. 33–38). One consequence of this was that henceforth any new settlers enjoyed rights of occupation rather than of possession over the land which they had cleared. A further statute enacted in 1683 drew boundaries between village lands and common lands in places where no such boundaries had existed (Linnamies 1970, p. 108–109), and later, in 1734, it was ordered that boundaries were to be established between private and State forest lands. This could be seen as the beginning of the present-day concept of non-industrial private forest ownership.

The Great Partition, which began in the 1750's, defined forest ownership more precisely, through a detailed act of parliament passed in 1775. Its purpose was to gather the farms which had become dispersed as a result of the plot system into a smaller number of integral units, and at the same time to distribute the forests of a village among its inhabitants (Riihinen 1963, p. 8). The Great Partition as applied under Swedish rule meant a major advance in rural settlement in southern and western Finland, though it scarcely altered circumstances in eastern Finland at all, where the farms still possessed relatively large parcels of land. All told, the Great Partition period, 1749–1805, provided for the reapportionment of over six million ha of land and the creation of 6000 farms and almost 23 000 tenant farms. The population of Finland also doubled during this period, reaching almost 900 000 inhabitants by the latter date (Siuruainen 1978, p. 71). The Great Partition evidently gave rise to a number of independent hereditary farms, which after further division have yielded the majority of the present-day small farms.

The first major state intervention in the formation of farms came in 1918, with the Leasehold Property Laws, by which tenant farmers were permitted to acquire the land which they had farmed at a modest price. The purpose of this law was to improve the economic and social position of the large class of dependent tenant farmers

which had emerged during the 18th and 19th centuries (Kallio 1954, p. 5). In accordance with the law, some 47 000 tenant farms and approx. 55 000 other leasehold estates were established. With the aim of creating new farms and rendering existing small farms more viable by increasing their land area, a law was passed in 1922 to allow the acquisition of land for settlement purposes either from state-owned lands or by voluntary or compulsory purchase (Siuruainen 1978, p. 75).

The increase in the number of farms continued between 1930 and 1960, caused by first of all by the government's settlement policy, embodied in the Settlement Law of 1922 and later in that of 1936, which was similar in principle. Both laws maintained that farms should be of a sufficient size to supply wood for household use only (Helander 1949, p. 322). Execution of the Settlement Law of 1936 was interrupted by the outbreak of the Winter War in autumn 1939, however, and in the wake of this war Finland was obliged to cede large territories to the Soviet Union. To provide land for the people who had lost their farms and others who were homeless, an emergency Resettlement Act was passed in 1940. Implementation of this was again interrupted, by the outbreak of the Continuation War against the Soviet Union in 1941.

After the Continuation War Finland was again faced with having to cede large areas of land to the Soviet Union, including the province of Karelia. In order to deal with the enormous problem of rehousing refugees from these areas, the Land Acquisition Act was passed in 1945 (Siuruainen 1978, p. 75–76). According to Hietanen (1984, p. 212), only one farm in every three that was established during the period up to the Second World War can be ascribed to settlement activities, but the estimate tells us nothing about the post-war era. Ilvessalo (1962, p. 149–152) emphasizes the detrimental effects of this resettlement policy on forestry, in that forest land already being managed rationally was given to small forest owners, which meant less effective utilization. The resettlement policy naturally also interfered with the partitioning of NIPF holdings.

3.3 Property Rights Relating to Forest Ownership

This chapter discusses briefly the history of property rights relating to forest land. The discussion is focused on the theory and development of such rights and on interventions in private land ownership in Finland. Demsetz (1967) formulated a theory of property rights which predicts that laws that define and enforce rights and duties regarding an economic asset appear at the point where the property in question begins to increase in value. Later, Alchian (1987) defined property rights as socially enforced rights to select the economic uses to which property may be put. Property rights are always restricted in some way. Recent studies of the evolution of rights with respect to land have focused on changes in the property rights system as part of a complex process in which the historical setting plays an important role (Kantor 1991, Eggertson 1992, Ellickson 1993, Roos 1996).

According to Roos (1996, p. 2–3) a person will use resources to enforce private property rights if it is profitable to do so. Enforcement by the individual of his or her private rights is socially unproductive, however, so that when individuals increase their efforts to protect their rights, the total demand for the provision of more precise property ownership institutions in society increases. These institutions can be supplied by the local community or by an outside authority, and they can consist of either formal laws or informal norms. If this demand is satisfied, individuals can direct more of their efforts towards productive activities and less towards the enforcement of their property rights.

Property laws that increase welfare, however, are not automatically imposed by society but rather their supply depends on the authorities' efficiency and impartiality. Furthermore, in the likely event of a new property rights system that increases total welfare not being a pareto-improvement, the winners in an institutional change must be powerful enough to steer it through, or else make compensatory side-payments to the losers. It is assumed here, however, that when no property rights exist, such institutions will emerge as an asset increases in value.

Roos (1996) inferred that the above theory would provide a model for the evolution property rights over forest land in Sweden. Users of forest spend more resources on property rights enforcement as the forest resources become more valuable – in either monetary or non-monetary terms – as rivalry increases, as exclusion becomes cheaper, or as common-use privileges diminish. Conflicts can emerge in this process, and new laws that define property rights are normally implemented. New uses for the forests have changed the relative value of different forest resources from time to time throughout history, and if rights have not already been defined, one would expect conflicts result from each such change and new property rights institutions to be subsequently enforced.

In general, the evolution of rights to forest land ownership has proceeded in a straightforward manner from open access or a common land ownership system to the modern private property rights system that prevails in Finland. Nevertheless, different interests have been trying to adjust the land ownership system throughout the country's history according to their own priorities. At least four stages can be defined in the evolution of Finnish NIPF ownership institutions in the current century, although the boundaries between these stages are indeterminate and the stages themselves have varied in length from a matter of years to decades.

In the first stage, until the early 20th century, a transition in private land ownership took place from common or village ownership to individual ownership. The rights and duties of ownership were clarified, and were defined and protected by law. One characteristic of this period was the development from extensive to intensive ways of using the forests. Simultaneously rights of ownership were strengthened along with the increased duties of ownership.

Finnish settlement policy in the period 1918–58 comprised the second stage, during which there was considerable state intervention in private land ownership rights. This period was characterized by unusual social conditions, which were tried to solve by means of efficiency land policy. The Leasehold Property Law of 1918 was a response to the economic and social problems caused by the existence of a landless rural population, and settlement laws were implemented after the Second World War in order to guarantee a living for those who had lost their lands and homes in conjunction with the wars against the Soviet Union. In accordance with this settlement legislation, the state intervented in land ownership rights by expropriating land from private persons and companies (Linnamies 1970). While the fundamental ownership rights already existed, the duties of ownership focused on how forest owners should manage their forests.

The Land Use Act of 1958 began the third phase in the evolution of the Finnish NIPF ownership, when land policy liberalized as a whole. State interventions came to an end and restrictions on the sale of land were lifted. This led to increased free market purchases of land, which was seen to reduce the vitality of the rural areas in the late 1960's (Reunala 1975). Simultaneously, one landowners' interest group, the Central Union of Agricultural and Forestry Producers, and political forces that were close to it instigated public discussion about land policy, which of course served their own particular goals (Sauli 1987). An important duty of forest ownership during this period was considered to be investment in timber production.

The Land Acquisition Right Act of 1978 and other farm legislation brought the liberal period in Finnish land policy to an end mostly because it restricted the rights of persons other than economically active farmers to buy land. This fourth stage in the evolution of Finnish land ownership rights prevailed when the empirical data for the present work were collected. One aim of land policy during this period was to keep the forests in the hands of farmers. On the other hand, one duty attached to forest ownership was considered to be the securing of a plentiful timber supply. The restrictions on the acquisition of land have recently been reduced in the southern part of Finland however (Valtioneuvoston... 1995). The controlled land acquisition policy obviously placed more emphasis on the inheritance system in transfers of ownership, as will be shown in the following sections.

3.4 The System of Control over Changes in Land Ownership

3.4.1 The Inheritance System

The code of inheritance in Finnish law does not give any precise answer to the question of how and in what proportions the property surviving a deceased person is to be divided up. The situation is influenced by the grounds on which the division is to be made and amongst whom. Inheritance differs from other forms of legal conveyance in that the previous owner is no longer alive by the time a decision has to be made as to who is to receive the property.

The purposes of the inheritance system may be examined from the viewpoint of either the individual or society at large. The former describes the purposes and aims of inheritance as an institution, for the sake of which the system has been adopted, and the latter takes account of the social conditions under which it operates. Its purposes may also be conflicting, as the system may be invoked to achieve a number of mutually irreconcilable goals. The appropriateness of a division of inheritance can also depend on the set of values by reference to which its purposes have been defined, in which case one is faced with a possible conflict of interests between the autonomy of the division of inheritance and the social purposes that it is intended to serve.

If the appropriateness of a division of inheritance emphasizes the independence of the individual vis à vis the state and the inviolability of private ownership rights, the code of inheritance represents a form of protection for the individual against the interests of society. This has been referred to as the autonomy aim of inheritance. If, on the other hand, the interests of society are given priority and emphasis is placed on the responsibility of society for satisfying the needs of its citizens in an impartial manner, the inheritance legislation may be looked on simply as one means of implementing social justice (Aarnio and Kangas 1991, p. 3–6).

The code of inheritance also has many other functions. It conveys social opportunities from one generation to another, and in an economic context it is a socially acceptable way of transferring the means of production from one generation of owner to another without payment, in which case it serves to promote the accumulation of capital.

The question of the choice of recipient of the principal item of property, the land holding, became a matter of importance in society at the point where regulations that allowed for an uneven distribution were felt to be socially unjust. This happened in Finland when the quantity of timber required by industry increased and the value of forest land reached quite new proportions, for it was then no longer equitable that one of the heirs should receive the whole land holding. This was the determining factor in the transition from the ideology of primogeniture to that of equal inheritance (Aarnio and Kangas 1991, p. 10–12).

The main principles of equal inheritance have been applied in Finland throughout the independence period, prior to which the sons of the deceased inherited double shares of the estate relative to the daughters. Even so, the choice of who should receive the farm did not cause any great problems even in the early 1960s, as this property almost always remained in the family. The main reason for this was the existence of the old social order of the agrarian community, which exercised a parallel influence over the choice of recipient alongside the system of equal inheritance.

The inheritance of land involves a number of difficult questions relating to forestry, perhaps the most important of which is what happens to a forest holding if its owner has more than one heir. Although equal division would correspond best to our democratic sense of justice, it is not without problems where forest is concerned, for if divisions are made among several heirs the holding will disintegrate into tiny fragments in the course of a few generations.

The change of owner is not a straightforward process even in the case where one of the heirs buys out the others, for this will mean the payment of large sums to the others, which is often financed by sale of the standing timber, possibly in excess of its sustainable allowable cut. It has been shown, in fact, that the use made of the allowable cut in a forest varies according to the lifespan of the owner (see Kuuluvainen 1989), and it is well known that a young person who has just taken possession of the forest holding will have a greater need of money than an elderly, well established owner.

The difficulties of buying out the co-heirs have been compounded in recent times by the high price of forest land and by a mistrust in the value of money in the long term, so that not all the co-heirs are necessarily willing to part with their share of the forest land in exchange for an often protracted debt to be recovered from its purchaser. A further problem is that where active farms are concerned the co-heirs to the arable land are frequently paid off in forest land (af Heurlin 1978).

Financial assistance, e.g. favourable loans, is indeed available to ensure the transfer of active, viable farms from one generation to another, but only in cases where the new owner intends to use the farm as a source of livelihood of a kind qualifying for economic support. This means that most heirs to forest holdings fail to meet the requirements for this assistance aimed at preventing fragmentation (e.g. Torvela and Siitonen 1992) .

The increase in joint ownership by heirs to an estate which is characteristic of the current structural change taking place in NIPF ownership may be seen as a consequence of problems experienced in distributing the estates of deceased farmers and finding successors to take over farms. This form of ownership entails certain conflicts as far as forestry is concerned. Its good point is that it does not as such mean that the forest holding is divided up, but it has the drawback that forest management measures and sales of timber in principle require the agreement of all the parties which is difficult to obtain in practice (see Järveläinen 1984, Ripatti 1991).

3.4.2 Farm Legislation

The ownership of real estate is more extensively defined in Finland than is the ownership of personal property, because land use and land ownership are dependent on legislation associated with land policy (af Heurlin 1978). This means that any change in the ownership of real estate is connected with the regulations that make up land policy, which in turn depend on institutions of land ownership. As stated by Vehkamäki (1990, p. 6), the fundamental objectives of the regulations governing land ownership have varied in accordance with political and economic circumstances. Since the regulations are largely based on acts of parliament, which determine their implementation, certain types of owners are usually favoured or discriminated against.

The ownership of forest land and arable land is substantially interdependent in Finland, so that forestry and agricultural policies have influenced land policy. Recognizing the need to control land ownership, a number of acts of parliament have been introduced to promote land policy by means of injunctions and subsidies. Up to the late 1970's, Finnish land policy was mainly regulated by the 1958 Law on Land Use, but from that time onwards the legislative basis for land ownership has been considerably strengthened. The main elements in the legislation regarding land ownership since the 1970's have been as follows:

- The Farm Act (Maatilalaki 1977)
- The Rural Livelihoods Act (Maaseutuelinkeinolaki 1990)
- Chapter 25 of the Code of Inheritance (Perintökaaren 25. luku 1989)
- The Land Acquisition Right Act (Laki oikeudesta hankkia maa- ja metsätalousmaata 1978)
- The Farm Closure Pension Act (Luopumiseläkelaki 1974)
- The Law on Pensions Payable on the Transfer of a Farm to a Descendant (Laki maatalousyrittäjien sukupolvenvaihdoseläkkeestä 1990)

Preparations for the Farm Act were begun in the early 1960's, but it was more than fifteen years before the act came into force in 1977. It replaced the Land Use Act of 1958, had a broader mandate with respect to agricultural measures, and effectively formed the basis of agricultural policy in the 1980's (Sauli 1987, p. 250–256). The Farm Act covered mainly agriculture and forestry practiced on farms, and it also concerned the acquisition of residential farms. The principle was that a farmer should receive his livelihood primarily from own farm. One important condition for support was that a farm should be regarded as capable of continuous profitable activity, although this was actually measured in terms of a minimum area of arable land in ha. In addition, a farmer was expected to reside on his farm or close by and to possess the necessary knowledge and skills for farming (Heikkilä 1984, p. 8–11).

The Farm Act was replaced by the Rural Livelihoods Act of 1990 at the beginning of 1991. The two resemble each other in their main principles, but the concept of the new act is wider and it also covers farms that are engaged solely in forestry and other small-scale rural enterprises. Perhaps the most essential difference lies in the definition of economic continuity, for where only a minimum area of arable land was needed earlier to qualify for financial support, one important condition under the present legislation is that the farm should be regarded as capable of continuous profitable activity. A loan should not be granted, for example, if the farm's expenditure debt repayments is too high in relation to its income (Torvela and Siitonen 1992, p. 13–15). The present act also contains regulations concerning the partitioning of farms, in that an application for financial support can only be granted on condition that the farm has not been partitioned by a former owner within the last ten years and that the support must be repaid if the farm is partitioned by the subsequent owner within the first five years following ownership change.

Chapter 25 of the Code of Inheritance is directly connected with the other legislation concerning farms. One vital aim, for example, is to encourage the transfer of areas of arable and forestry land to uses that will serve the purposes of the Rural Livelihoods Act. It also includes regulations concerning the partitioning of farms upon inheritance. If a person who has inherited a farm under the Rural Livelihoods Act conveys it or an essential part of it to somebody other than his or her immediate heir or spouse, he or she is obliged to pay compensation for this to the other legatees.

The Land Acquisition Right Act was passed in 1978. It enables economically active farmers to receive prior information on the sale of neighbouring arable and forest land and gives them priority purchasing rights. One essential aim of the act is to assist rationalization of the size of farms. The act concerns the rights of natural persons whose main source of livelihood is not agriculture or forestry, i.e. non-economically active farmers, companies, co-operative societies, associations and foundations, to purchase more than two ha area of arable or forestry land, since land purchasing permission is needed when the buyer is not an economically active farmer.

It can be speculated that the act affected the size distribution of forest holdings in two ways. Firstly, it tends to increase the average size of forest holdings owned by economically active farmers, whereas the average size of the holdings of other NIPF owners has decreased (Ihalainen 1992, p. 13). It has been assumed that the latter is partly a consequence of the fact that non-farmer legatees have a unique opportunity to obtain forest land by inheriting land without having to apply for permission. Further, it has been shown that holdings of non-farmers have been partitioned more often than holdings of farmers in conjunction with division on inheritances (Ripatti 1993). Most non-farmer heirs are thus able to become forest owners in this way.

The aim of the Farm Closure Pension Act of 1974 is to encourage farm enlargement by the consolidation of arable land, i.e. by offering a special retirement pension to economically active farmers aged over 55 years on condition that they undertake to sell their arable land to another farmer or to the state. They can then proceed in due course to the normal state pension scheme. The act does not concern forest land, however, so that it can be said to have resulted in an ageing of NIPF owners and an increase in the number of forest owners who do not possess any arable land (Ripatti 1994, p. 15–18). The aim of the other pension act associated with farm husbandry, the 1990 Act on Pensions Payable on the Transfer of a Farm to a Descendant, is to improve the age structure of economically active farmers and to promote the transfer of farms to descendants without division. It is closely associated with the Rural Livelihoods Act.

3.5 Social Change in Finland

3.5.1 Mechanism of Change

Cumulative Growth and Regional Differentiation

When describing the mechanism of social change, Myrdal's (1964) theory of cumulative growth and regional differentiation provides a useful basis for identifying both regions and their socioeconomic conditions. The origin of the theory lies in a rejection of the equilibrium assumption in economic theory according to which every disturbance in an economic system provokes a reaction directed at restoring the equilibrium. An economic system which is not at rest is considered to be moving towards equilibrium.

According to Myrdal it is proposed that the accumulation of economic activities in prosperous, growing regions will influence the less prosperous ones in two ways. Industrialization is characterized by the regional differentiation of economic activity. Strong areas develop, while backward areas characteristically suffer from a weakening of the preconditions for economic activity. This process does not proceed in a linear manner, however, for apart from growth areas and backward areas, areas with a spread effect also develop which receive stimulating influences from the growth areas. This means a distribution of scarce resources in such a way that economic expansion in one area is accompanied by at least a relative contraction in some other areas.

It is argued that non-economic factors are also important in the cumulative process leading towards regional inequality. Industrialization is accompanied by significant non-economic changes in the structure of society and in social values. It manifests itself in the first place in an effort to organize productive resources to serve human objectives as efficiently as possible. All relevant adverse changes which originate outside a region are effects which occur by way of migration, capital movements and trade, and have effects which occur via the whole spectrum of social relations (Riihinen 1965). In this sense, industrialization can be regarded as a social change brought about by aspirations of efficiency, and the pertinent non-economic changes can in a general way be described by comparing the characteristic features of traditional, non-industrialized and modern industrialized systems (Järveläinen and Riihinen 1979, p. 212).

Regions with spread effects derive benefits from the stimulation of an increased demand for raw materials and foodstuffs, and from the rapid diffusion of innovations. Regions adjacent to growth centres frequently receive spread effects, but distant locations may also benefit if favourable conditions exist for producing raw materials for the growth centres. Such localities may attract sufficient economic activity to become new growth centres in their own right. Backward regions, on the other hand, suffer as the result of the development of growth centres, as net movements of population, capital and goods favour the latter. Rural areas lose population to the growth centres and consequently suffer a deterioration in the age structure of the remaining population, which is often aggravated by high fertility in the lower economic and social strata.

Rural Regions and the Role of Forestry

Myrdal's theory has been widely adopted for the examination of the behaviour of Finnish landowners (e.g. Riihinen 1963, Järveläinen 1971, Hahtola 1973, Järveläinen and Riihinen 1979, Selby 1980, Mustonen 1991), as it allows the identification of growing, stagnant and declining regions. Hahtola (1973, p. 20–23), for instance, formulated a typology of ideal types of natural conditions and socio-economic environment for Finnish farming starting out from Myrdal's theory. The agricultural problem areas are well known: a low stage of industrialization and predomination of small-scale farming to name but two key aspects. It is on account of the agricultural problem areas that pronounced structural change in NIPF ownership has taken place, to the extent that absentee and non-farmer owners as well as joint ownership have become common.

The optimum regions for farming are described as the intermediate zones between the depressed remote regions and the growth areas. These optimum farming regions are characterized by an adequate communal infrastructure and a social environment that is sympathetic to agriculture. The conditions for forestry and for forest ownership are therefore determined by the status of forestry in the farm economy. In areas with village settlements, where conditions for arable farming are usually good, the ratio of forest land to total farm area is characteristically small.

Regions with expansive and spread effects usually possess a population with rising levels of aspiration and weakened social norms, both of which facilitate the modernization of agriculture. Rural occupations have to compete with urban ones, however, and urban occupations are often incompatible with farming. Thus the importance of forestry to forest owners is decreasing, and forest holdings serve mainly as an economic reserve or source of recreation.

In spite of this, Järveläinen and Riihinen (1979, p. 213) note that there are some differences between forestry and other economic activities with respect to their effect on the economic and social life of society or a given region. One important feature is that forestry is more directly concerned with rural districts than most other economic pursuits. From the viewpoint of NIPF ownership there may be some influences which one can classify as socially undesirable as far as traditional rural society is concerned. One basic element is the almost unavoidable disintegration of ancient social institutions and structures. Economic change brings about, or is conditioned by, certain deep-seated non-economic changes in a society, and the process of social change is a circular one in where many economic and non-economic factors are operating simultaneously. Even when the local population wishes to retain its traditional way of life it is difficult to avoid certain qualitative changes in the structure of society or of the local community and its social values.

Our modern society has caused the rural areas to undergo major social changes, in which the dynamic forces of industrialization and modernization have led to a functional and regional differentiation of economic activities, so that specialization in production, e.g. in forestry work, has increased and expansive growth centres, areas with spread effects and backward areas have developed. In the remote rural areas in particular the whole structure of the social system has almost broken down on account of cumulative processes generated mainly by large scale migration and the movement of capital (Järveläinen and Riihinen 1979). The role of forestry in rural areas has changed as industrialization and modernization have proceeded.

3.5.2 Change in the Social Environment

As social change is described through changes in the distribution of certain social positions, one essential element in it is economic development. This may lead to an unavoidable general overemphasis on economic aspects, for it is clear that social values and changes in the social environment should also be taken into consideration (Järveläinen 1971, p. 23).

Certain conceptual starting points based on ideal types have proved useful when describing regional differentiation. Social pressures and dependence relations in village settlements are of the type embodied in traditional values, while the individual in a scattered settlement has a much more independent relationship to the community. In Finland, Riihinen (1965, p. 10) regarded social disengagement as differentiating between village and scattered settlements, with pressure to conform placing the village community at one end of the continuum and scattered settlements and individual areas at the other. Regions with pronounced disengagement exhibit little pressure to conform, and vice versa.

An extension of the theory of cumulative growth and regional differentiation was achieved by adding social institutions (Riihinen 1965). It was pointed out that a lowering of the pressure to conform in several sub-systems of society seems to be an essential part of the process of industrialization. Furthermore, the division of labour is closely related to the performance of the population. Social disengagement is considered to be directly associated with archaic forms of economic activity. A clear contrast in the degree of social disengagement with respect to local customs has been found between the western and eastern parts of Finland (e.g. Selby 1980), reflecting the history of village settlement in the latter areas and of scattered settlements in the former (Rikkinen 1976). Individuals and families in village areas are more dependent on the community than their counterparts in the regions of scattered settlement.

The agrarian society felt a great veneration for land, because it was this that provided the foundation for living. Property was kept in the family, because it was understood that a farm is owned by a family and not by an individual. The productivity of the land had to be protected and the principles of land use was based on norms and customs (Aaltonen 1964). The regional differentiation and social pressure that were once characteristic of forest ownership have now declined, however, and as noted by Granberg (1989), this has been reflected in a weakening of social norms connected with one's farm and one's birthplace.

Another essential aspect of the change in the social environment is related to the customs operating between the generations. The average length of NIPF ownership in Finland is about 30 years (Ripatti 1993, p. 45), which means that the previous ownership changes of the holdings studied here had taken place on average in the late 1950's. It is probable that the norms and customs of agrarian society, which still prevailed at that time, will have influenced the present arrangements for changes in ownership. Furthermore, regional differences between the eastern and western parts of the country in customs regarding ownership change may well reflect the impact of the history of settlement.

The changes in the social environment are particularly reflected in the changing goals of NIPF owners, possibly as a result of a structural change in NIPF ownership itself, increased personal leisure-time, or substantial independence from traditional forestry. These changing goals may also be attributed to changing values in society as a whole (Karppinen 1995). The goals and values of NIPF owners can be seen to play an important role in ownership change arrangements, as the number of forest owners who reside in urban areas is increasing even though their ownership rights are tied to rural areas.

At the international level, changing norms and customs may be perceived by comparing NIPF ownership between countries that underwent industrialization at an early stage and those doing so later. In the United States, for example, a forest holding is of little value in itself because land is often a mechanism for profit-seeking (see Granberg 1989). It is possibly for this reason that a considerable proportion of NIPF holdings change hands on the open market, e.g. 70 per cent in the state of South Carolina (Marsinko et al. 1987), as compared with less than 20 per cent in Finland, partly because the regulations act against such trading.

3.5.3 Changes in Occupational Structure

The structure of the economically active population by occupation is one of the most frequently used indicators of social positions. A very rapid structural change by international standards has

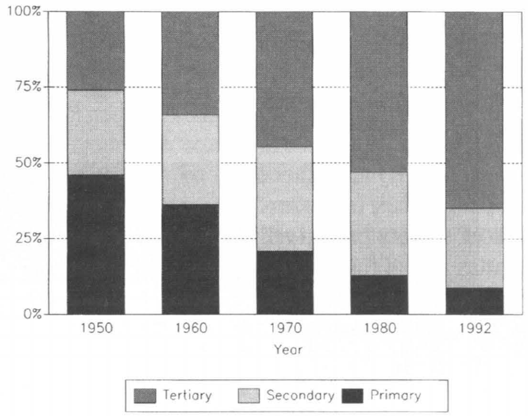


Fig. 3. Economically active population from 1950 to 1992 by occupation.

taken place in Finnish society since the Second World War, for where one fifth of the economically active population worked in primary production, i.e. agriculture and forestry, in 1950, this proportion is today about 5 per cent (Fig. 3). At the same time the proportion of the population engaged in manufacturing, transport, construction etc. increased until the mid-1970's, since when it has decreased steadily, whereas the proportion accounted for by the tertiary sector, i.e. trade and services, had increased from about one quarter in 1950 to more than two thirds by 1990. (Statistical... 1995). This rapid change has meant that the trend in Finland has differed in one important respect from that in countries that became industrialized earlier, namely that the proportion employed in the secondary sector never reached as high a level as it did in Great Britain or Sweden, for instance (Alestalo 1986, p. 39).

The origins of this change may be seen in the adoption of technological innovations. In agriculture, for example, the average large farm with more than 50 ha of arable land gave work to nine persons in 1950, but less than four in 1970, and the trend in the 1990s has been for a further decline. At the early stages it was the movement away from small farms with less than 5 ha of arable land that accounted for much of the structural change in agriculture, so that family members working on farms and hired labour have practically disappeared (Haggren et al. 1986). These enormous changes have obviously meant a more

homogeneous structure of agriculture, in which medium size farms with no hired workers have become the common basic unit.

One consequence of this was a migration of rural employees to urban areas, where work was available. The main flow of migration has in fact been from northern and eastern parts of the country to the south and southeast. A large number of migrants also moved to Sweden at the end of the 1960's (Söderling 1989, Valkonen 1990), and this again may be seen as an indication of a penetrating change in demographic and socio-economic structure in the Finnish countryside, leaving a distorted situation in which the young, well-educated element in the rural population has decreased (Haggren et al. 1986) while the number of well-educated white-collar employees has increased in the urban areas even though the proportion of young people in the total population has declined.

This short discussion indicates that Finnish society has experienced exceptionally rapid economic growth since the Second World War, with simultaneous far-reaching changes in the occupational structure. In forty years Finland has developed from an agrarian society into an industrialized urban one in which the majority of the labour force is engaged in manufacturing and services. As a result of this transformation, a considerable change has also taken place in the NIPF ownership.

3.6 Structural Changes in NIPF Ownership

3.6.1 Description of Ownership Change

Along with social change, NIPF ownership has undergone transformations in many respects, a process that is often described as a transfer of forest lands from farmers to non-farmers. In practice, this has taken place mostly by division of the land on inheritance and by purchases from parents or other relatives, and to some extent through changes of occupation on the part of farmers (Reunala 1974). In other words, ownership changes mostly act as an intermediary mechanism in this process. It is estimated that 10 000 holdings, or about 3 per cent of total holdings, change hands annually (Ripatti 1993, p. 45).

According to the established definition adopted by Reunala (1972, 1974) and Järveläinen (1974), farmers are forest owners, whose main source of livelihood comes from agricultural production or forestry. Other forest owners are then classified as non-farmers. Retiree forest owners can also be classified as farmers or non-farmers on the basis of their former occupation, just as jointly owned holdings are classified on the basis of the occupation of the person responsible for managing the holding.

As Reunala (1974, p. 33–36) points out, the structural change in NIPF ownership can be described as a system formed by a set of elements and a relationship between them and between their states. The elements in this system are the NIPF holdings, the states the farmers and non-farmers, and the relationship the channels through which NIPF ownership can change from one state to another. Modifications are also needed in the system, and these can be described as changes in properties, states or relationships occurring in time.

Farmers have owned the majority of the area of forest land in the past, and a stable inheritance system of the current kind has existed for a long time. The structural change has occurred in the occupational distribution of the farmers' heirs, an increasing number of them not being farmers themselves, in accordance with the general change in society. Thus where inheritance is concerned, the process of change can be regarded as an input from the environment into the NIPF ownership system. Change is also found to be an input in the case of purchases of holdings and changes in occupation.

The proportion of the area of NIPF land owned by non-farmers in the late 1940's was just under 10 per cent (Fig. 4), after which the structural change in ownership proceeded gradually, so that by the beginning of the period of extensive structural change in society in the early 1970's, the proportion of the area of forest land owned by non-farmers was about one fifth. By 1990 this figure was 44 per cent, though non-farmers represented a majority among NIPF owners (Reunala 1974, Ihalainen 1992).

In view of the crude nature of the farmer/non-farmer distinction, the structure of NIPF ownership has also been described in many other ways (see Hannelius 1980, Häkkilä and Voutilainen

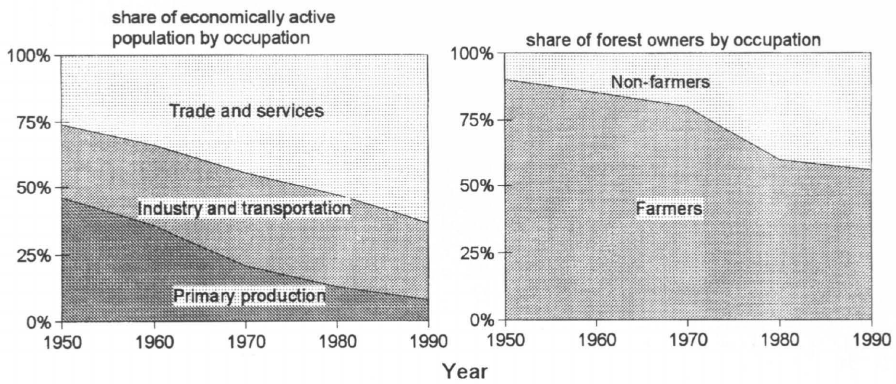


Fig. 4. Comparison of the structure of the economically active population with the structure of NIPF ownership.

1984, Karppinen and Hänninen 1990, Ruuska 1994, Ripatti 1995, Mustonen 1996). Ripatti, for instance, classifies owners by socio-economic status, pointing out that ageing of the population, the decrease in the number of farms and the increase in the number of heirs, i.e. fundamental factors associated with the structural change in NIPF ownership, have made the structure of this ownership more diverse. In fact, it was pensioners who made up the largest group of owners in 1990 (36 %), while the proportion of economically active farmers was still about one third. Wage and salary earners represented about one quarter of all owners and the remaining 5 per cent were private entrepreneurs.

3.6.2 Holding and Ownership Characteristics

Along with the change in NIPF ownership and the increase in the number of NIPF holdings, the proportions of jointly owned holdings and holdings with no permanent residents have increased and the mean age of forest owners and mean length of ownership have continued to increase. In addition, the number of holdings used mainly for non-productive purposes has risen. These factors are all associated with changes in age and occupational structure in the population as a whole and with migration.

As the proportion of jointly owned holdings has increased, that of family-owned holdings has correspondingly decreased (Fig. 5). Thus the number

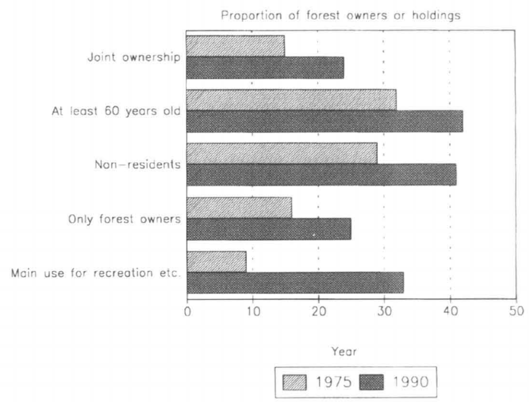


Fig. 5. Main characteristics of NIPF ownership in 1975 and 1990.

of holdings owned jointly by heirs increased by 6 per cent from 1975 to 1990, to reach 18 per cent, and concern holdings doubled to 6 per cent over the whole country (Järveläinen 1978, Ihalainen 1992). Most family-owned holdings are in the possession of a married couple, while those owned by heirs have approx. four joint owners on average and concern ownership usually involves three participants. Thus, given that the number of NIPF holdings with at least 1 ha of forest land is about 444 000, the total number of forest owners can be estimated at about 800 000. This implies that every sixth Finn owns forest in one way or another (Ripatti 1994, p. 14). This estimate was confirmed by Hänninen and Karppinen (1996) who found out the total number of Finnish forest owners by deriving it from total population.

The mean age of forest owners increased by one year to 54 years, between 1975 and 1990, i.e. it is fairly high. At the same time the proportion of forest owners aged at least 60 years increased by 10 per cent to 42 per cent and the proportion of female forest owners increased by 8 per cent to one fourth. The latter trend was related to the increase in jointly owned holdings, as a half of the heirs responsible for managing the forest holding were female in 1990 and one in three of those responsible of concern owned forests (Järveläinen 1978, Ihalainen 1992).

The duration of ownership, i.e. the period elapsing since the last change by the time of the study, increased from 18 years in 1975 to 20 years in 1990, but the total length of ownership is assessed to be on average about ten years longer, just over 30 years (Ripatti 1993, p. 45). One interesting feature is the tendency for increased duration in the case of joint ownership by heirs, an effect which accounted for much of the average total increase. One reason for this can be assumed to be the former taxation system, which favoured a continuation of joint ownership of inherited property, in spite of the fact that this is intended to be only a temporary form of ownership. The new taxation system was passed in 1993.

Although the majority of forest owners still resided permanently on their holdings in 1990, the proportion doing so has declined steadily, e.g. from 71 per cent to 59 per cent between 1975 and 1990 (Järveläinen 1978, Ihalainen 1992). Nevertheless, only one fifth of all forest owners in 1990 felt themselves to be town dwellers (Ripatti 1994, p. 15). In addition, the owners who resided permanently on their holdings, owned two thirds of the area of NIPF land, i.e. they had larger holdings than those who resided elsewhere.

The changes in the structural characteristics of NIPF ownership seem also to have affected the main uses to which the holdings are put (see Karppinen 1995). In the forest owners' own opinions, agriculture, forestry, and especially a combination of the two, have decreased markedly as the main uses of holdings while non-productive purposes such as recreation have increased. The proportion of holdings used mainly for non-productive purposes increased from about one tenth (5 % of the area of forest land) in 1975 to one third (25 % of the area of forest land) in 1990. This should not be oversimplified to mean that one third of the holdings and one quarter of the area of NIPF land have been withdrawn from timber production, however, for almost all forest owners in 1990 still used their forests for timber production to some extent (Ihalainen 1992, p. 24–26).

Not only has the proportion of the area of NIPF land used mainly for agriculture and forestry decreased, but equally the areas of arable land and of forest land under separate ownership have increased (Ihalainen and Ripatti 1990), so that where 16 per cent of the forest owners possessed exclusively forest land in 1975, this proportion was one quarter in 1990 (Järveläinen 1978, Ihalainen 1990). One key factor affecting this trend – despite the intentions to the contrary – is the farm legislation. Under the Farm Closure Pension Act a 55-year-old farmer may transfer to a special retirement pension, after which the normal state pension scheme applies on condition that his arable land is committed to be sold to another farmer or to the state, but this does not apply to forest land. Sauli (1987, p. 263–264) states that almost a half of the farmers who transferred to a farm closure pension during 1974–82 retained their forests, with the consequence that the area of NIPF land owned by pensioners grew by over 40 000 ha per year during that period.

There were some differences in the above factors between western and eastern parts of Southern Finland in 1990, the average area of forest land being substantially smaller in the west, 26 ha vs. 32 ha, but that of arable land greater, 10 ha vs. 5 ha (Table 1). In addition, the proportion of NIPF owners possessing exclusively forest land was about one quarter in the west but as high as 40 per cent in the east (Fig. 6). These figures indicate that agriculture is of considerably greater significance among NIPF owners in the western region,

Table 1. Mean characteristics of the NIPF holdings and owners in 1990 by regions of southern Finland.

	Western region	Eastern region
Area of forest land (ha)	26	32
Area of arable land (ha)	10	5
Owners' age (years)	53	55

i.e. the proportion of farmers among NIPF owners is higher.

Another interesting feature is that about one-third of the NIPF holdings in the western region had no permanent inhabitant, as compared with almost every second holding in the east. Also, one quarter of the NIPF owners in the western region used their holdings mainly for non-productive purposes, as compared with one-third in the east. This difference broadly supports the above assumption of a difference in agricultural production between the western and eastern regions. No other essential regional differences were found in the characteristics of holdings and their ownership. The mean age of owner and the proportion jointly owned holdings were similar in both regions, for instance.

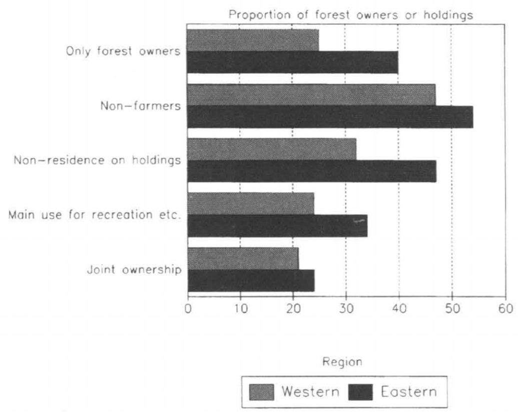


Fig. 6. Main characteristics of NIPF ownership in the western and eastern regions of southern Finland.

3.6.3 Trends in number of holdings

The first numerical data concerning the number of NIPF holdings were collected in connection with the first Agricultural Census in 1929–30, in which the total area of NIPF land was estimated to be 10.5 million hectares, nearly three million less than in the first National Forest Inventory (Ilvessalo 1927). This difference was caused mainly by the accuracy of the classification of forestry land and the exclusion of holdings with no arable land. Nevertheless, this gives quite a reliable picture of the number of holdings and their size distribution, as the act for the redemption of Leasehold Properties of 1918 had already been put into effect. Thus almost all of the NIPF holdings must have been identified in the Census (Osara 1935). About a half of the holdings were less then 20 ha in size, and these represented about 10 per cent of the area of NIPF land (Table 2). The proportion of large holdings of at least 100 ha was about 10 per cent and their proportion of the forest land more than half. The total number of holdings amounted to 232 000.

Table 2. Trends in numbers of NIPF holdings from 1929–30 to 1994 by size categories.

Size category	1929–30[1] number	%	1959[1] number	%	1969[1] number	%	1980[2] number	%	1994[2] number	%
1.0–4.9	37 803	16.3	67 156	20.4	55 010	15.6	132 382	32.2	153 380	34.9
5.0–19.9	73 129	31.4	114 824	34.8	128 109	36.4	117 314	28.5	124 794	28.4
20.0–49.9	63 373	27.2	91 313	27.7	103 469	29.4	102 986	25.1	100 325	22.8
50.0–100.0	32 823	14.1	39 123	11.9	45 891	13.0	42 022	10.2	43 519	9.9
>100	25 281	11.0	17 588	5.3	19 784	5.6	16 340	4.0	17 222	3.9
Total	232 409	100.0	330 004	100.0	352 263	100.0	411 044	100.0	439 240	100.0
Forest land area (million ha)	10.5		11.0		11.4		11.1		11.5	
Average size of holding (ha)	45		33		32		27		26	

[1] Sources: Census of Agriculture.
[2] Sources: National Board of Taxation, farm register.

The trend in the number of NIPF holdings and their size distribution from 1930 to 1960 can be appreciated by comparing the Agricultural Censuses of 1929–30 and 1959. The number of holdings increased by about 100 000 to 330 000 in 1959, largely by virtue of small holdings of less than 5 ha and 5–20 ha, although holdings of medium size, 20–50 ha and 50–100 ha, increased to some extent. On the other hand, large holdings of 100 ha or more decreased in number. In relative terms, the most significant changes were those that affected the size classes of less than 5 ha and at least 50 ha.

The Agricultural Censuses of 1959 and 1969 and the land register of the National Board of Survey allow us to estimate that the number of holdings increased by 20 000 per decade in 1960–80 (Ripatti and Reunala 1989, p. 7). A more exact picture of trends in the number of NIPF holdings and their size distribution since 1980 is available from the farm register maintained by the National Board of Taxation, which suggests that the number of holdings with at least 1 ha of forest land was 411 000 in 1980 and had increased to 444 000 by 1994. In other words, NIPF holdings increased in number by 2300 per year. Again small holdings of less than 20 ha accounted for much of the increase, while the number of large holdings of at least 50 ha rose only slightly and that of medium-sized holdings, from 20 ha to 50 ha, decreased.

The average size of NIPF holding has undoubtedly declined during the independence period, but the lack of any uniform long-term data makes it difficult to describe the changes in average size reliably, and only a general trend is available. The average size was about 45 ha in 1929–30 and about 33 ha in 1959, decreasing to 27 ha by 1980 but becoming only very slightly smaller since then, so that the figure in 1994 was 26 ha. These figures nevertheless underestimate the total area of NIPF land, which is shown by the National Forest Inventories to have been a good one million ha greater than the figure presented above. Thus, the "real" average size of holding would likewise be greater, assuming that the number of holdings remains unchanged.

3.7 The a Priori Model

3.7.1 Explanation in Terms of Structural Factors

Explanations can be classified in many ways, but broadly speaking two kinds of classification can be distinguished. The first is concerned with different approaches. That which predominates in the natural sciences is the causal explanation, which specifies on the basis of a general law a preceding or simultaneous event A which under the stated conditions is sufficient and necessary for the occurrence of B, the event to be explained. It is essential for causal explanation that the cause A and the effect should be logically independent, separately identifiable, observable phenomena (Allardt 1972, p. 54, Uusitalo 1991, p. 100–102).

The teleological approach is employed mostly in the behavioural and social sciences, but even here the general trend seems to be towards causal explanation. In the teleological approach an effort is made to attain intellectual satisfaction by specification of the goal or result for the sake of which the event is said to occur. Contrary to the empirical, causal relation, the relation between an action and its result is in general conceived to be not empirical but conceptual. Thus, the teleological approach is a device for understanding and interpretation rather than explanation (see Taylor 1980, p. 6, Uusitalo 1991, p. 105–107).

The second classification is, as Allardt (1972, p. 54) points out, somewhat philosophical. He states that explanations of behaviour in sociology are mainly given in terms of either causes, habits or motives. Although sociological explanations in terms of cause do not fulfill the requirements for true causal explanations, they resemble these in the sense that they are based upon overt observations. The use of different forms of explanation is connected with different interpretations of social reality. Some aspects of social reality are permeated by the ideas that participants have about reality, while others can be observed independently of the participants' ideas.

Structural explanations are based on overtly observable causes. Broadly speaking, structural terms include such things as the division of labour, or income distribution. Institutional explanations are based at least partly on habits and traditions, which are independent of the ideas of the participants, while cultural explanations are based on the ideas which the participants have about the social reality, available alternatives and values. The prototype for a cultural explanation is the "practical syllogism", which is related to teleological explanation (von Wright 1971, p. 91–98). The terms culture and structure can be used to distinguish between these two aspects, with institutions constituting an intermediate category (e.g. Hahtola 1973, p. 10).

It is thought that the structural explanation of the behaviour of NIPF owners may be of value in the present situation. This type of explanation in terms of the characteristics of holdings and their ownership which is associated with regional differentiation represents the causal approach. The ideal is to formulate a model in which structural factors and the partitioning of NIPF holdings are separately identifiable and observable phenomena (Scheffler 1969, p. 23–29). Thus the structural explanation approach is in reality a device for explaining factors affecting the partitioning of NIPF holdings.

Most of the structural factors operate at the holding level, though some have to be filled out by taking into consideration the characteristics of institutional and cultural explanation in terms of interpretation. For example, the traditions and habits associated with arrangements for changes in the ownership of NIPF holdings, along with the regulations prescribed by various regions and the whole of society, provide appropriate examples of institutional explanation. Nevertheless, they can be interpreted as if they were structural in character, because the establishment of these factors, e.g. the occupation structure of forest owners, appears only to be based on external observation. Allardt (1972, p. 58) has pointed out that we all, by and large, have a concept of these, but the important thing from the point of view of sociological methodology is that we usually construct such variables without considering the notions of the individuals studied. To be sure, there are structural factors of other kinds, but in order to establish such a variable as the main use of a NIPF holding, we have to rely on the opinions of the NIPF owners involved.

On the other hand, factors such as the location of a NIPF holding in either the western or eastern region of Finland carry with them cultural explanations. The relationship between culture and behaviour is not contingent and empirical, however, but conceptual. Actions which are said to depend on culture are expressions of ideas and action precepts that are part of the culture (Allardt 1972, p. 57). As a consequence, the use of structural factors does not mean, in somewhat oversimplified terms, that explanation is understood as causal in its approach. In addition, the use of structural factors cannot be understood as a fully deterministic explanation as in orthodox causal analysis, as the term explanation may also mean finding a surplus value for the interpretation of the variables used. Nevertheless, all the structural factors used here will offer an adequate base for causal explanation.

3.7.2 Formal Model for Ownership Change

An a priori model is an analytic construct applied to reality, which is a construct growing out of experience of the real world. As pointed out by Harvey (1976, p. 38–39), an a priori model therefore allows manipulations to be made and conclusions drawn regarding a set of phenomena in the absence of a full theory. This makes the model an act of inductive inference that serves as a substitute for a theory. Inductive inference based on empirical observations is an approach which has dominated the construction of models to the extent that Eskola (1981, p. 181–191) states that when little in the way of theory has been developed concerning a particular subject, empirical analysis usually aims at defining the variables to be included in a causal model and the elements of such a model therefore act as a hypothesis to be verified by empirical analysis.

A mathematical model for changes in the ownership of NIPF holdings will assist us in combining the frame of reference with an empirical analysis. The idea of the mathematical form for the model is adapted from Binkley (1981, p. 43), who applied choice model of McFadden (1973) to the study of whether decide to harvest or not. Alrich and Nelson (1984) also present a model with the same content, i.e. a rational choice perspective model in which the individual is faced with a choice between two alternatives.

Consider that a holding changes hands and that there are a number of variables denoted by the vector x' ($x_1, x_2, x_3 \ldots, x_i$) that determine whether or not it will be partitioned. The model can be developed as follows. Index the collectively exhaustive and mutually exclusive choices by (i), which run from zero to one. A holding (h) is affected by the alternative (i) if and only if the conditions (c) for (i) are more powerful than those for all the other alternatives:

$$C^h(x^i) > C^h(x^j)$$

where x^i, x^j are vectors of characteristics for alternatives i and j.

Let us now assume that the choice is not completely determined, but that some errors enter into the process, because we cannot measure all the attributes relevant to the choice. The formula will then be as follows:

$$C^h(x^i) = V^h(x^i) + \in^i$$

where $\in^i$ is the stochastic disturbance term and its distribution is left unspecified for the moment. The probability of occurrence of alternative (i) will be

$$P[C^h(x^i) > C^h(x^j)] = P[V^h(x^i) + \in^i > V^h(x^j) + \in^j] = P[V^h(x^i) - V(x^j) > \in^j - \in^i]$$

It has been proved (see McFadden 1973) that if $\in^i$ and $\in^j$ are independent with a Weinbull distribution, then

$$P_j^h = \frac{\exp[V^h(x^j)]}{\exp[V^h(x^i)]}$$

where P_j^h = probability of holding (h) being affected by alternative(j).

That is, the probability of an individual holding (h) undergoing alternative (j) follows a logistic distribution (see page 40). If (V) is specified as linear in its parameters but is not necessarily a linear function of the characteristics themselves (e.g. Kuuluvainen et al. 1983, p. 22–24), then the computer software, BMDPLR in the present case (see Engelman 1990), can be used to derive maximum likelihood estimates for the coefficients. A statistical test can also be performed in this framework.

3.7.3 Elements of the Model

The elements of the a priori model can be roughly divided into four groups (Fig. 7). Socio-economic factors describe the socio-economic state and demographic structure, ownership factors make up the structural factors related to the holding, holding size factors relate predominantly to the area of land involved, and regional factors at an aggregate level are used on account of the different degrees of regional differentiation. This grouping sets apart the factors affecting partitioning when the purpose is to influence partitioning through forest policy. Size and ownership factors, for instance, are both associated with structural policy for forestry, whereas the regional factors are associated more with regional policy.

Taking the socio-economic factors first, advanced age on the part of NIPF owners is a factor that is considered to refer ownership change problems from one generation to another (Granberg 1989). It can generally be assumed that ageing in forest owners enhances the likelihood of partitioning. Especially in a farming context, advanced age of a NIPF owners is correlated with defective economic continuity on the farm. Consequently, most people inheriting farms are regarded as taking on a new occupation. On the other hand, if none of the legatees wish to receive the farm, the continuity question may contribute to the fairly high mean age of forest owners. If the occupation of the former owner was something other than a farmer, the implications of ageing for partitioning remain unclear.

The occupation of farmer is assumed to place restraints on partitioning, just as all other occupations are assumed to promote it. Two reasons can be distinguished for this. Firstly, the norms and customs connected with farming support ownership changes within a single entity, and secondly, one precondition for financial support under the Rural Livelihoods Act is that the whole farm, including forest land must have been transferred to a new owner, whose occupation is that of a farmer, in one entity. If the new owner's occupation is farmer it is very likely that his or her parents were farmers too.

The next group of a priori factors to be considered concern the ownership of holdings. According to the Rural Livelihoods Act, a further pre-

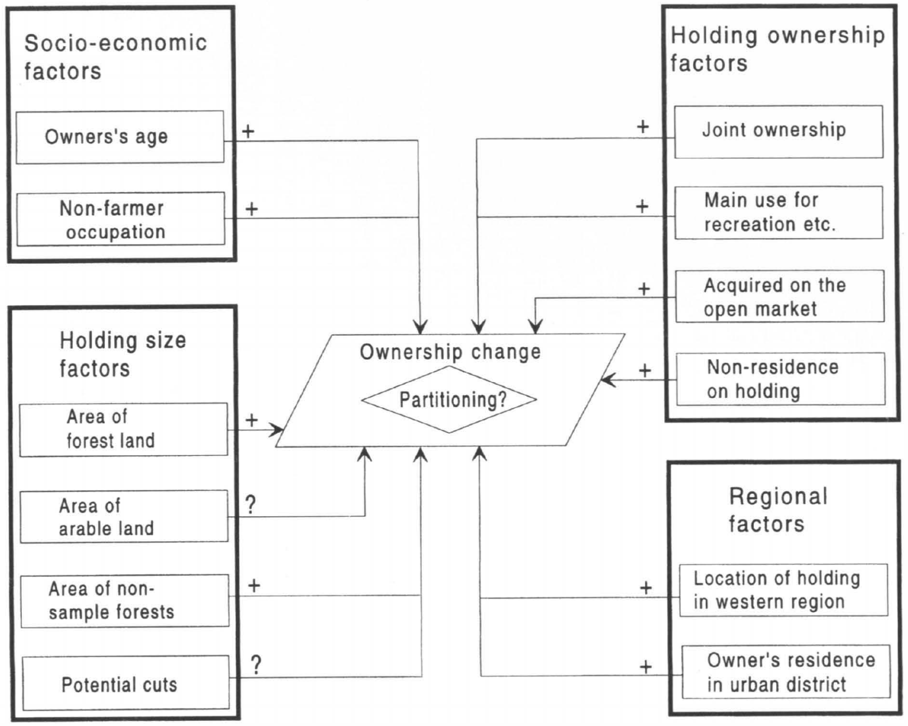


Fig. 7. Elements of the a priori model.

condition for financial support when a farm changes hands is that the subsequent owner should reside permanently on the farm. Thus, a permanently resided holding evidently decreases the probability of partitioning as what comes the influence of the act. Further, the intrinsic value of forest ownership will probably be greater if the farm is permanently occupied. It is therefore assumed that absentee ownership promotes partitioning. The early work of Schallau (1965) in the United States supports this assumption.

The type of acquisition of a holding by its former owner may likewise influence partitioning. If a holding had been purchased on the open market, it has nothing in the nature of family ownership, which may be assumed to argue in favour of partitioning, while purchase from parents or relatives, or inheritance of the holding, may have the opposite effect, because there is an essential meaning attached to the length of ownership in the family: the longer a farm has been in the hands of the same family, the greater the probability that it will not be divided.

Ownership can be divided into two types: stable ownership, or family ownership, and unstable ownership, or joint ownership. The latter, like ageing on the part of the forest owner, as mentioned earlier, is a factor associated with the economic continuity of a holding and is assumed to promote partitioning. Joint ownership, especially among the heirs to a holding, is usually a starting point for the implementation of a partition, in which case it is also clear that a great number of heirs will be a factor that further increases the probability of partitioning.

The main uses of holdings, for agriculture, forestry or agriculture and forestry equally, can be assumed to restrict partitioning. It is fact that a holding which is not principally used for production purposes, i.e. is used mainly for recreation etc., can be divided more easily, because the size of the new holdings will not hamper their use for the same purpose in the future. On the other hand, it has been proved that the holdings used mainly for non-production purposes have less allowable cuts than holdings used mainly for production

purposes (Karppinen and Hänninen 1990). In this respect holdings used mainly for non-production would be easier redeem as one entity. However, the first-mentioned way of thinking is assumed stronger.

The third group of a priori factors, those related to holding size, refer to the resources possessed by a holding, and can be expected to carry positive signs with respect to partitioning, as the larger the area of a holding is, the greater the possibility for dividing it. It is obvious that a young legatee who has inherited part of a holding and purchased more of it from other heirs will be greatly in need of money, especially as he or she may well be at an age where marriage and starting a family are common, creating a further need for money. As extra money is not usually available, the probability of partitioning of the forest holding will be enhanced. On the other hand, a large arable area may indicate the vitality of a farm, which can also seen as a decrease in the probability of partitioning the entire holding. Thus, no a priori expectation can be expressed regarding the sign attached to the area of arable land.

A large timber stock will add to the value of a forest holding, but its impact on partitioning may be a dual one. In the first place, a large timber stock may make it difficult to keep the holding as a single entity as its maintenance will call for considerable investments. On the other hand, the greater the timber stock – and the greater the wealth represented by it – the better the chances of realizing this capital and maintaining the holding as a single entity. Therefore, no a priori expectation can be expressed regarding the sign attached to this factor. In addition, other factors, such as site quality and the age structure of the forest may be more important to the value of forest property than the timber stock itself. In order to avoid misinterpretations of timber stock relative to the value of the forest holding, the allowable cut will be used rather than the timber stock in empirical part of this work.

The area of non-sample forests refers to the area of forest land belonging to the same family within a single municipality which is under a different type of ownership from the index holding. In Finland a forest holding is a property located within a single municipality and under the same type of ownership, and therefore a large area of non-sample forests belonging to the same entity will probably promote partitioning by rendering it technically easier to perform.

Finally, regional factors need to be taken into account, i.e. the probability of partitioning is considered to be greater if an owner lives in an urban municipality and his or her holding is located in the western part of the country, the latter because forestry itself and its significance to farms as a whole and to the livelihood obtained from them is greater in eastern Finland. On the other hand, features reflecting the scattered settlement history of eastern Finland may have the opposite influence. In addition, residence away from the holding, especially in a area of an urban type, may promote partitioning, since an urban way of life reflects urban norms and manners. It is probable, however, that if a forest owner lives in an urban district, preserving the holding as a single entity will not be the uppermost aim in mind when it changes hands.

4 Data and Methods

4.1 Population, Sample and Data Collection

There are in principle at least two ways in which one could study empirically the factors lying behind changes in the ownership of NIPF holdings and their partitioning. One could take a sample of holdings and observe their ownership arrangements for a sufficiently long time, e.g. a few generations, a type of data probably not available anywhere, for practical reasons, or else one could collect a sample of NIPF holdings, including ones that have undergone ownership changes, a less costly and better controlled method. It is the latter which is used here. This method can even be more reliable, as the characteristics of holdings and their ownership change with time, so that there might be a danger of confusing the contributory factors with those brought about by temporal effects. In addition, institutional aspects such as farm legislation have changed markedly in recent times.

According to the farm register maintained by the National Board of Taxation, the number of NIPF holdings with at least 5 ha of forest land in Southern Finland is about 240 000 (Ripatti and Reunala 1989, p. 13–20), which implies that, since it has been estimated that the average length of NIPF ownership is about 30 years (Ripatti 1993, p. 45), over 7000 holdings change hands annually. As no listing of these holdings exists, the investigation had to be based on a sample. Typically, the first step in a sample survey is to list the population in order to create a sampling framework, but due to the ownership changes and fragmentation of holdings, no reliable, up-to-date registers on Finnish NIPF holdings and their owners were available.

Various sampling frameworks have been used previously to obtain information on NIPF holdings and their owners. Agricultural Censuses were used from the Second World War until the late 1960's (e.g. Osara et al. 1948, Pöntynen 1962, Ervasti et al. 1969), whereas Holopainen (1956, 1959) used taxation lists. Most later studies of NIPF owners (e.g. Seppälä 1974, Järveläinen 1978) were based on cluster sampling, because use of the Agricultural Censuses and the farm and forest holding register maintained by the National Board of Agriculture became less practicable, largely on account of the omission of an increasing number of new forest owners, typically upon the holdings changing hands (Häkkilä and Voutilainen 1984, Sillanpää 1984).

Since it was necessary in the present case for information on forest holdings to be available for use at two separate points in time, the same holdings were studied in 1990–91 which had been involved in an earlier investigation conducted at the Finnish Forest Research Institute over the period 1980–86. We are thus concerned here with holdings which underwent ownership changes between 1980–86 and 1990–91. On the basis of the number of holdings and the average length of ownership, the population – of holdings in Southern Finland with at least 5 ha of forest land – may be estimated to number about 50 000 (Fig. 8).

The sample for the earlier investigation had been chosen by two-stage areal cluster sampling, employing the Basic Map sheet as the sampling unit at the first stage and the individual forest holding at the second stage. A more detailed description of the cluster sampling technique is given by Seppälä (1971a, 1971b). The data were collected by interviewing the owners of 2121 NIPF holdings with at least 5 ha of forest land in Southern Finland and making inventories their forests. The process of data collection is presented in detail by Karppinen and Hänninen (1990, p. 13–16).

The same holdings were then re-surveyed by means of a postal questionnaire in 1990, and partly by interviewing forest owners in 1991, as described in detail by Ovaskainen and Ripatti (1994, p. 10–11). The interviews and replies to the questionnaire together numbered 1578, given a response rate of 74 per cent. Where an ownership

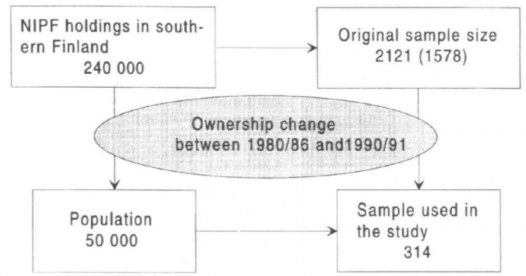


Fig. 8. Numbers of NIPF holdings in southern Finland, original sample size, population, and response in the present material.

change had taken place on one of these holdings, the case was accepted for the specific sample. Such cases numbered 314, and it was these that comprised the definitive sample. Thus, it is noted that independent variables are dated from the period 1980–86 while the dependent phenomenon is dated from years 1990–91.

These cases were then classified into two groups: unpartitioned holdings and partitioned holdings, amounting to 230 and 84 respectively. A division into western and eastern regions yielded two groups of 157 holdings each, although the occurrence of one case which could not be investigated reduced the eventual number of cases in the analysis to 313, including 156 in the western part of Southern Finland and 157 in the eastern part.

4.2 The Data

Since the purpose of the earlier investigation in 1980–86 had been to provide information on the actual and allowable cut on NIPF holdings, the selection of variables was not the best for the present purposes. The data did not include such important variables as value (price) of the holdings or the owner's marital status, number of children, or wealth or income, whereas only a small part of the information obtained for the original study could be used. Ignoring the economic and market-level factors implies that subsequent owners of the holdings would not be discriminated by value of the holdings or their volume of timber. In these circumstances the differences in ownership arrangements will be due to factors concerned with former holding and ownership characteristics.

Furthermore, the data do not cover northern Finland, and there are also certain other limitations in addition to these deficiencies in quality and areal coverage. On the other hand, a large amount of information was gathered when re-surveying the holdings, including their ownership arrangements and whether or not they had been partitioned in connection with ownership changes. The answer to the latter question was used as the response variable in the analysis.

One methodological problem arose from the determination of ownership changes. These were interpreted as having taken place whenever the holding was owned by a different person from before, when the type of ownership had changed, or if the area of forest land had decreased by more than half compared with the first survey. The simplest case was a straightforward change of owner, although it was most common for a change in the type of ownership to have taken place as well. In addition, there were a few cases in which the ownership characteristics had changed substantially, involving a decrease in the area of forest land.

The frame of reference presented above implies that the partitioning of NIPF holdings is influenced by numerous factors, and it is also clear that factors affecting the behaviour of forest owners are influenced by variables at different levels (see Tikkanen 1981, Järveläinen 1988). With respect to the characteristics of the data employed here, however, it was only possible to study the direct effects on partitioning, and therefore multi-order analyses such as path analysis were inapplicable.

The number of variables which could have been used to describe partitioning was very large, but a total of twelve were hypothesised to affect the partitioning of NIPF holdings. These were chosen on the basis of the theoretical considerations presented above and empirical observations made in earlier studies of NIPF owners (see Ihalainen 1990, Ovaskainen and Kuuluvainen 1994), even though the initial selection was primarily determined on the basis of the data collected at the first stage. The distributions of the variables classified and their means, standard deviations and the min-

Table 3. Minimum, maximum, and mean values and the standard deviation of continuous variables for unpartitioned and partitioned holdings.

Variable	Unpartitioned holdings (n=230)				Partitioned holdings (n=84)			
	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation
Area of forest land (ha)	5.19	456.51	27.97	28.25	6.00	1455.89	35.63	45.85
Area of non-sample forests (ha)	0.00	155.00	1.69	7.86	0.00	326.00	2.84	11.89
Area of arable land (ha)	0.00	106.96	8.10	9.73	0.00	65.06	8.26	10.94
Potential cut (cubic metres)	0.00	19.30	3.89	3.36	0.00	18.40	5.15	3.74
Age of forest owners (years)	18.00	85.00	59.60	13.05	26.00	89.00	56.06	13.19

imum and maximum values of the continuous variables among unpartitioned and partitioned holdings are given in Tables 3 and 4. It should be noted that due to the selected nature of the data, applying only to holdings which had undergone ownership changes, the figures in the tables deviate from the NIPF ownership factors as a whole.

The variables used can be described briefly as follows. They included both dichotomous and continuous variables, and divided the forest owners into farmers and non-farmers, employing the individual's former occupation where necessary. The present or former occupation of the person responsible for managing the holding was used if the holding was owned jointly.

Type of ownership was used both in the result line denoting the mechanism of partitioning and as a variable in the logit analysis. It was divided into three categories in the first case: owned by a family, owned by heirs, and owned by a concern, and two in the latter: owned by a family or owned jointly. The family-owned holdings comprised those that were in the hands of one owner alone or together with his/her spouse and/or children, whereas the jointly owned holdings comprised those owned by heirs or concerns.

The variable indicating the main use to which the holding was put was based on opinions expressed by the forest owners themselves, the holdings being classified into those used mainly for agriculture, forestry or agriculture and forestry equally, i.e. productive use, and those used mainly for recreation, residence or leisure, i.e non-productive use.

The division into western and eastern regions (Fig. 9) placed the former forestry board districts

Table 4. Distributions of dichotomous variables in unpartitioned and partitioned holdings.

Variable	Unpartitioned n=230	Partitioned n=84	Total n=314
Occupation of owners			
farmer	80.1	46.7	71.8
non-farmer	19.9	53.3	28.2
Residence on holdings			
not permanently	31.9	54.2	37.4
permanently	68.1	45.8	62.6
Type of ownership			
family owned	81.6	59.8	76.2
jointly owned	18.4	40.2	23.8
Main use of holdings			
agriculture etc.	84.4	60.7	78.5
recreation etc.	15.6	39.3	21.5
Region			
eastern region	56.7	40.2	52.7
western region	43.3	59.8	47.3
District of residence			
urban district	75.2	80.4	76.4
rural district	24.8	19.6	23.6
Means of acquisition			
purchased on open market	60.4	59.8	60.3
other	39.6	40.2	39.7

of Helsinki, Lounais-Suomi, Uusimaa-Häme, Pirkka-Häme, Satakunta, Etelä-Pohjanmaa, Pohjanmaa and Keski-Pohjanmaa in the western region and those of Itä-Häme, Etelä-Savo, Etelä-Karjala, Itä-Savo, Pohjois-Karjala, Pohjois-Savo and Keski-Suomi in the eastern region.

Holdings were divided into inhabited and uninhabited, and this was used as a dummy variable. A holding was required to be permanently inhab-

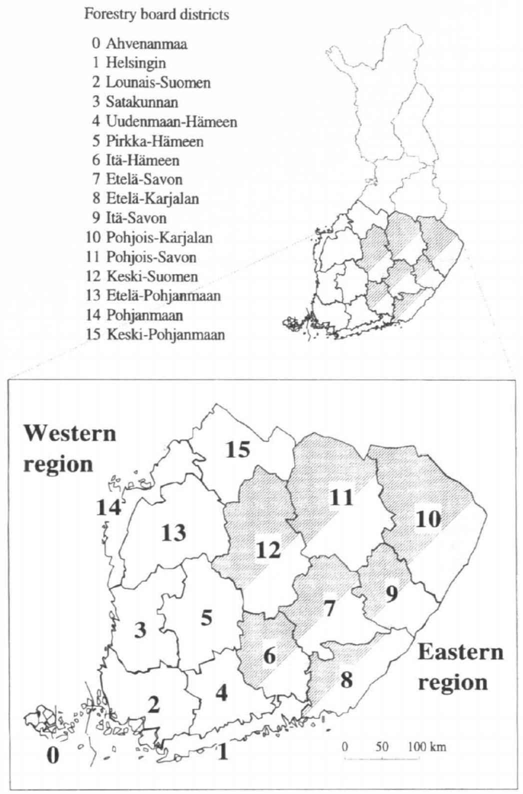


Fig. 9. The area of southern Finland studied here and its division.

ited, otherwise it was classified as uninhabited, whereupon a separate residence variable was used to describe the character of the municipality in which the owner lived, rural or urban.

In addition to the above, the means of acquisition by the former owner was used as a dummy variable in the logit analysis. Accordingly, the holdings were divided into those purchased on the open market and those inherited or purchased from relatives. The means of acquisition by the subsequent owner was also used to describe the mechanism of partitioning. Here three categories were used: inherited, purchased from relatives, and purchased on the open market.

The remaining five variables were used primarily in a continuous form. The area of forest land, the area of arable land and the area of non-sample forest land were indicated in hectares. The area of non-sample forest refers to the area belonging to the family within the same municipality but under a different type of ownership than the index holding. The potential cut was represented by the annual allowable cut determined on a silvicultural basis and described in cubic metres. A more detailed description of principles followed in calculating this allowable cut is given by Karppinen and Hänninen (1990, p. 18–21). The ages of the forest owners are denoted in years at the moment of interview at the first stage of data collection. It was possible to express these variables also in quartiles, and eventually in dichotomous form if necessary, when constructing the logistic regression models.

On account of the areal cluster sampling technique, the probability of a forest holding entering the sample was proportional to its area of holding, i.e. sampling was carried out using varying selection probabilities. The observations were therefore weighted, distributions and means being multiplied by the reciprocal of the total area of the holding. For a detailed description of the weighting method, see Järveläinen (1981, p. 9) and Karppinen and Hänninen (1990, p. 23–24).

The result lane describing the mechanism of partitioning contained percentage distributions in terms of the means of transfer from the former owner to the subsequent owner, whereas the results of the logistic regression analysis were presented in conventional terms as adopted from Hosmer and Lemeshow (1989). The data were analysed using the BMDPLR statistical software (Engelman 1990).

4.3 Logistic Regression Modelling

4.3.1 Basic Concept of the Analysis

Linear regression analysis is one of the most widely used methods in many sciences for describing the relationship between a response variable and one or more explanatory variables. It is often the case, however, that the response variable is dichotomous, i.e. taking on only two values, and the most suitable application is bivariate analysis, e.g. logistic regression analysis. In other words, the major distinction between logistic and linear regression is that the response variable is dichotomous in logistic regression whereas in linear regression it is linear (e.g. Cramer 1991).

The logistic function was designed as early as 1845 in the form of a growth curve, and the bivariate probability model, identified exclusively with a normal probit model, dates initially from the biological statistics of the 1930's. The theory of discrete choice of a random utility arose as part of abstract economic theory around the 1950s. The full development of the generalized logit model dates from its use in traffic analysis in the early 1970's (Cramer 1991, p. 39), but it is not until recent years that logistic regression analysis has become the standard method in dichotomous response variable situations.

Numerous investigations into the behaviour of NIPF owners have been carried out around the world, but logistic regression analysis proper was adopted for this purpose only in the 1980s. Similarly, little use has so far been made of this method in Finland, although Kuuluvainen et al. (1983) did use it to determine timber sales probabilities for forest owners, and Ollikainen and Salonen (1986) formulated a sequential binary model to analyze factors that affect their sales frequency.

It was not until almost ten years later that Ovaskainen et al. (1994) calculated the probabilities of forest owners with different characteristics investing in timber growth and Hänninen and Viitala (1994) used logistic regression analysis to compare the extension behaviour of active and non-active forest owners. Ripatti (1996) used the same method to determine preliminary how holding and ownership characteristics affect the probability of partitioning when holdings change hands, and Karppinen (1995) used logit models to identify NIPF owners belonging to goal groups. In addition, logistic regression analysis has been used to predict forest owners' choice of forest taxation principle when a reform in the Finnish forest taxation system was introduced in 1993 (Pesonen et al. 1995).

What are the advantages of logistic regression over linear regression? The first difference concerns the nature of the relationship between the response or outcome variable and independent variables. In any regression problem the key quantity is the mean value of the outcome variable, given the value of the independent variable. This quantity is called the conditional mean and may be expressed by $E(Y \mid x)$, where Y denotes the outcome variable and x a value of the independent variable. The quantity $E(Y \mid x)$ is read as the expected value of Y, given the value x. In linear regression we assume that this mean may be expressed as an equation that is linear on x, such as

$$E(Y \mid x) = \alpha + \beta_{1x} \qquad (1)$$

This expression implies that is possible for $E(Y \mid x)$ to assume any value as x ranges between $-\infty$ and $+\infty$. With dichotomous data the conditional mean must be greater than or equal to 0 and less than or equal to 1, and approaches 0 and 1 "gradually", i.e. the change in $E(Y \mid x)$ per unit change in x becomes progressively smaller as the conditional mean comes closer to 0 or 1. The curve is referred to as S-shaped (Fig. 10) and resembles a plot of the cumulative distribution of a random variable. It is not surprising that some well-known cumulative distributions have been used to provide a model for $E(Y \mid x)$ in the case where Y is dichotomous.

As pointed out by Hosmer and Lemeshow (1989, p. 6), there are two primary reasons for choosing a logistic distribution: it is an extremely flexible and easily used function and it lends itself to meaningful interpretation. The following presentation of the logistic regression analysis technique is mainly adapted from Aldrich and Nelson (1984), Hosmer and Lemeshow (1989) and Demaris (1992). Nevertheless, before the presentation, two essential concepts of the logit models should be presented. The first is probability which is defined in relation to x as $\pi(x)$, when the second concept, odds can be defined as $\pi(x) / [1 - \pi(x)]$.

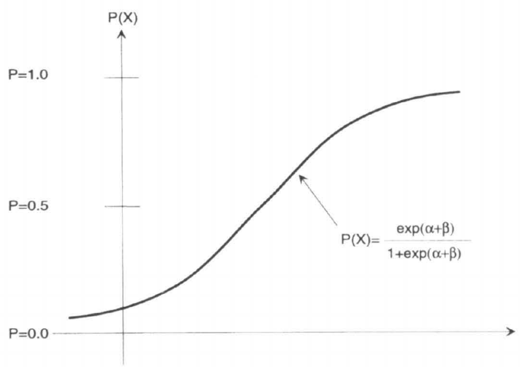


Fig. 10. The logistic model.

In order to simplify the notation, the quantity $\pi(x) = E(Y \mid x)$ will be used to represent the conditional mean of Y given x when the logistic distribution is used. The specific form of the logistic regression model to be used is as follows:

$$\pi(x) = \frac{e^{\alpha+\beta_{1x}}}{1+e^{\alpha+\beta_{1x}}} \qquad (2)$$

A transformation by $\pi(x)$ is referred to as a logit transformation. This is defined in terms of $\pi(x)$, as follows:

$$g(x) = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right] = \alpha + \beta_{1x} \qquad (3)$$

The significance of this transformation is that $g(x)$ has many of the desirable properties of a linear regression model. The logit, $g(x)$, is linear, continuous and may range from $+\infty$ to $-\infty$, depending on the range of x. It should be noted that as the value (x) varies from 0 to 1, the odds vary from 0 to ∞ because it is defined as $\pi(x) / [1 - \pi(x)]$. When $\pi(x) = 0.5$, the odds value is 1. Values from 0 to 1 on the odds scale correspond to values of $\pi(x)$ from 0 to 0.5. On the other hand, values of $\pi(x)$ from 0.5 to 1 result in odds values of between 1 and ∞. Taking the logarithm of the odds will resolve this symmetry. When $\pi(x) = 0$, the odds value is $-\infty$, and when $\pi(x) = 1$, it is $+\infty$ (Afifi and Clark 1990, p. 320).

Another important difference between the linear and logistic regression models concerns the conditional distribution of the outcome variable. In the linear regression model we assume that an observation of the outcome variable may be expressed as $y = E(Y \mid x) + \varepsilon$. The quantity ε is called the error, and expresses the deviation of an observation from the conditional mean. The most common assumption is that follows a normal distribution with mean zero and some variable that is constant across all levels of the independent variable.

It follows that the conditional distribution of the outcome variable given as x will be normal with mean $E(Y \mid x)$ and a variance that is constant. This is not the case with a dichotomous variable, however, when the value of the outcome variable given as x as may be expressed as $y = \pi(x) + \varepsilon$. Here the quantity ε may assume one of two possible values. If $y = 1$ then $\varepsilon = 1 - \pi(x)$ with probability $\pi(x)$, and if $y = 0$ then $\varepsilon = -\pi(x)$ with probability $1 - \pi(x)$. Thus, ε has a distribution with mean zero and variance equal to $\pi(x)[1 - \pi(x)]$. That is, the conditional distribution of the outcome variable follows a binomial distribution with probability given by the conditional mean, $\pi(x)$ (Hosmer and Lemeshow 1989, p. 7).

4.3.2 Fitting the Logistic Regression Model

The method most often used in linear regression for estimating unknown parameters is that of least squares, in which we choose values of α and β_l which minimize the sum of the squared deviations of the observed values of Y from the predicted values based on the model. Under the usual assumptions for linear regression, the method of least squares yields estimators with a number of desirable statistical properties. Unfortunately, when the method of least squares is applied to a model with a dichotomous response the estimators no longer have these same properties.

The general method of estimation that leads to a least squares function under the linear regression model is called maximum likelihood. This will provide the foundation for our approach to estimation using the regression model. In a very general sense, the method of maximum likelihood yields values for the unknown parameters which maximize the probability of obtaining the observed set of data. In order to apply this method we must first construct a function, called the likelihood function, which expresses the probability attached to the observed data as a function of the unknown parameters. The maximum likelihood estimators of these parameters are the values which maximize this function. Thus, the resulting estimators are those which agree most closely with the observed data (Hosmer and Lemeshow 1989, p. 8)

To find these values from the logistic regression model, we operate as follows. If Y is coded as zero or one, then the expression for $\pi(x)$ given in equation 2 provides the conditional probability that Y is equal to 1 given x. This will be denoted as $P(Y = 1 \mid x)$. It follows that the quantity $1 - \pi(x)$ gives the conditional probability that Y is equal to zero given x, $P(Y = 0 \mid x)$. Thus, for pairs (x_i, y_i) where $y_i = 1$ the contribution to the likelihood function is $\pi(x_i)$ and for pairs where $y_i = 0$ the contribution to the likelihood function is $1 - \pi(x_i)$

where the quantity $\pi(x_i)$ denotes the value of $\pi(x_i)$ computed at x_i. A convenient way of expressing the contribution to the likelihood function for the pair (x_i, y_i) is through the term

$$\zeta(x_i) = \pi(x_i)^{y_i}[1-\pi(x_i)]^{1-y_i} \quad (4)$$

Since the observations are assumed to be independent, the likelihood function is obtained as a product of the terms given in expression 4 as follows:

$$l(\beta) = \prod_{i=1}^{n} \zeta(x_i) \quad (5)$$

The principle of maximum likelihood states that we use as our estimate of β the value which maximizes the expression in equation 5. It is easier mathematically, however, to work with the log of equation 5. This expression, the log likelihood, is defined as Hosmer and Lemeshow (1989, p. 9) have displayed

$$L(\beta) = \ln[l(\beta)] \sum_{i=1}^{n} \{y_i \ln[\pi(x_i)] + (1-y_i)\ln[1-\pi(x_i)]\} \quad (6)$$

To find the value of β that maximizes $L(\beta)$ we differentiate $L(\beta)$ with respect to β and set the resulting expressions equal to zero, these equations are as follows:

$$\sum_{i=1}^{n} [y_i - \pi(x_i)] = 0 \quad (7)$$

and

$$\sum_{i=1}^{n} x_i[y_i - \pi(x_i)] = 0 \quad (8)$$

These are called the likelihood equations. It is understood in equations 7 and 8 that the summation indicated by Σ is over i, varying from 1 to n. In linear regression the likelihood equations obtained by differentiating the sum of the squared deviations functions with respect to β are linear in the unknown parameters and thus are easily solved. For logistic regression, however, the expressions in equations 7 and 8 are non-linear in β, and thus require special solution methods. The value of β given by the solution to equations 7 and 8 is called the maximum likelihood estimate, and will be denoted as $\hat{\beta}$. Use of the symbol (^) will denote the maximum likelihood estimate for the respective quantity. Thus $\hat{\pi}(x_i)$ is the maximum likelihood estimate of $\pi(x_i)$, for example. This quantity provides an estimate of the conditional probability that Y is equal to 1, given that x is equal to x_i. As such, it represents the fitted or predicted value for the logistic regression model. An interesting consequence of equation 7 is that

$$\sum_{i=1}^{n} y_i = \sum_{i=1}^{n} \hat{\pi}(x_i)$$

That is, the sum of the observed values of y is equal to the sum of its predicted values (e.g. Hensher and Johnson 1981).

4.3.3 *Interpretation of the Parameters*

The estimated coefficients for the independent variables represent the slope or rate of change of a function of the partitioning of NIPF holdings per unit of change in the independent variable. Thus interpretation involves two issues: determining the functional relationship between partitioning and the independent variable, and defining the unit of change appropriately for the independent variable. These questions will be considered below. We will first discuss the characteristics of the results of logistic regression models. Following that we will consider the interpretation of the parameters for univariate logistic regression for dichotomous and continuous independent variables. Finally, multivariate case with two or more independent variables will be presented.

Logistic regression analysis is very recent adaptation of bivariate analysis especially in forest economics, and this may be one reason why there is considerable confusion over the interpretation of its results. As Demaris (1993, p. 1057) points out, this confusion centres on an intractable problem in the logistic regression model: as long as the probability of an event is the response of a unit of interest, there is no measure that exactly summarizes the net impact of the response of an unit increase in a given explanatory variable independently of other predictors in the model (e.g. Baer et al., 1990, Roncek 1991). The odds value is mathematically defined as $\pi/(1-\pi)$, which is the ratio of an event occurring (π) to that of it not occurring $(1-\pi)$. With 2:1 odds, the event will occur twice as often as not, or is twice as likely to occur as not.

Table 5. Values of the logistic regression model with a dichotomous independent variable.

		Independent variable $x = 0$	$x = 1$
Outcome variable	$y = 0$	$1-\pi(0) = \dfrac{1}{1+e^{\alpha}}$	$1-\pi(1) = \dfrac{1}{1+e^{\alpha+\beta}}$
	$y = 1$	$\pi(0) = \dfrac{e^{\alpha}}{1+e^{\alpha}}$	$\pi(1) = \dfrac{e^{\alpha+\beta}}{1+e^{\alpha+\beta}}$

As mentioned earlier, partitioning of NIPF holdings must be coded as either 0 or 1. If we now assume that an independent variable, e.g. the forest owner's occupation, is dichotomous and is also coded as either 0 or 1, we obtain a case which is not only the simplest but will provide a conceptual foundation for all other situations. In this case there are two values of π (occupation, x) and equivalently two values of $1-\pi$ (occupation, x). These may be conveniently displayed in a two-times-two table, as shown in Table 5.

The odds of the partitioning among $x = 1$ (non-farmers) are defined as $\pi(1)/[1-\pi(1)]$, and the odds of partitioning among $x = 0$ (farmers) as $\pi(0)/[1-\pi(0)]$. Thus the logarithm of the odds are

$$g(1) = \ln\{\pi(1)/[1-\pi(1)]\}$$

$$g(0) = \ln\{\pi(0)/[1-\pi(0)]\} \quad (9)$$

The odds ratio, denoted by ψ, is defined as the ratio of the odds for non-farmers ($x = 1$) to those for farmers ($x = 0$), and is given by the equation

$$\psi = \frac{\pi(1)/[1-\pi(1)]}{\pi(0)/[1-\pi(0)]} \quad (10)$$

The logarithm of the odds ratio is

$$\ln(\psi) = \ln\left[\frac{\pi(1)/[1-\pi(1)]}{\pi(0)/[1-\pi(0)]}\right] = g(1) - g(0) \quad (11)$$

which is the logit difference. The expressions for the logistic regression model are shown in Table 5. The odds ratio is

$$\psi = \frac{\left(\dfrac{e^{\alpha+\beta_1}}{1+e^{\alpha+\beta_1}}\right)\left(\dfrac{1}{1+e^{\alpha}}\right)}{\left(\dfrac{e^{\alpha}}{1+e^{\alpha}}\right)\left(\dfrac{1}{1+e^{\alpha+\beta_1}}\right)} = \frac{e^{\alpha}+e^{\beta_1}}{e^{\alpha}} = e^{\beta_1} \quad (12)$$

Hence, for logistic regression with a dichotomous independent variable $\psi = e^{\beta l}$ and the logit difference, or logarithm of the odds ratio, is $(\psi) = \ln(e^{\beta l}) = \beta_l$. This fundamental fact indicates that the odds ratio is obtained from coefficient β_l by taking antilog $e^{\beta l}$. It should also be noted, as stated by Demaris (1993, p. 1058), that the interpretation of the odds ratio is strictly in terms of odds and not probabilities. Thus it is correct to say that the odds of partitioning is x times higher or lower among non-farmers than among farmers, for instance. Moreover, it should be emphasized that when an independent variable x increases by one unit, from x to x+1, there is an increment to π of $\pi'(x)$ along the tangent line at x, but the increment to π is considerably smaller along the function itself. The increment to π need not necessarily be smaller than $\pi'(x)$ in absolute value, but it will always be different from $\pi'(x)$ (Demaris 1993, p. 1059).

In order to develop a method for interpreting the coefficient for a continuous variable, the logit is assumed to be a linear variable (e.g. Agresti 1990) in the continuous covariate, x, so that its equation is $g(x) = \alpha + \beta_1 x$. It follows that the slope coefficient, β_1, gives the change in the log odds for an increase of "1" unit in x, that is, $\beta_1 = g(x+1) - g(x)$ for any value of x. The value of "1" is not usually very interesting, however. For example, an increase of 1 hectare in the area of forest land may be too small to be considered important, and a change of 10 hectare might be considered more useful. Hence, to provide a useful interpretation for continuous scaled covariates, it is necessary to develop a method for point and interval estimation given an arbitrary change of "c" units in the covariate (Hosmer and Lemeshow 1989, p. 57).

The log odds for a change of c units in x are obtained from the logit difference $g(x+c) - g(x) = c\beta_l$, and the associated odds ratio is obtained from the exponent of this logit difference, $\psi(c) = \psi(x + c, x) = \exp(c\beta_1)$. An estimate may be obtained by replacing β_1 with its maximum likelihood estimate $\hat{\beta}_1$. An estimate of the standard error needed for confidence interval estimation is obtained by multiplying the estimated standard error of $\hat{\beta}_1$ by c. Hence the endpoints of the $100(1-\alpha)$ % CI estimate of $\psi(c)$ are

$$\exp\left[c\hat{\beta}_1 \pm z_1 - \alpha/2 \times \hat{SE}(\hat{\beta}_1)\right] \quad (13)$$

As in the case of univariate logistic regression, the estimated coefficients of the multivariate can be interpreted according to the same principles. In order to fully understand the estimates of the coefficients obtained from a multivariate logistic regression model, however, one requires a clear understanding of what is actually meant statistically by the term adjusting for other variables. Let $x_1, x_2 \ldots x_i$ be independent variables, and let π be the conditional probability that partitioning of NIPF holdings is taking place and $1 - \pi$ the conditional probability that partitioning is not taking place. Then the logistic regression model for the log odds on partitioning is

$$\ln\frac{\pi_i}{1-\pi_i} = \ln CO = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i \quad (14)$$

where CO represents the conditional odds on partitioning, given the explanatory variables. The present logistic regression model will be employed with both dichotomous and continuous variables, a situation which is frequently encountered in studies of the forestry behaviour of NIPF owners when exposure to a behaviour factor is recorded as being either present or absent.

Probabilities themselves are also interesting. Demaris (1993, p. 1061) points out that probability approaches are appropriate when focusing theoretically on the probability of an event or developing a model as a predictive tool for identifying categories of individuals at risk with respect to a given event. Demaris (1993, p. 1063) also mentions that predicted probabilities reflect only the impacts of predictors at specific combinations of predictor values, and are thus not useful as summary statistics. We intend here to calculate probabilities of partitioning for NIPF holdings in substantively interesting cases. In terms of the probability assignable to the population (P), the equation can be written as follows:

$$P = \frac{1}{1 + \exp[-(\alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i)]} \quad (15)$$

4.3.4 *Testing for the Significance of the Coefficients*

Two approaches were employed for testing the statistical significance of the coefficients of variables. The first was comparison of the observed values of the response variable with those predicted by each of two models, the first with and the second without the variable in question. In logistic regression the comparison of observed and predicted values is based on the log likelihood function, employing the following expression:

$$D = -2\ln\left[\frac{\text{(likelihood of the current model)}}{\text{(likelihood of the saturated model)}}\right] \quad (16)$$

A saturated model is one that contains as many parameters as there are data points. The quantity inside the large brackets in equation 16 is called the likelihood ratio. The reason for using minus twice its log is mathematical and is necessary in order to obtain a quantity whose distribution is known and thus can be used to test hypotheses. Such a test is called the likelihood ratio test, and is described by the equation

$$D = -2\sum_{i=1}^{n}\left[y_i \ln\left(\frac{\hat{\pi}_i}{y_i}\right) + (1-y_i)\ln\left(\frac{1-\hat{\pi}_i}{1-y_i}\right)\right] \quad (17)$$

The statistic D is called the deviance (McCullagh and Nelder 1989). For the purpose of assessing the significance of an independent variable, the values of D with and without this independent variable are compared in the equation. The change in D required to include the independent variable in the model is obtained as follows: likelihood ratio test statistic $G = D$(for model without the variable) D(for the model with the variable).

The other test is the Wald test (e.g. Menard 1995), obtained by comparing the maximum likelihood estimate of the slope parameter, $\hat{\beta}$, with an estimate of its standard error. The resulting ratio, given the hypothesis that $\beta = 0$, will follow a standard normal distribution. The ratio can be read roughly in the manner of t statistics (Engelman 1990, p. 1021). The Wald test statistics, W, is given by the expression

$$W = \frac{\hat{\beta}}{\hat{SE}(\hat{\beta})} \quad (18)$$

Both the likelihood ratio test and the Wald test were used, even though Hauck and Donner (1977) found that the Wald test behaved in an aberrant manner, often failing to reject cases in which the coefficient was significant.

4.3.5 *Assessing Goodness-of-Fit*

In general terms, the goodness-of-fit means how well the derived model fits the data. Two approaches to assessing this were employed here. The classical approach begins by identifying combinations of values of variables used in the model, called patterns, while in the other the probability of belonging to a certain population was calculated for every individual in the sample and the resulting numbers arranged in increasing order. The first case was employed when the model included only dichotomous variables and the latter case was suitable for a model with continuous variables. The first, the goodness-of-fit chi-square case, was computed as follows:

$$G^2 = \sum_{j=1}^{J} 2 \times o_i \times \ln\left(\frac{o_i}{e_i}\right) \quad (19)$$

where o_i denotes observed numbers of individuals in populations and e_i their expected numbers. The distribution of the statistic G^2 under the assumption that the fitted model was correct in all aspects was assumed to be chi-square with degrees of freedom equal to $J - (p+1)$. The problem is that when $J \approx n$, the distribution is obtained under n-asymptotic, and hence the number of parameters is increasing at the same rate as the sample size. It has been proved that the statistic G^2 is asymptotically distributed (see McCullagh and Nelder 1989). Consequently, this statistic gave a misleading impression when the number of distinct patterns was too large. A large number of distinct patterns occurred when continuous variables were used (Afifi and Clark 1990, p. 331).

Another goodness-of-fit approach, i.e. the Hosmer-Lemeshow goodness-of-fit test had to be used when the number of distinct patterns was large. In this approach the probability of belonging to the certain group was calculated for every individual in the sample, and the resulting numbers were arranged in increasing order. The first group contained all the subjects whose estimated probability was less than or equal to 0.1, while the tenth group contained those for whom it was greater than 0.9. For either grouping strategy, the Hosmer-Lemeshow goodness-of-fit statistic was obtained by calculating the chi-square statistic from the table of observed and estimated expected frequencies. A formula defining the calculation of HL^2 is the following:

$$HL^2 = \sum_{j=1}^{10} \frac{(o_i - e_i)^2}{e_i} \quad (20)$$

Hosmer and Lemeshow (1980, 1989) claim that when $J=n$ and the fitted logistic regression model is the correct model, the distribution of the statistic of Hosmer-Lemeshow is well approximated by the chi-square distribution with 8 degrees of freedom.

4.3.6 *Model-Building Strategy*

The criteria for inclusion of a variable in a model may vary from one scientific discipline to another. The traditional approach to statistical model building involves seeking the most parsimonious model that still explains the data. Thus we follow here Model-building strategy and methods for logistic regression approach of Hosmer and Lemeshow (1989). In order to create an informative model within the context of the present problem, we need a plan to select the variables for the model and a set of methods for assessing the adequacy of the model both in terms of the individual variables in the model and from the point of view of its overall fit.

Selection of the variables for the final models began with univariate logistic regression analysis. Likelihood ratio tests were used when the observed value of the response variable was to be compared with the predicted value obtained from a model with a constant only and one with both a constant and the independent variable in question. The likelihood ratio test statistics, G, were obtained as minus twice the difference between the log-likelihoods. Any variable whose p-value for the G statistic was less than or equal to 0.10 was regarded as a candidate for the multivariate model. A 0.10 level was used because the traditional 0.05 level may fail to identify variables known to be important (Mickey and Greenland 1989).

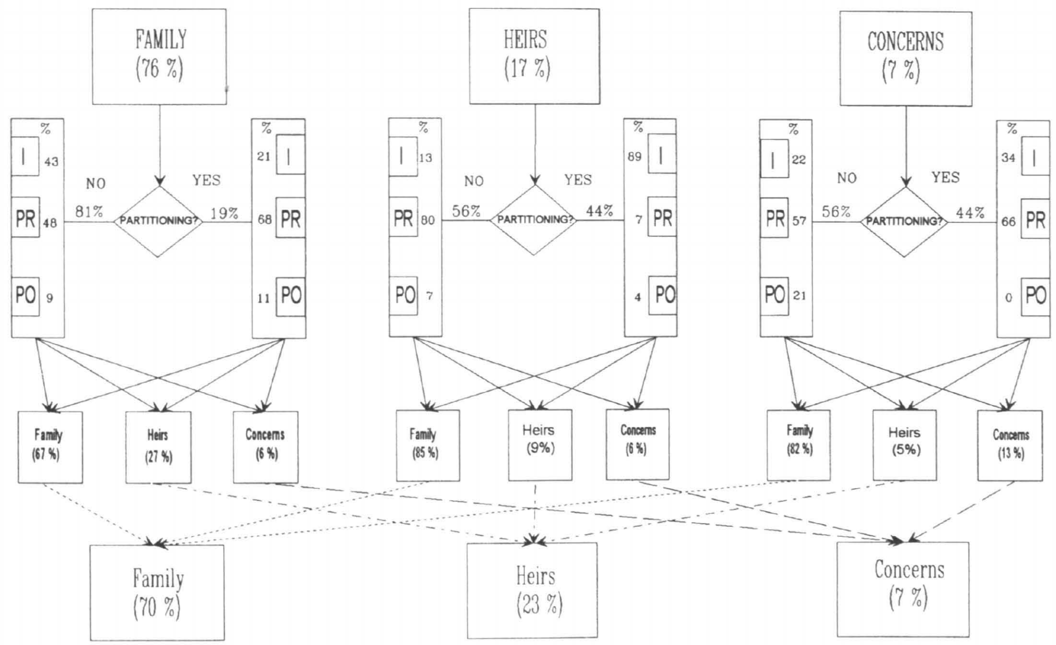
Following the univariate analysis, the importance of each variable included in the model has to be verified, for which purpose the Wald test was used, i.e. the estimated coefficients were divided by their estimated standard errors. Values below 1.645 were not statistically significant at the 0.10 level, and variables that did not contribute to the model based on this criterion were eliminated. Thereafter, the statistical significance of the whole model was tested using the conventional goodness-of-fit tests presented above. If the p-value was more than 0.10, the fit was accepted. Otherwise, the variable or variables that caused the model not to fit the data were examined and some were re-transformed. This particularly concerns continuous variables, which were transformed into quartile or dichotomous form if necessary in order to check the assumption of the linearity.

5 Ownership Factors Affecting Partitioning

5.1 Mechanism of Partitioning

One out of four holdings had undergone partitioning in conjunction with a change in ownership, but there were essential differences in the means of transfer from the former owner to the subsequent owner depending on the type of ownership from which the change arose. Thus it would be of interest to know how the type of ownership affects the decision process involved in a change of ownership. Broadly speaking, family holdings can be viewed as a permanent type of ownership, whereas joint holdings especially by groups of heirs, can be understood as being a temporary type.

Taking the permanent type of ownership first. Where family ownership does not change in conjunction with changes in ownership, it is probable that the ownership change has taken place through purchase either from relatives or on the open market, i.e. inheritance system has not been a way of ownership change. Obviously, in that case the former owner must have been involved in the decision process associated with the ownership change. As Reunala (1974, p. 30) puts it, there are, however, essential differences in the purpose of purchase. Sales arrangements between relatives are usually designed to maintain the integrity of the holding and to manage the question of inheritance between the children. In same cases, also, sales between relatives may be preferred in order



Family=Family-owned holdings
Heirs=Heir-owned holdings
Concerns=Concern-owned holdings

I=Inheritance system
PR=Purchases from parents or relatives
PO=Purchases on open market

Fig. 11. Principles governing ownership changes in unpartitioned and partitioned holdings.

to avoid inheritance taxes. Sales between relatives can thus be considered as inheritance which, for practical reasons, is carried out in the form of sale.

The other main way of obtaining a holding is the inheritance system, involving cases in which the transaction arises from a holding owned by a group of heirs. This means a situation in which, in the first place, the type of ownership has changed from family ownership to heirs in conjunction with the death of the former owner, who thus could not be involved in deciding the actual ownership arrangements. With respect to the inheritance system, in which every heir has the same equal right to the inheritance, a partitioning of the holding must take place unless one heir buys off the others.

The testable hypothesis presented here reduces to whether there is systematic variation in partitioning according to the type of ownership and means of acquisition. The principles governing changes in the ownership of unpartitioned and partitioned holdings can be illustrated as in Fig. 11. The frequencies of partitioning by type of ownership show that one fifth of the family-owned holdings and nearly half of the jointly owned ones were partitioned. The unpartitioned holdings were typically acquired by purchase from relatives, while the partitioned ones were more often acquired by inheritance.

The proportion of family-owned holdings before the changes in ownership was 76 per cent, and about one-fifth of these underwent partitioning, typically upon purchase from relatives, whereas the proportion of holdings owned by groups of heirs was 17 per cent and those that were partitioned (44 %) had typically been acquired by inheritance. The proportion of concern owned holdings was 7 per cent, and the proportion of these that were partitioned was similar to the case of those owned by heirs, although there were clear differences in the manner of ownership change. The partitioned holdings owned by heirs were more often acquired by inheritance, while those owned concern were more often acquired by the purchase from parents or relatives.

It is interesting in the context of the structural change in NIPF ownership to examine changes in the type of ownership. Between 1980–86 and 1990–91 the proportion of family-owned holdings decreased by 6 per cent to 70 per cent, while that of holdings owned by heirs increased correspondingly by 6 per cent to 23 per cent, so that the proportion of concern owned holdings did not change. This result parallels that found regarding the whole NIPF ownership structure in Finland, where the proportion of family-owned holdings, for example, was 85 per cent in 1975 and had decreased to 76 per cent by 1990 (Järveläinen 1978, Ripatti 1991). Partitioning obviously seems to be associated with joint ownership and the inheritance system, but this result is not very useful on its own.

Table 6. Names of variables, expected signs, and definitions and coding of the independent variables.

Variable name	Expected sign	Definition and coding
OCCUP	+	*Owner occupation* Coded 0=farmer, 1=non-farmer
RESID	+	*Residence on holding* Coded 0=permanently, 1=not permanently
OWN	+	*Type of ownership* Coded 0=family owned, 1=jointly owned
MUSE	+	*Main use of holding* Coded 0=agriculture, forestry or agriculture and forestry equally, 1=recreation etc.
REGIO	+	*Location of holding* Coded 0=eastern part of southern Finland, 1=western part of southern Finland
RESCO	–	*District of residence* Coded 0=urban, 1=rural
ACQUI	–	*Acquisition of holding* Coded 0=purchased on open market, 1=other
FOR	+	*Area of forest land* Coded in hectares
NFOR	+	*Forest ownership elsewhere* Coded in hectares
ARAB	?	*Area of arable land* Coded in hectares
PCUT	?	*Potential cut* Coded in cubic metres
AGE	+	*Age of owner* Coded in years

Table 7. Univariate logistic regression models for partitioning.

Independent variable	$\hat{\beta}$	$SE\hat{\beta}$	Odds ratio	Log-Likelihood	G	p
Constant	–1.09	0.13		–176.96		
OCCUP	1.58	0.28	4.85	–160.74	32.43	0.00
RESID	0.99	0.27	0.37	–169.99	13.92	0.00
OWN	1.14	0.28	3.13	–168.95	16.02	0.00
MUSE	1.27	0.30	3.56	–167.87	18.16	0.00
REGIO	0.58	0.26	0.56	–174.50	4.90	0.03
RESCO	–0.24	0.32	0.79	–176.67	0.58	0.45
ACQUI	–0.05	0.27	0.95	–176.94	0.03	0.86
FOR	0.67 E2	0.39 E2	1.01	–175.46	2.99	0.08
NFOR	0.12 E1	0.14 E1	1.01	–176.53	0.86	0.35
ARAB	0.16 E2	0.13 E1	1.00	–176.95	0.02	0.90
PCUT	0.97 E1	0.36 E1	1.10	–173.30	7.31	0.01
AGE	–0.20 E1	0.98 E2	0.98	–174.80	4.31	0.04

5.2 Towards a Logistic Regression Model

In the previous chapter we focused on describing the mechanism of partitioning when the variables were treated one by one in situations where it was not possible to take into consideration the effects of the other variables. In further analysis the differences between the unpartitioned and partitioned holdings will be examined in more detail by formulating a bivariate multi-equation model. In order to advance in this question, capability of the data to use in the analysis will be shortly handled.

As shown in Tables 3 and 4, the total of 314 sample holdings included one partitioned holding which could not be handled statistically, since it possessed a large area of forest land (FOR) that exceeded even one thousand hectares. If we were to use unlimited observations, the results would lead to wrong conclusions. Also, the use of unlimited observations could have a weighting effect on the other observations. Thus the number of observations considered here was 313.

The partitioning of each NIPF holding, the outcome variable, was coded either 0 (not partitioned) or 1 (partitioned). The independent variables on the code sheet are listed in Table 6, and the results of fitting the univariate logistic regression models to these data are given in Table 7, in which the following information is presented: the estimated slope of the coefficients, the estimated standard errors, the estimated odds ratios, the log-likelihood value, the likelihood ratio test statistics for the hypothesis that the slope coefficient is zero, and the p-value of the likelihood ratio test statistics in the last column.

With the exception of the age of the forest owner (AGE), there was evidence that each variable had the expected sign. Therefore, it was rejected from the subsequent analysis. Apart from AGE, variables which had a p-value greater than 0.10 were rejected from the subsequent analysis, because the small value for the likelihood-ratio test statistics indicated little association with partitioning. Also, detailed analysis of the continuous variables area of non-sample forests (NFOR) and area of arable land (ARAB) obtained from the quartile analyses confirmed that there was little association between these and partitioning. Thus multivariate analysis was begun without AGE, type of residence (RESCO), means of acquisition of holding (ACQUI), NFOR and ARAB, leaving seven independent variables.

The expected sign of AGE was positive, but its coefficient in the univariate model was, unexpectedly, negative, indicating a greater probability of partitioning the younger the age of the forest owner. How is this possible? Ageing of forest owners is associated with their occupation (OCCUP) and with the type of ownership (OWN), both of which had a negative correlation with AGE (Appendix 1). This means that the farmers and owners of family-owned holdings were older than the non-farmers and joint owners, which was confirmed by cross-tabulation of AGE against these variables (Table 8).

The results of fitting the preliminary multivariate logistic regression model are given in Table 9. The Hosmer-Lemeshow goodness-of-fit statistic was used because the model contained continuous variables. The results indicated that the model did not fit the data well, as the statistic was 15.352, indicating a p-value of 0.053 with 8 degrees of freedom. To improve the fit of the model, transformations of continuous variables were used in further analyses.

For some adverse reproductive outcomes and for some populations it has been shown that the logit as a function of certain continuous variables might be quadratic (Kay and Little 1987, Hosmer and Lemeshow 1989). To examine whether this was the situation in the present data, we formed three design variables based on the quartiles of area of forest land (FOR) and potential cut (PCUT), and replaced the continuous variables with these design variables. Summaries of the quartile analyses are presented in Tables 10 and 11.

The estimated coefficients and odds ratios denote significant quadratic trends. In both cases the fourth quartile in particular was greater than the third quartile, which supports a quadratic trend. This argues for treating FOR and PCUT as dichotomous variables in the logit analysis. We began by determining the quartiles of the distribution of FOR and PCUT and creating three design variables using the highest quartile as the reference group. These observations suggest that we should create dichotomous variables by taking the value 1 if FOR and PCUT are in the fourth quartile and 0 otherwise.

The use of PCUT in dichotomous form was problematic, however, in that it did not improve the fit of the multivariate model, which argues for treating PCUT as continuous in the logit after all. In addition, as PCUT is not known to interact with any of the other variables, it should be kept in the model. Unlike PCUT, the use of FOR in dichotomous form did improve the fit of the multivariate model. Additional logistic regression diagnostics are presented in Appendix 2. The final logistic regression model therefore contained six dichotomous variables and one continuous variable. The value of the Hosmer-Lemeshow goodness-of-fit statistic was 9.258, indicating a good fit, with a p-value of 0.321. The predicted value of the model for partitioning was 0.19, which underestimated the true value, as the proportion of partitioning in the sample was about one quarter.

Table 8. Mean age of forest owners by occupation and type of ownership.

	Mean age, years
Occupation	
farmers	61
non-farmers	51
Type of ownership	
family owned	61
jointly owned	50

Table 9. Estimated coefficients, standard errors, Wald test statistics, and odds ratios with 95 % confidence interval for the logistic regression model for southern Finland.

Independent variable	Coefficient	Standard error	Wald test statistics	Odds ratio	95 % CI of OR
Constant	–3.840	0.464	–8.28		
OCCUP	1.204	0.375	3.21	3.33	[1.59,6.98]
RESID	0.503	0.366	1.38	1.65	[0.81,3.39]
OWN	1.065	0.339	3.14	2.90	[1.49,5.65]
MUSE	1.540	0.363	4.25	4.67	[2.29,9.53]
REGIO	0.964	0.323	2.98	2.62	[1.39,4.95]
FOR	0.020	0.005	3.69	1.02	[1.01,1.03]
PCUT	0.063	0.043	1.47	1.06	[0.98,1.16]

Number of observations	313
Log-likelihood	–136.652
Goodness-of-fit	15.352
Degrees of freedom	8
P-value of goodness-of-fit	0.053

Table 10. Result of the quartile analyses of FOR as contained in the model in Table 9.

Quartile	I	II	III	IV
Coefficient	0	–0.016	–0.665	0.591
Standard error	0	0.371	0.418	0.353
Coeff/SE	0	–0.04	–1.59	1.67
Odds ratio	1.00	0.98	0.51	1.80

Table 11. Result of the quartile analyses of PCUT containing the model in Table 9.

Quartile	I	II	III	IV
Coefficiet	0	–0.166	–0.3158	0.8924
Standard error	0	0.398	0.406	0.357
Coeff/SE	0	–0.42	–0.78	2.50
Odds ratio	1.00	0.85	0.73	2.44

Table 12. Estimated coefficients, standard errors, Wald test statistics, and odds ratios with 95 % confidence interval for the logistic regression model for southern Finland.

Independent variable	Coefficient	Standard error	Wald test statistics	Odds ratio	95 % CI of OR
Constant	–3.754	0.436	–8.60		
OCCUP	1.249	0.384	3.25	3.49	[1.64.7.42]
RESID	0.621	0.377	1.65	1.86	[0.89.3.91]
OWN	1.116	0.347	3.22	3.05	[1.54.6.04]
MUSE	1.540	0.373	4.13	4.66	[2.24.9.72]
REGIO	1.023	0.329	3.11	2.78	[1.46.5.31]
FOR, dichotomous	1.742	0.370	4.71	5.71	[2.75.11.80]
PCUT	0.043	0.044	0.98	1.04	[0.96.1.14]

Expected probability of partitioning	0.19
Number of observations	313
Log-likelihood	–132.959
Goodness-of-fit	9.258
Degrees of freedom	8
P-value of goodness-of-fit	0.321

5.3 Model for Southern Finland

5.3.1 Estimated Coefficients

The results of the model are shown in Table 12, in which the estimated coefficients and standard errors are presented first. The Wald test statistics after the standard errors indicate statistical significance. According to the asymptotic W-test, five variables were statistically significant at the 0.1 per cent level and one (RESID) at the 10 per cent level. One variable (PCUT) was not statistically significant. In order to provide more insight into the quantitative effects, the estimated odds ratios are presented in the next column.

The odds ratio is usually the parameter of interest in a logistic regression, due to its clarity of interpretation (Demaris 1992), but an odds ratio estimate will tend to have a skewed distribution, due to the fact that it is bounded away from zero. Inferences are usually based on the sampling distribution of $\ln(\hat{\psi}) = \beta_1$, which tends to follow a normal distribution for much smaller sample sizes. A $100 \times (1-\alpha)$ % confidence interval estimate for the odds ratio is obtained by first calculating the end points of the confidence interval for the coefficient and taking the exponent of these values (Hosmer and Lemeshow 1989, p. 44). In view of the importance of the odds ratio as a measure of association, 95 per cent confidence intervals are presented in the last column.

The odds ratio for partitioning with respect to owner occupation (OCCUP) was 3.5, indicating that odds of partitioning was 3.5 times greater among non-farmers than among farmers. The odds ratio for partitioning with respect to residence on the holding (RESID) was 1.9. This may be interpreted as suggesting that odds of partitioning took place nearly twice as frequently on holdings with no permanent resident than on holdings with a permanent resident. The confidence interval for the odds ratio lay between 0.9 and 3.9, however, which means that it was not statistically significant, as in rule-of-thumb terms, the lower end point of the confidence interval should be at least 1.0 (Rita and Ranta 1996). It should also be noted that the interval is slightly skewed to the right.

The odds ratio for partitioning with respect to the type of ownership (OWN) was 3.1, i.e. odds of partitioning occurred more than three times more frequently in the case of jointly owned holdings than in that of family-owned holdings. The second highest odds ratio in the model was for the main use of the holding (MUSE). The odds of partitioning was 4.7 times greater on holdings used mainly for recreation, residence or leisure than on holdings used mainly for agriculture, forestry or agriculture and forestry equally.

The odds ratio for partitioning with respect to location of the holding (REGIO) was 2.8, which means that odds of partitioning was nearly three times greater in the western part of southern Finland than in the eastern part. On the other hand, taking the inverse of the odds ratio, it can also be inferred that odds of partitioning was 0.4 times smaller to occur in the eastern part.

The odds ratio for partitioning with respect to FOR was the highest in the model. The odds of partitioning took place as much as 5.8 times more frequently on large holdings of more than 37 ha than on small holdings of 37 ha or less. The transformation of the continuous variable FOR into dichotomous form was considered essential from the viewpoint of both the fit of the model and the statistical significance of FOR.

The potential cut variable (PCUT) appeared to be an important one in the univariate analysis, but was not statistically significant in the model. In any case, the odds ratio for partitioning with respect to PCUT was 1.04. When the model contained a continuous variable, the interpretation of the odds ratio depended on how it was entered and the units in which it was expressed (Liao 1994). Thus the odds ratio for partitioning with respect to PCUT may be said to indicate that the "risk" of partitioning increases 1.04 times for every increase of one cubic metre in the potential cut (see Cramer 1991, p. 33–35).

5.3.2 Probabilities of the Partitioning

It should be noted that the odds ratios in the model indicate the changes in the odds of partitioning in terms of ceteris paribus but not in changes in probability. Therefore, predicted probabilities were determined for substantively interesting cases of partitioning (Table 13). The probability of partitioning was lowest, 0.03, when the owner was a farmer or family living permanently on the holding and using it mainly for agriculture, forestry or agriculture and forestry equally, and when the holding was located in the eastern part of southern Finland and had 37 ha or less of forest land and a potential cut of 4.1 m^3/ha/a. Conversely, the probability as high as 0.98 when the holding was owned jointly by non-farmers not living on it permanently and using it mainly for recreation or leisure, and when the holding was located in the western part of southern Finland and had more than 37 ha of forest land and a potential cut of 4.1 m^3/ha/a.

The predicted probability of partitioning in terms of the mean values of the variables is presented in the penultimate column in the table. It should be noted, however, that there is no such thing as an "average" holding in this analysis, as the dichotomous variables are coded with values of either zero or one. In addition, it should be pointed out that the number of variables in the model plays an important role when predicting the probability of belonging to a certain group (see Karppinen 1995). The more precise the model, i.e. the greater the number of variables, the smaller the probability of belonging to a certain group.

The ownership characteristics identified by the model could be used in particular to focus on owner groups whose holdings are more likely to be partitioned. In order to demonstrate the effect of a change in the probability attached to each of the independent dichotomous variables in the model, the values of the remaining variables were set to one. Given the greatest possible probability of partitioning of 0.98, as shown in the second column of Table 13, a change in the value of FOR from one to zero would reduce this by 0.10, while a change in the value of RESID from one to zero would do so only by 0.02. Consequently, the results of the model could be used to focus on different owner groups.

Table 13. Effects of the variables in the logistic regression model on probability of partitioning with brim and average options and the effect of a change in each independent dichotomous variable on the probability. The mean value of the continuous variable PCUT is used.

Variable	Low probability	High probability	"Average"	Change in mean probability
OCCUP	0	1	0.279	0.06
RESID	0	1	0.375	0.02
OWN	0	1	0.248	0.05
MUSE	0	1	0.209	0.08
REGIO	0	1	0.489	0.04
FOR	0	1	0.251	0.10
PCUT	4.103	4.103	4.103	
π	0.03	0.98	0.19	

$$\pi = \frac{1}{1+\exp(-3.754+1.249\times OCCUP+0.621\times RESID+1.116\times OWN+1.540\times MUSE+1.023\times REGIO+1.742\times FOR+0.043\times PCUT)}$$

An intuitively appealing way of summarizing the results of the model is via a classification table, the result of cross-classifying partitioning against a dichotomous variable whose values were derived from the estimated logistic probabilities. To obtain the derived dichotomous variable, we must define a cutoff point and compare each estimated probability with it. If the estimated probability exceeds the cutoff point, we give the derived variable the value one; otherwise it is zero. The most commonly used value for such a cutoff point is 0.5 (Schuster 1983). The appeal of this type of approach to model assessment comes from the close relationship between logistic regression and discriminant analysis, so that the distribution of the covariates is multivariate and normal within the two outcome groups (Afifi and Clark 1990).

Ultimately, the choice of cutoff point depends on the objective of the analysis. Schuster (1983, p. 5–7), for instance, used a cutoff point which helped to recognize NIPF owners who were involved in forestry assistance programmes, as the capability for providing assistance was limited and the greatest possible profit would be gained by concentrating on owners who had been active in obtaining assistance. In the present case the main objective was not to classify holdings by the probability of partitioning but to quantify each factor affecting partitioning on a ceteris paribus basis, and therefore the commonly preferred cutoff point of 0.5 was chosen. The model predicted that 231 unpartitioned holdings out of the 234 observed would remain unpartitioned, whereas 43 partitioned holdings out of the 79 were correctly classified (Table 14). The overall rate of correct clas-

Table 14. Classification of individual holdings used for construction the model with a cutoff point of 0.5.

		Predicted Unpartitioned	*Predicted* Partitioned	Total
Observed	Unpartitioned	231	3	234
Observed	Partitioned	36	43	79
	Total	267	46	313
	Observations correctly classified, per cent	99	54	88

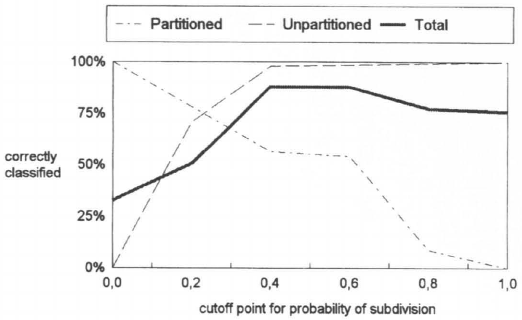


Fig. 12. Percentages of NIPF holdings classified correctly regarding partitioning with cutoff points between 0.0 and 1.0.

sification was estimated to be 88 per cent, being 99 per cent for unpartitioned holdings and 54 per cent for partitioned holdings.

This is indicative of certain some problems, in that the cutoff point had been chosen so as to be arbitrary. As Pindyck and Rubinfeld (1981) point out, classification is sensitive to the relative size of the two component groups and will always favour classification into the larger group. This can be seen in the graph in Fig. 12, which shows the percentage of holdings that would be correctly classified as unpartitioned and partitioned for cutoff points from 0.0 to 1.0. If the objective of the classification were equally successful classification of both groups, for instance, it would have been possible to classify nearly 80 per cent of both unpartitioned and partitioned holdings correctly with a cutoff point of 0.25. A more detailed description of the classifications of holdings obtained with varying cutoff points is presented in Appendix 2.

5.4 Models for the Western and Eastern Regions of the Southern Finland

There has been much debate in Finland over regional differences in the factors affecting partitioning, and it has even been claimed, for instance, that partitioning takes place more frequently in eastern regions than in western regions (Kantee 1988, 1993). This is based on the assumption that ownership changes in western regions are more often arranged through purchases by relatives whereas in eastern regions they more often involve inheritance. Neither an earlier study (Ripatti 1991) nor the model for the whole sample can be said to support this claim. Results for the whole sample indicate clearly that partitioning takes place more often in the western parts of Finland.

It has been pointed out on many occasions that considerable areal discrepancies exist in the characteristics of the Finnish forestry (Häkkilä 1980). The growth factor is naturally a highly important aspect of the problem as far as the continuity of timber production is concerned, with the annual increment is somewhat higher in the south than in the north, and it is also understandable for geographical reasons connected with settlement and economics, for instance, that regional differences should exist in forestry. Thus regional differences should also be perceivable in NIPF ownership and farm husbandry (Järveläinen 1971,1988).

It has been shown that both NIPF ownership and forestry as whole occupy a different position in the eastern part of the country from what they do in the west (Varmola 1987, Järveläinen 1988). Forest resources and stumpage incomes play important roles in the viability of farms in eastern Finland, whereas the role of agriculture receives more emphasis in the west. In addition, the economic importance of the forestry sector as a whole is greater in the eastern regions. As noted above, the sample holdings similarly indicate regional differences in the characteristics of holdings and their ownership. With this in mind, the partitioning equation was calculated for these regions separately in order to check whether the data point to any differences. The results are given in Table 15.

The signs of the coefficients of the independent variables in both regions were the same as for the whole country, but the numbers of statistically significant coefficients, excluding REGIO, were smaller, at least partly because of the decrease in the number of observations. All the coefficients of the independent variables except OCCUP and PCUT became statistically significant at the 10 per cent level in the model for the western region, where in the eastern region model the coefficients of RESID and PCUT were not statistically significant at the 10 per cent level. The variables with statistically significant coefficients are shown after the standard errors. As in the model for the whole

Table 15. Estimated coefficients, standard errors, and Wald test statistics of variables in the logistic regression models for western and eastern regions of southern Finland.

Independent variable	Western region Coefficient	Western region Standard error	Western region Wald test statistics	Eastern region Coefficient	Eastern region Standard error	Eastern region Wald test statistics
Constant	−2.894	0.535	−5.41	−3.698	0.603	−6.13
OCCUP	0.947	0.597	1.59	1.357	0.601	2.26
RESID	0.931	0.542	1.72	0.474	0.581	0.82
OWN	1.463	0.511	2.86	0.925	0.550	1.68
MUSE	1.761	0.562	3.13	1.445	0.635	2.28
FOR, dichotomous	1.398	0.546	2.56	2.205	0.560	3.93
PCUT	0.056	0.062	0.90	0.013	0.074	0.18
Number of observations		156			157	
Log-likelihood		−72.256			−59.195	
Goodness-of-fit		28.457			5.440	
Degrees of freedom		8			8	
P-value of goodness-of-fit		0.000			0.710	

Table 16. Estimated odds ratios and 95 % confidence intervals (CI) in the logistic regression model for the western and eastern regions of the southern Finland.

Independent variable	Western region Odds ratio	Western region CI	Eastern region Odds ratio	Eastern region CI	Relative OR Western/Eastern
OCCUP	2.58	[0.79,8.39]	3.89	[1.18,12.70]	0.67
RESID	2.54	[0.87,7.40]	1.61	[0.52,5.06]	1.58
OWN	4.32	[1.57,11.90]	2.52	[0.85,7.47]	1.70
MUSE	5.82	[1.92,17.70]	4.24	[1.21,14.90]	1.37
FOR, dichotomous	4.05	[1.37,11.90]	9.07	[3.00,27.40]	0.45
PCUT	1.06	[0.94,1.20]	1.01	[0.88,1.17]	1.04

sample, the predicted value for partitioning underestimated the true situation in both subsamples.

The difference between the regional models was tested by studying the difference between the value of the log-likelihood function for the whole sample and the sum of the log-likelihood values for the regional sub-samples. Given the null hypothesis of no difference between the regions, a figure representing twice this difference should have a chi square distribution (Theil 1971, p. 396–397). The result of the test indicated that the coefficients of the models collectively differed statistical significantly. In addition, a pairwise *t*-test showed that all the coefficients of variables differed significantly between the two regions.

In order to check the regional differences in terms of odds ratios, we can now introduce the relative odds ratio, a quantity which has a fundamental role to play in the analysis of regional differences (Table 16). A relative odds ratio greater than 1 indicates a greater odds ratio in the western region than in the eastern region. The general observation to arise from this examination is that four out of the six odds ratios were higher in absolute terms in the eastern region, and that only the odds ratios for partitioning with respect to OCCUP and FOR were lower in the western region than in the eastern region, giving a relative odds ratio less than 1. Note, however, that many of the confidence intervals attached to the odds ratios were below 1.0.

The relative odds ratio for partitioning with respect to OCCUP was 0.7, indicating that odds of partitioning was 0.7 times smaller to occur on holdings owned by non-farmers in the western region than in the east, whereas that with respect to RESID was 1.6, which may be interpreted as suggesting that odds of partitioning was 1.6 times greater on holdings with no permanent residents in the western region. The relative odds ratio for partitioning with respect to OWN was 1.7, and that with respect to MUSE 1.4.

The relative odds ratio of partitioning with respect to FOR indicates that odds of partitioning is 0.5 times smaller on large holdings of more than 37 ha in size in the western region than in eastern region. Finally, the relative odds ratio for partitioning with respect to PCUT indicates that the "risk" of partitioning was 1.04 times greater for every cubic metre of potential cut in the western region.

The results of regional models confirm the assumption that there are major regional differences in the characteristics of holdings and their ownership that lie behind partitioning. The odds ratios for partitioning with respect to OCCUP and FOR were more important variables in the eastern region, whereas those with respect to RESID, OWN, MUSE and PCUT were more important in the west. It seems that these regional differences will be strengthened as a consequence of structural changes in non-industrial private forestry.

5.5 Interpretation of Results Related to a Priori Expectations

A total of twelve characteristics of NIPF holdings and their ownership were hypothesized to affect partitioning, but one surprising result of the univariate analysis was that the sign attached to the age of the forest owner was the opposite to that expected, indicating a smaller likelihood of partitioning the higher the age. Thus it was not reasonable to use the age variable in the analysis because as early as the univariate analysis indicates the opposite sign than expected. In addition, the means of acquiring the holding, the area of arable land and the area of non-sample forests possessed only slight associations with partitioning and were therefore rejected from the analysis. Consequently, the logistic regression model was performed using seven independent variables.

Before interpreting the variables in the model, we should consider briefly why the sign for forest owners' age was positive but its coefficient in the univariate model was, unexpectedly, negative indicating a greater probability of partitioning the younger the age of the forest owner. In addition to an older owner's connections with farming as an occupation and with family ownership, the interval in age between parents and children may be an important aspect when arranging ownership changes. The normal can be assumed to be approx. 30 years. It can be seen from Table 3, however, that the mean age of the former owners of unpartitioned holdings was about 60 years, four years higher than the mean age of the former owners of partitioned holdings. The greater the age of the parents at a change in ownership, the more probable it is that the heirs are no longer economically tied to their parents. This could be seen to influence the probability of a holding not being divided.

The seven independent variables represented all the four variable groups which indicate that the grouping was reasonable. One out of two socio-economic variables, three out of four ownership variables, two out of four size variables and one out of regional variables comprised the final model.

Holdings owned by farmers are less likely to be partitioned than those owned by non-farmers. Farmers are often "closer-to-ownership" and they are generally able to understand the meaning of large-scale forestry ownership. In addition, the farm legislation provides financial support for the transfer of farm ownership in one entity to the next generation. If a farm offers good economic circumstances for the continuation of this form of livelihood, it is usually passed on unpartitioned.

Holdings with permanent residents are less likely to be partitioned than holdings with absentee owners. This is probably due to the observation that a permanently inhabited holding is often associated with farming, which in turn favours keeping it as a single entity. In addition, a permanently inhabited holding is closely associated with the farm legislation concerned with ownership changes. Schallau (1965) also notes that absentee ownership is one of the major reasons for the partitioning of NIPF holdings in the United States.

Jointly owned holdings are more likely to be partitioned than family-owned ones. Joint ownership represents an unstable ownership stage, which leads to partitioning in every second case of division of the estate of the deceased (Ripatti 1994). The inheritance system is therefore a fundamental reason lying behind partitioning. Under the code of inheritance, i.e. the provision that every heir has an equal right to the inheritance, NIPF holdings will be partitioned unless one of the heirs buys up the shares of all the others.

Holdings used mainly for non-productive purposes are more likely to be partitioned than ones used mainly for production purposes. The latter activities are often associated with large-scale ownership. On the other hand, the size of the holding is of no importance if a holding is to be used mainly for recreation and other such purposes in the future. In most cases the use of the holding does not change when the ownership changes. Thus holdings used mainly for non-productive purposes can be partitioned more readily.

As expected, holdings are more likely to be partitioned in the western part of southern Finland than in the eastern part, a conclusion supported by both the theory and empirical results. Forest resources and stumpage incomes play important roles in the viability of farms in the eastern part, whereas the role of agriculture receives more emphasis in the western part (see Varmola 1987, Mustonen 1991). In addition, the economic importance of the forestry sector as a whole is greater in the east. It is obvious that as the importance of forestry increases in the local economy, the probability of partitioning will decrease.

The larger the holding, the more likely it will be partitioned. Besides being positively influenced by the large size of holdings, partitioning is also influenced by the volume of growing stock, even though the potential cut was not statistically significant as an independent variable in the multivariate model. The large resources possessed by a holding is more likely to be partitioned obviously because the new owner, mostly a young person burdened by debts, will not have enough money to pay off a large holding immediately, even though its large timber stock may be a powerful factor arguing in favour of acquiring the holding in its unpartitioned form.

Inspection of the odds ratios calculated for the regional models revealed a few differences between the western and eastern regions. Holdings in the east seem to be more sensitive to changes in the owner's occupation from farmer to non-farmer and differences in the area of forest land between small holdings and large holdings. On the other hand, holdings in the western region were more sensitive to the changes in residence on the holding from permanent residence to absentee ownership, changes from family-owned holdings to jointly owned ones, changes in the main use of holdings from forestry production to non-productive purposes, and increases in potential cut. These result is supported by theoretical inferences.

5.6 Effects of Ownership Changes on the Size of Holdings

There has been considerable public debate in Finland over the changes in the average size of NIPF holdings. The overall trend seems to be towards a smaller average size, but this may be viewed as the outcome of institutional changes on the one hand, changes in the area of forest land itself on the other. In fact, there are two principle ways in which the size of holdings may change: one is through the reclassification of forestry land and the other is through fragmentation and consolidation of the holdings. Ripatti (1992) demonstrates that the major part of the change in the average size of holdings is caused by institutional aspects, i.e. factors associated with practical ownership arrangements. Thus the main factor bringing about changes in the area of forest land, for example, was the inheritance system, which resulted in an average decrease of 40 per cent in the size of holdings.

When considering changes in the size of holdings, defined in the narrow sense of referring to partitioning, it has been customary to focus on changes in average size, which has resulted in a lack of information on the gross effects of partitioning on the size distribution of holdings. Changes in the size distribution of NIPF holdings are usually analysed using either macro-data, in which the number of holdings or the area of forest land in each size category is known, or micro-data, in which movements of individual holdings from one size category to another, or their continuation in the same size category, are recorded (see Karppinen 1988, Ripatti and Reunala 1989, Ripatti 1992). Typically, only macro-data are available,

Table 17. Estimates of the probabilities of (A) the number of forest holdings and (B) the area of forest land moving from one size class to another from 1980–86 to 1990–91.

A	Size class	from size class < 5.0	5.0–9.9	9.9–19.9	20.0–49.9	50.0–100.0	>100
	< 5.0	0.000	0.914	0.073	0.013	0.000	0.000
	5.0–9.9	0.000	0.717	0.252	0.031	0.000	0.000
to	9.9–19.9	0.000	0.039	0.833	0.111	0.012	0.005
size	20.0–49.9	0.000	0.000	0.051	0.881	0.056	0.012
class	50.0–100.0	0.000	0.000	0.061	0.071	0.816	0.052
	>100	0.000	0.000	0.000	0.101	0.106	0.793
B	**Size class**	**from size class < 5.0**	**5.0–9.9**	**9.9–19.9**	**20.0–49.9**	**50.0–100.0**	**>100**
	< 5.0	0.000	0.587	0.094	0.319	0.000	0.000
	5.0–9.9	0.000	0.693	0.228	0.079	0.000	0.000
to	9.9–19.9	0.000	0.018	0.744	0.172	0.037	0.029
size	20.0–49.9	0.000	0.000	0.018	0.866	0.085	0.031
class	50.0–100.0	0.000	0.000	0.017	0.050	0.834	0.052
	>100	0.000	0.000	0.000	0.034	0.068	0.898

and it is thus rare to find matrices constructed from micro-data. The present material is unusual in that data on individual changes in NIPF holding size are available from two cross-sectional surveys of 1980–86 and 1990–91. This allowed transition probability matrices to be derived from the data.

The process of change in size distribution may be described in the form of a matrix P of transition probabilities. The typical element Pij of such a matrix indicates the probability that a holding in size category i in 1980–86 will move to size category j by 1990–91. In slightly more detail, the change in size distribution is treated as a random process in which there are a finite number of possible categories. A holding may be in any one of these categories at each of a finite number of equidistant points in time. The probability distribution of the holdings amongst the size categories depends only on the distribution in the previous period. A process satisfying these conditions is called a Markov chain (e.g. Mäkinen 1990). With these assumptions, $Yj(t)$, the holdings in the jth size category at time t, is determined by the following relationship:

$$Yj(t) = \sum_i Yi(t-1).Pij \qquad (21)$$

which says that the holdings in the jth category during this period is the sum of the products of the holdings in each size category i in the last period and the probability of a holding moving from category i to category j. Because Pij are probabilities, they cannot be negative or greater than unity, and thus, $0 \geq Pij \geq 1$ Also, if the system is closed, i.e. the size categories are exhaustive and mutually exclusive, then a further condition on the probabilities is that a holding in the system in one period must be found in one or other of the states in the next period. This can be expressed as

$$\sum_i Pij = 1$$

The information required in order to construct a transition probability matrix for number and area consists of the number of holdings and the area of forest land in six size categories for the cross-sectional data, followed by the changes in size distribution of the holdings. Transition probability matrices for the number of holdings and area of forest land from 1980–86 to 1990–91 are shown in Table 17. The most conspicuous feature of the matrices is the size of the diagonal elements which lie between 0.69–0.89, excluding the smallest size class. The closer a figure is to unity, the more the result suggests that holdings remained in the same size class through the ownership changes.

It may be seen from the transition matrix for the

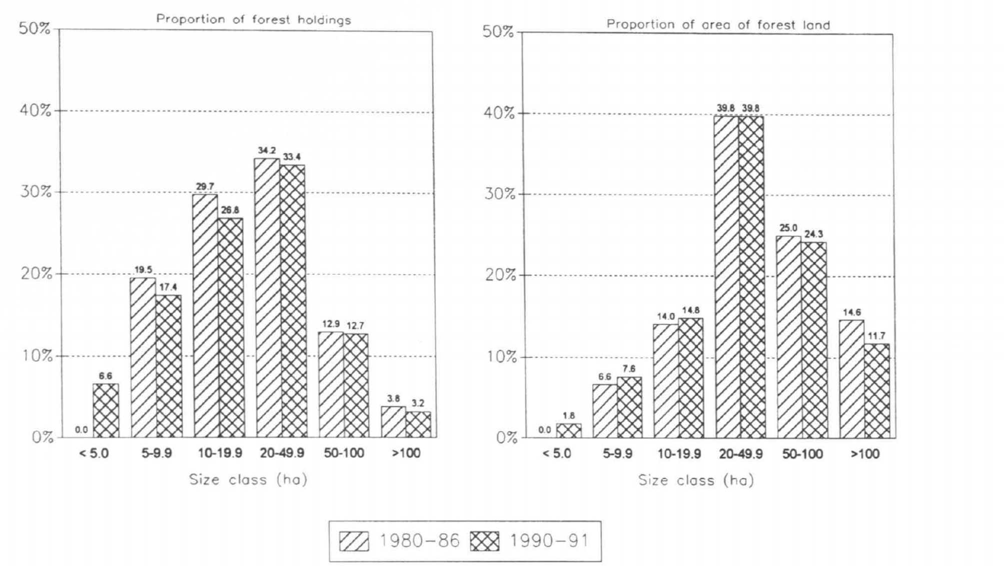


Fig. 13. Size distribution of the holdings both before and after ownership changes.

number of holdings that the most stable size class was from 20.0 to 49.9 hectares and the least stable from 5.0 to 9.9 hectares. The transition probabilities are interpreted as follows: the probability of a holding if size from 20.0 to 49.9 hectares remaining in the same size class is 0.88, that of a smaller holding moving to this class is 0.05, and that of a larger holding moving to the same class is 0.07, whereas the probability of a move from the size class 50.0–100 hectares is 0.06 and that from the size class >100 hectares is 0.01. The index of stability is 0.67, the index of downward mobility 0.26 and the index of upward mobility 0.07.

The transition probabilities determined according to the area of forest land differ somewhat from those based on the number of holdings. Here the transition matrix shows the most stable size class to be the largest, holdings of more than 100 hectares, and the least stable size that from 5.0 to 9.9 hectares. The index of stability is 0.67, the index of downward mobility 0.29 and the index of upward mobility 0.03. This result indicates that the trend towards smaller size classes was slightly greater in terms of areas of forest land than in terms of numbers of holdings.

The size distributions in 1980–86 and in 1990–91 based on the number of holdings and the area of forest land are presented in Fig. 13. That for the number of holdings shows the increase in the size class of less than 5.0 hectares to account for much of the structural change, and highlights the trend towards smaller proportions in all the other size classes. In terms of the area of forest land, the proportions of all the size classes less than 20.0 hectares increased as those of the large size classes, 50.0 hectares or more, decreased.

Taking a broad view of the question, it is interesting to examine the growth in the cumulative proportions of holdings and the area of forest land from the smallest size class to the largest. Essential changes took place in the categories of less than 5.0 hectares and less than 10.0 hectares, the former increasing by 6.6 per cent and the latter by 4.5 per cent. In terms of the area of forest land, the changes in the cumulative proportions of the small size classes were very slight from 1980–86 to 1990–91, but the area of forest land on holdings of less than 5.0 hectares increased by 1.8 per cent and the increase of the total area of forest land on holdings of less than 10.0 hectares was 2.8 per cent. The average size of holdings had been 29.9 hectares in 1980–86, but had decreased by 1.2 hectares to 28.7 hectares in 1990–91.

Some reservations nevertheless have to be made regarding the changes in size distribution. Since the data apply only to holdings which underwent ownership changes between 1980–86 and 1990–91, the changes do not represent the structural change in the size distribution of NIPF holdings as a whole. In addition, there is a problem concerning holdings of less than 5 ha, as the data do not cover holdings which were of this size at the first stage, in 1980–86, but since changes of ownership involving such holdings were measured at the later stage. Another problem which arises in using the same holdings, i.e. panel data is the closed nature of such a statistical system, which does not allow new holdings to be introduced, in spite of the fact that the number of holdings has increased by approx. 20 000 per decade, as noted in Chapter 3. Because of these problems, the results regarding changes in the size distribution of NIPF holdings between 1980–86 and 1990–91 are mostly of the status of trends.

6 Discussion

6.1 An Overview of the Starting Points of the Research

What do these findings reveal about small sized NIPF holdings and their partitioning in Finland? The partitioning of holdings has continued to increase during this century to the extent that there have been approx. 20 000 more holdings each decade. Alongside this, the discussion on the small size and partitioning of NIPF holdings has continued up to the present-day. In Finnish forest policy statements (e.g. Metsä 2000 -ohjelma 1985) the small average size of holdings and the trend towards smaller holdings have been seen to have many negative influences on non-industrial private forestry. These questions have been discussed under the heading of "fragmentation problems". The most worrying problems are those connected with logging and silvicultural practices as well as with the timber supply.

In order to evaluate these problems, a survey of existing research into the size of NIPF holdings in relation to the economics of forestry and owners' forestry behaviour was performed. The literature on the economics of holding size clearly indicates that this is an important factor determining the costs of logging and silvicultural operations. This has been confirmed a numerous occasions, i.e. the smaller the holding or treatment unit, the greater will be the cost per unit volume of the timber. Some other disadvantages of small size were also found, such as high administrative costs (Cubbage 1983).

The size of NIPF holdings has been considered an important background factor in most of studies of the timber sales behaviour of forest owners. Many of these indicate that the frequency of timber sales increases with holding size. This does not necessarily mean a decrease in timber supply, however, if timber sales per hectare are excluded. If one aims to study the size effects of NIPF holdings on the timber supply in a cautious manner, timber sales per hectare should be studied over a sufficient period of time (Cleaves and Bennett 1994, p. 205–206).

In addition, the use of holding size as an independent variable has often indicated that small size is detrimental to the timber supply (see Cleaves and Bennett 1995).

The size of holding has proved to be of little importance in multi-equation timber supply models, however (see Dennis 1989, Hyberg and Holthausen 1989, Kuuluvainen 1989, Kuuluvainen and Ovaskainen 1994). All told, the size of NIPF holdings naturally affects the timber supply, but its importance has been greatly exaggerated. The elasticity of timber sales per hectare with respect to the area of forest land, for instance, was as low as 0.05 according to Kuuluvainen and Ovaskainen (1994, p. 49), which means that timber sales per hectare will increase 1.05 times for every increase of 10 ha in the area of forest land.

Evidently, the small holdings size cause some problems for the economics of non-industrial private forestry, even if there has been considerable confusion about the interpretation of concepts related to the size of NIPF holdings. In addition to size of holding, estate structure, i.e. the shape and number of forest parcels and their position in relation to each other are important points related to the discussion of the size of NIPF holdings (Häkkilä 1974). Therefore, a clear distinction should be made between holding size and estate structure. Determining the costs of logging and silvicultural operations both the holding size and the estate structure are important factors, but when studying the timber supply the whole decision-making unit of forest ownership must be taken into consideration.

Some attempts have been made to circumvent the partitioning process and increase the average size of holdings as well as to promote development the estate structure of NIPF holdings. The most recent suggestions being those put forward in the Forest 2000 Programme (Metsä 2000 -ohjelma 1985), but they have not achieved the desired results from the point of view of those responsible for Finnish forest policy. One may surmise that there is a lack of research results concerning factors capable of altering partitioning, though a considerable amount of debate has been devoted to the topic.

On the basis of the above circumstances, the objectives of this work have been to describe the mechanism of partitioning, factors affecting partitioning and its effects on the size distribution of NIPF holdings in Finland. The work undertaken here consequently arises out of forest policy and its aim is to quantify holdings and the characteristics of their ownership that lie behind partitioning by providing a model that can be used as a tool for screening forest policy measures. It should be emphasized that although the focus is on the size of holdings, it is mostly their partitioning, i.e. their division into two or more smaller units in conjunction with a change of ownership, that is discussed.

6.2 Ownership Factors at the Back of Partitioning

The frequency of partitioning was about one quarter among all holdings, one fifth among family-owned holdings and nearly a half among jointly owned holdings. The partitioned family-owned holdings had typically changed owner by purchase from parents or relatives, whereas nearly all of those owned jointly by the heirs of the previous owner had been acquired by inheritance. About two-thirds of the concern owned holdings that had been partitioned had changed owner through purchase from parents or relatives. Purchases from parents had often been made in order to arrange the inheritance among the children and in order to avoid inheritance tax. The inheritance system as a whole may therefore be regarded as a reason for the partitioning of holdings. As the frequency of partitioning seems to vary according to the type of ownership, it can be assumed that the increase of the numbers of the holdings owned by groups of heirs will affect the frequency of partitioning as a whole.

Logistic Regression Analysis

The differences between the unpartitioned and partitioned holdings were examined more detailed by formulating a logistic regression model. Seven out of the twelve candidate variables were inserted into the final model, six being dichotomous variables and one a continuous variable. Thus the Hosmer-Lemeshow goodness-of-fit test was used to assess the fit of the model, since it contained at least one variable in continuous form. The test indicated that model fits well with the data. The partitioning predicted by the model nevertheless fell slightly short of the true value, as 274 out of the 313 holdings were classified correctly with a cutoff point of 0.5, i.e. the overall rate of correct classification was 88 per cent. The classification favoured the larger, unpartitioned group and therefore only a good half of the partitioned holdings were classified correctly (see Pindyck and Rubinfeld 1981).

The results were calculated for the whole sample and for the western and eastern regions separately. This regional division was made in order to see whether the results gave any indications of variables affecting partitioning to different degrees in the regions relative to each other or to the whole sample. In this case the regional dichotomy could itself become a relevant explanatory variable or display different behaviour when data for one region are used in the model (see Kuuluvainen 1989, p. 184). The difference in goodness-of-fit between the regions was considered statistically significant, the model fitting the data for the eastern region particularly well, but those for the western region less well.

The antilog of the coefficient β_1, i.e. the odds ratio, is the parameter of interest in a logistic regression model (e.g. Demaris 1993). In spite of some slight confusion over the interpretation of odds ratios, the situation is really very straightforward. Even though the probability of an event is more familiar than odds ratios, they may be interpreted as a "times as more or less" relationship with respect to the odds of partitioning. In the model constructed for the whole sample all the statistical significant odds ratios lay between 1.9 and 5.7, while comparison between the models for the two regions showed the odds ratios for the western region to be generally higher, even though the model did not display a good fit. This means that the factors used as individual explanatory variables in the western region model gave greater odds ratios, but the predicted probability attached to the model for partitioning became smaller.

The odds ratio for partitioning with respect to the owner's occupation in the model constructed for the whole sample indicated that odds was 3.5 times greater among non-farmers than among farmers, while the sub-sample models indicated that odds occurred twice as often among non-farmers in the eastern region than in the western region, where the odds ratio was not statistically significant. It seems that the occupation of a farmer and the institutions associated with this provide support for the transfer of a NIPF holding in unpartitioned form to a subsequent owner, and that this also implied in the regional models. These assumptions gain support from both the theoretical and empirical results. This means, however, that the existing trends away from farmers' ownership of NIPF land towards non-farmers ownership will, other things being equal, increase the total frequency of partitioning. In fact, Ripatti and Järveläinen (1996) forecast that the proportion of Finnish non-farmer forest owners will increase from 52 per cent in 1990 to 68 per cent by 2020.

The odds ratios for partitioning with respect to the residence on holding in the models for the whole sample model and the western region were almost statistically significant and that in the eastern region model was not significant. A permanently inhabited land holding has in the past been closely associated with farming and the regulations that govern it, which favour transfer of the holding to the next generation in an unpartitioned state. Today, however, a large number of NIPF owners who live permanently on their holdings are not involved in farming (see Järveläinen 1988), so that the influence of the owner's place of residence on partitioning will become weaker. This will also mean, in turn, that the trend towards absenteeism or living on the holding for only part of the year will not have any notable effect on partitioning.

The odds ratios for partitioning with respect to the type of ownership were statistical highly significant in the models for the whole sample and for the western region, and almost significant in that for the eastern region. The type of ownership must be looked on first and foremost as the starting point for any juridical change in ownership. Family ownership mostly represents a stable stage, whereas joint ownership implies an unstable stage. It can be even claimed that ownership of a holding by its heirs marks a preliminary step towards division (Ripatti 1991).

The overall trend seems to be towards more jointly owned NIPF holdings, associated with the ownership transition problems affecting farming in particular (Järveläinen 1988, p. 7). The theoretical and empirical results support the assumption that the frequency of the ownership transition problems follows that of partitioning. In the forest owners' own opinion, for instance, the economic continuity of a farm was considered to be the factor of greatest importance for transfer of the holding as a single entity (Ripatti 1991, p. 25). The frequency of partitioning was almost 50 per cent in the case of joint holdings, and the trend seems to be for these holdings to increase in number.

The very high odds ratios for partitioning with respect to the main use of holding both in the model for the whole sample and in the regional models imply the ascendancy of non-productive forms of land use in cases where partitioning takes place. There is also evidence that the main use of holdings is associated with their size, the average size of forest holdings used mainly for timber production being greater than that of holdings used mainly for other purposes (Ripatti 1994, p. 18). This is because economic timber production often calls for large-scale forestry, and thus larger areas of forest, whereas size is of no importance when a forest holding is being used for non-productive purposes. Thus, a holding used mainly for non-productive purposes is more readily partitioned. Social change and the changing goals of NIPF ownership suggest that the number of holdings used mainly for non-production purposes will increase if, other things being equal, the frequency of partitioning increases in the future (Karppinen 1996).

The theoretical inferences that a large area of forest land is more likely to be partitioned was confirmed by the empirical models. The odds ratio for partitioning with respect to the area of forest land in the model for the whole sample was as high as six, i.e. odds of partitioning was six times greater on large holdings than on small ones. In addition, the relative odds ratio derived from the regional models showed a marked difference in the impact of the forest area, the odds ratio with respect to the area of forest land being twice as high in the eastern region than in the west. It should be noted, however, that the average area of forest land was 32 ha in the east as compared with 26 ha in the west. There seems to be an overall trend towards smaller holdings in both regions, however, which, other things being equal, would reduce the frequency of partitioning.

The potential cut appeared to be an important independent variable, but was not statistically significant in the definite model, and the odds ratio for partitioning with respect to the potential cut did not reach statistical significance in either region separately. Other investigations have nevertheless pointed to the importance of the timber stock for the behaviour of NIPF owners, especially for timber sales behaviour. Many problems remain to be solved regarding the importance of timber stock (Kuuluvainen and Ovaskainen 1994). The potential cut can be calculated according to various criteria, but here it was defined in cubic metres on a silvicultural basis (see Karppinen and Hänninen 1990).

Changes in the Size Distribution of Holdings

Although the size distribution of NIPF holdings has been changing throughout the period of Finnish independence, most noticeably in the 1920s and the post-war period, we are concerned here only with the changes that took place in the 1980s. Analyses of changes in the size distribution of NIPF holdings are usually based on macro-data in which the number of holdings or area of forest land in each size category in the cross-sectional data is known. In this respect the present data are unusual, as movements of individual holdings from one size category to another and instances of their remaining in the same category are recorded. This makes it possible to study the effects of partitioning on the size distribution of NIPF holdings.

When examined in terms of the number of holdings, the increase in holdings in the smallest size category, less than 5 ha of forest land, accounted for much of the change, with a trend towards smaller proportions in all other size categories. On the other hand, the changes in the areas of forest land represented by the size categories indicated a trend towards relatively higher proportions in all size categories below 20 ha and a decrease in the proportion of the large size categories, those over 50 ha. The average size of the holdings undergoing ownership changes decreased from 29.9 ha to 28.7 ha over the approximate interval 1983–90. Further, the transition probability matrix indicated that moves of holdings from large to small size categories mostly involved in small, from 5 to 10 hectares and from 10 to 20 hectares size categories.

The present data nevertheless do not describe the changes in the complete size distribution of NIPF holdings, as they do not include holdings which had not undergone ownership change during the period concerned, nor do they allow for the area of forest land on a holding changing on account of reclassification. Ripatti (1992, p. 180–181), for instance, calculated that the reclassification of forestry land in southeastern Finland in 1986–1991 produced an increase of 0.4 ha per holding. In order to form a more reliable picture of changes in the size distribution of NIPF holdings, aggregate cross-sectional data compiled at repeated intervals in time would have to be used.

The data from the farm register maintained by the National Board of Taxation suggest that the number of holdings in the whole country increased by 2300 per year between 1980 and 1994, and the average size of holding decreased from 27.2 ha to 26.3 ha. A trend towards relatively smaller proportions was observable all size categories except the smallest, less than 5 ha, although an increase in absolute numbers occurred in every size category except the medium one, from 20 to 50 ha. Thus the changes in size distribution and in average size of holding seem to be small. On the other hand, it should be remembered that one is always operating in the long term in forestry. Besides, one may ask why the changes are the opposite to what they might be.

6.3 Policy Implications

The above findings have implications for the discussion of the size of NIPF holdings in relation to partitioning. The factors influencing partitioning are related to clearly measurable holdings and ownership characteristics. Although the results provided by the model are not in themselves surprising, the logistic regression model presented here entails one essential advantage: it can help one to conduct sensitivity analyses to determine how a given change in the characteristics of holdings and their ownership might alter the probability of partitioning. This should assist forest and rural policy makers in identifying the clientele for their programmes when the aim is to prevent partitioning via forest or rural policy means. In addition, the model combination can be used as an example for the resolving of other questions, as the response is defined as dichotomous.

The results given by the model can be used when targeting NIPF owners for programmes and when developing new programmes. Forest policy often has the underlying objective of minimising programme costs while obtaining the best possible response (see Schuster 1983, Clements and Jamnick 1989), and in this sense the model could be used as a screening tool to direct programmes at those NIPF owners likely to respond favourably. The ownership characteristics identified by the model could be used in particular to focus on owner groups with holdings that are more likely to be partitioned. For example, if programmes targeted at joint owners of NIPF holdings are successful and all the other variables remain unchanged, the probability of partitioning will decrease by 5 per cent, assuming that joint owners behave as if they were involved in family ownership.

Unfortunately, the model does not exactly address the quantitative effects or statistically validate the importance of the factors affecting partitioning, because it contains only structural background variables. Nevertheless, whatever its assumed explanatory basis, the partitioning-oriented classification of NIPF holdings offers a challenge to conventional notions of policy or programme targets and can be viewed as a target "guide". In general the concept of targeting public support for NIPF owners will encounter serious problems, however, unless public support is fairly sharply defined. The criterion of a minimum area of forest land, for instance, may be useful for targeting policies that are intended to achieve a general reduction in the frequency of partitioning, e.g. public support and programmes for preventing partitioning could be aimed at holdings greater than 5 ha in size. This question has also been discussed in the United States (e.g. Row 1978, Weatherhead 1984, Bliss 1990).

Besides, the results could be used by policy makers to plan land policy reforms. The most effective way of preventing partitioning, if this were necessary, would be to change the provision in the code of inheritance that every heir has equal rights, but would that be possible? The present inheritance system is evidently a very powerful factor lying behind partitioning, but it constitutes one of the fundamental civil rights of the present-day. In order to be successful, any such change would, of course, have to observe the principles of justice and would have to be based on investigations into the effects of the existing and modified inheritance procedures. In fact, some suggestions of this kind have been made (Metsätaloustilojen... 1994), but the process is still unfinished, as it would not be reasonable to change the whole inheritance system just for the sake of preventing the partitioning of NIPF holdings.

Secondly, use of the Land Acquisition Right Act to prevent partitioning has not achieved the desired results from the forestry viewpoint because the act has been contradictory. It has in practice restricted the rights of persons other than economically active farmers to buy forest land exceeding two hectares in a single unit, in order to guarantee the availability of supplementary forest land to the economically active farmers, but as a consequence of the structural change in NIPF ownership, the proportion of economically active farmers among NIPF owners is decreasing, being only one third in 1990.

The Land Acquisition Right Act has two disadvantages from the viewpoint of achieving a favourable trend in the size distribution of NIPF holdings. First of all, a party to an unpartitioned estate can only become a forest owner without special permission by inheriting his or her share in the forest. It is obvious that the law lying behind this unique event has often resulted in the partitioning of holdings joint owned by heirs. Secondly, the law has set limits on the acquisition of supplementary forest land by non-economically active farmers. From the forestry viewpoint, the law should be revised or revoked, as NIPF ownership conditions have changed dramatically since it was first planned and implemented (see Uusivuori and Ylätalo 1993). These restrictions were abolished in the southern part of Finland in 1995 (Valtioneuvoston... 1995).

Finally, it should be stated that due to the fundamental civil rights of the present-day in relation to land ownership, the prevention of partitioning is very difficult in practice. Nevertheless, if one aims to enlarge the treatment units for silvicultural and logging operations, any means of improving the NIPF estate structure and achieving regional co-operation may serve in a way to increase those treatment units. A fairly large proportion of NIPF owners seem to be willing to participate in co-operation with others (e.g. Järveläinen 1983, p. 28, Karppinen 1985, p. 21–23), although this willingness has diminished along with the structural change in NIPF ownership (Mäkelä 1974, 1979).

6.4 Reliability of the Results

The reliability of the results can be considered under the headings of external and internal reliability, the corollaries of external and internal errors. The concept of external error, or sampling error, is familiar from statistics, whereas that of internal error is mostly used in the social and behavioural sciences. The total error is the sum of these two. To reduce the total error, it is necessary to reduce both the external and internal error at the same time. Thus improving either external reliability or internal reliability will not reduce the total error (Fig. 14).

The external or sampling error describes the representatives of the results calculated from the sample. Systematic sampling error occurs when the sample is biased due to non-random sampling or a high non-response rate. Random error in sampling naturally means that the results obtained from the sample cannot be exactly the same as those for the total population. Reliability and validity are both internal, or measurements errors.

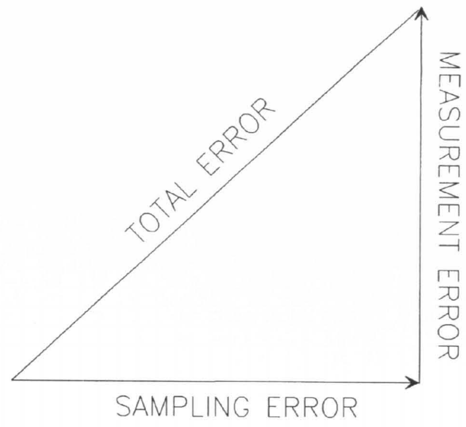


Fig. 14. Illustration example of the composition of total error in a survey. Adapted from Blalock (1985, p. 412).

Reliability can be defined as non-randomness in the results (Eskola 1981, p. 77) and is equal to the observed variance as a proportion of the true variance (Tarkkonen 1984, p. 249). Broadly speaking, validity means the ability of a variable to measure exactly what it is supposed to measure. More detailed descriptions of error types in survey analysis are presented elsewhere (e.g. Valkonen 1984, Kirk and Miller 1986).

There was concern during the planning of data collection that external or sampling errors might probably cause a large bias in the results, as it was known that the original data was a representative sample of NIPF owners in southern Finland which did not possess sampling errors (Karppinen and Hänninen 1990), so that external error would be concentrated only in non-response or sampling error in the data collection at the second stage. Due the composition of the original data, however, it was known that a specific problem might occur in the areas of reliability and validity.

External Reliability

The external reliability of the results is derived predominantly from the original data and from non-response at the later data collection stage. The earlier work concerned 2121 NIPF holdings, and the data was collected by interviewing forest owners and making inventories of their forests in 1980–86. The authors came to the conclusion that the sampling and non-response, less than 5 per cent did not create a bias in the results (Karppinen and Hänninen 1990, p. 57–61).

The same holdings were re-surveyed by means of a postal inquiry in 1990, and partly by interviewing forest owners in 1991. During the planning of the mail inquiry, there was concern that too many questions might discourage people from participating, and therefore the number of questions and the appearance of the questionnaire were planned very carefully (see Foddy 1994). Also, the timing of postage was taken into consideration, as most of forest owners are difficult to contact during the summer holiday season and at sowing times on farms. The questionnaire was therefore posted first in September 1990, with a second round two weeks later and reminders, where necessary, about five weeks after the initial posting.

The number replies obtained to the postal inquiry and the interviews was 1578, i.e. the non-response rate was 26 per cent. The characteristics of this non-response were studied by interviewing 67 forest owners who did not return the questionnaire. Comparison of the inquiry data with the non-response cases revealed no statistically significant differences in any essential area. A more detailed description of the analysis of non-response is presented by Ripatti (1991, p. 10–11). The eventual sample comprised 314 holdings which had undergone ownership changes. Taking approx. 30 years as the average length of ownership, it can be estimated that this population might comprise about 50 000 holdings altogether, but in view of the lack of information on these, it is difficult to obtain any reliable evaluation of the external error entailed in the eventual sample.

Karppinen et al. (1994) studied in detail the problem of non-response in postal surveys and found that the length of NIPF ownership was shorter among the non-respondents than among the respondents, although this was statistically significant only at approx. the 10 per cent level. This indicates that owners with a recent history of NIPF ownership changes were less likely to respond to the postal inquiry than more long-term owners. Thus the present data may include a systematic sampling error, as the subsequent owners are obviously younger and better educated than the former owners. The well-planned sampling, representative sample and high response rate in both the original inquiry and the repeat survey nevertheless suggest that external error is not a large problem here. In addition, the analysis of non-response did not reveal any essential differences between the respondents and non-respondents.

Internal Reliability

The internal error of the results can be considered in terms of reliability, corresponding to the accuracy of the measurement, and validity, corresponding to the ability of the measurement scales to give real information on the desired traits. The quality of measurement consists of these components. They are not independent, because if a measurement lacks reliability, it will be random and can have no validity. On the other hand, a measurement can be reliable without being valid (Tarkkonen 1987, p. 9). In other words, an improvement in reliability always also increases the validity, but the opposite is not true (Eskola 1981, p. 56, Valkonen 1984, p. 69).

In their discussion of the reliability of the data collected at the first stage, Karppinen and Hänninen (1990, p. 52–54) conclude that collection had been reliable, first of all because it had been done by interviewing forest owners and making inventories of their forests. The reliability of the interviews were taken care by educating interviewers and controlling the interviews. In addition, the data can be considered reliable because most of the questions in the interview concerned structural factors pertaining to forest ownership, which are of greater reliability than opinions, for example (Karppinen et al. 1994, p. 124).

At the second stage of data collection, via the questionnaire, the owners were asked about their ownership arrangements and whether or not their holdings had been partitioned upon changing hands. Ownership changes were defined in terms of the replacement of individuals and changes in the type of ownership. In addition, if the area of forest land had decreased by more than half in the interval the holding was accepted for the sample.

Even though the factors concerning ownership arrangements were measured reliably, some validity problems are still involved in the concept of "ownership change", which are related to the final results of partitioning. This question will be discussed later.

In addition to the postal inquiry, the variables relating to ownership were checked from the farm registers in local tax offices, and therefore the information concerning the replacement of individuals and changes in the type of ownership can be considered reliable. In addition, the areas of forest land were assessed carefully. These were found out beforehand at both stages of data collection, and owners were requested to check the information. In conclusion, the holding and ownership variables and the factors concerning ownership were measured in quite a reliable manner.

One validity problem was caused by the sampling. A sample holding did not describe the total area of forest land in the possession of its owner or his or her family, because the sample unit was marked off as being located within a single municipality. Thus the holdings studied here did not necessarily make up the total decision-making unit of forest ownership. Karppinen and Hänninen (1990, p. 54) estimate that a good 10 per cent of the forest owners in the original sample owned forests in another municipalities as well. From the present purpose it would have been better if the whole unit could have been taken into consideration.

Another problem is the interpretation of the final results of partitioning. It was possible, for instance, for the area of forest land in a partitioned holding not to decrease in conjunction with a change in ownership. For example, if a party to a forest estate on a partitioned holding owned jointly by heirs also possesses forest elsewhere in the same municipality, but in a different type of ownership, the area of forest land belonging to the sample holding may increase upon incorporation of the prior and inherited parcels. In addition, if the party concerned was responsible for the management of the holding of half of all the heirs, the ownership factors will be attributed to that person.

A further validity problem arises from certain characteristics of holdings and their ownership. The classification of forest owners by occupation as either farmers or non-farmers is crude, because pensioners were classified on the basis of their former occupations. This classification is discussed in more detail by Järveläinen (1980), Hanelius (1980), Häkkilä and Voutilainen (1984), Ruuska (1994), Ripatti (1995) and Mustonen (1996). On account of the overall changes in society, the socio-economic structure of forest owners has also changed. In fact, retirees comprised the largest forest owner group, 36 per cent of all NIPF owners in 1990. It is difficult to say, however, how the world of ideas and behaviour of forest owners changes upon retirement or how retirement affects the ownership arrangements when a holding changes hands.

The implications of the variable describing the main use to which the holding is put has been discussed e.g. by Karppinen (1994, p. 34). The forest owners were asked in this case, "What is the main use made of your holding as a whole?", which elucidates most of all the significance of forestry and agriculture and their mutual dependence within the economics of farms. In addition, recreation, residence and leisure do not necessarily exclude the above forms of production because the use of forests and the use holding are different matters. It would therefore have been appropriate to study the main use made of forest ownership, but such information was not available.

6.5. Concluding Remarks

In conclusion, a few reservations should be made regarding this research. In the first place, the main aim was to determine how the characteristics of NIPF holdings and their owners affect partitioning in conjunction with ownership changes. Thus little attention were paid to "fragmentation problems" as such or to changes in the size distribution of NIPF holdings, the latter because it could have been studied only with aid of panel data, i.e. by means of a closed system. The effects of the small average size of holdings on non-industrial private forestry were also secondary questions, even though the research itself arose out of the many threats to timber production that are related to small holding size.

Secondly, it must be stated that this work sets out from Finnish forest policy and assumes that partitioning is mostly an undesirable phenomenon. However, as indicated by the changes in the size distribution of the holdings studied here, partitioning is producing, also, an increase in the size of forest holdings, even though the overall trend is towards smaller average holdings. In addition, the existence of a broad NIPF ownership base can similarly be regarded as a desirable feature on general grounds. Also, it has always been considered a desirable thing to possess forest, on account of its intrinsic value (Carlén 1990).

The lack of an official, uniform, up-to-date register of NIPF holdings and their owners makes it difficult to describe changes in NIPF ownership reliably. It is for this reason that numerous postal inquiries and interview surveys of forest owners have been carried out (see Ihalainen 1990). The population studied comprised NIPF holdings which had undergone changes in ownership between 1980–86 and 1990–91.

Since it was necessary in the present case to be able to use information on forest ownership at two points in time, the same holdings which had been involved in an earlier study conducted at the Finnish Forest Research Institute (see Järveläinen 1988, Karppinen and Hänninen 1990) were re-surveyed. The purpose of the earlier work had been to provide information on the actual and allowable cut on NIPF holdings, however, and thus the variables selected were not the very best ones for the present purpose.

The data did not include, for instance, such important variables as the prices of holdings, nor the owner's marital status, number of children, wealth or income. It must therefore be stressed that the results are restricted and the conclusions based on them only preliminary. Market and economic factors could be essential aspects requiring further study. The frame of reference could not be subjected to a complete quantitative test here, on account of its size and the presumably very complicated time-lag structure involved. These properties place high demands on the quantity and quality of the data.

Besides, the period covered by the data is about seven years, which is a very short time compared to the average length of NIPF ownership, approx. 30 years, and it does not necessarily give a realistic view of ownership arrangements and partitioning processes in a historical perspective, especially when using holding-level data. In addition, the factors affecting partitioning are likely to be relatively stable over time. Thus it has become apparent that further investigations are required using aggregate data. Further research should focus on the general social change and the role of landownership in our society at all and their implications for partitioning. Also, more emphasis should be put on theoretical considerations of landownership. The effects of partitioning of NIPF holdings are reflected in changes in both the size distribution of holdings and their average size, and it has become apparent that further study is required in this area using aggregate data.

In the sphere of logistic regression analysis, an important area for further exploration could be the use of quantitative forest policy variables, which would be capable of indicating, for instance, that if forest owners were exposed to a certain number of additional extension courses, then the probability of partitioning would decrease by a certain percentage. In addition, little is known about the interaction between factors operating at various levels, which could be studied by path analysis. As a statistical technique, this does not add anything to conventional regression, but as an aid to interpretation, it might be valuable because it requires explicit assumptions and permits the analysis of indirect causal connections in addition to direct effects (Duncan 1978).

As regards transfers of NIPF ownership, Törnqvist (1995) has studied NIPF ownership in Sweden as a multi-generation project, i.e. forest owners as entrepreneurs and forest managers, by bringing together different aspect under the concept of forest ownership and providing a view of the emergence of forest ownership, the institutional frameworks in society and the modes of action manifested at the level of the forest estate. This kind of study might provide a valuable approach for understanding multi-dimensional aspects related to arrangements for the transfer of NIPF ownership in Finland as well.

Regional conditions and theories should give further insight into regional differentiation in ownership change arrangements and in partitioning, but one should take into account in this context the orientation of production on holdings, especially on farms. Regional aspects may well play an important role in modulating partitioning processes. Tykkyläinen et al. (1996) present theories on regional development and discuss their relevance to the forest sector, but most of them are global, too extensive or otherwise discordant in relation to the present case. Thus it must be said that the theory related to the present work is not well developed and that there is a lot of work to be done on it. Finally, more research should be focused on forest land markets and public policies imposed on them, and on the implications of these institutions for trends in the average size and size distribution of NIPF holdings.

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Total of 223 references

Appendix 1. Correlation matrix of the variables used in the study, whole sample, number of observations 314.

	PARTIT	OCCUP	RESID	OWN	MUSE	REGIO	RESCO	ACQUI	FOR	NFOR	ARAB	PCUT	AGE
PARTIT	1.000												
OCCUP	0.333	1.000											
RESID	0.213	0.491	1.000										
OWN	0.234	0.244	0.039	1.000									
MUSE	0.252	0.143	0.130	0.044	1.000								
REGIO	0.125	–0.048	0.059	–0.084	0.011	1.000							
RESCO	–0.043	0.178	0.287	0.231	–0.042	0.075	1.000						
ACQUI	–0.011	0.077	0.014	0.401	0.118	–0.212	0.129	1.000					
FOR	0.100	–0.069	–0.168	0.003	–0.236	–0.125	0.026	–0.085	1.000				
NFOR	0.055	0.032	0.113	–0.075	–0.079	–0.004	–0.086	–0.038	0.230	1.000			
ARAB	0.007	–0.308	–0.459	0.020	–0.236	0.164	–0.131	–0.103	0.322	0.013	1.000		
PCUT	0.157	0.137	0.027	0.169	0.038	0.105	0.141	–0.060	–0.081	0.028	0.000	1.000	
AGE	–0.118	–0.332	–0.040	–0.369	0.226	0.012	0.027	–0.076	–0.020	–0.041	–0.099	0.037	1.000

Appendix 2. The logistic regression model diagnostic.

```
BMDPLR - STEPWISE LOGISTIC REGRESSION
Release: 7.0 (BMDP/DYNAMIC)
Date: 01/17/94  at 17:58:58
Site: S2U00172CK

/problem        title='BMDPLR logit model for Southern Finland'.

/input          file='c:\divlog\logit.bmd'.
                code=odds.

/var            use=PARTIT,OCCUP,RESID,OWN,MUSE,REGIO,PCUT,FOR.
                freq=nweight.

/group          codes (PARTIT)=1,0.
                names (PARTIT)=YES,NO.

/regress        depend=PARTIT.
                model=OCCUP,RESID,OWN,MUSE,REGIO,FOR,PCUT.
                interval=PCUT.

/print          cost.
                hist.

/end

NUMBER OF CASES READ. . . . . . . . . . . . . .  314
CASES WITH USE SET TO NEGATIVE VALUE. . . . . .    1
REMAINING NUMBER OF CASES. . . . . . . . . . .  313
DEPENDENT VARIABLE. . . . . . . . . . . . . . .  86 PARTIT
COUNT VARIABLE. . . . . . . . . . . . . . . . .  74 nweight
SCOUNT VARIABLE. . . . . . . . . . . . . . . .  0
FCOUNT VARIABLE. . . . . . . . . . . . . . . .  0
METHOD TO SELECT NEXT TERM TO REMOVE OR ENTER .  ACE
HIERARCHICAL TERM INCLUSION RULE USED . . . . .  SING
REMOVE LIMIT (P-VALUE MUST BE GREATER). . . . .  0.1500  0.1500
ENTER LIMIT (P-VALUE MUST BE LESS). . . . . . .  0.1000  0.1000
TOLERANCE . . . . . . . . . . . . . . . . . . .  0.0001000
CONVERGENCE CRITERION ON LIKELIHOOD . . . . . .  0.0000100
CONVERGENCE CRITERION ON PARAMETERS . . . . . .  0.0001000
MAXIMUM NUMBER OF ITERATIONS. . . . . . . . . .  10
                  STEP ADJUSTMENTS. . . . . . .   5


TOTAL NUMBER OF RESPONSES USED IN THE ANALYSIS . . . 314
SUCCESS  . . . . . . . . . . . . . . . . . . . . . .  79
FAILURE  . . . . . . . . . . . . . . . . . . . . . . 235
NUMBER OF DISTINCT COVARIATE PATTERNS  . . . . . . . 251
```

DESCRIPTIVE STATISTICS OF INDEPENDENT VARIABLES

VARIABLE NO. N A M E	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION	SKEWNESS	KURTOSIS
93 PCUT	0.0000	19.3000	4.2103	3.4988	1.1096	1.4540

VARIABLE NO. N A M E	GROUP INDEX	FREQ	DESIGN VARIABLES (1)
87 OCCUP	0	226	0
	1	87	1
88 RESID	0	196	0
	1	117	1
89 OWN	0	236	0
	1	77	1
90 MUSE	0	248	0
	1	65	1
91 REGIO	0	160	0
	1	153	1
92 FOR	0	235	0
	1	78	1


```
                                  LOG LIKELIHOOD =   -132.959
GOODNESS OF FIT CHI-SQ   (2*O*LN(O/E)) =   247.877  D.F.= 243  P-VALUE= 0.401
GOODNESS OF FIT CHI-SQ (HOSMER-LEMESHOW)=    9.258  D.F.=   8  P-VALUE= 0.321
GOODNESS OF FIT CHI-SQ   ( C.C.BROWN ) =     0.277  D.F.=   2  P-VALUE= 0.871
```

TERM	COEFFICIENT	STANDARD ERROR	COEF/SE	EXP(COEF)	95% C.I. OF EXP(COEF) LOWER-BND	UPPER-BND
OCCUP	1.249	0.384	3.25	3.49	1.64	7.42
RESID	0.621	0.377	1.65	1.86	0.89	3.91
OWN	1.116	0.347	3.22	3.05	1.54	6.04
MUSE	1.540	0.373	4.13	4.66	2.24	9.72
REGIO	1.023	0.329	3.11	2.78	1.46	5.31
FOR	1.742	0.370	4.71	5.71	2.75	11.80
PCUT	0.043	0.044	0.98	1.04	0.96	1.14
CONSTANT	-3.754	0.436	-8.60	0.02	0.99	0.55

```
HISTOGRAM OF PREDICTED PROBABILITIES OF SUCCESS  FOR GROUP SUCCESS
EACH 'X' REPRESENTS 1 RESPONSE.
     'M' MARKS THE MEDIAN, 'Q' MARKS THE QUARTILES.
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
                                      X
               X                      X
               XX X                   X
    XX  XX     XX X            X  X   X     X
    XXXXXX     XX X  X         X  X  XX X X X  X
.+....+....+...Q+....+....+....M....+.Q..+....+....+....+....+.
     .10       .30       .50       .70       .90      1.1
0.0       .20       .40       .60       .80       1.0       1.2


                      PROB- GROUP SUCCESS
HISTOGRAM OF PREDICTED PROBABILITIES OF SUCCESS  FOR GROUP FAILURE
EACH 'X' REPRESENTS 1 RESPONSE.
     'M' MARKS THE MEDIAN, 'Q' MARKS THE QUARTILES.
       X
       X
       X
       X
  X    X
  X  X X
  X  X X
  X  X X
  XX X X  X
  XXXX X  X
  XXXXXX  X
  XXXXXX  X  X
  XXXXXX  X  X
  XXXXXX  X  X
  XXXXXX  X  X X
  XXXXXX  X  X XX
  XXXXXXX X  X XX XX
  XXXXXXX X  XXXXXXX
  XXXXXXXXX XXXXXXXXX
  XXXXXXXXXXXXXXXXXXX X              X      X
.+..Q.+M...+.Q..+....+....+....+....+....+....+....+....+....+.
     .10       .30       .50       .70       .90      1.1
0.0       .20       .40       .60       .80       1.0       1.2
```

PREDICTED PROBABILITIES CAN BE USED TO CLASSIFY CASES INTO GROUPS.
A CASE IS 'PREDICTED' TO BE IN GROUP. FAILURE IF PROBABILITY LESS
THAN OR EQUAL TO CUTPOINT, OR IN GROUP. SUCCESS IF PROBABILITY GREATER
THAN CUTPOINT. EACH CUTPOINT YIELDS A CLASSIFICATION MATRIX,
CONTAINING COUNTS OF

	PREDICTED AS SUCCESS	PREDICTED AS FAILURE
CASES IN SUCCESS	(A BELOW)	(B BELOW)
CASES IN FAILURE	(C BELOW)	(D BELOW)

THE CROSS PRODUCT RATIO (COL. 11 BELOW) IS COMPUTED FROM THE CLASSIFICATION
MATRIX AS THE PRODUCT OF THE COUNTS OF CORRECT CLASSIFICATIONS
DIVIDED BY THE PRODUCT OF THE COUNTS OF INCORRECT CLASSIFICATIONS (AD/BC)
THE 'COST' MATRIX TIMES THE CLASSIFICATION MATRIX YIELDS THE GAIN/LOSS FUNCTION

THE COST MATRIX

	P R E D I C T E D	
	SUCCESS	FAILURE
SUCCESS	0.00	-1.00
FAILURE	-1.00	0.00

LOSS = + 0.0000 A - 1.0000 B - 1.0000 C + 0.0000 D

CUT-	CORRECT PRED			% CORRECT			INCORRECT PRED			CR.PROD.	GAIN OR
POINT	SUCCE	FAILU	TOTAL	SUCCE	FAILU	TOTAL	SUCCE	FAILU	TOTAL	RATIO	LOSS
0.030	46.	16.	62.	100.0	11.1	32.6	0.	128.	128.	UNDEFINED	-128.00
0.050	46.	28.	74.	100.0	19.4	38.9	0.	116.	116.	UNDEFINED	-116.00
0.070	44.	39.	83.	95.7	27.1	43.7	2.	105.	107.	8.17	-107.00
0.090	42.	54.	96.	91.3	37.5	50.5	4.	90.	94.	6.30	-94.00
0.110	41.	64.	105.	89.1	44.4	55.3	5.	80.	85.	6.56	-85.00
0.130	40.	84.	124.	87.0	58.3	65.3	6.	60.	66.	9.33	-66.00
0.150	38.	88.	126.	82.6	61.1	66.3	8.	56.	64.	7.46	-64.00
0.170	36.	90.	126.	78.3	62.5	66.3	10.	54.	64.	6.00	-64.00
0.190	36.	102.	138.	78.3	70.8	72.6	10.	42.	52.	8.74	-52.00
0.210	36.	103.	139.	78.3	71.5	73.2	10.	41.	51.	9.04	-51.00
0.230	36.	105.	141.	78.3	72.9	74.2	10.	39.	49.	9.69	-49.00
0.250	36.	114.	150.	78.3	79.2	78.9	10.	30.	40.	13.68	-40.00
0.270	36.	117.	153.	78.3	81.3	80.5	10.	27.	37.	15.60	-37.00
0.290	32.	123.	155.	69.6	85.4	81.6	14.	21.	35.	13.39	-35.00
0.310	29.	128.	157.	63.0	88.9	82.6	17.	16.	33.	13.65	-33.00
0.330	29.	131.	160.	63.0	91.0	84.2	17.	13.	30.	17.19	-30.00
0.350	26.	135.	161.	56.5	93.8	84.7	20.	9.	29.	19.50	-29.00
0.370	26.	139.	165.	56.5	96.5	86.8	20.	5.	25.	36.14	-25.00
0.390	26.	141.	167.	56.5	97.9	87.9	20.	3.	23.	61.10	-23.00
0.410	25.	141.	166.	54.3	97.9	87.4	21.	3.	24.	55.95	-24.00
0.430	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.450	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.470	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.490	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.510	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.530	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.550	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.570	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.590	25.	142.	167.	54.3	98.6	87.9	21.	2.	23.	84.52	-23.00
0.610	23.	142.	165.	50.0	98.6	86.8	23.	2.	25.	71.00	-25.00
0.630	23.	142.	165.	50.0	98.6	86.8	23.	2.	25.	71.00	-25.00
0.650	23.	142.	165.	50.0	98.6	86.8	23.	2.	25.	71.00	-25.00
0.670	21.	142.	163.	45.7	98.6	85.8	25.	2.	27.	59.64	-27.00
0.690	21.	142.	163.	45.7	98.6	85.8	25.	2.	27.	59.64	-27.00
0.710	21.	142.	163.	45.7	98.6	85.8	25.	2.	27.	59.64	-27.00
0.730	20.	143.	163.	43.5	99.3	85.8	26.	1.	27.	110.00	-27.00
0.750	5.	143.	148.	10.9	99.3	77.9	41.	1.	42.	17.44	-42.00
0.770	5.	143.	148.	10.9	99.3	77.9	41.	1.	42.	17.44	-42.00
0.790	4.	143.	147.	8.7	99.3	77.4	42.	1.	43.	13.62	-43.00
0.810	4.	143.	147.	8.7	99.3	77.4	42.	1.	43.	13.62	-43.00
0.830	3.	143.	146.	6.5	99.3	76.8	43.	1.	44.	9.98	-44.00
0.850	3.	143.	146.	6.5	99.3	76.8	43.	1.	44.	9.98	-44.00
0.870	1.	144.	145.	2.2	100.0	76.3	45.	0.	45.	UNDEFINED	-45.00
0.890	1.	144.	145.	2.2	100.0	76.3	45.	0.	45.	UNDEFINED	-45.00
0.910	1.	144.	145.	2.2	100.0	76.3	45.	0.	45.	UNDEFINED	-45.00
0.930	0.	144.	144.	0.0	100.0	75.8	46.	0.	46.	UNDEFINED	-46.00

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