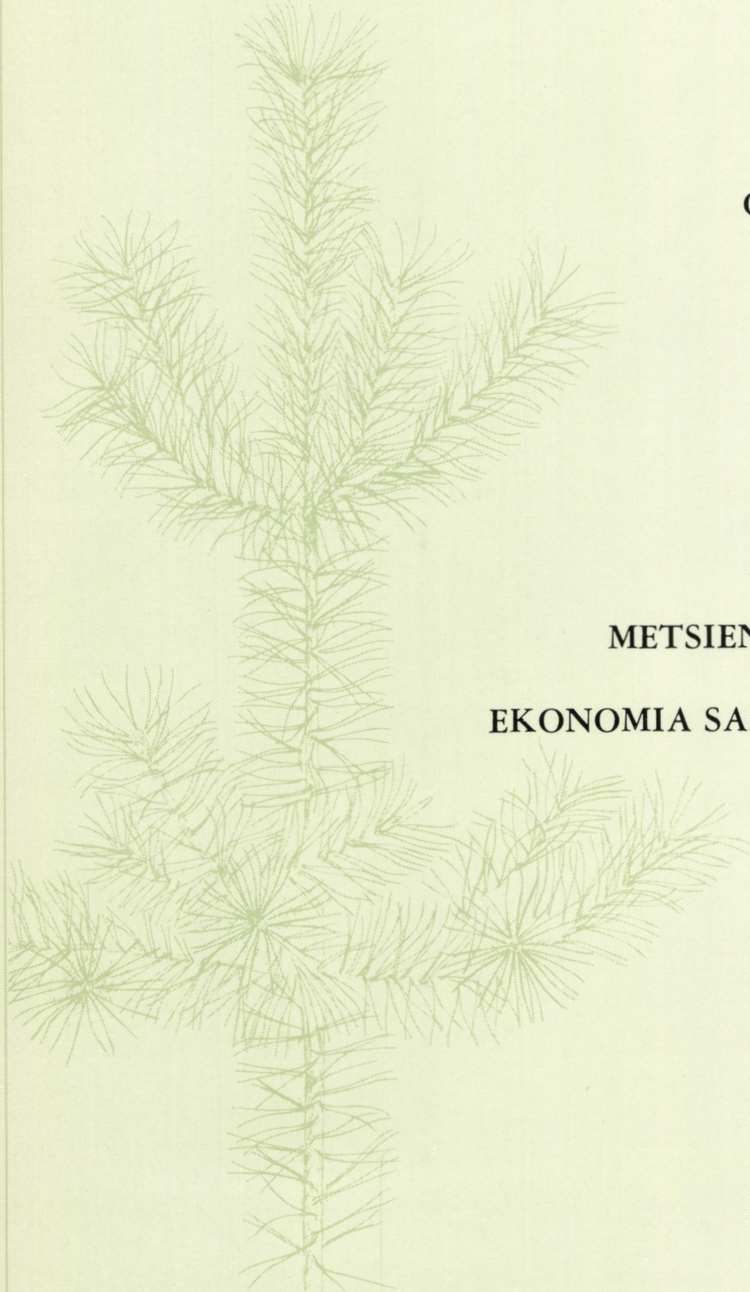
COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE 104

ECONOMICS OF MULTIPLE-USE FORESTRY IN THE SAARISELKÄ FOREST AND FELL AREA



OLLI SAASTAMOINEN

SELOSTE

METSIEN MONINAISKÄYTÖN

EKONOMIA SAARISELÄN METSÄ- JA

TUNTURIALUEELLA

HELSINKI 1982

COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE

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Cover (front & back): Scots pine (*Pinus sylvestris* L.) is the most important tree species in Finland. Pine dominated forest covers about 60 per cent of forest land and its total volume is nearly 700 mill. cu.m. The front cover shows a young Scots pine and the back cover a 30-metre-high, 140-year-old tree.

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The purpose of the study is to examine the mutual relationships and economics of timber production, reindeer grazing and outdoor recreation, which are the main uses of forestry land in Finnish Lapland. The study area covers 1 757 sq.km consisting of forests and treeless fells.

In the theoretical part of the study the multiple use of forests is considered from the point of view of production theory. The approach of multicommodity production is regarded as being useful because in it the emphasis is laid on the mutual relationships of the uses which are central in solving the problems of multiple-use forestry.

In the empirical part the separate production possibilities of each use in the study area are outlined in their present state and the long term and the product relationships and joint production possibilities are considered empirically in the conditions of the study area as well as in light of the literature. The economic importance of the uses is analyzed by the help of two measures: total value of production and value added of production.

In the study area outdoor recreation measured by the returns of tourism enterprises appeared to be economically the most important land use. Also timber production had an importance in spite of severe climatic conditions. As an extensive land use the economic importance of reindeer grazing remained considerably lower than the other two.

The most appropriate multiple use combination in the study area seems to be that of outdoor recreation and reindeer grazing. Wilderness appeal in outdoor recreation strongly restricts timber production but, on the other hand, seems to give better possibilities for reindeer grazing than the combination of timber production and reindeer grazing would provide.

Työn tarkoituksena on tutkia Lapin metsätalouden maan kolmen keskeisen käyttömuodon – puuntuotannon, poronhoidon ja ulkoilukäytön – keskinäissuhteita ja ekonomiaa Saariselän metsä- ja tunturialueella. Alueen pinta-ala on 1 757 km^2.

Tutkimuksen teoreettisessa osassa metsien moninaiskäyttöä tarkastellaan tuotantoteorian näkökulmasta. Monihyödyketuotannon lähestymistapaa pidetään hyödyllisenä koska siinä painopiste asettuu käyttömuotojen keskinäissuhteisiin, jotka ovat ydinkysymyksiä moninaiskäytön ongelmien ratkaisemisessa.

Empiirisessä osassa hahmotellaan kunkin käyttömuodon erilliset tuotantomahdollisuudet nykytilanteessa ja pitkällä tähtäimellä sekä tarkastellaan käyttömuotojen keskinäissuhteita ja yhteistuotantomahdollisuuksia empiirisesti tutkimusalueen olosuhteissa ja kirjallisuuden valossa. Käyttömuotojen taloudellista merkitystä on analysoitu kahden tunnuksen – tuotannon kokonaisarvon ja sen arvonlisäyksen – avulla.

Tutkimusalueella ulkoilukäyttö mitattaessa sitä matkailuyritysten tuottojen avulla osoittautui taloudellisesti tärkeimmäksi käyttömuodoksi. Myös puuntuotannolla on varteenotettava taloudellinen merkitys huolimatta ilmastollisesti epäsuotuisista olosuhteista. Ekstensiivisenä maankäyttömuotona poronhoidon taloudellinen merkitys jää selvästi ulkoilukäyttöä ja puuntuotantoa alhaisemmaksi.

Alueen käyttövaihtoehdoista tarkoituksenmukaisimmalta näyttää ulkoilukäytön ja poronhoidon yhdistelmä. Erämaaluontoon hakeutuva ulkoilukäyttö rajoittaa puuntuotantoa voimakkaasti mutta näyttää tarjoavan paremmat edellytykset poronhoidon harjoittamiselle kuin mitkä mahdollistuisivat puuntuotannon ja poronhoidon yhdistelmässä.

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CONTENTS

PREFACE

This study was begun at the Department of Social Economics of Forestry at the University of Helsinki under the guidance of Professor Päiviö Riihinen and present Professor Matti Keltikangas, Department of Business Economics of Forestry. They participated actively in the planning phases of the study, made it possible to carry out the study as dissertation work and as assessors helped to clarify the structure and the scope of the study with their criticisms.

Later the study was moved to the Finnish Forest Research Institute, by the kind help of Professor Lauri Heikinheimo, head of the Department of Social Economics of Forestry. Professor Heikinheimo has in many ways supported the study and criticized the manuscript. The comments and criticism of Professor Kullervo Kuusela are also acknowledged as well as the discussions with and comments by Dr. Pekka Kilkki.

Most of the time the study was carried out at the Rovaniemi Research Station of the Finnish Forest Research Institute. The rapidly developing research station – first headed by present Professor Erkki Lähde – has provided good working conditions, and its staff, all groups of personnel included, has created an active research atmosphere.

The completion of the study has entailed wide data collection, in which many authorities, organizations, enterprises and persons have helped. They are too numerous to list separately, but the main sources of data and knowledge of different land uses are acknowledged. Concerning timber production the most help was provided by the Inari District and the North Finland Region of the National Board of Forestry as well as the Experimental Office of the Forest Research Institute. In reindeer husbandry, acknowledged is the help of the Association of Reindeer Management Co-operatives, the Reindeer Management Co-operative of Sodankylän Lappi and Pekka Aikio. Data and material concerning outdoor recreation in the study area was supplied by the National Board of Survey, the Experimental Office of the Forest Research Institute, Virkamiesliitto and Saariselän retkeilykeskus, the Finnish Tourist Association and Laanihovi, Suomen Latu and Kiilopään Koulutuskeskus, other enterprises, organizations, communities and private persons owning vacation houses or wilderness huts in the area, numerous interviewed recreationists, and Matti Toivola, the main guide-guardian of the area.

As research assistants the following persons have worked the longest time: Seppo Lohiniva, Unto Matinlompolo, Johanna Niemelä, Hannele Nivala and Kaija Sälevä. In the study of landscape preferences Hellevi Salonen assisted. The inventory of reindeer winter ranges was done by the field crews of range survey of National Forest Inventory. A great deal of the calculations concerning range inventory was done by Aleks Vasiljeff. In this connection also the help of Eero Mattila is acknowledged. Some mathematical formulations were checked by Risto Sievänen.

Figures were drawn by Hannele Nivala. Most of office personnel participated in the typewriting of the different versions of the manuscript. The English text was checked by Richard Foley.

In addition to persons mentioned earlier following persons have read and commented on the whole manuscript or parts of it: Pekka Aikio, Arvi A. Koivisto, Pekka Ollonqvist, Viljo Ovaskainen, Auvo Sahavirta, Markku Simula and Pertti Veijola. The remaining obscurities and mistakes, however, are mine alone.

Financially the study was supported by the Finnish Natural Resource Research Foundation, the Academy of Finland, the Society of Forestry in Finland and the Cultural Foundation of Finland.

I would like to express my sincere thanks to all individuals and organizations who in different ways have provided help, advice and criticism during the long study period. Last, but not least, thanks belong to my family.

Rovaniemi, November 1981

Olli Saastamoinen

1. INTRODUCTION

11. A forestry peculiarity – product multiplicity

Among the most important peculiarities of forestry – the long production period, the similarity of product and the factor of production, the reproductive ability of forests and the multiplicity of products (e.g. *Saari* 1928, p. 6–13, *Duerr* 1960, p. 182–193, *Vasil'ev* et al. 1965, p. 6–8, *Dzhikovich* 1970, p. 25–27, *Keltikangas,* V. 1971, p. 180–182, *Gregory* 1972, p. 168–171), the last two named command nowadays special attention. Of these, the latter is an object of interest here.

Although the variety of forestry products has aroused much interest, especially during most recent decades, it by no means can be considered to be a recently discovered forest characteristic. Many historical reviews of forestry (e.g. *Helander* 1949, *Makkonen* 1975, *Stridsberg* and *Mattsson* 1980) have indisputably shown the complexity of benefits characterizing the relationship between people and the forest from the beginnings of mankind.

A short survey of the history of forestry in Finland alone (e.g. *Helander* 1949, *Alho* 1968, *Yli-Vakkuri* 1980, *Palo* 1981) confirms the idea that even the main product of forestry (e.g. game, fuelwood, ash for agricultural use, tar, timber) has varied greatly; a multiple dependence on and utilization of forest resources have played an important role throughout. It can be concluded that while the combination of relevant forest products or at least the emphasis laid on each product has changed considerably from time to time, the multitude of products as such has been a constant phenomenon.

One may then ask why it is that only in recent times has so much attention been given to the multiple products of forests.

An answer may be found in a basic concept of economics – scarcity. The essential difference between the traditional and present utilization of the many forest products is that many forest products have become scarce. Scarcity, of course, as such, is a very relative concept, but it is clear that increased demand for many forest products in the relatively constant or even decreasing supply conditions has created a situation which is crucially different from that which obtained in earlier times (*Lloyd* 1969, p. 45, cf. *Hofstad* 1976).

It can be concluded that even if the need for multiple products is an old one, the conditions in which this need is to be satisfied are much more complicated at present than in olden times.

This is a reason for the greatly increased concern about the multiple products of forests. This is also why the question of how the multiple products of forests are produced and used has become the focus of scientific, professional and public interests.

It has become common practice to deal with the production and use of the many forest products through the concept of multiple use of forests.

12. The multiple use of forests

The multiple-use principle has developed in forestry practice as a guiding management idea both in Europe and in the United States (e.g. *Gregory* 1955, 1972, p. 391–392). In Europe it has been said to derive from estate forestry, in which the goal was often to produce hunting opportunities for nobility, (e.g. Multiple . . . 1975, *Gregory* 1972, p. 391) or from town forests, which were established as much for protecting municipal water sources as for furnishing fuel and other wood products for the local citizenry (e.g. *Gregory* 1972, p. 391). In the United States the problems of multiple use first appeared in the management of public lands (e.g. *Duerr* and *Vaux* 1953, p. 12, *Zivnuska* 1961, *Gregory* 1972, p. 391–392).

One of the first to consider the multiple use of forests as an economic concept was *Ciriacy–Wantrup* (1938). He analysed the difference between multiple and optimum use of wild lands under different economic conditions.

Gregory (1955) was the first to consider multiple use from the standpoint of production theory. He also gave a general interpretation to multiple use of land: it is, broadly speaking, the use of a particular land area to produce more than one type of good or service.

More closely, multiple use of forest land involves three somewhat different ideas (*Rowe* and *McCormack* 1968): (1) different uses of adjacent subareas which together form a composite multiple-use area, (2) the alternation in time of different uses on the same area, (3) more than one use of an area at one time.

Concerning the historical development of multiple use *Rowe* and *McCormack* (1968) point out that in new countries such as Canada, single use of land has been the rule. With sparse population and much land, there was not at first any need for multiple use. Only when population expanded and became urbanized have pressures developed to force a variety of uses on land.

In the Central European countries the concept of multi-goal forestry (*Mehrzweckforstwirschaft*) is often used to describe the idea of multiple-use forestry. E.g. *Niesslein* (1976, p. 45) considers that multi-goal forestry entails the production of varying and manifold benefits of forests for different interest and consumer groups, i.e. the combination of the function of timber production as well as protective and recreational functions. *Goosen* (1976, p. 181) emphasizes that in a densely populated country with few forests – such as the Netherlands – land-use planning, allocation and management can only be directed toward the multiple use of forests (different functions in the same place at the same time). *Roisin* (1975, p. 25–46) regards multiple use as to taking into account of the diverse functions of forests. The importance of the integration of the different functions of forests is also emphasized, e.g., in the conditions in Czechoslovakia (*Papanek* 1975, p. 296).

According to an Australian definition multiple use is the use of a given area for several different purposes such as watershed protection, timber production and recreation (Multiple . . . 1975, p. 2).

The leading direction of forestry in the Soviet Union, Poland and the German Democratic Republic is the complex utilization and reproduction of forest resources, to which also the concept of multi-trade (*Mehrfachfunktionen*) function of forests belongs (*Petrov* et al. 1975, p. 112). Forest resources must be seen as a complex of greatly varying benefits, satisfying different needs of people and economy (*Petrov* 1978, p. 4). *Moiseev* (1976, p. 11) uses the term "complex utilization of forest resources and benefits".

In Scandinavian countries, the concept of multiple use of forests appeared in the end of the sixties in the discussion of forestry. It has been touched upon from a silvicultural point of view (e.g. *Mikola* 1966, 1969, 1973; *Kardell* 1969, *Huikari* and *Paavilainen* 1971, *Helminen* 1980, *Kellomäki* 1980) and related to other economic considerations as well (e.g. *Holopainen* 1956, *Riihinen* 1967, *Palo* 1971, *Hämäläinen* 1973, *Kuusela* 1974). The multiple use of forests has been dealt with from the standpoint of economics in greater detail by *Riihinen* (1972), *Jørgensen* (1974), *Saastamoinen* (1974), *Lönnstedt* (1975), *Jaatinen* (1977) and *Helles* (1977).

Briefly, multiple use of forests as used here means the management of forestry land area for producing and utilizing several use values. The use values refer to the physical form of the forest benefits irrespective of the extent to which they are subject to pricing.

13. Alternative approaches

There are many alternative approaches to treating multiple use problems. Here three possible approaches are considered: in a somewhat loose way they are called the *rent approach* in land use economics, *linear programming* and *production theory.* These groupings are not mutually exclusive; they illustrate, however, important differences in the *a priori* knowledge on production functions.

The economics of land use (or land resources) deals with allocating scarce land resources for competing uses. As an economic resource most land can be utilized through any of several activities. On a very general level, land (use) economics is concerned with the optimum allocation of land resources, the central issue in this process being land rent. Land rent indicates the price for the use of a piece of land. If a new user buys the land instead of renting it from an owner, the price he will have to pay represents a capitalisation of the expected rents at the appropriate current rate of interest. Thus, rent also serves as a basis for the price of land (*Hoover* 1971, p. 94).

In societies where land use is governed by a price system, the allocation of land resources is mainly, but not solely, determined by land rent. Land tends to be directed to the use for which its ceiling rent is greatest (e.g. *Riihinen* 1967).

The economic analysis typical for problems of land use in this tradition attempts to determine the land rents of alternative uses of different pieces of land and thus demonstrate the optimal pattern of land uses. The problems dealt with most often in Nordic countries have concerned primarily the afforestation of farm land and the cultivation of forest land (e.g. *Jørgensen* 1956, *Pihkala* 1965, Comparative . . . 1969, *Strand* 1969, *Selby* 1980). However, from the standpoint of multiple use of forestry, this approach usually results in a specific land use pattern in which the total area has multiple uses, but every subarea is devoted to a *single* (or at least primary) use.

It means only one – of course in the case of exclusive land uses also the only possible –way to organize the several uses. In principle this approach is also applicable in comparing the different combinations of land uses for the same piece of land but it presupposes *a priori* knowledge of the relationships between uses and in fact this is most often the problem. In addition, the rent approach is most suitable for cases where the benefits derived from land uses are directly measured in money terms, as is the case when comparing agriculture and timber production. In many cases, e.g., those concerning collective utility (e.g *Strand* 1969, p. 241) this is not so.

Linear programming provides another possible analytical framework for handling problems of multiple use.

Linear programming is a mathematical technique which yields the optimal solution to problems defined by a linear objective function subject to a set of linear constraints (*Naylor* and *Vernon* 1969, p. 195).

The constraints may be either inputs or outputs of the production process and they can be assumed to get variable values (*Kilkki* 1979, p. 33). An important advantage of linear programming is its capacity to handle simultaneously both the quantities of the products produced and the optimal technological arrangement of productive activities (*Naylor* and *Vernon* 1969, p. 228).

The most important concept in linear programming is that of an "activity". An activity is defined as a particular way of combining variable factors for the production of output. A given product may be produced by several different activities, each using different factor-input ratios. These ratios are constant and independent of the extent to which each activity is used, i.e. constant returns to scale are assumed. Two or more activities can be used simultaneously subject to the limitations of the fixed factors available (*Naylor* and *Vernon* 1969, p. 226).

The many possibilities for using linear programming techniques for problems of multiple use are presented, e.g., by *Manning* (1971) and *Kilkki* (1979, p. 90–91).

However, even with linear programming the basic difficulty lies with the production function. The exact nature of the activities must be predetermined by a set of technical decisions (*Naylor* and *Vernon* 1969, p. 226); and these, when final, presuppose certain knowledge or assumptions about the shape of the relationships between the products and factor-inputs.

A third way of dealing with the multiple use problems is not to make *a priori* assumptions on production functions but simply to start studying the relationships prevailing between the variety of forest products and the factors of production. This is the approach chosen here. It is here called the approach of *production theory* because the focus of interests lies on the varying biological and/or physical relations which determine the production possibilities of multiple forest production. As it is later (Chapter 31) indicated, this is a narrow interpretation of production theory which excludes, for example, all aspects of value and distribution theories.

An attempt is made to employ the apparatus and concepts of production theory for the study of the problems of the multiple use of forests. This kind of approach is not new; it has been presented and emphasized by many writers, e.g., *Gregory* (1955, 1972), *Zivnuska* (1961, 1978), *Lloyd* (1969) and *Clawson* (1976).

2. PURPOSE AND OUTLINE OF THE STUDY

21. Study objectives

The purpose of this work is to study the characteristics and mutual relationships of three major and economically different uses of forestry land in Finnish Lapland under the conditions of the northern boreal coniferous zone in an area which includes large non-forested open fells.

The uses considered – in other words the products or production lines of forestry land – are *timber growing and harvesting, reindeer grazing and outdoor recreation.*

Each of them has, at least theoretically, the ability to use every hectare of forest and scrub-land in Lapland, with reindeer grazing and recreation even succeeding in utilizing treeless lands of forestry.

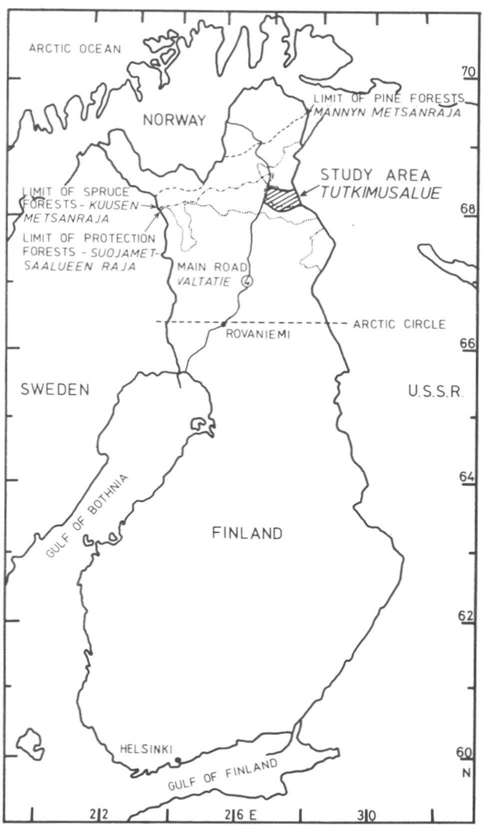


Figure 1. The location of the study area.
Kuva 1. Tutkimusalueen sijainti.

In practice each of them is carried on simultaneously on the same tracts of forestry land throughout almost the whole area of Finnish Lapland. Of course, the potential importance of specific pieces of land and actual intensities of use on them vary very much locally and regionally by site types.

The relative economic importance of timber production, reindeer husbandry and recreation (tourism) at the provincial level varies very much, but each of these major forest land uses has a real positive effect on the social welfare of the people of Lapland. Therefore, it is important to study their mutual relationships.

It is especially important in the areas where the conflict situations seem to be most severe. The study area is no doubt a most striking example in this sense.

The study objectives are derived from the actual empirical problems as well as from general theoretical considerations related to them. The detailed study objectives have been formulated in the following way:

1. to apply the concepts of production theory to the multiple-use problem area;
2. to outline the general features of the production functions of the specific uses and to determine the (biological or technical) production possibilities of each in the study area;
3. to study the (biological and physical) relationships between the forest uses and to consider them from the stand point of product-transformation;
4. to consider the problems of the economic evaluation of the specific forest uses and to discuss the economic importance of the probably feasible product-mixes.

22. Study area

The study area consists of the vast fell ridge of *Rautuntunturit* and the *Saariselkä* fells (here shortened to Saariselkä). The slopes of the fells and the large valleys between them are forested, the Scots pine being the dominant tree species.

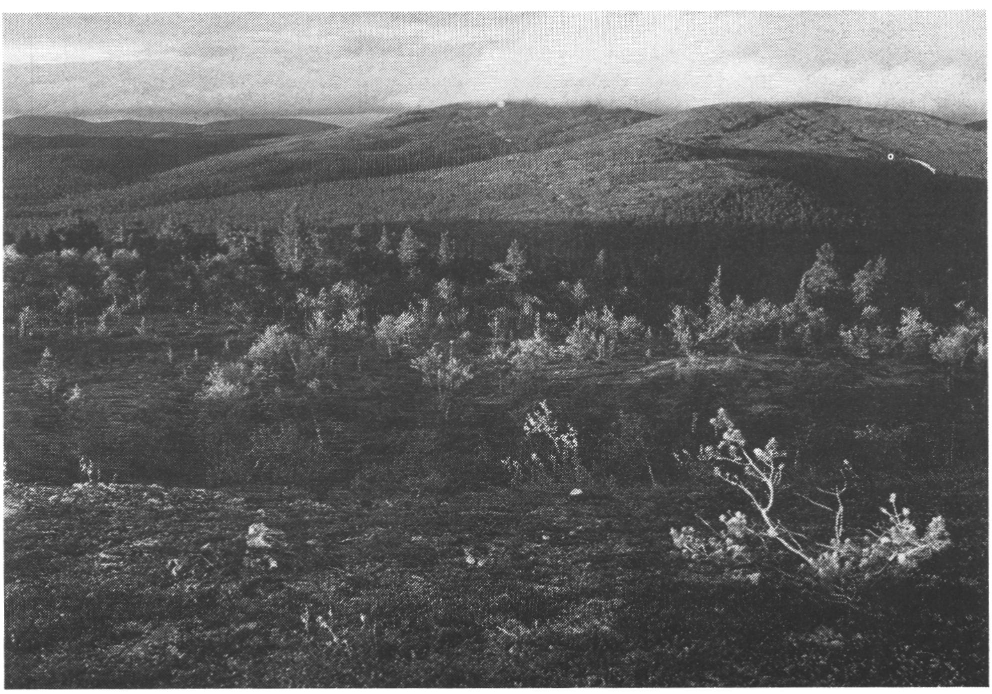
The Saariselkä fell tract is located in Finnish Lapland about 250 km north of the Arctic Circle. The northern parts of the study area lie approximately at latitude 68° 28' and the southern parts at latitude 68° 08'. The longitudes of the westernmost and easternmost points are 27° 15' and 28° 50'. The area lies between Main Road 4 and the border of the Soviet Union (Figure 1). Its area is 1 757 sq. km. The average distance from north to south is 32 km and from west to east 55 km. The area is a roadless wilderness with the exception of some short spur roads made during recent decades mainly for harvesting but also, for example, for tourism.

Typical of the topography of the Saariselkä area are the rounded bare fell tops which contrast with the forested river valleys. The differences in elevation are for Finnish conditions relatively great. In general, the elevations change gradually; the profiles of fells are rounded without the steep and rugged features typical of, e.g., the Scandinavian Köli mountains and, even more so, of the Alps.

The lowest point, the River Lutto near the border of the Soviet Union, lies at an altitude of 110 m. The highest point, Sokosti Fell is 718 meters above sea level. The fells are divided into groups by large valleys, at the head of which are passes rising to altitudes of 400–500 metres (see Figure 9).

Through the southern parts of the study area goes the main watershed divide of Maanselkä. The most prominent river of the area flows into the Arctic Ocean, the others run to the south, comprising part of the Kemijoki river system.

The fell ridge of Saariselkä forms the climatological divide. To the north of the study area the influence of the Arctic Ocean is reflected in milder winters and cooler summers (*Rintanen* 1968, p. 227). However, the southern part of the study area belongs to the most continental and even to the coldest areas of Northern Finland (*Kolkki* 1966, p. 6, *Franssila* & *Järvi* 1974, p. 49). The mean annual temperature 1931 – 1960 in Laanila (at an elevation of 285 metres) was –1,3 °C, the means for January and July being –13,6



(Photo – *Kuva: Jorma Luhta*)

Figure 2. Open rounded fells, zone of birches and pine-dominated coniferous forests are the main vegetation zones of Saariselkä.
Kuva 2. Pyöreälakisten tuntureiden paljakkamaa, kapea koivuvyöhyke ja mäntyvaltaiset havumetsät ovat Saariselän hallitsevat kasvillisuusvyöhykkeet.

°C and 13,0 °C respectively. Annual precipitation in the same period was 439 mm; this figure is lower than in the more southern parts of Finnish Lapland (*Kolkki* 1966), but evaporation also remains low because of the short and cool summer.

The permanent snow cover comes to Saariselkä in the end of October and disappears by the end of May. The average snow depth in March is 60 cm (*Solantie* 1974).

In addition to rivers and brooks, there are some small lakes in the area. A special feature is the scantiness of peatlands. It is one of least swampy areas in Finland (e.g. *Salminen* 1973).

From the point of view of forest vegetation, Saariselkä is an important area. It is one of the few vast areas in Finland where alpine forest lines occur. The southern half of the area is also swept by the northern limit of continuous spruce forests (*Heikinheimo* 1920, *Norokorpi* 1979). Especially for the sake of alpine forest lines the whole area belongs to the wide zone of protection forests which covers most of the forestry land in the northernmost part of Finnish Lapland (Figure 1).

23. Some remarks on land use history

The history of land uses in Saariselkä begins with hunting and fishing. In the first half of nineteenth century the area was an important region for wild reindeer hunting. The semi-domestic reindeer were used only as draught animals (e.g. *Helle* 1980a). However, the large-scale reindeer husbandry took over the area from wild reindeer hunting towards the end of century when the Lapp reindeer herders from *Enontekiö* were obliged to move there in 1852 after the border between Norway and Finland was closed because of the Crimean war and the reindeer lost their summer ranges on the Norwegian shore of the Arctic Ocean. The increase of semidomestic reindeer and probably also excessive hunting brought an end to wild reindeer hunting in Saariselkä. Other forms of hunting, however, have maintained some standing even to the present time.

Thereafter, reindeer husbandry occupied the status of main industry in the area. Some small peatlands in the southern part of the area had importance as natural meadows for

(Photo – *Kuva: Jorma Luhta*)

Figure 3. Pine forest with some spruce in the southern part of the study area.
Kuva 3. Mäntymetsää ja "kurukuusikkoa" tutkimusalueen eteläosassa.

cattle for the small local population, which consisted of both Lapps and Finns (e.g. *Havukkala* 1964). Some brooks in the eastern part of the area were the object of a gold rush. Even now, there is a gold washing place, maintained, however, mainly for tourists.

Logging operations swept the outskirts of the area, first near the Lutto River and along the upper branches of the Kemi River, the most important floating channel in Lapland, and then near the sides of the Main Road 4. However, large-scale logging, which included a plan to build a road directly across the wilderness, in the thirties, was not achieved because of World War II (which also left its traces on the area).

When the transit road plan for logging purposes was considered anew in the sixties, it was rejected due to the objections of outdoorsmen and conservationists (*Kojo* 1967, p. 132). The logging operations on the outskirts of the area as well as on minor part whithin it, however, have continued up to the present.

The National Board of Forestry set aside the core area of 1 000 sq. km in 1962 for recreational purposes. During the sixties and seventies numerous propositions with varying limitations were made to establish the study area and also vast adjoining forest areas southeast of it as a national park (e.g. Koilliskairatoimikunnan 1972).

In 1980 a decision in principle was made by the Finnish Government to create the Koilliskaira National Park in honor of President Urho Kekkonen on the occasion of his 80th birthday. The study area includes a large part of the planned national park. However, nature conservation as land use is not considered in this study.

3. PRODUCTION THEORY AND MULTIPLE USE

31. Production theory

The theory of production, when understood in a broad sense, can be said to be nearly as old as economic science itself (*Danø* 1966, p. 1).

The early works of physiocrats were mainly concerned with the problems of production and of productive activities. The best known of them, Quesnay, used a model of industrial production which is similar to our input – output tables (*Näslund* and *Sellstedt* 1978, p. 9). The classical economists Smith and Ricardo stressed in their analyses the determining role of the techniques and relationships of production even as such, i.e not only as a coherent part of their value and distribution theory (*Meek* 1977, p. 16). The conditions of production served also as the starting point for Marxian tradition where the emphasis is, however, on value and distribution theory. The neoclassical tradition took another starting point: it based its analysis mainly on the conditions of exchange (*Meek* 1977, p. 17). Therefore the problems relating directly to production received less emphasis.

According to *Naylor* and *Vernon* (1969, p. 70–71) the neoclassical approach to production theory has its origins in the work of von Thünen. Wicksteed in 1894 and Wicksell in 1901 were the first economists to treat the production function explicitly and Hicks developed in 1939 the standard textbook example of neoclassical production theory (*Naylor* and *Vernon* 1969, p. 70–71). Among the more recent treatments of the production theory under the assumptions of marginal analysis are, for example, the works of *Danø* (1966) and *Frisch* (1965). The technical concepts applied in this study are also mainly from these two sources. As such they are seen as "universal" concepts having no connections, for example with the aspects of value and distribution theories usually related to the neoclassical production theory (e.g. *Osadtšaja* 1976, p. 68–75).

Among the other types of production models, which fall outside the neoclassical category, one may find the linear programming production models and engineering production models (*Naylor* and *Vernon* 1969, p. 85–88). The works of many agricultural economists (e.g. *Heady* 1952, *Weckman* 1970, *Sirén* 1978) fall into these categories.

Especially in forestry, production function (e.g. the growth and yield tables, output series of logging operations) comprise the necessary backbone of the economic analysis –without them the analyses would certainly be impossible. The explicit and systematic use of the concept of production function has been perhaps less common, but it has, however, clearly left its mark in the literature on forest economics (e.g. *Vaux* 1954, *Gregory* 1955, 1972, *Barlowe* 1958, *Kilkki* 1971, 1979, *Hämäläinen* 1973, *Duerr* et al. 1979, *Hyde* 1980).

In a narrow sense, the theory of production is a theory of production functions, concentrating on the technological relations between inputs and outputs in production with special reference to the possibilities of substitution (*Danø* 1966, p. 2). The theory of production is understood here in this specific sense. Yet it must be emphasized that, in addition to the fact that even elementary economic analysis in our problem area presupposes some knowledge of production functions, there is also another important reason for a study of them. In the words of *Danø* (1966, p. 2): "While production technology as such does not, strictly speaking, fall within the province of economics, it has an economic aspect in so far as the production function permits of economic choice; to the extent that this is the case, the study of technical input – output relationships becomes a basic concern of the economist's and a prerequisite of dealing with problems of allocation in production".

If anywhere, in the case of multiple production of forests there is room for an economic choice in production; this is, therefore, another important reason for the study of relationships in production.

32. Production

What is production? *Frisch* (1965, p. 3–10) differentiates between production in the *economic* and in the *technical* sense. By the former he means the attempt to create a product which is *more highly valued* than the original input elements. For the term *technical production* he adopts a wide definition, meaning any transformation process which can be directed by human beings or which human beings are interested in. The term transformation indicates that there are certain things (goods or services) which enter into the process and lose their identity in it, i.e. cease to exist in their original form, while other things (goods or services) come into being in that they emerge from the process. The former may be referred to as *production factors* (input elements), while the latter category may be referred to as *products* (the output or resultant elements). According to *Frisch* (1965, p. 3) the transformation called production in the technical sense need not alter the actual material qualities of the things concerned. Often it need only be a movement, a selection or a conservation ('a movement in time').

According to this wide definition of production, forest production in a technical sense is any transformation process in forests which can be directed by human beings or which human beings are interested in. In this sense forest production includes all useful functions of forests from timber production to their environmental influences and use as national parks.

Forest production in an economic sense is more complicated to define than it is in a technical (or biological) one. It is clear, however, that production in an economic sense is a narrower concept than in a technical one. Berry production in forests in a technical (biological) sense is many times greater than the actual annual amounts of forest berries collected which comprise the core of economic production. Forests produce apparently some benefits more than require economic consideration. On the other hand, it is not difficult to find forest benefits, serious deficiencies of which prevail, at least locally. Some of the forest products are perhaps totally included in the sphere of economic production, others partially or not at all. Apparently, there must be some criterion which determines the limits of production in an economic sense. That criterion is provided by the concept of *value*. In any theory of production to be incorporated in a truly economic analysis, some form of *value judgement* must be incorporated (*Frisch* 1965, p. 5–8). Value judgement concerns both products and production factors. It serves as a common denominator for making production factors and products comparable and for estimating the economic appropriateness of the transformation process concerned, i.e. an attempt to create a product which is more highly valued than the original production factors.

How the products and production factors in fact will be evaluated is another problem area. Depending on the circumstances, market prices, shadow prices or other coefficients may be used. The nature of the argument leading up to an economic optimum will, however, remain principally the same for any kind of evaluation coefficients (*Frisch* 1965, p. 10). The background of evaluation problems is considered later on.

33. Products

What are the products and production factors in the case of multiple-use forestry? It is most convenient to begin with an examination of the products.

There are many criteria for dealing with products in economics.

An important division is that between *goods* and *services*. Goods are material products such as timber and the non-wood products of forests. Services are non-material benefits of forests such as their soil- and water-protecting functions, their role in environmental protection and value as an environment for recreational activities.

The clear distinction between goods and services, besides that in their different material form, is also apparent in their transportability; services are produced and consumed on-site at the same time (e.g. *Leppo* 1971, p. 11–13).

Another division of forest products may be made on the basis of their place in different stages of the production and consumption processes; they may be used directly in consumption (*consumer's goods or services*) or for making other commodities (*producer's goods and services*). In the latter group forest products may be raw materials, (e.g. timber) or supply productive services (the protective role of forests, e.g., in agriculture). Forest berries and edible fungi represent examples of consumer's goods and recreational use of forests serves as an example of consumer's services.

According to the importance that the different products play in the production process, three different types of products may be distinguished: *main products, by-products* and *waste products* (*Frisch* 1965, p. 11). In forestry this classification is a traditional one. The concept of by-products or *minor* forest products has been used for a long time, e.g., in reference to the products of ground vegetation and the use of the needles, bark and resin of forest trees (*Saari* 1928, *Wegelius* 1957). It is important to notice that the changes in prices or in social needs may result in the by-product's being elevated to the status of main product or may considerably reduce the share of waste products. The development towards the more keen utilization of timber, e.g., for pulpwood, has greatly decreased the share of forest and cutting wastes; the re-emergence of fuel-wood needs may wholly alter the position of cutting wastes to that of a by-product.

The most frequently discussed topic concerning forest products has been the distinction between *marketable* and *non-marketable* goods and services of forests (e.g. *Clawson* and *Knetsch* 1966, p. 213, *Gregory* 1972, p. 402–403, *Castle* 1977, p. 26, *Convery* 1977, p. 254). Timber is by far not the only marketable product of forests. Market prices are to be found, e.g., in Finland for some minor forest products as forest and peatland berries, edible fungi and decorative lichens. All these products are also exported. However, only for the collection of decorative lichens must land rent be paid to the forest owner. The collection of berries and edible fungi is free for everybody in private as well as in state forests thanks to the traditional everyman's rights for nature. Hunting and game represent yet another case. For most hunting a licence and the permisson of the forest owner are required. Most game species nowadays are not marketable, but there are some exceptions. It is, however, easy to determine the equivalence prices for game on the basis of, e.g., the prices of meat in agricultural animal production. Recreation in Finland is free for everybody irrespective of the form of land ownership. However, the prices of forest land with frontage on a lake when sold or rented as building sites for summer vacation houses no doubt are greatly influenced by the amenity values. In many other countries walking and hiking in private forests may not be allowed without payments but are free in the state forests. In addition, there are many forest benefits and influences, e.g., forests' role in the production of oxygen which are nowhere made payable.

Our conclusion is that the distinction between marketable and non-marketable forest products only partly reflects the physical differences of the products. Probably it is just as much a result of the varied institutional factors (e.g. *Gregory* 1972, p. 418–419).

Some of the physical product differences which have effects on the marketability concept can be described by an additional classification of the forest products, that is a distinction between *single (private)* and *collective (public)* goods (and services) (*Mishan* 1972, p. 98, *Gregory* 1972, p. 415). For a single or private good each person or household separately consumes the amount of the good that he buys. The opposite concerns public or collective goods: the more there is for one household, the more – not the less – there is for others. Public goods will not be provided at all in a purely competitive market because their benefits are indivisible. It may be true that there are, as *Blaug* (1977, p. 605) says, very few examples of pure public goods. Nevertheless, forestry abounds in products which have more or less the character of public goods. And it is important to notice that as long as some activities have even a trace of public character, price calculations will fail to drive the economic system to the social optimum (*Blaug* 1977, p. 605).

34. Production factors

Production factors, in the most general sense, are all those factors influencing the result of production. However, no analysis can include all of them at once. In a production analysis the relevant factors are selected for closer consideration. They are called the *specified* factors. The others are the *implied* factors (*Frisch* 1965, p. 14).

In forestry as well as in agriculture there is an important distinction between *controllable* and *non-controllable* factors. The latter include, e.g., the yearly variations in the quantities and distributions of precipitation and temperature sum. Especially in Lapland, where intensive forestry and agriculture are practised in their northern peripheries, it is justifiable to speak about the "climatic hazard factor" in grain cultivation (*Hustich* 1947) or to consider the possibilities for forestry to adapt to the climatic fluctuations (*Pohtila* 1980).

The distinction between *scarce* and *free* factors is a familiar one. Sometimes it may be necessary to include the latter in the analysis. Clean water and fuel-wood in light-use wilderness areas may be regarded as free factors: however, if the recreation use is assumed to be increasing it is useful to take into account in advance future scarcity and pollution problems. In this case the distinction between scarce and free factors is related to time. Generally one may see that the sphere of free factors of production is becoming more and more narrow.

Economically central is the question of *fixed* and *variable* factors (*Frisch* 1965, p. 15–16) Fixed factors are those determining the capacity of the production unit (e.g. the total land area of forestry unit) and because of their constant nature they usually may be excluded from analysis (*Gregory* 1972, p. 41). The quantities of variable factors, (e.g., labour, fertilizers), on the other hand, are gradually changeable and in most cases it is exactly the purpose of production analysis to consider the effects of these changes on the result of production.

Which factors are to be regarded as fixed, which as variable, depends as a rule on the length of time one is considering. In the long term the quantity of fixed factor may be (step-wise or in lumps) increased, e.g., by land purchases or by building new plants.

The more fixed a factor is, the more *irreversible* it also is. Raw materials exemplify *reversible* factors, as do many other variable factors (*Frisch* 1965, p. 16–17). The concepts of irreversibility and reversibility may be also related to the uniqueness of the factors. The last wilderness forests may be seen to be irreversible production factors: if they are harvested they are irreversible in the time horizon of the living or next generations. In extreme conditions, e.g., near the tree line, they may be, if clear-felled, even lost "forever".

If it is easy to define in what particular product unit a particular factor unit is incorporated then it is a case of *special* factor (effect-individualisible factor). If the effect of a contributory factor can not be correlated with a certain product, that factor is called a *general factor,* (*Frisch* 1965, p. 17). In multiple forest production the cases of general factors are very common, i.e. thinning operations or fertilizing have effects not only on timber growth but also on forage, berries or wildlife.

It is also useful to mention the *complementary, alternative* (competitive) and *independent* factors. The factors are complementary if an increase in the quantity of one factor increases the marginal productivity of the other, and alternative in the opposite case (*Frisch* 1965, p. 60).

If two factors are capable of replacing (being substituted for) one another, they are called *substitution* factors. If no factor substitution is possible, the factors are *limitational* (*Frisch* 1965, p. 228, *Danø* 1966, p. 16).

The distinction between production factors and products is conventional in that it depends to a certain extent on the stage of production considered (e.g. *Frisch* 1965, p. 4–5, *Duerr* et al. 1979, p. 38–39). From the viewpoint of the timber-growing process the mature tree is a product, but for harvesting and transportation process it is a production factor (raw material) which after felling, hauling and floating is transformed into the product of harvesting and transportation, i.e. a log lying in the sawmill.

It is therefore necessary to specify the production stage when considering the production factors. An important distinction will be the one between the production factors of primary forest production and those of secondary forest production (cf. e.g. *Svendsrud* 1977, p. 11).

Production factors of primary production are: 1) the land with its geographical and site characteristics (including climatic factors), 2) growing stock with its reproductive capability, 3) other vegetation including the brush layer and ground flora, 4) forest fauna with its variety, 5) constant physical improvements in "nature" such as roads, ridges and drainage systems, 6) other constant installations such as buildings, communications networks and 7) labour, including biocultural practices and engineering and managerial activities (cf. *Keltikangas,* V. 1971, p. 181, *Duerr* et al. 1979, p. 159–172, *Saastamoinen* 1976, p. 92–93).

The most important production factors of secondary production (harvesting, hunting, reindeer production, recreational use of forestry land) can be grouped in the following way: 1) relevant products of primary production (e.g. standing timber, wildlife, forage, recreational environment), 2) labour, 3) materials, equipment and machines, 4) roads, buildings and other facilities. Many of factors (e.g. roads) are common to both primary and secondary production (processes).

The factor combination of secondary production includes more labour and technological factors and therefore it sometimes has been called *engineering production* in contradistinction to the biological nature of the primary production.

35. Production function

The production function is the function showing the technical relationship of dependence between the product quantity(-ies) on the one hand and the factor quantities on the other. The essence of the production function is (are) the functional relation(s) expressing the dependence of product quantity(-ies) on factor quantity(-ies) (*Frisch* 1965, p. 25, 349).

Danø (1966, p. 10) uses also a more general term, a production model, and states that the production model is often referred to as the production function even when it consists of more than one input-output relation. In his words a production function – or production model – is a system of quantitative relationships expressing the restrictions which the technology of the process imposes on the simultaneous variations in the quantities of inputs and outputs. *Baumol* (1972, p. 275) says concisely that the production function summarizes the technological information of production.

Numerous types and forms of production functions are represented in the literature. Some of the basic differences are evaluated in the following.

It is usually assumed that production functions are *linear, homogenous* and *continuous.* Linearity refers to the algebraic form of the production equation. In fact, especially the production functions expressing biological relations are often *non-linear.* However, in many cases the non-linearity can be manipulated into linear form or the linear form can be seen as a sufficient approximation of the non-linear production function.

Algebraically the homogeneity refers to the relation between the increase of the arguments and the increase of the value of the function (e.g. *Kivikoski* 1970, p. 117). In economics the homogeneity of the production function has many important implications. First of all, it refers to the returns to scale, e.g., constant returns to scale prevail if a production function is homogenous of degree one (e.g. *Baumol* 1972, p. 281, *Frisch* 1965, p. 99). Secondly, it relates to the form of expansion path (only if a production function is homogenous will the expansion path be linear) (*Naylor* and *Vernon* 1969, p. 96). The homogeneity of the production function also is connected with the divisibility problem of a fixed factor (*Danø* 1966, p. 111).

The last named aspect is more closely connected to the third common property of traditional production functions, to continuity. The fact that only continuity factors occur in a production function means that in each factor point the production function has continuous partial derivatives of the first order with respect to each factor (*Frisch* 1965, p. 228). From the point of view of economics this presupposes that production factors are perfectly divisible. Indivisible or discontinuity factors, on the other hand, are those factors which can be used only in discrete amounts, i.e. in "lumps". Indivisibility in use implies that this "lump" or "fixed factor" has to be used in combination with given amounts of other factors if these other factors are to be efficiently employed (*Naylor* and *Vernon* 1969, p. 85).

A distinction is made between *static* and *dynamic* production functions. The production functions are usually static or assume instantenous production. Neither the parameters nor the form of production function are permitted to change over the time period concerned. Obviously this is not always the case. Especially in forestry, where the time factor plays a special role (*Keltikangas,* M.

1969 a, 1971), the need for dynamic production functions is emphasized. The other example where the distinction between static and dynamic production functions appears is the technical change (e.g. *Niitamo* 1969). The effect of technological change becomes more pronounced in the distinction between *short-run* and *long*-run production functions. However, this distinction primarily concerns the degree of fixity of production factors (e.g. *Baumol* 1972, p. 287–288, *Naylor* and *Vernon* 1969, p. 81). It may be added that, from the point of view of investment decisions for example, also *ex ante* and *ex post* production functions can be distinguished (e.g. *Ollonqvist* 1979, p. 19).

An important criterion for classifying the production functions is the level of aggregation. Usually a distinction is made between *macro* and *micro* production functions. Macroeconomic production functions are usually applied to the economy as a whole. Microeconomic production functions, on the other hand, concern an industry or most usually a production unit such as a firm. However, in many cases the most fruitful approach may be to keep the analysis at the lowest possible level of aggregation, e.g., at the level of individual processes (*Danø* 1966, p. 4).

In forestry the explicit and, perhaps even more so, the implicit use of production functions appears at a very low level of aggregation, e.g., in stand management or in planning of activities. Indeed one may say that the "art" of forestry is essentially based on the knowledge of production functions.

The production functions most familiar in forestry are expressed in tabular form, e.g., the growth and yield tables. *Frisch* (1965, p. 42) also expressly states that in a given case the form of a production function can be represented *analytically, numerically in the form of a table,* or *graphically.*

36. The types of multi-commodity production

361. Single production and multi-commodity production

Multi-commodity production is the opposite of single production and it will be useful to start with the latter concept.

Single production assumes that a single uniform article or service is produced. The most essential feature of single production is that the result is a technically homogeneous product, whose size is measured by the number of units produced (*Frisch* 1965, p. 10).

If single production is determined by this measurability condition, we can say that the production of pulp in a mill or the production of corn on a particular piece of land are examples of single production in this general sense.

The product function for a single production can be expressed as follows (*Frisch* 1965, p. 41)

$$X = X(v_1, \ldots, v_n)$$

where X means the quantity of the product and $v_1, v_2, \ldots v_n$ are the factor quantities.

The multi-commodity (multi-product, multi-ware) production is defined as follows: "If there exists some kind of technical connection between several products, e.g., because there are certain production factors which can be used or on technical grounds *must* be used *jointly,* or because certain factors can be used *alternatively for one product or the other, with resultant technical consequences for the production of the other(s), then we say that these products are (technically) connected, or that we are dealing with multi-ware production* (*Frisch* 1965, p. 269). In a most general way, the multi-ware production can be expressed by the following system of production relations

$$F^{\mu}(X_1, \ldots, X_m; v_1, \ldots, v_n) = 0$$

where $X_1, \ldots, X_m$ are the product quantities and $v_1, \ldots v_n$ the factor quantities to be analyzed simultaneously. The technical conditions for the production are defined by μ production relations, where product quantities and/or factor quantities occur (*Frisch* 1965, p. 269, 278, *Danø* 1966, p. 189).

The range of choice in optimizing production depends on the number of degrees of freedom in the production model. The optimization problem is economically interesting when the production function has enough degrees of freedom to allow substitution, i.e. when the same level of output or the same batch of outputs can be produced by alternative combinations of inputs (*factor substitution*) or when a given input (factor) combination can produce alternative combinations of outputs (*product substitution*). It must be emphasized that the relevant range of economic choice is restricted to the set of technically efficient points. This means that it is not possible to produce more of one output without having to produce less of any other output and without using more of any input, or that it is not possible to produce the same amounts of all outputs with less of one input and not more of any other input (*Danø* 1966, p. 14–15).

There are several kinds of technical connections between the products and factors in multi-ware production. The most important forms of the connections can be examined using the concepts of *assortment* and *coupling*.

The degree of *assortment* is equal to the number of products minus the number of production relations. When it is one or greater, freedom of assortment exists. If it is zero (as in the case of single-product production) there is no assortment. And when the degree of assortment is negative, it signifies

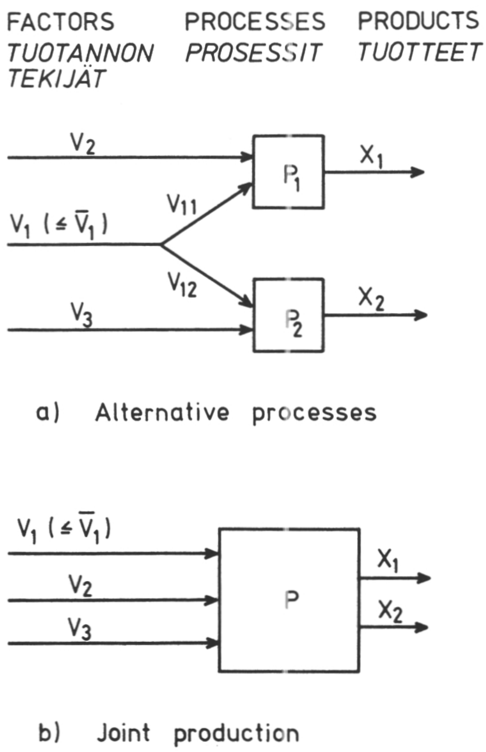


Figure 4. Illustrations of alternative processes (a) and joint production (b) according to *Danø* (1966, p. 166–167).
Kuva 4. Vaihtoehtoistuotanto (a) ja yhteistuotanto (b) Danøn (1966, s. 166–167) mukaan.

the case where one or more pure factor bands exist (*Frisch* 1965, p. 269–270, 279).

The degree of *coupling* tells us the number of factor free relations between the product quantities. In other words, it is a number of product relations which only link together certain product quantities, i.e. the number of pure product bands (*Frisch* 1965, p. 270–271).

In the following the classification of the types of multi-commodity production will be mainly based on the concepts of assortment and coupling.

362. Assorted (alternative) production

A common problem in agriculture is the profitability of changing from one kind of crop, e.g., grain, to another kind, e.g., potatoes. The main production factors (land, labour and fertilizers) can be applied alternatively for the production of either product. This is called the case of *assorted production* (*Frisch* 1965, p. 10–11).

Danø (1966, p. 166–167) describes the corresponding case of *alternative processes* where the products are made in distinct processes which have only the joint use of the plant's fixed facilities in common. A simple case of this type is illustrated in Figure 4a, where the processes, i.e. the products, share the limited capacity of a fixed factor's (e.g. land's) services.

The technical relationships between v_{11}, v_2 and x_1 represent the production function (production model) for P_1, and similarly for P_2. The two process models (production functions) are interdependent in that $v_1 = v_{11} + v_{12}$ cannot exceed the capacity limit, $\bar{v}_1$ (e.g. the available land area).

On the basis of factor relationships *Danø* (1966, p. 168–181) presents three subcases for alternative processes: that of limitational factors, that of discontinuous factor substitution and that of continuous factor substitution.

363. Joint production

The typical feature of (truly) joint production is that the products are made in a single process which is indivisible. The total amount of each input used, and so also total cost, cannot be allocated to the respective outputs (*Danø* 1966, p. 181). This is illustrated in Figure 4b, where v_1, v_2 and v_3 represent the factors and x_1 and x_2 the products.

Two main cases of joint production will be outlined: that of *coupled products* and that of *separable products.*

In the case of coupled products the ratio between two products is fixed. For example, we can assume that the quantity of wool bears a fixed ratio to the quantity of mutton. A change in the factor quantities – according to the technical circumstances prevailing in this case – will mean that the quantity of wool and the quantity of meat change in the *same* proportion. This is the case of coupling where the quantitative ratio between the two product quantities is constant.

However, the quantity ratio between the two products may not be constant as above, but rather a function of the product quantities. This is another case of coupling (*Frisch* 1965, p. 271).

In the case of separable products it is assumed that we have two products produced by means of n factors and in such a way that if the factor quantities are given, then both product quantities are given.

An example is the production of eggs and poultry. When the needed production factors (work, feed and materials) are applied, then in the same process both the products mentioned emerge. However, the ratio between the products might be altered – at any rate within certain limits – by means of suitable changes in the factor constellation. By a change in care and feeding more emphasis may be put on poultry production and less on egg production or vice versa. In this case, the products are separable to a certain degree.

The main types of multi-commodity production are further illustrated in Figure 5, where they are presented both in factor and product diagrams.

37. Product relationships

When considering the relationships between the different forest products, usually four types of relationships are presented (*Lloyd* 1969, *Schwarz* et al. 1976, *Duerr* et al. 1979, *Saastamoinen* 1976). These can be called *complementary, independent* (compatible, supplementary), *competitive* (conflicting) and *incompatible* (exclusive) relationships between the outputs of different products.

We can examine the relationships between the forest products from two somewhat different points of view: production at a given level of (variable) factor use or the case in which the quantities of variable factors can freely change and the level of production can change.

At a *given production level* the relationships between the different forest products can be considered by a *rate of product transformation.* For any two products X_1 and X_2 the rate of product transformation between the two products is defined as (e.g. *Naylor* and *Vernon* 1969, p. 72)

$$RPT = -\frac{\delta x_1}{\delta x_2}$$

The RPT between two products measures the number of units of one product which can be attained when production of the other is reduced by one unit, given a constant level of factors. Graphically the rate of product transformation can be presented by a *product transformation curve* in a product diagram.

The case of *changing the level of production* needs some further consideration. In industrial production the expansion of output which exceeds the present level of new capacity is easily possible through the creation of capacity. That can – but not so easily – be done also in agriculture and it is not unknown even in forestry (peatland drainage, afforestation of bare lands) although the changes in forestry are more or less marginal, especially in old forestry countries. However, in the case of a changing production level two subcases must be differentiated: changes of production within the limits of prevailing capacity (the fixed area of forest land) and changes of production when also the capacity (fixed) factor (land area) is allowed to increase. The most typical case of the latter is the afforestation of non-forested lands.

In the case of two products their relationships in the conditions of changing production level can be graphically illustrated by *product* (coupling or substitution) *curves* in product diagrams (*Frisch* 1965, p. 274). They differ from the more familiar expansion paths (which are usually presented in factor diagrams) in that they present not necessarily the least-cost solutions, but the production possibilities of the two products concerned. Analytically the product curves can be presented by the functional relationships, which do not contain the factor quantities.

In the following the relationships between forest uses (products) will be considered both graphically and analytically in the case of two forest uses (forest products) with comments on the cases also in respect of the type of multi-commodity production.

First, a given level of production (given factor use) is assumed. The properties of product transformation curves will be examined mainly by studying the first and the second partial derivatives of the curves (*Kivikoski* 1970, p. 32–33). When the rate of product transformation,

$$\mathrm{RPT} = -\frac{\delta x_1}{\delta x_2} > 0$$

the product transformation curve is downward sloping and a *competitive* relationship between the products prevails.

The competitive relationship, on the other hand, may occur in three different subcases, which can be examined with the help of the second partial derivatives of the product transformation curves.

First, if

$$\mathrm{RPT'} = -\frac{\delta^2 x_1}{\delta x_2^2} = 0$$

the competitive product transformation curve is a line and a constant rate of product transformation prevails between the pro-

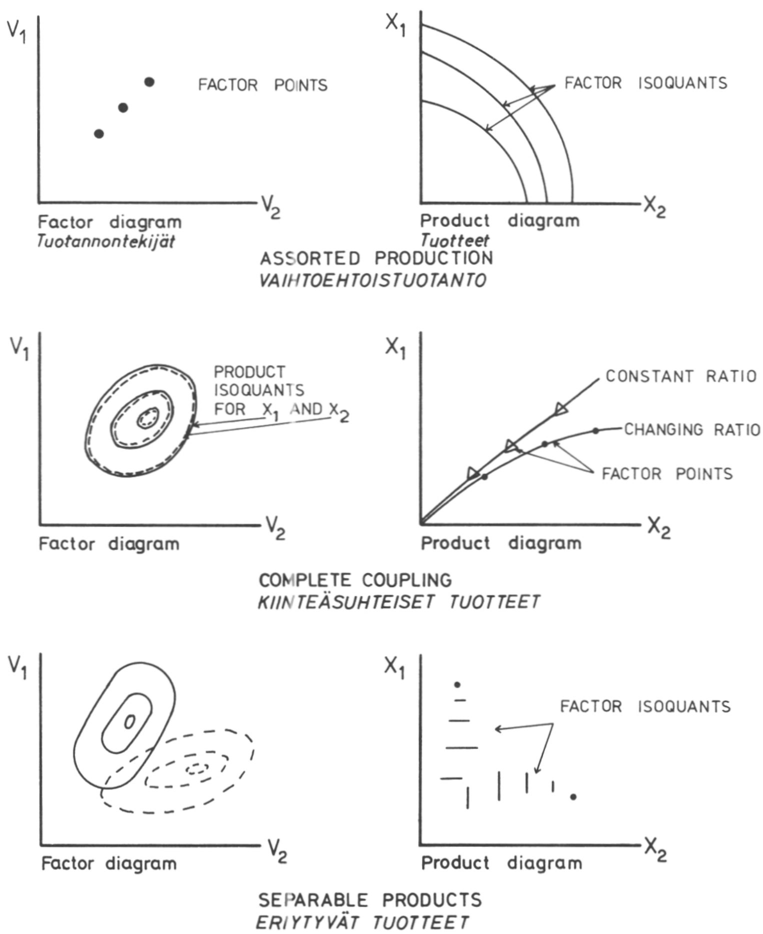


Figure 5. Main types of multi-commodity production.
Kuva 5. Monihyödyketuotannon päätyypit.

ducts (Figure 6a). This case may occur, for example, when the only factor concerned is a given land area which can be divided between the two uses.

Second, if

$$RPT' = -\frac{\delta^2 x_1}{\delta x_2^2} > 0,$$

the competitive product-transformation curve is concave, which implies an increasing rate of product transformation between the two products (Figure 6b). That is also the most common and typical form of production transformation curve cited in economic literature.

In the third case, if

$$RPT' = -\frac{\delta^2 x_1}{\delta x_2^2} < 0,$$

the product transformation curve is convex, which indicates a decreasing rate of product transformation (Figure 6c). In general economic literature, convex product transformation curves are uncommon (see, however *Danø* 1966, p. 178), but in forestry, according to e.g. *Gregory* (1972, p. 265) and *Zivnuska* (1978) they are quite possible and even common.

When there is no possibility of product transformation at a given level of factor use, it means that the transformation curve will be a point in product space. It can be then defined that

$$RPT = 0.$$

If, for a given $x_1 > 0$ also $x_2 > 0$ and is determined by that point, a *complementary* relationship between the products prevails (Figure 6d). The complementary relationship is more interesting in the case of a varying level of production.

The other subcase of no product transformation occurs when $x_1 > 0$ but $x_2 = 0$ (or analogously $x_2 > 0$ and $x_1 = 0$). This implies an *exclusive* relationship between the products (Figure 6e). Either one product or the other is produced. It can be said that in a sense the exclusive relationship represents an extreme

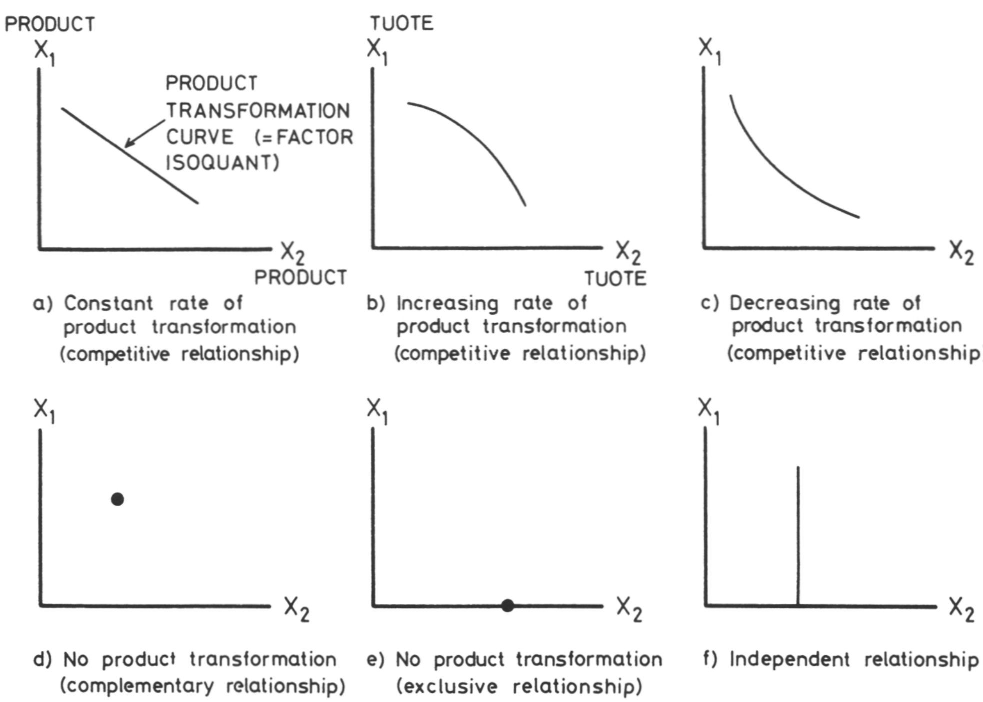


Figure 6. Product relationships at a given level of factor use.
Kuva 6. Tuotteiden väliset suhteet annetulla tuotannontekijöiden tasolla (a=kilpaileva vakiolla transformaatiosuhteella, b=kilpaileva lisääntyvällä ja c=kilpaileva vähenevällä transformaatiosuhteella, d=täydentävä, e=poissulkeva ja f=riippumaton suhde).

case of the convex-shaped competitive relationship.

The last case under the assumption of a given factor use is when the product transformation curve is parallel to either of the coordinate axes. When it is vertical,

$$RPT = \infty,$$

and when it is horizontal

$$RPT = 0.$$

Then an *independent* relationship between the two products prevails. At a given output level of the one product, the output of the other may vary at least within certain limits without the need to change the factor combination (Figure 6 f).

In the situation where the level of output can vary (the factor quantities are not given) the basic relationships between the products remain essentially the same. Economically, this situation, of course, is wholly different and with it some new aspects may be added to the problems of product relationships.

The first of the new aspects is related to the complementary relationship, which in this case has two variants: constant and varying complementary relationships (between the products) (Figure 7 a and b). It really is so that the concept of complementary relationship has its main economic relevance only in the case of varying production level and in the presence of its variant of varying relationship.

The competitive relationship in the situation of varying production level has as before three subcases (cf. Figure 6 a-c). The production curves show the degree of competition in the different phases of the production of the "argument" product and the other.

The independent and exclusive relationships are most interesting when they occur as parts of production curves including varying relationships in their different phases (Figure 7 c). The prevalence of production curves with varying relationships is one of the most important aspects of the case of varying production level. It emphasizes the fact that often the relationships between the two (or more) forest products (forest uses) cannot be described simply by one category of relation but require different categories in different production phases or different states of starting conditions (e.g. the cases of bare land or mature forest as starting points referred to earlier).

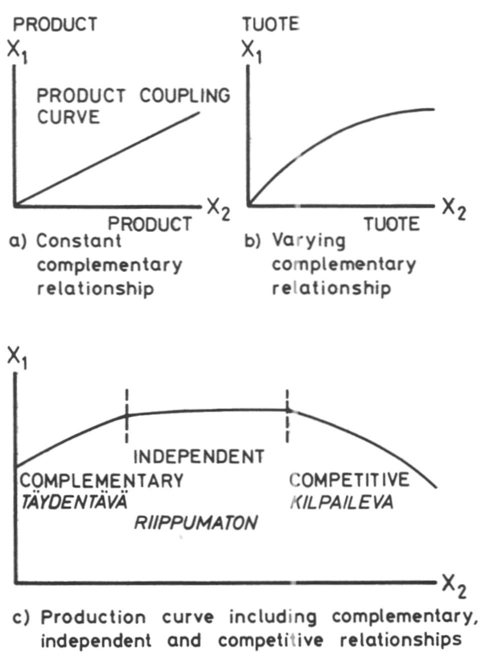


Figure 7. Product relationships when the level of production is allowed to vary.
Kuva 7. Tuotteiden väliset suhteet tuotannon määrän vaihdellessa (a=vakiosuhteisesti täydentävä, b=muuttuvasuhteisesti täydentävä, c=vaihteleva suhde).

38. Multiple use and multi-commodity production

The question of what kind or type of multi-ware production in fact is the nearest counterpart to the actual case of multiple-use problem cannot as a rule be answered without detailed knowledge of production functions. Indeed, the lack of specific production functions is one of the main difficulties in the multiple-use development.

However, one principal distinction, which has dominated the discussion on multiple-use forestry, can be dealt with using the concepts of multi-ware production theory.

According to e.g. *Gregory* (1972, p. 395) the two most common interpretations of multiple-use forest management are the following.

The first of these can be called the solution of single-use subareas. The total area produces several products but every specific subarea is devoted to a single (or at least primary) use. The subareas are managed solely according to the demands of a single (or primary) use. Secondary uses are permitted only if they do not interfere with the primary use.

The alternative approach makes no subdivision as to area. The whole area produces several products, the combination of which is determined by the production possibilities and the economic evaluation of the optimal product mix. The multiplicity of uses may prevail on every hectare of the total area.

The two approaches have been applied –implicitly or explicitly – in multiple-use forest management from its earliest forms to the present day. In North American literature they are sometimes called, according to *Gregory* (1972, p. 395), the "Pearson approach" (1944) and the "Dana-McArdle" approach (1943, 1953) on the basis of articles by these authors where the interpretations were, in essence, outlined.

In the first approach the fixed factor (specific land area) was divided among several uses (products). In each subarea the production of a product has its own production function. Clearly this is the case of *assorted production* (*Frisch* 1965, p. 10–11) or that of *alternative processes* as *Danø* (1966, p. 166) calls it. This solution is typical also in agricultural production (e.g. *Heurlin* 1954, p. 100–107) and it is applicable also for alternating the uses in time (*Danø* 1966, p. 167, *Rowe* and *McCormack* 1968).

The second approach, where the same piece of land produces several goods or services, belongs to the general class of *joint production* (*Frisch* 1965, p. 11). *Danø* (1966, p. 167) calls it truly joint production; in addition he points out that the fundamental distinction between alternative processes and joint production will usually but not always coincide with the criterion of whether or not it is possible (though not necessarily economical) to produce each output without making any of the others. Borderline cases are conceivable where solutions on the boundary of the range of product substitution are possible even though the joint process cannot be broken down. It may be added that a production process in multiple-use forestry, which is technically a case of joint production may, from the point of view of economic analysis, represent a case of alternative processes. This is due to the fact that from a purely technical point of view the total forest production can hardly be regarded as single production.

More generally, from the point of view of production theory the multiple use of forests can be defined as multi-commodity production of a forestry land area.

39. An analytical frame-model

On the basis of the above consideration of various aspects of production theory and multiple-use forestry, the central study problems can be formulated in a more analytical way.

The basic starting point is that the study area can be used alternatively for single production of any of the three products, namely timber, reindeer grazing and outdoor recreation. Thus each of them has the following production functions

$$T = f_1(V_1, \ldots, V_i, V_{i+1}, \ldots, V_k)$$
$$G = f_2(V_1, \ldots, V_i, V_{k+1}, \ldots, V_n)$$
$$R = f_3(V_1, \ldots, V_i, V_{n+1}, \ldots, V_p)$$

where

T = timber output
G = reindeer grazing output
R = outdoor recreation output
$V_1, \ldots, V_i$ = common production factors
$V_{i+1}, \ldots, V_k$ = production factors used only for timber production
$V_{k+1}, \ldots, V_n$ = production factors used only for reindeer grazing
$V_{n+1}, \ldots, V_p$ = production factors used only for outdoor recreation.

The single-production possibilities of each product are considered in Chapters 4 to 6.

The multi-commodity production problem in the study area is not merely due to the circumstance that there are some jointly-used production factors, but also to the fact that the output of one product has also direct, i.e. purely physical, effects on the output of the other products.

Thus the following functional relationships between the products prevail

$$F_1(T,G) = O$$
$$F_2(T,R) = O$$
$$F_3(R,G) = O$$

The central problem is to study the form of functional relationship between each of the product pairs, above all the form of the production-transformation curves. Analytically, it means to study as earlier stated, the properties of F' and F''. This will, be done for each two-product relationship in Chapters 72–74, but only in general terms.

In a more concise way, the joint relationships between the products can be expressed by a three commodity function of the form

$$F(T,G,R) = O.$$

If solved for T, we get

$$T = f(G,R),$$

which can also expressed in a form

$$T = T(G,R).$$

If for G or R some fixed value, G' or R' is given, we get the following functions

$$T = T(G',R) = f_{G'}(R),$$
$$T = T(G,R') = f_{R'}(G).$$

Then

$$\frac{\delta T}{\delta R} = \frac{\delta T\,(G',R)}{\delta R} = \frac{d}{dR}\, f_{G'}\,(R)$$

and

$$\frac{\delta T}{\delta G} = \frac{\delta T\,(G,R')}{\delta G} = \frac{d}{dG}\, f_{R'}\,(G)$$

which mean rates of product transformation between two products when the third product has a fixed quantity.

If both G and R are allowed to have small changes, the change of T is obtained from an equation

$$dT = \frac{\delta T}{\delta G}\, dG + \frac{\delta T}{\delta R}\, dR.$$

Analogically,

$$dR = \frac{\delta R}{\delta G}\, dG + \frac{\delta R}{\delta T}\, dT$$

and

$$dG = \frac{\delta G}{\delta T}\, dT + \frac{\delta G}{\delta R}\, dR.$$

These "combined" rates of product transformation are illustrated by the help of a graphical model in Chapter 75 and with numerical examples in Chapter 86, which also composes the information about production possibilities and product mixes in a case of three products.

The choice of optimal product mix presupposes that cost functions of multicommodity production would be available. In this study this is not the case. Therefore, this choice problem will be considered only tentatively, in the light of product relationships and values of output in Chapter 86.

4. TIMBER PRODUCTION

41. Considerations concerning production function

As opposed to *momentary production* the production process of timber is typically *time-shaped.* Therefore the problems of total production period and the distribution in time of input elements need special attention. They can be treated with the help of the following concepts: the *number of production stages, stage tempo, stage interval, production period* and *time elasticity* of the production process (*Frisch* 1965, p. 29 – 36).

For timber production the very long production period is a well-known characteristic distinguishing it, e.g., from industrial production and agriculture (e.g. *Keltikangas, M.* 1971, p. 5 – 10, *Hämäläinen* 1973, p. 59 –61). During the production period a number of production stages e.g., planting, cleaning of sapling stand, thinning, increment felling, fertilization, final felling, are carried out. Each stage represents a certain *point input* of labour and possibly other production factors. The speed at which a stage in the process is completed is called the *stage tempo.* The stage interval describes the way in which the various stages are distributed over the total production period. The *time elasticity* of the timber production can be used to express the flexibility in determining the time of final cutting (the end of production period) as well as in timing the certain production stages (e.g. silvicultural measures). The time elasticity of timber growing has, of course, a limited nature. As biological units the trees need a certain (and very long) period to mature and only after that does the flexibility in determining the time of final cutting occur. However, the period of flexibility as such may be very long – in the extreme case in Saariselkä the amplitude of rotations in a stand may vary from 150 to 250 years.

The length of production period in timber growing expresses itself a time rigidity but the adjustment possibilities within it are manifestations of time elasticity.

The longer the production period in timber production is the longer usually are the stage intervals and, in addition, the less the number of stages. Schematically the actual differences occurring in this sense can be used to describe the different levels of intensity of timber production, which, e.g., prevail between the northernmost and southern part of Finland.

The point inputs (silvicultural and cutting measures) and the relatively short stage tempos of timber production do not mean that the effects of these on other forest uses are only transitory. The stage tempos of, e.g., final cutting can vary to some extent (e.g. from some weeks to some months in an average stand) depending mainly on the quantity of labour used but are as a rule actually short compared to the total production period of the stand. The effects of the cuttings are, however, far more lasting depending on the forest and ground vegetation successions. Of course, for other forest uses, it is just these effects which are significant ones.

The relatively low intensity of timber production, which is determined by production period and by the number and the substance of production stages, has however, profound implications for other forest uses. It seems reasonable to hypothesize that the less intensive timber production is, the better it is for those forest uses which thrive in natural forests.

The production function for timber can be constructed in many ways, depending on the scope and the targets of the analysis (e.g. *Gregory* 1972, *Kilkki* 1971, 1979, *Duerr* et al. 1979, *Hyde* 1980). Here it is used only to focus attention on the most important factors of timber production in the study area conditions, where mainly nature forests prevail. The following production function illustrates the most important specified factors of timber production in this study

$AC = f(GS, R, IRC, DCS, SM)$,
where
AC = allowable cut
GS = growing stock
R = rotation (production period)
IRC = intensity of regeneration cuttings
DCS = development class structure
SM = silvicultural measures.

It is assumed that the forestry land area by land and site classes and their possible growth capacities is given. It is further assumed that, besides common silvicultural measures, any forest improvements can be disregarded here.

A comment is needed here. Even if timber production is here considered as a single product – or single use – it must be pointed out that in reality timber itself, with its many assortments and tree species, is an outstanding example of multi-goods production.

42. Conditions of timber production

421. General conditions of timber production

The distinguishing features of the subarctic forests, i.e. the proximity of the polar and alpine forest limits, severe climatic conditions and the slow timber growth rate they imply, low population density and long distances to wood-processing industries, do not suggest favourable conditions for economic timber production. Many of the economic problems, which generally render forestry in Lapland difficult (e.g. *Keltikangas, M.,* 1969), appear pronounced in the study area and its surroundings. The fact is, however, that economically feasible and silviculturally sound timber production in the vast areas of the Inari region has been practised for a long time. This situation is, of course, a result of long economic development; it is also due, however, to certain favourable natural factors which counteract the severe climatic conditions.

The first, and perhaps decisive, natural advantage is the dominant tree species, Scots pine. In contrast to most parts of the polar forest limit, e.g., Siberia, Canada, in Finnish Lapland pine forests – not spruce or larch –constitute the most northern forests (*Hustich* 1952, *Pohtila* 1977). The productivity of Scots pine considerably exceeds that of Norway spruce in Finnish Lapland (*Ilvessalo* 1937, 1970). It seems evident that the further north we go, the greater the difference in productivity between these species. The resistance of pine stands also is an important advantage.

The second natural advantage of forestry in the Inari region is a rather good – though slow – *natural regeneration of pine forests.* This is mostly due to the humidity of the climate and the predominance of dry site types with their thin or non-existent humus layer (*Mikola* 1952, *Sirén* 1961). However, it must be pointed out that, especially in the sphere of the timber line, climatic fluctuations always introduce a measure of uncertainity.

The economic factors supporting the rationality of timber production in these remote areas are the opportunity to use floating to overcome the main part of long distances, the low regeneration costs of using a method of natural regeneration and last, but not least, the gradually increasing stumpage price level; this covers both the traditionally marketed saw logs and other special assortments and was extended in the course of the 1960's to cover pulpwood as well. In addition, the organizational framework of state forest administration provides the necessary preconditions for utilizing the advantages of large-scale forestry.

The floating channels have played an important role in the development of forestry in Finnish Lapland and they will be beneficial also in the future. The timber from the Inari region usually is first transported by truck over the watershed and then floated about 400 km to the seashore, where the largest saw mills and pulp and paper mills are located.

The low regeneration costs are no doubt one of the main advantages in the economy of timber production in the Inari region. The silvicultural costs per unit of removal (FIM-/cu.m) or compared to total income in the Inari region have been at a level remarkably lower than that in other forest districts of North Finland under the National Board of Forestry. For example, in 1971 – 78 the silviculture costs in the Inari forest district were 4,3 % of total income, while the average of all forest districts of North Finland was 13,9 %. Of course, to some degree the relatively low level of silviculture costs in Inari forest district is explained by the possibility which exists of cutting mature stands. However, principally it is an example of a general statement that not only great income but also

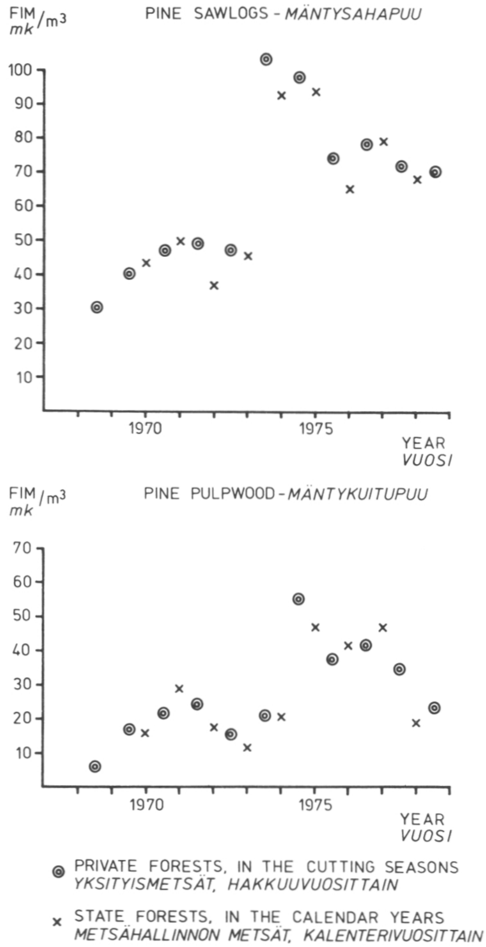


Figure 8. Stumpage prices of Inari district, real prices.
Kuva 8. Inarin alueen reaaliset kantohinnat.

low expenses can ensure profitable timber production (e.g. *Riihinen* 1966).

In a way familiar in any stumpage price development process, sawlogs and other special timber were the first objects of commercial cuttings. Later on also the best cordwood could be sold. However, the utilization of stems was for a long time very inefficient. The peak is represented by the Inari area railway sleeper delivery for export in the 1950's and early 1960's. In some cases 60 % of the stems were left in the forest as butts, cuttings, crowns and surface boards (*Kuusela* 1961). On the whole, until the end of the 1940's, in the Inari district the delivery cuttings were quite sporadic (Metsähallinnon . . . 1953).

After the pulp mill expansions on the coast and the establishment of a new pulp mill in-land, commercial cuttings for pulpwood increased. In Figure 8 the stumpage price development in the Inari region is outlined. The stumpage prices in the Inari region have been at a considerably lower level than those on average in the District Forestry Board of Lapland, which in turn are lower than those in southern Finland. However, there has been a tendency towards a decrease in regional differences in stumpage prices (e.g. *Lehikoinen* 1977, *Hyppönen* 1981).

In his well-known essay on pecularities of forestry *Saari* (1928) enumerates factors, that emphasize the superiority of state ownership as a form of organization in forestry. It is easy to see that in the circumstances prevailing near forest limits many of these factors have special relevance.

Of course state ownership does not automatically guarantee the rationality of forestry, but perhaps better than the private ownership it can ensure the necessary prerequisites for sustained yield, security and long-term perspectives in planning.

An additional fact that needs to be mentioned when speaking about forestry conditions in the Inari region, and which at first sight may seem even surprising, is the high percentage of area covered by forest to the south-east of *Lake Inari*. According to *Salminen* (1973, p. 52), the forest-land percentage in the total land area is one of the highest in the whole country. Mainly, this is due to the scantiness of peatlands.

422. Vegetation zones and land classes

The study area belongs to the protection forest zone, which was established in 1939 on the basis of the protection forest legislation of 1922. The characteristic feature of timber production conditions in the area are alpine forest limits and the wide treeless areas above them. The alpine coniferous forest limits in Saariselkä extend on the average 300–400 m above sea level. Between the coniferous forest limit and treeless alpine belt there is a birch zone of varying width which sometimes includes sparse coniferous trees. The treeless alpine belt begins rather abruptly at the contour line 400 m above sea level (Figure 9).

The coniferous belt, alpine birch belt and treeless alpine belt are nearly – but not exact-

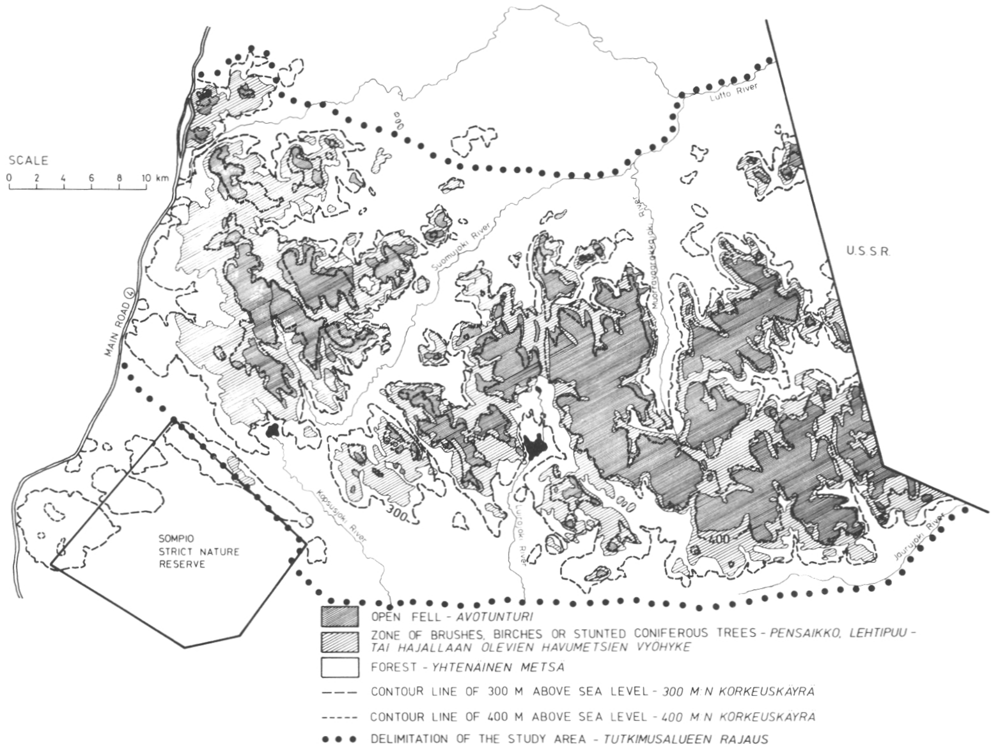


Figure 9. Vegetation zones and the delimitation of the study area.
Kuva 9. Tutkimusalueen rajaus ja kasvillisuusvyöhykkeet.

ly the same as the land classes of *forest land, scrub land* and *waste land* used in forest inventory. In the forestry inventory classification, the botanical coniferous belt belongs mainly to forest land, but part of it is classified as scrub land. Nearly half of all land is waste land of forestry and a third belongs to forest land (Table 1). From the standpoint of timber production only the forest land has relevance. However, it must be emphasized that, especially in the coniferous belt, the difference between forest land and scrub land in many cases is very vague (*Poso* and *Kujala* 1971).

Waste land has the potential for producing a mean annual increment of less than 0,1 m^3/ha of stem wood, including bark, during a rotation of 100 years (*Kuusela* and *Salminen* 1969). It comprises open areas and sites on which scattered stunted trees and shrubs grow.

The subclasses of waste land are shown in Table 2. Because of the mountainous terrain,

Table 1. Forestry land classes.
Taulukko 1. Metsätalouden maan pääryhmät.

	hectares *ha*	per cent *%*
Forest land[1] – *Metsämaa*	63 195	36
Scrub land[2] – *Kitumaa*	28 622	16
Waste land – *Joutomaa*	83 866	48
Forestry land – *Metsätalouden maa*	175 683	100

[1] Productive forest land according to the older classification – *Kasvullinen metsämaa vanhan käytännön mukaan*
[2] Poorly productive forest land according to the older classification – *Huonokasvuinen metsämaa vanhan käytännön mukaan*

Table 2. Subclasses of waste land.
Taulukko 2. Joutomaan alaryhmät.

	hectares *ha*	per cent *%*
Open fell – *Avotunturi*	33 072	39
Alpine birch zone (brushlike) – *Koivupensaikkoa kasvava vyöhyke*	36 851	44
Open swamps – *Nevat*	8 149	10
Poor pine swamps – *Rämeet*	5 656	7
Poor spruce swamps – *Korvet*	138	0
Total – *Yhteensä*	83 866	100

Table 3. Sub-classes of scrub land
Taulukko 3. Kitumaan alaryhmät.

	hectares *ha*	per cent *%*
Birch zone – *Koivuvyöhyke*	2 936	10
Hill tops covered by stunted trees – *Lakimaa*	5 183	18
Coniferous zone on fells – *Havupuuvyöhyke tunturilla*	16 446	58
Rocks or sites with scattered boulders – *Kallio tai louhikko*	1 062	4
Pine swamps – *Rämeet*	2 083	7
Spruce swamps – *Korvet*	912	3
Total – *Yhteensä*	28 622	100

only small peatland areas occur. The large open peatland located south of Saariselkä remain mainly outside the limits of the area in question. Waste land consists mainly of open fells.

Scrub land has the potential for producing a mean annual increment of 1,0–0,1 m^3/ha of stem wood, including bark (*Kuusela* and *Salminen* 1969). The dominant subclasses are the birch zone on fells, the coniferous zone on fells and hill tops covered by stunted trees (Table 3). Altogether, scrub land comprises about one sixth of the total land area.

Forest land has the potential for producing a mean annual increment of at least 1 m^3/ha of stem wood, including bark, during a rotation of 100 years and under favourable stand conditions (*Kuusela* and *Salminen* 1969). However, as *Kuusela* (1977) points out, it would be more logical to use the rotation of maximum volume increment. In North Lapland, the latter can be as long as 200 years (*Ilvessalo* 1970). In fact, in the latest forest inventory the classification presupposes the use of the rotation of maximum volume increment (*Mattila* & *Kujala* 1980, p. 7).

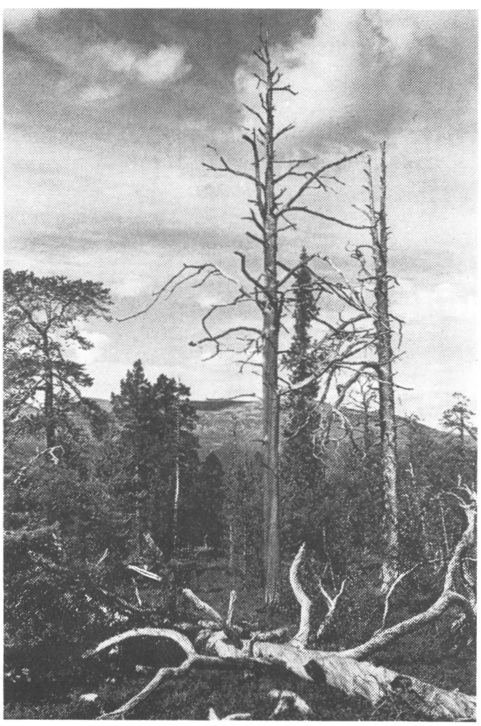
The dominant forest site types are *Myrtillus-Calluna-Cladonia* and *Empetrum-Myrtillus* site types (Table 4). Dry or barren sites together comprise two thirds of the forest land area. However, as *Sarvas* (1952) has pointed out, many of forest site types regarded as "dry" in the northernmost part of Finland are more properly "cold".

423. Growing stock

Both the material on growing stock and the above data about forestry land are from the stand survey data of forest management plans of the National Board of Forestry and for a smaller area also from those of the Forest Research Institute. The field surveys of

Table 4. Subclasses of forest land
Taulukko 4. Metsämaan alaryhmät

	hectares *ha*	per cent *%*
Cladina Type – *Jäkälätyyppi (ClT)*	3 566	6
Myrtillus – Calluna – Cladina Type – *Varpu – Jäkälätyyppi (MCClT)*	38 548	61
Empetrum – Myrtillus – Type – *Variksenmarja – mustikkatyyppi (EMT)*	18 819	30
Hylocomium – Myrtillus Type – *Seinäsammal – mustikkatyyppi (HMT)*	2 088	3
Swamps – *Suot*	174	0
Total – *Yhteensä*	63 195	100



(Photo – *Kuva: Jorma Luhta*)

Figure 10. Pine forest of scrub land. The standing barkless pines, snags, are amenity factors of forest landscape in the study area.
Kuva 10. Kitumaan männikköä. Kelot ovat tärkeä maisemallinen tekijä tutkimusalueella.

Table 5. The volume of growing stock on forest and scrub land.
Taulukko 5. Puuston tilavuus metsä- ja kitumaalla.

	1000 m³	per cent %	m³/ha
On forest land - *Metsämaalla*	4 392	86	69,5
On scrub land - *Kitumaalla*	745	14	26,0
Total - *Yhteensä*	5 137	100	56,0

the forest management plans of the National Board of Forestry were done in 1953–1959. Thus the characteristics of the growing stock are more than twenty years old. Because of the progressive development of pine forests –even older ones – these volume characteristics of growing stock have been multiplied by a rough correction factor (1,3) obtained by comparing the old survey data to the recent outturn data in 13 cutting areas bordering on and also partly belonging to the study area.

The total growing stock is 5,1 mill. m³, of which 4,4 mill. m³ (86 %) is on forest land (Table 5). In the following, only the growing stock on forest land is being considered.

The *dominant tree species* is pine. Spruce and birch occur as dominant species only in the southern part of the area (Table 6). The spruce stands are part of the forest limit of spruce, which here goes along the southern slopes of the Saariselkä fell area. One can find isolated spruce stands also farther north (e.g. *Norokorpi* 1979).

The *age structure* of the stands shows that about 78 per cent of the stands are older than 170 years (Table 7).

According to the *development class* distribution, 42 per cent are mature stands (Table 8). The development class distribution shows

Table 6. Dominant tree species and volume of growing stock by tree species.
Taulukko 6. Pääpuulajivaltaisuus metsämaalla ja puulajisuhteet kokonaiskuutiomäärästä.

Tree species – *Puulaji*	Dominance of tree species, per cent of area – *Pääpuulajivaltaisuus, % pinta-alasta*	Per cent of volume – *% kuutiomäärästä*
Pine – *Mänty*	91	89
Spruce – *Kuusi*	7	6
Birch – *Koivu*	2	5
Total – *Yhteensä*	100	100

Table 7. The age[1]-class structure of the stands on forest land.
Taulukko 7. Metsiköiden ikäluokkarakenne[2] metsämaalla.

Age class, years – *Ikäluokka, v*	Per cent of forest land area – *% metsämaan alasta*	Per cent of growing stock – *% puustosta*
0	0	0
10	1	0
30	4	1
50	1	1
70	1	0
90	2	1
110	3	2
130	2	2
150	8	8
170	16	16
190	13	13
201+	49	56
Total – *Yhteensä*	100	100

[1] In the age class structure the changes caused by cuttings are taken into account. Elsewhere the structure is that at the time of inventory (see p. 33).

[2] *Hakkuiden aiheuttamat muutokset ikäluokkarakenteeseen on huomioitu mutta muilta osin ikäluokkarakenne on inventointiajankohdan mukainen (ks. s. 33).*

Table 8. The development class structure of the stands on forest land.
Taulukko 8. Metsiköiden kehitysluokkarakenne metsämaalla.

Development class – *Kehitysluokka*	Per cent of forest land area – *% metsämaan alasta*
1 Open area or seed tree stand *Aukea ala tai siemenpuusto*	1
2 Small seedling stand *Pieni taimisto*	7
3 Seedling or sapling stand *Taimisto tai riukuasteen metsikkö*	6
4 Young thinning stand *Nuori kasvatusmetsikkö*	3
5 Thinning stand in advanced state *Varttunut kasvatusmetsikkö*	26
6 Mature stand *Uudistuskypsä metsikkö*	42
7 Shelterwood stand *Suojuspuumetsikkö*	6
8 Low yielding stand *Vajaatuottoinen metsikkö*	9
Total – *Yhteensä*	100

(Photo – *Kuva: Olli Saastamoinen*)

Figure 11. Seed-tree method is mainly used in regeneration fellings in pine forests.
Kuva 11. Männyn uudistushakkuissa käytetään pääasiallisesti siemenpuumenetelmää.

that there have been cuttings in the area but that the main part of it has never been cut.

The mean volume on forest land is 69,5 m^3/ha and 26,0 m^3/ha on scrub land.

The current increment on the average in northern Lapland is on damp sites 1,3 m^3/ha, on sub-dry sites 1,0 m^3/ha and on dry and barren sites 0,8 m^3/ha according to the taxation classes (*Kuusela* 1977).

If calculated using these average figures, the total current increment on the forest land in the study area is about 55 000 m^3.

43. Short term cutting possibilities

Saariselkä belongs to the protection forest zone, where the intensity of cuttings is restricted. However, according to the present directions the regeneration fellings are allowed in the protection forest zone under the altitudinal limits of 250 – 300 meters (Ohjekirje . . . 1969). It is presupposed that special care be taken in cutting to prevent lowering of the forest limit.

Cuttings have been carried out since the 1950's. Experiences have been mostly positive. The natural regeneration of pine stands has been sure even if slow (e.g. *Lehto* 1969, *Norokorpi* 1981). However, regeneration cutting in a few spruce-dominated stands have presupposed artificial regeneration, which has not always been very successful. Therefore, cuttings in pure spruce stands are nowadays either not carried out or are strictly limited (Ohjekirje . . . 1969, cf. Metsähallitus . . . 1981).

The cutting methods used in pine forests are shelter tree or seed tree cuttings. Clear fellings is not used. In the shelter-tree method the number of shelter trees remaining is 80–120 per hectare. When there are seedlings enough under the shelter trees, the number of shelter trees is decreased to 30–50 trees per hectare. In the seed-tree method the number of seed trees remaining is exactly the abovementioned 30–50 trees per hectare. When the sapling stand is permanent, the cutting of standards is carried out. In young stands, intermediate cuttings are carried out. Above the cutting limit, only selective cuttings of standards is allowed. (Ohjekirje . . . 1969).

The estimation of short-term (here, the next 20 years) cutting possibilities is an involved task. There are many conditional factors which have substantial effects on the estimate of short-term cutting possibilities.

The most important conditioning factors are the intensity of cuttings, the rotation chosen, and the altitudinal cutting limit and other attendant restrictions. In each of these there is some variation.

The cutting intensity in the protection forest zone may in principle vary over a rather wide range. The least intensive way would be to collect only dead, damaged or other weak trees, i.e. to take over only mortality. This alternative, although costly, might not be economically senseless given the high value of standing and barkless dead pines (snags) for recreation houses.

The other extreme alternative would be to cut these forests in the same way as other forests outside the zone of protection forests.

Here three alternative cutting intensities are applied. The least intensive alternative is more intense and the most intensive less intense than the respective extremes mentioned above.

The alternative cutting intensities are:

Slight (the volume of the remaining seed trees (shelter tree) stand 40–50 m^3/ha),

Medium (the volume of the remaining seed tree stand about 30 m^3/ha),

Strong (the volume of the remaining seed tree stand about 20 m^3/ha).

Also there is a certain range in choosing the applicable *rotation.*

The normal rotation in Northern Lapland is about 160–180 years *(Kuusela* 1977). However, because of the accumulation of old forests, longer rotations are applied in practice. The pine stands are hardy and the growing stock is increasing, though slowly, even beyond the age of 200 years (*Ilvessalo* 1970).

The two rotations used are 150 years and 201+ years at the time of inventory (see page 31). In fact, because of the time lag between the present and the inventory, the rotations are actually about 20 years longer.

The third decisive point in estimating the short-term cutting possibilities is the emphasis laid on the *altitudinal factor.*

The coniferous forest limit in the area extends approximately to 300–400 m above sea level (Figure 9). The coniferous zone does not consist only of forest land, rather part of it is scrub land (cf. Table 3). According to the prevailing cutting directions cuttings are not carried out on scrub land in protection forests.

Not even all forest land belongs to the area where cuttings are allowed according to prevailing directions. Cuttings are not carried out above an elevation of 250 m (on northern and eastern slopes) or 300 m (on southern and western slopes) in the area north of Saariselkä nor in the area south of Saariselkä above an elevation of 300 m (Ohjekirje . . . 1969).

Thirty per cent of the forest land is located above the cutting limit (Table 9). The cutting limit is taken here as absolute. In practice there is some flexibility in applying it, depending, for instance, on the limits of the stand and the characteristics of the growing stock.

The only cuttings allowed above the cutting limit are the removal of standards from saplings over the height of two metres. Their practical meaning is insignificant.

Other restrictions are that spruce stands are not managed with cuttings. Forests on stony, rocky or paludified sites are also left uncut.

The range of alternative short-term allowable removals varies from 29 000 m^3/year to 81 000 m^3/year assuming that all cutting possibilities under the cutting limit are utilized in 20 years (Table 10).

The cutting limit and other (minor) restrictions reduce the short term cutting possibilities by roughly 30 per cent (cf. Table 9). The effects of alternative rotations and cutting intensities are even stronger. The shortening of rotation by 50 years increases the short-term cutting possibilities on the average by 43 per cent. The application of a strong cutting intensity in regeneration cuttings instead of a

Table 9. Forest land and its growing stock by elevation zones.
Taulukko 9. Metsämaa ja puusto korkeusvyöhykeittäin.

	Per cent of forest land – *% metsämaasta*	Per cent of growing stock – *% puustosta*
Forest land above cutting limit – *Toimenpiderajan yläpuolella olevava metsämaa*	30	28
Forest land under cutting limit – *Toimenpiderajan alapuolella sijaitseva metsämaa*	70	72
Total – *Yhteensä*	100	100

proper economy forests was 1,96 m^3 per ha and in protected forests 1,48 m^3 per ha (*Kuusela* 1960). The latter is more readily comparable to the Saariselkä area, which also belongs to the zone of protected forests.

The estimated long term wood production capacity is theoretical in many senses. First, it must be emphasized that the yield studies of forests of northern Lapland are as yet too few. Yield studies of managed forests are almost completely lacking. Therefore, the estimates of long-term mean yields are more or less tentative. This is also why the possible effect of stoniness and paludification has been disregarded here.

A second important factor affecting the uncertainity of mean yields is the effect of elevation. The altitudinal variation of forest land in Saariselkä is very great, extending from 110 m to the alpine timber line at an elevation, as mentioned, of 400 m. Elevation has clear effects on the wood production capacity of forest land (*Poso* and *Kujala* 1973, *Roiko-Jokela* 1980). The effect of elevation is also regarded as very considerable in forestry practice, as illustrated by the concept of the "cutting limit".

The effect of a cutting limit is a factor somewhat subject to interpretation, but it can be considered to reduce the cutting possibilities by a little bit less than the relative share of forest land above the cutting limit (30 %, Table 9) or of that of the present growing stock above that limit (28 %, Table 9) and thus by roughly 25 %. This is due to the better growth conditions below the cutting limit.

The share of mortality (natural removal) varies according to *Ilvessalo* (1970, p. 31–33) by age of stand and by forest site types. At the age of 220 years the total natural removal was 45–51 % of total production in pine stands on the three most common forest site types of the study area. However, a great deal of mortality can be harvested by proper intermediate cuttings. The growth conditions of northern Lapland entail still one advantage: because of the extremely slow decomposition the dead trees remain usable a long time and – as stated earlier concerning large standing dead trees usable as building materials for vacational houses – even improve in value. It is here assumed that the relative share of unused mortality remains at a level of 17 % of the total production and the share of forest waste is assumed to be 18 % of total production. These figures correspond to those used in the allowable drain calculation of a recent forest inventory (*Mattila* and *Kujala* 1980, p. 21) although they are not, strictly speaking, fully comparable.

The initial long term total production of 86 612 m^3 must thus be reduced by the effect of cutting limit (25 %), by mortality (17 %) and forest waste (18 %) and the remaining *allowable removal* are thus 42 139 m^3.

On the per hectare basis the allowable removals under cutting limit are 0,96 m^3/ha. In the state forests of Inari forest district the allowable removals (calculated cut) for present growing stock are 0,65 m^3/ha calculated on the basis of exploitable forest land (Yearbook . . . 1979, p. 176). In a recent inventory of forests of the northernmost Lapland the rational minimum allowable removals of present growing stock on forest land were estimated to be 0,69 m^3/ha (*Mattila* and *Kujala* 1980). In a collective forest of Enontekiö, which is wholly located in the zone of protection forests, the allowable removals for present growing stock were 0,9 m^3/ha and correspondingly in a collective forest in Inari, half of which is located in the zone of protection forests, the allowable removals were about 1,1 m^3/ha.

Compared to these figures the estimated average long term allowable removals can be regarded as an optimistic rather than a conservative figure if considered on a per hectare basis. On the other hand, the restrictions concerning the cutting limit and the fact that no cuttings are assumed to be carried out on scrub land have the opposite effect.

5. REINDEER GRAZING

51. General description

The grazing of the domestic or semi-domestic livestock on forestry land is a world-wide phenomenon. However, most grazing is located on non-forested lands or only poorly productive forest lands such as natural grasslands, savannas, shrublands, deserts, tundras, alpine communities, coastal marshes and wet meadows (*Schwarz* et al. 1976). Therefore the production of meat by the grazing of animals and the production of timber on the same forested areas is not very usual even if in recent times it has gained an increasing concern in the terms of "agroforestry" (e.g. *King* 1979, *Tustin* et al. 1979).

Reindeer grazing is the most important form of grazing in the subarctic zone. Reindeer grazing, or reindeer husbandry as it is called, is nowadays carried on most widely in the Soviet Union, Finland, Sweden and Norway. In Alaska and in Northern Canada some attempts have been made at grazing (*Scotter* 1970). In the Soviet Union, where three-fourths of world's total reindeer live, the reindeer graze almost exclusively on tundra and in the forest tundra zone (*Vostryakov* 1971, cf. however, *Segal'* 1962, p. 60). Also in Norway, the main rangelands for reindeer are mountain birch forests and other mountain pastures (*Scotter* 1965). Forest pastures play an important role in Sweden, (e.g. *Mattsson* 1981) but in Finland they are crucial.

The reindeer grazing area of Finland extends deep into the coniferous zone. It may be estimated that three-fourths of the roughly 200 000 reindeer (*Rangifer tarandus tarandus* L.) in Finland graze in the coniferous forest zone, which is also intensively used for timber production (*Saastamoinen* 1978). In northern Finland timber production and reindeer husbandry are overwhelming examples of the multiple use of forestry land: they are spatially coincident land uses.

52. Considerations concerning production function

The principal forage which makes the reindeer husbandry possible as a main form of animal production in the northernmost areas is lichen. The domestic reindeer is the only domestic animal which feeds on lichens. With the help of reindeer the large natural forage resources can be put to productive use (*Andrejev* 1954, p. 11, *Helle* R. 1966, p. 60). Apart from the Cladonia-lichens growing on the ground, reindeer utilize arboreal lichens, which have crucial importance when deep or hard snow prevents the reindeer digging for ground lichens (cf. *Helle,* T. 1975, *Saastamoinen* 1978). This dependence on arboreal lichens is the peculiarity of reindeer grazing in the forest zone; it has only minor importance in practically treeless tundra or forest tundra conditions (cf. *Andrejev* 1954, p. 61). Conditions similar to those prevailing for reindeer in the forest zone have also been reported for caribou in British Columbia. During the winter epidendric lichens provide most of caribous' food and their survival depends in part upon the availability of them (*Edwards* et al. 1960). Besides the ground and arboreal lichens, the winter diet of reindeer is composed of dwarf shrubs, grass, birch and willow shoots and some bog plants (*Andrejev* 1954, *Skuncke* 1958, *Ahti* 1961, *Helle,* T. 1975, *Mattila* and *Helle* 1978). The lichens are an inseparable part of northern forest ecosystems. This is most concretely indicated by the fact that in the Finnish classification of forest site types, which is mainly done according to the ground vegetation, some forest site types (e.g. *Cladina*-type and *Ericaceae-Cladina* -type) are named according to the dominant lichen vegetation (*Cajander* 1949).

Ground vegetation in the form of lichens is most prevalent in climax ecosystems. Any kind of forest manipulation for timber production inevitably changes the growth condi-

(Photo – *Kuva: Jorma Luhta*)

Figure 13. In summer reindeer seek fresh forage in bogs.
Kuva 13. Kesällä porot hakevat ravintoa soilta.

fell areas where there are fewer plants. After July the harm caused by mosquitoes greatly lessens and the late summer is the best time for reindeer. There is plenty of forage available including increasing amounts of edible fungi, which are an important fattening forage. In autumn begins the short rutting period, which usually occurs in October near the fell zone. After that come generally, in turn, the work of rounding up reindeer for the first slaughterings, which, however, in the study area as well as in other herding cooperatives in the northernmost part of Lapland begin later than in the area of the continuous coniferous zone. The reason for this is the arrival of snow conditions which permit the use of snowmobiles for round-up work. Usually the slaughterings are done in November-January, but sometimes they are done even later. In winter the reindeer seek ground lichens in pine forests, where they are intensively herded and protected against predators. Not until the spring, when the snow cover becomes too hard for digging, do the reindeer seek arboreal lichens; in the study area, however, most animals usually are moved to the fell area where snow remains shallow and where the best conditions for calving can be found.

54. Short term and long term production possibilities

Production possibilities in reindeer husbandry are almost solely dependent on the reindeer population, on which the range capacity sets its limits. According to the Reindeer Management Law, the highest permitted numbers of reindeer (older than one year) are confirmed by authorities for each herding co-operative for one ten-year period at a time. Thus the production possibilities are in fact determined by administrative decisions; these, in turn, are based on past experience and are influenced by the reindeer herders own organizations, each herding co-operative and the Association of Herding Co-operatives.

The highest permitted number of reindeer in the herding co-operative of *Sodankylän Lappi* in the study area in the 1950's was 10 000, in the 1960's, 10 000, in the 1970's, 9 000 and, in this decade, 7 500. Eighty per cent of the last figure means that the present highest permitted number for the study area is approximately 6 000 reindeer over one year old. This can also be seen as representing the short term production possibilities

(Photo – *Kuva: Olli Saastamoinen*)

Figure 14. Reindeer are collected in a corral for winter slaughtering.
Kuva 14. Teuraseläimiksi erotellut porot aitauksessa.

–at least from the point of view of the authorities.

On the average in 1970–78 the number of counted reindeer for the study area was 4 879. If one figures in the traditional way that 15 % of the reindeer remain uncounted, it means that the total number of reindeer in the study area in the 1970's was about 5 600 – a little less than the official short-term estimate.

The official short-term estimate, however, is not suitable for our purposes because of its implicit assumption of continuous recreational use. What is needed are the "pure" production possibilities without the effects of any disturbing factors. Herein lie the main difficulties, for it is impossible to say with present knowledge what is the weight of each factor in the past development.

One can perhaps more fruitfully seek the limits of reindeer production in the knowledge of range requirements for reindeer. When considered in the long run, one can assume well-stocked fully productive ranges, although the course from the present situation of heavy grazing to the optimal one is not an easy one.

There are many studies on the lichen range requirement per reindeer. Most studies (e.g. *Andrejev* 1954, *Skuncke* 1964) regard 8 ha of lichen range per animal as being enough in winter whereas the need is 10–15 ha according to the practical experiences of reindeer herders (e.g. *Alaruikka* 1964, p. 55). The need depends, however, largely on range quality, which varies not only by site types but also by geographical area (*Hustich* 1951, *Andrejev* 1954).

At the present level of knowledge, there are no certain data based on quantitative measurements of the range values of different site types and vegetation zones in the study area. *Ahti* (1960) has, however, in conjunction with reservoir planning attempted to determine the range values for different forests and swamp types precisely for the herding co-operative of Sodankylän *Lappi,* basing his evaluation partly on the comprehensive work of *Skuncke* (1958). Later *Helle,* R. (1966) further modified the classification. In the following, the approximate evaluation of range values of different site types in the study area is a modification of that of *Ahti* (1960). Some refinements have also made on

Table 13. An estimate of the long run (potential) grazing capacity of reindeer by winter ranges of the study area.
Taulukko 13. Arvio talvilaidunten pitkän tähtäimen kantokyvystä laidunlajeittain tutkimusalueella.

Type of winter range (site type) *Talvilaiduntyyppi (kasvupaikkatyyppi)*	Area *Pinta-ala* hectares *ha*	Approximate range requirements (hectares) per animal on sustained yield basis[1] *Arvioitu laiduntarve (ha) poroa kohti*[1]	Potential grazing capacity *Potentiaalinen laidunten kantokyky* Number of reindeer *Poroja kpl*
Cladina Type (*ClT*)	3 566	12	297
Myrtillus-Calluna-Cladina Type (*MCClT*)	38 548	16	2 409
Empetrum-Myrtillus Type (*EMT*)	18 819	24	784
Hylocomium-Myrtillus Type (*HMT*)	2 088	16	130
Coniferous zone on fells and hill tops (incl. rocky sites) – *Kitumaan havumetsävyöhyke*	22 691	20	1 134
Alpine birch zone – *Koivuvyöhyke*	39 787	28	1 421
Open fells – *Avotunturi*	33 072	40	826
Total – *Yhteensä*	158 571		7 001

[1] See text – *Ks. teksti*

the basis of recent range inventory (*Mattila* and *Helle* 1978, *Mattila* 1981, see also p. 57) which, however, tell more about the actual than the potential range values. The range values applied in Table 13 are in reverse form, i.e. they show how much winter range (in hectares) is needed per animal.

The approximate calculations (Table 13) show that in the long run it is possible to increase the reindeer population on a sustained yield basis. The estimated increase seems to be about one fifth of the present highest allowed number of reindeer. The latter, however, was calculated on the basis of the highest allowed number of reindeer for the whole herding co-operative and as such also contains some approximations.

6. OUTDOOR RECREATION

61. General description

In their pioneering work, *Clawson* and *Knetsch* (1966) begin the treatment of the concept *outdoor recreation* from the latter word. The distinguishing characteristic of recreation is, according to the authors, not the activity itself but the attitude with which it is undertaken. When there is little or no feeling of compulsion, an activity is almost surely recreation. Recreation is, therefore, closely related to leisure. In a deeper psychological sense, recreation refers to the human emotional and inspirational experience arising out of the recreation act. *Outdoor recreation,* then, is simply recreation that is typically carried on outdoors. It requires space and resources for its enjoyment. A natural resource for recreation is land, water or any other natural features actually used for recreation. In any event, it is *use* or the possibility of early use which determines that natural features are actual or potential recreation resources. In this respect, outdoor recreation is no different from any other use of natural resources, such as farming, forestry, grazing, and mining (*Clawson* and *Knetsch* 1966, p. 6–7, 145).

Recreation revitalizes the spirit. It restores a person's vitality, initiative, and perspective on life, thereby preparing the individual to return to his toil (*Douglass* 1975, p. 7). *Grushin* (1967) singles out two main functions of leisure time: the first is the restoration of strength consumed by labour and other necessary pursuits, the second the intellectual (cultural, ideological, aesthetic) and physical development of the individual. *Taran* (1979) stresses that the satisfying of the recreational needs is generated from the basic duties to maintain people's health, to raise the level of living of all members of the society and to develop the personality comprehensively and harmoniously.

It is logical to consider free time to be behaviour that is valuable in itself or the time of those actions and those periods of activity in which there is an element of value-in-itself (*Gordon* and *Klopov* 1975, p. 63). Forest recreation is any form of outdoor recreation that takes place in forested areas whether or not the forest provides the primary purpose of the activity. Whether or not the activity requires the direct use of the forest for consumption or indirectly as a background setting, that activity is included as forest recreation. If managing and altering of the forests would have an impact on the activity, it should be considered as forest recreation management (*Douglass* 1975, p. 10).

Strictly speaking, the forest produces recreational opportunity; recreation requires the use of the opportunity by someone. No outdoor recreation has been produced unless there are users, regardless of how much opportunity there may be (*Clawson* 1979, p. 199).

There are many arguments for the common belief that forest recreation has many positive social effects and therefore it must be regarded as a desirable form of recreation, as opposed, for instance, to the use of drugs. That kind of socially desirable good is called *merit good* (cf. *Gregory* 1972, p. 463) and the arguments for or against the use of some commodities are called *merit wants* (*Culyer* 1973, p. 237). The merit want argument cannot be evaluated by the Paretoan approach, which assumes that only each individual can know his own interests (*Culyer* 1973, p. 237).

Mack and *Myers* (1965) have proposed the use of "merit-weighted user days" instead of dollars. They argue that social merit accorded a user day should vary, e.g., a day spent by a child at a day camp produces more benefits than an adult's day of picknicking in a crowded park. This approach does not exclude interpersonal comparisons of well-being and the probably different marginal utilities of the service use. Thus it can be said to follow the Pigouvian tradition of welfare economics.

62. Considerations concerning production function

From the standpoint of production, it is important to consider the product characteristics of forest recreation production. The economic role of forest recreation in production theory seems to be a very complex one. Somewhat as in timber production the recreation forest is at the same time a production factor and a part of a final product. In a sense, the forest land and the growing stock are production factors of a certain recreation output.

If one considers recreation forest the output, the production function in its simplest form may be formulated as follows

RF = f(L, GS, M)
where
RF = recreation forest
L = forestry land
GS = growing stock
M = forest manipulation

But, as is the case with timber, the product in the economic sense is not standing trees at any location or of any kind whatsoever but rather the "sold" trees. Supplying the recreation forest can be productive only when there is not only potential but also actual demand for it. "Recreation production" is realized only when it is consumed. Thus, the output of recreation production must be the recreation actually consumed. In this case, we need another production function

R = f(RF, A, S)
where
R = recreation
RF = recreation forest
A = accommodation and other facilities
S = service works (labour input)

The division of "recreation production" into two production stages seems to be useful not only theoretically but also practically. In theory, it enables us to distinguish between products and production factors. What appears as a product in the first stage (recreation forest) appears as a production factor in the second stage (*Frisch* 1965, p. 5). In practice, it may help, for example, in defining precisely the production goods. In practice, the two stages can be separated or integrated. If they are integrated, it is a case of vertical integration.

There still remain some considerations concerning the nature of the forest recreation product. "Recreation forest" can be easily classified as an *intermediate* product and "recreation" as a final product. As products they must also be classified as services rather than goods.

63. Outdoor recreation in the study area

631. The type of area and forms of recreation

A peculiarity of recreation production is that every recreation area is unique. There are no identical recreation areas. In this sense, supplying recreation services differs, for example, from timber production, in which products are usually regarded as homogenous units of mass production. However, despite these real dissimilarities, recreation areas can also be classified into certain categories to help the varying needs for analysis. From numerous classifications described in the literature (e.g. *Vesikallio* 1974, *Heikinheimo* et al. 1977, p. 17–18) the threefold one: user-oriented, resource-based and intermediate areas presented by *Clawson* and *Knetsch* (1966, p. 36–38) is convenient for many purposes. Saariselkä no doubt is a resource-based area, the dominant characteristic of which is outstanding physical resources. It is located far from heavily populated regions (Figure 1) and, as a result, is mainly visited during the holidays. Saariselkä is a harmonious composition of rounded mountains, fells, vast forested slopes and valleys. It is one of those not so few areas, each of which, according to the skillful advertising, has the honour of being the last wilderness area in Europe.

The recreation activities in the area can be classified into four categories according to the season of visit and accommodation used. There are two seasons: the summer season consists of the snowless time from June to October and the snowy winter season comprises the rest of the year; during the latter, however, recreation is concentrated in the bright spring months from February to the beginning of May.

In winter time the principal activities are cross-country (fell) skiing and, to a lesser extent, slalom. In summer the main recreation activity is hiking. According to the accommodation use both in summer and in winter the visitors are divided into two groups: those who are lodged in the numerous hotels, hostels and private homes or vacation houses owned by organizations and those who spend their nights in the small wilderness cottages or outdoors in the wilderness areas.

The main forms of recreation and the corresponding visitor groups are the following:

a) Summer vacationists usually making daily hikes in the surrounding wilderness area. The length of the daily hikes is 5–15 km.
b) Winter vacationists making the same kind of cross-country skiing trips (also slalom is pursued). The length of the daily skiing trips is 10–30 km.
c) Summer backpackers making on the average one week pack trips in the wilderness, usually staying overnight in the wilderness cottages or in tents. The length of a trip is about 50–100 km.
d) Winter cross-country skiiers with backpacks spending the nights in the wilderness cottages or (sometimes) outdoors. The average duration of a backpacking trip is 5–7 days and length 50–150 km (*Saastamoinen* 1972, p. 41, 80).

In the recreational use of Saariselkä area there are some peculiarities which may not be very usual outside the Scandinavian countries.

First, there is the overwhelming preference for cross-country (fell) skiing among the vacationists and, for obvious reasons, it is the sole mode of travel for winter backpackers. The other peculiarity is the common occurrence of small wilderness cottages, which are free for hikers to use. The open wilderness cottages are a tradition and their role nowadays is the same as earlier: they make hunting, reindeer herding and hiking possible in the wilds where, especially in winter, the climatic conditions can be very severe. According to tradition, they are always open for every arrival and although in some new cottages which the National Board of Forestry has built for vacationists there is a rentable room, there is always the traditional open room, too.

632. The development of accommodation capacity

The first refuge huts in the Saariselkä wilderness were built in the nineteenth century, perhaps to serve as way stations of ancient routes. Later on some refuge huts were built by hunters, fishermen, pearl seekers, gold washers and reindeer herders. The first refuge hut for recreational use was the old fishermen's hut rebuilt by a hikers' organization in 1948 and in that year the recreational use of the wilderness generally is considered to have begun although some exploratory trips had been made already in the thirties (*Saastamoinen* 1972, p. 35). The development of the number of wilderness huts and their capacity to give a night's shelter for hikers is seen in Figure 15.

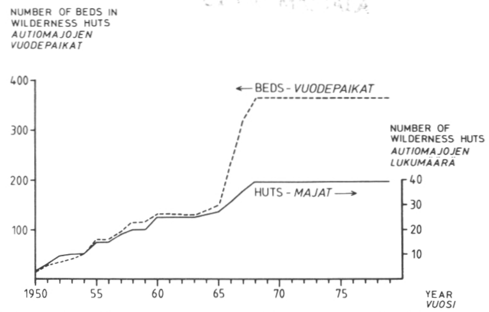


Figure 15. The development of the number of wilderness huts and their capacity in 1950–1979.
Kuva 15. Autiomajat ja niiden vuodekapasiteetti vuosina 1950–1979.

Likewise, in the resort area the first guest house for travellers and state employees was built by the state. The first commercial tourist lodge served also mostly travellers as do the present accommodation facilities, especially in summer. The first tourist lodge to serve the vacationists staying in the area was built in 1949. With that began the rapid development of accommodation capacity which is outlined by type of accommodation in Figure 16, (see also Figure 17).

The data for capacity development was obtained mainly from organizations and private individuals by questionnaire. In the questionnaire the development of the number of visits and days spent in the area was also asked. Data was also provided by the state administration in charge of managing the land (the National Board of Forestry, the

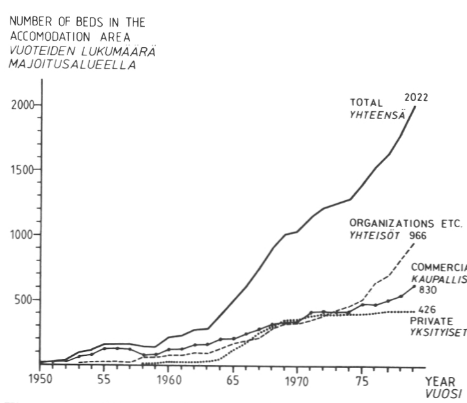
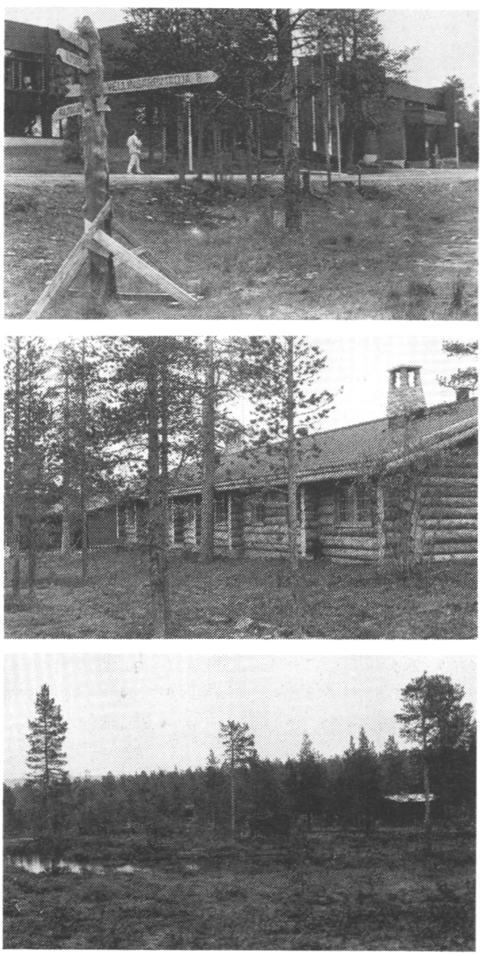


Figure 16. The development of the accommodation capacity (number of beds) in the accommodation area in 1950–1979.
Kuva 16. Majoituskapasiteetin kehitys lomamajojen alueella vuosina 1950–1979.

Forest Research Institute) and the National Board of Survey which made the development plan for vacation accommodations and related facilities (Maanmittauslaitos 1972, *Luoma* 1974).

The data concerning the commercial (or semi-commercial) firms is based on exhaustive material and is very reliable. The scope of data concerning the capacity and use of vacation lodges of different organizations and firms (for the use of their personnel) is also nearly complete. The data concerning the capacity and use of private vacation cottages is less accurate, but covers, however, 60 % of their total. For the rest, average figures have been used.



(Photos – *Kuvat: Olli Saastamoinen*)

Figure 17. Accommodation facilities in resort area: a hotel (above), a vacation house of a collective body (midst) and a private vacation cottage (below).

Kuva 17. Lomamajojen alueen majoitustyyppejä: hotelli (ylinnä), yhteisömaja (keskellä) ja yksityinen lomamökki (alinna).

633. The development of recreation use

6331. Units of measurement

The unit of measurement of recreation use depends to a great extent on the type of the area as well as on the goals of the analysis. Most commonly, a proper description of the use of the area entails the use of different characteristics.

The following units are relevant in describing the use of a resource-based area of the Saariselkä type:

a) A *visit* is one of the most usual units in recreational use measurement. It means one individual's staying once in the area. If the visits to the area are homogeneous as to length and type it alone may be a satisfactory unit. However, this is an exception rather than a rule. Other characteristics are therefore needed.
b) The *length of stay* of a visit is the other basic figure. It can be measured in hours or in days or in any other time units. In certain areas, the length of stay can vary from half an hour to some weeks. Therefore, it is important to choose the proper unit for the length of stay of visits. Sometimes the recreation use is reported as visitor days while it would be more precise to use visitor hours. Here the length of stay is measured in days; shorter visits are only mentioned later and have been excluded from the main analysis.
c) The *total time spent* will be obtained by multiplying the number of visits by the average length of stay. It will be expressed in recreation hours (*Grayson* et al. 1973, p. 4) or use days. The total time spent is the most complete measure of the recreational use, which makes possible comparisons between the different areas. In these comparisons the *total time spent per unit of area* (per ha or per sq.km) can also be used.
d) *Number of visitors* differs from the number of visits in that the same individual can visit the area more than once during the season or the year. With the help of the number of visitors the *participation rates* for different populations can be calculated – presupposing that the (needed) characteristics of visitors are known.

6332. The development of the use in the day-use area

The day-use area consists of the accommodation area (the area of hotels, hostels, other leisure houses and services) and that part of the wilderness area which belongs to the

(Photo – *Kuva: Lapin Kansan kuva-arkisto)*

Figure 18. The nearest wilderness huts serve also as turning points for winter vacationists making skiing trips in the day-use area.
Kuva 18. Lähimmät autiomajat ovat myös talvilomailijoiden päiväretkien tukikohtia.

sphere of daily hikes (in summer) and daily ski tours (in winter). It is not easy to determine exactly the size of the day-use area because the length of daily trips is different in summer and in winter (see p. 45) and even varies within a season – especially winter –according to the climatic and snow conditions. Individual differences in the lengths of daily trips may also be mentioned. However, roughly speaking, the day-use area extends 10–20 kilometers east from Main Road 4 and the accommodation houses lying along it. Its size is approximately 250 sq. kilometers.

The development in the number of visits from 1950 to 1979 is shown in Figure 19. A visit means a stay of at least one night in the accommodation area and thus excludes the day-users who in summer time stop only for a short time period to view the landscape or to use services of the tourism firms. It also excludes in winter time some "real" local day-users, who come to the area from neighbouring small towns. This group also includes some winter tourists, who are lodged not in the study area but in these neighbouring villages. Especially during the high season (e.g. Easter) there may be many of them but for the whole winter time they hardly constitute more than a few per cent (*Saastamoinen* 1972, p. 70–71).

The data from the 1950's are less accurate than those for other decades because the statistics from some early hostels are lacking. The number of visits and use-days seems to have increased, however, relatively rapidly due to the modest level of use in the first years of the 1950's (300–400 visits and 1 100–1 300 visitor-days in 1950) and to the great relative increase in accommodation capacity. The average yearly growth percentage in 1950–59 of the number of visits was 27,0 and that of use -days 28,2.

In the 1960's the growth rates continued to be high. The average yearly growth percentage of visits in 1960–69 was 24,1 and that of visitor-days 23,4. In 1969 the number of visits was estimated to be 16 500 and the number of use-days 50 000 (Figures 19 and 20).

The rate of growth of recreation use clearly decreased in the 1970's but still remained at a rather high level. In 1970–79 the average growth percentage was 9,4 for visits and 11,3

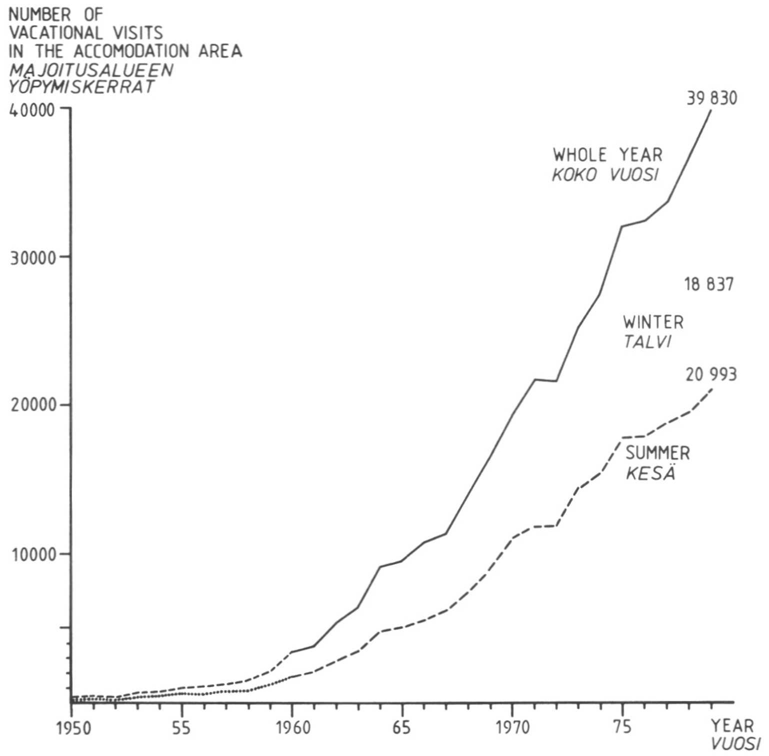
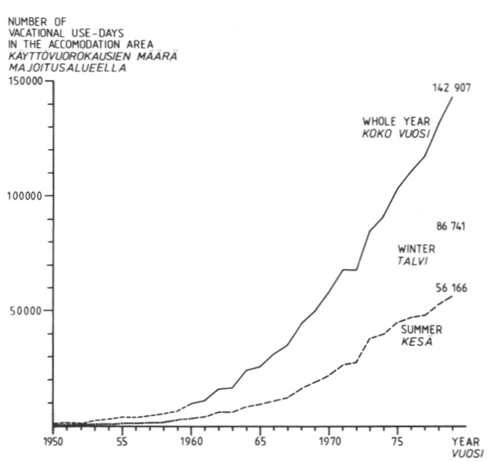


Figure 19. The development of the number of overnight visits in the day-use area in 1950–1979.
Kuva 19. Yöpymiskertojen kehitys ns. päiväkäyttöalueella vuosina 1950–1979.

for use-days. In 1979 the number of visits was 40 000 and the number of use-days 143 000. Compared to the steady growth on the annual level in the 1960's one can see in the 1970's a slight absolute decrease in the number of visits in 1972.



6333. The development of the wilderness use

The area outside the sphere of daily hikes and skitours is mainly used for backpacking recreation both in summer and in winter.

The data on the development of the number of backpackers was based on the guestbooks in wilderness huts. For every hut, the time series were compiled within the limits of the available guestbooks. In addition, the number of different persons making entries in the guestbooks was separately calculated for the years 1953 and 1975. These figures, with assumed proportions of non-entries (5 % in winter and 15 % in summer) served as base points, and the figures for other years were obtained on the basis of yearly changes (separately for summer and winter) in the total guestbook data. The estimates for average length of stay are from an earlier study (*Saastamoinen* 1972). All in all, the compli-

Figure 20. The development of the number of use-days in the day-use area in 1950–1979.
Kuva 20. Käyttövuorokausien kehitys ns. päiväkäyttöalueella vuosina 1950–1979.

(Photo – *Kuva: Hannu Lipitsä*)

Figure 21. Summer backpackers leaving a wilderness hut.
Kuva 21. Eräretkeilijät lähdössä autiomajalta.

cation of time series for the backpacking recreation was a laborious task.

In the first two years of the 1950's the number of backpacking visits was not more than 100–200 (Figure 22). In 1956, a clear decline occurred, probably due to the general strike in Finland in that year. On the other hand, in 1959 the number of visits doubled as compared to the previous year. This is generally interpreted as an "information effect", i.e. a result of the publication of a book which enthusiastically told about backpacking recreation in the study area (Kullervo Kemppinen: Lumikuru. Porvoo 1958. WSOY). In 1959 the number of backpacking visits was 1 400 and the average growth percentage in 1950–59 was 38,2.

In the 1960's, the steady growth continued. The average yearly growth rate was 10,8 %. Only in 1969 did a decrease in the number of visits occur due to the reduction in summer visits. In the late 1960's especially, the number of winter visits increased clearly thanks to the new wilderness huts built by the National Board of Forestry.

In the years 1970–78, the average growth rate was estimated as remaining at a high 9,0 % although the development was more unstable than in the 1960's. The total number of backpacking visits in 1978 was about 8 000, of which 76 % were summer visits and 24 % winter visits.

The total number of backpacking use-days can be calculated only on the basis of the average length of stay from 1970. In that year the average length of a winter visit was 6,5 days (days spent in wilderness) and that of summer visit 7,9 days (*Saastamoinen* 1972, p. 37). If one assumes that the lengths of stays have remained constant, the total number of backpacking use-days in the study area in 1978 was 60 000 days, of which 79 % were spent during the snowless season.

6334. The total outdoor recreation use

The total outdoor recreation use of the study area is the sum of the use-days of the

Table 14. The total number of visits (one night or more) and use-days in the study area in 1979.
Taulukko 14. Käyntikertojen (vähintään 1 vrk:n viipyneet) ja käyttöpäivien kokonaismäärä Saariselällä v. 1979.

Pattern of use – *Virkistysmuoto*	Visits – *Käyntikerrat* Summer – *Kesä*	Winter – *Talvi*	Whole year *Koko vuosi*	Use-days – *Käyttöpäivät* Summer – *Kesä*	Winter – *Talvi*	Whole year – *Koko vuosi*
Resort use – *Lomailukäyttö*	20 993	18 837	39 830	56 166	86 741	142 907
Per cent – %	52,7	47,3	100,0	39,3	60,7	100,0
Backpacking use[1] – *Eräretkeily*[1]	6 000	1 898	7 898	47 400	12 337	59 737
Per cent – %	76,0	24,0	100,0	79,4	20,6	100,0
Total use – *Kokonaiskäyttö*	26 993	20 735	47 728	103 566	99 078	202 644
Per cent – %	56,5	43,4	100,0	51,1	48,9	100,0
	Per cent by pattern of use – *% virkistysmuodon mukaan*					
Resort use – *Lomailukäyttö*	77,8	90,8	83,4	54,2	87,6	70,5
Backpacking use[1] – *Eräretkeily*[1]	22,2	9,2	16,6	45,8	12,4	29,5
Total – *Yhteensä*	100,0	100,0	100,0	100,0	100,0	100,0

[1] Assumed to be the same as in 1978 – *Otaksuttu samaksi kuin vuonna 1978*

visitor's lodgings at different types of tourist and vacational houses and the use-days of backpackers spending their nights outdoors or in huts deeper in the wilderness. The total number of the visits, i.e. of the persons staying at least one night in the area was in 1979 about 48 000, of which 17 % were backpacker visits[1] (Table 14). The total number of use-days in 1979 was estimated as being 203 000, of which 30 % consisted of use-days of backpackers.

Of all visits 57 % were made in summer and in autumn (snowless season) and 43 % in winter. The distribution of use-days in 1979 was more even: 51 % of use-days were spent in summer time and 49 % in winter.

A minor part (12 %) of the winter use-days were those of backpackers. In summer the role of backpacking was much greater: 46 % of the summer use-days were wilderness hikes by backpackers.

If backpacking recreation, when measured by use-days, was clearly concentrated in the summer time, the opposite is true for recreational use of non-backpackers: 61 % of use-days of people lodged in hotels, hostels, leisure homes, etc. occurred in the winter time.

[1]It is assumed that in 1979 the number of backpacking visits was the same as in 1978.

On the whole, one can say that the recreational use of the study area is many-sided and the total use period, thanks to summer and winter seasons, comparatively long. From the standpoint of economic efficiency that, of course, is an important benefit.

64. Considerations concerning the potential of recreational output

One of the most difficult problems in the economics of recreation is determining the maximum volume of recreation production (recreation use) for a certain area. Of course, actually the planner is interested in optimum use, but this cannot be known without considering the concepts of maximum use. The recreation production differs essentially, for example, from timber or reindeer production in that the limits of production growth are social rather than physical or biological. Nature sets the physical limits for forest growth, but it does not do so for recreation. The concept of carrying capacity is often used to describe the maximum possible use of certain area. That term may have been first used by biologists to describe the tolerance of the ecosystems to support populations (the concept of carrying capacity from ecological and economic points of view is considered, e.g.,

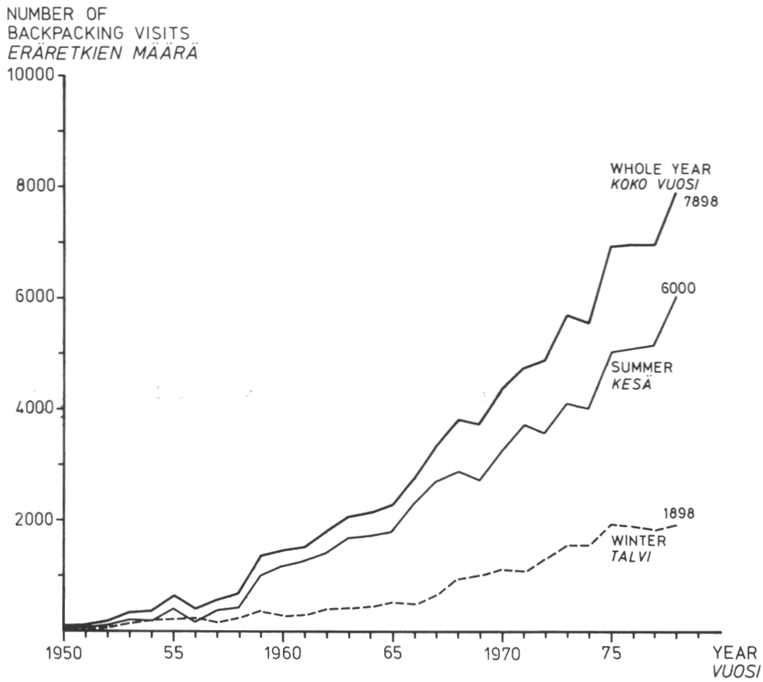


Figure 22. The development of the number of backpacking visits in Saariselkä in 1950–1978.
Kuva 22. Eräretkien lukumäärän kehitys Saariselällä vuosina 1950–1978.

by *Jaatinen* 1978, p. 33–36) and in a similar sense it has been used many times also in recreation planning, e.g., to describe the maximum use which will not destroy the vegetation or soil (e.g. *LaPage* 1962, 1967, *Kellomäki* 1973, *Kellomäki* and *Saastamoinen*, V-L. 1975). No doubt the biological or ecological carrying capacity has an important place when determining the carrying capacity of recreation areas. However, for the many possibilities for minimizing the vegetational and other environmental damages it is generally considered that above all the carrying capacity has social or psychological meaning (e.g. *LaPage* 1963, *Wagar* 1964, *Clawson* and *Knetsch* 1966, p. 167–170, *Cope* 1972, p. 36–45). The difficulties lie in the fact that when recreation production (e.g. number of visits) increases, the product (recreation experience) changes.

The products of a "low-use" wilderness area and that of the same area when "overused" are not the same. The user satisfaction for a wilderness area may be highest at a relatively low level of use and fall steadily when the intensity of use rises (e.g. *Clawson* and *Knetsch* 1966, p. 167). User satisfaction in wilderness experience is thus a function of its consumption. If the product is defined as wilderness experience, it can be said that, with increasing production, a *product adjustment* takes place. The problem is very similar to that of congestion in many water resource projects. Congestion results in the users' imposing *external diseconomies* on each other (*Herfindahl* and *Kneese* 1974, p. 296). Congestion means that the common view which considers recreation services as public goods which are non-rival in consumption (e.g. *Gregory* 1972, p. 415), is problematic.

The difficulties in determining the full capacity-use of the Saariselkä area arise to a large extent from the social or psychological nature of user satisfaction. It may be easy to approve the hypothetical form of dependence between the user satisfaction in recreation experience and intensity of use as presented by e.g. *Clawson* and *Knetsch* (1966, p. 168). But it is difficult to determine empirically the proper relationship. If the satisfaction with a visit decreases only slowly with an increasing number of visits, then the total satisfaction increases to the point where the curves of marginal and average satisfactions intersect. Even at that point roughly the same level of total satisfaction can include

Table 15. "It is difficult to find peace and solitude during the seasonal peaks in Saariselkä". The statement was presented in 1970 to 791 visitors (Saastamoinen 1972, p. 97)

Taulukko 15. "Saariselältä on sesonkiaikoina vaikea löytää rauhaa ja yksinäisyyttä". Asenneväittämä esitettiin v. 1970 yhteensä 791 ulkoilijalle (Saastamoinen 1972, s. 97).

	Agree[1] *Samaa mieltä*	Disagree[1] *Eri mieltä*	Cannot say *Vaikea sanoa*	Total *Yhteensä*
		per cent – %		
Winter vacationists – *Talvilomailijat*	18	69	12	100
Summer vacationists – *Kesälomailijat*	23	57	20	100
Backpacking hikers in summer – *Kesäretkeilijät*	32	55	13	100
Backpacking cross-country skiers in winter – *Talvieräretkeilijät*	51	43	7	100
All visitors – *Kaikki kävijät*	29	60	11	100

[1]The class "Agree" comprises the answers "I agree fully" and "I agree in part", and the class "Disagree" the answers "I disagree fully" and "I disagree in part".

[1]*Luokkaan "samaa mieltä" on luettu "täysin samaa mieltä" ja "jokseenkin samaa mieltä" vastaukset ja luokkaan "eri mieltä" luettu "täysin" ja "jokseenkin eri mieltä" vastaukset.*

rather wide fluctuations in the number of visits.

The problem is complicated by the number of visits, which is not constant during the year but varies according to the seasonal and institutional factors (temperature, sunshine, end and beginning of the school year, Easter holidays). The crowding problems are naturally most concrete during seasonal peaks.

Some light can be shed on the question by examining the situation ten years ago when a statement concerning the crowding was presented to the visitors (Table 15).

Half of the wilderness skiers consider that there is crowdedness during periods of most intensive use; of all visitors 29 per cent represented the same opinion. It is difficult to conclude anything definite from one statement. However, there was a difference of attitude between vacationists and recreationists hiking (skiing) deeper in the wilderness. In the environment of vacationists, especially in that of winter vacationists, the visitor density was manyfold compared with that of wilderness visitors (p. 53). They, however, did not regard the problem of crowdedness as severe as the wilderness recreationists did. This may simply reflect the differences between the recreation experiences (products) which the group of visitors were seeking. It is also interesting to seek explanations for the fact that winter wilderness recreationists found more crowdedness than summer hikers despite the considerably greater number of the latter (Chapter 6333). One reason for this may be the degree of concentration in terms of time and space (and especially the dependence on wilderness huts, practically the only shelter for the night in winter). This tendency is emphasized to a higher degree in winter recreation.

Another factor increasing the crowding in winter is that the wanderings of winter vacationists and wilderness backpackers intersect each other more in the winter than in summer, due to the greater mobility of skiing vacationists.

The above considerations on the attitudes concern the year 1970. Since then, the number of wilderness visitors has doubled and that of vacationists has trebled (see Figures 19 and 22). There are no recent sociological data about the development of visitors' attitudes towards crowding.

Of course, it may be hypothesized that increasing visits as such are evidence that crowding has not yet become a factor retarding the growth of use. That kind of reasoning implies a belief in some kind of self-regulating development in recreation use. With the possibly ongoing product adjustment some of visitors may have moved to other areas to seek more solitude, more difficult conditions and most probably also new experiences. The change to new areas is a natural development and only seldom reflects a direct "escape" from the area of increasing use.

Alongside this movement the visitors may be reacting to the increasing use by timing their visits at the beginning or the end of seasons. Also avoidance of the crowded subarea may have relieved overuse elsewhere.

Some basis for the evaluation of full-use capacity can be obtained by examining the intensity of use for the area. The intensity of use can be calculated – as earlier stated – by dividing the total use time by area.

$$\text{Intensity of use} = \frac{N \cdot L}{A}$$

where,

N = numberof visits within a time period

L = average length of stay

A = area

Intensity of use, however, does not tell the whole story. The same intensity of use can be obtained with different combinations of visits and lengths of stay. Therefore another measure *user density* is needed.

$$\text{User density} = \frac{N_t}{A}.$$

where,

N_t = number of visitors at a certain moment of time t

A = area

User density varies during the seasons and for a given season an average must be calculated.

The user densities vary very much also for different zones. In the day-use area the user densities are much greater than in the vast area used for backpacking.

The user density in day-use area (ca. 250 sq.km) was for a whole year in 1979 1,5 persons/sq.km/day. Peak month is April when it was 4,8 persons/sq.km/day and for a peak day, which occurs at Easter, it can be calculated that the user density rises to about 9 persons/sq.km/day.

In the backpacking (wilderness) area (ca. 1 500 sq.km) the user densities are only a fraction of the above figures. Also the seasonal pattern is the opposite of that in the day-use area. For a whole year in 1979 the user density was 0,1 persons/sq.km/day and for August, when the backpacking recreation is at its height, it was 0,3 persons/sq.km/day. The rule-of-thumb estimate for peak-day in August is about 0,5 persons/sq.km/day.

In other words, in a peak month in the backpacking area, there is, on the average 2–3 sq.kms per hiker. It is difficult to say whether that figure represents the full use of capacity.

No domestic standards are available. International standards have not been developed either, which partly reflects the fact that these types of recreation activities are not very common. For many reasons, this kind of comparison can hardly be more than tentative. However, even as such it can be useful and interesting.

The United Stated Forest Service regards the encountering of two parties per day as an informal standard of use within wilderness areas (*Clawson* and *Knetsch* 1966, p. 168). There is no doubt that in the surroundings of refuge huts in Saariselkä area this standard is exceeded. But if the visitors do not follow the trails and if they do not use refuge huts, that standard may be realized (e.g. *Kemppinen* 1975).

The more formal standard of the U.S. Forest Service for the carrying capacity of its wilderness area is 1,2 hectares (3 acres) per man-day of use each year (*Douglass* 1975, p. 46). If only the back-packing (wilderness) part of Saariselkä area is taken the corresponding figure was 2,5 hectares (6,4 acres) per man-day of use in 1979.

According to this, the present use of the wilderness part of Saariselkä would be about one half of that of the "possible" full capacity. But as above stated that must be regarded only as an experiment of thinking. Yet it must be emphasized that more than on the total number of recreation days the wilderness experience is dependent on the actual number of visitors during their stay in the area; and this is primarily determined by the average length of stay and by the seasonal pattern of use.

It must be concluded that a basis for determining the full use-capacity of the Saariselkä area is almost entirely lacking. For the purpose of this study, the following assumption will be made: the full-capacity use of both the wilderness part and the day-use part of Saariselkä area will be 1,5 x the present level of use. This projection may be more a conservative than a liberal one. If the present rate of growth of recreation does not decrease substantially, the projected level of use will be reached in about ten years.

7. PRODUCT RELATIONSHIPS

71. General considerations

The basic knowledge needed in the management of multiple-use forestry is that of the physical relationships between the different uses of forestry land. In the concepts of production theory that means, as earlier stated, the knowledge of production functions for multi-commodity forest production. However, it must directly be said that the goal of constructing such production functions in an exact sense is still remote. Most knowledge in the area consists by far of the effects of point inputs of timber production (e.g. silvicultural or cutting measures) on other uses or short bits of a production function for not more than two commodities. This is the present situation at least in Finland and perhaps the situation elsewhere can be characterised in more or less the same way. This, at least to some extent, is understandable. As it has taken numerous decades to construct production functions for timber only, it is only natural that it also takes time to construct joint production functions for two or more commodities. And it is logical that progress towards the goal goes stepwise via the increasing knowledge of point inputs and of bits of joint production functions.

In the following, the emphasis is on defining the general forms of product curves illustrating the relationships between timber, reindeer and recreation in the conditions of the study area. The conclusions drawn are partly based on the empirical material collected in this study, partly on other studies and – illustrating the present state of our knowledge – to a large extent also on deductive reasoning. The three commodity production model summarizing the findings of the chapter still remains more illustrative than empirical.

72. Timber production and reindeer grazing

721. The nature of the multi-commodity production problem

The simultaneous production of timber and reindeer in Northern Finland is a rather special phenomenon in world forestry. Only in Sweden does a similar joint production problem prevail to a comparable extent.

In broad terms the joint production problems arise from the mutual connections between the two forestry land uses or, in other words, between the two types of production. The main characteristic of these connections is their multiplicity: they are varying in extent, intensity and duration; they may be one or two-sided and they may occur at the level of primary or secondary production. According to the earlier classification of multi-commodity production (see Chapter 36), the case of reindeer and timber stands for that of separable products, especially if we look at the primary production phases. But if the production of timber and reindeer is considered from the standpoint of secondary production, then the case gets more traits typical of assorted production; this ambiguity only reflects the special nature of joint forest production.

The central problem in the joint production of reindeer and timber is, of course, the relationships prevailing between them. The long history of the co-existence of reindeer grazing and timber production in Finnish Lapland and in Sweden indisputably indicates that they are not incompatible (exclusive) uses of forestry land.

Although this is the case there still remains a number of alternative relationships between timber and reindeer. The still current discussion on the conflicts between reindeer grazing and timber production explicitly – or at least implicitly – indicates the competitive relationship assumed to dominate between them. This may be the case. However, there still are many alternative degrees of competition; and further, it may be asked whether the competitive relationship prevails at all levels of timber production.

722. Timber production and ground lichens

7221. Earlier studies

The relationships between timber production and reindeer grazing in Northern Finland have been discussed since the beginning of the present century (Porolaidunkomisioonin . . .1914, *Reuter* 1914, *Renvall* 1919, *Aaltonen* 1919). The emphasis in the early discussions was on the assumed negative effects of reindeer on forest regeneration (cf. Chapter 724).

Since the 1950's, as the cuttings and silvicultural measures have become more intensive the effects of timber production on the ranges of reindeer have aroused more and more concern (e.g. *Helle,* R. 1966, *Pohtila* 1970, *Vaara* 1972, *Kärenlampi* 1973, *Mikola* 1973, *Saastamoinen* 1977b, 1978, *Mattila* and *Helle* 1978, *Helle* and *Saastamoinen* 1979, *Mattila* 1979). Also in Sweden similar problems have become current (*Skuncke* 1955, 1958, 1963, 1964, Kungl. Lantbruksstyrelsen 1970, Lantbruksstyrelsen 1976, *Eriksson* 1975, *Engsås* 1975, *Mattsson* 1981).

There are really many considerations concerning the influences of cuttings and silvicultural measures on reindeer forage. However, systematic and long-term studies are lacking. Also, the more comprehensive studies are directed only to the effects of certain measures (point inputs), not to those of the whole timber production process. Therefore only a tentative description of the relationships of timber production and reindeer forage can be outlined. The following presentation will be limited to the most important winter forage plants: ground lichens (*Cladina* spp.), arboreal lichens (*Bryoria* spp., *Alectoria* spp, *Parmelia* spp.) and wavy hairgrass (*Deschampsia flexuosa).*

As forage resources of semidomestic reindeer, lichens have a peculiar position in that they are not converted to meat to any great extent. The production of reindeer meat is primarily the result of summer forage. However, lichens allow the reindeer to survive over the long winter period. No other food is steadily available then in sufficient amounts (*Helle* and *Oksanen* 1978).

The most important lichen ranges are barren (ClT), dry (ErClT) and sub-dry (EMT) Scots pine stands on mineral soils. The main characteristic of lichen woodlands in Finnish Lapland is the dominance of Scots pine. In northern Canada, on the other hand, the dominant tree species on lichen woodlands is spruce and in the U.S.S.R Siberian larch as well (*Ahti* 1978). Pine-dominant lichen woodlands are also important in the U.S.S.R (*Andrejev* 1954).

The positive effects of forests on the growth of lichens comprise protection from wind, which increases the relative moisture of the soil, and gathering of snow, which prevents early freezing as lichens may grow for some time under the snow cover (*Andrejev* 1954, p. 46–47).

The common view in Finland is that the most abundant lichen cover will develop in mature pine stands, where the growth conditions for lichens are favourable. This point of view is supported by the knowledge about forest and lichen succession.

As stated above lichens are characteristic of certain forest site types, the classification of which is made on the basis of the mature state of the community (e.g. *Lehto* 1964, p. 21). Therefore, the predominance of lichens on the ground layer of certain forest site types is characteristic of the late stages of succession. This is also clearly seen from vegetation succession after a forest fire on some forest site types (*Sarvas* 1937, p. 28, *Ahti* 1977). The abundance of reindeer lichens (*Cladina* spp.) grows as the time since the forest fire increases (*Sarvas* 1937, p. 28; Figure 23). Also the observations by *Scotter* (1964, p. 48) confirm an increase of reindeer lichens with the age of forest.

It can be argued that the effect of clear cuttings on reindeer lichens resembles that of a forest fire, but is by far not so drastic. Further, it may be supposed that in seed tree cutting which represents a less intensive method of regeneration cutting than clear cutting, the influences upon reindeer lichens are even a little less drastic. Maybe the differences between clear cutting (which in practice is not used for regeneration of pine forests in the sphere of the study area) and the common seed tree method would not turn out to be significant because of the number of shelter trees left after the cutting is, practically speaking not so great (cf. p. 32). *Eriksson* (1975) also considers that from the standpoint of reindeer grazing there is no great difference between the clear cut and the seed tree cutting.

Besides the negative changes for growth conditions of reindeer lichens the cuttings cause also direct physical impediments, e.g., heavy logging machines crush lichens and slash covers them, making it difficult also for animals to graze on lichens. On the other hand, lichens protected by slash may grow rather swiftly (*Eriksson* 1975).

After the area has become restocked by natural regeneration the ordinary production stages follow in due course: removal of shelter trees, cleaning of sapling stands and thinnings. The effects of these measures remain much weaker compared with regeneration fellings. Some positive effects may appear, e.g., the thinning of a sapling stand too dense may improve the growth of reindeer lichens (*Kärenlampi* 1973).

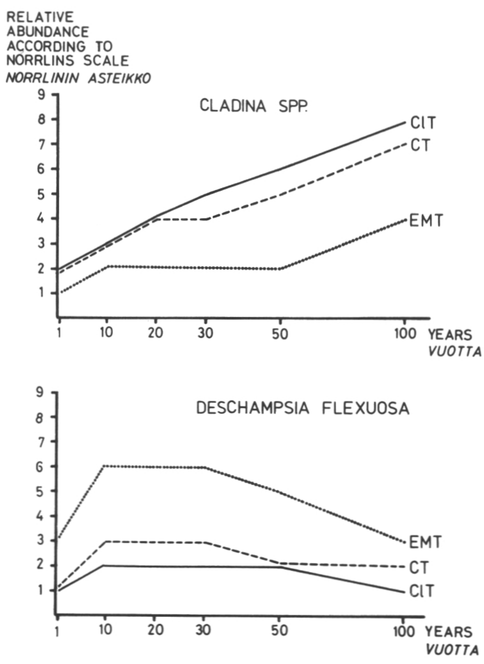


Figure 23. Ground lichen and *Deschampsia* succession after forest fire on the basis of *Sarvas* (1937, p. 28).
Kuva 23. Maajäkälien ja metsälauhan sukkessio kulon jälkeen Sarvaksen (1937, s. 28) esittämien tietojen mukaan.

The above considerations concern the effects of timber production on ungrazed lichen stands. The problem is further complicated by the fact that lichen resources as a rule are heavily grazed; they are far from being in the most productive state (e.g. *Aaltonen* 1919, *Ahti* 1961, *Andrejev* 1977, *Kärenlampi* 1973, *Mattila* and *Helle* 1978, *Mattila* 1981). When the lichen ranges are heavily grazed the detrimental effects of cuttings concern less the available lichen resources than their potential growth.

This situation makes it more difficult to evaluate the real disadvantages of cuttings on the present lichen ranges (*Kärenlampi* 1973). However, according to the results of winter range inventory attached to the National Forest Inventory, the average quantities of reindeer lichens were somewhat smaller in young forests than in older ones (the latter even including also shelterwood stands) (*Mattila* 1981).

Still it must be emphasized that more important than the actual quantities of reindeer lichens is the productivity and the availability of lichen stands. The productivity of reindeer lichen stands is optimal when they are neither too young nor too old (*Andrejew* 1954, p. 50–51, *Scotter* 1964, *Kärenlampi* 1973).

The availability of lichen stands, on the other hand, depends primarily on the properties of the snow cover. The risk of hard snow preventing digging is greater on a cleared site than in an area protected by forests (*Eriksson* 1975).

7222. The results of the inventory of winter ranges and an example of the product-transformation curve

The inventory of reindeer winter ranges of the study area was carried out using the method developed for the reindeer range inventory in connection with the National Forest Inventory (*Mattila* and *Helle* 1978, p. 7–11, *Mattila* 1981). Field work was done in connection with that total inventory, and a part of the sample plots (67) were combined. However, most of the sample plots (215) were collected separately using a systematic line plot survey. Four sample plot lines, a to-

(Photo – *Kuva: Olli Saastamoinen*)

Figure 24. Ungrazed reindeer lichens.
Kuva 24. Laiduntamatonta jäkälikköä.

tal of 107,5 km, were drawn through the study area. Two sample plots per kilometer were systematically sampled. The total number of sample plots was 282. In each plot the range characteristics were estimated from ten experimental squares (50 x 50 cm). The basic stand characteristics concerned the plot stand. The quantities of dry matter were calculated according to the functions of Helle (*Mattila* and *Helle* 1978, p. 11).

In the study area reindeer are grazing the year round. All land, except the narrow zone near the state border, is continuously used by reindeer. The effects on reindeer lichen stands of timber production are strongly complicated, perhaps even eradicated, by the varying grazing pressure on different stands. The drastic difference between average biomass of lichen stands on the few sample plots in the ungrazed zone (1754 kg/ha) and the grazed area (212 kg/ha) shows the strong influence of grazing. Thus the following results must be considered as no more than tentative.

The stages of timber production are here described only by the development class of the stand. As earlier stated the development class distribution of the area is far from normal. Therefore, only some sample plots were located in young forests. It must be pointed out, however, that most stands in many different development classes are unmanaged and are in their successive stage after, e.g., forest fire. The comprehensive stand description was, however, available only for a rather small part of the plots, the number of which was too small for more detailed analysis.

The quantities of lichen stands by development class and by two site types for pine forests are shown in Figure 25. Two conclusions, given the above, seem to be justifiable. The quantities of lichen in seedling and sapling stands are smaller than in stands at later stages. The shelterwood cuttings decrease the amount of lichen compared with that in mature or pre-mature forests. The differences in the data, however, are not very great.

The combination of the quantities of reindeer lichens with the development classes of forest by site types is a modification of the production function to the case of two products: reindeer lichen and timber. The way of presenting the relationships between timber and reindeer lichens in Figure 25 does not represent a product-product curve. However,

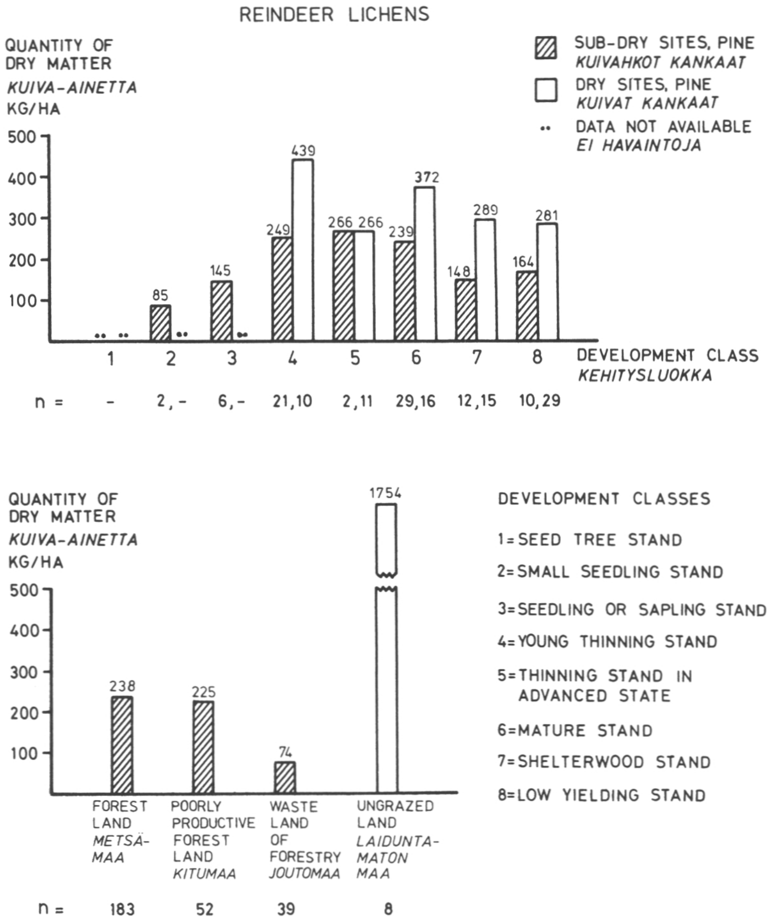


Figure 25. Results of the inventory of reindeer winter range in the study area.
Kuva 25. Porojen talvilaitumien inventoinnin tuloksia tutkimusalueella. Kehitysluokat: 1=aukea ala tai siemenpuusto, 2=pieni taimisto, 3=taimisto tai riukuasteen metsikkö, 4=nuori kasvatusmetsikkö, 5=varttunut kasvatusmetsikkö, 6=uudistuskypsä metsikkö, 7=suojuspuumetsikkö, 8=vajaatuottoinen metsikkö.

it is possible to construct the product-product curve on the basis of data similar to those in Figure 25 presupposing that we have a complete series of the quantities (or outputs) of lichen stands by development class. The principles of the product-transformation curve and a hypotethical example are outlined in the following.

The long term mean yield of timber is crucially dependent on the development class structure of the forest area. If there are only constantly mature stands the harvestable net increment remains very low, perhaps near the zero level. The lichen production in mature stands will be large. If, on the contrary, the development class structure of the forest area is such that it consists of enough seedling and sapling stands and stands at thinning stage, the area of stands over regeneration age remaining very low, the long term mean yield of timber will be the greatest (*Kuusela* 1977, p. 7). The lichen production will then be on a lower level because of the greater share of young development classes. However, also the optimal development class structure for timber yield consists of some mature stands and largely stands at pre-mature stages. Therefore the lichen production will never reach zero; rather, it will remain at the level, which depends on the actual lichen production of the different development classes. As the actual relationships between lichen production and the development classes of stands are not known without the grazing effect, the approach is illustrated in Table 16 using a hypothetical develop-

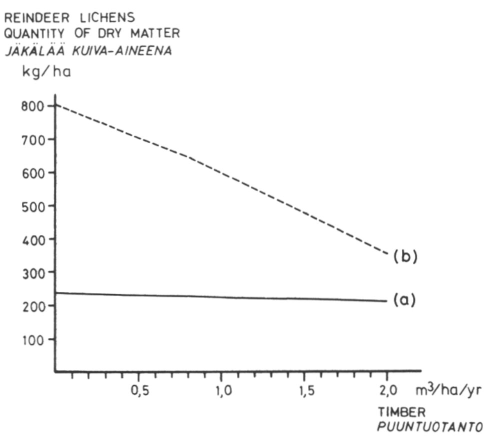
Table 16. An illustrative example of product-product (product transformation) relationships between timber and reindeer lichen production on sub-dry sites dominated by pine in the study area. Quantity of lichens by stand development class is illustrated by two alternatives: (A) denotes the results of this study under grazed conditions (*=extrapolated), (B) is hypothetically ajusted from grazing effects. Long term mean yields of timber through different combinations of development classes are tentative estimates.

Taulukko 16. Esimerkinomaiset tuote-tuote-(tuotetransformaatio-)suhteet puuntuotannon ja poronjäkälän välillä mäntyvaltaisilla kuivahkoilla kankailla tutkimusalueella. Jäkälämäärää kehitysluokittain kuvaa kaksi vaihtoehtoa: (A) on tämän tutkimuksen mukainen, jossa laiduntaminen vaikuttaa tuloksiin (=ekstrapoloitu); (B) vaihtoehto on hypoteettinen ilman laidunnusvaikutusta. Puun pitkän tähtäimen keskituotokset eri kehitysluokkayhdistelmien vallitessa ovat suuntaa-antavia arvioita.*

	Stand development class[1] *Metsikön kehitysluokka*[1]							Timber production *Puun-tuotanto* Long term mean yield *Keskituotos* m³/ha/y	Quantity of reindeer lichens *Poronjäkälien määrä* (A) According to this study in grazed conditions *Tämän tutkimuksen mukaan laidunnetuissa oloissa* kg/ha	(B) Hypothetical without the effect of grazing *Hypoteettinen ilman laiduntamisen vaikutusta* kg/ha
	1	2	3	4	5	6	7			
	Quantity of lichens by development classes *Jäkälää kehitysluokissa* kg/ha									
(A)	50*	85	145	249	266	239	148			
(B)	50	85	145	300	500	800	148			
	Areal distribution of development classes, per cent *Kehitysluokkajakautuma pinta-alan mukaan, %*									
	0	0	0	0	0	100	0	0,0	239	800
	1	2	2	4	5	85	1	0,4	233	724
	2	3	4	9	10	70	2	0,8	229	649
	3	5	5	15	15	55	2	1,1	225	576
	3	7	7	20	20	40	3	1,4	221	502
	4	8	9	25	25	25	4	1,7	216	428
	5	10	10	30	30	10	5	2,0	211	353

[1]See Figure 25 – *Ks. kuva 25*

ment series of ungrazed lichen stands on sub-dry pine site type (B in Table 16). Even the long term mean yields of timber are proxy values. The hypothethical and the empirically estimated product-product curves are shown in Figure 26.



On the basis of Table 16 and Figure 26, even taking into account their hypothethical nature, it is possible to make an important conclusion: lichen production and timber production are competitive forest products but only at a certain level. Even the optimal development class structure of stands from the standpoint of timber production maintains lichen production, which, however, remains under the level of that in mature forests. On the basis of the data of this study it is not possible to determine the decrease concerned quantitatively.

723. Timber production and arboreal lichens

When hard or deep snow prevents reindeer digging down to ground lichens, arboreal lichens provide the most important natural forage for reindeer in the forest zone.

Figure 26. Illustrative product-transformation curves for timber and reindeer (ground) lichens on the basis of table 16: (a) is the result of this study in heavily grazed conditions, (b) is a hypothetical one. The long term mean yields of timber represent tentative estimates.

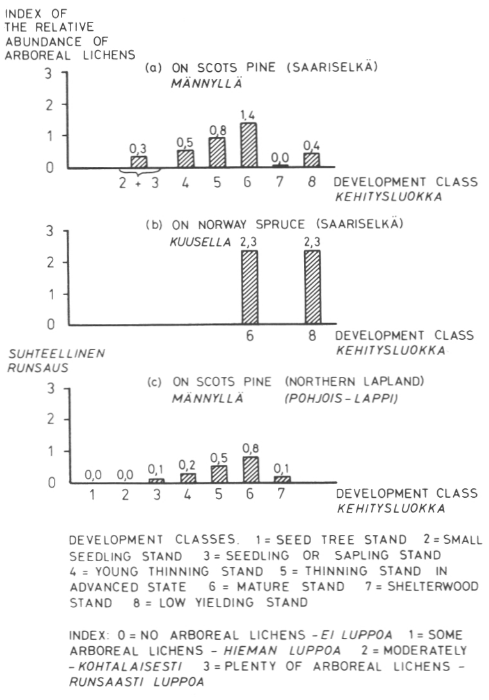
Kuva 26. Esimerkinomaisia transformaatiokäyriä puuntuotannon ja poronjäkälien määrän välillä taulukon 16 mukaisesti: (a) on tämän tutkimuksen tulosten perusteella laskettu voimakkaan laidunnuspaineen oloja edustava, (b) on hypoteettinen. Puun pitkän tähtäimen keskituotokset ovat suuntaa-antavia arvioita.

The typical species of arboreal lichens are *Bryoria fuscences* -group, *Bryoria fremontii, Bryoria furcellata* and *Alectoria sarmentosa.* Also the epiphytic *Parmelia* lichens – especially on birch trunks – may be mentioned (*Ahti* 1978).

The effects of logging on the availability of arboreal lichens have contradictory features.

At first sight benefits from logging are conceivable. Cutting areas make tree lichens abundantly available for reindeer. It has been estimated that in the mid 1970's a tenth of the reindeer in the whole reindeer management area were pasturing in the cutting areas during the harshest part of winter. However, the regional differences were very great (*Saastamoinen* 1978).

Arboreal lichens provide an example of a type of joint production, which, according to the classification adopted here, represents primarily a case of *coupled products.* When a tree is cut the whole amount of arboreal lichens on it is available to reindeer for winter forage. The more trees are felled, the more forage there is for reindeer.



However, the forage of arboreal lichens will be efficiently consumed by reindeer only if the forest rich in arboreal lichens is cut in winter, especially when the digging for ground lichens has become difficult.

It is easy to see that from the standpoint of the utilization of arboreal lichens two extreme cutting models can be evaluated. The first will proceed only from the needs of timber production, arboreal lichens being only an attending by-product which as such has no effect on production decisions. The other proceeds from considerations of reindeer grazing, the volume and the timing of cuttings being entirely determined by the annually varying needs of reindeer for arboreal lichens in winter. In the latter case, the supply of arboreal lichens would be the main product and timber a by-product. In fact, about a hundred years ago this kind of system actually existed: the cutting of old spruce forests rich in arboreal lichens was to a large extent done for the purposes of reindeer grazing (*Heikinheimo* 1922, Porolaidunkomisiooni 1914). The explanation was, of course, the lacking commercial value of spruce forests at that time. In this respect, the situation has radically changed.

The yearly timing of the cutting of forests rich in arboreal lichens for late winter is no doubt useful to reindeer. However, a more crucial problem in present day cuttings is the sufficiency of arboreal lichens (*Saastamoinen* 1978).

The most abundant resources of arboreal lichens are to be found in old forests. According to *Mattila* (1979) forests with at least moderate amounts of arboreal lichens in the whole reindeer management area are mostly more than 120 years old. Two thirds of forests with moderate amounts or plenty of arboreal lichens consist of mature stands. About one half of the pine forests with arboreal lichens and a total of three fourths of the spruce forests with arboreal lichens in the whole reindeer management area should be regenerated within ten years if treated solely according to silvicultural requirements (*Mattila* 1979). The rapid regeneration of forests rich in arboreal lichens would mean a heavy decrease in the stock of arboreal lichens,

Figure 27. The dependence of arboreal lichens on the development classes of the stands: (a) and (b) are the results of this study, (c) is calculated from the data of *Mattila* (1979).

Kuva 27. Lupon runsauden riippuvuus kehitysluokista: (a) ja (b) ovat tämän tutkimuksen tuloksia, (c) on laskettu Mattilan (1979) esittämästä aineistosta. Kehitysluokkien selitykset ks. kuva 25.

which already have become scarce because of the vast regeneration fellings in recent decades.

The dependence on the stand characteristics of the amount of arboreal lichens is illustrated in Figure 27. The amount of arboreal lichens in a stand is expressed using an ordinal scale and therefore the averages of the scale do not indicate absolute, but rather some kind of relative amounts of arboreal lichens in a development class. In any case the relationships between the relative abundance of arboreal lichens and the development classes of stands appear as elementary joint production functions. The two uppermost diagrams, (a) and (b), are the results of this study; diagram (c) is calculated from the data of *Mattila* (1979).

It is obvious that regeneration cuttings, even those carried out by seed-tree or shelterwood methods, sharply decrease the stock of arboreal lichens. The more interesting feature is the very slow rate of revival of the arboreal lichens in the course of stand development. It seems to follow the forest succession in that the most abundant resources of arboreal lichens are found in mature forests, which in extreme conditions may take 200 years to mature.

The higher stocks of arboreal lichens in mature spruce forests as compared with mature pine forests is visible in Figure 27. However, the sample of spruce stands was very small and comparisons between spruce forests and pine forests in other development classes cannot be made.

More clearly than in the case of ground lichens it can be deduced that cuttings decrease the long-term yield of arboreal lichens although the cutting of mature forests for a short time increases the available supply of arboreal lichens. On the basis of the available data, it is not possible, however, to determine the decrease of the yield quantitatively. The relative decrease seems to depend mainly on the development class distribution of the forest area. In any case the normally managed forest area produces also arboreal lichens and thus timber production and the production of arboreal lichens are not exclusive but competing forms of production.

724. The influence of reindeer on forests

As in many other cases of multi-commodity production in forestry, the relationships between reindeer and timber are reciprocal: besides the influences of forestry operations on reindeer production one must also take into account the influences of reindeer on forests.

In fact, in the beginning of the present century precisely these latter influences were in the limelight when the relationships between reindeer and forestry were intensively discussed. It was assumed that reindeer hamper the regeneration of pine forest and in the worst case even cause the lowering of timber line (e.g. *Renvall* 1912, 1919, Porolaidunkomisioonin mietintö 1914, *Reuter* 1914). Reindeer were thus considered to be very harmful animals for forestry and propositions were made for limiting their number. However, even at that time views were also presented, according to which reindeer do not create serious harm for forest regeneration (*Aaltonen* 1915, 1919). This point of view has later gotten wide support (*Kangas* 1937, *Lehto* 1969, *Norokorpi* 1971, 1981, *Heikkilä* 1981). However, the damages caused by reindeer are, as a rule, only occasionally serious (cf. *Bergan* 1962), e.g., for birch plantations (*Lähde* and *Raulo* 1977). In recent decades some new attention has been focused on the possible favourable effects of reindeer on forest regeneration instead of on the damages (*Repnevski* 1963, *Lehto* 1969, *Brown* and *Mikola* 1974).

Generally speaking, under the conditions prevalent in Finnish Lapland, semi-domesticated reindeer are harmless animals as far as forests are conserned. In this respect, they differ from elk (*Alces alces*), the most important game species in Finland at the present time.

73. Timber production and recreation

731. General considerations

The relationships between timber production and recreation are, to say the least, diverse. To put it briefly, these relationships depend on the form of recreation and on the forest characteristics which, together with the economic factors, determine the main features of timber production. It is important to notice that the intensity and the methods of timber production vary depending on site, climatic conditions, economic circumstances and, in addition, country (for the above reasons and for other reasons as well, e.g., mere tradition). However, at least as much as the forms of timber production, also the forms of recreation vary. Therefore, for considerations concerning the relationships between recreation and timber production, it is often useful to determine explicitly the forms of both forest uses in question. That, however, does not mean that generalizations about the relationships between timber and recreation are impossible. They surely are not. However, as is true for many other forestry questions there is a strong need for research which is specific not only to a particular region (*Andrews* 1979) but which also takes into account the highly varying forest characteristics.

The effects of timber production practices on recreational activities depend, both on the above-mentioned considerations and on the role of forests in the recreation environment and in the landscape. In this sense, the concept of visual vulnerability means the potential of a landscape to absorb man's activities or be visually disturbed by them (*Litton* 1974). The concept of wilderness, on the other hand, implies a certain kind of social aspect or significance in the visual vulnerability assessment. According to *Leopold* (1921) a wilderness is a continuous stretch of country preserved in its natural state, open to lawful hunting and fishing, big enough to absorb a two weeks' backpacking trip, and kept devoid of roads, artificial trails, cottages, or other works of man.

The distinction between the visual and social vulnerabilities of the recreational landscape means that one timber production practice having the same visual vulnerability can have the different effects on social vulnerabilities of the landscape. For this reason, among others, the evaluation of recreational environments implies more qualitative than quantitative aspects. As *Litton* (1979) puts it: many visual elements and relationships can be measured and scaled, but resulting assessments are relative rather than quantitative. Qualitative approaches are the norm for present landscape evaluations.

The emphasis on qualitative aspects of the evaluation of recreation environments does not imply that landscape evaluation basically is subjective. As a matter of fact, the question of the subjective or objective nature of landscape values is important even if it is not often explicitly considered. Even here, it must be left without further consideration.

The relationships between timber production and recreation are reciprocal. However, in the following, the direct physical effects of recreational use on timber production are only briefly considered.

732. The impact of timber production on recreation: the preferences of recreationists

7321. The study method

There are many alternative methods for studying the impact of timber production on recreation. It is possible to seek the optimal physical conditions for each form of recreation and then evaluate the characteristics of forest areas or stands using the conditions as criteria. Many of the practical directives of the forestry or planning authorities are based on this kind of deductive reasoning on the basis of practical experience (e.g. *Veijola* 1979, Metsähallitus 1970, Luonnonsuojelu 1970). However, this approach presupposes certain assumptions about the preferences of the recreationists that need to be studied more closely. This kind of work has also been done, concentrating, however, largely on the study of verbal attitudes. Most often the preferences of recreationists concerning the forest environment and timber management practices have been studied by the methods of field interviews and questionnaires (in Finland e.g. *Loven* 1971, 1973a, 1973b, 1974, *Saastamoinen* 1972, *Kellomäki* 1975, 1978, *Jaatinen* 1976).

The verbal statements used in questionnaires and interviews can, however, give only very general knowledge about attitudes. If there is a need to get more detailed and less ambiguous information about, e.g., stand preferences, the only possibility is to interview the recreationists in the forests (e.g. *Kellomäki* 1975) or to use photographs or slides (e.g. *Shafer* et al. 1969, *Hultman* 1976, 1979, *Kardell* 1978).

Here the *slide method* was chosen because of its many advantages (e.g. *Daniel* and *Schroeder* 1979). The most important advantage of slides in studying stand preferences is the possibility of concentrating on the essential characteristics of stands thereby cutting down the effects of background landscape, terrain forms and illumination or weather conditions. The showing of slides can be organized in peaceful laboratory-like conditions for many people at the same time. With the aid of slides it is possible to repeat performances and to collect easily a large body of material. The greatest difficulty in the slide method is probably the collection of homogenous and technically invariable slides which are valid for the study problem (cf. *Probst* 1979, *Brush* 1979); however, there is much evidence that people evaluate representations of landscapes in the same manner in which they evaluate actual scenes (*Shafer* and *Richards* 1974, *Daniel* and *Boster* 1976).

The study was limited to the stand level because the stand is the basic unit of timber production. A series of 40 slides was collected on different pine stands in the Saariselkä area. The slides were taken in the years 1976–78. The presentation of slides to recreationists was organized in August 1978 in the study area. The recreationists rated the slides according to landscape value and value for recreation by using a scale from 4 to 10 points (a scale familiar from school). Here only the value of stands for recreation is considered. A total of 108 recreationists evaluated the slides, usually in groups of 5–7 persons. The whole series of 40 slides was first shown to the group of recreationists in a few minutes and then one by one for 30 seconds. It was emphasized to the recreationists that they pay attention only to stands, not to the technical properties of slides. The main stand characteristics were rated separately on the basis of the slides by a small expert panel. Here the only characteristic used is the development class, which also can be rather uniformly determined from slides.

7322. Main hypotheses and results

The first hypothesis concerned the uniformity of recreationists' preferences. It is assumed that there is a certain level of uniformity in the evaluations of the recreational value of stands.

The results concerning the preference uniformity hypothesis are shown in Figure 28, where, besides the means of scores and their standard deviations, the distribution of scores by stands are represented. The stands are in order of preference. General uniformity in the evaluations of stands can be said to prevail. The standard deviations are moderate and no clear two-peak phenomenon in the distributions of scores can be seen. The standard deviations were smallest among the best and worst evaluated stands. This, however, reflects also the effect of the scale. The standard deviations were largest for natural-state stands where there were many decaying fallen trees (stands n:o 13, 27, 15, 16, 22, 17) or for seedlings (stands n:o 8,10).

The second hypothesis was that the recreation value of a stand depends on its development class. It is assumed that the later stages of succession of stands are preferred to the earlier ones.

The relationship between the recreation value of stands and the development classes

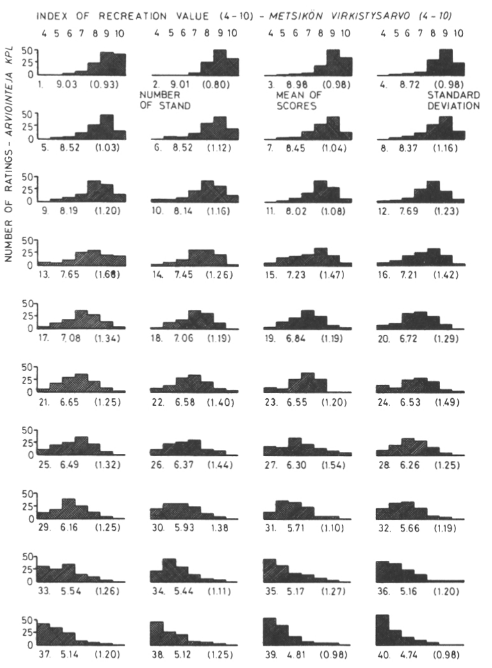


Figure 28. The uniformity of landscape preferences. Stands (1–40) are in order of preference. Scaling: 10=best, 4=lowest. Total of 108 recreationists evaluated the stands on the basis of slides.

Kuva 28. Maisema-arvostusten yhdenmukaisuus. Metsiköt (1–40) ovat preferenssijärjestyksessä. Arvosteluasteikossa 10=korkein, 4=alhaisin pistemäärä. Metsiköiden retkeilyarvon arvioi dia-kuvilta 108 retkeilijää.

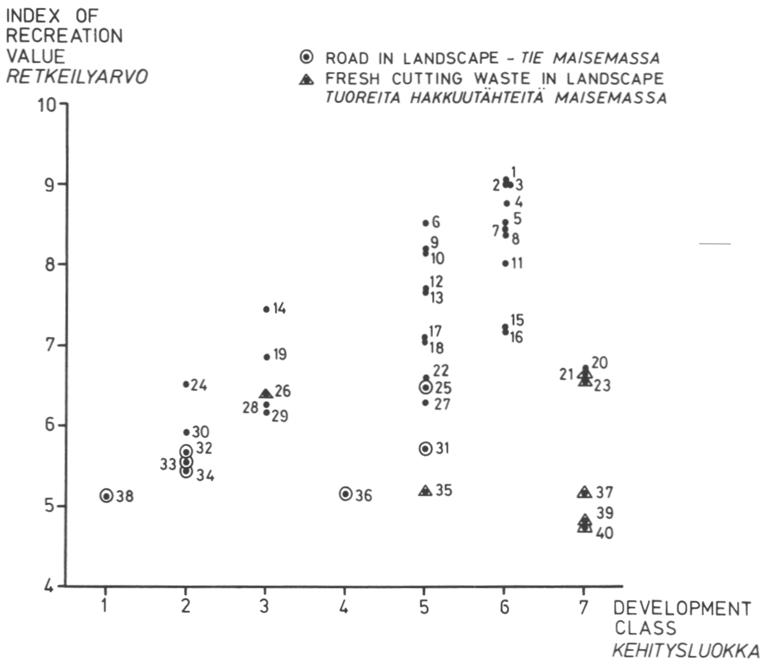


Figure 29. The dependence of the recreation value of a stand on its development class and prevalence of forest roads and fresh cutting waste. The number of stand refers to Figure 28.
Kuva 29. Metsikön retkeilyarvon riippuvuus metsikön kehitysluokasta sekä teiden ja tuoreiden hakkuutähteiden näkymisestä metsikkökuvassa. Metsikön numerointi viittaa kuvaan 28. Kehitysluokat: 1=aukea ala tai siemenpuusto, 2=pieni taimisto, 3=taimisto tai riukuasteen metsikkö, 4=nuori kasvatusmetsikkö, 5=varttunut kasvatusmetsikkö, 6=uudistuskypsä metsikkö, 7=suojuspuumetsikkö.

of stands is presented in Figure 29. First a weakness in the data must be mentioned: all development classes are not well represented. Secondly there are also stands the recreation values of which reflect not only stand characteristics but also other landscape elements (roads, fresh cutting waste). They relate to a third hyphothesis which will be treated later.

In spite of the low representation of younger development classes it seems justifiable to say that the most appreciated development class from the standpoint of recreation value is that of mature forests. Generally this material seems to suggest that the recreation value of stands increases continuously from small seedling stands to mature stands. Shelterwood stands seemed to be approximately at the level of seedlings or sapling stands. It can be assumed that a seed tree stand will be rated somewhat lower than a shelterwood stand. As we have stated earlier, open areas (clear cuttings) do not belong to the normal treatment of pine forests in the study area.

The third hypothesis was that the forest roads, which mean a permanent change in landscape, will be rated lower than other treatments (cuttings) of stands. The pictures of stands where forest roads were visible were generally rated low. However, in this material it seems that pictures of stands with rather fresh cutting waste got approximately equally low – perhaps even lower – scores. If the possible effect of slide variability here (as in other scores also) is disregarded, it may be assumed that the difference between permanent (forest roads) and temporary (cutting waste) landscape changes had not influenced the evaluations of recreationists.

The possible effects of slide variability or order of presentation were not tested here. As stated above an attempt was made to eli-

Table 17. An illustrative product-product (product transformation) relationship between recreation (index of recreation value) and timber in the study area.
Taulukko 17. Esimerkinomainen transformaatiosuhde puuntuotannon ja ulkoilukäytön (retkeilyarvon) välillä tutkimusalueella.

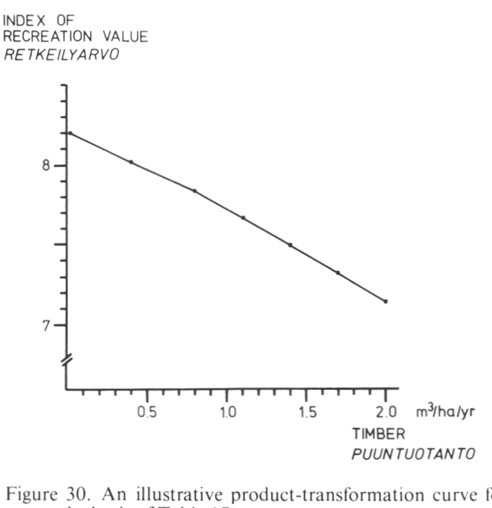
Stand development class[1] *Metsikön kehitysluokka*							Timber production	Outdoor recreation
1	2	3	4	5	6	7	*Puuntuotanto*	*Ulkoilukäyttö*
Index of recreation value by development classes *Retkeilyarvoindeksi kehitysluokittain*							Long term mean yield[2]	Index of recreation value for the study area
5.6	6.1	6.6	7.1	7.7	8.2	6.7		
Areal distribution of development classes, per cent *Kehitysluokkajakautuma pinta-alan mukaan, %*							*Puuntuotos*[2] m^3/ha/y	*Alueen retkeily-arvoindeksi*
0	0	0	0	0	100	0	0,0	8,20
1	2	2	4	5	85	1	0,4	8,02
2	3	4	9	10	70	2	0,8	7,84
3	5	5	15	15	55	2	1,1	7,67
3	7	7	20	20	40	3	1,4	7,50
4	8	9	25	25	25	4	1,7	7,32
5	10	10	30	30	10	5	2,0	7,14

[1]See Figure 29 – *Ks. kuva 29*
[2]See Table 16 – *Ks. taulukko 16*

minate the former by oral directives and the latter by showing all slides once before rating.

7323. Considerations concerning the form of product-transformation curve

As in section 7222., it is possible to construct a product-product curve for recreation and timber. The index of the stand's recreation value, which was estimated for development classes by graphical smoothing from the material presented in Figure 29, will be used here as a recreation product. The method of calculating the index of recreation value for the study area is presented in Table 17 and a product-product curve is presented in Figure 30.



The constructed product-product curve is in many ways hypothetical. Even so it shows that a competitive relationship between recreation and timber prevails in a forest area. However, it must be remembered that the index of recreation value was here calculated for the whole area on the basis of the stand. In fact, it is clear that the total value of the study area for recreation is not the sum of the values of the discrete forest stands. This can be explained, e.g., by a marked difference between the *enclosed* and *canopied* landscapes (*Litton* 1979, p. 221–222).

Yet another side of the problem is that any index of the recreation value of the landscape is, strictly speaking, only one factor, however important, influencing actual recreational use. Many other factors influence it as well, especially the nature and the strength of demand.

One must therefore conclude that the study of landscape preferences at the stand level, although it yields important results, is as such insufficient for constructing a pro-

Figure 30. An illustrative product-transformation curve for timber and outdoor recreation (recreation value), on the basis of Table 17.
Kuva 30. Esimerkinomainen transformaatiokäyrä puuntuotannon ja ulkoilukäytön (alueen retkeilyarvon) välillä taulukon 17 tietojen pohjalta.

duct-product (product transformation) curve for timber and recreation.

Deductive reasoning is the only way here to treat the gap between the empirical results about stand preferences ant the needed information on the effects of timber production on the actual recreational use in the study area.

The point of departure is that forests in the study area constitute only one landscape element among others. Besides dense, well-developed forest there are a great deal of scrubland forest and open fell as well as rivers and some lakes. One of the most important amenities of the study area is its harmonious, diverse topography, which is a fundamental and constant element of the landscape.

However, despite the indisputable facts above, one can postulate that the mainly virgin and unmanaged forests constitute the decisive factor which gives the area its wilderness appeal. And if the concept of wilderness is regarded as a central factor in the recreational use of the study area, then it rather definitely also determines the relationships between recreation and timber production. All definitions of wilderness types emphasize them as wide areas preserved in their natural state, kept devoid of roads and artificial trails, and without the effects, of e.g., logging (*Leopold* 1921, *Schwarz* et al. 1976). One may think that as far as the wilderness is concerned, the construction of forest roads has even more profound effects than, for example, silvicultural or seed-tree cuttings because roads represent a permanent and irreversible change in the landscape. However, forest roads will not be constructed without logging although, at least in some cases, it is technically possible to do logging in winter without permanent forest roads by taking advantage of the snow cover. The high costs of roadless winter logging may make this method hard to apply. Moreover, according to the common characteristics of wilderness areas, even this would be incompatible with the meaning of wilderness.

The empirical results about stand preferences showed a competitive relationship prevailing between recreation and timber in the study area. On the basis of the above reasoning it can be further concluded that, because the study area clearly has retained the character of a wilderness, the degree of competition between recreation and timber production is so strong that it gets the form of a *convex* product transformation curve.

733. The effects of recreation on timber production

In contrast to the serious effects of timber production practices on recreation, the physical effects of recreation on timber production are insignificant in the study area. Three principal types of effects could emerge: trampling damages affecting forest regeneration, effects of trampling on tree growth and other damage recreationists cause to living trees.

The first two types of damages are insignificant in the study area because of the low recreation use intensity which is typical of wilderness recreation. In the whole study area the average use intensity in summer was estimated to be only 59 use days/sq.km. This is, for example, roughly 1/3 000 of the intensity of the camping areas on which *Nylund* et al. (1979) studied the deterioration of forest ground vegetation and the decrease in the radial growth of trees. In that study it was estimated that after ten years' use the growth in the trampled areas was 35 % lower than in untrampled areas. Similar results have been reported, e.g., by *LaPage* (1962), *Prohorov* (1977) and, from a more general point of view e.g. *Gordienko* (1977) but they all concern the areas with heavy use intensity.

The more probable effects are the damages to the living trees. Young trees are occasionally used for camping purposes and sometimes fresh wood is used also for fuelwood, especially in the case of small birches in the fell area. From the standpoint of economic timber production they have no practical significance.

The bigger question is the use of dry fuelwood by recreationists. It is estimated that during a year, about 700 m^3 of dry pine wood is consumed in the wilderness huts owned and managed by National Board of Forestry (*Martikainen* 1980) and perhaps as much in the other huts and outdoor camps. The supply of fuelwood for wilderness huts and "saunas" has become not an easy task. Compared to the figures presented by *Gordienko* (1977) the above seem, however, modest and may, in fact, be underestimated.

When considering the physical effects of recreation on timber production; we can say that at the level of use at present or in the near future they are insignificant. The physical effect of recreation on timber production at the present level of use represents an indifferent influence.

74. Recreation and reindeer grazing

As uses of forestry land, recreation and reindeer grazing have some common features.

Both are more or less extensive land uses if the extensiveness is measured by the size of population per unit of area. The average number of reindeer older than one year in the whole reindeer management area varies generally from 1 to 2 per sq.km. In the northern parts it is approximately 2 reindeer per sq.km. (e.g. *Helle,* R. 1966, p. 30–31). The average user density in the wilderness part of the study area was earlier estimated to be about 0,1 persons per sq.km in recent years (see p. 53) although higher in summer months.

Reindeer grazing and recreation are both flexible and "moving" land uses with areally, seasonally and annually varying patterns of use of forestry land. In reindeer husbandry the movements of reindeer can be influenced by herding measures: in recreation the changes in the pattern of use can be achieved, e.g., by information, by directives or by guides. In both cases, however, the flexibility of movements has only a certain scope; for reindeer it is limited by the food supply and for recreation it is limited by the nature of the recreation experience.

A further common feature of reindeer grazing and recreation is their need for certain types of forest environments. As has been outlined in the preceeding chapter, both reindeer grazing and recreation forests with mature stands or thinning stands in an advanced state are preferred. These kind of forests have probably the best capacity to produce recreation and reindeer grazing (winter forage) outputs.

The relationships between reindeer grazing and recreation are not easy to explain unambiguously. Recreation has negative effects on reindeer grazing. There is hardly any physical influence of recreation which could be interpreted as being positive for reindeer husbandry. However, the evaluation of the degree of these negative effects is a much more complicated task. On the other hand, the effects of reindeer grazing on recreation are mainly positive. Reindeer increase the attractiveness of a recreation area. Even more generally the reindeer is one of the most characteristic "trademarks" of the tourism in Lapland for native as well foreign tourists (e.g. *Helle,* R. 1966).

In more detail the effects of recreation (wilderness hiking, day-trips) on reindeer grazing can be grouped in the following way:

1) The deterioration of lichen stands by trampling and camping.
2) The disturbances and flight of reindeer caused by recreationists.
3) Other troubles caused by recreation (e.g. injuries to reindeer caused by sewage).

It is well known that ground lichens are very delicate and can be damaged even by occasional trampling. This has been confirmed by many studies, which have shown that the trampling tolerance of ground lichens is particularly low (e.g. *Willard* and *Marr* 1970, *Kellomäki* and *Saastamoinen,* V-L. 1975, *Hoogesteger* 1976).

However, the real effects of trampling on ground lichens depend decisively on how evenly trampling is distributed over the area.

Even if hiking both in the day-use part and in the wilderness part of the study area is free everywhere a majority of recreation probably concentrates along the many trails leading to the surroundings of wilderness huts or camping places near rivers and brooks. Clear signs of deterioration of ground vegetation by trampling are mostly to be found in these areas and in the neighbourhood of the hotels and other accommodation houses (*Hoogesteger* 1976). But as a rule the effects of trampling are not clearly visible outside the trails, huts and other places where the recreational use is concentrated.

The main reason for using trails on a large scale when hiking between the huts is the relatively long distances between huts; a heavy pack compels one to choose the most convenient route to one's destination and these kinds of choices generate the system of trails. Other reasons for using the trails, in addition to minimizing physical strain, may be the ease of orientation, safety reasons or a desire to meet other hiking people or parties. But for many hikers these at the same time can be the reasons for the opposite choice, i.e. for avoiding trails and this no doubt does more harm to the lichen stands. However, even they have some kind of carrying capacity. Only an insignificant part of the forest land consisted of barren sites with an almost pure lichen cover, the trampling tolerance of which must be regarded as being the lowest.

In accordance with the inventory of reindeer forage resources, some observations were made on the deterioration of ground vegetation by trampling. An attempt was also made to determine the relative weight of trampling among the other factors causing the deterioration of ground vegetation.

In the systematic line plot survey (p. 56) observations in each plot were made in a circular sample plot, the radius of which was 20 m. Each circular sample plot was classified according to the following scale: no deterioration, light deterioration, moderate deterioration and strong deterioration. The last class meant that in a circular sample plot there was extensive uncovering of mineral soil and the humus layer. Light deterioration meant that the signs of deterioration are slight, but in any case clearly visible.

There are many factors causing deterioration of ground vegetation and soil. Many of them are at work simultaneously. Often it is difficult to determine the weight of each factor. In this sample, however, an attempt was made to determine the main factor causing deterioration in each circular sample plot. The following classes of probable main causes were formulated:

1. None of the following
2. Hiking and camping
3. Motorized terrain vehicle (excl. logging machines)
4. Reindeer
5. Natural erosion (wind, water, frost etc.)
6. Logging
7. Unknown

The results of the inventory are shown in Table 18.

Signs of deterioration in ground vegetation, the humus layer or mineral soil were observed in two thirds of the circular sample plots. Of these, however, the greater part was considered to be due to the effects of natural erosion or reindeer. Signs of hiking or camping were observed in 6 % of all 217 systematic sample plots, of which most had lightly or moderately deteriorated. These results are in many ways uncertain. The classes were subjective and the determination of the main causes was difficult. Even the number of sample plots, which was determined by the method of forage inventory, was rather small. In each plot the exact proportion of deteriorated area remained undetermined. Therefore only tentative conclusions can be made.

The signs of recreation are clearly visible in the study area. However, the proportion of deteriorated area cannot be determined by the method used. Its upper limit according to this material is considerably less than the above-mentioned 6 %, which shows the share of plots where signs of deterioration were observed. The deteriorated area may be estimated roughly at 1–2 % at the most, but is probably even less.

The trampling effects of recreation do not depend solely on the quantity of the area which has deteriorated, but even more on the

Table 18. The deterioration of ground vegetation and the uncovering of the mineral soil with the probable main causes according to the systematic line plot survey (217 plots).
Taulukko 18. Kasvillisuuden kuluminen ja kivennäismaan paljastuminen todennäköisine syineen systemaattisen linjan-arvioinnin mukaan (217 koealaa).

Degree of deterioration *Kulumisaste*	Probable main causing factor – *Todennäköinen syy*: None of the following *Ei mikään seuraavista*	Natural erosion *Luonnon eroosio*	Reindeer *Poro*	Hiking and camping *Ulkoilukäyttö*	Logging *Puunkorjuu*	Motorized terrain vehicle (excl. logging machines) *Moottoroitu ajoneuvo (ei metsäkone)*	Unknown *Tuntematon*	Total *Yhteensä*
No deterioration – *Ei kulumista*	73							73
Light – *Lievä*		28	36	5	2	3	4	78
Moderate – *Kohtalainen*		19	19	5	4			47
Strong – *Voimakas*		12	3	3		1		19
Total – *Yhteensä*	73	59	58	13	6	4	4	217

quality of the trampled area as range. The plots classified as deteriorated were more often than other plots on forest land. However, the number of deteriorated plots was small.

The quantity of lichen on the deteriorated plots did not essentially deviate from that on other plots. This was a somewhat surprising result, which may result from the low grazing pressure on areas which are in the sphere of recreation. Because of the small number of deteriorated plots, this may be also the result of random factors, however.

In any case, it seems that the weight of trampling in the deterioration of ground vegetation is clearly less than that of natural factors and of reindeer itself. From the standpoint of reindeer grazing it is, nevertheless, an extraordinary pressure.

It is possible that more harmful than the trampling effects for reindeer is the disturbance of reindeer by hikers and skiers. Reindeer are very timid and flee easily when met by a group of hikers. Especially in winter, this causes an energy loss which can be noticeable in poor nutrition conditions.

No attempt is made here to determine the number of encounters between hikers and skiers and reindeer. It depends on the yearly range rotation of reindeer and the movements of the recreationists. In winter the decisive factor is the degree of herding of reindeer. By continuous herding and by proper guiding of recreationists the encounters can be minimized.

In 1970, according to the questionnaire (*Saastamoinen* 1972, p. 113) 23 % of winter vacationists and 15 % of wilderness skiers complained about the small amount of reindeer. Among the summer vacationists and hikers, the figures were 6 and 5 %, respectively. These figures, however, do not tell about the number of encounters, but only about the fact that in summer the encounters between recreationists and reindeer were probably more frequent than in winter.

Closely related to the disturbance of reindeer by recreationists is the actual loss of range caused by the abundance of recreationists in the day-use area near outdoor centers. Reindeer from this area have fled on a large scale and thus reindeer husbandry has lost some important calving areas (*Aikio* 1977, Matkailu/porotaloustoimikunnan . . . 1973, *Lenstra* 1973).

Other nuisances that recreation can cause for reindeer husbandry are refuse, e.g., bottles, tins (which sometimes can hurt reindeer), the leaving open of gates of reindeer fences, unintentional disturbances by recreationists which hamper collection and herding of reindeer, congestion problems in wilderness huts, many of which have been built by reindeer management units, and the difficulty of supplying of fuelwood owing to the greater consumption of fuelwood in the vicinity of huts (see e.g. *Viranto* 1977).

One may enumerate many similar nuisances for reindeer husbandry caused by recreation. Their significance in practice, however, hardly approaches that of the first two groups of negative effects. It is also worth mentioning that, although recreation at the physical level causes almost solely negative effects on reindeer husbandry, the socioeconomic effects are in the main positive. Recreation and tourism greatly increase the demand of reindeer meat and souvenirs made of reindeer material. It is also probable that recreation as such increases the generally positive attitude toward reindeer husbandry.

Lastly, one can mention that reindeer grazing also has some effects on recreation. The heavy grazing decreases to some extent the visual grace of lichen stands (*Sarvas* 1970). On the other hand, reindeer themselves represent the exciting and appreciated elements in the landscape (e.g. *Helle,* R. 1966). There is no doubt that the importance of the latter exceeds that of the former manyfold.

75. Product mix alternatives

A product mix is a concept which tells what commodities are chosen for production and in what quantities. In other words, it indicates the combination of forest uses in a certain area and also the level of intensity for each use.

The product mix alternatives are the solutions of the multi-commodity production function for the area – if one succeeds in the construction of such a function. In this study the empirical and even technical knowledge does not reach that level. The technical production functions for each forest use were only schematic ones and the attempts to construct the empirical two-commodity product

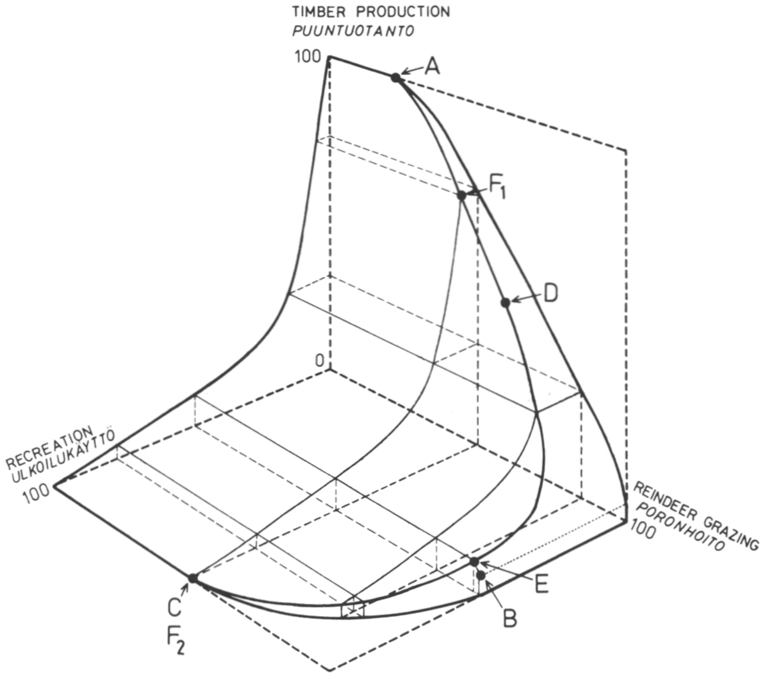


Figure 31. An illustrative three commodity model. Each axis show the relative volume of production, 100=full capacity production or full use.
Kuva 31. Esimerkinomainen kolmen hyödykkeen malli puuntuotannon, poronhoidon ja ulkoilukäytön kesken. Kukin akseli osoittaa tuotannon suhteellista tasoa, 100=tuotantomahdollisuudet täysin käytössä.

functions produced only fragmentary knowledge of the prevailing relationships.

Even if the empirical data is still insufficient for constructing production functions for the three commodity case, it is possible to analyse the product mix problem with the help of a general three commodity model. The model is presented graphically in Figure 31. The model is, as stated, a deductive one. It is not based on empirical data even though the shapes of relationships between the forest uses get support from data collected or presented in this study. In a theoretical sense the three-commodity model synthetizes the findings presented in this study.

In the graphical model (Figure 31) each axis represents the relative volume of respective forest uses. The zero point indicates that the commodity is not produced at all in the study area, the other end of the axis means that the potential production capacity of the area for that forest use is fully utilized.

The points A, B and C show the production mixes when alternately the maximum production capacity of the area is utilized for the benefit of each of the forest uses. In point A timber production is 100 (= the timber producing capacity of the area is in full use) and the relative levels of reindeer grazing and recreation are 20 and 1 respectively. In point B the value for reindeer grazing is 100, for recreation 50 and for timber production 5. In point C correspondingly recreation is 100, reindeer grazing 50 and timber production 1. The above figures, even if hypothetical, indicate that in the conditions of the study area every fully applied forest use always leaves some room at least for one other forest use.

Point D indicates the case when timber production is 50 and other uses are at their maximum (reindeer grazing 69 and recreation 10) in this level of timber production. Correspondingly point E shows the half capacity point (50) for recreation when timber production and reindeer grazing are at their conditioned maximum (10 for timber production and 99 for reindeer grazing). If reindeer grazing is kept at the level of 50 there remain two alternative combinations for the maximum of other uses: in point F_1 timber production is 74 and recreation 6 whereas in point F_2 recreation is 100 and timber production therefore 1. Point F_2 then joins point C.

If reindeer grazing is pursued in a relatively extensive way (1–20 per cent of full capacity) it has no effects on production decisions, which will be then directed to favour either timber production or recreation. If the intensity of reindeer grazing varies from 20 to 50 per cent of full capacity the relationship between reindeer grazing and recreation does not play any role in decision making. At a level of intensity of reindeer grazing greater than 50 per cent of full capacity, all three forest uses influence decision making when only the technical aspect of it is concerned.

There are indeed plenty of alternative product mixes which can be chosen. What the criteria are for choosing any of the numerous possible product mixes is another question. The difficult answer involves the "pure" economic part of the whole range of problems of multiple-use forestry and this is considered in the following chapters.

8. ECONOMIC EVALUATION OF FOREST USES

81. Theoretical considerations

The technical analysis of production problems shows the feasible alternatives of production possibilities, but as such it does not say anything about the desirability of the feasible product mixes.

If one wishes to say that one product mix is better than another, one must have some criteria for comparison. The choice of criteria for comparison is the first step in the process of evaluation.

The choice of the criteria for comparison is at the same time the choice of the value(s) from the point of view of which the comparison will be carried out. The assignment of quantitative or qualitative measures of value to the alternatives is the second phase in the evaluation process; on this basis, the final rating of alternatives is made.

The choice of criteria is no doubt the most critical point in the evaluation process. Different criteria lead to different ratings. If, for example, in the product-mix problem concerned, the main criteria for evaluation should be the preservation of the culture of an ethnic minority, the outcome of the rating would surely be different from that obtained by using the alternative criteria of satisfying the raw material needs of the forest industry. The former belongs to the group of cultural or social values, while the latter may be said to have more the character of economic values.

In fact, the concept of value admits of various interpretations. It is a concept of philosophy, sociology and of economics as well. Consequently, one may speak of e.g., ethical, cultural, social or economic values on the basis of the character of the main criteria and argumentation used in evaluation.

However, the scope of interest here is the evaluation problem from the standpoint of economics. It may be useful to consider first what the main difference between "economic" and "other" values is.

The core of the economic problem has been generally said to be the allocation of scarce resources to alternative uses (e.g. *Tamminen* 1967, p. 37). Economics is about making the best of things (*Layard* and *Walters* 1978, p. 3). From these very short definitions one can conclude that there exist no principal differences between economic and other goals as such; rather, the differences lie more in the way these goals are achieved. If scarce resources are needed in achieving a goal in a way which means a sacrifice in the achievement of another goal, then the situation has the character of economic problem.

It is useful to mention explicitly that economic values can be non-monetary ones. The lack of monetary prices does not mean that things are not – or cannot be – considered economic goods. If the decisions concerning non-monetary values arise from competing demand for scarce resources, they are basically economic ones (*Sinden* and *Worrell* 1979, p. vii). In fact, as *Sinden* and *Worrell* (1979, p. 86–88) show, there are many situations where reasonable decisions can be made without the need of monetary equivalents for (goal) values; it is presupposed, however, in most cases that monetary costs are known.

In economics, the concept of value has many special meanings which are important from the point of view of economic evaluation.

In a general sense, as a product of unit price and quantity, the term value indicates the volume of that quantity in monetary terms. In the following chapters, the values of outputs of different products are expressed in this customary way.

The concept of value has more specific meanings in the theories of value. According to *Schumpeter* (1954, p. 588), the problem of value must always hold a pivotal position as the chief tool of analysis in any pure theory that works with a rational schema.

In value theories, the term "value" refers to a quantity which more or less closely serves as a causative basis for price.

It must be pointed out that in the theories of value the meaning of *value* deviates from that of common usage. This concept means a more or less abstract quantity which serves as or is the "cause", "source", or "substance" of that common characteristic of commodities which makes them exchangeable. In the labour theories of value, it is the quantity of labour embodied in commodities (*Ricardo* 1817, p. 63, *Marx* 1867, p. 49, *Young* 1978, p. 13), in subjective and marginalist value theories it is utility in a more or less pronounced form (*Jevons* 1871, p. 2, *Marshall* 1890, p. 51–53, *Wicksteed* 1910, p. 382, *Samuelson* 1964, p. 433).

More concrete concepts than value itself are those of *use value* and *exchange value.* Use value refers to the utility of a commodity, i.e. to the useful properties of a thing in their "natural" form (e.g. *Neelsen* and *Mueller-Bülow* 1973, p. 14–17). Exchange value of a commodity, on the other hand, refers to the amount of other commodities which can be obtained in exchange for the commodity concerned.

It is important to notice in the evaluation of forest benefits that use value and exchange value are conceptually very different and can vary markedly (e.g. *Wennergren* and *Johnston* 1977, p. 4, *Tsymek* 1980, p. 18). This is obvious, for example, in the case of recreational benefits of forests.

As use values, commodities differ qualitatively from each other. One cannot add up recreation days, cubic metres of timber and kilograms of reindeer meat much as it is impossible to add up apples and oranges. However, a possibility in the case that one alternative product entirely lacks exchange value could be the study of the alternatives in terms of use values. This kind of approach is applied in the following chapters.

Finally, some words are needed on the relations between values and *prices.* Price is regarded as exchange value expressed in monetary terms. As a rule, prices refer to *market prices,* which are those prices that can be actually observed when goods and services are exchanged in markets. For many reasons, e.g., the effects of demand and supply, market conditions etc., market prices may deviate from values not only quantitatively but also qualitatively.

In the cases where market prices do not exist or for one reason or another are considered inadequate, shadow pricing can be used. *Shadow prices* are estimates of "real" economic values in the above cases (e.g. *Gregersen* and *Contrera* 1979). In this study, the use of shadow prices would be possible in the economic evaluation of backpacking as a wilderness use. However, they are not used on account of the assumption that all recreation benefits are to be realized in the returns of tourist enterprises of the study area.

The economic evaluation of each land use (product) is made by using two measures of economic importance. First among these is the *value of total output,* which is calculated for timber and reindeer as value = quantity x market price. The value of total output of recreation (tourism) is calculated by summing up the values of outputs (gross receipts) of tourism enterprises.

The second measure is *value added.* Value added is obtained by subtracting from the value of total output all purchased intermediate goods and services. It measures properly that part of total value which is produced on site. Value added includes wages, profits and rents.

For the evaluation of product mixes, values added are used. In addition, as mentioned above, an attempt is made to utilize use values.

82. The value of output of timber production

As market prices are available on the case of timber production, the value of the total output of timber production can be calculated in the usual way; value = quantity x unit market price.

There are no principal difficulties in estimating the value of timber production in the above sense. There are data available on the costs and prices of timber production in the statistics of state forests. Also the quantities of timber production in the study area can be determined within certain limits which are due to the nature of the problem.

The only principal point which needs some consideration is the phase or level of production which is chosen as the basis of value determination.

The value of timber production can be determined in different stages of timber production on the stump (stumpage value), at the beginning of the long-distance transport (delivery value) or at the end of long-distance transport ("factory value").

When timber production is considered as the output of forestry land in a certain area, it is the delivery value which best expresses this point of view.

The delivery prices of timber, as well as timber prices generally, are, in practice the result of many factors (e.g. *Gregory* 1972, p. 327, *Palo* 1979). Formally they are the sum of delivery costs and stumpage prices.

The structure of average delivery costs for state forests in the Inari region for some recent years are shown in Table 19. It can be seen that felling and cross-cutting of timber make up on the average about 45 % and haulage 25 % of total delivery costs.

Table 19. The main components of total average delivery costs in state forests of Inari region, in 1975–78, real prices.
Taulukko 19. Keskimääräisten hankintakustannusten rakenne metsähallituksen Inarin hoitoalueessa vuosina 1975–78, reaalihintoihin.

	1975	1976	1977	1978
	FIM/cu.m. – *mk/m³*			
Joint delivery costs – *Hankinnan yhteiskustannukset*	7,15	6,08	6,17	6,87
Felling and preparation of timber – *Puutavaran valmistus*	21,08	23,49	23,46	21,78
Haulage – *Lähikuljetus*	11,93	11,48	11,80	11,64
Administrative and subsidiary activities – *Hallinto ja aputoiminnot*	7,57	8,50	7,56	8,63
Total delivery costs – *Hankintakustannukset yhteensä*	47,73	49,55	48,99	48,92

The stumpage prices of delivery sales in state forests are computed values and reflect, e.g., the effects of changes in timber stocks. So they can fluctuate a little bit more than the real stumpage prices.

The delivery prices applied to the study area, obtained by summing up the average delivery costs of state forests and stumpage prices of state forests are shown in Table 20. The costs and stumpage prices are real from years 1975–78 expressed in 1978 money.

Table 20. Delivery prices of timber in the state forests of Inari region in 1975–1978, real prices.
Taulukko 20. Reaaliset hankintahinnat Inarin valtion metsissä vuosina 1975–1978.

	1975	1976	1977	1978
	FIM/cu.m. – *mk/m³*			
Stumpage price – *Kantohinta*	58,48	47,40	54,38	31,08
Total delivery costs – *Hankintakustannus*	47,73	49,55	49,01	48,92
Delivery price – *Hankintahinta*	106,21	96,95	103,39	80,00

The "moderate" stumpage price level in the Inari region is due to the local saw mills, to a lesser extent also to the higher stumpage prices of building snags and dry (barkless) pulpwood and the scale advantages in sales and transport of timber in the state forest organization. However, it is possible that the calculated delivery prices are a little too high; on the other hand one might say that in fact a part of long-distance transport costs could be included in the delivery value of the study area.

The *value of total output* of timber production calculated on the basis of average delivery price of 1975–78 and alternative cutting removals is presented in Table 21.

The value of short term timber production varies from FIM 2,8 mill. to FIM 7,8 mill. depending on the alternative of allowable removals. The value of the estimated long term timber production is FIM 4,1 mill. annually.

Value added of timber production is obtained by subtracting intermediate consumption from the value of total output.

Intermediate consumption in timber production comprises mainly operating costs of power saws and forest tractors including some other minor costs (*Mäkelä* and *Nurminen* 1980, p. 50). Here it is assumed that intermediate consumption is 15 % of costs of felling and preparation of timber, 25 % of forest haulage costs and 10 % of other delivery costs.

In 1978 intermediate consumption was 7,8 % of the value of output of timber production and the same figure concerns also the average for the years 1975–1978.

In 1978 value added of timber production

Table 21. The value of total output of timber production according to alternative allowable removals, in 1978 money.
Taulukko 21. Puuntuotannon arvo vaihtoehtoisilla kertymäsuunnitteilla, vuoden 1978 rahassa.

Alternative allowable removals – *Kertymäsuunnite-vaihtoehto*	m^3 per yr *m^3/v*	Delivery price *Hankintahinta* FIM/m^3 *mk/m^3*	Value of timber production *Puuntuotannon arvo* Mill FIM *milj. mk*
Short term, minimum[1] *Lyhyt tähtäin, minimi*[1]	29 309	96,60	2,831
Short term, average[2] *Lyhyt tähtäin, keskiarvo*[2]	51 927	96,60	5,016
Short term, maximum[1] *Lyhyt tähtäin, maksimi*[1]	80 678	96,60	7,793
Long term allowable removals[3] *Pitkän tähtäimen kertymäsuunnite*[3]	42 139	96,60	4,071

[1] See table 10. – Ks. taulukko 10.
[2] The average of the alternatives in table 10. – Taulukon 10 vaihtoehtojen keskiarvo.
[3] See table 12 and text p. 36. – Ks. taulukko 12 ja teksti s. 36.

was FIM 4,6 mill. and the annual long-term estimate is FIM 3,8 mill.

83. The value of output of reindeer management

The value of reindeer management output can be calculated in a way similar to that used for timber production, i.e. the quantity of reindeer meat produced x its unit market price.

Besides meat, the output of reindeer production includes hides and antlers but, according to common practice, the reindeer are sold as whole carcasses including the by-products.

Reindeer are slaughtered in corrals, where all reindeer are gathered in late autumn and in winter. Slaughtered animals are then transported by deep-freeze trucks to plants for further processing.

The price of reindeer meat in corrals corresponds then to the delivery price of timber. Reindeer meat sold in corrals can be said to be at the beginning of long-distance transport and therefore at the same stage of the production process.

The *values of total outputs* of reindeer production for some recent years are presented in Table 22. The yearly slaughterings vary very much depending, e.g., on the survival of calves and on the succes in gathering reindeer. In 1978 the value of the output of reindeer production in the study area was about FIM 0,7 mill.

The estimate of the long term value of reindeer production on the sustained yield basis is a little higher, about FIM 1,0 mill. annually according to the average real price of 1975–1978.

Value added of reindeer production is the value of total output minus intermediate consumption. The most important purchased inputs related to reindeer management work are the costs of snowmobiles. In the study area, most reindeer management work is carried out in winter with snowmobiles, which means great fuel and oil costs. In snowless periods cross-country motor cycles are also used. The fuel and lubrications costs of motorized vehicles (including cars) make up about half of the whole intermediate consumption. Other cost items are, e.g., repair of motorized vehicles, snowplowing in corrals and transport of supplementary feed. The share of intermediate consumption was calculated on the basis of estimated "normal year" cost and price level and thus represents only a rough approximation. The figure 21,8 % was obtained for the share of intermediate consumption in the value of total

Table 22. The value of total output of reindeer production in 1975–78, in real prices.
Taulukko 22. Porotalouden tuotannon arvo vuosina 1975–78, reaalihintoihin

Year *Vuosi*	Number of reindeer older than one year *Lukuporot kpl*	Number of slaughtered reindeer *Teuras-tettuja poroja kpl*	Unit weight *Teuras-paino* kg/reindeer *kg/poro*	Meat production *Lihan-tuotanto* kg	Price of reindeer meat[1] *Poron-lihan hinta[1]* FIM/kg *mk/kg*	Value of reindeer production *Porotuo-tannon arvo* FIM *mk*
1975	3 544	932	26.0	24 232	18,75	454 350
1976	5 310	1 732	26.0	45 032	17,85	803 821
1977	5 139	1 816	26.0	47 216	16,20	764 899
1978	3 118	1 577	26.0	41 002	16,40	672 433
Long term estimate[2] *Pitkän täh-täimen arvio[2]*	7 001	2 310	26.0	60 068	17,30	1 039 176

[1] Gross price including the value of hides and antlers. – Ns. karvakilon hinta, johon sisältyvät talja ja sarvet.
[2] See table 13. – Ks. taulukko 13.

output of reindeer production. It is lower than the percentage estimated for a whole reindeer management area by *Mäkelä* and *Nurminen* (1980, p. 35) for the year 1975, owing primarily to the unusually low value of total output of reindeer production for the whole reindeer management area in that year.

Values added of reindeer production in 1978 and in the long term are thus lower by this percentage than the values of total output, FIM 0,5 mill. in 1978 and annually FIM 0,8 mill. in the long term.

84. The value of recreation (tourism) output

There has been a good deal of discussion on the pricing problems of recreation benefits (e.g. *Clawson* and *Knetsch* 1966, *Grayson* 1972, *Gundermann* 1976, *O'Connel* 1976, *Zivnuska* 1978).

No attempt is made to review the discussion here, but some conclusions made in the course of the discussion may be illuminating. *Gundermann* (1976) concludes his review on economic procedures used in outdoor recreation evaluations with the following observations: all evaluation methods discussed, in as much they implicitly or explicitly involve utility, display no empirical strength precisely because they are to be based on this operationally exclusive concept in the first place. *Zivnuska* (1978) points out that over the years a considerable amount of time and effort has been devoted to attempts to develop proxy values for extra-market costs and benefits which could be introduced into economic analyses as the full equivalents of market values. In his judgement there have been few, if any, useful results from such efforts. After the critical curvey of the concept of consumers' surplus as a proxy for the market value of, e.g., a visitor day, he makes the following skeptical statement: indeed, it may be that this whole effort to find a market value proxy involves a search for that which does not exist.

The problem of dealing with extra-market costs and benefits is encountered, besides in the economics of multiple use of forests, also elsewhere in forest economics, above all in many areas of general economics. The problem of "unpriced values" is familiar in the spheres of, e.g., welfare economics, public economics, environmental economics (e.g. *Mishan* 1974, *Johansen* 1970, *Musgrave* 1959, *Mäler* 1974). Even more generally it concerns the theories of value (e.g. *Saastamoinen* 1977c, cf. *Ahonen* 1970).

The purpose of this study is not to consider the theoretical problems involved in evaluating recreational benefits; indeed, a pragmatic solution has been applied here which deals with the products not at a primary but at a secondary stage of production. It is later assumed that the income from tourism is comparable to the delivery values of timber and reindeer.

However, a brief comment on the discussion will be made. It is possible that much of the confusion and ineffectiveness in attempts to find substitute or shadow prices for unpriced recreational benefits is due to an unclear notion of what is really being sought: a shadow price for exchange value or a shadow price for use value. As was earlier pointed out, this distinction is a fundamental one. This subject receives no further consideration; rather, attention is shifted to the nature of the pragmatic solution applied here.

Although the outdoor recreation in an urban forest or park satisfies the same human needs as outdoor recreation in remote wilderness areas, the expenditures on these two recreation alternatives differ strikingly. While the former is usually free or includes only minor transport costs, the latter includes always high transport costs, food costs and usually also lodging and other costs.

The expenditure of recreationists are distributed widely by region: some expenditure will be made in their home town, some on route and some on or near the recreation site (*Clawson* and *Knetsch* 1966, p. 232–239, *Saastamoinen* 1972, p. 129–139).

The part of recreationists' expenditure which is consumed on the recreation site is of particular interest. In a way it measures the recreational value of the site. It is undoubtedly clear that an area with excellent recreational characteristics has the ability to gather more visitors and visitors who stay longer than an area of similar location but without the same kind of outstanding features. Of course it is true that there may have been many nearby and equivalent areas, of which only one is chosen for tourism development. In such a case, the lack of recreational facilities does not mean non-existent potential recreational value. However, if the choice has not been an arbitrary one, the developed area also must have had some preferable characteristics.

The statement that the expenditures of recreationists in the area somehow measures the recreational value of the area is a very general one. For many reasons, it also will remain so.

The first reason was already mentioned above. The lack of recreational facilities (and therefore the lack of consumption possibilities for recreationists) as such does not deny the potential of recreational value.

The second reason is that on-site recreational expenditures are generated by the purchases of marketable goods and services in the area. Depending on the recreational use patterns of the area, these may more or less fully reflect the role of the area in the recreation production. It is possible that a certain area is in intensive wilderness use without even having any lodging or other services in the vicinity. On the other hand, there may be a vast concentration of lodging and other tourist services in the sphere of some wilderness area, the facilities serving, however, only transit visitors, who do not use the wilderness area itself. In the latter case it is not reasonable to say that the income of tourist traffic can be ascribed to any extent to the wilderness area.

Even in the case where lodging, restaurant and other facilities indisputably serve the users of a certain area, the question of what part of total income (of total expenditures) can be considered to be "a product" of the recreation area remains open.

In a sense the problem resembles that of stumpage price formation. Is there any residual remaining when the wage costs, costs of goods purchased, owner's compensation and other similar cost items have been subtracted from the total income (total returns) which can be said to be the "share" of land used for recreation in a way similar to stumpage? In fact, the minimum of that kind of residual can always be found. It is the land rent paid by the tourist hotels, hostels and other recreation houses to the land owner. However, this usually includes compensation only for the building sites even if it also somehow reflects the effects of wilderness area. Compared to the total returns of the tourist enterprises, however, this form of land rent is usually minimal and only to a minor degree illustrates the "real share" of recreation land.

In this context the problem area needs no further consideration. The way of scrutinizing the values of outputs in this study proceeds from the value corresponding the delivery value of timber. It is assumed here that in recreation, in the conditions of the study area, the most reasonable substitute is the total income from tourism as such or, rather, in value added form.

This assumption merits some further consideration. As an industry, tourism belongs to tertiary production, while timber production as well as reindeer husbandry are branches of primary production. However, when considered from the standpoint of a given area, this difference loses much of its significance. All three industries are primary users of forestry land, though in varying ways.

The difference in the recreation product as compared with timber and reindeer is in its being a final product; the others are (predominantly) intermediate products which are transported for further processing. As a service the recreation product is consumed at the same time as it is produced. However, the common feature for the value of output of all three products, when considered as the products of study area, is the absence of long-distance transport costs. The value of recreation output measured in terms of on-site expenditures of recreationists does not include travel costs from their home town to the recreation area. These travel costs, even if in a reverse form, can be regarded as counterparts of the long-distance transport costs of timber. The other question is that many of the goods purchased by recreationists in the recreation area do not include long-distance transport costs if produced (and a considerable part of them always are) elsewhere than in the vicinity of the area concerned. That problem relates to the value added form of recreation output (*Clawson* and *Knetsch* 1966, p. 239), which, however, principally concerns timber and reindeer. If the recreation value is presented in the value added form then, of course, the same must concern also the other products.

The basic conclusion is that, in spite of the very peculiar nature of recreation product, it is logically consistent to see the total income of tourism in the study area principally as the most reasonable correlate to the delivery value of timber and reindeer. Yet it must be pointed out that the total income from tourism is not regarded as the only or even the theoretically best measure of recreation value. It is only postulated that it offers a realistic basis for comparative analysis.

Table 23. Gross receipts of tourism enterprises in the study area in 1975–1978, in real prices (in 1978 money)

Taulukko 23. Matkailutulo (matkailuyritysten kokonaistuotot) tutkimusalueella vv. 1975–1978, reaalihintoihin (vuoden 1978 rahassa)

	1975	1976	1977	1978
	Mill FIM – *milj. mk*			
Bigger enterprises (on the basis of book-keeping data) – *Suurehkot yritykset (kirjanpidon perusteella)*	5,667	6,142	6,212	7,537
Other enterprises (on the basis of nightings) – *Muut yritykset (yöpymisvuorokausien perusteella)*	0,667	0,775	0,984	1,360
Gross receipts of tourism enterprises – *Matkailuyritysten kokonaistuotot*	6,334	6,917	7,196	8,897

The *total income from tourism* (gross receipts of tourism enterprises) in the study area is presented for some years in Table 23.

The total income is based on book keeping data of the four largest tourism enterprises, covering 73 % of the bed capacity of the commercial or semi-commercial enterprises. As far as the minor enterprises are concerned the calculations are based on the known number of nights and the approximate value of total expenditures per person per night in these enterprises. The total income includes also the one-night visitors, many of whom are transit visitors, especially in the summer. On the other hand the total income does not include the nominal lodging payments in the numerous recreation houses owned by organizations and firms and built for the use of their own employees. The total income also includes the expenditures of local people in the restaurants, for example; this sum however, is very small because of the small number of local residents.

In 1978 the total income was estimated to be FIM 8,9 mill. The long term income from tourism was estimated conservatively as being 1,5 times the 1978 income (cf. p. 53) and is FIM 13,3 mill. annually.

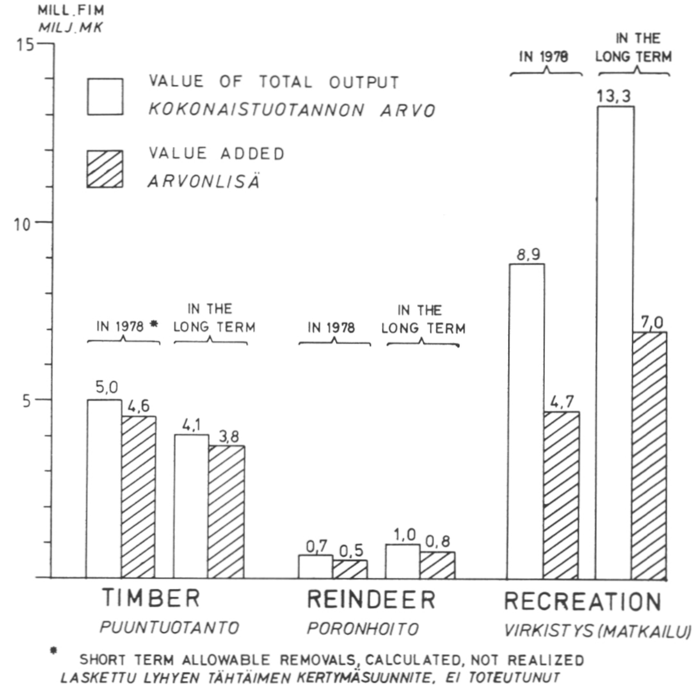


Figure 32. The economic importance of the land uses in the study area measured by value of total output and value added in 1978 and in the long term annually.
Kuva 32. Tutkimusalueen käyttömuotojen taloudellinen merkitys tuotannon kokonaisarvolla ja arvonlisällä mitattuna vuonna 1978 ja pitkän tähtäimen arviona vuositasolla.

Value added of tourism is obtained in a way similar to that used for the other two land uses, i.e. by subtracting intermediate consumption from the value of total output (total income from tourism).

Intermediate consumption of tourism enterprises consists of material purchases (e.g. foodstuffs, alcohol and non-alcoholic beverages, souvenirs from producers etc.), repair and maintenance costs, heating costs and some other items. The share of intermediate consumption was calculated from the bookkeeping data of three largest tourism enterprises on the average for the years 1976–78 and it was assumed to be the same also for other enterprises. The share of intermediate consumption in tourism enterprises is relatively high when compared to other land uses – 46,8 % in 1978 and 47,7 % on the average in 1976–1978.

Value added of tourism in 1978 was FIM 4,7 mill. and the long term estimate of it is FIM 7,0 mill. annually.

85. Comparisons of the economic importance of the land uses

The above calculations yield opportunities to compare the economic importance of each land use (product) in the study area. With the help of two measures the economic importance, i.e. values in a general sense, can be considered for the situation prevailing at the end of the 1970's (the volumes are from 1978 and prices are represented in 1978 money) and for the long term: *value of total production* and *value added.* The results of the study have been collected in Figure 32.

The value of total output of recreation (tourism) was clearly the greatest at the end of the 1970's. It was 1,8 times greater than that of timber production and 12,7 times greater than that of reindeer grazing. However, the comparisons concerning timber production at present or in the short term are unreliable because of the wide amplitude of possible alternative allowable removals when mature forests predominate. In this comparison one must further remember that the value of the output of timber is estimated (it indicates the value of possible short-term cuttings), whereas the values of output of reindeer and recreation (tourism) are real figures. In fact, if those cuttings had been realized it would have reduced the volume of recreation and reindeer production.

Comparison on a value-added basis at the end of the 1970s show timber production and recreation to be roughly equal, which is due mainly to the relatively large intermediate consumption of tourism enterprises. Value added of reindeer husbandry was at that time about 12 % of that of recreation and timber production.

For the long term, it was concluded that reindeer production would be able to increase its output somewhat and that recreation could do so considerably. Long term production of timber, on the other hand, was assumed to remain at a somewhat lower level than the short term cutting possibilities. This changes the situation in that the relative importance of recreation increases both in respect to timber production and to reindeer grazing.

On the basis of assumptions related to the long term calculations, one may see that the value of the total output of recreation (tourism) would be 4,0 times greater than that of timber production and 13,2 times greater than that of reindeer grazing. As earlier, these differences are not so great when measured by value added figures, but are still significant. Value added of recreation (tourism) would be in the long term 1,9 times greater than that of timber production and 8,8 times greater than that of reindeer grazing.

Considering the study area as a whole, recreation (tourism) is economically the most important land use. This can be seen in the situation which prevailed at the end of the 1970s and it becomes all the more pronounced when looking at the long term.

Clearly, timber production takes second place. If only the value added of timber production at the end of the 1970s is considered, it is even roughly the same as that of recreation (tourism). However, in the long term its volume decreases and it cannot compete with recreation (tourism) in economic importance when the area is taken as a whole. Of course, it must be pointed out that the output of timber here originates only from forest land, whereas in recreation and reindeer grazing it is a product of scrub land and waste land as well.

Reindeer grazing is an extensive land use and therefore its value of production remains low. Even though in the study area its relative weight as compared to timber production is higher than on the average in Finnish Lapland, it is clear that the value of output of reindeer grazing on forest land even in the conditions of Northern Lapland remains considerably lower than that of timber production.

Even more generally it is important to notice that the economic significance of the three land uses in the study area is different from that on the average in Finnish Lapland. At the provincial level, i.e. the whole of Finnish Lapland, the relative weights of the land uses concerned during the first half of the 1970's were roughly the following: timber production 100, recreation (tourism) 38 and reindeer grazing 6 (*Saastamoinen* 1977). In the study area the corresponding relative weights at the end of the 1970s were the following (using timber similarly as a measurement unit): recreation (tourism) 177, timber production 100 and reindeer grazing 14. It is likely that the change between relative weights of timber and reindeer is mostly due to the general tendency that the importance of reindeer grazing as compared to timber production increases as one moves northwards. The prominence of recreation in the study area, on the other hand, is due mostly to the special amenities of the study area itself.

The figures which describe in a different way the economic importance of each land use (product) provide even as such an important basis for decisions on land use. However, the core of the problem lies in the evaluation of alternative use combinations (product mixes). This question is considered in the next chapter.

86. Product mix alternatives as values added and use values

The available product-mix (use-combination) alternatives depend on the relationships between the products (uses). These relationships were considered earlier by pairs (Chapters 72–74) and then with the aid of the general three-commodity production model (Chapter 75). It was emphasized that the model was not an empirical one, even if it was assumed that the main forms of relationships in it were in harmony with the conclusions drawn in the earlier parts of the study.

The economic problem of the choice between the product-mix (land use) alternatives is demonstrated by means of that model. One must then bear in mind the putative character of the model.

In addition, the simplifying assumption is made that only the value added of each product (land use) is considered, the costs and cost structures of achieving the different outputs and their different levels being disregarded. In reality, of course, they play the most important role in determining the levels of output. For the sake of simplicity they have been put aside here. This means, however, that with the model it is possible to evaluate the relevance of alternative product mixes only from the point of view of the value of production under the assumption that each level of production as such would be economically feasible. Optimality from the point of view of profitability can not be evaluated with a model which excludes costs.

One assumption still needs some clarification. Recreation is here considered as a whole and coherent land use even though in practice it consists of two different groups of recreational activities (referred to earlier as "resort or day use" and "backpacking use"), the space demands and relationships to other land uses of which may in fact vary a great deal. The treatment of recreation as a whole has, however, the advantage that we can avoid the difficult problem of evaluating the free back-packing use of wilderness by simply assuming that it too is, at least to some extent, "realized" in the turnover of the hotels, hostels, etc. in the resort area. In other words, it is assumed that the real turnover can be credited to the whole study area, including its most remote and extensively used parts, which belong, however, indisputably to the natural entity of the recreational environment.

The output values are presented as *values added* because, more realistically than values of total output, they reflect the on-site benefits.

The values of alternative product mixes are considered from the standpoint of long term production possibilities, which are valued at real prices of late seventies. The long term view may be better suited than the short-term when one considers the assumptions entailed by the applied three-commodity model. Also, the estimates for long-term production possibilities for timber and reindeer rest theoretically – although not necessarily practically – on more solid ground than the short term estimates. However, the opposite concerns recreation, the long term estimate for which is the most uncertain. The long term maximum of recreation use was assumed to be 1,5 times the present level of use. Correspondingly, the volume of reindeer grazing was regarded as possibly increasing to about 1,2 times the present allowable volume. The long term output of timber, on the other hand, was estimated to be 0,5–1,4 times the estimated highest and lowest short term allowable removals and clearly lower than the average of them. Then one can say that the long term perspective to some extent is biased against timber production and favours recreation and reindeer grazing. This is still truer if one takes into account the different expansion paths for timber and reindeer grazing over the long term. However, because of the putative nature of the approach these viewpoints are not considered further.

Besides the volumes, the output values of each use are determined by unit prices. As stated above the unit prices are average real prices from late seventies expressed in 1978 money and the relative prices are assumed to have remained constant. The unit prices and especially the price relations are, of course, a critical point in the evaluation. However, in addition to examination of the alternatives and their valuation according to present prices, also analysis employing only use values is applied.

The range of feasible product mixes as use values and the corresponding output values as values added are shown in Table 24. As has been stated, the figures concerning the level of use in different product mixes are demonstrative ones. The long term values added, on the other hand, are estimates of this study.

The estimated long term value added of output for recreation (tourism) (FIM 6,98 mill) is almost two times greater than that of timber production (FIM 3,75 mill) and about nine times greater than the value added of long term output of reindeer grazing (FIM 0,79 mill). It is easy to see that due to its greatest weight, recreation has become the dominant use when the output value of product mixes is determined. The high output values were obtained for those product mixes where the level of recreation is approximately at least half of its maximum volume; and because of the convex type of the competitive product-product relation between recreation and timber production that always means a

Table 24. The range of feasible product mixes (as use values) and the corresponding values added based on a demonstrative three commodity production model.
Taulukko 24. Toteuttamiskelpoiset tuoteyhdistelmät (käyttöarvoina) ja vastaavat arvonlisät esimerkinomaisessa tuotantomallissa.

Level of use from maximum *Käyttömuodon taso maksimista*			Volume of output (use values) *Tuotannon määrä (käyttöarvot)*			Value added of the output *Tuotannon arvonlisäys*			
Timber *Puu*	Reindeer *Poro*	Recreation *Virkistys*	Timber *Puu*	Reindeer *Poro*	Recreation *Virkistys*	Timber *Puu*	Reindeer *Poro*	Recreation *Virkistys*	Total *Yhteensä*
per cent –%			m^3	kg	use-days *käyttöpäiviä*	Mill FIM – *milj. mk*			
100	20	1	42 139	12 014	3 040	3,753	0,162	0,070	3,985
90	37	2	37 925	22 225	6 079	3,379	0,301	0,140	3,818
80	45	4	33 711	27 031	12 159	3,002	0,366	0,280	3,647
70	53	6	29 497	31 836	18 238	2,627	0,431	0,419	3,477
60	61	8	25 283	36 641	24 317	2,252	0,496	0,558	3,306
50	69	10	21 070	41 447	30 397	1,877	0,561	0,698	3,135
40	77	12	16 856	46 252	36 476	1,501	0,626	0,838	3,034
30	85	15	12 642	51 058	45 595	1,126	0,683	1,047	2,856
20	92	20	8 428	55 262	60 793	0,751	0,748	1,396	2,894
10	99	52	4 214	59 467	158 062	0,375	0,804	3,629	4,809
1	100	50	421	60 068	151 983	0,038	0,813	3,490	4,340
5	*100*	50	2 107	60 068	151 983	0,188	0,813	3,490	4,490
5	*90*	78	2 107	54 061	237 093	0,188	0,731	5,444	6,363
3	*80*	89	1 264	48 054	270 530	0,113	0,650	6,212	6,975
1	*70*	95	421	42 048	288 768	0,038	0,569	6,631	7,237
1	*60*	98	421	36 041	297 887	0,038	0,488	6,840	7,365
1	*50*	100	421	30 034	303 966	0,038	0,406	6,980	7,424
1	*40*	100	421	24 027	303 966	0,038	0,325	6,980	7,342
1	*30*	100	421	18 020	303 966	0,038	0,244	6,980	7,261
1	*20*	100	421	12 014	303 966	0,038	0,162	6,980	7,180
1	*10*	100	421	6 007	303 966	0,038	0,081	6,980	7,098
1	*1*	100	421	601	303 966	0,038	0,008	6,980	7,025
1	50	*100*	421	30 034	303 966	0,038	0,406	6,980	7,424
2	79	*90*	843	47 454	273 569	0,075	0,642	6,282	6,999
4	89	*80*	1 686	53 460	243 173	0,150	0,723	5,584	6,457
6	95	*70*	2 528	57 065	212 776	0,225	0,772	4,886	5,883
8	98	*60*	3 371	58 867	182 380	0,300	0,796	4,188	5,284
10	99	*50*	4 214	59 467	151 983	0,375	0,804	3,490	4,670
12	98	*40*	5 057	58 867	121 586	0,450	0,796	2,792	4,039
15	96	*30*	6 321	57 665	91 190	0,563	0,780	2,094	3,437
20	92	*20*	8 428	55 262	60 793	0,751	0,748	1,396	2,894
53	66	*10*	22 334	39 645	30 397	1,989	0,536	0,698	3,223
100	20	*1*	42 139	12 014	3 040	3,753	0,162	0,070	3,985

low volume of timber production. On the other hand, the concave type of product-product relationship prevailed between recreation and reindeer grazing leaving the competitive area both narrow and light. Therefore, high volumes of recreation allow also a considerable volume for reindeer grazing.

According to the figures presented inTable 24 the product mix maximizing the value added of total output includes roughly the maximum of recreation, 50 per cent of that of reindeer grazing and only 1 per cent of that of timber production giving the total value added of FIM 7,42 mill. It is not more than about half a million marks greater than the value of output produced by recreation solely in this demonstrative model. If the relative output values of recreation and reindeer grazing were more balanced, the "maximum" product mix would include more reindeer grazing and timber and less recreation. In short, the "value maximizing" product mix depends on two groups of relationships: technical (physical, biological) relationships (which in their most concise form are presented by production functions as earlier mentioned) and on price relationships between the products.

If the pricing of one or more forest uses (products) is, for theoretical reasons, unsure, allowing too much room for speculative or

Table 25. Rates of product-transformation as use values in alternative product mixes.
Taulukko 25. Tuotteiden transformaatiosuhteet käyttöarvoina vaihtoehtoisissa tuoteyhdistelmissä.

Change in the relative volume of production *Tuotannon suhteellinen muutos*			Rates of production transformation *Tuotteiden transformaatiosuhteet*		
Timber *Puu*	Reindeer *Poro* Per cent–%	Recreation *Virkistys*	Timber *Puu*	Reindeer *Poro*	Recreation *Virkistys*
			m^3	kg/m^3	days/m^3 *pv*
100→90	20→37	1→2	1	2,42	0,72
90→80	37→45	2→4	1	1,14	1,44
80→70	45→53	4→6	1	1,14	1,44
70→60	53→61	6→8	1	1,14	1,44
60→50	61→69	8→10	1	1,14	1,44
50→40	69→77	10→12	1	1,14	1,44
40→30	77→85	12→15	1	1,14	2,16
30→20	85→92	15→20	1	1,00	3,61
20→10	92→99	20→52	1	1,00	23,08
10→1	99→100	52→50	1	0,16	–1,60
			m^3/kg	kg	days/kg *pv*
5	*100→90*	50→78	0	1	14,17
5→3	*90→80*	78→89	–0,14	1	5,57
3→1	*80→70*	89→95	–0,14	1	3,04
1	*70→60*	95→98	0	1	1,52
1	*60→50*	98→100	0	1	1,01
1	*50→40*	100	0	1	0
1	*40→30*	100	0	1	0
1	*30→20*	100	0	1	0
1	*20→10*	100	0	1	0
1	*10→1*	100	0	1	0
			m^3/days *pv*	kg/days *pv*	days *pv*
1→2	50→79	*100→90*	0,01	0,57	1
2→4	79→89	*90→80*	0,03	0,20	1
4→6	89→95	*80→70*	0,03	0,12	1
6→8	95→98	*70→60*	0,03	0,06	1
8→10	98→99	*60→50*	0,03	0,02	1
10→12	99→98	*50→40*	0,03	–0,02	1
12→15	98→96	*40→30*	0,04	–0,04	1
15→20	96→92	*30→20*	0,07	–0,08	1
20→53	92→66	*20→10*	0,46	–0,51	1
53→100	66→20	*10→1*	0,72	–1,01	1

theoretically unclear assumptions, it is always possible to abandon prices and to consider the products only in their concrete and natural form as use values. This point of view is also illustrated in Table 24, where the alternative product mixes are presented in their physical units of measurement.

Each row in the middle columns of Table 24 is an example of a feasible product mix. For example, the first row tells that when 42 139 m^3 of timber are produced annually, it is possible to produce also 12 014 kg of reindeer meat but only 3 040 use days of recreation. According to the twelfth row, on the other hand, it is possible to produce at the same time 2 107 m^3 of timber, 60 068 kg of reindeer meat and 151 983 use days of recreation. However, even here it must be pointed out that the figures cannot be considered real but putative.

The use value figures as such do not tell anything about valuation of different products or product mixes. However, different product mixes can be evaluated in terms of lost use values. This is the principle of *opportunity costs* in physical units. For example, the choice of the second row product mix instead of that of the first indicates that an increase of 10 211 kg of reindeer meat and 3 039 use days of recreation is obtained instead of the 4 214 m^3 of timber lost. The *rates of product-transformation* in this case are 2,42 kg reindeer meat/m^3 and 0,72 use day/m^3. The corresponding rates of product-transformation as use values are calculated for all other such shifts ot the product mixes in Table 25. Although the figures are here called the rates of production transformation, it must be emphasized that different product mixes include not constant but different use of production factors (cf. p. 25).

The average long term product-transformation rate for reindeer meat and timber is 1,25 kg/m^3, for recreation and timber 7,21 use days/m^3 and for recreation and reindeer meat 5,06 use days/kg when the assumed joint production conditions prevail. One can see, however, that the rates of product transformation are not constant; rather, they vary with the varying levels of product mixes. Further, it is to be seen that the rates of product transformation between the two products are influenced by the level of intensity of the third product. For example, if in the uppermost part of Table 25 timber production should decrease from the level of 10 % of maximum to 1 %, this would substantially increase the rate of product transformation between recreation and timber; in fact, however, the effect turns out to be negative due to the fact that reindeer grazing achieves its maximum level first.

The information about physical production possibilities (about use values) and about the rates of product transformation prevailing between the products (uses) is a necessary condition for any deeper study of multiple use alternatives. Thus, it is always a first step in economic analyses. However, it should be emphasized here that sometimes it also may become the last step if no proper way can be found to establish substitute prices for non-market benefits.

87. Conclusions concerning the land use in the study area

The central objective of this treatise has been to study the physical and economic relationships between timber production, reindeer grazing and recreation in the Saariselkä fell area, the forests of which belong to the northern boreal zone. During the last ten to fifteen years, a lot of discussion has appeared concerning the conflicts between the above-mentioned land uses in the study area as well outside it. The main results of this research, concerning the problems in the study area can be summed up as follows:

1) Features highly characteristic of the relationships between each pair of land uses, and even more so of the relationships within the triplicity of uses, are complexity and changeability. The biological and physical effects of each land use on the others are numerous and they vary greatly in intensity and duration. It is usually not difficult to identify the variety of such effects, the difficulties lie in quantifying each of them and, above all, in comparing and quantifying the total aggregate relationships.

2) The occurrence of conflicts between the uses in the area is a function of use intensities. When low, extensive levels of use prevail, no conspicuous confrontations between the uses are to be expected. The level of the indifferent (noncompetitive) part of the potential production of each use varies, however, depending on the use. When considered from the point of view of the area's capacity, all the uses are compatible to some extent.

3) The range of the production possibilities of the study area is wide. It is technically possible to devote the area to anyone of the uses or to more or less varying range of use combinations (product mixes), the limits of which are determined by the mutual relationships between the uses (products).

4) Between timber production and reindeer grazing a concave production transformation curve seems to prevail. It means that in the study area timber production always leaves room for a significant amount of reindeer grazing.

5) Between reindeer grazing and recreation also a concave product-transformation curve was found to prevail. The competitive area was assumed to be narrower than between timber and reindeer, which means better conditions for co-existence of the uses.

6) Between recreation and timber production in the study area a form of convex product-transformation curve was deduced. This deduction, however, contains less empirical support and more controversial points than the two above. Convex relationships between timber and recreation in the

study area mean that they are compatible only when both remain at an extensive level. Beyond that level an increase in intensity of the one strongly decreases the volume of the other.

7) When measured by the value added of long-term output, recreation (tourism) is economically the most important land use in the study area. It was estimated to be almost two times greater than the value added of timber production and about nine times greater than the value added of long term output of reindeer grazing. The calculations have been made using average real prices of late seventies and changes in relative prices between the products (uses) would of course change the results.

8) In the long term, the use combination (product mix) yielding the greatest total value added of output in the study area given the above forms of product-transformation curves and treating both forms of recreation, i.e. day-use as well as long-distance backpacking and cross-country skiing trips, as a single, indivisible whole includes a great deal of recreation, a moderate amount of reindeer grazing and almost no timber production.

If the assumption of a convex relationship between timber production and recreation in the study area is abandoned, then, presumably, the product mix would include more timber production and less recreation and reindeer grazing.

If, on the other hand, the assumption is abandoned that the different forms of recreation in the study area compose a coherent entity from the point of view of their output value estimation, then the other approach as applied here should be employed for evaluation of the recreational benefits of wilderness hiking.

9) A comparison of different products (land uses) or product mixes as use values provides a simple but theoretically solid basis for decision making, especially when there is a need to apply other than "pure" economic decision criteria. A central suggestion, however, for every kind of decision making, is that the varying rates of product-transformation in different use combinations be taken into account. Product-transformation rates provide useful information about the opportunity costs of each product mix in the terms of lost use values.

9. DISCUSSION

Forests constitute an unparalleled production apparatus. The diversity of forest products, the multitude of forest uses and functions besides the other well-known pecularities make forestry a unique branch of production – and forests a "sui generis" among the production factors (*Keltikangas,* V. 1962, p. 4.).

Geographical factors leave pronounced marks on the product multiplicity of forests. The product mixes vary by forest vegetation zones and subzones, by countries and by provinces preserving a certain range of variety down to the level of a single stand. However, it can be seen that among the abundant variety there are also factors supporting some consistency for the formation of the combination of forest uses. An important such factor is the timber line.

The polar, alpine or other timber line areas frequently represent conditions which often share universally some traits. From the standpoint of timber production, they generally appear as marginal lands where forest productivity is relatively low and which for biological, protectional, topographical or economic reasons in most cases are – if used at all – only extensively used for commercial timber production. However, in some cases –and the study area is an example – they may be interesting and at least locally important also for commercial timber.

On the other hand the combination of unforested and forest land generates often the most favourable conditions for different types of grazing of cattle, sheep, goats and horses or – as in many polar timber line areas – the grazing of reindeer. This is also the case in the study area.

Besides grazing animals the timber line conditions often attract outdoor people. The attractiviness of the combination of forest and unforested land is often highlighted by topographical factors, especially in alpine timber line conditions. If the terrain makes easy going possible, if the climate is favourable and if transport connections do not prevent potential recreation demand – if there is any – from being actualized, some form of recreation is probable in the use combination. In the common use combination of timber line forest areas naturally also other forest uses, such as protectional functions of forests, watershed management, wildlife preservation and nature conservation may occur. In fact, all of them have some relevance also in the study area, but they are left outside the scope of this study.

Timber production, grazing of livestock and outdoor recreation are, however, the common actual or potential uses of timber line areas in many parts of the forested world. In this sense the problem of this study – the technical and economic relationships between the uses – contains also some elements of a more general character.

The approach of the study emphasized the importance of the close investigation of the physical relations between the uses concerned – timber production, reindeer grazing and outdoor recreation – under prevailing conditions. However, in practice these physical relations are the most complicated to study empirically. This can be illustrated by two examples from the study.

One of most controversial issues in the relationships between timber production and reindeer grazing is the impact of the post-cutting forest succession on the stock of ground lichens. It is logical to assume that the ground lichen succession follows that of forests and that mature forests produce more ground lichens than young forests. Although the empirical results showed that there were less lichens in young development classes than in mature ones, the differences were not very large, possibly a result of the relatively heavy grazing pressure in all forests but especially in the mature ones.

The other central problem in the study was the relationship between recreation and timber production. The landscape preferences of the recreationists were studied and as such the results seemed to be rather unambiguous: recreation values of stands increased from small seedling stands to mature ones and stands where forest roads or fresh cutting waste were to be seen were least appreciated. Problems arose, however, on how to use this information on stand level preferences to predict the actual use of the whole area.

Of course, the two examples indicate that the problems should have been studied by other methods than used here. The effects of forest succession (stand development classes) should have been studied on ungrazed areas for example outside the reindeer management area. Instead of landscape preferences of stands of the study area one should have compared visitor frequencies of the study area to those of similar areas managed with varying intensities for timber production, supposing that comparable areas are available.

In fact, one must consider what kinds of problems are worth the tiresome efforts of collecting empirical material even in the important problem area of the physical relations between the forest uses. There may be some problems which are better handled by deductive reasoning and included as premises rather than investigated by difficult and in the final analysis insufficient empirical methods. This, however, is not a problem characteristic only of research in the field of multiple-use forestry.

In the study of relations between the forest uses the way of thinking and concepts of production theory were regarded as useful. The apparatus of production theory is surely worthy of more explicit use in forest economics because of the great emphasis on different biological or technical (engineering) production problems in multiple-use forestry. Even if it is difficult to find the production functions – in the sense of physical relations between both the different forest uses and different amounts of each kind of factors –they in fact constitute the necessary backbone for decision making at all levels of management of multiple-use forestry (e.g. *Lloyd* 1969, p. 52, *Clawson* 1976, p. 34).

The special feature of multiple use research is in the twofold burden it puts on the shoulders of a researcher. The complicated problems of lacking production functions are matched by the many unsolved problems of valuation and pricing.

The latter problems in this study were only touched from a point of view of general value theories. It was agreed that the problems of so called non-market values are at least as much the headache of general economics as of forest economics.

Price is preceded by value and therefore different value concepts were analysed. Without going very deep into theory the basic difference between use value and exchange value (price) was considered an essential one. The value theories recognizing this difference may prove to be useful in the way of theoretically explaining the problems of non-existence of prices for some apparent use values of forests. However, in the empirical application of this study the whole pricing problem was omitted by using the total income from the tourism as a measure of the value of recreation output, which in this study was the only exponent of non-market values. Even here it must be emphasized that this is not considered a theoretical but rather a practical choice.

The comparison of the values of outputs of each use showed that the economic importance of outdoor recreation (in fact that of tourism) in the study area exceeded clearly those of the others at the present level of use for each and especially in the estimated long-term level. This is not changed by the fact that the long-term estimate of recreation output was made in a rough way, for it can be regarded as a conservative estimate.

It seems that in the study area or in similar conditions, which are favourable for recreation, this has possibilities to become the most important land use as measured by the value of output. This is mostly due to the fact that, unlike both timber production and reindeer grazing, the output of recreation is not limited by biological or climatological factors.

Generally speaking, the areas near the timber line are not very important for timber production. In this sense, they are mostly marginal lands. However, the study area consists largely also of pine-producing forest land which makes timber production a significant land use alternative even in these rather extreme conditions.

Compared to timber production, the value of output of reindeer grazing remain clearly the lesser, especially if it is taken into consideration that it is a product not only of forest land but to some extent also of scrub and waste land. However, it can be concluded that the relative importance of reindeer grazing compared to timber production grows when moving from south to north within the reindeer management area. This is mainly due to the increasing share of dry and barren site types and to the increasing long distance transport costs for timber.

In the case of reindeer grazing the social narrowness of measures like output value becomes most apparent. But regardless of that, it no doubt has some basic information value.

The comparison of single production values is a stage for the analysis of the values of multiple use alternatives. This was done by the help of a three commodity production model, which, however, in some essential respects must still be considered a putative one.

If the strongly competitive, convex relationship between timber production and recreation in the study area can be regarded as a valid one (and it must be viewed as such in our opinion although in this study it could not be shown empirically), then the product mix giving the greatest value of output consists of nearly the maximal output of recreation, practically none of timber production and about a half of the possible volume of reindeer grazing. The multiple-use combination in this case was almost solely determined by recreation. Other price relationships or other production relationships would of course give a different type of result.

The consideration of production possibilities merely in the light of use values gives a more concrete picture on the substitutability among the three land uses. Of course, the study of use values represents the simplest and, as it seems, even the most naive starting point for economic analysis. But, paradoxically enough, it may in some cases also represent a threshold which cannot be crossed within the framework of pure economic analysis. In these kind of cases also the task of economic analysis becomes different. It is not a task of determining the best product mix, but instead the task of solving how the pre-determined product mix could be achieved in the economically most efficient way.

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SELOSTE

Metsien moninaiskäytön ekonomia Saariselän metsä- ja tunturialueella

Johdanto

Eräs metsätalouden erikoisuus on sen tuotteiden moninaisuus. Vaikka tähän seikkaan onkin viime vuosikymmeninä kiinnitetty paljon huomiota se ei suinkaan ole uusi metsätalouden ominaisuus: metsien ja ihmisten suhdetta on aina leimannut metsästä hankittujen tai saatujen hyötyjen monilukuisuus. Nykytilanne poikkeaa kuitenkin entisestä siinä, että yhä useampi metsän tuote on käymässä niukaksi.

Metsän monilukuisten tuotteiden tuottamista ja käyttöä on alettu käsitellä metsien moninaiskäyttö-käsitteen avulla. Siitä on eri maissa esitetty jonkun verran toisistaan poikkeavia määritelmiä. Yhteistä niille on kuitenkin se, että metsän tuotteiden joukkoon luetaan kaikki metsän hyödyt, hyödylliset ominaisuudet tai vaikutukset riippumatta siitä onko niiden taloudellinen tai yhteiskunnallinen merkitys suoraan tai välillisesti mitattavissa. Tässä tutkimuksessa metsien moninaiskäytöllä tarkoitetaan usean käyttöarvon tarkoituksellista tuottamista ja hyödyntämistä metsäalueella.

Metsien moninaiskäytön ongelmaa voidaan tutkia monella vaihtoehtoisella tavalla. Tutkimuksessa on tarkasteltu maankäytön ekonomiassa sovellettua maankorkomenetelmää, lineaarista ohjelmointia ja tuotantoteoreettiseksi kutsuttua lähestymistapaa. Ne eivät ole toisiaan poissulkevia mutta eroavat tuotantofunktiolle *a priori* tehtävien olettamusten suhteen. Tuotantoteoreettinen lähestymistapa on valittu tässä tutkimuksessa siksi koska se ei edellytä etukäteisolettamuksia tuotantofunktioista. Niiden tutkiminen onkin yleensä keskeisin mutta samalla myös vaikein ongelma moninaiskäytön tutkimuksessa.

Tutkimuksen tarkoitus ja rakenne

Tutkimuksen tarkoituksena on tutkia Lapin metsätalouden maan kolmen keskeisen käyttömuodon, puuntuotannon, porotalouden ja virkistyskäytön ominaispiirteitä, keskinäissuhteita ja ekonomiaa Saariselän metsä- ja tunturialueella.

Yksityiskohtaisemmin jäsenneltynä tutkimuksen tarkoituksena on:

1. soveltaa tuotantoteorian käsitteistöä moninaiskäytön ongelma-alueella;
2. hahmotella kunkin käyttömuodon tuotantofunktion yleisiä piirteitä ja määrittää niiden tuotantomahdollisuudet tutkimusalueella;
3. tutkia metsänkäyttömuotojen keskinäissuhteita ja käsitellä niitä tuotetransformaation näkökulmasta;
4. pohtia kunkin käyttömuodon ekonomista evaluointia ja mahdollisten tuoteyhdistelmien taloudellista merkitystä.

Tutkimusalue on Saariselän metsä- ja tunturialue Sodankylän ja Inarin kunnissa (kuva 1). Alueen laajuus on 1 756 km^2 ja sen käytöstä on käyty paljon keskustelua, erityisesti on tehty lukuisia aloitteita ja erilaisia rajauksia alueen muodostamiseksi kansallispuistoksi. Vuonna 1980 tehtiin periaatepäätös Urho Kekkosen kansallispuiston perustamiseksi. Tutkimusalue muodostaa tästä kansallispuistosta huomattavan osan mutta luonnonsuojelu ei kuitenkaan kuulu tutkittaviin käyttömuotoihin.

Tuotantoteoria ja moninaiskäyttö

Tuotantoteoria on tässä tutkimuksessa ymmärretty suppeassa mielessä teoriana tuotantofunktioista, jossa keskeisenä kysymyksenä on panosten ja tuotosten väliset tekniset suhteet sekä niiden substituutiomahdollisuudet.

Tuotantoa voidaan tarkastella sekä teknisenä että taloudellisena ilmiönä. Taloudellisessa mielessä tuotanto tarkoittaa yritystä luoda tuote, joka on arvokkaampi kuin alkuperäiset panokset. Teknisessä mielessä tuotanto voidaan laajasti käsittää transformaatioprosessina, jota ihminen voi ohjata tai josta hän on kiinnostunut. Metsäntuotantoon tässä mielessä kuuluvat kaikki metsien käyttökelpoiset funktiot puun tuotannosta niiden ympäristövaikutuksiin ja käyttöön esim. kansallispuistona.

Metsän tuotteita voidaan ryhmitellä monella tapaa. Keskeisiä ovat jaot tavaroihin (aineellisiin tuotteisiin) ja palveluihin (aineettomiin hyötyihin), markkina- ja ei-markkinahyödykkeisiin sekä yksityisiin ja kollektiivisiin hyödykkeisiin. Myös tuotannontekijät voidaan ryhmitellä monin tavoin.

Tuotantofunktio ilmaisee tuotannontekijöiden ja tuotteiden väliset tekniset riippuvuudet. Tuotantofunktio on yhteenveto tuotannon teknologisesta informaatiosta. Metsätalouden harjoittamisen taito perustuukin eksplisiittisesti tai implisiittisesti tuotantofunktioiden tuntemiseen.

Tuotanto voi olla yksittäistuotantoa (*single production*) tai monihyödyketuotantoa (*multicommodity production*). Monituotetuotannon lajit ovat vaihtoehtoistuotanto (*alternative* tai *assorted* *production*) ja yhteistuotanto (*joint production*) (kuva 4). Yhteistuotannossa voidaan erottaa kiinteäsuhteisten (*complete coupling*) ja eriytyvien tuotteiden (*separable products*) tapaus (kuva 5).

Metsien moninaiskäytössä keskeisiä kysymyksiä ovat eri käyttömuotojen tai tuotteiden väliset suhteet. Ne jaotellaan tavallisesti neljään ryhmään: täydentäviin, riippumattomiin, kilpaileviin ja poissulkeviin suhteisiin ja niitä voidaan tutkia tuotetransformaatiosuhteen avulla (*rate of product transformation*) analyyttisesti ja kuvata transformaatiokäyrillä (kuvat 6 ja 7).

Metsien moninaiskäytön järjestelyssä on keskeisesti ollut esillä kaksi periaateratkaisua: rinnakkaiskäytön ja päällekkäiskäytön periaatteet. Edellisessä metsäalueen eri käyttömuodot sijoittuvat kukin omalle osa-alueelleen, jälkimmäisessä tapauksessa eri käyttömuodot toisiinsa sopeutettuina hyödyntävät samanaikaisesti koko aluetta. Tuotantoteorian näkökulmasta rinnakkaiskäytön periaate edustaa vaihtoehtoistuotannon tapausta (*assorted* tai *alternative production*) ja päällekkäiskäytön periaate kuuluu puolestaan yhteistuotannon (*joint production*) pääryhmään. Metsien moninaiskäyttö yleisesti voidaan tuotantoteorian käsittein määritellä metsätalouden maan monihyödyketuotannoksi.

Puuntuotanto

Puun tuotantoprosessille on tyypillistä pitkä ajallinen ulottuvuus ja panosten pisteluonne (*point inputs*) eri tuotantovaiheissa.

Puun tuotantoprosessi on myös tietyssä määrin ajan suhteen joustava. Pitkän tuotantoajan ohella nämä tekijät vaikuttavat olennaisesti puuntuotannon ja muiden käyttömuotojen välisiin suhteisiin. Hahmoteltu tuotantofunktio on deskriptiivinen ja sen tarkoituksena on vain osoittaa tutkimuksen kannalta keskeiset puuntuotannon tuotannontekijät. On myös tarpeen huomauttaa siitä, että vaikka tässä tutkimuksessa puuntuotanto edustaakin yksittäistuotantoa – yhtä käyttömuotoa – niin todellisuudessa se erilaisine puutavara- ja puulajeineen itsekin on esimerkki monituotetuotannosta.

Saariselän puuntuotannon yleisiin edellytyksiin vaikuttavat pohjoinen sijainti ja alpiinisen metsänrajan esiintyminen alueella (kuva 8). Puuntuotannon kannalta keskeisin myönteinen tekijä on pääpuulaji mänty, jonka luontainen uudistuminen alueella on yleisesti ottaen varmaa vaikkakin hidasta. Kaukaisesta sijainnista huolimatta puuntuotannon taloudellisuutta puoltavat uudistusikäisten metsien runsauden ohella mm. uittomahdollisuus, alhaiset uudistamiskustannukset, kohonnut kantohintataso (kuva 9) sekä valtion metsätalouden mahdollistama pitkäjänteisyys.

Alueen pinta-alasta 36 % on metsämaata, josta valtaosa kuivia ja kuivahkoja kankaita (taulukot 1–4). Puustoa koskevat tiedot ovat peräisin pääasiassa metsähallituksen 1950-luvulla tehdyistä talouskirjoista ja kuutiomäärätietoja on korjattu likimääräisellä kertoimella 1,3, joka on saatu vertaamalla hakkuista saatuja puumääriä talouskirjoissa esitettyihin. Kokonaiskuutiomäärä on 5,1 milj. m^3, siitä metsämaalla 4,4, milj. m^3. Keskikuutio metsämaalla on 69,5 m^3/ha. Metsämaan pinta-alasta 78 % metsiköistä on yli 160-vuotiaita (inventointiajankohtana) ja 42 % kuuluu uudistuskypsiin metsiköihin. Puustosta toimenpiderajan yläpuolella on 28 % (taulukot 5–9).

Lyhyen tähtäimen ja pitkän tähtäimen hakkuumahdollisuudet on arvioitu yksinomaan puuntuotannon näkökulmasta ottaen kuitenkin huomioon suojametsäalueella tapahtuvan toiminnan rajoitukset. Lyhyen tähtäimen kertymäsuunnitteet vaihtelivat 29 000–81 000 m^3/v välillä kiertoajasta ja käsittelyn voimakkuudesta riippuen kun kaikki toimenpiderajan alapuolella olevat hakkuumahdollisuudet realisoitaisiin 20 vuodessa (taulukko 10).

Pitkän tähtäimen metsämaan kankaiden puuntuotantokyky laskettiin metsätyypittäisten keskituotosten avulla (taulukot 11 ja 12). Toimenpiderajan alapuolisen metsämaan pitkän tähtäimen kertymäsuunnitteen arvio on 42 000 m^3/v (s. 36).

Poronhoito

Laiduntaminen on sinänsä melko yleinen metsätalouden maan käyttömuoto, mutta useimmiten se kuitenkin sijoittuu puuttomille tai vähämetsäisille alueille. Suomen poronhoidon erikoispiirre on sen painottuminen voimakkaasti havumetsävyöhykkeelle, missä 3/4 koko porokannasta laiduntaa. Samalla se merkitsee sitä, että poronhoito ja puuntuotanto ovat suureksi osaksi päällekkäisiä metsätalouden maan käyttömuotoja.

Poronhoidon perustana ovat laidunkasvit, erityisesti minimitekijöiksi tunnetut talvilaitumien maa- ja puujäkälät. Poronhoidon tuotantofunktio periaatteellisella tasolla voidaan jakaa primääriseen vaiheeseen, jossa erityisesti puusto ja sen käsittely vaikuttaa laidunkasvien tuotantoon ja sekundääriseen vaiheeseen, jossa porojen lukumäärä – ja sitä kautta poronlihan tuotanto – riippuu laidunkasvituotannosta ja poronhoitotöistä, joilla mm. laidunkasvien hyväksikäyttöä säädellään.

Tutkimusalueen valtaosa kuuluu Sodankylän Lapin paliskuntaan ja pieni osa Ivalon paliskuntaan. Alueen poronhoidollista merkitystä arvioitaessa on otaksuttu sen kokonaisuudessaan vastaavan 80 % Sodankylän Lapin paliskunnan poronhoidon tuotannosta (kuva 12). Suurin sallittu poroluku Lapin paliskunnssa on tekojärvien ja muiden häiriötekijöiden vuoksi vuosiksi 1970–1979 alennettu 7 500 lukuporoon. Siitä 80 % on 6 000 lukuporoa mikä on jonkun verran suurempi luku kuin tutkimusalueen osuus paliskunnan luetuista poroista + 15 %:n tavanomainen lisäys laskematta jääneistä poroista, yhteensä 5 600 poroa.

Pitkän tähtäimen tuotantomahdollisuudet poronhoidossa arvioidaan saman periaatteen mukaisesti kuin puuntuotannonkin osalta ottamatta huomioon muiden käyttömuotojen rajoittavia vaikutuksia. Alueen talvilaidunluokkien kantokyvyn harkinnanvaraisen bonitoinnin perusteella päädytään arvioon, jonka mukaan tutkimusalueen potentiaalinen laidunten kantokyky olisi 7 000 poroa (taulukko 13).

Ulkoilukäyttö

Metsien ulkoilukäytöllä tarkoitetaan niitä ulkoilutoimintoja, joita harjoitetaan metsäisillä alueilla riippumatta siitä onko metsä näiden toimintojen keskeinen ympäristö tai vain maisemallinen tausta.

Vaikka metsien ulkoilukäytön rooli tuotantoteorian näkökulmasta onkin monitahoinen, voidaan sitä tarkastella kaksivaiheisena tuotantoprosessina. Ensimmäisessä vaiheessa tuotos on virkistysympäristö ja toisessa vaiheessa tosiasiallisesti tapahtunut ulkoilukäyttö, jonka tuotantofunktion tuotannontekijöihin virkistysympäristö keskeisesti kuuluu.

Saariselkä kuuluu ulkoilu- ja virkistysalueiden luokittelussa resurssipohjaisiin (*resource-based*) alueisiin, joiden vetovoimaisuus virkistyskohteena perustuu ensisijaisesti niiden luonnonarvoihin.

Saariselän ulkoilukäytön muodot ja ulkoilijaryhmät voidaan käyntiajankohdan ja majoitustavan perusteella jakaa kahteen pääluokkaan: kesälomailijat ja talvilomailijat tekevät päiväretkiä majoituspisteistä (lomailukäyttö), kesäeräretkeilijät ja talvieräretkeilijät puolestaan vaeltavat "maastossa" yöpyen autiomajoissa tai teltoissa (eräretkeilykäyttö).

Saariselän ulkoilukäytön kehitystä on tutkimuksessa tarkasteltu vuosina 1950–1979. Eräretkeilyä palvelevan autiomajaverkoston kehitys alkoi jo 1940-luvun loppupuolella. Kehitys oli erityisen nopea 1960-luvun loppupuolella, jolloin metsähallitus rakensi uusia autiomajoja alueelle (kuva 15). Lomailua palvelevien yksityisten lomamökkien, yhteisöjen lomamajojen ja yritysluontoisten matkailuyksikköjen vuodekapasiteetin kehitys nopeutui 1960-luvulla ja jatkuu voimakkaana. Vuonna 1979 vuodepaikkojen lukumäärä oli yhteensä 2 022 (kuva 16).

Lomamajojen vähintään yhden yön mittaisten käyntikertojen lukumäärä (kuva 19) ja yöpymisvuorokausien määrä (kuva 20) on kasvanut vuodesta 1950 majoituskapasiteetin myötä lähes keskeytyksettä. Vielä 1970-luvulla keskimääräinen vuotuinen käyntikertojen kasvuprosentti oli 9,4 % ja käyttövuorokausien kasvu 11,3 %.

Eräretkeilyn kehitys Saariselän alueella on myös ollut nopeaa joskin jonkin verran epävakaisempaa kuin lomailukäytön kehitys (kuva 22). Tarkastellun jakson alussa, 1950-luvun ensivuosina, eräretkiä alueelle tehtiin 100–200 vuodessa, vuonna 1978 7900. Keskimääräinen vuotuinen kasvuprosentti 1970-luvulla oli 9,0 %.

Saariselän alueen ulkoilukäytöksi vuonna 1979 kokonaisuudessaan saatiin 48 000 käyntikertaa ja 203 000 käyttöpäivää (taulukko 14). Käyntikerralla tarkoitetaan yhden henkilön viipymistä alueella ainakin yhden yön. Käyntikerroista lumettomana aikana tehtiin 57 % ja käyttöpäivistä 51 %. Eräretkeilyn osuus käyttöpäivistä oli 30 %.

Ulkoilukäytön pitkän tähtäimen laajenemismahdollisuuksia tarkasteltiin mm. kävijätiheyden avulla. Lomamajojen lähiympäristön ns. päiväkäyttöalueella (n. 250 km^2) kävijätiheys korkeimmillaan huhtikuussa 1979 oli keskimäärin 4,8 henkilöä/km^2/pv ja varsinaisella erämaa-alueella (n. 1 500 km^2) elokuussa keskimäärin 0,3 henkilöä/km^2/pv. Ratkaisevilta osiltaan perusteet määrittää Saariselän alueen "täyden" ulkoilukäytön määrä kuitenkin puuttuvat. Pelkästään tutkimuksen myöhempiä laskennallisia tarkoituksia varten on varovaisesti oletettu sen olevan 1,5 kertainen vuoden 1979 käyttöön verrattuna.

Käyttömuotojen suhteet

Puuntuotannon ja *poronhoidon* väliset suhteet ovat monitahoiset ja myös monimutkaiset. Keskeiset kysymykset liittyvät kuitenkin siihen miten hakkuut ja muut puuntuotannolliset toimenpiteet vaikuttavat poron talvella käyttämiin ravintokasveihin, erityisesti maa- ja puujäkäliin. Voidaan hyvin olettaa että hakkuiden aiheuttamat muutokset poronjäkälien sukkessioon eivät ole yhtä voimakkaat kuin kulojen aiheuttamat (kuva 23). Alueen talvilaidunten inventoinnissa todettiin eniten poronjäkälää olevan nuorissa ja varttuneissa kasvatusmetsiköissä sekä uudistuskypsissä metsiköissä (kuva 25) sekä eniten luppoa uudistuskypsissä metsiköissä (kuva 27). Laidunnuspaine vaikuttaa kuitenkin olennaisesti eroihin (kuva 25). Eräin olettamuksin voidaan kuitenkin tehdä johtopäätös jonka mukaan puu ja jäkälä ovat kilpailevia metsän tuotteita mutta vain tietyllä tasolla: puuntuotannon kannalta optimaalinenkin metsiköiden kehitysluokkarakenne pitää yllä jäkälätuotantoa, joka jää kuitenkin pienemmäksi kuin se minkä varttuneet metsät tuottavat. Kvantitatiivisesti tätä vähennystä ei tämän tutkimuksen aineiston perusteella kuitenkaan voitu arvioida – sen sijaan suhteen luonnetta on havainnollistettu hypoteettisen esimerkin avulla (taulukko 16 ja kuva 26).

Puuntuotannon ja *ulkoilukäytön* suhteet ovat myös monivivahteiset ja erityinen paino niissä on laadullisten tekijöiden osuudella. Keskeinen ongelma on puuntuotannollisten toimenpiteiden vaikutukset ulkoilijoiden maisema-arvotuksiin ja ulkoilukäyttöön. Tätä kysymystä tutkittiin diamenetelmän avulla. Saariselän käsittelyltään ja kehitysluokiltaan erilaisista männiköistä koostettiin 40 dian sarja, jonka avulla selviteltiin ulkoilijoiden maisema-arvostuksia. Ne todettiin koko lailla yhdenmukaisiksi (kuva 28) ja kehitysluokasta sekä käsittelytavasta riippuviksi (kuva 29). Teiden ja hakkuutähteiden näkyminen maisemassa alensi selvimmin metsikön arvoa retkeilymielessä. Kehitysluokittaisen metsiköiden virkistysarvon ja puuntuotannon kannalta vaihtoehtoisten kehitysluokkarakenteiden kautta voidaan esimerkinomaisesti todeta puuntuotannon ja ulkoilukäytön kesken vallitsevan kilpailevan suhteen (taulukko 17 ja kuva 30). Tämä tieto on kuitenkin vielä riittämätön selvittämään puuntuotannollisten toimenpiteiden vaikutuksia ulkoilukäytön määrään tutkimusalueella. Empiiristen tietojen puuttuessa kysymystä arvioidaan deduktiivisesti ja päätellään, että erämaaluontoon hakeutuvan ulkoilukäytön ja puuntuotannon välillä vallitseva kilpailusuhde on niin voimakas, että sitä vastaava tuotantotransformaatiokäyrä on muodoltaan konveksi. Tämä tarkoittaa sitä, että tutkimusalueella puuntuotannon ja ulkoilukäytön yhteensovittamisen mahdollisuudet ovat vähäiset.

Ulkoilukäytön ja *poronhoidon* välisiä suhteita leimaavat ulkoilun aiheuttamat haitat poronhoidolle. Niitä ovat tallaamisen ja leirinnän aiheuttama jäkälikköjen kuluminen ja häviäminen, ulkoilukäytön mukanaan tuoma porojen häiriintyminen sekä muut poronhoidolle aiheutetut haitat. Linjoittaisen inventoinnin perusteella voidaan arvioida, että tallaamisen ja leirinnän osuus muiden jäkälikköjen kulumista aiheuttavien tekijöiden joukossa ei ole vielä kovin suuri (taulukko 18).

Porojen häirintä ja erityisesti ns. lomailu- ja päiväkäyttöalueen aiheuttamat laidunmenetykset merkinnevät enemmän. Kokonaisuudessaan voitaneen kuitenkin olettaa, että ulkoilukäyttö ja poronhoito ovat muita käyttömuotopareja paremmin yhteensovitettavissa ja että niiden välinen kilpailu tulee merkittävästi esille vasta molempien käyttömuotojen korkealla intensiivisyystasolla.

Tutkimuksessa esitetty materiaali käyttömuotojen suhteista ei ole riittävä kolmen hyödykkeen empiirisen tuotantofunktion rakentamiseen. Kuitenkin on mahdollista valottaa tuoteyhdistelmien tai käyttömuotoyhdistelmien valinnan ongelmia teoreettisen kolmen hyödykkeen graafisen mallin avulla, joka yhdistää edellä esitetyt tulokset ja johtopäätökset (kuva 31). Malli ei siis ole empiirinen mutta eri käyttömuotojen keskinäissuhteita kuvaavien transformaatiokäyrien yleinen muoto on kuitenkin pyritty päättelemään tutkimuksessa kootun aineiston tai esitetyn tiedon perusteella. Malli osoittaa, että käyttömuotojen keskinäissuhteisiin vaikuttaa olennaisesti kunkin tuotannon voimakkuusaste (suhteellinen tuotannon taso maksimaaliseen nähden) ja että vaihtoehtoisten tuotantoyhdistelmien joukko ja vaihteluväli on hyvin suuri. Valinta eri vaihtoehtojen kesken on ensisijassa ekonomisen analyysin ongelma.

Käyttömuotojen ekonominen evaluointi

Evaluoinnin, arvottamisen eli vaihtoehtojen "suotavuuden" arvioinnin kriittinen vaihe on arviointikriteerien valinta. Ekonomisessa evaluoinnissa nämä kriteerit ovat taloudellisia arvoja, jotka saavat taloudellisen sisältönsä niukkojen resurssien vaihtoehtoisen käytön ongelmakentästä.

On hyödyllistä korostaa erikseen sitä, että taloudelliset arvot voivat olla ei-monetaarisia ts. myös muutoin kuin rahayksikön avulla mitattavia arvoja. Monessa tapauksessa järkevien päätösten tekeminen on mahdollista ilman että tavoitteet on rahayksikön avulla mitattavissa – edellytyksenä on kuitenkin usein se, että monetaariset kustannukset tunnetaan.

Taloustieteessä arvon käsitteellä on monta merkitystä. Keskeinen on ero käyttöarvon ja vaihtoarvon välillä. Käyttöarvo viittaa tuotteen hyödyllisyyteen (hyödyllisiin ominaisuuksiin) ja se ilmaistaan tavallisesti fyysisin mitoin. Vaihtoarvo puolestaan osoittaa tuotteen vaihtosuhteen toisiin tuotteisiin ja se osoitetaan tavallisesti markkinahintojen avulla. Metsän hyötyjen evaluoinnissa on tärkeätä huomata että käyttöarvo ja vaihtoarvo voivat poiketa huomattavastikin toisistaan: esimerkiksi monilla virkistyshyödyillä voi olla melkoinen käyttöarvo mutta ei lainkaan vaihtoarvoa. Tapauksissa, joissa markkinahintaa ei esiinny tai se katsotaan soveltumattomaksi, voidaan korvikkeina käyttää ns. varjohintoja. Niiden käyttö olisi myös tässä tutkimuksessa ollut mahdollista eräretkeilyn arvottamisessa. Varjohintoja ei kuitenkaan ole tässä käytetty vaan on oletettu myös eräretkeilyn hyötyjen realisoituvan alueen matkailuyritysten tuotoissa.

Käyttömuotojen taloudellista merkitystä on mitattu tutkimuksessa kahdella mittarilla: tuotannon kokonaisarvolla ja arvonlisällä (*value added*). Arvonlisä saadaan kun tuotannon kokonaisarvosta vähennetään ostettujen välituotteiden arvo. Käyttömuotoyhdistelmien (tuoteyhdistelmien) tarkastelu tapahtuu arvonlisäysten avulla. Lisäksi sovelletaan pelkästään käyttöarvoihin perustuvaa tarkastelua.

Puuntuotannon arvo on laskettu hankinta-arvon periaatteella, koska sen katsotaan parhaiten kuvastavan puuntuotannon merkitystä tutkimusalueen kannalta. Hankintahinta on laskettu Inarin hoitoalueen keskimääräisten hankintakustannusten (taulukko 19) ja kantohintojen summana (taulukko 20, ks myös kuva 8) ja kokonaistuotannon arvo laskettiin hankintahintojen ja vaihtoehtoisten kertymäsuunnitteiden avulla (taulukko 21). Lyhyen tähtäimen hakkuumahdollisuuksien arvot vaihtelevat kertymäsuunnitevaihtoehdosta riippuen 2,8 milj. mk:sta 7,8 milj. mk:aan vuotta kohti. Pitkän tähtäimen puuntuotannon vuosittainen arvo arvioitiin 4,1 milj. mk:ksi. Välituotteiden osuus puuntuotannossa oli 7,8 % tuotannon kokonaisarvosta ja lyhyen tähtäimen hakkuumahdollisuuksien keskiarvona vuodelle 1978 laskettu arvonlisäys oli 4,6 milj. mk ja pitkällä tähtäimellä 3,8 milj. mk.

Porotalouden tuotannon arvoksi laskettiin teurastettujen porojen arvo erotusaidalla. Se vastaa käsitteellisesti puuntuotannon hankinta-arvoa. Vuonna 1978 porotalouden tuotannon arvo oli 0,7 milj. mk ja pitkän tähtäimen kokonaistuotannon vuosittainen arvo 1,0 milj. mk. Välituotteiden osuudeksi saatiin 21,8 % ja arvonlisä vuonna 1978 oli siten 0,5 milj. mk ja pitkällä tähtäimellä 0,8 milj. mk vuodessa.

Ulkoilukäytön evaluoiminen on eräs paljon keskusteltu aihe metsäekonomiassa. Keskeisin ongelma on ollut löytää teoreettisesti perusteltu korvaava hinta tai varjohinta ulkoilukäytön hyödylle. Tähän keskusteluun esitetään eräs kommentti: on mahdollista että keskustelun hajanaisuus johtuu paljolti siitä, ettei ole tehty selväksi kummalle arvon lajille – käyttöarvolle vai vaihtoarvolle – varjohintaa itse asiassa haetaan.

Tässä tutkimuksessa on päädytty ratkaisuun, jonka mukaan alueen matkailuyritysten tuotot kuvastavat ulkoilukäytön hyötyjä ja ovat samalla perusteltavissa oleva vastine puuntuotannon hankinta-arvolle. Vuonna 1978 alueen matkailuyritysten kokonaistuotot olivat 8,9 milj. mk. Pitkän tähtäimen arvio on aikaisemmin esitetyn mukaisesti varovaisesti 1,5-kertainen ja siten 13,3 milj. mk. Välituotekäytön osuus on matkailuyrityksissä suhteellisen suuri, 47,7 %. Ulkoilukäytön arvonlisä matkailuyritysten tuottojen avulla laskettuna oli vuonna 1978 4,7 milj. mk. Pitkän tähtäimen arvonlisän arvio on vastaavasti 7,0 milj. mk vuodessa.

Tutkimusalueen käyttömuotojen taloudellisen merkityksen vertailussa ulkoilukäytön kokonaistuotannon arvo ja arvonlisäys osoittautuivat suurimmaksi sekä vuonna 1978 että varsinkin pitkällä tähtäimellä (kuva 32). Puuntuotannon arvonlisäys vuonna 1978 oli likimain yhtä suuri kuin ulkoilukäytön mutta vertailu on hankala koska puuntuotannon osalta kysymys ei ole realisoituneista vaan mahdollisista kertymäsuunnitteista. Ekstensiivisenä elinkeinona poronhoidon tuotannon arvo ei nouse kovin korkeaksi ja se jää selvästi myös puuntuotantoa pienemmäksi sekä lyhyellä että pitkällä tähtäimellä.

Vaihtoehtoisten käyttömuotoyhdistelmien tarkastelu tehtiin luvussa 75 esitetyn graafisen mallin avulla sijoittamalla kunkin käyttömuodon lasketut pitkän tähtäimen tuotantomahdollisuudet siihen. Koska malli ei kuitenkaan ole empiirinen on sen avulla saaduilla tuloksilla vain esimerkinomainen ja viitteellinen luonne. Ne havainnollistanevat kuitenkin sitä millaiset ovat mallin mukaisten käyttömuotojen suhteiden vallitessa toteuttamiskelpoiset käyttömuotoyhdistelmät sekä fyysisinä yksikköinä (käyttöarvoina) että arvonlisäyksinä ja niiden summina (taulukko 24). Koska ulkoilukäytön arvonlisäys oli selvästi suurin, vaikuttaa se keskeisesti siihen mitkä käyttömuotoyhdistelmät antavat suurimman arvonlisäysten summan. Suurimmillaan se on mallin mukaan silloin kun ulkoilukäytön volyymi on karkeasti ottaen maksimissaan, poronhoidon volyymi puolessa ja puuntuotannon volyymi – ulkoilukäytön ja puuntuotannon konveksin kilpailevan suhteen vuoksi – minimissä. Mallin käyttömuotoyhdistelmiä on hyödyllistä tarkastella myös pelkästään käyttöarvoina (keskimmäiset sarakkeet taulukossa 24), jotka varsinkin niissä tapauksissa, joissa jonkun käyttömuodon hinnoitteluun liittyy teoreettista epävarmuutta, antavat päätöksenteolle yksinkertaisen mutta konkreettisen pohjan. Käyttöarvojen perusteella on mahdollista laskea myös eri käyttömuotoyhdistelmien vaihtoehtoiskustannuksia menetettyjen käyttöarvojen muodossa. Ne voidaan esittää eräänlaisten tuotannon transformaatiosuhteiksi kutsuttavien lukujen avulla (taulukko 25) vaikka ne edustavatkin tuotannontekijöiden käytön kannalta erilaisia tapauksia. Olennaista on huomata näiden suhteiden vaihtelu käyttömuotojen tason vaihtelun myötä.

Tutkimusalueen maankäytön ongelmista voidaan tutkimuksen perusteella esittää seuraavia päätelmiä. Käyttömuotojen keskinäiset suhteet ovat monimutkaiset. Yksittäisiä vaikutuksia ei kuitenkaan sinänsä ole vaikea identifioida mutta niiden kvantifiointi on vaikeaa. Erityisen vaikeaa on varsinkin eri käyttömuotojen välisten aggregoitujen kokonaissuhteiden kvantifiointi. Käyttömuotojen välisten ongelmien esiintyminen on käyttömuotojen intensiteettien funktio. Alueen mahdollisten käyttövaihtoehtojen skaala on laaja mutta kuitenkin käyttömuotojen keskinäisten suhteiden rajaama. Puuntuotannon ja poronhoidon välillä näyttäisi vallitsevan konkaavilla tuotantotransformaatiokäyrällä kuvattava suhde, samoin ulkoilukäytön ja poronhoidon välillä. Viimeksimainittu suhde näyttää olevan edellistä paremmin yhteensovitettavissa. Ulkoilukäytön ja puuntuotannon välistä suhdetta tutkimusalueella pääteltiin kuvaavan muodoltaan konveksin transformaatiokäyrän. Tämän johtopäätöksen tueksi on esitettävissä vähemmän empiiristä tukea kuin kahden edellisen. Matkailuyritysten tuottojen avulla mitattu ulkoilukäyttö on taloudellisesti merkittävin alueen käyttömuoto, puuntuotanto on toiseksi merkittävin selvästi poronhoitoa suuremmalla tuotannonarvolla. Pitkällä tähtäimellä ja pelkästään alueen käyttömuotojen arvonlisäysten summan perusteella tarkasteltuna tarkoituksenmukaisimmalta alueen käyttövaihtoehdolta näyttää ulkoilukäytön ja poronhoidon yhdistelmä. Erämaaluontoon hakeutuva ulkoilukäyttö rajoittaa voimakkaasti puuntuotantoa mutta näyttäisi mahdollistavan korkeamman poronhoidon tuotannon tason kuin mikä olisi saavutettavissa puuntuotannon ja poronhoidon muodostamassa arvonlisäystä maksimoivassa käyttövaihtoehdossa.

SAASTAMOINEN, O. 1982. Economics of multiple-use forestry in the Saariselkä forest and fell area. Seloste: Metsien moninaiskäytön ekonomia Saariselän metsä- ja tunturialueella. Commun. Inst. For. Fenn. 104:1–102.

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In the empirical part single and joint production possibilities are analyzed. The economic importance of the uses are measured by total value and by value added of production. Outdoor recreation measured by the returns of tourism enterprises appeared to be economically the most important land use. The output value of reindeer grazing remained lower than that of timber production. The most appropriate multiple use combination seemed to be that of outdoor recreation and reindeer grazing.

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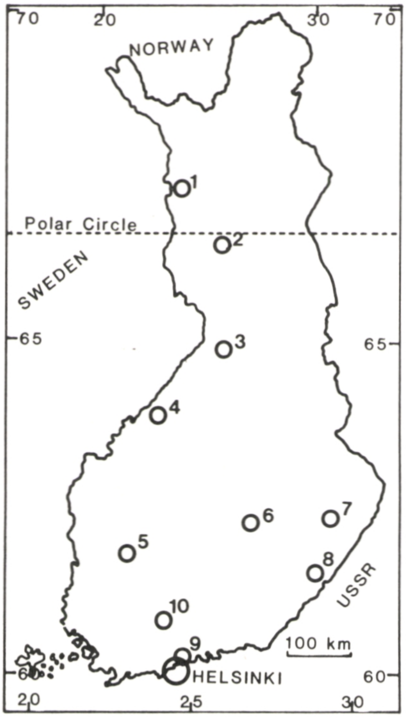

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Total land area: 304 642 km^2 of which 60–70 per cent is forest land.

Mean temperature,°C:	Helsinki	Joensuu	Rovaniemi
January	-6,8	-10,2	-11,0
July	17,1	17,1	15,3
annual	4,4	2,9	0,8
Thermal winter *(mean temp.* $<$ 0°C):	20.11.–4.4.	5.11.–10.4.	18.10.–21.4.

Most common tree species: Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens

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