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FINNISH FOREST RESOURCE ACCOUNTING AND ECOLOGICAL SUSTAINABILITY

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FOREWORD

Finnish Forest Resource Accounting and Ecological Sustainability studies the possibilities to develop a forest resource accounting system that would describe the well-being of Finnish forest resources. A particular area of interest is the converting of current data on forests into a useful form for decision-making in society. In practice the data can be converted by means of various environmental accounting frameworks. The ultimate aim is to measure sustainable development.

Systematic environmental accountings were begun to be developed intensively in various countries at the beginning of the 1990s. The background to this development lies in the observation that efficient and cost-effective social policy requires the combining of scattered information on the environment and the economy into one entity to form a basis for decision-making. The UN issued handbook for System of Integrated Environmental and Economic Accounting, the SEEA, in 1993. By its nature, the SEEA is a satellite accounting system, which can, if desired, be combined with the national accounts, thus producing parameters that describe how well sustainable development has been achieved. In Finland, environmental accounting will at the initial stage include the most important natural resources and environmental impacts, such as the forests and air pollutants, which have great economic significance, and expenditure on environmental protection. The forest resource accounting system under development will form part of Finland's environmental accounting system.

This study was carried out at Statistics Finland. Numerous parties provided assistance during the course of the work. I would like to extend my warmest thanks to Mr. Timo Kukko of the Finnish Forest and Park Service, Mr. Martti Aarne, Mr. Yrjö Sevola, Mr. Eero Mikkola, and Ms. Marjatta Hytönen of the Finnish Forest Research Institute, as well as Mrs. Marja Kivimäki, Ms. Hilkka Lehikoinen and Mr. Jukka Muukkonen of Statistics Finland. I would furthermore like to extend special thanks to the Director

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Helsinki, May 1997

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ABSTRACT

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This study provides an overview of Finland's forest resources on the basis of existing research evidence as well as statistical data. The specific concern is with the human influence on forests and forest ecosystems, which in Finland has been very significant. The study also discusses the development of a forest resource accounting system as part of the broader mechanism of environmental accounting, on the basis of which the country's green GDP can be calculated. UN guidelines for integrated environmental and economic accounting (SEEA) as a complement to national accounts were issued in 1993. In Finland, environmental accounting based on the SEEA guidelines will initially comprise the country's most important natural resources and environmental impacts as well as expenditure on environmental protection. This study provides the groundwork for the later development of an official forest resource accounting system in Finland. The qualitative development of Finland's forest resources is here examined from the point of view of ecological sustainability. Referring to existing statistics, indices are constructed to describe the ecological quality of the country's forests. Trends of variables expressed in money terms are also followed. It is only in recent years that this sort of information on values has been more readily available in connection with the environment, so this analysis is restricted to the 1990's.

Comprehensive forest resource accounting requires that annual accounts are compiled to monitor the principal physical changes occurring in forests. Indicators describing the development of sustainability, for instance, are based on these systematic accounts. On the basis of the indicators proposed in this study, the burden imposed by forestry on the biodiversity of forests has been significantly reduced since the mid-1970s; at the same time, the chances to preserve that

biodiversity have improved. According to statistics, forestry in Finland has clearly moved in the direction of greater ecological sustainability. Moreover, the acidifying effect of air pollution has steadily diminished in the 1980's and 1990's. According to an indicator that has been created, the stress caused to forests by forest management has decreased by as much as 80 per cent since the late 1970's. At the same time, the indicator depicting the diversity of forest ecosystems shows that diversity is has also been slowly increasing.

The findings of this study indicate that the main value of Finland's forest resources in money terms is represented by wood production: in 1996 some 49 per cent of the estimated gross product of forest ecosystems services came from logging and 15 per cent from the net growth of forest (i.e. production for stock). Other forest-related products accounted for 10 per cent of the total gross value. The study also assessed the value of forest-related air pollution placement and recreation service-s. Air pollution placement represented 13 per cent of the total gross production value, while the share of recreation services was 12 per cent. The net production value of forests was some 54 per cent of the gross production value. There are fairly comprehensive statistics in Finland on the values of wood production, by-products from forests as well as environmental protection. In contrast, further research is required into the values of carbon dioxide binding, air pollution deposition and forest-related recreation services.

The study also examines possibilities for adjusting the national accounts by combining existing data on environmental resources and data on environmental expenditure. In practice, expenditure on environmental protection by the state, the municipalities and industry can be analyzed fairly comprehensively, and some of the damage caused by air pollution can also be estimated. Even a cautious estimate puts this environmental expenditure at 4 to 5 per cent of the value of the net national product. In the future, we should also pay particular attention to examining the environmental expenditure arising from the utilization of other natural resources, and changes in recreational values, as we would then come closer to a real account of well-being in adjusting the national accounts.

Key words:
environmental accounting
environmental indicators
forests
green GDP

1
INTRODUCTION

Description of the subject matter

The transformation from an industrial society into a service and information society which took place at the end of the 1980's and the beginning of the 1990's has in many ways changed our view of the nature of well-being. Alongside material values, a new kind of discussion on new attitudes to work, on a "citizens' wage", on various spiritual values and environmental issues have gained importance. Among other things, the environment is being seen more and more as one of the crucial sources of well-being. This change in ways of thinking has manifested itself in the rise of environmental movements, in various conflicts, in changing policies in various countries and in the increasing stress on effective environmental protection. However, the threats ensuing from environmental problems have often been seen as overwhelming compared to the available solutions.

Concern about the explosive growth of population, the increasingly acute environmental problems and the scarity of natural resources led the United Nations to set up a World Commission on Environment and Development in 1983. In its final report, published in 1987, the World Commission demanded that the structure of economic growth be changed to be based much less on energy and raw materials, and that the growth of population and consumption be adapted to the limits of nature's productive capacity. The Commission called these ideas the policy of sustainable development which "satisfies the needs of the present generation without jeopardising those of the generations to come". The principles of the policy of sustainable development were agreed on in 1992, at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro.

Another aim set by the Rio de Janeiro Conference was the development of a system of integrated environmental and economic accounting to replace national accounts by the year 2000. The new accounting system is to take the environmental impacts of economic activity into account in a more comprehensive manner and to act as an indicator of sustainable development. The System of Integrated Environmental and Economic Accounting, abbreviated to SEEA, was compiled by the United Nations Statistical Office. At least at the initial stages, the SEEA supplements traditional national accounting rather than replaces it. The SEEA is, however, intended to be a permanent part of the national decision-making system. In practice, the system would combine the data in the national accounts with statistics on the environment and natural resources.

By means of the SEEA, it is also possible to calculate a "green" national product. In order to calculate a national product that takes the environment into account, information is required on, among other things, environmental resources and changes in their values. Most environmental resources do not, however, have a market price, and thus the SEEA's perhaps most problematic aspect is the evaluation of natural resources and the environment in monetary terms. The SEEA may be looked at as a kind of "menu system", from which each country can choose the components it considers useful. Industrialised countries, where pollution is considered the greatest problem, will probably concentrate more on the interrelation between the environment and the economy. In developing countries, where the economy is usually based on the export of raw materials, the SEEA framework can be used, for example, for measuring and evaluating natural resources.

Purpose of the study

The general purpose of the study is to examine the targets of sustainable development related to forests, to study the development of balance sheets and indicators measuring the implementation of the policy targets, and also to develop the accounting of these factors in monetary terms. The work started from the premise that the development work would primarily be carried out by combining and improving existing databases. The work has involved close cooperation with the Finnish Forest and Park Service's development project for monitoring natural resources, which is at a pilot survey stage. By means of the new monitoring system, it will later be possible to obtain quality information on state forests for use in the national forest resource accounting system. Later on it will perhaps be possible to obtain the corresponding information on private forests. Statistics Finland's actual forest resource accounts will be compiled within the next few years. The perspective taken is clearly a human-centered one, and the starting point taken is the environment as a source of human well-being. In principle, it should be possible to express the well-being that people derive from nature in monetary terms, as in the SEEA system. These problems are discussed in more detail in Chapter 2.

Information on the status of the forests is required when predicting the future growth and development and other possible uses of forests, the quantities of wood raw material and of other products, and recreational values. Chapter 3 deals with the development of Finnish forest policy and forest management. This kind of information is in addition required when considering methods for preventing, controlling or alleviating the destruction of forests. It must also be possible to integrate these most significant indicators revealing the quality of the forests and the economic information available into the SEEA environmental accounting system. By means of the overall picture thus obtained it is possible to estimate how well the principles of sustainable development have been noticed in the forest sector.

In Finland, the introduction of the SEEA system will require data on pollution and the quantity and quality of the most important natural resources. As forests and the trees growing in them are the most important natural resource for the Finnish national economy, it is quite natural to start the development of environmental accounting with the forest sector. Statistics Finland's current three balance sheets of the wood accounts describe Finnish stemwood resources, their growth and depletion, the use of wood by the wood-processing industry and other sectors of the national economy, and the export of wood in the form of raw timber and wood products, and in addition the structure of timber use by the wood-processing industry. The weakness of the accounting system from the point of view of the SEEA is that it does not take into account any other uses of forests nor quality factors. Thus the accounts do not distinguish between living and healthy trees and dead or damaged trees. For the future and well-being of Finland, the difference is, however, significant. With a view to the above problems, Finland needs a new accounting system giving a comprehensive description of the development of forests. The principles of the forest resource accounting system are outlined in Chapter 4. Forest resource accounting on the basis of physical quantities is discussed in Chapter 5 and quality indicators in Chapter 6.

Monetary values concerning forests are presented in a form that is useful from the point of view of the national accounts at the end of the study. In addition, the study presents other environmental expenditure significant for Finland, such as expenditure on environmental protection and air pollution figures, and this information is added to the national accounts.

According to the forest strategy report prepared by the European Parliament, the EU's aim is to promote the commercial utilization, multiple use and diversity, and ecological, economic and social sustainability of European forests. The target for the future is to increase the amount and utilization of forest resources, but, on the other hand, also to enhance the protection of forests. The member states are primarily responsible for their forest policies, but, for the first time, the EU attempts to coordinate these policies. In order to carry out the measures required by the forest strategy, information must be produced on the Union's forest resources.

2
MEASURING SUSTAINABLE DEVELOPMENT

Environmental resources as factors of well-being

According to the prevailing trend in economics - neo-classical economics - well-being consists of both economic commodities, that is, goods and services produced by the economy, and free commodities provided by nature. The problem is that commodities offered by nature lack a market price based on supply and demand and thus they cannot be taken into account in drawing up economic models and forecasts. Thus, from the point of view of economics, the effect of the quality of the environment and of various natural resources on the well-being of people has remained at guesswork level.

Since societies have previously disregarded the effect of the environment and natural resources on well-being, and these resources have been relatively freely exploited, environmental problems have rapidly grown to catastrophic proportions. Efficient problem-solving requires integrating the

Figure 1. Perspectives on sustainable development

Perspectives on sustainable development	Replaceability of natural capital	Principal goal
Economically sustainable development	Nature can be replaced by man-made capital	Continous "sustainable" growth of the economy
Socially sustainable development	Nature can partly be replaced by man-made capital	Continous growth of the well-being of people
Ecologically sustainable development	Nature cannot be replaced by man-made capital	Securing the well-being of nature

aims of environmental policy with the planning of economic policy to form one entity. The purpose of sustainable development policy is to make possible the integration of environmental and economic planning, by providing them with a common framework. However, the definition of sustainable development requires more detailed specification, because sustainable development can be seen from three different perspectives, which are shown in Figure 1.

Of these perspectives, economically sustainable development is based on a production-centred view according to which nature's sole function is to provide input for production. According to this view, therefore, nature may even be destroyed completely, as long as the economic gain obtained from it is higher than the losses caused by it.

Socially sustainable development is based on a man-centred view, according to which nature is of value only in relation to man. Nature is thus significant only when it brings benefit and well-being to people. The ecological perspective, on the other hand, is based on a nature-centred view, according to which nature is of value as such, even without people. The ecological trend aims at guaranteeing the well-being and biodiversity of nature's ecosystems and species. Of these approaches, ecologically sustainable development is perhaps most clearly justifiable, because the well-being of nature and the preservation of its biodiversity are in the long run also optimal for man.

Ecologically sustainable development requires a transition from favouring the quantitative development of production to promoting qualitative development. The use of natural resources and the amount of pollutants formed per commodity unit produced should then fall continuously, in order for technological development to lead to reduced environmental stress. Economically sustainable development in particular aims at exploiting the improvements brought about by qualitative development for increasing production. The policy of economically sustainable growth thus only aims at securing continued economic growth, without paying sufficient attention to people's needs. Man is, however, part of nature and many of the commodities provided by nature are necessary for the existence of man.

Natural capital usually refers to an entity comprising all natural resources and the services (functions) provided by nature. As the state of the environment deteriorates, the value of this natural capital obviously decreases. The biodiversity of nature - of both species and ecosystems - is part of the natural capital, although it has no market price. Thus the biodiversity of nature can be considered to be the basic condition for sustainable development (Arjopalo 1994, p. 6).

Several factors should be taken into account when calculating the real value of natural capital. The total economic value of environmental commodities consists of different utility values and other values, in addition to the market price. This is illustrated by Figure 2.

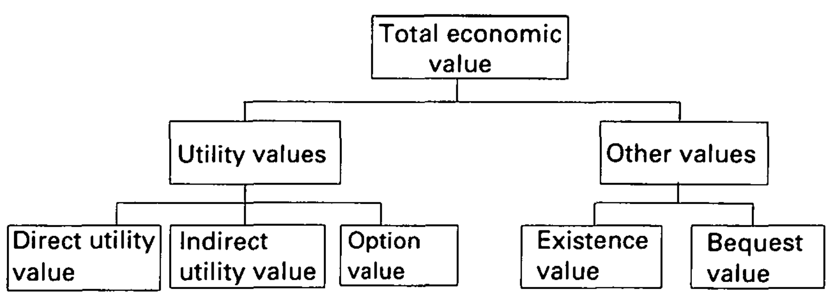
Utility values indicate the benefits enjoyed by the present generation. Direct utility value refers to products and services offered by nature for direct consumption. Services provided by entire ecosystems, for example forests which prevent desertification, have indirect utility value. Option value, on the other hand, describes the direct and indirect utility values of nature in future. The other values shown in Figure 2 relate to views on socially and ecologically sustainable development. Bequest value indicates the value of the natural capital left behind for future generations, and existence value measures the right of species to exist. Existence values are closely related to preservation of the biodiversity of nature and to views on ecologically sustainable development.

The definitions of these different values relating to forests are as follows:

(1) *Direct utility value* indicates the value of the direct well-being provided for man through the consumption of environmental commodities.

(2) *Indirect utility value* reveals the value of an indirect benefit obtained by man from nature. For example, the ability of ecosystems to prevent natural catastrophes such as desertification and floods has indirect utility value.

Figure 2. Different values of environmental commodities



Source: Pearce et. al.: Blueprint for a Green Economy 1991

(3) *Option value* measures direct and indirect utility values of nature in future. The option value reveals how much people are prepared to pay for nature in future.

(4) *Bequest value* reveals the value of nature left to future generations.

(5) *Existence value* reveals the value of a natural resources or living species from the point of view of existence alone. This means that their mere existence is considered to have a certain value. Existence value may be defined on the basis of moral and philosophical views, in which case it measures the right of species to exist. Existence values are closely connected with preserving the biodiversity of nature and ecologically sustainable development.

In practice, any values other than monetary values of nature are not of much use in decision-making in society. It is, therefore, usually necessary to find economic benefits or threats of economic loss to justify the preservation of the biodiversity of nature. The borders between direct utility value, option value and existence value are then rather vague and easily crossed.

The direct utility values of forests are based on the physical scarcity of different components and are thus often market prices. They do not always provide comprehensive data on the real price level, but rather are indicative. For example for different types of wood, there are stumpage or market prices which are based on their physical scarcity in the Nordic countries. There are also market prices for game and berries brought for sale to shops. However, they cover only part of the production of the commodities in question.

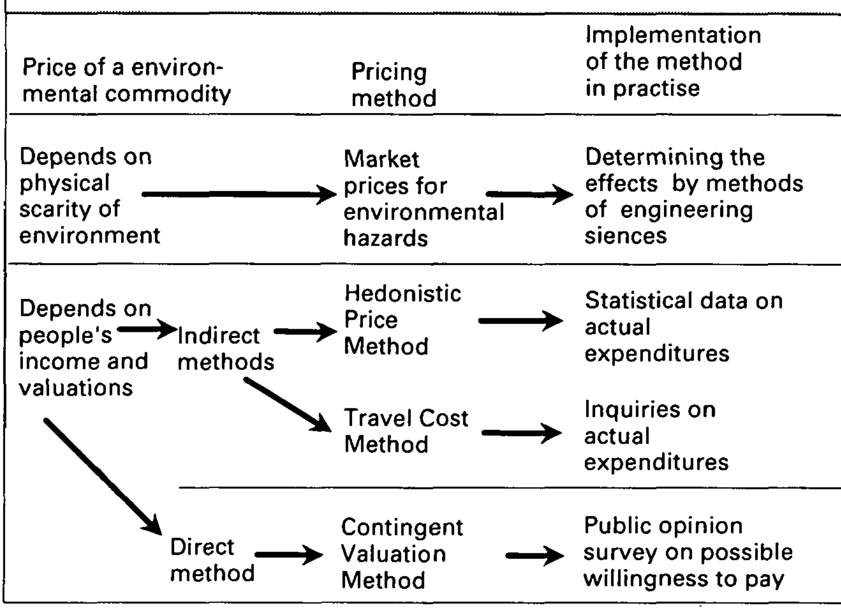
Other values of forests than direct utility value are tied to the *quality of the forest*. Especially option values, existence values and bequest values reveal the quality of the forest, that is, its value in future, and the market machinery cannot determine prices to describe these. This means that the values must be justified using pricing methods by means of which the values are given artificial prices. There are several different methods for calculating these values and they are shown in Figure 3.

The value of a forest can be measured on the basis of the physical scarcity of its various parts, in which case people's opinions have no effect on the prices. The values of the different functions of the forest can then be determined on the basis of cleaning costs, lost profits and losses to the well-being of society. The forest can also be priced by society through political decisions, for example, by means of taxes.

Pricing the functions of forests by surveying people's opinions is based on consumers' willingness to pay -approach. This is done by asking how much people are prepared to pay for a commodity provided by the environment. The price thus obtained for a particular environmental commodity is closely connected with the consumers' level of income. The various utility, option and existence values of forests can be determined by means of studies on willingness to pay.

In the *Contingent Valuation Method (CVM)*, a public opinion survey is conducted to find out how much the respondents are prepared to pay for the improvement of the state of the forests or how much they would have to be paid to make them give up the improvement. *The consumers' willingness to pay* can be determined *subjectively* and *objectively*. According to the subjective approach, consumers are asked how much they would be willing to pay *(WTP)*, for example, for the improvement of the state of a forest. According to the objective approach, on the other hand, the question is how much the consumers should be paid for the deterioration of the state of the forest. It has been noticed in practice that the *willingness to accept (WTA)* obtained as a result of the

Figure 3. Methods for pricing the quality of forests



Source: Hoffrén 1994, p. 69

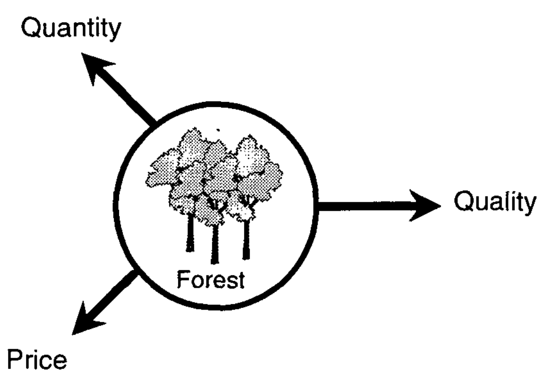
objective method exceeds the result of the subjective method. Because of this implementing the willingness to accept -approach has to a great extent been given up.

In indirect methods, such as the *Hedonistic Price Method* and the *Travel Cost Method*, the aim is to try to find equivalents for the different uses of the forest among market commodities or other factors that can be measured in monetary terms. The Hedonistic Price Method was originally developed to explain the price formation of real estates and it takes into account all the factors affecting the price of the site. According to the Travel Cost Method, the consumers' total travel expenses for example to a recreational site determine the value of the forest.

It has been observed in practice that the existence values of nature do not have much value in decision-making in society. Maintaining biological diversity based on option and existence values is, however, economically valuable, for example, for the pharmaceutical and biotechnology industries, when the amount, quality and prototypes (models) of the genetic material required by biotechnological processes are preserved.

Statistics taking into account biodiversity and environmental commodities may be considered to contain three essential components. The first is the quantity of the natural resource, which also ensures diversity within the species. The second is the price, which indicates the scarcity of the natural resource and its usefulness to man (utility values). The third component is the quality of the natural resource, which indicates its usefulness and existence in future (option, bequest and existence values). The different dimensions of a natural resource are illustrated in Figure 4.

Figure 4. The dimensions of a natural resource



Environmental accounting and natural resource accounting are based on compiling statistics on the three dimensions shown in Figure 4. A natural resource is usually not useful to man if its reserves are very small in quantity. The quantitative dimension guarantees for its part the biodiversity of a biological natural resource. The qualitative perspective ensures the quantitative dimension in future. The price of a natural resource, on the other hand, describes to some extent its utility value to man. These price, quantity and quality dimensions must be considered when compiling the statistics in order to make it possible to create a picture of the overall economic value of an environmental commodity.

The current natural resource accounting system, which is based on physical quantities, and the national accounts, which contain the market prices for environmental commodities, do not give a sufficiently comprehensive picture of environmental commodities. Information on the quality and development of environmental commodities is also required. In practice, natural resource accounting can be broadened into environmental accounting by adding to it the qualitative factors relating to the environment and natural resources. Whereas natural resource accounting looks at the environment only from the angle of quantities, the new environmental accounting system also takes account of the other dimensions of the environment.

The UN's System of Integrated Environmental and Economic Accounts - SEEA

The System of Integrated Environmental and Economic Accounts, or the SEEA, was developed by the UN statistical office UNSTAT and the World Bank. The purpose of this accounting system - which will be adopted in 2000's - is to combine information on the economy and that on the environment. At least in the initial stages, the SEEA supplements rather than replaces the traditional national accounts. The SEEA combines in practice the information contained by the national accounts with existing information on the environment and natural resources. In future, it will also form an integral part of national decision-making systems. As the gross national product cannot include too many environmental aspects without its capability as an indicator of economic trend being lost, the SEEA takes environmental matters into account in separate satellite accounts.

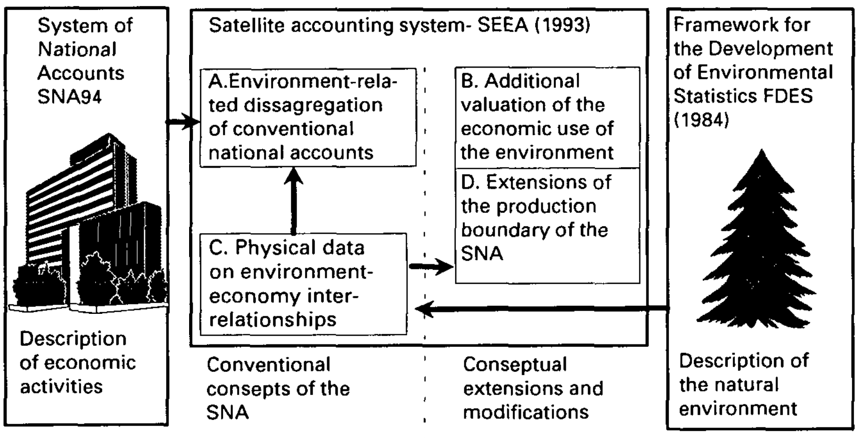
Normally, economic as well as environmental information is submitted to decision-makers in the form of a compact indicator. The national accounts are compressed into the gross national product, the current account, unemployment rate and inflation. For indicators of sustainable development to be equally easy to use and effective, they require as background a similar systematic statistical system as that of the national accounts. The SEEA also contains a "green" national product, the calculation of which requires information on environmental changes. However, most of the products provided by the environment do not have a market price. Perhaps the greatest problem of the SEEA is, in fact, the pricing of natural resources and the environment. The structure of the SEEA is shown in Figure 5.

The SEEA satellite accounts system shown in Figure 5 consists of four parts:

A. The environmental data contained in the current national accounts. This data, which can be found in the input-output tables of the production and consumption accounts must, however, be classified more precisely than before on the basis of environmental impacts.

B. Description of the cycle of the exploitation, utilisation in the economy and discarding of natural resources in physical quantities. At this point the input-output tables of the national accounts are followed and thus the physical information is comparable with that used in the national accounts.

Figure 5. The system of accounts for sustainable development - SEEA



Source: SEEA handbook, p.27.

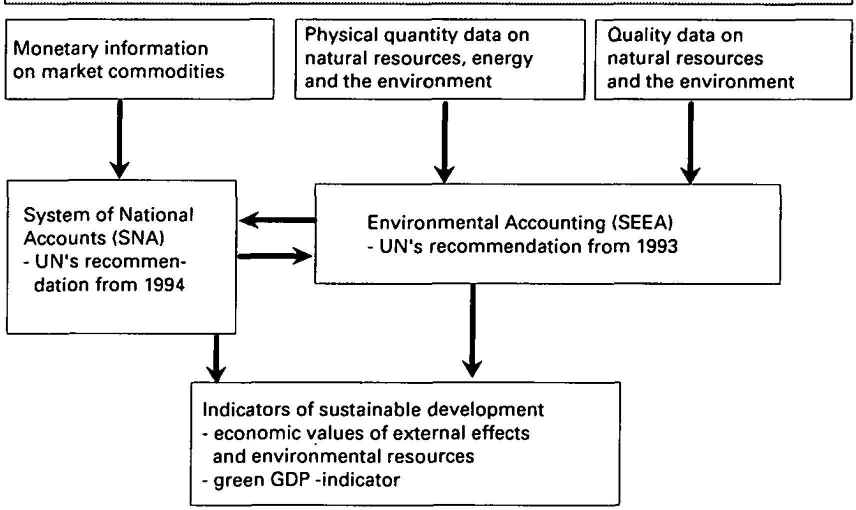
C. The expenses for the economic utilisation of the environment, which can be calculated with the help of the market prices, the cost of maintaining the quantity and quality of natural resources unchanged, or on the basis of the consumers' willingness to pay.

D. The possible future expansion of the concept of production, to include, for example, productive activities of households.

The concepts and mode of presentation of the SEEA follow the national accounts as closely as possible, and thus the material in the national accounts is directly comparable with the environmentally adjusted material. This uniform classification makes it easier to combine environmental variables with economic statistics. The SEEA also aims at presenting physical accounts and monetary accounts side by side.

Drawing up the SEEA requires quite comprehensive accounts on the environment and natural resources. The latest recommendation for national accounts from 1994 (System of National Accounts, SNA -94), contains opening and closing stocks in accordance with current natural resource accounting. Thus the classifications of the national accounts and of the natural resource accounting system become mutually compatible and the quality data accounts must also follow the same principles to make the measurement of sustainable development possible. The combining of price, quantity and quality data in measuring sustainable development is illustrated in Figure 6.

Figure 6. Accounting systems of sustainable development

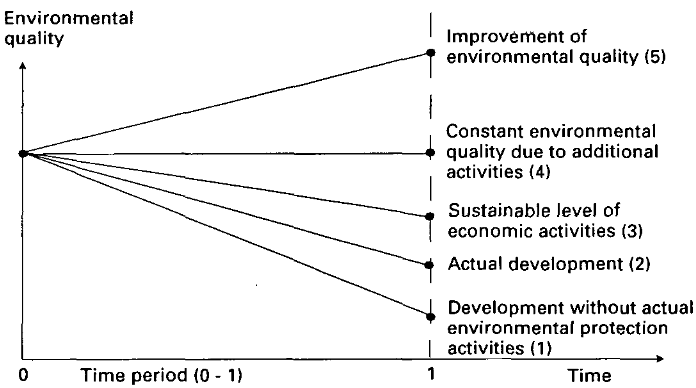


The final goal in developing environmental accounting is to report the external effects on the environment - as defined in neo-classical economics - in monetary terms, and to measure in this way the sustainability of development by means of a "green" or "sustainable" national income. In order to make it possible to draw up a "green" GDP, it must be possible to combine environmental accounts with other accounts by some certain mechanism. Comprehensive data on the quality of forests in monetary terms is, however, only available starting from the 1990s.

Various approaches can in principle be applied to pricing the quality of the environment. As regards pricing the quality of forests, the values of recreational use and of the effects of air pollutants, for example, can be taken into account using the pricing techniques presented in Figure 3. On the other hand, nature conservation costs are real, market-based values, and they can be established directly. How these different environmental values correlate with the implementation of a policy of sustainable development has been described in Figure 7.

Without environmental protection measures, the quality of the environment would decline steeply down to point 1. The distance between points 1 and 2 thus refers to expenditure on environmental protection to avoid deterioration of the environment. The distance between points 2 and 3 refers

Figure 7. Development of environmental quality



Source: Wouter Van Dieren (ed.) 1995, p. 248 to the actual decrease in the natural capital, which has to be priced using the techniques described in Figure 3. If the decrease in natural capital could be avoided, we would be at point 3, where the economy is on a sustainable basis. If society invests in extra environmental protection action and the quality of the environment remains as it is, we are at point 4. Point 5 presents an alternative in which the state of the natural resource or environment improves, which naturally has a positive effect on the well-being of society.

In the SEEA system, natural capital is divided into environmental resources already included in the national accounts and other environmental resources. The national accounts include, among other things, exploited and other non-exploited natural resources, expenditure on environmental protection and monetary data on other protection activities concerning the environment. The analysis of this expenditure involves disaggregation of the national accounts from the environmental perspective. Other environmental costs, such as maintenance costs for natural resources, the deterioration of soil and ecosystem quality, the use of the environment for disposing of pollutants and waste and the impacts of the deterioration of the quality of the environment on human well-being can be priced on the basis of accounting by physical quantities. Monetary information, of course, looks at a situation that has already existed (history), from man's point of view. This is why various indicators must be resorted to in order to make it possible to anticipate the future from the ecological perspective.

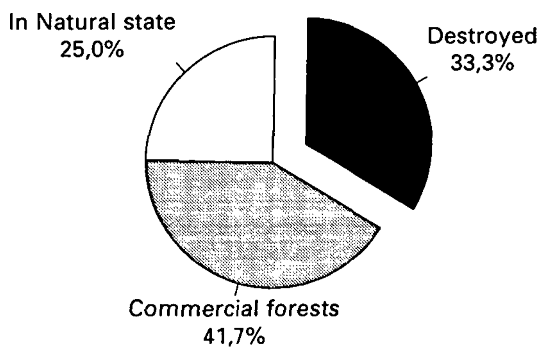
3
SUSTAINABLE USE OF FORESTS

Development of the biodiversity of forests

Before mankind started to practise agriculture, the estimated amount of forests on earth was some six billion hectares. With the advance of agriculture, man started to clear forests for fields and cut down trees for his other needs. Today, there are four billion hectares of forests left on earth, only 1.5 billion hectares of which are untouched and in their natural state. The situation is illustrated in Figure 8.

A large part of the earth's forests have disappeared completely as a result of human activity, and a considerable part of those remaining have been subject to human intervention. The impact of human activity on the diversity of forests can be seen as parallel to the development of agriculture. At the dawn of agriculture about 12 000 years ago, the first cultivation systems and cultivated plants emerged. Today, there are approximately 300 000 plant species in the

Figure 8. The status of the world's forests



world, 150-200 of which are cultivated. The majority of the food consumed by human beings comes from only 3-5 cultivated plants or varieties bred from them. The disappearance of diversity is almost entirely due to human activity, and especially to the explosive growth of the world's population. As the cultivation methods have become more efficient, the diversity of cultivation systems has been drastically reduced. The biggest crops are usually yielded by efficient monocultures, which, however, have high operating costs. As the size of the crops grows, the investments needed also grow according to a principle known in economics as the law of diminishing returns. Near peak production, besides high costs, various ecological and economic distortions are also created. As regards forests, a similar development is at present under way in many respects.

Already half of the forest cover in the tropics has disappeared, and half of the remaining forests have been treated in such a way that they are slowly disappearing. The species in the tropical forests are abundant and the growth faster than in temperate forests, but, correspondingly, tropical forests are far more vulnerable. Many tropical forests cannot survive a single large-scale clear cutting without soil erosion and damage to the ecosystems. In this respect, tropical forests cannot always be considered a renewable, but rather a non-renewable natural resource. It has been estimated that at least 50 per cent of all species in the world are in tropical forests, although tropical forests cover only seven per cent of the land area of the earth.

The biggest temperate forests are in Canada and Russia, where there are 1.4 billion hectares left. On the other hand, a third of the forests of the United States has disappeared, and China has lost as much as three quarters of her forests. In Europe, there are hardly any forests in their natural state, only commercial forests. Even though the forest area of the temperate zone is at present fairly stable, the quality of the forests is deteriorating and the number of species living in them and the amount of nutrients in the soil are decreasing. Of European forests under sustainable management, as much as three quarters have been damaged by air pollution and acid rain. (Meadows et al. 1993, pp. 56-57, 60)

As the forest area has decreased and the number of species diminished, the biodiversity of the forests has also decreased alarmingly. As a consequence, when defining sustainable development, one requirement has been the safeguarding of ecological biodiversity. The Biodiversity Convention concluded in connection with the Conference on Environment and Development in Rio de Janeiro defines biodiversity as diversity and variation of all flora, fauna and micro-organisms and their environment. This biodiversity manifests itself on three levels:

1) diversity within species
2) diversity between species and
3) diversity of ecosystems.

Of these, diversity within species is manifested as the variation of genes within one species, subspecies or strain; diversity between species is concerned with the diversity of different species within a specific area and the diversity of ecosystems is concerned with the variation among ecosystems. In practice, the protection of biological diversity requires varied and detailed data on the objects of protection. (UNCED 1993, pp. 157-158) Diversity within species can for the most part be maintained by ensuring the preservation of diversity between species and diversity of habitats. However, intensive plant breeding and cloning can, if carried out on a large scale, result a decrease in biodiversity.

Nearly all countries have signed the Biodiversity Convention. In the Convention, living organisms are regarded as natural resources in the same way as, for example, mineral and oil resources. They become economically valuable in practice when part of the economic profit arising from genetic resources is remunerated to the country of origin. In this case, for example, the medical industry and the biotechnology industry will have to pay remuneration for the genetic resources they have exploited. In the medical industry, secondary compounds of plants, insects, bacteria, marine invertebrates and fungi have now begun again to replace synthetic medical planning and production since the 1980's. The biotechnology industry is also growing, and it has been estimated that in the year 2000, products of the biotechnology industry worth 10 to 100 billion dollars will be sold to the agricultural sector in the United States alone. Thus, it is possible, for example, to evaluate the tropical rain forests for the first time from an economic point of view. There is, however, a danger of being short-sighted in the field of gene technology, because aiming at maximum boosting of production, disregarding the principles of sustainable production, leads to a decrease in biodiversity and even to its complete disappearance.

The Biodiversity Convention aims to involve the business sector to the protection of wildlife by making enterprises compete in developing better production techniques and environment-friendly products. For example, due to the pressure exerted by buyers, Finnish wood-processing industry enterprises will in the future have to compete on the Western European markets by emphasising environmentally sustainable production. The capital-intensive Finnish wood-processing industry cannot afford to place the production capacity of the forests at risk, but the exploitation of forests must in the future be based on the sustainable use of renewable forest resources. Until now, Finnish forestry has, to a large extent, operated in a way similar to a centrally-planned economy, concentrating on profits and the volume of timber. Earlier, the market did not consider biodiversity important, which has also been seen in the results of silviculture.

The Biodiversity Convention concluded at the Rio Conference came into force after 36 countries had ratified it at the beginning of 1994. The Biodiversity Convention obliges the signatory states to draw up a report summarising their biodiversity resources, as well as the present status and the measures taken to safeguard the conservation of the resources. After the report, the states will draw up a national programme of action to preserve ecological biodiversity and to function as a basis for the sustainable use required by the Biodiversity Convention.

At the Rio Conference, the Finnish standpoint was that the point of departure for the utilisation of forests should be to develop forestry that allows for the multiple use and biodiversity of forests. The presupposition is that the use of forests is based on a policy of sustainable development, and the aim is that forest resources and the forest area will not diminish after the year 2005. The vitality of forests should also be preserved, which, in the long run and especially in the industrialised countries, means ensuring the health and regeneration of forests. Special attention shall also be paid to the effects of impurities in the air and their prevention. Moreover, according to Finland's standpoint, a global forest agreement based on the sustainable use of forests should be concluded as soon as possible after the Rio Conference on Environment and Development.

The concept of sustainable development derives from forestry, where sustainability has primarily meant ensuring the availability of timber for society's needs. At different times, however, sustainability in forestry has been understood differently. Originally, the idea of sustainable forestry was born about 300 years ago in France and Germany, when this densely populated part of Europe was threatened by a shortage of wood. Wood was in those days used abundantly in the reconstruction after the Thirty Years War, in the heating of homes and in cooking, in the mining industry, shipbuilding and other industrial activity. The fear that wood as a raw material might run out led states to restrict felling in different parts of Europe. The idea of sustainability was based on the view of forests as a renewable natural resource. If care was taken to safeguard the condition of standing timber and the soil on which it grew, stable and continuous wood production could be maintained forever. (Parviainen and Seppänen 1994, p. 10)

In Finland, cultivation method of agriculture based on slash-and-burn techniques and the unplanned cutting down of forests to be used as fuel or as raw material in tar burning, shipbuilding and the sawmill industry, destroyed the forests near villages almost entirely in the 18th and 19th centuries. At the same time, serious disagreements arose between the government officials who tried to restrict the use of forests by legislation and the industrial establishments rural population pursuing short-term profit. It was only in 1928 that the Private Forest Act secured that the use of forests must be in line with the principles of sustainable wood production. (Parviainen and Seppänen 1994, p. 11)

In Finland, the use of forests has been based on the principles of forestry aiming at sustainable wood production ever since the 1920's. The idea has been to ensure maximum wood production of each tree generation ie. lifecycle. Forestry based on the idea of the sustainable wood production with emphasis on the productive and economic factors relating to forests ended the wasteful cuts in forests and created a tradition of planning in forestry and forestry sciences studying wood production. Planning was used to guide the development of a forest to reach a certain objective, i.e. maximum wood production. (Parviainen and Seppänen 1994, p. 12, 16)

Sustainable multiple-use forestry is an extension of the original sustainability of wood production. The concept was born in the 1950's and 1960's, when there was a shortage of other commodities provided by forests. These other products included for example game, berries, mushrooms and lichen, and other public and social amenities, such as recreational, conservation and landscape values. The aim of sustainable multiple-use forestry is to provide a maximum supply of wood and other commodities in cycles from forests. This means that the cutting may not, during a specific period, exceed the growth of the forests; the forest area and the health of the forests shall remain stable; and requirements concerning the protection and multiple use of forests are to be taken into consideration in forestry. (Parviainen and Seppänen 1994, p. 17)

Multiple-use forestry is, in practice, based on the use of similar planning methods as sustainability in wood production. The problems of the planning system have been the low value attached to the other commodities provided by forests, and the impossibility of comparing them in commensurable terms with other forest products as well as the lack of knowledge on and ingnorance of biodiversity.

In their Conference in Helsinki in June 1993, the European ministers responsible for forestry stated that maintaining and promoting biodiversity is an essential part of sustainable forestry. The ministers also agreed with the view presented at the Rio Conference that the principal aim of forestry is the maintenance of biological diversity that will secure the preservation of forests in the future. In the resolution signed at the end of the Conference, sustainable management of forests has been defined precisely on the basis of the principles of ecologically sustainable forestry. Europe-wide criteria for ecologically sustainable forestry have been developed in the follow-up process to the Helsinki Conference. They are:

1. Forest resources and carbon absorption
2. Conservation the health and vitality of forests
3. Maintaining and increasing the production capacity of forests (timber products and other products)
4. Protection of the diversity of forest ecosystems
5. Protection of forests and taking into account the protection requirements in silviculture of commercial forests
6. Other social and economic effects of forestry

Source: Finland's Natural Resources and the Environment 1995, p. 13

At the Helsinki Conference, Finland also gave commitments, among other things, to practise ecologically sustainable forestry and to protect the biodiversity of forests. In 1994, as a result of the Conference, the Ministry of Agriculture and Forestry and the Ministry of the Environment drew up an environmental programme promoting biodiversity. According to the programme, the requirements of wood production, conservation, recreation and game management are to be given more consideration than in the past, also in the treatment of commercial forests. The new silvicultural recommendations of Forestry Centre Tapio, which gives guidance in the management of private forests, were completed in 1994. The new recommendations allow more scope for decision-making according to local conditions. (Finland's Natural Resources and the Environment 1995, p. 15-16)

The aim of the recommendations of Forestry Centre Tapio is sustainable forestry, in which *forests and forest land are treated and used in such a way that their biodiversity, productivity, regenerational capability and vitality are preserved.* Moreover, *the possibility, now and in future, to carry on significant ecological, economic and social activities is preserved. When such activities are conducted in a sustainable way, the environment is not harmed. An environment characterised by biodiversity contains a large number of living species, the genetic material of the species is rich and varied and there is a great variety of different biotopes.* The recommendations are based on *"research, long experience and current conceptions of good management of forests and forest ecology"*. The recommendations are meant as an aid and support for forest-owners and the experts of the forestry organisations assisting them. (Natural Kind of Forestry 1994, p. 3)

According to the recommendations, the aims of forestry shall be natural regeneration, when the prerequisites for this are considered sufficient, growing broadleaves to add variety to coniferous forests, and selective cutting to ensure both healthy stands and a good income. In addition in clear cuttings old trees should be left standing, more attention should be paid to maintaining the forest's health and to prevent natural destructions, and, on the shores of lakes and rivers, careful silvicultural measures should be favoured and the habitats of rare species should be maintained and actively protected. Landscape management, multiple use of forests, especially game management, and recreational values shall also be taken into consideration in forest management. (Natural Kind of Forestry 1994, p. 72)

In the 1990's, discussion on forests, both on the national and the international level, has centred on defining new ecologically sustainable forestry policy. So far, no consensus has been reached on a detailed plan of action for ecologically sustainable forestry, but the conditions for such a plan are taking shape in the social debate between forestry experts, environmentalists, researchers and ecologists. The environmental organisations in particular want to see the introduction of forest management that imitates the natural development of forests. (Parviainen and Seppälä 1994, p. 19, 22)

As regards Finland, it is of vital importance to maintain the wood producing capacity of the forests, from the point of view both of ecology and of the successful future of the national economy, because, in the long run, preservation of entire forest ecosystems is the prerequisite for the maintenance of the wood producing capacity. It is, however, unclear how large areas of the forests should be protected, how different species move from one old-growth forest site to another, and what is the smallest viable population possible. According to a Swedish estimate, for example, as much as 30 per cent of forest land should be protected, if promotion of the biodiversity of species is confined only to conservation areas.

Life-cycle of Finnish forests in their natural state

Finnish forests represent the fire ecology of the boreal coniferous forest zone, where, in the natural state, recurrent forest fires destroyed the forest at irregular intervals. Forest fires were typically started by lightning recurred in dry sand and gravel soils on average every 50 years. In fresh clay soil, fires recurred in forests in their natural state every 100 to 150 years, and in humus-rich, moist soils the average interval between fires was more than 200 years. Only large mires and wetlands usually remained untouched by fires. In Finland, natural fires were usually fairly small in area. Often both single seed trees and clumps of trees escaped the fires, and so a varied forest mosaic was built up. In warm, dry and windy summer, thousands, even tens of thousands of hectares forests were destroyed by single forest fire. (Kuusela 1993, p. 7)

Forest fires released nutrients which were absorbed by the humus layer formed from partly decomposed plant residue, and lowered the acidity of the soil by 1-2 pH units. The decomposing of the plant residue was partly accelerated by sun rays penetrating freely down on the treeless surface of the earth. The growing ground vegetation used the released nutrients and made them available in turn to saplings. In moist heaths and other rich habitats, the first pioneer tree species were birch, alder and aspen. In dry sand and gravel soil, the most common pioneer species was pine. The areas of pioneer trees, however, soon became stocked with young spruces, and little by little spruce became the dominant species. As the time went by and the forest grew larger and older, the humus absorbed nutrients, especially nitrogen, in a form that was useless for the plants, and so the acidity of the humus increased. At the same time, the nutrient cycle between trees and the soil decreased, and the biological output and diversity of the ecosystem also diminished. (Kuusela 1993, p. 7-9)

In the boreal coniferous forest in its natural state, recurrent forest fires maintained the nutrient cycle, high biological output and biodiversity. In the raw humus of an area growing old spruces, there might be 1 500 kilograms of nitrogen per hectare in a form that was unusable for plants, while only 20 kg/hectare of this is involved in the nutrient cycle between trees and soil. Forest fires released nutrients, and the majority of them were utilised by the ground vegetation, which flourished. Old-growth forests, which in their most natural state have come into being as a result of forest fires and which have developed without human interference, are called ancient forests. In a typical ancient forest, there are big, old living trees, dead standing trees and numerous fallen and decaying trees. Ancient forests contain a rich variety of organisms. According to estimates, there are as many as 30 per cent more species in ancient forests than in commercial forests. In addition, the species differ considerably from those in a commercial forest. Many of the species in ancient forests cannot survive in commercial forests under human management. In this respect, ancient forests act as genetic reserves of forest biodiversity. Especially decaying tree trunks offer habitats for many rare species.

The majority of forests in Southern Finland remained in their natural state until the beginning of modern times, and in Northern Finland until the 20th century. In particular, converting felled forest into agricultural land by the so called slash-and-burn technique, became more widespread as the population grew in Finland. Barley, rye, turnip and flax were grown in the soil fertilised by ash. Once the forest had been burned, the soil usually gave one or two cereal crops, and the cycle lasted 15 to 20 years. After cereal cultivation, hay was mowen from the burnt land for a couple of summers, after which it was turned over to pasture for cattle. In Finland, slash-and-burn agriculture had been practised on a large scale ever since the end of the late Middle Ages, although the peak period of slash-and-burn agriculture was at the beginning of the 19th century. It is estimated that in the 1850's, the area under slash-and-burn agriculture was four million hectares, and 100 000 hectares of forest was burned every year. The government began to restrict the use of slash-and-burn agriculture at the end of the 19th century, when crops began to decrease as the soil became impoverished and, on the other hand, as the price of forest products rose. In Savo and Carelia, it was still practised in the early 20th century. In 1938, half of the land previously under slash-and-burn agriculture was still pasture for cattle, and as late as the 1950's, forest grazing was common. The slash-and-burn technique practised for hundreds of years had a great impact on the forests. The proportions of different trees in the forests were largely determined by the slash-and-burn cycle and cattle grazing. For example, spruce forests were destroyed almost totally in some parts of Savo and Carelia. (Jauhiainen 1990, p. 16)

Tar burning in Ostrobothnia and Kainuu and the increasing demand for sawn timber at the end of the 19th century revived the fear that forests, and especially large saw logs, would run out quickly. At the same time, the demand for wood was also increased with the establishment of the first wood processing factories in Southern Finland, which needed wood as their raw material. The Private Forest Act enacted in 1928 prohibited forest destruction, which included cutting trees that were in their prime growing period, and cutting where the regeneration of the forest was neglected. (Jauhiainen 1990, p. 17-18)

The influence of intensive silvicultural measures

After the Second World War, the central position of forestry in the Finnish national economy became more and more important, and decision-makers began to look at forests merely as a source of raw material. In the 1960's and 1970's, the idealisation of economic growth also changed the aims of forestry. Instead of sustainability, people started to advocate progressive forestry aiming at continuous increase of wood production. Natural development was set aside, and even-aged forests of one or two tree species became the ideal. Seeding was used to ensure the rapid regeneration of forests, and prescribed burning was replaced by ploughing or harrowing. The coppices of broadleaves competing with planted trees were destroyed, mainly chemically, and fertilisation of the forests became quite normal procedure. (Jauhiainen 1990, p. 18-19)

In Finland, the most important principle of forestry policy has always been the principle of sustainability in various forms. At first, it only meant that the cuttings may not exceed the annual increment of the forests. Up until the 1950's, another principle in forest management was "naturalness", which meant that the tree species that was best suited for a particular habitat was grown in that place. In ideal cases, the development of the forest was pointed in the desired direction very carefully, without much human intervention. It must be noted, however, that forestry aiming at sustainable wood production was by no means the same thing as ecologically sustainable forestry. The most important measures in forest management and other human influence on the lifecycle of the forests is presented in Figure 9.

The most important form of forest improvement aiming at increasing wood production was drainage. Large areas of bog and mire were drained as early as the 1930's, but drainage reached its height at the end of the 1960's, when first-time drainage affected some 300 000 hectares of forest annually. Today, the annual areas drained are very small, as the best lands suitable for drainage have already been drained. (Jauhiainen 1990, p. 19). Figure 10 shows the forests drained between 1950 and 1995.

Figure 9. Factors that have affected the forest most significantly

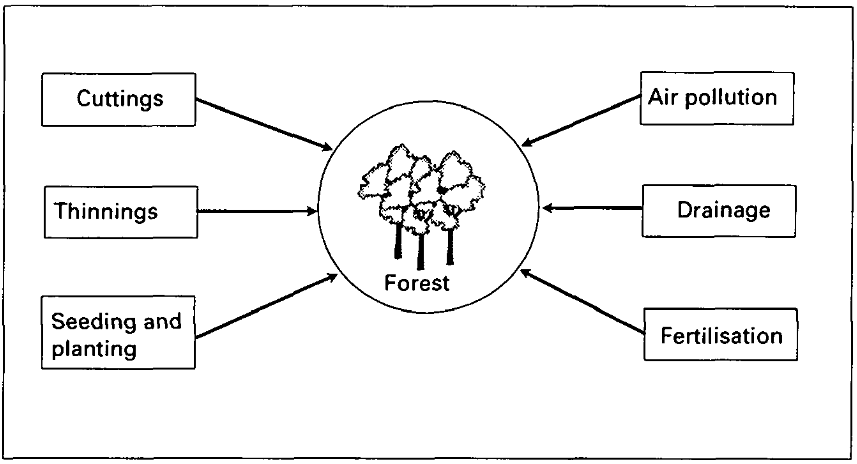
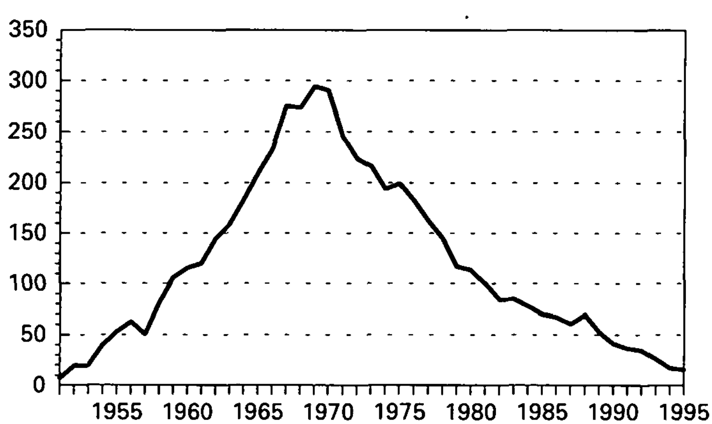


Figure 10. Development of new drainage areas 1950 to 1995 (thousand hectares)



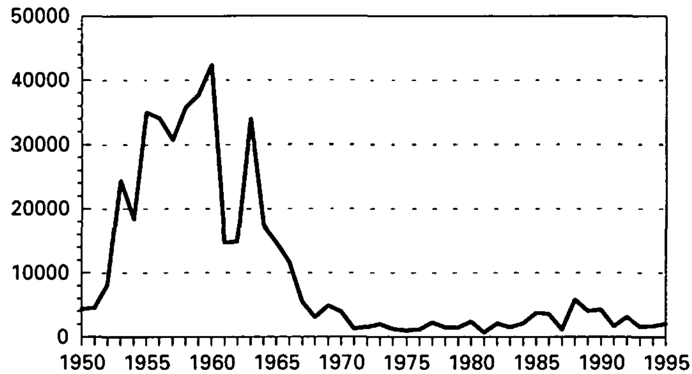
Source: Finnish Forest Research Institute

Drainage has had a huge influence on the peatland environment. If the Finnish environment were in its natural state, bogs and mires would account for a third, i.e. about 11 million hectares, of the land area. Of this area, almost eight million hectares would be treeless bog or would grow only stunted trees; in other words, bogs and mires would account for double the area they cover at present. In particular, bogs and mires rich in nutrients, such as rich fens, herb-rich spruce mires and herb and grass mires, would be much more extensive than at present. There would also be more fertile herb-rich forests. (Jauhiainen 1990, p. 14)

In the natural lifecycle, forests are regenerated after a certain period through forest fires. In the case of forestry, this cycle has been accelerated in order to increase wood production. When the forest had reached a certain stage of development, a so-called "final" cutting was carried out and new seedlings were planted in the clear-cut area. Prevention of forest fires is also a part of forest management, which has had a great influence on the cycle of the forests. Usually, the annual area of prescribed burning was tens of thousands of hectares, and in the warm and dry summers in the 18th and 19th centuries, it could be considerably more. In the 1950's, the area of forests burnt in forest fires totalled almost 6 000 hectares a year, and, at the same time, prescribed burning covered almost 20 500 hectares. Prescribed burning was hardly practised at all in the 1970's, but it became more general again in the 1980's. In the 1980's, forest fires burned more than 300 hectares of forest, and prescribed burning covered 2 200 hectares. The areas of forests burnt in forest fires and through prescribed burnings are shown in Figure 11.

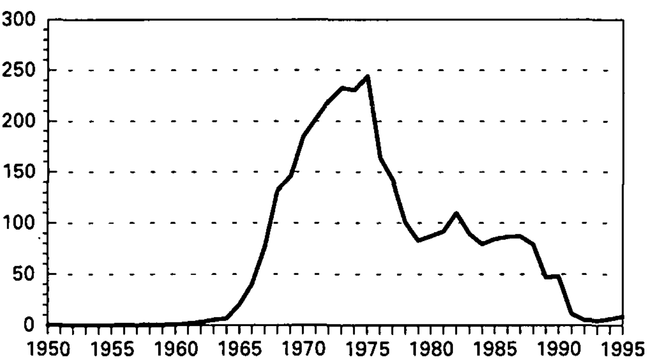
The area of forest burnt either by a forest fire or as a result of prescribed burning has decreased particularly sharply since the end of the 1960's. When the alternation of pioneer and climax stages, the periodical acceleration of the nutrient cycle and the biological diversity that are integral elements of a fire ecology cannot be maintained in forestry, the forest becomes impoverished and forest biodiversity starts to decrease slowly but surely. Prescribed burning for the area to be regenerated is the best way to get close to the positive effects of a forest fire. At present, increasing prescribed burning is considered favourable from the viewpoint of biological diversity. The development of forest fertilisation is shown in Figure 12.

Figure 11. Forest fires and prescribed burnings, 1950 to 1995 (hectares)



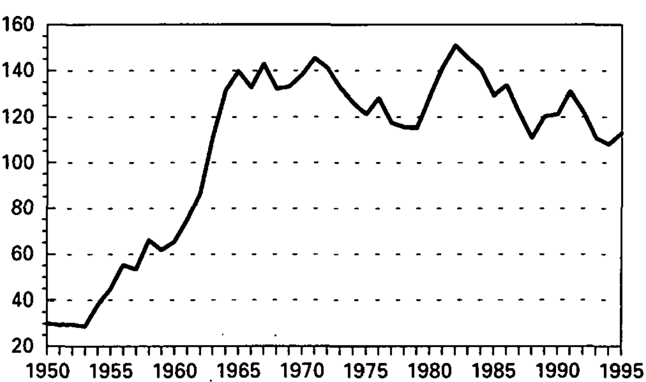
Source : Finnish Forest Research Institute

Figure 12. Fertilised areas, 1950 to 1995 (thousand hectares)



Source: Finnish Forest Research Institute

Figure 13. Forest cultivation, 1950 to 1995 (thousand hectares)



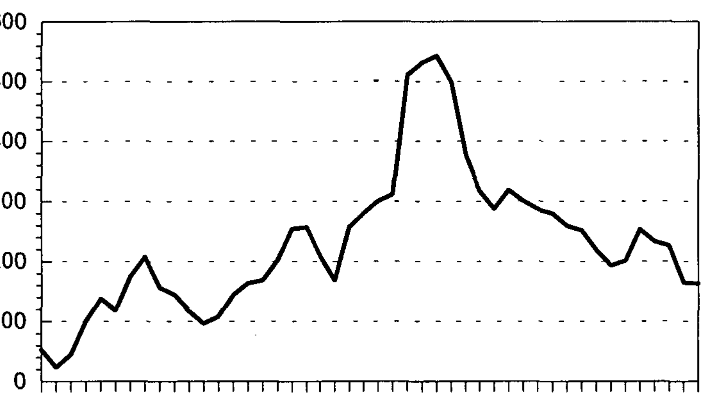
Source: Finnish Forest Research Institute

The volume of forest fertilisation has dropped sharply since the peak years of the mid-1970's. The reasons have been, for example, the falling prices of timber, "polluter pays" taxation of fertilisers which raised fertiliser prices, and the stronger environmental awareness of the eutrophising effects of fertilisers on watercourses. Fertilising has been used especially to increase the timber production of drained peatland forests. As less land has been drained and the trees have started to grow, the need for fertilising has also diminished. The natural regeneration of the forests has had to give way to forest cultivation. The development of forest cultivation (seeding and planting) between 1950 and 1994 is shown in Figure 13.

The large-scale planting of forests was started at the beginning of the 1950's and since then, well over 100 000 hectares of the forest area have been cultivated annually. Besides forest cultivation, thinnings have also increased. The aim has been to produce saleable timber as quickly as possible. The development of the area under thinnings from 1950 to 1995 is shown in Figure 14.

The peak years in the thinnings fell at the end of the 1970's, when the annual areas managed exceeded 500 000 hectares. The biggest threats to biodiversity among the individual methods available are clear cuttings, forest drainage, selective cuttings, clearing of forests to fields and the decreasing number of forest fires. The fall in the number of forest fires can be compensated, for example, by practising prescribed burning on clear cut areas where stem wood has

Figure 14. Thinnings 1950 to 1995 (thousand hectares)



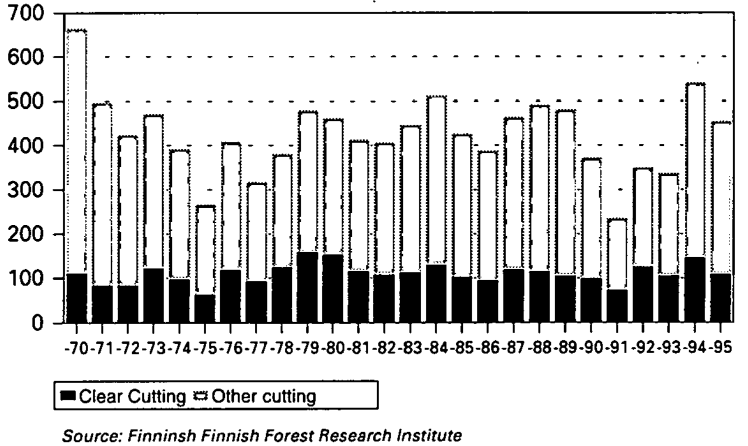
Source: Finnish Forest Research Institute

been left. In addition, clumps of trees can be left in the middle of large cuttings, which are then burnt. In management of seedling stands and in selective cuttings, some dead and decaying trees should also be left in the forests. Moreover, in selective cuttings, dead trees and some of the ailing trees and broadleaves should be left uncut. Figure 15 shows the development trend in the area of forests cut by different methods in Finland.

If Finland were in its natural state, the total number of living species would be smaller than at present, because the so-called cultural species that spread to the country along with human settlement, would be absent. The biggest difference would be the absence of species belonging to field and meadow environment in the countryside. On the other hand, there would be considerably more ancient forest species and wilderness species typical of the boreal coniferous forest zone. Many endangered and rare species would be common. The wild animal population, such as wolves, eagles and wolverines would be considerably larger than at present, whereas there would be fewer hares, elks and many bird species. (Jauhiainen 1990, p. 14)

Of the animal and plant species classified as endangered in Finland, 43 per cent live in the forests. Seen in proportion to the area, there are fewer endangered species in the forests than in other environments. Most of the species living in the forests depend on decaying tree, and they require old-growth forest or burned areas as their habitat. Usually dead and ailing trees as well as tree species of no economic

Figure 15. Forest cutting areas, 1970 to 1995 (hectares)



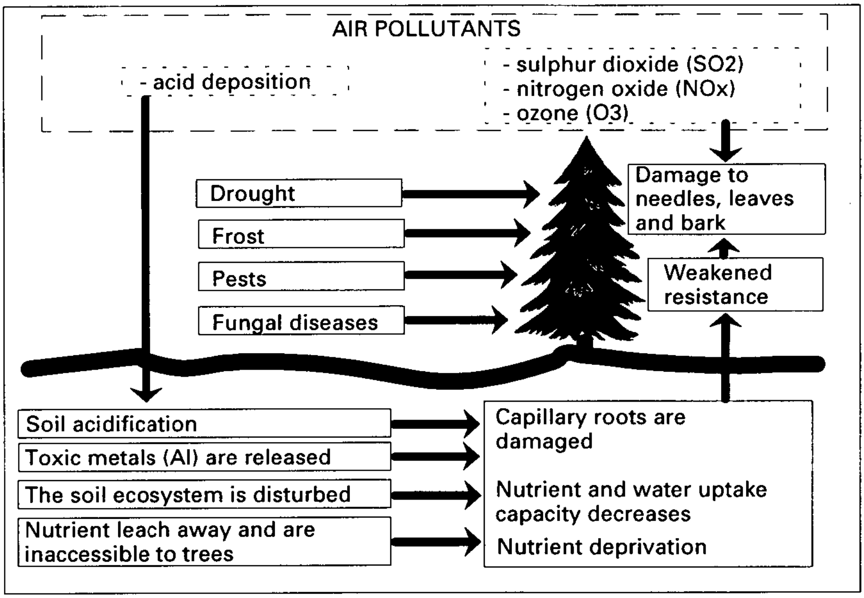
Source: Finninsh Finnish Forest Research Institute value are removed form commercial forests. Damage caused by natural causes, such as trees blown down, or trees which have died as a result of fungal and insect attack, are removed as soon as possible, because it is considered that forest hygiene increases the economic yield of wood production.

In order to maintain the Finnish forest environment as diverse as possible, besides conservation areas, changes in the management of commercial forests are needed. Dead standing trees are especially important for many insects. Broadleaves also offer habitats for many different species of insects. The report of the Ad-hoc Committee for Endangered Species of Flora and Fauna states, among other things, that *forestry is the most important factor threatening the conservation of our species. Besides forest management, the most significant factors are the diminishing numbers of broadleaves and decaying trees.* Of the 1 692 endangered species in Finland, 41 per cent are endangered through forestry procedures.

In the last few years, the indicator of the health of the trees used has most often been defoliation or needle loss, i.e. the number of needles that are missing as compared to a healthy tree. Defoliation is estimated by visual inspection, i.e. by comparing a tree to a healthy tree in the same forest, and it is described as a percentage of missing needles or leaves. The number of needle age classes is also considered an indicator. A healthy pine, for example, has 2 to 4 age classes, whereas a damaged tree may only have 1 to 2 age classes, and they may not be as dense as usual. The Europe-wide standard classification divides trees into five classes on the basis of the level of damage. In class 1, the tree has dropped 0 to 10 per cent of its needles, and no needle loss is considered to have occurred. In class 2, there has been 11 to 25 per cent needle loss, which is considered a slight loss. Considerable loss is considered to have occurred to trees of the third class, which have lost 26 to 60 per cent of their needles, and the fourth class refers to the situation where severe loss has occurred, and a tree has lost more than 60 per cent of its needles. Trees in the last, or fifth class, are dying because of needle loss. (Wahlström et al. 1992, p. 116, 119) The impact of air pollution on forests is shown in Figure 16.

In Finland, the reasons for needle loss are, besides the age of the trees, also the weather, climatic factors and air pollution. Old trees suffer from needle loss and die about 20 per cent faster than middle-aged trees of about 50 years. On

Figure 16. The impact of air pollutants on forests



Source: Wahlström et al. 1992, p. 120

the other hand, young trees lose their needles as much as 20 per cent more slowly than middle-aged ones. Trees older than 60 years suffer, therefore, more from needle loss than younger trees. (Wahlström et al. 1992, p. 121) Air pollutants and deposition weaken the resistance of the trees, and disease, animals, frost and wind easily damage the trees. Acidification caused mainly by air pollution lowers the quality of watercourses, soil, groundwater and forests in many places. Particularly in Northern Europe, the growth of trees has traditionally been limited by lack of nitrogen. Forests are capable of utilising nitrogen deposition, and therefore the fertilizing effect of nitrogen is far greater than its acidifying effect. The limit of nitrogen saturation, i.e. the limit where the soil cannot fully absorb and utilise nitrogen deposition, is not yet known exactly. According to some estimates, the limit may be reached within a few decades.

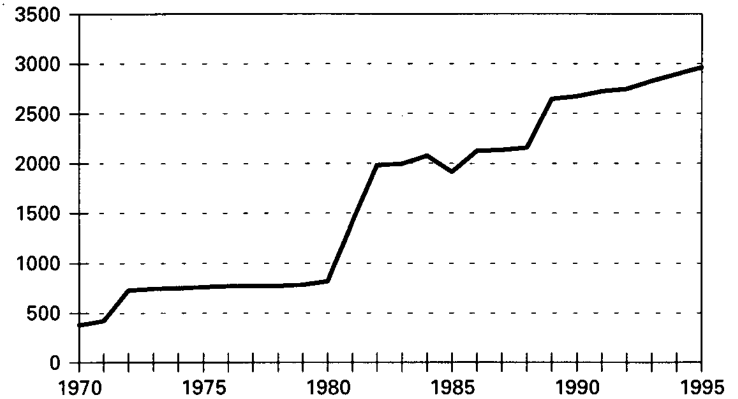
Critical load means the greatest deposition that nature can tolerate without significant damage. In Finland, depositions have, since the 1980's, continuously exceeded the critical load. However, this must be seen in relation to long-term targets, not in the short term. Therefore, exceeding the critical load only means that, in the long run, there is a risk of damage. Depending on the region and the situation, the depositions can usually be reduced to the level of the critical load limit simply by decreasing sulphur and nitrogen depositions. (Wahlström et al. 1996 p. 138)

Besides air pollution, acidification is caused by logging, drainage, the extraction of gravel and other silvicultural measures. The proportion of tree species in the forest is also important, since predominantly conifer forests become acid more easily than predominantly broadleaf forests. Acidification can be prevented by increasing the number of decaying trees left in forests, but this possibility is not optimal from the logging point of view. Acidification of forest land can also be prevented by lime application, which, however, decreases the wood production capacity of the forest. According to estimates of the Finnish Forest Research Institute, 10 per cent of the growth volume of spruce and three per cent of that of pine is lost because of liming. It has been estimated that forestry accounts for a half of the acidification in Northern Sweden and for about a third in Southern Sweden. In Finland, the forestry probably accounts for a similar proportion of acidification. (Wahlström et al. 1996 p. 143-144)

The lifecycle of a forest in its natural state from birth to death lasts from 50 to 300 years. When practising forestry, the period of forest regeneration varies according to the type of forest and tree species. The shortest cycle for coniferous forests growing in fertile soil in Southern Finland is about 80 years and for birch forests 60 to 70 years. In barren soils, and in Northern Finland, the cycle is longer. On average, the cycle in a commercial forest is a hundred years in Finland. The differences between commercial forests and natural forests are greatest in old-growth forests. The biological age and the wood producing age of the forest also emphasise the differences. The maximum age of a pine in Southern Finland is about 300 and in Northern Finland 600 years, whereas the corresponding maximum ages from the wood producing point of view are respectively 100 and 200 years. As a consequence, the conservation of the species in old-growth forests inevitably requires the establishment of conservation areas. The development trend in the area of conservation sites in Finland is shown in Figure 17.

The general purpose of setting up conservation areas in Finland has been defined in the old Nature Conservation Act of 1923, according to which the areas are set up in order to preserve nature untouched. However, neither the purpose of special nature reserves - which most of the conservation areas in Finland are - nor the aim of protection have generally been defined clearly in Finnish legislation. Since 1916, a

Figure 17. Total area of conservation areas, 1970 to 1995 (hectares)



Sources: Ministry of Environment, Finnish Forest and Park Service, Finnish Forest Research Institute

total of 1.25 million hectares of conservation areas and 1.5 million hectares of wilderness reserves have been set up.

The purpose of national parks is, above all, to preserve Finnish nature in its original and untouched state for future generations. In national parks, nature's own cycle of development is not affected by human intervention. National parks offer habitats and indeed sanctuaries for many animal and plant species that require an environment in its natural state. Of the national parks in Finland, 24 are under the control of the Finnish Forest and Park Service and three under the Finnish Forest Research Institute. They cover a total area of 7 100 square kilometres.

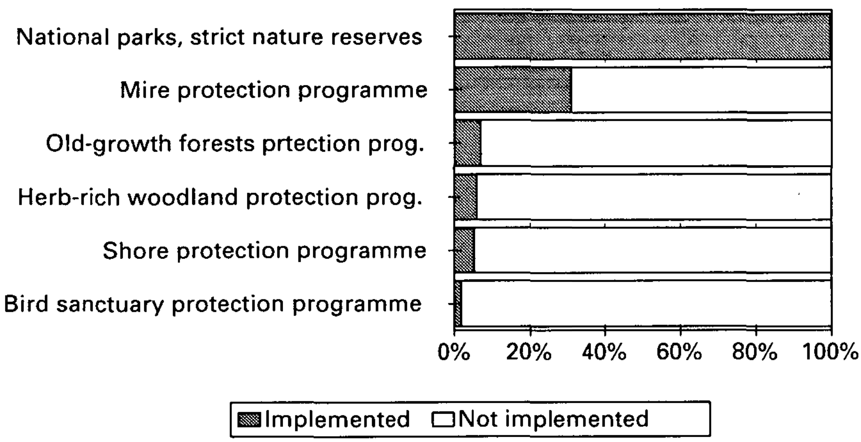
Nature parks have been founded mainly for scientific purposes, and they primarily serve scientific research and as nature reserves. For reasons of, the authorities want to preserve the parks as undisturbed as possible, and ordinary citizens may usually not enter without written permission. Of the nature parks, 14 are under the control of the Finnish Forest and Park Service and five under the Finnish Forest Research Institute, their area totalling 1 530 square kilometres.

The protection regulations for peatland reserves are less strict than those for national parks and nature parks. In peatland reserves, the primary concern is the protection of peatland environment. The actual bogs and mires, i.e. peatlands, are left completely in their natural state, but in most mineral soils, forestry that respects nature conservation and landscape conservation values can be practised. The peatland reserves established in Finland since 1982 are under the control of the Finnish Forest and Park Service.

In addition, other conservation areas of various sizes have been set up on state-owned lands, with nature and protection aims resembling to varying degrees those of nature parks and national parks. In these areas, protection may concern either the nature of the entire area or only certain components, formations or organisms in it. These conservation areas are under the control of the Finnish Forest and Park Service, the Finnish Forest Research Institute and certain other state authorities. In addition, various, typically fairly small, conservation areas have been set up in privately-owned forests, and at the beginning of 1995 their area totalled 24 000 hectares. Figure 18 presents the level of implementation of protection programmes approved of by the Council of State at the beginning of 1996. At present, the focus in the setting up of conservation areas is on the protection of old-growth forests.

The vast majority of the conservation areas in Finland are in the Northern part of the country. Of forests south of Lake Oulujärvi, only 0.25 per cent are preserved, about a third of which can be considered ancient forest. The conservation areas have, to a great extent, been set up in areas of low wood productivity, i.e. on scrubland and wasteland. Only 24 per cent of the area protected by law is forest land, while 66 per cent of the total land area is forest land. Of conservation areas prescribed by law, 27 per cent is scrubland and 54 per cent wasteland. Of the total land area, 11 per cent is scrubland and 12 per cent wasteland. On the whole, of land

Figure 18. Implementation of protection programmes in privately-owned land, as January 1, 1997



Source: Ministry of Environment

under forestry (forest land, scrubland and wasteland), 10.2 per cent has been protected by law.

It is not possible to completely remove the threats to biodiversity merely by changing the way forests are managed, but, in practice, the only way to maintain a suitable living environment for all species seems to be sufficient forests in natural state in different habitats in various parts of the country. The key word in new forest management is biodiversity of the forests. Wood production should not be the only way in which forests are used - it should be possible to use normal commercial forests, for example, for recreation and game management. Usually forests of many wood species are also more resistant to disease than monocultures, and mixed woods containing broadleaves slow down the acidification of the soil caused by air pollutants. (Jauhiainen 1990, p. 22)

The extent to which the forests are in their natural state can be used as the guideline in planning the protection of biodiversity in commercial forests. The natural state of a forest is not, however, a static state, but a forest represents a temporally and regionally dynamic system. When defining "natural state", the crucial factors are the method and the time span of regeneration.

Discussion has also arisen on the correct percentage of conservation areas in the total forest area. Ten per cent of the forest area, for example, has been considered appropriate. On the other hand, where intensive forestry is practised, it has been demanded that 15 to 30 per cent be protected, whereas if the maintenance of biodiversity is taken into account in forest management, 5 per cent has been considered sufficient. The intention is to considerably speed up the acquisition of areas falling within the scope of nature conservation programmes in the next few years. In March 1994, a working group set up by the Ministry of the Environment presented its own programme for protecting the diversity of the Finnish forest environment. The focus of the programme was on discussion of the effects of the inadequacy of conservation areas on forests, and on proposing improvements to the problems arising from this. The starting point for the proposal of the working group was to create sufficiently large and ecologically uniform areas, which would ensure the preservation of the species in question. Thus, the working group proposed one hundred hectares as the minimum size of conservation area for protecting old-growth forests. The proportion of protected forest land should also be raised from

2.6 per cent to 5 per cent, which would cost approximately FIM five billion. In the forests of Southern Finland, the percentage would be fivefold, but would still not contain more than 2.5 per cent of all productive forest land.

In the programme, forests have been divided into four zones according to vegetation, and the most important types of forest needing protection have been defined for each zone. In particular, herb-rich forests and the old-growth forests on eskers, in coastal areas and privately-owned forests are in need of protection. According to the working group appointed by the Ministry, the need to establish expensive conservation areas could be reduced by creating a new type of forest, a so-called forest of high ecological value, between commercial forests and nature conservation forests. These would be set up on state-owned land near the conservation areas, and they would act as ecological corridors between the protected forest areas and would promote the spread of species. In practice, commercial forests would be returned to their natural state, for example, through prescribed burning and by letting the forest develop naturally after that.

Pressures to change statistics on forests

Reliable data on the state of Finnish forests are available from the 1920's, when inventorying of the forest resources of the country was started on the national level. The National Forest Inventory (VMI) of the Finnish Forest Research Institute concerns all forests including conservation areas. Finnish forests were inventoried for the first time between 1921 and 1924 (VMI I), and for the second time between 1936 and 1938. The third inventory was carried out between 1951 and 1953, and the fourth between 1960 and 1963. The fourth National Forest Inventory was carried out between 1963 and 1970, the sixth between 1970 and 1976, the seventh between 1977 and 1984, and the eighth between 1986 and 1994. The ninth National Forest Inventory was started in the summer of 1996.

The National Forest Inventories have been based on surveys carried out in systematically placed sample plots. In the eighth inventory, the sample plots were combined into parcels of 21 sample plots, the distance between them being eight kilometres in the north-south direction and seven kilometres in the east-west direction. The state of health of the forests has only been monitored since 1985 in the National Forest Inventories. In addition, the Finnish Forest Research Institute has produced annual data on needle loss since 1986. The state of health of the forests has been monitored in one-time sample plots in the eighth inventory, and in permanent sample plots, 3 009 of which were established between 1985 and 1986. In some of the permanent sample plots, 450 plots, surveys have been carried out annually since 1986. (Statistical Yearbook of Forestry 1993, p. 31, 69)

At present, the statistics in the Statistical Yearbook of Forestry published by the Finnish Forest Research Institute depict the Finnish forest stock, the deployment of labour in forestry, transportation of raw timber, use of wood, the output of the wood-processing industry and foreign trade. As regards the data produced by the National Forest Inventory, the problem is the lack of annual data. In other words, during the period of Finland's independence, the country's forests have been inventoried only eight times. However, in order to draw up a forest accounting system, an essential prerequisite is the availability of annual data on the most important natural resources, i.e. also on forests. Therefore, the data presented by the Finnish Forest Research Institute has to be converted into annual data in order to be usable.

In Finland, the first natural resource accounting application was carried out in the forest sector in 1992. The wood accounts compiled by Statistics Finland depict the timber stocks in Finnish forests, their growth and depletion between 1980 and 1990. Also depicted is also the conversion of harvested raw wood by the wood-processing industry and its use in the other industries and in households. The accounts also include data on the consumption of raw wood in semi-manufactured and manufactured products, fuel wood and wood-containing waste. The unit of measurement used is solid cubic metre.

The biggest deficiency of the wood accounts is that they do not take into account the use of forests in other than wood production. As such, they are not sufficient to be used to depict sustainable forestry by forest resource accounts. Thus the wood accounts will have to be supplemented by data on the other uses of forests and the development of their biodiversity. This need for statistics is a result of the new forest management policy and society's requirements regarding the management of forest resources.

In Finland, the answers to issues of preserving biological diversity have been sought through a research programme on natural biodiversity (the LUMO project) coordinated by the Finnish Environment Agency. The LUMO project is a national framework programme that covers many branches of science, and on the basis of its results the report on Finland will be submitted to the UN Sustainable Development Commission during 1996. (Jäppinen and Väisänen 1993, p. 3, 27)

The Finnish Forest Research Institute has also started a research programme with the aim of clarifying the notion of forest biodiversity. The results should be available in 1997. The name of the programme is "The Biological Diversity of Forests and Its Dynamics and a Method for Evaluating Biodiversity", and its aim is to create a proposal for a method that can be used to monitor the overall picture and development of biodiversity.

4
BACKGROUND TO FOREST RESOURCE ACCOUNTING

Importance of forest resources for the Finnish economy

Unlike other countries in Europe, the Finnish economy has largely been and is also currently largely based on the exploitation of one raw material, the forests. Of all the countries in the world practising forestry, Finland lies the furthest north. Of the country's area, 69 per cent, i.e. 233 665 km^2, is forest, with only 5.1 million inhabitants. Other parts of the world as far north as Finland are mainly treeless tundra. The majority of Finnish forests belong to the boreal coniferous forest zone. Finland's rise to become a developed industrialised country has been based on the exploitation of forest resources and on the development of a modern wood-processing industry, which has meant that income from the processing of the raw material has remained in Finland. In 1995, forestry and the wood-processing industry accounted for 9.4 per cent of the gross national product. It has also been estimated that Finland accounts for 0.5 per cent of the world's forest resources, 2.5 per cent of commercial felling and 5 per cent of the output of the wood-processing industry.

The majority of raw timber used by the Finnish wood-processing industry is from Finland. Nearly three quarters of the wood raw material used by the industry comes from privately-owned forests. The average size of privately-owned forest is 30 hectares, which explains the small scale characteristic of Finnish forestry. In the 1990's, the import of wood has grown quickly. In 1995, 51 million solid cubic metres of wood were felled in Finland for the use of industry, and 11.3 million cubic meters of raw timber were imported. Of the imported raw timber, 75 per cent was broadleaves and the majority came from Russia. In 1995, the turnover of the wood-processing industry totalled FIM 73.9 billion and the total value of exports FIM 59.1 billion. Of this, the chemical forest industry accounted for FIM 47 billion and the mechanical forest industry for FIM 12.1 billion. The value of paper exports was FIM 31.3 billion, and 70 per cent of exports were to countries within the European Union. In terms of the value of the products produced by the wood processing industry, the most important countries to which Finland exported were Germany, Great Britain and France.

Finland's well-being is to a considerable extent based on sustainable exploitation of a renewable natural resource - the forest. Thus Finland meets all the prerequisites for maintaining an economic system that is in line with sustainable development. However, this requires that the costs arising from exploitation of the environmental resources and other costs arising from environmental impacts are included in the prices of the products. They can then be taken into account in economic decision making, as is assumed in theories of economics.

Monitoring the quality of forests

Chapter 3 described the lifecycle of Finnish forests in their natural state and charted the most extensive impacts of human activity on the state of forests, which made it possible to ascertain the changes influencing the ecological quality of forests. At present, in addition to the cultivation of standing timber, the state of health of the forests is also monitored. From the natural science point of view particular attention is paid to the impacts of air pollutants and natural pests on the health of the forests.

The indicators depicting the health of forests defined by the Finnish Forest Research Institute (FFRI) are:

1. indicators directly depicting the state of standing timber

- the volume of photosynthesising needle and leaf mass: defoliation and the number of needle age classes
- growth of trees
- cellular damage of needles
- visible signs in needles and foliage (discoloration, secondary branches, fertility)
- nutrient state and the heavy metal and sulphur contents of the needles

2. indicators indirectly depicting the state of a forest

- the soil and changes in it (acidity, nutrient state, level of saturation of alkalinity)
- vegetation indicators: occurrence of the so-called indicator lichen, elemental composition of lichens, other ground vegetation
- other indicators: e.g. changes in the species, occurrence of insects and changes in their colour

According to the estimates of the Finnish Forest Research Institute, it is fairly easy to outline the health of Finnish forests on the natural sciences side by using these indicators. On the basis of the indicators, it seems that the forests are clearly suffering from the air pollutants. On the other hand, there is not adequate information on the influence mechanisms, the state, speed of progress and means of prevention of extensive damage, nor on the tolerance of the forests. According to the opinions of the researchers of the Finnish Forest Research Institute, the only way to ensure the vitality of the forests in the future is a considerably large reduce of air emissions. Through silvicultural measures the tolerance of the forests against effects of air pollutants can only be improved slightly. Due to the high costs of these measures, they are also uneconomic.

According to the fairly unanimous opinion of Finnish forestry experts, the preservation of the biodiversity of Finnish forests requires the following measures:

(1) preservation of old-growth forests

(2) increase in the number of broadleave forests

(3) saving herb-rich forests and riparian forests

(4) leaving dead trees in the forests

(5) increase of areas prescribed burned

(6) saving wetlands and other similar areas

(7) decrease of the sizes of cuttings

(8) protection of species considered important

(9) protection the habitats of endangered species.

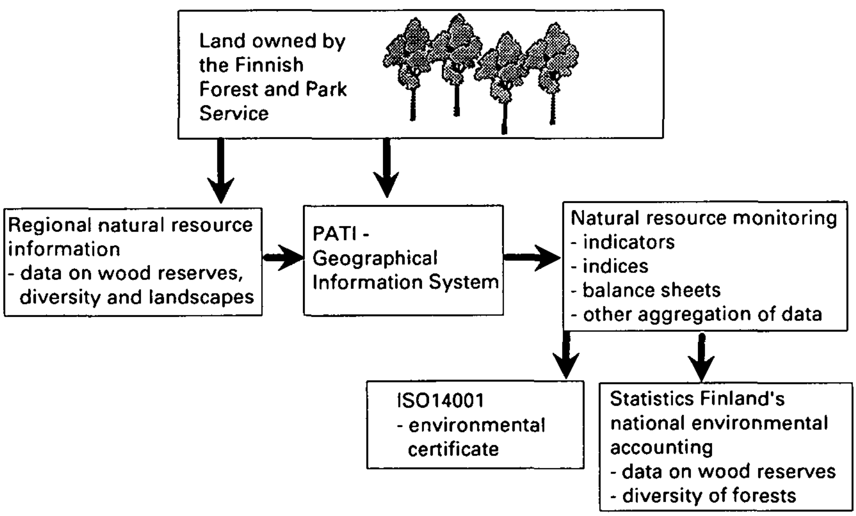
Kolehmainen 1994, p. 7

Natural resource monitoring of the Finnish Forest and Park Service

The monitoring of natural resources by the Finnish Forest and Park Service responsible for the management of state-owned forests is to be based on a geographical information system (PATI), which includes data on all land under the control of the Finnish Forest and Park Service. The part of the PATI system that covers standing timber throughout the country is to be in use by the end of year 2000. Thereafter, it will be possible to make extensive use of natural resource monitoring system based on indicators. Figure 19 gives a general view of the system for natural resource monitoring of the Finnish Forest and Park Service.

In 1994, the Finnish Forest and Park Service started to draw up regional-ecological plans which, besides data on standing timber, also include other natural, recreational and cultural values. The Finnish Forest and Park Service has also decided to begin the natural resource monitoring and draw up regional plans on natural resources based on the above GIS-system. An investigation leading up to the introduction of a system of environmental management was started in 1995. External certification will be sought for this system at the end of 1997. By implementing this system based on the environmental standard ISO14001, the Finnish

Figure 19. Monitoring of natural resources by the Finnish Forest and Park Service



Source: Finnish Forest and Park Service

Forest and Park Service wants to improve the level of nature conservation and meet the demands of the markets for ecological wood production. (Kukko 1996, p. 29-31, 41)

Statistics Finland will in future receive the data on the status of state-owned forests needed in the forest accounts from the Finnish Forest and Park Service. Later, corresponding data on privately-owned forests will be available through the Forestry Centre Tapio. The Finnish Forest and Park Service intends to use the monitoring of natural resources in following up the development of the areas under its control. According to a pilot study, the entities to be monitored are compiled of various variables as follows :

1. The production potential of land
   - 1.1 Area of land in different vegetation areas
   - 1.2 Distribution of the type of habitat
   - 1.3 State of health and destruction of forests

2. Biodiversity and natural state
   - 2.1 Proportion of protected forests in total forest area
   - 2.2 Numbers of different habitats
   - 2.3 Numbers of endangered species
   - 2.4 Change in habitats
   - 2.5 Amount of wood important for biodiversity
   - 2.6 Proportion of natural regeneration in total regenerated area
   - 2.7 Uniform areas of old-growth forests

3. Recreational value of forests
   - 3.1 Total area and number of areas reserved for recreation
   - 3.2 Total area of other areas that are recreationally valuable
   - 3.3 Standing timber in recreational areas
   - 3.4 Level of recreational use as compared with the maximum capacity for recreational use
   - 3.5 Amount of forests with landscape values
   - 3.6 The usability of watercourses for recreation

4. Other forest products
   - 4.1 Berries and mushrooms
   - 4.2 Lichen
   - 4.3 Game
   - 4.4 Reindeer
   - 4.5 Fish

5. State of the environment
   5.1 Air quality
   5.2 Usability of surface water
   5.3 Health status and destruction of forests

The index value for each entity consists of 3-7 different variables, on the basis of whose index values the part-index for the entity is calculated. The base year is given the value 100. A positive change raises the value of the index above 100, and a negative change drops it below 100.

Forest indicators and forest accounting in Sweden

In Sweden, the importance of biodiversity to sustainable forestry was recognised a few years earlier than in Finland. In addition, Sweden has taken firm action and embarked in developing a new kind of policy on sustainable forestry. The development of an environmental accounting system applicable to Sweden was started in the spring of 1992, when the Statistics Sweden (Statistiska centralbyrå, SCB) was given the task of creating a system of physical environmental accounting and of developing and improving its environmental statistics. The State Economic Research Centre (Konjunkturinstitut, KI) was given the task of finding out what the most important interrelationships between the economy and the environment are, and of studying and developing environmental accounting in monetary terms. The task to prepare a proposal for the environmental index system describing the state of ecosystems in Sweden and the changes in them was given to the Swedish Nature Conservation Institution (Sveriges Naturvårdsverket, SNV).

The proposal for environmental indices describing the state of forests in Sweden was completed in April 1993. It has been drawn up, by order of the Swedish government, by the Swedish Nature Conservation Institution, the Statistics Sweden (SCB) and the Forest Inventory Institute of the Swedish Agricultural University (Sveriges lantbruksuniversitets institution för skogstaxering). The Swedish Board of Forestry (Skogsförstyrelsen) has also been involved in the development work. The starting point has been to develop indicators and indices depicting biological diversity and the state of renewable natural resources. (Söderberg and Fridman 1993, p. 1-2)

In the Swedish proposal, the environmental indicators have been divided into three different categories: production potential of forest land, biological diversity, and human reactions to aesthetic values. The production potential of forest land depends mainly on the effects of air pollutants. The last category depends on human experience and observations on the landscape and the state of the forests. The data needed for calculating the indicators in Sweden have been obtained from national forest inventories. The data have been considered suitable for calculating the indicators, since it is temporally representative. The proposal for the indicators is presented in Table 1.

Table 1. Sweden's proposal for forest indicators

Indicator	Production potential of forest land	Biological diversity	Recreational and aesthetic values
Defoliation	X		
Proportions of Ca/Al in the soil	X		
Cation capacity of the soil	X		
Level of alkalinity of the soil	X		
Growth in volume of standing timber	X		
Occurrence of lichens	X	X	
Ground vegetation	X	(X)	(X)
	Index		
Volume of broadleaves		X	X
Mixture of different broadleaves		X	X
Trees of large diameter		X	X
Old-growth forests	X	X	
Dry trees (dead standing trees etc.)		X	X
Peatland forests			
Types of forest ownership	X	X	
Trees left standing in cuttings		X	X
Size of cuttings		(X)	X
		Index	**Index**

Source: Söderberg and Fridman 1993, p. 20-21

In certain cases, it may be necessary to divide ecosystems into areas. This is the case, for example, when a positive development in one part of a country is compensated by a negative development in some other part. In the proposal, Sweden has been divided into four areas: Southern Sweden (Götaland), Central Sweden (Svealand), Southern Norrland and Northern Norrland.

As regards the calculations of the production potential of forest land, there are data on the types of selectively cut forests and pines suffering from defoliation. The mean values of the variables calculated in the forest inventories between 1985 and 1987 are regarded as base values and they are given the index 100. The values for the years 1988-1991 have been calculated as percentages of this value. The indices depicting the recreational value of forests are based on the change in the number of trees left standing in cuttings and on the changes in the proportion of single-species spruce forests. The indices describe the proportional change compared with the values for 1985-1987.

The calculation of biological diversity is based on the changes in the broadleaved tree stocks and the amount of selective cuttings in which broadleaved trees have been left standing. The development of biodiversity between 1988 and 1991 has been calculated. On the basis of these Indexes, it is

Table 2. Values of Swedish part-indices in 1991

Production potential of forest land	**Value**	**Index**
Level of alkalinity of the soil	-	-
Type of forest	123	77
Defoliation	97	97
Part-index (2 indicators out of 3)		**87**
Biological diversity		
Stocks of broadleaves		108
Proportion of broadleaved trees		99
Trees of large diameter		105
Untouched old-growth forests		78
Dry trees (dead standing trees etc.)		96
Part-index		**97.2**
Reactive values and human experiences		
Trees left uncut	91	91
Single-species pine forests	91	101
Part-index		**96**

Source: Söderberg and Fridman 1993, p. 22 possible to calculate the forest indices for 1991 for the whole of Sweden. A summary of all these part-indices is presented in Table 2. (Söderberg and Fridman 1993, p. 17)

According to the results presented in Table 2, deterioration of the environment has taken place in all the sectors under examination. The greatest difference concerns the production potential of forest land. This is due to the variables chosen, which give a good indication of the direct effect that air pollutants have on forests. In both indicators, the annual fluctuation is great, but the general trend is declining. The change has been smallest in biological diversity. The value of the part-index was 96.4 in 1988, 97 in 1989, 96 in 1990 and 97.2 in 1991. Commercial forest utilisation has had the most serious impact on biological diversity.

In the calculation, the weighting coefficient used in all indicators was 1. According to the Swedish proposal, it is difficult to find good grounds for using other weighting coefficients, although intuitively, one can presume that the values are different. The problem becomes even more difficult in calculating an overall index for the forests.

Table 3. Total income from forest resources in Sweden in 1991 (billion Swedish krona, SEK)

Type of income	
Wood production	
Value of gross production	21.30
Factors of production	- 4.30
Change in the volume of timber	5.67
Forest management costs	- 2.04
Total 1	**20.63**
Other forest products	
Other production	
Berries	0.41
Mushrooms	0.30
Lichen	0.75
Total 2	**2.20**
Changes in environmental resources	
Diversity	- 1.46
Carbon dioxide absorption	3.06
Loss of the cation capacity of soil	- 0.98
Loss of possibility to produce lichen	- 0.06
Total 3	**0.56**
Net production value	**23.39**

Source: SWEEA 1994, p. 53

In Sweden, the State Economic Research Centre (Konjunkturinstitut) has studied the possibilities to start environmental accounting in monetary terms applicable to forests. It would make it possible to more extensively measure the economic profit, in this case net output, gained from forest ecosystems. Table 3 presents some monetary values relating to Swedish forests.

Many of the prices in Table 3 are largely estimates. The values of wood production are from the national accounts, other production is based on statistics on volumes and prices of goods for sale. By estimating these prices by methods used in the engineering and natural sciences, values relating to the status of the environment have been obtained. Not included in the table are the use of forests for recreation and the economic value attached to this use, which, in practice, can be obtained by willingness to pay -studies.

In order to evaluate the effects of air pollutant, data on the cause and relations between the emissions and the environmental effects are needed. Combining the cause and relations into one whole has been a great problem in Sweden. Data produced on sulphur dioxide emissions, for example, give information on the reasons, i.e. the sources of emission, but not on their effects on the state of the environment. The environmental index system, on the other hand, gives information on the effects of pollutants on the state of the environment, but not on the sources of emissions. Through monetary evaluation, then, it is possible to form an idea of the kinds of extra costs relating to the status of the environment arising from economic measures. These costs will usually be realised only later in the future. (SWEEA 1994, p. 42)

Draft for Finland's forest accounting system

In Finland, the purpose of forest accounting is to allow measurement of ecologically sustainable development as regards forests and monitoring of developments in the values of environmental resources, and also to make it possible to measure sustainable development on the national level as part of the SEEA environmental accounting. Figure 20 presents the general structure of the forest accounting system. Accounting framework is divided into quantitative data based on physical quantities, i.e. on natural resource accounting, forest quality indicators and accounting in mone-

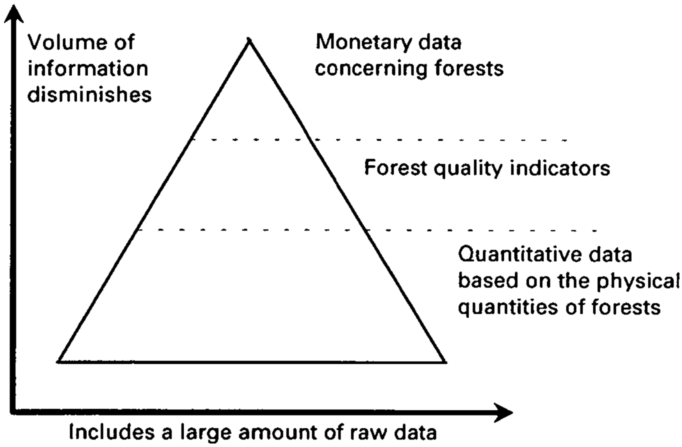
Figure 20. Finnish forest accounting system

Forest Resource Accounting	Areas to be described	Target group :
Physical quantity accounts	- Development of forest area - Data on biodiversity - Wood material - Carbon binding - Air pollutants and acid deposition - Recreational information	Researchers
Forest quality indicators	- Ecosystem indicator - Species indicator - Recreational indicator - Overall index	Social planners
Monetary accounts	- Use of wood - Forest growth and carbon binding - Other forest products - Protection of diversity - Cost of acid deposition - Recreational values - Sustainable income from forests	Decision-makers

tary terms. Quantitative data give an extensive description of the status and utilisation level of forest ecosystems. With the help of the indicators, it should be possible to widely monitor the development trend in different sectors of sustainability. Data in monetary terms, on the other hand, give simplified information on some of the most important factors concerning the utilisation and well-being of the forests.

Natural resource accounting based on physical quantities includes the forest balance sheet of wood accounts, the forest stock account describing the diversity of forest ecosystems, and statistics on the development of diversity and recreation. Forest quality indicators depict recreation and the diversity of forest ecosystems and species, and the overall index depicts the overall status of forest ecosystems. Accounting in monetary terms covers the utilisation of timber, silviculture, carbon absorption and the values of other forest products as well as the costs of the protection of biodiversity and recreational values. Figure 21 presents the interrelation between these sectors of the accounts.

Figure 21. Utilisation of data from forest accounts



When estimating the sustainability of forests, experts form their opinion on the basis of environmental statistics and natural resource accounts which include large quantities of "raw data". These are often based on physical quantitative data describing different aspects of the environment, which have been obtained using scientific research methods. For decision-makers and ordinary citizens, on the other hand, the sustainability of the entire ecosystem has to be depicted by a few easy indicators and data in monetary terms. These compress the extensive data on forests into an overall picture of the status and development of the forests. In the following chapters, the structure of forest accounting is described in more detail.

5
ACCOUNTING ON THE BASIS OF PHYSICAL QUANTITIES

Depicting quality by physical quantities

The Finnish forest resource accounting system is based on statistics on different natural resources relating to forests and physical quantities relating to forms of utilisation. On the basis of this data, it is possible to create indicators which can be used to monitor how well ecologically sustainable development has been achieved. Data on physical quantities also makes possible to produce monetary data concerning forests. It is then possible to measure the ecological sustainability of development and to evaluate different forms of forest utilisation by applying economic values relating to forests.

Accounting by physical quantities is based on making a distinction between reserves and flows of natural resources. The most useful way of presenting information on the basis of physical quantities is to use balance sheets, which enables systematic annual scrutiny of changes in the reserves. The difference between the situation on the first and last days of the year is accounted for by the growth and depletion of reserves within the calendar year. In practice, accounting on the basis of physical quantities requires fairly detailed data on the amount of the natural resource in question. As regards forests, there is comprehensive data on the area and also on the amount of wood. Using quantitative data on wood, it is possible to calculate similar balance sheets for the amount of carbon dioxide bound by stemwood.

Forest stock balance, forest balance sheet and carbon balance can mainly be used to monitor the development of factors influencing the wood producing capacity of the forests. They cannot be used as indicators of forest quality alone, but data on the changes affecting other environmental resources and general environmental conditions are also needed. These include, besides data on forest management, also data on recreation and on the effects of air pollution on forests. On the basis of physical quantities, it is also possible to form an overall picture of the direction in which forest quality is developing. This is discussed in more detail in Chapter 6. Figure 22 describes the aspects that accounts based on physical quantities in forest accounting should depict.

Figure 22. Accounting on the basis of physical quantities

1. Forest stock account - Development of forest area - Development of the uses of forests - Regeneration and felling of forests - Data on diversity in terms of forest management	4. Air pollutants - Defoliation - Acidification of forest land - Sources of carbon dioxide emissions
2. Forest balance (wood material) - Amount of wood in forests by species - Growth and depletion of forests 3. Carbon balance - Amount of carbon absorbed by the different tree species in forests - Binding and depletion of carbon	5. Recreational information - Number of visitors to nature conservation areas - Hunting and picking of berries and mushrooms as recreation - Wandering and other recreation in forests

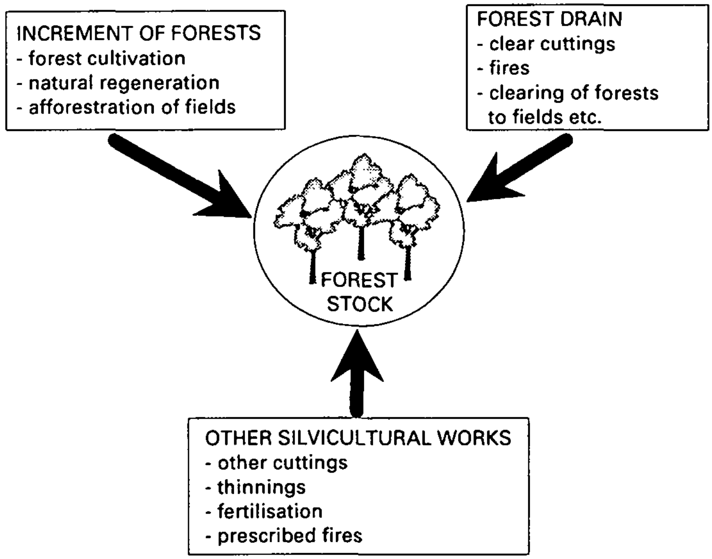
Forest stock account

The general structure of the forest stock account is to a great extent similar to the structure of the forest balance sheet. This is important, in order to ensure that their data will later be commensurable. The biodiversity of a forest ecosystem has been examined in relation to the fact that human activity has made forest ecosystems one-sided. The factors having the greatest impact on the deviation of forests from their natural state are presented in Figure 23.

The most important factors influencing the structure of forests relate to (a) silviculture, such as management of seedling stands, fertilisation, forest cultivation and cuttings, and (b) measures which change forests permanently, such as clearing of forests and drainage of bogs. The purpose of a forest stock account that is based on Figure 22 is to provide a general description of forests.

The forest stock account of Finland for 1994 is presented in Table 4. The forest stock account gives the area subject to forest management at the beginning and at the end of 1994, as well as the magnitude of the changes. In addition, it gives

Figure 23. Factors behind the changes in forest land area



information such as what is the percentage of the total reserves of each variable on January 1st and, on the other hand, how much the variable has changed since 1970. The change is given as an index in such a way that a value exceeding 100 means that the value of the variable has increased and a value below 100 means that the value of the variable has decreased.

The forest stock account gives the changes in forests that are due to human activity during any one year. On the basis of this information, it is possible to form the indicators presented in Chapter 6. The forest stock accounts of Finland for 1990-1994 are enclosed in the Statistical Appendix.

Table 4. Forest stock account for 1995

	Use of forest land	Percentage of the total reserve	Index 1970=100
Stock 1.1	**26 243 900**	**100.00**	**98.18**
Commercial forests	21 662 175	82.54	90.37
Areas under restricted wood production	1 620 000	6.17	68.03
Conservation areas	2 961 725	11.29	781.47
Annual increment	**149 137**	**0.57**	**102.97**
Forest cultivation	113 000	0.43	81.77
Planting	81 000	0.31	75.77
Seeding	32 000	0.12	102.24
Forestration of fields	4 137	0.02	62.36
Total removal	**112 043**	**0.43**	**95.83**
Clear cutting	110 000	0.42	97.35
Fires and prescribed burning	2 043	0.01	52.06
Other depletion	..	..	..
Other silvicultural works	**534 434**	**2.04**	**44.62**
Selective cutting	241 800	0.92	112.47
S&S cutting	57 100	0.22	59.48
S&S depletion	41 000	0.16	24.40
Other cutting	6 600	0.03	8.80
Thinning	162 700	0.62	96.79
Drainage	15 300	0.06	5.27
Fertilisation	8 534	0.03	4.63
Prescribed burning	1 400	0.01	155.56
Stock 31.12.	**26 280 994**	**100.14**	**98.31**

S&S = seed tree and shelter wood
.. = not known

Source: Statistics Finland, Environmental Accounts

Forest balance and carbon balance

One central part of the new forest resource accounting system is the forest balance sheet of the Wood Material Accounting. It describes the quantities of wood in Finland divided by tree species into pine, spruce and broadleaved trees on the first and last days of single year. In addition, it takes into account the increment in and depletion of the reserves. The Finnish forest balance sheet is based on a Norwegian model dating from the 1970's, which was used to compile statistics on quantities of natural resources. The Finnish forest balance sheet for 1996 is presented in Table 5.

Table 5. Finnish forest balance sheet for 1996 (1000 solid cubic metres)

	Total	Pine	Spruce	Broadleaves
Stock 1.1.	**1 964 700**	**910 800**	**679 000**	**374 900**
Annual increment	75 400	33 000	25 800	16 600
Net removals	50 400	19 400	22 400	8 600
Silvicultural waste	5 000	1 300	1 500	2 100
Natural losses	1 300	600	400	300
Stock 31.12.	**1 983 400**	**922 000**	**680 000**	**381 000**

Source: Statistics Finland, Environmental Accounts

The forest balance sheet is important in a situation where commercial forests are used mainly for wood production. However, the other forms of forest utilisation have become more important with changing of attitudes in society since the early 1990's, when biodiversity became a value worth consideration in forestry, too. One form of utilisation the importance of which has been ignored until the last few years is the forests' capacity to bind carbon. Forests bind carbon to a considerable extent and, for their part, prevent the global greenhouse phenomenon. In early 1990s the annual net accumulation of carbon in Finnish forests corresponded to some 37-55 million tonnes of carbon dioxide. At the same time 51-58 million tonnes of carbon dioxide were released in emissions from fossil fuels. According to research, the type of forests that bind most carbon are young forests which are growing rapidly. As the forests grow, the amounts of carbon absorption and release approach to each other. The volume of carbon bound in the Finnish forest ecosystems will, it is estimated, continue to grow for at least the next 15-20 years.

Data on carbon dioxide emissions are needed in forest resource accounting for comparing carbon dioxide emissions in the national accounts with carbon dioxide binding in forests. This makes it possible to determine Finland's contribution to the worsening of the global greenhouse effect. The carbon balance for stem wood is calculated on the basis of the forest balance sheet given in Table 8 and using the coefficients given in Karjalainen and Kellomäki's (1991) study. The dry matter content of pine has been calculated with the coefficient 409 kg/m^3, spruce 387 kg/m^3 and broadleaved trees 488 kg of dry matter/m^3 wood. The concentration of carbon of the dry matter in pine and spruce has been calculated

Table 6. The carbon balance of stem wood in Finland in 1996 (1000 tons of carbon)				
	Total	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**422 067**	**193 372**	**136 389**	**92 305**
Annual increment	17 448	7 005	6 353	4 088
Net removals	10 736	4 118	4 499	2 118
Silvicultural waste	1 094	276	301	517
Natural losses	282	127	80	74
Stock 31.12.	**426 231**	**195 856**	**136 690**	**93 684**

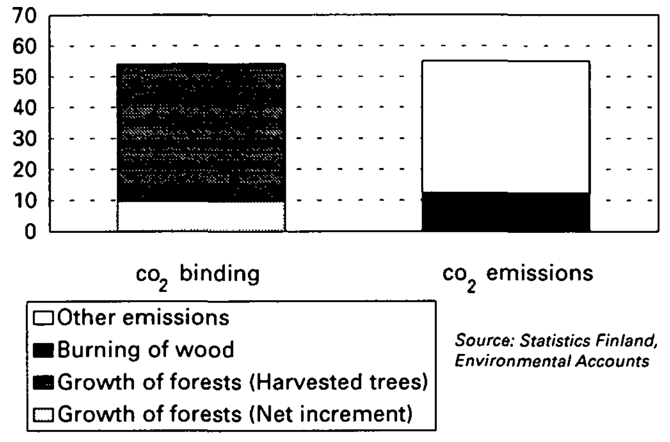
Source: Statistics Finland, Environmental Accounts

with the coefficient 0.519039 kg C/kg of dry matter and of broadleaved trees with the coefficient 0.504669 kg C/kg of dry matter. The calculation formula is the amount of stem wood in solid cubic metres multiplied by the dry matter content of the tree species multiplied by the coefficient for the concentration of carbon in the dry matter of the tree species. (Seppälä and Siekkinen 1993, p. 20) The carbon content of stem wood in Finland in 1996 is presented in Table 6.

Even though, according to Table 6, a great deal of carbon is annually bound in stem wood, according to a study carried out by Karjalainen and Kellomäki, its proportion of all carbon bound in the entire Finnish forest ecosystem is only 15 per cent. The majority, i.e. 73 per cent of carbon was bound in the soil (0-30 cm deep). Tree roots account for six per cent and branches for four per cent of the carbon reserve (stock), needles and leaves for one per cent and ground vegetation for one per cent. In 1990, there were 2 800 million tons of carbon bound in forest soil and vegetation, and approximately 640 tons were bound in peatland. The formation of peat in bogs binds almost 0.8 million tons of carbon annually, and in peat digging, an amount corresponding to approximately 5.3 tons of coal is removed. It has been estimated that the drainage of peatlands diminishes the quantity of carbon bound. The major domestic carbon dioxide flows, carbon bound by the growth of forests and total Finnish emissions, in 1995 are presented in Figure 24.

The annual growth of stem wood in forests binds almost all of the domestic carbon dioxide emissions. Most carbon is bound by the growth of forests when, as a result of intensive forestry, forests are young and growing rapidly. In old-growth forests that have reached their climax stage, the

Figure 24. The carbon dioxide emissions and binding by forests in 1995 (millions of tons)



Source: Statistics Finland, Environmental Accounts

amount of carbon binding is equal to the amount of carbon released. Usually conservationists and environmental authorities want to protect old-growth forests because of their biodiversity. As regards the slowing down of the greenhouse effect, cutting old-growth forests and producing sustainable products from the timber obtained as well as planting new forests increase the total binding of carbon by the forests. One of the principles in forestry has been that in the long run the carbon cycle should be in balance in a forest that is in its natural state and that has been managed according to the principles of sustainable development.

Only some 15 - 20 per cent of the carbon bound by growth of forests is bound into the annual increment of stemwood that is left into the forest. The rest of annual increment is harvested and thus the carbon absorbed by forests is then bound into the various products made of wood. The longer the life cycle of wood products and converted wood products, the more carbon they store. Carbon is best preserved in sawn products and in building material, whose decay period is around 80 years. On the other hand, the release time of carbon in paper and cardboard products is only about two years, although some paper and cardboard products can be preserved in libraries and archives for even hundreds of years. When wood is burnt, carbon dioxide is released immediately. It is difficult to present reliable estimates on the life cycles of factors increasing carbon storage, such as the wood mass bound in products of the wood-processing industry and its carbon content and on carbon release, i.e. the decrease in carbon storage.

Airborne pollutants are by-products of economic activity, which are difficult to monitor closely and whose impacts are not always clearly known. As regards the well-being of consumers, however, they have an extremely detrimental effect. Forest resource accounting should also include data on the impact of airborne pollutants on trees and on the fixation of air pollutants in forest land, although the influence of air pollutants on forest ecosystems is not fully known. In practice this would mean the inclusion of data obtained from monitoring annual sulphur and nitrogen depositions. However, one problem is how to define harmful nitrogen emissions, because, in practice, nitrogen emissions fertilize barren forests and increase the growth of trees. The level of nitrogen saturation, which is important when evaluating the harmfulness of nitrogen depositions, has not yet been determined. As regards acidifying depositions, the use of balance sheets is at present prevented by the lack of exact data on reserves, in other words, data on the amounts of pollutants stored in the soil.

Finland's own emissions into the air and transboundary emissions of airborne pollutants are indisputably a threat to forest ecosystems and, in the long run, a risk to the sustainable use of natural resources. Reducing emissions of greenhouse gases was agreed on in a framework convention concluded at the United Nations Conference on Environment and Development in Rio de Janeiro in 1991. As regards greenhouse gases, Finland's objective is to halt the increase of the emissions by the year 2000 and later to cut them down to the level of 1990. The most significant of all greenhouse gas emissions are carbon dioxide emissions, and other greenhouse gases are nitric oxides, methane and nitrous oxide. The biggest sources of carbon dioxide emissions are the combustion of coal, traffic fuels, wood and spent liquor from the wood-processing industry. (Energy and Emissions 1996, p. 6, 11)

The most significant cause of sulphur deposition in Finland is the combustion of fossil fuels and the greatest sources of nitrogen deposition are traffic, agriculture and industry. Finland has signed international agreements and thus committed herself to reduce her sulphur emissions by 80 per cent from the level of 1980 by the year 2000, and this goal has been achieved. Nitric oxide emissions were frozen at the level of 1987 by 1994, as agreed. Moreover, Finland has announced that by 1998 it will reduce its nitrogen emissions by 30 per cent from the level of 1980. Almost a half of the nitrogen emissions come from traffic. (Finland's Natural Resources and the Environment 1996, p. 27-28) The development of Finland's sulphur, nitrogen and carbon dioxide emissions is described in Table 33 of the Statistical Supplement.

However, as much as 88 per cent of acidifying sulphur deposition and 85 per cent of nitrogen deposition come from outside Finland. On the other hand, 69 per cent of Finland's own sulphur emissions and 82 per cent of her nitrogen emissions are carried across the borders. Acid depositions that exceed the critical load with detrimental effects occur in many places in Southern and Central Finland and in some places in Lapland. (Wahlström et al. 1996) Table 7 shows an estimate of the development of the most important acid depositions between 1985 and 1994.

Air pollutants are also partially the cause of needle loss in forests. In the 1990's, forests with over 40 per cent annual needle loss have accounted for 4-7 per cent of all forests. Needle loss cannot be depicted in the form of balance sheets due to the lack of data on reserves, i.e., the fact that the phenomenon is not a natural resource by nature. Therefore, only the so-called flow data can be presented. Economically, however, the phenomenon is significant, because it hinders the growth of forests, and should therefore be included in forest resource accounting. Data on the needle loss of Finnish forests have been presented in Table 28 of the Statistical Supplement.

Table 7. Estimate of the development of acid deposition in Finland 1985-1994 (1000 tonnes)

	SO2	NOx
1985	219	63
1986	232	79
1987	191	59
1988	208	77
1989	177	75
1990	153	66
1991	153	72
1992	130	66
1993	107	55
1994	105	55

Source : EMEP MSC-W 1995

According to information collected in 1985 by the UN Economic Commission for Europe (ECE) and the UN's Food and Agriculture Organization (FAO), the recreational values of forest land in the Nordic countries were considered high. Of Finnish forests, 55.9 per cent are considered to have significant recreational value. Recreation value has been understood to comprise walking, hiking, camping, hunting and other similar recreation. The purpose of compiling statistics on recreation is to broaden the understanding of multiple use and especially the recreational values of forests. The problem is deciding what are the most representative and extensive variables depicting recreation. At present, there is information available, for example, on the quarry hunted, on the time and money spent on hunting, and on the number of visitors to national parks.

The starting point in this study has been the idea that an ecologically valuable forest is also valuable from the recreational point of view. This condition is met when the forest is diverse, i.e. has a varied landscape and an abundant fauna so that it attracts hunters, berry pickers or hikers. Table 8 shows numbers of visitors to the national parks.

Table 8. Estimates on the number of visitors to national parks

	FFPS	FFRI	Total
1987	153 000 *)	160 000	313 000
1988	186 300 *)	165 000	351 300
1989	214 000 *)	225 000	439 000
1990	268 000 *)	225 000	493 000
1991	319 000 **)	180 000	499 000
1992	358 000 **)	160 000	518 000
1993	388 000 **)	300 000	688 000
1994	495 000	320 000	815 000
1995	668 000	295 000	963 000
1996	714 000	310 000	1 024 000

*) only persons visiting the guidance centres
**) only persons staying overnight in the parks

Source: the Finnish Forest and Park Service and the Finnish Forest Research Institute

Hunting is by nature a pastime in which economic profit not is usually sought. The catch is of great or very great economic significance for only about 10 per cent of the hunters or their households, and only four per cent of hunters draw an income from selling their catch or hunting rights. In an inquiry by the Finnish Game and Fisheries Research Institute, 21 per cent of hunters said that their motive for hunting was the experience of being close to nature, 17 per cent the desire to get away from daily routine, 15 per cent relaxation and 12 per cent the desire to learn about animal behaviour and nature. The catch was a motive only by three per cent to the hunters. (Ermala and Leinonen 1995a, p. 9 and 1995b, p. 43) There are approximately 290 000 persons who hunt as a sport in Finland, of whom more than 200 000 shoot hares, 170 000 shoot birds and 100 000 take part in elk hunting. In 1994, 295 000 persons had bought a game license. The development of the recreational accounts has not been completed yet, largely due to the problems in pricing. The intention is, however, that the recreational accounts should in future give as extensive a picture as possible of the different recreational values of forests.

6
INDICATORS OF FOREST QUALITY

Framework for forest quality indicators

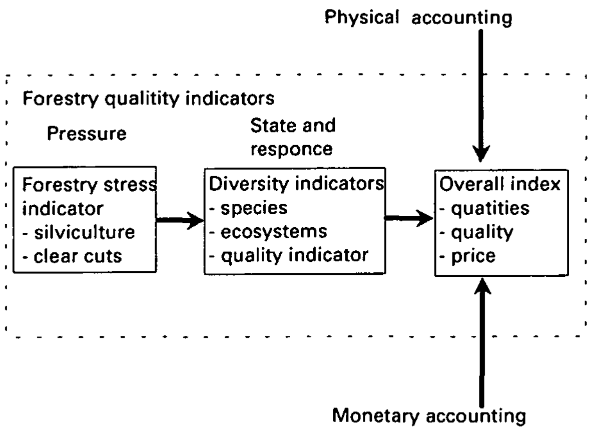
The greatest advances in developing indicators depicting the development of the environment have been made by the Organisation for Economic Co-operation and Development OECD, which adopted the Recommendation on Environmental Indicators and Information in 1993. The OECD Environmental Performance Review, a programme evaluating the effectiveness of the environmental policies of its member states in relation to international agreements and the country's own targets, was founded in 1992. In 1993, the programme developed a general framework for indicators and determined the core set of indicators. The OECD indicator framework can be used, not only in evaluating the effectiveness of environmental policies, but also as a basis for indicators of sustainable development. (Environmental indicators 1994, p. 8-9)

The OECD indicators are based on the so-called Pressure-State-Response framework (PSR), which examines the consequences of various factors. Human activity causes pressures on the environment and on nature, which change the quality of the environment and the amount of natural resources. The actual state of the environment is described by the State indicators. Society reacts to the state of the environment by making various changes in the environmental policy and in general economic policy, and the Response Indicators depict society's responses to the changes in the environment. Response Indicators include expenditure on environmental protection, expenditure on monitoring and controlling pollution and citizens' opinions on the environment. The interaction between these three groups of indicators is not complex, but it requires deep-going analysis of the interaction between the environment and the economy. Of the OECD indicators, Pressure Indicators are mostly suitable for taking the environmental aspect into account in sectoral policies while State Indicators are applicable to evaluating the effectiveness of environmental policy and taking the environmental aspect into account in economic policy, for example, through environmental accounting. Response Indicators are suitable for reporting on the state of the environment.

The first nine points on the list of environmental issues in the OECD indicator framework focus on depicting the quality of the environment, mainly through environmental problems. These are climate change, ozone layer depletion, eutrophication, acidification, toxic contamination, urban environmental quality, biodiversity, landscapes and waste. There are four issues depicting mainly natural resources: water, forest and fish resources and soil degradation. The list also includes so-called General Indicators, which are not useful when depicting certain issues; these are population growth and the development of expenditure on environmental protection. As regards forest resources, the recommended Pressure Indicators are the amount of logging and the wood producing capacity of forests. Suitable State Indicators are forest area and data on species composition and age distribution of trees. Response Indicators include the development of forest management methods and data on forest conservation. (Environmental Indicators 1994, p. 15)

Originally, the development of Finnish forest quality indicators was started on the basis of the variables that the OECD had recommended as indicators for inclusion in the framework, but in such a way that the indicators primarily aimed at depicting diversity as defined by the Rio de Janeiro Conference on Environment and Development. The aim of Finnish forest resource accounting is to give as diverse a picture as possible of the diversity and well-being of forest ecosystems and the ways in which forests can be utilized, because natural resource accounting based on physical quantities is restricted by the fact that the variables depicting the quality of forests are incommensurable and it is therefore not possible to form an overall picture of how the well-being of forests has developed. Forest quality indicators enables it to form an overall picture of the direction of the most important changes. The framework for forest resource accounting in Finland presented earlier includes four different indicators and an overall index. Of these, the stress indicator depicts changes in the forest ecosystem caused by human activity, mainly forestry. The diversity indicators, the species and ecosystem indicators, depict how the state of the forest ecosystem is developing. Applying the overall index, the development of the state of forests from the viewpoint of the society's well-being is analyzed, taking into account data on quantities, prices and quality. The indicators for forest resource accounting are presented in Figure 25.

Figure 25. Indicators for forest resource accounting



Forestry stress indicator

The forest stock account presented in Table 4 includes the silvicultural measures under "Other silvicultural works ", but the measures do not influence the volume of the reserve. However, it is clear that silvicultural measures have a great impact on the quality of forests. Figure 26 presents a forest stress indicator that depicts the stress caused to nature by forest management calculated according to the development of clear cuttings, forest cultivation, thinnings and the development of fertilised areas. For practical reasons, a base year has to be chosen against which the situation in each year is compared. The year 1970 has been chosen as the base year, and it will in the following be given the value 100. The purpose is to create indicators using and combining existing data. The calculation formula is the following:

$$I^{Stress} = \left\{ \frac{I^1 + I^2 + I^3 + I^4}{4} \right\}$$

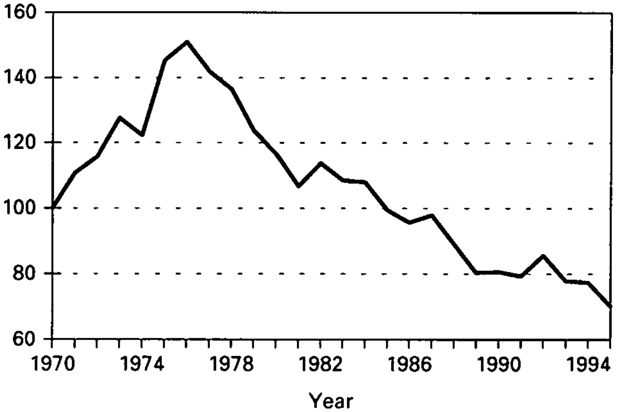
in which

I^1 is the index depicting total annual clear cutting areas
I^2 is the index depicting the annual area of forest cultivation

I^3 is the index depicting the annual area of thinnigs
I^4 is the index depicting the annual development of the area under forest fertilisation.

As can be seen in Figure 26, the stress exerted on forests by silviculture increased from 1970 to 1976, which was the year of maximum stress. Since then, the amount of stress has been decreasing. 1985 was the first year when the stress level fell below the level of 1970, and in 1995, it was only about 70 per cent of the 1970 level.

Figure 26. Stress exerted on forests by forest management 1970-1995 (1970=100)



Biodiversity indicators

In Chapter 3 it was stated in the Rio Conference that biodiversity manifests itself as the diversity within species, between species and variety of ecosystems. Moreover, it was considered possible that diversity within species would be preserved if only the two latter types of diversity were ensured. Statistics should, therefore, concentrate on depicting the diversity of ecosystems as a deviation from the natural state, and diversity between species using the abundance of their habitats. Biodiversity indicators have been developed on the basis of the data in the forest balance sheet and forest stock accounts. There are separate indicators for both the diversity of ecosystems and diversity between species.

The index depicting the diversity of ecosystems includes changes in the area of forest land, the development of the silvicultural quality of forests, and the drainage of peatlands as factors reducing diversity. The index has been calculated with the following formula.

$$I^{Ecosystems} = \left\{ \frac{I^5 + I^6 + I^7}{3} \right\}$$

in which

I^5 is the index depicting the change in the area of forest land,
I^6 is the index for the silvicultural quality of forests and
I^7 is the index depicting the change in the area of peatland.

Diversity between species has at this stage been approached by looking at the number of broadleaved forests and quantity of broadleaved wood material, the development of forest area treated by forest fires and prescribed burning and the trees suffering from defoliation between 1987 and 1995. The effects of increasing diversity of forest fires and prescribed burnings is estimated to last some five years after which the areas are naturally turned into broardleaved forests. The formula for calculating the index is the following:

$$I^{Species} = \left[\left(\frac{I^8 + I^9}{2} \right) + \left\{ \left(\frac{I^{10_i} + \ldots I^{10_{i-4}}}{5} + \frac{I^{11_i} + \ldots + I^{11_{1-4}}}{5} \right) \Big/ 2 \right\} + I^{12} \right] \Big/ 3$$

in which

I^8 is the index for the total area of broadleaved forests
I^9 is the index for broadleaved tree stocks
I^{10} is the index for the development of prescribed burning
I^{11} is the index for the development of forest fires and
I^{12} is the index depicting defoliation.
i marks the year in question

Annual part-indices for 1970-94 have been calculated for both the diversity of ecosystems and diversity between species. The base year 1970 is given the value 100. The values of the indices are presented in Table 9.

Table 9. Diversity indices 1970-1995			
Year	Ecosystems	Species	Forest quality
1970	100.0	100.0	100.0
1971	98.8	89.5	94.2
1972	97.7	81.1	89.4
1973	96.5	81.5	89.0
1974	95.5	85.1	90.3
1975	94.5	80.4	87.4
1976	93.5	80.7	87.1
1977	92.4	85.2	88.8
1978	91.4	84.8	88.1
1979	90.4	85.4	87.9
1980	89.4	90.4	89.9
1981	89.1	89.9	89.5
1982	88.7	89.0	88.9
1983	88.4	92.6	90.5
1984	88.1	95.8	91.9
1985	87.8	102.3	95.0
1986	87.5	112.6	100.0
1987	87.2	109.8	98.5
1988	86.9	123.1	105.0
1989	86.6	129.5	108.1
1990	86.3	130.7	108.5
1991	86.1	124.4	105.2
1992	85.9	129.5	107.7
1993	85.7	113.7	99.7
1994	85.5	108.6	97.1
1995	85.4	100.4	92.9

As can be seen from the table, the capacity to offer diversity to ecosystems decreased between 1970 and 1995. However, the index depicting the capacity to offer diversity to species decreased at first, but increased in the late 1980's and even exceeded the level of 1970. The diversity index presented here is at present based on only some of the variables intended to be included in it, and, for example, the effects of fires and prescribed burning on the improvement of diversity in the years to come have not been included. The indicator "quality of Finnish forests" depicting the actual quality of forests has been calculated on the basis of these two diversity indices. The forest quality indicator is described in more detail in the following Chapter.

The indicator of forest quality includes the development of the area of forest land, the area of forest and peatland burnt as a result of fires or prescribed burning, as well as the development in the number of broadleaved trees, the silvicultural quality of forests as a variable reducing diversity and the state of health of the forests (needle loss) between 1986 and 1994. The calculation formula is the following:

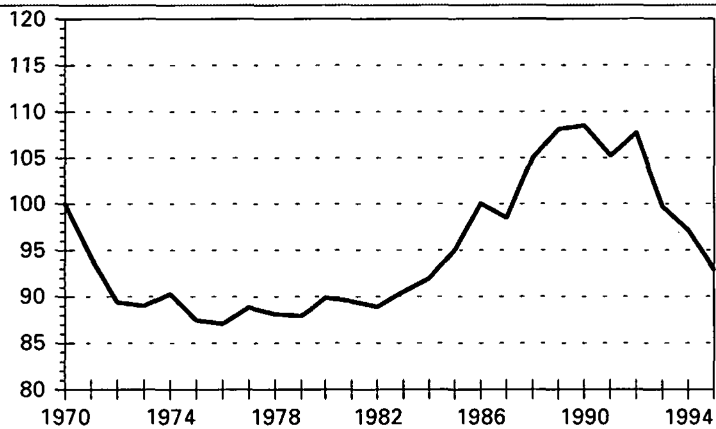
$$I^{Quality} = \left(\frac{I^{Ecosystems} + I^{Species}}{2} \right)$$

in which

$I^{Ecosystems}$ is the index for diversity of ecosystems and
$I^{Species}$ is the index for diversity between species.

As can be seen from Figure 27, the quality indicator has reached the level of the year 1970 only in late 1980's, and in other years the quality has been inferior to the base year. The picture of the development of forest quality given by Figure 27 depends to a great extent on the variables included in the indicator. At present, for example, data on the impact of air pollutants such as the acidity of the soil, and actual data on the number of plant and animal species and its development are not included in the indicator. Figure 27 shows the development of quality indicator between 1970 and 1995.

Figure 27. Development of forest quality indicator, 1970 to 1995 (1970=100)



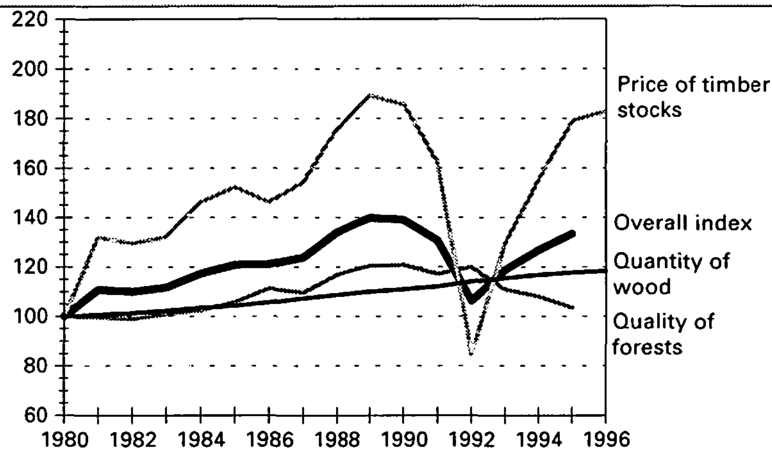
As discussed in Chapter 2, a natural resource has both a quantitative, a qualitative and a price dimension. By indexing these variables, the implicit value of the natural resource can be estimated. Figure 28 gives the quantitative and price changes affecting forests and the change in the quality of forests (i.e. deviation from the natural state) based on the timber stocks in Finnish forests.

The index for the development of the timber stocks given in Table 10 has been calculated on the basis of the forest balance of Wood Material Accouns by Statistics Finland, and the index depicting the price of the forest resources on the basis of a study "Measuring Ecologically Sustainable Development" by Statistics Finland. (Natural Resource Accounts 1992, and Arjopalo 1994, p. 29) The indices in Table 10 are presented in the form of a graph in Figure 28.

Table 10. Forests: quantity of wood, price and quality 1980-1995 (1980=100)

	Quantity	Price	Quality	Overall index
1980	**100.0**	**100.0**	**100.0**	**100.0**
1981	100.6	131.9	99,5	110.7
1982	101.3	129.5	98.9	109.9
1983	102.2	132.0	100,7	111.6
1984	103.3	146.1	102,3	117.2
1985	104.3	152.2	105,8	120.7
1986	105.6	146.2	111,3	121.0
1987	107.3	154.2	109,6	123.7
1988	108.7	176.2	116,8	133.9
1989	109.9	189.1	120,3	139.8
1990	110.9	185.5	120,7	139.0
1991	112.1	162.3	117,1	130.5
1992	114.0	84.7	119,8	106.2
1993	115.4	129.4	110,9	118.6
1994	116.7	155.2	108,1	126.7
1995	117.6	179.1	103,3	133.3

Figure 28. Development of the indicators 1980-1995 (Base year 1980=100)



As can be seen from Figure 28, the market price of the forest stock rose more quickly than the amount of timber stocks during the entire 1980's. The price of timber stocks rose quickly in the 1980's mainly due to the period of economic upswing and began to fall again with the economic recession in early 1990's. The development of the quality of forests followed to a certain extent the development of timber stocks during 1980's. In early 1990's, due to the recession, the quality first rose and then because of the economic upswing dropped close to the 1970 level. Trend of the overall index depicting the trade-off between different components of the forest resource has been slightly positive during the entire period under examination.

Using the indicators

Above it has been attempted to describe the development of the most important variables influencing the quality of forests by using indicators. In this study it has been concentrated on evaluating the effects of the forest sector's activities from the perspective of diversity. Work has been restricted by the limited data, and the indicators are therefore based on only a few aggregate variables. For example, the effects of air pollution have been included in the forest quality indicator only as regards needle loss. On the other hand, the species indicator could include populations of certain animal species, such as golden eagles, wolves, bears and certain endangered species. Changes in the populations of single animal species can be both surprising, and, at the same time, completely natural. Since there are no reliable data on changes in the populations, these variables have not been included in the system.

The original basis for this work was the data on indicators recommended in the OECD indicator framework. Whereas the OECD utilizes forest indicators in assessing, for example, the effectiveness of the environmental policies of its member states and thus helping the governments themselves to assess their own environmental policies, this study aims at examining the development of the state of the environment. Forest quality indicators primarily aim at describing the diversity of forest ecosystems as defined by the Rio de Janeiro Conference on Environment and Development. They are not meant for evaluating the effectiveness of environmental policies. The forest stress indicator depicts how well environmental aspects are taken into consideration in forest management methods. The forest quality indicator, on the other hand, depicts changes in the overall well-being of forests and serves to support the development of SEEA environmental accounting. The development of the state of the environment in Finland is reported in Finland's Natural Resources and the Environment published annually. The OCED is also evaluating the effectiveness of Finnish environmental policy using the PSR indicator framework during 1997.

7
MONETARY VALUES OF FOREST RESOURCES

Applying SEEA

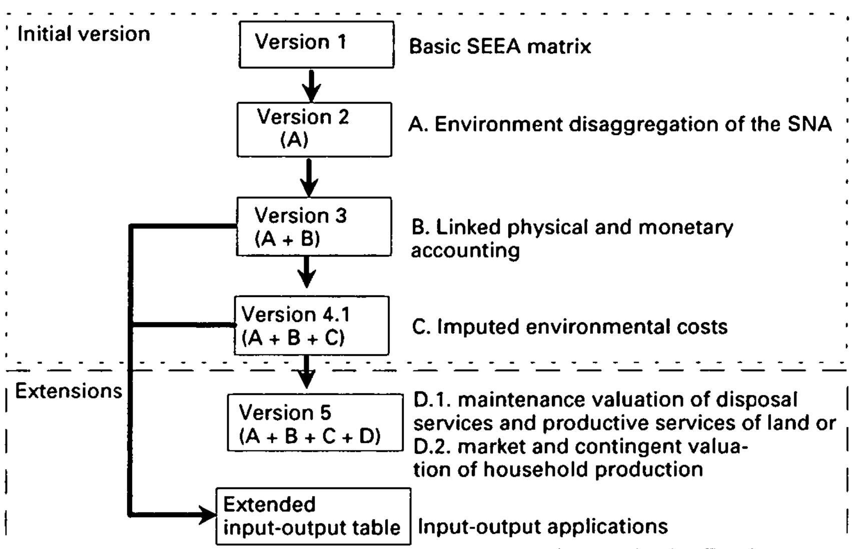
Up to the present, the environmental policies of industrialized countries have focused on alleviating environmental problems that have been identified, rather than on solving them. One apparent reason for this is the inability of environmental statistics to look at large entities encompassing the viewpoints of various branches of science. As such, there is no lack of data measurements concerning the environment. An enormous number of measurements are carried out annually to monitor changes in one particular factor of the environment, and most environmental statistics do no more than present their results. A great challenge for statistics is to find a way to condense the individual results into an overall picture that would illustrate the state of the environment. In the future, environmental statistics should, however, be able to depict better than before the development of the environment in a simple and graphic fashion. Environmental statistics should also be made more useful for environmental and economic decision-making in society.

It is possible to effectively condense data on the environment using different environmental indicators and environmental accounting systems, but this solution is not adequate from the perspective of decision-making in society. It should be able to integrate environmental and economic values into one easy-to-use indicator depicting the changes in the overall well-being as experienced by the members of the society. This is what the UN's System of Integrated Environmental and Economic Accounts aims at. Even though the idea of measuring overall well-being seems very reasonable and not particularly difficult to implement, applying it in practice has proved problematic. The biggest problem in applying SEEA is the pricing of quantitative data based on physical quantities, which, in principle, can be done using the pricing techniques presented. In practice, however, pricing changes in the quality of the environment is difficult. Depending on which environmental resources we want to and can price, several different versions of SEEA can be constructed. Figure 29 shows the different versions of SEEA as contained in the handbook.

In the basic version of SEEA, the idea is to take into account the expenditure on environmental protection of the national economy, to combine the data in natural resource accounts with the data in the national accounts and to price the changes in the natural resources using the techniques presented in Chapter 2.3. In the second phase of the basic version of SEEA, data concerning the environment in the national accounts are separated from the data on the national economy and are handled separately, through satellite accounts. In the third phase, the physical natural resource accounts are integrated with accounts in monetary terms applying SEEA. In the fourth phase, the changes in physical accounts are valuated, and these values are integrated with other data in the national accounts applying the SEEA framework.

As regards extensions of SEEA, it is possible to take into account either the production capacity of a country (environment) and the treatment services for waste and pollutants it offers, using pricing based on maintenance costs, or the production activities of households using the CVM pricing method. Another possibility is to proceed from versions 3

Figure 29. Alternative versions of SEEA



Source: Integrated Environmental and Economic Accounting 1993, p.29 and 4 to extended input-output tables, as is done, for example, in the Dutch NAMEA system (National Accounting Matrix Including Environmental Accounts). Then it is usually only the direct environmental impacts of the economy, such as impacts of pollutants and waste, that are taken into account in adjusting the NNI indicator of the national accounts. (Hoffrén 1992, p. 93) The strength of version 5 of SEEA in comparison with NAMEA is precisely the fact that it also takes into consideration changes in the natural resources and their quality, which can be priced.

In the following Chapter, there has been presented the data included in the national accounts on the forest sector and the possibilities of producing physical accounts and other material on forests, and price these changes in the quality of forests using the techniques presented in Chapter 2. The final aim is to present the net production value of the Finnish forests in a way that approximates closely to version 5 of SEEA. Monetary values concerning forests are presented in following Chapters. In addition, Chapter 8 presents an extension of version 5 to cover the entire national economy in 1990-1996.

Values of timber production

The monetary evaluation of forests requires the support of comprehensive environmental accounts combining quality and quantity data, which bind together data based on the physical quantities of the natural resource accounts and quality data, which at present are expressed mainly in the form of indicators. Only after this can the various values attached to forests be priced in monetary terms.

As regards timber production, values based on market prices used in the current Finnish national accounts are available. In the national accounts, production in forestry is calculated through expenditure. The major part of the total production of forestry - some 85 to 90 per cent - consists of wood production. The income from logging (gross stumpage earnings) is calculated by multiplying the number of trees cut during the year by the average stumpage prices in private forests by tree species. The stumpage prices are agreed prices for raw timber in standing sales from private forests. Information on cutting and prices can be obtained from the Finnish Forest Research Institute's statistics and the utilisa-

Table 11. Value of wood production (FIM millions, current prices)

	Gross stumpage earnings	Depreciations on cultivation of timber	Net stumpage earnings
1990	8 016	1 404	6 612
1991	5 513	1 494	4 019
1992	5 358	1 475	3 883
1993	5 305	1 444	3 861
1994	7 500	1 411	6 089
1995	8 691	1 388	7 303
1996*)	7 945	1 440	6 505

*) = forecast

Source: Statistics Finland, National Accounts

tion of timber by households from separate accounts. The price statistics on raw timber in private forests are used as the price for the total quantity cut. Each tree species has its own regional stumpage price, with the exception of fuel wood. The price of fuel wood has been estimated annually to comply with the price of broadleaved pulp wood. Table 11 shows Finnish gross stumpage earnings, depreciations on cultivation of timber and net stumpage earnings.

When the depreciations on timber cultivation are deducted from the gross stumpage earnings, the difference equals net stumpage earnings. The depreciations on timber cultivation constitute a depreciation item which corresponds to investments in forest cultivation, drainage, forest road construction etc. In the model for calculating fixed capital in the national accounts, all the investment expenditures of previous years, which are still - according to a certain statistical asset retirement pattern - in the capital stock of the year under review, are added up. The consumption of fixed capital is calculated by deducting from the investments for each year the change in net capital stock from the previous year. In the asset retirement pattern, the presumed useful life of civil engineering structures is 40 years.

According to the new UN recommendation for a system of national accounts (1994), the growth of natural resources should also be considered as production. According to the recommendation, the growth of forests should be included in productive activities in forestry. The value of the growth of Finnish commercial forests is shown in Table 12. To begin with, the net increment of wood in forests has been calcu-

Table 12. Value of growth of the commercial forests (FIM millions, cp)

	Value of annual increment (total stock)	Value between increment and total drain in commercial forests
1990	11 501	2 914
1991	9 011	3 839
1992	8 311	2 502
1993	7 723	2 065
1994	9 149	1 506
1995	10 502	1 523
1996	10 644	2 416

lated from the wood accounts by deducting depletion from increment. In addition, the proportion of standing timber accounted for by commercial forests has been allowed. Some 6.9 per cent, or 131 million solid cubic metres, of the total quantity of timber in Finland is located in areas where timber production is restricted. After this, the annual net increment of commercial forests has been multiplied by average annual stumpage prices by tree species, which has thus given the total value of the difference between increment and total drain.

Other forest products

In addition to wood, forests contain also other assets economically valuable such as game and wild mushrooms and berries. With regard to these, supply and demand partly meet, which means that market prices are also formed for these products. This happens when products collected from forests are delivered for sale at market places and in shops. On the other hand, the values of berries and mushrooms collected for one's own consumption also have to be estimated in the national accounts. Some 10 per cent of the production in forestry comes from sources other than timber production. Table 13 shows the gross output values of these and certain other forest products.

The gathering of berries and mushrooms, and the values of reindeer farming and the export of lichen are included in the total output of agriculture in the national accounts. The

Table 13. Value of other forest products (FIM millions, cp)

	Berries	Mush-rooms	Lichen	Peat farming	Reindeer	Game	Christmas trees
1990	191.6	47.8	9.2	781	65	227	57
1991	261.0	72.2	7.7	854	96	245	52
1992	162.2	42.2	7.1	1 077	109	246	45
1993	167.1	21.7	8.1	1 045	82	255	40
1994	395.6	41.6	7.0	1 327	90	240	41
1995	177.0	29.0	3.0	1 299	85	220	46
1996*)	159.2	30.8	3.0	1 190	74	197	46

**) = forecast*
Source : Statistics Finland, National Accounts

value of peat production, on the other hand, falls under the manufacturing sector as part of mining and quarrying of energy producing material. As regards berries and mushrooms, the figures include the values of berries and mushrooms gathered for own use in addition to those delivered for sale in shops. In 1995, for example, the value of mushrooms delivered for sale in shops was FIM five million, whereas the value of mushrooms gathered for own use totalled FIM 24 million. Similarly, in 1995, the value of berries delivered to shops was FIM 58 million, and the value of own consumption amounted to FIM 119 million.

Total output from hunting, which corresponds to the value of the game catch, is included in the national accounts. The catch quantities of tetraonid birds, farmlands gamebirds, water birds, hare, fur animals, elks and other deer. The share accounted for by elks in the total output of hunting is 55-60 per cent. The data on quantities of game caught and prices are obtained from the Finnish Game and Fisheries Institute. The value of Christmas trees is included in the national accounts. It is based on an expert estimate of the average market price of Christmas trees and on the assumption that 70 per cent of households buy a Christmas tree.

The preservation and restoration of the biodiversity of forests and their ecosystems, biotopes, living species of organisms and their different stocks is important to Finland to ensure that timber production is on a sustainable time path. At the Ministerial Conference on the Protection of Forests in Europe held in Helsinki in 1993, Finland undertook, among other things, to practise ecologically sustainable forestry and to protect the biodiversity of forests. Reforming the management of commercial forests will not suffice to completely eliminate the risks threatening the biodiversity of nature, but in practice, the only way to preserve a suitable environment for all species is by leaving a sufficient amount of forests in their natural state in different habitats around the country.

One of the central aims of nature conservation is in fact to preserve the biodiversity of nature with a view to the needs of the present and future generations and for research purposes. To meet these needs, various nature conservation areas have been established in Finland. Their aim is to preserve Finnish nature in its original, untouched state. At present, 15.8 per cent, or 4.2 million hectares, of forestry land is subject to some kind of restrictions in wood production, and 10.2 per cent, or 2.7 million hectares, are completely protected.

At present, especially herb-rich forests and old-growth forests on eskers and in coastal areas as well as those owned

Table 14. Expenditure on nature conservation (FIM millions, cp)

	Purchase of areas	Running expenditure of nature conservation	Compensations paid	Total
1990	60.0	36.2	3.0	99.2
1991	109.5	51.3	10.0	170.8
1992	117.3	91.1	26.2	234.6
1993	146.4	84.1	16.2	246.7
1994	141.6	87.9	16.2	245.7
1995	159.1	75.2	19.0	253.3
1996	159.0	104.2	19.0	282.2
1997*)	235.0	68.0	43.0	346.0

*) = forecast

Source : Statistics Finland, Environmental Accounts by private persons require protection. As regards the protection programmes ratified by the Council of State, 200 000 hectares of private land, with a total purchase value exceeding FIM two billion, are still unprotected. Some one billion of this amount is accounted for by the protection of coastal areas. Table 14 shows Finland's expenditure on nature conservation.

As a large proportion of Finnish forests are commercial forests, the management methods used in these forests are in a key position in protecting biodiversity. The utilisation of commercial forests has in recent years shifted in a direction which emphasises the preservation of biodiversity, in compliance with the environmental programme confirmed by the Ministry of Agriculture and Forestry in 1994. Efforts have been made to give more consideration than before to the requirements of nature conservation, recreation and preservation of game, in addition to those of timber production, in the management of commercial forests. The Finnish Forest and Park Service, which answers for the management of state-owned forests to the extent of 97 per cent, has taken nature conservation and recreation into account in all its activities since 1991 and has committed itself to sustainable utilisation of natural resources since 1995. The Finnish Forest and Park Service aims at obtaining official certification in compliance with the ISO14001 standard for its environmental management system in 1997 (Kukko 1996, p. 23, 41).

In 1994, Forestry Centre Tapio completed its new forest management guidelines for private forest owners, which give greater priority to the protection of biodiversity than before. The Central Union of Agricultural Producers and Forest Owners (MTK) published its own guidelines with the same content in 1995. According to MTK's calculations, the preservation of the biodiversity of private forests does cause forest owners some extra expense. These costs arise from the fact that saleable timber is being left standing, the number of fallen trees and dead and rotting trees increases, and the cost of the first selective cutting increases. Savings in costs would result, for example, from reduced thinnings. According to MTK, the costs incurred by the forest owner for the preservation of the biodiversity of forests amount to FIM 1 370 per hectare. In final cutting, costs arise from growing trees and dead and rotting trees being left in the forests and from higher logging costs up to FIM 1 950 per hectare. However, FIM 530 per hectare is saved in reforestation and

FIM 250 per hectare is saved in the thinnings. The additional costs for the first selective cutting amount to FIM 200 per hectare. Within one year, therefore, the additional cost incurred through nature conservation is FIM 14-15 per hectare.

Commercial forests owned by private persons and industry in Finland amount to 15 053 000 hectares. In addition, the Finnish Forest and Park Service controls 3 303 000 hectares of commercial forests. Thus the estimated annual cost of protecting the biodiversity of commercial forests would be about FIM 266 million. Regeneration cutting (Clear cutting) was carried out on 117 370 hectares in 1994. According to public opinion polls, Finnish citizens' were of the opinion that Finnish forestry did in fact more ecologically sustainable during 1994-1996. Thus, on the basis of final cutting and reforestation costs, the cost of maintaining biodiversity could be estimated at roughly FIM 170 million for the years 1994, 1995 and 1996.

Airborne pollutants and the binding of carbon

The increase of the carbon dioxide content in the atmosphere and nitrogen deposition are estimated to have contributed to the growth of Finnish forests in recent decades. Defoliation, on the other hand, has been found to reduce the growth of trees. For the time being, there is no reliable information on the economic effects of the damage to Finnish forests on timber production, but so far hardly any deterioration has been observed in the growth of trees for this reason over the whole country. However, changes in the environment take place slowly, and severe forest damage is a threat in future, unless airborne pollutant emissions are reduced to such an extent that critical pollutant concentrations are not exceeded.

According to results obtained using the MESTA computer model, which is a version of the *Global Trade Model* for forestry products adapted to Finnish conditions, even a relatively sharp - on average one per cent per year - reduction in the growth of standing timber due to damage to the forests, will not reduce cutting until after the year 2020 (Hyvärinen et al. (ed.) 1993, p. 192, 198-199). In table 15, a price has been estimated on the basis of information on defoliation

Table 15. Estimate of the values of carbon binding and airborne pollutants (FIM millions)

	1990	1991	1992	1993	1994	1995	1996
Carbon binding	1 931	1 747	1 880	1 898	2 003	2 032	1 938
Placement of airborne pollutants	-4 818	-5 074	-4 450	-3 678	-3 633	-3 600*)	-3 500*)
Defoliation	-418	-498	-528	-351	-521	-476	-489
Total	**-3 305**	**-3 825**	**-3 098**	**-2 131**	**-2 151**	**-2 044**	**-2 051**

*) = forecast

and stumpage prices, for the growth of wood lost as a result of defoliation. It is possible to estimate an economic value for the carbon bound by the growth of timber stock on the basis of the valid carbon dioxide damage cost and the data in the forest balance sheet (cf. Seppälä and Siekkinen 1993, p. 44). The environmental expenditure arising form carbon dioxide binding has been estimated on the basis of the guideline value of FIM 170 per tonne used by the Finnish National Road Administration in its project evaluations.

The effects of the placement services (cf. landfills) offered by forests to airborne pollutants (external effects) and of defoliation in trees can be estimated on the basis of acid deposition and data on the defoliation of trees. According to the calculations of the programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe (EMEP), in Finland the acidifying deposition consisted of some 105 000 tonnes of sulphur and 55 000 tonnes of nitrogen oxides in 1995 (see table 8). Nitrogen oxide and sulphur dioxide values can be determined using, for example, the prices of the IIASA (International Institute for Applied Systems Analysis) research project on environmental technology). The price for acid deposition is thus FIM 22 000 per tonne. Thus the total value of the acidifying deposition was FIM 3.2 billion in 1995.

The economic values relating to forests presented above are largely based on market prices. On the other hand, when pricing recreational values and the state of the environment, methods used in the engineering and natural sciences must be applied, as well as various willingness to pay studies, as presented in Chapter 2. Some of the most important recreation values are shown in Table 16.

On the basis of, for example, in willingness to pay studies carried out in Finland, the recreation value of gathering and hunting has been considered to equal that of the berries and mushrooms gathered and the game catch. The value may, however, be estimated even higher, because according to one study, the real cost of hunting totalled FIM 716.1 million in 1993. The figure includes travel, clothing, guns, cartridges, other trapping gear and equipment, packed lunches, permits, membership fees, rent on land and costs arising from hunting dogs (Ermala and Leinonen 1995a, p. 43).

The recreation values of national parks and recreational areas are also based on willingness to pay studies. In Finland, the use of national parks and other protected areas for recreation has increased with urbanisation in recent years. As a result, for example guide centres have been built in several areas to meet the increased demand. On the other hand, there is no comprehensive information on the value of the recreational use of these areas. According to a willingness to pay study carried out in Sweden in 1991, people who

Table 16. Estimate of recreation values (FIM million)

	1990	1991	1992	1993	1994	1995	1996
Gathering	239	333	204	189	437	206	190
Hunting	227	245	246	255	240	220	197
National parks	337	341	354	470	557	658	699
Recreational areas	18	18	22	22	22	22	22
Hiking etc.	1 200	1 200	1 200	1 200	1 200	1 200	1 200
Costs of intensive forestry	-340	-340	-340	-340	-340	-340	-340
Total	**1 682**	**1 797**	**1 686**	**1 796**	**2 116**	**1 966**	**1 968**

had visited a nature conservation area were prepared to pay SEK 990, that is, some FIM 683 per visit for the experience, including travel. According to a study on the willingness to pay carried out in the Luukkaa recreational area near Helsinki, the amount of a possible hypothetical entrance fee was FIM 12 per visit (Hytönen 1995, p. 264, 346). On the basis of this information, time-budget surveys and the number of people who have used different recreation services, it is, however, possible to produce estimates on the values of national parks, recreational areas and other forms of hiking and nature study activities in the forest.

According to a willingness to pay study carried out in Norway, the environmental detriment caused to the multiple use of forests and recreation by intensive forestry amounted to some hundreds of millions in 1991. Taking into account Finland's larger forest area and population, the value of corresponding detriment in Finland would be FIM 340 million per year (Arjopalo 1994, p. 32).

Monetary forest resource accounting

On the basis of the monetary values of forests presented above, it is possible to draw up an estimate of the total economic value of the different products and services provided by Finnish forests. Emphasising the significance of one form of forest utilisation increases its value and decreases that of one or more other uses. The value of the total net production of the services (functions) provided by forests to society must be maximised, where forest management and exploitation are otherwise close to the limits of ecological sustainability. In practice, the natural capital must remain at least the same, that is, for example the value of the difference between increment and total drain should be zero or positive. Figure 19 shows the values of the various products and services provided by Finnish forests and the value of total net production.

The values relating to forests shown in the table are real benefits and expenses that have real market prices as under topics 1-3. The values of timber production are taken from the national accounts, other production of goods is based on statistics on the quantities and prices of goods delivered to shops. The prices under topics 4 and 5, on the other hand, are largely estimates based on methods used in the natural

Table 19. Monetary values of forest resource accounting (FIM millions, cp)

	1990	1991	1992	1993	1994	1995	1996*)
1. Timber production							
Gross stumpage earnings	8 016	5 513	5 358	5 305	7 500	8 691	7 945
Difference between increment and total drain (comm. forest)	2 914	3 839	2 502	2 065	1 506	1 523	2 416
Depreciation on cultivation of timber	-1 404	-1 494	-1 475	-1 144	-1 411	-1 388	-1 440
Timber harvesting (intermediate consumption)	-815	-682	-707	-724	-840	-856	-1 220
Total 1	**8 711**	**7 176**	**5 678**	**5 502**	**6 755**	**7 970**	**7 701**
2. Other forest products							
Berries	192	261	162	167	383	177	159
Mushrooms	48	72	42	22	42	29	31
Lichen	9	8	7	8	7	3	3
Peat	781	854	1 077	1 045	1 327	1 299	1 190
Reindeer farming	65	96	109	82	90	85	74
Game catch	227	245	246	255	249	220	197
Christmas trees	57	52	45	40	41	46	46
Total 2	**1 379**	**1 588**	**1 689**	**1 619**	**2 139**	**1 859**	**1 700**
3. Protection of biodiversity							
Purchase of nature conservation areas	-60	-110	-117	-146	-142	-159	-159
Running expenditure of nature conservation	-36	-51	-91	-84	-88	-75	-104
Compensations paid	-3	-10	-26	-16	-16	-19	-19
Biodiversity of commercial forests	0	0	0	0	-170	-170	-170
Total 3	**-99**	**-171**	**-235**	**-247**	**-416**	**-423**	**-452**
4. Effect of emissions							
Binding of carbon	1 931	1 747	1 880	1 898	2 003	2 032	1 938
Placement of a irborne pollutants	-4 818	-5 074	-4 450	-3 678	-3 633	-3 600	-3 500
Defoliation	-418	-498	-528	-351	-521	-476	-489
Total 4	**-3 305**	**-3 825**	**-3 098**	**-2 131**	**-2 151**	**-2 044**	**-2 051**
5. Recreational values							
Recreational value of gathering	239	333	204	189	437	206	190
Recreational value of hunting	227	245	246	255	240	220	197
National parks	337	341	354	470	557	658	699
Recreation areas	18	18	22	22	22	22	22
Hiking etc.	1 200	1 200	1 200	1 200	1 200	1 200	1 200
Costs of intensive forestry	-340	-340	-340	-340	-340	-340	-340
Total 5	**1 682**	**1 797**	**1 686**	**1 796**	**2 116**	**1 966**	**1 929**
VALUE OF NET PRODUCTION OF FORESTS	**8 368**	**6 565**	**5 720**	**6 539**	**8 443**	**9 328**	**8 866**

*) = estimate

sciences and willingness to pay studies. The impacts of airborne pollutants on the state of the environment were calculated by estimating the prices corresponding to these using methods offered by the engineering and natural sciences. In practice, the recreational use of forests and its economic value can only be ascertained through willingness to pay studies.

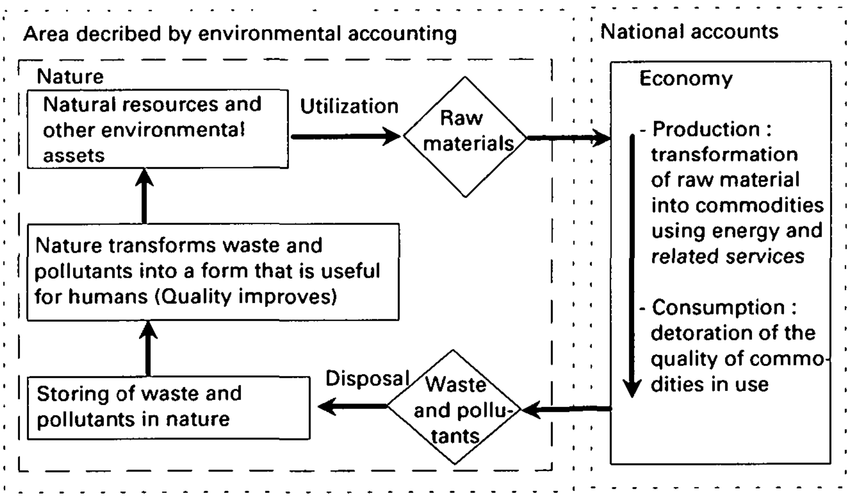
8
ADJUSTING THE NATIONAL ACCOUNTS WITH ENVIRONMENTAL

Tasks of the national accounts

The national accounts, which are the most central instrument of social planning even today, were developed in the 1940's and 1950's after the Great Depression, mainly to depict economic fluctuations. The system is based on recommendations given by the UN, of which the 1968 recommendation (SNA-68) is in use. Since the national accounts mainly depict economic fluctuations, the picture they give of the actual well-being of society is very misleading, even though it is well-being that they are generally considered to depict.

In principle, the national accounts constitute a model depicting the economic activity of a society and describing all the activities measurable in monetary terms of all economic units in that society. The national accounts are based on the classification and combination into the form of systematic accounts of observations made on economic activities. They are based on the assumption that the production, income and expenditure in the national accounts are equal in the system. The basic indicator of the national accounts, the gross domestic product (GDP), can be calculated as (1) the sum of the value added of production (2) the sum of the values of the end products or (3) the sum of the factor income. The GDP includes all economic activity that takes place in the country in question and that yields profit. The GDP in its present status is not an indicator of well-being, but rather of economic activity. The GDP measures the income of a society, in other words, the value of the goods and services when employed for their end use, produced in a country within a certain period. The GDP as such does not distinguish between production that is useful or harmful. At present, the GDP indicator does not take into consideration the increase in natural resources, commodities obtained free of charge from nature, domestic work or the use of wealth accrued earlier. This is illustrated in Figure 30.

Figure 30. Describing the flow of materials between nature and the economy



When calculating the net national product, the system of national accounts takes into account the depletion of capital created by man, but it does not take into consideration the decrease of natural capital. Part of what the system of national accounts records as income are, in reality, proceeds from selling capital, i.e, "eating" of wealth, which should not be counted as income. If we want to convert the gross national product in the present system into sustainable income, we must deduct from it the cost of protecting households, i.e. the monetary value of the damage caused to the environment. These "costs of non-sustainability", i.e. expenditure on environmental protection, constitute the depletion of capital created by man and of natural capital. Sustainable income is a steady flow of goods and services that the economy can produce indefinitely.

The most recent recommendation on national accounts, SNA-93, given by the UN in 1993, aims at more accurate measurement of actual well-being by regarding as production the growth of natural resources, for example. However, the system does not include the environmental impacts of production, for example. The reason for this is that, if the present GDP indicator is burdened with too many new perspectives, it will no longer serve to describe the fluctuations. The aim is to include environmental values by means of separate satellite accounts integrated, when necessary, into the national accounting system, as in the SEEA system. The new calculation method for the national accounts based on the recommendation will be introduced step by step between 1998 and 2001.

According to the SEEA handbook, it is important that the industrialized countries produce physical accounting on changes in land use, product flows in the economy, waste, soil pollution, waste water and air pollutants. Statistics on biological resources, mineral resources and recreational use of the environment are of moderate significance, whereas the application of physical accounting to water resources and the environmental impacts of agriculture is of little significance.

Table 18. Priorities for implementing the SEEA

	Physical accounting		Monetary accounting	
	Developed country	Developing country	Developed country	Developing country
1. Use of natural assets (except discharge of residuals):				
Depletion of				
1.1 Biological assets	+	++	+	++
1.2 Subsoil assets	+	++	+	++
1.3 Water	0	++	0	++
Degradation of land (landscape):				
1.4 Restructuring (urbanisation)	++	++	+	0
1.5 Agricultural use (soil erosion)	0	++	0	++
1.6 Recreational use	+	+	+	+
2. Product flow analysis	++	0	0	0
3. Degradation of the natural environment by discharge of residuals				
3.1 Wastes and land contamination	++	0	+	+
3.2 Waste water	++	+	+	+
3.3 Air pollution	++	+	+	+
4. Actual environment costs				
4.1 Environment protection activities			++	+
4.2 Damage costs			+	0

++ = high priority, + = medium priority, 0 = low priority

Source: Integrated Environmental and Economic Accounting 1993, s. 153

According to the handbook, industrialized countries should start compiling monetary accounting by examining expenditure on environmental protection. (Integrated Environmental and Economic Accounting 1993, p. 153) Areas of application of the SEEA system and their significance are presented in Table 18.

The most important single natural resources for Finland are forests, which need to be accurately taken into account in the environmental accounts to be compiled. Land use is also significant for Finland, although it is difficult to estimate its economic value. Other natural resources, such as water, fish and mineral resources, are of minor importance. In Finland, environmental protection has in the last few decades been effective, and there has even been an improvement in the state of the environment. Thus already at present the expenditure on environmental protection covers a large proportion of the earlier costs of externalities. Of environmental impacts caused by human activity, it is important to take into consideration air pollutants. Largely thanks to the unspoiled condition of the environment in Finland, the value of the recreational use of forests is also great, while, due to the small population, waste, soil pollution and waste water are probably of minor economic significance.

For integrated data on the environment and economy to be useful in decision making, an illustrative and compact indicator has to be created. This indicator has generally been called the "green national product". The SEEA system also includes an indicator of this kind, the so-called environmentally adjusted domestic product. The aim of the indicator is to better depict the development of the actual well-being of a society, and thus to help the decision-makers to make optimal decisions concerning well-being.

The environmentally adjusted domestic product, or EDP, is calculated as follows:

Gross Domestic Product, GDP
- Factor incomes from the rest of the world
- Indirect taxes from ROW
= **Gross National Product, GNP**
- Consumption of fixed capital
= **Net National Income, NNI**
- Environmental expenditure
- Changes in Environmental assets
= **Environmentally adjusted domestic product, EDP**

Expenditure on environmental protection in Finland

Version 2 of SEEA requires that expenditure on environmental protection in the national economy is separated from the accounts in the national accounts. In the end, these costs will in principle always be paid by consumers. However, rather than trying to separate environmental costs from the prices of commodities bought by consumers, it is easier to analyze these costs at the production phase (by production sectors). Of the expenditure on environmental protection by the entire national economy, the largest proportion is made up of industrial and public administration costs, while in the producer sectors, smaller proportions are probably constituted by the trade and other service sectors, households' own production and environmental organizations.

In the 1970's Finnish environmental policy focused largely on water protection. It was only later that attention was paid to air pollution control, which was the target of investment in the early 1980's. There are data on expenditure on water protection by industry and municipalities from the early 1970's. The wood-processing and chemical industries have also collected data on their own expenditure on environmental protection since the mid-1980's. The systematic collection of data on environmental protection expenditure was started by Statistics Finland, beginning from 1992. As regards the public sector, Statistics Finland has subsequently examined the expenditure on environmental pro-

Table 19. Development of expenditure on environmental protection (FIM million, cp)

	1990	1991	1992	1993	1994	1995	1996*)
State	639	929	1 309	1 336	1 689	2 893	3 630
Transfers to municipalities and industry	-33	-50	-36	-76	-77	-62	-64
Municipalities	3 408	3 610	4 300	4 307	3 469	3 253*)	3 200
Industry	1 935	1 682	2 446	2 326	2 187	2921	2 900
Environmental organisations	7	11	14	14	14	15*)	15
Total	**5 956**	**6 182**	**8 033**	**7 907**	**7 282**	**9 020**	**9 455**

*) = estimate

tection by central and local government, based on their accounts since 1980. The compilation of data on expenditure on environmental protection has been complicated by difficulties in defining it, changes in the methods of compiling accounts and the difficulty of separating the proportion of actual environmental protection costs from other costs. The development of expenditure on environmental protection by the state, the municipalities and industry is presented in Table 19, and the corresponding time series of expenditure on environmental protection in Table 36 of the Statistical Supplement.

Values of changes in environmental resources

Of the net production of Finnish forests, net stumpage earnings and values of forest by-products are already included in the information in the national accounts (SNA-68) in use at present. Expenditure on nature conservation is included in the expenditure on environmental protection presented above, and is taken into consideration in version 3 of SEEA. The next, fourth version of SEEA, also takes into account the values of the changes in environmental resources, which are based on physical data on quantities. Some of these changes are easy to price on the basis of real market prices. From the Finnish standpoint, the most important value in terms of environmental changes is the value of the growth of timber, i.e. the growth of forests presented in Chapter 7, which is calculated using the method presented in Chapter 7.2.

Besides the data in the national accounts, expenditure on environmental protection and changes in the quantities of environmental resources, version 5 of SEEA takes into account also the values of other productive functions of nature and its use in terms of fixing waste and pollution. In the case of Finland, this means in practice taking into account the value of carbon dioxide emissions contributing to the greenhouse effect, the net value of carbon dioxide fixed in stemwood, part of the recreational values and the value of acid deposition. These values will have to be estimated on the basis of various pricing techniques.

As regards emissions into the air, the values of needle loss and acidification of forest land caused by the emissions

Table 20. Estimates of the values of major impacts of air pollutants (FIM million)

	1990	1991	1992	1993	1994	1995	1996*)
Greenhouse effect							
Carbon dioxide emissions	-9 027	-9 270	-9 197	-10 369	-10 395	-9 298	-9 300
Forests							
Binding of carbon	1 931	1 747	1 880	1 898	2 003	2 032	1 938
Acid deposition							
Sulphur and nitrogen deposition	-4 818	-5 074	-4 450	-3 678	-3 633	-3 600*)	-3 500
Forests							
Defoliation	-418	-498	-528	-351	-521	-476	-489
Total	**-12 332**	**-13 095**	**-12 295**	**-12 500**	**-12 546**	**-11 342**	**-11 351**

*) = forecast

will have to be estimated. In addition, it is possible to estimate the monetary values of Finland's emissions into the air, such as emissions of carbon dioxide, nitrogen oxides and sulphur dioxide. However, it has not been possible to estimate the values of air pollution emissions and acid depositions in subsequent years, when they are stored in ecosystems and in the soil - the depositions are only included in the year when they occur. Estimates of the values of some impacts caused by air pollutants are presented in Table 20.

The environmental expenditure arising form carbon dioxide emissions presented in Table 21 has been estimated on the basis of the guideline value of FIM 170 per tonne used by the Finnish National Road Administration in its project evaluations. In 1995, the value of Finland's carbon dioxide emissions was FIM 9.3 billion. Allowing for the binding of carbon, however, it was only FIM 7.8 billion. Acid deposition in Finland consists mainly of sulphur and nitrogen deposition. The value taken is the guideline value of the IIASA, which is FIM 22 000 per tonne. Thus, in 1995, the total value of Finland's acidifying deposition was FIM 3.2 billion, and the values of the environmental impacts of air pollutants including the binding of carbon in trees were estimated at FIM 11.5 billion.

Calculating the environmentally adjusted national product

By integrating the environmental expenditure presented in previous Chapters with the data in the national accounts, we can estimate the value of the environmentally adjusted national product of Finland. The figure includes all the most important monetary values concerning the environment. The EDP 1 in line with SEEA's, version 3, is obtained by deducting expenditure on environmental protection, which are real costs, from the NNI indicator produced by the national accounts. The EDP 2 is calculated by taking into consideration all the above mentioned changes in environmental resources. The environmentally adjusted national product thus calculated corresponds largely to SEEA, version 5. The development of the environmentally adjusted national product in Finland between 1990 and 1996 is presented in Table 21.

Table 21. Finland's environmentally adjusted domestic product 1990-1996 (FIM million, cp)

	1990	1991	1992	1993	1994	1995	1996*)
SNA-68:							
GDP	**515 430**	**490 868**	**476 778**	**482 397**	**510 992**	**545 765**	**569 083**
Factor incomes from ROW	-15 040	-19 569	-24 811	-29 763	-23 426	-20 213	-20 437
Indirect taxes from ROW	–	–	–	–	–	-1 029	-1 023
GNP	**500 390**	**471 299**	**451 967**	**452 634**	**486 498**	**524 324**	**547 623**
Consumption of fixed capital	-79 512	-82 170	-81 892	-83 819	-85 480	-87 384	-88 195
NNI	**420 878**	**389 129**	**370 075**	**368 815**	**402 086**	**437 139**	**459 428**
SNA-93:							
Growth of forests	2 914	3 839	2 502	2 065	1 506	1 523	2 416
SEEA:							
Environmental expenditure	-5 956	-6 182	-8 033	-7 907	-7 282	-9 020	-9 455
EDP 1	**417 836**	**386 786**	**364 544**	**362 971**	**396 310**	**429 642**	**452 389**
Other changes in environmental assets	-12 332	-13 095	-12 295	-12 500	-12 546	-11 342	-11 351
EDP 2	**405 504**	**373 691**	**352 249**	**350 471**	**383 764**	**418 300**	**441 038**

ROW = Rest of the World – = not in use *) = estimate

Main source: Statistics Finland

The estimated environmental expenditure presented in Table 21 has in the early 1990's been 4-5 per cent of the annual value of the net national product. However, the monetary values of the changes in the quality of environmental resources in the table do not include all changes in the quality of the environment. Waste and waste water can have significant negative effects locally, but it is difficult to estimate their overall monetary value. Likewise, it is difficult to estimate the environmental impacts caused by changes in land use. Harm caused to watercourses by air pollution, such as acidification of lakes, is significant, but it is difficult to calculate the monetary values of the loss of well-being caused thereby. There are no reliable estimates on the effects of air pollution on capital created by man, i.e. buildings and machinery, for example. Moreover, it is difficult to establish in a comprehensive and reliable way the recreational values represented by nature.

Besides forests, Finland does not in fact have any other significant natural resources, unless natural resources are understood to comprise clean water, of which there is an abundance in the Finnish bedrock, and in inland waters. The monetary values of these domestic non-renewable natural resources, such as water and fish resources, are apparently fairly small and controversial from the perspective of the national economy, so they are excluded from the present study. It is difficult to establish the monetary values of non-renewable natural resources, such as domestic mineral and land resources, due to the difficulties of underpricing and of determining the level of "real" sustainable use, so they have not attempted to be estimated. The study also excludes the values of the use of imported renewable and non-renewable natural resources in Finland, such as ores, oil, gas, coal and fish, although in principle, it might seem that their values should decrease environmentally adjusted national product, at least to some extent.

9 CONCLUSIONS

In this study, there has been attempted to outline the structure of a forest resource accounting system that is suitable for Finnish circumstances. A forest resource accounting system should be applicable to measuring ecologically sustainable development as part of SEEA environmental accounting system. According to the results, forest resource accounting should offer basic data based on physical quantities and indicators depicting the quality and well-being of forests, and also offer monetary data on the influences of forests on society's well-being. Therefore it is needed to compile accounts based on physical quantities on changes in the forestry sector and on the impacts of forest management, forest balance sheets on the quantity of wood and carbon balances on the carbon dioxide fixed by stemwood. A graphic examination of changes in the quality of forests is made possible only by using aggregated indicators. The actual adjustment of the national accounts to conform more closely to "welfare" accounting calls for monetary accounting on, among other things, the values of wood production and other forest products, of expenditure on environmental protection, of the effects of air pollution, mainly acidification and needle loss, and of changes in recreational values.

This study has charted some of the important factors influencing the quality of forests, and thus the picture it presents is partly incomplete. The forest quality description and sustainable development have been examined from an ecological point of view and on the assumption that, in the long run, the well-being of nature also brings the maximum benefit for the well-being of human beings. Ecologically sustainable development is based on the conservation of natural biodiversity. The starting point has been the view that any kind of deviation from the natural state of a forest caused by human activity implies a deterioration in the quality of the forest. Deterioration of quality can also be interpreted as a decrease in forest biodiversity. In practice, however, it is impossible to determine the state of Finnish forests before the existence of human beings. Restrictions may also be caused by the unavailability of statistics. The National Forest Inventories were started after the war, and it was not until then that useful data on forests began to be available. Data concerning several important factors only exist from the past few years, and even this data is often very scattered. Problems are also caused by the difficulties in the indexation, aggregation and discounting of the time series, but these problems can be solved.

The work of developing the Finnish forest resource accounting system has been started, by focusing on physical quantities, indicators and accounting in monetary terms. However, the compilation and development of data on diversity and recreation, in particular, are not complete yet. It seems probable, however, that these data will be obtained in the near future, after which the accounts concerning forest quality would be based on systematically compiled accounts. The development of forest quality from 1970 to the present has been depicted using various indicators. As can be seen from the development of the forest stress indicator calculated on the basis of the data in the forest stock accounts, the effect of silvicultural measures on reducing forest diversity began to fall in the 1980's and 1990's. The indicator of forest quality also shows that forest quality started to improve at the end of the 1980's.

One purpose of the study has been to compare the data on quantities, prices and quality of forests by indexing their values. As their name suggests, indicators indicate the direction of development, and do not tell the whole truth about the state of forests. However, it is necessary to use indicators when trying to anticipate the development and future of the forests, because information in monetary terms cannot do this. For the most part, monetary information can only be used for verifying the development (history) that has taken place.

The present national accounts are based on Keynesian macroeconomics theory which, according to most economists, has largely lost its ability to explain economic phenomena. But, in practice, it is impossible to imagine in the long run, a situation in which the system for monitoring the national economy is not based on generally accepted theories. It seems that in the future the national accounts will increasingly be based on the welfare economics of neoclassical economic theory, and the national accounts will become more like accounts of society's well-being. It has to been taken into account, not only the present economic values, i.e. values created by human beings, but also the values represented by nature and intellectual capital. The economics of welfare take well-being into consideration only to the extent that the pricing system makes the kind of consumption that increases well-being visible and measurable. Without pricing immaterial goods, it is not possible to examine the effects of environmental resources on a society's well-being. This becomes a problem when the society wants to optimize well-being in different decision-making situations. As regards future development, we should therefore invest effort in developing the pricing techniques used to price environmental resources and to reach international agreements on concluding those techniques.

In this study, it has been discussed adjusting national accounts to include the values of expenditure on environmental protection by the state, the municipalities and industry, and the values of air pollution. According to estimates, this environmental expenditure is 4-5 per cent of the value of the net national product. In the future, environmental expenditure arising from the utilization of other natural resources and changes in recreational values should also be examined. This would enables it to come closer to a real account of well-being. According to this study, it would seem necessary to start compiling systematic accounts, similar to the forest resource accounts, on air pollution emissions, and their "import" and "export". It would seem fairly important also to develop methods of compiling statistics on fish, water, mineral and land resources. Moreover, annual accounts are needed on the utilization of foreign environmental resources, as well as on waste flows and on recycling. Besides data on the physical quantities of these resources, estimates on their monetary values are badly needed.

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STATISTICAL APPENDIX

Tables

Table 22. Area of forestry land and conservation areas, 1970-1995

	Forestry land	Conservation areas
1970	26 730 429	378 995
1971	26 746 286	421 114
1972	26 762 143	727 895
1973	26 778 000	744 649
1974	26 720 286	748 830
1975	26 662 571	760 518
1976	26 604 857	769 844
1977	26 547 143	770 402
1978	26 489 429	773 545
1979	26 431 714	782 040
1980	26 374 000	816 524
1981	26 367 000	1 411 141
1982	26 360 000	1 979 403
1983	26 353 000	1 993 133
1984	26 346 000	2 076 100
1985	26 339 000	2 100 534
1986	26 332 000	2 124 967
1987	26 325 000	2 135 220
1988	26 318 000	2 157 537
1989	26 311 000	2 646 236
1990	26 304 000	2 670 293
1991	26 297 000	2 723 313
1992	26 290 000	2 746 875
1993	26 283 000	2 825 489
1994	26 276 000	2 893 607
1995	26 280 000	2 962 000

N.B. Conservation areas include nature conservation areas implemented by legislation, private nature conservation areas and areas protected by FFPS's and FFRI's own decisions.

Table 23. Development of certain silvicultural measures, 1950-1995 (hectares)

	Drainage	Fires and prescribed burning	Forest cultivation	Thinning	Fertilisation
1950	10 400	4 300	29 900	52 600	6
1951	6 900	4 500	29 200	23 200	28
1952	19 000	8 164	29 500	44 200	20
1953	19 000	24 355	28 700	99 900	5
1954	39 700	18 358	38 100	137 300	71
1955	52 900	34 979	44 600	118 100	23
1956	62 500	34 072	55 300	174 600	146
1957	50 200	30 662	53 300	207 000	47
1958	81 200	35 720	66 100	155 400	147
1959	105 700	37 662	61 700	143 900	149
1960	115 300	42 372	65 300	117 600	472
1961	119 700	14 698	74 800	96 600	1 497
1962	144 400	14 841	86 500	107 900	2 972
1963	158 500	33 983	111 000	143 900	5 022
1964	182 800	17 392	131 400	163 000	6 611
1965	209 900	14 741	139 600	168 300	20 160
1966	233 000	11 700	132 600	202 000	39 403
1967	274 500	5 461	142 800	254 000	75 471
1968	273 100	3 035	132 100	256 800	131 424
1969	294 100	4 871	132 900	208 900	145 571
1970	290 400	3 924	138 200	168 100	184 441
1971	245 000	1 262	145 300	257 500	202 417
1972	223 500	1 532	141 200	279 300	220 051
1973	216 100	2 001	132 600	299 900	232 381
1974	193 500	1 250	126 300	310 900	230 200
1975	198 900	1 019	121 400	510 000	243 962
1976	182 100	1 143	128 300	531 400	163 566
1977	162 100	2 245	117 500	542 500	141 342
1978	144 800	1 501	115 500	499 000	100 563
1979	117 100	1 444	115 200	375 800	82 905
1980	113 400	2 374	128 700	317 100	87 226
1981	99 800	702	141 400	287 000	91 832
1982	84 000	2 113	151 000	318 400	109 758
1983	84 600	1 500	145 500	300 500	89 667
1984	77 500	2 101	140 500	286 300	79 514
1985	70 000	3 738	129 200	279 400	84 353
1986	67 200	3 567	133 500	258 900	86 661
1987	60 500	1 153	121 700	251 200	87 118
1988	69 400	5 789	110 900	218 600	79 147
1989	52 500	4 016	120 300	192 900	46 798
1990	41 100	4 233	121 100	201 000	47 655
1991	36 300	1 627	130 900	252 900	11 239
1992	34 500	3 081	122 500	233 100	5 026
1993	25 800	1 580	110 900	226 400	4 076
1994	16 900	1 700	108 000	164 500	6 003
1995	15 300	2 043	113 000	162 700	8 534

Table 24. Development of different methods of cutting, 1970-1995 (hectares)

	Type of cutting					
	Selective cutting	Clear cutting	S&S cutting	S&S depletion	Others	Total
1970	215 000	113 000	96 000	168 000	75 000	666 000
1971	164 000	85 000	74 000	123 000	52 000	498 000
1972	120 000	85 000	61 000	126 000	33 000	425 000
1973	100 000	124 000	60 000	153 000	35 000	472 000
1974	117 000	99 000	45 000	97 000	36 000	393 000
1975	89 000	65 000	26 000	63 000	26 000	268 000
1976	108 783	119 875	34 057	114 068	32 789	409 572
1977	78 087	93 753	23 973	97 484	25 306	318 588
1978	84 257	125 072	28 943	122 238	22 361	382 871
1979	128 289	161 496	34 043	129 060	28 752	481 640
1980	140 947	154 901	35 606	106 600	25 745	463 799
1981	159 042	117 408	30 812	68 967	40 041	416 270
1982	172 745	109 294	28 072	72 405	24 708	407 224
1983	186 942	114 147	37 086	75 616	32 759	446 550
1984	230 477	131 461	47 001	70 293	35 226	514 458
1985	196 651	104 195	38 241	51 190	37 977	428 254
1986	192 396	96 063	29 551	35 011	36 728	398 749
1987	221 833	120 576	42 949	50 332	29 625	465 315
1988	247 146	116 512	54 662	52 634	22 221	493 175
1989	258 500	106 100	52 800	51 900	13 200	482 500
1990	180 266	100 819	43 357	40 504	8 449	373 395
1991	110 169	74 134	25 383	21 346	6 284	237 316
1992	137 700	127 000	43 400	36 200	7 100	351 400
1993	141 359	106 161	45 835	37 567	8 817	339 739
1994	259 500	147 200	71 000	50 000	14 800	542 500
1995	241 800	110 000	57 100	41 000	6 600	456 500

S&S = seed- and shelterwood
Source: Statistical Yearbook of Forestry 1996

Table 25. Silvicultural quality of forests, 1970-1995

	Class 1.	Class 2.	Class 3.	Class 4.	Class 5.	Index I[6]
1970	23.11	41.29	8.66	9.06	17.89	100.00
1971	23.54	41.06	9.57	8.17	17.66	99.69
1972	23.97	40.83	10.49	7.29	17.43	99.38
1973	24.40	40.60	11.40	6.40	17.20	99.07
1974	25.29	40.40	11.43	6.27	16.61	98.01
1975	26.17	40.20	11.46	6.14	16.03	96.94
1976	27.06	40.00	11.49	6.01	15.44	95.88
1977	27.94	39.80	11.51	5.89	14.86	94.81
1978	28.83	39.60	11.54	5.76	14.27	93.75
1979	29.71	39.40	11.57	5.63	13.69	92.68
1980	30.60	39.20	11.60	5.50	13.10	91.61
1981	31.46	38.59	11.44	5.63	12.89	91.23
1982	32.32	37.98	11.28	5.76	12.68	90.84
1983	33.18	37.37	11.12	5.89	12.47	90.45
1984	34.04	36.76	10.96	6.02	12.26	90.06
1985	34.90	36.15	10.80	6.15	12.05	89.67
1986	35.76	35.54	10.64	6.28	11.84	89.29
1987	36.62	34.93	10.48	6.41	11.63	88.90
1988	37.48	34.32	10.32	6.54	11.42	88.51
1989	38.34	33.71	10.16	6.67	11.21	88.12
1990	39.20	33.10	10.00	6.80	11.00	87.73
1991	39.20	33.10	10.00	6.80	11.00	87.73
1992	39.20	33.10	10.00	6.80	11.00	87.73
1993	39.20	33.10	10.00	6.80	11.00	87.73
1994	39.20	33.10	10.00	6.80	11.00	87.73
1995	39.20	33.10	10.00	6.80	11.00	87.73

$$Index = 200 - \left\{ \frac{each\ year's\ \ class\ 1. + class\ \ 2.}{class\,1. + class\,2.\ of\,1970} \right\} x\ 100$$

Source: Statistical Yearbook of Forestry 1996

Table 26. Development of peatland area, 1970-1995 (hectares)				
	Peatland	**Undrained**	**Drained**	**Index I[7]**
1970	9 481 714	5 839 286	3 642 429	100.00
1971	9 437 143	5 648 857	3 788 286	96.73
1972	9 392 571	5 458 429	3 934 143	93.47
1973	9 348 000	5 268 000	4 080 000	90.21
1974	9 301 000	5 165 143	4 135 857	88.45
1975	9 254 000	5 062 286	4 191 714	86.69
1976	9 207 000	4 959 429	4 247 571	84.93
1977	9 160 000	4 856 571	4 303 429	83.17
1978	9 113 000	4 753 714	4 359 286	81.40
1979	9 066 000	4 650 857	4 415 143	79.64
1980	9 019 000	4 548 000	4 471 000	77.88
1981	9 009 200	4 518 400	4 495 690	77.38
1982	8 999 400	4 488 800	4 520 380	76.87
1983	8 989 600	4 459 200	4 545 070	76.37
1984	8 979 800	4 429 600	4 569 760	75.86
1985	8 970 000	4 400 000	4 594 450	75.35
1986	8 960 200	4 370 400	4 619 140	74.84
1987	8 950 400	4 340 800	4 643 830	74.34
1988	8 940 600	4 311 200	4 668 520	73.83
1989	8 930 800	4 281 600	4 693 210	73.32
1990	8 921 000	4 252 000	4 669 000	72.82
1991	8 921 000	4 210 900	4 710 100	72.11
1992	8 921 000	4 174 600	4 746 400	71.49
1993	8 921 000	4 140 100	4 780 900	70.90
1994	8 921 000	4 114 300	4 806 700	70.46
1995	8 921 000	4 099 000	4 822 000	70.20

Index based on the undrained value.

Table 27. Stress indicators, 1970-1995

	I[1]	I[2]	I[3]	I[4]
1970	100.00	100.00	100.00	100.00
1971	75.22	105.14	153.18	109.75
1972	75.22	102.17	166.15	119.31
1973	109.73	95.95	178.41	125.99
1974	87.61	91.39	184.95	124.81
1975	57.52	87.84	303.39	132.27
1976	106.08	92.84	316.12	88.68
1977	82.97	85.02	322.72	76.63
1978	110.68	83.57	296.85	54.52
1979	142.92	83.36	223.55	44.95
1980	137.08	93.13	188.64	47.29
1981	103.90	102.32	170.73	49.79
1982	96.72	109.26	189.41	59.51
1983	101.02	105.28	178.76	48.62
1984	116.34	101.66	170.32	43.11
1985	92.21	93.49	166.21	45.73
1986	85.01	96.60	154.02	46.99
1987	106.70	88.06	149.43	47.23
1988	103.11	80.25	130.04	42.91
1989	93.89	87.05	114.75	25.37
1990	89.22	87.63	119.57	25.84
1991	65.61	94.72	150.45	6.09
1992	112.39	88.64	138.67	2.72
1993	93.95	80.25	134.68	2.21
1994	130.27	78.15	97.86	3.25
1995	97.35	81.77	96.79	4.63

Table 28. Status of health of forests, 1987-1995						
	Defoliation class (%)					
	0–20	21–40	41–60	61–80	81–	Index I^{12}
1986	86.1	10.8	2.4	0.6	0.1	100.0
1987	82.5	13.0	3.3	0.9	0.4	98.6
1988	78.2	16.0	4.1	1.3	0.5	97.3
1989	75.8	17.8	4.2	1.6	0.6	96.7
1990	76.5	16.5	4.5	1.7	0.7	96.1
1991	79.5	14.0	4.3	1.6	0.6	97.0
1992	81.8	12.5	3.9	1.4	0.4	97.4
1993	79.4	15.8	3.5	1.0	0.3	98.2
1994	82.4	13.5	3.0	0.7	0.4	99.0
1995	80.6	15.1	3.3	0.9	0.2	99.1

The index is based on defoliation classes 020 and 2140.

Table 29. Indicators of biodiversity, 1970-1995								
	I^5	I^6	I^7	I^8	I^9	I^{10}	I^{11}	I^{12}
1970	100.00	100.00	100.00	100.00	100.00	100.00	100.00	–
1971	100.05	99.69	96.73	97.93	98.95	55.56	25.20	–
1972	100.11	99.38	93.47	95.86	97.91	55.56	34.13	–
1973	100.17	99.07	90.21	93.79	96.89	77.78	43.02	–
1974	99.96	98.01	88.45	93.96	97.47	88.89	14.88	–
1975	99.74	96.94	86.69	94.14	98.03	33.33	23.78	–
1976	99.53	95.88	84.93	94.31	98.58	66.67	17.96	–
1977	99.31	94.81	83.17	94.48	99.11	211.11	11.41	–
1978	99.09	93.75	81.40	94.67	99.63	77.78	26.49	–
1979	98.88	92.68	79.64	94.83	100.14	100.00	17.99	–
1980	98.66	91.61	77.88	95.01	100.63	177.78	25.60	–
1981	98.57	91.23	77.38	95.62	101.40	55.56	6.70	–
1982	98.47	90.84	76.87	96.22	101.41	177.78	16.96	–
1983	98.38	90.06	75.86	97.44	101.05	200.00	10.00	–
1985	98.29	89.67	75.35	98.05	101.10	388.89	7.87	–
1986	98.29	89.29	74.84	98.66	101.13	355.56	12.14	100.00
1987	98.29	88.90	74.34	99.27	101.86	111.11	5.60	98.60
1988	98.29	88.51	73.83	99.88	101.79	611.11	9.56	97.30
1989	98.30	88.12	73.32	100.49	101.80	388.89	17.06	96.70
1990	98.41	87.73	72.82	101.10	101.40	422.22	14.32	96.10
1991	98.38	87.73	72.11	102.50	101.12	155.56	7.51	97.00
1992	98.35	87.73	71.49	104.70	100.95	222.22	35.75	97.40
1993	98.33	87.73	70.90	106.45	100.77	111.11	19.18	98.20
1994	98.30	87.73	70.46	108.03	100.61	188.89	52.08	99.00
1995	98.18	87.73	70.20	109.49	100.75	155.56	21.26	99.10

General formula for calculating the indicators: $I^i = \left\{\frac{X^n}{X^1}\right\} x\ 100$

– = not in use

In which:
I^i is the indicator of the respective year (i=1970-1994)
X^1 is the data for the base year 1970 and
X^n is the data for the years 1970-1994.

Table 30. Finnish forest stock balances, 1990-1995

1990	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1.	**26 304 000**	**100.00**	**98.41**
Commercial forests	22 109 000	84.03	92.24
Areas under restricted wood production	1 524 707	5.79	64.03
Conservation areas	2 670 293	10.15	704.57
Annual increment	**129 680**	**0.49**	**89.54**
Forest cultivation	121 135	0.46	87.65
Planting	97 200	0.37	90.93
Seeding	23 900	0.09	76.36
Forestration of fields	8 545	0.03	128.81
Total removal	**122 680**	**0.47**	**95.12**
Clear cutting	100 819	0.38	89.22
Fires and prescribed burning	4 233	0.02	107.87
Other depletion	17 628	0.07	146.21
Other silvicultural works	**525 040**	**2.00**	**43.83**
Selective cutting	180 266	0.69	83.85
S&S cutting	43 357	0.16	45.16
S&S depletion	40 504	0.15	24.11
Other cutting	8 449	0.03	11.27
Thinning	201 009	0.76	119.58
Drainage	41 100	0.16	14.15
Fertilisation	47 655	0.18	25.84
Prescribed burning	3 800	0.01	422.22
Stock 31.12.	**26 297 000**	**99.95**	**98.38**

1991	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1	**26 297 000**	**100.00**	**98.38**
Commercial forests	22 066 087	83.90	92.06
Areas under restricted wood production	1 526 200	5.81	64.09
Conservation areas	2 704 713	10.28	713.65
Annual increment	**141 357**	**0.54**	**94.60**
Forest cultivation	130 900	0.50	94.72
Planting	102 500	0.39	95.88
Seeding	28 500	0.11	91.05
Forestration of fields	10 457	0.04	157.63
Total removal	**134 357**	**0.51**	**104.17**
Clear cutting	74 100	0.28	65.58
Fires and prescribed burning	1 627	0.01	41.46
Other depletion	58 630	0.22	486.27
Other silvicultural works	**465 021**	**1.77**	**38.82**
Selective cutting	110 169	0.42	51.24
S&S cutting	25 383	0.10	26.44
S&S depletion	21 346	0.08	12.71
Other cutting	6 284	0.02	8.38
Thinning	252 900	0.96	150.45
Drainage	36 300	0.14	12.50
Fertilisation	11 239	0.04	6.09
Prescribed burning	1 400	0.01	155.56
Stock 31.12.	**26 290 000**	**99.95**	**98.35**

1992	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1	**26 290 000**	**100.00**	**98.35**
Commercial forests	21 923 125	83.37	91.46
Areas under restricted wood production	1 620 000	6.16	68.03
Conservation areas	2 746 875	10.45	724.78
Annual increment	**139 581**	**0.53**	**96.37**
Forest cultivation	122 500	0.47	88.64
Planting	99 100	0.38	92.70
Seeding	23 400	0.09	74.76
Forestration of fields	17 081	0.06	257.48
Total removal	**132 581**	**0.50**	**102.79**
Clear cutting	127 000	0.48	112.39
Fires and prescribed burning	3 081	0.01	78.52
Other depletion	2 500	0.01	20.74
Other silvicultural works	**464 528**	**1.77**	**38.78**
Selective cutting	137 700	0.52	64.05
S&S cutting	43 400	0.17	45.21
S&S depletion	36 200	0.14	21.55
Other cutting	7 100	0.03	9.47
Thinning	233 100	0.89	138.67
Drainage	34 500	0.13	11.88
Fertilisation	5 028	0.02	2.73
Prescribed burning	2 000	0.01	222.22
Stock 31.12.	**26 283 000**	**99.95**	**98.33**

1993	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1.	**26 283 000**	**100.00**	**98.33**
Commercial forests	21 779 594	82.84	90.86
Areas under restricted wood production	1 620 000	6.16	68.03
Conservation areas	2 883 406	10.97	760.80
Annual increment	**128 588**	**0.49**	**88.78**
Forest cultivation	110 900	0.42	80.25
Planting	88 500	0.34	82.79
Seeding	22 400	0.09	71.57
Forestration of fields	17 688	0.07	266.63
Total removal	**121 588**	**0.46**	**94.27**
Clear cutting	106 161	0.40	93.95
Fires and prescribed burning	1 580	0.01	40.27
Other depletion	13 847	0.05	114.85
Other silvicultural works	**465 006**	**1.77**	**38.82**
Selective cutting	141 359	0.54	65.75
S&S cutting	45 835	0.17	47.75
S&S depletion	37 567	0.14	22.36
Other cutting	8 817	0.03	11.76
Thinning	226 389	0.86	134.68
Drainage	25 800	0.10	8.88
Fertilisation	4 076	0.02	2.21
Prescribed burning	963	0.00	107.00
Stock 31.12.	**26 276 000**	**98.95**	**98.30**

1994	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1	**26 276 000**	**100.00**	**98.30**
Commercial forests	21 762 393	82.80	90.79
Areas under restricted wood production	1 620 000	6.16	68.03
Conservation areas	2 893 607	11.01	763.49
Annual increment	**116 801**	**0.44**	**80.65**
Forest cultivation	108 000	0.41	78.15
Planting	79 500	0.30	74.37
Seeding	28 500	0.11	91.05
Forestration of fields	8 801	0.03	132.67
Total removal	**148 900**	**0.57**	**115.44**
Clear cutting	147 200	0.56	130.27
Fires and prescribed burning	1 700	0.01	43.32
Other depletion	..	..	..
Other silvicultural works	**584 403**	**2.22**	**48.79**
Selective cutting	259 500	0.99	120.70
S&S cutting	71 000	0.27	73.96
S&S depletion	50 000	0.19	29.76
Other cutting	14 800	0.06	19.73
Thinning	164 500	0.63	97.86
Drainage	16 900	0.06	5.82
Fertilisation	6 003	0.02	3.25
Prescribed burning	1 700	0.01	188.89
Stock 31.12.	**26 243 900**	**99.85**	**98.18**

1995	Use of forest (ha)	Per cent of stock	Index 1970=100
Stock 1.1	**26 243 900**	**100.00**	**98.18**
Commercial forests	21 662 175	82.54	90.37
Areas under restricted wood production	1 620 000	6.17	68.03
Conservation areas	2 961 725	11.29	781.47
Annual increment	**149 137**	**0.57**	**102.97**
Forest cultivation	113 000	0.43	81.77
Planting	81 000	0.31	75.77
Seeding	32 000	0.12	102.24
Forestration of fields	4 137	0.02	62.36
Total removal	**112 043**	**0.43**	**95.83**
Clear cutting	110 000	0.42	97.35
Fires and prescribed burning	2 043	0.01	52.06
Other depletion	..	..	..
Other silvicultural works	**534 434**	**2.04**	**44.62**
Selective cutting	241 800	0.92	112.47
S&S cutting	57 100	0.22	59.48
S&S depletion	41 000	0.16	24.40
Other cutting	6 600	0.03	8.80
Thinning	162 700	0.62	96.79
Drainage	15 300	0.06	5.27
Fertilisation	8 534	0.03	4.63
Prescribed burning	1 400	0.01	155.56
Stock 31.12.	**26 280 994**	**100.14**	**98.31**

Table 31. Finnish forest balances, 1990-1996 (1000 solid cubic metres)

1990	Total	Pine	Spruce	Broadleaves
Stock 1.1	**1 841 400**	**836 900**	**663 500**	**342 000**
Annual increment	75 400	33 000	25 800	16 600
Net removals	48 900	19 100	20 500	9 300
Silvicultural waste	4 800	1 400	1 200	2 200
Natural losses	1 300	600	400	300
Stock 31.12.	**1 861 800**	**848 800**	**666 200**	**346 800**
1991	***Total***	***Pine***	***Spruce***	***Broadleaves***
Stock 1.1	**1 861 800**	**848 800**	**666 200**	**347 800**
Annual increment	75 400	33 000	25 800	16 600
Net removals	39 400	14 600	18 800	7 500
Silvicultural waste	3 500	1 000	1 200	1 300
Natural losses	1 300	600	400	300
Stock 31.12	**1 893 100**	**865 800**	**673 200**	**354 300**
1992	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1	**1 893 100**	**865 800**	**673 200**	**354 300**
Annual increment	75 400	33 000	25 800	16 600
Net removals	45 200	17 700	19 200	8 300
Silvicultural waste	4 600	1 200	1 300	2 100
Natural losses	1 300	600	400	300
Stock 31.12.	**1 917 600**	**879 100**	**678 200**	**360 300**
1993	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**1 817 600**	**879 100**	**678 200**	**360 300**
Annual increment	75 400	33 000	25 800	16 600
Net removals	47 700	18 400	21 900	8 800
Silvicultural waste	4 800	1 300	1 400	2 200
Natural losses	1 300	600	400	300
Stock 31.12	**1 939 200**	**891 900**	**681 700**	**365 700**
1994	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**1 939 200**	**891 900**	**681 700**	**365 700**
Annual increment	75 400	33 000	25 800	16 600
Net removals	55 000	21 000	25 000	9 100
Silvicultural waste	5 400	1 400	1 700	2 200
Natural losses	1 300	600	400	300
Stock 31.12.	**1 952 900**	**901 800**	**680 400**	**370 700**
1995	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**1 952 900**	**901 800**	**680 400**	**370 700**
Annual increment	75 400	33 000	25 800	16 600
Net removals	56 700	21 800	25 100	9 800
Silvicultural waste	5 600	1 500	1 700	2 400
Natural losses	1 300	600	400	300
Stock 31.12.	**1 964 700**	**910 800**	**679 000**	**374 900**
1996	***Total***	***Pine***	**Spruce**	**Broadleaves**
Stock 1.1.	**1 964 700**	**910 800**	**679 000**	**374 900**
Annual increment	75 400	33 000	25 800	16 600
Net removals	50 400	19 400	22 400	8 600
Silvicultural waste	5 000	1 300	1 500	2 100
Natural losses	1 300	600	400	300
Stock 31.12.	**1 983 400**	**922 000**	**680 000**	**381 000**

Table 32. Carbon balances of Finnish stemwood 1990-1996 (1000 tonnes of carbon)

1990	Total	Pine	Spruce	Broadleaves
Stock1.1.	**395 166**	**177 663**	**133 276**	**84 227**
Annual increment	17 448	7 005	6 353	4 088
Net removals	10 463	4 055	4 118	2 290
Silvicultural waste	1 080	297	241	542
Natural losses	282	127	80	74
Stock 31.12.	**399 618**	**180 189**	**134 019**	**85 409**
1991	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**399 618**	**180 189**	**134 019**	**85 409**
Annual increment	17 448	7 005	6 353	4 088
Net removals	8 560	3 057	3 656	1 847
Silvicultural waste	773	212	241	443
Natural losses	282	127	80	74
Stock 31.12.	**406 279**	**183 798**	**135 224**	**87 256**
1992	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**406 279**	**183 798**	**135 224**	**87 256**
Annual increment	17 448	7 005	6 353	4 088
Net removals	9 679	3 779	3 857	2 044
Silvicultural waste	1 050	276	281	493
Natural losses	282	127	80	74
Stock 31.12.	**411 584**	**186 622**	**136 229**	**88 734**
1993	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**411 584**	**186 622**	**136 229**	**88 734**
Annual increment	17 448	7 005	6 353	4 088
Net removals	10 191	3 906	4 118	2 167
Silvicultural waste	1 078	255	281	542
Natural losses	282	127	80	74
Stock 31.12.	**416 335**	**189 339**	**136 932**	**90 064**
1994	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**416 335**	**189 339**	**136 932**	**90 064**
Annual increment	17 448	7 005	6 353	4 088
Net removals	11 701	4 458	5 002	2 241
Silvicultural waste	1 202	318	341	542
Natural losses	282	127	80	74
Stock 31.12.	**419 407**	**191 440**	**136 671**	**91 295**
1995	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**419 407**	**191 440**	**136 671**	**91 295**
Annual increment	17 448	7 005	6 353	4 088
Net removals	12 083	4 628	5 042	2 414
Silvicultural waste	1 251	318	341	591
Natural losses	282	127	80	74
Stock 31.12.	**422 067**	**193 372**	**136 389**	**92 305**
1996	**Total**	**Pine**	**Spruce**	**Broadleaves**
Stock 1.1.	**422 067**	**193 372**	**136 389**	**92 305**
Annual increment	17 448	7 005	6 353	4 088
Net removals	10 736	4 118	4 499	2 118
Silvicultural waste	1 094	276	301	517
Natural losses	282	127	80	74
Stock 31.12.	**426 231**	**195 856**	**136 690**	**93 684**

Table 33. Development of sulphur, nitrogen and carbon dioxide emissions, 1980-1995 (1000 tons)

	SO2	NOx	CO2
1980	584	295	54 000
1981	534	276	44 700
1982	484	271	42 800
1983	372	261	42 400
1984	368	257	43 400
1985	382	275	49 500
1986	331	277	48 100
1987	328	288	51 900
1988	302	293	51 600
1989	244	301	51 900
1990	260	300	53 100
1991	194	290	53 200
1992	141	283	51 400
1993	124	283	52 300
1994	112	282	58 300
1995	96	258	55 100

N.B. The figures in table 33 do not include foreign traffic. Carbon dioxide emissions include emissions caused by the combustion of fossil fuels and peat for energy, sulphur emissions include the sulphur emissions caused by energy combustion calculated in sulphur dioxide, and nitrogen oxide emissions include the nitrogen oxide emissions arising from industry and energy combustion calculated as nitrogen dioxide.

Source: Statistics Finland, Environmental Accounts

Table 34. Monetary values of wood in forests, 1980-1996 (FIM billions, current prices)

	Value of the total stock	Value of total annual increment	Value between increment increment and total drain	Value between increment and total drain in commercial forests
1980	153.0	6.2	0.8	0.7
1981	201.7	6.9	1.2	1.2
1982	198.1	6.8	1.6	1.5
1983	201.8	6.9	1.8	1.7
1984	223.5	7.6	1.8	1.7
1985	232.7	9.0	2.7	2.5
1986	223.7	8.7	3.1	2.9
1987	235.8	9.2	2.8	2.6
1988	269.5	10.5	2.8	2.6
1989	289.3	11.0	2.5	2.3
1990	283.8	11.5	3.2	2.9
1991	248.3	9.0	4.1	3.8
1992	129.5	8.3	2.7	2.5
1993	197.9	7.7	2.2	2.1
1994	237.3	9.1	1.6	1.5
1995	274.0	10.5	1.6	1.5
1996	279.5	10.6	2.6	2.4

N.B. Currency rates as of March 26, 1997 : 1 FIM = 0,199 USD = 0.173 ECU, 1 USD = 5.026 FIM and 1 ECU = 5.792 FIM.

Table 35. Value of wood production, 1980-1996 (FIM billions, current prices)

	Gross National Product (GNP)	Gross stumpage earnings	Depreciations on cultivation of timber	Net stumpage earnings
1980	191 376	5 075	-596	4 479
1981	216 660	5 409	-697	4 712
1982	243 585	5 213	-767	4 446
1983	271 607	5 028	-845	4 183
1984	304 597	5 852	-910	4 942
1985	331 628	6 332	-969	5 363
1986	354 994	5 413	-1 049	4 364
1987	386 855	6 081	-1 069	5 012
1988	434 341	7 437	-1 162	6 275
1989	486 998	8 122	-1 287	6 835
1990	515 430	8 016	-1 404	6 612
1991	490 868	5 513	-1 494	4 019
1992	476 778	5 358	-1 475	3 883
1993	482 397	5 305	-1 144	3 861
1994	510 992	7 500	-1 411	6 089
1995	545 765	8 691	-1 388	7 303
1996*)	569 083	7 826	-1 400	6 426

*) = forecast *Source: Statistics Finland, National Accounts*

N.B. Currency rates as of March 26 1997 : 1 FIM = 0,199 USD = 0.173 ECU, 1 USD = 5.026 FIM and 1 ECU = 5.792 FIM.

Table 36. Finland's environmental protection expenditure, 1980-1996 (FIM million, current prices)

	State	Transfers	Munici-palities	Industry	Organi-sations	Total
1980	163	-37	1 536	340	..	2 002
1981	199	-42	1 661	340	..	2 158
1982	231	-53	1 764	510	..	2 452
1983	251	-53	1 748	435	..	2 381
1984	304	-57	2 153	395	..	2 795
1985	399	-53	2 299	1 035	..	3 680
1986	435	-38	2 396	1 049	..	3 842
1987	536	-33	2 535	910	..	3 948
1988	480	-30	2 625	1 269	..	4 344
1989	684	-33	2 937	1 647	..	5 235
1990	639	-33	3 408	1 935	7	5 956
1991	929	-50	3 610	1 682	11	6 182
1992	1 309	-36	4 300	2 446	14	8 033
1993	1 336	-76	4 307	2 326	14	7 907
1994	1 689	-77	3 469	2 187	14	7 282
1995	2 893	-62	3 253*)	2 921	15*)	9 020
1996	3 415	-75	3 200*)	2 900*)	15*)	9 455

N.B. **State**: environmental expenditure arising from environmental administration, from cooperation with the neighbouring regions, from environmental protection and nature conservation, from environmental research and agriculture, and expenditure arising from action aimed at saving energy. **Transfers**: the transfers refer to various transfers of income, such as subsidies and support to municipalities and enterprises. **Municipalities**: expenditure on sewerage, waste water treatment, waste management and environmental management. The expenditure on air protection by municipal energy providers is included in the figures for 1992 to 1996. **Industry**: 1980-1984, only industry'- expenditure on water protection, 1985-1987 expenditure on water protection and other expenditure on environmental protection by the wood-processing industry, 1988-1991 expenditure on water protection, other expenditure on environmental protection by the wood-processing industry and the chemical industry and 1992-1996, all environmental expenditure of industry. **Organisations**: Payroll of the non-governmental environmental protection organisations

*) = forecast .. = data missing

Currency rates as of March 26, 1997 : 1 FIM = 0,199 USD = 0.173 ECU, 1 USD = 5.026 FIM and 1 ECU = 5.792 FIM.

Sources: State bookkeeping, Finnish Environment Institute, Finnish Forest Industries Federation, Chemical Industry Federation and Statistics Finland.

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