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Environmental Accounts

for

Forest

Test of a proposed framework for

Non-ESA/SNA Functions

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Environmental accounts for forests

Non ESA/SNA functions

Foreword

In 1992 the Swedish government assigned Statistics Sweden to develop physical environmental accounts and the National Institute of Economic Research (NIER) to report on the most important links between the economy and the environment and including R&D in the field of monetary accounts.

Forest accounts, describing the stocks and changes of stocks for forest land and timber, together with analyses of the supply and use of timber have earlier been developed jointly by the environmental division and the national account division of Statistics Sweden. The results "Result of a pilot application" have been published by Eurostat in The European Framework for Integrated Environmental and Economic Accounting for Forest (IEEAF).

That first part of the forest accounts did not regard functions of the forests without market values as carbon binding, recreation, biodiversity, protective functions, all of them important for understanding the development of sustainable forest management. Therefore, the Eurostat Task-Force on Forest Accounts developed a set of tables describing ecological and social functions of the forest. The aim of the tables is twofold. Firstly to develop physical data and secondly to test different valuation methods for these functions.

This report, which is a test to link physical data with economic valuation methods, consists of two sections. Section one comprises a discussion of the physical tables of non-SNA function of forest, suggested by Eurostat, discussion of data availability and data quality and compilation and presentation of available data. Section two includes a monetary valuation of non-SNA functions produced by the Swedish forest ecosystems.

As a summery an overview of the physical and monetary data is presented.

The report is prepared on commission from Eurostat, who supports and coordinates development of environmental accounts in the EU member states. The European commission (DG Environment) has contributed financially to the project.

Part one "Physical description of non-ESA/SNA functions" is prepared by Leif Norman, Statistics Sweden, with assistance by Hillevi Eriksson, National Board of Forestry and Marianne Eriksson, Statistics Sweden. Part two "Monetary Forest accounts for timber and other forest related goods and services for Sweden 1987-99" is prepared by Kristian Skånberg, National Institute of Economic Research (NIER).

Comments and conclusions are the views of the authors and not necessarily the view of Statistics Sweden or NIER.

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0.1 Background

As a part of developing Environmental Accounting Eurostat has set up a European Framework for Integrated Environmental and Economic Accounting for Forests (IEEAF). The results of the first IEEAF pilot application have been published as 'The European Framework for Integrated Environmental and Economic Accounting for Forests: Results of Pilot applications' (European Commission 1999a, Eurostat catalogue number CA-22-99-329-EN-C).
The IEEAF was developed by contributions from members of the Eurostat Task-Force on Forest Accounts including Germany, France, Italy, Austria, Finland and Sweden.

The first objective of the IEEAF is to consistently link forest balance sheets and flow accounts for land and timber, forest related economic activities and supply and use of wood within the economy, in physical and monetary terms. The framework presents guidelines for definition and classification, an accounting framework and recommendations for valuation of the main forest related assets.

The proposed framework covers:

- A core classification of forest related assets, wood products and related industries.
- Balance sheets of forest related assets, in monetary and physical units, integrating the description of all changes that affect forest related assets.
- Monetary accounts for activities and transactions related to forests (forestry, logging etc.).
- Supply and use tables, in monetary and physical units.
- Mass balances and flows of residuals accounts, in physical units.

The second objective of the IEEAF is to integrate monetary and physical data on non-market environmental and protective functions of forests, biodiversity, the health status of forests etc.. As a first step to integrate the non-SNA functions in the forest Accounts, the Eurostat Task Force on Forest Accounts has suggested a set of tables containing ecological and social function of the forests.

Statistics Sweden offered to test the suggested tables according to relevance, data availability and data quality and compile data. In the same project NIER, who has conducted R&D concerning monetary valuation of non-market environmental goods and services, offered to carry out a study of monetary valuation. In this report part one deals with the physical data of non-SNA functions and part two presents Forest accounts for timber and other related goods and services for Sweden 1987-1999.

Much of the information used in this report is collected from the Statistical Yearbook of Forestry (by NBF), which partly is based on the National Forest Inventories at the Swedish University of Agricultural Sciences.

The figures presented in the report are preliminary and have not the status as official statistics from Statistics Sweden.

0.2 Physical data and monetary valuation

In this report the physical description of non-SNA functions of forests and monetary valuation are partly based on the same basic data and partly on different sources. For some of the valuation items there are, at present, no regularly produced statistics. In these cases the valuation have to be based on expert estimates. Other indicators are important for describing the development of the ecological and social functions of forests in order to monitor sustainable forest management. However, these indicators are not always useful for monetary valuation.

In the table below, the set of tables with physical data suggested by Eurostat and the basic information used in the valuation study by NIER are compared. Of the 13 suggested tables 6 have been used in the valuation study; three more tables would have been used if data had been available. Of the valuation items, 4 are based merely on estimates by experts.

The physical and monetary information complement each other, the basic parts have the same elements. As there are different methods for valuation, the results can differ considerably, as will be shown below in the report. Therefore it is very important in the first stage to agree on a basic set of physical tables based on regularly produced statistics with time-series to monitor trends. On the other hand in some cases valuation based on expert estimates may be the best possibility to get information on changes in ecological and social functions of forests.

Swedish Forests accounts: Overview of physical Non-SNA tables and monetary valuation components

	Suggested tables from the Eurostat Task Force on Forests accounts	**Phy-sical data**	**Monetary valuation by NIER**	**Mone-tary data**	**Comments**
Non-timber goods					
Harvested berries, mushrooms hunted game	Not relevant, since values are included in SNA (the agricultural sector) from 1995(?)	X	Value of picked berries, game and lichen (reindeer feed)	X	Included in the valuation study in order to set up comparable time series from 1987
Change of production capacity of non-wood forest goods	Not included		Included as change of capital	X	Based on expert estimates. There are no available statistics at the moment.
Non-wood services					
Carbon binding	E1 Carbon balances and accumulation in standing timber, tons of carbon	X	Valuation with data from E1, net growth of stem timber	X	All tables concerning binding of carbon should be harmonized with the Kyoto agreement
	E2 Balance and accumulation of woody biomass dry matter	X	Not used		
	E3 Balance and accumulation of woody biomass dry matter ton of carbon	X	Valuation with data from E3	X	
	E4a Changes in carbon stored in the forest eco system		Not included due to lack of data		At present no data is available on changes of carbon stored in forest soils
	E4b Changes in land cover, ha	X	Used for valuation of quantitative changes of the forest ecosystem area, See below	X	
	E5 Changes in total carbon storage (forest related resources and products)		Not included due to lack of data		At present no data is available on changes of carbon stored in forest soils, Accumulation in wood products can be roughly estimated

	Suggested tables from the Eurostat Task Force on Forests accounts	Phy-sical data	Monetary valuation by NIER	Mone-tary data	Comments
Recreation	E9 Recreational areas, 1000 ha	X	Not included		Not part of the valuation. Sweden has a law of common access, which makes all forest area accessible for recreation. Special information on the availability of urban recreation areas is a valuable indicator of possibilities for forest recreation.
	E10 Visits by main purpose	X	Main information for valuation of recreation	X	Based mostly on willingness to pay studies
	Proposal for a new table Accessibility	(X)			Important indicator for access to recreational areas. Also a suggested indicator for monitoring of the Swedish environmental objective 'A good urban environment'. So far no valuation studies have been carried out, but it could be done with CVM studies for valuation of change of (recreation) cap.
	Proposal for a new table: Forest areas free from noise				Important part of recreational values, but so far no valuation studies have been carried out.
Protective functions	E11, Primary management objective of forest land		Valuation of protection of soils	X	Based on estimates by experts
			Valuation of shielding urban areas from noise	X	Based on estimates by experts

	Suggested tables from the Eurostat Task Force on Forests accounts	Phy-sical data	Monetary valuation by NIER	Mone-tary data	Comments
Maintenance of biodiversity, quality changes	E6 Forest occurring species at risk or endangered	X	Not part of the valuation		Not part of the valuation but can be done with CVM studies. The physical indicator is important to detect threats to different species
	E7 Forest balance: Protection of forest and other wooded land	X	Base for valuation of biodiversity	X	The valuation is based on the difference between actual protected area and the national target. As the national target can be political or ecological it is important to notice any difference.
	E8 Regeneration and extension of forest and other wooded land	X	Not part of the valuation		Important indicator of forest management i.e. detection of monocultures or natural regeneration of forests
Health of trees	E12 Defoliation of trees by classes and species	X	Not part of the valuation		Useful physical indicator to compare the health state of forests between different countries. Valuation is based on other items such as loss of production capacity of soils.
Chemical quality changes	Not included		Chemical quality changes of soils, affecting production capacity in the future	X	Valuation by the cost of liming to counteract acidification Possible physical data could be areas with need for liming
Quantitative changes of forest ecosystem area	See table E4b	X	Valuation of loss of productive capacity	X	Based on statistics of area changes, valuation by estimates by experts

	Suggested tables from the Eurostat Task Force on Forests accounts	Phy-sical data	Monetary valuation by NIER	Mone-tary data	Comments
External effects affecting the forestry sector			No valuation		Discussion of possible effects, no data Need to be further researched
External effects caused by the forestry sector			No valuation		Discussion of possible effects, no data Need to be further researched
Possible long term environmental threats having an impact on forest ecosystem			No valuation		Discussion of possible effects, no data Need to be further researched
Possible measures to increase overall forestry efficiency			No valuation		Discussion of possible effects, no data Need to be further researched

1. Physical description of non-ESA/SNA functions of forests

1.0 Non-ESA/SNA functions of forests

To explain what is meant by and the object behind the interest in the non-ESA/SNA functions of forests the following lines from the document "Physical description of non-ESA/SNA functions of forests" by the Eurostat Task Force on Forest and Environmental Accounting (Luxembourg, August 1999) are useful.
"Traditionally, sustainable forest management meant to secure the supply of timber i.e. to maintain the quantitative balance between natural growth and timber. However, increasingly the focus has turned to issues of sustainable forest ecosystem management. This implies the protection of forest ecosystems so as to preserve different functions.
From a national accounting point of view, this requires going beyond the conventional needs of ESA/SNA to include non-ESA/SNA (non-wood, non-market) values of forests expressed as parameters of ecological and social functions of forests. The conception is to monitor how well sustainable forest management has been achieved."

1.1 Discussion of the proposed tables and the possibilities to compile the data

The tables referred to in the following discussion are the ones proposed by the Eurostat Task Force on Forest Economic and Environmental Accounting and which are presented in the document "Physical description of non-ESA/SNA functions of forests" (Luxembourg, August 1999).

The tables contain parameters connected to physical indicators of ecological and social forest functions.
The indicators are:

- carbon binding (6 tables)
- biological diversity (3 tables)
- recreational services/functions (2 tables)
- protective functions (1 table)
- health of trees (1 table)

General remarks:
- The distribution of the number of tables between the indicators seems to be uneven. Why use 6 tables to depict carbon binding but just 1 each for protective functions and health of trees? Does the complexity of the issue of carbon binding motivate the number of tables?

- What administrative or geographical levels are the most appropriate? The national or regional level could be supplemented by reporting on squares, NUTS 3 and river basin level. Different levels can be appropriate depending on the purpose of the compilation. The conditions in some parts of a country can be completely different compared to other parts. This can also be applied on regions of countries.
A discussion on this subject would be valuable.

- The contents of the tables on carbon binding have to be adapted to the forthcoming international agreed definitions and interpretations of the Kyoto Protocol.

1.1.1 Carbon binding

This section includes comments on tables E1 to E5.

Table E1. Carbon balances and accumulation in standing timber (1000 tons of carbon)

	Total	Coniferous	Broad-leaved
Opening stock Natural growth Fellings Catastrophic losses Other changes - Deforestation **Closing stock**			

The table is to be provided **annually** derived from simplified stocks and flows of standing timber.
Natural growth is defined as biological growth net of natural losses.

Comments:
Why not include changes in land classification as an identified part of Other changes? What is the difference between fellings and deforestation?

To make the report work on this table straightforward and easy, we have coupled it directly to certain statistics. Since the method to determine afforestation and deforestation is not yet developed, such numbers are not reported in the table at this stage. However, such changes concern less than 10 000 ha/year over the last decades in Sweden.
The reported figures in Tables E1a-b concern "managed forest land". The stock increase in woody biomass on all land-use classes (on which the regular tree inventory take place) is almost 10 % higher. "Managed forest land" is land which is not primarily used for other purposes and where tree stands may grow at a rate exceeding 1 m^3/ha/year.

Catastrophic losses have to be defined. Examples of losses that could be included are losses caused by insects, fungus, game, weather and climate; acid rain; and fire.
A limit could be defined such that losses are "catastrophic" if they kill more than a certain percentage, for example 1 %, of the standing stock in one year.

It should not be necessary to use "and accumulation" in the titles (tables E1-E3). It would be sufficient with "balances". Perhaps a better alternative could be to use "fluxes and stocks".

Table E.2 Balances and accumulations of woody biomass (1000 metric tons of dry matter)

	Opening stock	Natural growth 3)	Fellings	Catastr. losses	Other changes	Changes in land class.	Closing stock
Above stump biomass 1)							
-Trees on wooded land							
-available for wood supply							
--coniferous							
--broad-leaved							
-not available for wood supply							
Other woody biomass 2)							
Total							

The table is to be provided for a reference period of five years by using standard coefficients (to be added here).

1) the mass of the woody part (stem, bark, branches, twigs) of trees, alive or dead, shrubs and bushes, measured to a min. of 0 mm, excluding stumps and roots, and foliage
2) Stumps and roots
3) Natural growth is to be sub-divided by data on natural growth of forests afforested from 1990 and onwards as requested by the Kyoto Protocol

Natural growth is defined as biological growth net of natural losses.

Comments:

It seems as Table E2 is just a conversion table to reach table E3. Since carbon is used as measurement unit in table E3 we do not see the need of specifying table E2.

Table E3. Carbon balances and accumulations related to woody biomass (1000 tons of carbon)

	Opening stock	Natural growth 3)	Fellings	Catastr. losses	Other changes	Changes in land class.	Closing stock
Above stump biomass 1)							
-Trees on wooded land							
-available for wood supply							
--coniferous							
--broad-leaved							
-not available for wood supply							
Other woody biomass 2)							
Total							

The table is to be provided for a reference period of five years by using standard coefficients (to be added here).

1. The mass of the woody part (stem, bark, branches, twigs) of trees, alive or dead, shrubs and bushes, measured to a minimum of 0 mm, excluding stumps and roots, and foliage
2. Stumps and roots
3. Natural growth is to be sub-divided by data on natural growth of forests afforested from 1990 and onwards as requested by the Kyoto Protocol

Comments:
This is exactly the same table as E2 except for the use of 1000 tons of carbon instead of 1000 tons of dry matter. Our proposal is to cut out table E2. However, it is important to show the coefficients of the calculations.

Table E4a. Changes in carbon stored (1000 tons of carbon) in the forest ecosystem

	Opening stock	Changes in carbon	Closing stock
Woody biomass in forest			
Needles and leaves			
Ground vegetation			
Forest soils			
Total			

Comments:
New data collection is needed.

Table E4B. Changes in land cover (1000 ha)

	Forest and other wooded land	Agricultural land	Artificial surfaces	Other land	Total land
Opening area					
Afforestation					
Deforestation					
Natural colonisation or regression					
Other changes					
Changes in land classification					
Closing area					

The tables E4a and E4b are to be provided for a reference period of five years. The second table intends to establish a link between land cover changes in carbon stored in the forest ecosystem and constitute a basis for estimating carbon binding in forest soils.

Comments:
- It is necessary to define “artificial surfaces” and “other land”
- Natural colonisation or regression could be exemplified by the colonisation of trees on pasture land
- We suppose water surfaces are excluded, otherwise it is our proposal

- A methodology for ARD (afforestation, deforestation and reforestation) counting does not yet exist. However, it is possible to estimate some changes.

Table E5. Changes in total carbon storage (forest related resources and products)

	Opening stock	Changes in carbon	Closing stock
Forest biomass 1)			
Forest soils			
Wood products			
Peat land			
Total			

The table is to be provided for a reference period of five years.

1) Tree and ground vegetation biomass
2) Net of additions (to be derived from supply and use of wood) and withdrawals (to be based on a perpetual-inventory-type method or on waste statistics)

Comments:

- it is important to establish the level of carbon stocks in 1990 (Kyoto protocol)
- “wood products” have to be defined (several studies have been carried out in this area)
- regarding wood products, we suggest that imports should be added and exports withdrawn.

1.1.2 Maintenance of biodiversity

This section includes comments on tables E6 to E8.

Table E6. Forest-occurring species at risk or endangered

	Total number of known species	Of which: endangered (1)	Percent of total (%)
Trees (coniferous and broad-leaved species) Other vascular plants (flowers) Total Vascular plants			
Mosses Lichens Macrofungi Algae Total Non-vascular plants			
Mammals Birds Other vertebrates (fish, amphibians, reptiles, snakes) Total Vertebrates			
Insects Other invertebrates Total invertebrates			

Two tables are to be provided; one for a reasonable post-1950 year and the other for the most recent year.

1) A species is endangered when it is facing a high risk of extinction in the wild in the near future (IUCN-categories)

Comments:

- the IUCN-categories included in the group “endangered” or “facing high risk of extinction” should be reported specifically
- it could be important to distinguish between species threatened globally and regionally (if possible)
- special attention should be given endemic species
- restructure the table by giving each of the IUCN categories its own column

Table E7. Forest balance: Protection of forest and other wooded land (1000 ha)

	IUCN categories I and II	IUCN categories III to IV	Legal protection (1)	Percent of total (%)	National target (%) (2)
Opening area					
Afforestation					
Deforestation					
Natural colonisation or regression					
Other changes					
Changes in land classification					
Closing area					

The table is to be provided for a reference period of five years

1) Forest not available for wood supply with severe legal restriction on wood production (e.g. national parks, nature reserves and other protected areas such as those of special scientific, historical or cultural interest) as requested by the 'European Forest Economic and Environmental Accounting Framework'
2) The national proportion of forest and other wooded land to be exempted from wood production in order to safeguard and preserve the level of biodiversity and allow species to spread

Comments:

- Other protected forest areas than legally protected should also be reported.
- Ecologically cultivated forest areas (certificated) should be reported on.
- Data on remaining areas of primeval forests (virgin forest) and "nature forests" is important to include in the table (EU-parliament)
- The main purpose with protected areas is to save them from exploitation. To divide changes after the proposed types is problematic. Changes by natural causes occurring within the protected areas will probably not have an impact on the category of protection. Other changes are by definition excluded.
- Specify the national target, should it be the official (=political) or statements from ecologists?

Table E8. Regeneration and extension of forest and other wooded land (1000 ha)

	Annual average area over 10-year period	Percent of total
Regeneration of forest		
Natural regeneration (1)		
(Net) extension of forest		
Afforestation of former agricultural or other land		
Deforestation		
Natural colonisation and natural conversion (2)		

The table is to be provided for a reference period of ten years

1) Re-establishment of a forest by natural means, i.e. by natural seeding or vegetative regeneration.
2) The colonisation of non-forest land through stages of natural succession without human intervention and the colonisation of other wooded land as a result of natural processes.

Comments:

- We suppose that total regeneration of forest is the sum of natural regeneration and plantation of wooded land after felling. Otherwise it is our proposal.
- It would be easier to understand the table if also the active plantation area regeneration could be shown.
- It is very difficult to give data on net flows. It would be very costly and it is doubtful whether it is worth the effort.

Proposal:
New tables:
The best alternative would be to divide the table in two, table E8a and E8b. Table E8a would contain Regeneration of forest and other wooded land and table E8b Extension of forest and other wooded land. Regeneration of forest would include the lines “natural regeneration”, “plantation” and “total regeneration”. Plantation should be subdivided in “coniferous” and “broad-leaved”. Broad-leaved should be divided in ordinary species and rare (precious??). Alien species should also be noted. The columns would be the same as in table E8. Table E8b would include the rest of table E8.

1.1.3 Recreational functions

Table E 9. Recreational areas of forest and other wooded land (1000 ha)

	Opening area	Changes		Closing area
		Area per inhabitant	1000 ha	
National parks				
Urban recreation areas (1)				
Other publicly owned recreation areas				
Total				

The table is to be provided for a reference period of five or ten years

1) Forests within a certain distance from urban areas according to national definitions

Comments:

- Urban agglomerations in Sweden are demarcated every five years and the work is when possible connected to the Population Censuses. Our proposal is to use a reference period of five years.
- To present area per inhabitant is questionable. The differences in recreational conditions between different parts of a country will not be reflected using area per inhabitant. Distance is important. If, however, area per inhabitant should be used as a variable in the table, it should be calculated based on the opening and closing areas instead of the area changes.
- In practice almost all forest land falls under the “right to public access”, which means that all forest land also is possible to use for recreation purposes (Sweden).
- Privately owned land reserved for recreation or otherwise protected should be included in the table
- Nature reserves should also be included
- A definition of urban areas is needed. Each country should at least state its own definition. In Sweden we define all agglomerations with more than 200 inhabitants as urban areas. Furthermore, the distance between the houses must not exceed 200 meters.

Table E10. Recreation visits to forests by main purpose

Main purpose	Number of visits/year	Regulated by law (yes/no)	Percent of total (%)	Number of visits/inhabitant
Hiking/Skiing Camping Hunting and fishing Off-road driving Bird-watching Picking berries/mushrooms Other				
Total				

The table is to be provided every five or ten years

Comments:

- Recreation has to be defined. It is doubtful whether “off-road driving” could be included in such a definition. This type of activity is illegal in Sweden.
- Time spent (hours) should also be specified by main purpose
- Separate the visits in “a couple of hours”, day visit and over night visit

Proposal:
New Table: Accessibility - distance

Variable: Average distance (in km or hours) to forest, divided in categories

- population in urban agglomerations
- population in the countryside (thinly populated areas)
- population with access to holiday cottages
- number of nights spent in the cottage

Comment:

- All forest land is in principle accessible for the public in Sweden. The conditions of access to forest land differ from country to country

New table: Forest areas free from noise

Variables: Sources and zones of noise should be defined, other areas should be regarded as free from noise. Suggestion:

Source		Zone
Urban agglomeration		200 meters
Other settlements		150 meters
Road 1 (>5000 vehicles/day)	500 meters	
Road 2 (1000-5000 vehicles/day)		250 meters
Railroad		200 meters
Larger pit		1000 meters
Smaller pit		500 meters
Larger airports	?	
Smaller airports	2000 meters	
Power transmission line		40 meters

1.1.4 Protective functions

Table E.11. Primary management objective of forest and other wooded land

	Opening area	Changes			Closing area
		1000 ha	Percent of total (%)	'Of which': Legal protection	
Soil protection					
Protection of water resources					
Avalanche protection					
Other or multiple objectives (1)					

The table is to be provided for a reference period of ten years

1) E.g. when soil, avalanche and water protection are overlapping

Comments:

- No data exists in Sweden showing these types of protective functions. However, for valuation of forest the information is important and in the second part of the report information has been assessed and collected from different researchers.

- Table E7 also deals with the protection aspect. Should the protected areas in E11 be part of the areas in E7?

1.1.5 Health of trees

<u>Table E12. Defoliation of trees by classes and species (%)</u>

	None (1)	Slight (2)	Moderate (3)	Severe and dead (4)
Pine Spruce Broad-leaved				
All species				

The table is to be provided annually as a complement to simplified stocks and flows of standing timber

1) Up to and including 10 %
2) >10 to 25 %
3) >25 to 60 %
4) >60 %

Comments:
- the defoliation should be measured on trees in their “middle ages”.

1.1.6 Soil Chemistry. (Proposal for a new section)

Table. The need for liming

Content: Years, areas in need of treatment

Year	Hectare
1995	
1999	

1.2 Discussion of data availability and data quality

Table E1-E3. Carbon balances

Data availability and data quality:

Ground data for production of tables E1-E3 comes from the Swedish National Forest Inventory (NFI) which is an annual inventory carried out by the Swedish University of Agricultural Sciences. It has been undertaken since 1923 and the main purpose with the NFI is to describe the state of and changes in forest resources in Sweden - growth and cuttings for instance. However, there are numerous fields of application. For example, the NFI is a powerful resource for environmental monitoring. The inventory includes 13 500 sample plots and 9 300 of these plots are inventoried in the field. All types of land are included in the survey. However, the most detailed information concerns forest land.

The main observations on all land are: land use category, ownership category, growing stock, growth, tree distribution and recent fellings.
Additional observations on forest land: terrain conditions, vegetation cover, maturity class, age, site quality, recent and suggested silvicultural measures, degree of stocking damage and regeneration status (in young stands).

The inventory is dimensioned to be able to provide high quality estimates of the growing stock and the forest area, as well as other variables related to these two. For more seldom occurring variables, like afforestation and deforestation, the data quality is rather low.

In table E1 data for single years are provided. However, the quality of the reported information is low, it would be better to report an average based on 5 or even 10 years instead of single years. We believe all EU-countries are facing the same problem.

Data from the NFI is presented at their own web-site www-nfi.slu.se. Some figures can also be found at the National Board of Forestry's web-site www.svo.se/fakta/stat/ssi/engelska/ or www.svo.se/statistik, but unfortunately most of the information is in Swedish.
Information can also be found in the Statistical Yearbook of Forestry (in Swedish with an English summary) and in Skogsdata (in Swedish) which is the University’s publication of results from the NFI. These are annual publications.

References:

“Statistical Yearbook of Forestry”, 1995, National Board of Forestry.
“Statistical Yearbook of Forestry”, 2000, National Board of Forestry.
”Skogliga Konsekvensanalyser 1999 – Skogens möjligheter på 2000-talet”, (”Possibilities for forest utilisation in the 21st century”), Anon., 2000.

Table E4 and E5. Changes in carbon stored, changes in land cover and changes in total carbon storage

Data availability and data quality:

Afforestation, reforestation and deforestation (ARD) are listed as activities that will (most likely) be accounted for in the Kyoto Protocol. Countries that sign the protocol will be allowed the time until 2005 to determine a methodology for the ARD accounting. Sweden has a good basis for this accounting from the National Forest Inventory. However, there are difficulties concerning definitions of the land classes and problems of uncertainty. Thus, the Swedish National Board of Forestry believes it would be inappropriate to deliver official ARD data until the final methodology is set. Moreover, Sweden is now performing a national inventory on forest soils, that includes determination of the carbon content of various layers, for the second time. Within one or two years, data on carbon stock changes in forest soils could be delivered from the responsible research department. Thus, at present Sweden chooses to leave out E4a and E5 and only delivers some rough estimates for table E4b. This information includes transfer of wooded land to urban areas and transfer from agriculture land to forest land.

References:

"Land use in Sweden" 1993 and 1998, Statistics Sweden.

Table E6. Forest-occurring species at risk or endangered

Data availability:

The Swedish Environmental Protection Agency (Swedish EPA) determines the official list of endangered species. The list, the Red List of Swedish Species is compiled by the "Artdatabanken" (Swedish Threatened Species Unit) at the Swedish Agricultural University. In the Unit a continuous work on updating the information on flora and fauna is undertaken. In the Red List every species is described with Red List Category and their occurrence in different administrative provinces. The complete list is easily available on the web-site of the Unit, www.dha.slu.se.

In May 2000 a new list of endangered species was determined by Swedish EPA, the 2000 Red List. The list is based upon the criteria and categories compiled by the IUCN.

Table E6 suggests that a species is endangered when it is facing a high risk of extinction in the wild in the near future. This could be allied to the categories CR (critically endangered), EN (endangered) and VU (vulnerable), which together form a category group regarded as threatened by the Swedish EPA. The total number of species in the three categories is 1953 according to the list, of which forest-occurring is 934. These figures are according to the Unit an underestimate of the real numbers. Within the categories DD (data deficient) and NE (not evaluated) there is probably a large number of threatened species. For some groups of organisms the real number of threatened species could be twice as much as what is reported.

There is also problem to distinguish the total number of known forest-occurring species from the estimation of the total number of species in the country. There is no such dividing in biotopes in the list when it comes to the total number of species. The information on the total number of species by group of species is also a quite rough estimate, because of lack of knowledge.

Providing information on forest-occurring species for a reasonable post-1950 year seems to be impossible. There is no data available. The first year that possibly could be feasible is 1985. However, knowledge on threatened species was very vague at that time. New knowledge is gained continuously and much information in the "list" from 1985 is changed, not because of changes in the occurrences of species but because of better knowledge. To make a fair comparison between lists from different years one must distinguish the differences caused by better knowledge from real changes in the number of a species.

Furthermore, it is important to study the movements of species between the three categories CR, EN and VU within the group of endangered (threatened) species, over time.

Data quality:

There is a Red List of Endangered species specified in IUCN-categories.

The total number of known forest-occurring species is not specified in Sweden. Only rough estimates of total number of species by group of species country-wide exist. These estimates are used in the table (E6).

Endangered forest-occurring species are specified in the Red List. The number of species in the categories defined as threatened are under-estimated because of lack of knowledge. Some species in the categories DD (data deficient) and NE (not evaluated) would probably be reclassified if sufficient knowledge existed.

The information on mammals, birds and other vertebrates have better accuracy because of better knowledge than for example data on species in the invertebrates group, where even the total number of species is quite rough.

No reliable data earlier than 1985 is possible to compile.

References:

"Red List of Swedish Species, 2000", "Artdatabanken" (Swedish Threatened Species Unit), the Swedish Agricultural University

Table E7. Forest balance: Protection of forest and other wooded land

Data availability:

At the Swedish EPA there is a database on protected forest and other wooded land, which is up-dated continuously (the Nature Conservation

Register). The register is based on information gathered by the county authorities. Each year a statistical bulletin is compiled by Statistics Sweden and Swedish EPA based on the existing information in the register.
The register contains about 5 300 objects. Each object is described with:

- identity number
- code number
- attribute
- name
- co-ordinates
- total area
- land area
- nature type
- administrator
- motive of protection
- extent of protection
- management plan
- protected period
- type of forest protection (no particular, limited, complete)

The variable "nature types" consists of 14 different categories of forest and wooded land:

- Coniferous mixed forests
- Coniferous forests
- Birch and aspen forests
- Beech and hornbeam forests
- Oak, elm, ash and linden (lime) forests
- Spruce (fir) forests
- Deciduous and coniferous mixed forests
- Deciduous forests
- Forest
- Wooded or bush-covered land
- Wood-covered mixed mire
- Wood-covered marsh
- Pine forests
- Other deciduous forests

In the annual bulletin the categories are aggregated in three classes, deciduous forests, mixed forests and coniferous forests. For productive forest land in these classes, the type of protection is divided in complete, limited and no protection. Complete protection means that no forestry is allowed. Limited protection signifies that forestry is restricted, while no protection implies that there is no restrictions on the forestry. In 1998, 761 400 hectares of forest and other wooded land were legally (completely) protected. This equals to 3,3 percent of the total productive forest area.

It is not possible to separate the protected areas according to the IUCN categories. Just the total area "IUCN-protected" land is listed in the report. However, the Swedish EPA has tentatively classified all national parks as category 2, all nature reserves as category 4 and all nature management areas as category 5. Table E7 is filled in according to this classification, regardless of the fact that IUCN only considers objects larger than 1000 ha. This means that the areas in the table are overestimated. This information is also reported to the World Resources Institute.

Classifying the single objects in the database by IUCN category will make it possible to provide reliable information on object level and to sum up to category and to separate forest land. According to information from the Swedish EPA this work will start during 2001.

The national parks and the nature reserves are the categories of land which are legally protected. Forest and other wooded land in each protected object has been estimated. This information appears in table E7. Also, forests with other protection than legal is introduced in table E7.

The national target proposed by the Swedish government in 2000 is to increase the protected are of forest and other wooded land (now 865 000 hectares) by 800 000 hectares to the year 2010, which equals about 6 % of the productive forest land. This target includes both legally and otherwise protected forest land.

References:
"Protected Nature", annual statistical report, Swedish EPA and SCB
"Living forests", SOU 2000:52

Table E8. Forest balance: Regeneration and extension of forest and other wooded land (1000 ha)

Data availability and data quality:

It is quite difficult to quantify the natural regeneration. In the Forest Statistical Yearbook there is a graph showing the percentage of the felling areas intended by the forest owners to be regenerated in a natural way. For 1999, the figure is about 25% of the area.
Another source is the National Forest Inventory which among other things investigates the share of "final felled areas 3 to 5 years ago with 'seed-trees'" The percentage of such areas was 26 % during the period 1993-1997 (5-year average) and during 1988-1992 the corresponding area was 16 %.
Even though the years between the two surveys are different the results are similar. Comparing other periods could however give another outcome.

To be able to illustrate the area of natural regenerated forest land it is necessary to multiply the area percent above with the area of total final felling.

This area is according to the Forest Statistical Yearbook possible to count using two different methods, either the "Stump Enumeration" by the National Forest Inventory or the calculated felling area by the National Board of Forestry (NBF). From the stump enumeration the felling area is calculated by registration stumps from the last completed felling year.

The felling area calculated by the NBF is based on intended felling areas reported by the landowner. The owner is only obliged to report and to get a permission to felling on land which is difficult to regenerate. Not all intended felling are reported and all reported fellings are not carried out, which makes the information less reliable.

The best way of getting information on natural regeneration should be to use the data from the National Forest Inventory. Calculating the natural regenerated areas of forest by using the 26% ("seed-tree area") and the final felling area (198 000 ha), gives a figure of 48 000 ha per year.

Over a 10-year-period (1988-1997) the corresponding area is 40 000 ha (190 000 ha x 21%).

Total planted area during 1988 and 1997 was in average 155 000 ha, according to the National Forestry Board.

The areas of plantation and natural regeneration should equal the total regenerated forest area. Of course combining calculated results from different sources is always difficult and especially if one remembers the time period between the felling year and the observations of seed-trees.
For the 10-year average the deviation is 5 000 ha (195 000 minus 190 000), which in fact is reasonably good.

Also, some areas in the mountains where climate conditions are extreme have suffered from deforestation caused by felling followed unsuccessful plantation and/or natural regeneration.

Calculations of land use changes are very complicated to produce. The total change of forest and wooded land within a 10-year-perod can be calculated but changes between specific land use classes is almost impossible to estimate.
Some marginal figures on net extension of forest divided in the three proposed categories can be specified. In 1998, subsidies were given for the transfer of 38 hectares of agricultural land to selected valuable broad-leaved forest. In 1999 the area was 5 hectare. Of course, the total afforestation of former agricultural land has been much bigger. Estimations based on information on abandoned agricultural land give figures around 10 000 hectares per year which can be regarded as transformed to forest land. Also, the transfer of swamps and peat land to forest and wooded land has been considerable. No figures are available. Ditching is now restricted.
Deforestation by expanding urban agglomerations and extended infra-structure have also been significant. It is estimated that since 1960 about 50 000 ha of forest land has been used for expansion of urban areas. However the pace is decreasing and for the last two decades this land transfer is estimated to about 700 hectares per year.
If we include the forest areas on protected land the result will be that forest and wooded land has extended almost continuously since the 1920-ies. However, since protected forest land by official definition is not regarded as forest land the total forest and wooded land in Sweden have decreased. Considerable areas have been transferred from managed forests to non-managed forests. Also, the Swedish National Forest Inventory, which

measures the development of the forest and wooded land, is based on a sample survey. Depending on differences in the samples, comparisons between different 5-year periods can give surprising results due to sample errors.

References:

"Forest Statistical Yearbook", National Board of Forestry
"The Stump Enumeration", National Forest Inventory, the Swedish Agricultural University
"Result archives", the web-page of the National Forest Inventory, the Swedish Agricultural University
"Land Use in Sweden", Statistics Sweden (1998)
"Statistical Yearbook", Statistics Sweden (2000)

Table E9. Recreational areas of forest and other wooded land (1000 ha)

Data availability and data quality:

All Swedish forest areas including national parks and nature reserves are accessible for the public and hence have to be regarded as recreational areas ("the right of common access"). Information on these two area-classes is given annually in the report "Protected Nature", by the Swedish EPA and Statistics Sweden. Forest and other wooded land are also specified. The first report was published in 1991. Before that year it is difficult to obtain accurate information. In the tables the reference period is 1991 to 1998.
It is possible to divide the protected (=recreational) areas by NUTS-2 region and attempts to distribute the areas by municipality have also been done.

Studies by Statistics Sweden have been made on land surrounding urban agglomerations. The surrounding land was divided in kilometre zones from the border of the agglomeration. The land of common access, i.e. the recreational areas were measured. Land of common access is mostly forest and other wooded land. Agricultural land is excluded. Theses studies have been carried out for the years 1980 and 1990. The latter comprised urban recreation areas around the 10 biggest urban agglomerations (cities) and was surveyed by Statistics Sweden in 1994. No regular statistical production using this methodology is planned.

One way of getting regular information on the surrounding area of urban areas is to define buffers within a certain distance from them, for example 3 kilometres, and process the information using geographical information technique. To determine the share of forest land within these zones it is possible to use the information from the above mentioned studies which estimate this area to 42 % of the total surrounding area. Since demarcation of urban areas is carried out every 5 years it is possible to get an fairly accurate estimate of forests within a certain distance from urban areas.

References:

"Protected Nature", annual statistical report, Swedish EPA and SCB (Na/Mi 41 SM)

Table E10. Recreation visits to forests by main purpose

Data availability and data quality:

Three studies on recreation habits among Swedes have been carried out during the last decades; one by the National Institute of Economic Research (NIER) in co-operation with Statistics Sweden ("Recreation value of the Swedish forests", 1997) and the other two by Statistics Sweden ("Leisure time 1976-1991", 1993 and "Leisure time 1999"). The first was carried out in connection with the elaboration of the report "Forest Economic and Environmental Accounting", by Statistics Sweden.
The NIER survey registered the frequencies of eight specified activities by visitors to the forest during leisure time for a period of twelve months. Persons between 18 and 74 years old were surveyed. Variables (activities) measured do not totally correspond to the proposed table. Camping was not included in the survey. Bird-watching was not specified but included in the variable flora- and fauna-studies. On the other hand was the camping variable part of the surveys by Statistics Sweden, which reported 12 million visits. The total number of visits in the two surveys were very similar, 373 and 371 million visits. It could be possible to redistribute the forest visits in the NIER-study in order to separate the camping variable. The easiest way is to reduce "Hiking/Skiing" with the same number of visits (12 million).

The SCB-studies are part of the Swedish National Survey of Living Conditions, which regularly updates the information on 11 different welfare components, among theses "leisure time". Starting in 1979 the components are grouped into four main themes in which the components are given a broader and deeper illumination every 7 to 8 years. The activities registered in the survey correspond poorer to the proposed table E10 than the NIER-study. Therefore, the NIER-study was chosen for the completion of the table. However, it would be an advantage if table E10 could be altered to match "the survey of living conditions" better, because of the regularity in the survey. Hiking/skiing, camping and hunting are the three activities registered in the survey, where hiking/skiing is divided in strolling (including picking berries or mushrooms), walking, footpath walking and exercising.

References:

"Recreation value of the Swedish forests", 1997, the National Institute of Economic Research (NIER)
"Leisure time 1976-1991", 1993, Statistics Sweden
"Leisure time 1998", 2000, Statistics Sweden
"Forest Economic and Environmental Accounting, a pilot study of a first implementation", Statistics Sweden

Table E.11. Primary management objective of forest and other wooded land.

Data availability and data quality.

Legally protected areas in Sweden are national parks, nature reserves, nature management areas and wildlife sanctuaries, which in all encompass 3.1 million hectares of land. Protected forest land covers 641 000 hectares. To

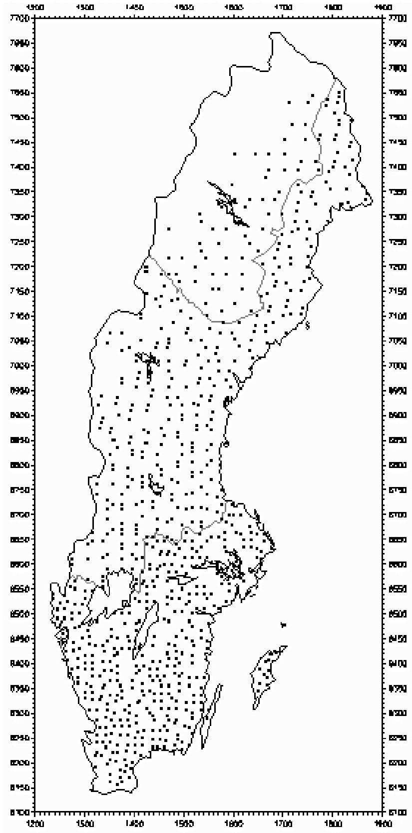
this figure 120 000 hectares of productive forest land without legal protection can be added, acquired by the government. In total protected forest land makes up 760 000 hectares.
The statistical bulletin “Protected nature” by Statistics Sweden reports annually the situation and changes in this field.
When it comes to dividing the protected forest areas in different protective management objectives the data availability is rather poor. All protected areas are divided in classes named motive of protection. 14 different classes are distinguished and the major motive of protection is scientific. Almost all protected objects have more than one motive for protection.
These classes correspond weakly with the objectives in the proposed table E11.
At present it is not possible to provide statistics for the table, with the exception of planted forests as protection against sand and soil erosion along some stretches of the coast.

References:
“Protected Nature”, annual statistical report, Swedish EPA and SCB (Na/Mi 41 SM)
“Oral information” National Board of Forestry

Table E12. Defoliation of trees by classes and species (%)

Data availability and data quality.

As for the health of trees there are two regular surveys measuring defoliation of pine and spruce respectively. The Swedish National Forest Inventory started data collection on defoliation in 1984 and reports the results annually. The National Board of Forestry gather information on defoliation from 223 permanent observation areas. These areas were visited for the first time in 1997.
Both surveys are carried out according to international standards and are co-financed by the European Union and are reported in the Forest Statistical Yearbook. There are considerable variations between single years in northern Sweden, which probably depend on the relatively small sample size. Differences between single years must therefore be interpreted with caution. Only pine and spruce are regularly surveyed.
In table E12, data from the National Forest Inventory is used.



The national monitoring system of forest conditions includes 778 permanent sample plots surveyed annually (the national forest inventory).

References:

Forest Statistical Yearbook, National Board of Forestry
National Forest Inventory

1.3 Summary of the presented data

Carbon Binding
Between 1990 and 1998 the carbon accumulation in standing timber in managed forests has increased steadily from 514 to 556 million tons of carbon. This progress is applicable to both coniferous and broad-leaved forests.

The same pattern of increasing accumulation of carbon during the last decade is shown for carbon related to woody biomass. This is caused by the fact that natural growth in general exceeds the fellings each single year.

Carbon stored in the forest ecosystem has also increased during the last 5-year period (1990-1994).

Maintenance of biodiversity
According to the Red List only a small percentage of forest occurring species are endangered. The highest share of species at risk is reported on the group mammals, which has 15 % of all species endangered, followed by birds with 7 %. This means in fact that the higher complexity of a species, the higher is the risk. And, of course, the better is the knowledge of that species.

The areas of protected forest and wooded land has increased between 1993 and 1998. The protected forest is now (1998) 3,3 percent of total forest land. Although, there is some steps to take before the national target of 6,3 % can be achieved.

Regeneration of forests is normally done by plantation, about 79 % of total regeneration.
The change in total managed forest land is negative during the last decade (1988-1997), minus 800 thousand hectares, due to change in land classification.

Recreational functions
Recreational areas of forest and other wooded land has increased by about 220 thousand hectares between 1990 and 1998. The total area was 1998 about 3,9 million hectares.

The number of visits per inhabitant to forests1996 were 62. The main purpose of the visits referred to hiking or skiing.

Protective functions
The protective functions of forest have been described in previous functions (above), mainly in connection with biodiversity.
Unfortunately, there is no data available to specify the primary management objective of forest and other wooded land. The only exception being information on planted pine, 33 thousand hectares, on some stretches of coast, to protect against sand and soil erosion.

Health of trees
The majority of trees investigated does not suffer from defoliation. Spruce are more affected than pine and about 30 % of all pine trees are defoliated. But only 3 % of all pine are severely affected or dead.
No information on broad-leaved species is available.

1.4 Presenting data for one year/one reference period for the proposed tables using existing data

Table E1a. Carbon stock changes in standing timber in managed forests[A] in Sweden 1990-1996 (MtonC[B])

Year		Total	Coniferous (1)	Broad-leaved
1990	**Opening stock**[2]	514	439	75
	Growth[3]	18	15	3,1
	Natural loss[4]	0,9	0,78	0,13
	Natural growth[5]	18	14,5	3,0
90/91	Fellings[6]	14	12	2,2
	Catastrophic losses	0	0	0
	Closing stock	518	442	76
1991	Growth[3]	18	15	3,1
	Natural loss[4]	1,0	0,86	0,15
	Natural growth[5]	17	14	3,0
91/92	Fellings[6]	12	9	2,0
	Catastrophic losses	0	0	0
	Closing stock	524	447	77
1992	Growth[3]	18	15	3,1
	Natural loss[4]	1,1	0,94	0,16
	Natural growth[5]	17	14	3,0
92/93	Fellings[6]	13	11	1,6
	Catastrophic losses	0	0	0
	Closing stock	529	450	79
1993	Growth[3]	18	15	3,1
	Natural loss[4]	1,3	1,10	0,20
	Natural growth[5]	17	14	2,9
93/94	Fellings[6]	11	9	1,5
	Catastrophic losses	0	0	0
	Closing stock	535	455	80
1994	Growth[3]	18	15	3,1
	Natural loss[4]	1,4	1,3	0,23
	Natural growth[5]	17	14	3,0
94/95	Fellings[6]	12	10	1,4
	Catastrophic losses	0	0	0
	Closing stock	540	460	82
1995	Growth[3]	18	15	3,1
	Natural loss[4]	1,4	1,2	0,21
	Natural growth[5]	17	14	2,9
95/96	Fellings[6]	14	12	1,8
	Catastrophic losses	0	0	0
	Closing stock	544	461	83

[1] Includes also all standing stems classified as dead in the inventory (no data on species for dead trees in the Statistical Yearbook of Forestry)

[2] Statistical Yearbook of Forestry 1995 (**SYF**-95) Table 3.5: report on stock from the inventory 1988-1992

[3] SYF-95 Table 3.8: reported average growth rates for 1990-1994

[4] Natural loss according to Skogsdata (2000): division between coniferous and broad-leaved was made proportional to stock portions

[5] Natural growth = Growth – Natural loss

[6] SYF-00 Table 7.7

[A] see table 1b

[B] see table 1b

Table E1b. Carbon stock changes in standing timber in managed forests[A] in Sweden 1996-1998 (MtonC[B])

Year		Total	Coniferous (1)	Broad-leaved
1996	**Opening stock**[2]	546	463	83
	Growth[3]	18	15	3,3
	Natural loss[4]	1,4	1,2	0,2
	Natural growth[5]	17	14	3,1
96/97	Fellings[6]	13	11	1,2
	Catastrophic losses	0	0	0
	Closing stock	550	466	85
1997	Growth[3]	18	15	3,3
	Natural loss[4]	1,4	1,2	0,2
	Natural growth[5]	17	14	3,1
97/98	Fellings[6]	11	10	0,9
	Catastrophic losses	0	0	0
	Closing stock	556	469	87
1998	**Opening stock**	556	469	87

[1] Includes also all stems classified as dry in the inventory (they are not divided with respect to species in the Statistical Yearbook of Forestry)
[2] Statistical Yearbook of Forestry 2000 (**SYF**-00) Table 3.5: report on stock from the inventory 1994-1998
[3] SYF-00 Table 3.8: reported average growth rates for 1994-1998
[4] Natural loss according to Skogsdata (2000): division between coniferous and broad-leaved was made proportional to stock portions
[5] Natural growth = Growth – Natural loss
[6] SYF-00 Table 7.7

[A]Definition of managed forest:
Land suitable for wood production and not primarily used for other purposes.
Potential yield under ideal management conditions at least 1 m3 per hectare and year.

[B]Throughout this report, the conversion factors used between m^3 wood and ton C were:

- 1 m^3 = 0.42 ton d.w.
- 1 ton d.w. = 0.46 ton C

Table E2 Balances and accumulations of woody biomass 1990-1994, (1000 Mtons of dry matter[B])

	Opening stock	Natural growth	Fellings	Cata-strophic losses[5]	Other changes [6]	Changes in land classifi-cation	Closing stock
Above-stump biomass:							
- trees on forest areas	1196	197	135	0	0	0	1257
- managed forests	1117	188	132	0	0	0	1174
- coniferous	954	156	113	0	0	0	997
- broad-leaved	163	32	19	0	0	0	176
- other forest areas[2]	78	9	4	0	0	0	83
- branches+ foliage[3]	600	68	68	0	0	0	600
Stumps and roots[4]	413	51	47	0	0	0	417
TOTAL	2209	315	250	0	0	0	2275

Table E3 Balances and accumulations of woody biomass 1990-94, (1000 Mtons of C[B])

	Opening stock	Natural growth	Fellings	Cata-strophic losses[5]	Other changes [6]	Changes in land classifi-cation	Closing stock
Above-stump biomass:							
- trees on forest areas	550	90	62	0	0	0	578
- managed forests[1]	514	86	61	0	0	0	540
- coniferous[1]	439	72	52	0	0	0	459
- broad-leaved[1]	75	15	8,7	0	0	0	81
- other forest areas[2]	36	4,0	1,7	0	0	0	38
- branches+foliage[3]	276	31	31	0	0	0	276
Stumps and roots[4]	190	23	21	0	0	0	192
TOTAL	1016	145	115	0	0	0	1046

[1] Opening stock, natural growth and fellings from Table E1 - year 1990
[2] All data derived from forest statistics on land types other than “managed forests”(see [A]), such as swamp, rock surface, subalpine woodland etc.
[3] Opening stock (Anon. 2000); Felling: proportional to stock 1990; Closing stock: very little or no increase in canopy biomass follows from an stemwood increase at present (Anon., 2000); Natural growth: derived from addition of stock change and felling.
[4] Opening stock and felling: using relation between stump and root biomass and stem biomass from Anon. (2000). Closing Stock: same accumulation rate as in the SKA99 study. Natural growth: derived from addition of stock change and felling.
[5] Using a definition on “catastrophic” that is if more than 1 % of the standing stock is killed by natural causes (fire, pests, wind, etc) in one year.
[6] Some 0,2-0,3 million hectares of managed forests were preserved during this period and thus transferred to other forest areas. This is neglected here.

Table E4b. Changes in land cover (1000 ha)
1990-1995

	Forest and other wooded land	Agricultural Land	Artificial surface	Other land	Total land
Opening area	24 334	3 517	1 111	16 034	44 996
Afforestation	2	-2			
Deforestation	-4		4		
Natural colonisation	7	-7			
Other changes	84	55	7	-146	
Changes in land classification					
Closing area	24 423	3 563	1 122	15 888	44 996

Data on afforestation, deforestation and natural colonisation is estimated. No official method exists for measuring these changes exists.

Table E6. Forest-occurring species at risk or endangered 2000

	Total number of known species	Of which: endangered, IUCN-category CR (1)	Of which: endangered, IUCN-category EN (1)	Of which: endangered, IUCN-category VU (1)	Of which: endangered (1), CR+EN+VU	Percent of total (%)
Trees (coniferous and broad-leaved species)	78	2	2	0	4	5,13
Other vascular plants (flowers)	2100	..	..	..	44	2,10
Total Vascular plants	2200	..	..	..	48	2,18
Mosses	1060	13	9	23	45	4,25
Lichens	2300	20	47	53	120	5,22
Macrofungi	4000	28	65	128	221	5,53
Algae	34	0	0	0	0	0,00
Total Non-vascular plants	7400	61	121	204	386	5,22
Mammals	67	2	4	4	10	14,93
Birds	253	2	1	15	18	7,11
Other vertebrates (fish, amphibians, reptiles, snakes)	183	0	0	4	4	2,19
Total Vertebrates	503	4	5	23	32	6,36
Insects	25000	45	122	280	447	1,79
Other invertebrates	5000	1	3	17	21	0,42
Total invertebrates	30000	46	125	297	468	1,56

Two tables are to be provided; one for a reasonable post-1950 year and the other for the most recent year.

1) A species is endangered when it is facing a high risk of extinction in the wild in the near future (IUCN-categories)
CR = critically endangered
EN = endangered
VU = vulnerable

Table E7. Forest balance: Protection of forest and other wooded land (1000 ha). 1993 - 1998

	IUCN categories I and II	IUCN categories III to IV	Legal protection (1)	Other protection	Protected forest in percent of total (%)	National target (%) (2)
Opening area, 1993	33	382	415	303	3,1	-
Afforestation						
Deforestation						
Natural colonisation or regression						
Other changes						
Changes in land classification	6	220	226	-183	0,2	
Closing area, 1998	39	602	641	120	3,3	6,3

The table is to be provided for a reference period of five years

1) Forest not available for wood supply with severe legal restriction on wood production (e.g. national parks, nature reserves and other protected areas such as those of special scientific, historical or cultural interest) as requested by the 'European Forest Economic and Environmental Accounting Framework'
2) The national proportion of forest and other wooded land to be exempted from wood production in order to safeguard and preserve the level of biodiversity and allow species to spread

Table E8. Regeneration and extension of forest and other wooded land (1000 ha), 1988-1997

	Annual average area over 10-year period	Percent of total (%)
Regeneration of forest	190	
Natural regeneration (1)	40	21
(Net) extension of forest	-74	
Afforestation of former agricultural or other land	9	..
Deforestation	-0,7	..
Natural colonisation and natural conversion (2)	..	..

The table is to be provided for a reference period of ten years

1) Re-establishment of a forest by natural means, i.e. by natural seeding or vegetative regeneration.
2) The colonisation of non-forest land through stages of natural succession without human intervention and the colonisation of other wooded land as a result of natural processes.

Table E8a. Regeneration of forest and other wooded land (1000 ha). 1988 - 1997

	Annual average area over 10-year period	Percent of total (%)
Regeneration of forest	190	
Natural regeneration (1)	40	21
Plantation	150	79
-coniferous	..	..
-broad-leaved	..	..
--ordinary species	..	..
--precious	..	..

Table E8b. Extension of forest and other wooded land (1000 ha). 1988 - 1997

	Annual average area over 10-year period	Percent of total (%)
(Net) extension of forest	-74	..
Afforestation of former agricultural or other land	9	..
Of which: Natural colonisation and natural conversion	*7*	..
Deforestation	-0,7	..
Changes in land classification	-82	..

The table is to be provided for a reference period of ten years

Table E 9. Recreational areas of forest and other wooded land (1000 ha), 1990 - 1998

	Opening area, 1990		Changes		Closing area, 1998	
	1000 ha	Area per inhabitant	1000 ha	Area per inhabitant	1000 ha	Area per inhabitant
National parks	33	0,0038	6	0,0007	39	0,0044
Urban recreation areas (1)	2 953	0,3437	153	0,0173	3 106	0,3508
Other publicly owned recreation areas	661	0,0769	61	0,0069	722	0,0815
Total	3 647	0,4245	220	0,0248	3 867	0,4368

The table is to be provided for a reference period of five or ten years

1) Forests within a certain distance from urban areas according to national definitions

Comments:

Reference year is 1990 and 1998

Forests within 3 km from urban areas (1995)

The unit used for measuring Area per inhabitant is hectare

Table E10. Recreation visits to forests by main purpose

Main purpose	Number of visits/year (million)	Regulated by law (yes/no)	Percent of total (%)	Number of visits/inhabitant
Hiking/Skiing[1]	184	no	49	31
Camping	..	no	..	..
Hunting and fishing[2]	11	yes	3	2
Off-road driving	..	yes	..	..
Bird-watching [3]	46	no	12	8
Picking berries/mushrooms	45	no	12	8
Other [4]	87	no	23	15
Total	373		100	62

The table is to be provided every five or ten years.
Reference year is 1996

1) Including "outdoor life" (29 million visits)
2) Fishing excluded
3) Including all studying of flora and fauna
4) Including sports activities (54 million) and collecting fire-wood (21 million)

Table E.11. Primary management objective of forest and other wooded land

	Opening area	Changes			Closing area
		1000 ha	Percent of total (%)	'Of which': Legal protection	
Soil protection	33				33
Protection of water resources					
Avalanche protection					
Other or multiple objectives (1)					

The table is to be provided for a reference period of ten years

1) E.g. when soil, avalanche and water protection are overlapping

Comment: Pine plantation along some streches of coast (source: NBF)

Table E12. Defoliation of trees by classes and species (%)

	None (1)	Slight (2)	Moderate (3)	Severe and dead (4)
Pine	89,0	9,8	0,7	0,5
Spruce	71,1	21,0	4,8	3,1
Broad-leaved	..	..	..	..
All species				

The table is to be provided annually as a complement to simplified stocks and flows of standing timber

1) Up to and including 10 % - see below
2) >10 to 25 % - see below
3) >25 to 60 % - see below
4) >60 % - see below

Comments:
a) Reference year is 1999
b)The defoliation classes are different from the original table.
Proposed new classes are: None=0-20 %, Slight=21-40%, Moderate=41-60% and Severe and dead>60%

2. Monetary forest accounts for timber and other forest related goods and services for Sweden 1987-1999

2.1. Introduction

Forests have throughout history served mankind and its economic activities with food, energy and materials. Forests have also been used for recreation, and filled religious and cultural purposes. Furthermore, forest soil and the species growing and living there are part of the biogeochemical cycles, fulfilling several ecological functions, promoting biodiversity, other ecosystems and thereby other economic sectors. The forest soil conditions, local climatic factors, the vegetation cover and the species living there determine the natural conditions for the forest ecosystem (a natural capital) and how much it produces as an annual yield: e.g. timber, berries, mushrooms and game. The yield can be enhanced by forestry efforts and negatively affected by e.g. pollution. Naturally, the yield produced by the forest ecosystem can change between years. However, if the natural capital capacity to produce forest goods and services has changed, that has to be accounted for separately. To account for the annual flows of goods and services and the changes in the stocks related to forests is important for a number of reasons:

- to gain knowledge of the economic and ecological interactions in the forestry sector and in society at large,
- to assign “correct” values in monetary terms (accounting prices) on all forestry entities, which is important for management decisions, environmental and economic policy,
- to show how one can extend the accounting practices of the System of National Accounts, in this case by introducing non-timber values of forests, thereby getting more complete production and stock accounts[1].

2.2. Background

Green accounting issues, how to incorporate e.g. ecosystem’s production of goods and services into accounting systems, and how changes in natural capital should be treated, are questions that have been discussed for two decades, starting with Tobin and Nordhaus (1972). Partial studies focusing on certain sectors, e.g. the forestry sector, or on how sectoral results could be used to construct environmentally adjusted net domestic product (NDP) measures, have been published in both theoretical and empirical environmental economics journals during the last decade. Especially the work lead by the U.N. to complement the System of National Accounts (SNA), by constructing a System of Environmental and Economic Accounting (SEEA), has generated many publications.

Hartwick (1990) and Mäler (1991) constructed theoretical model economies to create a structure for a green accounting system. Hartwick discussed

[1] Extending the accounts involves risks, as the data on quantities and prices usually are more uncertain for non-marketed goods.

accounting rules for resource depletion and pollution. Mäler modelled the timber stock and amenities from Nature, and described how changes in those should be accounted for. Vincent and Hartwick (1998) modelled the forestry sector explicitly and showed how accounting rules could be derived. Vincent (1998) and Kriström (2000) have surveyed the published empirical green accounting forest studies and compared them with what theory prescribes.

Empirically, Repetto (1989) and Peskin (1996) study the development of forests in developing countries, while Hultkrantz (1991), Eliasson (1994), and Hoffren (1997) present Swedish and Finnish forest accounts. They describe the value of the harvested timber production, the net growth of the timber stock, the production of game, mushroom and berries and some qualitative changes of the forest natural capital such as acidification. Ahlroth (2000) shows how the results of Swedish valuation studies on, e.g., acidification in forest soils, can be built into a model, thereby combining the theoretical and empirical work.

In this study, the Hultkrantz (1991) and Eliasson (1994) forest accounts for Sweden will be extended in time and scope. Data are provided for another four years. More ecological services and quality changes are described and valued. Alternative valuation methods to the items included in the accounts will also be discussed. The Eurostat workshops on wood and non-wood values provided by forest ecosystems, feeding into the SEEA-work going on at the U.N. and many of its member countries, have been very useful in the process of producing these Swedish accounts.

2.3. Monetary forest account components

In the Swedish forests accounts, timber production, the production of non-wood products, the provision of ecological services, and net changes in capital stocks related to timber and non-wood goods production will be discussed. In this report all monetary values are transformed from the physical data of the different years, valued at the Swedish price vector of the year 1999 and converted to Euro according to the exchange rate at the beginning of year 2000; SEK/Euro 8,50. Sections 2.3.1-10 proceed from a more traditional forestry accounting framework to environmentally extended accounts in monetary terms.

Table 2.1: Summary of the Contents of the Forestry Accounts; describing how the values relate to the SNA-system and the valuation methods used

Section	Comprises	SNA/non-SNA	Valuation method(s) used
2.3.1	Timber	SNA; in forestry sector	market prices
2.3.2	Non wood goods (berries, game, …)	mostly SNA; food/agriculture	mostly market prices
2.3.3	Change of non-wood prod. capacity	non-SNA	expert estimates
2.3.4	Forest services (recreation, ...)	non-SNA	different methods
2.3.5	Qualitative changes (biodiversity, ...)	non-SNA	avoidance/restoration costs
2.3.6	Changes in land area	non-SNA	estimated land taxation values
2.3.7	External effects on forestry	indirectly in SNA[2]	expert estimates
2.3.8	External effects, caused by forestry	indirectly in SNA	insufficient data: no valuation
2.3.9	Possible long term effects (climate, ...)	non-SNA	insufficient data: no valuation
2.3.10	Possible efficiency gains	would raise both	insufficient data: no valuation

2.3.1 Timber values

The gross revenue of the Swedish forestry sector can be found in the national accounts. The value added of the forest sector is its revenue minus all inputs from other sectors, e.g. fuels.

The value added of the forestry sector, the timber stock growth not included, has been approximately Euro Mill. 3000 during the last decade, as can be seen in Table 2.2, contributing around 1,5% to the Swedish GDP. More detailed information about the economics of the forestry sector is published in the yearly statistics from the National Board of Forestry, where timber prices and harvested volumes are presented.

Table 2.2: Value Added in the Swedish Forestry Sector: Mill. of Euros[3]

	1987	1991	1993	1995	1997 [4]
Gross revenue	3570	3010	3450	3770	3750
Inputs from other sectors	600	610	480	500	510
Value added	**2970**	**2400**	**2970**	**3270**	**3240**

[2] Income in forestry sector impaired; had it not been for the external effect, or if the polluter would have to pay for the damage caused; forestry income would have been higher

[3] This is the only table where the production result is valued by the price vector of that year. All prices are then converted to 1999/2000 prices by the Swedish GDP-deflator, and converted to Euro at the exchange rate of 2000-01-01; SEK/Euro 8,50.

[4] Swedish SNA-data for the forestry sector have not yet been presented for 1999.

To measure the value of the annual biological production, the growing timber stock has to be valued, and to simplify the comparison between years, the same price vector should be used. In all upcoming Tables, the price vector of 1999 is used. The compensation to labour and capital can also be withdrawn if one wants to calculate land rents.

Since the new SNA standard of 1993, the GDP-measure also incorporates net changes in the standing timber stock. The Swedish forests have for some decades produced more timber than has been harvested. Hence, the net growth of the Swedish timber stock contributes to the GDP-growth. The simplest method to value the net growth (change) is to multiply the net growth figure by the stumpage value, i.e., what a forest owner is paid for a cubic meter of standing timber [5]. Taking account of the growing timber stock in 1999, approximately another Euro Mill. 600, can be added to the contribution of the forestry sector to the Swedish GDP, as can be seen in Table 2.3. The annual timber production of Swedish forests seems to have increased somewhat between 1987-1999, but as all stock-increase figures are calculated from moving yearly averages it is difficult to determine the outcome from an individual year. The climatic factors as temperature and rainfall might also temporarily change the production, even if the underlying production capacity is the same.

Table 2.3: Value of Swedish Timber Production Including Compensation to Labour and Capita

	1987	**1991**	**1993**	**1995**	**1997**	**1999**
Harvested timber: Mill. m^3sk[6]	60,5	61,5	64,5	75	72	70
Nominal timber price index[7]	90	100	84	110	103	101
Swedish GDP-deflator	74	100	104	110	113	118
Mill. of Euros	**2050**	**2080**	**2180**	**2540**	**2430**	**2370**
Net growth of timber stock:						
Mill. m^3	27	35	31	21	25	27
Nominal Stumpage price index[8]	89	100	86	132	123	115
Mill. of Euros	**600**	**780**	**690**	**470**	**560**	**600**
Total: Mill. of Euros	**2650**	**2860**	**2870**	**3010**	**2990**	**2970**

[5] The valuation improves if there are data on how the net growth is divided, e.g., between age classes, as the price for timber depends largely on what it can be used for, which in turn depends on its dimension (age), quality and tree species (Vincent, 1999).
[6] Forest cubic meters (standing volumes)
[7] Nominal price index for all timber: the base year is 1991, when the price was SEK 295/m3 (=Euro 36)
[8] Nominal stumpage price index (standing timber): the base year is 1991, when the price was SEK171/m3 (=Euro 18,5)

The costs of buying intermediate goods from other sectors were subtracted from the revenues to get the value added in Table 2.2. There are also other costs related to forestry than inputs bought from other sectors. All other costs, paying the wages to the workers and the rents to the real capital owners in the forestry sector, are included in the value added. Subtracting these costs – the costs of silviculture, forest fertilising, pre-commercial thinning, harvesting, maintenance of and investments in roads and drainage, which are needed to secure the continuing productivity in the sector – from the value added and adding the value of the change in the timber stock, yield the land rent, i.e. the compensation to the land-owner. In Table 2.4 the Swedish forest land rent is presented, i.e. the stumpage value of the total timber growth during a year. In the future, compensation for ecological services provided, e.g. carbon sequestration, might also be part of the land rent. Sold hunting licences or the value of the hunted game-meat could also be considered to be part of the land rent. In Sweden, the right to common access to forests makes berry- and mushroom-production public land rent goods, while it in other countries might be a part of the land-owner's rent.

Table 2.4: Land Rent of Swedish Timber Production: Mill. of Euros

	1987	**1991**	**1993**	**1995**	**1997**	**1999**
Total timber value: (from Table 2.3)	2650	2860	2870	3010	2990	2970
Costs related to forestry:						
Logging	1230	1025	840	890	790	775
Forestry	570	625	435	385	410	325
Net value of timber growth;						
Timber land rent:	**850**	**1210**	**1595**	**1735**	**1790**	**1870**

The land rent measures the value of the biological (timber) production, the work performed free of charge by Nature. The Swedish forest ecosystem contributed with half of the value of the forestry sector, approximately Euro Mill. 1800, almost 1% of GDP, during the last years of the 1990s. The net value of timber production has doubled during the period under study, 1987-1999. However, this is probably primarily a result of lower costs of logging and forestry, and not so much an effect of increased biological production. The decreasing cost of logging might be explained by the introduction of modern and more efficient harvesting machines, working around the clock. The decreasing forestry cost may be the effect of neglected maintenance of forest roads, which might lead to increasing forestry costs in the future.

2.3.2 Values of non-wood goods

Except for timber, the forest ecosystem produces other, non-wood goods, as well. The yearly yield of berries, mushrooms and game consumed by humans and lichen consumed by reindeer will be valued in this Section. Changes in the forest ecosystem's capacity to produce berries and lichen will be analysed in Section 2.3.3.

Only 25% of all berries and mushrooms picked, and game hunted, in Sweden are sold on commercial markets. Furthermore, in the 1990s, approximately only three percent of the berries and mushrooms produced were picked, and only the value of these, picked berries and mushrooms will enter the forest accounts. The rest of the berries and mushrooms will be considered to be inputs into the forest ecosystem's food web, producing game and re-circulating nutrients.

Concerning game, the most valuable species in Sweden are hunted at established administrative levels. The numbers of elks and deer could be higher if the forests were used primarily to breed game, but as the browsing costs from large game stocks are high, the hunting quotas are set partly to offset these negative browsing effects.

Since some hunters and berry and mushroom-pickers sell their products, market prices for these non-wood forest goods are established. Time series of market prices, Euro/kg, paid for berries, mushrooms and game meat from the export statistics have been used to value all volumes picked and hunted. The market price valuation of the non-wood goods produced by forests are comparable to the value added of forestry sector, as it includes compensation for labour and capital involved in picking and hunting activities including distribution.

Lichens, the main winter forage for reindeer, grow on the ground and on old trees. In Northern Sweden, the Sami people have a historical right to feed reindeer with lichen. That means that no market price on lichen, i.e. of the forage right, exists. The alternative to lichen forage is to feed the reindeer with hay, which has to be done from time to time, due to hard winters or too large a reindeer-stock compared to the lichen supply. The production of lichen is forecasted in a model from forest (age) data (Wilhelmsson, 1989) [9] . The annual production of lichen is lower than the demand, if the reindeer population exceeds 200.000 individuals, as has been case within the time-period of this study. A reindeer consumes 1,25 kg of lichen a day, which means that the 70.000 ton of lichen forage produced in 1999 represented 56 Mill. days of reindeer feeding. To feed the remaining reindeer hay cost approximately Euro 1½ a day per reindeer in 1999, which give the annual lichen production a value of Euro Mill. 84 [10].

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[9] The model covers the regions Norr- and Västerbotten, where some 80% of Swedish reindeers reside. The model results are multiplied with 1,25 to get an approximation for the whole of Sweden.

[10] 56 Mill. days times Euro 1½. GDP-deflator has been used as the nominal price index to transform the hay-feeding price between different years.

Table 2.5: Volumes of Non-Wood Goods Produced by the Swedish Forest Ecosystem[11]

	1977	**1987**	**1991**	**1993**	**1995**	**1997**	**1999**
Berries (Mill. Liters):							
Household Production[12]							
Lingonberries	35	*23*	*18*	*15*	12	11	*10*
Blueberries	30	*18*	*14*	*12*	10	8	*7*
Wild Raspberries	7	*6*	*5*	*5*	4	2	*2*
Cloudberries	5	*5*	*4*	*4*	4	2	*2*
Commercially Sold Wild Berries		30	30	30	30	30	30
Mushrooms (Mill. Liters):							
Household Production	22	*18*	*16*	*15*	14	15	*15*
Commercially Sold		10	10	10	10	10	10
Game[13] (1000 ton)							
Elk		16,8	16,5	12,7	12,3	12,8	13,8
Deer		1,6	3,9	4,6	3,1	2,5	2,6
Lichen[14] (1000 tons)		80	78	76	74	72	70

The human consumption of the forests' production of non-wood goods has decreased between 1987 and 1999. Table 2.6 shows that the non-wood value produced by the forest ecosystem and consumed by society shrank by more than 20% between 1987 and 1999.

[11] All berry and mushroom household production data in italics are interpolated values – 1999 extrapolated – while the data in normal typing – 1977, 1995 and 1997 are empirical data (homepage of Swedish Board of Forestry: (www.svo.se). Commercially sold goods are estimated from SNA-input-output tables and data retrieved from the home page of the Swedish National Agricultural Board (www.sjv.se).
[12] Amounts picked/hunted for own use
[13] National Forestry Board, 25% of game volume and value commercially sold, 75% household production, but all game meat is accounted for in SNA
[14] Wilhelmsson 1989

Table 2.6: Values of Non-Wood Goods Produced by the Swedish Forest Ecosystem:

	1987	1991	1993	1995	1997	1999
Berries: Mill. kg (50% of liter value)						
Volume	41	35	33	30	27	26
Nominal price index of berries[15]	75	100	94	137	88	88
Value Mill. of Euros	**68**	**59**	**55**	**50**	**43**	**41**
Of which household production (non-SNA)[16]	*45*	*36*	*32*	*27*	*20*	*18*
Of which commercially sold (in SNA)	*23*	*23*	*23*	*23*	*23*	*23*
Mushrooms: Mill. kg (20% of liter-value)						
Volume	5,6	5,2	4,8	4,8	5,0	5,0
Nominal price index of mushrooms[17]	47	100	60	79	38	35
Value Mill. of Euros	**20**	**18**	**16**	**16**	**17**	**17**
Of which household production (non-SNA)	*13*	*11*	*9*	*9*	*10*	*10*
Of which commercially sold (in SNA)	*7*	*7*	*7*	*7*	*7*	*7*
Game: 1000 ton	18,4	20,4	17,3	15,4	15,3	16,4
Nominal price index of game meat	103	100	88	142	149	137
Value Mill. of Euros (in SNA)	**93**	**103**	**87**	**78**	**77**	**83**
Lichen: Reindeer feeding days, Mill.	64	62	60½	59	57½	56
Value Mill. of Euros (in SNA*[18])	**96**	**93**	**91**	**89**	**86**	**84**
Total Value of Non-Wood Goods: Mill. of Euros	**277**	**273**	**249**	**233**	**223**	**225**
Compared to the timber values from Table 2.3:	**2650**	**2860**	**2870**	**3010**	**2990**	**2970**

[15] The price of berries comes from foreign trade statistics. Prices of lingon-, blue- and raspberries follow more or less the same pattern between the years (price/kg do not differ between the different berries). Cloudberries cost twice as much. Base year of the index is 1991 (=100), when lingon- and blueberries cost SEK 16/kg (=Euro 2). 1kg of berries is approximately 2 liters

[16] Household production of berries and mushrooms do not enter GDP, while the amounts commercially sold do. However, the values are presented as value added of the agricultural sector (foods), not the forestry sector. Concerning game, all volumes/values consumed, commercially sold or not, enter GDP (as agricultural production).

[17] The price of mushrooms comes from the foreign trade statistics. Prices of the most valuable species, like chantarelles, can be twice the price of ordinary species. The base year of the index is 1991, when the price of ordinary species was SEK 58kr/kg (=Euro 7). It is assumed that half of the mushrooms picked are chantarelle-like species. 1 kg of mushrooms is assumed to be approximately the same as 5 liters.

[18] Indirectly, the value enters GDP as reindeer meat (as agricultural production), but as lichen is grazed/browsed free of charge, the forestry sector does not get credited for the input it provides.

None of the values of the forest ecosystems' production being used by the economy and private households enter the forestry sector's value added in the SNA. Table 2.7 shows where the values appear, if they appear at all, in the SNA-system (GDP-figure).

Table 2.7: Values of Non-Wood Goods Divided up as Agricultural SNA-Output and non-SNA Household Production Output: Mill. of Euros.

	1987	1991	1993	1995	1997	1999
Total value: non-wood goods:	**277**	**273**	**249**	**233**	**223**	**225**
In SNA as agricultural output						
Berries, mushrooms and game	123	133	117	108	107	113
Lichen as (free) input in reindeer meat	96	93	91	89	86	84
Household production (non-SNA)	58	47	41	36	30	28

To be able to compare the land rent components of the value of the non-wood products with the timber value, the non-wood goods have to be evaluated by another set of prices, such as licence prices, reflecting the willingness to pay (WTP) for getting access to berries and mushrooms on private property [19]. The licence price, Euro/kg, paid by wholesale firms to get the right to pick berries and mushrooms on private property, was Euro ½/kg lingonberries and Euro 2/kg mushroom in 1999. The compensation varied somewhat, depending on species and volume.

There also exist prices on hunting licences. However, contrary to berries and mushrooms, the price paid for a hunting licence is much higher than the market price for the corresponding game meat, as the recreational aspects of hunting are highly valued. A day of elk hunting can cost up to Euro 1000, while a day of bird hunting can cost less than Euro 50. Recreational values of hunting are treated separately in Section 2.3.4.1.
In the land-rent valuation of non-wood goods presented below in Table 2.8, the game and lichen production are valued by the market prices described in Table 2.6, as the licence price is no less than the market price.

[19] Most retailers of berries and mushrooms buy privately picked products, but recently, retailers have also published prices for the right to pick on private property. The Swedish right to common access concerns all areas out of sight from private houses. Thus, the licence to pick business must be small, mostly aiming at getting information on where in the country the supply of berries and mushrooms is the best. Prices are published e.g. on the home page of Softplock (homepage reached through altavista-search; search on Softplock to find page)

Table 2.8: Land Rent of Non-Wood Goods[20]: Mill. of Euros.

	1987	**1991**	**1993**	**1995**	**1997**	**1999**
Berries: Euro ½/kg	21	18	17	15	14	13
Mushrooms: Euro 2/kg	11	10	10	10	10	10
Game: Euro 5/kg	93	103	87	78	77	83
Lichen: Euro1,25/feed day	96	93	91	89	86	84
Total non-wood land rent	**221**	**224**	**205**	**192**	**187**	**190**
Compared to timber land rent	850	1210	1595	1735	1790	1870

In a rapidly growing economy, driven by technological change, a primary sector like forestry, dependant to a large extent on land rents, can not possibly keep up its share of GDP. In the timber logging better technology can be used. No such technological improvement will ever affect non-wood forest production. In a society free from food scarcity, goods like non-wood food products, will logically have problems to attract people's attention (time). The decreasing volumes of household production picking of berries and mushrooms, which can be seen in Tables 2.7 and 2.8 can perhaps be explained by the rather low, and non-increasing, economic value of the non-wood goods. However, household production of the non-wood forest goods also has recreational aspects (described in Section 2.3.4.1), that might become more important in the future.

2.3.3 Valuing the eroding production capacity of non-wood forest goods

The forest ecosystem's capacity to produce berries and mushrooms is affected by natural climate variations. However, some other factors such as forest management, acidification, eutrophication and overgrazing can also affect the ecosystem's production capacity of non-wood products. The value of such changes in the forest's natural capital and its production capacity of non-wood goods should be registered in the monetary forest accounts.

The forest ecosystem's capacity to produce berries decreases, because of acidification and eutrophication, especially in the southern parts of Sweden [21]. Other species are better suited for the currently more acid and nitrogen-saturated soil conditions. Productivity is also lost as the denser forests (larger timber stock on the same forest acreage) let in less light. It is complicated to value the forest eroding capacity to produce berries, especially as surveys show that Swedish consumers pick less and less berries, seemingly independently of the decreasing supply situation in the forests [22]. More than 95% of the annual production of berries and mushrooms is left in the forests

[20] Same volumes as in Table 2.5, but berries and mushrooms valued by licence prices
[21] The lost production capacity is estimated by Lars Kardell, Professor in Environmental Forestry, who has made field experiments on berries since the 1970s, telephone interview 1 March, 2001.
[22] Lindhagen and Hörnsten (2000)

for deer and other species to graze. However, under the assumption that the berries remaining in the forest, approximately 400 Mill. kilograms annually, are considered to be as valuable as the ones picked, the berry production capacity, and how it changes over time, can be calculated.
At the moment, the forest ecosystem's capacity to produce mushrooms seems to be constant. Naturally, the same calculations can be performed concerning the value of mushroom production capacity if the capacity will change for worse or better in the future.

The land rent of the berries picked annually, some 25-40 Mill. kilograms, using the average annual value of the period studied (1987-99), was Euro Mill. 17. If the remaining 400 kilograms of berries are assumed to possess the same value, the total annual flow of berries, picked by humans, grazed by other animals or just recirculated as nutrients, annual produced by the forest ecosystem is worth Euro Mill. 34. Using a discount rate, comparable to the projected long term GDP-growth of Sweden in the Long Term Surveys published by the Swedish Ministry of Finance (1999), 2%, the capitalisation value of the forest ecosystem's berry production capacity is Euro Mill. 1700.[23]

According to Lars Kardell, the forest ecosystem's capacity to produce berries has decreased during the last decades. Kardell estimates that the annual production has decreased by 10-15% from 1980 to the present, i.e. by 0,5-1% annually. Consequently, the value of the forest ecosystem's capacity to produce berries has eroded by approximately Euro Mill. 13 annually [24].

Lichen are overgrazed by reindeer at the present. The northern Swedish forest ecosystem's capacity to produce lichen decreases by 1% a year according to the Wilhelmsson (1989) study. The forest ecosystem's capacity to produce lichen is worth Euro Bill. 4.5, using the same calculation method as for the berries above. Thus, the value of the 1% annual decrease of the lichen production capacity is Euro Mill. 45.[25]

Table 2.9: Estimated Annual Changes 1987-1999 for Berry, Lichens and Mushroom Natural Capital

	Value of capital stock; Mill. of Euros	Annual change: %	**Mill. of Euros**
Berries	2700	- 0,75	**-20**
Lichen	4500	- 1	**-45**
Mushrooms[26]	500	0	**0**
Total	7700		**-65**

[23] (34/0,02 = 1700)
[24] 0,75% of Euro Mill. 1700 = Euro Mill. 13.
[25] An annual yield of Euro Mill. 90, gives a capital value of Euro Bill. 4,5, using a 2% discount rate (Euro Mill. 90/0,02=4500). A 1% decrease of that capital is worth Euro Mill. 45.
[26] Using the same calculation method as for berries and mushroom (Euro Mill.10/0,02=500)

Note that the value of annually lost production capacity of berries and lichen is half as much as the value of the annual yield consumed. Concerning lichen, eroding production capacity is mostly a problem related to overgrazing, even if forestry management is also to blame, as will be discussed in Section 2.3.10. Concerning berries, the production capacity is eroded by the effects of air pollution deposited, mainly acidification.

2.3.4 The value of services provided by forest ecosystems

Forest ecosystems do not only produce consumption goods, they also provide services and public goods. Recreation, biodiversity, protection of soils, shielding urban areas from noise, and carbon sequestration are considered the most important ones.

2.3.4.1 The value of forest recreation

Several recreational activities take place in forest ecosystems. Some, as picking berries and hunting game, are historically household production activities that were necessary for survival. Today, these activities are mainly recreational, although if they also contribute to private consumption, as was shown in Section 2.3.2.

The total number of visits to Swedish forests is approximately Mill. 373 a year. Lindhagen and Hörnsten (2000) present a survey of the forest activities in Sweden. They can only find small changes in visiting frequencies between 1977 and 1997. The purpose of the forest visits, around 60 visits per person and year, which can be studied in Table 2.10, was analysed in a study by Statistics Sweden (1995, published 1999).

Table 2.10. Swedish Visiting Frequencies to Forests in 1995

Activity	Number of visits; Mill.	Percentage
Walking/skiing	155	40%
Running/jogging	54	15%
Studying flora&fauna	46	12%
Picking berries&mushrooms	45	12%
Hiking	29	8%
Hunting	11	3%
Others	33	10%
Total	373	100%

Researchers, which have tried to assign values to activities such as picking berries and mushrooms, and especially game hunting, report much higher values on the recreational aspects than the market price of the berries, mushrooms or game-meat. Most Swedish recreation valuation studies are Contingent Valuation (CV) studies, asking willingness to pay (WTP) questions, but market-price studies based on valuations such as excursion fees exist as well.

The value of the forest related activities mentioned in Table 2.10 has been analysed in Jämttjärn (1996), using several Swedish valuation studies from the 1980s and early 1990s. The mean value of a forest visit was found to be Euro 6. Using that value and the visiting frequencies from Table 2.10, the annual forest recreation value per person in Sweden is calculated to Euro 360.

Wibe (1994) cites forest studies from all countries, stating on average a recreation value of Euro 25 per daily visit in a forest. The most frequently used opportunity cost to spend a day in the forest, the after tax minimum wage, is approximately Euro 25/day in Sweden

Many of the most frequent visits described above (walking, skiing, jogging, running) usually takes only an hour or two, which can explain part of the difference between the valuation in Jämttjärn (short visits) and Wibe (full day visits). On the other hand the most important aspect of a forest visit is probably to get the opportunity to get outdoors in a pleasant surrounding (recreation as such), not the visit duration as such. The other explanation to the difference between the two metastudies is that Wibe refers to more CV-studies, which generally tend to state higher values.

All activities in Table 2.10, except for hunting, have more or less the same valuation in Jämttjärn (1996) and Wibe (1994). Summing up, the 362 Mill. forest related non-hunting visits can be valued at between Euro 6 and 25 a piece. The total number of visits indicates that many can not possibly be full day activities, which is the reason for using the lower valuation, Euro 6/visit, in the calculations here. That gives the recreational services provided by forest ecosystems, hunting excluded, a total annual value of Euro Bill. 2,2.

Hunting is valued at Euro 22/day in Jämttjärn (1996), using CV-studies, of which a third can be ascribed to the meat-value. The total WTP sums up to Euro Mill. 242, of which Euro Mill. 78 can be ascribed to meat value, and the remaining Euro Mill. 164 to recreation.

Mattson (1990) shows that some 300.000 Swedes spent on average almost 30 days hunting. 80% of the hunters hunted elk regularly and valued the recreational part (meat value subtracted) of the elk hunting at Euro 400 a year. 75% of the hunters hunted other game regularly and valued the recreational part of that hunting at Euro 350 a year. This sums up to a total recreational value of Euro Mill. 96 + 79, close to the figures in Jämttjärn (1996). Taking the average of the two studies, the annual recreational value of hunting is estimated to be Euro Mill. 170.

Table 2.11: Recreational Values of Forest Visits:

Activity	Mill. Visits	Value/day; Euro	**Total value; Mill. Euros**
Hunting	11	15	**170**
A visit to the forest	362	6	**2200**
Total			**2370**

2.3.4.2 Valuing the forest ecosystem's capacity to provide protection of soils and noise

Tree roots bind forest soil and prevent it from eroding. At the same time forests can prevent nearby agricultural soils from eroding, both by decreasing the wind factor and by decreasing the surface water run off, as a forest soil also binds water. Swedish agricultural soil erosion is low by international standard. Some 0,06% of the Swedish soils, measured as agricultural production losses, are lost every year due to erosion (Haasund 1986). Hypothetically, without protection from forests, especially the tree shields In the agricultural areas in southern Sweden, the erosion damage could, hypothetically, be twice as high, without the protection from surrounding forests or groups of trees. Consequently, the forests' soil protecting function saves agricultural soils from erosion at an annual value of approximately Euro Mill. 5 in Sweden (Skånberg 2001).

The topography of the Swedish landscape is rather flat and trees do not grow at all above an elevation of 700-800 meters. This means that landslides and avalanches in areas that could have been forested rarely occur. Locally, incidents with increased water run off or even landslides in newly harvested forest areas have happened. However, harvesting procedures restrict the maximum logging area, and logging has to be performed according to rather restrictive forest laws in sensitive areas, which further reduces the risk of negative effects. It is difficult to find a value reflecting how much damage the existence of forests prevents, since hardly any costs from landslides or avalanches have been incurred.

Forests can shield urban areas from noise, provide scenery and decrease air pollution through the capacity of leaves and needles to filter particles. For noise reduction, valuation estimates exist, even if they are not primarily done to value the forests' noise protective effect [27]. Noise costs society approximately Euro Mill. 300 a year (Johansson 1995 and Hansson 1994).

Noise is mostly an urban problem, but the median distance a Swede lives from the nearest forest area is 300 meters, according to Hörnsten and Fredman (2000). It seems likely that existing forests, near residential areas, function as noise shields. Swedish hedonic price studies (Wilhelmsson 2000) show that noise-disturbed houses have market values as much as 30% below houses with the same characteristics, except for the dB-level (noise). If forests reduce the noise-nuisance by, hypothetically, 5%, which seems likely as Swedish urban areas are known for their green belts of forests and parks, that service would be worth Euro Mill. 5 a year.

The air cleansing capacity of forests has been measured in acidification studies, where deposition of acid compounds are much higher in forest areas, especially at the forest frontier, than elsewhere. However, the air cleansing capacity of forests has not yet been valued, but the highest values (damage costs or WTP) reached in environmentally related studies all come from studies measuring health aspects in connection with urban air quality.

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[27] Geographical information system researchers study the opposite of noise, quietness, and map the increasingly scarce quiet zones in Sweden. These maps could in the future be used as an alternative approach to value the positive aspects of quietness instead of the negative aspects of noise

The scenic aspects of forests in real estate valuation are difficult to analyse, as the more remote the location, the closer to forests in a country like Sweden, and consequently the lower the market price of the estate. However, a Finnish hedonic price study has shown that real estate values have a premium if they are situated close to forests (Tyrväinen 1999). Many Swedish holiday cottages are situated in forest surroundings. Real estate agents marketing holiday cottages usually emphasise close access to forest recreation, forest scenery and quietness. These positive aspects of forests, related to housing, can partly have been valued in the recreational studies described in Section 2.3.4.1. Combining geographical information systems, showing the location of Swedish houses in relation to forests areas, and a hedonic price study, as the one performed in Finland, would make it possible to estimate the positive scenic and recreational aspects forest ecosystem have on real estate values.

Table 2.12: Value of the Forest Ecosystem's Capacity to Prevent Soil Erosion and Noise

Protective function	**Value: Euro Mill. a year**
Protect agricultural soils	**5**
Reduce noise	**15**
Avoid avalanches, landslides, floods …	low in Sweden, high elsewhere
To improve air quality	high, not yet studied
As a component of real estate prices	high, not yet studied
Total	**20** (potentially much higher)

2.3.4.3 Valuing the forest ecosystem's capacity to sequester carbon

The Swedish timber stock is a carbon sink. The forest ecosystem's capacity to act as a carbon sink is a service that in the near future might be monetarily rewarded, as a consequence of the Kyoto-protocol. The Intergovernmental Panel on Climate Change, IPCC, discusses the necessity to decrease emissions of greenhouse gases. One way to remove carbon dioxide from the atmosphere is to bind it in soils or bio-mass, e.g. in standing forests. There are different ways to value carbon sequestration:

- The alternative to sequester carbon in forests (letting a tree stand) is to harvest. Thus, foregone forestry revenue is a possible valuation of carbon sequestration. The income foregone from letting the timber stock increase sets a lower bound to the carbon-binding value, if society rather has the tree standing than harvested, and chooses to have a growing timber stock for that reason. The value of the increase in the Swedish timber stock was Euro Mill. 600 in 1999, as was shown in Table 2.3.
- The carbon tax reflects a social value, or a shadow price, of carbon emissions. If it costs to be a carbon source, it should logically pay, exactly as much, to act as a sink. The Swedish carbon tax is Euro 42/ton carbon dioxide, i.e. Euro 155/ton carbon. Sweden has the highest carbon tax in the world, but it seems correct to use the

Swedish tax rate on Swedish carbon binding in Swedish forest accounts than any other country's tax rate. However, in an international comparison, the same carbon-binding value should be applied to all countries. The carbon sequestered by forests in 1999 was estimated to be 5,2 Mill. metric tons. The value of the forest ecosystem's capacity to sequester carbon, using the carbon tax to price the service, was Euro Mill. 775.

- The price of a carbon-emission-right or a flexible mechanism-contract on carbon binding is a third possibility to value carbon sequestration. The price for letting someone else reduce emission or sequester carbon will differ depending on the result from the post-Kyoto-protocol negotiations. These negotiations started in Hague in November 2000 and concern so called flexible mechanisms. The participating countries are supposed to determine how countries can take credit for emission reductions, sequestration of carbon in sinks and joint implementation projects installing modern technology abroad, and the exact terms for trading these credit rights internationally. As of March 2001 no treaty has been signed, but the negotiations are supposed to be continued in the second half of 2001. A treaty stating no cap on trading and allowing many sinks could lead to a carbon price as low as Euro 20-40 per ton carbon [28]. A treaty, minimising the opportunities to buy emission rights or sink capacity abroad might lead to much higher carbon prices, possibly as high as the marginal cost to reduce carbon emissions in Sweden today, which lies in the interval Euro 200-400 per ton carbon. Swedish model simulations have shown that a carbon tax in that interval might be needed to reduce the emissions enough to meet the Swedish Kyoto-protocol obligation. In Table 2.13, the lowest price presented above, Euro 20 per ton carbon, will be called the emission/sink trading-price. The highest price presented above, Euro 400 per ton carbon, will be called the post-Kyoto-price, as the carbon price will probably be rising in the future if the global community can agree on adequate measures to reduce greenhouse gas emissions. Long term, greenhouse gas emissions must be cut by 50-80% from today's levels in the industrialised countries for the concentrations in the atmosphere to level off at the IPCC recommended targets.

- From the demand side, it is interesting to study what the cost is to live with a carbon-dioxide concentration in the atmosphere, twice, three or four times as high as the pre-industrial level of 280 ppm. Nordhaus (1992) showed in his DICE-model that the productivity of primary sectors in the US would be affected negatively by climate change. However, the primary sectors only make up a small portion of the total American economy, and the loss of productivity would not cause any nutritional (starvation) problems. By extrapolating projected American damage caused by future climate change, Nordhaus discusses possible effects on all global economies. These global

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[28] More information about the flexible mechanisms, cost structures for different mechanisms in different countries and other climate change issues can be found on the IPCC homepage (www.IPCC.ch) or in the two Swedish climate commission reports, SCR 2000:23 and 2000:45

damage projections overlooked the fact that in the developing countries, billions of people are living mostly from primary sectors, close to starvation margins. Hence, the consequences for poor countries would be much graver. The carbon-value presented by Nordhaus is Euro 8 per ton carbon emitted [29].

- It would also be possible to establish a carbon-price by in asking in a CV-study for the WTP for reducing the risk of climate change by limiting the emission to certain levels, equivalent to stabilising the greenhouse gas concentration in the atmosphere at certain levels.

Table 2.13: Value of Carbon Sequestration in Swedish Forests, Depending on the Valuation Method Used

	1987	1991	1993	1995	1997	1999
Net growth of timber, Mill. m^3	27	35	31	21	25	27
Mill. tons of carbon sequestered[30]	5,2	6,8	6,0	4,0	4,9	5,2
Valuation method: Mill. of Euros						
Stumpage value	600	780	690	470	560	600
Carbon tax	**810**	**1050**	**930**	**630**	**750**	**810**
Emission/sink trading price	110	145	125	85	1051	110
Post-Kyoto-sustainability price	2080	2700	2390	1630	1940	2080
Damage cost	42	55	48	33	39	42
CVM-price		yet to be determined by a CV-study				

In the Swedish monetary forest accounts, the carbon tax valuation will be used, until there is an established carbon price on the international carbon-emissions trade market. The range between the possible carbon sequestration value of the Swedish forest ecosystems spans from Euro Mill. 42 to 2080 for 1999. There is a factor of 50 between Nordhaus' damage cost estimation per ton of carbon emitted, and the possible post-Kyoto-price, which may meet carbon emitters in upcoming decades. If carbon prices reach those heights, timber prices will necessarily also rise, as the supply of timber otherwise would disappear if all forest owners focus on sequestering carbon, and not on logging and selling timber.

[29] Azar and Sterner (1996) calculate the possible damage cost of climate change in a different way than Nordhaus. First, they use a lower discount rate, which heavily influences the outcome as the relevant time perspective of climate change is centuries and the damage appear far away in the future. Second, they take into consideration the possibly graver consequences of climate change in poorer countries and do not use US projections, but rather more country specific cost estimates depending on the proportion of agriculture to the national economy. Under those assumptions the damage estimate of climate increases to Euro 130-550 per ton carbon emitted.

[30] Including not only stems, but also carbon in all other tree bio-mass. The amount of carbon sequestered in soils, due to an increase in the timber stock is yet to be determined.

Carbon sequestration will be focused upon as long it is believed that it can help to slow down climate change. Supposedly, the forest's capacity to sequester more carbon will be more or less emptied in the Swedish forests before 2050, if the present trend of an increasing timber stock continues [31], or even accelerates, due to a carbon subsidy. Even if some agricultural land is afforested, the capacity does not increase that much. In other countries the forest carbon sequestration may be of some importance for another few decades.

2.3.5 Valuing qualitative changes of the Swedish forest ecosystem

The Swedish forest ecosystems change over. The enhanced timber production capacity has already been valued in Section 2.3.1. However, the forestry sector still has a negative influence on biodiversity, despite many improvements in the silvicultural methods the last decades and the increased focus on ecological considerations in the last decade. The chemical status of the forest soils has also changed, due to acidification and contamination.

2.3.5.1 Valuing (risk) of biodiversity loss

The Swedish forest ecosystem is not rich in species in comparison to other forest ecosystems around the world. The reasons are to be found in climate factors, especially the fact that ice covered Scandinavia only 10000 years ago. It takes time to build up biodiversity. However, loss of biodiversity can be very rapid. Perrings (1994) discusses the value of (an ecosystem's) biodiversity in terms of providing life support, not only for the ecosystem itself, but also for surrounding ecosystems and the human society. All goods and services discussed so far in this paper are totally dependent on a well-functioning life supporting system. Loss of biodiversity increases the risk for disturbances in that system. Protecting biodiversity is like investing in activities that reduce your insurance premiums. The more complicated the food-web making up an ecosystem, the more robust to resist change (chocks) it is. Even more important is that a biodiverse ecosystem is also more resilient, i.e. more likely to return to its original state, if hit by chocks.

Biodiversity loss is perhaps the most difficult change to value in a forest ecosystem. Two possible valuation methods will be presented below:

- the WTP stated by consumers to preserve biodiversity. Note that the question asked must concern biodiversity as such, not preservation of individual species, as WTP answers should not be summed up to get a total value.
- the estimated costs to live up to the biodiversity preserving environmental targets set by political consensus or ecological expertise. These protective costs have two major components: government outlays to buy, manage and restore land, and incomes foregone by forest owners when they are not allowed to manage and harvest their forests from purely commercial criteria, but have to take ecological concerns into account.

[31] Research on this topic is performed at the Department of Forestry Production Ecology at The Swedish University of Agricultural Sciences; personal communication with Peter Eliasson.

A handful of tree species (4% of total tree species) some forty plants (2%), 200 lichen and macrofungi (5%), 10 mammals (15%), 18 birds (7%) and 450 insects (1½%) were considered to be threatened at the turn of the millennium[32]. It is considered too complicated to calculate the costs of living with a reduced biodiversity, which may be caused by the fact that Sweden does not yet meet its own political targets, and even less to the more severe targets set up by ecological experts. No one knows the possible consequences of a reduced gene pool for the functioning of ecosystems, medical research, evolutionary development, plant and animal breeding etc. However, CV-studies on people's WTP to preserve biodiversity have been published.

Johansson (1990) asked a sample of Sweden's population how much they were willing to pay to protect the 300 species being threatened at that time. The answer was Euro Mill. 65 a year. Several studies exist on the willingness to pay to save certain species, but aggregation problems make it complicated to present those figures in a forest account, focusing on the threat against several species. Boman and Kriström (2000) list most of the existing Swedish CV-studies concerning preservation of one or a few species.

In order to provide threatened species better living conditions, ecologists (Liljelund 1992) propose that larger areas, up to three times as much as today, i.e. 10% instead of the 3.3% of all forest land, which is protected at present. The politically decided target is 7% (SCR 2000:52). If the most biologically/ ecologically valuable Swedish forests had been protected, forestry itself would not pose any threat to the national biodiversity, according to the ecologists. In that case old forests, dead wood, and selected broad-leaved forests would be the first forest areas to be protected, as they host most threatened species.

By already having set aside some 3.3% of the forest area, Swedish forestry foregoes income. The forestry sector would forego even more income if more land, another 3.7% to meet the political target, would be set aside. This valuation method, translating the cost to meet the environmental targets concerning biodiversity set by ecologists (Liljelund 1992) to the cost of the risk to lose biodiversity, was used in Hultkrantz (1991) and Eliasson (1994). The cost of protecting biodiversity was calculated to be Euro Mill. 230 in 1987, and Euro Mill. 200 in 1991. The decreasing cost of not meeting the biodiversity targets depends on the fact that more land was set aside in 1991 than in 1987. Since then, even more land has been protected, which means that the cost of not meeting the biodiversity target has decreased further since 1991. Recently, the costs of reaching the new environmental targets concerning biodiversity set up by the government was analysed (SCR, 2000:52). The annual cost of protecting another 3,7% of forest land, and prioritise sensitive and valuable biotopes would cost the government Euro Mill. 90 annually. The forest companies would also lose Euro Mill. 70 annually in revenue, as their harvesting volumes would decrease (SCR 2000:52). Hultkrantz and Eliasson calculated the cost of foregone income on 10% of the Swedish forest area, but did not account for the governmental strategy to buy land. The Swedish Report (SCR 2000:52) has a lower target concerning protected land. On the other hand, a more efficient protection is achieved if the government buys land as this allows for specially designed silvicultural management methods and restorations. The two slightly different

[32] National Board of Forestry Statistics (homepage)

methods of calculating the cost to meet the different biodiversity targets end up costing the same in 1999. Therefore they are presented in the same row and will be used as the value of (the risk of) biodiversity loss in the Swedish monetary forest accounts.

Table 2.14: Value of (the Risk for) Biodiversity Loss in Swedish Forests: Mill. of Euros

	1987	**1991**	**1993**	**1995**	**1997**	**1999**
WTP to preserve biodiversity[33]	65	65	65	65	65	65
The cost to meet biodiversity targets	**230**	**200**	**190**	**180**	**170**	**160**

2.3.5.2 Valuing changes in the chemical balance of Swedish forest soils

Soil quality and climatic factors determine the naturally given productivity of a land area. Thus, an accumulation of pollutants in a forest soil may negatively affect that naturally given productivity of a forest ecosystem. In Sweden, acidification and contamination from heavy metals and radioactive substances are possible reasons for reductions of the productivity of the forests, affecting the production of berries, mushrooms, game and possibly also timber. Recreational values could be lost as well. Climate change also affects productivity and variability, which will be described in more depth in Section 2.3.8.2.

In large areas of Sweden the deposition of acidifying substances is above the critical load, i.e. the amount the ecosystem can receive over time without being negatively affected. The pH-level of (water in the) soils might affect the base cat-ion stock in the soil, which in turn could impair the future possible timber growth, according to scientists in soil chemistry. This hypothesis is based on mathematical models and experiments on young plants in laboratories. Field studies have not shown any major effects on timber growth from acidification. The view that soil chemistry and the pH-value of the water in the forest soils are more or less unrelated to timber productivity is presented in Binkley and Högberg (1997). In summary, the natural scientists do not fully agree on when and how (much) acidification affects timber productivity, nor do they agree on what other factors may cause the damage seen on trees today.

It is evident that acidification changes the qualitative chemical status of the soil. The valuation results presented below should primarily be seen as an example of how one can account for the environmental phenomena affecting biological production. Science still has to resolve if acidification affects timber productivity, and in that case (exactly) why, when and how much, depending on tree species, age, and other factors which could play a role in a possible damaging process.

[33] Biodiversity changes are hard to detect between years. Assuming that the threat of biodiversity loss is the same in all of the years studied, increasing pressure on the one hand, but more and more land set aside on the other, the Euro Mill. 65 is used across the whole period.

Below, two different valuation methods to determine the cost of chemical imbalances in forest soils will be presented:

- Model simulations based on soil chemistry and biological plant experiment results, combined with geographical information system data on acid deposition, weathering velocity, soil chemistry, forest areas, and timber growth. Projections of when and how much timber growth will be affected in different areas of Sweden provide annual estimates of how many cubic meters of timber are forgone, due to acidification in different years. These foregone incomes can be traced back to the acid deposition and the chemical imbalances caused in certain years.
- Liming costs to restore the chemical balance to pre-industrial levels. The more acid deposition exceeds the critical load in a certain year, the larger part of the total liming cost will be assigned to that year. The costs rise in proportion to how much the chemical quality (base cat-ion/aluminium ratio) was eroded a certain year.

The acidification process spans over decades, even centuries, which makes it necessary to use a model to answer questions about how much each year's emissions of acid substances might affect the final acidification outcome. A modelling approach also allows for different assumptions on future actions to reduce emissions. Such an exercise, based on results from soil chemistry research (Sverdrup and Warfvinge 1994), has been performed at the Swedish National Institute of Economic Research (Skånberg 1994). According to the simulations, the Swedish forest owners will lose Euro Bill. 15 during the 21st century, due to soil acidification, even if the international agreements on reducing acidifying emissions are implemented. The cost of impaired timber productivity in acidified areas will rise from low annual figures in the late 1990s to a maximum of Euro Mill. 300 annually, during the next decades. However, the acid deposition, and hence the chemical changes in the soil, peaked in the 1970s.

The total future productivity loss caused by the chemical imbalances caused in 1993 is valued at Euro Mill. 110. The model can track back projected future decreased production of timber in Swedish forests to the deposition of acid rain and the lack of re-circulating nutrients in the forestry sector in that year. In 1997 the cost is estimated to be Euro Mill. 100, due to the somewhat lower acid deposition that year. [34]

Dickson (2000) estimates the total cost of liming the chemical status of forest soils back to pre-industrial levels to be Euro Bill. 12. To compensate for the upcoming acid deposition in future decades, until the reduction has lead to that critical loads are not exceeded anywhere in the Swedish ecosystem, would cost another Euro Bill. 3. Ideally, the liming should take place every year in proportion to how much the critical loads were surpassed. Incidentally, as the cost caused by acidification in the model has the same magnitude as the liming cost, and as the costs should be proportional to the exceedence of critical load according to both methods, these two valuation

[34] Acidification effects on timber growth already started to appear in the Swedish forests in the mid-nineties according to the model. The loss of income to the forest owners was calculated to be negligible in 1993 and Euro Mill. 75 in 1997. However, Euro Mill. 74 is due to emissions in previous years and only Euro 1 Mill. can be blamed on emissions in 1997

methods produce identical results. The liming costs will be used in the monetary Swedish forest accounts, as the model results have not yet been confirmed by empirical forest data.

Table 2.15: Value of Quality Degradation of the Chemical Properties of Swedish Forest Soils: Mill. of Euros.

	1987	1991	1993	1995	1997	1999
Soil chemistry model results	125	115	110	105	100	95
Liming costs to restore base cation ratios	**125**	**115**	**110**	**105**	**100**	**95**

2.3.5.3 Valuing recreational losses due to acidification and contamination of forest soils [35]

Acidification of soils can locally cause soil contamination. Soils, which contain heavy metals, harmless if immobile, but potentially very harmful if mobilised, can start to leak mercury and cadmium if the pH-level in the soil water gets low enough. Toxic metals can start circulating in the ecosystem and accumulate in the food-web as grazing animals eat plants that have absorbed metals. The mobilisation of heavy metals, due to acidification, could pose a threat to animal health, and consequently to human health if the consumption of locally hunted game and fish is high. Up to a quarter of the Swedish forest area have local problems from high heavy metal-concentration in berries, mushrooms and game.

Heavy metals are also spread through the use of fertilisers, air pollution and leakage from waste deposits, but the areas involved are small. Less than 1% of the Swedish forests are considered contaminated through these channels.

The effects from the Chernobyl accident in 1986 can be seen in plants and game locally. Three percent of Sweden's forests are considered cesium-contaminated.

The entire contaminated forest area exceeds 5% of the total Swedish forest area. Contaminated areas can not serve all its potential recreational purposes, either because the ecological living condition have changed or because the goods provided by the forest ecosystem are no longer suitable for consumption. Recreational value could be negatively affected by ecosystem changes not as drastic as soil contamination leading to health risks, as well. Hence, if it had not been for the contamination and acidification of soils, the recreational values presented in Section 2.3.4.1 could have been at least 5% higher, i.e. the annual recreational loss due to soil degradation should according to this line of thinking be valued at least Euro Mill. 150, possibly twice as a large part of the Swedish forest soils suffer from acidification and not only the 5% being described in more depth above.

A Swedish CV-study [36] (from 1995, published in Ahlroth 2000) about the WTP to halt acidification can also be used to value the recreational loss from

[35] The estimation of contaminated forest areas are from SEPA (1993)

forest acidification. According to the CV-study Sweden's population was willing to pay Euro Mill. 300 a year for a program that would eventually halt forest acidification. Assuming that the qualitative degradation caused by acid deposition is proportional to the exceedence of critical loads concerning acid deposition; i.e. following the same trend as in Table 2.14 and 2.15, the cost of recreational values lost can be calculated for the years 1987-1999. The rationale behind the decreasing WTP is that the exceedence decreases, which means that not as much additional money has to invested to close the exceedence gap, the amount of acid deposition surmounting the critical load.

Table 2.16: Loss of Forest-Related Recreational Values, due to Acidification and Contamination of Forest Soils: Mill. of Euros.

	1987	**1991**	**1993**	**1995**	**1997**	**1999**
WTP to halt forest acidification	360	330	315	300	285	270

2.3.6 Valuing quantitative changes of the Swedish forest ecosystem area

Forest land is continually exploited, e.g. through urban expansion, causing loss of forest ecosystem production capacity. Converting agricultural land to forest land, or the other way around, on the other hand, does not change the area on which photosynthesis, i.e. biological production, can take place, but only moves that capacity between different sectors.

The location of most building projects in Sweden is in densely populated areas, i.e. Southern Sweden's mostly agricultural parts. That means that at least as much agricultural land as forest land is exploited, even if less than 10% of all Swedish land is agricultural, while some 60% is forested. Every year a couple of thousand hectares (ha) are converted from productive land, where photosynthesis would otherwise have occurred, into biologically sterile land [37]. GDP is affected as some forestry and agricultural production is lost. Some more profitable economic activities will substitute for agriculture or forestry, creating value added that enters GDP. The conversion of productive land usually entails the loss of photosynthesis for many decades, even centuries. The conversion renders society a permanent opportunity cost, as productive capital is eroded [38]. The solar driven production of renewable resources and energy are the only economic activities continuing without human participation. Self-regenerating capital is destroyed as fertile land is transformed into infertile land. Land rents are lost for many years to come [39]. In this study the exploited hectares of forest land are valued at half the price of average Swedish agricultural land. The reason is that in recent years, marginal agricultural land, that is worth less than average agricultural land,

[36] The question asked in the CV-study was how much a person would be willing to pay annually through the tax system, to secure that the deposition in Sweden fell below critical load, thereby giving the forest ecosystem a chance to recover.
[37] Statistics of Land Use in Sweden (1998).
[38] The estimation of contaminated forest areas are from SEPA (1993)
[39] The scarcity value of land for locational purposes can be much higher than the land rent, but locational value does not add to resource generation.

has been converted to forest land. To use average forest land prices, which are harder to come by, would also be misleading as most exploitation of forest land takes place in southern Sweden, where land is more productive than the Swedish average forest land, due to climatic factors.

Each year, during the last two decades, 700 hectares of forest land, worth Euro 2000 per ha, summing up to Euro Mill. 1.4 , is lost to urbanisation. That value is a low estimate of the value of the loss of continued photosynthesis, as it only incorporates the private gains from land. Many other public goods, including life support services, e.g. pollination services and waste degradation through the ecological cycles, are lost, but the values of these services are too difficult to try to evaluate in monetary terms.

On the other hand, the forest area increases as agricultural land at present is converted to forest land more rapidly than forest land is built upon. Each year, almost 9000 ha are converted to forest land through natural regeneration or plantation. That conversion increases the total value of forest land by Euro Mill. 18 annually. However, as one photosynthesis area, agricultural land, is converted to another, forest land, no land rents are won. The value of forest land increases on behalf of agricultural land. If the new land use is more productive, the economy would gain from the conversion, but during the last few years, the conversion has been caused by EU agricultural subsidies, which makes it doubtful whether there are any socio-economic gains from the conversion process.

Table 2.17: Value of Quantitative Changes in Forest Land Area: Mill. of Euros

	1987	1991	1993	1995	1997	1999
Forest land lost to urbanisation	-1,4	-1,4	-1,4	-1,4	-1,4	-1,4
Agricultural land converted to forest land	18	18	18	18	18	18

2.3.7 Valuing negative external effects on the forestry sector

Tropospheric (ground) ozone, which is known to damage agricultural crops, does harm to tree species, as well. Experiments with young spruce, exposed to Swedish ozone concentration levels, showed a bio-mass loss of 5% after four years. This can be transformed to a loss of 10% of stem-wood at harvest, if ozone is assumed to offset growth during the whole life-time of the tree. A 10% production loss of stem-wood in the southern part of the country, where one third of the timber production volume-wise is exposed to ozone-concentrations high enough to cause damage, has a value of approximately

Euro Mill. 80 annually [40]. The forestry loses this value annually while the polluter, the emitter of nitrous oxides and volatile organic compounds, which convert to ground ozone in sunlight, causing the problem is not charged anything. A redistribution exercise, according to the "polluter pays principle", would raise forestry income, but not GDP, as other sectors would have to pay out Euro Mill. 80.

Table 2.18: Timber Income Lost, due to Ground Ozone: Mill. of Euros.

	1987	1991	1993	1995	1997	1999
Ozone damage on timber growth	80	80	80	80	80	80

2.3.8 External effects caused by the forestry sector

External effects from the forestry sector are difficult to calculate as problems downstream from forestry areas partly are blamed on other sectors emissions of nitrogen, causing both eutrophication and acidification, and sulphur, adding to acidification. The nitrogen and sulphur deposited on forest soil can explain many of the environmental problems that the forestry sector seems to cause, mostly in fresh-water ecosystems. Nitrogen saturated soils leak nitrogen to downstream watersheds, especially if the harvesting methods are not designed to minimise the leakage. Thus, groundwater basins, streams, lakes and finally the oceans, can be affected by the nitrogen leakage from forest soils. The acid substances also flow downstream from forest soils to watersheds. The total cost of production losses of fish is calculated to be Euro Mill. 15 annually, due to eutrophication (Brann 1996). Groundwater acidification causes costs of the same magnitude, as filters have to be installed and maintained in private wells (NIER 1998:2). Welfare losses, including loss of the recreational fishing, caused by lake and sea eutrophication and lake acidification amount to Euro Bill. 1 (NIER 1998:9), of which the forestry sector's own negative external effect, its contribution to acidification and eutrophication, is one of many contributors. Science has not yet been able to determine how large the contribution to these problems the forestry sector is responsible for. The silvicultural methods play a role, but so does the acid and nitrogen deposition on forest soils, which the originally emitting sectors should be responsible for.

At this moment the external effects caused by the forestry sector will be kept outside the monetary forest accounts, due to insufficient data on the forestry contribution to the acidification and eutrophication problem of waters.

[40] Given that the ozone levels (numbers of episodes with high ozone concentration) in air have not changed much during the last decade, which they do not seem to have been doing according to the measurements done (Skärby 1999). In Section 2.3.5.2 the effects from acidification on timber growth, which according to the model already may have started, were valued at Euro Mill. 75 in 1997. Thus, the Swedish timber production could have been Euro Mill.155 higher in 1997 if it had not been exposed to damaging concentrations of ground ozone and acidification, or if other sectors, causing the problems, would have compensated the forestry sector according to the "polluter pays principle".

2.3.9 Possible long term environmental threats having an impact on forest ecosystems

Almost all environmental problems affect forestry and the forest ecosystems directly or indirectly. Most environmental threats have been treated one way or the other in the Sections above. However, the depletion of stratospheric ozone (the hole in the ozone layer), the possible effects of climate change, and the possible future imbalances of soil nutrients will be elaborated on below, as they might have long term impacts not mentioned above.

2.3.9.1 Possible effects on forest ecosystems from increased ultraviolet radiation due to a thinner ozone-layer

Increased ultraviolet radiation is believed to damage all biological structures. Especially (ocean) alga species are thought to be sensitive, but also the leaves and needles of plants might be affected, as might be the skins of animals and humans. There are now two ozone holes (thinning of layers), one above each pole, and the northern one uncovers part of Scandinavia to radiation, when hole is maximal. The effects from an increasingly larger ozone-hole, if the present measures to halt emissions of ozone-depletion substances are not enough, will include decreasing productivity and biodiversity in the forest ecosystem.

2.3.9.2 Possible effects on forest ecosystems from projected climate change

The Intergovernmental Panel on Climate Change has recently presented a new report (IPCC 2001) on how the increasing concentration of greenhouse gases in the atmosphere could affect the future climate. In Sweden, researchers try to transform the global climate predictions into regional ones (Sweclim, 2000). The predicted increasing temperatures in Scandinavia, 2-4 degrees (Celsius) in a hundred years time, prolong the cultivation season by up to a month in both ends. Increasing precipitation will also promote growth in almost all areas in Sweden. Only in the dry Southeastern parts the evaporation will increase more than the precipitation, making water scarcer than today, in dry summer months. Altogether, timber growth is predicted to increase nationally by 20%, and by as much as 40% in the Northeast, while in the dry Southeast the changes will be small. On average, the Swedish forest sector will gain from climate change, if the present projections hold and no negative surprises, such as those mentioned below, will dominate the positive effects.

Possible threats from a warmer, windier, and more humid climate include:

- an increase in existing pests, e.g. insects and fungi, and new ones entering the county from the South,
- increased wind falls,
- the question how existing plants, living on their climatic borders, e.g. spruce in southern Sweden, will cope with the changes. Forest owners can plant new suitable species on their land, but what will they do with standing forests, increasingly more unsuitable for the “new”, warmer, windier and more humid climate?

All of these threats increase the risks the individual forest owner runs. Expected income will probably increase, but so will the variability, and this may call for new insurance solutions. Forest owners might encounter increasing management costs and possibly or need to prematurely harvest forests, which can be costly as timber income is dependant on timber dimensions (age).

There could also be negative effects on biodiversity, as sensitive plants and animals, living in slowly moving or locally disappearing ecological niches, may not be able to "move along". The local forests will not look the same as they did before, as the climatic factors shaping their surroundings move North. This could be regarded as positive as the broad-leaved species, appreciated by recreationers, will be found further North. Visiting one's childhood forest may require travelling North, which for cultural, homebound reasons probably will be considered a welfare loss.

Forests may play a central role in fighting climate change, as one of the possible substitutes for fossil fuels is bio-mass. To live up to the Kyoto protocol, and coming protocols, the burning of fossil fuels has to decrease. One way of achieving this is to increase the use of bio-mass in the energy sector. In 1999, 84 TWh of the 630 TWh energy totally supplied in Sweden, came from bio-mass. Calculations (SAME 1997) show that it is possible to increase the supply of bio-mass to the energy sector by 35-55 TWh, without threatening the timber supply and the biodiversity.

2.3.9.3 The development of the Swedish forests' soil-nutrient capital[41]

The present lack of recirculation of nutrients and the loss of base cations, due to acidification, could cause nutrient imbalances in the forests soils in coming centuries, if not proper measures to halt the nutrient losses are taken. During the 20th century, the annual timber growth in Sweden has almost doubled, partly due to intensified silvicultural management. In the short run, nitrogen deposition also acts as a growth promoting fertiliser, while the long term effects, including acidification and nitrogen saturation, might be troublesome. The increased propensity to make use of whole trees, not only the stems, at the harvest, is the third factor behind the increase in the amounts of nutrients leaving the forests. These nutrient losses have to be compensated for somehow, so as not to risk impaired future timber growth. One way to bring back the nutrients lost could be to spread ashes, or other fertilisers, containing the elements necessary to sustain forest productivity. The only other supplier of nutrients to the soil is the weathering from rocks. According to soil studies this supply, and atmospheric deposition, will be insufficient to meet the uptake necessary to maintain timber growth in some parts of Sweden in the coming centuries, and in some locations as soon as in the coming decades. One explanation to the recent death of oak and beech trees in southern Sweden is supposedly nutrient imbalances. The recipe for soils, compatible with sustainable forestry, contain i.a. decreased deposition of nitrogen and other substances contributing to acidification, a better husbandry of existing soil nutrients through e.g. harvesting rules, recirculation of nutrients, and adapting the intensity of forestry to the local soil conditions.

[41] SUFOR 1999

2.3.10 Measures to increase overall forestry efficiency

In the Swedish Natural Resource Commission Report (SCR 2001:2) the Swedish forestry sector was analysed from a forest-usage perspective, where conflicts between different forest-uses were in focus. How could the overall efficiency of Swedish forests increase, contributing even more to overall welfare by combining the goals of timber production with the goals of binding carbon, promote recreational values and to supply reindeers with lichen?

In Sweden, which is largely forested, it is not primarily afforestation that is the most important measure to sequester more carbon. Instead, the primary option is to increase the amount of bio-mass (carbon) per hectare of standing forest, as has been discussed in Sections 2.3.3.4 and 2.3.9.2. The Swedish Commission on efficient natural resource use (SCR 2001:2) discusses that the efficient rotation period, especially in low-productive northern areas, would be longer, if carbon-binding would pay as much as carbon-emission cost, i.e. the carbon tax rate. Still, one has to remember that building up the carbon stock in standing forests is a one-time gain, because when old forests reach a certain age, they do not increase their bio-mass anymore, i.e. they do not sequester any more carbon. At that stage the forest might have other values, e.g. promoting biodiversity, but from a carbon-sequestration perspective, the wood is best put to use in the economy, e.g. in the energy sector, substituting for fossil fuels, while other, still growing forests, can be kept unharvested, sequestering carbon.

In the slow-growing forests in northern Sweden, where reindeer are bred, a study (SCR 2001:2) of the co-production of timber and lichen also shows that longer rotation periods is a more economically efficient alternative. The reason is that lichen production depends on older trees. To get maximum value from the forests of northern Sweden, they should be managed in a way that maximises their co-production capacity.

Forests near urban areas, especially in the relatively densely populated areas in southern Sweden, possess the maximum recreational value. Among these “urban” forests, open, rather old, mixed tree-species-forests are the most valuable. A study (Mattson and Li, 1993) shows that forests, managed to please recreational activities, were worth four times as much as the worst managed forests. Hence, to prolong rotation periods near urban areas, and generally managing them so as to promote recreation, i.e. keep them open and mixed, could be another way to by which at small costs, more societal value could be extracted from forests.

2.4 Concluding remarks

Many different forest accounts, and forest ecosystem production measures, can be constructed from the material presented in Section 2.3, depending on:

- Which aspects (timber, forest co-production capacity, …) one wants to focus on,
- Which valuation methods one feels comfortable with,
- If the purpose is to analyse the socio-economic importance of the forestry (ecosystem) sector as a part of the Swedish economy: i.e. to

bring all forest-related SNA and non-SNA items, wherever they appear at the moment, into the accounts.

- If the purpose is to discuss possible efficiency gains (cost-benefit analysis) in the forestry (ecosystem) sector ; i.e. discuss production measure improvements, no matter under which heading (forestry, agriculture, tourism) they appear.

The accounts and production measures will have to be constructed differently when it comes to scope (what is included), valuation methods used and aggregation level (aggregated GDP-level, or disaggregated into different economic sectors, or even goods: timber, non-wood goods, forest services). Table 2.19 present the Swedish forest accounts, summarising the items presented in Sections 2.3.1-6 into three subtotals, which can be added upon preference. The results from sections 2.3.7-10 are commented on separately.

Subtotal 1 comprises timber values and non-wood goods. Except for the rather small volumes of household production of berries and mushrooms, subtotal 1 consists of SNA values; i.e. the values that add up to GDP or somehow appear in the System of National Accounts. In subtotal 2, the value of forest services is presented, of which all items are non-SNA values, even if the carbon sequestration could also be presented as the stumpage value of the change in the timber stock, which would turn it into a SNA-value. Subtotal 3 comprise stock changes related to forest area changes, soil chemistry, biodiversity, and berry and lichen production capacity. The forest area is included in the SNA stock accounts, as a part of the wealth of a nation, while the others are non-SNA stock changes.

Table 2.19: Total Value of Swedish Forests: Mill. of Euros

	1987	1991	1993	1995	1997	1999
Value of timber harvest[42]	2050	2080	2180	2540	2430	2370
Total value of non-wood goods	277	273	249	233	223	225
Subtotal 1 (forest goods)	**2327**	**2353**	**2429**	**2743**	**2663**	**2595**
Value of forest services:						
Recreation[43]	2370	2370	2370	2370	2370	2370
Protection of soils + noise[44]	20	20	20	20	20	20
Carbon sequestration[45]	810	1050	930	630	750	810
Subtotal 2 (forest services)	**3200**	**3440**	**3320**	**3020**	**3140**	**3200**
Changes in natural capital stock:						
Non-wood capital	-65	-65	-65	-65	-65	-65
Biodiversity	-230	-200	-190	-180	-170	-160
Chemical soil quality	-125	-115	-110	-105	-100	-95
Forest area	17	17	17	17	17	17
Subtotal 3 (stock changes)	**-403**	**-363**	**-348**	**-333**	**-318**	**-303**
Sum of subtotal 1+2+3 (Value of goods+ services+stock changes)	**5124**	**5430**	**5391**	**5430**	**5485**	**5492**

The net national product of the forest ecosystem's production capacity shows a rather stable trend. The recreational value is the single most important item. The visiting frequencies, and hence the value, do not show any changes over time. The second largest item, the timber harvest, seems to be increasing slowly. The third largest item, the carbon sequestration, is proportional to the growing timber stock. However, only one of these two possible valuations

[42] The value of the timber harvest could have been Euro Mill. 80 higher annually if it had not been for the damage caused by ground ozone.

[43] The value of recreation could have been Euro Mill. 360 in 1987 and Euro Mill. 270 higher in 1999, if it had not been for acid deposition and acidification-related problems.

[44] Forestry affect downstream watershed (Section 2.3.8), probably to a greater extent than it protects agricultural soils and residential areas. That fact would turn up as a cost if the polluter pays principle would be used bilaterally.

[45] To avoid double counting, the value of the timber stock is taken out of the accounts, as the increased timber storage is valued at the carbon price, exceeding the timber price with 30%. Timber stock changes could have been accounted for either as timber production not yet harvested in subtotal 1,or as a stock change in subtotal 3. That could be the case if e.g. the carbon sequestration price would have been less preferable, or if production services were not to be included in a more limited version of forest accounts.

can be accounted for. Using the timber stock as a carbon sink prohibits logging and the other way around. Here, the carbon sequestration value is presented, as the carbon price exceeds the stumpage value. Concerning the natural capital stocks, biodiversity, chemical soil status and loss of non-wood production capacity contribute negatively to the result. However, the capital depreciation seems to be slowing down, thanks to environmental policies. Still it is worrying that capital seems to be eroding. What if these negative stock changes prove to be more important than the valuations indicate – and what if one adds on the long term environmental threats?

The value of harvested timber will probably increase, due to better management methods, the expected positive impact of climate change and the fact that the timber stock will reach its maximum in a few decades, which will enforce larger logging volumes. Nutrient imbalances and potentially increased ultraviolet radiation will partly offset the positive effects. Non-wood goods production will suffer not only from the ongoing negative trend, but also from nutrient imbalances and especially from climate change, which might hurt the reindeer/lichen production severely. The carbon sink will probably reach its peak before 2050 and not contribute positively to the forest accounts after that. Recreation will hopefully continue to be important in the decades and centuries to come. Hopefully, policies performed to halt biodiversity loss and acidification will have succeeded, helping up the situation also for non-wood capital. Efficiency gains concerning carbon sequestration, lichen production, managing “urban” forests to promote recreational values, but also halting acidification, and ground ozone creation, could possibly raise both timber production and recreational values, increasing total forestry income and Swedish GDP.

References

Ahlroth, S, [2000], Correcting Net Domestic Product for Sulphur Dioxide and Nitrogen Oxide Emissions: implementation of a theoretical model in practice, Swedish National Institute of Economic Research (KI), working paper No 73, Stockholm (or report 121 from the Swedish University of Agricultural Sciences, Department of Forest Economics, Umeå).

Azar, C, Sterner T, [1996], Discounting and Distributive Considerations in the Context of Global Warming, Ecological Economics 19, p 169-185.

Brann, K, Ahnér, E, [1996], Fish - an Environmentally Threatened Natural Resource, (In Swedish, Fisk - en miljöhotad naturresurs), NIER/Konjunkturinstitutet, Stockholm.

Binkley, D, and Högberg, P, [1997], Does Atmospheric Deposition of Nitrogen Threaten Swedish Forests?, Forest Ecology and Management, 92, 119-152.

Boman, M, Kriström, B, [2001], World Forests, Markets and Policies, ed. Palo, M, Valuing the Multiple Functions of Forests, Kluwer Academic Publishers, The Netherlands.

Chichilnisky, G, Heal, G, [1998], Economic Returns from the Biosphere, Nature, Feb 1998.

Dickson, W, Svensson, T, [2000], Liming in the 21st Century (in Swedish: Kalkning på 2000-talet), Report 5086, Swedish Environmental Protection Agency, Stockholm.

Eliasson, P, [1994], Environmentally Adjusted National Accounts for the Swedish Forest the Years 1987-1991, (In Swedish, Miljöjusterade nationalräkenskaper för den svenska skogen åren 1987 till 1991), Swedish University of Agricultural Sciences, Department of Forest Economics, Report 108, Umeå, Sweden.

Haasund, K P, [1986], Arable Land Resource Economics, (In Swedish, Jordbruksmarken i naturresursekonomiskt perspektiv), Swedish University of Agricultural Sciences. Uppsala, Sweden.

Hansson, L [1994], Valuation of Traffic Noise, (in Swedish, Värdering av trafikbuller), IIIEE, Lund Sweden.

Hartwick, J M., [1990], Natural Resources, National Accounting and Economic Depreciation, Journal of Public Economics 43, pp.291-304, North-Holland.

Hoffren, J, [1997], Finnish Forest Resource Accounting, Statistics Finland, Helsinki

Hultkrantz, L, [1991]. National Accounts of Timber and Forest Environmental Resources in Sweden. Environmental and Resource Economics 2(1): 283-305.

Hörnsten, L and Fredman, P, [2000]. On the Distance to Recreational Forests in Sweden. Landscape and Urban Planning (in press).

IPCC, homepage: www.ipcc.ch

Johansson, L, Ed, [1993], Does the Forests Need Intensive Care?(In Swedish, Behöver skogen intensivvård?) FRN Källa 42, Swedish Council of Planning and Coordination of Research, Stockholm

Johansson, O, [1995], External Cost of Road Transport in Sweden, in Pearce et al Blueprint 5: The true cost of transport, Earthscan , UK

Johansson, P-O, [1990], Willingness to Pay Measures and Expectations, Applied Economics, 22, 313-329.

Jämttjärn, J, [1996], The Swedish Forest's Recreational Value, (In Swedish, Svenska skogens rekreationsvärde), NIER/Konjunkturinstitutet, Stockholm

Kriström, B, [2000]. Valuing Forests, Forthcoming in Chichilnisky, G. & P. Raven Managing Human-Dominated Ecosystems, MBG Press, St Louis.

Liljelund, L-E, et al, [1992], Forestry and Biodiversity, (In Swedish, Skogsbruk och biologisk mångfald, Botanisk tidskrift 86, 227-232

Lindhagen, A, Hörnsten, L, [2000], Forest Recreation in 1977 and 1997 in Sweden: changes in public preferences and behaviour. Forestry 73 (2), 143-153.

Long Term Survey [1999], Main Report and Supplement 2, The Environment and the Economy, Swedish Ministry of Finance, Stockholm

Mäler, K-G, [1991], National Accounts and Environmental Resources, Environmental and Resource Economics 1, pp 1-15.

Mattsson, L. [1990], Hunting in Sweden: Extent, Economic Values and Structural Problems. Scandinavian Journal of Forest Research 5(4): 563-573.

Mattsson, L. and Li, C-Z, [1994], How do Different Forest Management Practices Affect the Non-timber Value of Forests? - An Economic Analysis. Journal of Environmental Management 41: 79-88.

National Board of Agriculture, homepage: www.sjv.se

National Board of Forestry, homepage: www.svo.se.

NIER and Statistics Sweden, [1998], SWEEA - Swedish Environmental and Economic Accounts 1998:2, (In Swedish, Svenska miljöräkenskaper - En lägesrapport från Konjunkturinstitutet och Statistiska Centralbyrån, Miljöräkenskapsserien 1998:1, Statistics Sweden and NIER/Konjunkturinstitutet, Stockholm

NIER, [1998], Swedish Environmental Accounts for Sulphur and Nitrogen and The Costs for Nitrogen Emission in Sweden, (In Swedish, Svenska miljöräkenskaper för svavel och kväve och Sveriges kostnader för kväveutsläpp), Miljöräkenskapsserien 1998:9. NIER/Konjunkturinstitutet, Stockholm.

Nordhaus, W, Tobin, J, [1973], Is Growth Obsolete?, Review of Income and Wealth, vol.38, New York,: National Bureau of Economic Research.

Perrings, C, [1994], Biotic Diversity, Sustainable Development and Natural Capital, Ed Jansson A-M, Investing in Natural Capital, Island Press, N.Y.

Peskin, H, Delos Angeles, M, [1996], “Environmental Accounting as Instrument of Policy: The Philippine Experience”, Papers of IARIW [1996], International Symposium on Integrated Environmental and Economic Accounting in Theory and Practice, IARIW, Economic Research Institute, Economic Planning Agency and Government of Japan, Tokyo.

Repetto, R., McGrath, W., Wells, M., Beer, C., and Rossini, F., [1989], Wasting Assets: Natural resources in the national income accounts, World Resources Institute, Washington D.C.

SAME [1999], Sustainable Energy Future?, (In Swedish, Hållbar energiframtid), Report from The Swedish EPA, Stockholm

Skånberg, K, [1994], A Calculation of the Costs of Damage due to Forest Acidification, (In Swedish, En beräkning av skogsförsurningens skadekostnader), NIER/konjunkturinstituet, Stockholm.

Skärby, L., Selldén, G., Wallin, G., Karlsson, P.E., Sutinen, S., Ottosson, S., Medin, E.L., Räntfors, M, [1999] Effects of Ozone on Forests. In: Ground-level ozone - a threat to Vegetation (ed. Pleijel H). Report 4970. Swedish Environmental Protection Agency, Stockholm.

Statistics Sweden, database, Foreign Trade Statistics, homepage: www.scb.se

Statistics Sweden, [1992], National Wealth and Stocks of Fixed Assets, Stockholm

Statistics Sweden, [1998], Land Use in Sweden, (In Swedish, Markanvändningen i Sverige), Stockholm

Statistics Sweden, [1999], Forestry Accounts in Physical Terms, (In Swedish, Fysiska Skogsräkenskaper), Stockholm

Statistics Sweden, [2000], The Natural Environment in Figures 2000, Stockholm

SUFOR [2000], Swedish Forestry in Southern Sweden, Annual Report 1999, a MISTRA-funded program run by the Department of Plant Ecology at Lund University, Sweden

SCR [2000:23], Swedish Governmental Commission Report, SOU 2000:23, A Swedish Strategy on Climate Change, Stockholm

SCR [2000:45], Swedish Governmental Commission Report, SOU 2000:45, Flexible Mechansism, Stockholm.

SCR [2000:52], Swedish Governmental Commission Report, SOU 2000:52, Targets to Secure the Environment of the Future, Stockholm.

SCR [2001:2], Swedish Governmental Commission Report, SOU 2001:2, Natural Resource Efficiency, Stockholm.

Sverdrup, H, Warfvinge, P, [1994], Assessment of Soil Acidification Effects on Forest Growth in Sweden, Water, Air and Soil Polution 78:1-36.

SWECLIM, Swedish Regional Climate Modelling Programme, [2000], Annual Report 1999, Norrköping, Sweden

Swedish EPA [1993], The Nordic Environment – State, Development and Threats, Monitor 13, Swedish EPA, Stockholm

Tyrväinen, L, [1999], Economic Estimates of Urban Forests: Comparison of Economic Estimates, in The Living Forest: Non Market Benefits of Forestry. Forestry Commission, The Stationary office, London.

Vincent, J. and Hartwick, M. [1997]. Forest Resources and the National Income Accounts: Concepts and Experience. FAO, Rome.

Vincent, J, [1999], Net Accumulation of Timber Reserves, The Review of Income and Wealth 45, 251-262

Wilhelmsson, M, [2000], Traffic Noise and Property Values, dissertation, Stockholm Royal Institute of Technology, Stockholm.

Wilhelmsson, E, [1989], Model and Reality, Report 48 from the Department of Forest Forecasting, Swedish Unviersity of Agricultural Sciences

Wibe, S, [1994]. Non-Wood Benefits in Forestry - Survey of Valuation Studies. Swedish University of Agricultural Sciences, Department of Forest Economics, Working Report 199. Umeå.