DANMARKS
STATISTIK

Danish Forest Accounts 1990-2001

Ismir Mulalic

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Summary

The goal of the Danish government is to double the Danish forest area in a tree generation starting from 1989. At the end of 2001, the Danish forest area was 481 thousand hectares, which is a rise from 1990 of 33 thousand hectares. The afforestation will on average have to increase in the following years, if the goal of doubling the wooded area of Denmark within a tree generation is to be reached, that is within a period of 80 to 100 years counting from 1989. We have presented a physical balance for the forest area of Denmark for the period from 1990 to 2001. The balance sheet rests heavily on the forest census of 2000 along with the forest census of 1990. From 2002, a new sample-based National Forest Inventory has been launched, which will replace the Forestry Census. For the years in between the balance rests on measures on afforestation made by the Danish Forest and Nature Agency along with assumptions made about afforestation by private forest owners who are not recipients of state funding. The Danish forest is measured to 11.3 percent of the total Danish land area in 2000, and total forestry industry made up only about 1.0 percent of the total production in the economy and about 4.3 percent of the manufacturing industry. The forests give a production value of almost 15 billion DKK to the Danish economy. In other words, the total forestry industry accounts for about 1.0 percent of the total production in the economy and about 4.3 percent of the manufacturing industry. Christmas trees account for about 2.0 billion DKK of the forestry industry production value and ornamental branches made up about 31 percent. The Danish forest area is estimated to have a value of 11.9 billion DKK at the end of 2001, which is 1.4 billion DKK more than the estimated value of forest land in 1990, a rise of 12.8 percent in the period. This rise over such a long period can be explained by the fact that the land values in the tax assessments have fallen both as a percentage of the total forest value in the period and absolutely. The values have been estimated using the physical data from the physical balance sheet for land and a combination of actual transactions of forests and the tax assessment values of forests.

On the basis of information from the forestry censuses of 1990 and 2000, as well as numbers from a new sample-based National Forest Inventory, the volume of standing timber has been estimated to be 80 million m^3 at the end of 2001 – a rise of 13 million m^3 or 20 percent since 1990. If this rate of rise keeps up – the volume of timber will double much faster than the area of forests. Part of this rise in the volume of standing timber was lost during the hurricane of 1999. This can be seen in the balance sheet for 2000 where the volume of standing timber actually declined. In 2001, however, the volume of standing timber is rising again. For the valuation of the timber the stumpage value was used. The value of standing timber is estimated to about 14.3 billion DKK by the end of 2001.

The standing stock of wood was 79.6 Mm^3 ultimo 1991. This stock of wood was equivalent to 27535 tonnes C or 98419 tonnes CO_2. Wood volumes are converted to carbon stores by multiplying with conversions factors. Assuming that all Danish forest soil is well drained, it can be concluded that total CO_2 storage in Danish forest soils is about 220 millions tonnes. However, this number is undervalued because an essential part of Danish forest soils are bed drained swamps, etc. In these forest soils, there exists actually far more CO_2 storage because of lack of oxygen. Unfortunately, total carbon balance for the Danish forests ecosystem cannot be calculated, because data on carbon storage in 'other biomass' and 'other biomass in forest' does not yet exist in Denmark.

Forests are the most popular recreation and leisure areas in Denmark. About 90 percent of the adult Danish population spent time in the forest at least once a year. A typical Dane visits forest about 10 times a year and average visiting time per visitor was 1.55 hours. Most Danes visit forests for the purpose of enjoying the nature or walking. The transport time has decreased by 10 percent from 1976. The average transport distance dropped as well. According to several examination the recreational value of Danish forests is about a half billion DKK per year.

The data situation for areas with protective functions is not very good at the moment, but we can expect more data in the near future because of new sample-based National Forest Inventory. The hurricane in 1999 had an impact on groundwater. 4 percent of Danish forest area had been destroyed by the hurricane. It can be expected that groundwater will be negatively impacted in the 5 years after the hurricane on this area. 34000 ha forest in Denmark to protect land from sand drift and another kind of erosion has been established.

A new sample-based national forest inventory has been launched which will replace the Forestry Census. Preliminary results from sample-based national forest inventory may be obtained from 2004, but complete sample-based national forest inventory will be complete in 2006. Future work on this field is dependent on the new sample-based national forest inventory. However, it is possible to establish several balances on an annual basis. They are: forest balance for the area of wooded land, forest balance for volume of standing timber and monetary balances analogous to these two balances. We can also establish IEEAF tables with three year difference; also in 2004 we will be able to establish IEEAF tables for 2001. Total carbon balance for the Danish forest ecosystem can not be calculated, because data on carbon storage in other biomass and other biomass in forest does not yet exist in Denmark. These series are expected to be available from sample-based national forest inventory. This will probably

make it possible to calculate total carbon balance for the Danish forest ecosystem. It is not possible to establish tables for recreational areas of forest and tables for forest protective functions on an annual basis. Data on these fields is not yet produced on an annual basis. Future work on this field is depending on the new sample-based national forest inventory. Future possibilities for economic analysis will increase with introduction of this new forest inventory.

We have now established principles and methods for compiling physical and monetary balance sheets for the area of forests and for the volume of standing timber. Accounts for carbon balance in Danish forests, recreational areas of Danish forests and Danish forest protective function were presented as well. Some of the methods used for building up the forest accounts rest heavily on the forest census, while other methods can be used in between years with a census.

1. Introduction

This report is a follow-up to the report on Danish forest accounts presented to Eurostat in the fall of 2002. In that report, physical and monetary accounts for Danish forests were presented. The accounts were presented for the years 1990 to 2000, and specific tables (the IEEAF[1]-tables) were presented for 1998. In this report, focus is on 2001 and the possibility of building up a system for annual forest accounts. In addition to presenting physical and monetary accounts for forests, this report deals with non-ESA/SNA functions[2] of forests, specifically a carbon balance for standing timber is presented, and changes in the stored carbon in the forest ecosystem are examined. Forests and other wooded land with protective functions and the recreational functions of Danish forests are examined as well.

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In section 2, we establish both physical and monetary accounts for the forest area. The section starts with a presentation of the Danish forest area, different definitions and available data. We also look at the development in the forest area, from 1990 to 2001. A physical balance sheet for forested area in Denmark is presented for the same period. The monetary accounts for forest area are established as well. The result of the valuation is presented in monetary balance sheet for forested area.

Section 3 presents physical and monetary accounts for the volume of standing timber. Volume of standing timber is described and the changes in this volume due to natural growth and due to fellings. In finishing the description of the volume of standing timber, we present the monetary balance sheet for the volume of standing timber.

In section 4, we calculate total forest value for Denmark. Beside pure calculation we also discuss different problems in connection with forests valuation in Denmark.

Section 5 shows accounts for carbon binding. The section starts with presentation of the carbon storage in standing timber. The possibilities for establishing of accounts for carbon stored in the forest ecosystem are discussed as well.

In section 6, accounts for recreational areas of Danish forests are presented. We look at many aspects of forests recreational areas, and finish the description with the presentation of an estimated value of the Danish forest recreational areas.

Section 7 presents accounts for forest protective function. We look primarily at the relationship between forests and groundwater protection and protection from erosion.

In section 8, we present most important results in the form of the IEEAF (*The European Framework for Integrated Environmental and Economic Accounting for Forests*) tables for 1999 that are to be reported to Eurostat on a regular basis. These tables give the physical forest balance sheet for the area of wooded land and for the volume of standing timber and the corresponding monetary balance sheets. Following this, data on the health of trees in Danish forests are presented. Subsequently, tables with economic accounts for forestry and logging are presented. At the end of Finishing this section is a sequence of tables presenting physical and monetary supply – use tables for industries and products related to forestry.

In section 9, we discuss data availability and possibilities for annual production of tables presented in this rapport.

[1] IEEAF : the European Framework for **Integrated Environmental** and **Economic Accounting** for **Forests**

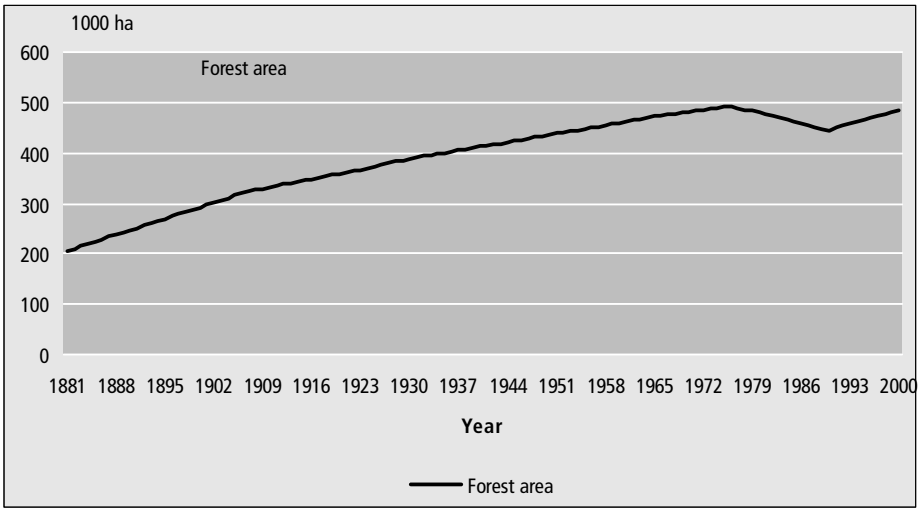
[2] Besides wood and non-wood products recorded in the national accounts forests provide a set of 'free services'. However, these services contribute, directly or indirectly, either to production, or to the welfare of individuals. Some of the non-ESA/SNA functions of forests are: recreational services and aesthetic values, environmental protection and services, pollutant sink or deposition services, cultural values, etc. (Eurostat (1999))

2. The forest land

2.1 The Danish forest

If Denmark was uninhabited, then the land would be covered by forest. Deforestation through millenniums implied that only 4 percent of Danish area was covered by forest in 1800. The Danish government issued in 1781 and 1805 an arrangement about forests, and since then the forest area in Denmark has been increasing.

Figure 1 Forest area, 1881-2000



Source: Forests 1990 and the forestry census of 2000

It can be seen from the figure 1 that the forest area has markedly risen through the period. The forest area has more than doubled from 1881 to 2000.

Denmark has a long tradition of compiling forests statistics at regular intervals. Monitoring of the Danish forest started with the establishment of the National Forest Resources Assessment in 1881. The assessment is carried out approximately every ten years. 10 forestry censuses have been conducted after 1881.

The basis for the physical data presented in this report is the forestry censuses of 1990 and 2000 carried out by Statistics Denmark and the Danish Forest and Nature Agency. The censuses cover all forests in Denmark of 0.5 ha and above, including areas with Christmas trees and decorative greenery, see Statistics Denmark (1994) and (2002).

The forests covered in the Danish forest census comply with the international definitions of forests. The wooded land includes all forests, i.e. wooded areas that now or later will produce trees or other wood products and also fields of Christmas trees and ornamental branches of conifer. The wooded land also includes temporarily uncovered areas (not *other wooded land*), i.e. areas that after felling again will be planted and also areas that have been exposed to forest fires etc.

Denmark, compared to other countries, has a relatively small part of land covered by forest and the Danish forests are only of minor importance in the economy. However, the forested area of Denmark forms a considerable and visible part of Denmark.

The Danish forestry act was introduced in 1989 with the intention to double the wooded area of Denmark within a tree generation, i.e. within a period of 80 to 100 years from 1989. A tree generation varies from species to species. In general, a tree generation for broadleaves is well over 100 years while a tree generation for conifers is less than 100 years.

Box 1: The definition of a forest

The definition of a forest is almost fully harmonised internationally for Eurostat, Integrated Environmental and Economic Accounting for Forests (IEEAF), Food and Agriculture Organisation of the United Nations (FAO), OECD, and United Nations Commission for Europe (UN-ECE). The common definition of a forest is given as follows: "Land with tree crown cover of more than 10 percent and area more than 0.5 ha. Trees should be able to reach a minimum height of 5 meters in maturity. Included are young natural stands and all plantations established for forestry purposes which have not yet reached crown density of more than 10 percent or tree height of 5 m; areas normally forming part of the forest area which are unstocked as a result of human intervention or natural causes but which are expected to revert to forest; forest roads, cleared tracts, firebreaks and other small open areas, as well as forest nurseries and seed orchards that constitute an integral part of the forest; forest in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest; windbreaks and shelter belts of trees with an area of more than 0.5 ha and a width of more than 20 m; and rubber wood plantation and cork oak stands" (see European commission (1999)). The land predominantly used for the agricultural practices is excluded by IEEAF's definition.

Other wooded land with some forestry characteristics is not forest as defined above. Other wooded land includes open wooded land with tree crowns cover of 5-10 percent of trees able to reach a height of 5 m at maturity in situ, or a crown cover of more than 10 percent of trees no able to reach a height of 5 m at maturity in situ and shrub or bush cover; see European commission (1999). Definition excludes areas having the tree, shrub and bush cover specified above but of less then 0.5 ha and width of 20 m, which are classed under "other land" as well as land predominantly used for agricultural practices.

A subdivision of forests into *forests available* for wood *supply* and *forests not available for wood supply* is used in the IEEAF. Forest available for wood supply includes forests where legal, economical or specific environmental restrictions do not have a significant impact on the supply of wood. Forest not available for wood supply includes forests where legal, economic or specific environmental restrictions prevent any significant supply of wood.

The UN report on forest resources in the industrialized temperate countries (called the TBFRA-2000, see UN-ECE/FAO 2000) in addition defines managed forests as forests managed in accordance with formal or informal plans applied regularly over a sufficiently long period (five years and more).

Table 1 shows the area of forests and plantations in Denmark in 1976, 1990 and 2000. There are two columns of forest area for 1990. This is because the forest census of 2000 made it clear that the figures from the forest census in 1990 did not quite cover the whole forest area of Denmark. On the basis of the forest census of 2000, new figures for the forest area have been calculated resulting in the second 1990 column. There is a difference of 29000 ha or 7 percent between the figures for the wooded area from the forest census of 1990 to the recalculated figures for 1990.

In the remaining part of this report, the recalculated figures for 1990 are used where nothing else is mentioned.

The table shows a rise in the wooded area of Denmark of 67000 hectares from 1976 to 2000 or a 17 percent rise in the total wooded area since 1976. Some of this increase is not a result of afforestation, but simply a result of better registration of forests, as was the case for 1990. The greatest rise comes from the area covered with broadleaves while there has been a smaller rise in the area covered with conifers in the period from 1976 to 1990. From 1990 to 2000, the broadleaved-covered area rose from 166 to 174 thousand hectares or 5 percent, while the rise in the conifers-covered area was from 274 to 294 thousand hectares or 7 percent. Conifers account for 62 percent of wooded area, and Norway spruce, Sitka spruce and others spruce account for 56 percent of conifers in year 2000.

Table 1 Forest area by species 1976, 1990 and 2000

	1976	1990[1]	1990[2]	2000
	1.000 hectares			
Total forest area	**493**	**445**	**476**	**486**
Auxiliary areas[3]	87[4]	28	30	13
Wooded area, total	**406**	**417**	**446**	**473**
Temporarily uncovered area	**0**	**6**	**5**	**5**
Broadleaves, total	**137**	**143**	**166**	**174**
Beech	75	72	78	80
Oak	25	30	39	43
Ash	10	10	12	13
Sycamore	5	8	9	9
Other broadleaves	22	23	28	30
Conifers, total	**269**	**268**	**274**	**294**
Norway spruce, Sitka spruce and others	168	170	205	166
Silver fir and other fir	25	34	46	56
Other conifers	76	64	23	72

Source: Forests 1990 and the forestry census of 2000

[1] Figures from the 1990 census.

[2] Figures for 1990 recalculated on the basis of the 2000 forest census.

[3] Auxiliary areas are areas that are not by themselves productive, but are necessary for the forest production (e.g. forest roads, fire belts, storing areas, houses etc.)

[4] After the 1990 census, only auxiliary areas in connection with forestry are included in the total forested area while earlier the temporarily uncovered was part of the total forested area.

The Danish forest is measured to 486 235 hectares[3] or 11.3 percent of the total Danish land area in 2000.

There are many small forests in Denmark and they account for a small part of total forest area, cf. table 2. It can also be seen in table 2 that there are just a few big forests, but they account for most of the Danish forest area. Developments in the picture of forest area by size show that there are more small forests and fewer big forests in year 2000 than in 1976.

Table 2 Forest area by size

	1976		1990		2000	
	number	ha	number	ha	number	ha
	pct.					
Total	100,0	100,0	100,0	100,0	100,0	100,0
0,5- 1,9 ha	41,6	2,1	35,0	1,6	32,2	1,9
2,0- 4,9 ha	30,9	4,9	30,0	4,1	31,5	5,2
5,0- 9,9 ha	12,9	4,5	15,9	5,0	17,6	6,6
10,0- 19,9 ha	7,6	5,3	9,5	5,9	9,6	7,3
20,0- 49,9 ha	4,0	6,2	5,2	7,2	5,4	9,1
50,0- 99,9 ha	1,2	4,3	1,8	5,8	1,5	5,7
100,0- 249,9 ha	1,0	8,6	1,4	10,2	1,2	10,6
250,0- 499,9 ha	0,5	9,1	0,6	10,1	0,5	9,2
500,0- 999,9 ha	0,3	11,0	0,4	11,5	0,3	10,8
1000 ha and above	0,3	44,1	0,3	38,6	0,2	33,6

Source : Danish Forest and Nature Agency

46 pct. of Danish forests area is privately owned forests, and 28 percent are owned by public sector. Joint-stock companies own 26 percent of Danish forest.

[3] The total area of Denmark was 4 309 588 hectares on January 1 2000.

Table 3 Forest area by ownership

	1990		2000	
	1000 ha	pct.	1000 ha	pct.
Total	445		486	
Privately owned forests	202	46	224	46
Joint-stock companies etc.	103	22	125	26
The National Forest and Nature Agency	114	26	113	24
Other public owned forests	26	6	25	4

Source: Forestry census of 2000 and 1990 (not recalculated)

2.2 Afforestation

The stock of forested land may increase because of the establishment of new forests on land which was previously not classified as forested land or as result of silvicultural measures or natural expansion. Total increase in forested land can also be classified as either man-made afforestation (silvicultural measures including planting and seeding) including plantations, or natural expansion resulting from natural seeding, sprouting suckering or layering. Forest renewal by natural or silvicultural measures after clear cutting does not qualify as an increase in forested land. This land remains classified as forested land except when clear cutting is preliminary to putting the land to an alternative use such as agriculture or construction.

Table 4 Afforestation by species and ownership 1990-1999 (incl. Christmas trees)

	Total	Private	Joint-stock companies etc.	Danish Forest and Nature Agency	Other state-owned
	1 000 ha				
Total afforestation	**27,5**	**18,1**	**4,2**	**4,1**	**1,2**
Broadleaved, total	**8,0**	**3,1**	**1,2**	**2,8**	**0,8**
Beech	1,9	0,7	0,2	0,8	0,1
Oak	3,9	1,3	0,7	1,5	0,3
Ash	0,5	0,2	0,1	0,2	0,0
Sycamore	0,2	0,1	0,0	0,0	0,0
Other broadleaves	1,5	0,7	0,2	0,2	0,3
Total conifers	**19,6**	**14,9**	**3,0**	**1,2**	**0,4**
Norway Spruce	3,2	2,3	0,7	0,1	0,1
Sitka spruce and other spruce	0,8	0,3	0,1	0,3	0,0
Silver fir and other fir	2,1	1,5	0,4	0,2	0,0
Noble fir, Caucasian fir	11,4	9,5	1,6	0,3	0,1
Mountain pine and lodge pole pine	1,3	0,8	0,2	0,3	0,1
Other conifers	0,8	0,4	0,2	0,1	0,1

Source: Forestry census of 2000

Danish Forest and Landscape Research Institute offers a picture of the yearly afforestation for the period 1990 to 2000.which is presented in table 5. Data on the area afforested by state forest districts, other public forest owners and private land owners receiving subsidies is based on an evaluation report on afforestation (Jensen 2003). We reestimated the area afforested by private land owners without subsidies by subtracting the afforestation categories mentioned above from the total area afforested per year in the period 1990-99 as recorded in latest forestry census and by distributing this number among years in the period 1990-99, and by adding the real series for period 1998-2001 received from Danish Forest and Nature Agency. The Nordmann's fir plantations were not included in the afforested area used in Danish Forest and Landscape Research Institute reporting, while the forestry census included Nordmann's fir plantations for Christmas trees and greenery on arable land as afforestation. Total afforestation in tables 4 and 5 is 27500 ha, while according to Danish Forest and Landscape Research Institute the afforested area for the same period is represented with 16456 ha. Also, there is a difference of 11044 ha, or about 40 percent. This number could be understood as Christmas trees part of total afforestation.

Table 5 shows a constant rise in afforestated area from 1990 to 2001. The greatest rise comes in 1999. It is probably because the Danish state decided in 1999 to increase subsidies for private afforestation. The Danish State decided again in 2000 to reduce subsidies. Afforestation falls in 2000 and 2001 in proportion to 1999. Table 5 shows, however, the rise in afforestated area in 2000 and 2001 in proportion to the period 1990-1998. It is probably because of the hurricane. After the hurricane in 1999, private owners have received grants to plant new trees.

Table 5 Afforestation area by landowners (incl. Christmas trees)

Year	State forests	Other publicly owned forests	Private forests with subsidies	Private forests without subsidies	Total area
			ha		
1990	107	12	0	1667	1786
1991	300	12	70	1667	2049
1992	562	12	70	1667	2311
1993	450	149	70	1667	2336
1994	553	149	178	1667	2547
1995	396	141	178	1667	2382
1996	407	146	212	1667	2432
1997	414	267	968	1667	3316
1998	146	101	547	547	1341
1999	278	150	3304	3304	7036
2000	126	150	1800	1764	3840
2001	133	158	1899	1288	3478

Source: Danish Forest and Landscape Research Institute. The area afforested by private land owners without subsidies is recalculated (explained above)

2.3 Physical balance sheet for the forest land

The basic characteristic of the classification of IEEAF is the distinction between wooded land available for wood supply and wooded land not available for wood supply. Most Danish forests (98 percent) are available for wood supply. Almost all Danish forests are subject to "The forest preservation act". This implies that the area cannot be used for other than forest and when felling has taken place new trees are to be planted. About 6500 hectares of Danish forest are not available for wood supply. These are forests that will stay untouched in the future. These forest areas are called “natural forest”. According to IEEAF natural forests are defined as forests with natural species and ecological processes and for which there has been continuity of ecological processes over a very long period of time. The time period of continuity is sometimes quoted as being of more than 200 years, but this may not be relevant for all types of forest. The degree of naturalness of forest is difficult both to define and measure. Therefore, results may not be fully comparable between countries. These forests will be part of the balance sheet for the forest area.

Deforestation can, in theory, exist in Denmark. The extent of deforestation is, however, assumed to be so small that it can be ignored.

Under *other changes* natural colonisation, natural regression and other changes are placed. Natural colonisation is when the forest by itself takes new land. This can, of course, take place in Denmark, but the actual extent of this is not known, but assumed to be of such little importance that it can be ignored. The same is the case for natural regression.

The physical balance for the area of wooded land is given in table 6. Given the assumptions, the forest area of Denmark is estimated to be of 445782 ha in 1990 rising to 477158 ha in 2001, a rise of 7 percent. The goal of doubling the forested area of Denmark in a tree generation seems to be on its way, but if it is to be reached the pace has to be raised. Assuming a tree generation of 100 years (somewhere in-between the assumed length of a tree generation of conifers and broadleaves), where ten years have already passed, we can conclude that a rise in the area of wooded land of 8916 ha per year is required to reach the double area of wooded land counting from 1990, but the afforestation rate has been much lover than needed with the average afforestation rate of 2905 ha per year for the period 1990-2001.

Table 6 Forest balance for the area of wooded land, 1990 – 2001 (incl. Christmas trees)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	ha											
Opening area	445 782	447 568	449 617	451 928	454 264	456 811	459 193	461 625	464 941	466 282	473 318	477 158
Changes due to economic activities	1 786	2 049	2 311	2 336	2 547	2 382	2 432	3 316	1 341	7 036	3 840	3 478
Afforestation	1 786	2 049	2 311	2 336	2 547	2 382	2 432	3 316	1 341	7 036	3 840	3 478
Deforestation	0	0	0	0	0	0	0	0	0	0	0	0
Other changes	0	0	0	0	0	0	0	0	0	0	0	0
Natural colonisation	0	0	0	0	0	0	0	0	0	0	0	0
Natural regression	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0
Changes in use/status (wooded land)	0	0	0	0	0	0	0	0	0	0	0	0
Closing area	447 568	449 617	451 928	454 264	456 811	459 193	461 625	464 941	466 282	473 318	477 158	480 636

Source: Forest census 1990 and 2000 (figures for 1990 recalculated on the basis of the 2000 forest census)

2.4 Monetary accounts for forests

Forests, like other land and natural resources, are part of the total resources and part of the national wealth of Denmark. A System of National Accounts - SNA (see United Nations (1993 a)) defines assets as entities over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time (1993 SNA, §10.2). The forest is a tangible produced asset where the total stock of standing timber is part of the inventories under work in progress on cultivated assets and the value of the land on which the timber stands is a tangible non-produced asset placed under land (land under cultivation AN.2119), see appendix 1. Forests should therefore in the national accounts appear as a tangible non-produced asset in the form of land and as a rise/fall in the inventories in the form of annual increment in the volume of standing timber corrected for annual fellings. According to the national accounts the value of production of timber should be the value of the annual rise in the volume of standing timber, i.e. in addition to the fellings, we also need to account for the net natural growth in the volume of standing timber.

2.5 Forest valuation for Denmark

Stocks and changes in stocks are described in monetary terms in the forest accounting framework (IEEAF). The framework is built up in accordance with the ESA/SNA classification of economic assets. Appendix 1 gives an overview of relevant ESA/SNA classification. ESA/SNA distinguishes as mentioned land from biological assets on land. Land rarely changes in quantity as a result of production processes, while it is the nature of biological assets to grow, be harvested etc. This distinction between land and biological assets should lead to separate valuations of the two. A separation could be difficult, especially since transactions of forests usually include both land and trees. There are several valuations principles for forests: transaction value method applied to forest real estates, net present value method, consumption value method and stumpage value method.

The general principles of valuation of assets in the national accounts are that any item should be valued as if it was acquired at the day the balance sheets relate to. Ideally, it should be valued at prices observed in the market. The market price is the preferred method for valuing assets, but this is very often not available for environmental assets. If such prices do not exist they should be valued at prices earlier observed in the market or alternatively if no such prices exist, market prices should be estimated from observed prices or incurred costs approximated by either revaluation and accumulating acquisitions less disposals or the present or discounted value of future returns. This will often involve a discussion of expected life length, a calculation of the resource rent provided by the asset and a choice of a discount factor.

A simple method for valuing forest estates is to calculate the average price of one hectare of forest and to apply it to the whole forest area. Average prices may be calculated from a register of transactions or a fiscal database. Data on transactions exist in Denmark, but are very partial. In Denmark not many sales of forests take place every year.

The general opinion is that the tax assessments do not give the right value of properties. This might be true as the values are set relatively low because of the great uncertainty in predicting a value for forests. There are few sales of

forests in Denmark – too few to be able to conclude anything certain about the market price for the entire forest land. Sales of wooded land without the forest have, of course, never taken place, so there is actually no way of knowing how right or wrong the value of the land itself is set. Comparing the averages of the sold estates to all estates, the tax assessment values of the sold estates are higher indicating that good forests have been on the market, to a greater extent, than less attractive forests.

2.5.1 Hedonic price model

The estimation of valuing forest estates used in this report consists of three steps. In the first step we estimate the relation between actual sales value and the values for the property and land (in DKK). In the second step we construct an estimated sales value of forest estates transferring this to the tax assessment register in order to use this in the process to make an estimated land value for all forest estates. And finally in the third step we estimate the land value.

First step
First, we estimate the relation between actual sales value and the values for the property and land (in DKK). This model uses a data set for the sales that have taken place and are registered in a register of all sales of properties in Denmark. The sales that are registered are sales of forest estates – e.g. there is no separation of land and forest. These transactions that do take place may be influenced by hunting rights etc., as much as by pure forestry motivations. The data set includes five variables: year of sale, area of the forest property, sales value in DKK for the forest property, tax assessment value for the property and tax assessment value of the land. The data set contains 3131 observations. Some of the observations were incomplete. They were removed from the data set. The selection procedure leaves us with 1946 observations. Different specifications of a model have been examined. The simplest model assuming only one explanatory variable – the tax assessment value did not give a very good match – indicating some systematic deviations according to the area of the estate or other factors. The model specification that seemed to explain the data is best presented in Box 2.

Second step
The relation from step 1 is used to estimate the total sales value of all forest estates from the tax assessment register. We could make one estimation covering all the years or making one estimation for each year or some kind of average over some years to smoothen the estimates. For simplicity and because we lack the information on sales from 1990 and 1991, we have chosen to make one estimation covering all years (see Box 2).

Third step
In the third step we finally estimate the land value by taking a fixed proportion of the total estate value. This proportion could be the average of the share of land value to tax assessment value each year. It could also be the share of land value to tax assessment as an average over the period. For simplicity we use the average share of the land value to the forest estate value from the tax assessment and apply this to the estimated value.

This gives an estimate of the pure land value each year that we will apply to the monetary balance of wooded land. In the IEEAF hunting values and values of the "glory" of forests and other values are included in the land value. In setting the tax assessment values for the estates these values are often given the same value as the pure land. An estimate for the land, including other values than standing timber, is therefore found by doubling the share of the land value, which is given in box 2. Calculations can be seen in Box 2.

Box 2 Hedonic pricing calculations

First step:

We estimate first the relation between actual sales value and the values for the property and land (in DKK). This model uses a data set for the sales that have taken place and are registered in a register of all sales of properties in Denmark.

Let
S_v = Sales value in DKK for the forest property
T_v = Tax assessment value for the property

L_v = Tax assessment value of the land
I = Interaction term between T_v and the area
A = Area in ha of the forest property
ε = Error term
$\alpha, \beta, \delta, \gamma$ are coefficients

Then let the sales value be given by

$$S_v = \alpha + \beta T_v + \gamma A + \delta I + \varepsilon$$

Assuming ε has the classical properties estimates of the coefficients can be found using ordinary least squares, giving the relationship between the sales value and the tax assessment value. The interaction term is included under the assumption that the area of a property has an effect on the sales price. The estimation gives the following results:[1]

variable	parameter estimate	standard deviation	t-value	Pr >|t|
T_v	1,00351	0,03565	27,45	<.0001
A	1,15166	0,13818	8,33	<.0001
I	-0,00002856	0,00000570	-5,01	<.0001

The estimation gives also the following relationship of the estimated sales value of forests:

$$\hat{S}_v = 1.00351T_v + 1.15166A - 0.00002856I$$

with an r^2 of 0.79 and a level of significance of 0.1 of all the coefficient, but α, indicating that they all are significantly different from 0 and hence assuming the associated variables have some explanatory power in this relation. Constant α has not a level of significance of 0.1, and this is why it was kept out of model. Also, all tree attributes are significant factors. T_v and L_v have positive sign, whereas I has a negative sign, as it was to be expected. L_v has a strongest effect on estimation.

Second step:

With this estimated model we can construct an estimated sales value of forest estates transferring estimated relationship to the tax assessment register.

Let
E = Estimated sales value of forest estates
V_p = Value for the property
L_a = Assessment value of the land
I = Interaction term between V_p and L_a

Transferred model gives the following relationship:

$$E = 1.00351V_p + 1.15166\,L_a - 0.00002856I$$

Third step:

Now, we can estimate the land value. For simplicity we use the average share of the land value to the forest estate value from the tax assessments each year and apply this to the estimated sales value. Shares are represented in table A. Estimate is then multiplied with factor 2, which is used to regulate tax assessment registers undervaluation of land value. Tax assessment registers undervaluation of land value happens because share of the land value is more or less politically determined. According to "Custom and Tax agency" share of land value is larger (then politically determined) and should multiply with factor 2.

Table A

year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
share of the pure land value	0.38	0.38	0.37	0.38	0.31	0.30	0.29	0.29	0.28	0.28	0.28
share of the hunting right, etc.	0.38	0.38	0.37	0.38	0.31	0.30	0.29	0.29	0.28	0.28	0.28
total share of land	0,76	0,76	0,74	0,76	0,62	0,60	0,58	0,58	0,56	0,56	0,56

Now we can calculate estimate for the land value. Calculating process is shown by the following example. Assume that
V_p = 44503
L_a = 78
I= 3491 and
Share of the land value for 2001= 0.56

Then the estimated land value for 2001 is given by

$E=(1.00351V_p + 1.15166\,L_a - 0.00002856I)*0.28 = 12350$

Estimate for the land value for 2001 is 24700 DKK per hectare multiplied with 473318 hectares, i.e. 11663 mio. DKK.

2.5.2 Monetary balance sheet for forest land

The value of the opening area in the balance sheet for the area of wooded land is the value of wooded land in the beginning of the period and is the same as at the end of the previous year.

Under the category *changes due to economic activity* afforestation and deforestation are placed. The value of afforestation is given by the value of wooded land per hectare in the opening balance multiplied by the afforestation area of that year.

The difference from table 6 giving the physical balance for the area of wooded land is the revaluation. This is given as a residual between the opening area, afforestation and the closing area of a year. This value is primarily a result of the difference in the value of wooded land per ha from one year to another.

The value of wooded land is of 11.7 billion DKK in 2001, while it was 10.6 billion DKK in 1990. In other words, there has been a rise in the value of wooded land of 1.1 billion DKK in the 11 year period from 1990 to 2001. The first years after 1990 there was an annual rise in the value of forested land reaching a peak in 1993. After 1993 there was a fall until 1997 where the trend turned upwards again. Revaluation in 1990 is equal to 0 because 1990 is base year for our calculations.

Table 7 Monetary forest balance for the area of wooded land 1990 - 2000

mio. dkr	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Opening area	10 563	10 583	12 684	13 926	12 498	10 792	9 522	9 110	10 137	9 783	10 658	11 663
Changes due to economic activities	42	51	55	49	43	37	36	39	38	40	44	44
Afforestation	42	51	55	49	43	37	36	39	38	40	44	44
Deforestation	0	0	0	0	0	0	0	0	0	0	0	0
Other changes	0	0	0	0	0	0	0	0	0	0	0	0
Natural colonisation	0	0	0	0	0	0	0	0	0	0	0	0
Natural regression	0	0	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0	0	0
Changes in use/status (wooded land)	0	0	0	0	0	0	0	0	0	0	0	0
Changes in classification	0	0	0	0	0	0	0	0	0	0	0	
Revaluation	0	2 050	1 186	-1 477	-1 749	-1 307	-448	988	-392	853	961	216
Closing area	10 583	12 684	13 926	12 498	10 792	9 522	9 110	10 137	9 783	10 658	11 663	11 942

3. Standing timber

On the basis of information from the forest census on year classes and yield classes an estimate for the volume of standing timber is made using standard production tables. The Danish Forest and Landscape Research Institute carries out the actual calculations in connection with the forest census.

Table 8 shows the estimated volume of standing timber and the expected annual mean increment in 2000-2009. Conifers have seen the greatest rise in the volume of standing timber. This greater rise can be seen as a result of conifers growing faster than broadleaves, which could also be the reason why planting of conifers is often seen as the most profitable.

Table 8 Estimated standing volume over bark in 1990 and 2000 and mean annual increment in the period 1990-2000 and 2000-2009 by species

	Standing volume		Expected mean annual volume increment
	1990	2000	2000-2009
	Mill. m^3		Mill. m^3/year
Total	**64,9**	**77,9**	**5,2**
Broadleaved, total	**25,8**	**29,1**	**1,3**
Beech	17,8	18,3	0,7
Oak	3,9	4,8	0,3
Ash	1,0	1,3	0,1
Sycamore	0,8	1,2	0,1
Other broadleaves	2,4	3,5	0,2
Total conifers	**39,1**	**48,8**	**3,8**
Norway Spruce	20,5	25,1	1,8
Sitka spruce and other spruce	5,8	6,6	0,5
Silver fir and other fir	3,2	4,4	0,3
Noble fir, Caucasian fir	1,6	3,2	0,2
Mountain pine and lodge pole pine	2,1	5,8	0,5
Other conifers	5,9	3,6	0,3

Source: Forestry census 1990 and Forestry census 2000

3.1 Removals of timber from forests

Figures for removals of timber from forests are available from a separate survey in Statistics Denmark called felling statistics. Table 9 shows the removals of timber in the period from 1990 to 2001. The total removals have been around 2 mill. m^3 a year during the period, with the exception of 2000 where the removals reached almost 3,7 mill. m^3. The rise in the removals in 2000 is largely due to the hurricane of December 1999. The removal of timber is registered when the timber is moved from the forest to be stacked at the forest road. While the timber is lying in the forest it is still regarded as part of the volume of standing timber. Hence, removals of timber will not have taken place to a greater extent in 1999 because of the hurricane, since it was so late in the year. Most of the extra removals because of the hurricane have obviously taken place in 2000 because the level in 2001 is again just below 2 mill. m^3.

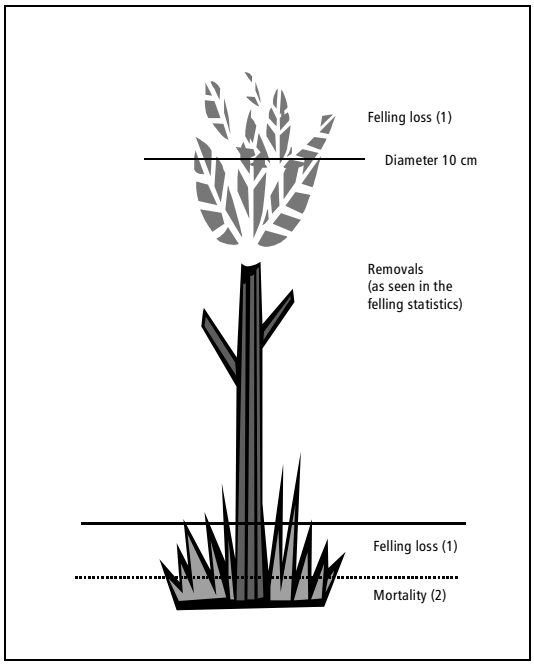
When felling a tree, some of the tree and its branches are considered felling loss, and will not be part of the felling statistics. This is illustrated in figure 2. A tree is usually cut off where the diameter is 10 centimetres at the top. The rest of the top will be felling loss. The tree is also felled a little above the ground and the rest of the stem is also felling loss. In Denmark this felling loss is assumed to be about 20 percent of the timber sold. In other countries this felling loss is assumed to be about 45 percent. There are two main reasons for this difference. There is a tradition of utilizing a great deal of the trees, for e.g. firewood etc., in Denmark. The other reason is that in Denmark the timber is measured with bark, taking the bark away of course gives a greater felling loss. Total removals will therefore be calculated as fellings plus 20 percent. New planted trees do not give any measurable volume of standing timber the first many years they exist.

Table 9 Removals of timber in forests

	Beech	Oak	Other broadleaved	Conifers	Total
			1000 m^3		
1990	483	71	135	1 329	2 018
1991	496	87	153	1 178	1 915
1992	488	74	151	1 202	1 915
1993	494	59	144	1 080	1 777
1994	476	83	140	1 153	1 852
1995	488	75	143	1 220	1 926
1996	476	66	140	1 195	1 876
1997	464	56	129	1 169	1 818
1998	414	57	120	1 118	1 710
1999	416	56	106	1 138	1 715
2000	491	56	94	3 031	3 671
2001[4]	315	72	118	1 289	1 795

Source: Agricultural statistics 2000, 2001

Figure 2 Illustration of the relation between volume of standing timber and fellings.



The description of forests is mainly described in existing statistics according to the economic use. Looking from that economic point of view forests are of importance when it comes to production of timber. Production of timber is important in connection with delivering intermediate inputs to processing industries and final uses.

The forests are of minor importance in relation to the Danish economy as they appear in the national accounts. The gross value added of forestry and logging was of 1001 million DKK or 0.1 percent of the total gross value added in 1999. The production value of forestry was 2.0 billion DKK in 1999, while manufacturing of wood and wood products had a production value of 12.8 billion DKK. All together, this gives a production value of almost 15 billion DKK. The production value for the total Danish economy was of 1982 billion DKK, while the manufacturing industry had a production value of 469 billion in 1999. In other words the total forestry industry made up about 1.0 percent of the total production in the economy and about 4.3 percent of the manufacturing industry. Christmas trees account for about 2.0 billion DKK of the forestry industries production value. Ornamental branches made up about 31 percent.

[4] Estimated number

Table 10: Some indicators for Danish forestry, 1999 (billion DKK)

	——billion DKK——
Production value of forestry	2
Gross value added of forestry	1
Manufacturing of wood and wood products	13
Production value of the total Danish economy	1982
Manufacturing production value	469

In the present Danish national accounts the value of forestry is estimated using the value of annual fellings, assuming fellings are equal to the annual rise in the volume of standing timber. Assuming a net rise in the volume of standing timber the production value can therefore be assumed to be underestimated. Now the value of rise in the volume of standing timber will be used in the calculations, and the difference between value of volume of standing timber and value of annual fellings will be accounted as standing stock. For instance, in the present Danish national accounts for year 1999, the value of 590 million DKR of annual fellings in 1999 is used as estimate for value of the volume of standing timber in same year. When we now remove assumptions about value of volume of standing timber, the value of 852 million DKR will be used in the national accounts. The difference between 852 millions and 590 millions DKR, also 262 millions DKR, will be entered as standing stock. The revision of forests value in Danish national accounts will be conducted for the period 1990 and forward.

3.2 Physical balance sheet for standing timber

The balance sheet for the volume of standing timber consists of the opening stock of standing timber, natural growth, fellings and removals, catastrophic losses due to fires and storms, natural losses of standing timber, other changes in stocks of standing timber (conversion, deforestation) and changes in classification of standing timber due to changes in use/status.

Box 3: Definition of volume of standing timber

> The volume of standing timber is defined as the volume above-stump measured over the bark to the top. This includes tops of stems, large branches, and dead trees lying on the ground, which can still be used as fibre or fuel. Small branches, twigs and foliage are excluded. The volume of standing timber is as mentioned calculated using standard production tables made with basis in the forestry census' age classes and yield class information.

Yearly increment in the volume of standing timber is dependent on climate – precipitation and temperature, felling, planting etc. The total increment in the volume of standing timber is the annual growth in the existing volume of standing timber. Whatever is felled during the year will appear under total removals.

The balance of the volume of standing timber is shown in table 11. As mentioned, since the hurricane of 1999 was so late in the year, this has not affected the closing stock of standing timber in 1999.

The yearly net increments in the volume of standing timber has been estimated using the difference in opening stock of standing timber in 1990 and 2000 and information about the yearly fellings in the years in-between from Forest census 2000. Any annual differences due to climate conditions are overlooked. After 2000 the yearly increment will be estimated using the estimated yearly increment in the 2000 census together with information about the annual fellings.

Table 11 shows that the volume of standing timber has been raised from 64.9 million m^3 in the beginning of 1990 to 79.6 million m^3 at the end of 2001. This is a rise of 23 percent or 1.3 million m^3 a year. During 2000 there was actually a fall in the volume of standing timber, basically because of the hurricane in December 1999.

Table 11 Forest balance for the volume of standing timber 1990 – 2001 (incl. natural forest)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1 000 m^3											
Opening stocks	64 883	66 183	67 483	68 782	70 082	71 382	72 682	73 982	75 281	76 581	77 881	77 642
Gross increment	4 454	4 444	4 473	4 410	4 468	4 567	4 570	4 488	4 221	4 217	5 176	5 176
Total removals	3 154	3 144	3 173	3 111	3 168	3 268	3 271	3 188	2 922	2 917	5 415	3 171
Other changes[1]												
Changes in use/status												
Closing stock	66 183	67 483	68 782	70 082	71 382	72 682	73 982	75 281	76 581	77 881	77 642	79 647

[1] Including natural losses that are assumed to be zero. This does not correspond to the TBFRA-2000, but the natural loss reported here was assumed to be too high and did not have basis in any scientific knowledge.

3.3 Monetary balance sheet for standing timber

For the valuation of the timber the stumpage value method will be used. The stumpage prices will be calculated using market prices for different species from the Danish Forest Association using the fellings as weights to achieve an average market price. To calculate a stumpage price the accounts for private forest owners will be used. We have calculated an average net price for timber per m^3 for each year using some average market prices for different species. From the market price costs in connection with bringing the timber down and making it ready for sale have been deducted giving the net price that will be used as an estimate of the stumpage price. The volumes used in the calculations are not the same as the volumes reported in table 10 because not all the standing timber has a value. When removing a tree, there is as mentioned a felling loss of 20 percent of the timber sold – hence only 4/5 of the standing timber has value.

From 1994 some forest areas have been designated to natural forests. These forests are not natural forests as such, but it has been decided that in the future they will not be touched. These forests have a land value, because they can be sold, but they do not have a timber value because the timber from these forests can never be sold. These forests make up 6500 hectares and will be kept outside the valuation of the standing timber.

The opening stock of standing timber (that is 4/5 of it) is multiplied by this net price resulting in the value of standing timber presented in table 12. The same procedure is followed for the gross increment and total removals. The total removals are not multiplied by the gross price, but by the net price like the stock. Transferring this to current accounts, the net value of timber will be part of the total output from forestry. In addition the value added by the felling will be included in the output.

The value of standing timber is 14.3 billion DKK by the end of 2001, which is small rise from 1990. The volume of standing timber increased by 23 percent in the same period. The value of standing timber fell during 2000 by 4.4 billion DKK because of felling prices due to the rise in supply of timber because of the hurricane, and the value by the end of 2001 is still smaller than the value of standing timber was at the beginning of 2000. The fall in the volume of standing timber in the same period was of 0.3 percent.

Table 12 Monetary forest balance for the volume of standing timber[1] excl. Christmas trees 1990 – 2000 (million DKK)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Opening stocks	13 619	13 892	12 653	12 287	10 925	13 065	14 805	13 645	14 939	15 653	15 745	11 374
Gross increment	935	833	799	688	818	930	843	891	863	852	758	929
Total removals	662	590	567	485	580	666	603	633	597	590	793	569
Other changes	0	0	0	0	0	0	0	0	0	0	0	0
Changes in use/status	0	0	0	0	0	0	0	0	0	0	0	0
Changes in classification	0	0	0	0	0	0	0	0	0	0	0	0
Revaluations	0	-1 483	-599	-1 564	1 903	1 475	-1 400	1 036	448	-171	-4 335	2 562
Closing stock	13 892	12 653	12 287	10 925	13 065	14 805	13 645	14 939	15 653	15 745	11 374	14 296

1 excl. natural forests

3.3.1 Christmas trees

The value of standing timber does not include the value of Christmas trees. The forest area includes Christmas trees, but Christmas trees are usually no more than 10 years old, and hence their volume of standing timber is very limited. The Christmas tree production in Denmark makes up a substantial part of the total output of the forestry industry and is a very important part of the forestry economy for the individual forest owner. The production value for Christmas trees in 1999 was of 513 million DKK or 56 percent of the total production value of forestry that year.

4 Total forest value

We have now estimated a value for the wooded land and a value for the volume of standing timber. With these two values we can calculate the total forest value for Denmark.

The tax assessments of the total forest suggest a total value of the forest of 43 billion DKK at the end of 2001. The sum of the land value (11.9 billion) and the timber value (14.3 billion) give a value of 26 billion DKK. A total forest value of about 26 billion DKK is hence our best estimate of a total value for the Danish forests.

The tax assessment value contains, besides value of land and timber, recreational value of Danish forest, value of carbon binding, etc. If we look at estimate for pure forested land and timber in 2001, 26220 millions DKK, then the forest value is much lower than average sales value of forest. Also, there is a difference of 16 billion DKK in proportion to 42.6 millions DKK that was suggested by the tax assessment. This amount of money could represent a value of buildings in forests, value of carbon binding, etc. It is very difficult to distribute this amount of money to different elements, because we do not now exactly which elements have an influence on forests and what is exactly their part of the accumulated effect.

Table 13 Differences between sales value of forest and estimated values of land and timber, ULTIMO

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
						millions DKK						
1. Total sales value of forest	27 851	33 379	36 647	33 779	28 399	30 715	30 366	34 956	33 733	38 065	41 654	42 584
of this land value	10 583	12 684	13 926	12 498	10 792	9 522	9 110	10 137	9 783	10 658	11 663	11 924
2. Standing timber	13 892	12 653	12 287	10 925	13 065	14 805	13 645	14 939	15 653	15 745	11 374	14 296
3. Land+Timber	24 476	25 337	26 212	23 423	23 857	24 327	22 755	25 077	25 435	26 403	23 038	26 220
4. Difference (1.-3.)	3 375	8 042	10 434	10 356	4 542	6 388	7 611	9 879	8 298	11 663	18 617	16 365

5. Carbon binding

Forests are important in the global carbon cycle. Through the process of the photosynthesis, trees and other forest plants take up carbon dioxide from the atmosphere. The carbon is retained for long periods in the forest biomass and soils, and later in wood products, so carbon binding in the ecosystem contributes to the reduction in the concentration of the greenhouse gas carbon dioxide in the atmosphere.

5.1 Carbon storage in standing timber

Table 14 shows how much volume of different species standing timber contributes to the storage of carbon. The standing stock of wood was 79.6 Mm^3 ultimo 1991. This stock of wood was equivalent to 27535 tonnes C or 98419 tonnes CO_2. Wood volumes are converted to carbon stores by multiplying with conversions factors. The Danish conversation factors result in slightly lower C stores than when using Intergovernmental Panel of Climate Change (IPCC) factors. The Danish factors differ from IPCC factor because the reported biomass in the Danish Forestry Census is total above ground biomass.

It can be seen in table 14 that conifers contributed to 62 percent of carbon storage in 2001. Beech and Norway spruce contributed to more than half of the carbon storage in 2001. Even though Beech represents only 16 percent of Danish forest area in 2000, beech contributed to 22 percent of carbon storage and carbon dioxide storage in 2001.

Table 14 Carbon storage in the volume of standing timber ultimo 2001

	Carbon		CO2	
	per Ha	total		percent of total
	tonnes/ha	1000 tonnes	1000 tonnes	
Total	**57**	**27 535**	**98 419**	
Broadleaves total	**56**	**9 765**	**35 905**	**37**
Beech	77	6 126	21 895	22
Oak	38	1 635	5 842	6
Ash	34	431	1 541	3
Sycamore	38	359	1 283	2
Other broadleaves	39	1 158	4 139	4
Conifers total	**58**	**17 049**	**60 940**	**62**
Norway spruce	65	8 569	30 724	31
Sitca spruce	64	2 190	7 829	8
Noble fir	35	417	1 490	2
Caucasion fir	25	705	2 520	3
Other silver fir	97	1 504	5 377	5
Pine	47	2 241	8 011	8
Other conifers	58	1 403	5 015	5

Source: Forestry census 2000

Tables 15 and 16 show carbon balance and carbon dioxide balance for standing timber. The series in these two tables are calculated using information from Forestry census 2000. The forestry census 2000 assumed that there is 57 tonnes of C or 208 tonnes of CO_2 per ha in volume of standing timber, 7 tonnes C or 25 tonnes CO_2 per ha in afforested volume of standing timber, 4 tonnes C or 14 tonnes CO_2 per ha net carbon binding in trees from before 1990. Further, it is assumed that there is 634000 tonnes C or 2324113 tonnes CO_2 in fellings per year in the period 1990-99. We assumed that the amount of C and CO_2 in fellings for years 2000 and 2001 is the same as for years in the period 1990-99.

Table 15 Carbon balance for standing timber

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1000 tonnes of carbon											
Opening stock	22 146	22 565	22 989	23 416	23 847	24 282	24 719	25 160	25 610	26 059	26 532	27 030
Changes in carbon storage	420	423	427	431	435	437	441	450	450	473	498	505
From afforestation	5	7	8	9	10	9	9	15	9	29	18	19
From trees in older forests	1 049	1 051	1 053	1 056	1 059	1 062	1 066	1 069	1 074	1 077	1 114	1 120
Fellings	634	634	634	634	634	634	634	634	634	634	634	634
Closing stock	22 565	22 989	23 416	23 847	24 282	24 719	25 160	25 610	26 059	26 532	27 030	27 535

As shown in table 15, stock of carbon in forest has increased to 27.5 millions tones of carbon in 2001. The annual sequestration of C and CO_2 is expected to increase even more over the next decades since afforestation is expected to reach its maximum. Table 16 shows also the comparatively small amounts of CO_2 sequestered due to afforestation since 1990.

Table 16 Carbon dioxide balance for standing timber (1000 tones of carbon)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1000 tonnes of carbon											
Opening stock	78 651	80 191	81 744	83 311	84 891	86 486	88 090	89 707	91 358	93 007	94 741	96 567
Changes in carbon storage	1 540	1 553	1 568	1 579	1 596	1 604	1 617	1 651	1 649	1 734	1 826	1 852
From afforestation	18	25	31	32	37	33	34	56	35	108	67	69
From trees in older forests	3 846	3 852	3 861	3 872	3 883	3 896	3 907	3 919	3 938	3 950	4 084	4 107
Fellings	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324	2 324
Closing stock	80 191	81 744	83 311	84 891	86 486	88 090	89 707	91 358	93 007	94 741	96 567	98 419

5.2 Carbon stored in the forest ecosystem

A recent Danish investigation (see Forests 2000) of the Danish soil shows the amount of carbon down to a one meter depth in the Danish forest soil. The storage of carbon varies geographically and by the quality of the soil. There is a large difference in total C among soil orders. Spodosols[5] have the greatest C content and Alfisols[6] the smaller. The main contributor to the high content in Spodosols is the spodic horizons containing illuvial humus, and thick organic horizons. On average, however, it is assumed that there are 458 tonnes of CO_2 per ha forest corresponding to 125 tonnes of carbon per ha. Tables 17 and 18 show carbon balance and carbon dioxide balance for Danish forests soil.

Table 17 Carbon balance for Danish forests soil (1000 tonnes of carbon)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1000 tonnes of carbon											
Opening stock	55 723	55 946	56 202	56 491	56 783	57 101	57 399	57 703	58 118	58 285	59 165	59 645
Changes in carbon storage	223	256	289	292	318	298	304	414	168	880	480	435
Closing stock	55 946	56 202	56 491	56 783	57 101	57 399	57 703	58 118	58 285	59 165	59 645	60 080

Assuming that all Danish forest soils are well drained, it can be concluded that total CO_2 storage in Danish forest soils is about 220 millions tonnes. However, this number is undervalued because an essential part of Danish forest soils are bad drained swamps, etc. In these forest soils there actually exist far more CO_2 storage because of the lack of oxygen.

[5] Spodosols are ashy gray, acidic soils with a strongly leached surface layer. Their suitability for cultivation is limited to acid-tolerant crops and orchards, provided that sufficient lime and fertilizer are applied. Covering about 3.5 percent of the nonpolar continental land area on Earth (see Britanica.com)

[6] Alfisols are arable soils with water content adequate for at least three consecutive months of the growing season. Prior to cultivation they are covered with natural broad-leaved deciduous forest vegetation, sometimes interspersed with needle-leaved evergreen forest or with grass (see Britanica.com)

Table 18 Carbon dioxide balance for Danish forests soil (1000 tonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1000 tonnes of carbon											
Opening stock	204 168	204 986	205 925	206 983	208 053	209 219	210 310	211 424	212 943	213 557	216 780	218 538
Changes in carbon storage	818	938	1058	1070	1167	1091	1114	1519	614	3222	1759	1593
Closing stock	204 986	205 925	206 983	208 053	209 219	210 310	211 424	212 943	213 557	216 780	218 538	220 131

Total carbon balance for the Danish forests ecosystem cannot be calculated, because data on carbon storage in 'other biomass' and 'other biomass in forest (including needles and leaves and ground vegetation)' does not yet exist in Denmark. These two series are expected to be available in the near future from the Danish Forest and Landscape Research Institute. Table 19 shows available series for carbon balance for the forest ecosystem in 2001. We can see from table 19 that carbon storage in standing timber raised with 1.8 percent and carbon storage in forest soils raised with 0.7 percent.

Table 19 Carbon balance for the forest ecosystem 2001 (except other biomass)

	Opening stock	Changes in carbon stores	Closing stock
	million tonnes		
Forest ecosystem			
Standing timber	27 301	505	27 806
Forest soils	59 645	435	60 080

6. Recreational areas of forests

A greater need has arisen in the past twenty years for outdoor activities. Some of the most important reasons usually given for this rise are the population growth in combination with increasing urbanisation, the higher standard of living and the enhanced mental strains in life conditions (Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999). Danish politicians had in the last period increasingly emphasized the importance of the forests for outdoor recreation.

Box 4 The Danish forest act

The Danish forest act puts emphasis on the fact that forests are to be managed in order to improve and increase wood production and to protect landscape amenity, nature conservation, cultural heritage and environmental protection interests as well as recreational activity interests. This means that in planning and management of Danish forests, consideration has to be given to recreational activities. As a consequence of the fact that all Danish forests are, in principle, open to the public. Private forests are open to the public during the day light hours – from 7 in the morning to sunset. The public is allowed to use paths and roads in private forests. Public forests can be used in the dark hours as well and the public can move around outside paths and roads.

If the private forests are of less than 5 ha there is a possibility of setting further limits to the public access to the forest. Most forests in Denmark are private and many are less than 5 ha, see table 20.

Table 20 Forest area after ownership and size in relation to admission for private access 2000

	1000 ha	number
Total	486	26 548
State forests	113	26
Other public forests	25	305
Private forests of more than 5 ha	314	9 361
Private forests less than 5 ha	34	16 856

Source: Forests 2000

Table 21 shows that forests and other nature areas are the most popular recreation and leisure activities in Denmark. Over 90 percent of the Danish population visit forests at least ones a year. Examinations from 1976 and 1994 show that forests take the first place in the public's choice of recreational areas. Forests account for about 42 millions visits in 1976 and about 52 millions in 1994. It has just recently been possible to adjust this last figure on the basis of actual counting on 174000 ha forest. This adjustment now leads to a (conservative) estimate of around 75 million visits a year of the adult Danish population (Jensen 2003). Only the beaches are almost as popular as forests. A typical Dane visits forests about 10 times a year. The rise in the average number of visits – and with that the total number of visits to forests - can thus be attributed to an increasing number of frequent forest visitors. This has involved that in the period from the 1970s to the 1990s, the number of visits has increased by about 25 percent (15 percent if the increase in population is taken into account).

There are large differences in population use of forests. The first difference that can be seen is visitor's intensity. Average visiting time per visitor was 1.9 hours in 1974 and 1.8 hours in 1994. Also, average visiting time per visitor is falling.

Table 21 The percentage of the adult Danish population who have taken advantage of the listed leisure options at least once a year

Forest/Nature areas	91
Libraries	55
Art exhibitions	37
Museum (excl. art)	38
Theatres	31
Sport grounds	32
Concert halls (excl. classic)	19

Source: Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999

Table 22 shows that the share of short visits are larger in 1994 than in 1976, while the share of longer visits is smaller. This is a development which might indicate a "faster" lifestyle. It can be concluded that Danes visit forests more often, but the time they spend in forests is getting shorter.

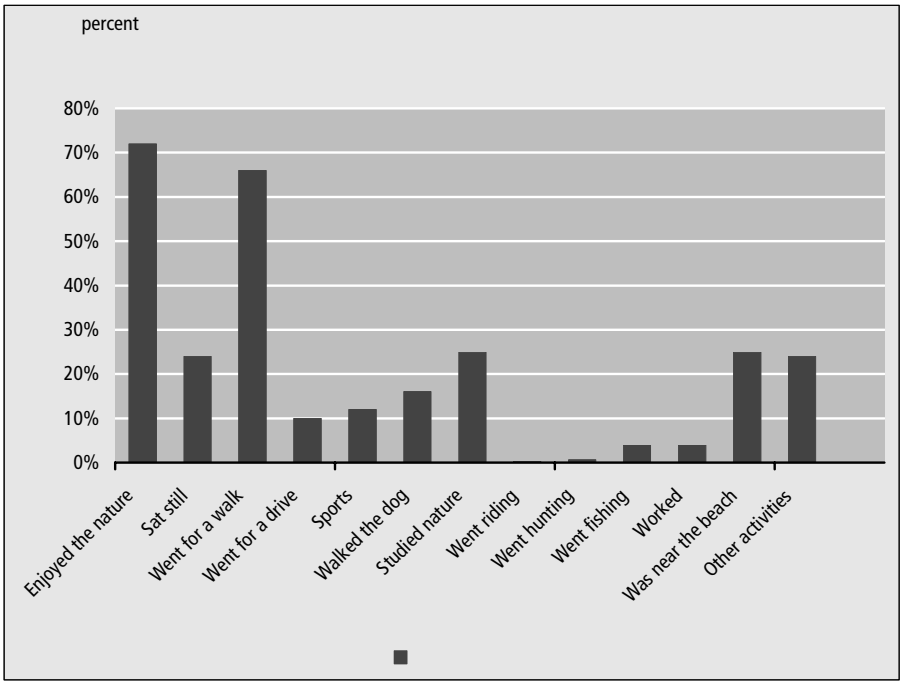
Table 22 Distribution of the respondents by duration of the forest visit in 1976 and 1994 (in percent)

	1976/77	1993/94
More then 8 hours	1.3	1.6
5 to 8 hours	3.0	2.8
3 to 4 hours	11.1	8.1
A couple of hours	36.6	28.9
On hour	34.3	36.5
Half an hour	9.8	16.0
Quarter of an hour	3.4	4.9
Less than 5 minutes	0.6	1.1

Source: Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999

Many different activities take place in the forest. Around two thirds of the visitors visit forests for the purpose of enjoying the nature or walking.

Figure 3 Distribution of the respondents by forest activities in 1994



Source: Danish Forests 2000

Sitting still, sports and taking the dog for a walk are activities that take up around 10 percent. Other purposes, like hunting and fishing account for less than 5 percent.

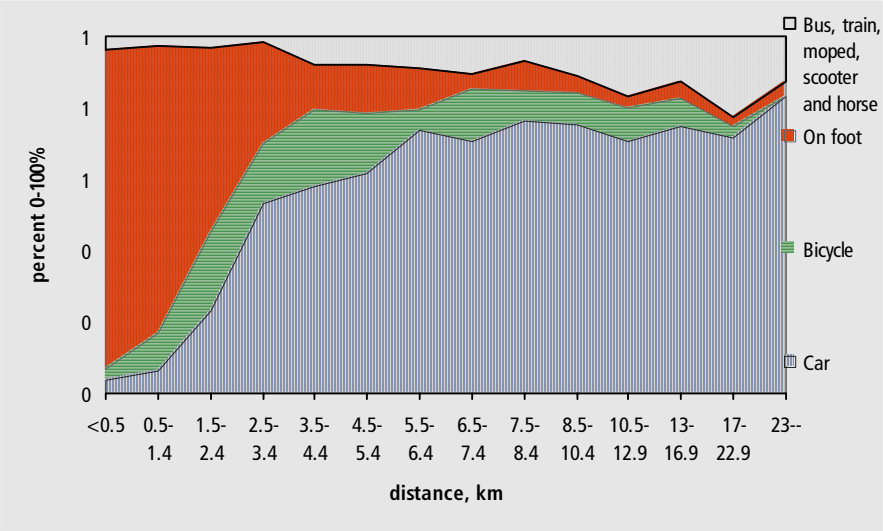
Table 23 Means of transportation for forest visits

	1976/77	1993/94
	percent	
Train/tube	3.0	3.5
Bus	3.3	2.9
Car	55.3	48.8
Motor cycle/scooter	0.4	0.5
Moped	2.2	0.7
Bicycle	7.4	10.8
Horse	0.9	1.0
On foot	27.1	31.8

Source Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999

Just like in 1976, most of the Danish population use cars as primary means of transportation to forest in 1994, see table 23. But more and more Danes are using the bicycle or are walking, when they want to visit forests, while fewer people are using the moped.

Figure 4 The influence of travelling distance on the choice of means of transport to the forest in 1994



Source Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999

The average transport distance has a decisive influence on population choice of means of transportation, see figure 4. In both 1976 and 1994 the forest visitors mainly walked to the forest when it was within a distance of about 2 km. Bicycles were used by a relatively large part of forest visitors for a distance of 1-8 km in 1976 and 1-15 km in 1994. Using of car is rising with the average distance to the forest.

The average distance to the forest was 10.5 km in 1976 and 8.5 km in 1994 (transport distance >89 km is not taken under calculation of average transport distance). The average transport time spent per forest visitor on the trip to their forest visit was 30 minutes in 1976 and 27 minutes in 1994. So, in 1994 the transport time became 10 percent smaller, compared with 1976. Table 24 shows that almost 80 percent of the forest visitors spent less than half an hour on transport to the forest in both 1976 and 1994. Table 24 also shows that there has been a shift over the period, implying that a larger number of the forest visitors spent less time on transport.

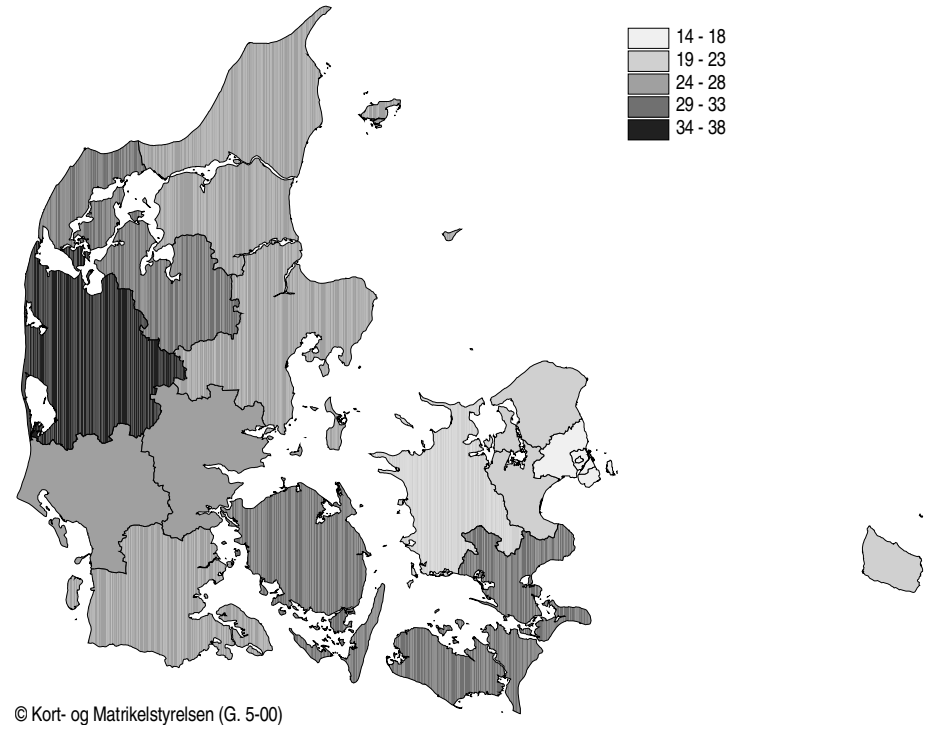
Table 24 Distribution of the respondents by transport time out to the forest (in percent)

	1976/77	1993/94
	percent	
More then ½ hours	3.5	3.4
An hour and a half	3.9	3.8
Tree quarters to an hour	13.3	10.6
Half an hour	22.3	18.6
Quarter of a hour	26.2	24.2
5 to 10 minutes	18.6	22.2
2 to 5 minutes	8.8	11.8
Less than 2 minutes	3.3	5.4

Source Danish Forest and Landscape Research Institute; Jensen, Frank Søndergaard 1999

Figure 5 shows transport time to the forests by counties.

Figure 5 Average transport time out to the forest by counties (minutes)



Source: Danish Forest and Landscape Research Institute

6.1 The recreational value of Danish forests

According to the preliminary results of an examination which is carried out by The Royal Veterinary and Agricultural University, the recreational value of Danish forests is about half a billion DKK per year. Several other research results yield more or less the same conclusion. Average willingness to pay for one season ticket for all Danish forests is calculated to 134 DKK. From this number the average willingness to pay for one visit to forests can be calculated. An expression of the Danish population's total willingness to pay can be calculated if the number of Danes used for calculations in the examination (almost 4 million persons) multiplies with average payment for one season ticket (134 DKK). It gives a total recreational value of Danish forests of 540 millions DKK per year.

7. Forests and protective functions

The protective functions of forests include, among others, protection of groundwater sources and protection from erosion. Forests can be also used for protection of infrastructures against avalanches and mud slides, but these forests protective functions are not important for countries like Denmark. The protective functions can be changed by human intervention in the form of air pollution, climate changes, change in forestry etc.

The data situation for areas with protective functions is not very good at the moment, but we can expect more data in the near future because of the new sample-based National Forest Inventory.

7.1 Forests and groundwater sources

Forests are characterised as land with permanent plant cover, few interventions in a year, limited use of fertilization and very small use of pesticides. This is a reason why forests soils are more protected from erosion and forests groundwater sources are more protected from pesticides and nitrogen than agricultural soils.

There are several aspects that should be considered when we examine forests groundwater sources. First, less groundwater is formed under forests than under arable land because rain stays in tree crowns or evaporates. More than half of the rainfall in Danish forests evaporates. The remaining part of the rainfalls leaches through the ground down to the groundwater. Figure 25 shows the percent of water in treetop distributed by conifers and broadleaves. It can be seen that conifers have bigger water capacity in their treetops than broadleaves. The percent of water in treetop is also larger in conifers treetops.

Table 25 Percent of water in treetop

	Percent of water in treetop	Treetops capacity (mm)
Conifers	25-58	2.8-5
Broadleaves	15-28	0.5-1.2

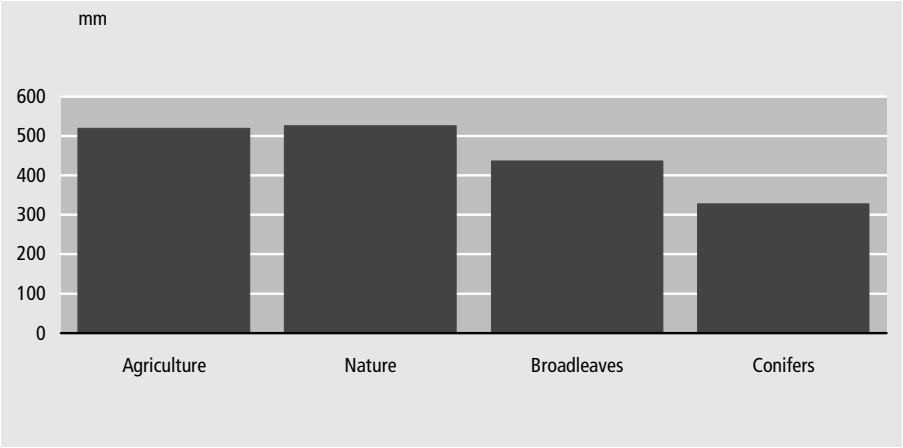
Source: Danish Forest and Landscape Research Institute

Figure 6 compares different uses of area by same leaching[7] (the process of seeping). Leaching is about 100 mm smaller than is normal under broadleaves and about 200 mm smaller than is normal under conifers in conjunction with the same rainfall. Leaching is almost on the same level for both agriculture and nature. Areas covered with conifers are giving less leaching than areas covered with broadleaves. Therefore, groundwater under areas covered with broadleaves is more protected.

A considerable part of rainfalls on these areas streams to ditches and streams. Most of that water will leach to the groundwater if these areas become afforested. This can have a negative influence on groundwater, depending on forested area. That is why the Danish authorities should consider this problem before possible afforestation. It should be investigated whether reduction of leaching is a problem in areas with a smaller amount rainfall.

7 Percolation of underground water through the banks and into a stream or other body of water.

Figure 6 Yearly leaching at different use of land



Source: Danish Forest and Landscape Research Institute

The Danish authorities had in 1997 pointed out areas with special drinking water interests. The special drinking water interests are connected to areas with large needs for drinking water. Table 26 shows total forest area in areas with special drinking water interests. Forests account for 20 percent of areas with special drinking water interests.

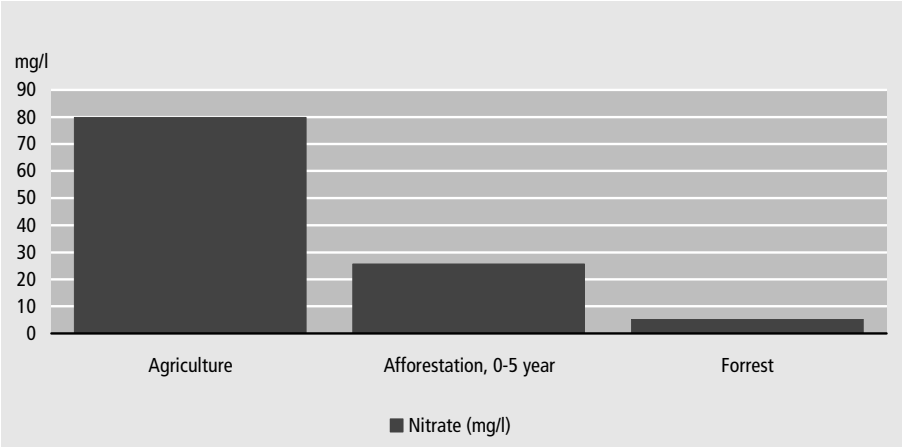
Table 26 Forest areas in areas with special drinking water interests

	Special drinking water interests	Forest	Nature
	1 000 ha	———1000 ha (percent) ———	
Denmark	1 467	288 (20)	140 (7)
Jutland	760	159 (21)	61 (8)
Islands	708	129 (18)	43 (6)

Source: Forest 2000

Agriculture's nitrogen emission and use of pesticides has a big influence on groundwater pollution. The biggest problem for groundwater pollution is the process of nitrogen leaching in the form of nitrate. Figure 7 shows nitrate substance in the water that leaches to the groundwater. Nitrate substance for agriculture lies far above the permitted limit for drinking water (50 mg/l). Forests have in contrast a very low nitrate substance in the leaching water. New forests have a higher nitrate concentration in leaching water because old arable land contains a larger amount of pesticides. Nordmann's fir plantations for Christmas trees and greenery on arable land are not included in the forest areas in this figure. The Nordmann's fir plantations were not included because they never become closed forest as the trees are harvested within a ten year rotation, and land owners may revert the land to use in agriculture after a few years. These plantations have large nitrogen emission and use of pesticides. Therefore, they have a negative influence for groundwater pollutions. If they were counted in forests, then the forests will have a considerable higher nitrate concentration in leaching water.

Figure 7 Nitrate in leaching water (in depth 70-100 cm)



Source: Danish Forest and Landscape Research Institute

Many investigations showed that nitrate content is bigger in small than in big forest areas, because small forests are more exposed to pollution. Soil characteristics also have an influence on nitrate concentration. Forests with a nitrogen-poor soil can almost always absorb all nitrogen so nitrate concentration in groundwater is almost 0.

Groundwater under forests is considered to be well protected from pesticides. Use of pesticides for forests protection is very small, and therefore they don't have a big influence on the forest groundwater.

A big evaporation on area covered with conifers causes lower water streams than in areas covered by broadleaves. 62 percent of Denmark is covered with conifers. This explains why a big part of Denmark is negatively influenced by the current choice of tree species.

Forest exploitation and especially afforestation can also have an impact on the groundwater. Table 27 shows distribution of forests areas with high and low risks of having an impact on the groundwater. Areas with low risk of having an impact on the groundwater are areas with forests older than 10 years. Areas with high risks are areas where trees are small and where fertilization and pesticides are regularly used. The highest risks of having an impact on the groundwater are areas planted with Christmas trees.

Table 27 Forests areas with high and low risks of having an impact on the groundwater (percent of total forest area)

	1980-1989	1990-1999
	percent	
Areas with low risk		
Areas with intact vegetation older then 10 years in 1989 and 1999	93	87
Areas with high risk		
Christmas trees and rock greenery younger then 10 years	2	5
Afforestation	1	3
Other	4	5
Hurricane in 1999/2000		4

Source: Forest 2000

The hurricane in 1999 also had an impact on the groundwater. 4 percent of Danish forest areas had been destroyed by the hurricane. It can be expected that the groundwater will be negatively impacted in the next 5 years after the hurricane on this areas, because forests soils are more protected from erosion and forest groundwater sources are more protected from pollution than groundwater sources under other soils.

7.2 Protection from erosion

34000 ha forests in Denmark have been established to protect land from sand drift and another kind of erosion. It accounts for 8 percent of the total Danish forest area. It has been also evaluated that there is no need for erosion protection of Danish coasts, because of the more gentle use of coast areas. Protective forests can have a variety of

other functions. One of the most important forest protective functions for a country like Denmark is the protection of agricultural areas that lie behind forests. It will be almost impossible to cultivate some of those agricultural areas without forest protection.

8. IEEAF tables for 1999

The framework for integrated environmental and economic accounting for forests (IEEAF) (see Eurostat (1999)) deals with the physical and monetary description of stocks of forest related assets (land and timber), monetary accounts for forest related activities (forestry and logging) and physical and monetary supply and use tables for wood and wood products. Some of these issues have already been handled in the earlier parts of this report, but we will in the following provide figures specifically for 1999.

Table 28 corresponds to the IEEAF table 1 a, and gives the forest balance in 1999. The table corresponds to table 6 above focusing on 1999 and dividing the area available for wood supply and area not available for wood supply. The area not available for wood supply is 6500 ha and represents only 1.4 percent of the total area of wooded land.

Table 28 Forest balance 1999 (IEEAF 1a)

	Available for wood supply	Not available for wood supply	Total
	ha		
Opening area	459 782	6 500	466 282
Changes due to economic activities	7 036	0	7 036
Afforestation	7 036	0	7 036
Deforestation	0	0	0
Other changes	0	0	0
Natural colonisation	0	0	0
Natural regression	0	0	0
Other	0	0	0
Changes in use/status (wooded land)	0	0	0
Closing area	466 818	6 500	473 318

Table 29 corresponds to the IEEAF table 2 a, and gives the forest balance for the volume of standing timber in 1999. The table corresponds to table 11 above focusing on 1999 and dividing the volume of standing timber available for wood supply and not available for wood supply. On the area of wooded land not available for wood supply it is assumed to be 1 million m^3 of standing timber. It is assumed that the density of timber is the same in the area not available for wood supply as in the area available for wood supply.

Table 29 Forest balance for the volume of standing timber 1999 (IEEAF 2a)

	Standing volume on wooded land			On other land	Total
	Available for wood supply	Not available for wood supply	Total		
	1.000 m^3				
Opening stocks	75 514	1 068	76 581	-	76 581
Gross increment	4 198	18	4 217	-	4 217
Total removals	2 917	0	2 917	-	2 917
Other changes	0	0	0	-	0
Changes in use/status	0	0	0	-	0
Closing stock	76 795	1 086	77 881	-	77 881

Table 30 corresponds to the IEEAF table 1 b presenting a monetary balance for the area of wooded land in 1999. This is almost the same table as table 8 above, focusing on 1999 and giving a separate estimate of the value of the area not available for wood supply. The area not available for wood supply is, as mentioned, in section 2.5.1, given the average value of land. This gives a value of the wooded area not available for wood supply of 127 million DKK at the end of 1999.

Table 30 Monetary forest balance for the area of wooded land 1999 (IEEAF 1b)

	Forest and other wooded land		
	Available for wood supply	Not available for wood supply	Total
	millions DKK		
Opening area	9 646	136	9 783
Changes due to economic activities	40	0	40
Afforestation	40	0	40
Deforestation	0	0	0
Other changes	0	0	0
Natural colonisation	0	0	0
Natural regression	0	0	0
Other	0	0	0
Changes in use/status (wooded land)	0	0	0
Changes in classification	0	0	0
Revaluation	845	-9	853
Closing area	10 531	127	10 658

Table 31 corresponds to the IEEAF table 2 b, and gives the monetary forest balance for the volume of standing timber in 1999. Again, this table corresponds to table 12 above, just focusing on 1999 and presenting a separate value for the timber on the area not available for wood supply. As mentioned above, however, this timber has no monetary value since it cannot be sold and hence the value of the total volume of standing timber is the same as the value of standing timber on land available for wood supply, 15.7 billion DKK.

Table 31 Monetary forest balance for the volume of standing timber 1999 (IEEAF 2b)

	Standing volume on wooded land			On other land	Total
	Available for wood supply	Not available for wood supply	Total		
	Mill. DKK				
Opening stocks	15 653	0	15 653	-	15 653
Gross increment	852	0	852	-	852
Total removals	590	0	590	-	590
Other changes	0	0	0	-	0
Changes in use/status	0	0	0	-	0
Changes in classification	0	0	0	-	0
Revaluations	-171	0	-171	-	-171
Closing stock	15 745	0	15 745	-	15 745

Table 32 corresponds to table 2 c of the IEEAF tables, and gives the level of defoliation in 1999. In 1999, 9 percent of conifers and 19 percent of broadleaves had a level of defoliation greater than 25, which is set as the value that distinguishes healthy trees from unhealthy trees.

Table 32 Defoliation (% of sample trees) (IEEAF 2c)

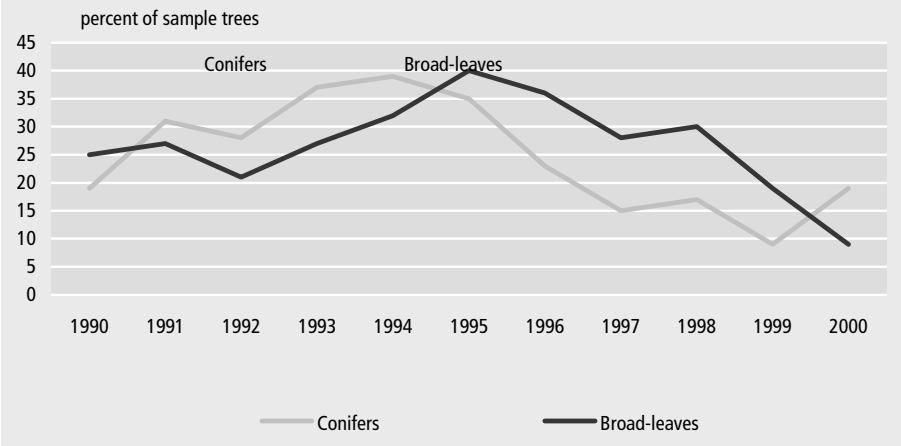
	2 National survey data Defoliation % > 25 1999	3 Corresponding area (1000 ha) 1999
Conifers	9	12.870
Broad-leaves	19	50.920
Total	14	63.790

Source : Danish Forest and Nature Agency

The level of defoliation has decreased over the past few years. This can be seen in figure 8. In the "top years" the defoliation was of more than 40 percent both for conifers and broadleaves. This level has fallen, and in 1997 the

level of defoliation was in 1999 at its lowest since 1990 for conifers and the lowest since 1994 for broadleaves. In 2000, the level of defoliation for conifers has increased again.

Figure 8 Percentage of trees with defoliation of more than 25 percent 1990-2000



Source: Statistics Denmark (2001 b)

Economic transactions
The IEEAF tables 3a, 3c, 4a, 4b, 5a, 5b describe the economic transactions. The product and industry classification given in the IEEAF "manual", see Eurostat 1999, allows for a detailed description of the transactions in the industries related to forests and the corresponding products. The accounting framework integrates the economic accounts for the specified industries and describes gross fixed capital formation, changes in inventories and net acquisition of land.

Appendix 3 table A1 gives an overview of the industries represented in this report. Similarly, table A2 gives an overview of the products represented in this report and which Danish National accounts products go into which group of products.

In the industry of forestry and logging natural growth of cultivated timber is recorded as forestry output. Forestry and logging accounts are separated on the basis of functional analysis of the economic accounts for forestry. In IEEAF forestry is defined as the activity of growing standing timber, coppice and pulpwood, including Christmas tree growing, including the services of inventories, timber evaluation fire protection etc. On the same basis, logging is defined in the IEEAF as the activity of felling timber and production of wood in the rough, including transportation of logs within the forest. The output of forestry is placed under work in progress and accrues to inventories of standing timber. The value of the timber that is removed from the forest is valued at stumpage prices and enters into intermediate consumption of logging.

Table 33 corresponds to the IEEAF table 3 c presenting the economic accounts for forestry and logging for 1999. This table is drawn up on the basis of a functional analysis of the forestry and logging industry transactions as they are recorded in the national accounts. Separate data for forestry has been estimated under the same basic assumptions that were used in compiling the monetary balance sheets above. The natural growth of timber, i.e. the gross increment in the volume of standing timber, has been added to the output of forestry (1264 million DKK). The felled timber valued at stumpage prices has been added to the intermediate consumption of logging (1009 million DKK). The difference between the value of the natural growth and the stumpage value of the fellings (262 million DKK) has been added to changes in inventories (work in progress).

This results in an estimated gross value added for forestry and logging of 1.3 billion DKK in 1999. The inventories of work in progress have been set to the opening stock value of standing timber in 1999, while the land area has been set to the opening balance value of forest land in 1999.

Table 33 Economic accounts for forestry and logging (mill. DKK) 1999 (IEEAF 3c)

	Forestry and logging industry		
	Total	of which forestry	of which logging
Current transactions			
Output (basic prices)	**2 273**	**262**	**2 010**
Market output	2 273	262	2 010
Own account output	-	-	-
Other non market	-	-	-
Intermediate consumption	**1 009**	**0**	**1 009**
Standing timber	0	-	0
Other products	1 009	0	1 009
Seeds and plants	181		
Energy	47		
Fertilisers and soil improvers	34		
Material, small tools etc.	133		
Services	402		
Other and adjustment	212		1
Gross value added	**1 264**	**262**	**1 001**
Compensation of employees	598		
Other taxes less subsidies on production	0		
Consumption of fixed capital	189		
NOS/mixed income	**476**		
Imputed unpaid labour	0		
Imputed return to fixed capital		-	-
Return to land and standing volume			
Capital formation			
Gross fixed capital formation	**172**		
Construction	140		
Equipment	20		
Other gross fixed capital formation	12		
Changes in inventories	**262**	**262**	**0**
of which work in progress	263		
Supplementary data			
Labour inputs	4 175		
Net fixed capital stock	1 900		
Inventories of work in progress	15 745		
Land area	10 531		

Table 34 corresponds to the IEEAF table 4 a, presenting a table for physical use side in the supply–use tables for 1999. The table is a standard use table of the national accounts, but in physical units. The physical data are estimated using partly information from the industrial commodity statistics and partly information from the forest census along with figures from the national accounts. The industries represented separately in the table are forestry and logging, manufacturing of wood products, manufacturing of paper and pulp (which cannot be divided into paper and pulp separately) and printing. The remaining industries represented are joined *other* industries. The table shows that the use side of forestry and logging consist of standing timber, a little saw logs and wood waste.

Table 34 Supply – Use physical tables: use 1999 (IEEAF 4a)

	Intermediate consumption of industries					Total	Final consump-tion	Capital formation	Exports	Total
	Forestry and logging	Manufac ture of wood products	Manufacture of paper and pulp	Printing	Other					
Standing timber (1000 m^3 over bark)	0	0	0	0	0	0	0	4 217	0	4 217
Saw logs (1000 m^3)	26	981	0	0	501	1 508	0	16	379	1 902
Fuel wood (1000 m^3)	0	85	0	1	296	381	399	43	3	827
Pulp wood (1000 m^3)	0	10	0	0	0	10	2	0	1	13
Wood and wood-products (1000 m^3)	0	207	2	0	1 960	2 170	121	29	519	2 838
Paper pulp (1000 t)	0	0	42	0	29	70	0	1	2	73
Paper (1000 t)	0	13	350	0	1 016	1 379	62	-37	462	1 866
Wood waste as a product (1000 t)	111	534	1	0	1 081	1 728	124	-7	176	2 021
Paper waste as a product (1000 t)	0	0	0	0	0	0	0	-212	378	166

Table 35 corresponds to the IEEAF table 4 b, presenting the physical supply side in the supply-use table for 1999. The table is a standard supply table of the national accounts, but in physical units. It describes the supply of products by industry and imports. The output standing timber is found in the forestry and logging industry along with output of saw logs and fuel wood. In addition to logs, the forestry and logging industry also has some output of wood waste.

Table 35 Supply – Use physical tables: supply 1999 (IEEAF 4b)

	Output of industries					Total	Imports	Total
	Forestry and logging	Manufacture of wood products	Manufacture of Pulp and Paper	Printing	Other			
Standing timber (1000 m^3 over bark)	4 217	0	0	0	0	4 217	0	4 217
Saw logs (1000 m^3)	765	193	0	0	0	958	941	1 898
Fuel wood (1000 m^3)	568	37	0	0	2	607	220	827
Pulp wood (1000 m^3)	0	1	0	0	0	1	12	13
Wood and wood-products (1000 m^3)	0	1 610	0	0	49	1 659	1 179	2 838
Paper pulp (1000 t)	0	0	0	0	0	0	73	73
Paper (1000 t)	0	0	399	0	34	433	1 433	1 866
Wood waste as a product (1000 t)	105	468	0	0	0	576	1 445	2 021
Paper waste as a product (1000 t)	0	0	63	0	21	84	82	166

Table 36 gives a summary of the physical supply-use tables from tables 34 and 35 for 1999. The table consists of the total intermediate consumption, final consumption, capital formation and exports from the use side and output of industries and imports from the supply side. The total from the use side equals the total from the supply side.

Table 36 Summary Supply – Use physical tables 1999

	Intermediate consumption	Final consumption	Capital formation	Exports	Total use= Total supply	Output	Imports
Standing timber (1000 m^3 over bark)	0	0	4 217	0	4 217	4 217	0
Saw logs (1000 m^3)	1 508	0	16	379	1 902	958	941
Fuel wood (1000 m^3)	381	399	43	3	827	607	220
Pulp wood (1000 m^3)	10	2	0	1	13	1	12
Wood and wood-products (1000 m^3)	2 170	121	29	519	2 838	1 659	1 179
Paper pulp (1000 t)	70	0	1	2	73	0	73
Paper (1000 t)	1 379	62	-37	462	1 866	433	1 433
Wood waste as a product (1000 t)	1 728	124	-7	176	2 021	576	1 445
Paper waste as a product (1000 t)	0	0	-212	378	166	84	82

Table 37 corresponds to the IEEAF table 5a, and gives the monetary use side from the supply use tables for 1999. The monetary use table records the intermediate consumption of the specified products by industry and final uses

of the products. The final uses consist of final consumption, capital formation and exports. The table is the standard use side of the national accounts for specified forest-related products. The monetary data basically comes from the national accounts. The monetary use side corresponds to the physical use side. The only difference is that in addition to the commodities, there are some lines showing the generation of income in the industries represented separately, which are in some way related to forestry. The uses are recorded at purchaser's prices.

Table 37 Supply – Use monetary table: use (Million DKK) 1999 (IEEAF 5a)

	Intermediate consumption of industries					Total	Final consump-tion	Capital formation	Exports	Total
	Forestry and logging	Manufactu re of wood products	Pulp and paper	Printing	Other					
Standing timber	0	0	0	0	0	0	0	262	0	262
Saw logs	5	358	0	0	232	596	0	7	370	973
Fuel wood	0	58	0	0	204	263	680	30	3	976
Pulp wood	0	28	0	0	1	29	0	6	6	41
Wood and woodprod.	0	787	14	2	11 518	12 322	1 058	319	4 351	18 049
Paper pulp	0	0	169	0	115	284	0	2	7	294
Paper	0	348	2 305	2 281	13 435	18 369	2 547	128	4 147	25 190
Waste wood	57	2 326	6	5	5 366	7 760	702	156	709	9 327
Waste paper	0	0	753	0	20	773	0	-55	157	875
Other wood products	0	0	0	0	55	55	0	0	2	57
Other products	946	3 944	2 887	0		914 757	906 638	240 345	447 250	2 509 589
Total intermediate consumption	1 009	7 849	6 135	8 071	932 144	955 207	911 625	241 799	457 002	2 565 633
Gross value added	1 853	4 943	4 010	6 733						
Consump. of fixed cap.	189	573	703	1 159						
Net value added	1 664	4 370	3 307	5 574						
Compensation to empl.	598	3 709	2 847	4 583						
Other taxes less subs.	0	0	0	0						
NOS/Mixed income	1 066	661	460	991						
Output (basic prices)	2 862	12 792	10 145	14 804						

Table 38 corresponds to the IEEAF table 5b, presenting the monetary supply side from the supply-use tables for 1999. The monetary supply table records the output of specified products at basic prices by industry and import. The table is the standard supply side of the national accounts for specified forest-related products.

Table 38 Supply – Use monetary table: supply (Million DKK) 1999 (IEEAF 5b)

	Output of industries					Total (basic prices)	Imports	Net taxes on products	Trade and transport margins	Total (pur chasers prices)
	Forestry and logging	Manufactu re of wood products	Paper and pulp	Printing	Other					
Standing timber	262	0	0	0	0	262	0	0	0	262
Saw logs	357	120	0	0	0	477	438	-32	89	973
Fuel wood	464	28	0	0	2	494	77	129	275	976
Pulp wood	0	11	0	0	0	11	29	0	2	41
Wood and wood-products	0	9 308	1	0	424	9 734	3 206	240	4 870	18 049
Paper pulp	0	0	0	0	0	0	254	0	40	294
Paper	0	6	9 514	507	230	10 257	9 630	1 107	4 197	25 190
Wood waste (product)	52	1 419	0	0	10	1 481	3 992	135	3 714	9 327
Paper waste (product)	0	0	23	0	9	32	40	0	803	875
Other wood products	0	0	0	0	0	0	54	0	3	57
Other products	1 727	1 899	606	14 297	1 941 411	1 959 350	384 150	179 540		250 9046
Total	2 862	12 792	10 144	14 804	1 942 086	1 982 698	401 816	181 119		2 565 633

Table 39 gives a summary of the monetary supply-use tables for 1999 from tables 37 and 38. As in table 36, this table also consists of the total intermediate consumption, final consumption, capital formation and exports from the use side and output of industries and imports from the supply side. The total from the use side equals the total from the supply side.

Table 39 Summary Supply – Use monetary table (Million DKK) 1999

	SUPPLY					USE			
	Total output (basic prices)	Imports	Net taxes on products	Trade and transport margins	Total use (purchasers prices)	Inter mediate consumption	Final consumption	Capital formation	Exports
Standing timber	262	0	0	0	262	0	0	262	0
Saw logs	477	438	-32	89	973	596	0	7	370
Fuel wood	494	77	129	275	976	263	680	30	3
Pulp wood	11	29	0	2	41	29	0	6	6
Wood and wood-products	9 734	3 206	240	4 870	18 049	12 322	1 058	319	4 351
Paper pulp	0	254	0	40	294	284	0	2	7
Paper	10 257	9 630	1 107	4 197	25 190	18 369	2 547	128	4 147
Wood waste (product)	1 481	3 992	135	3 714	9 327	7 760	702	156	709
Paper waste (product)	32	40	0	803	875	773	0	-55	157
Other wood products	0	54	0	3	57	55	0	0	2
Other products	1 959 350	384 150	179 540		2 509 046	914 757	906 638	240 345	447 250
Total	1 982 698	401 816	181 119		2 565 633	955 207	911 625	241 799	457 002

9. Sample- based National Forest inventory for Denmark

Danish forest legislation has always focused on the wood producing function of forests. In the beginning of the 1980's, other functions that were also taken into consideration. This led to a revision of the Forest Act. From 2002, a new sample-based national forest inventory has been launched which will replace the Forestry Census.

The idea of sample-based national forest inventory is to give detailed information on the development of forests and to conduct sustainable forest management.[8] This sample-based inventory will show and validate the development of the forestry and forests in Denmark. The inventory will especially include: *changes of forest area for different forest types, changes in areas of different management regimes, species composition, including mixed forests related to regions and soil properties, volume of forests, including dead wood and forest structure, removals, performance of cutting, increment related to regions and site conditions and physiogenic forest damage (Södeberg 2000)*. Many other aspects of forest inventory will be included too.

Preliminary results from the sample-based national forest inventory may be obtained from 2004, but complete sample-based national forest inventory will be complete in 2006.

Data from the sample-based national forest inventory can be used in our economic analysis for the forest and forestry. Future possibilities for economic analysis will increase with the introduction of this new forest inventory. It will be possible to make many of tables presented in this rapport on an annual basis when data from sample-based national forest inventory is available.

9.1 The path forward

Future work on this field is dependent on the new sample-based national forest inventory. However, it is possible to establish several balances on an annual basis. They are: forest balance for the area of wooded land, forest balance for volume of standing timber and monetary balances analogous to these two balances.

We can also establish IEEAF tables with three year difference; also in 2004 we will be able to establish IEEAF tables for 2001. Total carbon balance for the Danish forest ecosystem cannot be calculated, because data on carbon storage in other biomass and other biomass in forest does not yet exist in Denmark. These series are expected to be available from the sample-based national forest inventory. This will probably make it possible to calculate total carbon balance for the Danish forest ecosystem.

It is not possible to establish tables for recreational areas of forest and tables for forest protective functions on an annual basis. Data on these fields is not yet produced on an annual basis. Some of this series are expected to be available in the near future from the Danish Forest and Landscape Institute. This will probably make it possible to establish more tables on these two fields.

Table 40 shows summary of the most important series and sources in the report.

[8] Denmark has also committed itself in Lisbon in 1998 to report on 6 criteria and 27 indicators for sustainable management of the European forests on a regular basis

Table 40 The most important series and sources

	The Forestry Census of 1990	The Forestry Census of 2000	Danish Forest and Landscape institute	Statistics Denmark	Danish Forest and Nature Agency
Afforestation area by landowners		figures for "private without subsidies" recalculated on the basis of 2000 forest census	period 1990-2001; source Lars Vesterdal: "Removals by Sinks"		
Afforestation area by species and ownership		period 1990-1999			
Carbon dioxide storage in forest soil	calculated by multiplying carbon accounting-factors with quantities for period 1990-2002				
Carbon dioxide storage in the volume of standing timber	calculated by multiplying carbon dioxide accounting-factors with quantities for period 1990-2001				
Carbon storage in forest soil	calculated by multiplying carbon accounting-factors with physics amounts for period 1990-2001				
Carbon storage in the volume of standing timber	calculated by multiplying carbon accounting-factors with physics amounts for period 1990-2001				
Forest area by ownership	year 1990	year 2000			
Forest area by size					years 1976, 1990 and 2000
Forest area by species	years 1976 and 1990	year 2000 and figures for 1990 recalculated on the basis of 2000 forest census			

Table 40 (cont) The most important series and sources

	The Forestry Census of 1990	The Forestry Census of 2000	Danish Forest and Landscape institute	Statistics Denmark	Danish Forest and Nature Agency
Forest areas in areas with special drinking water interests	1000 ha and percent				
Nitrate in leaching water			in depth 70-100 cm by agriculture, afforestation and forest		
Recreational areas			Several publications by Frank Søndergaard Jensen		
Area of wooded land 1990-2001	year 1990	year 2000; figures for period 1991-1999 and 2001 estimated			
Area of wooded land 1990-2001	year 1990	year 2000; figures for period 1991-1999 and 2001 estimated			
Volume of felling by area				year 2001	
Volume of felling by type of product				period 1990-2001	
Volume of removals of timber				period 1990-2001; source: agricultural statistics 2000 and 2001	
Volume of standing timber	year 1990	year 2000; figures for period 1991-1999 and 2001 estimated			
Volume of standing timber (monetary)	year 1990	year 2000; figures for period 1991-1999 and 2001 estimated			
Volume of standing timber by species	year 1990	year 2000 and figures for 1990 recalculated on the basis of 2000 forest census			
Water in treetop			percent		
Yearly leaching of different use of land			year 2000		

11. Literature

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Appendix 1

The System of National Accounts (SNA, see United Nations 1993 a) and European System of Accounts (ESA 1995, see Eurostat 1996) do not present a definition of forests as such. Both SNA and ESA consider only economic assets. In ESA the definition of an economic asset is given in paragraph7.10 as: *Economic assets are entities functioning as a store of value over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them or using them over a period of time.*

Almost all Danish forests can be used for wood supply and hence may give the owner some economic benefits.

In ESA and SNA forests are divided into land (in AN.211) and biological assets (in AN.1114, AN.1221 and AN.213).

Box 5 Land and biological resources in SNA and ESA

AN.1114 Cultivated assets
Livestocks of breeding, dairy, draught, etc. and vineyards, orchards and other plantation trees yielding repeat products that are under the direct control, responsibility, and management of institutional units.....

AN.1221 Work in progress on cultivated assets
Livestock raised for products yielded only on slaughter, such as fowl and fish raised commercially, trees and other vegetation yielding once only products on destruction and immature cultivated assets yielding repeat products.

AN.213 Noncultivated biological resources
Animals and plants that yield both once only and repeat products over which ownership rights are enforced but for which natural growth and/or regeneration is not under the direct control, responsibility and management of institutional units. Examples are virgin forests and fisheries within the territory of the country. Only those resources that are currently, or are likely to soon be, exploitable for economic purpose should be included.

AN.211 Land
The ground, including the soil covering and any associated surface waters, over which ownership rights are enforced. Also included are major improvements that cannot be physically separated from the land itself. Excluded are any buildings or other structures situated on it or running through it, cultivated crops, **trees** and animals subsoil assets non-cultivated biological resources and water resources below the ground. Land consists of land underlying buildings and structures, land under cultivation, recreational land and associated surface water and other land and associated surface water, as defined below.

AN.2111 Land underlying buildings and structures
Land on which dwellings, non-residential buildings and structures are constructed or into which their foundations are dug, including yards and gardens deemed an integral part of farm and non-farm dwellings and access roads to farms.

AN.2112 Land under cultivation
Land on which agricultural or horticultural production is carried on for commercial or subsistence purposes, including, in principle, land under plantations, orchards and vineyards.

AN.2113 Recreational land and associated surface water
Land that is used as privately owned amenity land, parklands and pleasure grounds and publicly owned parks and recreational areas, together with associated surface water.

AN.2119 Other land and associated surface water
Land not elsewhere classified, including private gardens and plots not cultivated for subsistence or commercial purposes, communal grazing land, land surrounding dwellings in excess of those yards and gardens deemed an integral part of farm and non-farm dwellings and associated surface water.

Source: United Nations 1993 a, Eurostat 1996

ESA and SNA distinguish in the classification of assets between land (AN.211) and biological assets (AN.1114, AN1221, AN.213). In this logic, forests as such do not exist. Instead, ESA/SNA operate with wooded land and biological assets related to wooded land separately classified and recorded in the balance sheets and in current, capital and other changes in asset accounts.

The System of Environmental Economic Accounts (SEEA, see United Nations 1993 b) reorients SNA and ESA towards environmental concerns. Like SNA and ESA, a division between land and timber is made. SEEA gives this classification with reference to SNA:

Box 6 Land and natural resources in SEEA

EA.1	**Natural Resources**
EA.14	Biological resources
EA.141	*Timber resources (cubic metres, hectares)*
EA.1411	*Cultivated (part of AN.1221)*
EA.1412	*Non-cultivated (part of AN.213 [5])*
EA.2	**Land and surface water (hectares) (AN.211)**
EA.23	Wooded land and associated surface water (part of AN.2119)
EA.231	Forest land
EA.2311	Available for wood supply
EA.2312	Not available for wood supply
EA.232	Other wooded land

Source: United Nations 1993 b

As far as possible, we will follow the ESA and SNA definitions and guidelines in developing economic accounts for forests. This means that we will divide forests in one part, i.e. the forested land and another part, i.e. the standing timber or to put it in SNA/ESA terms biological assets, which is the same as the SEEA calls natural resources.

ESA balance sheets and accumulation accounts for produced timber

Opening balance sheets	Value of inventories of standing timber at the beginning of the period (AN.1221)
Capital accounts transactions	
Changes in inventories (P.52)	Changes in inventories result from natural growth, harvest or sales
Additions to work in progress	Natural growth as output of the forestry activity
Withdrawals of inventories of work in progress	Transfer to inventories of finished goods (AN.123) when harvested or sold for being harvested
Other changes in volume of asset accounts	
Catastrophic losses (K.7)	Covers decrease of the value of timber due to natural disasters etc.
Uncompensated seizures (K.8)	Covers the seizures of timber without full compensation
Other volume changes in produced timber (K.9)	Covers all other volume changes of timber
Changes in sector classification and structure (K.12.1)	Only applies to sector balance sheets and covers changes in the sector classification of the owner of the produced timber
Changes in classification of assets (K.12.22)	Changes in classification of timber (e.g. from economic to non-economic, the same absolute value being recorded in both entries)
Revaluation account	
Nominal holding gains/losses (K.11)	The value of the benefit accruing to the owner of the timber as a result of a change in its price, or more generally, its monetary value over time
Closing balance sheets	Value of inventories of standing timber at the end of the period (AN.1221)

Appendix 2

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	9.591367E15	3.197122E15	2481.95	<.0001
Error	1943	2.502878E15	1.288151E12		
Uncorrected Total	1946	1.209424E16			

Root MSE	1134967	R-Square	0.7931
Dependent Mean	1096180	Adj R-Sq	0.7927
Coeff Var	103.53842		

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
EJDV	EJDV	1	1.00351	0.03656	27.45	<.0001
SAREAL	SAREAL	1	1.15166	0.13818	8.33	<.0001
intera		1	-0.00002856	0.00000570	-5.01	<.0001

Sum of Residuals	7239426
Sum of Squared Residuals	2.502878E15
Predicted Residual SS (PRESS)	2.568468E15

Appendix 3

Table 41 The industries represented in this report are

		NACE classification	Danish NA classification
Forestry and logging	02	02	020000
Manufacturing of wood products	20	20.1, 20.2, 20.3, 20.4, 20.5	200000
Manufacturing of pulp and paper		21.11, 21.12, 21.2	210000
Printing	22	22.1, 22.2	220900

Table 42 The products represented in this report are

	CPA classification	Danish NA classification
Standing timber	02.01.5	
Wood in the rough	02.01.11 to 13	
Saw logs	02.01.14	
Fuel wood	02.01.15	v440303, v440305, v440307,
Pulp wood		V440101, V440400
Wood and wood products	20.1 to 20.5 (except20.4) 20.52	V440800, V441000, V441100, V441201, V441203, V441300, V441400, V441501, V441503, V441600, V441700, V441801, V441803, V441900, V442000, V442100
Paper pulp	21.11	V470100, V470200, V470300, V470400, V470500, V470600
Paper	21.12 (except 21.12.6) 21.2	V480100, V480201, V480203, V480205, V480207, V480300, V480401, V480403, V480501, V480503, V480505, V480600, V480700, V480801, V480803, V480805, V480901, V480903, V480905, V481001, V481003, V481101, V481103, V481105, V481107, V481109, V481200, V481301, V481303, V481401, V481403, V481405, V481500, V481601, V481603, V481701, V481703, V481801, V481803, V481805, V481901, V481903, V481905, V481907, V481909, V481911, V482000, V482100, V482200, V482301, V482303, V482305, V482307, V482309
Wood waste as a product	20.10.4	V440103, V440105, V440301, V440500, V440601, V440603, V440700, V440900
Paper waste as a product	21.12.6	V470700
Other wood products		V060401, V140100, V140200, V140300, V140401, V450101, V130101, V130103, V130105, V400103