

Supplementary information on land use, land-use change
and forestry (LULUCF) activities under Article 3.3 and
3.4 of the Kyoto Protocol

*Annex to Greenhouse gas emissions in Finland 1990–2005, National
Inventory Report to the UNFCCC*

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EXECUTIVE SUMMARY

ES.1 Background information on reporting greenhouse gases under Article 3.3 and 3.4 of the Kyoto Protocol

Finland reports on a voluntary basis the supplementary information on land use, land-use change and forestry activities under Article 3.3 and Forest management under Article 3.4 of the Kyoto Protocol. It should be noted that all the data, methodology applied and results are preliminary. The methods applied to this report are under development and they are expected to change before the final reporting. Also changes in selected activity data are expected. Finland has chosen to account for the activities under Article 3.3 (Afforestation, Reforestation and Deforestation) and Article 3.4 (Forest Management) for the whole commitment period. In this report, the period 2001–2005 corresponds to the Kyoto Protocol commitment period 2008–2012. The additional accounting table was filled in for year 2005 to test the calculation of the accounting quantity for each activity under Article 3.3 and 3.4.

Finland has approached this voluntary reporting as a learning process. Data and information collection is tested as well the calculation procedures. Further development is needed since some lacks and limitations in activity data and applied methods were found out.

ES.2 Overview of source and sink category emission estimates

Net emissions and removals due to Afforestation/Reforestation (AR), Deforestation (D) and Forest Management (FM) activities in years 2001–2005 are given in Table 1. Article 3.3 activities have been a net source in whole period, whereas Article 3.4 Forest management activity has been a net sink. AR activity has been a slight sink. The trend of each activity has been the same since 1990.

Table 1. Net emissions (+) and removals (-) by ARD activities and FM activities in 2001–2005.

Activity	2001	2002	2003	2004	2005	2001-2005
	Gg CO ₂ eq.					
Article 3.3						
Afforestation/Reforestation	-54	-50	-42	-33	-25	-203
Deforestation	3 446	3 695	3 579	4 201	3 409	18 330
Total	3 392	3 645	3 537	4 168	3 384	18 127
Article 3.4						
Forest Management	-30 320	-29 333	-27 954	-28 809	-39 616	-156 032

The carbon stock change in soil organic matter has been a net source for all activities (Table 2). Organic soils (peatlands) covers about 30 % of Finland's land area. Drainage of peatlands changes the water table and releases CO₂ by oxidation of the organic matter. On afforested/reforested croplands the loss of carbon continues even the drainage is abandoned.

Reported CH₄ and N₂O emissions are from biomass burning on forest land, N fertilization, and from disturbance associated with forest land conversion to cropland. Emissions from fertilization and biomass burning are reported under Forest management, because the activity data is not available for AR-areas.

N₂O emissions from drainage of soils are not reported; national emission factors were not yet available for this reporting. Carbon emissions from lime application are not included in this report; they are reported to the UNFCCC under CRF Category 5.B Cropland.

N₂O-emissions from other land-use conversions than from forest to cropland are not asked to report. Finland has estimated that from afforested/reforested organic soils about 430 Gg CO₂ eq. N₂O has been released in 2001–2005.

Table 3 deals with emissions and removals by sub-division according to land-use transitions in reporting period. The most important category has been the conversion from forest land to cropland. This table shows how organic soils are CO₂ sources after afforestation/reforestation. The growth of biomass does not compensate the emissions from soil.

The calculation gives Finland for period 2001–2005 an accounting quantity for Article 3.3 Deforestation activity 18.33 Mt CO₂ eq., which is equal to the cumulative net emissions and removals of the reporting period. Finland does not have units of land harvested during the reporting period following the afforestation or reforestation, thus the accounting quantity, -0.20 Mt CO₂ eq., for AR activity equals the total net emissions and removals during the period. The Finland's FM cap is 2.93 Mt CO₂ eq. ($0.16 \cdot 44 / 12 \cdot 5 = 2.93$). Because the sum of accounting quantity of AR and accounting quantity of D is greater than 0 but less than 165, the 3.3 offset is 18.13 Mt CO₂ eq. Total net emissions and removals for Forest Management for the 5 years period is -156.03 Mt CO₂ eq. The accounting quantity for Forest Management is -21.06 Mt CO₂ eq.

Table 2. The estimated emissions (+) and removals (-) in ARD activities under Article 3.3 and in Forest Management under Article 3.4 during the period 2001–2005.

	Carbon stock change in biomass			Net carbon stock change in DOM	Net carbon stock change in SOM	CH ₄	N ₂ O	Net CO ₂ emissions/ removals
	Removals	Emissions	Net change					
Gg CO ₂ eq.								
Article 3.3								
Afforestation/ Reforestation	-2 065	IE ¹⁾	-2 065	NE ²⁾	1 862	NE ³⁾	NE ³⁾	-203
Deforestation	IE ⁴⁾	9 820	9 820	3 992	4 485	NE ⁵⁾	32 ⁶⁾	18 330
Article 3.4								
Forest Management	-573 869	437 660	-136 208	-36 765	16 861	22	59	-156 032

¹⁾ Emissions in carbon stock change in biomass concerning afforestation are included in removals

²⁾ Litter and dead wood accumulation were not estimated in afforested areas

³⁾ CH₄ and N₂O emissions in afforested areas were not reported

⁴⁾ Removals in carbon stock change in biomass concerning deforestation are included in emissions

⁵⁾ CH₄ emissions in deforested areas were not estimated

⁶⁾ N₂O emissions in deforested areas were reported only in areas converted to croplands/grasslands

Table 3. The estimated emissions (+) and removals (-) in ARD activities under Article 3.3 and in Forest Management under Article 3.4 by subdivided into land-use categories during the period 2001–2005.

	Conversion from or to						Total	
	Cropland		Grassland		Wetlands			Settlements
	Mineral soils	Organic soils	Mineral soils	Organic soils	Non forest peatlands	Peat production areas		
Gg CO ₂ eq.								
Afforestation/ Reforestation	-1 392	850	-67	127	206	182	-110	-203
Deforestation	6 791	6 837	IE ¹⁾	IE ¹⁾	104	1 347	3 251	18 330
Forest Management								-156 032

¹⁾ Conversion to grasslands is included in conversion to croplands

1. General information

1.1 Definition of forest

Forest is defined under the Kyoto Protocol reporting using the definition applied in the Temperate and Boreal Forest Research Assessment 2000 to the United Nations Economic Commission for Europe and Food and Agriculture of the United Nations (UN-ECE/FAO TBFRA 2000). This definition is consistent with the definition given in Marrakesh Accords. Forest is a land with tree crown cover of (or equivalent stocking level) of more than 10 per cent and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 per cent or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest. For linear formations, a minimum width of 20 m is applied. Forest roads are included. Parks and yards, e.g., are excluded regardless that they would meet Forest land definition.

Finland has applied this forest definition in the Forest Research Assessments 2005 (FRA 2005) to the FAO and to the Ministerial Conference on the Protection of Forests in Europe (MCPFE 2007). The same definition is applied for forest land in the UNFCCC reporting and for the reporting Forest management activities under Article 3.4 and activities under Article 3.3 with some exceptions described later.

National Forest Inventory of Finland is the main area data source in greenhouse gas reporting. The FAO definitions for forest, other wooded land and other land have been applied since 1998 in field measurements in parallel with national definitions. A study was carried out to assess the FAO category to field plots measured in 1986–1997. All other parameters of FAO forest except the minimum area were able to take into consideration. In NFI the minimum area for forest stand is 0.25 ha in South Finland. In North Finland it is 0.5 ha.

The FAO definitions base on the crown cover and the height of trees, whereas the national definitions rest on the productivity of the site. National forest land is defined as land where the mean annual increment of growing stock with bark over rotation period is at least 1 m³/ha, and poorly productive forest land is land where the increment is less than 1 m³/ha but at least 0.1 m³/ha. According to the NFI9, the area of forest land was 20.34 mill. ha and the area of poorly productive forest land 2.67 mill. ha. The area of FAO forest was 22.47 mill. ha. The figures show the relation between national definition and FAO definition; about one fifth of the poorly productive forest land is left out the FAO forest area.

The method how forest area is estimated for UNFCCC reporting for years 1990–2005 is described in the NIR Chapter 7.2 *Forest land*, Section 7.2.1 *Source category description*. A consistent method is applied to estimate forest area for Forest management activity under Article 3.4.

1.2 Elected activities under Article 3.4

Finland has elected Forest Management activity under Article 3.4. In Table NIR-1 the notation key 'NA' is indicted for activities Cropland Management, Grazing Land Management and Revegetation. Land-use category determines management activity which land is subject to. All forests in Finland are considered as managed and all forests are subject to Forest Management activity. In the future Finland may revise the definition of a Forest management concept. Finland applies land-use categories presented in the IPCC GPG for LULUCF (IPCC 2003). A detailed description of relationships between IPCC land-use categories and national land-use classes are given in the NIR Chapter 7.1 *Overview of sector/Land areas and land-use categories used in the Finnish Inventory*.

1.3 Implementation of activity definitions under Article 3.3 and 3.4

Area data of afforestation/reforestation and deforestation activities was reported on the basis of statistics and NFI data. These time series as such are consistent but some discrepancy in definitions between statistics and NFI data exist. Area in statistics is compiled for nationally defined forest land, and thus the minimum area of 0.5 ha has not been in use. Differently from NFI data (see Section 1.1 *Definition of forest*), the statistical forest area data has not been harmonized with FAO forest definition. Even if the minimum area applied on statistics is not defined, a minimum area generally used in forestry in South Finland is 0.25 ha and in North Finland 0.5 ha. The discrepancies in minimum areas of detected land-use changes may cause a slight overestimation to ARD areas.

2. Land related information

2.1 Identification of geographical location

Finland uses the Reporting Method I provided in the IPCC GPG for LULUCF (IPCC 2003) to report land units subject to Article 3.3 and 3.4. Finland is stratified into two regions, South Finland and North Finland (Fig. 1). Administratively these two regions do not exist but municipal, county, Forestry Centre and other administrative regions form this boundary. This division is also taken into consideration when NFI sampling regions are composed (see the NIR, Appendix_7). Applied identification codes are the names of the regions: South Finland and North Finland.

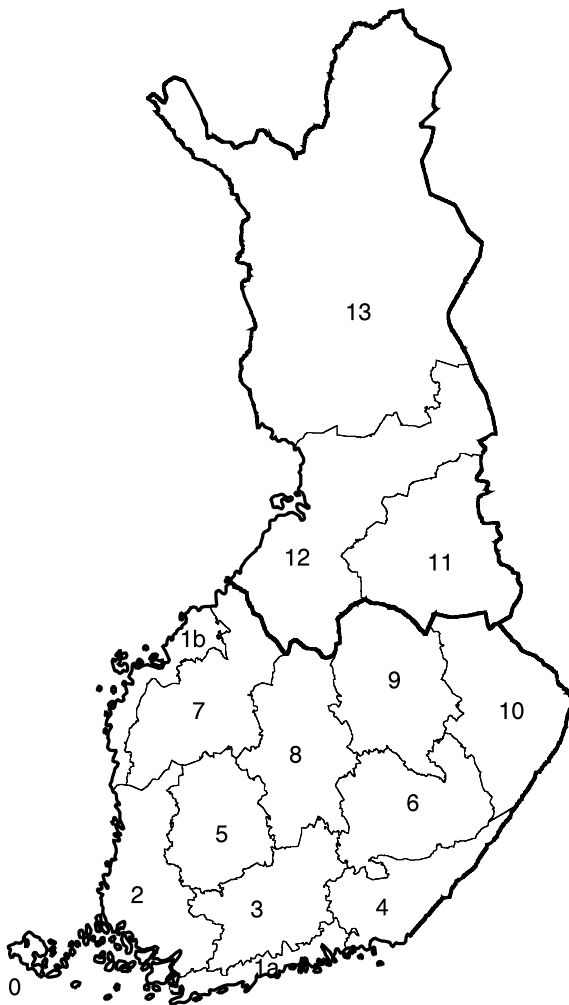


Figure 1. Map of Finland. The border between South and North Finland and the Forestry Centre regions.

Two kinds of information sources were used to determine area of land under Article 3.3. Information based on statistics were applied to afforested/reforested cropland and cutaways (formerly peat production areas), and to areas deforested for agricultural use, and to restored forest peatlands which after restoration measures are classified as wetlands. Other land-use change areas were estimated on the basis of NFI data. NFI estimates for land-use changes from and to forest land are available since the 10th inventory, measured in 2004 and 2005. In the previous 9th inventory land-use changes were assessed between national land-use classes and thus some changes between forest land and other IPCC land-use categories

are not possible to estimate. Harmonisation of NFI9 and NFI10 data would need an extensive workload and history information for all sample plots. These were the reasons to combine statistics with NFI information.

On the basis of two years measurement of NFI10, reliable estimates can be calculated only for large regions like South and North Finland. In the future, estimates can be calculated for smaller regions e.g. Forestry Centres (see Figure 1). Geographical location of NFI sample plots is known. About a fourth of the plots are established as permanent and these plots are mapped. All plots, temporal and permanent, are located with GPS and thus, the coordinates are known.

Statistics base on the regional reporting systems which forward the data to the authorised statistic compilers like Finnish Forest Research Institute and the statistics unit of the Ministry of Agriculture and Forestry. Statistical data is available for sub-regions as described later.

Afforestation and reforestation

Afforestation and reforestation was subdivided into following categories. The codes after the category names refer to the codes used in the Section 3.1.1 *Methodologies and underlying assumptions* and in the Table 8.

Conversion from Cropland and Grassland to Forest land (A1, A2)

Area data of afforestation/reforestation of arable land are compiled by Finnish Forest Research Institute and statistics are published annually in the Finnish Statistical Yearbook of Forestry (Table 4). Arable land includes cropland and abandoned cropland which are classified as grassland in this report. Reforestation is carried out by planting or seeding. Data is compiled for Forestry Centre regions (Fig. 1).

Area of naturally reforested grasslands was estimated from NFI10 data. Forest land stands which have transformed from grassland since 1990 were included in the calculations. These sites were considered as abandoned croplands. Forest stands originated since 1990 or after that were accepted. The site where the development from cropland to grassland and after that to forest land has started earlier, that is the decision of abandonment of cropland has made before 1990, were excluded. The measured age of a forest stand was used in the selection.

The time of land-use change is assessed with one year accuracy for 10 previous years but for older changes in five years classes. Change area per year was thereby calculated as a mean of five years sum. The same value for the area estimate was used in five years intervals: 1990–1994, 1995–1999 and 2000–2004. For 2005 the value of year 2004 was applied. The five years averages of areas were used to avoid abrupt fluctuation between years which due the fact that the NFI10 sampling grid is not yet complete. The situation will be improved when NFI10 measurement will be completed in 2008.

Conversion from Wetlands to Forest land (A3)

Afforestation/reforestation of wetlands was approached in two ways; AR of wetlands in forestry use, and AR of peat extraction areas.

Wetlands with tree cover, that is the sites not fulfilling the thresholds of forest land, are drained to improve the site conditions for wood production. Drainage of peatlands in natural state is no more permissible but cleaning of ditches and supplementary ditching are carried out. Areas where these actions have occurred since 1990 and the land use has changed to forest land were included in the calculations. Area of this activity was estimated from NFI data (Table 4).

Information about afforestation and reforestation of cutover peat extraction areas bases on VAHTI database (see the NIR, Chapter 7.5 *Wetlands* and *Annex 2*). Data in VAHTI database is received from the Association of Finnish Peat Industry and from Finland's environmental administration. At the moment is

not possible to present the figures separately for South and North Finland. In the CRF Tables North Finland is included in South Finland.

Conversion from Settlements to Forest land (A4)

Area transferred from settlements to forest land was estimated from NFI data (Table 4). Annual change area was calculated as a mean of five years. For years 1990–1994 the NFI9 and for years 1995–2005 the NFI10 estimates are presented. This category includes area transitions for example from abandoned dwelling places, gravel pits and traffic lanes.

Deforestation

Conversion from Forest land to Cropland and Grassland (D1, D2)

Area cleared from forest land to cropland is based on the statistics on the area of fellings. Statistics are compiled by Finnish Forest Research Institute and they statistics are published annually in the Finnish Statistical Yearbook of Forestry (Table 5). Fellings are grouped into intermediate fellings, regeneration fellings and other fellings. Fellings for clearing land for agriculture are included in other fellings. The reported area seems to be an overestimate because the area includes also fellings to clear land for settlements, roads etc. A comparison between applied area and area reported by Tike (the statistics unit of the Ministry of Agriculture and Forestry) was made. The area of the Tike includes area of new croplands but also old arable land returned eligible for farming subsidies. The applied area was in line with Tike area.

In the CRF Tables the conversion from forest land to cropland includes also conversion to grassland. Information is available for Forestry Centres (Fig. 1).

Conversion from Forest land to Wetlands (D3)

Two different kind of changes are reported in this category; restored wetlands and forest cleared for peat production. State enterprise Metsähallitus administers the most part of state-owned forests and almost all state-owned protected areas. Metsähallitus restores drained forest mires blocking ditches and removing trees to return the hydrology of the area to its state before drainage. To some extent restoration work has been done also in private forests, but that area information is not available at the moment. A rough estimate is that since the 1990s about 100 ha of mires have been restored on private lands (Restoration... 2003). Area of peatlands restored by Metsähallitus has increased from 0 ha in 1990 to about 2 500 ha in the last years. Deforestation is assumed to concern half of the restored peatland area. The other half fall below the thresholds of forest land already before the restoration measures being wetland, or staying after measures in the forest land category.

Area of lands cleared for peat production was estimated from NFI data. For years 1990–1994 the NFI9 estimates and for years 1995–2005 the NFI10 estimates are given. The Association of Finnish Peat Industry collects extensive area information concerning peat production areas. The weakness of that data is that it is not know if the former land-use category has been forest land or wetland.

Conversion from Forest land to Settlements (D4)

NFI9 and NFI10 data was applied to estimate land-use conversion from forest land to settlements.

2.2 Spatial assessment unit

In the 10th national forest inventory, land-use category according to the FAO definition (forest, other wooded land, other land) is assessed on the every sample plot. Utilising FAO category, national land-use class and other land use related information, the IPCC land-use category was created. The former land-

use class and FAO category is also assessed in field, if a detected change has occurred since 1990. Spatial assessment unit is 0.5 ha in NFI10 data and that relates to NFI9 data in North Finland. Smaller unit, 0.25 ha, was applied to NFI9 data in South Finland. The spatial assessment unit for statistical data is not known.

Table 4. Area per year and cumulative area in hectares of afforestation and reforestation in 1990–2005 in South and North Finland.

Afforestation/ reforestation	Conversion from					Total
	Cropland	Grassland	Wetlands		Settlements	
			Drained peatlands	Afforestation of cutaways		
ha						
South Finland						
1990-2000	8 259 ¹⁾	165 ¹⁾	256 ¹⁾	220 ¹⁾	737 ¹⁾	9 637 ¹⁾
2001	5 375	157	870	558	160	7 120
2002	2 396	157	870	557	160	4 140
2003	1 713	157	870	563	160	3 463
2004	2 043	157	870	500	160	3 730
2005	1 925	157	870	500	160	3 612
2001-2005	13 452	785	4 350	2 678	800	22 065
1990-2005	104 298	2 602	7 170	5 093	8 910	128 073
North Finland						
1990-2000	1 209 ¹⁾	300 ¹⁾	622 ¹⁾	IE ²⁾	318 ¹⁾	2 449 ¹⁾
2001	634	0	700	IE	0	1 334
2002	309	0	700	IE	0	1 009
2003	243	0	700	IE	0	943
2004	320	0	700	IE	0	1 020
2005	352	0	700	IE	0	1 052
2001-2005	1 858	0	3 500		0	5 358
1990-2005	15 153	3 300	10 346		3 500	32 299
Finland, total						
1990-2000	9 467 ¹⁾	465 ¹⁾	879 ¹⁾	220 ¹⁾	1 055 ¹⁾	12 086 ¹⁾
2001	6 009	157	1 570	558	160	8 454
2002	2 705	157	1 570	557	160	5 149
2003	1 956	157	1 570	563	160	4 406
2004	2 363	157	1 570	500	160	4 750
2005	2 277	157	1 570	500	160	4 664
2001-2005	15 310	785	7 850	2 678	800	27 423
1990-2005	119 451	5 902	17 516	5 093	12 410	160 372

¹⁾ Annual average

²⁾ Area of afforested cutaways in North Finland is included in area of South Finland

Table 5. Area per year and cumulative area in hectares of deforestation in 1990–2005 in South and North Finland.

Deforestation	Conversion to					Total
	Cropland	Grassland	Wetlands		Settlements	
			Restoration of peatlands	Clearing for peat product.		
	ha					
South Finland						
1990-2000	3 553 ¹⁾	IE ²⁾	171 ¹⁾	539 ¹⁾	6 885 ¹⁾	11 147 ¹⁾
2001	9 053	IE	204	730	3 930	13 917
2002	10 333	IE	175	730	3 930	15 168
2003	8 099	IE	546	730	3 930	13 305
2004	9 477	IE	980	730	3 930	15 117
2005	5 988	IE	915	730	3 930	11 563
2001-2005	42 950		2 820	3 650	19 650	69 070
1990-2005	82 029		4 703	9 580	95 380	191 692
North Finland						
1990-2000	2 729 ¹⁾	IE	102 ¹⁾	555 ¹⁾	2 157 ¹⁾	5 544 ¹⁾
2001	2 119	IE	118	160	2 630	5 027
2002	1 254	IE	66	160	2 630	4 110
2003	2 984	IE	229	160	2 630	6 003
2004	5 212	IE	433	160	2 630	8 435
2005	2 822	IE	526	160	2 630	6 138
2001-2005	14 391		1 372	800	13 150	29 713
1990-2005	44 411		2 497	6 910	36 880	90 698
Finland, total						
1990-2000	6 282 ¹⁾	IE	273 ¹⁾	1 095 ¹⁾	9 042 ¹⁾	16 692 ¹⁾
2001	11 172	IE	322	890	6 560	18 944
2002	11 587	IE	241	890	6 560	19 278
2003	11 083	IE	775	890	6 560	19 308
2004	14 689	IE	1 413	890	6 560	23 552
2005	8 810	IE	1 441	890	6 560	17 701
2001-2005	57 341		4 192	4 450	32 800	98 783
1990-2005	126 440		7 200	16 490	132 260	282 390

¹⁾ Annual average

²⁾ Grasslands are included in croplands

2.3 Land transition matrix in Table NIR 2

Table NIR-2 was produced for year 2005 as follows. The area staying in AR category is the sum of areas of AR activities in 1990–2004. Similarly the area of deforestation staying in the same category is the sum of deforestation activities in years 1990–2004. AR area increases in reporting year by the sum of AR activities carried out in 2005. This area represents the change from other land to AR. Land subject to Forest Management in the end of 2005 is the difference of land subject to FM in the end of 2004 and the area deforested during 2005. Sum of all activities under Article 3.3 and 3.4 and other land is the total land area in 2005.

The land transition matrix bases on the Finland's official land area, reported annually by the National Land Survey of Finland (Table 6). NFI area estimates, like forest land area, also base on this land area (Table 6). The NFI method for area estimates is described in the NIR Chapter 7 and Appendix_7. As it

can be seen in Table 6, the total land area varies year to year. The Land Survey of Finland has implemented a new geographical information system and database to produce up-to-date information. During the implementation some corrections have been made to data. The variation in forest land area is due to the change in total land area and the different sampling designs of NFI8, NFI9, and NFI10. The variations were not eliminated or taken into consideration in any way in calculations. The discrepancy between sequential years in NIR-2 tables follows from that reason.

Table 6. Total land area and area of Forest land in Finland 1990–2005 (1000 ha).

Year	Total land area	Forest land
1990	30 458	21 961
1991	30 459	21 967
1992	30 459	21 973
1993	30 459	21 979
1994	30 459	22 041
1995	30 459	22 103
1996	30 459	22 165
1997	30 459	22 227
1998	30 453	22 285
1999	30 452	22 344
2000	30 452	22 403
2001	30 448	22 460
2002	30 447	22 518
2003	30 447	22 396
2004	30 447	22 275
2005	30 411	22 128

3. Activity-specific information

3.1 Methods for carbon stock changes and GHG emission and removal estimates

3.1.1. Methodologies and underlying assumptions

In the greenhouse gas reporting to the UNFCCC the forest land remaining forest land and lands converted from other land-use categories to forest land is reported as a one category. The methods applied to carbon stock changes in living biomass, dead organic matter and soil organic matter are described in the NIR/7.2 *Forest land*. These methods are not straightforwardly usable in reporting under Kyoto Protocol to estimate carbon stock changes due to yearly land-use conversions. The drain of growing stock is needed to estimate yearly biomass losses and that is not available for land-use conversion categories. Also there is not appropriate activity data for Yasso-model.

Finland considers equal the area of managed forest and the land subject to forest management, and therefore the following approach was arrived to estimate emission and removals under Article 3.4:

1. to estimate the emissions/removals on forest land
2. to estimate the emissions/removals under Article 3.3 Afforestation/reforestation activity
3. subtract the emissions/removals under Article 3.3 AR activity from the emissions/removals on forest land.

In afforested and reforested areas an average growth of tree biomass was estimated from NFI10 data. An annual growth of volume on the forest land converted from land-use category in question was estimated as a result of the mean volume and the average time elapsed from the conversion. Thus, the growth includes also the drain of growing stock, and due to this in the CRF Table 5(KP-I)A.1.1 the losses in carbon stock change in living biomass is reported to include in gains. Growth estimates were converted to biomasses with Karjalainen & Kellomäki (1996) biomass expansion factors (Table 7). The change in carbon pool below-ground biomass is included in the carbon pool above-ground biomass.

Estimation of growth of ground vegetation was omitted, calculation method is under development. No accumulation of litter and dead wood were assumed in any afforestation land-use change categories, due to lack of national empirical data. The notation key NE is applied to net carbon stock change in litter and dead wood in the CRF Table 5(KP-I)A.1.1. Estimation of carbon stock changes in organic soils were based on measured emission coefficients, which describe decomposition of soil organic matter (SOM). Since these emission coefficients include also decomposition of below ground litter, the litter input to below ground must be estimated and subtracted from the total decomposition estimates to give carbon stock change estimate. Whereas in all afforested mineral soils carbon stocks were assumed to be unchanged. The notation key NE is applied to net carbon stock change in mineral soils (CRF KP(5-I)A.1.1).

Table 7. The coefficients by tree species according to Karjalainen and Kellomäki (1996).

Tree species	ef	dw (Mg/m ³)	cc	cf (Mg C /m ³)
Pine	1.527	0.390	0.519	0.3091
Spruce	1.859	0.385	0.519	0.3715
non-coniferous	1.678	0.490	0.505	0.4152

dw is a conversion factor to dry matter (Kellomäki et. al 1992), ef is expansion factor to expand stemwood to total tree biomass (Kellomäki et al. 1992), cc is carbon content (Karjalainen and Kellomäki 1993), cf is conversion factor from stem volume to total biomass carbon content

In deforested areas, mean volume of growing stock according to the NFI10 results (Korhonen et al. 2006) was applied to estimate the removed living biomass of trees. Reported volume estimates were converted to biomasses with Karjalainen & Kellomäki (1996) biomass expansion factors. Carbon stock change in below-ground biomass is included in carbon stock change in above-ground biomass (CRF 5(KP-I)A.2). Biomass of ground vegetation was omitted, calculation method is under development.

Litter and dead wood estimates were based on work done for NIR 2006. Carbon stock change in dead wood is included in reported changes in litter (IE in the CRF Table 5(KP-I)A.2 for carbon stock change in dead wood). Estimation of carbon stock changes in organic soils was made similarly as in afforestation sector basing on measured emission coefficients and litter inputs to below ground. Whereas in mineral soils carbon stock change estimations were mostly omitted except in agricultural soils cleared from forest, where default method (Tier 1) was used.

Description of methodologies used in each land-use change categories is presented in detail below. The biomasses and emission coefficients used in each method are presented in Table 8. In Table 8 land-use change categories are represented with codes, A1–A4 and D1–D3, which are described in text below.

Afforestation and reforestation

Conversion from Cropland to Forest land (in mineral soils A1.1, in organic soils A1.2)

Converted area was divided into mineral soils and organic soils on the basis of NFI10 data. 20 % of the converted area was estimated to be organic soils.

Estimated growth of trees in the areas after conversion was based on NFI10 measurements. In South Finland the applied growth in mineral soils was 2.2 m³/ha per year and in organic soils 2.5 m³/ha per year. In North Finland the estimates were 1.8 m³/ha and 1.0 m³/ha per year respectively.

Many studies have shown that there is no consistent pattern on the magnitude and direction of long-term soil carbon stock changes in afforested mineral croplands (IPCC 2003). National measurement about the phenomenon are lacking, thus no changes were assumed in carbon stock in mineral soils in the first 20 years after conversion (NE in the CRF Table 5(KP-I)A.1.1). In organic soils measured emission coefficients reported by Mäkiranta et al. (2007) were used in estimating the decomposition of SOM. Annual root litter production from ground vegetation was estimated according to Laiho et al. (2003). Tree root litter was estimated basing on tree growth and corresponding root biomasses (Lehtonen et al., 2004) and turnover rates (Liski et al., 2006; NIR Chapter 7.2.2).

Conversion from Grassland to Forest land (in mineral soils A2.1, in organic soils A2.2)

Division of the area to mineral and organic soils was based on NFI10 data, giving estimation that 50 % of the converted area was in organic soils.

Estimated growth of trees in the areas after conversion was based on NFI10 measurements. In South Finland the applied growth in mineral soils was 5.2 m³/ha per year and in organic soils 1.8 m³/ha per year. In North Finland the estimates were 2.2 m³/ha and 1.0 m³/ha per year respectively.

Carbon stock in soil was assumed to be unchanged in mineral soils in the first 20 years after conversion similarly as in cropland conversion to forest. In organic soils measured emission coefficients reported by Mäkiranta et al. (2007) were used in estimating the decomposition of SOM. Litter input to below ground soil was estimated similarly as in afforested organic croplands.

Conversion from Wetland to Forest land (afforest. of drained peatlands A3.1, afforest. of cutaways A3.2)

This land-use category includes two kinds of conversions, first afforestation of drained peatlands and secondly afforestation of cutaways (area formerly in peat production).

Estimated growth of trees in the areas after conversion was based on NFI10 measurements. In the category A4.1 applied growth estimate in South and North Finland is 1.0 m³/ha per year, and in the category A4.2 in South Finland 1.8 m³/ha and in North Finland 1.0 m³/ha per year.

Carbon stock change in soil of the afforested wetlands was estimated using measured emission coefficients, for drained peatlands reported results by Minkkinen et al. (2007; manuscript) were used and for cutaways reported results by Mäkiranta et al. (2007) were used. In drained peatlands litter input to below ground soil was estimated similarly as in afforested organic croplands. In afforested cutaways growth of ground vegetation was assumed to be zero, and only tree growth produced root litter (method similar as in organic croplands).

Conversion from Settlement to Forest land (A4)

Estimated growth of trees in the areas after conversion was based on NFI10 measurements. The same value of 1.4 m³/ha per year was applied to South and North Finland. Carbon stock in soil was assumed to be unchanged in mineral soils in the first 20 years after conversion.

Deforestation

Conversion from Forest land to Cropland (in mineral soils D1.1, in organic soils D1.2) and Grassland (in mineral soils D2.1, in organic soils D2.2)

The division of the reported area to mineral and organic soils was made according to a study made by the Ministry of Agriculture and Forestry. In the study data was collected in questionnaire, where all the forests cleared for agriculture in years 2002 and 2003 were presented with their geographical boundaries. This information was combined with geographical map of peatlands in Finland. According to these results on average 40 % of the cleared areas for agriculture were in organic soils.

Average biomass of trees was based on NFI10 measurements from areas where forestry is allowed normally or with minor restrictions (Korhonen et al. 2006). Mean volume of growing stock applied to estimate removed biomass were in South Finland for mineral soils 134 m³/ha and for organic soils 117 m³/ha, and in North Finland 71 m³/ha and 72 m³/ha respectively. It is assumed that all biomass is removed and land is planted in annual crops. The default value 5 tonnes of carbon per hectare for carbon stock after one year growth is applied (IPCC GPG LULUCF 2003, p. 3.87). Due to this in the CRF Table 5(KP-I)A.2 for subdivisions Cropland mineral and organic soils and Grassland mineral and organic soils, the notation key IE is applied for gains in carbon stock change in above-ground biomass.

Above ground litter and dead wood estimates were based on work done for NIR 2006. In this land-use change living biomass, dead wood and above ground litter were assumed to be removed and the carbon stock included in them to be oxidized immediately.

Soil organic matter was assumed to decompose in an accelerated rate after conversion to cropland. In mineral soils default method (Tier1) was used, with basic assumption that 29 % of SOM (pre-conversion) decomposes in 20 years in areas in temperate and moist conditions. Addition of organic inputs (e.g. animal manure) and/or management with reduced tillage decrease decomposing rate. In organic soils measured emission coefficients were used in estimating the decomposition of SOM.

Conversion from Forest land to Wetland (reforestation D3.1, clearing for peat production D3.2)

This land-use category includes two kinds of conversions, first restoration of forest in peatlands and secondly clearing forest for peat production.

Estimated biomass of trees in the areas before conversion was based on NFI10 measurements (Korhonen et al. 2006). The restored areas were assumed to be on the nationally defined poorly productive forest lands, a scarce part of the FAO forest land, and the removed volume of the growing stock was assumed to be 21 m³/ha in South Finland and 19 m³/ha in North Finland. The applied mean volume estimates for areas cleared for peat production were 109 m³/ha in South Finland and 52 m³/ha in North Finland. All biomass is cleared and the biomass after conversion is 0 tonnes C per hectare. Estimates for above ground litter and dead wood in areas cleared for peat production were based on work done for NIR 2006.

Carbon stock change in soil in the peat production areas were estimated using measured emission coefficients reported by Nykänen et al. (1996). Restoration in peatlands includes filling of the ditches, which causes a rise to the ground water level and thereby stops the decomposition process. Thus no changes in carbon stock were assumed in the restored lands.

Conversion from Forestland to Settlement (D4)

Estimated biomass of trees in the areas before conversion was based on NFI10 measurements from areas where forestry is allowed normally or with minor restrictions (Korhonen et al. 2006). The estimate applied to South Finland was 126 m³/ha and the one to North Finland 63 m³/ha. In this conversion part of the trees are saved from harvesting and in some cases new trees are planted. For tree biomass after conversion an average value 20 tonnes of carbon per hectare measured by Hyvärinen (unpublished data) was used. The notation key IE for gains in carbon stock change in above-ground biomass is used.

Above ground litter and dead wood estimates were based on work done for NIR 2006. And here also, dead wood and above ground litter were assumed to be removed and the carbon stock included in them to be oxidized immediately.

Carbon stock in soil was assumed to be unchanged in this conversion.

Direct N₂O emissions from forest fertilisation

In the CRF Table 5(KP-II)1 are reported direct N₂O emissions from N fertilisation. The amount of N applied to forest land is available for total forest land in Finland. All emissions are reported under Forest management in South Finland. Emissions on afforested and reforested lands are included in category Forest management. The applied method is described in the NIR/7.7.1 Direct N₂O emissions from fertilisation.

N₂O emissions from drainage of soils

Emissions from drainage of soils on lands subject to Forest management under Article 3.4 are not reported (CRF Table KP(II)2).

N₂O emissions from disturbance associated with land-use conversion to cropland

N₂O emission during decomposition in mineral soils was estimated using average C/N -ratio of forest soils reported by Tamminen et al. (manuscript) (CRF Table KP(II)3). N₂O emission during decomposition in organic soils is included in the agriculture sector reporting and is thus not reported here (IE in the CRF Table KP(II)3)

Carbon emissions from lime application

In the CRF Table KP(II)4, the NO is reported under afforestation/reforestation. In Finland lime is not applied to forest land. Lime is applied to lands converted from forest to cropland. Nevertheless the CO₂ emissions from liming from lands under deforestation are not reported. At the moment there is inadequately information available about the area and amount of lime applied to lands subject to deforestation. Anyhow, the CO₂ emissions from liming are reported in the GHG reporting to the UNFCCC under the CRF Category 5.B Cropland.

Emission from biomass burning

In the CRF Table 5(KP-II)5, the emissions from biomass burning on forest land are reported. Controlled burnings on afforested and reforested lands do not occur and NO is reported. Wildfires are not possible to separate for lands under Article 3.3 and 3.4 and all emissions are reported under Forest management category. Detailed descriptions of method and activity data are given in the NIR, in the Section 7.7.4 *Biomass burning*.

Table 8. The estimated biomasses and emission coefficients used in calculation methods under Article 3.3. Codes for conversion categories A1–D3 are presented in text above.

South Finland	Biomass before conversion 3, 7)	Biomass after conversion 1, 2)	DOM before conversion 12)	DOM after conversion	Growth of trees after conversion 3, 11)	CO ₂ emission 8, 10, 14)	Below ground litter 4, 5, 6)	N ₂ O emission 9, 10, 13, 14)
	g C m ⁻²				g C m ⁻² yr ⁻¹			g N ₂ O m ⁻² yr ⁻¹
A1.1	0	(see growth of trees after conversion)	NE ^{b)}	NE	-89	NE	NE	NE
A1.2	0		NE	NE	-93	480	-193	NE
A2.1	0		NE	NE	-200	NE	NE	NE
A2.2	0		NE	NE	-70	480	-183	NE
A3.1	0		NE	NE	-31	288	-173	NE
A3.2	0		NE	NE	-70	377	-183	NE
A4	0		NE	NE	-50	NE	NE	NE
D1.1	4 736	500	1 363	0	-	53	-	0.04
D1.2	4 134	500	924	0	-	490	-	NE
D2.1	IE ^{a)}	IE	IE	IE	-	IE	-	NE
D2.2	IE	IE	IE	IE	-	IE	-	NE
D3.1	696	0	NE	NE	-	NE	-	NE
D3.2	3 839	0	924	0	-	247	-	NE
D4	4 461	2 000	1 266	0	-	NE	-	NE

North Finland	Biomass before conversion 3, 7)	Biomass after conversion 1, 2)	DOM before conversion 12)	DOM after conversion	Growth of trees after conversion 3, 11)	CO ₂ emission 8, 10, 14)	Below ground litter 4, 5, 6)	N ₂ O emission 9, 10, 13, 14)
	g C m ⁻²				g C m ⁻² yr ⁻¹			g N ₂ O m ⁻² yr ⁻¹
A1.1	0	(see growth of trees after conversion)	NE	NE	-89	NE	NE	NE
A1.2	0		NE	NE	-93	480	-173	1.02
A2.1	0		NE	NE	-200	NE	NE	NE
A2.2	0		NE	NE	-70	480	-173	1.02
A3.1	0		NE	NE	-31	288	-173	0.23
A3.2	0		NE	NE	-70	377	IE ^{b)}	0.15
A4	0		NE	NE	-50	NE	NE	NE
D1.1	2 384	500	1 043	0	-	53	-	0.04
D1.2	2 520	500	1 051	0	-	490	-	NE
D2.1	IE ^{a)}	IE	IE	IE	-	IE	-	NE
D2.2	IE	IE	IE	IE	-	IE	-	NE
D3.1	637	0	NE	NE	-	NE	-	NE
D3.2	1 807	0	1 051	0	-	247	-	NE
D4	2 128	2 000	1 045	0	-	NE	-	NE

¹⁾ Hyvärinen, unpublished data; ²⁾ IPCC, 2003; ³⁾ Karjalainen & Kellomäki, 1996; ⁴⁾ Laiho et al., 2003; ⁵⁾ Lehtonen et al., 2004; ⁶⁾ Liski et al., 2006; ⁷⁾ Metsätieteen aikakauskirja 1B/2006; ⁸⁾ Minkkinen et al., 2007; ⁹⁾ Minkkinen, manuscript; ¹⁰⁾ Mäkiranta et al., 2007; ¹¹⁾ NFI10; ¹²⁾ NIR, 2006; ¹³⁾ Nykänen et al., 1996; ¹⁴⁾ Tamminen et al., manuscript.

^{a)} D2 is included in D1

^{b)} Afforestation of cutaways in North Finland is included in afforestation in South Finland

3.2 Information for activities under Article 3.3

Compilation of statistics on forestry activities has a long history in Finland and all organisations involved in the process are well prepared to collect data and deliver it to the data compiler annually. Yearly statistics and time series for several decades are published in Finland's official statistical book by the Finnish Forest Research Institute. This process ensures that information is applied to right years. Statistics cover all forest owner groups and geographically entire Finland.

The landowner or holder of the right of possession have to in accordance with the Forest Act (1093/1996) make a forest use declaration to the forestry centre before the start of felling; the type of felling (intermediate, regeneration, other), area to be felled, and the reason to felling if forest is cleared for other use than forestry (agriculture, settlements). The statistic on other fellings basis on these forest use declarations.

Land-use change areas estimated from national forest inventory data are the five years averages and therefore the activity may not be applied in exactly right year. It has become certain that the periods of five years fit the given time point of 1990, and the reported commitment period 2001–2005. In the field a problem can be to make a difference between a silvicultural clear cutting for regeneration and a clear cutting for land-use change concerning the recent fellings. Usually a right choice can be made with the assistance of near surrounding and the manner which actions have carried out.

Units of land harvested since 1990 on lands subject to Article 3.3 (short rotation forests) do not occur in Finland, thus the notation key NO is applied in the CRF Table KP(-I)A.1.2. Deforestation and disturbances occurred on lands subject to Article 3.3 can't be distinguished from lands subject to Forest Management. The weakness of the applied method to detect units of land under Article 3.3 is that only the last activity is recorded.

In accordance with forest land definition, the forest roads are classified as forest land. The area cleared for forest roads is estimated from NFI data (Table 9).

Table 9. Forest land area cleared for forest roads in 1990–2005 in South and North Finland. Source: Finnish Forest Research Institute/National Forest Inventory.

Region	1990–1994	1995–2000	2001–2005	1990–2005
			ha	
South Finland	2 600	1 500	2 000	6100
North Finland	1 500	1 700	2 700	5900
Total	4 100	3 200	4 700	12 000

3.3 Information for activities under Article 3.4 - Forest Management

Forest Management activities include silvicultural and forest-improvement practices, restoration measures as well in forests in forestry use as in protected forest areas. Also forests under different planning activities are included; regional and estate level forest planning, landscape ecological planning and regimes and management plans for protected areas. The Regional Forestry Programmes constitute a development plan for the whole forest sector. Sustainable development of forests is taken into consideration in the Programmes. The Forestry Centres draw up the programmes of the region concerned and they are revised every 5 years. Metsähallitus carries out landscape ecological planning (LEP), forest planning and planning of protected areas in state-owned forest. Practically all forest in Finland are in some extend under the plan. Planning process has finished (LPE) or has been revised since 1990.

The carbon stock changes on forest land under Article 3.4 are calculated applying the method described in the NIR. The method applies the forest land definition given in item 1.1. The definition of forest applied in the statistics on forest wildfires to calculate the emission from the category Biomass burning (CRF 5(V)) /Wildfires is not assured. Areas of land-use categories wetlands and other land may be reported under forest.

Silvicultural measures are tending of seedling stands, intermediate fellings, fellings for regeneration, site preparation, planting, seeding, pruning and fertilisation for growth. To forest-improvement works are included ditching, construction and improving of forest roads and remedial fertilisation. Ecologically important sites are treated to maintain and improve biological diversity as well in forest on forestry use as in protected areas. Protected areas are restored for example damming and blocking ditches, removing trees, making small clearings, deliberately damaging trees, lighting artificial forest fires. Hiking and outdoor recreation areas are treated taking into consideration the needs of visitors building camping areas, paths, ski trails as well the ecological aspects.

4. Emissions by sources and removals by sinks

4.1 Estimates of emissions by sources and removals by sinks

The estimated emissions and removals by carbon pools in the commitment period by human-induced activities - afforestation and reforestation, deforestation and forest management - are presented in Tables 10–12. The emissions and removals from activities under Article 3.3. by land-use change categories are presented in Tables 13 and 14.

Table 10. The estimated emissions (+) and removals (-) under Article 3.3 activities Afforestation and Reforestation in 2001–2005. Due to the applied method, emissions in carbon stock change in biomass are included in removals ²⁾.

Afforestation/ reforestation	Carbon stock change in biomass			Net carbon stock change in DOM	Net carbon stock change in SOM ¹⁾	CH ₄	N ₂ O	Net CO ₂ emissions/ removals
	Removals	Emissions	Net change					
	Gg CO ₂ (eq.)							
South Finland								
2001	-332	IE ²⁾	-332	NE	247	NE ¹⁾	NE	-85
2002	-353	IE	-353	NE	271	NE	NE	-83
2003	-364	IE	-364	NE	288	NE	NE	-77
2004	-374	IE	-374	NE	303	NE	NE	-70
2005	-384	IE	-384	NE	319	NE	NE	-65
2001-2005	-1 807	IE	-1807	NE	1 427	NE	NE	-380
North Finland								
2001	-48	IE ²⁾	-48	NE	79	NE	NE	31
2002	-50	IE	-50	NE	83	NE	NE	33
2003	-52	IE	-52	NE	87	NE	NE	35
2004	-53	IE	-53	NE	91	NE	NE	38
2005	-55	IE	-55	NE	95	NE	NE	40
2001-2005	-258	IE	-258	NE	435	NE	NE	177
Finland, total								
2001	-380	IE ²⁾	-380	NE	326	NE	NE	-54
2002	-404	IE	-404	NE	354	NE	NE	-50
2003	-416	IE	-416	NE	375	NE	NE	-42
2004	-427	IE	-427	NE	394	NE	NE	-33
2005	-438	IE	-438	NE	413	NE	NE	-25
2001-2005	-2 065	IE	-2 065	NE	1 862	NE	NE	-203

¹⁾ Includes emissions from organic soils, for mineral soils no change in C stock is assumed

²⁾ Emissions from carbon stock change in biomass are included in removals

Table 11. The estimated emissions (+) and removals (-) under Article 3.3 activity Deforestation in 2001–2005. Due to the applied method, removals in carbon stock change in biomass are included in emissions.

Deforestation	Carbon stock change in biomass			Net carbon stock change in DOM	Net carbon stock change in SOM	CH ₄	N ₂ O	Net CO ₂ emissions/removals
	Removals	Emissions	Net change					
	Gg CO ₂ (eq.)							
South Finland								
2001	IE	1 789	1 789	601	380	NE	3	2 773
2002	IE	1 976	1 976	657	463	NE	3	3 099
2003	IE	1 658	1 658	560	556	NE	4	2 777
2004	IE	1 871	1 871	620	630	NE	5	3 125
2005	IE	1 358	1 358	468	716	NE	5	2 547
2001-2005	IE	8 651	8 651	2 906	2 744	NE	20	14 321
North Finland								
2001	IE	176	176	188	306	NE	2	673
2002	IE	114	114	155	325	NE	2	596
2003	IE	240	240	221	337	NE	2	801
2004	IE	403	403	307	364	NE	3	1 076
2005	IE	236	236	215	409	NE	3	862
2001-2005	IE	1 169	1 169	1 086	1 741	NE	12	4 009
Finland, total								
2001	IE	1 965	1 965	790	687	NE	5	3 446
2002	IE	2 089	2 089	812	788	NE	6	3 695
2003	IE	1 898	1 898	781	893	NE	6	3 579
2004	IE	2 274	2 274	927	993	NE	7	4 201
2005	IE	1 594	1 594	683	1 124	NE	8	3 409
2001-2005	IE	9 820	9 820	3 992	4 485	NE	32	18 330

Table 12. The estimated emissions (+) and removals (-) under Article 3.4 activity Forest Management in 2001–2005.

Forest Management	Carbon stock change in biomass			Net carbon stock change in DOM	Net carbon stock change in SOM	CH ₄	N ₂ O	Net CO ₂ emissions/removals
	Removals	Emissions	Net change					
	Gg CO ₂ (eq.)							
South Finland								
2001	-78 797	68 095	-10 702	-4 245	135	3	11	-14 797
2002	-78 807	69 146	-9 661	-3 627	-250	4	12	-13 521
2003	-78 809	70 027	-8 782	-3 376	-780	3	12	-12 924
2004	-78 808	69 362	-9 446	-3 599	-1 280	1	12	-14 311
2005	-89 636	66 789	-22 846	-1 595	-1 532	2	11	-25 960
2001-2005	-404 856	343 419	-61 437	-16 442	-3 706	13	58	-81 514
North Finland								
2001	-33 428	18 190	-15 238	-4 699	4 411	3	0.3	-15 523
2002	-33 428	18 252	-15 177	-4 776	4 139	2	0.2	-15 811
2003	-33 429	18 999	-14 430	-4 636	4 033	2	0.2	-15 031
2004	-33 428	19 404	-14 025	-4 399	3 926	0.3	0.03	-14 497
2005	-35 299	19 396	-15 903	-1 814	4 059	2	0.2	-13 656
2001-2005	-169 013	94 241	-74 772	-20 324	20 568	9	1	-74 518
Finland, total								
2001	-112 225	86 285	-25 940	-8 944	4 546	5	12	-30 320
2002	-112 235	87 397	-24 838	-8 403	3 890	6	12	-29 333
2003	-112 237	89 026	-23 211	-8 012	3 252	5	12	-27 954
2004	-112 236	88 766	-23 470	-7 998	2 647	2	12	-28 809
2005	-124 935	86 185	-38 749	-3 408	2 527	4	11	-39 616
2001-2005	-573 869	437 660	-136 208	-36 765	16 861	22	59	-156 032

Table 13. The estimated CO₂ emissions (+) and removals (-) under Article 3.3 activity Afforestation and Reforestation. In the first row of each region concerning years 1990-2000 emissions and removals are given as annual averages.

Afforestation/ reforestation	Conversion from							Total
	Cropland		Grassland		Wetlands		Settlements	
	Mineral soils	Organic soils	Mineral soils	Organic soils	Drained peatlands	Afforestation of cutaways		
	Gg CO ₂ (eq.)							
South Finland								
1990-2000	-124 ¹⁾	69 ¹⁾	-3 ¹⁾	4 ¹⁾	5 ¹⁾	7 ¹⁾	-6 ¹⁾	-49 ¹⁾
2001	-237	132	-7	8	9	25	-15	-85
2002	-251	140	-7	8	12	31	-15	-83
2003	-257	143	-8	9	15	37	-16	-77
2004	-261	146	-8	10	17	42	-16	-70
2005	-267	149	-9	10	20	48	-16	-65
2001-2005	-1 272	709	-39	45	73	182	-78	-380
North Finland								
1990-2000	-12 ¹⁾	14 ¹⁾	-4 ¹⁾	12 ¹⁾	10 ¹⁾	IE ²⁾	-5 ¹⁾	15 ¹⁾
2001	-22	27	-6	16	22	IE	-6	31
2002	-23	28	-6	16	24	IE	-6	33
2003	-24	28	-6	16	27	IE	-6	35
2004	-24	29	-6	16	29	IE	-6	38
2005	-25	30	-6	16	31	IE	-6	40
2001-2005	-119	141	-28	82	133		-32	177
Finland, total								
1990-2000	-135 ¹⁾	83 ¹⁾	-7 ¹⁾	16 ¹⁾	14 ¹⁾	7 ¹⁾	-11 ¹⁾	-34 ¹⁾
2001	-259	158	-12	24	31	25	-21	-54
2002	-274	167	-13	25	36	31	-22	-50
2003	-281	172	-13	25	41	37	-22	-42
2004	-286	175	-14	26	46	42	-22	-33
2005	-292	178	-14	27	51	48	-23	-25
2001-2005	-1 392	850	-67	127	206	182	-110	-203

¹⁾ Annual average

²⁾ Area of afforested cutaways in North Finland is included in area of South Finland

Table 14. The estimated CO₂ emission (+) and removals (-) under Article 3.3 activity Deforestation. In the first row of each region concerning years 1990-2000 emissions and removals are given as annual averages.

Deforestation	Conversion to							Total
	Cropland		Grassland		Wetlands		Settlements	
	Mineral soils	Organic soils	Mineral soils	Organic soils	Restoration of peatlands	Clearing for peat product.		
	Gg CO ₂ (eq.)							
South Finland								
1990-2000	459 ¹⁾	359 ¹⁾	IE ²⁾	IE ²⁾	4 ¹⁾	113 ¹⁾	941 ¹⁾	1 876 ¹⁾
2001	1 164	886	IE	IE	5	181	537	2 773
2002	1 333	1 037	IE	IE	4	188	537	3 099
2003	1 070	961	IE	IE	14	194	537	2 777
2004	1 250	1 112	IE	IE	25	201	537	3 125
2005	832	947	IE	IE	23	208	537	2 547
2001-2005	5 649	4 942			72	972	2 686	14 321
North Finland								
1990-2000	192 ¹⁾	217 ¹⁾	IE	IE	2 ¹⁾	94 ¹⁾	93 ¹⁾	598 ¹⁾
2001	174	311	IE	IE	3	72	113	673
2002	121	287	IE	IE	2	74	113	596
2003	234	374	IE	IE	5	75	113	801
2004	381	496	IE	IE	10	76	113	1 076
2005	233	426	IE	IE	12	78	113	862
2001-2005	1 142	1 895			32	375	565	4 009
Finland, total								
1990-2000	651 ¹⁾	576 ¹⁾	IE	IE	7 ¹⁾	207 ¹⁾	1 034 ¹⁾	2 474 ¹⁾
2001	1 337	1 197	IE	IE	8	253	650	3 446
2002	1 453	1 324	IE	IE	6	261	650	3 695
2003	1 304	1 336	IE	IE	19	269	650	3 579
2004	1 631	1 608	IE	IE	35	278	650	4 201
2005	1 065	1 373	IE	IE	36	286	650	3 409
2001-2005	6 791	6 837			104	1 347	3 251	18 330

¹⁾ Annual average

²⁾ Grasslands are included in croplands

4.2 Key category analysis

The key categories identified in UNFCCC inventory were the result of a Tier 2 analysis (see NIR Chapter 1.5 *Brief description of key categories*). The main suggested principle in GPG2003 (Chapter 5.4.4), which says that assessment of key categories under Article 3.3 and 3.4 of the Kyoto Protocol is the same as the assessment made for the UNFCCC inventory), was followed here. Considering the association between the LULUCF key categories and the items under Kyoto Protocol Article 3.3 and selected Forest Management activity under Article 3.4 we get the following list of key categories:

- 5.A.1. Forest Land remaining Forest Land: carbon stock change in living biomass,
- 5.A.1. Forest Land remaining Forest Land: carbon stock change in mineral soils,
- 5.A.1. Forest Land remaining Forest Land: carbon stock change in organic soils,
- Afforestation/reforestation: carbon stock change in living biomass,
- Afforestation/reforestation: carbon stock change in mineral soils,

- Afforestation/reforestation: carbon stock change in organic soils,
- Deforestation: carbon stock change in living biomass,
- Deforestation: carbon stock change in mineral soils,
- Deforestation: carbon stock change in organic soils.

Also according to qualitative criteria named in GPG 2000 the items of ARD activities should be identified as key categories while having high uncertainties (for uncertainties see next chapter).

4.3 Uncertainty of emission and removal estimates

Following relative standard errors were presented in UNFCC inventory for carbon stock changes in tree biomass, 3.8 % for C-uptake, 4.6 % for C-release and 18.8 % for net change of C (NIR/7.2 Forest land/7.2.3 Uncertainty and time series' consistency). Further, 81% relative standard error for carbon stock changes in mineral soil and 92% in organic soils was estimated in UNFCC inventory. The errors are assumed to be at least in the same level for carbon stock changes under Forest Management.

The activity data concerning converted areas was partially based on statistics and partially on NFI data. For statistical data used it is not possible to estimate the uncertainty associated. In addition, uncertainties associated to preliminary methodologies used assessing carbon stock changes in living biomass and in soil (DOM and SOM) in converted areas are also difficult to estimate, they surely are bigger than the standard errors in corresponding methodologies in UNFCC inventory. The methodology for estimating the uncertainties associated to the results is under development.

5. Information relating to Article 6

Finland doesn't have projects under Article 6.

References

- Finnish Statistical Yearbook of Forestry. 2006. SVT. Agriculture, forestry and fishery, 2006. Finnish Forest Research Institute.
- Forest Act (1093/1996). <http://www.finlex.fi/en/laki/kaannokset/1996/en19961093>
- Forest Resources 2000. Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand. UN-ECE/FAO Contribution to the Global Forest Resources Assessment 2000. United Nations. New York Geneva, 2000.
- Hyvärinen, J. unpublished data.
- IPCC 2003. Good Practice Guidance for Land use, Land-use change and Forestry (ed. Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., and Wagner F.) Hayama: IPCC and IGES. <http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf.htm>
- Karjalainen, T. and Kellomäki, S. 1996. Greenhouse gas inventory for land-use change and forestry in Finland based on international guidelines. *Mitigation and Adaptation Strategies for Global Climate* 1: 51–71.
- Korhonen, K.T., Heikkinen, J., Henttonen, H., Ihalainen, A., Pitkänen, J., & Tuomainen, T. 2006. Suomen metsävarat 2004–2005. *Metsätieteen aikakauskirja* 1B/2006: 183–221. (In Finnish)
- Laiho, R., Vasander, H., Penttilä, T. & Laine, J. 2003. Dynamics of plant-mediated organic matter and nutrient cycling following water-level drawdown in boreal peatlands. *Global Biogeochemical Cycles* 17(2), 1053, doi:10.1029/2002GB002015, 2003.
- Lehtonen, A., Mäkipää, R., Heikkinen, J., Sievänen, R. & Liski, J. 2004a. Biomass expansion factors (BEFs) for Scots pine, Norway spruce and birch according to stand age for boreal forests. *Forest Ecology and Management* 188: 211–224.
- Liski, J., Lehtonen, A., Palosuo, T., Peltoniemi, M., Eggers, T., Muukkonen, P. & Mäkipää, R. 2006. Carbon accumulation in Finland's forests 1922–2004 – an estimate obtained by combination of forest inventory data with modelling of biomass, litter and soil. *Annals of Forest Science* 63 (2006):687–697.
- METINFO. Forest Statistics Information Service databases. <http://www.metla.fi/metinfo/tilasto>. (In Finnish)
- Minkkinen, K., Laine, J., Shurpali, N., Mäkiranta, P., Alm, J. and Penttilä, T. 2007. Heterotrophic soil respiration in forestry-drained peatlands. *Boreal Environment Research* (in print).
- Minkkinen, K. Assessment of regional N₂O emissions from the drained peatland forests in Finland (manuscript).
- Mäkiranta, P., Hytönen, J., Aro, L., Maljanen, M., Pihlatie, M., Potila, H., Shrupali, N., Laine, J., Lohila, A., Martikainen, P.J. and Minkkinen, K. 2007. Soil greenhouse gas emissions from afforested organic soil croplands and cutaway peatlands. *Boreal Environment Research* (in print)
- Nykänen, H., Silvola, J., Alm, J. and Martikainen, P. (1996). Fluxes of greenhouse gases CH₄, CO₂ and N₂O on some peat mining areas in Finland. In: Laiho, R., Laine, J. and Vasander, H. (eds.) (1996). *Northern Peatland in global climate change*. Helsinki: The Academy of Finland. Pp. 141–147. (Proceedings of the International Workshop held in Hyytiälä, Finland, 8–12 October 1995, The Finnish Research Programme on Climate Change – SILMU).

Restoration in protected areas: report by the working group on restoration. 2003. The Finnish Environment 618. Ministry of the Environment. (In Finnish).

Tamminen, P. and Starr, M. Soil properties on forested mineral soils in Finland (manuscript).