Norway

A Submission to the Ad-Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP)

Land Use, Land Use Change and Forestry (LULUCF)

In order to enhance the understanding of the implications of the options and proposals for the treatment of LULUCF in the second commitment period, the AWG-KP has encouraged Parties to share information, and particularly data where available, before its ninth session held in Bangkok 28 September to 9 October 2009.

In this submission we provide historical data on land area for all land use categories in Norway. Furthermore we provide historical data on emissions and removals from the LULUCF sector for the period 1990- 2007, and projections for the years 2010, 2015 and 2020. The data covers the activities under Article 3.3. and forest mangement under Article 3.4. of the Kyoto Protocol. In addition we present historical data on the other activities under Article 3.4 (except revegetation), land use categories, harvested wood products (HWP), natural disturbance related to orest fires and emissions of non-CO_2 gases.

In addition to data on the elements mentioned above, this submission also provide information on the assumptions made to produce the data.

1. Land use areas

Historical data

Table 1 shows historical land area for all land use categories in the period 1990-2007. This is a reproduction of the data reported to the UNFCCC in the National Inventory Report 2009 (NIR2009)and is based on data from the National Forest Inventory (NFI) and Statistics Norway.

Norway is currently working on updating the historical data on land area. This may change the numbers presented in table 1. Norway will submit this data as soon as the update is completed.

The data shows that the area of forest land has increased by 4.6 per cent in the period 1990-2007. This is mainly due to conversion of cropland to forest land and other land to forest land.

Projections

We make the assumption that the area in the categories wetlands and other lands will be reduced in the future, by 5000 and 7000 ha per year, respectively. We assume that this area is converted to forest land. In total it is assumed that 1.2 million ha will be converted from these two categories to forest land over the next 100 years.

The data shows that areas converted from settlement, cropland and grassland to Forest land have remained constant in the last 5 year-period. We therefore assume a net change in emissions of zero.

Uncertainties

About 17 000 permanent plots are available from the NFI. These plots will be revisited during each 5 year period. With the high number of plots, the precision of the estimates (in relative terms) will be high for the common Land Use categories. However, the relative errors of the uncommon categories are rather high. The relative precision increases as the certain category becomes more frequent.

Table 1. Historical data on land area for all land use categories. (in 1000 ha)

	Forest land	Cropland	Grassland	Wetlands	Settlements	Other lands
1990	8870	1070	72	2348	623	19051
1991	8897	1070	72	2348	623	19051
1992	8891	1066	72	2346	626	19058
1993	8885	1063	72	2344	629	19065
1994	8880	1059	73	2341	632	19071
1995	8875	1056	73	2339	635	19078
1996	8871	1052	73	2336	637	19085
1997	8867	1049	74	2334	640	19092
1998	8862	1045	74	2331	643	19099
1999	8932	1033	80	2295	644	19035
2000	8989	1026	88	2266	647	19008
2001	9035	1024	92	2247	655	18980
2002	9079	1021	89	2227	661	18961
2003	9110	1012	93	2204	667	18942
2004	9142	1008	96	2175	675	18927
2005	9177	1007	93	2147	684	18918
2006	9214	999	102	2124	683	18903
2007	9274	980	113	2095	680	18883
1990-2007 (%)	4,6	-8,4	56,9	-10,8	9,1	-0,9

2. Emissions and removals from the LULUCF sector

Definitions

Definitions for land use categories are in accordance with the definitions in the Global Forest Resources Assessment (FRA) 2004, and definitions used for the activities under Article 3, paragraph 3 and 4 are in accordance with the annex of decision 16/CMP.1.

Activity based approach

Historical data

The historical data (1990-2007) on emissions and removals presented in Table 2 is based on the data submitted to the UNFCCC in Norwegian national inventory report (NIR 2009). An exception is emissions and removals relating tothe activities under Article 3.3 and on Forest management under Article 3.4, where updated data on land use change is used. In order to ensure consistency between the Convention reporting and the Kyoto Protocol accounting, we have made the following assumptions:

Article 3.3 afforestation and reforestation includes the annual living biomass increment on afforestation and reforestation areas accumulated since 1990 converted to CO_2 equivalents ("Land converted to forest land"). Afforestation and reforestation do not include CO_2 accumulation in soil and dead organic matter.

Article 3.3 deforestation includes the instantaneous emissions that occur from living biomass removal in conjunction with the deforestation event ("Forest land converted to other land uses"). After the deforestation event a net accumulation of zero is assumed (no further biomass removal or increment occurs). Deforestation, however, does not include CO_2 emissions from soil and dead organic matter.

Article 3.4 forest management includes the annual living biomass increment on forested areas converted to CO_2 equivalents ("Forest land remaining forest land"). Forest management includes CO_2 accumulation in soil and dead organic matter, but does not include emissions from drained organic soils and N_2O from fertilization.

Article 3.4 **cropland management** includes "Cropland remaining cropland" and Article 3.4 Grazingland management includes "Grassland remaining grassland".

Figure 1 shows the annual emissions and removals from activities under Article 3.3 and 3.4 for the period 1990-2007. While emissions from deforestation, grazing land and cropland management as been rather stable around 2-3 million tonnes CO_2 per year. Forest management, however, has increased from approximately 14 million tonnes CO_2 in 1990 to nearly 30 million tonnes the last 5 years. This increased removal is mainly due to active forest management the last 70 years and relatively stable harvest rate the same period, see figure 2.

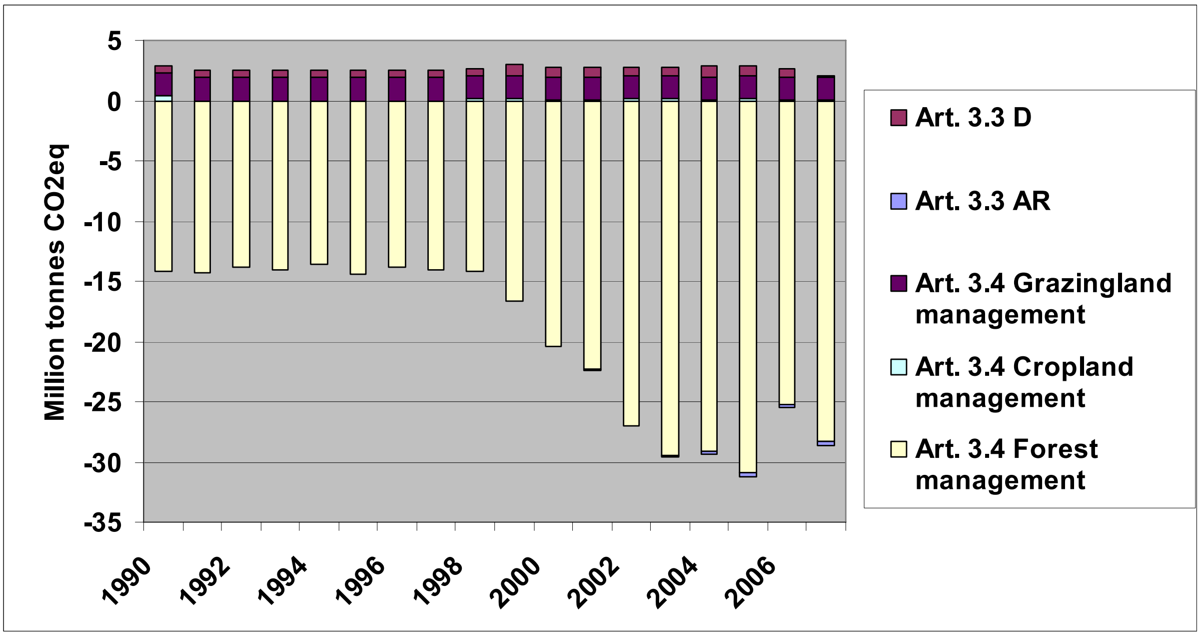

Figure 1. Annual emissions and removals for activities under Article 3.3. and 3.4 in Norway for the period 1990- 2007

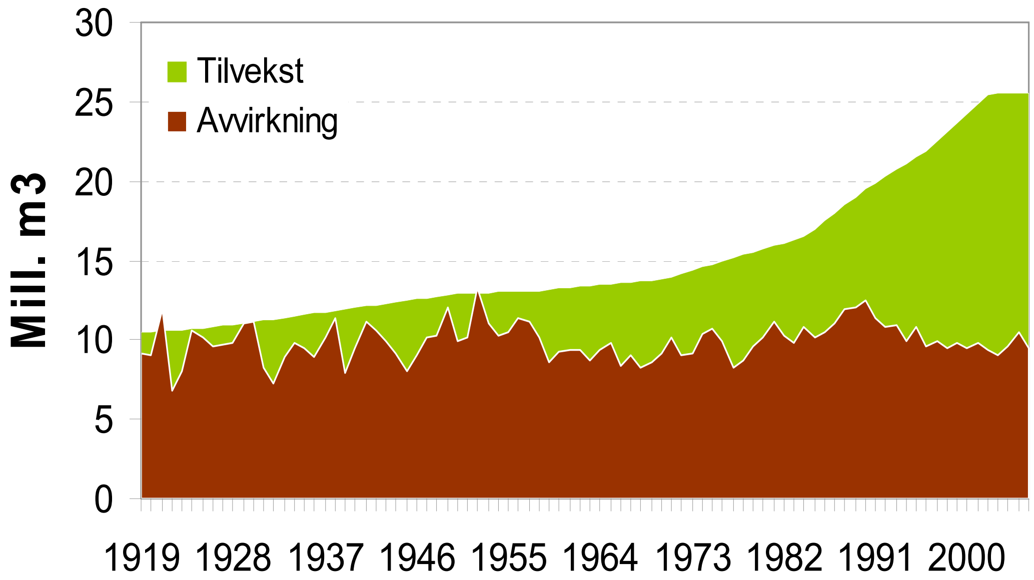

Figure 2. Annual forest harvest (brown) and annual increment (green)in Norway - 1990-2006

<u>Projections</u>

Projections of emissions and removals in the years 2010, 2015 and 2020 are based on data from the Norwegian Forest and Landscape Institute. The aim of the projection presented in this submission is to describe the expected development in emissions and removals from the LULUCF sector based on existing forest and climate change policy, i.e. business as usual projections (BAU).

For **forest management** under Article 3.4, the projections of productive forest are developed by using the projection model Avvirk 2000 (Eid and Hobbelstad 1999) and by doing the following modifications:

1) increased productivity due to an increase in the temperature of 2 ºC,
2) inclusion of calculations on biomass and on dead organic material,
3) a modified mortality rate on old forest and
4) a direct link to the dynamic soil carbon model YASSO.

Unproductive forests do not have any productivity class, and projections for these forests therefore can not be estimated using the model described above. The biomass increment in unproductive forests is estimated to 0.4 ton per hectare per year. This is independent of age and is based on observed net increment in unproductive forests in the period 1990-2008. The net increment includes natural mortality.

The projections for forest management are estimated based on two possible future scenarios in order to reflect business as usual:

> <u>*Scenario 1:*</u> Scenario 1 assumes a continuation of present logging rate and forest management. It is assumed a logging rate of 10 million m3 per year and an annually planting intensity of 20 million plants.
>
> <u>*Scenario 2:*</u> Sustainable forest management, increased use of harvested wood products and increased production of bioenergy are all political goals in Norway. In order to fulfil them, the logging intensity has to increase. Scenario 2 therefore assumes an

increased logging rate from 10 million to 15 million m3 per year and planting intensity at the same level as today. However, due to a larger area cleared for planting, the number of plants will in this scenario increase to 30 million plants annually.

It is reasonable to expect that the business as usual scenario will be somewhere between these two scenarios.

Figure 3 shows the two different scenarios for forest management, and hence the difference between a situation with the same harvest rate as today (Scenario 1) and a situation where the harvest rate is increased (Scenario 2). With an increased harvest rate as given in scenario 2, the annual removals from Forest Management in 2020 will be reduced from 21.9 Mton CO_2/year in scenario 1 to 16.4 Mton CO_2e/year.

The figure also shows that the annual removal of CO_2 from forest management probably may have reached its highest level in the period 2003-2007. The annual removal of CO_2 will continue to be high, but is expected to decrease towards 2020. This is due to the age structure of the forests. Most forest areas in Norway have now reached their most productive phase, which indicates that the biomass growth rate will decrease in the future.

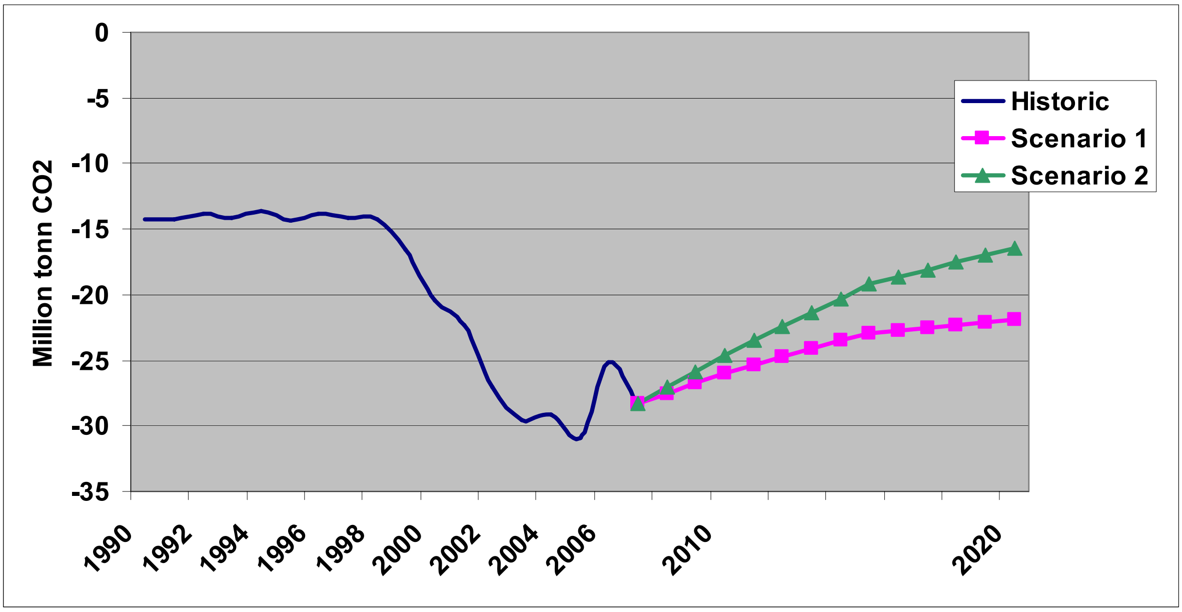

Figure 3. Emissions and removals from Forest management. Historical data and projections.

In table 2 both historical data and the projections for all the different LULUCF activities are presented.

The contribution from **deforestation under Article 3.3** is projected by assuming an annual emission of 0.6 Mtonne CO_2 /year for all years from 2010 to 2020, which is equivalent to the average emissions between 2002 and 2007. The contribution from **afforestation and reforestation** is projected by assuming an annual increase in forest area of 32 000 ha, leading to an increased annual CO_2 removal of -0.70 ton/ha. Table 2 shows that deforestation, afforestation and reforestation under Article 3.3 probably will result in net emissions from 1990 to 2015. In 2020 the emissions from activities under Article 3.3 are expected to be close to zero.

Article 3.4 Cropland management and Grazing land management are projected by assuming an annual emission of 0.15 Mton/year and 1.9 Mton/year, respectively, which is equivalent to the average change between 2002 and 2007.

Table 2. Annual emissions and removals for Article 3.3 and 3.4 for the period1990- 2007[1], and for the years 2010, 2015 and 2020[2] for Scenario 1 and Scenario 2 (in million tonnes CO_2-equivalents).

	Article 3.3 Afforestation Reforestation	Article 3.3 Deforestation	Article 3.4 Forest management		Article 3.4 Cropland management	Article 3.4 Grazingland management
Historical data						
1990	0.00	0.6	-14.2		0.4	1.9
1998	0.00	0.6	-14.2		0.2	1.9
1999	-0.01	0.9	-16.6		0.2	1.9
2000	-0.03	0.8	-20.4		0.1	1.9
2001	-0.05	0.8	-22.3		0.1	1.9
2002	-0.05	0.7	-27.0		0.2	1.9
2003	-0.10	0.7	-29.5		0.2	1.9
2004	-0.20	0.9	-29.1		0.1	1.9
2005	-0.26	0.8	-30.9		0.2	1.9
2006	-0.28	0.6	-25.2		0.1	1.9
2007	-0.35	0.1	-28.3		0.1	1.9
Projections						
			Scenario 1	Scenario 2		
2010	-0.35	0.6	-26.0	-24.6	0.2	1.9
2015	-0.46	0.6	-22.9	-19.2	0.2	1.9
2020	-0.57	0.6	-21.9	-16.4	0.2	1.9

[1] The historical data is preliminary and changes will occur until the final reporting for the first commitment period is completed.
[2] The projections are based on the reporting of historical values and will undergo changes when the historical values change.

Land based approach

Historical data

Historical data (1990- 2007) on emissions and removals from all land use categories is presented in Table 3 and reproduces the data reported to UNFCCC in NIR 2009. For each category, the data represents the net-emissions, i.e. from land remaining in the category and from land converted to the category.

It is important to note the difference between the figures in table 2 and in table 3, as table 3 shows the total contribution from the land category while Table 2 shows the contribution from activities which include only fractions of the land categories (see definitions in Chapter 2). The differences are described below the table.

It is also important to note there is some inconsistency in the results due t the fact that we only have updated data on the activities under Article 3.3 and on the activity Forest management under Article 3.4

Table 3. Emissions and removals from cropland, grassland, wetlands, settlements, other land and other for the period 1990- 2007 (in million tonnes).

	Forest land	Cropland	Grassland	Wetlands	Settlements	Other[1]
1990	-15.1	0.5	1.9	0.003	0.5	0.01
1991	-14.3	0.4	1.9	0.003	0.5	0.01
1992	-13.8	0.4	1.9	0.003	0.5	0.01
1993	-14.1	0.4	1.9	0.003	0.5	0.01
1994	-13.6	0.3	1.9	0.003	0.5	0.02
1995	-14.4	0.4	1.9	0.003	0.5	0.02
1996	-13,8	0.3	1.9	0.003	0.5	0.02
1997	-14.1	0.3	1.9	0.003	0.5	0.03
1998	-13.9	0.3	1.9	0.003	0.5	0.02
1999	-16.8	0.4	1.9	0.003	0.7	0.03
2000	-20.1	0.1	2.0	0.003	0.8	0.03
2001	-21.8	0.4	1.9	0.003	0.6	0.02
2002	-26.7	0.2	1.9	0.003	0.9	0.02
2003	-28.9	0.3	2.2	0.003	0.7	0.02
2004	-29.2	0.1	1.9	0.003	1.2	0.02
2005	-30.8	0.3	1.9	0.003	0.7	0.02
2006	-25.2	0.1	1.9	0.003	0.6	0.02
2007	-28.0	0.1	1.9	0.003	0.1	0.02

[1] Liming of lakes

Forests cover around 30 per cent of the mainland area of Norway and is the most important land use category considered managed. All Forest land in Norway is used either for wood harvesting, hunting, recreation etc, and is therefore classified as managed. The only difference between the Land Use category Forest land and the LULUCF activity Forest management is therefore that Land converted to forest land is extracted from Forest management in order to report Afforestation and reforestation as an activity under Article 3.3. The removals from Forest land will therefore be higher than for Forest management.

The activity Deforestation is a conversion from Forest Land to other Land Use categories.

Since the land based categories Cropland and Grassland include both Land remaining in the category and Land converted to the category, the emissions from the categories will be higher than the emission from the activities Cropland management and Grazing land management, where we have assumed that only Land remaining in the category is included.

<u>Projections</u>

We have not made any projections for categories under the land-based approach. However, emissions and removals for these categories will in general follow the same development up to 2020 as related activities under Article 3.3 and 3.4.

Uncertainties

There are always uncertainties related to projections and historical data. The projections on both short and long term are sensitive to fluctuations and their effects on forestry. In the long run the projections are dependent on the climate development and the effects on forest health and growth. For the historical data the uncertainties are smaller. However, the historical data is preliminary and changes will occur until the final reporting for the first commitment period is completed.

The uncertainties in emissions and removals figures are substantially higher for all Other Land Use categories compared to forest.

3. Harvested wood products (HWP)

Historical data

In Norway, as in many other countries, the stock of HWP has been increasing over the last couple of years and it is likely to further increase. Changes in the HWP pool will therefore influence the amount of CO_2-emissions.

This submission presents the HWP contribution in Norway based on the IPCC HWP model and the following approaches; the stock change approach (SCA), the production approach (PA) and the stock change approach for HWP of domestic orgin (SCAD).

The approaches differ in how the emissions from HWP are allocated to different countries depending on imports and exports, and will usually give different output with respect to both level and trend. In short, the SCA includes all HWP residing within the national boundaries, regardless of country of origin, the PA accounts for all domestically harvested wood, including the amount that is exported, while the SCAD only includes domestically harvested wood that stays within the national boundaries.

The IPCC HWP model is presented in the 2006 Guidelines as a default model (Tier 1). We have, wherever possible, estimated national values to be used instead of the default values provided by the 2006 Guidelines, turning it into a Tier 2 model. Activity data on production, imports and exports of semi-finished wood products are used, together with estimates on the lifetimes of the different products. The semi-finished products are aggregated into two main groups with different lifetimes; solid wood products (sawnwood, wood-based panels and optionally other industrial roundwood), and paper products (paper and paperboard).The model is especially sensitive to the assumption of lifetimes. For paper products we have used a half-life of 2 years, while the half-life used for solid wood products is 30 years.

The product groups “other industrial roundwood” and waste are not included in the calculations.

Figure 4 and Table 4 show the historical HWP contribution.

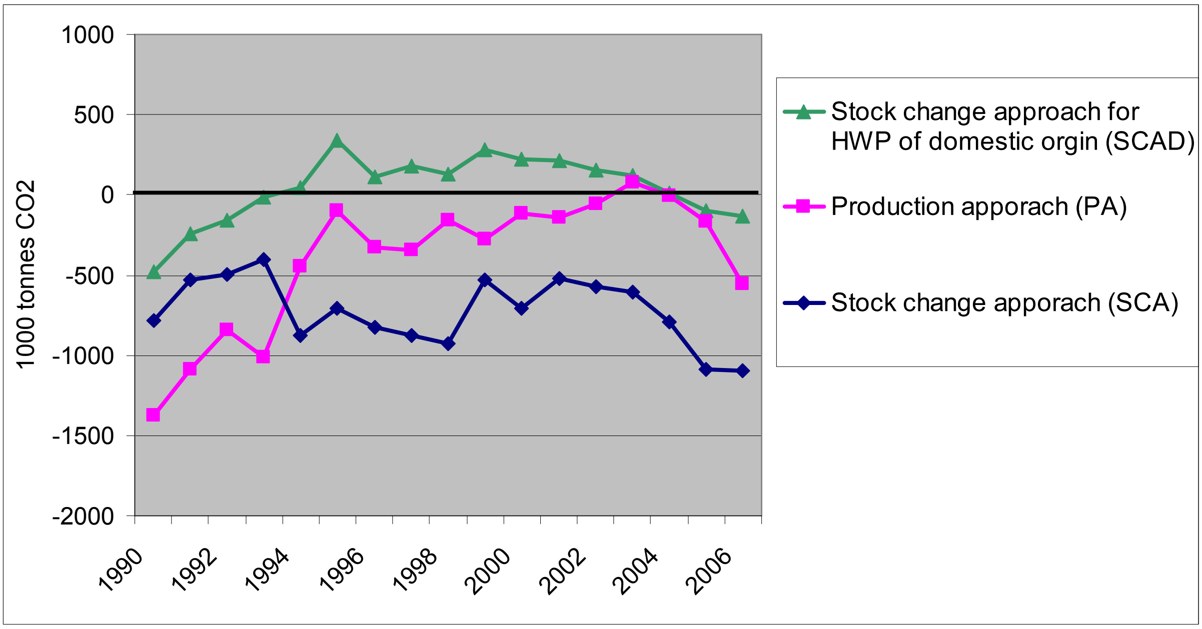

Figure 4. Emissions and removals from HWP for the different approaches in the period 1990-2006

Table 4. Emissions and removals from HWP for the different approaches (SCA, PA and SCAD) for the period 1990- 2006 (in million tonnes CO2).

	Stock change approach (SCA)	Production approach (PA)	Stock change approach for HWP of domestic origin (SCAD)
1990	-783	-1374	-482
1991	-533	-1089	-241
1992	-493	-846	-159
1993	-405	-1009	-12
1994	-872	-447	42
1995	-706	-97	337
1996	-829	-328	109
1997	-880	-343	180
1998	-923	-159	133
1999	-526	-273	279
2000	-705	-114	220
2001	-519	-143	214
2002	-572	-54	153
2003	-605	81	125
2004	-794	-4	10
2005	-1086	-167	-96
2006	-1096	-554	-131

Future effects of increased harvest rate (Scenario 2 for forest management)

An increased harvest rate from 10 million to 15 million m3 annually, as is assumed for scenario 2 for forest management, represents 1.25 million m3 additional lumber produced. If one assumes that this lumber is used to substitute energy intensive materials as steal and concrete this substitution can contribute to a reduced emission of 1 Mtonne CO_2e per year.

Additionally, the increased use of HWP can result in a delayed emission of approximately 1 MtonCO_2e per year.

Uncertainties

The production approach (PA) will always be associated with higher uncertainties than the other approaches, since estimates of the fate of exported HWP are highly uncertain. The stock change approach of domestic origin (SCAD) is probably associated with a lower uncertainty than PA and a higher uncertainty than the stock change approach (SCA), especially if HWP in landfills are included. There is also an uncertainty concerning the assumption that all lumber substitutes energy intensive materials.

The largest uncertainty in the IPCC HWP model is connected to the lifetime assumption and is about 50 percent.

4. Natural disturbance

Forest fires

Data on area burned in forest fires in Norway are available from the Directorate for Civil Protection and Emergency Planning for 1993- 2006. For 1990-1992 only data in the number of fires were available and these data were used to estimate the area burned on the ratio for subsequent years. This method may be inaccurate because the size of the fires is very variable.

Table 5. Forest fires in Norway, 1990-2007

	Number of fires	Unproductive forest (ha)	Productive forest (ha)	Total area burnt (ha)
1990 *	578	680	256	934
1991 *	972	1 143	431	1 574
1992 *	892	1 049	396	1 444
1993	253	136	88	224
1994	471	124	108	232
1995	181	78	36	113
1996	246	170	344	514
1997	533	606	261	866
1998	99	165	110	275
1999	148	734	13	86
2000	99	143	29	172
2001	117	84	5	90
2002	213	125	96	221
2003	198	906	37	942
2004	119	85	32	117
2005	122	253	93	345
2006 **	205	3222	661	3 883
2007	65	22	106	128

* Area estimated by NIJOS (2005)
** Updated activity data

There are no exact data on the amount of biomass burned per area. Normally, only the needles/leaves, parts of the humus and smaller branches are burned. We have estimated CO_2-

emissions from forest fires (Table 6) based on the following assumptions: 1) there is 20 m3 biomass per ha and the mass of trees burned constitute 25 percent of this, 2) 1 m3 dead-wood per ha will be affected by fires due to dryness, and 3) there is about 7- 500 kg humus per ha; 10 percent of this is burned.

Table 6. CO_2-emisisons from forest fires. 1000 tonn., 1990- 2007

	Living biomass	Dead wood	Humus	Total
1990	17.2	0.9	1.3	19.3
1991	28.9	1.4	2.2	32.5
1992	26.5	1.3	2.0	29.8
1993	4.1	0.2	0.3	4.6
1994	4.2	0.2	0.3	4.7
1995	2.1	1.0	0.2	2.3
1996	9.4	0.5	0.7	10.6
1997	15.9	0.8	1.2	17.9
1998	5.0	0.3	0.4	5.7
1999	1.6	0.1	0.1	1.8
2000	3.2	0.2	0.2	3.6
2001	1.6	0.1	0.1	1.8
2002	4.0	0.2	0.3	4.5
2003	17.3	0.9	1.3	19.5
2004	2.1	0.1	0.2	2.4
2005	6.3	0.3	0.5	7.1
2006	71.2	3.6	5.3	80.1
2007	2.4	0.1	0.2	2.7

The total CO_2 emissions from forest fires have varied from 2 to 80 ktonnes during the period 1990- 2007. The high emissions in 2006 were 0.36 percent of the net emissions from the LULUCF sector that year.

Due to the expected future increase in global temperature one can expect a greater risk of natural disturbances like forest fires in Norway.

Other natural disturbances

Based on work done by the Norwegian Forest and Landscape Institute it is registered that 75 percent of the natural mortality in Norwegian forests is due to wind- and snow damage. However, if the area damaged each year does not exceed the area needed for the annual harvest, it will not affect the annual emissions.

It is likely that an increased temperature will increase the occurrence of natural disturbances of all kinds. In Canada a correlation is proven between the increased temperature over the last couple of years and an increased number of fungal attacks on young plantations.

5. Non-CO_2 emissions

Changes in forest and other land use changes will influence emissions of other greenhouse gases than CO_2. Emissions of methane (CH_4) are mainly caused by fires. Emissions of nitrous oxide (N_2O) are, in addition to fires, caused by soil organic matter mineralization, nitrogen input and cultivation of organic soils. The emissions of non-CO_2 gases are however small, and the uncertainties in the estimates are relatively high.

There are no national data on emission factors for non-CO_2 emissions from forest fires. Estimates of non-CO_2 emissions are therefore based on the C release as described in "Good Practice Guidance for Land use, Land use change and Forestry". The CH_4 emissions from forests have varied from 8 to 350 tonnes CH_4 per year, while the N_2O emissions have varied from 0.05 to 2.4 tonnes N_2O per year. Converted to emissions of CO_2e, the emissions have varied from 180 to 8000 tonnes, The emissions were highest in 2006, due to a large number of wildfires that year.

Table 7: Estimates of CH_4 and N_2O emissions from forest fires, 1990-2007

	CH_4 Tonnes	N_2O Tonnes	Total CO_2eq 1000 tonnes
1990	84	0.58	1.9
1991	142	0.97	3.3
1992	130	0.89	3.0
1993	20	0.14	0.5
1994	21	0.14	0.5
1995	10	0.07	0.2
1996	46	0.31	1.1
1997	78	0.54	1.8
1998	25	0.17	0.6
1999	8	0.05	0.2
2000	15	0.16	0.4
2001	8	0.06	0.2
2002	20	0.14	0.5
2003	85	0.58	2.0
2004	11	0.07	0.3
2005	31	0.20	0.7
2006	349	2.40	8.1
2007	12	0.10	0.2

Fertilization of forest is of little importance in Norway, and the emissions from the activity are only about 2-4 tonnes N_2O, or 620-1240 tonnes CO_2e, per year. This is estimated by using an emission factor of 1.25 percent. The emission factor is very uncertain. According to "Good Practice Guidance for Land use, Land use change and Forestry" the range in emission factor can be from 0.25 percent to 6 percent.

The area drained in Norway is currently low, and we do not have any national data available. The estimates on the N_20 emissions from drainage are therefore based on "Good Practice Guidance for Land use, Land use change and Forestry". The N_2O emissions from drainage of forest soils have been 40 tonnes N_20 per year throughout the period 1990-2007, which is equal to 12 400 tonnes CO_2e.

Conversion of forest, grassland and other land to cropland is expected to increase N_2O emissions. This is due to mineralization of soil organic matter. In Norway, the area converted, and hence the emissions of N_20 have decreased from 2.202 tonnes N_20 in 1990 to 0.476 tonnes N_2O in 2007. This is a decrease from 683 to 148 tonnes CO_2e.