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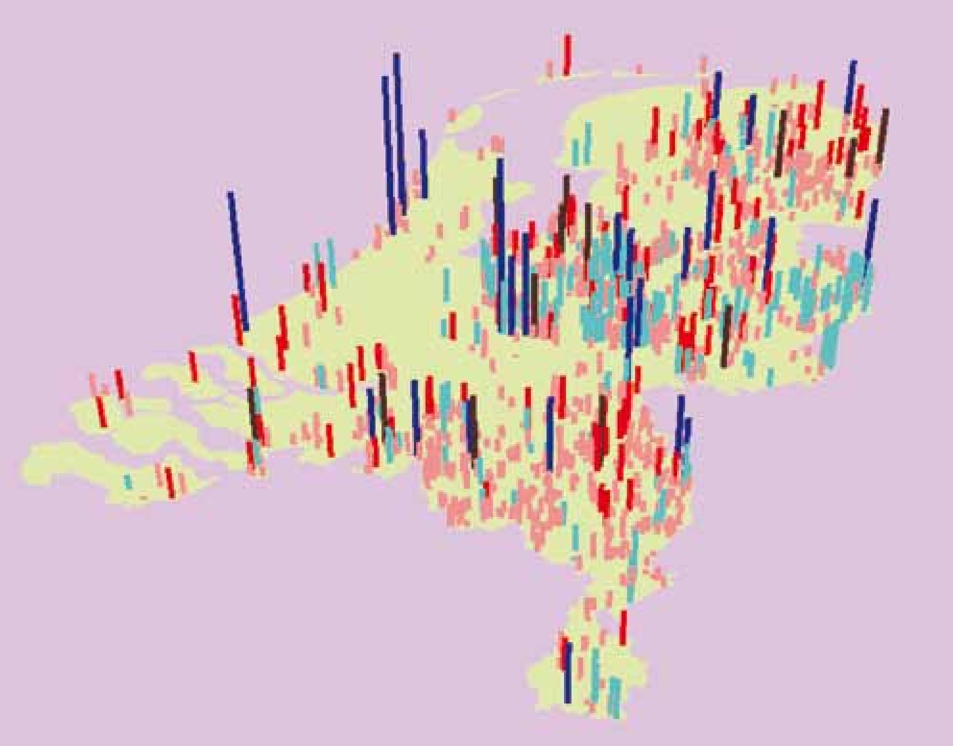
I.J.J. van den Wyngaert
H. Kramer
P. Kuikman
J.P. Lesschen



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ABSTRACT

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This report contains a complete description of revisions and updates of the Dutch Greenhouse gas calculations and reporting of the LULUCF sector used for the 2009 submission.

Keywords: LULUCF, national system greenhouse gases, Netherlands

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P.O. Box 47; 6700 AA Wageningen; The Netherlands
Phone: + 31 317 484700; fax: +31 317 419000; e-mail: info.alterra@wur.nl

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Preface

This report contains a full description of the Dutch National System for Greenhouse gas Reporting of the LULUCF sector used for the 2009 submission. It includes all changes initiated after the 2007 review that were included in the submission 2009.

Summary

This report contains a full description of revisions and updates of the Dutch Greenhouse gas calculations and reporting of the LULUCF sector used for the 2009 submission. Parts were earlier described in Nabuurs et al. (2003, 2005), De Groot et al (2005), Kuikman et al. (2003; 2005) and Van den Wyngaert et al. (2007, 2008). An overview of the history of this system since its development is given in chapter 2.
This system has been reviewed by an external expert (Van den Wyngaert et al., 2007) and by several UNFCCC review teams. The outcomes of the 2007 in country review indicated several areas of possible improvement. This led to a series of proposed improvements in 2008, which were implemented for the 2009 submission. As some of the comments indicated a limited transparency of the system to the reviewers, this report does not limit itself to the changes but described the full system as it is now after the improvements.

A comprehensive overview is given of how land use information was classified into the 6 IPCC land use categories (Forest Land, Cropland, Grassland, Wetland, Settlements and Other land) in chapter 3. The chapter concludes with a table indicating all Dutch land use classes and how they relate to the IPCC categories.

For the 2009 submission, and updated land use matrix was calculated and motivated. In Kramer et al. (2009) the full process of the new land use matrix is described in detail, and this is summarized in chapter 4. Additionally, the overlay of the land use maps and a soil carbon map, as well as a peat soil map, is discussed in chapter 4.
In chapters 5 and 6 the calculations related to Forest Land as well as land conversion to and from Forest land are described. Updates related to previous submissions include:

- Use of the complete inventory cycle for the MFV dataset (2001-2005)
- Synchronizing of harvest data with FAO statistics
- Update of the assumptions underlying the calculation of carbon emissions related to conversion of land to Forest Land (par **5.3.1**, see also Annex D)
- Carbon emissions from deforestation are based on annual simulated mean carbon stocks in biomass
- Carbon in litter is fully emitted when Forest land is converted to another land use category

In chapter 7 the motivation for reporting a "not estimated" sink (i.e. there is a sink but the magnitude is too uncertain to estimate) as a conservative estimate for the overall carbon stock changes in mineral soils in the Netherlands is given, as well as the basic calculation of the carbon emissions from organic soils.

In chapter 8 the values submitted in the NIR 2009 are presented, and an extensive comparison is made between those and the values reported in 2008. Four major types of updates were responsible for the changes in carbon emissions between the submissions of 2008 and 2009:

Specification of the quantitative differences between submission 2008 and submission 2009 (Gg CO_2)

	Difference between submissions 2008 and 2009 for reporting years (in Gg CO_2):	
	1990	**2006**
CRF 2008 – CRF 2009 for:		
Soil emissions associated with conversions to and from Other Land	225,02	225,02
Deforestation	-168,20	-414,73
Forest Land remaining Forest Land	23,50	69,54
Land converted to Forest Land	-10,13	294,14
Total	**70,19**	**173,98**
Total CRF 2008 – Total CRF 2009:	**70,19**	**173,98**

In Chapter 9 and Annex F the formal QA/QC is presented. Finally, in chapter 10 a first outlook into the future is proposed. The following improvements were identified in previous reports but were envisaged for the NIR 2010 or later, either because they are still under discussion, still under development or need additional data that will become available only at a point further in time:

- Definition and use of more subcategories in Grassland, i.e. distinction between rotational grassland, permanent grassland and natural grasslands
- Periodic updating of carbon dioxide emission from change in biomass in Forest land remaining Forest land as new data become available (new MFV cycles)
- An integrated and wall to wall calculation of soil carbon dynamics and carbon dioxide as result of observed land use and land use change in The Netherlands based on existing data to provide a more detailed and enhanced accuracy of the carbon dynamics and carbon dioxide emission from mineral soils in agricultural and non agricultural use in the Netherlands.

1 Introduction

As a Party to the United Nations Framework Convention on Climate Change the Netherlands has the obligation to design and make operational a system for reporting of greenhouse gases (GHG) (Article 5 of the UNFCCC). For GHG reporting of the Land Use, Land Use Change and Forests (LULUCF) sector, the Netherlands has developed and improved an overall approach within the National System since 2003. This LULUCF part of the National System has been deployed for the National Inventory Reports (NIR's) since 2005, covering the period since 2003. It was also used for a full recalculation of the period 1990 – 2003. This LULUCF part of the Dutch National System has been documented in several publications. See e.g. Nabuurs et al. (2003, 2005), Van den Wyngaert et al. (2007; 2008) and De Groot et al (2005), Kuikman et al. (2003; 2005).

In an earlier report, a series of envisioned improvements to the National System for the LULUCF sector were identified (Van den Wyngaert et al., 2008). This report describes the current version of the National System for the LULUCF sector, after implementation of these improvements and updates, as used for the 2009 submission. An overview of this version, with the current Tiers and methodologies is provided (chapter 2). A new land use change matrix was planned for the 2009 submission, and the occasion has been used to clarify and for some categories update the definitions of land use categories (chapter 3). The new land use change matrix is incorporated and consequences for the submitted values are discussed (chapter 4). The updates in calculation methods for living biomass in Forest Land are elaborated in chapter 5, while chapter 6 deals with the calculation of carbon storage (changes) in dead organic matter in Forest Land. Chapter 7 deals mainly with reporting of carbon emissions from mineral soils. Chapter 8 summarizes all values and compares the net effect of all improvements with earlier submissions. This year, a new QA/QC process has been followed, and the results of this are given in chapter 9. The report concludes with a plan of future improvements to the National System for LULUCF (chapter 10).

2 The National System for GHG reporting for the LULUCF sector – an overview

2.1 The national system from 2009 submission onwards

The current national system is based on the establishment of a land use and land use change matrix for the period 1990-2004 based on topographical maps (see also de Groot et al. 2005 for motivation of topographical maps as basis for land use calculations). The maps for 1990 and 2004 are gridded in a harmonised way and an overlay produced all land use transitions within this period (Kramer et al., 2009). An overlay between the two land use maps with the organic soil map (Kuikman et al., 2005) allowed estimating the areas of organic soils for reporting categories Forest Land, Cropland and Grassland.

The carbon balance for live and dead biomass in Forest Land remaining Forest Land is based on National Forest Inventory (NFI) data using a simple bookkeeping model (Nabuurs et al., 2005). NFI plot data are available from two inventories: the HOSP dataset (1988-1992; 3448 plots) and the MFV dataset (2001-2005; 3622 plots). This submission is the Carbon stored in forest litter reported this year for the first time at Tier 2 level. It is estimated by combining several (historic) data sets (Van den Wyngaert et al., 2009; see also chapter 7).

The carbon balance for areas changing away from Forest Land is based on the mean national stocks as calculated from the NFI data for biomass and the combined data sets for forest litter. The carbon balance for areas changing to Forest Land is based on national mean growth rates fro young forests derived from the NFI data (see also chapter 6). Both are updated compared to previous submissions.

Carbon in the soil is based on a recent National Soil Sampling Programme (NSSP) carried out between 1990 and 2000 (de Groot et al., 2005). A national soil C map was constructed based on these samples (including some gaps). The C stock for each land use (transition) category was derived from overlays between the soil C map and the land use maps for 1990 and 2000 (de Groot et al., 2005). The carbon emission from cultivation of organic soils was estimated for all organic soils based on ground surface lowering and the characteristics of the peat layers (Kuikman et al., 2005). Ground surface lowering was estimated from either ditch water level or mean lowest groundwater level (Kuikman et al., 2005).

From the 2009 submission on, the following calculated emission values are reported (Table 2-1).

Table 2-1:Variables for which emissions are reported in the National System per land use (transition) category in 2009. New variables are printed with black background

From→ To↓	**Forest**	**Cropland**	**Grassland**	**Wetland**	**Settlement**	**Other land**
Forest	**Biomass (gain, loss) + DOM (dead wood, litter)**	**Biomass gain**	**Biomass gain**	**Biomass gain**	**Biomass gain**	**Biomass gain**
Cropland	**Biomass loss + DOM (dead wood, litter)**	Lime application	-	-	-	-
Grassland	**Biomass loss + DOM (dead wood, litter)**	-	Cultivation of organic soils	-	-	-
Wetland	**Biomass loss + DOM (dead wood, litter)**	-	-	-	-	-
Settlemen t	**Biomass loss + DOM (dead wood, litter)**	-	-	-	-	-
Other land	**Biomass loss + DOM (dead wood, litter)**	-	-	-	-	-

Table 2-2: Variables for which emissions were reported in the National System per land use (transition) category in 2005-2008

From→ To↓	**Forest**	**Cropland**	**Grassland**	**Wetland**	**Settlement**	**Other land**
Forest	Biomass (increase, decrease) + DOM (dead wood)	Biomass increase + Soil	Biomass increase + Soil	Biomass increase + Soil	Biomass increase + Soil	Biomass increase + Soil
Cropland	Biomass loss	Lime application	-	-	-	Soil
Grassland	Biomass loss	-	Cultivation of organic soils	-	-	Soil
Wetland	Biomass loss	-	-		-	-
Settlement	Biomass loss	-	-	-		Soil
Other land	Soil	Soil	Soil	Soil	Soil	

2.2 Previous situation

Until 2004 the Netherlands reported only carbon emissions for a few categories in the Land Use Change and Forestry sector to the UNFCCC (Nabuurs et al., 2003; Klein Goldewijk et al., 2004). As there were no justifications for the forest sector to be considered a key category, calculations were based in IPCC default methods (Tier 1 methodology) and data: one nationally derived stem increment was converted to tree biomass change based on one IPCC biomass expansion factor.

However, for a series of reasons this was not tenable (Nabuurs et al., 2005). A full overview of the discrepancy of future reporting requirements and the former reporting practice is given in Nabuurs et al. (2003) and Kuikman et al. (2004). Based on an inventory of the databases available (Nabuurs et al., 2003) and the outcomes of an expert meeting on potentially important options under the Kyoto 3.4 article, a National System to report carbon emissions from the LULUCF sector using mostly Tier 2 methodology was set up (Nabuurs et al., 2003, 2005; Kuikman et al., 2004).

The first version of this National System was described in three reports:
1. Nabuurs et al. (2005) for forests and land use data;
2. Kuikman et al. (2005) for emissions from cultivated organic soils and
3. De Groot et al. (2005) for carbon in soils.

Until the previous submission, following calculated emission values were reported (Table 2-2).

3 Definition of Land Use categories

The IPCC GPG distinguishes six main groups of land use categories: Forest Land, Cropland, Grassland, Wetland, Settlements and Other Land. Countries are encouraged to stratify these main groups further e.g. by climate or ecological zones, or special circumstances (e.g. separate forest types in Forest Land) that affect emissions. In the Netherlands, stratification has been used for Forest Land, Grassland and Wetlands.

The natural climax vegetation in the Netherlands is forest. Thus, except for natural water bodies and coastal sands, without human intervention all land would be covered by forests. Though different degrees of management may be applied in forests, all forests are relatively close to the natural climate vegetation. Extensive human intervention creates vegetation types that differ more from the natural climax vegetation like heathers and natural grasslands. More intensive human intervention results in agricultural grasslands. In general, an increasing degree of human intervention is needed for croplands and systems in the category Settlements are entirely created by humans. This logic is followed in the allocation of land to land use categories. In addition, lands are allocated to wetlands when they conform to neither of the former land use categories and do conform to the IPCC GPG definition of wetlands. This includes open water bodies, which are typically not defined as wetlands in the scientific literature. Until the 2008 submission, open water bodies were included in the Other Land category for that reason. However, from the 2009 submission on they form a separate subcategory of wetlands. The remaining lands in The Netherlands, belonging to neither of the former categories, are sandy areas with extremely little carbon in the soil. These were and are again included in Other Land.

3.1 Forest Land

The land use category 'Forest Land' is defined as all land with woody vegetation consistent with thresholds used to defined forest land in the national GHG inventory, sub divided into managed and unmanaged units and also by ecosystem type as specified in IPCC Guidelines. It also includes systems with vegetation that currently fall below, but are expected to exceed the threshold of the forest land category (IPCC, 2003, 2006).

The Netherlands has chosen to define the land use category 'Forest Land' as all land with woody vegetation, now or expected in the near future (e.g. clearcut areas to be replanted, young afforestations. This is further stratified in:

- 'Forest' or 'Forest according to the Kyoto definition' (FAD), i.e. all forest land which complies to the following (more strict than IPCC) definition chosen by the Netherlands for the Kyoto protocol: forests are patches of land exceeding 0.5 ha with a minimum width of 30 m, with tree crown cover at least 20% and tree height at least 5 meters, or, if this is not the case, these thresholds are likely to be achieved at the particular site. Roads in the forest less than 6 meters wide are also considered to be forest. This definition conforms to the FAO reporting and was chosen within the ranges set by the Kyoto protocol.

- 'Trees outside Forests' (TOF), i.e. wooded areas that comply with the previous forest definition except for their surface (=< 0.5 ha or less than 30 m width). These represent fragmented forest plots as well as groups of trees in parks and nature terrains and most woody vegetation lining roads, fields etc… These areas comply to the GPG-LULUCF definition of Forest Land (i.e. they have woody vegetation) but not to the strict forest definition that The Netherlands applies.

The TOP10Vector map classes that are reported under FAD and TOF are deciduous forest, coniferous forest, mixed forest, poplar plantations and willow coppice. A patch of a certain forest class is allocated to FAD if it exceeds the minimum requirements and to TOF otherwise. Groups of trees are mapped as forest only if they have a minimum surface of 50 m^2, or of 1000m^2 in built-up areas or parks.

3.2 Cropland

The land use category '**Cropland**' is defined as all arable and tillage land, including rice-fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category (IPCC, 2003).

The Netherlands has chosen to define croplands as arable lands and nurseries (including tree nurseries). Intensive grasslands are not included in this category and are reported under Grasslands. For part of the agricultural land, rotation between arable land and grassland is frequent, but data on where exactly this is occurring are as yet lacking. Currently, the situation on the topographical map is leading, with lands under agricultural crops and classified as arable lands at the time of recording reported under Cropland and lands with grass vegetation at the time of recording classified as Grassland.

The TOP10Vectore class arable land is reported under Cropland, as well as the class Tree nurseries. The latter does not conform to the forest definition, and the agricultural type of farming system justifies the inclusion in Cropland. Greenhouses are not included in Cropland, but instead they are considered as Settlement.

3.3 Grassland

The land use category '**Grassland**' is defined as rangeland and pasture land that is not considered as croplands. It also includes vegetation that falls below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, subdivided into managed and unmanaged consistent with national definitions. (IPCC, 2003). It is stratified in:

- ‘Grasslands’, i.e. all areas predominantly covered by grass vegetation (whether natural, recreational or cultivated)
- ‘Nature’, i.e. all natural areas excluding grassland (natural grasslands and grasslands used for recreation purposes). It mainly consists of heathland, peat moors and other nature areas. Many have the occasional tree as part of the typical vegetation structure. This category was in the previous submissions a subcategory within Forest land

The Netherlands currently reports under grassland any type of terrain which is predominantly covered by grass vegetation (equivalent to one general class of grasslands on the TOP10Vector maps). No distinction is made between agricultural intensively and extensively managed grasslands and natural grasslands. However, the potential and the need for this is currently under discussion.

Apart from pure grasslands, all orchards (with standard fruit trees, dwarf varieties or shrubs) are included in the category grasslands. They do not conform to the forest definition, and while agro-forestry systems are mentioned in the definition of Croplands, this is motivated by the cultivation of soil under trees. However, in The Netherlands the main undergrowth of orchards is grass. We therefore chose to report them as grasslands. As for grasslands no change in above-ground biomass is reported, the carbon stored in these trees is not reported.

The TOP10Vector map class heathland and peat moors, reported as ‘Nature’, includes all land that is covered (mostly) with heather vegetation or rough grass species. Most of these were created in The Netherlands as a consequence of ancient grazing and sod cutting on sandy soils. As these practices are not part of the current agricultural system anymore, conservation management is applied to halt the succession to forest and conserve the high landscape and biodiversity values associated it.

3.4 Wetland

The land use category **‘Wetland’** includes land that is covered or saturated with water for all or part of the year and does not fall into the forest land, cropland, grassland or settlements categories. It includes reservoirs as a managed sub-division and natural lakes and rivers as unmanaged sub-divisions (IPCC, 2003).

Though The Netherlands is a country with many wet areas by nature, many of these are covered by a grassy vegetation and those are included under grasslands. Some wetlands are covered by a more rough vegetation of wild grasses or shrubby vegetation, which is reported in the subcategory ‘Nature’ of Grassland. Forested wetlands like willow coppice are reported in the subcategories FAD or TOF of Forest Land, depending on their surface.

In The Netherlands, only reed marshes and open water bodies are included in the Wetland land use category. Reed marshes are areas where the presence of Common

Reed (*Phragmites australis*) is indicated separately on the TOP10Vector maps. These may vary from wet areas in natural grasslands to extensive marshes. The presence of reed is marked with individual symbols which are translated to surfaces (Kramer et al., 2008) and conform to neither of the previous categories.

Open water bodies are all areas which are indicated as water on the TOP10Vector maps (water is only mapped if the surface exceeds 50 m^2). This includes natural or artificial large open waters (e.g. rivers, artificial lakes), but also small open water bodies like ditches and channels as long as they cover enough surface to be shown in the 25 m x 25 m grids. Additionally, it includes so called 'emerging surfaces', i.e. bare areas which are under water only part of the time as a result of tidal influences, and very wet areas without vegetation. It also includes 'wet' infrastructure for boats, i.e. waterways but also the water in harbours and docks.

3.5 Settlements

The land use category '**Settlements**' includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories (IPCC, 2003).

In The Netherlands, the main TOP10Vector classes included in Settlements are urban areas and transportation infrastructure, and built-up areas. Built-up areas include any constructed item, independent of the type of construction material, which is (expected to be) permanent, fixed to the soil surface (i.e. to distinguish from caravans,…) and serves as place for residence, trade, traffic and/or labour. Thus it includes houses, blocks of houses and apartments, office buildings, shops and warehouses but also fuel stations and greenhouses.

Urban areas and transportation infrastructure include all roads, whether paved or not, are included in the land use category Settlements with exception of forest roads less than 6 m wide (?), which are included in the official forest definition. It also includes train tracks, (paved) open spaces in urban areas, parking lots and graveyards. Though some of the last class are actually covered by grass, the distinction cannot be made based on maps. As even the grass graveyards are not managed as grasslands, inclusion in the land use category 'Settlements' conforms better to the rationale of the land use classification.

3.6 Other Land

The land use category '**Other Land**' was included to allow the total of identified land to match the national area where data are available. It includes bare soil, rock, ice and all unmanaged land area that do not fall in any of the other five categories. (IPCC, 2003)

In general, Other Land does not have a substantial amount of carbon. The Netherlands uses this land use category to report the surfaces of bare soil which are not included in any other category. It does not include bare areas that emerge from shrinking and expanding water surfaces (these 'emerging surfaces' are included in wetlands).

The TOP10Vector classes dominated by sand are completely included in it. It includes all terrains which do not have vegetation on them by nature. The last part of the phrase 'by nature' is used to distinguish this class from settlements and fallow croplands. It includes coastal dunes and beaches with little to no vegetation. It also includes inland dunes and shifting sands, i.e. areas where the vegetation has been removed to create spaces for early succession species (and which are being kept open by wind). Inland bare sand dunes developed in The Netherlands as a result of heavy overgrazing and were combated by planting forests for a long time. These areas were, however, the habitat to some species which have become extremely rare nowadays. Inland sand dunes can be created as vegetation and top soil is again removed as a conservation measure in certain nature areas.

3.7 Overview of land use allocation

The basis of allocation for IPCC land use (sub)categories is the TOP10Vector land use/cover classification. For most of the TOP10Vector classes, there was one IPCC land use (sub)category where it could be unambiguously included. For other TOP10Vector classes, there were some reasons to include it in one, and other reasons to include it in another IPCC land use (sub)category. In these cases, we allocated it to the land use category where (in sequential order):

1) the majority of systems (based on surface) in the TOP10Vector class would fit best based on the degree of human impact on the system (see also introduction)
2) or if this did not give an unambiguous solution, we allocated it where the different types of carbon emission considered/reported represented the situation in the TOP10Vector class best.

The resulting classification is summarized in Table 3-1.

Table 3-1: Overview of allocation of TOP10Vector classes to IPCC land use (sub)categories (based on Kramer et al., 2007)

TOP10Vector	Dutch TOP10Vector name	GPG classes
Deciduous forest	Loofbos	Forest Land
Coniferous forest	Naaldbos	Forest Land
Mixed forest	Gemengd bos	Forest Land
Poplar plantation	Populierenopstand	Forest Land
Willow coppice	Griend	Forest Land
Arable land	Bouwland	Cropland
Tree nurseries	Boomkwekerij	Cropland
Grasslands	Weiland	Grassland
Orchard (high standards)	Boomgaard	Grassland
Orchard (low standards & shrubs)	Fruitkwekerij	Grassland
Heathland & peat moors	Heide & hoogveen	Grassland
Reed marsh	Rietmoeras	Wetland
Water (large open water bodies)	Water (grote oppervlakte)	Wetland
Water (small open water bodies)	Oeverlijn / Water (kleine oppervlakte)	Wetland
Ditch	Sloten	Wetland
Emerging surfaces	Laagwaterlijn / droogvallende gronden	Wetland
'Wet' infrastructure	Dok	Wetland
Urban areas and transportation infrastructure	Stedelijk gebied en infrastructuur	Settlement
Built-up areas	Bebouwd gebied	Settlement
Greenhouses	Kassen	Settlement
Coastal dunes and beaches	Strand en duinen	Other land
Inland dunes and shifting sands	Inlandse duinen	Other land

4 Update of the land use change matrix

4.1 Introduction

The Netherlands has developed an overall approach within the National System since 2003, which has been deployed for the National Inventory Reports since 2005. It was taken into account to provide a full recalculation of the period 1990 – 2003. After an extensive inventory of available land use datasets in The Netherlands (Nabuurs et al., 2003), information on the surface of the different land use categories and conversions between categories was based on a wall-to-wall map overlay, resulting in a national scale land use and land use change matrix (Nabuurs et al., 2005). The previous submissions for the LULUCF sector were based on a land use change matrix that was derived from two maps representing the land use in 1990 and 2000 (Van den Wyngaert et al., 2008).

During the in-country review in April 2007, the Expert Review Team (ERT) was critical about the methodology to derive the land use matrix and experienced a limited transparency on the procedures and values used for land use and land use change. The information on the land use change matrix was either unpublished or scattered over several reports. For the 2009 submission to the UNFCCC the land use change matrix was updated and based on an improved wall-to-wall approach derived from topographical maps. Updates in methodology and data sets were included in order to present the best estimate of land use and land use change in The Netherlands that is currently possible. In Kramer et al. (2009) all steps involved in the calculation of the land use and land use change matrix used from 2009 on are described. They also motivate why The Netherlands considers the approach taken as the best possible in their specific situation. In this chapter only a short summary of the new methodology is given.

4.2 Methodology

The new land use maps are based on two maps for monitoring nature development in The Netherlands, 'Basiskaart Natuur' (BN), which are based on the Top10Vector topographical maps for 2004 (BN2004) and on a combination of Top10Vector and Top25 maps for 1990 (BN1990). The maps were created to monitor changes in nature areas, but because of its national coverage and inclusion of other land use types it is also very suitable as land use data set for the reporting of the LULUCF sector.

Though based on the same data sets, the methodology for digitalisation, classification and aggregation was improved and for 1990 in correspondence with the map for 2004. One of the main improvements for the 1990 map is a much better distinction between built-up areas and agricultural lands. This was based on manually checking of all areas. For the BN2004, information from the Top10Vector map was combined with four other sources, i.e. information from two subsidy regulations (information from 2004), a map with the geophysical regions of the Netherlands and a map with the land use in 2000 (Kramer et al., 2007). In Table 4-1 the characteristics of both maps are presented.

Table 4-1. Characteristics of the BN1990 and BN2004 maps

Characteristics	**BN1990**	**BN2004**
Name	Historical Land use Netherlands 1990	Base map Nature 2004
Aim	Historical land use map for 1990	Base map for monitoring nature development
Resolution	25 m	25 m
Coverage	Netherlands	Netherlands
Base year source data	1986-1994	1999-2003
Source data	Hard copy topographical maps at 1:25,000 scale and digital topographical maps at 1:10,000	Digital topographical maps at 1:10,000 and additional sources to distinguish specific nature types
Number of classes	10	10
Distinguished classes	Grassland, Arable land, Heath land/peat moor, Forest, Buildings, Water, Reed marsh, Sand, Built-up area, Greenhouses	Grassland, Nature grassland, Arable land, Heath land, Forest, Built-up area and infrastructure, Water, Reed marsh, Drifting sands, Dunes and beaches

The land use change matrix is the result of an overlay between the 25 m × 25 m land use maps of 1990 and 2004. For both years, the land use maps were based on topographic maps, either digital (Top10Vector) or paper (Top25). The source material for BN1990 consists of the topographic map 1:25,000 (Top25) and digital topographical map 1:10,000 (Top10Vector). Map sheets with exploration years in the period 1986-1994 were used. The source material for BN2004 consists of the digital topographic map 1:10,000 (Top10Vector). All topographic maps have been explored in the period 1999-2003. Auxiliary information on areas managed for nature purposes was dated on 2004. The Top10Vector has an update frequency of 4 years, now decreasing to between 2 and 4 years. Higher update frequencies occur in urban areas, lower in rural areas

For both years map sheets were selected to constitute the source information of the land use maps. If the source information was a paper map, it was converted to a digital high resolution raster map. Then both Top10Vector files and digitised Top25 maps were (re)classified to match the requirements set by nature monitoring and UNFCCC reporting. In this process additional data sets were used. Simultaneously, harmonisation between the different source materials was applied to allow a sufficiently reliable overlay. The final step in the creation of the land use maps was the aggregation to 25 m × 25 m raster maps. For the 1990 map, which had a large part of the information derived from paper maps, an additional validation step was applied to check on the digitising and classifying processes.

4.3 Land use change matrix

The resulting land use map for 2004 is shown in Figure 4-1. An overlay was produced of the land use maps of 1990 and 2004, which resulted in a land use and land use change matrix over 14 years (1 January 1990 – 1 January 2004). The matrix shows the changes for thirteen land use categories (Table 4-2). For the purpose of the CRF and NIR, the thirteen land use categories are aggregated into the six land use classes that are defined in the LULUCF guidelines. The definition of the UNFCCC land use categories is given in Chapter 3. In Table 4-3 the resulting land use change matrix is given for the six UNFCCC land use categories.

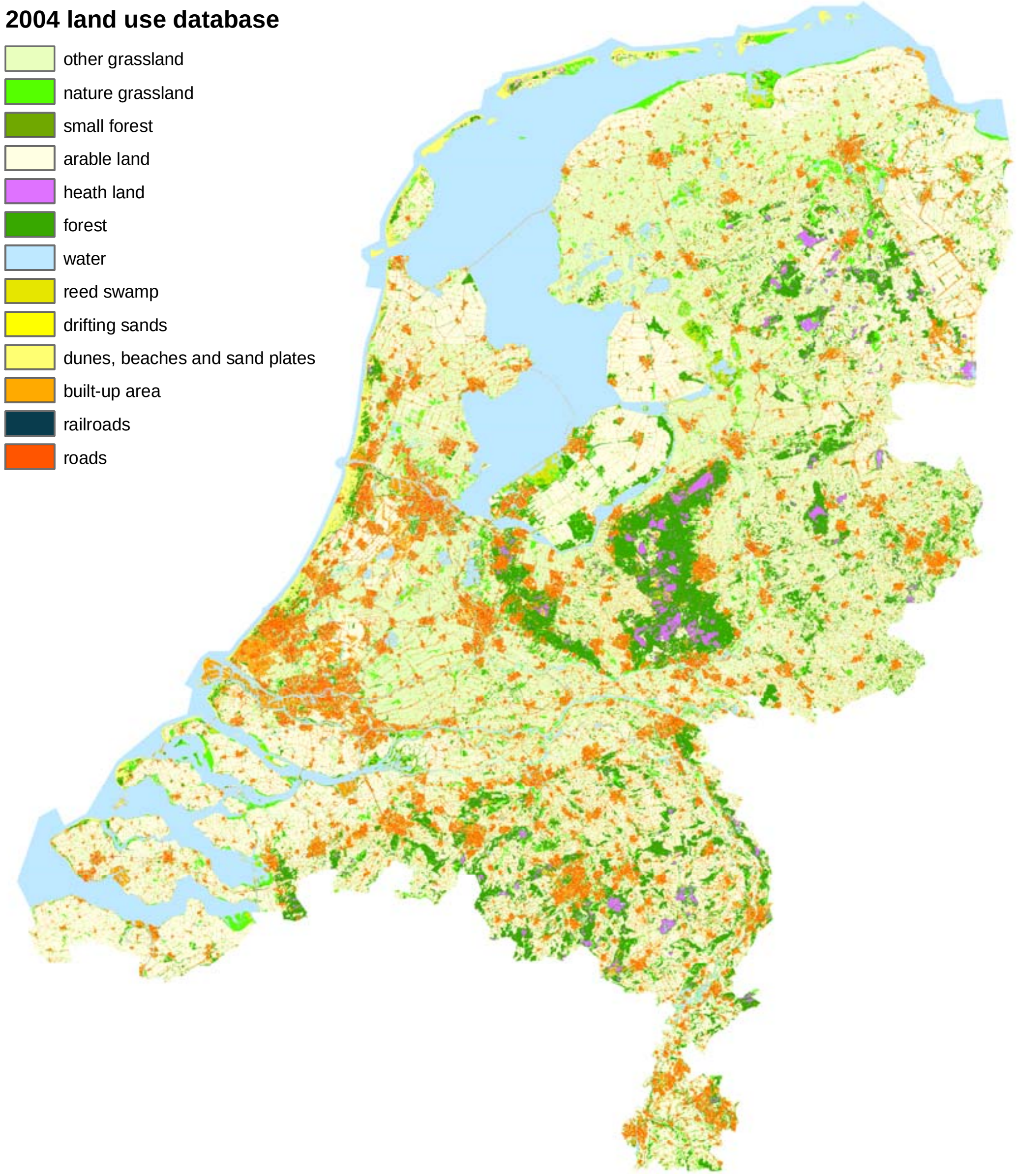

Figure 4-1. Land use map of 2004

Table 4-2. Land Use and Land Use Change Matrix based on the classification in 13 classes (in ha). Shaded cells indicate surfaces not changing land use between 1990 and 2004.

	BK_1990													
BK_2004	10	11	14	20	30	40	70	80	90	91	101	102	103	Grand Total
10 Grassland	1047889		2781	159806	255	6388	3924	1196	130	216	9505	134	953	1233176
11 Nature grassland	58206	40878	380	16350	759	4918	1679	1958	74	1438	275	8	51	126973
14 Trees outside Forest	3949	306	11336	2039	220	2852	274	54	15	83	979	13	85	22207
20 Arable land	195545	1002	386	739190	48	1218	523	73	4	5	1456	9	158	939617
30 Heather	332	338	155	641	42083	3280	291	44	437	252	52	5	5	47915
40 Forest (Kyoto)	10194	3065	2352	12520	4806	334211	569	319	205	348	1198	24	230	370041
70 Open water	8019	1763	247	5042	739	1197	757870	1419	171	2332	1248	5	86	780139
80 Reed marsh	3813	4274	71	1780	33	306	1141	15577	1	78	44	3	3	27126
90 Shifting sands	94	21	9	88	147	197	103	1	2303		8		1	2971
91 Coastal dunes	139	381	101	113	124	502	2663	24	3	30838	103	0	10	35002
101 Built-up area	67151	889	2768	71942	334	6344	2398	158	235	345	163204		10587	326353
102 Railways	372	2	29	590	7	103	20	4	0	1		4885	183	6195
103 Roads	9434	60	192	9252	11	583	240	17	6	43	10456	119	203371	233784
Grand Total	1405136	52979	20806	1019353	49567	362100	771696	20843	3584	35979	188529	5205	215723	4151500

The total area of land use change in the period 1990 to 2004 is about 6700 km^2, which is around 16% of the total area. The largest changes in land use are the conversion of cropland to grassland and vice versa. Other important land use changes are the conversions of cropland and grassland to settlement (urbanisation), which is occurring at the rate of 114 km^2 per year.

Table 4-3. Land Use and Land Use Change Matrix aggregated to the six UNFCCC land use categories (in ha)

BN 2004	***BN 1990***						
	Forest land	**Cropland**	**Grassland**	**Wetland**	**Settlement**	**Other land**	**Total**
Forest land	350 751	14 560	22 540	1 217	2 530	651	392 248
Cropland	1 605	739 190	196 595	596	1 623	8	939 617
Grassland	17 902	176 797	1 190 740	9 092	10 987	2 547	1 408 064
Wetland	1 822	6 821	18 641	776 007	1 390	2 583	807 265
Settlement	10 019	81 783	78 259	2 836	392 805	630	566 332
Other land	809	201	907	2 791	122	33 144	37 974
Total	**382 907**	**1 019 353**	**1 507 682**	**792 539**	**409 457**	**39 563**	**4 151 500**

4.4 Peat soils

For the 2009 submission the areas of peat soils under cropland, grassland and forest land have to be reported separately. Therefore an overlay between the new land use maps and the Dutch soil map (de Vries et al., 2003) indicating the peat areas was made. The results are presented in Table 4-4. Regarding the six UNFCCC land use categories, 283 km^2 of peat soils was under cropland, 2050 km^2 under grassland and 131 km^2 under forest land in 2004. More information about the emission from organic soils can be found in Chapter 7.

Table 4-4. Peat areas under different land uses in 1990 and 2004

Land use	**Peat area 1990** ha	**Peat area 2004** ha	**Total area** ha	**% total land**	**% total land**
other grassland	199552	175028	1233176	16.2	14.2
nature grassland	10330	24963	126973	8.1	19.7
small forest	1305	1377	22207	5.9	6.2
arable land	31265	28336	939617	3.3	3.0
heath land	5260	4999	47915	11.0	10.4
forest	10341	11724	370041	2.8	3.2
water	9509	11059	780139	1.2	1.4
reed swamp	7625	8909	27126	28.1	32.8
shifting sands	12	10	2971	0.4	0.3
dunes, beaches and sand plates	1	2	35002	0.0	0.0
built-up area	5661	13078	326352	1.7	4.0
railroads	268	325	6195	4.3	5.2
roads	7741	9060	233784	3.3	3.9
Total	288869	288869	4151497		

4.5 Conclusions

The ‘Basiskaart Natuur’ matches the requirements for a primary land use dataset for carbon reporting in a small, intensively managed country as The Netherlands. It is spatially explicit, covers the entire country and the spatial resolution allows sufficiently detailed representation of the fine-grained land use mosaic in The Netherlands. It is the basis for the monitoring of nature in The Netherlands, and as such it has a legal status. It is based on the digital topographical maps (Top10Vector) which had an update frequency of 4 years, which will even increase in the future. The spatially explicit land use map allows overlays with other maps to fulfil additional needs like reporting the areas on peat soils.

The land use change matrix was derived by overlaying the 1990 and 2004 land use maps. The results were compared with expectations from policies and other sources. Taking into account all uncertainties, the trends and results from the land use matrix matched other sources remarkably well and could be explained from the specific land use policies in The Netherlands. It is therefore concluded that the approach taken is in compliance with GPG-LULUCF and gives the best estimate currently possible for land use and land use change for The Netherlands. Inconsistencies that were suspected by the Expert Review Team based on counterintuitive land use change results were either solved as good as possible using auxiliary data sets or - if they were genuine results - explained by examples and land use policies specific to The Netherlands.

5 Update of the carbon emissions from living biomass

5.1 Forest land remaining Forest Land

The land use category 'Forest land' is defined as all land with woody vegetation consistent with thresholds used to defined forest land in the national GHG inventory. In The Netherlands, unmanaged forests are practically nonexistent and the only subdivision is based on the extent of the forest occurring:

- 'Forest according to the Kyoto definition' (FAD) is all forest land which complies to the following definition: patches of land exceeding 0.5 ha with a minimum width of 30 m, with tree crown cover at least 20% and tree height at least 5 meters, or, if this is not the case, these thresholds are likely to be achieved at the particular site. Roads in the forest less than 6 meters wide are also considered to be forest. This definition is used for the Kyoto protocol article 3.3 and as requested by 16/CPM.1, Annex E, section 16, included in the Initial Report.
- 'Trees outside Forests' (TOF) are wooded areas on the map that comply with the forest definition except for their surface (=< 0.5 ha). These represent fragmented forest plots as well as groups of trees in parks and nature terrains and most woody vegetation lining roads, fields etc…

In the following paragraphs the methods are described to calculate the changes in carbon stock for Forest Land remaining Forest Land (both subdivisions), and changes to and from Forest Land, as used for the 2009 submission. Where any updates, changes or improvements relative to earlier submissions are implemented, this is noted but not elaborated. The reader is then referred to the respective annex where the full motivation and comparison with earlier submissions is given.

5.1.1 Forest according to the Kyoto definition

The basic approach follows the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry where a stock change approach is suggested. The net flux is calculated as the difference in carbon contained in the forest between two points in time. Carbon in the forest is derived from the growing stock volume, making use of other forest traits routinely determined in forest inventories. If no repeated measurements are available, the flux is derived from the volume increment in consecutive years. The last approach was used in the Netherlands.

For the period of interest, i.e. 1990 and on, two types of National Inventories were available for the Netherlands: the so called HOSP data (1988-1992) and the MFV data (2001-2005). The HOSP (Hout Oogst Statistiek en Prognose oogstbaar hout) inventory was designed to get insight in the amount of harvestable wood. In total 2007 plots (~ 400 plots per year) were characterized by age, tree species, growing stock volume, increment, height, tree number and dead wood. Each plot represented a certain area of forest ('representative area') of between 0,4 ha and 728,3 ha.

Together they represent an area of 310736,3 ha, the estimated surface of forest where harvesting was relevant in 1988 (The HOSP inventory was designed in 1988 and conducted between 1988 and 1992). The MFV (Meetnet Functie Vervulling Bos) inventory was designed as a randomized continuous forest inventory. In total 3622 plot recordings with forest cover were available for the years 2001, 2002, 2004 and 2005 (2003 was not inventoried because of a contagious cattle disease). Apart from the live and dead wood characteristics, in 2004 and 2005 litter layer thickness was measured in stands on poor sand and loss (Daamen and Dirkse, 2005).

Both forest inventories yielded the initial data needed to allow a plot level calculation of the increase in volume of living and dead wood. The amount of wood harvested was available only at the national level and was downscaled to plot level according to the probability of harvesting as calculated from plot age and growing stock volume. The volumes harvested per year are taken from the FAO harvest statistics (www.fao.org) (see also Annex E). The wood production is given as production roundwood in m^3 underbark. The total annual volume removed from the forest includes bark as well as losses during harvesting and is calculated from roundwood underbark as follows:

$$H_{NL} = H_{NLub} \cdot f_{\frac{ob}{ub}} \cdot f_{\frac{tw}{rw}}$$

With

H_{NL}	Annually extracted total volume overbark from forests in NL (m^3 year^{-1})
H_{NLub}	Annually extracted volume roundwood underbark from forests in NL (m^3 year^{-1})
$f_{\frac{ob}{ub}}$	Conversion from underbark to overbark (1,136 m^{3}o.b. / m^{3}u.b.)
$f_{\frac{tw}{rw}}$	Conversion from roundwood to total wood (1,06 m^3 wood / m^3 roundwood year^{-1})

All harvests were calculated as thinnings.

The conversion from plot characteristics to whole tree carbon was based on allometric relations from the COST E21 database converting plot diameter and height to above and below ground biomass (Annex G). Selection of the most suitable equations was based on a database collected by Van Hees (pers. comm.) and extended for this purpose. See Nabuurs et al. (2005) for a more detailed description of the database and a list of studies included. The use of allometric relations yielding biomass directly made any conversions including wood density obsolete. Carbon content of live biomass was calculated assuming a IPCC default carbon concentration of 0.5 g C g^{-1} DM (IPCC, 2003). The conversion of dead wood volume to carbon did not take into account anything but the volume of the logs. This was converted to mass using an average dead wood density half that of live trees. The full set of equations converting plot data into carbon fluxes for forests remaining forest is given in Annex A(I).

These calculations were performed for all plots with complete data coverage (missing data category (0)). Plots with missing data were separated into 3 categories (see also Annex B):

(1) plots with volume and increment data, but missing one or more of the following variables: height, diameter or recording year

For these plots, volume increment was converted to a carbon flux based on a national mean BEF2 (= carbon flux due to biomass increase / increment). This was calculated from plots with full data coverage. Carbon flux from dead wood was scaled using growing stock volume.

(2) plots with no volume and increment data but with the designation 'clearcut area'

Plots with the designation 'clearcut area' were assumed to have no volume and no increment, and no carbon flux from live trees or dead wood.

(3) plots with no volume or increment data

Plots with no data at all were extrapolated using the area corrected average for the other three categories.

Thus the following calculation is used to correct for missing data for carbon stock change due to biomass increase:

$$\Delta C_{(1)} = I_{(1)} \frac{\Delta C_{(0)}}{I_{(0)}}$$

$$\Delta C_{(2)} = 0$$

$$\Delta C_{(3)} = \left(\Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)}\right) \cdot \frac{Area_{(3)}}{\sum_{x=0,1,2} Area_{(x)}}$$

$$\Delta C_{FF_G} = \Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)} + \Delta C_{(3)}$$

with

$\Delta C_{(x)}$	annual increase in carbon stocks (in Gg C) due to biomass increase in area represented by plots with missing data category x
$Area_{(x)}$	total representative area for plots with missing data category x
$I_{(x)}$	total increment in m^3 $year^{-1}$ for area represented by plots with missing data category x
ΔC_{FF_G}	annual increase in carbon stocks in Gg C due to biomass increase in forests in The Netherlands

The net carbon balance in FAD due to changes in biomass is then calculated as

$$\Delta C_{FF_{LB}} = \Delta C_{FF_G} - \Delta C_{FF_L}$$

With

$\Delta C_{FF_{LB}}$	annual change in carbon stocks (in Gg C) due to biomass change in forests in The Netherlands
ΔC_{FF_G}	annual increase in carbon stocks (in Gg C) due to biomass increase in forests in The Netherlands
ΔC_{FF_L}	annual decrease in carbon stocks (in Gg C) due to biomass decrease in forests in The Netherlands (for calculation see Annex A)

5.1.2 Trees outside Forest

For Trees outside Forest, no data on growth or increment are available. Similar to earlier years, it is assumed that Trees outside Forest grow with the same growth rate as Forests according to the Kyoto definition. The only difference between them is the size of the stand (< 0.5 ha for Trees outside Forest), so this seems a reasonable assumption. It is assumed that no build up of dead wood or litter occurs. It is also assumed that no harvesting takes place. Even if this assumption would not completely be met, the error would be negligible, as the harvested wood would be counted in the national harvest statistics and therefore would be counted under Forests according to the Kyoto definition.

5.2 Forest Land converted to other land use classes

5.2.1 Forest according to the Kyoto definition

The total emissions from the tree component after deforestation is calculated by multiplying the total area deforested with the average carbon stock in living biomass, above- as well as below ground (Nabuurs et al., 2005) and the average carbon stock in dead organic matter. Thus it is assumed that with deforestation, all carbon stored in above- and below ground biomass as well as in dead wood and litter is lost to the atmosphere. National averages are used as there is no record of the spatial occurrence of specific forest types.

The average carbon stock in living biomass follows the calculations from the gapfilled NFI data (see par 5.1.1. and Annex A). The emission factors (in Mg C ha-1) are given in Table 5-1. The sytematic increase in average standing carbon stock reflects the fact that annual increment exceeds annual harvests in The Netherlands.
The average carbon stock in dead organic matter is the sum of two pools: dead wood and the litter layer (L+F+H) (IPCC, 2003). The average carbon in dead wood follows the calculations from the gapfilled NFI data (see par 5.1.1. and Annex A).

The systematic increase reflects the increasing attention for more nature oriented forest management. The average carbon in litter is based on a national estimate using best available data for The Netherlands as described in chapter 7.

Table 5-1: Emission Factors for deforestation in Mg C ha^{-1}

NFI	Year	EFbiomass	EF litter	EF dead wood
Hosp	1990	60.4	28.97	0.45
Hosp	1991	61.5	29.38	0.71
Hosp	1992	62.6	29.79	0.98
Hosp	1993	63.8	30.19	1.24
Hosp	1994	64.9	30.60	1.51
Hosp	1995	66.1	31.01	1.78
Hosp	1996	67.2	31.42	2.04
Hosp	1997	68.3	31.82	2.32
Hosp	1998	69.2	32.23	2.59
Hosp	1999	70.2	32.64	2.86
MFV	2000	71.7	33.05	0.69
MFV	2001	73.0	33.45	0.96
MFV	2002	74.3	33.86	1.24
MFV	2003	75.7	34.27	1.51
MFV	2004	77.1	34.27	1.79
MFV	2005	78.4	34.27	2.06
MFV	2006	79.8	34.27	2.34
MFV	2007	81.1	34.27	2.62

5.2.2 Trees outside Forest

For Trees outside Forest the same biomass is assumed as for Forest according to the Kyoto definition. However, no dead wood nor litter layer is assumed.

5.3 Land converted to Forest Land

5.3.1 Forest according to the Kyoto definition

The built up of carbon in land converted to Forest Land is only reported for biomass. It is assumed that build up of dead wood starts only after the initial 20 years. For litter, good data are lacking to relate the built up of carbon to age.

The current estimates of assumption of half the rate found for existing forest is the outcome of the following steps/assumptions:

1. At time of regeneration, growth is close to zero.
2. Between regeneration and 20 years of age, the specific growth curve is unknown and is approximated by the simplest function, being a linear curve.
3. The exact height of this linear curve is best approximated by a linear regression on the mean growth rates per age as derived from the NFI. One mean value for each age is taken to avoid confounding effects of the age distribution of the NFI plots (some of which are not afforested but regenerating after a clearcut).

4. The emission factor is calculated for each annual set of afforested plots separately. Thus the specific age of the re/afforested plots is taken into account, and a general mean value is reached only at a constant rate of afforestation for more than 20 years.
5. Between 1990 and 2000, rates are based on the Hosp inventory. From 2000 on, rates are based on the MFV inventory (Figure 5-1).

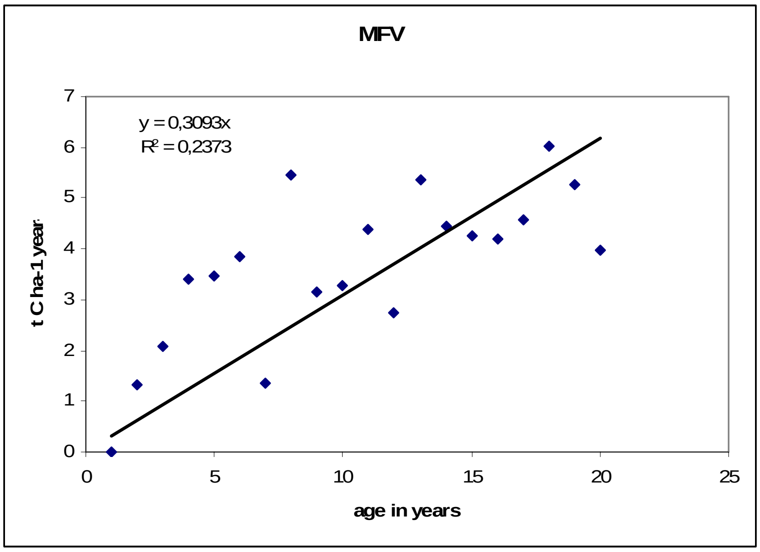

Figure 5-1: Regression of carbon emission (as calculated from increment data and IPCC expansion & conversion factors) on age

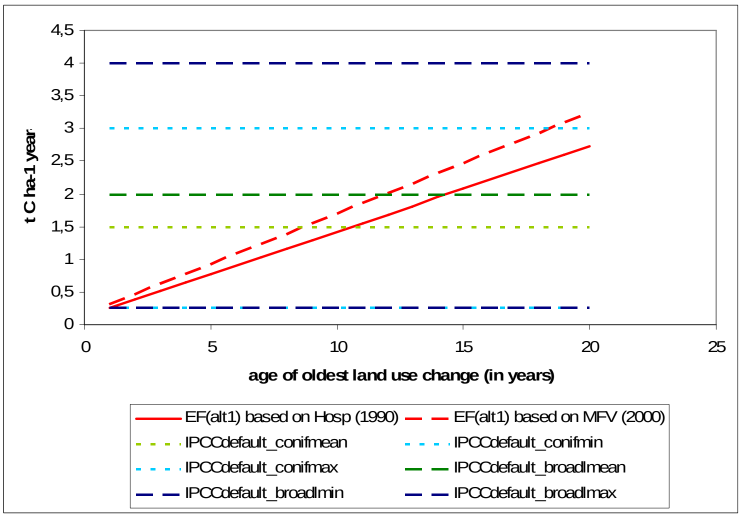

Figure 5-2: Country specific Emission Factor (EF) for afforestation in The Netherlands assuming a constant afforestation rate and IPCC default emission factors for afforestation

5.3.2 Trees outside Forest

For Trees outside Forest the same biomass increase is assumed as for Forest according to the Kyoto definition. Similarly, no dead wood nor litter layer built up is assumed.

6 Update of the carbon emissions from dead organic matter in forests

6.1 Forest according to the Kyoto definition

Dead wood volume was available from the Hosp and MFV forest inventory datasets. The change in dead wood was calculated using an average tree mortality of 0,4% and dead wood longevity from van Hees and Clerckx (1999). The conversion of dead wood volume to carbon did not take into account anything but the volume of the logs. This was converted to mass using an average dead wood density half that of live trees. The equations are given in Annex A and a more detailed description is provided in Nabuurs et al., 2005.

Similarly the following calculation is used to correct for missing data for carbon stock change due to change in dead wood:

$$\Delta C_{(1)} = V_{(1)} \frac{\Delta C_{(0)}}{V_{(0)}}$$

$$\Delta C_{(2)} = 0$$

$$\Delta C_{(3)} = \left(\Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)}\right) \cdot \frac{Area_{(3)}}{\sum_{x=0,1,2} Area_{(x)}}$$

$$\Delta C_{NL} = \Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)} + \Delta C_{(3)}$$

with

$\Delta C_{(x)}$	carbon budget in Gg C for category x
$Area_{(x)}$	total representative area for plots with missing data category x
$V_{(x)}$	total volume in m^3 for area represented by plots with missing data category x

The carbon stock change from changes in the litter layer was estimated using a stock change method at national level. Data for litter layer thickness and carbon in litter were available from five different datasets (data from Schulp and coworkers ; de Vries and Leeters, 2001; Van den Burg, 1999; Forest Classification database; MFV litter inventory). The data from Van den Burg (1999) were collected between 1950 and 1990 and were used only to estimate bulk density based on organic matter content. The data from de Vries and Leeters (2001) were collected in 1990 and their median was used until now as a generic national estimate. They also provide species specific values of (mostly) conifer species. However, they sampled sandy soils only. The Forest Classification dataset was designed to provide abiotic attributes for a forest classification in 1990, not to sample the mean litter in forests. However, it is the only database that has samples outside sandy areas. Schulp and coworkers intensively sampled selected forest stands in 2006 and 2007 on poor and rich sands with the explicit purpose to provide conversion factors or functions. They based their selection of species and soils on the MFV forest inventory. During the last two years (2004 & 2005) the litter layer thickness was measured for plots located on poor sands and loss (veldwerkhandleiding). For 1440 plots values were filled, but only 960 (951 on sands) plots had any non-zero values. As it could not be made likely that all-zero value plots were really measured, only plots with at least one of the litter layers present were selected.

None of these datasets could be used exclusively. Therefore, a stepwise approach was used to estimate the national litter carbon stock and change therein in a consistent way.

First the datasets were compared for (if available) bulk density and carbon or organic matter content of litter separately as well as these combined into conversion factors or functions between litter thickness and carbon stock. Based on appropriate conversion factors, litter carbon stock was calculated for the Forest Classification database and the MFV inventory. These were compared to each other and the available data from de Vries and Leeters (2001). From these, a hierarchy was developed to accord mean litter stock values to any of the sampled plots of the HOSP (1988-1992) and MFV(2001-2005) inventories. The followed hierarchy was

1. For non-sandy soils the only source of information was the Forest Classification database. Though sampled around 1990, it was used for 1990 and 2004 alike. As such it is considered a conservative estimate for any changes occurring. The use of the same dataset in 1990 and 2004 means that changes in total litter stock on non-sandy soils only occur through changes in forest area and tree species composition. Peaty soils were kept outside the analysis.
2. For sandy soils with measured litter layer thickness (i.e. only from the MFV in the years 2004 & 2005), regressions for rich and poor sands based on data from Schulp and co-workers were used to convert them into litter carbon stock estimates. For sand rich in chalk (5 plots) the regression equation of rich sand was used.
3. For sandy soils in the MFV without measured litter layer thickness, but with all other information, a regression was developed from the 951 plots with measured litter layers to estimate the carbon stock from plot location and stand characteristics. However, as this estimate was completely based on data from the MFV alone, we did not use it for the HOSP plots.
4. For sandy soils with missing data for the regression equation mentioned in 3. or for the sandy soils in the HOSP inventory, the following procedure was used:
   4a. for reasons of consistency with the non-sandy soils, if a mean estimate was available for the tree species from the Forest Classification database, that was accorded to the plots

4b. if no such estimate was available, the species specific estimate from the study of de Vries and Leeters (2001) was accorded. In this study, only median values were given and the mean value was taken as midway between the 5% and the 95% percentile.

4c. if no such estimate was available, the mean aspecific value for sandy soils from the Forest Classification database was accorded. This value was always available. However, the next option would have been to accord the mean aspecific value from de Vries and Leeters (2001).

Though this implied using data from 1990 for 2004, this was thought of as a conservative estimate, i.e. underestimating rather than overestimating change. As the changes pointed to an increase of carbon in litter at the national level, an underestimate of change was considered to be conservative for the reporting of emissions.

5. For plots with missing soil information, the total area was summed and the total carbon litter stock in mineral soils was scaled up on an area basis.

The difference between 2004 (MFV litter layer thickness measurements) and 1990 (Forest Classification database, de Vries and Leeters, 2001) was estimated and a mean annual rate of carbon accumulation was calculated. A Monte Carlo uncertainty analysis was carried out with random carbon litter stocks assigned to plots from a distribution rather than from the mean values. The results of the Monte Carlo analysis consistently showed a carbon sink in litter, however the magnitude was very uncertain. As such, it was assumed to be the more conservative estimate to set the accumulation of carbon in litter in Forest Land – FAD remaining Forest Land-FAD to zero. The uncertainty was attributed largely to the fact that no litter information was collected in the HOSP inventory which was used for 1990. In future, when a new MFV inventory will be carried out, more certain estimates of the carbon accumulation in litter over time will be possible and will be reported.

6.1.1 Trees outside Forest

For Trees outside Forest no dead wood nor litter layer build up is assumed. As the patches are smaller and any edge effects therefore larger, the uncertainty on dead wood and litter accumulation is much higher here. For very small patches and linear woody vegetation, the chance of dead wood removal may be very high. Disturbace effects on litter may prevent accumulation. Therefore the conservative estimate of no carbon accumulation in these pools is applied.

7 Update of the carbon emissions from soils

Within its National Inventory Report the Netherlands does report how carbon stocks are determined and how changes in the stocks are calculated as a part of internationally mandatory reporting to UNFCCC. In 2002 and 2003 it was investigated how stocks can be determined and which databases are available for a Dutch monitoring system and which data are missing (see Kuikman et al., 2003; Nabuurs et al., 2003; Kuikman et al., 2004). In 2004 a reporting system was developed with a protocol and on this basis calculations were done to determine the organic carbon stocks (de Groot et al., 2005). These stocks were used for the submissions of 2005 to 2008 to the UNFCCC. After comments of the review experts and new results from two recently published papers on changes in soil organic carbon over time The Netherlands decided to leave the difference between reported and non-reported carbon (in Other Land) for the 2009 submission, and state that The Netherlands as a whole is not a source for carbon for mineral soils. The motivation for this is described in this chapter.

The Netherlands has detailed soil information on its entire land area, which is derived from the soil map of The Netherlands at a scale of 1:50,000. The carbon content in the soil can therefore be expressed with a relatively high degree of accuracy. Kuikman et al. (2002) made a start on this topic using descriptions of profile details in the so-called LSK, a national sample survey of soil map units (Finke et al., 2001). A limited number of soil chemical parameters were quantified in the laboratory, including soil organic matter content. This sample survey was meant to provide further quantitative information for the existing soil maps.

The sample survey was implemented in the period 1990-2000 on a nationwide and stratified scale, where main soil categories were combined in order to produce a more homogeneous grouping with respect to landscape position, soil formation or parent material. Based on the ALBOS file, the land use ‘nature’ has been distinguished separately (see Nabuurs et al., 2005). In total about 1200 locations were sampled at five different depths. Each of these sample points can be linked to a soil unit of the soil map of the Netherlands. The resulting soil carbon stock map based on the LSK survey is shown in Figure 7-1. More information about the quantification of the soil organic carbon stocks and its uncertainties is given in de Groot et al. (2005).

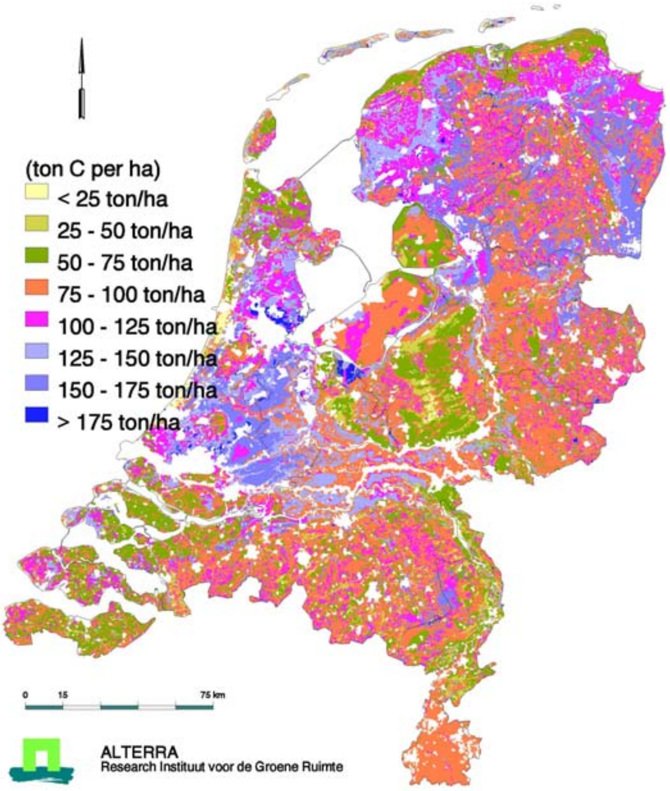

Figure 7-1. Soil carbon stocks (0-30 cm) for The Netherlands

The samples were stratified to soil mapping unit and groundwater class, and especially the last one is highly correlated to SOC level (de Groot et al., 2005). Also, the stratification was not based on land use. The latter would be required for an assessment of SOC stocks and stock changes for the different land use types required in the reporting to the UNFCCC.

Reijneveld et al. (2009) report on the changes in the mean SOC contents of the topsoil (0–5 cm) of grassland and the topsoil (0–25 cm) of arable land in the Netherlands during the period 1984–2004. The analyses were made for all agricultural land on mineral soils and for agricultural land in nine regions with distinct differences in mean soil textures and SOC contents, and for different land uses (arable land and permanent grassland). The study did not include samples from peat soils and samples with a SOC content of more than 125 g/kg. Mean SOC content of soils under arable land in 2003 ranged from 13 to 22 g/kg for sand, loess and clay soils to 59 g/kg for reclaimed peat soils. Mean SOC content of soils under permanent grassland in 2003 ranged from 22 to 56 g/kg for sand and clay soils. Mean SOC contents of all mineral soils under grasslands and arable land tended to increase annually by 0.10 and 0.08 g/kg, respectively (Figure 7-2). Large differences in mean trends were observed between regions. Regions with relatively low SOC contents tended to accumulate C by up to 0.37 g/kg/year, while regions with relatively high SOC contents (e.g., peaty clays) tended to lose C by up to 0.98 g/kg/year. They concluded that mean SOC contents of the topsoil of mineral soils of agricultural land in most regions in the Netherlands tended to increase slightly during the period 1984–2004.

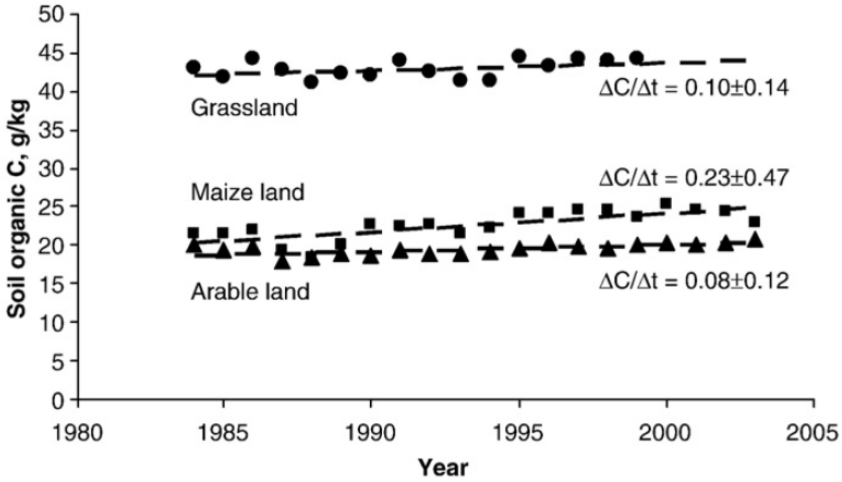

Figure 7-2. Changes in mean soil organic carbon contents of grassland (period 1984–2000), maize land (1984–2004) and arable land (1984–2004) in the Netherlands. The mean annual change in SOC is indicated as ΔC/Δt, in g/kg/year (Source: Reijneveld et al., 2009)

Hanegraaf et al. (2009) performed a trend analysis of SOM contents in sandy soils, with data from grass, grass-maize rotation and maize fields in four adjacent provinces that had been sampled four to five times during the period 1984–2004. The mean SOM content showed a north-south gradient per cropping system. No single uniform trend in SOM contents over time was found for any of the three systems (Figure 7-3). Over the 20-year period, SOM declined in about 25% of all grasslands, whereas in increase was found in about 50% of the grassland fields. The area where a decrease in SOM was observed accounts for 185,000 out of the 635,000 hectares of land under grass and forage crops in the four provinces, whereas an increase in SOM was found for a total of 267,000 hectares. Carbon accumulation in grassland sandy soils was calculated at 39 g C m^{-2} $year^{-1}$ for the top 5 cm of the soil.

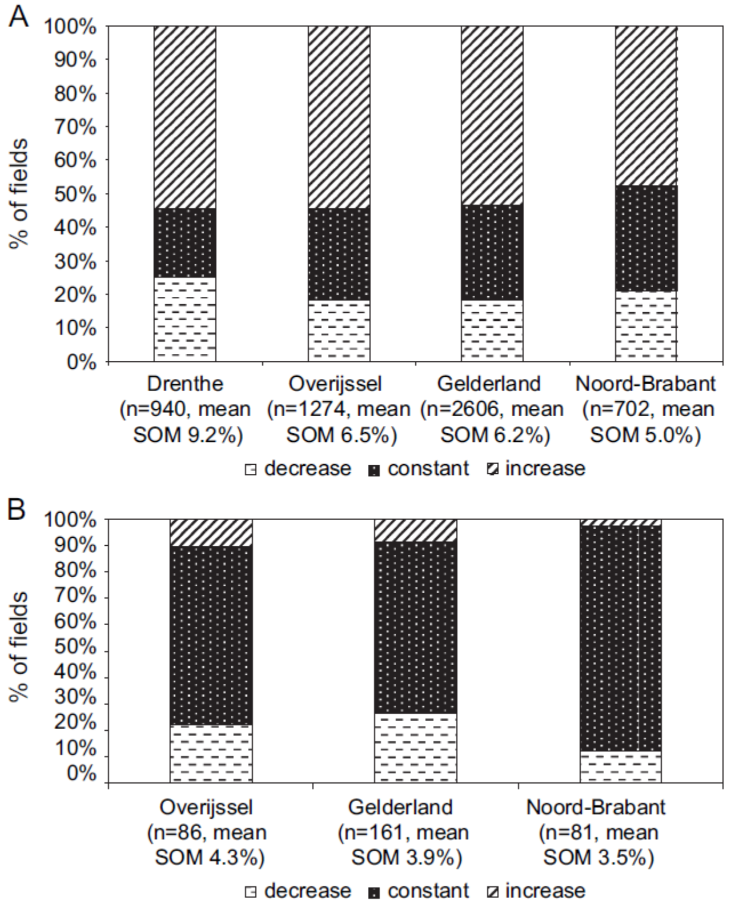

Figure 7-3. Absolute changes in SOM content (%) in sandy soils in four provinces in the Netherlands over 20 years (increase, +1% or more; decrease, –1% or more). (A) grassland; (B) continuous maize (no results for Drenthe due to lack of data) (Source: Hanegraaf et al., 2009)

From the data of Reijneveld et al. (2009) a small increase of 0.032 ton C/year could be calculated for the 6 arable combinations of region and soil type. From the data on maize land in Noord-Brabant, published by Hanegraaf et al (2009), a weighted average loss of 0.3 ton C/ha/yr can be calculated. Silage maize is a crop known to cause a decrease in SOC. From the data of Reijneveld et al. (2009) a small increase of 0.089 g/kg/yr could be calculated for the 4 grassland combinations of region and soil type. From the data on grassland in Noord-Brabant, published by Hanegraaf et al. (2009), a weighted average increase of 0.09 ton C/ha/year can be calculated. Thus, both from Dutch studies indicate a small increase in SOC on grassland, but the increase is lower then the estimations made by IPCC and Janssens et al. (2004).

Both Reijneveld et al. (2009) and Hanegraaf et al. (2009) found a constant or increasing SOC level in most cases for the period between 1984 and 2004. This can possibly be explained by the large amount of manure applied in The Netherlands. Although the amount of manure that is allowed to be applied on land has been reduced in the Netherlands during the last decades, this still amounts about 37 ton animal slurry/ha/year for arable land and up to 51 ton/ha/year for grassland. These amounts of applied animal manure generally lead to a build-up of SOC (Smith et al., 1997; Sleutel et al., 2006).

These two studies are further discussed in Chardon et al. (in press), who compare the results with other studies on temporal trends of soil organic carbon in Western Europe. Chardon et al. (in press) also reviewed the effects of manure application on the soil organic carbon levels from several studies and from a modelling approach with the Century model, which was calibrated for Dutch conditions (see also Heesmans and de Willigen, 2008).

For the NIR, we have concluded from the above studies that for the majority of the mineral and non-organic agricultural soils (< 70 g C/kg), the SOC content is either constant or slightly increases, and in only a minority of the cases may decrease slightly particularly following conversion of grassland to continuous maize cropping. The fact that the majority of the agricultural soils in the Netherlands to a large extent maintain or slightly increase their SOC content is probably best explained by the relatively high amounts of animal manure that is applied on these soils. In the absence of a detailed monitoring system, it is considered fair to conclude that the SOC content of the Dutch agricultural soils overall does provide a small sink. The magnitude of this sink is unknown and at this moment cannot be estimated. Therefore it was decided to take a conservative approach and no longer report emissions of carbon dioxide from carbon stock changes in mineral soils.

Carbon emissions from cultivated organic soils

For carbon dioxide emissions from cultivated organic soils[1] the methodology is described in Kuikman et al. (2005). This method is based on measurements on subsidence as a consequence of oxidation of organic matter.

The carbon emissions per ha are calculated from the mean ground surface lowering using the following general equation:

$$C_{em} = R_{GSL} \cdot \rho_{peat} \cdot f_{ox} \cdot [OM] \cdot [C_{OM}] \cdot f_{conv} \tag{1}$$

with

C_{em}	Carbon emission from oxidation of peat (kg C ha^{-1} year^{-1})
R_{GSL}	Rate of ground surface lowering (m year^{-1})
ρ_{peat}	Bulk density of lowest peat layer (kg soil m^{-3})
f_{ox}	Oxidation status of the peat (-)
$[OM]$	Organic matter content of peat (kg OM kg^{-1} soil)
$[C_{OM}]$	Carbon content of organic matter (0.55 kg C kg^{-1} OM)
f_{conv}	Conversion from kg C m^{-2} year^{-1} to kg C ha^{-1} year^{-1} (10^4)

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[1] N_2O is reported under land use category 4 Agriculture and not further considered here.

For deep peats (> 120 cm), the calculation is based on the properties of raw peat (bulk density of 140 kg soil m^{-3}, oxidation status of 1, and organic matter content of 0.80 kg OM kg^{-1} soil), which results in an emission of 616 kg C ha^{-1} year^{-1} for each mm of annual ground surface lowering.

For shallow peat soils (40 < depth < 120 cm), the (higher) bulk density of half ripened peat should be used. During the process of oxidation of the peat and further ground surface lowering, the decomposability of the remaining peat decreases, resulting in a decreasing rate of ground surface lowering, an increasing bulk density and a decreasing organic matter content. Up to a peat layer depth of about 80 cm all values in equation (1) can be the same as for a deep peat soil, because the change in subsidence and bulk density of the raw peat below 60 cm depth is negligible. Also for peat soils thinner than 80 cm all values in equation (1) were used. This estimation is done because there is no data on subsidence of such shallow peat soils and because this with just cause a small error, because the fast majority of the Dutch peat soils are thicker than 80 cm. Besides, the underestimation of the bulk density will be compensated more or less by the overestimation of the subsidence.

In Table 7-1 the calculated ground surface lowering and the surface is shown for the different combinations of soil type of the upper soil layer, the peat type and drainage class. In the last column of the table the annual emission of Carbon is reported. The total annual loss of carbon from organic soils under agricultural land use is 1.158 Mton of C, which is an annual emission of 4.246 Mton of CO_2. This emission is reported under the category grassland remaining grassland.

Table 7-1: Carbon emissions as resulting from classification of peat soils in The Netherlands, estimated mean ground surface lowering (gsl) and surface (in ha)

Soil type upper soil layer	**Peat type**	**Bad drainage**		**Reasonable drainage**		**Good drainage**		**Total**	**C emission**
		gsl	**Surface (ha)**	**gsl**	**Surface (ha)**	**gsl**	**Surface (ha)**	**Surface (ha)**	**ton C year^{-1}**
Clay	**Eutrophic**	**3**	**16149**	**8**	**17250**	**13**	**531**	**33929**	**119100**
	Mesotrophic	**3**	**12780**	**8**	**22294**	**13**	**2863**	**37935**	**156403**
	Oligotrophic	**3**	**9421**	**8**	**10480**	**13**	**416**	**20315**	**72380**
Peat	**Eutrophic**	**6**	**16668**	**12**	**16846**	**18**	**206**	**33719**	**188415**
	Mesotrophic	**6**	**18668**	**12**	**31607**	**18**	**7169**	**57443**	**382118**
	Oligotrophic	**6**	**8688**	**12**	**10054**	**18**	**1168**	**19911**	**119381**
Humus-rich sand	**Mesotrophic**	**3**	**148**	**8**	**3184**	**13**	**4771**	**8102**	**54167**
	Oligotrophic	**3**	**27**	**8**	**760**	**13**	**2256**	**3041**	**21856**
Sand	**Mesotrophic**	**3**	**1365**	**8**	**3370**	**13**	**1318**	**6051**	**29681**
	Oligotrophic	**3**	**415**	**8**	**1450**	**13**	**836**	**2700**	**14604**
Total			**84325**		**117291**		**21531**	**223147**	**1158105**

8 The submission 2009: values and comparison with previous submissions

8.1 Calculated values for the submission 2009

Table 8-1 shows the integral set of values reported for main land use categories in the NIR 2009, including activity data, for 1990 (baseline year) and 2007 (t-2 year). Changes relative to the submission 2008 are identified and discussed in paragraph 8.2 for all categories A-F.

Table 8-1: Sectoral report for land use, land-use change and forestry of Net CO2 emissions or removals in 1990 and 2006 as submitted in the NIR2009. NE: not estimated. NA: not applicable

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Activity data (ha)**		**Net CO_2 emissions/ removals**	
Reporting year	**1990**	**2007**	**1990**	**2007**
Total Land-Use Categories	**4,194.15**	**4,194.15**	**2,597.10**	**2,537.23**
A. Forest Land	**383.57**	**394.92**	**-2,531.75**	**-2,741.91**
1. Forest Land remaining Forest Land	380.61	341.56	-2,528.93	-2,167.08
2. Land converted to Forest Land	2.96	53.35	-2.82	-574.83
B. Cropland	**1,027.97**	**931.15**	**34.68**	**47.69**
1. Cropland remaining Cropland	1,013.66	1,013.66	NA,NE	NA,NE
2. Land converted to Cropland	14.32	14.32	34.68	47.69
C. Grassland	**1,516.21**	**1,395.24**	**4,640.47**	**4,788.24**
1. Grassland remaining Grassland	1,500.69	1,379.72	4,246.00	4,246.00
2. Land converted to Grassland	15.52	15.52	394.47	542.24
D. Wetlands	**793.54**	**811.42**	**40.29**	**55.38**
1. Wetlands remaining Wetlands	791.31	809.19	NE	NE
2. Land converted to Wetlands	2.23	2.23	40.29	55.38
E. Settlements	**433.06**	**623.55**	**212.14**	**291.85**
1. Settlements remaining Settlements	420.66	611.15	NE	NE
2. Land converted to Settlements	12.39	12.39	212.14	291.85
F. Other Land	**39.79**	**37.86**	**18.13**	**24.91**
1. Other Land remaining Other Land	39.449	37.5195		
2. Land converted to Other Land	0.35	0.35	18.13	24.91
G. Other			**183.15**	**71.08**
Harvested Wood Products			NE	NE
Lime application in all land use categories			183.15	71.08
Information items				
Forest Land converted to other Land-Use Categories			699.70	962.05
Grassland converted to other Land-Use Categories			-1.53	-312.23

8.2 Comparison with submission 2008

Table 8-2: Submitted values for 1990 and 2006 for main land use categories in 2008 (submitted 15 april 2008) and in 2009. Values are rounded to 2 decimals. Subcategories not changing between submissions are shaded.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**Net CO_2 emissions/removals in 1990 (Gg C)**		**Net CO_2 emissions/removals in 2006 (Gg C)**	
Submission year	**Subm 2008**	**Subm 2009**	**Subm 2008**	**Subm 2009**
Total Land-Use Categories	**2,667.30**	**2,597.10**	**2,574.36**	**2,400.38**
A. Forest Land	**-2,518.38**	**-2,531.75**	**-2,509.28**	**-2,872.96**
1. Forest Land remaining Forest Land	-2,505.43	-2,528.93	-2,289.10	-2,358.64
2. Land converted to Forest Land	-12.95	-2.82	-220.18	-514.32
B. Cropland	**-35.57**	**34.68**	**-35.57**	**46.90**
1. Cropland remaining Cropland	NA,NE	NA,NE	NA,NE	NA,NE
2. Land converted to Cropland	-35.57	34.68	-35.57	46.90
C. Grassland	**4,439.99**	**4,640.47**	**4,439.99**	**4,779.38**
1. Grassland remaining Grassland	4,246.00	4,246.00	4,246.00	4,246.00
2. Land converted to Grassland	193.99	394.47	193.99	533.38
D. Wetlands	**NE**	**40.29**	**NE**	**54.48**
1. Wetlands remaining Wetlands	NE	NE	NE	NE
2. Land converted to Wetlands	NE	40.29	NE	54.48
E. Settlements	**-151.54**	**212.14**	**-151.54**	**286.97**
1. Settlements remaining Settlements	NE	NE	NE	NE
2. Land converted to Settlements	-151.54	212.14	-151.54	286.97
F. Other Land	**749.65**	**18.13**	**749.65**	**24.50**
1. Other Land remaining Other Land				
2. Land converted to Other Land	749.65	18.13	749.65	24.50
G. Other	**183.15**	**183.15**	**81.12**	**81.12**
Harvested Wood Products	NE	NE	NE	NE
Lime application in all land use categories	183.15	183.15	81.12	81.12
Information items				
Forest Land converted to other Land-Use Categories	487.55	699.70	487.55	946.23
Grassland converted to other Land-Use Categories	378.84	-1.53	378.84	-279.36

The changes in calculated values between the 2008 and 2009 submissions are shown for 1990 and 2006 in Table 8-2. Major changes in value occurred in all land use categories and almost all subcategories with actual values as the implementation of the new land use change matrix changed activity data. In addition, a series of improvements in calculations were implemented that changed (implied) emission factors for Forest Land as well as categories changing to or from Forest Land. Finally, some changes were implemented that affected the inclusion of (sub)categories and the place and way of reporting of carbon stock changes. This also affected the distribution and total amount of reported carbon stock changes. In view of the many changes that occur simultaneously, the submissions 2008 and 2009 are compared in detail for all categories A – F ass well as the information items in the paragraph 8.3. Category G has not changed and is not further considered.

Due to major changes in the place of reporting of emissions (e.g. disaggregation of deforestation from Grasslands to all land use categories) only few land use categories remain the same between 2008 and 2009 submission. However, the actual changes in value are not as many as seems from this table and can be summarized in four categories (Table 8-2).

Table 8-2: Specification of the quantitative differences between submission 2008 and submission 2009 (Gg CO_2)

	Difference between submissions 2008 and 2009 for reporting years (in Gg CO_2):	
	1990	**2006**
CRF 2008 – CRF 2009 for:		
Soil emissions associated with conversions to and from Other Land	225,02	225,02
Deforestation	-168,20	-414,73
Forest Land remaining Forest Land	23,50	69,54
Land converted to Forest Land	-10,13	294,14
Total	**70,19**	**173,98**
Total CRF 2008 – Total CRF 2009:	**70,19**	**173,98**

The omission of 'administrative' reporting of carbon stock changes **associated with changes to and from Other Land** causes 225 Gg CO_2 less emission. These are further specified in Annex F.

The emissions associated with associated with **deforestation** (Forest Land FAD & TOF converted to other land use type) are almost 170 (1990) to more than 400 (2006) Gg CO_2 higher in the 2009 submission (Table 8-2). Both the emission factor and the activity data have changed in the new submission. The area deforested has increased with 12,5% compared to the submission of 2008, and this explains between 40 % (1990) and 17% (2006) of the difference between the submissions. The remaining 60% to 83% is explained by (see also Table 8-3):

- additional emissions from removal of dead wood (0,45 – 3 Mg C ha-1) and litter (29 – 36 Mg C ha-1) with deforestation: this adds between 29 Gg C ha-1 and 39 Mg C ha-1 to the implied emission factor for deforestation of Forests according to the Kyoto definition, and between 23 and 28,5 Mg C ha-1 (i.e. an increase of between 30 and 40%) to the implied emission factor for the conversion of all Forest Land to any other land use category. These are newly reported emissions. The amount of dead wood and mean litter carbon stock were calculated/estimated in previous emissions (see also Nabuurs et al., 2005), but not reported at deforestation. The mean litter stock in Dutch forests is calculated in a more detailed way now and the reader is referred to chapter 7 for background information on calculations.
- a change from one mean emission factor for decrease of living biomass based on Hosp mean volume and IPCC default values (70,99 Mg C ha-1) in 2008 to an emission factor for decrease of living biomass based on the estimates for biomass originating from the simple bookkeeping model used for Forest Land remaining Forest Land. See also annex C for motivation and background. This new emission factor increases from 15% lower than the old value in 1990 to 15% higher in 2006 and reflects the built-up of growing stock in Dutch forests.

Table 8-3: Calculation of C emissions caused by deforestation – comparison of the values for 2008 and 2009 submission ((I)EF = (implied) emission factor; CSC = Carbon Stock Change).

		Submission 2009			Submission 2008	Subm 2009 - Subm 2008
	Category	FAD	TOF	FAD + TOF	FAD + TOF	FAD + TOF
1990	Area (kha)	1,788	0,508	2,297	2,042	0,25
	(I)EF_biomass_decrease (Mg C ha^{-1})	60,42	60,42	60,42	70,99	
	(I)EF_DOM (Mg C ha^{-1})	29,11		22,67		
	CSC_biomass_decrease (Gg C)	108,05	30,72	138,77	144,96	-6,20
	CSC_DOM (Gg C)	52,06		52,06		52,06
	CSC_tot (Gg C)	160,11	30,72	190,83	144,96	45,87
2006	CSC_tot (Gg CO2)	-589,09	-112,64	-701,73	-531,53	-168,20
	(I)EF_biomass_decrease (Mg C ha^{-1})	82,03	82,03	82,03	70,99	
	(I)EF_DOM (Mg C ha^{-1})	38,85		30,33		
	CSC_biomass_decrease (Gg C)	146,70	41,71	188,41	144,96	43,45
	CSC_DOM (Gg C)	69,65		69,65		69,65
	CSC_tot (Gg C)	212,17	41,71	253,88	144,96	108,92
	CSC_tot (Gg CO2)	-793,29	-152,94	-946,23	-531,53	-414,73

The changes in emissions associated with **Forest Land remaining Forest Land** are relatively minor. They are the net result of several changes occurring at the same time, with varying and opposing effects. Table 8-4 gives a more detailed overview of how the emissions of Forest land remaining Forest land are built up in the 2008 and 2009 submissions. The main effects are due to changes in emission factors as the changes in activity data range from less than 0,5% for 1990 to about 10 % for 2006.

The decrease in emission factor for carbon stock change due to biomass increase in living biomass is primarily due to the change in methodology on how to deal with missing values between 1990 and 2000 (see annex B) for the Hosp data and the inclusion of new plot data from the MFV inventory (collected in 2004 and 2005) for 2000 and onwards. The full set of plots from the 2001-2005 cycle is now used (3622 plots) instead of the preliminary set of the first 2 years (1811 plots) (see also Nabuurs et al., 2005; Van den Wyngaert et al., 2008).

For Trees outside Forest, a constant emission was reported in the 2008 submission, based on the average growth rate in FAD, and was not updated based on changing activity data. This resulted in changes in the implied emission factor that reflected changes in the activity data. In the 2009 submission, the IEF of carbon stock change due to biomass increase for TOF is set equal to the IEF for biomass increase in FAD and changes with changes in growth rate of the FAD (independent of changes in activity data).

The decrease in emission factor for carbon stock change due to biomass decrease is an effect of avoiding double counting of wood harvest from deforestation and regular harvests. In earlier submissions, the error by double counting was assumed smaller than the uncertainty of harvest figures. Subtracting wood harvests from deforestation from national harvest figures decreased the carbon stock change due to biomass loss with 360 Gg CO_2 in 1990 up to 860 Gg CO_2 in 2006. Additionally, a switch was made from in country but discontinuously available harvest estimates based on Daamen (1991 to 2000) to annual estimates based on the FAO statistics. This resulted in various and unsystematic differences between the two submissions over the time series (see annex E).

The change in emission factor for carbon stock change due to a change in dead organic matter is between a 7% decrease (1990) and 5% increase (2006). The carbon stock change due to a change in dead organic matter is entirely caused by dead wood, as changes in litter are not reported for Forest Land remaining Forest Land (see chapter 7). The calculation of the storage of carbon in dead wood is affected by both the change in how to deal with missing values (see annex B) as – after 2000- the update of the MFV inventory with the full set of plots (see paragraph on carbon stock change due to biomass increase). There is also an effect of changed harvest values on standing stock, with lower harvest estimates leading to higher standing stocks and – at a constant mortality rate- higher inputs into the dead wood pool.

Table 8-4: Calculation of C emissions in Forest Land remaining Forest Land– comparison of the values for 2008 and 2009 submission (EF = emission factor; CSC = Carbon Stock Change).

	Category	Submission 2009			Submission 2008			Subm 2009 - Subm 2008
		FAD	TOF	FAD + TOF	FAD	TOF	FAD + TOF	FAD + TOF
1990	Area (kha)	360,276	20,333	380,609	360,900	21,170	382,070	-1,46
	EF_biomass_increase (Mg C ha-1)	2,84	2,84	2,84	3,08	2,69	3,06	-0,22
	EF_biomass_decrease (Mg C ha-1)	-1,32		-1,25	-1,59		-1,51	0,26
	EF_DOM (Mg C ha-1)	0,23		0,22	0,25		0,24	-0,02
	CSC_biomass_increase (Gg C)	1023,94	57,79	1081,73	1110,80	57,00	1167,80	-87,07
	CSC_biomass_decrease (Gg C)	-475,99		-475,99	-575,50		-575,50	99,51
	CSC_DOM (Gg C)	83,93		83,97	91,00		91,00	-7,03
	CSC_tot (Gg C)	631,40	57,79	689,71	626,30	57,00	683,30	6,41
	CSC_tot (Gg CO2)	2317,04	211,89	2528,93	2296,43	209,00	2505,43	23,50
2006	Area (kha)	331,089	12,770	343,859	366,970	21,080	388,050	-44,191
	EF_biomass_increase (Mg C ha-1)	2,70	2,70	2,70	2,94	2,70	2,93	-0,28
	EF_biomass_decrease (Mg C ha-1)	-1,12		-1,08	-1,65		-1,56	0,48
	EF_DOM (Mg C ha-1)	0,26		0,25	0,25		0,24	0,03
	CSC_biomass_increase (Gg C)	893,53	34,46	927,99	1079,60	57,00	1136,60	-208,61
	CSC_biomass_decrease (Gg C)	-369,87		-369,87	-603,80		-603,80	233,93
	CSC_DOM (Gg C)	85,14		85,14	91,50		91,50	-6,36
	CSC_tot (Gg C)	608,80	34,46	643,27	567,30	57,00	624,30	18,97
	CSC_tot (Gg CO2)	2232,28	126,37	2358,64	2080,10	209,00	2289,10	69,54

The difference in emissions associated with **re/afforestation** (Land converted to Forest Land FAD & TOF) are caused by a 0,6% (1990) to a 27% (2006) increase in cumulative re/afforestation rate (Table 8-5) and an emission factor that reflects the age distribution of the re/afforested areas (see also annex D). The new emission factor ranges between 20% (1990) and 180% (2006) of the old emission factor, and will attain a constant value 20 years after 1990 with 3,25 Mg C ha^{-1}.

Table 8-5: Calculation of C emissions in land converted to Forest Land– comparison of the values for 2008 and 2009 submission (EF = emission factor; CSC = Carbon Stock Change).

		Submission 2009			Submission 2008	Subm 2009 - Subm 2008
	Category	FAD	TOF	FAD + TOF	FAD + TOF	FAD + TOF
1990	Area (kha)	2,391	0,573	2,964	2,945	0,02
	EF_biomass_increase (Mg C ha-1)	0,26	0,26	0,26	1,20	-0,94
	CSC_biomass_increase (Gg C)	0,62	0,15	0,77	3,53	-2,76
	CSC_tot (Gg CO2)	2,28	0,54	2,82	12,95	-10,13
2006	Area (kha)	40,65	9,74	50,39	39,649	10,741
	EF_biomass_increase (Mg C ha-1)	2,78	2,78	2,78	1,51	1,27
	CSC_biomass_increase (Gg C)	113,17	27,10	140,27	60,05	80,22
	CSC_tot (Gg CO2)	414,94	99,38	514,32	220,18	294,14

8.3 Explanation of the differences with the previous submission per land use category

8.3.1 Forest Land

8.3.1.1 Forest Land remaining Forest Land

Activity data

As shown in Table 8-7 the changes in activity data for subcategories of Forest Land remaining Forest Land is extremely small for 1990. However, the total surface of Forest Land remaining Forest Land was decreased as the subcategory 'Heather' (called 'Nature' in the protocols) was moved from Forest Land to Grassland (in order to comply to internationally accepted interpretation of the definition of Forest Land).

Over time, the difference between the submissions increases for subcategories. In the 2009 submission, the annual decrease was subtracted from each subcategory, but due to the cumulative way of reporting land converted to Forest Land, the latter was not (yet) added. Thus the area of Forest Land remaining Forest Land showed a linear decrease over time. Land converted to Forest Land is reported in this category for 20 years, and as such any increases in Forest Land remaining Forest Land due to afforestation will be reflected in activity data only from 2010 on.

Additionally, this year the area of organic soil was reported for the land use category Forest Land, Cropland and Grassland. For this, an overlay was made between the land use maps and a map with organic soils in The Netherlands (Kuikman et al., 2005).

Emissions and (I)EF

The changes in emissions associated with Forest Land remaining Forest Land are the net result of several changes occurring at the same time, with varying and opposing effects as explained in detail in the previous paragraph (par 8.2). Table 8-4 gives a more detailed overview of how the emissions of Forest land remaining Forest land are built up in the 2008 and 2009 submissions.

8.3.1.2 Land changing to Forest Land

Activity data

As shown in Table 8-7 the changes in aggregated activity data for subcategories of land converted to Forest Land is extremely small for 1990. In previous submission, though the category 'Heather' (called 'Nature' in the protocols) was included in Forest Land, land converted to Heather was not reported under land converted to Forest Land. This was motivated by the large difference in emission fator and the aggregated way of reporting associated with the use of correction factors (see Van den Wyngaert et al., 2007; 2008). No correction factors are used with the new land use change matrix and the activity data as well as fluxes are reported in a disaggregetd way in the 2009 submission. The subcategory 'Heather' (called 'Nature' in the protocols) was moved from Forest Land to Grassland (in order to comply to internationally accepted interpretation of the definition of Forest Land).

Over time, the difference between the submissions increases for subcategories. This is due to a calculation/copying error in the 2008 submission, rather than to a difference in land use change rates (these are almost equal in 1990) or a change in calculation (in both submissions the land converted to Forest Land is reported in a cumulative way).

Change in (I)EF and emissions for carbon stock increase due to biomass change

In previous submission, the IEF for biomass increase in land converted to either FAD or TOF was assumed to be half the rate of biomass increase in FAD remaining FAD. However, a check using actual data from the forest inventories Hosp and MFV forced us to reject this assumption. The EF for land converted to FAD (and assumedly also TOF) was adapted according to Annex D (see also par. 5.3 and par 8.2). Furthermore, in previous submissions the emissions for land converted to Forest Land were reported aggregated into one value under 'other land'. From the 2009 submission on, emissions are reported on the disaggregated level of subcategory (FAD, TOF) of Forest Land for each land use category converted to Forest land.

8.3.2 Cropland

8.3.2.1 Cropland remaining Cropland

Activity data

The differences in activity data of Cropland remaining Cropland are entirely due to the implementation of the new land use change matrix. Additionally, this year the area of organic soil was reported for the land use category Forest Land, Cropland and Grassland. For this, an overlay was made between the land use maps and a map with organic soils in The Netherlands (Kuikman et al., 2005).

8.3.2.2 Land converted to Cropland

Activity data

The differences in activity data of Cropland remaining Cropland are entirely due to the implementation of the new land use change matrix. Additionally, this year the area of organic soil was reported for the land use category Forest Land, Cropland and Grassland. For this, an overlay was made between the land use maps and a map with organic soils in The Netherlands (Kuikman et al., 2005).

New emission associated with Forest land converted to Cropland

In the previous submissions, the area converted from Forest Land to Cropland was reported at a highly aggregated level under Forest Land converted to Grasslands. However, from this submission on the land converted from Forest Land is reported at a highly disaggregated level from each subcategory of Forest Land to each other category of land use. The reader is referred to par 8.2 for a full comparison of total deforestation activity data and emissions between the submissions. This adds an annual emission of 34,68 Gg CO_2 (1990) to 46,90 Gg CO_2 (2006) to the category land converted to Cropland.

Removal of carbon emissions from mineral soil associated with conversion of Other Land to Cropland

The land use category Other Land is introduced to allow wall-to-wall reporting of land areas even if not all land could be allocated to a land use category. The carbon stored in land allocated to Other Land need not be reported (as it is assumed that Other Land has no carbon). In previous submissions, a quite broad definition of Other Land was used, and the carbon in land converted to or from Other Land was assumed to change between reported and not reported. Therefore, large positive and negative emissions were reported which did not actually reflect changes in carbon in soil, but the reporting status of carbon in soil. This was deemed not realistic. In the 2009 submission a more narrow definition of Other Land is used, and the reporting of ‘administrative emissions’ was stopped (see also Annex F). This removed an emission of -35,57 Gg CO_2 from the category land converted to Cropland.

8.3.3 Grassland

8.3.3.1 Grassland remaining Grassland

Activity data

As shown in Table 8-7 the change in activity data for the subcategory Grasslands of the category Grassland remaining Grassland is extremely small for 1990. In 2006, the difference is slightly more but still entirely due to the implementation of the new land use change matrix. However, the total surface of Grassland remaining Grassland was increased as the subcategory 'Nature' (called 'Heather' in the 2008 submission) was moved from Forest Land to Grassland (in order to comply to internationally accepted interpretation of the definition of Forest Land).

Additionally, this year the area of organic soil was reported for the land use category Forest Land, Cropland and Grassland. For this, an overlay was made between the land use maps and a map with organic soils in The Netherlands (Kuikman et al., 2005).

8.3.3.2 Land converted to Grassland

Activity data

Despite the addition of the subcategory 'Nature' (called 'Heather' in the 2008 submission) to the category Grassland, the activity data for land converted to Grassland are lower in the 2009 submission. This is almost completely due to the implementation of the new land use change matrix. The addition of area associated with the subcategory 'Nature' (i.e. 0,37 kha year^{-1}) was more than compensated for by the 'loss' of 0,763 kha year^{-1} that was reported under other land use categories in 2009 due to disaggregating the area of Forest Land converted to other land use categories.

In the 2008 submission, all Forest Land converted to other land use categories was reported as Forest land converted to Grassland, and this amounted to 2,042 kha year^{-1} . In 2009, only the area of Forest Land actually converted to Grassland (Grasslands or Nature) were reported here, and this was equal to 1,279 kha year^{-1}.

Reporting of emissions for Forest Land converted to Grassland

In the previous submissions, the total emissions associated with Forest Land converted from to other land use categories (531,51 Gg CO_2) was reported completely under Grassland. However, from the 2009 submission on the land converted from Forest Land is reported at a highly disaggregated level from each subcategory of Forest Land to each other category of land use. As such, only the emission associated with an actual conversion to Grassland (not any other land use category) was reported under Grassland. This resulted in an emission of between 394,47 Gg CO_2 (1990) and 533,38 Gg CO_2 (2006) for Forest land converted to Grassland. The increase in emissions over time is due to a change in emission factor for deforestation over time. The reader is referred to par 8.2 for a full comparison of total deforestation activity data and emission factors between the submissions.

Removal of carbon emissions from mineral soil associated with conversion of Other Land to Grassland

The land use category Other Land is introduced to allow wall-to-wall reporting of land areas even if not all land could be allocated to a land use category. The carbon stored in land allocated to Other Land need not be reported (as it is assumed that Other Land has no carbon). In previous submissions, a quite broad definition of Other Land was used, and the carbon in land converted to or from Other Land was assumed to change between reported and not reported. Therefore, large positive and negative emissions were reported which did not actually reflect changes in carbon in soil, but the reporting status of carbon in soil. This was deemed not realistic. In the 2009 submission a more narrow definition of Other Land is used, and the reporting of 'administrative emissions' was stopped (see also Annex F). This removed an emission of -337,52 Gg CO_2 from the category land converted to Grassland.

8.3.4 Wetland

8.3.4.1 Wetland remaining Wetland

Activity data

The total surface included in Wetlands remaining Wetlands increases from about 3 kha (1990) in the 2008 submission to about 800 kha in the 2009 submission. This is mostly due to the inclusion of the category 'Open water' in Wetlands (about 770 kha). In previous submissions open water was included in Other Land. Additionally, the area of reed marsh was estimated in a much more precise and labour intensive way, which increased the area of reed marsh about 10-fold in the new land use matrix (see report by Kramer et al., 2009)

8.3.4.2 Land converted to Wetland

Activity data

The surface land converted to reed marsh could not be estimated in the land use matrix used for previous submission and was reported IE (Forest Land converted to Wetlands was included in Forest Land converted to Grassland) and NE. In the land use change matrix used for the 2009 submission, the annual rate of change towards the aggregated category Wetland is 2,23 kha (Table 8-7). (see report by Kramer et al., 2009).

New emission associated with Forest land converted to Wetland

In the previous submissions, the area converted from Forest Land to Wetand was reported at a highly aggregated level under Forest Land converted to Grasslands. However, from this submission on the land converted from Forest Land is reported at a highly disaggregated level from each subcategory of Forest Land to each other category of land use. The reader is referred to par 8.2 for a full comparison of total deforestation activity data and emissions between the submissions. This adds an annual emission of 40,29 Gg CO_2 (1990) to 54,48 Gg CO_2 (2006) to the category land converted to Wetland.

Table 8-7: : Submitted activity data for 1990 and 2006 for land use (sub)categories in 2008 (submitted 15 april 2008) and in 2009. Grey colours (not included) mark the absence of the specific subcategory from that category for that submission. Empty cells mean the subcategory is aggregated in the category value.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES				
	Activity data (surface of land use and land use change) for 1990 (in ha)		**Activity data (surface of land use and land use change) for 2006 (in ha)**	
Submission year	**Subm 2008**	**Subm 2009**	**Subm 2008**	**Subm 2009**
Total Land-Use Categories	**4147,85**	**4194,15**	**4135,00**	**4194,15**
A. Forest Land	**435,35**	**383,57**	**427,70**	**394,25**
1. Forest Land remaining Forest Land	432,40	380,61	388,05	343,86
Forests acording to Kyoto definition	*360,90*	*360,28*	*366,97*	*331,09*
Trees outside forests	*21,17*	*20,33*	*21,08*	*12,77*
Heather = Nature	*50,33*	*n.i.*	*51,10*	*n.i.*
2. Land converted to Forest Land	2,95	2,96	39,65	50,39
Forests acording to Kyoto definition		*2,39*		*40,65*
Trees outside forests		*0,57*		*9,74*
Heather = Nature		*n.a.*		*n.a.*
B. Cropland	**976,51**	**1013,66**	**972,21**	**922,53**
1. Cropland remaining Cropland	957,11	999,34	952,81	908,21
2. Land converted to Cropland	19,40	14,32	19,40	14,32
C. Grassland	**1480,02**	**1500,57**	**1315,51**	**1386,72**
1. Grassland remaining Grassland	1460,21	1485,04	1295,70	1371,19
Grasslands	*1460,21*	*1435,96*	*1295,70*	*1324,00*
Heather = Nature	*n.i.*	*49,08*	*n.i.*	*47,19*
2. Land converted to Grassland	19,81	15,52	19,81	15,52
Grasslands				
Heather = Nature	*n.i.*		*n.i.*	
D. Wetlands	**2,59**	**793,59**	**IE,NE**	**810,42**
1. Wetlands remaining Wetlands	2,59	791,36	NE	808,19
Reed marsh	*2,59*	*20,55*		*27,73*
Open water	*n.i.*	*770,81*	*n.i.*	*780,46*
2. Land converted to Wetlands	IE,NE	2,23	IE,NE	2,23
Reed marsh				
Open water	*n.i.*		*n.i.*	
E. Settlements	**438,05**	**420,66**	**599,23**	**599,95**
1. Settlements remaining Settlements	425,42	408,27	586,60	587,55
2. Land converted to Settlements	12,63	12,39	12,63	12,39
F. Other Land	**815,33**	**39,45**	**820,35**	**37,63**
1. Other Land remaining Other Land	813,84	39,10	818,86	37,29
Other land				
Open water		*n.i.*		*n.i.*
2. Land converted to Other Land	1,49	0,35	1,49	0,35
Other land				
Open water		*n.i.*		*n.i.*

8.3.5 Settlements

8.3.5.1 Settlements remaining Settlements

Activity data

The differences in activity data of Settlements remaining Settlements are entirely due to the implementation of the new land use change matrix.

8.3.5.2 Land converted to Settlements

Activity data

The differences in activity data of land converted to Settlements are entirely due to the implementation of the new land use change matrix.

New emission associated with Forest land converted to Settlements

In the previous submissions, the area converted from Forest Land to Settlements was reported at a highly aggregated level under Forest Land converted to Grasslands. However, from this submission on the land converted from Forest Land is reported at a highly disaggregated level from each subcategory of Forest Land to each other category of land use. The reader is referred to par 8.2 for a full comparison of total deforestation activity data and emissions between the submissions. This adds an annual emission of 212,14 Gg CO_2 (1990) to 286,97 Gg CO_2 (2006) to the category land converted to Settlements.

Removal of carbon emissions from mineral soil associated with conversion of Other Land to Settlement

The land use category Other Land is introduced to allow wall-to-wall reporting of land areas even if not all land could be allocated to a land use category. The carbon stored in land allocated to Other Land need not be reported (as it is assumed that Other Land has no carbon). In previous submissions, a quite broad definition of Other Land was used, and the carbon in land converted to or from Other Land was assumed to change between reported and not reported. Therefore, large positive and negative emissions were reported which did not actually reflect changes in carbon in soil, but the reporting status of carbon in soil. This was deemed not realistic. In the 2009 submission a more narrow definition of Other Land is used, and the reporting of ‘administrative emissions’ was stopped (see also Annex F). This removed an emission of -151,54 Gg CO_2 from the category land converted to Settlement.

8.3.6 Other Land

8.3.6.1 Other Land remaining Other Land

Activity data

The total surface included in Other Land remaining Other Land decreases from about 815 kha (1990) in the 2008 submission to almost 40 kha in the 2009 submission. This is almost entirely due to the removal of the category 'Open water' to Wetlands (about 770 kha). In previous submissions open water was included in Other Land. Additionally, some very small changes were associated with the implementation of the new land use change matrix (see report by Kramer et al., 2009)

8.3.6.2 Land converted to Other Land

Activity data

The total surface included in Other Land remaining Other Land decreases from about 815 kha (1990) in the 2008 submission to almost 40 kha in the 2009 submission. This is almost entirely due to the removal of the category 'Open water' to Wetlands (about 770 kha). In previous submissions open water was included in Other Land. Additionally, some very small changes were associated with the implementation of the new land use change matrix (see report by Kramer et al., 2009)

New emission associated with Forest land converted to Other Land

In the previous submissions, the area converted from Forest Land to Other Land was reported at a highly aggregated level under Forest Land converted to Grasslands. However, from this submission on the land converted from Forest Land is reported at a highly disaggregated level from each subcategory of Forest Land to each other category of land use. The reader is referred to par 8.2 for a full comparison of total deforestation activity data and emissions between the submissions. This adds an annual emission of 18,13 Gg CO_2 (1990) to 22,15 Gg CO_2 (2006) to the category land converted to Settlements.

Removal of carbon emissions from mineral soil associated with conversion of Other Land to Settlement

The land use category Other Land is introduced to allow wall-to-wall reporting of land areas even if not all land could be allocated to a land use category. The carbon stored in land allocated to Other Land need not be reported (as it is assumed that Other Land has no carbon). In previous submissions, a quite broad definition of Other Land was used, and the carbon in land converted to or from Other Land was assumed to change between reported and not reported. Therefore, large positive and negative emissions were reported which did not actually reflect changes in carbon in soil, but the reporting status of carbon in soil. This was deemed not realistic. In the 2009 submission a more narrow definition of Other Land is used, and the reporting of 'administrative emissions' was stopped (see also Annex F). This removed an emission of 749,65 Gg CO_2 from the category land converted to Other Land.

8.3.7 Information items

Emissions of Forest Land converted to other land use categories

In the 2008 submission, only FAD converted to other land use categories was reported here, reflecting the deforestation that would be reported under the Kyoto protocol. However, as was commented by the 2008 review committee, the information item asks specifically for the area of Forest Land that is converted to other land use categories. Therefore, this information item was changed to conform to this.

Emissions of Grassland converted to other land use categories

In the 2008 submission, the emission from soil caused by Grassland converted to Other land was reported here. However, this emission was not included in the 2009 submission as it had a purely administrative background (par. 8.3.6.2). The emission from Grassland converted to Forest land, however, was included under this information item for the submission 2009. This could not be separated from other land use categories converted to Forest Land in the 2008 submission and was therefore omitted in previous submissions.

9 The QA/QC process

To improve the transparency and the quality of the LULUCF data a working document is drafted for discussion, dealing with track of planning as well as decisions, milestones and outputs (Annex F, in Dutch). This has proved useful to keep track of the flow and identify typing- and calculation errors. However, in the period before the submission the thorough revision of the system as well as the use of a new land use matrix created many delays. It is expected that this will be better for the 2010 submission.

10 Foreseen improvements and updates

At the time that the current national system for the LULUCF sector was implemented, it was already envisaged that there would be regular improvements over time. In Van den Wyngaert et al. (2008) a long list of proposed improvements was given. Most of these were either implemented or rejected, and the system has been thoroughly updated in 2008. Any further commenting and suggestions will follow after the 2009 review. Therefore, only two subjects now need further attention:

- installation of subcategories in Grassland, i.e. distinction between rotational grassland, permanent grassland and natural grasslands

More than half of the land use conversions occurs between Grassland and Cropland, in either direction. The use of land areas as grasslands as part of a full rotational cycle is part of the agricultural system in many parts of The Netherlands. However, sofar it is not possible to discriminate between "permanent" land use changes and its related emissions, and "temporary or rotational" land use changes between cropland and grassland and related emissions. Currently, it is possible to distinguish natural grasslands with a management directed towards the conservational value from grassland with a mostly agricultural purpose using a dataset on subsidies. In future it will likely be possible to add a further distinction between rotational grasslands and permanent agricultural grasslands. For the moment, this is just a conceptual idea.

- periodic updating of carbon emission from changes in biomass in Forest land remaining Forest land as new data become available (new MFV cycles)

The Dutch National Forest Inventory is a cyclic inventory. During a number of consecutive years, a country-wide subset of the total number of inventory plots is recorded. After a time lag, this is repeated for the permanent plots and a new selection of temporary plots is made to complement the set. Thus, a situation exists where only a small subset of plots is actually recorded for a certain year and for some years none.

Currently, the NFI data, though recorded over several years, are assigned to one year of NFI design. The calculations between 1990 and 2000 are based on 1990 data only, with additional year specific harvest data. When extrapolated one more year, this yielded estimates for 2000 which were in good accordance to the emissions based on data from MFV, collected in 2001 and 2002. In 2009 a recalculation will be submitted based on the whole set of 3622 plots collected between 2001 and 2005.

From 2010 (or later?) on new plot data will be collected, which will at first cover the whole country with a grid of low density, density increasing as the NFI cycle continues.

A strategy is developed how to incorporate the slowly becoming available of plot data for a cyclic NFI in the reporting system based on an overview of European reporting practices in this aspect. This will hopefully be available for the NIR 2010.

- quantitative integration of carbon emission from soil in all land use categories in The Netherlands

In the latest submission of the NIR, no carbon stock changes and subsequent emissions of carbon dioxide are reported from mineral soils. Though it is motivated that the soil of the Netherlands as a whole is very likely to be a sink for carbon (chapter 7), the magnitude of this sink remains uncertain. As such the conservative estimate of no change is our best estimate. Especially carbon stock changes from soils of lands that have no agricultural use (anymore) are currently not well quantified, and a quantitative integration for The Netherlands of all land use categories over all soil types has not been carried out. As this will add to the accuracy and likelihood of the estimates provided by the Netherlands, a study on such quantification may be initiated on the longer term. This should provide a more detailed and enhanced quantification of soil carbon dynamics and carbon dioxide as result of land use and land use change in The Netherlands.

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Annex A Carbon emission calculations for Forest Land remaining Forest Land (I) and fluxes associated with changes in biomass associated with the conversion of land to and from Forest (II)

A(I). Forest remaining forest

The carbon budget of forests in the Netherlands is based on a simulated annual carbon stock change budget for each of the NFI plots, which are then aggregated to the country scale based on the representative areas of the plots. The calculated biomass values are used for the calculation of an emission factor for deforestation.

Plot level simulation model to calculate annual plot scale carbon stock and carbon stock change

1. Calculate age from recording year and regeneration year

$$T_{it} = t_{rcd} - t_{reg}$$

where

T_{it}	Age of NFI plot i at time t (years)
t_{rcd}	Year of recording of NFI plot i
t_{reg}	(Estimated) year of regeneration of NFI plot i

2. Calculate maximal height from age and measured dominant height

$$h_{it} = SI_i \cdot (1 - e^{-c_7 T_{it}})^{c_8}$$
$$\Leftrightarrow SI_i = h_{it} / (1 - e^{-c_7 T_{it}})^{c_8}$$

where

T_{it}	Age of NFI plot i at time t (years)	
h_{it}	Dominant height of NFI plot i at time t (m)	
SI_i	Site index of NFI plot i, i.e. asymptote of $h_{dom} \rightarrow \infty$ (m)	[MFV]
c_7, c_8	Tree species specific constants ($year^{-1}$, -)	

3. Calculate current mean tree volume and dbh from total standing stock, tree density and dominant height

$$\overline{V}_{it} = \frac{V_{it}}{nt_{it}}$$

where

V_{it}	Stand volume of NFI plot i at time t (m^3 ha^{-1})
nt_{it}	Living tree density of NFI plot i at time t (ha^{-1})
$\overline{V}_{it}$	Average tree volume of NFI plot i at time t (m^3)

$$\overline{V}_{it} = \overline{dbh_{it}}^{a} \times h_{it}^{b} \times e^{c}$$
$$\Leftrightarrow \ln(\overline{V}_{it}) = a \times \ln(\overline{dbh_{it}}) + b \times \ln(h_{it}) + c$$
$$\Leftrightarrow \ln(\overline{dbh_{it}}) = \frac{1}{a} \times (\ln(\overline{V}_{it}) - b \times \ln(h_{it}) - c)$$

where

$\overline{V}_{it}$	Average tree volume of NFI plot i at time t (m^3)
$\overline{dbh_{it}}$	Average tree diameter of NFI plot i at time t (cm)
h_{it}	Dominant height of NFI plot I at time t (m)
a, b, c	Type-specific constants

4. Calculate current mean tree mass and total plot biomass and carbon from current tree dimensions

$$\overline{B_{it}} = \overline{B_{AG_{it}}} + \overline{B_{BG_{it}}}$$
$$\overline{B_{AG_{it}}} = bf_{AG}\left(\overline{dbh}_{it}, h_{it}\right)$$
$$\overline{B_{BG_{it}}} = bf_{BG}\left(\overline{dbh}_{it}, h_{it}\right)$$

where

$\overline{B_{it}}$	Average tree biomass of NFI plot i at time t (kg DW)
$\overline{B_{AG_{it}}}$	Above ground mean tree biomass of NFI plot i at time t (kg DW)
$\overline{B_{BG_{it}}}$	Below ground mean tree biomass of NFI plot i at time t (kg DW)
$bf_{AG}(\ )$	Biomass function relating mean tree above ground biomass to mean DBH and height
$bf_{BG}(\ )$	Biomass function relating mean tree below ground biomass to mean DBH and height

5. Calculate next years stand dominant height and volume from age and volume increment:

$$h_{i(t+1)} = SI_i \cdot (1 - e^{-c_7(T_{it}+1)})^{c_8}$$

where

T_{it}	Age of NFI plot i at time t (years)	
$h_{i(t+1)}$	Dominant height of NFI plot i at time t +1 (m)	
SI_i	Site index of NFI plot i, i.e. asymptote of $h_{dom} \rightarrow \infty$ (m)	[MFV]
c_7, c_8	Tree species specific constants ($year^{-1}$, -)	

$$V_{i(t+1)} = V_{it} + I_{V_{it}}$$

where

$V_{i(t+1)}$	Volume of standing stock for plot i at time t +1 (m^3 ha^{-1})	
V_{it}	Volume of standing stock for plot i at time t (m^3 ha^{-1})	[HOSP/MFV]
$I_{V_{it}}$	Annual volume increment for plot i at time t (m^3 ha^{-1} $year^{-1}$)	[HOSP/MFV]

$$nt_{i(t+1)} = (1 - f_{mort}) \cdot nt_{it}$$

$nt_{i(t+1)}$	Living tree density of NFI plot i at time t+1 (ha^{-1})
nt_{it}	Living tree density of NFI plot i at time t (ha^{-1})
f_{mort}	Annual mortality fraction (-)

6. Calculate next years mean tree dimensions from new total standing stock, tree density and dominant height

$$\overline{V}_{i(t+1)} = \frac{V_{i(t+1)}}{nt_{i(t+1)}}$$

where

$V_{i(t+1)}$	Stand volume of NFI plot i at time t+1 (m^3 ha^{-1})
$nt_{i(t+1)}$	Living tree density of NFI plot i at time t+1 (ha^{-1})
$\overline{V}_{i(t+1)}$	Average tree volume of NFI plot i at time t+1 (m^3)

$$\ln(\overline{dbh_{i(t+1)}}) = \frac{1}{a} \times (\ln(\overline{V_{i(t+1)}}) - b \times \ln(h_{i(t+1)}) - c)$$

where

$\overline{V_{i(t+1)}}$	Average tree volume of NFI plot i at time t+1 (m^3)
$\overline{dbh_{i(t+1)}}$	Average tree diameter of NFI plot i at time t+1 (cm)
$h_{i(t+1)}$	Dominant height of NFI plot i at time t +1 (m)
a, b, c	Type-specific constants

7. Calculate next years mean tree mass and total plot biomass and carbon from new tree dimensions

$$\overline{B_{i(t+1)}} = \overline{B_{AG_{i(t+1)}}} + \overline{B_{BG_{i(t+1)}}}$$
$$\overline{B_{AG_{i(t+1)}}} = bf_{AG}\left(\overline{dbh}_{i(t+1)}, h_{i(t+1)}\right)$$
$$\overline{B_{BG_{i(t+1)}}} = bf_{BG}\left(\overline{dbh}_{i(t+1)}, h_{i(t+1)}\right)$$

where

$\overline{B_{i(t+1)}}$	Average tree biomass of NFI plot i at time t (kg DW)
$\overline{B_{AG_{i(t+1)}}}$	Above ground mean tree biomass of NFI plot i at time t (kg DW)
$\overline{B_{BG_{i(t+1)}}}$	Below ground mean tree biomass of NFI plot i at time t (kg DW)
$h_{i(t+1)}$	Dominant height of NFI plot i at time t +1 (m)
$bf_{AG}(\ )$	Biomass function relating mean tree above ground biomass to mean DBH and height
$bf_{BG}(\ )$	Biomass function relating mean tree below ground biomass to mean DBH and height

8. Distribute national harvest values over plots

$$p_{it}(H) = \left[\begin{array}{l} 0 | V_{it} < 300 \wedge T_{it} < 110 \\ 1 | V_{it} > 300 \vee T_{it} > 110 \end{array}\right.$$
$$f_H = \frac{H_{NL}}{\sum [p_{it}(H) \cdot V_{it}]}$$
$$B_{L_{it}} = f_H \cdot p(H) \cdot nt_{it} \cdot \overline{B_{it}}$$

where

$p_{it}(H)$	Chance of a harvest occurring in plot i at time t (-)
V_{it}	Stand volume of NFI plot i at time t (m^3 ha^{-1})

T_{it}	Age of NFI plot i at time t (years)
f_H	Fraction of plot i that is harvested at time t (-)
H_{NL}	Annually harvested volume at national scale (m^3)
$B_{L_{it}}$	Biomass harvested in plot i at time t (kg DW)
nt_{it}	Living tree density of NFI plot i at time t (in ha^{-1})

9. Calculate carbon gain from tree growth and carbon loss from harvest

$$\Delta C_{FF_G} = \sum_{1}^{n} \left(A_i \bullet G_{TOTALi} \right) \bullet CF$$

$$G_{TOTALi} = \left(\overline{B_{i\,t+1}} - \overline{B_{i\,t}} \right) \cdot nt_{it}$$

where:

ΔC_{FF_G}	Total net carbon emission due to biomass increase for Forest land remaining Forest land – FAD in The Netherlands	kg C ha^{-1}
A_i	Area represented per NFI plot	ha
CF	Carbon fraction of living biomass	0.5

and

G_{TOTALi}	Biomass increase for NFI plot i	kg DW
$\overline{B_{i\,t}}$	Average tree biomass of NFI plot i at time t	kg DW
$\overline{B_{i\,t+1}}$	Average tree biomass of NFI plot i at time t+1	kg DW
nt_{it}	Living tree density of NFI plot i at time t	ha^{-1}

$$\Delta C_{FF_L} = \sum_{i=1}^{n} \left(B_{L_{it}} \cdot CF \right)$$

$$\Delta C_{FF_{LB}} = \Delta C_{FF_G} - \Delta C_{FF_L}$$

with

$\Delta C_{FF_{LB}}$	annual change in carbon stocks (in Gg C) due to biomass change in forests in The Netherlands
ΔC_{FF_G}	annual increase in carbon stocks (in Gg C) due to biomass increase in forests in The Netherlands
ΔC_{FF_L}	annual decrease in carbon stocks (in Gg C) due to biomass decrease in forests in The Netherlands (for calculation see Annex A)

10. Carbon stock change on dead wood

$$\Delta C_{FF_{DW}} = \sum \left(A_i \bullet \left(B_{DW\,\mathrm{int}\,o_i} - B_{DW\,out_i}\right)\right) \bullet CF$$

$$B_{DW\,\mathrm{int}\,o_i} = B_{it} \bullet f_{mort}$$

$$B_{DW\,out_i} = \left(\frac{V_{SD\,i}}{L_{SDi}} + \frac{V_{LDi}}{L_{LDi}}\right) \bullet D_{DW}$$

$\Delta C_{FF_{DW}}$	Total net carbon emission due to change in dead wood for Forest land remaining Forest land – FAD in The Netherlands
$B_{DW\,\mathrm{int}\,o_i}$	Annual mass transfer into dead wood pool of NFI plot i
$B_{DW\,out_i}$	Annual mass transfer out of dead wood pool of NFI plot i
B_{it}	Stand living biomass of NFI plot i at time t
f_{mort}	Mortality fraction (0.4% year^{-1})
$V_{SD\,i}$	Volume of standing dead wood of NFI plot i
V_{LDi}	Volume of lying dead wood of NFI plot i
L_{SDi}	Species specific longevity of standing dead wood
L_{LDi}	Species specific longevity of standing lying wood
D_{DW}	Species specific average wood density of dead wood

A(II). Afforestation & deforestation

Following calculations are carried out to derive the annual carbon balance from the live tree compartment through afforestation and deforestation

1. Afforestation

$$\Delta C_{LF_{Growth}} = \sum_{t=1}^{20} \left(EF_t \cdot A_{LF_t}\right)$$

where

$\Delta C_{LF_{Growth}}$	Change in carbon stock in living biomass in land annually converted to forest land (Gg C)
EF_t	Emission factor for young plots of age t (see par. 5.3.1) (Gg C ha^{-1})
A_{LF_t}	Area of land converted to forest of age t (ha)

2. Deforestation

$$\Delta C_{FL_{Loss}} = A_{FL_t} \cdot \frac{\sum \left(A_i \cdot B_{it} \right)}{\sum A_i} \cdot CF$$

$\Delta C_{FL_{Loss}}$	change in carbon stocks in living biomass due to conversion of Forest land to other land use categories (Gg C)
A_{FL_t}	Area of land deforested annually (ha)
A_i	Area of land represented by plot i (ha)
B_{it}	Stand biomass of living trees of NFI plot i at time t (kg DW)

Annex B New strategy for gapfilling plots with some but not all values missing

Rationale

During the 2007 in-country review discussion arose about the average volume as calculated from the HOSP inventory plots. The mean volume calculated from the plots used for carbon stock change calculation (186 m^3 ha^{-1}) was higher than officially reported in the HOSP report (173 m^3 ha^{-1}) (Schoonderwoerd & Daamen, 1999). This difference could be explained by the omission of plots with actual volume data, but missing other type of data which were needed for the simple model to calculate carbon stock change (e.g. age, height,...). It appeared that there was an over-representation of plots with high volumes among plots with complete data. Therefore a more detailed way of gapfilling was designed. This was applied to the whole time series, i.e. also to the MFV dataset.

Comparison of old and new method

The calculations as described in Annex A were performed only for plots with all data. Four types of 'data completeness' could be found:

(0) plots with al data

(1) plots with volume and increment data, but missing variables like height, diameter or recording year

(2) plots with the designation 'clearcut area' (and no volume or increment data)

(3) plots with no volume or increment data without any designation

The calculations as described in Annex A were performed for plots with all data only. In the old method (used for the submissions 2005-2008) these were scaled to national coverage on an area basis, i.e.:

$$\Delta C_{NL} = \Delta C_{(0)} \cdot \frac{\sum_{x=0}^{3} Area_{(x)}}{Area_{(0)}}$$

ΔC_{NL}	carbon budget for the Netherlands in Gg C (plot categories (0) – (3))
$\Delta C_{(0)}$	carbon budget for plots with no missing data in Gg C (plot category 0)
$\sum Area_{(0)}$	total representative area for plots with no missing data (plot category 0)
$\sum_{x=0}^{3} Area_{(x)}$	total representative area for the Netherlands (sum of plot categories (0) – 3))

For the submission 2009 a more advanced method is used, taking advantage of the partial data that are there in the plots not used for full calculations. Again calculations as described in Annex A were only performed on plots with all data, i.e. category (0).

From these a mean BEF2 (= carbon flux due to biomass increase / increment) was calculated that was used to convert increment data from plots with missing variables to carbon fluxes. Carbon flux from dead wood for plots with missing variables was scaled using growing stock volume. Plots subject to clearcut were assumed to have no volume and no increment, and no carbon flux from live or dead wood. Plots with no data at all were extrapolated using the area corrected average for the other three categories. Thus the following calculation is proposed to correct for missing data:

$$\Delta C_{(1)} = I_{(1)} \frac{\Delta C_{(0)}}{I_{(0)}}$$

$$\Delta C_{(2)} = 0$$

$$\Delta C_{(3)} = \left(\Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)}\right) \cdot \frac{Area_{(3)}}{\sum\limits_{x=0,1,2} Area_{(x)}}$$

$$\Delta C_{NL} = \Delta C_{(0)} + \Delta C_{(1)} + \Delta C_{(2)} + \Delta C_{(3)}$$

with

$\Delta C_{(x)}$	carbon budget in Gg C for
$Area_{(x)}$	total representative area for plots with missing data category x
$I_{(x)}$	total increment in m^3 year^{-1} for area represented by plots with missing data category x

For the Hosp and MFV datasets the consequences of the new gapfilling method have been summarized in Figure **A**1 and Table B1. As the MFV dataset has no plots in category (1), the impact on calculations is much less from 2000 on.

Table A1: Effect of gapfilling method on mean values for volume, carbon mass (EF deforestation) and carbon fluxes in forest plots (omitting other changes for 2009)

Variable	1990 Hosp		2000 MFV	
	Gapfilling 2005-2008	Gapfilling 2009	Gapfilling 2005-2008	Gapfilling 2009
Mean volume (m^3 ha^{-1})	186.9	173.8	198.3	197.6
Mean increment (m^3 ha^{-1} $year^{-1}$)	9.03	8.39	8.14	8.12
Mean C mass in biomass (Mg C ha^{-1})	65.0	60.4	72.0	71.7
Mean C flux in biomass (Mg C ha^{-1} $year^{-1}$)	3.060	2.842	2.803	2.795
Mean C flux in dead mass (Mg C ha^{-1} $year^{-1}$)	0.251	0.233	0.273	0.272
Mean C flux from harvest (Mg C ha^{-1} $year^{-1}$)	1.611	1.589	1.547	1.541
Mean net balance (Mg C ha^{-1} $year^{-1}$)	1.699	1.486	1.529	1.525

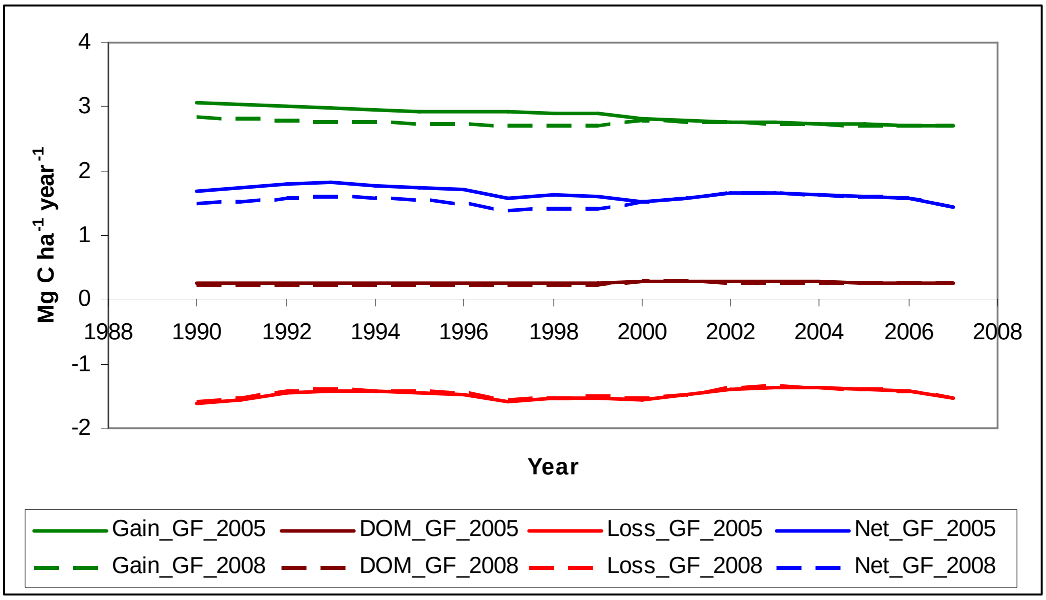


Figure 10-1: Effect of gapfilling method on mean plot carbon flux values.

Annex C Changed emission factor for deforestation

Rationale

During the 2007 in-country review discussion arose about the total emissions from the tree component after deforestation. This was calculated from the average volume using default biomass expansion factors (Nabuurs et al., 2005; Van den Wyngaert et al., 2008). The mean volume that was used to calculate the emission factor for deforestation (19x m^3 ha^{-1}) was higher than officially reported in the HOSP report (173 m^3 ha^{-1}) (Daamen,). For consistency reasons, it was preferred, when reconsidering the emission factor for living biomass after deforestation, to harmonize it with the calculations from the bookkeeping model used for Forest Land remaining Forest Land – Forests according to the Kyoto definition. Thus for the 2009 submission the emission factor for living biomass equals the average carbon contained in living biomass from that year as calculated from the NFI data (see Annex A).

Comparison of old and new method

The total emissions from the tree component after deforestation is calculated by multiplying the total area deforested with the average carbon stock in living biomass, above- as well as below ground (Nabuurs et al., 2005). Until now this average carbon stock is calculated from the average volume using default biomass expansion factors (method 2005-2008):

$$\overline{C} = \overline{V} \cdot BEF2 \cdot D_W \cdot [C]$$

With:

$\overline{C}$	mean carbon stock in kg C ha-1
$\overline{V}$	mean growing stock volume in m^3 = 19x m^3 ha^{-1}
$BEF2$	default biomass expansion factor type 2 = 1.66 kg DM(Whole tree) kg^{-1} DM(Stem)
D_W	default wood density = 0.45 kg DM m^{-3}
$[C]$	default carbon concentration = 0.5 kg C kg^{-1} DM

For the 2009 submission the average carbon contained in living biomass from that year as calculated from the NFI data is taken. Assuming that the 2009 gapfilling method is used and that harvest from deforestation is subtracted from harvest from plots, this will lead to the Emission Factors (in Mg C ha-1) as given in Table . This will be implemented already for the 2009 submission. <*to do: maybe this table will be changed into a figure*>

Table C1: Emission Factor for deforestation in Mg C ha^{-1}

NFI	Year	EF 2008	EF 2009
Hosp	1990	71.0	60.4
Hosp	1991	71.0	61.5
Hosp	1992	71.0	62.6
Hosp	1993	71.0	63.8
Hosp	1994	71.0	64.9
Hosp	1995	71.0	66.1
Hosp	1996	71.0	67.2
Hosp	1997	71.0	68.3
Hosp	1998	71.0	69.2
Hosp	1999	71.0	70.2
MFV	2000	71.0	71.7
MFV	2001	71.0	73.0
MFV	2002	71.0	74.3
MFV	2003	71.0	75.7
MFV	2004	71.0	77.1
MFV	2005	71.0	78.4
MFV	2006	71.0	79.8
MFV	2007	71.0	81.1

Annex D Changed emission factor for re/afforestation

Rationale

The total carbon emission from the tree component after afforestation is calculated at national level. Until now, the carbon emission rates for re/afforested areas were based on the assumption that half of the carbon uptake factor applies as found for the existing forest. This assumption was used as specific data for afforested plots were not available (Nabuurs et al., 2005). However, the availability of data from the NFI with plot age below 20 years allows a more specific value of carbon emission rates for young plots in The Netherlands.

Existing situation

The assumption of half the rate found for existing forest was the outcome of the following assumptions:

1. At time of regeneration, growth is close to zero.
2. At the age of 20 (i.e. when the forest is aggregated into the 'existing forest'), growth is not different from the national mean of Forests remaining Forests.
3. Between regeneration and 20 years of age, the specific growth curve is unknown and is approximated by the simplest function, being a linear curve.
4. The mean emission factor averaged over all ages is the average of this line between (including) 1 and 20 or between (including) 0 and 19 and is equal to half the carbon emission rate of Forests remaining Forests. Thus the specific age of the re/afforested plots is not taken into account, but a general mean value is calculated for the average re/afforested plot, assuming a constant rate of re/afforestation.

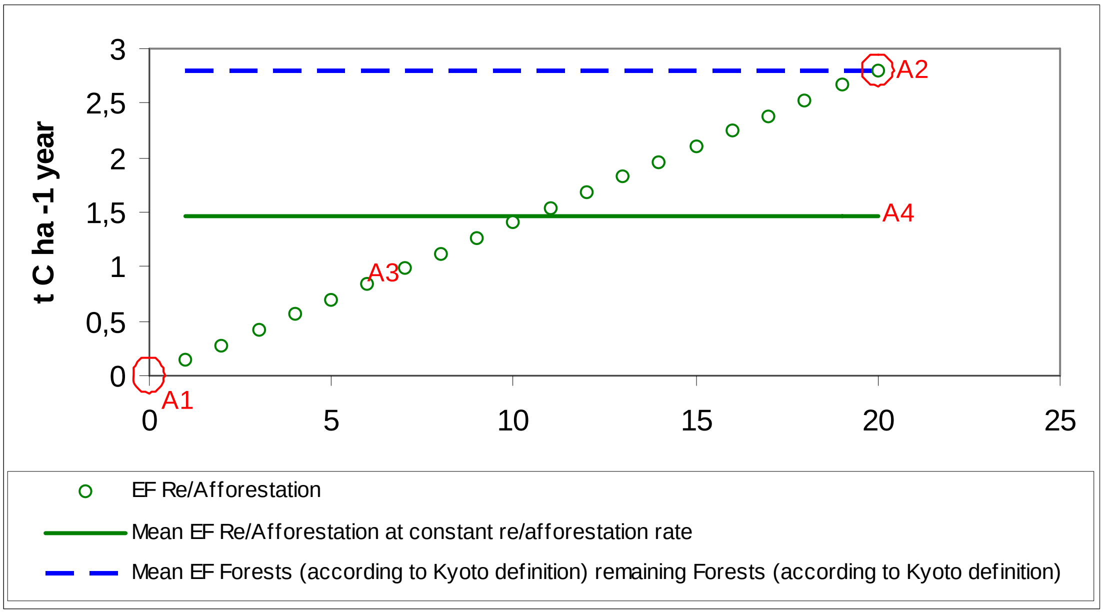


Figure 10-2: Compilation of the emission factor of re/afforested areas as used for the submissions 2005 to 2008. Thgick green line is the mean emission factor actually used. Assumptions are numbered in red.

Check on assumptions for the existing situation

The Hosp and MFV data allowed a check on the set of assumptions used until now to calculate the emission factor for re/afforestation. The check was performed on the increment data as well as on the carbon fluxes, which yielded similar results. In this paragraph the increment data are shown, in the presentation of the alternative possibilities to calculate emission factors from the data, the carbon flux data are presented.

This yielded the following outcome:

1. *At time of regeneration, growth is close to zero.*

Data for very young plots were very scarce and any result was not strong enough to either confirm or refute this assumption. Taking the whole dataset between 0 and 20 years, this seemed a good approximation for the Hosp data, but not for the MFV data. However, as any error caused by this assumption would result in a more conservative estimate, it was accepted by lack of any better alternative.

2. *At the age of 20 (i.e. when the forest is aggregated into the 'existing forest'), growth is not different from the national mean of Forests remaining Forests.*

This assumption was refuted for both the Hosp and the MFV inventories. The mean growth rate of plots at about 20 years old was much higher than the national mean for plots of all ages (Figure 10-3).

3. *Between regeneration and 20 years of age, the specific growth curve is unknown and is approximated by the simplest function, being a linear curve.*

This assumption was more or less confirmed by the Hosp increment data, but not by the increment data from the MFV inventory (Figure 10-4).

4. *The mean emission factor averaged over all ages is the average of this line between (including) 1 and 20 or between (including) 0 and 19 and is equal to half the carbon emission rate of Forests remaining Forests. Thus the specific age of the re/afforested plots is not taken into account, but a general mean value is calculated for the average re/afforested plot, assuming a constant rate of re/afforestation.*

This may have to be reconsidered, taking into account that at some time in the near future we will use not just the overlay between two maps, but several overlays between consecutive maps. Also, this is not correct as long as we do not take into account historic emissions and thus report for a part of the time series re/afforested areas which are not an average over 20 years.

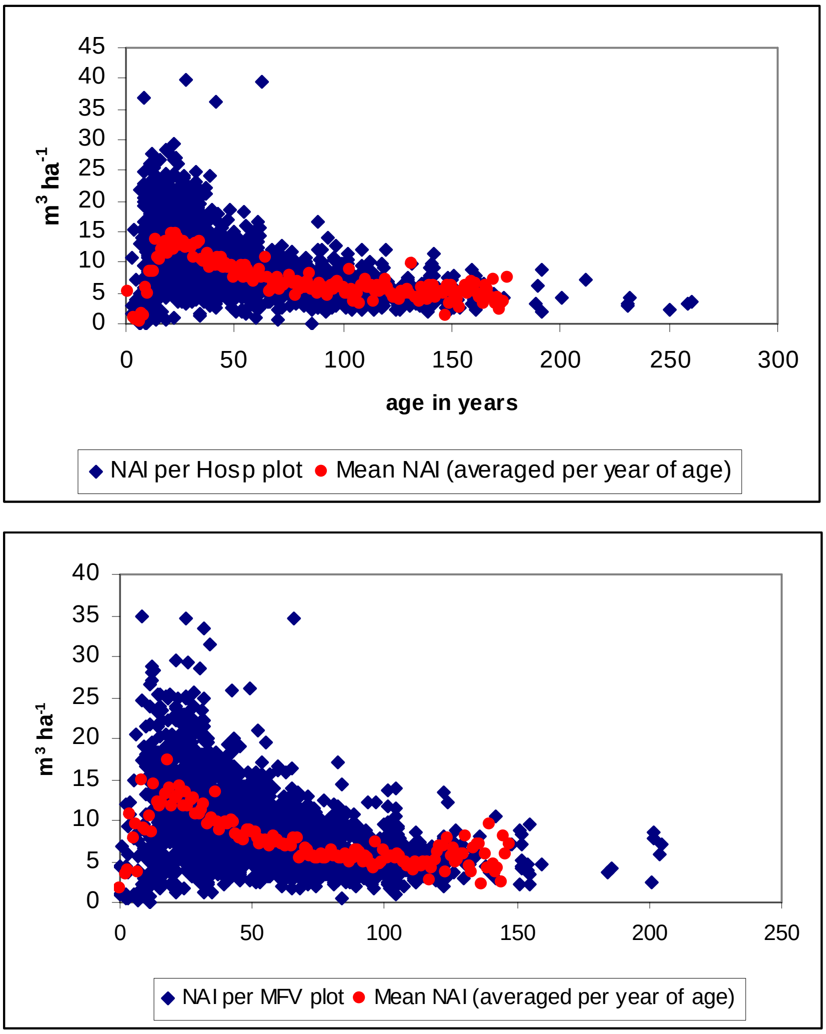
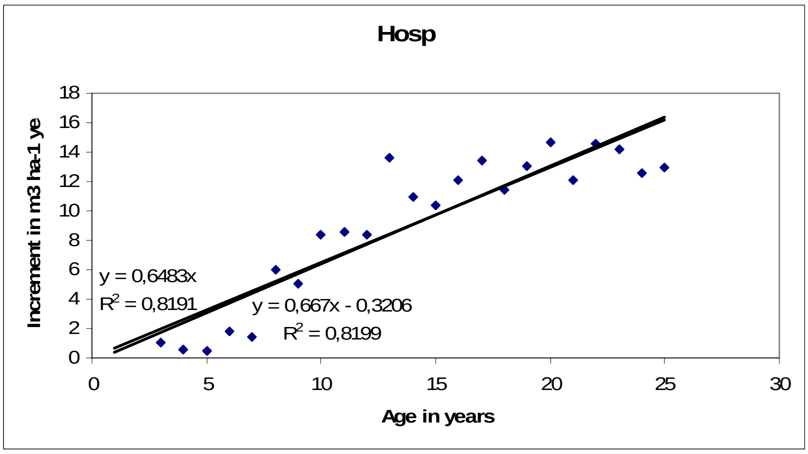


Figure 10-3: Net annual increment (NAI) for individual plots and mean NAI per year of age for the Hosp and MFV inventories.



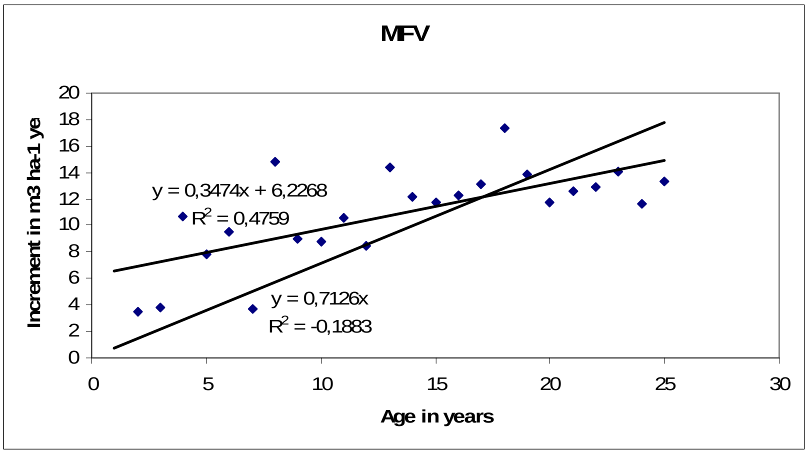


Figure 10-4: Mean NAI per year of age for the Hosp and MFV inventories for the plots up to 25 years old, and regression lines relating EF to age including or excluding intercept.

Proposals for improvement: 3 alternatives

The following alternatives are based on the increment data and the IPCC default biomass expansion conversion factors. Though for Forests remaining Forests The Netherlands uses allometric relations, these are considered to have a quite high uncertainty for very young plots. As the focus here is exclusively on plots less than 20 years old, the use of IPCC defaulr conversion factors was considered the safer option.

Alternative 1:

Regression of emission factor on age:

This option retains assumptions 1 (carbon emission is zero at age is zero) and 3 (linear interpolation between zero and 20 years of age). It replaces the refuted assumption 2 with an estimate of the steepness of the line based on the data of plots of 20 years old and less. It does not accept assumption 4, and thereby respects the effect of actual age on carbon emission. Once past 2010, the acceptation or rejection of assumption 4 has no effect on the emission factor anymore. The running mean

EF (showing in the CRF) of this method increases linearly to a constant value of 2,72 (Hosp) and 3,25 (MFV) t C ha-1 year-1 in 2010 and later on.

Alternative 2:

Mean emission factor over the period 0-20 years based on the regression of emission factor on age:

This option retains assumptions 1 (carbon emission is zero at age is zero) and 3 (linear interpolation between zero and 20 years of age) and 4 (constant rate of land use change, historic emissions included in emission factor). It replaces the refuted assumption 2 with an estimate of the steepness of the line based on the data of plots of 20 years old and less (Figure 10-5). Once past 2010, the acceptation or rejection of assumption 4 has no effect on the emission factor anymore. The running mean EF (showing in the CRF) of this method is constant at a value of 2,72 (Hosp) and 3,25 (MFV) t C ha-1 year-1 in 2010 and later on. It is possible to allow the value to increase monotonically between the Hosp (1990) and the MFV (2000) dates.

Alternative 3:

Mean emission factor over the period 0-20 years based on average emission factor per age:

This option retains assumptions 4 (constant rate of land use change, historic emissions included in emission factor). It does not make an assumption on the exact form of the line before 20 years of age (i.e. it does not need assumption 3), nor on the start point at age is zero (i.e, it does not need assumption 1). The mean value over the interval 0-20 years is calculated based on the mean carbon emission per age for the interval 0-20 years as calculated from the data of plots of 20 years old and less (i.e. the mean value of all points in Figure 10-5). The mean EF for the Hosp data is then 2,84 t C ha-1 year-1 and for the MFV data it is 3,34 t C ha-1 year-1.

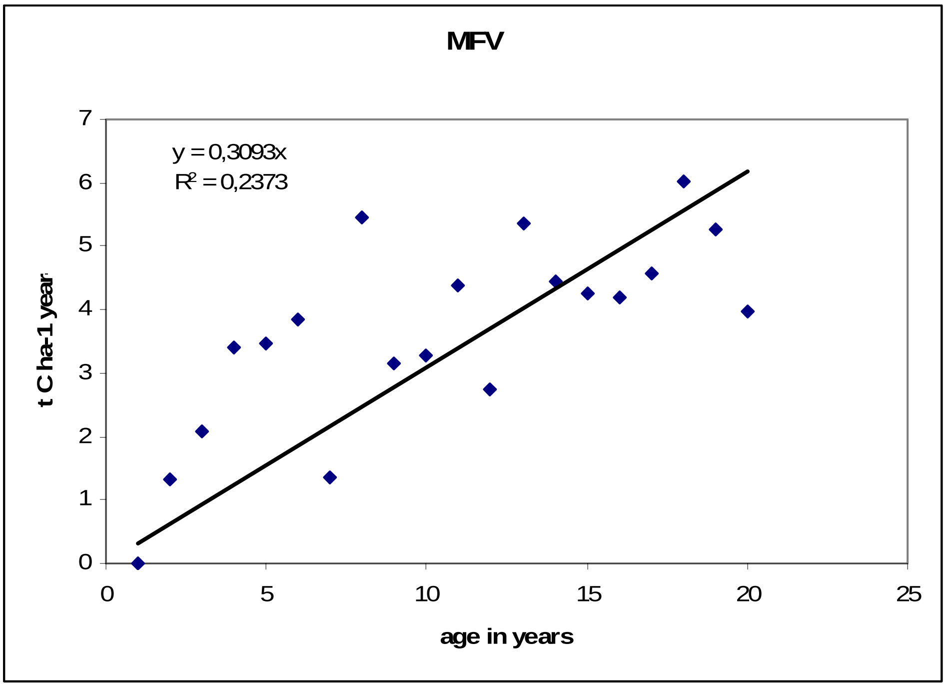
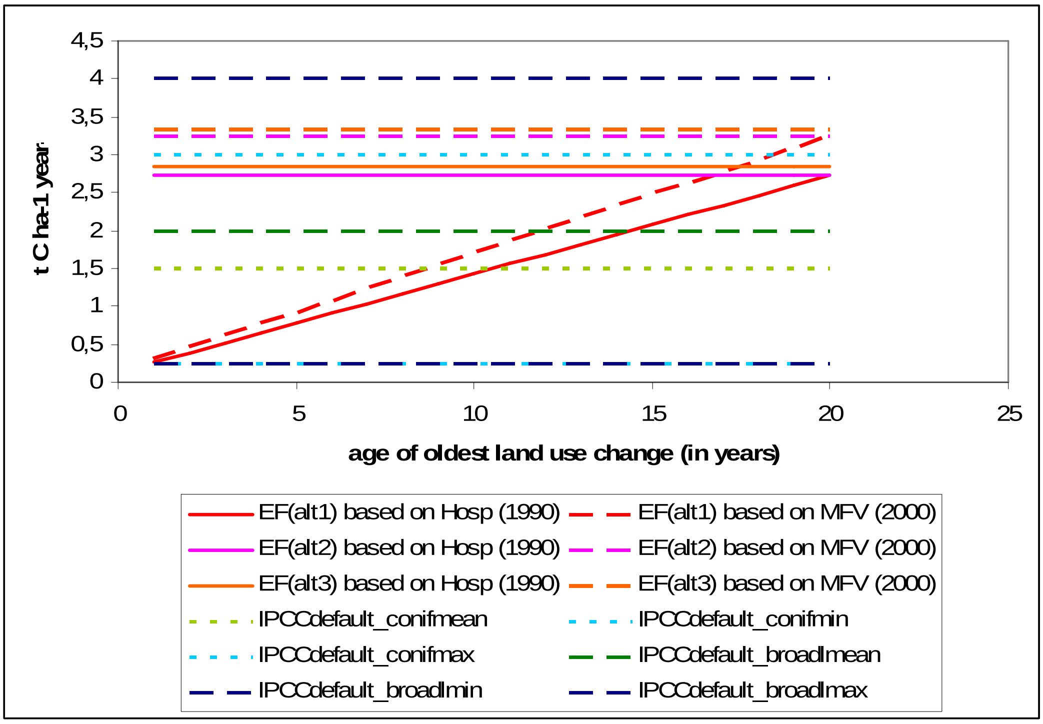


Figure 10-5: Regression of carbon emission (as calculated from increment data and IPCC expansion & conversion factors) on age

Conclusion

As we explicitly do not report historic emissions from before 1990, it is recommended to use alternative 1, which does not need an assumption on constant and equal fractions of land use change towards Forest over the years. This will be more important in the future, as we will use consecutive land use change matrices, with changing re/afforestation rates over time. All alternatives are within the ranges of the IPCC defaults. Though they are in the higher range, this can be understood from the high occurrence of young plots on good productive soils, as agricultural soil was used for afforestation.

The recommendation to use alternative 1 was accepted starting from the 2009 submission with general agreement.



Annex E National harvest data

Rationale

The current harvest data are based on reports from Daamen between 1991 and 2000 (Table 10-1). In the new forest inventory design less emphasis is placed on harvest and from 2000 on national harvest data were not available from the same source types. As a consequence, until the 2008 submission the values for 2000 were copied for the following years. This was probably a reasonable estimate for the first years but is not a sustainable option. The IPCC guidelines state that country submissions need to be consistent with (inter-)national statistics. Therefore, we used the FAO harvest statistics for The Netherlands for the 2009 submission. For reasons of consistency, the FAO harvest statistics are also used for years where national estimates are available from Daamen (1991 – 2000).

Comparison of old and new method

The harvest data are based, therefore, on the FAO harvest statistics (www.fao.org). The wood production is given as production roundwood in m^3 underbark. The total volume removed from the forest includes bark as well as losses during harvesting and is calculated as:

$$V_{HV}^{NL} = V_{RU}^{NL} \cdot 1{,}136 \frac{V_{Overbark}}{V_{Underbark}} \cdot 1{,}06 \frac{V_{\mathrm{Re}moved}}{V_{Roundwood}}$$

Both the previously used values derived from Daamen as the values derived from FAO statistics are shown in Figure 10-6

For matter of consistency, a recalculation should then be carried out for the years 1990-2007 with the harvest data derived from FAO statistics. The difference between the values used until now and the FAO statistics are visualised in Figure 10-6.

Table 10-1 National level wood production data: sources

Year /period	1000 m3/y	Type of felling	Reference
1990	313	Final cut	Daamen. 1991.
1990-1994	1196	Thinning	Daamen. 1994.
1991-1995	1568	Thinning and final cut from production forest plus outgrown coppice, and other	Daamen. 1996.
1992-1996	1339	production forest plus outgrown coppice, and other	Daamen. 1997.
1993-1997	1455	production forest plus outgrown coppice, and other	Daamen. 1998.
1995- 1999	1397	HOSP forest plus additional forest	Daamen. 2000.

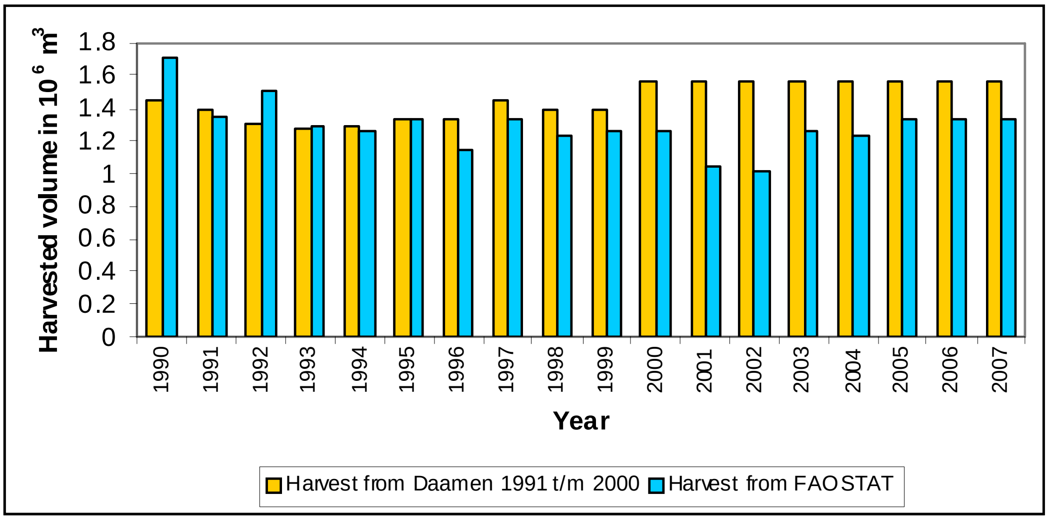


Figure 10-6: Total amount of wood harvested from the forest (forest remaining forest + deforestation) from Daamen 1991 t/m 2000 (orange) and based don FAO statistics (blue). Data after 2000 do not exist from Daamen 1991 t/m 2000 or similar sources and have been copied from the last available value.

Part of this annual harvest is the result of deforestation, while another part is derived from intentional harvesting of wood. To distinguish between these, and to avoid counting double wood removals, the total volume removed from the area deforested is estimated first. This is then subtracted from the national harvest. The remaining volume is then the result of a series of management practices and harvests in the existing forest. Assuming that the amount of wood harvested from TOF is negligible, this remaining harvested volume is attributed completely to FAD and used for the calculation of carbon decrease (by wood removal).

Annex F Change in emissions from soil for conversions to and from Other Land

Rationale

The land use category Other Land is introduced to allow wall-to-wall reporting of land areas even if not all land could be allocated to a land use category. The carbon stored in land allocated to Other Land need not be reported (as it is assumed that Other Land has no carbon) according to GPG-LULUCF. In previous submissions, a quite broad definition of Other Land was used, and the carbon in land converted to or from Other Land was assumed to change between reported and not reported. Therefore, large emissions were reported which did not actually reflect changes in carbon in soil, but the reporting status of carbon in soil. This was deemed not realistic. In the 2009 submission a more narrow definition of Other Land is used, and the reporting of 'administrative emissions' was stopped.

Comparison of old and new method

In the 2008 submission, the quantities in Table E1 were reported for carbon changing from reported (in any land use category but Other Land) to non-reported (in Other Land) and vice versa. In 2009 all carbon stocks in all soils were considered as to be reported and the conversions to and from Other Land were treated as all other land use changes.

Table E10-2: Emissions from mineral soils reported in the CRF 2008 as associated with conversions to and from Other Land (in Gg C if not indicated otherwise)

Emission associated with	Forest Land	Crop land	Grass land	Wet land	Settle ment	Total (Gg C)	Total (Gg CO_2)
change from Other Land to	0,00	9,70	92,05	0,00	41,33	143,08	-524,63
change to Other Land from	-31,63	-33,91	-103,32	-6,31	-29,28	-204,45	749,65
Net result	-31,63	-24,21	-11,27	-6,31	12,05	-61,37	225,02

Annex G Biomass expansion equations selected from the COST21 database (from Nabuurs et al., 2005)

Table 10-3: Allometric equations used to calculate aboveground biomass (in kg) from inventory data (D in cm, H in m)

Species group	Equation	Developed for	Country	Reference
Acer spp	$0.00029*(D*10)^{2.50038}$	Betula pubescens	Sweden	Johansson 1999a
Alnus spp	$0.00309*(D*10)^{2.022126}$	Alnus glutinosa	Sweden	Johansson 1999b
Betula spp	$0.00029*(D*10)^{2.50038}$	Betula pubescens	Sweden	Johansson 1999a
Fagus sylvatica	$0.0798*D^{2.601}$	Fagus sylvatica	The Netherlands	Bartelink 1997
Fraxinus excelsior	$0.41354*D^{2.14}$	Quercus robur & Quercus petraea	Austria	Hochbichler 2002
Larix spp	$0.0533*(D^2*H)^{0.8955}$	Picea abies	European Russia	Hamburg et al. 1997
Picea spp	$0.0533*(D^2*H)^{0.8955}$	Picea abies	European Russia	Hamburg et al. 1997
Pinus other	$0.0217*(D^2*H)^{0.9817}$	Pinus sylvestris	European Russia	Hamburg et al. 1997
Pinus sylvestris	$0.0217*(D^2*H)^{0.9817}$	Pinus sylvestris	European Russia	Hamburg et al. 1997
Populus spp	$0.0208*(D^2*H)^{0.9856}$	Populus tremula	European Russia	Hamburg et al. 1997
Pseudotsuga menziesii	$0.111*D^{2.397}$	Pseudotsuga menziesii	The Netherlands	Van Hees 2001
Quercus spp	$0.41354*D^{2.14}$	Quercus robur & Quercus petraea	Austria	Hochbichler 2002
Coniferous other	$0.0533*(D^2*H)^{0.8955}$	Picea abies	European Russia	Hamburg et al. 1997
Broadleaved other	$0.41354*D^{2.14}$	Quercus robur & Quercus petraea	Austria	Hochbichler 2002

Table 10-4: Allometric equations used to calculate belowground biomass (in kg) from inventory data (D in cm, H in m)

Species group	Equation	Species	Country	Reference
Acer spp	$0.0607*D^{2.6748}*H^{-0.561}$	Betula pubescens	European Russia	Hamburg et al. 1997
Alnus spp	$0.0607*D^{2.6748}*H^{-0.561}$	Betula pubescens	European Russia	Hamburg et al. 1997
Betula spp	$0.0607*D^{2.6748}*H^{-0.561}$	Betula pubescens	European Russia	Hamburg et al. 1997
Fagus sylvatica	$e^{-3.8219}*D^{2.5382}$	Fagus sylvatica	France	Le Goff & Ottorini 2001
Fraxinus excelsior	$-1.551*0.099*D^2$	Quercus petraea	France	Drexhage et al. 1999
Larix spp	$0.0239*(D^2*H)^{0.8408}$	Picea abies	European Russia	Hamburg et al., 1997
Picea spp	$0.0239*(D^2*H)^{0.8408}$	Picea abies	European Russia	Hamburg et al., 1997
Pinus other	$0.0144*(D^2*H)^{0.8569}$	Pinus sylvestris	European Russia	Hamburg et al., 1997
Pinus sylvestris	$0.0144*(D^2*H)^{0.8569}$	Pinus sylvestris	European Russia	Hamburg et al., 1997
Populus spp	$0.0145*(D^2*H)^{0.8749}$	Populus tremula	European Russia	Hamburg et al., 1997
Pseudotsuga menziesii	$0.0239*(D^2*H)^{0.8408}$	Picea abies	European Russia	Hamburg et al., 1997
Quercus spp	$-1.551*0.099*D^2$	Quercus petraea	France	Drexhage et al. 1999
Coniferous other	$0.0239*(D^2*H)^{0.8408}$	Picea abies	European Russia	Hamburg et al., 1997
Broadleaved other	$-1.551*0.099*D^2$	Quercus petraea	France	Drexhage et al. 1999

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Annex H QA/QC information

The following document has been used during the route towards the 2009 submission of the Dutch LULUCF values to the UNFCCC. It contains all the decisions made between the final submission for 2008 and the final submission for 2009, concerning the 2009 submission as well as plans for the long term.

Planning + proces management

Tabel 1: Planning of activities for the submission 2009 for the sector LULUCF

	Action	Planned	Changes	Finished
	Meeting WEBsinks	12 – 02- 2008	-	12 – 02- 2008
	Decide on planning for 2009 submission	12 – 02- 2008	-	12 – 02- 2008
	Select actions on improvements following review	12 – 02- 2008	Postponed to workshop in May	27-05-2008
	Decide on QA/QC actions	12 – 02- 2008	-	12 – 02- 2008
	Checks on submission 2008 t-2	02-2008	Checked against CRF reporter input and all found correct – found a copying error from worksheet to CRF reporter later	02-2008; found copying error 04-2008
	Prepare improvement proposals for workshop	06-2008	In draft version of update report	06-2008
	Finish update report 1035.6 with improvement proposals	06-2008	Draft version ready in May; Final version to be ready in summer	09-08-2008
	LULUCF-day	06-06-2008	postponed	27-06-2008
	Decide on proposed improvements & actions to be taken for this submission and future	06-06-2008		27-06-2008
	Values for 2009 ready, submit to Isabel	01-09-2008	delayed	1-11-2008
	First draft of 1035.7 ready	01-09-2008	Postponed on 27-06 to november	5-1-2008
	Integration of values	10-2008		12-2008
	Consistency check on values	11-2008		12-2008 / 2-2009
	WEBsinks	04-11-2008		4-11-2008
	Decide on final LULUCF values	04-11-2008	delayed	11-2-2009
	Submission of final LULUCF values to ER database & CRF reporter	30-11-2008	First submission in December, last changes to final values in April	First submission in December, last changes to final values in April
	Additional checks on submitted values			March
	Final version of 1035.7 ready for NIR preparation	31-12-2008	delayed	Chapter 8 ready for NIR in February Complete version: 8- 2009
	Check on draft CRF table	02-2009		02-2009

Improvements planned and carried out

In 2009 a series of actions for improvement were identified (see Van den Wyngaert et al., 2008 chapter 10). Part of these are relevant already for the 2009 submission. These are listed:

- improvements to land use and land use change area estimates
- litter carbon emissions when land use changes to and from forest
- litter carbon emissions in Forest Land remaining Forest Land
- a series of improvements to carbon emissions from biomass changes to Forest Land remaining Forest Land
- reporting of areas organic soils for categories 5A Forest Land, 5B Cropland and 5C Grassland

Motivation of changes to the system compared to the previous submission

See Alterra report 1035.6

Calculations

Tabel 2: Overview of calculations supporting the LULUCF submission 2009

Category	What	Who	Description
Activity data: area	Land use change matrix based on topographical maps	CGI, Alterra	Kramer et al., 2008
C emissions from changes in biomass for ‘Forest Land remaining Forest Land’	Simple bookkeeping model based on NFI data	Forest Ecology, Alterra	Nabuurs et al., 2005 Van den Wyngaert et al., 2007 (5A_CO2_forest_2009.pdf) Van den Wyngaert et al., 2009
C emissions from changes in DOM-dead wood for ‘Forest Land remaining Forest Land’	Simple bookkeeping model based on NFI data	Forest Ecology, Alterra	Nabuurs et al., 2005 Van den Wyngaert et al., 2007 (5A_CO2_forest_2009.pdf) Van den Wyngaert et al., 2009
C emissions from changes in DOM-litter for ‘Forest Land remaining Forest Land’	Stock change at national level using a combination of several data sets	Forest Ecology, Alterra	Van den Wyngaert et al., 2009
C emissions from changes in biomass for ‘Land converted to Forest Land’	Based on mean growth of young forest calculated from NFI data	Forest Ecology, Alterra	Nabuurs et al., 2005 (5A_CO2_forest_2009.pdf)
C emissions from changes in biomass for ‘Forest Land converted to other category Land’	Based on mean C stock in forest biomass from the model based on NFI data	Forest Ecology, Alterra	Nabuurs et al., 2005 (5A_CO2_forest_2009.pdf)
C emissions for cultivation of organic soils	Based on groundwater level map and soil surface lowering	Soil Quality & Nutrients, Alterra	1035.2 5_CO2_land_use_categories_2009.pdf
C emissions from use of calcareous fertilizers	Based on national use and default emission values	PBL	NIR

Activity data: areas for land use categories changes between them

The Dutch land use matrix is derived from an overlay between land use maps for 1990 and 2004. Both are made by Henk Kramer (Alterra) based on the topographical maps (Kramer et al., 2008). The reporting (sub)categories are determined from the topographical map classes as indicated in Table 3. The land use change matrix is delivered to Isabel van den Wyngaert (Alterra) who transfers them to the Emission Registration Database.

Tabel 3: Landgebruiksklassen zoals gebruikt bij de kaartoverlay & zoals vastgesteld door UNFCCC

UNFCCC landgebruiksklassen	Nederlandse landgebruiksklassen (TOP)
Forest Land – Forest according to the definition	Forest – patches of more than 8 pixels of 25 m x 25 m selected
Forest Land – Trees outside Forest	Forest – patches less than 8 pixels of 25 m x 25 m selected
Cropland	Cropland
Grassland - Grassland	Grassland
Grassland - Nature	Heather + peatlands
Wetland – reed marshes	Reed marshes
Wetland – open water	Open water
Settlements	Settlements & roads
Other land	Sand & dunes

Emissions associated with the conversion of land use (totals in Gg C)

For part of the land use categories and conversions between them an emission of carbon is reported. These are listed in Table 4.

Tabel 4: Rapportage van koolstoffluxen binnen de LULUCF sector

To↓ From→	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land
Forest Land	Biomass + Harvest + Dead wood + Litter	Biomass	Biomass	Biomass	Biomass	Biomass
Cropland	Biomass + Dead wood + Litter	-	-	-	-	-
Grassland	Biomass + Dead wood + Litter	-	Soil	-	-	-
Wetland	Biomass + Dead wood + Litter	-	-	-	-	-
Settlement	Biomass + Dead wood + Litter	-	-	-	-	-
Other Land	Biomass + Dead wood + Litter	-	-	-	-	-

The emission factor of emissions associated with conversions to and from Forest Land (Gg C ha^{-1}) are calculated by Forest Ecology (Alterra). Emissions associated with all other conversion are calculated from the map overlay between the land use change map and the soil carbon map by Centre for Geo-Information (CGI, Alterra) and Soil Quality and Nutrients (Alterra). Emissions or emission factors are sent to Forest Ecology (Alterra).

Emissions when land use does not change (totals in Gg C)

Carbon emissions when land use does not change are reported for Forest Land (Forests according to the Kyoto definition and Trees outside forest) and for Grassland. For the land use category Forest Land emissions are due to an increase and decrease in living biomass and a change in dead material. This is calculated by Forest Ecology (Alterra) as described in Nabuurs et al. (2005) en Van den Wyngaert et al. (2007).

For the land use category Grassland emissions are due to changes in the carbon stock in the soil due to the agricultural use of organic soils (reported under mineral soils, as some of the areas used may classify under mineral soils fro UNFCCC). This is calculated by the group of Soil Quality and Nutrients as decribed in Kuikman et al. (2005), and sent to Forest Ecology group (Alterra).

Emissions associated with agricultural liming

Carbon emissions associated with the agricultural use of chalk ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) on croplands or grasslands is calculated by PBL and sent to Forest Ecology (Alterra).

Summary

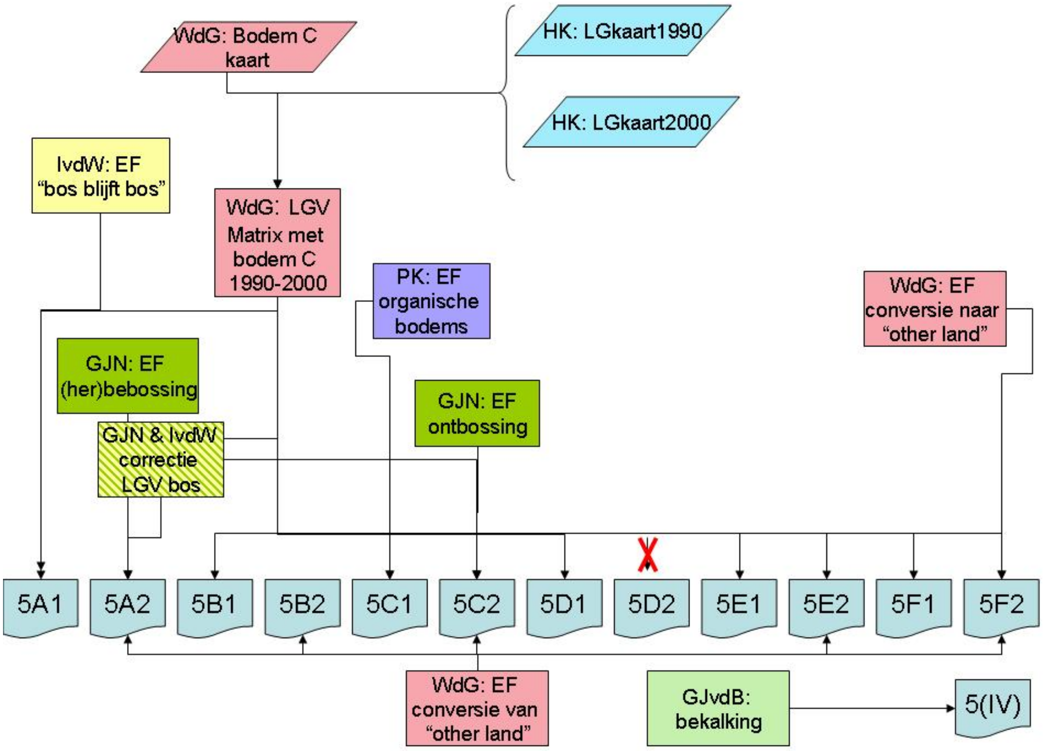


Figure 1: Calculations for sector LULUCF

Integration & Consistency checks

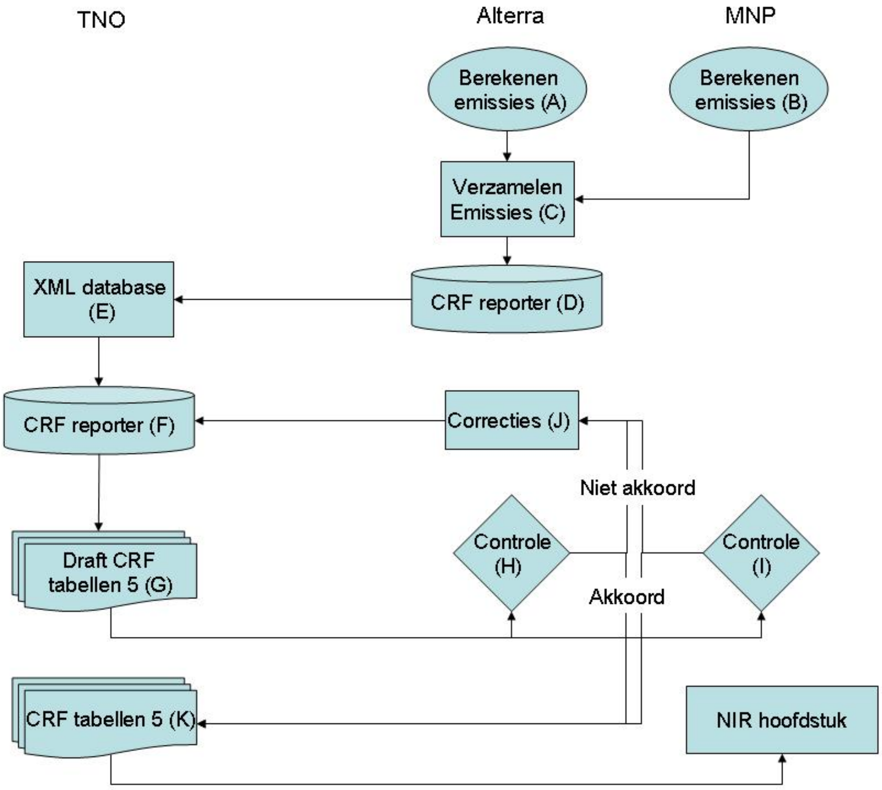
Once all values for the submission are available, a series of actions is performed to check for typing or copying errors, internal consistency, international consistency, completeness, etc... This list is in Excell to allow easy filling of the tables and available as separate file (QAQC_checklist_2009).

Submission route

The reported values are entered in a copy of the CRF reporter by Alterra (Figuur 2, A t/m D). After completely filling the LULUCF sector, a CRF is generated and checked by Alterra . After accordance a XML file is generated and sent to TNO gestuurd (Figuur 2, D t/m F).
Then the draft CRF tabels for LULUCF are generated from the CRF reporter by TNO en sent by TNO to Alterra and PBL for checking (Figuur 2, G t/m I).
Alterra sends the spreadsheet for internal checking class 5A (Forest) and for clases 5B to 5F (Cropland, Grassland, Wetland, Settlements, OtherLand). After checking and commenting Alterra reports back to TNO.
PBL checks independently whether the values in the CRF are right.
This is a check on all actions between calculating the values and the actual submission.

TNO generates the final CRF tables (Schema 2, H t/m J). This loop is followed until there is full accordance. The final tables are sent to PBL who actually performs the official submission (Figuur 2, K).

Base don the CRF and the different reports, PBL writes the LULUCF chapter for the NIR. This chapter is read by Alterra.



Figuur 2: datastroom van berekende emissiegetallen naar officiële rapportage