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LULUCF values under the Kyoto Protocol

Background document in preparation of the National Inventory Report 2011 (reporting year 2009)

I.J.J. van den Wyngaert, P.J. Kuikman, J.P. Lesschen,
C.C. Verwer & H.J.J. Vreuls

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Abstract
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This report collects all background information that is used for the 2011 submission under the Kyoto Protocol (KP) for the Netherlands. It includes the full text of the National Inventory Report (NIR)-II for LULUCF, as well as a description of the table-by-table methodologies, choices and motivations. In 2009 afforestation and reforestation activities produced a sink of 546.68 Gg CO_2 equivalents while deforestation caused an emission of 780,45 Gg CO_2 equivalents. These values were based on changes in above- and belowground biomass, dead wood, litter and soil (mineral as well as organic), and agricultural lime application on deforested areas. The values for 2008 were recalculated from last year, and the recalculation included changes due to: (i) This was the first year emissions from mineral and organic soils were reported for Afforestation, Reforestation, and Deforestation (ARD). (ii) An error in harvested wood was corrected, and (iii) The calculation of dead wood was improved. Some minor gaps remain to be solved in the coming year(s), especially for the estimation of uncertainty of all reported values.

Keywords: Greenhouse Gas Reporting:, Kyoto Protocol, National Inventory Report (NIR)

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Preface

This report describes the background information to the Dutch submission under the Kyoto Protocol. It is the first background document specific to the submission under the Kyoto Protocol. Background documents to the submissions under the Convention on Climate Change, dealing with similar topics, were published as Alterra reports, mostly but not exclusively in the 1035.x series. However, experience learned us that many improvements are initiated while the first submission is being compiled, therefore the structure of a WOT working document (WOt-werkdocument), stressing the work in progress, was used to collect and record all information specifically for reporting under the Kyoto protocol.

We would like to thank Klaas van der Hoek, Bas Clabbers and Gert-Jan van den Born for commenting on earlier versions of the report.

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Content

Summary

This report collects all background information that is used for the 2010 submission under the Kyoto Protocol (KP) for the Netherlands. As such it is complementary to and partly overlapping with the latest background report for reporting under the Convention on Climate Change (Van den Wyngaert *et al.*, 2009), which describes the latest improvements to the LULUCF sector part of the Dutch National System for reporting of greenhouse gases. Reporting under the Kyoto Protocol deals with the same type of pools and gases as the Convention, but emissions occurring from LULUCF are reported in more detail under the Kyoto Protocol. At the same time, the KP tables do not cover the full LULUCF sector. Experience gained in reporting under the Convention showed that many improvements are initiated while the first submission is being compiled, therefore the structure of a WOT working document (WOt-werkdocument) was used to collect and record all information specifically for KP reporting. A more official background document will be compiled when the reporting has a more definite form.

The Netherlands has chosen to define forests as having a minimum area of 0.5 ha, a minimum crown cover of 20% and a minimum height of 5 m. This is in line with our national forest definition as well as FAO reporting since 1984. The definition matches the subcategory "Forests according to the Kyoto definition" (abbreviated as "FAD") of Forest Land in the inventory under the Convention on Climate Change. Units of land that did not comply to the forest definition on 1st January 1990 and do so at any moment (that can be measured) before 31st December 2012 are reported as re/afforested. Units of land that did comply to the forest definition on or after 1st January 1990 and do not anymore so at any moment (that can be measured) before 31st December 2012 are reported as deforested. Once land is classified as deforested, it remains in this category, even if it is reforested and thus complies to the forest definition again later in time.

The identification of units of land subject to re/afforestation and deforestation (ARD) corresponds with the wall-to-wall approach used for reporting under the Convention (approach 3 in GPG-LULUCF chapter 2) and is described as reporting method 2 in GPG-LULUCF for Kyoto (par. 4.2.2.2). It is explained and motivated in detail in Kramer *et al.*, 2009. Comparison of land use maps dated 1st January 1990 and 1st January 2004 resulted in measured AR rates of 2559 ha year^{-1} and D rates of 1992 ha year^{-1} (Kramer *et al.*, 2009). These rates were extrapolated in expectance of a new land use map.

The linkage between AR and the reporting based on land use (sub)categories for the Convention are:

- 5.A.2.1 Cropland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.2 Grassland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.3 Wetland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.4 Settlement converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.5 Other Land converted to Forest Land – Forests according to the Kyoto definition;
- as well as the conversion from 5.1.1. Trees outside Forest to Forests according to the Kyoto definition, included in 5.1.1. Forests according to the Kyoto definition.

The linkage between D and the reporting based on land use (sub)categories for the Convention are:

- 5.B.2.1 Forest Land – Forests according to the Kyoto definition converted to Cropland;
- 5.C.2.1 Forest Land – Forests according to the Kyoto definition converted to Grassland;

- 5.D.2.1 Forest Land – Forests according to the Kyoto definition converted to Wetland;
- 5.E.2.1 Forest Land – Forests according to the Kyoto definition converted to Settlement;
- 5.F.2.1 Forest Land – Forests according to the Kyoto definition converted to Other Land;
- as well as the conversion from Forests according to the Kyoto definition to Trees outside Forest and, included in 5.1.1. Trees outside Forest.

Changes in carbon pools in land changing between Kyoto forest and cropland, grassland, wetlands, settlements or other lands are calculate as described for land use changes involving Forest land under the Convention. A distinction into above- and below ground biomass is made using appropriate R values, and only biomass gains (AR) or only biomass losses (D) are reported.

Changes in carbon pools in Kyoto forest changing to and from Trees outside Forest does not involve a discontinuity in woody cover and is calculated using the simple NFI based bookkeeping model applied for Forest land remaining Forest Land in Convention reporting (Van den Wyngaert *et al.*, 2009).

Changes in litter and dead wood pools are reported only for D, using national means resulting from the same simple bookkeeping model also used for living biomass stocks (Van den Wyngaert *et al.*, 2009). Carbon pool changes in mineral and organic soils will be reported in the next submission only.

Apart from changes in carbon pools, only liming of deforested soils changed to grasslands or croplands is reported.

This results in an estimated carbon sink for AR lands of 546.68 Gg CO_2 and an estimated carbon source of 780.45 Gg CO_2 (including liming of deforested croplands and grasslands).

As a number of improvements are due, it is expected that this amount will change. The most pressing issues are:
- Soil C emissions ARD for mineral, organic and “peaty” soils;
- Separate uncertainty estimates for Kyoto values;
- If a new land use matrix is used in 2011: what happens to land changing land use once it is deforested?
- how to calculate EF of afforested areas > 20 years old?

These issues will be studied and answered in the course of 2010-2011.

Uitgebreide samenvatting

Nederland heeft het Kyoto-protocol geratificeerd. Het heeft zich daarmee verplicht om te rapporteren over het al dan niet behalen van de doelstelling, i.e. om de gemiddelde jaarlijkse uitstoot aan broeikasgassen in de periode 2008-2012 met 6% terug te brengen ten opzichte van 1990. Dit rapport geeft inzicht in de achtergronden van de eerste submissie onder het Kyoto-protocol voor Nederland, over het jaar 2008. Het is daarmee complementair aan eerdere rapporten die een beschrijving geven voor het Nationaal Systeem voor de Rapportage van Broeikasgassen (Nabuurs, 2005; De Groot *et al.*, 2005; Kuikman *et al.*, 2005; Van den Wyngaert *et al.*, 2007; 2009). Vorige rapporten waren echter meer gericht op rapportage onder de Conventie over Klimaatverandering. Rapportage onder het Kyoto-protocol gaat in essentie over verandering in dezelfde type koolstofvoorraden en broeikasgassen. Het verschil tussen beide rapportagesystemen zit in het doel: rapportage onder de Conventie gaat over de monitoring van broeikasgassen, en het eerste doel hierbij is dus informatie. Rapportage onder het Kyoto-protocol is de basis om landen af te rekenen ('accounting') op hun broeikasgas-emissies. Hierdoor is op sommige vlakken meer detail gevraagd, of meer achtergrond, voor de rapportage onder Kyoto. Langs de andere kant worden landen afgerekend op slechts een klein deel van de sector landgebruik en bos: alleen veranderingen van en naar bos (volgens de Kyoto-definitie van bos) zijn onderdeel van de verplichte rapportage (hierna ARD (Afforestation, Reforestation, Deforestation) of artikel 3.3 rapportage genoemd). Het is mogelijk om – optioneel – ook te rapporteren over bosbeheer, agrarisch beheer, graslandbeheer en herstel van vegetaties (genoemd in artikel 3.4). Nederland heeft deze opties echter niet gekozen en daarmee zijn ze buiten de beschouwing van dit rapport gelaten.

Ervaring met rapportages onder de Conventie heeft aangetoond dat na de eerste werkelijke submissie, nog veel veranderingen en verbeteringen aangebracht worden aan het systeem. Hiervoor is gekozen om dit eerste achtergronddocument de status van een WOt-werkdocument te geven, waarbij de nadruk ligt op het feit dat dit 'werk in uitvoering' betreft.

Nederland heeft binnen de grenzen gesteld door het Kyoto-protocol, gekozen om 'Kyoto-bos' te definiëren als bos met een minimum areaal van 0,5 ha, een minimumkroonbedekking van 20% en een minimumhoogte van 5 m (bereikt of kan bereikt worden). Dit is in overeenstemming met de nationale bosdefinitie en met rapportages naar de FAO sinds 1984. Onder de Conventie wordt over dit type bos gerapporteerd onder het kopje 'Forests according to the Kyoto defnition' (FAD) als subcategorie van 'Forest Land'. Stukken land die op 1 januari 1990 voldeden aan deze definitie van bos, en dat op enig (gemeten) moment daarna niet meer deden, vallen onder de categorie 'ontbossing'. Stukken land die op 1 januari 1990 niet voldeden aan deze definitie van bos, en op enig (gemeten) moment wel, vallen onder de categorie '(her)bebossing'. Land kan wel van (her)bebossing overgaan naar ontbossing, maar niet omgekeerd, i.e. land dat ooit ontbost is, wordt vanaf dan altijd binnen deze categorie gerapporteerd, ook als het later weer wel aan de bosdefinitie voldoet.

Land dat voldoet aan de definities voor 'ontbossing' of '(her)bebossing' wordt geïdentificeerd aan de hand van landgebruikskaarten (Kramer *et al.*, 2009). Op dit moment zijn alleen kaarten met kaartdatum 1 januari 1990 en 1 januari 2004 beschikbaar, en de resulterende snelheden van ontbossing (1992 ha $jaar^{-1}$) en (her)bebossing (2559 ha $jaar^{-1}$) zijn na die periode geëxtrapoleerd in afwachting van een nieuwe kaart. Deze methode, waarbij de volledige bedekking van een land bekend is, komt overeen met de 'wall-to-wall' approach voor rapportage onder de Conventie en wordt omschreven als Rapportage methode 2 voor land onder het Kyoto-protocol (IPCC, 2003).

De overeenkomst tussen land dat aan de definitie voor '(her)bebossing' voldoet en arealen die gerapporteerd worden onder land dat verandert in Forest Land onder de Conventie zijn:

- 5.A.2.1 Cropland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.2 Grassland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.3 Wetland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.4 Settlement converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.5 Other Land converted to Forest Land – Forests according to the Kyoto definition;
- alsook de conversie van 5.1.1. Trees outside Forest naar Forests according to the Kyoto definition, die onder de Conventie meegerapporteerd wordt onder 5.1.1. Forests according to the Kyoto definition.

De overeenkomst tussen land dat aan de definitie voor "ontbossing" voldoet en arealen die gerapporteerd worden Forest Land dat ophoudt Forest land te zijn onder de Conventie, zijn:

- 5.B.2.1 Forest Land – Forests according to the Kyoto definition converted to Cropland;
- 5.C.2.1 Forest Land – Forests according to the Kyoto definition converted to Grassland;
- 5.D.2.1 Forest Land – Forests according to the Kyoto definition converted to Wetland;
- 5.E.2.1 Forest Land – Forests according to the Kyoto definition converted to Settlement;
- 5.F.2.1 Forest Land – Forests according to the Kyoto definition converted to Other Land;
- alsook de conversie van 5.1.1. Forests according to the Kyoto definition naar Trees outside Forest, die onder de Conventie meegerapporteerd wordt onder 5.1.1. Forests according to the Kyoto definition.

Van dit land dat gedefinieerd is als 'ontbossing' of '(her)bebossing' moet over de periode waarover verplichtingen zijn aangegaan (2008-2012), gerapporteerd worden wat de verandering in koolstof is in:
(1) bovengrondse biomassa (toename en afname afzonderlijk gespecificeerd),
(2) ondergrondse biomassa (toename en afname afzonderlijk gespecificeerd),
(3) dood hout,
(4) strooisel, en
(5) bodem (minerale bodem en organische bodem afzonderlijk gespecificeerd).

De methoden voor de berekening van deze fluxen voor landgebruiksveranderingen tussen Kyoto-bos en akkers, graslanden, wetlands, bebouwde gebieden en overig land komen overeen met de methoden die beschreven worden voor de Conventie voor conversies tussen 'Forest land' en andere landgebruikscategoriën. Onderscheid tussen boven- en ondergrondse biomassa is gebaseerd op IPCC GPG 2003. Voor (her)bebossing wordt alleen biomassa-toename gerapporteerd, uitgaande van de veronderstelling dat bos dat sinds 1990 bestaat, te jong is om al geoogst te worden. Voor ontbossing wordt alleen een biomassa-afname gerapporteerd in het jaar van ontbossing zelf.

Voor Kyoto-bos dat verandert van of naar 'Bomen buiten Bos' (Trees outside Forest) wordt er geen discontinuïteit verondersteld in de bosbedekking, alleen in de aansluiting op andere gebieden (en dus het areaal aaneengesloten bos). Fluxen voor deze categorieën worden gerapporteerd op basis van het eenvoudige boekhoudmodel beschreven in Van den Wyngaert *et al.*, 2009.

Veranderingen in de strooisellaag en in dood hout worden alleen gerapporteerd voor ontbossing, gebaseerd op nationale gemiddelde voorraden in Nederlandse bossen. Voor (her)bebossing de relatie met leeftijd is te zwak om betrouwbare getallen te rapporteren voor de opbouw van de strooisellaag en dood hout voorraad in de eerste 20 jaar na regeneratie, en er is voor gekozen om deze sink conservatief op 0 te rapporteren.

Bij deze submissie zijn voornamelijk emissies gerapporteerd uit veranderingen in koolstofvoorraad, die gerapporteerd worden in de zogenaamde KP-I tabellen. Emissies uit de KP-II tabellen zijn nauwelijks gerapporteerd, ofwel omdat ze in de Nederlandse context niet relevant zijn, of omdat een goede methode of dataset ontbreekt. Bemesting met stikstof of kalk bij de aanleg van bos komt in Nederland niet voor, en emissies hieruit zijn dus gerapporteerd als niet bestaande (NO). Bekalking van landbouwgronden na ontbossing komt wel voor, en de CO_2-emissie daaruit is geschat en gerapporteerd. Emissies geassocieerd met branden zijn niet relevant voor Nederland, aangezien gecontroleerd branden hier niet voorkomt en ook spontane branden te verwaarlozen zijn (gemonitord tot 1996).

Bovenstaande resulteerde in een geschatte koolstof-sink voor (her)bebossing van 546.68 Gg CO_2 en een geschatte koolstofbron van 780.45 Gg CO_2 (inclusief bekalking van ontboste gebieden die akkers of graslanden geworden zijn).

De volgende verbeteringen aan het systeem staan op de agenda voor 2011 of latere jaren:
- Koolstofveranderingen in de bodem na (her)bebossing en ontbossing voor minerale, organische en moerige gronden;
- Onzekerheidsschattingen voor waarden gerapporteerd naar Kyoto;
- Gevolgen van een nieuwe landgebruiksmatrix: welke emissies rapporteren we als landgebruik verandert van land dat reeds ontbost is?
- Welke emissiefactor gaan we gebruiken wanneer bos 20 jaar of ouder is?

In lijn met het Klimaatverdrag, dat aanspoort tot continue verbetering, kunnen deze onderwerpen leiden tot (deels) nieuwe berekeningswijzen die in toekomstige submissies gebruikt worden.

1 Introduction

The Netherlands has ratified the Kyoto Protocol as well as the Convention on Climate Change, and thereby has committed itself to yearly reporting on its greenhouse gas emissions. Whereas the Convention on Climate Change is mostly directed to accurate monitoring of greenhouse gas emissions, the Kyoto Protocol contains quantified targets for the reduction of greenhouse gas emissions. Both agreements require countries to design and implement a system for reporting of greenhouse gases (GHG) (Article 5 of the UNFCCC). Under the Convention of Climate Change, the Netherlands has been reporting emissions for the land use, land use change and forestry (LULUCF) sector according to the UNFCCC as of 2003. Methodologies used for 2003-2009 submissions are described in detail in the Alterra reports 1035.1-1035.7 (Nabuurs *et al.*, 2005; Kuikman *et al.*, 2005; De Groot *et al.*, 2005; Van den Wyngaert *et al.*, 2007, 2008, 2009).

In 2010 the Netherlands reported for the first time to the Kyoto Protocol (KP). Negotiations have led to different reporting rules for the LULUCF sector under the Convention and under KP. Whereas under the Convention land based reporting ideally covers the complete national surface, under KP activity based reporting was chosen. Only two types of activities, i.e. re/afforestation and deforestation have mandatory reporting. Other activities can be elected but The Netherlands has chosen not to do so. The difference in emissions to be reported and in accountability under the KP have led to a difference between reporting practice under KP and under the Convention. The LULUCF sector is the only sector that has two types of tables in the Common Reporting Format (CRF, i.e. tables used to harmonize the structure of the reported emissions), one for the Convention and one for KP.

This report describes the background for the reported emissions under the KP for the National Inventory Report (NIR) 2011 (KP reporting years 2008 and 2009). The 2011 submission is the 2nd submission under KP, and includes a number of improvements that were initiated in response to the experience gained in 2010 and the subsequent review by the UNFCCC.

Chapter 2 presents the background information for the Kyoto submission and is described following the structure of the annotated NIR. This chapter will be used as the basis text for the annotated NIR 2011.

Chapter 3 provides basic information on the Kyoto tables themselves. It presents the underlying sources of data and gives the equations used for estimating greenhouse gas emissions from LULUCF. The figures in every cell of the Kyoto tables are explained in this chapter.

In Chapter 4 the link is made between the values submitted under the Convention and under the KP. Special issues arising from the methodology used are further elaborated.

Results of the QA/QC process followed are reported in Chapter 5.

The document concludes with a chapter listing issues that need to be resolved to improve the quality of future submissions (Chapter 6).

2 Background information for submission to Kyoto

This chapter contains the information requested by the Kyoto Protocol, structured according to the outline of the annotated NIR. The sections allow a quick filling of the annotated NIR, but also provide space for extra information that will not be included in the NIR but should be readily available when asked for. This chapter also has been fully included in the NIR 2011.

2.1 General information

2.1.1 Definition of forest and any other criteria

The Netherlands identified in its Initial Report the single minimum values under Article 3.3 of the Kyoto Protocol.

The complete forest definition the Netherlands uses for Kyoto reporting is: Forest is land with woody vegetation and with tree crown cover of more than 20 per cent and area of more than 0,5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground; or of open forest formations with a continuous vegetation cover in which tree crown cover exceeds 20 per cent. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 20 per cent or tree height of 5 m are included under forest, as areas normally forming part of the forest area which are temporally unstocked as a result of human intervention or natural causes but which are expected to revert to forest. Forest Land also includes:

- forest nurseries and seed orchards that constitute an integral part of the forest;
- forest road, cleared tracts, firebreaks and other small open areas, all smaller than 6 m. within the forest;
- forest in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest, with an area of more than 0,5 ha and a width of more than 30 m;
- windbreaks and shelterbelts of trees with an area of more than 0,5 ha and a width of more than 30 m.

This excludes tree stands in agricultural production systems for example in fruit plantations and agro forestry systems.

This definition is in line with the FAO reporting since 1984 and was chosen within the ranges set by the Kyoto Protocol. The definition matches the subcategory “Forests according to the Kyoto definition” (abbreviated as “FAD”) of Forest Land in the inventory under the Convention on Climate Change.

2.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

The Netherlands has *not* elected any activities to include under Article 3, paragraph 4, of the Kyoto Protocol.

2.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

Units of land subject to Article 3.3 afforestation and reforestation are reported jointly and are defined as units of land that did not comply to the forest definition on 1st January 1990 and do so at any moment (that can be measured) before 31st December 2012. Land is classified as re/afforested as long as it complies to the forest definition.

Units of land subject to Article 3.3 deforestation are defined as units of land that did comply to the forest definition at any moment in time on or after 1st January 1990, and again ceased to comply to this forest definition at any moment in time (that can be measured) after 1st January 1990. Once land is classified as deforested, it remains in this category, even if it is reforested and thus complies to the forest definition again later in time.

2.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified.

This is not applicable as no article 3.4 activities have been elected.

2.2 Land related information

2.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The Netherlands has complete and spatially explicit land use mapping that allows for geographical stratification at 25 m x 25 m (0.0625 ha) pixel resolution (Kramer *et al.*, 2009). This corresponds with the wall-to-wall approach used for reporting under the Convention (approach 3 in GPG-LULUCF Chapter 2) and is described as reporting method 2 in GPG-LULUCF for Kyoto (par. 4.2.2.2). ARD activities are recorded on a pixel basis. For each pixel individually it is known whether it is part of a patch that complies to the forest definition or not.

Any pixel changing from non-compliance to compliance to the forest definition is treated as re/afforestation. This may be the result of a group of clustered pixels that together cover at least 0.5 ha of non-forest land changing land use into forest land. It may also occur when one or more pixels adjacent to a forest patch change land use. Similarly, any pixel changing from compliance with the Kyoto forest definition to non-compliance is treated as deforestation, whether it involves the whole group of clustered pixels or just a subgroup of them. Thus, the assessment unit of land subject to ARD is 25 m x 25 m (0.0625 ha).

2.2.2 Methodology used to develop the land transition matrix

The Netherlands has complete and spatially explicit land use mapping with map dates on 1st January 1990 and 1st January 2004 (Kramer *et al.*, 2009). An overlay was made between those two maps and this resulted in a land use change matrix between January 1990 and January 2004. Mean annual rates of change for all land use transitions between those years was calculated by linear interpolation, and after 2004 by extrapolation. The values based on extrapolation after 1st January 2004 will be subject to recalculation when a new land use map of later date has been created. Our aim is to make land use maps for 1st January 2008 and

1st January 2013, ensuring that we are able to capture land use changes between 1990 and 2008, and between 2008 and 2012 (IPCC, 2003).

Thus, in the Common Reporting Format (CRF) table NIR-2 the transitions from “other land” to either AR or D activities during the reporting year 2008 (last row in table NIR-2) are extrapolated values based on the mean annual rate of land use change between 1990 and 2004, and will be subject to recalculation when updates of the land use maps become available. Land subject to AR or D between 1990 and 2007 is based on the sum between:
(1) the cumulative area under AR respectively under D for the (reporting) years 1990 to 2003, as derived from a land use map overlay (these values can be considered as final), and
(2) the cumulative area under AR respectively under D for the (reporting) years 2004 to 2007, based on an extrapolation of the mean annual rate of land use change between 1990 and 2004 (these values will be subject to recalculation when updates of the land use maps become available).

Table 2-1 gives the annual values from 1990 on for the article 3.3 related cells in table NIR-2. Due to the use of extrapolation in the current submission, the values from 2004 on can be considered preliminary, with updates foreseen in the 2012 submission.

The summed values in Table 2-1 for AR (=AR land remaining AR land + Other land converted to AR land) match with the sum of values reported under the Convention sector 5.A.2 land converted to Forest Land subcategory Forests according to the Kyoto definition (FAD), and Forest Land - Trees outside Forest converted to Kyoto Forest (included in Forest land – Kyoto Forest) for the respective years. The annual values for deforestation (Other land converted to D land) match with the sum of the values reported in sectors 5.B.2.1 Forest Land - FAD to 5.F.2.1 Forest Land – FAD, and Forest Land – Kyoto forest converted to Trees outside Forest (included in Forest land - Trees outside Forest) for the respective years.

Table 2-1: Results of the calculations of the area change (in kha) of re/afforestation (ARF) and deforestation (Def) in the period 1990-2008.

Year	AR land remaining AR land	Other land converted to AR land	AR land converted to D land	D land remaining D land	Other land converted to D land	Other land remaining other land	Land in KP article 3.3 ARD
1990	0	2.559	0	0	1.992	4146.948	4.551
1991	2.559	2.559	0	1.992	1.992	4142.397	9.103
1992	5.119	2.559	0	3.984	1.992	4137.846	13.654
1993	7.678	2.559	0	5.976	1.992	4133.294	18.206
1994	10.237	2.559	0	7.968	1.992	4128.743	22.757
1995	12.797	2.559	0	9.961	1.992	4124.191	27.308
1996	15.356	2.559	0	11.953	1.992	4119.640	31.860
1997	17.915	2.559	0	13.945	1.992	4115.089	36.411
1998	20.474	2.559	0	15.937	1.992	4110.537	40.963
1999	23.034	2.559	0	17.929	1.992	4105.986	45.514
2000	25.593	2.559	0	19.921	1.992	4101.434	50.066
2001	28.152	2.559	0	21.913	1.992	4096.883	54.617
2002	30.712	2.559	0	23.905	1.992	4092.331	59.168
2003	33.271	2.559	0	25.897	1.992	4087.780	63.720
2004	35.830	2.559	0	27.889	1.992	4083.229	68.271
2005	38.390	2.559	0	29.882	1.992	4078.677	72.823
2006	40.949	2.559	0	31.874	1.992	4074.126	77.374
2007	43.508	2.559	0	33.866	1.992	4069.574	81.925
2008	46.068	2.559	0	35.858	1.992	4065.023	86.477
2009	48.627	2.559	0	37.850	1.992	4060.472	91.028

The system as defined above, with periodic updates, fulfils the requirements of p 4.287 (GPG-LULUCF) that "the systems must be able to define land use and forest in 1990, have an update cycle that is sufficiently short to capture land-use change events between 1990 and 2008, and between 2008 and 2012, and be of sufficiently spatial resolution to identify events of the size of the minimum forest area chosen by the country"

2.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The land use information reported under both the Convention (see also par. 7.1.2 of the Dutch NIR) and the Kyoto Protocol is based on two maps for monitoring nature development in the Netherlands, "Basiskaart Natuur" (BN) for 1990 and 2004.

The source material for BN1990 consists of the paper 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. For the BN2004, information from the Top 10 vector is combined with four other sources, i.e. information from two subsidy regulations (information from 2004), a map with the geophysical regions of the Netherlands (Fysisch Geografische Regio's) and a map with the land use in 2000 (Bestand BodemGebruik 2000) (Kramer *et al.*, 2007). Table 2-2 summarizes the characteristics of both maps (taken from Kramer *et al.*, 2009).

In 2008, a series of improvements were made to the methodology for digitalisation, classification and aggregation. 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. 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 UNFCCC reporting. In this process additional data sets were used, and the forest definition was applied to distinguish forests that comply to the minimum area and width chosen for the Kyoto Protocol (see Section 2.1.1) from other wooded areas ("Trees outside Forests").

Table 2-2: Characteristics of BN1990 and BN2004

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

Simultaneously, harmonisation between the different source materials was applied to allow a sufficiently reliable overlay. Harmonisation included the use of road maps to check the representation of linear features, and correct for any artefact movement of roads due to differences in source material.

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.

To distinguish between mineral soils and peat soils, an overlay was made between the two BN maps and the Dutch Soil Map (De Vries *et al.*, 2003). The result is a map with national coverage that identifies for each pixel whether it was subject to AR or D between 1990 and 2004, and whether it is located on a mineral or on an organic soil.

Following this procedure, the status as re/afforested area or deforested area is certain for each of the individual locations on the map that were subject to ARD between 1990 and 2004. However, it is unknown for each individual location when exactly this occurred. A mean annual rate for the Netherlands as a whole is derived from this by interpolating. For ARD occurring after 1st January 2004 until the reporting year, the mean annual rate for ARD activities is derived by extrapolating the mean annual rates between 1990 and 2004. As such, the exact location of ARD activities after 2004 is not known. The location will be specified as soon as a new land use map, of later date, is created. All ARD will be recalculated for the years where extrapolated data have been used.

2.3 Activity-specific information

2.3.1 Methods for carbon stock change and GHG emissions and removal estimates

Description of the methodologies and the underlying assumptions used

The linkage between AR the reporting based on land use (sub)categories for the Convention is as follows:

- 5.A.2.1 Cropland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.2 Grassland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.3 Wetland converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.4 Settlement converted to Forest Land – Forests according to the Kyoto definition;
- 5.A.2.5 Other Land converted to Forest Land – Forests according to the Kyoto definition;
- as well as the conversion from 5.1.1. Trees outside Forest to Forests according to the Kyoto definition, included in 5.1.1. Forests according to the Kyoto definition.

The methodologies used to calculate carbon stock changes due to AR activities are in accordance with those under the Convention as presented in paragraph 7.2.4 of the NIR and in Van den Wyngaert *et al.* (2009). The carbon stock changes due to changes in biomass were attributed to above- respectively below-ground biomass using one average R value derived from the plots 0-20 years old (Van den Wyngaert *et al.*, 2009). Carbon stock changes in dead wood and litter are not reported (see next section). Carbon stock changes in mineral and organic soils are reported in this submission for the first time, and a recalculation was made for 2008. The methods are presented below and results for carbon stock changes for all pools are given for the full time series since 1990 in Table 2-3.

Table 2-3: Emissions (in Gg C) of AR activities since 1990

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
1990	0,8	0,3	0,0	0,0	0,5	-1,4
1991	2,1	0,7	0,0	0,0	0,9	-2,7
1992	3,7	1,4	0,0	0,0	1,4	-4,1
1993	5,8	2,2	0,0	0,0	1,8	-5,4
1994	8,3	3,3	0,0	0,0	2,3	-6,8
1995	11,3	4,5	0,0	0,0	2,8	-8,1
1996	14,6	5,9	0,0	0,0	3,2	-9,5
1997	18,4	7,6	0,0	0,0	3,7	-10,8
1998	22,6	9,4	0,0	0,0	4,2	-12,2
1999	27,2	11,4	0,0	0,0	4,6	-13,5
2000	32,5	13,6	0,0	0,0	5,1	-14,9
2001	44,4	18,9	0,0	0,0	5,5	-16,2
2002	51,4	22,0	0,0	0,0	6,0	-17,6
2003	58,8	25,3	0,0	0,0	6,5	-18,9
2004	66,8	28,8	0,0	0,0	6,9	-20,3
2005	75,3	32,5	0,0	0,0	7,4	-21,6
2006	84,3	36,5	0,0	0,0	7,8	-23,0
2007	93,8	40,8	0,0	0,0	8,3	-24,3
2008	103,9	45,2	0,0	0,0	8,8	-25,7
2009	114,4	49,9	0,0	0,0	9,2	-27,1

The linkage between D and the reporting based on land use (sub)categories for the Convention is as follows:

- 5.B.2.1 Forest Land – Forests according to the Kyoto definition converted to Cropland;
- 5.C.2.1 Forest Land – Forests according to the Kyoto definition converted to Grassland;
- 5.D.2.1 Forest Land – Forests according to the Kyoto definition converted to Wetland;
- 5.E.2.1 Forest Land – Forests according to the Kyoto definition converted to Settlement;
- 5.F.2.1 Forest Land – Forests according to the Kyoto definition converted to Other Land;
- as well as the conversion from Forests according to the Kyoto definition to Trees outside Forest and, included in 5.1.1. Trees outside Forest.

The methodologies used to calculate carbon stock changes in biomass due to D activities are in accordance with those under the Convention as presented in par. 7.2.4 of the Dutch NIR (Maas *et al,* 2011. The carbon stock changes due to changes in biomass change were differentiated in above respectively below ground biomass using data available from the simple bookkeeping model used (Van den Wyngaert *et al.*, 2009). All emissions were attributed to the year of deforestation, and no emissions were reported for any other years. As under the Convention, emissions as well as areas under deforestation are reported on an annual basis, while under the KP areas are reported cumulative while all emissions are reported in the year of deforestation, emissions are equal under both reporting, but implied emission factors are different. Carbon stock changes in mineral and organic soils are reported in this submission for the first time, and a recalculation was made for 2008. The methods are presented below and results for carbon stock changes for all pools are given for the full time series since 1990 in Table 2-4.

Table 2-4: Emissions (in Gg C) of D activities since 1990

Year	CSC in AG biomass	CSC in BG biomass	CSC in litter	CSC in DW	CSC in mineral soil	CSC in organic soil
1990	-89,6	-17,9	-51,3	-0,8	0,1	-0,7
1991	-90,8	-18,1	-52,3	-1,1	0,1	-1,4
1992	-92,4	-18,5	-53,3	-1,4	0,2	-2,2
1993	-93,8	-18,8	-54,3	-1,6	0,3	-2,9
1994	-95,5	-19,1	-55,3	-1,8	0,3	-3,6
1995	-97,2	-19,4	-56,3	-2,0	0,4	-4,3
1996	-98,9	-19,8	-57,3	-2,2	0,4	-5,0
1997	-100,7	-20,1	-58,3	-2,3	0,5	-5,8
1998	-102,3	-20,4	-59,3	-2,4	0,6	-6,5
1999	-104,0	-20,8	-60,3	-2,5	0,6	-7,2
2000	-102,5	-19,5	-61,3	-2,6	0,7	-7,9
2001	-104,9	-19,9	-62,3	-2,6	0,8	-8,6
2002	-107,5	-20,4	-63,3	-2,5	0,8	-9,4
2003	-110,2	-20,9	-64,3	-2,6	0,9	-10,1
2004	-112,5	-21,3	-64,3	-2,6	0,9	-10,8
2005	-114,8	-21,8	-64,3	-2,6	1,0	-11,5
2006	-116,9	-22,1	-64,3	-2,7	1,1	-12,2
2007	-119,0	-22,5	-64,3	-2,7	1,1	-13,0
2008	-121,2	-22,9	-64,3	-2,8	1,2	-13,7
2009	-123,3	-23,3	-64,3	-2,8	1,3	-14,4

Method to estimate carbon stock change in ARD land in mineral soils
Carbon stock changes in mineral and organic soils are reported in this submission for the first time, and a recalculation was made for 2008. The carbon stock change in mineral soils was calculated for from base data from the LSK survey (De Groot *et al.*, 2005) The LSK database contains quantified soil properties, including soil organic matter, for about 1400 locations at five different depths. The soil types for each of the sample points were reclassified to 11 main soil types, which represent the main variation in carbon stocks within The Netherlands. Combined with the land use at the time of sampling, this lead to a new soil-land use based classification of all points.

The LSK data set only contains data on soil carbon stocks for the land uses grassland, cropland and forest. For the remaining land use categories separate estimates were made. For settlements (about 25% of deforested land becomes settlements) the estimates make use of information in the IPCC 2006 guidelines. An average soil carbon stock under settlement that is 0.9 times the carbon stock of the previous land use is assumed based on the following assumptions:

(i) 50% of the area classified as settlement is paved and has a soil carbon stock of 0.8 times the corresponding carbon stock of the previous land use. Considering the high resolution of the land use change maps in the Netherlands (25x25 m grid cells) it can be assumed that in reality a large portion of that grid cell is indeed paved.
(ii) The remainder 50% consists mainly of grassland and wooded land for which the reference soil carbon stock from the previous land use i.e. forest is assumed.

For the land use categories wetland and trees outside forest (TOF) no change in carbon stocks in mineral soils is assumed upon conversion to or from forest. For the category other land a carbon stock of zero is assumed. This is a conservative estimated, yet in many cases very realistic (other land in the Netherlands are sandy beaches and inland (drifting) sand areas).

The estimated annual C flux associated with re/afforestation or deforestation is then estimated from the difference between land use classes divided by 20 years (IPCC default):

$$E_{\min\_xy} = \sum_{1}^{i} \left(\frac{C_{yi} - C_{xi}}{T} \cdot A_{\min\_xyi} \right)$$

$E_{\min\_xyi}$ Annual emission for land converted from land use x to land use y on soil type i (Gg C yr^{-1})

$A_{\min\_xyi}$ Area of land converted from land use x to land use y on soil type i in years more recent than the length of the transition period (= less than 20 years ago) (ha)

C_{xi}, C_{yi} Carbon stocks of land use x respectively y on soil type i (Gg C.ha^{-1})

T length of transition period (= 20 years)

This results in a net sink of 4.4 kton CO_2 per year for deforestation and a net sink of 32.2 kton CO_2 per year for re/afforestation in 2008, and a net sink of 4.6 kton CO_2 per year for deforestation and a net sink of 33.9 kton CO_2 per year for re/afforestation in 2009. The reason for the net sink of deforestation is that a large part of the deforested area is located on poor sandy soils with conversion of forest land to grassland. On these sandy soils the soil carbon stock is higher for grassland compared to forest land. This results in an increase of the soil carbon pool, which offsets the negative soil carbon stock changes due to deforestation on soil types other than sandy soils.

Method to estimate carbon stock change in ARD land in organic soils
The area of organic soils under forests is very small: 11539 ha (4.0% of total peat area), based on the land use map of 2004. The area of re/afforested land on organic soils is 2912 ha (8% of re/afforested area) and of deforested land 1536 ha (5% of deforested area), based on the land use change between 1990 and 2004 (Kramer *et al.*, 2009). The majority of this is a conversion between Kyoto forest and agricultural land (cropland or grassland). Drainage of organic soils to sustain forestry is not part of the land management nor actively done. However, indirectly also organic soils under forest are affected by drainage from the nearby cultivated and drained agricultural land.

Based on the land use maps of 1990 and 2004 the locations of deforestation and re/afforestation were determined in the ongoing study by Van den Wyngaert *et al.* (in prep) and overlaid with the ground surface lowering map of peat areas. The emissions from organic soils are then calculated using the ground surface lowering rate, the bulk density of the peat, the organic matter fraction and the carbon fraction in organic matter (see Kuikman *et al.*, 2005). For organic soils under deforestation the assumption that emissions are equal to the emissions of cultivated organic soils is realistic. For re/afforestation this assumption is rather conservative as active drainage in forests is not common practice. For this reason and since no data is available about emissions from peat soils under forest or about the water management of forests, we have assumed that emissions remain equal to the emissions on cultivated organic soils before re/afforestation.

The result of the overlay of the ground surface lowering map of peat soils with the locations of re/afforestation and deforestation (land use changes from 1990 – 2004) results in area (ha) and emissions (kton CO_2). The average CO_2 emission from organic soils under re/afforestation is 23.7 ton CO_2 per ha per year and under deforestation 23.9 ton CO_2 per ha per year.

Method to estimate nitrous oxide emissions associated with disturbance of soils when deforested areas are converted to cropland

Nitrous oxide emissions associated with disturbance of soils when deforested areas are converted to cropland are calculated using equations 3.3.14 and 3.3.15 of Good Practice Guidance for LULUCF (IPCC, 2003) for each aggregated soil type (see mineral soils above). The default EF1 of 0.0125 kg N_2O-N/kg N was used. For 3 aggregated soil types average C:N ratio's, based on measurements, were available and used. For all other aggregated soil types we used the default C:N ratio of 15 (GPG p. 3.94 , IPCC, 2003). For aggregated soil types where conversion to cropland lead to a net gain of carbon the nitrous oxide emission was set to zero.

Method to estimate carbon stock change in ARD land due to liming

Liming of forest in the Netherlands might occur occasionally but no statistics are available. All liming based on quantities of product sold is attributed to agricultural land (Cropland, Grassland) which is the main sector where liming occurs. Liming is thus reported only for deforested land that is converted to any of these categories. The total amount of liming is reported in sector 5G of the Convention and described in par 7.8 of the NIR. There is no information how much of the total amount of lime is applied on croplands and grasslands that are reported under deforestation (as opposed to other croplands and grasslands). A mean per ha lime application was calculated based on the total amount of lime applied and the total area under grassland and cropland. This was multiplied with the total area of grassland and cropland reported under article 3.3 deforestation to calculate the amount of CO_2 emission due to liming.

Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3

Carbon stock change due to changes in dead wood and litter in units of land subject to article 3.3 AR

The national forest inventory provides an estimate for the average amount of litter (in plots on sandy soils only) and the amount of dead wood (all plots). The data do provide the age of the trees and assume that the plots are no older than the trees. As such the age of the plot does not take into account any litter accumulation from previous forests on the same location and does not necessarily represent time since re/afforestation. This is reflected in a very weak relation between tree age and carbon in litter (Figure 2-2), and a large variation in dead wood even for plots with young trees (Figure 2-1).

Apart from forests, no land use has a similar carbon stock in litter (in Dutch grasslands, management prevents the built-up of a significant litter layer). Thus, the conversion of non-forest tot forest always involves a built-up of carbon in litter. However, as good data are lacking to quantify this sink, we report the accumulation of carbon in litter for re/afforestation conservatively as zero. Similarly, no other land use has carbon in dead wood. Thus, the conversion of non-forest to forest involves a built-up of carbon in dead wood. However, as it is unlikely that much dead wood will accumulate in very young forests (having regeration years in 1990 or later), accumulation of carbon in dead wood in re/afforestated plots is most likely a very tiny sink that is too uncertain to quantify reliably. Thus we report this carbon sink conservatively as zero.

N_2O emission due to nitrogen fertilisation in units of land subject to article 3.3 AR

Forest fertilisation does not occur in the Netherlands. Therefore, fertilisation in re/afforested areas is reported NO.

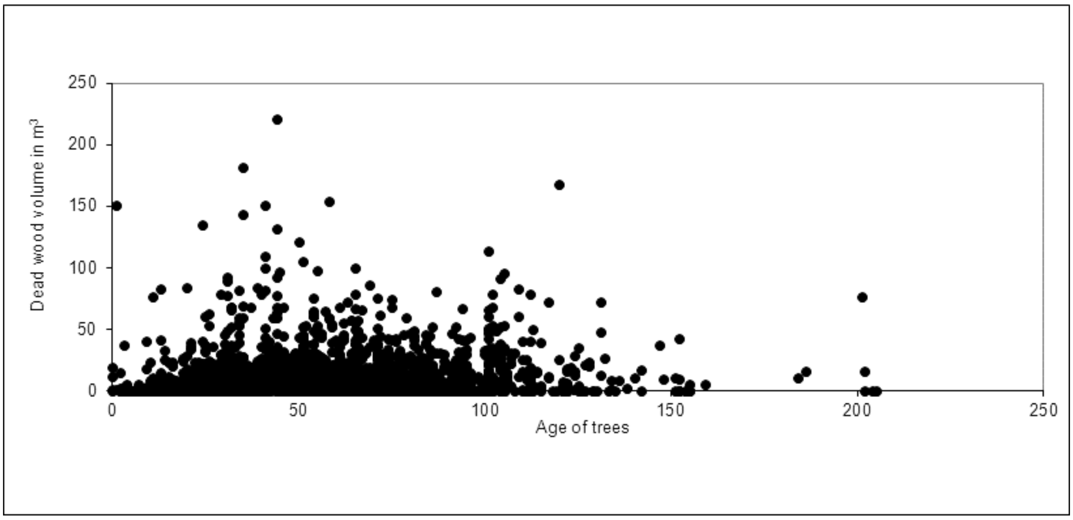

Figure 2-1: Volume of dead wood (standing and lying) in Dutch NFI plots in relation to tree age.

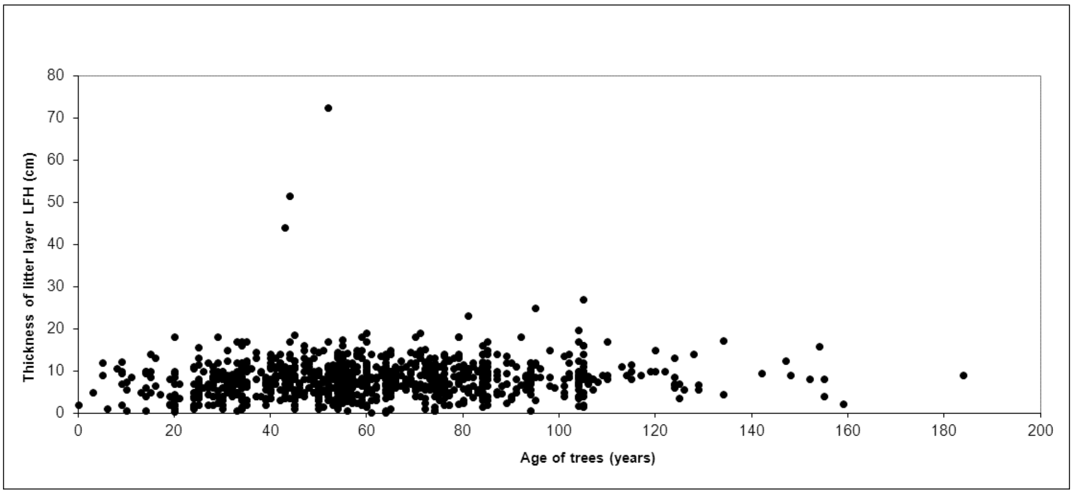

Figure 2-2: Thickness of litter layer (LFH) in Dutch NFI plots in relation to tree age. LFH measurements were conducted only in plots on sandy soils.

GHG emission due to biomass burning in units of land subject to article 3.3 ARD

Greenhouse gas emissions (CO_2, CH_4 and N_2O) related to biomass burning are not estimated because biomass burning has not been monitored since 1996. Wildfire statistics indicated that forest fires rarely occurred in the two decades before 1996 (Wijdeven *et al.*, 2006).

Information on whether or not indirect and natural GHG emissions and removals have been factored out

For all article 3.3 AR activities, forests were created only after 1990 and factoring out of effects on age structure of practices and activities before 1990 is not relevant. For article 3.3 D activities, the increase in mean carbon stock since 1990 may be an effect of changes in management as well as a change in age structure resulting from activities and practices before 1990. However, it is not known which factor contributes to what extent. This increase in mean carbon stock results in a higher carbon emission due to deforestation. Thus, not factoring out the effect of age structure dynamics since 1990 results in a more conservative estimate of emissions due to article 3.3 D activities.

There has been no factoring out of indirect GHG emissions and removals due to effects of elevated carbon dioxide concentrations or nitrogen deposition. To our knowledge, there is no internationally agreed methodology to factor out the effects of these that could be applied to our data.

Changes in data and methods since the previous submission (recalculation)

Values have changed for 2008 since the previous submission for:

1) *CSC in mineral soils in all ARD land*
   In the previous submission no estimate was given for CSC in mineral soils in ARD land, as research was ongoing. This has been finalized sufficiently now to allow a definite estimate. The method is explained short in par. 11.3.1.1 and more extensively in Chapter 3 and Annex 3.

2) *CSC in organic soils in all ARD land*
   In the previous submission no estimate was given for CSC in organic soils in ARD land, as research was ongoing. This has been finalized sufficiently to allow a definite estimate. The method is explained short in par. 11.3.1.1 and more extensively in Chapter 3 and Annex 3.

3) *CSC in biomass (losses) in deforested land*
   The harvest values since 2000 have been changed. This involved an error correction in attributing the values to the right years, and an update of the values (from 2007 on). This resulted in slightly modified values for the average amount of standing stock and thus standing carbon per hectare over the Netherlands. Thus the emission factor for biomass loss due to deforestation was slightly modified. See also Van den Wyngaert *et al.*, 2011.

4) *CSC in dead wood in deforested land*
   Built-up of dead wood was overestimated in the Netherlands. The decomposition of dead wood is based on measured values for longevity. However, the additional active removal of dead wood from forests was set to zero. This resulted in a built-up of dead wood between 1990 and 2000 that was not reflected in the measured values of dead wood in the NFI 2001-2005. The parameter describing the active removal of dead wood was therefore calibrated to match the observed built-up of dead wood between 1990 and 2000 and set to 20 %. Thus, on average 20% of all dead wood in the Netherlands is actively removed from site. See also Van den Wyngaert *et al.*, 2011.

5) *N_2O emission due to soil disturbance associated with conversion to cropland in units of land subject to. article 3.3 D*
   In the previous submission no estimate was given for N2O emission due to soil disturbance associated with conversion to cropland, as research on CSC after deforestation to croplands was ongoing. This has been finalized sufficiently now to allow a definite estimate according to Tier 1 methodology as explained in par. 2.3.1.1.

Uncertainty estimates

The Tier 1 analysis in the NIR Annex 7 Table A7.3 provides estimates of uncertainties of LULUCF categories. The Netherlands uses a Tier 1 analysis for the uncertainty assessment of the sector LULUCF. The analysis combines uncertainty estimates of the forest statistics, land use and land use change data (topographical data) and the method used to calculate the yearly growth in carbon increase and removals (Olivier *et al.*, 2009). The uncertainty analysis is performed for Forests according to the Kyoto definition (par. 7.2.5) and is based on the same data and calculations as used for KP article 3.3 categories.

Thus, the uncertainty for total net emissions from units of land under article 3.3 afforestation/reforestation are estimated at 63%, equal to the uncertainty in Land converted to Forest Land. Similarly, the uncertainty for total net emissions from units of land under article 3.3 deforestation is estimated at 66%, equal to the uncertainty in Land converted to Grassland (which includes for the sake of the uncertainty analysis all Forest land converted to any other type of land use – see Olivier *et al.*, 2009). As a result of recent improvements in both maps and calculations (see Van den Wijngaert et al, 2009), it is likely that the current estimate is an overestimate of the actual uncertainty. It is foreseen that new uncertainty estimates will be calculated before the final accounting for the KP commitment period.

Information on other methodological issues

There is no additional information on other methodological issues.

The year of the onset of an activity, if after 2008

The forestry activities under Article 3, paragraph 3 are reported from the beginning of the commitment period.

2.4 Article 3.3 of the Kyoto Protocol

2.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The land use map is dated on 1st January 1990. Only ARD activities relative to this map, i.e. after this date are taken into account.

In the Netherlands, forests are protected under the Forest Law (1961), which stipulates that "The owner of ground, on which a forest stand, other than through pruning, has been harvested or otherwise destroyed, is obliged to replant the forest stand within a period of three years after the harvest or destruction of the stand (...)". A system of permits is applied for deforestation, and compensation forests have been planted at other locations. This has in the past created problems for (local) nature agencies, that wanted to restore the more highly valued heather and peat areas in the Netherlands and as a result will not allow forest regeneration on areas where it is not intended.

With the historic and current scarcity of land in the Netherlands (which has the highest population density of Europe), any land use is the result of deliberate human decisions.

2.4.2 Information on how harvesting or forest disturbance that is followed by re-establishment is distinguished from deforestation

Following the forest definition and the mapping practice applied in the Netherlands, areas subject to harvesting or forest disturbance are still classified as forests and as such will not result in a change in land use in the overlay of the land use maps (Kramer *et al.*, 2009).

2.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

The land use maps do not provide information on forest areas that have lost forest cover if they are not classified as deforested. However, from the national forest inventory it can be estimated that about 0.3 % of the forests was classified as clearcut area, i.e. without tree cover.

2.5 Other information

2.5.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Under the Convention, conversion to Forest Land (5A2) is a key category. Despite differences in definition between forests under the Convention and under the Kyoto Protocol, 5A2 is a corresponding category and as such re/afforestation is considered a key category under the KP.

Under the Convention, conversion of Forest Land to Grassland (5C2) is a key category. Despite differences in definition between forests under the Convention and under the Kyoto Protocol, 5C2 is a corresponding category and as such deforestation is considered a key category under the KP.

The smallest key category based on level for Tier 1 level analysis including LULUCF is 541 Gg CO_2 (1A4 Stationary combustion: Other sectors, liquids excl. from 1A4c, see Annex 1). With -537.09 Gg CO_2 the (absolute) annual contribution of re/afforestation under the KP is just below the smallest key category (Tier 1 level analysis including LULUCF). Deforestation under the KP in 2009 causes an emission of 832.68 Gg CO_2, which is more than the smallest key category (Tier 1 level analysis including LULUCF). Additionally, deforestation is larger than the smallest key category in the Tier 1 key source analysis (excluding LULUCF), which is 603 Gg CO_2, (2B5 Caprolactam production).

3 Kyoto tables – detailed information

This chapter describes in detail the methods behind the filling of the KP LULUCF tables. The main aim is to provide background information on the values and notation keys that were used in the CRF tables.

The structure of this chapter follows the structure of the CRF tables and discusses the information submitted table by table: first the three tables with overview information on the submission (Section 3.1), then the tables that contain the changes in carbon stock due to article 3.3 activities (Section 3.2), a short note on information to be reported under article 3.4 (Section 3.3) and finally the tables with information on other greenhouse gas emissions to be reported under article 3.3 (Section 3.4).

3.1 NIR-tables

The KP LULUCF tables NIR-1 to NIR-3 summarize the status of the submission by giving information on completeness and forest definition (NIR-1), the land use (changes) matrix (NIR-2) and to what extent the KP-LULUCF tables contain emission sources that are to be considered as key sources (NIR-3). These three NIR-tables are also included in the NIR Chapter 11.

3.1.1 NIR-1 – completeness of reporting

Changes in carbon pools for re/afforested areas are reported for biomass (gains and losses) and soil (mineral as well as organic). Carbon stock changes in litter and dead wood in re/afforested areas are an unknown sink and as such are not reported. In deforested areas carbon stock change is reported for all pools (Table 3-1 and Table 3-2).

Fertilization in re/afforested areas does not occur in the Netherlands and is reported NO. Nitrous oxide emissions associated with disturbance of soils when deforested areas are converted to cropland are estimated from carbon stock changes in mineral soils converted to croplands.

Liming of forest in the Netherlands might occur occasionally but no statistics are available. All liming based on quantities of product sold is attributed to agricultural land (Cropland, Grassland) which is the main sector where liming occurs. Liming is thus reported only for deforested land that is converted to any of these categories.

Greenhouse gas emissions (CO_2, CH_4 and N_2O) related to biomass burning are not estimated because biomass burning is not monitored anymore since 1996. Wildfire statistics indicated that forest fires hardly occurred in the two decades before 1996 (Wijdeven *et al.*, 2006).

Table 3-1: Completeness of reporting for the changes in carbon pools. How they are reported is discussed with in the respective sections.

Activity	**Change in carbon pool reported**[(1)]				
	Aboveground biomass	*Belowground biomass*	*Litter*	*Dead wood*	*Soil*
Re/Afforestation	R	R	NR	NR	R
Deforestation	R	R	R	R	R

Table 3-2: Completeness of reporting for other greenhouse gases. How they are reported is discussed with in the respective sections.

Activity	Greenhouse gas sources reported[2]					
	Fertilization[3]	*Disturbance associated with land-use conversion to croplands*	*Liming*	*Biomass burning[4]*		
	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Afforestation and Reforestation	NO		NO	NE	NE	NE
Deforestation		R	R	NE	NE	NE

3.1.2 NIR-2 – land use and land use change matrix

The land use changes in the Netherlands for the period 1990 to 2003 are derived from overlays of maps dated 1st January 1990 and 1st January 2004 , though the actual surveys for some map sheets may have been carried out in earlier or later years (Kramer *et al.*, 2009). The land use matrix on the basis of these maps shows changes for 13 land use categories that can be aggregated to the 6 IPCC categories for LULUCF (IPCC, 2003): Forest Land, Cropland, Grassland, Wetland, Settlement and Other Land. As the Kyoto definition of forest does not match exactly with the definition of Forest land used for Convention reporting, aggregation for reporting under the Kyoto protocol results in 7 land use categories. Forests according to the Kyoto definition (FL-FAD) and Trees outside forest (FL-TOF) together sum up to the Convention land use category Forest Land (see also Section 4.1). The land use matrix between 1990 and 2004 is shown in Table 3-3, and the land use change matrix (showing annual rates of change between land use categories) is presented in Table 3-4. For background information on calculation of the land use (change) matrix and a discussion on the results in a broader framework the reader is referred to Kramer *et al.* (2009). In Van den Wyngaert *et al* (2009) it is explained how the distribution of land use classes over organic and mineral soils is calculated.

Not all land use changes are considered under the Kyoto Protocol. The colored cells in Table 3-3 and Table 3-4 indicate land use conversions that need to be reported under article 3.3, with green cells indicating afforestation and orange cells indicating deforestation. The assumption is that all land use changes to and from Kyoto forests are human induced as is motivated in Section 2.4.1.

Table 3-3: Land use and land use change matrix showing changes between 1990 and 2004 in ha. Red cells are areas reported under KP article 3.3 deforestation, green cells are areas reported under KP article 3.3 re/afforestation (FAD = Forests according to the Kyoto Definition; TOF = Trees outside Forest; FL = Forest land; CL = Cropland; GL = Grassland; WL = Wetland; Sett = Settlements; OL = Other land)

	BN 1990							
BN 2004	FL-FAD	FL-TOF	CL	GL	WL	Sett	OL	**Total**
FL-FAD	334211	2352	12520	18066	888	1452	552	370041
FL-TOF	2852	11336	2039	4475	328	1078	98	22207
CL	1218	386	739190	196595	596	1623	8	938399
GL	14586	3316	176797	1190740	9092	10987	2547	1393479
WL	1503	319	6821	18641	776007	1390	2583	805762
Sett	7031	2988	81783	78259	2836	392805	630	559301
OL	699	110	201	907	2791	122	33144	37275
Total	362100	20806	1019353	1507682	792539	409457	39563	4151500

Table 3-4 Land use change matrix (in ha per year). Red cells are annual deforestation rates reported under KP article 3.3 deforestation, green cells are annual re/afforestation rates reported under KP article 3.3 re/afforestation. Abbreviations as in Table 3-2.

	BN 1990							
BN 2004	FL-FAD	FL-TOF	CL	GL	WL	Sett	OL	**Total**
FL-FAD		168	894	1290	63	104	39	2559
FL-TOF	204		146	320	23	77	7	777
CL	87	28		14042	43	116	1	14316
GL	1042	237	12628		649	785	182	15523
WL	107	23	487	1332		99	184	2233
Sett	502	213	5842	5590	203		45	12395
OL	50	8	14	65	199	9		345
Total	1992	676	20012	22639	1181	1189	459	48148

The information in Table NIR-2 does not distinguish between land use categories and only considers annual rates of re/afforestation and deforestation. As such, the only values of importance for NIR-2 are total annual deforestation (lower row, orange cell, in table 3.4, i.e. 1992 ha per year) and total annual re/afforestation (last column, green cell, in table 3.4, i.e. 2559 ha per year). With only two land use maps available since 1990, one constant annual rate is reported since 1990. Between 1990 and 2004, this is the mean annual rate and will remain so. From 2004 on, this value should be considered an extrapolation that will be replaced by a real (mean) value as new land use maps become available. Land use maps with map dat 1st January 2009 and 1st January 2013 are expected.

Table 3-5: Results of the calculations of the area change (in kha) of re/afforestation (AR) and deforestation (D) in the period 1990-2012.

Year	**AR to AR**	**Other to AR**	**AR to D**	**D to D**	**Other to D**	**Other to Other**	**land in KP**
1990	0	2.559	0	0	1.992	4146.948	4.551
1991	2.559	2.559	0	1.992	1.992	4142.397	9.103
1992	5.119	2.559	0	3.984	1.992	4137.846	13.654
1993	7.678	2.559	0	5.976	1.992	4133.294	18.206
1994	10.237	2.559	0	7.968	1.992	4128.743	22.757
1995	12.797	2.559	0	9.961	1.992	4124.191	27.308
1996	15.356	2.559	0	11.953	1.992	4119.640	31.860
1997	17.915	2.559	0	13.945	1.992	4115.089	36.411
1998	20.474	2.559	0	15.937	1.992	4110.537	40.963
1999	23.034	2.559	0	17.929	1.992	4105.986	45.514
2000	25.593	2.559	0	19.921	1.992	4101.434	50.066
2001	28.152	2.559	0	21.913	1.992	4096.883	54.617
2002	30.712	2.559	0	23.905	1.992	4092.331	59.168
2003	33.271	2.559	0	25.897	1.992	4087.780	63.720
2004	35.830	2.559	0	27.889	1.992	4083.229	68.271
2005	38.390	2.559	0	29.882	1.992	4078.677	72.823
2006	40.949	2.559	0	31.874	1.992	4074.126	77.374
2007	43.508	2.559	0	33.866	1.992	4069.574	81.925
2008	46.068	2.559	0	35.858	1.992	4065.023	86.477
2009	48.627	2.559	0	37.850	1.992	4060.472	91.028
2010	51.186	2.559	0	39.842	1.992	4055.920	95.580
2011	53.745	2.559	0	41.834	1.992	4051.369	100.131
2012	56.305	2.559	0	43.826	1.992	4046.817	104.682

The technical aspects of filling NIR-2 are summarized in Annex 2. The current configuration of two land use maps and only article 3.3 reporting results in a simple filling of NIR-2 with annual re/afforestation and deforestation rates reported in the lower row, and cumulative areas since 1st January 1990 until the 1st January of the reporting year reported in the diagonal as:

$$A_{AR} = \Delta A_{TO\_FOREST} \cdot (t - 1990) \qquad =2.56*18=46.07$$

$$A_D = \Delta A_{FROM\_FOREST} \cdot (t - 1990) \qquad =1.99*18=35.86$$

with

A_{AR}, A_D: Cumulative area of re/afforested (AR) or deforested (D) units of land since 1st January 1990 at the start of the reporting year t (kha)

ΔA_{TO_FOREST}: Area of re/afforestation according to the KP (kha $year^{-1}$)

ΔA_{FROM_FOREST}: Area of deforestation according to the KP (kha $year^{-1}$)

t: reporting year (-)

This results in a linearly increasing area of land reported under KP since 1990 (Table 3-5). How the cumulative area under ARD is distributed over the different land use classes in 2008 is illustrated in Figure 3-1.

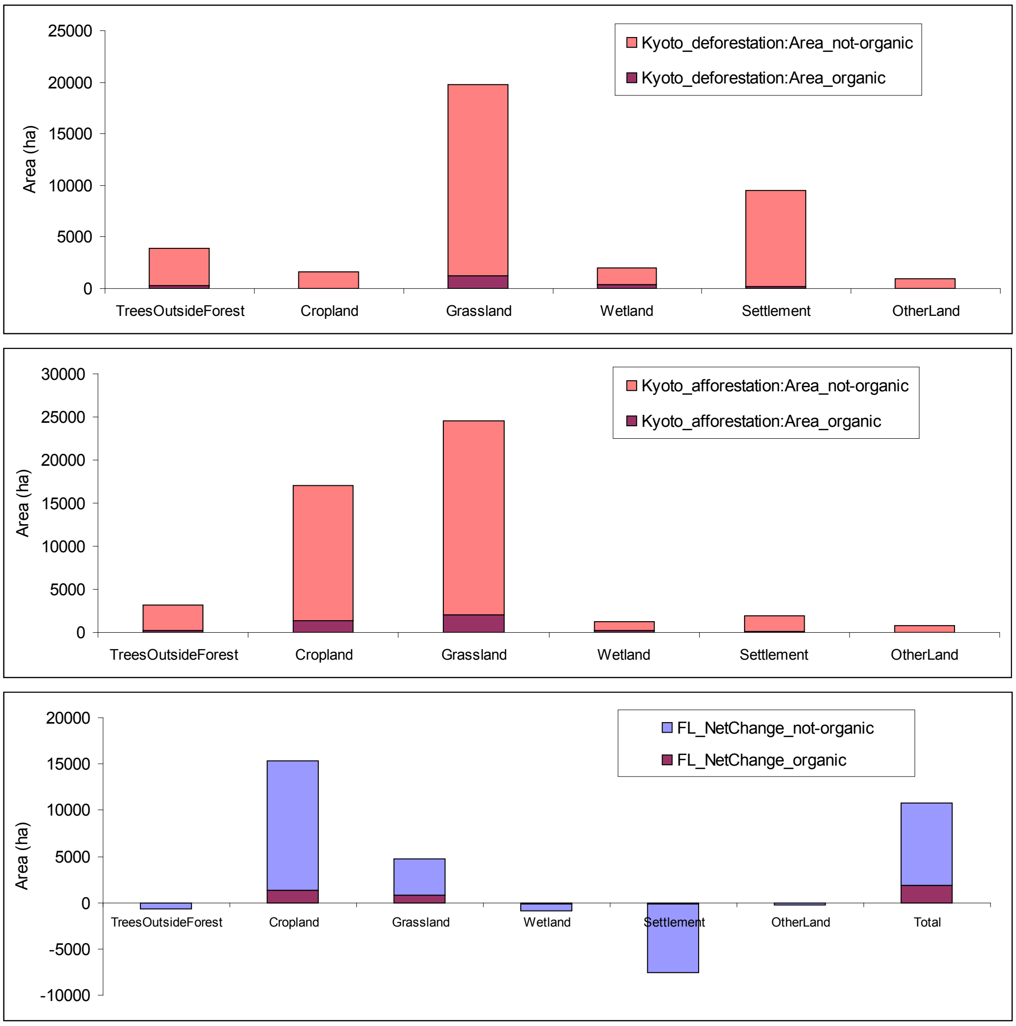

Figure 3-1: Accumulative area of deforestation and re/afforestation and the net change in forest area.

3.1.3 NIR-3 – key source analysis

Key category analysis is performed by comparing matching categories between KP reporting and Convention reporting (IPCC, 2003 par. 4.2.1) as well as by comparing KP reporting categories with the smallest Convention key categories for level (both including and excluding LULUCF).

3.2 KP(5-I) tables

The data tables for CSC under article 3.3: KP(5-I)A are filled according to the same structure:
- Aboveground biomass;
- Belowground biomass;
- Litter;
- Dead Wood;
- Organic soil;
- Mineral soil.

This structure is followed for each of the categories A.1.1 (units of land not harvested since the beginning of the commitment period) and A.2 (Units of land deforested). Category A.1.2 currently does not occur in the Netherlands.

In the Netherlands, Kyoto forest does not include all land with woody cover. Therefore a distinction is made between land use conversions that imply a discontinuity in land cover of the land units under consideration (conversions to and from cropland, grassland, wetland, settlement and other land) and conversions that change land use but not land cover (conversion to and from trees outside forest). See also Section 4.1.

3.2.1 KP(5-I)A.1.1 Units of land not harvested since the beginning of the commitment period

Re/afforestation from land use without woody cover

Aboveground and belowground biomass
For cropland, grassland, wetland, settlement and other land, conversion to Kyoto forest involves creating a growing carbon stock in living biomass. This carbon sink in biomass in re/afforested areas is calculated using the same assumptions and emission factors as for land converted to Forest according to the Kyoto definition under the Convention (Van den Wyngaert *et al.*, 2009). For completeness, the method is summarized in Annex 1. It is valid for forests up to 20 years old, consistent with Convention reporting. The calculated carbon sink in biomass is distinguished into above- and belowground biomass based on the mean ratio in the plots (each plot based on the respective IPCC default). This resulted in 69% of the carbon sink in the aboveground biomass and 31% in the belowground biomass. This ratio was applied consistently over all AR-forests.

Biomass loss was assumed to be negligible, as harvesting is not a regular practice in young forests. Data to relate harvesting to forest age are currently lacking, but will become available when the 2nd round of the MFV national forest inventory is finished.

Litter and dead wood
The national forest inventory provides an estimate for the average amount of litter (in plots on sandy soils only) and the amount of dead wood (all plots). The data do provide the age of the trees and assume that the plots are no older than the trees. As such the age of the plot does

not take into account any litter accumulation from previous forests on the same location and does not necessarily represent time since re/afforestation. This is reflected in a very weak relation between tree age and carbon in litter (Figure 3-3), and a large variation in dead wood even for plots with young trees (Figure 3-2).

Apart from forests, no land use has a similar carbon stock in litter (in Dutch grasslands, management prevents the built-up of a significant litter layer). Thus, the conversion of non-forest to forest always involves a built-up of carbon in litter. However, as good data are lacking to quantify this sink, we conservatively report the accumulation of carbon in litter for re/afforestation conservatively as zero. Similarly, no other land use has carbon in dead wood. Thus, the conversion of non-forest to forest involves a built-up of carbon in dead wood. However, as it is unlikely that much dead wood will accumulate in very young forests (having regeration years in 1990 or later), accumulation of carbon in dead wood in re/afforestated plots is most likely a very tiny sink that is too uncertain to quantify reliably. Thus we report this carbon sink conservatively as zero.

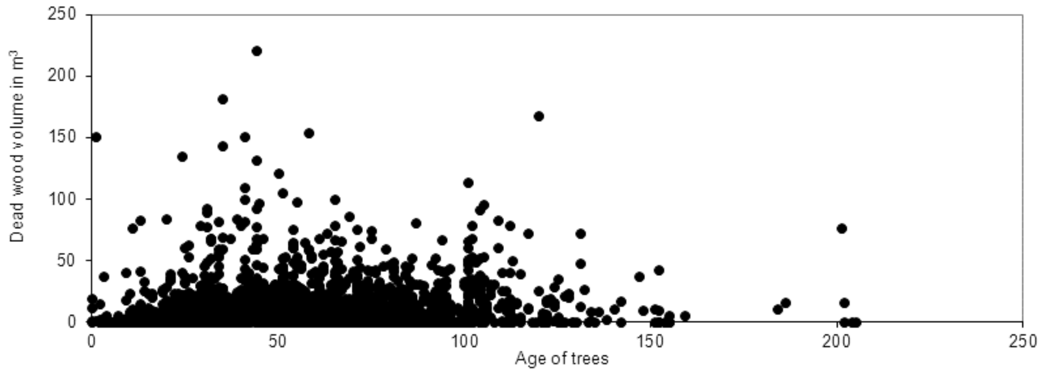

Figure 3-2: Volume of dead wood (standing and lying) in Dutch NFI plots in relation to tree age.

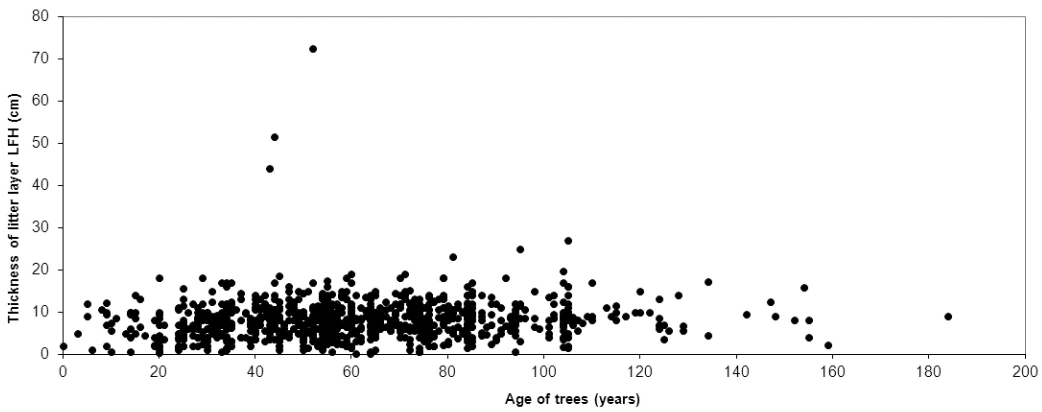

Figure 3-3: Thickness of litter layer (LFH) in Dutch NFI plots in relation to tree age. LFH measurements were conducted only in plots on sandy soils.

Mineral soils
Under the Convention, the Netherlands reports that as a whole, including all land uses and land use changes but leaving out the cultivation of organic soils for agricultural use, the soil of The Netherlands is most probably a sink of a highly uncertain magnitude. As such, no soil emissions are reported for mineral soils. The loss of C from cultivation of organic soils is reported separately under grassland.

For KP reporting, however, CSC in mineral soils need to be reported per pool/activity and cannot be reported an such an aggregated level. A methodology was developed to calculate the effect of land use on carbon stock in mineral soils based on data from the LSK survey (De Groot *et al.*, 2005) and IPCC GPG methodology. This is described in Annex 3.

Organic soils
About 8% of re/afforested land units and 5% of deforested land units is on organic soils. The majority of this is involved in a conversion between Kyoto forest and agricultural land (cropland or grassland). The emissions as calculated for cultivation of organic soils are based on an overlay with a map with water level regimes and assumptions typically valid for agricultural peat soils in the Netherlands. How these can be translated to the effects of conversion to other land use types was subject of a study in 2010 (Lesschen, 2009) and is described in Annex 3.

Re/afforestation from land use with woody cover

Aboveground and belowground biomass
Small units of lands with woody cover that do not meet the Kyoto forest definition may start to meet this definition when adjacent land is re/afforested. This does not involve a discontinuity in land cover for the units of land with woody cover, though the connection to a larger unit does involve a change in land use. The annual per ha carbon stock change of such units of article 3.3 AR land is calculated as the mean aboveground and belowground carbon sink due to volume increment calculated from inventory data using a simple bookkeeping model (Van den Wyngaert *et al.*, 2009). This method corresponds to the method used for Forest Land remaining Forest Land (Van den Wyngaert *et al.*, 2009).

Litter
Good information about litter in small woody patches or wooded land of low width (<30m) is not available. However, there is no reason to assume that it is very different than in Kyoto forests. Assuming a similar amount of litter in fragmented forest patches as in Kyoto forest, connection of these land units to Kyoto forests results in a negligible carbon stock change in litter, which is not reported.

Dead wood
Good information about dead wood in small woody patches or wooded land of low width (<30 m) is not available. However, there is no reason to assume that it is very different than in Kyoto forests. Assuming a similar amount of litter in fragmented forest patches as in Kyoto forest, connection of these land units to Kyoto forests results in a negligible carbon stock change in litter, which is not reported.

Mineral soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Mineral soils”

Organic soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Organic soils”

3.2.2 KP(5-I)A.1.2 Units of land harvested since the beginning of the commitment period

None of the afforested or reforested land as of 1990 was harvested within the commitment period. This category of harvested forest will not be reported here.

3.2.3 KP(5-I)A.1.3 Units of land otherwise subject to elected activities under Article 3.4

The Netherlands has not elected any activities under Article 3, paragraph 4, of the Kyoto protocol.

3.2.4 KP(5-I)A.2 Deforestation

In the Netherlands, the definition of forest that was chosen for the Kyoto Protocol does not include all land with woody cover. Therefore a distinction is made between land use conversions that imply a discontinuity in woody cover (conversions to and from cropland, grassland, wetland, settlement and other land) and conversions that imply a discontinuity in land use but not in land cover (conversion to and from trees outside forest). See also Section 4.1.

Deforestation to a land use category without woody cover

Aboveground and belowground biomass
A unit of land that is converted to a land use category without woody cover loses all carbon stock in the same year of deforestation. The emission factor for deforested areas changing to cropland, grassland, wetland, settlement or other land is the outcome of the following steps/assumptions:

- In the year of deforestation, all carbon in standing above- and belowground biomass is lost instantaneously. This standing carbon stock is equal to the average amount of carbon stored in aboveground biomass in Dutch forests in that particular year. The latter is derived from a simple bookkeeping model that extrapolates NFI measurements (Nabuurs *et al.*, 2005; Van den Wyngaert *et al.*, 2009). The emission factor increases over time, reflecting the built-up of C stocks in standing biomass with continuation of current management practices.
- In the years following deforestation, no additional carbon losses or gains are calculated. This is consistent with the not reporting of biomass fluxes if land uses other than forests.
- As a result of reporting of the accumulated area of deforested area, whereas emissions occur only in the year of deforestation itself, the IEF for biomass from deforestation decreases over time (Figure 3-4).

Litter
The loss of carbon from litter was calculated from the national average amount of carbon stored in litter as estimated from the NFI litter layer measurements and additional sources (Van den Wyngaert *et al.*, 2009). Between 1990 and 2003, an interpolation was made between the litter carbon stock estimate for the HOSP inventory and the MFV inventory. After 2003, the litter carbon stock was kept constant at the best estimate based on MFV data.

It was assumed that after deforestation, all carbon stored in litter was lost in the same year. This matches the methodology for the loss of carbon in biomass and dead wood upon deforestation. The emission factors for litter increases between 1990 and 2003, illustrating that Dutch forests accumulate carbon in litter, and remains stable from 2003 onwards as no data are available after 2003.

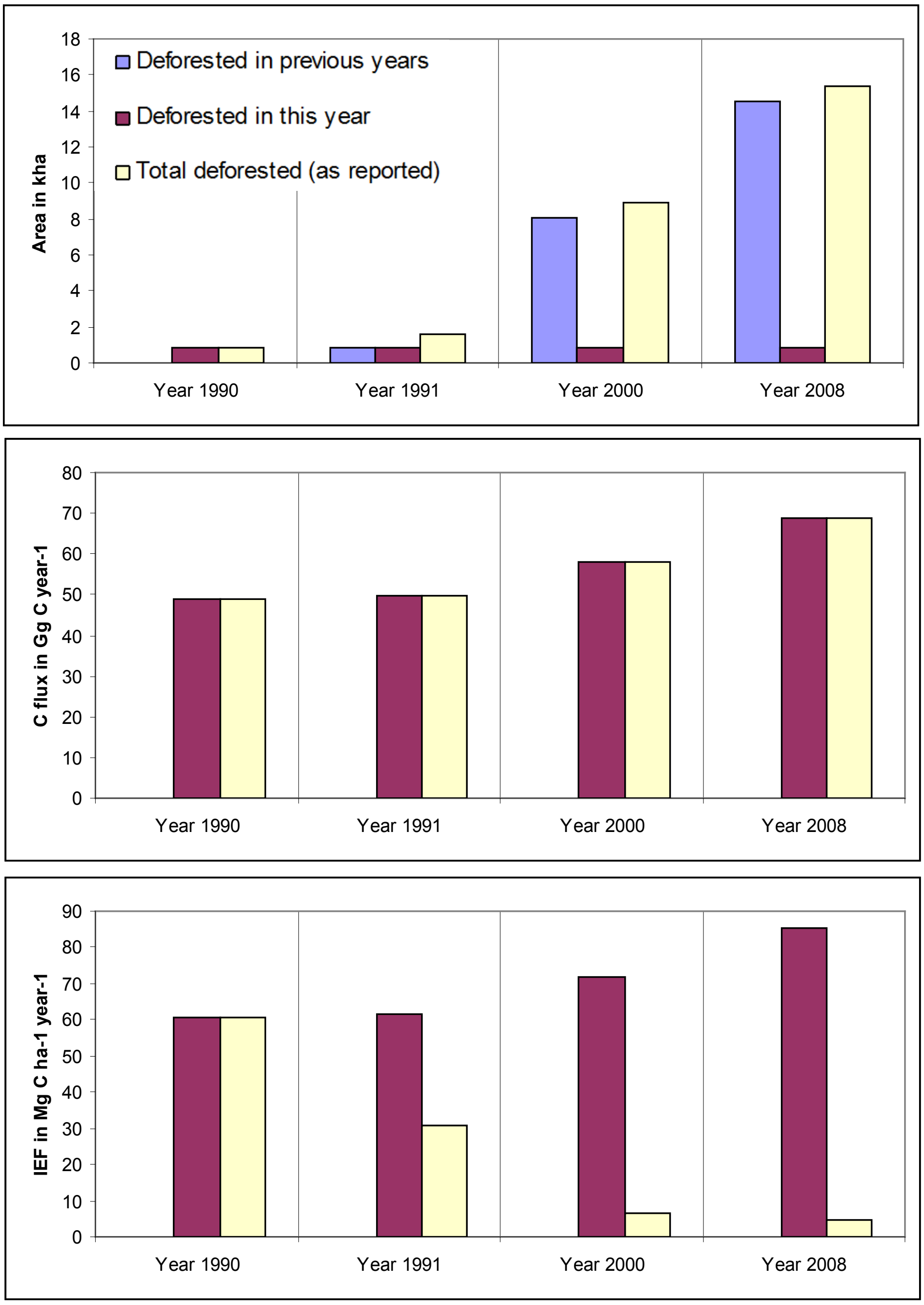

Figure 3-4: Areas, C emissions and IEF for Kyoto forest converted to grassland in four example years to illustrate the effect of reporting all deforestation emissions within the year of deforestation

Dead wood
The loss of carbon from dead wood was calculated in a similar way as the loss of carbon from biomass. The national average amount of carbon stored in dead wood (lying as well as standing for years after 2000) was available from a simple bookkeeping model (Nabuurs *et al.*, 2005; Van den Wyngaert *et al.*, 2009) and it was assumed that all carbon stored in dead wood was lost in the year of deforestation.

Mineral soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Mineral soils”

Organic soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Organic soils”

Deforestation to a land use category with woody cover

Aboveground and belowground biomass
Small units of lands with woody cover that do not meet the Kyoto forest definition may remain after deforestation of adjacent land. This does not involve a discontinuity in land cover for the units of land with woody cover, though the loss of connection to a larger unit does involve a change in land use. The annual per ha carbon stock change of such units of article 3.3 AR land is calculated as the mean aboveground and belowground carbon sink due to volume increment calculated from inventory data using a simple bookkeeping model (Van den Wyngaert *et al.*, 2009). This method corresponds to the method used for Forest Land remaining Forest Land (Van den Wyngaert *et al.*, 2009).

Litter
Good information about litter in small woody patches or wooded land of low width (<30 m) is not available. However, there is no reason to assume that it is very different than in Kyoto forests. Assuming a similar amount of litter in fragmented forest patches as in Kyoto forest, connection of these land units to Kyoto forests results in a negligible carbon stock change in litter, which is not reported.

Dead wood
Good information about dead wood in small woody patches or wooded land of low width (<30 m) is not available. However, there is no reason to assume that it is very different than in Kyoto forests. Assuming a similar amount of litter in fragmented forest patches as in Kyoto forest, connection of these land units to Kyoto forests results in a negligible carbon stock change in litter, which is not reported.

Mineral soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Mineral soils”

Organic soils
See Section 3.2.1 “Re/afforestation of land without woody cover” under “Organic soils”

3.3 Data tables for CSC under article 3.4: KP(5-I)B tables

The Netherlands has not elected any 3.4 articles.

3.4 Data tables for other gases under article 3.3: KP(5-II) tables

3.4.1 KP(5-II)1 Direct N2O emissions from nitrogen fertilisation

Nitrogen fertilization of forests does not occur in the Netherlands. Therefore, NO is reported here.

3.4.2 KP(5-II)2 N2O emissions from drainage of soils for areas under FM

The Netherlands has not elected any 3.4 articles.

3.4.3 KP(5-II)3 N2O emissions from disturbance associated with land-use conversion to cropland

Nitrous oxide emissions associated with disturbance of soils when deforested areas are converted to cropland are calculated using equations 3.3.14 and 3.3.15 of Good Practice Guidance for LULUCF (IPCC, 2003) for each aggregated soil type separately (for a description of soil types see Annex 3).

The N_2O emissions from disturbance associated with the conversion of forest to cropland is then calculated as follows:

$$N_2O - N_{conv} = N_2O_{net-\min} - N$$
$$N_2O_{net-\min} - N = EF_1 \cdot N_{net-\min}$$

Based on the method described in Annex 3, for each aggregated soil type the amount of C lost as a consequence of land use conversion of forest to cropland is calculated.

The default EF1 of 0.0125 kg N_2O-N/kg N was used. For 3 aggregated soil types calculated C:N ratios were available and used, for all other aggregated soil types we used the default C:N ratio of 15 (GPG p. 3.94, IPCC, 2003). For aggregated soil types where conversion to cropland lead to a net gain of carbon the nitrous oxide emission was set to zero.

3.4.4 KP(5-II)4 Carbon emissions from lime application

Activity data for lime are available only per type of lime applied (limestone and dolomite), not per land use category where they are applied. It is assumed that almost all of it is applied in agricultural grasslands and cropland. Liming of forests does not occur in the Netherlands, therefore liming is reported as NO for re/afforested areas.

As lime is applied on grasslands and cropland, it is most likely also applied on units of land that are deforested towards grasslands and cropland. However, there is no information how much of the liming is applied on croplands and grasslands that are reported under article 3.3 deforestation. Therefore an estimate is made. A mean national application rate is calculated for dolomite and limestone from the total amount applied and the total area where it can potentially be applied (i.e. the total area of croplands and grasslands reported under 5B and 5C of LULUCF). This mean application rate was then multiplied with the total area grassland and cropland reported under article 3.3 deforestation to calculate the amount of dolomite and limestone applied on article 3.3 deforestation land (Table 3-6). Lime application is converted to CO_2 emissions using default emission factors.

3.4.5 KP(5-II)5 Greenhouse gas emissions from biomass burning

In the Netherlands, controlled burning does not occur, nor for forests nor for any other land use types. Thus greenhouse gas emissions related to controlled burning are reported as NO.
Wildfires may occur in some years, but are not monitored since 1996. From the 1980's onwards forests were rarely affected by wildfires (see Figure 3-5). Forest composition has been changing gradually in the Netherlands and the area of coniferous monocultures shifted towards mixed broadleaved-coniferous forest that seems to be less fire susceptible (Wijdeven *et al.*, 2006). Thus, an unknown but very low occurrence of wildfires in re/afforested or deforested land is possible, and greenhouse gas emissions associated with wildfires is reported NE.

Table 3-6: Liming of deforested land converted to cropland and grassland

	National totals			Mean lime application rate			Lime applied in D land	
	Dolomite	Limestone	Area cropland + grassland	Dolomite	Limestone	area deforested to cropland and grassland	Dolomite	Limestone
	Mg yr-1	Mg yr-1	kha	Mg kha-1 yr-1	Mg kha-1 yr-1	kha	Mg yr-1	Mg yr-1
1990	330052	58449	2514	131.27	23.25	1.13	148.19	26.24
1991	267429	43636	2501	106.91	17.44	2.26	241.37	39.38
1992	253959	44734	2489	102.05	17.98	3.39	345.59	60.87
1993	247760	36652	2476	100.07	14.80	4.52	451.87	66.85
1994	169444	34021	2463	68.80	13.81	5.64	388.30	77.96
1995	173084	35549	2450	70.64	14.51	6.77	478.46	98.27
1996	178823	57403	2437	73.37	23.55	7.90	579.74	186.10
1997	175500	59728	2425	72.38	24.63	9.03	653.69	222.47
1998	163600	58979	2412	67.84	24.46	10.16	689.18	248.45
1999	147582	31760	2399	61.52	13.24	11.29	694.47	149.45
2000	155119	53701	2386	65.01	22.51	12.42	807.24	279.46
2001	128716	42291	2373	54.23	17.82	13.55	734.67	241.38
2002	128505	53018	2360	54.44	22.46	14.67	798.91	329.61
2003	125039	60828	2348	53.26	25.91	15.80	841.72	409.48
2004	117640	51977	2335	50.38	22.26	16.93	853.13	376.94
2005	103072	58122	2322	44.39	25.03	18.06	801.72	452.09
2006	114973	59715	2309	49.79	25.86	19.19	955.45	496.24
2007	100165	52952	2296	43.62	23.06	20.32	886.27	468.52
2008	134951	60625	2284	59.09	26.55	21.45	1267.47	569.39
2009	134951*	60625*	2271	59.43	26.70	22.58	1341.71	602.74

* values for 2008, will be replaced when actual data for 2009 become available

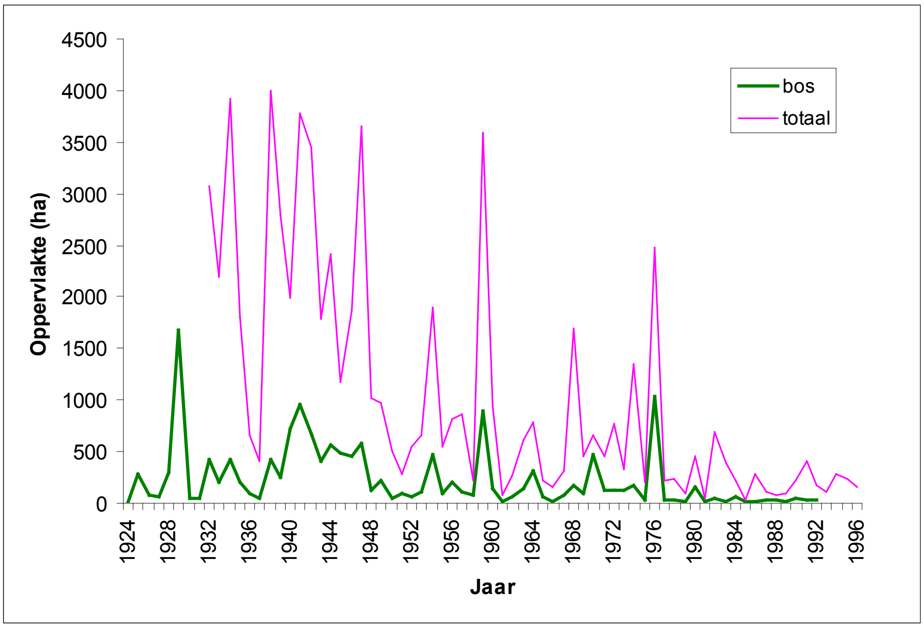

Figure 3-5: Area affected by wildfires in forest (bos) and in all nature areas (totaal) between 1924-1996 (Bosbescherming 1982, IKC 1993, UN-ECE/FAO 1996-1998, in: Wijdeven et al., 2006).

4 Comparison between Kyoto and Convention tables 2008-2012

The information required under the Kyoto Protocol for LULUCF is partly overlapping and partly supplementary to the information submitted under the Convention. In this section we make explicit how both reporting requirements relate to one another, and where differences emerge on the basis of the calculation made.

4.1 Definitions and matching of (sub)categories

Under the Convention, all land is classified in six land use categories, that are described in Good Practice Guidance for LULUCF (IPCC, 2003). Countries are free to choose the exact definition of these categories, depending on national circumstances, as long as they fit the descriptions. The Netherlands chose to define Forest Land in a rather broad way, including also mapped wooded ecosystems that did not match the area and width criteria of the Kyoto forest definition. Therefore all submissions to the Convention distinguish two subcategories: forests according to the Kyoto definition (FAD) and trees outside forest (TOF). The latter category is defined without minimum area and minimum width, and as such can include shelterbelts, groups of trees, forest remnants after fragmentation, all if large enough to show on the 25 m x 25 m raster land use map (Kramer *et al.*, 2009).

There is an exact match between the “forests according to the Kyoto definition” (FAD) under the Convention and forests reported under the Kyoto Protocol. Thus, any change in area of FAD emerges as either re/afforestation or deforestation under article 3.3 reporting and vice versa. However, under the Convention conversions between FAD and TOF are not singled out and are included in the respective categories where the land use is converted into (Table 4-1).

Table 4-1: Crossover between LULUCF (sub)categories under the Convention and under the KP (FAD = Forests according to the Kyoto Definition; TOF = Trees outside Forest; CL = Cropland; GL = Grassland; WL = Wetland; Sett = Settlements; OL = Other land)

Kyoto Subcategory	**Matching subcategory in Convention**
AR from Cropland	5.A.2. CL- FAD
AR from Grassland	5.A.2. GL- FAD
AR from Wetland	5.A.2. WL- FAD
AR from Settlements	5.A.2. Sett- FAD
AR from Other Land	5.A.2. OL- FAD
AR from Trees Outside Forest	Included in 5.A.1. FAD
D to Cropland	5.B.2. FL-FAD
D to Grassland	5.C.2. FL-FAD
D to Wetland	5.D.2. FL-FAD
D to Settlements	5.E.2. FL-FAD
D to Other Land	5.F.2. FL-FAD
D to Trees Outside Forest	Included in 5.A.1. TOF

4.2 Areas

Both under the Convention and under the KP land use conversions to and from FAD are reported. Both are based on the same set of land use maps and the same land use change matrix (Kramer *et al.*, 2009) and annual conversion rates for the same years are equal under both reporting agreements.

Re/afforestation

Under the Convention, the Netherlands chose to report in sector 5.A.2 on emissions from land converted to Forest Land not more than 20 years ago, but no earlier than 1st January 1990. Thus, for 2008 emissions are reported that occur between 1st January 2008 and 31st December 2008 on land converted to Forest land between 1st January 1990 and 31st December 2008. For 2012 emissions are reported that occur between 1st January 2012 and 31st December 2012 on land converted to Forest land between 1st January 1993 and 31st December 2012.

Under the Kyoto Protocol, the Netherlands is obliged to report on annual emissions from land converted to FAD since 1st January 1990. Thus, for 2008 emissions are reported that occur between 1st January 2008 and 31st December 2008 on land converted to Forest land between 1st January 1990 and 31st December 2008. For 2012 emissions are reported that occur between 1st January 2012 and 31st December 2012 on land converted to Forest land between 1st January 1990 and 31st December 2012.

As a result, in 2008 and 2009, equal areas show up in both CRF tables. However, from 2010 on, land is moved from A.2. (land converted to FL) to A.1. FL remaining FL under the Convention, and a difference will emerge between the matching subcategories in Table 4-1. The differences during the first CP will be one (2010), two (2011) or three(2012) times the annual re/afforestation rate (Table 4-2; Figure 4-1).

Deforestation

Deforestation rates are reported on an annual basis under the Convention, and cumulative since 1990 under the KP (Table 4-2).

Table 4-2: Relation between ARD area reported under the Convention (AR_{Conv} and D_{Conv}) and ARD area reported under KP (AR_{KP} and D_{KP}) for matching subcategories other than TOF from Table 4-1

	Re/Afforestation	Deforestation
2008	$AR_{KP} = AR_{Conv(2008)}$	$D_{KP} = \sum_{1990}^{2008} D_{Conv(i)}$
2009	$AR_{KP} = AR_{Conv(2009)}$	$D_{KP} = \sum_{1990}^{2009} D_{Conv(i)}$
2010	$AR_{KP} = AR_{Conv(2010)} + AR_{Conv(1990)}$	$D_{KP} = \sum_{1990}^{2010} D_{Conv(i)}$
2011	$AR_{KP} = AR_{Conv(2010)} + AR_{Conv(1990)} + AR_{Conv(1991)}$	$D_{KP} = \sum_{1990}^{2011} D_{Conv(i)}$
2012	$AR_{KP} = AR_{Conv(2010)} + AR_{Conv(1990)} + AR_{Conv(1991)} + AR_{Conv(1992)}$	$D_{KP} = \sum_{1990}^{2012} D_{Conv(i)}$

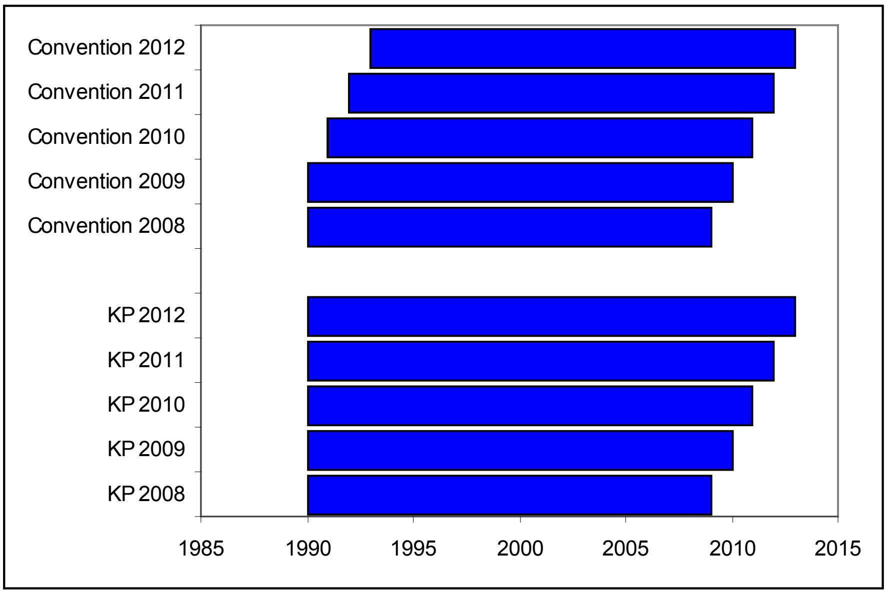

Figure 4-1: Years of conversion of land converted to Forest Land reported in sector 5.A.2 under the Convention (upper) and of re/afforested land under the Kyoto Protocol (lower). Note that in 2008 and 2009, the bars are equal under the Convention and the KP.

4.3 Emissions

Carbon stock changes under re/afforestation

Biomass losses are not occurring under re/afforestation. Above and belowground biomass gains are reported here as the net C change and data is as reported in 5A2 of the Convention. For future submissions, some methods are not finalised yet and these are marked with a "?".

Carbon stock changes under deforestation

All differences in biomass, dead wood and litter C due to deforestation are assumed to occur only in the year of deforestation. After that year the emissions from these components are assumed to be zero. Under the Convention, C emissions from mineral soils are reported at national scale for all land use (change) categories as "not a source". Under Kyoto, the issue of C emissions from soils is not fully resolved and these amissions are not yet reported.

Table 4-3: Relation between Convention reporting and Kyoto reporting for calculation of implied emission factor (IEF) for re/afforestation from Cropland, Grassland, Wetlands, Settlements and Other Land. Conv(x) = emission from category&pool x in the Convention reporting.

	Changes to/from CL, GL, WL, Sett, OL	
	AR (2008, 2009)	*AR (2010-2012)*
	IEF	*IEF*
Aboveground biomass - gain	=Conv(5A2 - biomass gain)*(1-R)	?
Belowground biomass - gain	=Conv(5A2 - biomass gain)*R	?
Aboveground biomass - loss	NO	?
Belowground biomass - loss	NO	?
Dead wood	NR	?
Litter	NR	NR
Mineral soil	NR	NR
Organic soil	NR	NR

Table 4-4: Relation between Convention reporting and Kyoto reporting for calculation of implied emission factor (IEF) for re/afforestation from Trees Outside Forest. Conv(x) = emission from category&pool x in the Convention reporting.

	Changes to/from TOF	
	AR (2008, 2009)	*AR (2010-2012)*
	IEF	*IEF*
Aboveground biomass - gain	=Conv(5A1 - biomass gain)*(1-R)	=Conv(5A1 - biomass gain)*(1-R)
Belowground biomass - gain	=Conv(5A1 - biomass gain)*R	=Conv(5A1 - biomass gain)*R
Aboveground biomass - loss	NO	NO
Belowground biomass - loss	NO	NO
Dead wood	NR	NR
Litter	NR	NR
Mineral soil	NR	NR
Organic soil	NR	NR

Table 4-5: Relation between Convention reporting and Kyoto reporting for calculation of implied emission factor (IEF) for deforestation to Cropland, Grassland, Wetlands, Settlements and Other Land. Conv(x) = emission from category&pool x in the Convention reporting.

	Changes to/from CL, GL, WL, Sett, OL	
	D (year of deforestation)	*D (after deforestation)*
	IEF	*IEF*
Aboveground biomass - gain	NO	0
Belowground biomass - gain	NO	0
Aboveground biomass - loss	=Conv(5X2FAD - biomass loss) * (1-R)	0
Belowground biomass - loss	=Conv(5X2FAD - biomass loss) * R	0
Dead wood	= Conv(5XFAD - DOM) * (DW/(Litter + DW))	0
Litter	= Conv(5XFAD - DOM) * (Litter/(Litter + DW))	0
Mineral soil	NR	NR
Organic soil	NR	NR

Table 4-6: Relation between Convention reporting and Kyoto reporting for calculation of implied emission factor (IEF) for deforestation to Trees Outside Forest. Conv(x) = emission from category&pool x in the Convention reporting.

	Changes to/from TOF	
	D (year of deforestation)	*D (after deforestation)*
	IEF	*IEF*
Aboveground biomass - gain	=Conv(5A1 - biomass gain)*(1-R)	=Conv(5A1 - biomass gain)*(1-R)
Belowground biomass - gain	=Conv(5A1 - biomass gain)*R	=Conv(5A1 - biomass gain)*R
Aboveground biomass - loss	0	0
Belowground biomass - loss	0	0
Dead wood	0	0
Litter	0	0
Mineral soil	NR	NR
Organic soil	NR	NR

5 QA/QC for the Kyoto reporting

Consistency with the values submitted for the Convention was assured by using the same base data and calculation structure, and apply different calculations only where applicable as formulated in Chapter 4. The data and calculations were thus subject to the same QA/QC (Van den Wyngaert *et al.*, 2009). The full time series since 1990 was calculated explicitly for re/afforestation and deforestation.

The calculated values were entered in the CRF reporting system at Alterra, and checked by the LULUCF sectoral expert. They were then exported as an XML file and sent to the Dutch inventory compiler at TNO/RIVM. They were there imported in the CRF database for all sectors and again checked. Any strange or incomplete values were reported to the LULUCF sectoral expert, checked and if needed corrected.

Verification with other international statistics was performed only with FAO. The area of forest is systematically lower for FAO. This may be due to a different methodology, for discussion on different outcomes of different estimates of forest cover in the Netherlands the reader is referred to Nabuurs *et al.*, 2005. The net increase in forest area in the FAO statistics (1.5 kha per year between 1990 and 2000, 1 kha per year between 200 and 2005) is higher than in our estimates (0.567 kha per year between 1990 and 2004), and this may indicate that the 1990 estimate may be low in the FAO statistics. These values indicate a conservative estimate of the net forest are increase in the Netherlands.

The mean C stock in Dutch forests (used as emission factor for deforestation under the KP) is slightly higher in the UNFCCC estimates than in the FAO estimates (Table 5-1). Considering that different conversion factors were used, the estimates are close together, while the difference has the tendency to increase. If this continues for the 2010 FAO estimate, this will be reason for investigation. These values indicate a conservative estimate of C emissions from deforestation.

Table 5-1: Comparison between FAO and UNFCCC values for the mean C stock in living biomass in Dutch forests in $t.ha^{-1}$

	FAO (biomass / area * 0.5)	**UNFCCC**
1990	59.4	60.4
2000	68.1	71.7
2005	71.1	81.3

No values from FAO are available on young forests. FAO statistics also provide no information on fires or disturbances for the Kyoto period, since at the national level, these statistics are not kept any more. The same accounts for EFFIS, the European Forest Fires Information System.

In this submission, the comments received during the review over the 2010 submission were addressed. Under "G.1 Information on activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol", 10 comments were made (comments 113-122). The following issues emerged (with their response in this submission):

- Carbon stock change in litter and dead wood of AR land was reported "NE" and the ERT considered that the Netherlands did not provide sufficient verifiable information to prove that this pool was not a source. In response, the Netherlands provided additional information, which satisfied the ERT. This additional information was included in the NIR for the 2011 submission (comment 15).

- Carbon stock change in mineral and organic soils in ARD land was reported “NE” and the ERT considered that the Netherlands did not provide sufficient verifiable information to prove that this pool was not a source. In the 2011 submission, the carbon stock change in soils in ARD land is reported and a recalculation has been made over 2008 (comments 115-117 and 212-122).
- N_2O emissions from disturbance associated with land-use conversion to cropland were reported as “NE”, as research was still ongoing. This year these emissions were estimated and reported (comment 118).
- The Netherlands reported controlled burning as “NO” and wildfires as “NE”. The ERT recommended the Netherlands to provide estimates in the next submission. However, due to the lack of any data, the Netherlands still reported “NO” respectively ”NE” for the 2011 submission (comment 119).

6 Foreseen improvements

The filling of the Kyoto tables has been improved between 2009 and 2010. Still, two areas for improvement are foreseen for 2011 or 2012:

- *Separate uncertainty estimates for Kyoto values*
  Under the KP, there should be separate annual uncertainty estimates for each LULUCF activity, reported carbon pool and geographical location. Currently, uncertainties are based on Tier 1 methods and linkages between KP and Convention categories. It is aimed to have separate uncertainties calculated using a Tier 2 method for 2011.

- *How to calculate EF of afforested areas > 20 years old?*
  The land under AR-activities currently has an emission factor that is estimated for forests between 0 and 20 years old (based on work for Convention reporting, where 20 years is the threshold to move land to Forest Land remaining Forest land). Under KP, the only land reported that is more than 20 years old, will be 21 to 23 years old, and it does not merge into a large pool of forests as it does under the Convention. An emission factor for these age categories (21 to 23 years) should be estimated for reporting of 2010 to 2012 in the 2012 to 2014 submissions.

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Annex 1 Aboveground and belowground biomass

For cropland, grassland, wetland, settlement and other land, conversion to FAD involves creating a growing carbon stock in living biomass. This carbon sink in biomass in re/afforested areas is calculated using the same assumptions and emission factors as for land converted to FAD under the Convention (Van den Wyngaert *et al.*, 2009). For completeness, the method is summarized below.

1) <u>It is assumed that the volume growth of recently established forest areas will be similar to the growth of young forests in the national inventories.</u>
   This is a conservative assumption, as forests historically were most prominent on the poorer soils of the Netherlands, while new forests are being created both on poor and richer soils. Figure A1-1 shows the change of (averaged) increment with plot age in the HOSP and MFV forest inventories. Plots of 20 to 25 years old have the highest mean NAI increasing up to 15 m^3 ha^{-1} $year^{-1}$, both in the HOSP and in the MFV inventory.

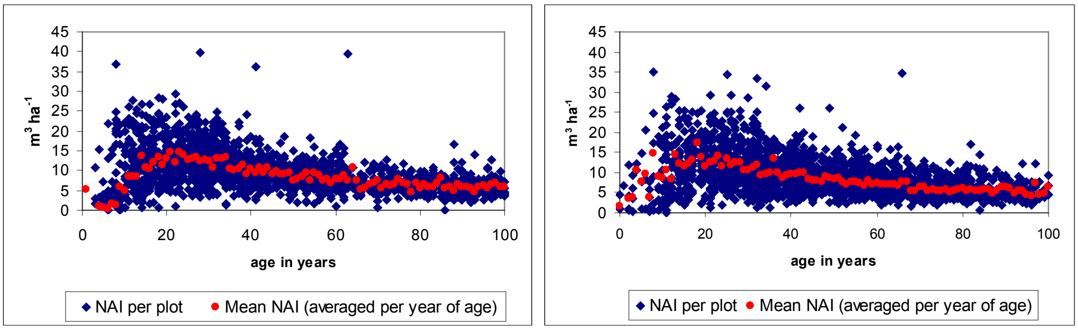

Figure A1-1: Net annual increment (NAI) over age for the HOSP (1988-1992) (left) and the MFV (2001-2005) (right) forest inventory

2) <u>It is assumed that for very young plots (i.e. up to 20 years), the use of IPCC default conversion factors is more robust than allometric relations. Carbon sink rates are calculated from increment rates using IPCC default conversion factors.</u>
   Most of the allometric relations are not developed for very young trees with low diameters. Therefore, carbon sink rates are calculated from increment data using IPCC default conversion factors.

3) <u>It is assumed that at time of regeneration, growth is close to zero</u>
   This assumption is quite general and Figure A1-1 shows that it is consistent with both HOSP and MFV data.

4) <u>Between forest regeneration and 20 years old forest, the specific growth curve is unknown and is approximated by the simplest function, being a linear curve</u>
   Figure A1-2 shows the carbon sink rate over age for both the HOSP and MFV inventories. For the HOSP inventory, the linear curve is a good approximation, for the MFV inventory, the linear curve underestimates the carbon sink for plots younger than 10 years. As such, the linear curve is a good cq. conservative approximation of the relation between carbon sink and age.

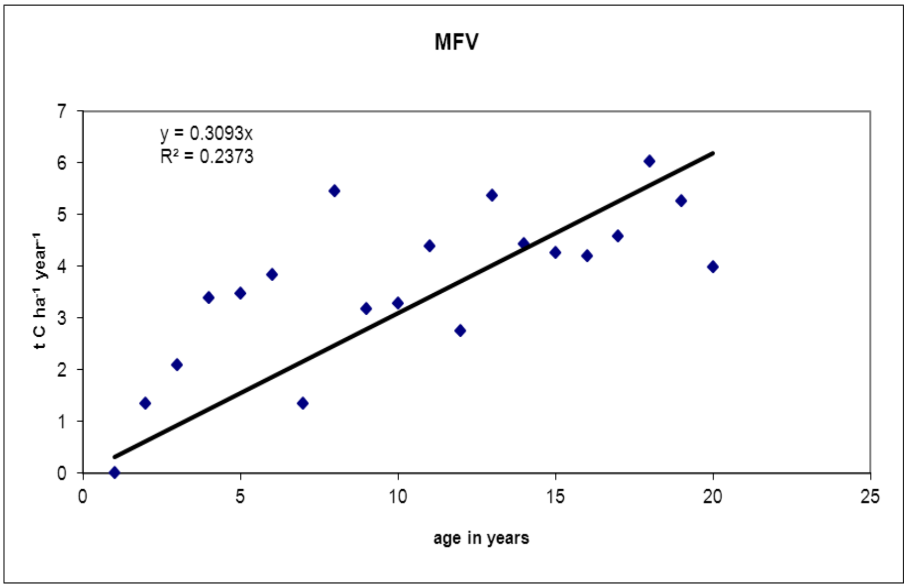

Figure A1-2: Regression of carbon sink in re/afforested plots up to 20 years old (as calculated from increment data and IPCC expansion & conversion factors) on age. Note that the HOSP regression line is below the MFV regression line due to increased net annual increments between the MFV (2001-2005) and the HOSP(1988-1992) inventories

5) <u>The exact height of this linear curve is best approximated by a linear regression of mean carbon sink rate on age. One mean carbon sink rate value is taken for each age, to avoid confounding effects of the age distribution on the NFI plots (not all of which were really afforested)</u>
   The regression lines are drawn in Figure A1-2. The high increments are translated in carbon sinks increasing up to 5 (HOSP) and 6 (MFV) Mg C ha^{-1} $year^{-1}$ for 20 year old forest, i.e. which is in its most productive phase.

6) Consistent with the way data are used for the calculation of carbon sink rates in forests, HOSP data are used between 1990 and 2000 and MFV data from 2001 onwards

7) The effect of age structure is retained when calculating the annual net emissions, i.e. as plots grow older, their carbon sink will increase according to the previous regression on age.
This means that with a constant rate of re/afforestation, the IEF will increase monotonically from very low values for 1 year old forest plots to slightly over 3 Mg C ha^{-1} $year^{-1}$ when plots of all ages are equally represented after 20 years. As Figure A1-3 shows, this is in the higher range of the IPCC default values. This can be understood from the high occurrence of young plots on former agricultural, productive soils, and also related to the history of high nitrogen deposition and nutrient enrichment on generally poorer forest soils in the Netherlands.

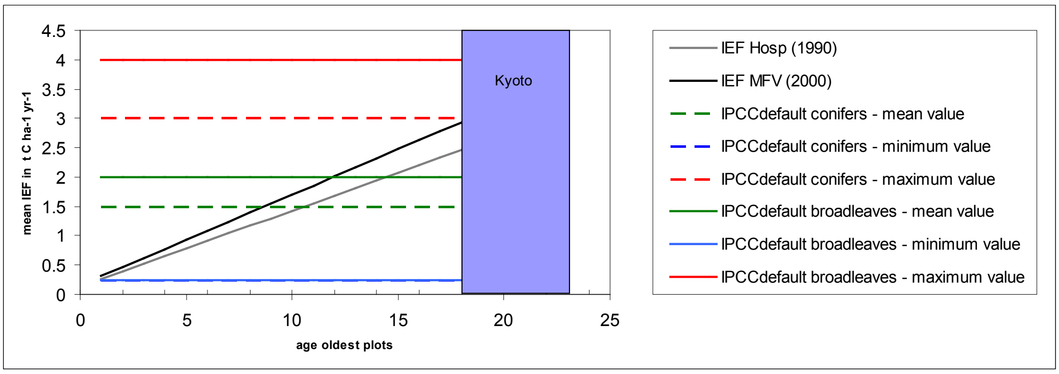

Figure A1-3: Mean IEF at national scale for cumulative AR-activities with constant rate of land use change.

8) Above- and below ground growth carbon sinks are distinguished based on the mean ratio in the plots (based on IPCC defaults) used as basis for the regression of the carbon sink on age
This resulted in 69% of the carbon sink in the aboveground biomass and 31% in the below ground biomass. This ratio was applied consistently over all AR-forests.

9) It is assumed that for forests younger than 25 years old, the occurrence of harvest and thinning is negligible. Thus, biomass loss is reported as (NO, 0)
No data are available to distinguish the origin of harvested wood.

The method as described above was developed to calculate the carbon sink associated with the conversion of land to Forest Land under the Convention. In the Dutch submission, land converted to Forest Land remains in a separate category (5.A.2) for 20 years, after which it is included in Forest land remaining Forest Land. Based on a linear regression, it is not correct to extrapolate beyond these 20 years of age. However, under the KP plots remain afforested for the whole length of the CP and possibly beyond. Thus, it is necessary to adapt or add to the method to ensure the transition to older afforested areas after 2010.

Annex 2 Filling of Table NIR-2

Annex 2 shows the rules followed to fill the table NIR-2. For the Netherlands, which has not elected any article 3.4 activities, the submission under the KP distinguishes three types of land: AR land, D land and other land. For any land under AR or D, carbon stock changes and greenhouse gas emissions need to be reported. Other land is land that is not under the KP and thus no emissions are to be reported. The sum of all land, i.e. AR, D and other, is the total area of the country (reported in the lower left cell) and remains constant over time.

The area of land that is newly re/afforested or deforested between the beginning and the end of the inventory year shows up in the 3rd row. It changes from “Other” (row heading) to either AR (1st column heading) or D (2nd column heading). The cumulative area of land that has been re/afforested in previous years is shown in the upper left cell, (AR-AR) and the cumulative area of land that has been deforested in previous years is shown in the cell in the same diagonal right of & below this one, i.e. the Def-Def cell. Previously re/afforested land can be deforested again, and is reported then as deforested land. The area AR land that moves to D during the current inventory year is reported in the upper row, 2nd cell from left (row heading = AR, column heading = Def). Once land is reported under D, it remains in this category, even when it is reforested again. Thus, the area of land in Def-Def can only increase, whereas the area of land under Other-Other can only decrease.

Table A2-1: Calculations of the area change of re/afforestation (ARF) and deforestation (Def) in the period 1990-2009. The red arrows indicate the possible pathways of land reported for the LULUCF sector under the KP submission.

	AR	**Def**	**Other**	**Total area at the beginning of the current inventory year**
AR	Cum AR 1990-2008 (=Annual rate ARF x 19)	0 (until new matrix)		Sum of cells left = total area under AR in previous year
Def		Cum Def 1990-2008 (= Annual rate Def x 19)		Sum of cells left = total area under D in previous year
Other	Annual rate AR 2009	Annual rate Def 2009	Area NL – area in the rest of the matrix	Sum of cells left = total area not under KP in previous year
Total area at the beginning of the current inventory year	Sum of cells above = total area reported under AR	Sum of cells above = total area reported under D	Sum of cells above = total area not under KP	Total area in country

Annex 3 Carbon stock change in mineral and organic soils for KP reporting

J.P. Lesschen
20-10-2010

Introduction

Under the Convention, the Netherlands reports that as a whole, including all land uses and land use changes but leaving out the cultivation of organic soils for agricultural use, the soil of the Netherlands is most probably a sink of a highly uncertain magnitude. As such, no soil emissions are reported for mineral soils (Van den Wyngaert *et al.*, 2009). However, for reporting under the Kyoto Protocol (KP) the carbon stock changes need to be reported separately per pool and per activity (i.e. deforestation and re/afforestation). Therefore, another methodology is needed to report correctly under the Kyoto Protocol, for which carbon pools are spatial allocated and linked to the areas of deforestation and re/afforestation.

For organic soils, the emissions from cultivation of organic soils are reported under the Convention as a total for the Netherlands, without allocating the emissions to a certain area or land use. For the Convention all emissions from organic soils are reported separately under grassland. The procedure is based on an overlay of a map with water level regimes and the soil map indicating the area with peat soils, combined with assumptions typically valid for agricultural peat soils in the Netherlands. However, to report the emissions correctly under the Kyoto Protocol for the areas of deforestation and re/afforestation a spatially distributed methodology is needed.

For both the mineral and organic soil carbon pool an updated methodology was developed to address the need for spatially distributed emissions and removals for KP reporting. In this note a brief description of the updated methodology for both mineral and organic soils is given and the new results for reporting under the Kyoto Protocol are presented.

Methodology

Mineral soils

The updated methodology for carbon stock changes in mineral soils is based on the previous methodology as described in De Groot *et al.* (2005). In this study a soil carbon stock map was made for the Netherlands based on data derived from the LSK, a national sample survey of soil map units (Finke *et al.*, 2001). The LSK database contains quantified soil properties, including soil organic matter, for about 1400 locations at five different depths. Based on these samples soil carbon stocks for the upper 30 cm were determined (De Groot *et al.*, 2005). The LSK was stratified to groundwater classes and soil type. However, land use was not included as separate variable. Therefore it was not possible to quantify carbon stock changes related to the Kyoto activities deforestation and re/afforestation.

In a new study the same base data from the LSK survey were used, but classified differently into new soil – land use combinations. For each of the sample locations the land use at the time of sampling was known. The soil types for each of the sample points were reclassified to

11 main soil types (Figure A3-1 and Table A3-1), which represent the main variation in carbon stocks within the Netherlands. The number of observations for each soil type is still sufficient to calculate representative average soil carbon stocks for the main land uses. In Figure A3-2 the calculated average carbon stocks for grassland, cropland and forest are shown.

Table A3-1: Main soil types in the Netherlands and number of observations in the LSK database

Soil Type	Soil type Dutch name	Area (km^2)	Nr. Observation
Brick soil	Brikgrond	272	32
Earth soil	Eerdgrond	2084	58
Old clay soil	Oude kleigrond	387	19
Loamy soil	Leemgrond	258	26
Sandy soil without lime	Kalkloze zandgrond	3793	249
Peaty soil	Moerige grond	1914	61
Podzol soil	Podzol grond	7393	246
River clay soil	Rivierklei grond	2652	111
Peat soil	Veengrond	3369	208
Marine clay soil	Zeekleigrond	7751	299
Sandy soil with lime	Kalkhoudende zandgrond	958	75

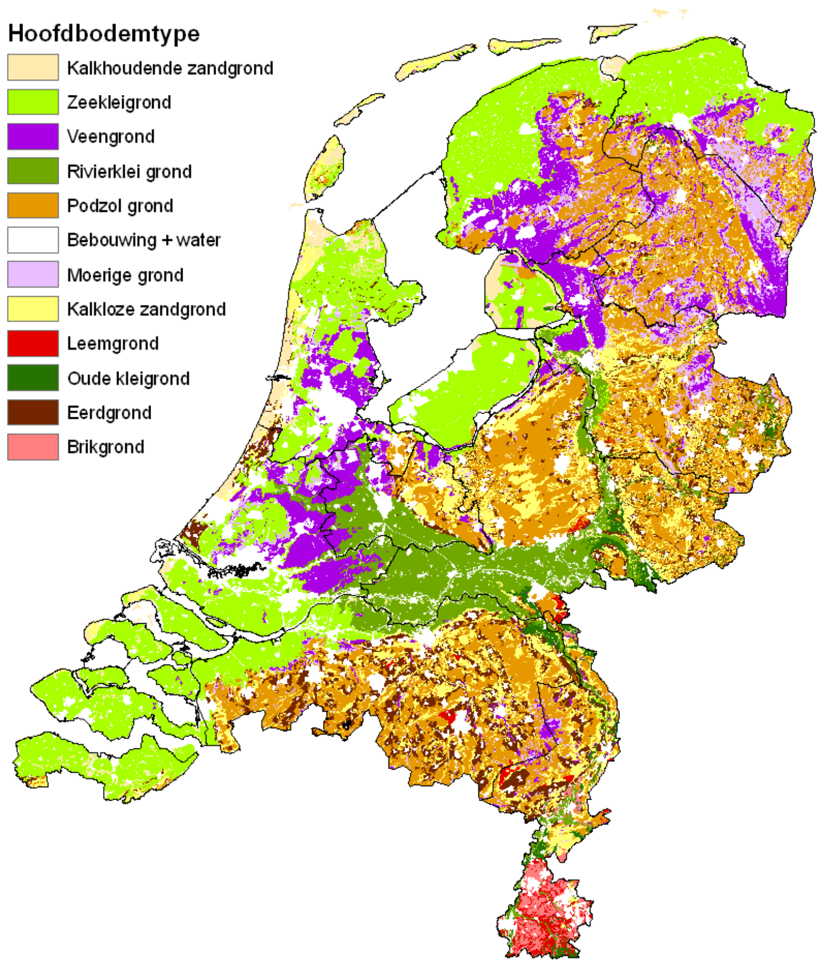

Figure A3-1: Distribution of the main soil types in the Netherlands

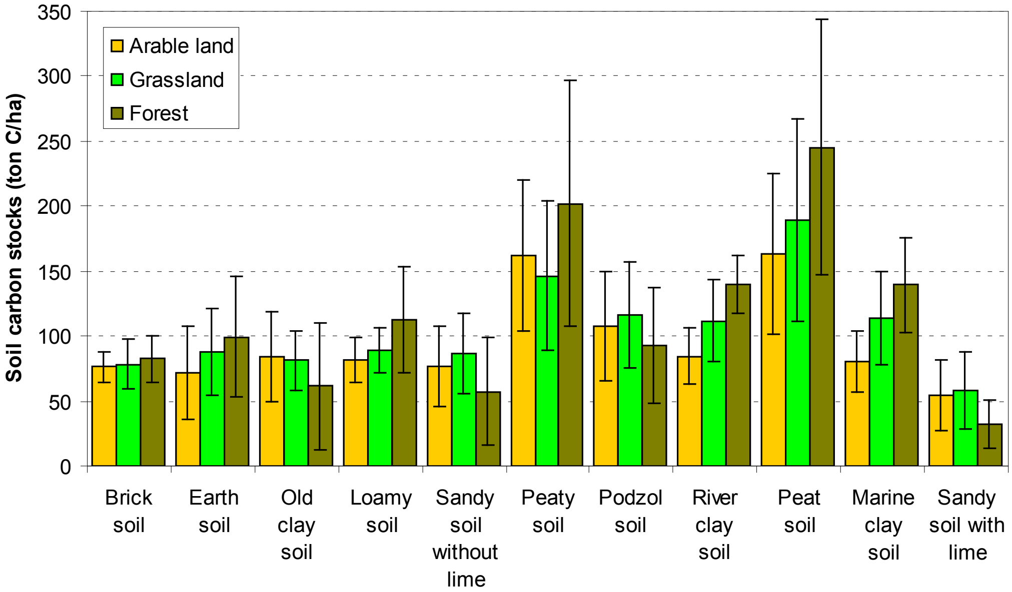

Figure A3-2: Average soil carbon stocks per land use soil type combination. The error bars indicate the standard deviation.

The LSK data set only contains data on soil carbon stocks for the land uses grassland, cropland and forest. For the remaining land uses no data about soil carbon is available in the LSK database or other studies. Therefore, estimates had to be made, especially for settlements it is important to estimate carbon stocks, since about 25% of the deforestation is conversion to settlements. In the IPCC 2006 guidelines some guidance is provided for soil carbon stocks for land converted to settlement, see the text box below. Considering the high resolution of the land use change maps in the Netherlands (25x25 m grid cells) it can be assumed that in reality a large portion of that grid cell is indeed paved. Using the following assumptions an average soil carbon stock under settlement that is 0.9 times the carbon stock of the previous land use is assumed:

- 50% of the area classified as settlement is paved and has a soil carbon stock of 0.8 times the corresponding carbon stock of the previous land use;
- The remainder 50% consists mainly of grassland and wooded land for which the reference soil carbon stock is assumed.

Textbox: The IPCC 2006 guidelines state the following for land converted to settlement for the soil carbon pool (IPCC, 2006):

Default stock change factors for land use after conversion (Settlements) are not needed for the Tier 1 method for *Settlements Remaining Settlements* because the default assumption is that inputs equal outputs and therefore no net change in soil carbon stocks occur once the settlement is established. Conversions, however, may entail net changes and it is *good practice* to use the following assumptions:

(i) for the proportion of the settlement area that is paved over, assume product of F_{LU}, F_{MG} and F_I is 0.8 times the corresponding product for the previous land use (i.e., 20% of the soil carbon relative to the previous land use will be lost as a result of disturbance, removal or relocation);
(ii) for the proportion of the settlement area that is turfgrass, use the appropriate values for improved grassland from Table 6.2, Chapter 6;
(iii) for the proportion of the settlement area that is cultivated soil (e.g., used for horticulture) use the no-till F_{MG} values from Table 5.5 (Chapter 5) with F_I equal to 1; and
(iv) for the proportion of the settlement area that is wooded assume all stock change factors equal 1.

For wetlands and trees outside forest (TOF) no change in carbon stocks in mineral soils is assumed upon conversion to or from forest. For other land a carbon stock of zero is assumed. This is a conservative estimated, but in some cases indeed a reality, e.g. forest is removed to create drifting sands areas for nature purposes, in that case the complete topsoil is removed (see Textbox).

The difference between land use classes, divided by 20 years (IPCC default) is the estimated annual C flux associated with re/afforestation or deforestation. Thus, re/afforestation of cropland to forest for example has the same annual C flux per hectare as deforestation from forest to cropland, but with an opposite sign:

$$E_{\min} = \frac{C_{t=20} - C_{t=0}}{t} * A_{\min\_x,t=20}$$

in which:

$C_{t=20}$ = the final carbon stock after 20 years
$C_{t=0}$ = the initial carbon stock 20 years ago
t = 20 years
$A_{min\_x\_t=20}$ = the area of mineral soil with land use x after 20 years

Organic soils

The area of organic soils under forests is small compared to the total forest area in the Netherlands and amounts 11539 ha (3.5%), based on the land use map of 2004. The area of re/afforested land on organic soils is 2912 ha (8%) and of deforested land 1536 ha (5%), based on the land use change between 1990 and 2004 (Kramer *et al.*, 2009). The majority of this is involved in a conversion between Kyoto forest and agricultural land (cropland or grassland). Drainage of organic soils to sustain forestry is not part of the management and not actively done, however, indirectly also organic soils under forest are affected by drainage from the nearby agricultural land.

Kuikman *et al.* (2005) established a relation between subsidence and either ditch water level or mean lowest groundwater based on many series of long-term measurements. The average ground surface lowering can be described as a function of the soil type of the upper soil layer and the drainage class. The following soil types were distinguished: peat, clay, sand and humus rich sand ('veenkoloniaal dek'). For peat the ground surface lowering is higher than for the other soil types. Three drainage classes are distinguished based on the GLG (average lowest groundwater level): bad drainage (GLG < 80 cm); moderate drainage (GLG 80-120 cm) and good drainage (GLG > 120 cm). In Kuikman *et al.* (2005) the groundwater information from the soil map was used, which was mainly collected during the sixties and seventies.

Since this information is outdated, since more land is now drained compared to the sixties, they assumed that 50% of the peat area in a certain groundwater class would now one class higher. In the updated calculation we used the updated groundwater data (GxG files), see De Gruijter *et al.* (2004) and Van Kekem *et al.* (2005). This map was made based on geostatistics, groundwater level databases and some additional new measurements of groundwater levels. The resulting ground surface lowering for all peat soils in the Netherlands is shown in Figure A3-3. The total area of peat soils under agricultural land use is 223 thousand ha in the Netherlands.

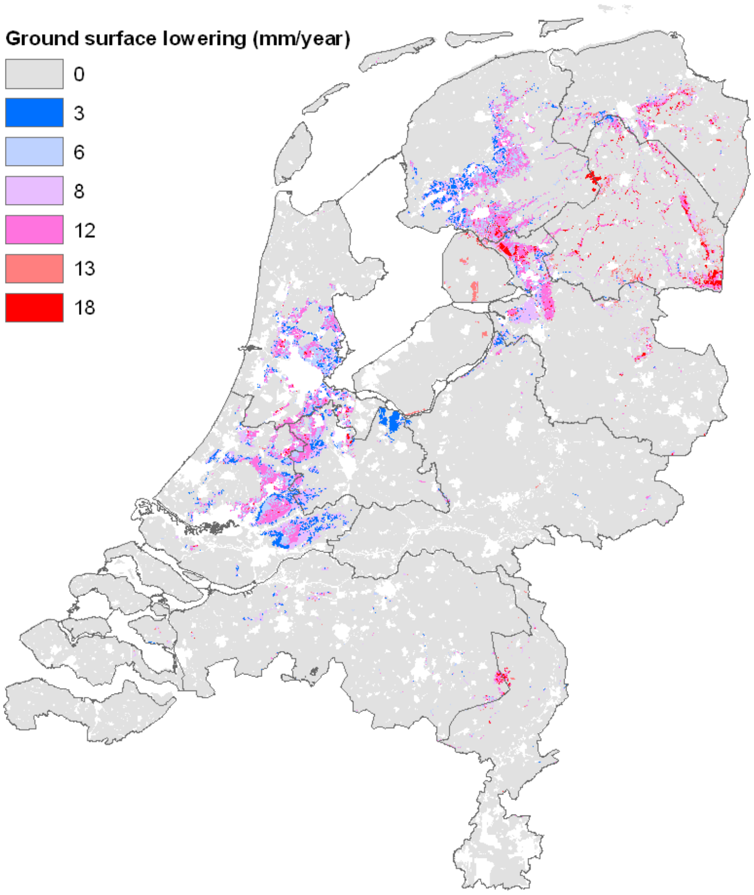

Figure A3-3: Location of the organic soils and their average ground surface lowering

Based on the land use maps of 1990 and 2004 the locations of deforestation and re/afforestation were determined and overlaid with the ground surface lowering map (Figure A3-3). The emissions from organic soils can now be calculated using the ground surface lowering rate, the bulk density of the peat, the organic matter fraction and the carbon fraction in organic matter (see Kuikman *et al.*, 2005). For organic soils under deforestation the assumption that emissions are equal to the emissions of cultivated organic soils seems valid. However, for re/afforestation this assumption rather conservative, since active drainage in forests is not common practice. However, since no data is available about emissions from peat soils under forest or about the water management of forests, we assume that emissions remain equal to the emissions on cultivated organic soils before re/afforestation.

Results

Mineral soils

Figure A3-4 shows the land use conversions for deforestation and re/afforestation based on the land use change matrix of 1990-2004. Deforestation is mainly due to conversions of forest to grassland and settlement, whereas re/afforestation is mainly due to conversions of grassland and cropland to forest. The distribution of these land use changes over the main soil types is shown in Figure A3-5. The average carbon stock changes per soil type for the land use conversion related to deforestation and re/afforestation are presented in Table A3-2.

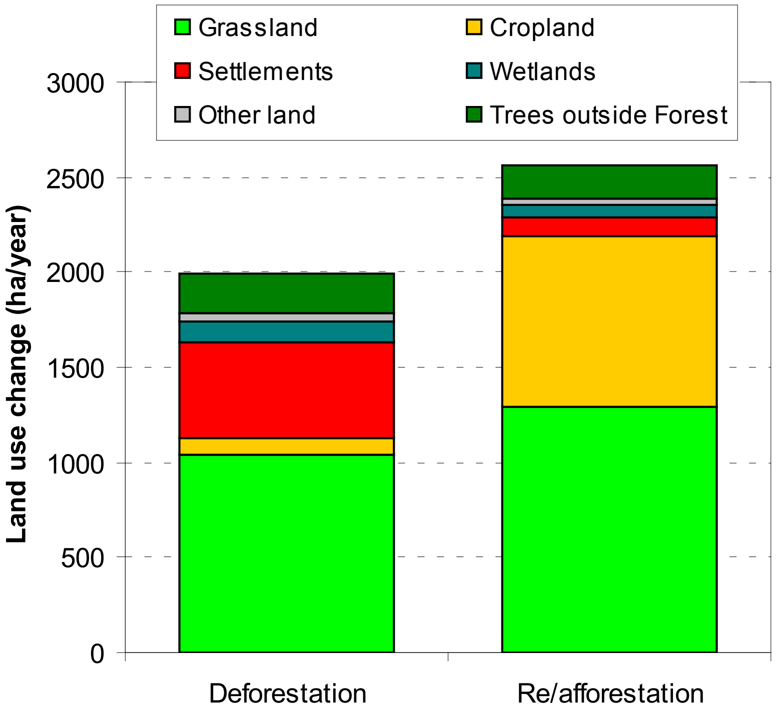

Figure A3-4: Land use changes for deforestation and re/afforestation

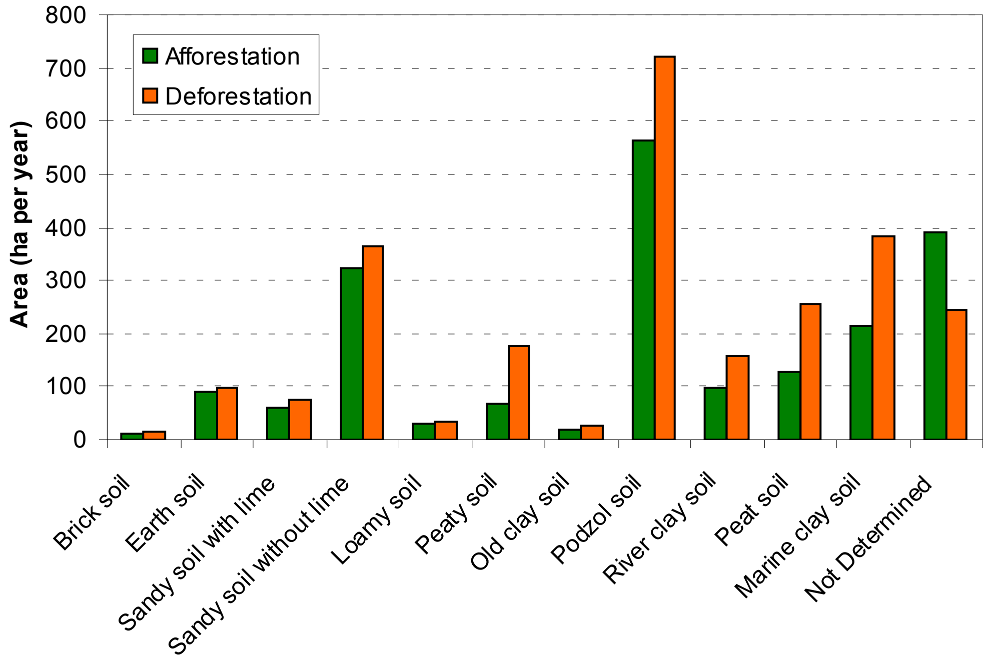

Figure A3-5: Areas of re/afforestation and deforestation in relation to soil type

Table A3-2: Average carbon stock changes per soil type for land use conversions (ton C/ha/year)

Soil type	**Grassland to forest**	**Cropland to forest**	**Settlements to forest**	**Wetlands to forest**	**Other land to forest**	**TOF to forest**	**Forest to grassland**	**Forest to cropland**	**Forest to settlements**	**Forest to wetlands**	**Forest to other land**	**TOF outside forest**
Brick soil	0.2	0.3	0.4	0.0	4.1	0.0	-0.2	-0.3	-0.4	0.0	-4.1	0.0
Earth soil	0.6	1.4	0.5	0.0	5.0	0.0	-0.6	-1.4	-0.5	0.0	-5.0	0.0
Sandy soil with lime	-1.3	-1.1	0.2	0.0	1.6	0.0	1.3	1.1	-0.2	0.0	-1.6	0.0
Sandy soil without lime	-1.5	-1.0	0.3	0.0	2.9	0.0	1.5	1.0	-0.3	0.0	-2.9	0.0
Loamy soil	1.2	1.5	0.6	0.0	5.6	0.0	-1.2	-1.5	-0.6	0.0	-5.6	0.0
Old clay soil	-1.0	-1.1	0.3	0.0	3.1	0.0	1.0	1.1	-0.3	0.0	-3.1	0.0
Podzol soil	-1.2	-0.8	0.5	0.0	4.6	0.0	1.2	0.8	-0.5	0.0	-4.6	0.0
River clay soil	1.4	2.8	0.7	0.0	7.0	0.0	-1.4	-2.8	-0.7	0.0	-7.0	0.0
Marine clay soil	1.3	2.9	0.7	0.0	7.0	0.0	-1.3	-2.9	-0.7	0.0	-7.0	0.0
Not determined	-0.9	0.3	0.4	0.0	4.4	0.0	0.9	-0.3	-0.4	0.0	-4.4	0.0

Combining the carbon stock changes per soil type with the related areas of deforestation and re/afforestation results in a net sink of 4.4 kton CO_2 per year for deforestation and a net sink of 32.7 kton CO_2 per year for re/afforestation in 2008. The reason for the net sink of deforestation is that a large part of the forest is converted to grassland and on sandy soils, where a large part of the forest is located, this results in an increase of the soil carbon pool. This offsets the negative carbon stock changes due to deforestation on other soil types.

Organic soils

In Table A3-3 the result of the overlay of the ground surface lowering map of peat soils with the locations of re/afforestation and deforestation is shown. The average CO_2 emission from organic soils under re/afforestation is 23.7 ton CO_2 per year and under deforestation 23.9 ton CO_2 per year. This is slightly higher compared to the average of all cultivated land in the Netherlands. The total calculated CO_2 emission from organic soils for 2008 (19 years) is 93.6 kton CO_2 for re/afforestation and 49.9 kton CO_2 for deforestation. In addition to CO_2 also N_2O is emitted from the organic soils, however, this is reported under agriculture and not included in this note.

Table A3-3: CO_2 emissions from organic soils under deforestation and re/afforestation

Ground surface lowering class	**Emission**	**Area**		**Total emission**	
		Re/afforestation	**Deforestation**	**Re/afforestation**	**Deforestation**
mm	kg C/ha/year	ha/year	ha/year	kton CO_2/year	kton CO_2/year
3	1848	12.1	6.5	0.08	0.04
6	3696	31.6	21.2	0.43	0.29
8	4928	47.5	16.4	0.86	0.30
12	7392	69.1	44.8	1.87	1.21
13	8008	22.4	5.7	0.66	0.17
18	11088	25.3	15.2	1.03	0.62
Total		208.0	109.7	4.9	2.6

Discussion and conclusion

The new approaches for the calculation of the changes in carbon pools for both mineral and organic soils for reporting under the Kyoto Protocol have been described in this note. The approaches can be considered as updates of previous approaches used for reporting to the UNFCCC. The carbon stock changes for these two pools for 2008 are summarized in Table A3-4.

Table A3-4: Summary of carbon stock changes for re/afforestation and deforestation for 2008 (kton CO_2)

	Re/Afforestation	Deforestation
Mineral soils	32.7	4.4
Organic soils	-93.6	-49.9

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