The Kyoto Article 3.3 and 3.4 Toolbox (KAT)

January 2000

S. Brinkman
P.J. Kuikman
P.H. Spiertz
G.J. Nabuurs
A.J. Dolman

Alterra-rapport 162.2

Alterra, Green World Research, Wageningen, 2001

ABSTRACT

Brinkman, S., P.J. Kuikman, P.H. Spiertz, G.J. Nabuurs en A.J. Dolman, 2001. *The Kyoto Article 3.3 and 3.4 Toolbox (KAT); januari 2000*. Wageningen, Alterra, Green World Research.. Alterra-rapport 162.2. 36 pp. 33 figs.; 10 tables; 5 refs.

The KAT-model provides a spreadsheet based framework to calculate C-sequestration in the commitment period (2008-2012) under Article 3.3 and 3.4 activities of the Kyoto Protocol for the EU15 countries and selected Annex 1 countries. Any combination of 3.3-scenarios, 3.4-activities and sub-rules on article 3.3 and 3.4 based on policy proposals can be chosen. The C-sequestration is calculated and presented in graphs and tables both in absolute values as well as in percentages of the1990 emissions. The user can interactively choose between a literature database and a database, which consists of data submitted by countries under the UNFCC regulations.

Keywords: CO_2 sequestration, KAT, Kyoto Protocol, Model, Sinks, Subrules

ISSN 1566-7197

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P.O. Box 47, NL-6700 AA Wageningen (The Netherlands).
Phone: +31 317 474700; fax: +31 317 419000; e-mail: postkamer@alterra.wag-ur.nl

Alterra is the amalgamation of the Institute for Forestry and Nature Research (IBN) and the Winand Staring Centre for Integrated Land, Soil and Water Research (SC). The merger took place on 1 January 2000.

Project 10483 [Alterra-rapport 162.2 / HM / 05-2001]

Contents

Preface

During the 6th meeting of the parties (COP-VI) in the Hague, decisions were expected to be made on the inclusion of sinks in the Kyoto protocol. The important paragraphs in the protocol are:

Paragraph 3.3 '..direct human-induced land use change and forestry activities, limited to afforestation, reforestation, and deforestation (ARD) since 1990, measured as verifiable changes in stocks in each commitment period shall be used to meet the commitments'

Paragraph 3.4 '… additional human induced activities …..by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to or substracted from the assigned amounts..'

Paragraph 3.7 'Those Parties … for whom land use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include … the aggregate anthropogenic carbon dioxide equivalent emissions minus removals in 1990 from land use change for the purposes of calculating their assigned amount.'

Paragraph 6.1 '…any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks …'

Alterra executed a number of small research projects, in support of the negotiations. These projects aimed that aimed at upgrading the existing knowledge on the areas of Afforestation, Reforestation, and Deforestation and the sequestration capacities of forest and forest management measures. The first project dealt with preparing the Dutch data for the EU 1 august 2000 submission on. This work is reported here. Another project was an extension of the model that was developed in the run-up to COP VI, Additional Country Specific Data (ACSD) which described the potential effects of different accounting modalities for article 3.4 additional activities. The upgrade was meant to turn potential use of paragraph 3.4 actions into actual more realistic estimates. A separate report describing the new ACSD model is in preparation. This report contains also the results of two supporting projects that aimed at analyzing the submissions of key countries. To achieve this, and to be able to calculate effects of particular definitions on the sink capacities of individual countries, the ACSD model was adapted to form the Kyoto article 3.3 and 3.4 Toolbox (KAT)..

We would like to thank two Dutch sink delegates Jeroen Vis (Ministry of Agriculture, Nature Management and Fisheries) and Hans Nieuwenhuis (Ministry of Housing, Spatial Planning and the Environment) for their support and advice during the preparation and execution of these projects.

1 Introduction

In 1999, Alterra developed on request of the Ministry of Agriculture, Nature Management and Fisheries and the Ministry of Housing, Rural Planning and Environment a model called Access to Country Specific Data (ACSD) in Microsoft Excel (Nabuurs et al., 1999) for. This model gave for the first time insight in the potential for carbon sequestration under the Kyoto article 3.4 activities. In 2000, the need for a extended model, that included the effects of Kyoto article 3.3 and 3.4, to support policy preparations to COP6 (Conference of the Parties, The Hague 2000was expressed by the two Ministries.).

The KAT-model includes both the effects of articles 3.3 and 3.4. The starting point was an extension of the ACSD model with article 3.3 to include afforestation, reforestation and deforestation (ARD). While both articles were implemented, countries developed some sub-rules to these Kyoto articles. Sub-rules are additional rules of the general definition of accounting of ARD and/or the additional activities. Several of these sub-rules were also added to KAT.

Under the UNFCC convention, countries are allowed to propose their own definitions and accounting systems 0 through their national submissions by the first of August 200. These proposals raised several additional issues.

- First, countries propose a broad definition of additional activities, while ACSD gives carbon sequestration by narrow defined activities[1]. Thus, for the KAT-model, ACSD data had to be transformed from narrow defined to broad defined data.
- Second, the national submissions were far from complete. Most countries delivered data based only on their own proposed definitions, so that a comparison between countries of C-sequestration in the commitment period (2008-2012) was difficult and at first incomplete. Furthermore, the national submission data consisted not only of literature data and expert opinion, but also of policy choices. This called for an extension of the database consisting of independent literature data and expert opinion. This would enable to compare the national submission data to independent data.
- Third, most countries appereared to be in favour of the IPCC scenario of article 3.3. The sub-rules are therefore based on this scenario. Though, the three FAO scenarios (activity, landbased I & II) are implemented as well.
- Fourth, four additional activities appeared as the most likely to be accepted activities for the first commitment period. These were forest management, cropland management, grazing land management and revegetation.

[1] Broad: the total managed area (forest and agricultural land) is considered to be Kyoto land and is given an average carbon uptake rate
Narrow: only a specific area on which a specific activity is applied, is considered to be Kyoto land and is given a specific carbon uptake rate

In September, co-operation with EU-experts started and resulted in extension of the KAT-model in three ways:

- A second model was made, including all the fifteen EU countries instead of the ACSD countries.
- The EU experts asked for a specific format in which data had to be given. This format was also implemented as a table in a new worksheet.
- The EU experts emphasised the importance of uncertainty ranges for the literature data. Therefore, two sheets are implemented in which graphs show the uncertainty ranges of literature data; the absolute as well as the relative uncertainty.

Many experts are working on article 3.3 and 3.4 in preparation to COP6. Often, separate calculations are made for each sub-rule, each scenario and each activity again. This process costs a lot of time. The KAT-model is meant to make these calculations easier and especially quicker, by being user friendly and interactive.By hanging tools like additional activities and sub-rules, changes in carbon sequestration are directly shown in output graphs.

2 Database for KAT

Two databases have been composed: one based on national submission data and the other based on literature data.

The national submission data are taken from the UNFCCC website (SBSTA/2000/MISC.6). The national submissions were rather incomplete and for some countries not available at first (Belgium, Spain, Portugal, Greece and Luxembourg). Therefore, it was difficult to compare countries on the basis of their national submission data. For instance, New Zealand reported only planting forest and no harvest of forest., This causes large sequestrations in article 3.3. However, they reported no data on article 3.4 activities.

The literature data are taken from ACSD (version2) for article 3.4 and from the IPCC SR 2000 on LULUCF (table 3-14 and 3-17) and the TBFRA 2000 report (UN-ECE/FAO, 2000, table 7) for article 3.3.

ACSD uses so-called narrow defined activities. A percentage of the total area of land-use (e.g. cropland) times the effectiveness of a specific activity (e.g. addition of animal manure) gives the C-sequestration per activity. To convert these narrow defined activities into broad defined activities, the total area of land-use times an average effectiveness for improved management on this land-use is taken from ACSD (table 2.1). A relatively high uncertainty can be expected in the broad defined effectiveness, because it is composed of several different types of effectiveness for specific activities on specific areas. This is likely to yield a higher effectiveness for a broad activity on a large area.

In KAT, the uncertainty ranges for effects of article 3.3 and article 3.4 activities taken from literature data are included. The uncertainty range of the land area estimates is not included because it is relative small compared to the uncertainty in the effectiveness (app. 5-10%, Nabuurs and Kuikman, 2000).

For article 3.4 activities, the uncertainty in soil carbon estimates is, similar to the soil carbon estimates itself, not included in KAT. If this were to be be done, the uncertainty range of soil carbon would have to be included as well. The uncertainty of AR activities is estimated at 50-60% and for D activities at 25-30%. If the local situation is unknown, the uncertainty will increase (Nabuurs, 2000). The uncertainty of soil carbon in article 3.3 activities is included in the effectiveness data by the IPCC (IPCC 2000).

Table 2.1 ACSD activities and areas that are used in KAT-model (ACSD, 1999)

Additional activity	**Forest management**	**Cropland management**	**Grazing land management**	**Re-vegetation**
ACSD activities	Conventional forest management	Conservation tillage No tillage Addition of animal manure Addition of sewage sludge Addition of cereal straw Increase productivity of arable lands	Addition of animal manure Increase productivity of pasture	Restoring of degraded forest
ACSD area	Forest available for wood supply	Arable land	Permanent pasture	Total forest minus forest available for wood supply

The IPCC SR gives ARD areas for most important countries. When only A/R or D area were available, data were completed by the TBFRA 2000 report. TBFRA gives annual forest area changes. Together with A/R or D, it is possible to derive D or A/R from the annual forest area changes. The IPCC SR gives an averaged effectiveness per climate zone. In table 2.2, an overview is given of countries and their assumed climate zone.

Table 2.2 Effectiveness from IPCC SR on LULUCF (table 3-17) as used for countries

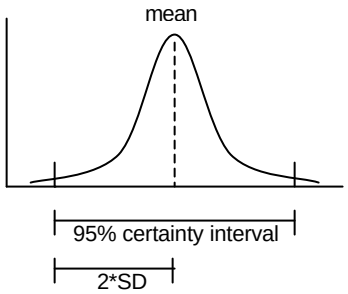
Boreal IPCC effectiveness	**Temperate IPCC effectiveness**
Finland	All other EU-countries
Sweden	USA
Iceland	Japan
Canada	Australia
Russian Federation	New Zealand
	EU_{15}

The literature data are without soil-C and non-CO_2 gases. The national submissions are often incomparable, as stated above. That is certainly true considering soil-C. Some countries included soil-C, others did not. For non-CO_2 gases all national submissions are similar : it is not included.

3 Methods

3.1 Calculation of uncertainties

The resulting uncertainty ranges were calculated with simple statistical methods. The literature uncertainty ranges were interpreted as a minimum and a maximum within a certainty interval of 95%. The 95% certainty interval is defined by 1.96 times the standard deviation (SD) of the mean (see graph). Therefor, approximately twice the standard deviation equals the uncertainty ranges in literature. There is only a 5% chance that the data will be outside this certainty interval.



3.2 Input

Several interactive tools are available in the first worksheet '*choices*'. Any change by a user in this sheet will directly change the output graphs as well. Some tools can be switched *on* or *off* and for some tools a value must be entered, as shown below.

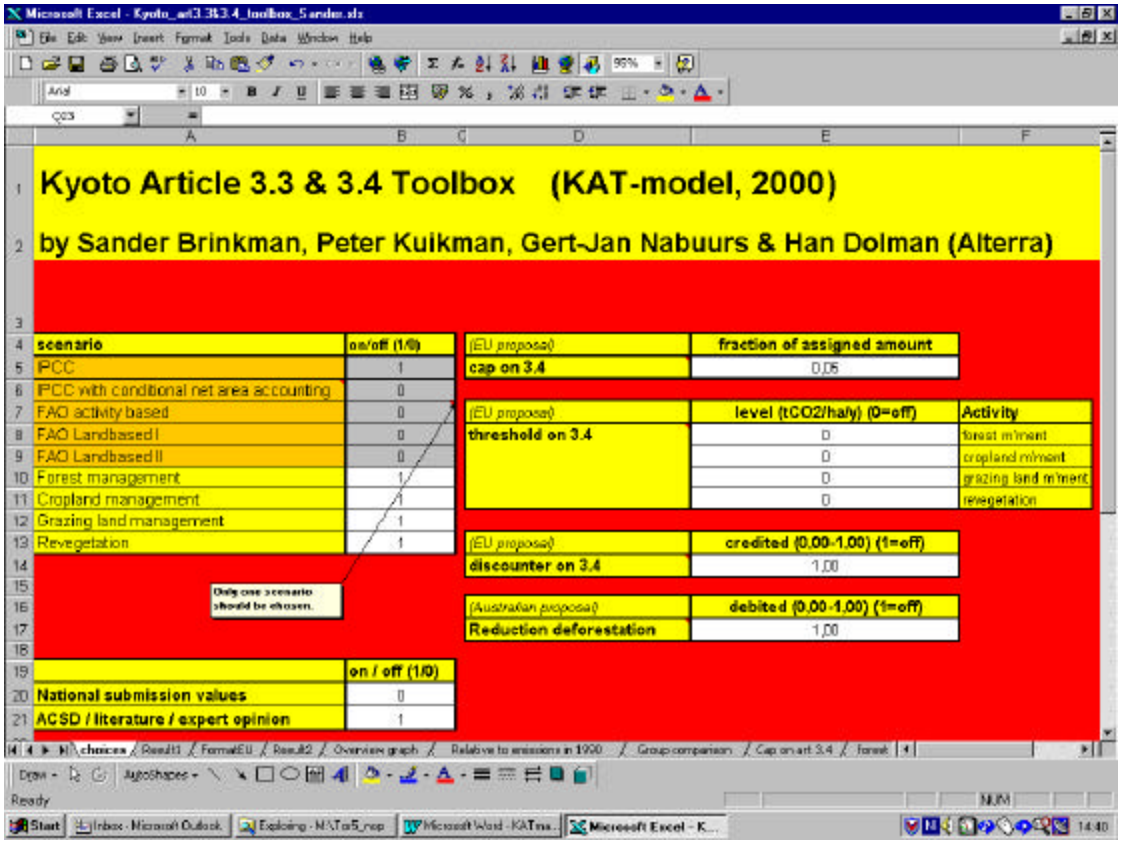


Figure 3.1 Input sheet KAT-model

3.2.1 Scenarios / additional activities / datasets

The user selects a scenario by putting a 1 behind it and switches it off by entering a 0. The scenarios are described and defined in the IPCC SRLULUCF (IPCC, 2000). The 'IPCC with additional net area accounting' is the scenario as proposed by the EU and is described in their publication of the 1st of August (UNFCCC, 2000). Furthermore, the user can choose from a set of additional activities: forest management, cropland management, grazing land management and re-vegetation.. It is possible to use more than 1 additional activity at the same time. Finally, the user can choose to use either the national submission dataset or the literature dataset by entering again a 0 (off) or a 1 (on).

3.2.2 Cap / threshold / discounter on article 3.4 (EU-proposal)

The EU proposed three mechanisms that would affect a countries acceptable emission (or sequestration) to be accounted under article 3.4.

1. A *cap* sets a maximum to the credits to be gained from article 3.4. It is calculated as a percentage of the assigned amount. If 1,00, then there is no cap or limit and all credits will count, if 0,05 the cap is 5% and only 5% of the 1990 emissions may be credited, etc..
2. The *threshold* cuts on the other side. Instead of at the top, it cuts at the bottom of the amount of C-sequestration. Thus, the threshold is a certain amount of CO_2, which are subtracted from the credits. It is accounted as a level of CO_2 per hectare per year per additional activity. For instance, when the forest management effectiveness is 1.2 tC/ha/y and the threshold 0.5 tC/ha/y, then the exploitable forest area has to be multiplied by 0.7 tC/ha/y to yield the amount of C-sequestration that can be credited. This mechanism is to prevent an overestimation of the creditable amount of C
3. The *discounter* enables to reduce the credits (or debits) of additional activities. By entering for instance 0.2, only 20% of the credits (or debits) of additional activities will be accounted.

3.2.3 Reduction deforestation on article 3.3 (Australian proposal)

Australia proposed to compare the CO_2-sequestration after deforestation in the commitment period (2008-2012) to the year 1990, instead of just before deforestation within the commitment period. This means CO_2-losses will be less, due to forest growth from 1990 up to deforestation. The tool allows the user to reduce the CO_2-losses by deforestation. If for instance 0.8 is entered, the deforestation emissions will be reduced by 20%.

3.3 Output

3.3.1 Comparison article 3.3 and 3.4

The user can see the differences in C-sequestration between different scenarios. The worksheet 'group comparison' displays all scenarios for all countries. One might also want to see which article gives most credits for each country. Therefore, an 'overview graph' is presented, in which the C-sequestration by articles 3.3 and 3.4 are shown. To compare this result with respect to overall emission, the 1990 emissions and the assigned amount are also shown in this graph . The most transparent view of the amounts of C-sequestration can be obtained by showing article 3.3 and 3.4 as a percentage of the 1990 emissions (figure 3.2).

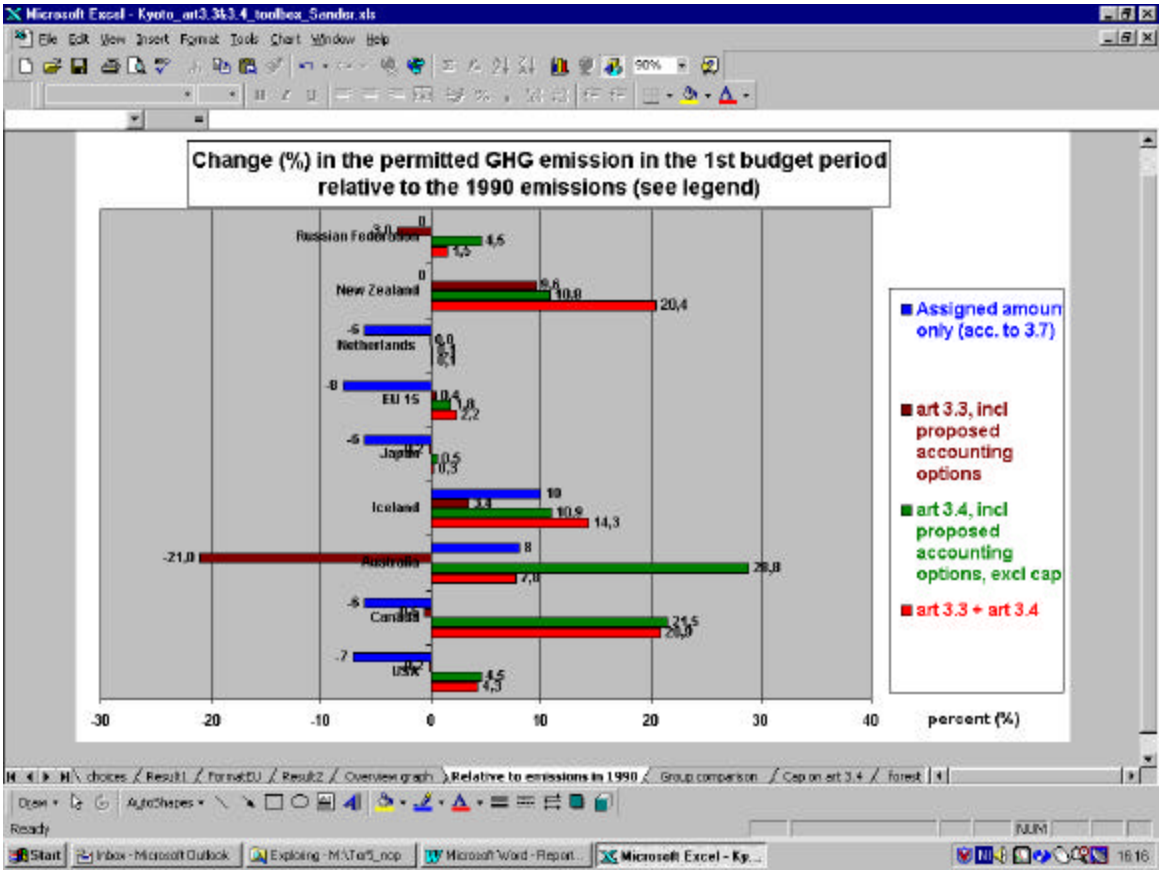


Figure 3.2 Worksheet 'relative to emissions 1990'

3.3.2 Threshold, discounter and reduction deforestation

The influence of the sub-rules on the C-sequestration in a year within the commitment period can be seen by entering some sub-rule values in the worksheet 'choices'.

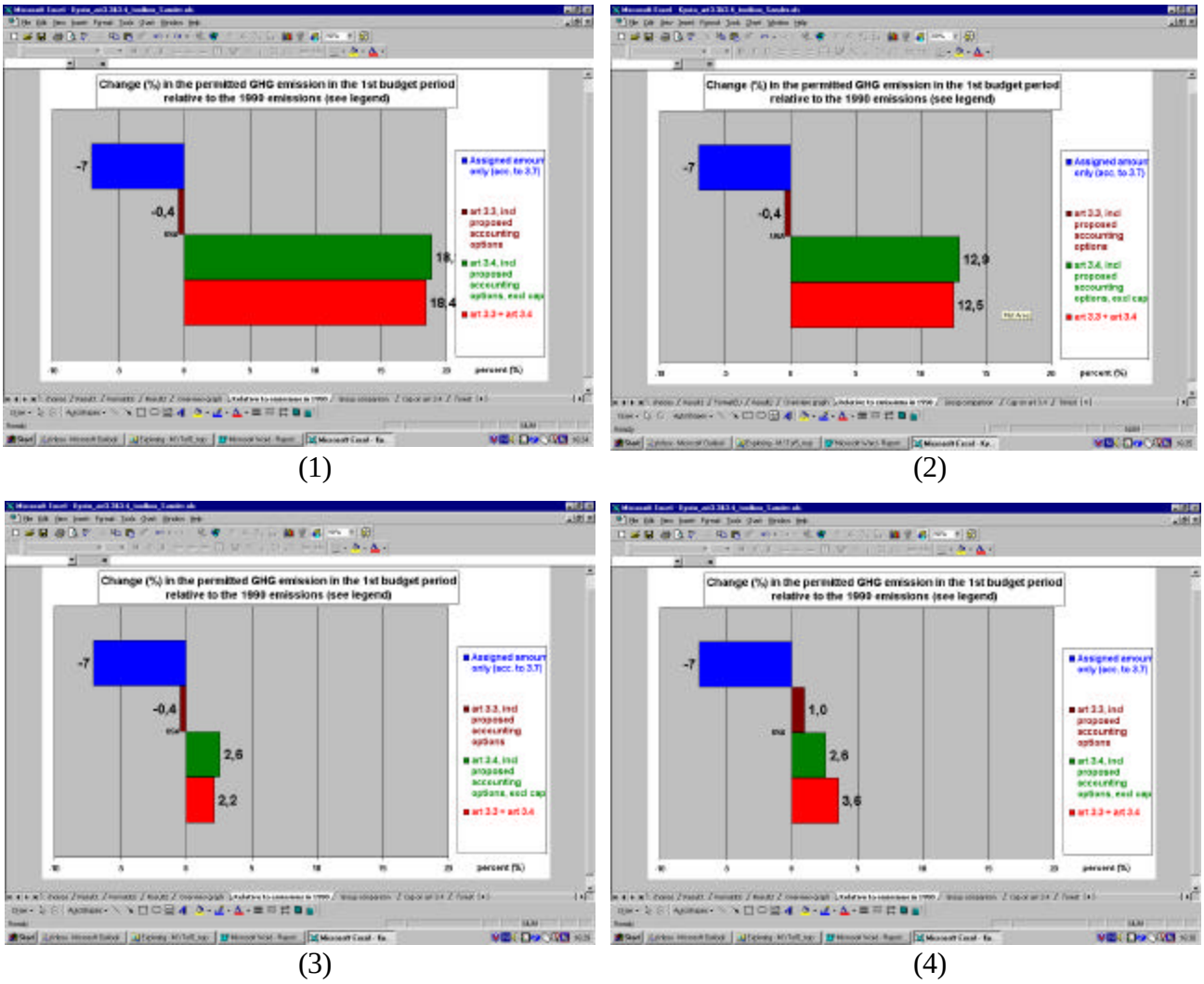


Figure 3.3 USA, IPCCscenario, national submission data (1), + threshold forest management 0,5 tC/ha/y (2), + discounter 80% (3), + reduction deforestation 50% (4)

In figure 3.3 the USA national submission is shown as an example. The blue bar represents the USA assigned amount (–7% of their 1990 emissions). The brown bar shows that the ARD activities (IPCC-scenario) give a source of 0.4%. The green bar shows the total of all additional activities. The USA reported forest management (5.3 Gt CO_2 in commitment period), cropland management (0.29 Gt CO_2 in commitment period) and grazing land management (0.15 Gt CO_2 in commitment period). These three activities together give a sink of 18.9% of the 1990 emissions. The red bar

represents the sum of article 3.3 and 3.4; this is 18.4 % in this case where no sub-rules were applied (1).

Using a threshold on forest management (0.5 tC/ha/y), the percentage of additional activities declines to 12.9% (2). This is because the USA gives a uptake rate of approximately 2 tC/ha/y, thus an uptake rate of only 1.5 tC/ha/y (2.0-0.5 tC/ha/y) is left to give credits.

At the same time, it is possible to implement a discounter. A discounter of 80%, together with the threshold gives a much smaller percentage of 2.6% of the 1990 emissions (3).

For article 3.3, the Australian sub-rule can be applied: reduction deforestation. When 50% of deforestation is reduced, the percentage of article 3.3 changes from a source (-0.4%) to a sink (+1.0%). This is because the brown bar is the sum of afforestation, reforestation and deforestation. When deforestation is reduced (-174 → -87 tCO_2/y), afforestation and reforestation (147 tCO2/y) remain the same and thus it is possible to get a sink instead of a source under article 3.3 (4).

3.3.3 Cap

The cap, that is a percentage of the assigned amount, is expressed in KAT as a percentage of the C-sequestration by the additional activities. When the 'cap as percentage of additional activities' is smaller than 100%, credits are cut by the cap. When the 'cap as percentage of additional activities' is larger than 100%, a country has no cut back due to a cap.

4 Results

4.1 Article 3.3

In the KAT-model, 5 different scenarios have been implemented. In fact, these are variations of only two scenarios: IPCC and FAO. The IPCC scenario is extended with a sub-rule as proposed by the EU, which is called the 'IPCC net area accounting'. The FAO scenario is divided into three scenarios. The 'activity based', the 'landbased I' and 'landbased II' scenario (IPCC, 2000).

4.1.1 Uncertainties

The article 3.3 uncertainty ranges are based on the uncertainty of the ARD effectiveness (IPCC 2000, table 3-17). The data on reforestation activities in temperate regions have the largest uncertainty ranges. Large differences between the average effect of article 3.3 and the uncertainty range can be identified. Especially, those countries that both have a large potential of AR and D activities. The USA, Australia, EU15 and the Russian Federation have large uncertainty ranges due to the large amount of reforestation activities. Increasing certainty on reforestation activities can decrease their overall uncertainty significantly.

Table 4.1 Effectiveness and uncertainty range (IPCC 2000)

IPCC	**Low**	**Mean**	**High**
A (boreal regions) (tC/ha/yr)	0.4	0.8	1.2
A (temperate regions) (tC/ha/yr)	1.5	3	4.5
D (boreal regions) (tC/ha)		35*	
D (temperate regions) (tC/ha)		60*	
FAO Land-Based I	**Low**	**Mean**	**High**
R (boreal regions) (tC/yr)	-209	-191	-164
R (temperate regions)	-557	-351	-125
FAO Land-Based II	**Low**	**Mean**	**High**
R (boreal regions)	-56	-38	-10
R (temperate regions)	-141	49	259

* uncertainty range is estimated +/- 20%
(Nabuurs, 2000)

According to IPCC (2000), the estimates are sensitive to the forest definitions used (for example whether conversion of savannahs is considered deforestation or not). Also, carbon sequestration is subject to annual weather conditions and will vary from year to year. More detailed data may decrease the uncertainty range.

4.1.2 IPCC scenario

The IPCC scenario appeared to be a easy to handle scenario. In practice, no distinction is made between afforestation and reforestation, contrary to the FAO scenarios. Compared to the other scenarios the IPCC scenario is an average source / sink for article 3.3. The eight Annex I countries in the KAT-model (USA, Canada, Australia, Iceland, Japan, EU, New Zealand and the Russian Federation) give a source of 164 Mt CO_2 per year in the first commitment period under the IPCC scenario.

4.1.3 IPCC net area accounting scenario

The IPCC net area accounting gives less deforestation debits than the IPCC scenario. This is because the D area can be subtracted from the A/R area and gives thus fewer debits. In total, this scenario gives a sink of 152 Mt CO_2 per year in the first commitment period for the KAT-countries.

4.1.4 FAO activity based scenario

The FAO scenario in general has one major difference compared to the IPCC scenario: it includes the harvest and regeneration (H&R) cycle. Each FAO scenario differs in accounting of the harvest and regeneration cycle.

The activity based scenario only includes the regeneration part of H&R and is thus not symmetric. It only includes the sink and does not include the source (harvest). Therefore, it is the most sequestrating scenario of all scenarios. The eight countries give a sink of 1293 Mt CO_2 per year in the first commitment period.

4.1.5 FAO landbased I scenario

The FAO landbased I scenario includes the whole H&R cycle. This means the growth of forest (regeneration) and the lost biomass, including slash (harvest). On the short term, this is a scenario, that gives a large source. Considering the long term, even H&R should be in balance in the the carbon cycle. However, the commitment period is relatively short term and therefore this scenario gives the largest source for article 3.3. The source is 1693 Mt CO_2 per year in the first commitment period for the eight countries.

4.1.6 FAO landbased II scenario

The FAO landbased I scenario liesbetween the other FAO scenarios. Decaying slash is accounted for, but no direct harvested woody biomass, in contrast to the

landbased I scenario. This scenario gives a source of 22 Mt CO_2 per year in the commitment period for the eight countries.

Table 4.2 C-sequestration by different scenariosfor article 3.3 for USA, Canada, Australia, Iceland, Japan, EU, New Zealand and the Russian Federation, based on literature data (IPCC, 2000)

Scenarios	**Source (-) / sink (+) (Mt CO_2/y)**	**Excludes**
IPCC	-164	H, R, S
IPCC net area accounting	152	H, R, S
FAO activity based	1293	H, S
FAO landbased I	-1693	
FAO landbased II	-22	H

H = harvest
R = regeneration
S = slash

4.1.7 Sub-rule reduction deforestation

The sub-rule reduction deforestation, as proposed by Australia, gives particularly more credits or less debits to countries with large deforestation areas. The USA and Australia, but also the Russian Federation appear to have most benefits of the reduction on deforestation (table 4.3).

Table 4.3 Article 3.3 sources (-) / sinks (+) under IPCC scenario with 0% and 50% reduction on deforestation, based on literature data (IPCC, 2000)

(Mt CO2/y)	**USA**	**Canada**	**Australia**	**Iceland***	**Japan**	**EU**	**New Zealand**	**Russian Federation**
no reduction	-12	-3,7	-115	0,1	-2,7	18	7,0	-54
reduction 50%	43	0,2	-55	0,1	-0,9	27	10,2	-25

* No deforestation found in literature

4.2 Article 3.4

In the KAT-model, four major additional activities are implemented:

- forest management,
- cropland management,
- grazing land management
- revegetation.

All kind of combinations of sub-rules (threshold/ discounter/ cap) can be applied to these activities.

4.2.1 Uncertainties

The article 3.4 uncertainty ranges are based on the high and low estimates of the narrow defined article 3.4 activities in the ACSD model. The high and low estimates represent the lowest and highest data found in literature for a specific activity (narrow defined). The uncertainty range increases by app. 25% (Brinkman, 2000) if the conversion from narrow to broad defined is s also included in the uncertainty range, but this is not the case here.

Table 4.4 Uncertainties in article 3.4 activities

Article 3.4 activities	**Uncertainties in effectiveness (derived from ACSD)**	
	High +/-	Low +/-
Forest management	100.3%	37.6%
Crop management	28,7%	19.6%
Grazing management	19.4%	11.3%
Revegetation	10,5%	4.5%

The uncertainty range varies for each country and each activity. The uncertainty ranges can be very large compared to the estimated sink capacity of article 3.4 activities[2]. This is primarily due to the uncertainty range of forest management activities.

4.2.2 Additional activities

Because the national submission data on article 3.4 are far from complete, emphasis is more on literature data. The absolute data table (Table 4.5a) shows that cropland management in the USA, re-vegetation in Canada and forest management in Australia could give large sinks. In general, , the larger the country, the larger the possibilities to obtain a sink under 3.4. The percentages in table 4.5b show however a different pattern. The best possibility to create large sinks (and compensate emissions) is likely to be in Canada, Australia and Iceland. This is because these countries have relatively few emissions and large sinks possibilities.

[2] When the average impact of 3.4 activities results in a sink, the uncertainty range will not exceed the total impact of article 3.4 activities. If one or more of the activities result in a source the uncertainty range could exceed the total impact of article 3.4 activities.

Table 4.5a Absolute data of article 3.4 sinks based on literature data (ACSD, 1999)

(Mt CO_2/y)	USA	Canada	Australia	Iceland	Japan	EU	New Zealand	Russian Federation
forest m'ment	41	37	93	0,0	2,7	14	1,6	38
cropland m'ment	129	19	13	0,0	2,7	48	0,32	71
grazing land m'ment	40	1,7	9	0,27	0,08	5,8	0,0	9
Re-vegetation	60	70	42	0,02	0,45	8,8	5,9	18

Table 4.5b Article 3.4 sinks based on literature data, relative to the emissions in 1990 (ACSD,1999)

%	USA	Canada	Australia	Iceland	Japan	EU	New Zealand	Russian Federation
forest m'ment	0,7	6,2	19,4	0,0	0,2	0,3	2,2	1,3
cropland m'ment	2,1	3,2	2,7	0,0	0,2	1,1	0,4	2,4
grazing land m'ment	0,7	0,3	2,0	10,3	0,0	0,1	0,0	0,3
Re-vegetation	1,0	11,8	8,8	0,6	0,0	0,2	8,1	0,6

4.2.3 Threshold / discounter / cap

The KAT-model uses a global threshold for each additional activity. The consequence of this is that countries with boreal forest are more reduced in C-credits than countries in the temperate region. When a threshold is going to be applied, a country-specific threshold is thus recommended. The discounter limits the credited C-sequestration evenly over all countries. The cap has a limiting effect on large countries with relatively small emissions; the large countries' possibilities on C-sequestration by additional activities quickly exceed the percentage of the assigned amount when the emissions are relatively small.
From table 4.6, one can see that the threshold is effective in countries with boreal forests (Canada, Iceland and the Russian Federation). The discounter is effective evenly over all countries, as expected. A cap of 1% of the assigned amount cuts the additional activities for almost all countries, except for the Netherlands and Japan. The latter is the result of large industry emissions and relatively small sinks.

Table 4.6 C-sequestration by article 3.4 activities using a threshold (0.5 / 0.1/ 0.1/ 0.1 tC/ha/y), a discounter (95%) or the cap (1% of 1990 emissions), given as a percentage of C-sequestration by all 3.4 activities, based on literature data.

	USA	Canada	Australia	Iceland	Japan	EU	Nether-lands	New Zealand	Russian Federation
Threshold as % total 3.4	33	6	66	0,3	18	26	67	42	18
Discounter as % total 3.4	5	5	5	5	5	5	5	5	5
Cap as % of total 3.4	21	4	3	190	53	656	9	22	21

4.2.4 Comparison datasets

In general, no major differences appear between the national submission data and literature on article 3.3, except for Australia. Australia gives much smaller debits on article 3.3 (-25 Mt CO2/y) compared to the literature data (-120 Mt CO_2/y, IPCC 2000).
Differences in data are larger for article 3.4 activities (table 4.7). The USA and Japan give much larger C-sequestration by their forest management than the literaturevalues would suggest. The difference is caused by the effectiveness, because the areused as the same size. ACSD used the effectiveness of conventional forest management, while the national submissions use other literature data. ACSD gives larger credits to cropland management, compared to the national submissions. Again, the difference is caused by a difference in the effectiveness. Grazing land management and re-vegetation are very difficult to compare between the two data sets. It depends very much on which activities are included. For instance the Netherlands includes drainage of grazing land on peatlands, which gives a large source, while ACSD does not include this kind of management (like many other countries). The Australian re-vegetation is slightly different, because the difference is in the area used. ACSD uses a much larger area, which can be revegetated compared to the national submissions of Australia.

Table 4.7 Comparison literature and national submission (n.s.) data on article 3.4 (Mt CO_2 in 2008-2012) (ACSD, 1999)

	Forest m'ment (n.s.)	**Forest m'ment (lit.)**	**Cropland m'ment (n.s.)**	**Cropland m'ment (lit.)**	**Grazing land m'ment (n.s.)**	**Grazing land m'ment (lit.)**	**Revetation (n.s.)**	**Revetation (lit.)**
USA	5287	209	286	647	150	203		
Canada	176	185	48	97	17	8,5		
Australia							40	213
Iceland							1,0	0,08
Japan	208	14						
Netherlands	0,56	0,35	1,15	1,14	-39,3	0,06		

4.3 COP 6

During the Climate Conference in The Hague (Conference of the Parties 6), staff of Alterra was present to estimate the consequences of new proposals for the capacity of sinks per country. The KAT model has been used to calculate the amounts of C-sequestration per country. Four tables have been produced directly out of the KAT model, of which three for the Dutch delegation and one for the Presidency of the Conference (see Appendix).

In the beginning of the second week of the conference, Japan, USA and Canada introduced a new proposal, the so-called JUSC-proposal. In short, it contains an initial interval (x% of 1990 emissions) on forest management. The initial interval means free accounting of forest management C-sequestration with a maximum of

x% of the 1990 emissions. Then, up to a threshold of 80% of the 1997 changes in forest and other woody biomass stocks, a discounter of x% should be applied. After the threshold, there will be full accounting again. Other activities than forest management are fully accounted for in this proposal.

The KAT model did not include an initial interval, but did include a threshold and a discounter. Therefore, the initial interval had to be added to KAT and the threshold and discounter were useful in the way they were implemented in KAT. The final result, as delivered to the Dutch delegation, is shown in the Appendix (table A1). The USA gets 9.3-13.8%, Japan gets 1.2-3.6% and Canada gets 4.0-6.2% of the 1990 emissions as a sink out of only forest management. These percentages are 1.9-10.8% for Australia and 0.3% for the EU15.

A second table (see Appendix table A2) has been made in cooperation with Michael Grub (European Commision). Its goal was to show the domestic abatement in relation to domestic sinks in article 3.3 and 3.4. The starting point was half of the assumed gap between the emissions in 2010 (business as usual) and the assigned amount is to be reached at the domestic level. The contribution of article 3.3 and 3.4 has been calculated for different scenarios. Michael Grub delivered the business as usual projections for 2010. The C-sequestration of different scenarios on article 3.3 and 3.4 have been taken from KAT.

For the different scenarios, the USA could get 1.5-29.9% of the gap out of the domestic sinks, Canada (–4.5)-(14.9)%, Japan (-0.6)-(8.9)% and the EU15 1.3-4.2%.

After a discussion between some members of the EU15, the need arose to look at the consequences of sinks in a different manner. Untill then, C-sequestration by sinks was mostly compared to the 1990 emissions (see figure A1). The idea was to compare discounted sinks to the assigned amount to see the impact of these sinks on the efforts a country has to make to reduce the emissions.

This new approach gives new insight in the importance of sinks in relation to the applied discounter. E.g. USA can get 100% of the assigned amount out of only forest management with a discounter of app. 45%. A more realistic discounter of 80% shows the following percentages of the assigned amount that are reached by only forest management: USA 38%, Canada 15%, Japan 8% and the EU15 0.5% (see figure A2).

In the second half of the second week the Presidency made a new proposal to bridge existing differences on interpretation of the protocolThey asked Alterra to calculate the sinks for different variable values. This proposal on article 3.4 included again an initial interval, but now it was related to article 3.3. When article 3.3 gave a source, this could be compensated by the initial interval in article 3.4, with a maximum of 20 Mt C. All the rest is discounted by x%. Thereby, the other activities got also a discounter. The discounter for forest management could be 85%, 90% or 95% and the discounter on the other activities could be 20%, 30% or 40%.

Because the initial interval was already implemented due to the JUSC proposal, KAT was capable to calculate the Presidency proposal immediately. The most likely combination was (according to the Presidency) a discounter of 85% on forest management and a discounter of 30% on the other additional activities. This resulted in a total of 4.0% reduction of the 1990 emissions for the USA, 5.0% for Canada, 0.9% for Japan and 0.9% for the EU15.

Conclusions

The original goal of the KAT-model was to enable users to make combinations of sub-rules applied on article 3.3 and 3.4 and to calculate and show the effects on C-sequestration within the commitment period. During COP6, this worked fine. While most researchers used only the national submission database in a simple spreadsheet, KAT had additional possibilities:

- The two databases, which could be, turned on/off. It was useful to compare the national submission data with literature data and enable the use of literature data to fill missing data in the national submissions. However, the transition of ACSD data ('narrow' defined) to 'broad'defined data may be subject to criticism. Compared to other data, the effectivenesses used from ACSD were rather high. The literature data derived from the IPCC Special Report on article 3.3 showed acceptable values and uncertainty ranges.
- It was very useful to be able to combine every sub-rule with another during the negotiations and to see directly the consequences in the amount of C-sequestration during the first commitment period. Within little time extensive records of data can be produced, both in tables as in figures to improve their accessibility to users.

Uncertainty ranges are given for literature data. The uncertainty in article 3.3 varies between 20% (deforestation) and 50% (afforestation / reforestation). The uncertainty in article 3.4 differs per additional activity. Forest management uncertainty varies between 38% and 100%, while the other activity uncertainties vary between 5% and 29%. To reduce these uncertainties and to be able to implement article 3.3 and 3.4 in the Kyoto Protocol, more research is needed on C-sequestration / emission by forests, croplands, grazing lands and re-vegetation activities.

Given article 3.3, the IPCC scenario is the most used scenario during COP6 and gives a source of 164 Mt CO_2 per year for eight Annex 1 Parties (table 4.1). All proposed sub-rules are based on the IPCC scenario. The sub-rule on article 3.3, which is implemented in the KAT-model, reduces deforestation while forests as a whole have to sequestrate carbon. The disadvantage of this sub-rule is that the 'business as usual' of forest management is not clearly left out of this definition.

Given article 3.4, the four additional activities are kept in the Protocol during negotiations in The Hague, but most attention was paid to forest management. The KAT-model shows that cropland management is at least as important as forest management, considering C-sequestration (table 4.3a).

Each sub-rule on article 3.4 has its own (dis-) advantages. The discounter limits each Party equally and is an easy to handle tool. The threshold is somewhat more complicated. It has to be defined per country (or even per part of a country) andthere has to be some coherence between the thresholds. A global threshold, which is used in KAT, is relatively large to a country with boreal forest, like Canada

and the Russian Federation. Hence, the boreal countries will get relatively fewer credits than the others will when a global threshold is used. The third sub-rule, a cap, is particularly limiting to countries, which are large and have relatively small emissions, like Canada and Australia. Small countries with large emissions will not reach the cap at all (Japan, the Netherlands).

Acknowledgement

The work to develop this KAT-model has been funded by the Dutch Ministry of Agriculture, Nature Management and Fisheries and the Dutch Ministry of Housing, Physical Planning and Environment. We would like to thank Jeroen Vis and Hans Nieuwenhuis for the pleasant co-operation and their valuable contribution in developing this toolbox.

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Appendix A

Table A1: JUSC-proposal

scenario 1 **ii=1%** **thr=80%** **disc=95%**

	Forest m'ment (Mt CO2/y)	% of em. 1990	% of full accounted forest m'ment
USA	526.9	9.3	49.8
Canada	22.7	4.0	64.4
Australia	*9.9*	*1.9*	*10.6*
Iceland*	*0.0*	*0.0*	*100.0*
Japan*	13.7	1.2	33.0
EU 15*	*14.0*	*0.3*	*100.0*
New Zealand	*0.8*	*1.1*	*47.5*
Russian Federation*	76.9	2.5	8.0

scenario 2 **ii=1%** **thr=80%** **disc=50%**

	Forest m'ment (Mt CO2/y)	% of em. 1990	% of full accounted forest m'ment
USA	778.2	13.8	73.6
Canada	28.6	5.1	81.2
Australia	*49.4*	*9.3*	*53.0*
Iceland*	*0.0*	*0.0*	*100.0*
Japan*	27.0	2.3	64.7
EU 15*	*14.0*	*0.3*	*100.0*
New Zealand	*1.2*	*1.6*	*72.4*
Russian Federation*	495.2	16.3	51.6

scenario 3 **ii=5%** **thr=80%** **disc=95%**

	Forest m'ment (Mt CO2/y)	% of em. 1990	% of full accounted forest m'ment
USA	757.5	13.4	71.6
Canada	29.4	5.2	83.6
Australia	*30.8*	*5.8*	*33.1*
Iceland*	*0.0*	*0.0*	*100.0*
Japan*	41.7	3.6	100.0
EU 15*	*14.0*	*0.3*	*100.0*
New Zealand	*1.6*	*2.2*	*100.0*
Russian Federation*	192.4	6.3	20.0

scenario 4 **ii=10%** **thr=80%** **disc=95%**

	Forest m'ment (Mt CO2/y)	% of em. 1990	% of full accounted forest m'ment
USA	607.6	10.8	57.5
Canada	35.2	6.2	100.0
Australia	*57.0*	*10.8*	*61.1*
Iceland*	*0.0*	*0.0*	*100.0*
Japan*	41.7	3.6	100.0
EU 15*	*14.0*	*0.3*	*100.0*
New Zealand	*1.6*	*2.2*	*100.0*
Russian Federation*	336.8	11.1	35.1

* no threshold

Table A2: Domestic abatement

Domestic abatement in a percentage of the difference between the BAU-emission 2010 and the assigned amount.

	USA	**Canada**	**EU**	**Japan**	**USA**	**Canada**	**EU**	**Japan**
assumed gap between BAU GHG emissions 2010 and assigned amount (Mt CO2eq.)	*2246*	*216*	*1614*	*442*				
	% domestic action, cumulative				*% additional contribution*			
domestic CO2 abatement no levy (%)*	50	42	51	39				
domestic CO2 abatement CDM levy $10/tC (%)	50	43	52	40				
with non-CO2 gases (%)**	55.0	50.0	57.0	41.0	5.0	7.0	5.0	1.0
Sinks art 3.3 and 3.4 cap 1% (%) ***	56.5	45.5	**60.5**	43.2	1.5	-4.5	3.5	2.2
Sinks art 3.3 and 3.4 discount 90% (%) ***	58.9	44.9	**58.3**	41.3	3.9	-5.1	1.3	0.3
Sinks art 3.3 and 3.4 JUSC proposal (%) ***	75.6	64.9	**61.2**	49.9	20.6	14.9	4.2	8.9
Sinks art 3.3 and 3.4 threshold (%) ***	84.9	42.7	**59.1**	40.4	29.9	-7.3	2.1	-0.6

* As derived from POLES model with10% CDM accessibility and 100MtC/yr (out of 325) 'hot air' excluded: price = 55$/tC in 1990US$.

In this model, the gap between 'business as usual'projections and Kyoto targets is in the range 35-37% for each of the four countries / regions.

** The additional contribution from non-CO2 gases assumed to be 1% (Japan), 5% (USA, EU) and 7% (Canada) of assumed gap

*** Domestic sink potential is simply added to domestic emission reductions, with no allowance for impact on prices. Price reductions in response to inclusion of sinks would reduce actual emission reductions in these models

bold = literature data (KATmodel), no national submission data delivered. Note that most sink data carry large uncertainties and have to be handled with great care

JUSC: ii=20 Mt C/y, discounter=2/3 on forest management, full accounting other activities(as proposed by Japan/USA/Canada)

discount: 10% of art 3.4 is credited (accounting example)

cap: maximum of 1% of 1990 emissions on article 3.4 (accounting example)

threshold: forest m'ment 0.5 tC/ha/y, other activities 0.1 tC/ha/y (accounting example)

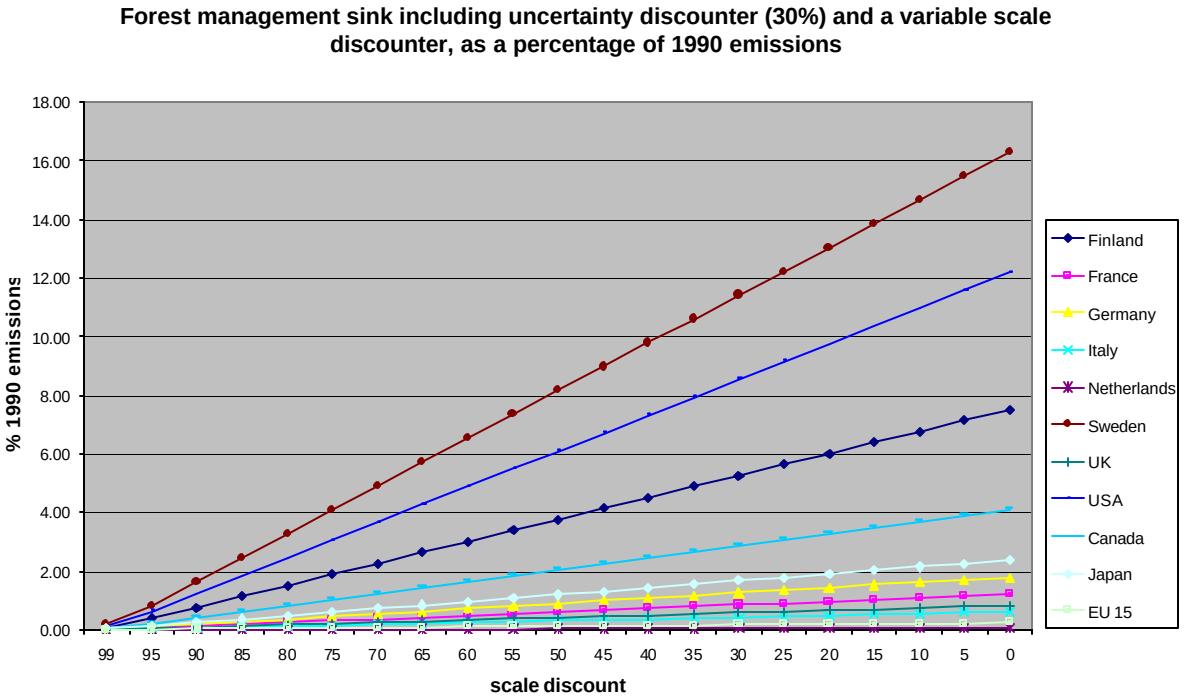

Figure A1 Forest management as a percentage of the 1990 emissions

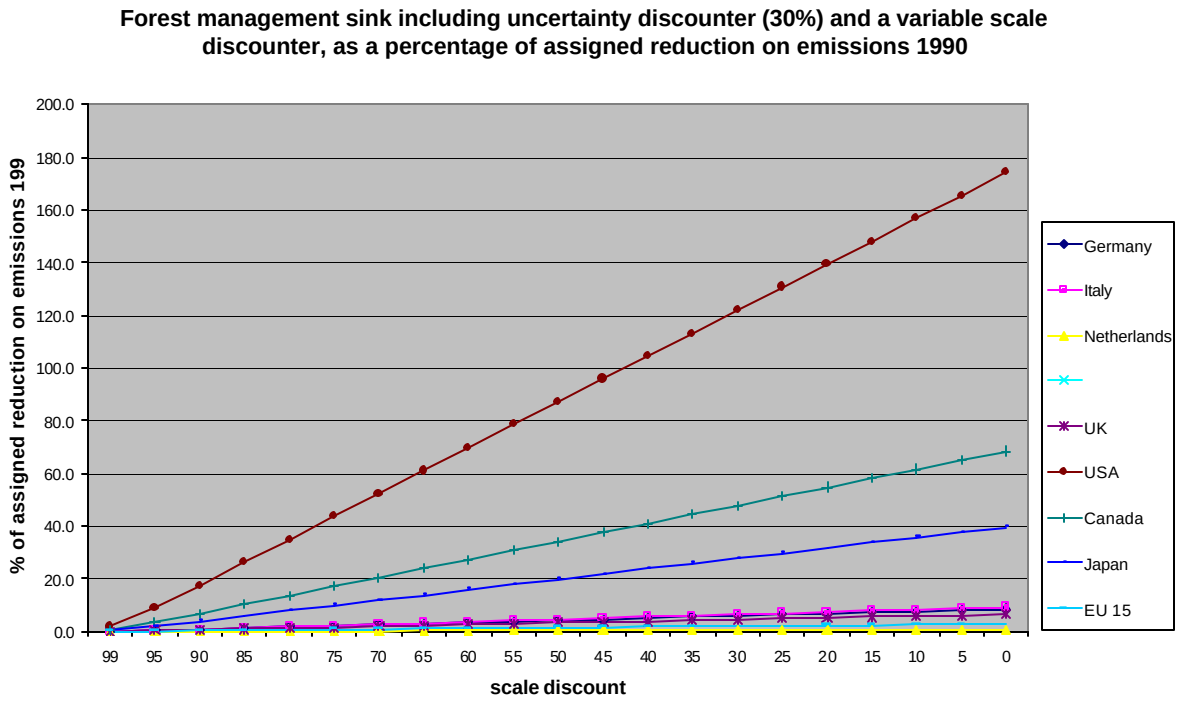

Figure A2 Forest management as a percentage of the assigned amount

Presidency proposal

absolute values emissions 1990		Forest Management				Cropland Management				Grazing Land Management			
	Mton CO2-eq.	Mton CO2/CP	85%	90%	95%	Mton CO2/CP	20%	30%	40%	Mton CO2/CP	20%	30%	40%
USA	6070	**5287**	**793**	**529**	**264**	**286**	**229**	**200**	**172**	**150**	**120**	**105**	**90**
Canada	600	**176**	**26**	**18**	**9**	**48**	**38**	**34**	**29**	**17**	**13**	**12**	**10**
Japan	1228	**208**	**31**	**21**	**10**	14	11	10	8	0	0	0	0
EU 15	4248	70	10	7	3	240	192	168	144	29	23	20	17

relative to emissions 1990

USA	6070	**17.4**	**2.6**	**1.7**	**0.9**	**0.9**	**0.8**	**0.7**	**0.6**	**0.50**	**0.40**	**0.35**	**0.30**
Canada	600	**5.9**	**0.9**	**0.6**	**0.3**	**1.6**	**1.3**	**1.1**	**1.0**	**0.56**	**0.45**	**0.39**	**0.34**
Japan	1228	**3.4**	**0.5**	**0.3**	**0.2**	0.2	0.2	0.2	0.1	0.01	0.01	0.00	0.00
EU 15	4248	0.3	0.0	0.0	0.0	1.1	0.9	0.8	0.7	0.14	0.11	0.09	0.08

	Total (85% and 30%)	Debit Art 3.3	Total
USA	3.6	0.4	4.0
Canada	2.4	2.6	5.0
Japan	0.7	0.2	0.9
EU 15	0.9		0.9