Green house gases and global warming

There is no abundant reliable evidence that leads to the following conclusions:

The atmosphere has always provided a warming blanket that allows solar radiation in but prevents some of it from leaving the earth. What has happened over the past 200 years if that the blanket effect has been enhanced, and so more heat is trapped by the atmosphere than before.

The enhanced greenhouse effect has largely been caused by increased concentrations of gases. These are CO2 (which causes about 60% of global warming, CH4 (25%), N2O (12%), halocarbons (x%) and troposphere ozone (x%). Note that ozone in the stratosphere cools the earth while ozone in the troposphere warms the earth., and levels of the latter ozone are increasing faster than those in the troposphere. All these gases are called greenhouse gases.

Aerosol particles also have an effect on atmospheric conditions. So-called while aerosol pollutants, the best known being sulphur dioxide (causes acid rain), reflect solar radiation and cool the earth. By contrast, black particles, such as soot from smoke, warm the earth because their dark colour means that they absorb heat.

Bush fires are a potential cause of global warming because of the CO2, black smoke, CH4, CO and Nox that they produce. What is the effect of CO and NOX?

Increased concentrations of these compounds, and the increased temperatures they cause are very largely due to human activities.

The main cause of global warming is the higher CO2 levels, which are now much higher than even before. Over the past 4 million years, CO2 concentrations fluctuated regularly in tune with Milankovic cycles every 110,000 years between 180 ppm during glacial period and 290 ppm during the peaks of interglacials. Levels now stand at 370 pp.

Windhoek's average temperature has risen by about 1.2 C since 1920. About half of this increase is due to global warming while the other half is due to the effect of urban development which creates a warmer micro-climate in the city, caused for example by the tarred roads, metal roofs and burning of heaters.

Global temperature increases have also been caused by land cover changes, and their effect in raising temperatures is about as important as that of increased emissions. The most important land cover changes are clearing which has reduced the capacity of the earth to absorb CO2.

The contribution of bush fires to increased CO2 levels is negligible. First, of the all the carbon absorbed and stored by plants, very little is burnt away as CO2. Most burnt material is grass which is low in volumes of carbon. Second, all CO2 which is produced by fire can be assumed to be reabsorbed during the next growing season. Third, most

> Size: 80896 bytes.
> Type: Excel-sheet
>

carbon in dry grass that is not burnt decomposes and is released into the atmosphere by the respiration by the organisms that do the decomposing. In essence, the bulk of material burnt by Namibian fires is grass and, being so low in carbon volume, little CO_2 is produced when it burns.

It is widely agreed that temperatures will rise between 2 and 6 C in the 21st century, and at least half of this is inevitable; there is almost nothing that can now be done to stop those increases because most will be caused by atmospheric changes that have already happened.

Predicting the consequences of global warming is extremely difficult. A warmer earth generally means more moisture in the air and more rainfall. However, most models suggest that southern Africa will be drier, and rainfall will be more variable. This, together with higher temperatures, will lead to lower agricultural production (more drought, beef and dairy cattle don't do so well, and seed setting is hampered by high temperatures). Malaria should also spread and more prevalent.

Some reduction in plant growth will be offset by the higher CO_2 levels which lead to better growth; in fact, higher CO_2 levels and temperatures are probably a contributing factor to bush encroachment.

Bush encroachment has occurred throughout the world in savannas where colonial farmers introduced cattle and caused over-stocking and reduced the incidence of fire. This is true in southern Africa, central and North America, and Australia.

Greater carbon uptake due to bush encroachment could mean that Namibia absorbs more carbon than it produces, and that might allow it to bargain with developed countries and sell our contribution to reducing greenhouse gas concentrations. Bush encroached areas may contain 3 times more carbon.

Sea levels are predicted to rise 0.5 m within the next 50 years, mainly because of expansion by the warmer seawater. Greenland's ice cap is certain to disappear altogether during the 21st century, but it will take much longer for the polar ice caps to melt. When that happens, sea levels will rise about 5 metres.

1 degree temperature rise will lead to 15% increase in evaporation over open water, but it will not lead to the same increase in evapotranspiration because higher CO_2 levels lead to lower water loss through the leaves. The higher CO_2 levels also lead to higher rates of plant growth.

Get a paper by William Bond on increased carbon sink/uptake due to bush encroachment.

Look on the web for map of the world's savannas

Look on web for map of fires worldwide.

Look for Modis fire scar data at NASA, contact droy@kratmos.gsfc.nasa.gov - Bob Scholes reckons that this is the most reliable fire scar data, contact Diane Davies about this as well

Namibia

Namibia now produces 5.t Tg of CO_2 (or equivalents) which amount to 0,013% of total global CO_2 production. 66% of Namibian production is due to agriculture, mainly methane production.

1 unit of methane is equivalent to 22 units of CO_2, while 1 unit of NO_2 is the same as 300 units of CO_2

The most important sources of emissions in Namibia are from petroleum fuels and methane from cattle and other ruminants.

Fire issues

There are relationships between tree and grass cover and rainfall. The more rain there is, the more tree and grass cover, but more tree cover leads to less grass.

CH_4 production in fire is very low, especially in flaming grass fires, because CH_4 is converted to CO_2. CH$ production is greater in smouldering fires.

Bush fires produce about 600 different gases.

There are higher levels of soil nutrients beneath a tree canopy because

AUTHORS AND REVIEW EDITORS

Coordinating Lead Authors

Timo Karjalainen (Finland) and Gary Richards (Australia)
Tomas Hernandez (Mexico), Samuel Kainja (Malawi), Gerry Lawson (UK), Shirong Liu (China), and Steve Prisley (USA)

Lead Authors

Juan Ivar Arana Pardo (Bolivia), Richard Birdsey (USA), Marie Boehm (Canada), Julius Daka (Zambia), Shigeo Kobayashi (Japan), H. Gyde Lund (USA), Roman Michalak (Poland), and Masamichi Takahashi (Japan)

Review Editors

Dhari Al-Ajmi (Kuwait), Evgeniy Botman (Uzbekistan), Sergio Gonzalez-Martineaux (Chile), Art Jaques (Canada), Ignatius Oluka-Akileng (Uganda), Helen Plume (New Zealand), and Andreas Schulte (Germany)

Contents

Figures

Tables

Boxes

ACKNOWLEDGEMENT

The success in the preparation of the report on *Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types* has depended foremost on the knowledge, enthusiasm and co-operation of the 15 Co-ordinating Authors and Lead Authors worldwide. We wish to thank the authors for the time and effort devoted to the task, as well as the commitment to the IPCC process.

Review editors have ensured that the process for consideration of the comments has been appropriate. We would like to thank them for this important task.

UNFCCC Secretariat staff, Roberto Acosta, Claudio Forner and Heikki Granholm participated in the preparation of the report giving background and guidance on issues related to the Convention, the Kyoto Protocol and the Marrakesh Accords. We wish to thank them for their valuable input.

The Steering Group, consisting of the IPCC TFI Co-chairs Taka Hiraishi and Thelma Krug, and Michael Gytarsky (Russian Federation), Dina Kruger (USA) and Jim Penman (UK), has guided the work and ensured internal consistency within the report as well as consistency with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. We would like to express our gratitude for their skilful leadership and guidance throughout the preparation of the report.

Four authors/experts meetings were held in Tampere, Finland; Rio de Janeiro, Brazil; Kuala Lumpur, Malaysia; and Sydney, Australia during the course of preparation of the report. We wish to thank the host countries and hosting organisations for co-organising these meetings.

Two combined government/expert reviews were organised during the preparation report; the first during the period 2 December 2002 to 27 January 2003, and the second during 2 May 2003 to 27 June 2003. The comments have provided additional expertise to the work in a constructive way, and consideration of the comments improved the drafts considerably. We wish to thank all reviewers for their comments.

The NGGIP Technical Support Unit (TSU Head Riitta Pipatti, Programme Officers Leandro Buendia, Kyoko Miwa, Todd Ngara, Kiyoto Tanabe and Fabian Wagner, Administrative Assistant Ayako Hongo, Project Secretary Akiko Kawase, and IT Officer John Lane) provided guidance as well as technical and organisational support for the project. They worked tirelessly with the authors as they managed the final editing of the report. We wish to thank them for their hard and competent work.

IPCC Secretariat (Rudie Bourgeois, Annie Courtin and Chantal Ettori) provided assistance for organising the meetings and for the reviews. We wish to thank them for their effort and flexibility in responding to the needs to the authors and the TSU during the tight schedule.

Last but not least, we wish to thank the IPCC Chair Rajendra Pachauri, IPCC Secretary Geoff Love (until August 2003), Acting Secretary Renate Christ and the Task Force Bureau on Inventories (Co-chairs, and Ian Carruthers, Soobaraj N. Sok Appadu, Kirit Parikh, Dhari Al-Ajimi, Jamidu Katima, Javier Hanna Figueroa (until June 2003), Sergio Gonzalez-Martineaux, Art Jaques, Dina Kruger, Helen Plume, Audun Rosland and Saad Khorfan) for their support, advice and encouragement. We would also like to express our gratitude separately to the Acting Secretary Renate Christ for her contribution and guidance to the authors during the first two meetings in preparing this report.

G.O.P. Obasi	K. Töpfer
Secretary-General World Meteorological Organisation	Executive Director United Nations Environmental Programme

PREFACE

This report on *Definitions and Methodological Options to Inventory Emissions from Direct Human-Induced Degradation of Forests and Devegetation of Other Vegetation Types* is the response from the Intergovernmental Panel on Climate Change (IPCC)[1] to an invitation from the United Nations Framework Convention on Climate Change (UNFCCC)[2] . The report was prepared in cooperation with the preparation of the other report under the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP), on *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF*).

The report discusses:

- Alternative definitions and provides possible framework definitions for countries to consider;
- Methodological options to inventory emissions from *degradation* and *devegetation* activities;
- Approaches to reporting and documentation; and
- Implications of methodological and definitional options for accounting under the provisions of Article 3.4 of the Kyoto Protocol (including issues of scale, costs and accuracy).

Guidance on possible methodologies for estimation of greenhouse gas emissions or removals provided in this report draws substantively on the *GPG-LULUCF*.

[1] IPCC was established jointly by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to:

- Make periodic assessments of the science, impacts and the socio-economic aspects of climate change and of adaptation and mitigation options to address it;
- Assess, and develop as necessary, methodologies such as the IPCC Guidelines for National Greenhouse Gas Inventories; and
- Provide, on request, scientific/technical/socio-economic advice to the Conference of the Parties to the Unite nations Framework Convention on Climate Change (UNFCCC) and its bodies.

[2] Decision 11/CP.7 (Land use, land-use change and forestry) in FCCC/CP/2001/13/Add.1, paragraph 3(c), page 55.

1 OVERVIEW

1.1 INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) at its XIX Session on 17-20 April 2002 responded to the decision on land use, land-use change and forestry (LULUCF) adopted by the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) at its seventh session (Decision 11/CP.7; Land use, land-use change and forestry) in the Marrakesh Accords (paragraph 3(c))[3] which invites the IPCC:

> *To develop definitions for direct human-induced 'degradation' of forests and 'devegetation' of other vegetation types and methodological options to inventory and report on emissions resulting from these activities, to be submitted for consideration and possible adoption to the Conference of the Parties at its ninth session.*

The IPCC Panel indicated that the work was to produce a methodology report prepared in close cooperation with the preparation of the report on *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF*).

The purpose of this report, as indicated by the IPCC Panel in the Terms of Reference for the work (Appendix J of the Report of the Nineteenth Session of the Intergovernmental Panel on Climate Change), is to "...respond to concerns that selection of eligible activities under Article 3.4 of the Kyoto Protocol could give rise to an unbalanced accounting if certain types of degradation or devegetation activities are not included. The report would develop definitions for direct human-induced degradation of forests and devegetation of other vegetation types, develop methods to inventory emissions from these activities and analyse the implications of different options to include the accounting of these activities under the provisions of Article 3.4 of the Kyoto Protocol, including the relation to forest management and revegetation."

In sum, the report would provide:

- Definitions for direct human-induced *degradation of forests* and *devegetation of other vegetation types*[4];
- Methodological options to inventory emissions from *degradation* and *devegetation* activities;
- Approaches to reporting and documentation; and
- Discussion of implications of methodological and definitional options for accounting under the provisions of Article 3.4 of the Kyoto Protocol (including issues of scale, costs and accuracy).

The report provides advice on alternative definitions that may be applied to the *degradation of forests* and *devegetation of other vegetation types* and their implications. These are specific in the context of reporting of greenhouse gas emissions from land use, land-use change and forestry activities under the Kyoto Protocol but recognise that the final form of the definitions will need to encapsulate policy choices that are yet to be made by Parties (e.g. on parameter choices and whether only carbon or a range of forest values may be 'degraded').

Key features of the definitions should:

- Enable the identification of relevant land areas;
- Specify the values to be considered (e.g. carbon only or broader values) and therefore relevant practices;
- Be harmonised with definitions in the *GPG-LULUCF* and, to the extent possible, other international reporting frameworks;
- Be measurable and quantifiable; and
- Be unambiguous and as free of subjective interpretation as possible.

---

[3] See paragraph 3 (c) in the decision 11/CP.7 (Land use, land-use change and forestry) contained in FCCC/CP/2001/13/Add.1, p.55.

[4] In this Report, "*degradation of forests*" may be referred to as "*forest degradation*" or simply "*degradation*" where no confusion is likely to occur. Similarly "*devegetation of other vegetation types*" may be referred to as "*devegetation*". These shortened forms have been adopted to improve readability and are not intended to modify the scope of the phrases included in the Marrakesh Accords.

Methodologies can be refined once Parties clarify the preferred final form of the definition on the basis of the framework set out here. In general, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines)*[5], the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG2000)*[6] and the *GPG-LULUCF* should already provide the basis for methodologies once the policy choices have been made. The scale of effect will clearly vary with the final choice of definitions; however, there appears to be little available information upon which to determine the potential scale of implications, though this may change as Parties' elected choices become clear.

The degree of *unbalanced* or *incomplete accounting* will also affect the implications of methodological options for *forest degradation* and *devegetation*. In general *unbalanced accounting* may occur if all emissions and removals are not reported. This may be due to *incomplete accounting*, which occurs if the area (e.g. of managed forest elected under Articles 3.3 and 3.4) is different from the area where relevant activities occur (e.g. the full extent of managed forest), or *asymmetric accounting* (where some emissions and/or removals are not accounted within the area included); the former may have implications for area coverage whilst the latter does not.

A specific issue raised by the IPCC Panel was a need to consider the potential for "*unbalanced*" accounting to occur through an election/non-election of eligible activities under Article 3.4 of the Kyoto Protocol. *Unbalanced accounting* refers to a situation where emissions and removals from relevant pools and lands are not all reported. *Asymmetric accounting* refers to unbalance only within an accounting framework, and includes also *incomplete accounting* that may occur by exclusion of emissions or removals outside of an accounting framework. Situations that may have the potential for *unbalanced accounting* include:

- Where emissions and removals are selectively reported from lands within the accounting framework. (The resultant emissions and removals occurring outside the framework do not impact on balance within the accounting framework.) This would lead to *asymmetric accounting*[7].
- Where selective application of the accounting framework leads to net resultant emissions or removals that are not reported. This is *incomplete accounting*.

In sum, "*unbalanced accounting*" could occur if the accounting is "*asymmetric*" or "*incomplete*" or both. However, the "*incompleteness*" is not a sufficient condition for "*unbalanced accounting*", since the accounting could be *incomplete* but *balanced* where no selective bias has been introduced.

1.2 STRUCTURE OF THE REPORT

The chapters of this report are organised as follows:

Chapter 1 Overview

This chapter provides a summary of the key findings of this report.

Chapter 2 Options for Definitions of Forest Degradation and Devegetation of Other Vegetation Types

This chapter provides a discussion on the elements of definitions (Section 2.1) leading to five alternative definitions of *forest degradation* (Section 2.2) and four alternatives for *devegetation of other vegetation types* (Section 2.3). Examples are provided and framework definitions are suggested for discussion by Parties.

Chapter 3 Methodological Options for Estimating Emissions from Forest Degradation and Devegetation

This chapter provides a discussion on methodological approaches that may be used to estimate annual changes in carbon stocks and emissions of non-CO_2 greenhouse gases caused by direct human-induced *forest degradation* and *devegetation* activities, and then considers possible methodologies for such estimation, substantively drawing upon Chapter 3 of the *GPG-LULUCF*. This chapter covers

---

[5] Intergovernmental Panel on Climate Change (IPCC) (1997). J.T. Houghton, L.G. Meira Filho, B. Lim, K. Treanton, I. Mamaty, Y. Bonduki, D.J. Griggs and B.A. Callander (Eds). *Revised 1996 IPCC Guidelines for National Greenhouse Inventories*. IPCC/OECD/IEA, Paris, France.

[6] Intergovernmental Panel on Climate Change (IPCC) (2000). J. Penman, D. Kruger, I. Galbally, T. Hiraishi, B. Nyenzi, S. Emmanuel, L. Buendia, R. Hoppaus, T. Martinsen, J. Meijer, K. Miwa and K. Tanabe (Eds). *Good Practice Guidance and Uncertainty Management*. IPCC/OECD/IEA, Hayama, Japan.

[7] See page 55, "Chapter 2 – Implications of Relevant Definitions and Generic Issues" Executive Summary; Intergovernmental Panel on Climate Change (IPCC). (2000). *Land use, Land-use Change, and Forestry: A Special Report*, R. Watson et al. (Eds.), Cambridge University Press. Cambridge, UK.

approaches to identification of land areas subject to *forest degradation* and *devegetation* (Section 3.2), estimation methods (Sections 3.3), approaches and tiers (Section 3.4), quality assurance/quality control (Section 3.5) and reporting and documentation (Section 3.6).

Chapter 4 Implications of Definitional Options for Forest Degradation and Devegetation under Article 3.4 of the Kyoto Protocol

This chapter discusses circumstances in which LULUCF accounting and reporting could be *unbalanced* and how the proposed accounting for *forest degradation* and *devegetation of other vegetation types* may address this, and the costs of accounting (including inventorying and reporting) for *forest degradation* and *devegetation of other vegetation types*. The potential scale of any *unbalanced accounting* for Annex I Parties under Article 3.4 of the Kyoto Protocol, and therefore the potential scale of emissions and removals reported under *forest degradation* and *devegetation of other vegetation types* are also discussed.

1.3 KEY FINDINGS

This report provides the principles and the framework for the development of final definitions of *forest degradation* and *devegetation of other vegetation types*. There are numerous definitions of *degradation* in use; nearly 50 published definitions were reviewed in this work. Only three published definitions of *devegetation* could be found. None of these existing definitions was found to be directly suitable for operational use in the context of the Kyoto Protocol, because they either lacked quantifiable thresholds or were not applicable to describing changes in carbon stocks.

Specific guidance on methodological options and the scale of *forest degradation* and *devegetation of other vegetation types* cannot be provided in advance of determination of finalised definitions, mainly because:

i. The intensity of emissions per unit of land will depend on the carbon stocks available for release and the degree and nature of application of the process that causes either emissions or removals.

ii. Despite review of the extensive range of international reporting instruments, none contain reporting of activities similar to those described as *forest degradation* and *devegetation of other vegetation types* in this report.

iii. It is not known what land areas may fall outside of any countries' accounting framework. This depends on the election of eligible activities under Article 3.4 and the extent of land covered by the elected activities.

Nevertheless, some conclusions regarding scale were drawn:

i. Article 3.4 of the Kyoto Protocol affects only Annex I Parties that are generally otherwise involved in a range of international initiatives and reporting arrangements for forests, e.g. Food and Agriculture Organization of the United Nations (FAO) Forest Resources Assessments, Montreal Process and Pan-European Process. Most report the overall sustainability of forest management on a national scale and have in place Forest Codes of Practice that provide for sustainability at stand and regional scales and this is likely to limit the scale of *forest degradation* in this context.

ii. No similar consistent reporting or policy framework exists that is relevant to *devegetation of other vegetation types* to help to indicate the scale or extent of activity, though the focus on Forest Codes of Practice will limit the former.

Regarding the potential for *unbalanced accounting* to arise from the election of eligible activities under Article 3.4 of the Kyoto Protocol and the potential role for *forest degradation* and *devegetation of other vegetation types* reporting, the following conclusions were drawn:

i. If *forest management* is elected then all emissions and removals on the areas of land covered will be reported in a *symmetrical* way. For areas of forest not included in the area of land reported for *forest management* or activities under Article 3.3 of the Kyoto Protocol, no emissions or removals are reported. A net emission or removal on these lands may occur, but this will not affect the *symmetrical* reporting of land drawn into the accounting framework.

ii. If *forest management* is not elected then no forest emissions or removals are reported (outside of those reported under Article 3.3 of the Kyoto Protocol) and *balanced* reporting within the accounting framework is achieved. The result of emissions and removals from forests not included under Article 3.3 or not elected under Article 3.4 will not be included in the accounting framework.

iii. In regard to the election or non-election of *forest management*, any emissions or removals occurring on managed land outside the accounting framework would be reported in national inventories under the UNFCCC.

iv. If *revegetation* is not elected then no emissions or removals associated with this activity are reported and reporting is *balanced* within the accounting framework.

v. If *revegetation* is elected then all emissions and removals from the areas of land covered are reported in a *symmetrical* way. However, as the inclusion of lands is based on "direct human-induced activity that increases carbon stock" the reporting will, at least initially, be influenced towards removals, giving rise to potential *unbalanced accounting* in the short term.

vi. Approaches exist to identify areas of land subject to *forest degradation* and *devegetation*.

2 OPTIONS FOR DEFINITIONS OF FOREST DEGRADATION AND DEVEGETATION OF OTHER VEGETATION TYPES

This chapter discusses and describes options for defining direct human-induced *forest degradation* and *devegetation of other vegetation types* and provides examples of activities that may lead to *forest degradation* or *devegetation of other vegetation types*. Hypothetical situations will be framed to illustrate the implications of different definitional options.

The options for definitions of forestry and land use terms discussed in this document are of course meant to be applied in the context of the Kyoto Protocol and may not be completely consistent with other uses of these terms.

2.1 ELEMENTS OF DEFINITIONS

The definitions chosen for *forest degradation* and *devegetation of other vegetation types* will affect how easy it is to inventory emissions. Definitions, in the context of the Kyoto Protocol, should:

1. Relate to direct human-induced changes in carbon stocks. They may include other values and attributes of forests or other vegetation types, but should at least include carbon stock changes in all relevant pools and emissions of non-CO_2 greenhouse gases.
2. Rely on quantitative, objective standards, and therefore should contain terms that are "measurable" or "detectable". Ideal definitions would be unambiguous and would support inventorying and reporting in a rigorous, verifiable, and transparent manner.
3. Be easy to apply with consistency across a wide range of biomes and relevant vegetation types. They should recognise that the technological feasibility to detect absolute carbon stock changes might vary across biomes.
4. To the extent possible, be consistent with established definitions such as those employed by the UNFCCC, the Kyoto Protocol, the Marrakesh Accords, and other widely used definitions such as those adopted by the FAO.
5. Reflect the availability of technically feasible methodological options for estimating and reporting emissions.
6. For *forest degradation*, specify that the long-term reduction in carbon stocks be such that the forest cover, height, and area are not reduced sufficiently to reclassify the land as non-forest under the definition accepted in the Marrakesh Accords. That is, the definition should provide a distinction between *forest degradation* and *deforestation*.
7. For *devegetation of other vegetation types* possibly mirror the definition of *revegetation* or perhaps *deforestation*.
8. Distinguish between long-term decline and temporal variability due to management or natural disturbance.
9. Should provide reference points such as baseline time frames, thresholds for vegetation removal, and levels of absolute or relative carbon stock changes.
10. Provide an agreed set of variables/indicators (and their proxies if necessary) that are measurable/detectable within the time frame of interest, and can be consistently applied.

The definitions may include an area threshold. If not included explicitly in a definition, area thresholds may need to be specified in accounting guidelines or it becomes difficult to define land areas that require an inventory of emissions and removals of greenhouse gases.

2.2 DEFINITIONS OF FOREST DEGRADATION

2.2.1 Possible Definitions of Forest Degradation and Their Key Features

Defining *forest degradation* is complex. There are numerous definitions in use that may provide little utility for the purposes of inventorying and reporting greenhouse gas emissions. In addition to the definition of "degraded forests" given in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*IPCC*

Guidelines; IPCC, 1997), *degradation* in a forest environment could be applied to forest productivity (products and services), genes, tree vigour and quality, species composition, soils, water, nutrients and the landscape. As widely used by forest scientists, *forest degradation* implies a long-term loss of productivity that is difficult to assess, especially when applied to soils, water, and the landscape. However, it is possible to have productivity impairment without substantial carbon loss, and it is possible to have carbon loss (e.g. thinning) without productivity impairment. A change in species composition may not degrade a forest in terms of productivity. In addition, several of the existing definitions of *forest degradation* are not restricted to human-induced activities. Lastly, normal forest management operations such as thinning, harvest and regeneration, while reducing the canopy cover, may not reduce the productivity or carbon storage capacity of the forest, and in fact may increase it. Thus, overstorey reduction alone may not entail *forest degradation*.

Several possible definitions of *forest degradation* are presented in Table 2.1. These definitions reflect a variety of definitional forms and features among existing and proposed definitions of *forest degradation*. Numbers 2 and 4 are drawn from other organisations and processes, the others are based on discussions between the authors in the light of review comments.

TABLE 2.1
ALTERNATIVE DEFINITIONS OF DIRECT HUMAN-INDUCED FOREST DEGRADATION

Definition	Methodological Implications
(1) A direct human-induced loss of forest values (particularly carbon), likely to be characterised by a reduction of tree crown cover. Routine management from which crown cover will recover within the normal cycle of forest management operations is not included.	<u>Land Area Identification</u> • Use of "crown cover" leads to readily identifiable land areas for monitoring and verification purposes. • Not all losses of forest values result in tree crown cover loss. <u>Emissions Estimation</u> • It is difficult to identify and separate routine or normal management operations. <u>General</u> • "Forest values" go beyond those relevant to emissions reporting and might be relatively difficult to define and quantify. • This definition restricts changes to those that are direct human-induced.
(2) Changes within the forests that negatively affect the structure or function of the stand and site, and thereby lower the capacity to supply products and/or services.	<u>Land Area Identification</u> • It is not technically feasible to implement identification of land areas. <u>Emissions Estimation</u> • Change in structure or function may not be accompanied by change in carbon stock. <u>General</u> • This is the FAO definition of *forest degradation* cited in the report on the Expert Meeting on Harmonization of Forest-related Definitions for Use by Various Stakeholders, Rome, 23-25 January 2002 (UNEP/CBD/COP/6/INF/26). • *Degradation* as defined may not be human-induced. • "Products and/or services" go beyond those values relevant to emissions reporting. • This definition includes changes that may be temporary.
(3) Direct human-induced activity that leads to a long-term reduction in forest carbon stocks.	<u>Land Area Identification</u> • This definition provides no basis for identifying land areas affected by *degradation*. <u>Emissions Estimation</u> • This definition explicitly links to change in carbon stocks. <u>General</u> • This definition specifies change in carbon stock is direct human-induced, and long-term, not temporary. "Long-term" requires interpretation.

TABLE 2.1 (CONTINUED) ALTERNATIVE DEFINITIONS OF DIRECT HUMAN-INDUCED FOREST DEGRADATION	
Definition	**Methodological Implications**
(4) The long-term reduction of the overall potential supply of benefits from the forest, which includes carbon, wood, biodiversity and any other product or service.	Land Area Identification • This definition provides no basis for identifying areas affected by *degradation*. Emissions Estimation • Consideration of forest values beyond carbon stocks is required. General • This definition follows recommendations from the FAO's second expert meeting on harmonizing forest-related definitions for use by various stakeholders (11-13 September 2002 in Rome). See the proceedings of the Expert Meeting on Harmonization of Forest-related Definitions for Use by Various Stakeholders. • It is impossible to quantify/verify a reduction in "potential supply of benefits". • This definition represents a broad set of values that would encourage a comprehensive treatment of forest values. • Comprehensive treatment going beyond those relevant to emissions reporting might be relatively difficult to define and quantify. • This definition does not specify it is direct human-induced.
(5) The overuse or poor management of forests that leads to long-term reduced biomass density (carbon stocks).	Land Area Identification • Determining overuse and poor management practices creates difficulty in identifying those areas to be reported and in estimating emissions. Emissions Estimation • This definition only explicitly links to change in "biomass" carbon stocks. General • This definition parallels the definition of "degraded forest" in the *IPCC Guidelines*. • This definition specifies change in carbon stock is direct human-induced, and long-term, not temporary. "Long-term" requires interpretation. • "Overuse" and "poor management" imply direct human-induced.

It is apparent from the alternative definitions in Table 2.1 how specific terms and phrases may affect the implementation of emissions inventory and reporting. Some of the concepts that surface in these definitions include:

Canopy change: Changes in forest structure that are not directly related to observable changes in canopy cannot be detected by remote sensing. Remote sensing remains one of the most efficient means of detecting activities across broad spatial extents that impact forests. For example, only two recent publications describe monitoring of *forest degradation*, and both appear to use tree cover as a surrogate for *degradation* (Lambin 1999; Gier and Hussin 1995).

Ambiguous terms: *Forest degradation* defined by terms such as "potential supply of benefits" or "poor management" requires subjective decisions to determine whether a candidate area has been subjected to *degradation*. Furthermore, reductions in potential supplies of benefits can be achieved by legislation or regulation (for example, by restricting access to the services a forest can provide). Therefore, such definitions can imply that forests might be degraded (or the reverse) by fiat, without any corresponding biological or physical changes.

Carbon stocks: Estimating emissions from changes in forest structure involves an assessment of carbon pools as elaborated in Chapter 3 of the *GPG-LULUCF*, implying that definitions not relating to carbon stocks may be less helpful in framing methodologies for inventory and reporting of emissions. In addition, definitions framed for example in terms of production impairment count as *degradation* situations in which there are no discernable carbon stock changes or emissions of non-CO_2 greenhouse gases, and conversely may exclude forests with substantial emissions.

Other forest values: Definitions that allude to multiple forest benefits may encourage a more comprehensive treatment of forest values, but may prove exceedingly difficult to implement in a consistent, transparent manner.

Long-term effects: While restriction of *forest degradation* to situations exhibiting long-term effects is helpful to exclude annual variability and normal management, it requires that "long-term effects" be specified. In some cases, operationalisation of definitions including "long-term effects" may require the prediction or estimation of whether observed changes would persist for a specified duration.

Exclusion of deforestation: For the purposes of the Kyoto Protocol, it makes sense to ensure that the definition of *forest degradation* is not construed as including *deforestation* as defined in the Marrakesh Accords.

Source of degradation: To maintain consistency with other definitions applied to the Kyoto Protocol, *forest degradation* should be limited to results from direct human-induced processes, activities, and practices.

Minimum area threshold: The Marrakesh Accords define forest as comprising "a minimum area of 0.05 to 1.0 hectare with tree crown cover (or equivalent stocking level) of more than 10-30 percent...". *Forest degradation*, being limited to forests, therefore embodies a concept of a minimum area. However, activities that cause *forest degradation* may occur in isolated portions of a forest, so it might be helpful to clarify the minimum area impacted by activities within a forest in defining *forest degradation*.

Biomass: Defining *forest degradation* based on changes in biomass may be the most straightforward to implement and can be directly related to estimates of all relevant forest carbon pools.

In fact none of the alternative definitions in Table 2.1 fully meets the desired characteristics of a definition of *forest degradation* that can be effectively operationalised. In the context of the Kyoto Protocol, a framework for a definition of *forest degradation* that meets the criteria discussed could be:

A direct human-induced long-term loss (persisting for X years or more) of at least Y% of forest carbon stocks [and forest values] since time T and not qualifying as deforestation or an elected activity under Article 3.4 of the Kyoto Protocol.

It would remain to specify an area threshold if desired, as well as time and carbon loss thresholds in order to operationalise such a definition.

2.2.2 Example Applications of Definitions of Forest Degradation

To illustrate how some of the example definitions and elements might be interpreted in specific instances, some hypothetical examples are useful. The situations in Box 2.1 might commonly be perceived as *forest degradation*, but show that this could be hard to detect, and application of various definitions could lead to differing results.

BOX 2.1
HYPOTHETICAL CASES ILLUSTRATING POTENTIAL FOREST DEGRADATION

Case A: **"High-grading".** A logging operation in a dense, mixed-age, mixed-species forest removes approximately 40% of existing crown cover. Residual crown cover is approximately 60%. Trees are selected for removal based purely on highest economic value, with no care or planning given to regeneration or to the health of residual trees. Mechanical logging and temporary road construction is conducted in such a way that considerable damage to the residual forest results.

Case B: **"Overgrazing".** An open forest (approximately 40% crown cover) is heavily grazed by livestock. Grazing intensity is at a level that has prevented regeneration of tree species or desirable understorey species. Soil compaction and bark stripping are expected to reduce the growth of forest trees over the long term.

Case C: **"Human incursion".** As a local human population expands, people have begun building dwellings and roads in a forest. Canopy loss at present is minimal; only very small-scale clearing has occurred. However, human impacts on the forest are increasing as more non-timber forest products are being extracted and selected trees of desirable species are harvested for economic returns.

The case of high-grading (Case A) represents an activity that should be detectable by remote sensing, activity reporting (assuming the logging was legal), and forest sampling. There is an immediate and measurable impact in the loss of forest carbon stocks. Longer-term impacts might include reduced biodiversity through the removal of certain species and prevention of their regeneration. Water and soil erosion may occur when mechanical logging is done on steep slopes, further degrading the long-term productivity of the site. In addition, damage to residual trees could be expected to result in mortality and/or growth loss, creating a longer-duration carbon impact. These long-term effects would be difficult to predict quantitatively. Since residual tree cover is high (60%), deforestation would not have occurred (unless perhaps a very small area threshold for *forest* were applied). If the activity as described were considered part of normal forest management, then a clause such as the one in the alternative definition (1) in Table 2.1 would exclude this activity from *degradation*.

In the case of overgrazing (Case B), it is expected that most remote sensing systems would be unable to detect this activity. Depending on the resolution of the remote sensing imagery, the season, and the degree of understorey vegetation removal, the lack of tree canopy impact may obscure the activity from aerial detection. Even ground sampling may not be able to detect this activity unless grazing impacts were severe. There is no immediate carbon stock change in the tree biomass, so standard approaches to estimating forest carbon stocks would show no change. Furthermore, definitions based on a carbon stock loss may not consider this situation a case of *degradation*. Longer-term impacts of reduced biodiversity in the understorey and growth loss due to damaged trees and compacted soils would be extremely difficult to quantify. This case also illustrates the challenge of defining land areas for emissions reporting.

Finally, in the case of human incursion into forested areas (Case C), the case represents a possible precursor to deforestation through land-use change (from forest to human settlements). As long as the tree crown cover threshold for "forest" as applied by the country has not been crossed, it can be reasoned that deforestation has not occurred. However, as in Case A, there is a detectable level of carbon stock changes (observable through remote sensing, forest sampling, or perhaps activity reporting). The immediate loss of carbon stocks in the limited clearing might be expected to remain. Additional longer-term carbon stock loss is likely but is difficult to predict. Also, in this case the short-term level of forest values (goods and services actually used) has likely increased, not decreased. Therefore, under the alternative definition (4) in Table 2.1, this activity would be considered to be *forest degradation* only if substantial long-term adverse impacts are predicted.

2.3 DEFINITIONS OF DEVEGETATION OF OTHER VEGETATION TYPES

2.3.1 Possible Definitions of Devegetation and Their Key Features

There are very few published definitions of *devegetation* and they are essentially the corollaries of *deforestation*. While the Marrakesh Accords do not define *devegetation*, they do define *revegetation* as "...a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation...."[8]

Therefore, several options for defining *devegetation* could be considered – including one as a corollary to *deforestation* and others as the reverse of *revegetation* (Table 2.2).

[8] See paragraph 1 (e) in the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry) contained in FCCC/CP/2001/13/Add.1, p.56.

TABLE 2.2
ALTERNATIVE DEFINITIONS OF DIRECT HUMAN-INDUCED DEVEGETATION OF OTHER VEGETATION TYPES

<table>
<tr><th>Definition</th><th>Methodological Implications</th></tr>
<tr><td>(1) A direct human-induced activity to decrease carbon stocks on sites through the removal of vegetation that covers a minimum area of 0.05 hectare and does not meet the definitions of deforestation or forest degradation.</td><td><u>Land Area Identification</u>
• Minimum area specification (0.05 hectare) comes from the revegetation definition.
<u>Emissions Estimation</u>
• This definition is related to carbon stock changes.
<u>General</u>
• This definition is the reverse of revegetation, and there is no removal threshold specified, though in practice there would be a minimum detectable level for decreases set by the sampling. The effect is to consider the degrading of carbon stocks in non-forest vegetation cover.
• While not explicitly stated, the intention is to be applied to non-forest land.</td></tr>
<tr><td>(2) A direct human-induced activity that decreases carbon stocks through changes in vegetation on non-forest land over an area of 0.05 hectare or greater. Changes within normal management cycles are not included.</td><td><u>Land Area Identification</u>
• Area threshold is applied to the area of vegetation change.
• It is necessary to specify the level of vegetation "change" that leads to a decrease in carbon stocks (complete removal of vegetation, change down to a threshold, or any change).
<u>Emissions Estimation</u>
• This definition is related to carbon stock changes.
<u>General</u>
• This definition excludes temporal changes related to normal management, although presents a difficulty in identifying normal management cycles.
• This definition applies to vegetated land not defined as forest land.
• As with the alternative definition (1) above, there would be a minimum detectable level for decreases set by the sampling.</td></tr>
<tr><td>(3) A direct human-induced activity that decreases carbon stocks on sites through the reduction of vegetation that covers a minimum area of 0.05 hectare and does not meet the definition of deforestation.</td><td><u>Land Area Identification</u>
• Area threshold is applied to the area of vegetation change.
• Minimum area specification (0.05 hectare) comes from the revegetation definition. To operationalise this definition, the amount of "reduction" needs to be defined (e.g. complete removal of vegetation, reduction to a threshold, or any reduction).
<u>Emissions Estimation</u>
• This definition is related to carbon stocks.
<u>General</u>
• This definition is identical to the alternative definition (1) in this table except for the use of "reduction" in place of "removal", and the exclusion of forest degradation.
• Because this definition applies to all lands except for deforestation, it could conceivably be applied to instances of forest degradation.
• As with the alternative definition (1) there would be a minimum detectable level for decreases set by the sampling</td></tr>
<tr><td>(4) The direct human-induced conversion of other vegetated land to non-vegetated land. (Deforestation equivalent).</td><td><u>Land Area Identification</u>
• No area specification is provided for what constitutes other vegetated land.
• The change in land cover would facilitate identifying relevant areas.
• To operationalise this definition, a definition of vegetated land (e.g. foliage cover of at least X%) is required.
<u>Emissions Estimation</u>
• This definition is based on land cover change, not carbon stocks.
<u>General</u>
• This definition parallels deforestation, providing clear thresholds (not present in revegetation) that trigger inclusion within the accounting framework. Vegetated areas, which are temporarily unstocked as a result of human intervention but will recover, are not necessarily excluded.</td></tr>
</table>

The alternative definitions given in Table 2.2 differ in terms of their implications for greenhouse gas emissions accounting and reporting from activities that cause *devegetation*. Concepts that should be considered in assessing differences among the definitions include:

> *Other vegetation types:* "Other vegetation types" means areas covered with vegetation other than forest. There is an issue as to how much cover is needed for an area to be considered vegetated. FAO uses 4% for classifying lands as vegetated while some countries have different thresholds. The thresholds should be similar to those for *forest* defined in the Marrakesh Accords – i.e. 10-30% cover.
>
> *Carbon stocks:* Definitions of *devegetation of other vegetation types* based on decreases in carbon stocks relate most directly to assessment of changes in carbon pools and emissions and removals of greenhouse gases. The ability to use remote sensing to detect decreases in carbon stocks will vary depending on how the decreases in carbon stocks are defined (i.e., changes in vegetation types, reductions in vegetation, or removal of vegetation as in definitions (1) to (3) in Table 2.2). Remote sensing offers efficient methods for detecting change across the large spatial areas required for national emissions inventory and reporting. Defining decreases in carbon stocks as a "change" in vegetation may have different implications for detection by remote sensing than a "reduction" or "removal" of vegetation.
>
> *Reduction/removal/change threshold:* In order to identify land affected by a "reduction" or "removal" or "change" of vegetation, or a change in vegetation type, thresholds of "reduction" or "removal" or "change" have to be defined. Thresholds should constitute a reduction/removal/change large enough to be detectable and measurable. The thresholds may be defined with reference to a baseline, in which case "reductions", "removals" or "changes" would be defined relative to the baseline condition. For example, the baseline condition could be a percentage of vegetation cover for a specific biome, region or land use that constitutes "vegetated".
>
> *Minimum area threshold:* The Marrakesh Accords define *revegetation* as the establishment of vegetation on a minimum area of 0.05 hectare. It may be useful to define a minimum area threshold for *devegetation of other vegetation types*. *Revegetation/devegetation of other vegetation types* accounting is most likely to be *balanced* if they share a common minimum area threshold.
>
> *Long-term effects*: The definition of *devegetation of other vegetation types* will be easier to implement if changes/removal/reduction in vegetation is defined as long-term and relative to a starting point. By referencing a starting point and the number of years that are considered long-term, *devegetation* represents a trend of decline in carbon stocks rather than periodic reductions in vegetation from which the system will recover. For example, within an annual cycle, carbon stocks could decline during grazing periods, but recover or exceed the initial condition on average over time.
>
> *Exclusion of deforestation or Article 3.4 activities*: For the purposes of the Kyoto Protocol, it makes sense to ensure that the definition of *devegetation of other vegetation types* is not construed as including *deforestation* or activities under Article 3.4 of the Kyoto Protocol (as defined in the Marrakesh Accords) but can be applied to all other lands.

Devegetation of other vegetation types could be defined as the reciprocal of *revegetation* (the alternative definitions (1) to (3) in Table 2.2) or as the counterpart to *deforestation* (the alternative definition (4) in Table 2.2). As noted in Table 2.2, to operationalise a *deforestation*-equivalent definition of *devegetation of other vegetation types* would require that vegetated land be defined, in the same way that *forest* is defined, because the change from vegetated land to devegetated land would be achieved by crossing specified thresholds, which may make detection relatively easy, but *devegetation of other vegetation types* would then be based on changes in land cover rather than on changes in carbon stocks.

None of the alternative definitions in Table 2.2 fully meets the criteria for a definition of *devegetation of other vegetation types* that would be practical to implement or operationalise. A framework definition that characterises *devegetation of other vegetation types* in the context of the Kyoto Protocol and practicality would be:

A direct human-induced long-term loss (persisting for X years or more) of at least Y% of vegetation [characterized by cover / volume / carbon stocks] since time T on vegetation types other than forest and not subject to an elected activity under Article 3.4 of the Kyoto Protocol. Vegetation types consist of a minimum area of land of Z hectares with foliar cover of W%.

It remains for the Parties to specify area thresholds, as well as time, reduction/removal thresholds, referencing point and biomass cover threshold for other vegetation types in order to operationalise such a definition.

2.3.2 Example Applications of Definitions of Devegetation of Other Vegetation Types

Box 2.2

Hypothetical cases illustrating potential devegetation of other vegetation types

Case A: **"Shrub suppression".** The vegetative community of a grazing land includes shrubs that cover 40% of that area. To improve the quality of the land for cattle grazing, the area is burned. The annual and grassy vegetation types return, but there is a decline in carbon stocks. After burning, the land is vulnerable to soil erosion until vegetation cover is re-established.

Case B: **"Overgrazing".** A grassland is heavily stocked with livestock so that grazing intensity exceeds the capacity of the vegetation to recover, causing changes to the vegetation community, which can lead to a decline in soil carbon stocks. There is an increase in bare ground and the risk of soil loss due to erosion.

Case C: **"Human incursion".** Expansion of human populations increases the amount of land taken up by dwellings, communities and roads in grassland. *Devegetation* can also occur if large herds of grazing livestock accompany the human incursion or if the grassland is cultivated for production of annual crops.

Case A, shrub suppression, represents a type of *devegetation* activity that should be detectable with remote sensing methods, activity reporting, and vegetation sampling. Shrub removal is immediate and measurable and represents a loss of aboveground organic carbon stocks. Longer-term impacts might include reduced biodiversity through the removal of shrubby species types, as well as changes in other vegetation types caused by fire. In the long-term, it is difficult to predict or quantify the magnitude of effect. Whether the grazing land recovers to the extent that there is no long-term change in carbon stocks will depend on how the land is managed after the shrub suppression.

Overgrazing, (Case B), would probably be more difficult to detect with remote sensing systems, unless the change was from very high to very low ground cover over a short time. More gradual or less severe overgrazing may not be detectable even with ground sampling. Long-term reductions in aboveground biomass will cause corresponding declines in soil carbon, and may also be associated with increased rates of soil erosion. Because overgrazing can occur episodically, it may be difficult to know whether detection of reduced vegetation due to grazing at any point in time represents "overgrazing" and *devegetation*. This case illustrates the difficulty in separating what is short-term and part of normal management from activities like overgrazing that cause long-term decline in carbon stocks and identify the land as devegetated.

Human incursion into a grassland (Case C) represents a possible precursor to land-use change (from grassland to human settlements). The conversion of grassland to roads or settlements is likely to reduce vegetation beyond a *devegetation* threshold that is detectable and measurable with remote sensing, sampling or activity reporting. Increased human proximity to the land could increase risks, such as fire, that could also result in large-scale and easily detectable losses of carbon. Other types of general human use of the land might cause vegetation losses that are less easy to detect or predict.

3 METHODOLOGICAL OPTIONS FOR ESTIMATING EMISSIONS FROM FOREST DEGRADATION AND DEVEGETATION

This chapter discusses methodological approaches that may be used to estimate annual changes in carbon stocks and emissions of non-CO_2 greenhouse gases caused by direct human-induced *forest degradation* and *devegetation* activities. The relationship to the activities under Article 3.4 of the Kyoto Protocol (i.e. *cropland management, grazing land management, forest management* and *revegetation*), and to non-CO_2 emissions from agricultural soils is addressed taking into account relevant material from the *IPCC Guidelines*, the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (*GPG2000*; IPCC, 2000a) and the *GPG-LULUCF*. Further development may or may not be required depending on the final form of definition adopted. However, the general suite of options for estimating emissions is discussed in this chapter.

3.1 INTRODUCTION

In general where *forest management* has been elected, all changes in carbon stocks and emissions and removals of greenhouse gases will be accounted for[9] within the areas accounted for and *forest degradation* within these areas should not be an issue. Similarly, *devegetation* should not be an issue where *cropland* and *grazing land management* are elected, irrespective of whether *revegetation* is elected itself. Other elected choices are in themselves no evidence that *degradation* or *devegetation* are taking place, but if a general methodology to estimate carbon stock changes and emissions and removals associated with them would include the following steps:

Step 1: Selection of reporting method for identification of geographical location of *forest degradation* and *devegetation*. Although explicit and complete identification of boundaries for areas throughout the country is possible, it may not be feasible in practice for many countries. Reporting could be based on broad area identification, which is a method at a local level using legal, administrative, or ecosystem boundaries or grids. Another method is a complete geographical identification of land areas subject to specified activities. More details of the methods are provided in Section 4.2.2, Chapter 4 of the *GPG-LULUCF* (Generic Methodologies for Area Identification, Stratification and Reporting).

Step 2: Identification of standards against which potentially degrading and devegetating processes can be compared. Conformity with codes of practice directed at sustainable management will provide an important indicator.

Step 3: Identification of lands where direct human-induced *forest degradation* and/or *devegetation of other vegetation types* according to selected/accepted definitions has led to long-term reduction of carbon stocks.

Step 4: Estimation of carbon stock changes and emissions and removals of non-CO_2 greenhouse gases due to direct human-induced *forest degradation* and *devegetation* activities. This can be done based on the methods described in Chapter 3 of the *GPG-LULUCF* (LUCF Sector Good Practice Guidance).

More detailed discussion on the steps is provided below.

3.2 APPROACHES TO IDENTIFICATION OF LAND AREAS SUBJECT TO FOREST DEGRADATION AND DEVEGETATION

Processes resulting in *forest degradation* may occur across a range of spatial scales, from limited tree removal to widespread removal of substantial portions of a forest. The elements of definitions discussed in Section 2.1, and a framework definition provided in Section 2.2 for *forest degradation* require the determination of thresholds for

[9] Subject to the (conservative) exemption of pools for which information can be provided that they are not a source.

time and detection of minimum carbon loss, and possibly also a minimum area threshold. Processes resulting in *devegetation of other vegetation types* may also occur across a range of spatial scales, from limited vegetation removal to widespread and complete removal of vegetation. The framework definition of *devegetation of other vegetation types* provided in Section 2.3 also requires determination of thresholds for time and minimum detection of removal/reduction/change of vegetation, and possibly also a minimum area threshold. Thresholds for long-term and minimum loss of carbon or vegetation will affect the method used for land area identification and subsequent quantification of the carbon and non-CO_2 greenhouse gas impacts of the activity that has lead to *degradation* or *devegetation*, according to the applied definition.

Identification of land areas subjected to processes resulting in *forest degradation* and *devegetation* is possible using approaches such as remote sensing with ground truthing, forest/vegetation sampling, activity reporting, or a combination of these methods (see Section 4.2.2, Chapter 4 of the *GPG-LULUCF* (Generic Methodologies for Area Identification, Stratification and Reporting)). Low or small thresholds may require higher-resolution remote sensing with continuous spatial coverage; higher intensity sampling systems, or detailed and comprehensive activity reporting systems. To determine that *forest degradation* or *devegetation of other vegetation types* is occurring, monitoring and measurements may be required through time. Hypothetical cases illustrating potential for *forest degradation* are provided in Section 2.2.2 and for *devegetation of other vegetation types* in Section 2.3.2.

3.3 ESTIMATION OF CARBON STOCK CHANGES AND NON-CO_2 GREENHOUSE GAS EMISSIONS

Once land areas subject to *forest degradation* or *devegetation of other vegetation types* have been identified, changes in carbon stocks and emissions of non-CO_2 greenhouse gases can be estimated. Methods for calculation of carbon stock changes vary for the relevant carbon pools (aboveground biomass, belowground biomass, litter, dead wood and soil organic carbon), as well as for emissions of non-CO_2 greenhouse gases and should be based on those given in the *IPCC Guidelines*. Further elaboration of the methods is described in Chapter 3 of the *GPG-LULUCF* (LUCF Sector Good Practice Guidance): namely, estimation methods described in Section 3.2.1 (Forest Land Remaining Forest Land) are applicable to *forest degradation*, and those described in Sections 3.3 (Cropland), 3.4 (Grassland) and 3.5 (Wetlands) are applicable for *devegetation of other vegetation types*.

Human-induced activities that lead to *forest degradation* and *devegetation of other vegetation types* often have the potential to change emissions of non-CO_2 greenhouse gases (CH_4 and N_2O). However, reliable estimation is often difficult because of paucity of data. In the *GPG-LULUCF*, emission sources of non-CO_2 greenhouse gases considered are fire, changes in water table in organic soils, and fertilisation. Methods for estimating emissions of non-CO_2 greenhouse gases from these processes are described in the *IPCC Guidelines*, the *GPG2000* (as regards non-CO_2 emissions from agricultural soils), and the *GPG-LULUCF* (Chapter 3).

3.4 APPROACHES AND TIERS

Estimation of annual changes in carbon stocks and emissions of non-CO_2 greenhouse gases from direct human-induced *forest degradation* and *devegetation of other vegetation types* can be obtained through the same approaches as those applied to activities under Article 3.4 of the Kyoto Protocol. A variety of means, encompassing the three general approaches to estimation of affected land area are provided in Section 4.2.2, Chapter 4 of the *GPG-LULUCF* (Generic Methodologies for Area Identification, Stratification and Reporting).

3.5 QUALITY ASSURANCE / QUALITY CONTROL

Chapter 8 of the *GPG2000* (Quality Assurance and Quality Control) defines quality assurance (QA) and quality control (QC), and provides guidance on the elements of a QA/QC system, taking into account the need for transparency and review.

The *GPG-LULUCF* describes methodological approaches to land area identification and estimation of emissions and removals of greenhouse gases. These approaches are also applicable to *forest degradation* and *devegetation of other vegetation types* (Chapter 3, LUCF Sector Good Practice Guidance, and Chapter 4, Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol). Chapter 5 of the *GPG-LULUCF* (Cross-Cutting Issues) sets out the principles for QA/QC and uncertainty management that are also applicable to estimation of emissions from *forest degradation* and *devegetation of other vegetation types*.

3.6 REPORTING AND DOCUMENTATION

Requirements for LULUCF related reporting and documentation under the Kyoto Protocol are outlined in the Marrakesh Accords and are summarised in Section 4.2, Chapter 4 of the *GPG-LULUCF* (Methods for Estimation, Measurement, Monitoring and Reporting of LULUCF Activities under Articles 3.3 and 3.4).

Reporting tables for the activities under Article 3.4 of the Kyoto Protocol are provided in Chapter 4 of the *GPG-LULUCF*. Tables have to be adapted to national circumstances. Those reporting tables are: the land transition matrix where the land area subject to the various activities in the inventory year and the previous year should be reported (Table 4.2.5 in the *GPG-LULUCF*); the tables to be completed annually for each elected activity (Tables 4.2.6a – 4.2.6c in the *GPG-LULUCF*); and the summary table of yearly carbon stock changes for the activities (Table 4.2.7 of the *GPG-LULUCF*).

All information used to produce estimates for emissions and removals of greenhouse gases should be documented and archived. Documentation should include references of data, methods used and interpretation of activity definitions in the Marrakesh Accords made by the Party according to national circumstances, and an analysis of fluctuations between years. Documented data and methods should be related to land identification and estimation of emissions and removals of greenhouse gases. Documentation should also include uncertainty assessment, QA/QC procedures, external and internal reviews, information on key categories and key category identification as described in Chapter 5 of the *GPG-LULUCF*, and planned improvements to the inventory.

The framework of these tables in Chapter 4 of the *GPG-LULUCF* could be retained, and added to as needed, to include *forest degradation* and *devegetation of other vegetation types*. The nature of additions would be dependent on the final choice of definition.

4 IMPLICATIONS OF THE DEFINITIONAL OPTIONS FOR FOREST DEGRADATION AND DEVEGETATION UNDER ARTICLE 3.4 OF THE KYOTO PROTOCOL

4.1 INTRODUCTION

This section of the report discusses:

- Circumstances in which LULUCF accounting and reporting could be *unbalanced* or *incomplete*;
- The implications of the discussed definitions of *forest degradation* and *devegetation of other vegetation types* for addressing potential *unbalance*; and
- Relative costs of the different definitional options in producing inventories and reporting for *forest degradation* and *devegetation of other vegetation types*.

The methodological guidance on the reporting of emissions and removals of greenhouse gases from land use, land-use change and forestry (LULUCF) will generally include the effects of any *forest degradation* and *devegetation of other vegetation types*, though there is no specific advice on identifying these as specific activities.

4.2 FOREST DEGRADATION

Under the Kyoto Protocol, Annex I Parties report carbon stock changes in forests mostly under Article 3.3 (*afforestation*, *reforestation* and *deforestation*) and Article 3.4 (*forest management*). Article 3.3 requires compulsory reporting of verifiable changes in carbon stocks and greenhouse gas emissions and removals resulting from *afforestation*, *reforestation* and *deforestation*. Accounting for activities under Article 3.4 is voluntary for the first commitment period.

This report considers the potential for *unbalanced accounting* in the case that a Party chooses to account for *forest management* under Article 3.4 of the Kyoto Protocol, but the total area of managed forest other than *afforestation*, *reforestation* and *deforestation* under Article 3.3 in that country is not the same as the area of land reported under *forest management*, plus areas reported under Article 3.3. In such circumstances, accounting for emissions and removals of greenhouse gases is *symmetric* within the boundary that encompasses the *forest management* land, but may be *incomplete* if there are areas of managed forest (other than those reported under Article 3.3) outside the *forest management* boundary that are net sources or net sinks of greenhouse gases (Figure 4.1). This difference may result from the literal interpretation and application of the *forest management* definition that requires this activity to fulfil "relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner"[10]. Forest land managed in ways that do not meet these criteria may be excluded from the reporting and accounting framework under Article 3.4 of the Kyoto Protocol. The possibility of *unbalance* through *incompleteness* may be addressed by making *forest management* and managed forest (other than those reported under Article 3.3) coterminous for the purposes of estimating carbon stock changes, emissions and removals for Kyoto accounting.

[10] See paragraph 1 (f) in the Annex to draft decision -/CMP.1 (Land use, land-use change and forestry) contained in FCCC/CP/2001/13/Add.1, p.56.

List of Reviewers

Argentina
Ginzo, H. Ministry of Foreign Affairs

Australia
Burrows, W. Cooperative Research Centre for Greenhouse Accounting(CRC GA) Queensland Department of Primary Industries (QDPI)
Carruthers, I. Australian Government
Henry, B. CRC GA Queensland Natural Resources and Mines (Qld NR&M)
Mokany, K. CRC GA
Raison, J. CRC GA & Commonwealth Scientific & Industrial Research Organisation (CSIRO)

Austria
Radunsky, K. Federal Environment Agency

Benin
Guendehou, S. Benin Centre of Scientific and Technical Research(CBRST)

Bolivia
Arana Pardo, I. National Climate Change Programmeof Bolivia

Brazil
Rocha, M. Centro de Estudos Avançados em Economia Aplicada (CEPEA-ESALQ/USP)

Canada
Huffman, T. Department of Agriculture and Agri-Food
Lempriere, T. Canadian Forest Service
Trofymow, J. Canadian Forest Service

China
Chen, Z. China Meteorological Administration
Gao, Y. China Meteorological Administration
Kong, X. Ministry of Foreign Affairs
Li, L. State Development Planning Commission
Li, Y. Chinese Academy of Agriculture
Liu, H. National Meteorological Center
Liu, S. Chinese Academy of Forestry
Lv, X. Ministry of Science and Technology
Ma, A. State Development Planning Commission
Qin, D. China Meteorological Administration
Wang, B. China Meteorological Administration
Wang, X. State Forestry Administration
Xu, D. Chinese Academy of Forestry
Yan, C. Ministry of Agriculture
Yang, Z. National Satellite Meteorological Center
Yi, X. Ministry of Foreign Affairs

China (Continued)
Ying, N. China Meteorological Administration
Zhang, L. National Satellite Meteorological Center
Zhang, X. Chinese Academy of Forestry
Zheng, G. China Meteorological Administration

Finland
Lapveteläinen, T. Ministry of Agriculture and Forestry
Vainio-Mattila, M. Ministry of Agriculture and Forestry

Germany
Fiedler, S. University of Hohenheim
Georgi, B. Federal Environmental Agency
Ploetz, C. on behalf of Umweltbundesamtes (UBA)
Strich, S. Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft (BMVEL)

Iceland
Ministry for the Environment

India
Satyanarayana, M. Ministry of Environment & Forests, Government of India
Surya Prakash, M. Ministry of Environment & Forests, Government of India

Italy
Italian Ministry of Environment and Territory
Tubiello, F. Columbia University

Japan
Fujimori, T. Japan Forest Technological Association
Handa, M. Organization for Landscape and Urban Greenery Technology Development
Harada, T. Forestry Agency, Ministry of Agriculture, Forestry and Fisheries
Hayashi, Y. National Institute for Agro-Environmental Sciences
Higashi, M. Ministry of Land, Intrastructure and Transport
Hiranuma, K. Ministry of Agriculture, Forestry and Fisheries
Honda, Y. Chiba University
Inoue, G. National Institute for Environmental Studies
Ishizuka, M. Forestry and Forest Products Research Institute
Itakura, T. Ministry of Eduation, Culture, Sports, Science and Technology
Itakura, K. Ministry of Land, Intrastructure and Transport
Kato, J. Ministry of Land, Infrastructure and Transport

Japan (Continued)

Kobayashi, S.	Forestry and Forest Products Research Institute
Kohyama, T.	Hokkaido University
Koike, T.	Hokkaido University Forests, FSC
Matsumoto, M.	Forestry and Forest Products Research Institute (FFPRI)
Matsuo, N.	Climate Expert
Minami, K.	National Institute for Agro-Environmental Sciences
Morikawa, Y.	Waseda University
Muto, N.	Forestry Agency, Ministry of Agriculture, Forestry and Fisheries
Nara, C.	Ministry of the Environment
Nouchi, I.	National Institute for Agro-Environmental Sciences
Ogiwara, H.	Forestry Agency, Ministry of Agriculture, Forestry and Fisheries
Ohta, S.	Forestry and Forest Products Research Institute (FFPRI)
Oikawa, K.	University of Tsukuba
Okuda, T.	National Institute for Environmental Studies
Shibasaki, R.	University of Tokyo
Shimizu, K.	Forestry and Forest Products Research Institute
Shirato, Y.	National Institute for Agro-Environmental Sciences
Sweda, T.	Ehime University
Takahashi, M.	Forestry and Forest Products Research Institute
Taniyama, I.	National Institute for Agro-Environmental Sciences
Tanouchi, H.	Forestry and Forest Products Research Institute
Tonosaki, M.	Forestry and Forest Products Research Institute
Tsuruta, H.	National Institute of Agro-Environmental Sciences
Watanabe, T.	Forestry Agency, Ministry of Agriculture, Forestry and Fisheries
Yagi, K.	National Institute for Agro-Environmental Sciences
Yamagata, Y	National Institute for Environmental Studies (NIES)
Yasuoka, Y.	University of Tokyo

Morocco

Yassin, M.	National Centre of Forest Research (CNRF)

New Zealand

Maclaren, P.	Piers Maclaren and Associates
Tate, K.	Landcare Research

Norway

Ministry of Agriculture

Lindstad, B.	Agricultural University of Norway
Løbersli, E.	Directorate for Nature Mangement
Pettersen, M.	Norwegian Pollution Control Authority

Norway (Continued)

Rosland, A.	Norwegian Pollution Control Authority
Rypdal, K.	Center for International Climate and Environmental Research – Oslo (CICERO)
Solberg, B.	Directorate for Nature Mangement
Utseth, A.	Directorate for Nature Mangement

Russia

Gytarsky, M.	Institute of Global Climate and Ecology

Spain

Sanz, M.	Centro de Estudios Ambientales del Mediterraneo (CEAM)
Vallejo, R.	University of Barcelona

Sweden

Swedish Meteorology and Hydrology Institute

Tuvalu

Fry, I.	Departmentt of Environment

UK

Gregory, S.	FC
Penman, J.	Department for Environment, Food & Rural Affairs (DEFRA)

Ukraine

Bondaruk, G.	Ukrainian Forest Research Institute

US

Andrasko, K.	USEPA
Buford, M.	USDA Forest Service R&D
Goklany, I.	DOI
Hohenstein, W.	USDA
Kruger, D.	USEPA
Lund, H.G.	Forest Information Services
Sampson, R.	The Sampson Group, Inc.
Smith, B.	USDA Forest Service
Stokes, B.	USDA Forest Service R&D

European Commission

Herold, A.	Öko-Institut
Matteucci, G.	Joint Research Centre, Institute forEnvironment and Sustainability (JRC IES)
Seufert, G.	JRC IES
Wenning, M.	

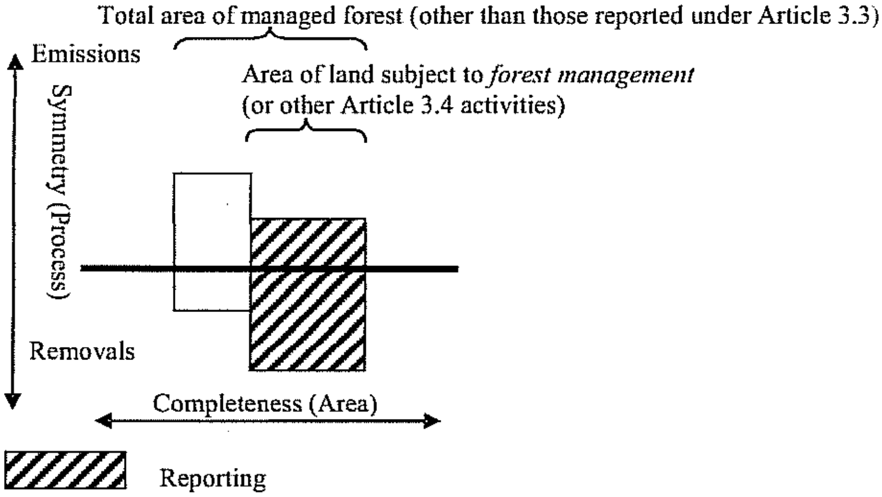
United Nation Framework Convention on Climate Change

Forner, C.	UNFCCC
Granholm, H.	UNFCCC

World Wildlife Fund

Rakonczay, Z.	WWF

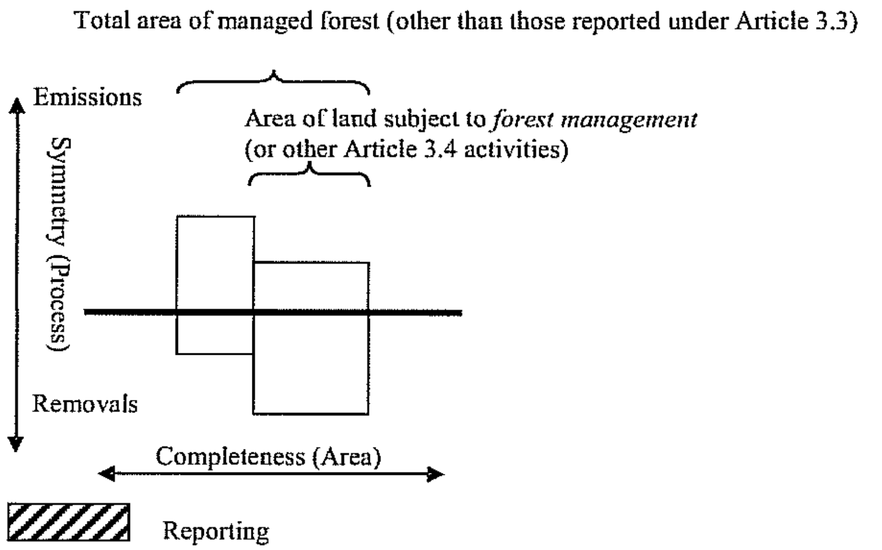
Figure 4.1 Symmetric and incomplete accounting (Case 1)



Note: Accounting on lands captured under Article 3.4 of the Kyoto Protocol is *symmetric* in that all emissions and removals are reported. The accounting may be *incomplete* to the extent that there are areas of managed forest that are not captured under the accounting framework by election or non-election of Article 3.4 activities. If the selection of land is biased toward either net emissions or removals, for example as a result of election of *forest management*, then accounting may be *unbalanced*.

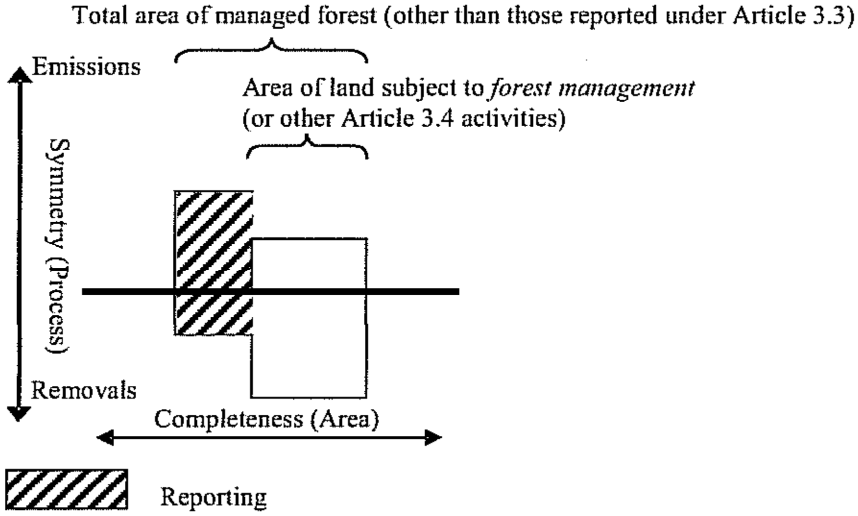
If a Party does not elect *forest management* under Article 3.4, then emissions or removals from the managed forest (other than those reported under Article 3.3) may not be reported. Accounting in that case is *incomplete* but *symmetric* since neither emissions nor removals are reported under Article 3.4 (Figure 4.2). The decision not to elect *forest management* may exclude either net sinks or net sources from the accounting framework, depending on how the forest is managed. If Parties that do not elect to account for *forest management* were to report emissions and removals due to *forest degradation* (by implication an emission source) accounting would be *incomplete* because emissions and removals would only be reported for the selected (degraded) land areas (Figure 4.3). Emissions and removals associated with forest 'aggradation' would not be reported and reporting would be biased toward emissions. Accounting within the identified land areas is *symmetric* (all emissions and removals are reported) and *unbalance* results only from *incomplete accounting*.

Figure 4.2 Symmetric and incomplete accounting (Case 2)



Note: If forest management (or another activity elected under Article 3.4 of the Kyoto Protocol) is not elected, then neither emissions nor removals are reported, so the accounting is *symmetric*, but it is *not complete*. In this case, there is no bias toward emissions or removals, which means the accounting is *balanced*.

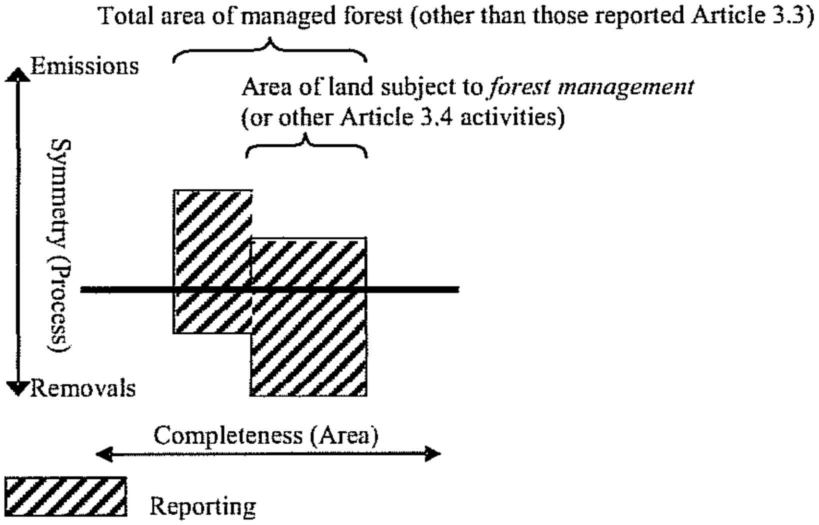
Figure 4.3 Symmetric and incomplete accounting (Case 3)



Note: If Parties were to account for *forest degradation* on land not covered by Article 3.3, *forest management* or other Article 3.4 activity, accounting on land subject to *forest degradation* would be *symmetric* if all emissions and removals are reported. It would be *incomplete* because not all of the managed forest would be included in the accounting framework. In this case, inclusion of land is biased toward net emissions as a result of reporting *forest degradation*, which means the accounting is *unbalanced.*

The scale of emissions and removals captured by including *forest degradation* in the carbon accounting system will depend on how *degradation* is defined. If the accepted definition is based on a broad set of forest values (forest productivity, genes, trees, species composition) some lands that have not lost carbon could be identified as degraded. It is even possible that the forest areas identified could have had an increase of forest carbon in one or more pools as a result of the detected *degradation.* More narrow definitions of *degradation* (i.e. biomass only) will identify only carbon emissions and removals associated with the defined pools. If defined *degradation* criteria are ambiguous and require subjective interpretation, it would be difficult to ensure that the reporting and accounting systems were consistent and homogeneous among the Parties. The consequences for *balanced* accounting of including *forest degradation* in the carbon accounting system if it is based on a definition that does not cover the same carbon pools as defined for Article 3.4 activities in the Marrakesh Accords are extremely difficult to assess. Only if Parties were to include all managed forest land within the accounting framework would all sources and sinks be accounted for and all problems of "*unbalance*" and "*incompleteness*" be avoided (Figure 4.4).

Figure 4.4 Symmetric and complete accounting

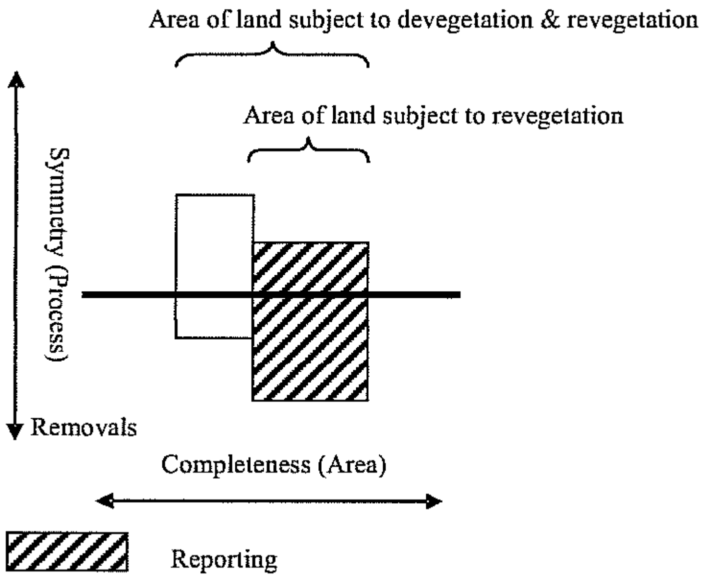


Note: All land affected by an activity under Article 3.4 of the Kyoto Protocol are captured under the accounting framework (*complete*) and all emissions and removals are reported (*symmetric*). In this case, all land is selected which means the accounting is *balanced.*

4.3 DEVEGETATION

Under Article 3.3 of the Kyoto Protocol, the reporting of emissions and removals of greenhouse gases associated with *deforestation* balances the activities associated with *afforestation* and *reforestation*. Under Article 3.4 of the Kyoto Protocol, however, *revegetation* (the establishment of vegetation types other than forest) has no "*devegetation*" counterpart for the reporting of emissions and removals of greenhouse gases associated with the loss of vegetation. Election of *revegetation* under Article 3.4 of the Kyoto Protocol could result in *incomplete* reporting (with respect to the totality of land affected by *revegetation* and *devegetation*) if emissions and removals associated with the establishment of vegetation (*revegetation*) are reported but emissions and removals associated with *devegetation* (the removal of vegetation) are not (Figure 4.5). On the *revegetation* lands themselves, all emissions and removals of greenhouse gases are estimated and the reporting is *symmetric*. The potential for *unbalanced* reporting arises because if only revegetation lands are represented in the accounting system, reporting could be, in the short term, biased toward removals. If *revegetation* is not elected, accounting is *incomplete* but *symmetric*, and not *unbalanced* – unless the emissions and removals are covered by election of *cropland management* and *grazing land management*.

Figure 4.5 Symmetric and incomplete accounting (Case 4)



Note: Selection of land would, in the short term, bias reporting toward net removals, which means the accounting is *unbalanced*, if only revegetation activities were elected. Blank areas in the graph represent non-forest lands outside of the revegetation boundary (lands outside the accounting framework) that could be associated with net emissions from *devegetation* that will not be reported.

4.4 METHODOLOGICAL IMPLICATIONS OF COSTS, SCALE OF APPLICATION AND ACCURACY

As discussed below, the existing literature, including the *IPCC Special Report on Land Use, Land-Use Change, and Forestry* (IPCC, 2000b) and relevant international reporting instruments (e.g. FAO-Forest Resources Assessment, Montreal Process Reporting, OECD/EUROSTAT) have some data relevant to estimating the aerial extent or scale of emissions and removals of greenhouse gases from *forest degradation* or *devegetation of other vegetation types*, although nothing linked specifically to the definitions discussed above. The definitions, accounting framework, and reporting requirements for LULUCF under the Kyoto Protocol are unique and specific to the Kyoto Protocol and the existing literature and reported data generally do not apply in that context.

A greenhouse gas accounting system should be transparent, consistent, comparable, complete, accurate and verifiable in recording and reporting changes in carbon stocks and/or changes in greenhouse gas emissions by sources and removals by sinks. Those factors provide the basis for assessing a Parties' performance in meeting their emissions reduction target under the Kyoto Protocol.

Changes in emissions and removals of greenhouse gases over time can be assessed on lands drawn into the accounting framework using a combination of direct measurements, activity data, and models based on acceptable statistical principles, vegetation, land-use and land management surveys, forest inventories, remote-sensing techniques, flux measurements, soil sampling and ecological surveys as described in the *GPG-LULUCF*. The *GPG-LULUCF* suggests that Parties should use methods that will provide the highest certainty possible, using available resources as efficiently as possible in relation to the size of the emissions and removals of greenhouse gases.

The Special Report on LULUCF recognised that under the specifications for LULUCF accounting and reporting of the Kyoto Protocol, accounting is not consistent with "full" carbon accounting (IPCC, 2000b). Because the Kyoto Protocol specifies that LULUCF accounting be restricted to land areas defined by specific human-induced activities (*afforestation, reforestation, deforestation, forest management, cropland management*, grazing *land management, revegetation*), the scope of accounting and reporting is limited to emissions and removals of greenhouse gases from areas of land affected by these activities.

Full costs of accounting for emissions and removals associated with *forest degradation* or *devegetation of other vegetation types* depends not only on national circumstances (natural conditions, country area, proportion of forested and other vegetated land, and advancement of existing inventory systems), but also on how *forest degradation* and *devegetation of other vegetation types* are defined, since this will influence the types of inventory methods that are applicable. Other factors affecting costs are scale of relevant inventory and the desired accuracy of measurements.

Identification of land areas affected by the applicable activities under Articles 3.3 and 3.4 of the Kyoto Protocol can be done using one of the approaches described in *GPG-LULUCF*. The ease with which land areas affected by *forest degradation* and *devegetation of other vegetation types* can be identified using the *GPG-LULUCF* approaches will depend on how *degradation* and *devegetation of other vegetation types* are defined. The use of ambiguous terms to define *degradatio*n or *devegetation* (e.g. "reduced potential supply of benefits" or "overuse or poor management") could make identification of the affected land areas more difficult, costly, qualitative and subject to interpretation than if measurable properties, such as carbon stocks, are used.

Spatial resolution has important cost and accuracy implications. In the Marrakesh Accords, the spatial resolution of forest is a minimum area of between 0.05 and 1.0 hectare, and revegetation is a minimum area of 0.05 hectare. If a small minimum resolvable area is used, the task and cost of assessment can be high. With a coarse spatial resolution, the data demand can be modest but significant areas subject to an activity may be lost from the accounting system.

The specificity of the definitions of human-induced "activities" under Articles 3.3 and 3.4 make it difficult to find data in the literature from which to derive information about the scale of *forest degradation* or *devegetation* activities. The Special Report on LULUCF (IPCC, 2000b) reported 12 million hectares of severely degraded land in Annex I countries, of which it was assumed that 5% would be subject to activities under Article 3.4 in 2010 (see Table 4, page 14 of the Special Report on LULUCF). That information provides some guidance on the scale of potential *revegetation* and *forest management*, but provides little information about the rate at which *forest degradation* and *devegetation* activities occur.

How *forest degradation* and *devegetation of other vegetation types* are defined will determine the scale of effect that is captured within the accounting framework. What is considered *forest degradation* or *devegetation of other vegetation types* and the degree of change, loss or reduction that is required (e.g. 5% loss of biomass, 10% loss of carbon stocks, or 25% reduction in the supply of benefits) together with the spatial scale of estimation (0.05 or 1.0 hectare) will all determine how much affected land is drawn into the accounting system. FAO, which has assessed the state of the world's forest cover since 1946 and studied forest land cover change in the tropics between 1980 and 1990 and 1990 to 2000 (FAO 1990, 1997, and 2000) provides some information on relative changes in rates of *forest degradation*. Reported changes in land cover categories that could be regarded as *forest degradation* (defined as decrease of density or increase of disturbance in forest classes) in the tropics showed a decline from 35 million hectares between 1980 and 1990 to 23.8 million hectares between 1990 and 2000. Similar data were not available for developed countries, and the Global Forest Resource Assessment (FAO 2000)) concluded that although information on forest area change could be derived with some precision, data on qualitative changes such as *forest degradation* were generally missing, even in developed countries with relatively advanced forest inventory methodology. Another possible indicator of *forest degradation* that is available for a majority of European countries is the ratio of tree damage, monitored under the International Co-operative Programme on Assessment and Monitoring of Air Pollution on Forests[11] (ICP Forests). However, this monitoring does not indicate the origin of damage and includes in the assessment also foliage losses that result from indirect human-induced activities. The proportion of trees with more than 25% defoliation in 2002 was

[11] Forest Condition in Europe. Results of the 2002 Large-scale Survey. 2003 Report, EC-UN/ECE, Brussels, Geneva, 2003, 114 p.

21.3%. Trees showing defoliation in excess of 60%, which might indicate durable damage, were 1.5% of the total sampled.

Another way of estimating how much land could be affected by *forest degradation* is to determine how much forest is covered by formal or informal management plans. Various "Codes of Practice" for forestry harvesting have been developed for use at the international, regional and national levels to improve harvesting practices following concepts of low-impact harvesting (e.g. Dykstra and Heinrich 1996). The global forest resources assessment 2000 (FAO 2000) indicated that 89% of the forests in industrialised countries (accounting for 45% of the global forest, mainly temperate and boreal) were subject to a formal or informal management plan. For example in most European countries the entire forest area is under forest management plans, likewise in Australia (100%), New Zealand (87%), Canada (71%) and the US (56%), all or most of the forest area is under forest management plans (FAO 2000). National figures are not available for many developing countries, but current results indicate that about 6% of that forest area is covered by formal, nationally approved forest management plans. These numbers, however, do not indicate whether the plan is appropriate, being implemented as planned or having the intended effects. Certification, an instrument used to confirm that certain predefined minimum standards of forest management in a given forest area at a given point in time has been achieved, also covers a number of international, regional and national forests. At the end of 2000, there were certified forests in the United States (12% certified), Finland (100% certified), Sweden (41% certified), Norway (63% certified), Canada (2% certified), Germany (30% certified) and Poland (30% certified) (FAO 2000).

REFERENCES

Di Gregorio A. and Jansen L.J.M. (2000). Land Cover Classification System (LCCS): Classification Concepts and User Manual. Version 1.0. FAO Land and Water Development Division, Environment and Natural Resources Service, Africover - East Africa Project, Nairobi, Kenya.
http://www.fao.org/DOCREP/003/X0596E/X0596e00.htm#P-1_0

Dykstra D.P. and Heinrich R. (1996). FAO Model Code of Forest Harvesting Practice. Food and Agriculture Organization of the United Nations, Rome. 85 p.

Food and Agriculture Organization of the United Nations (1990). Forest resources assessment 1990. FAO Forestry Paper 130. 152 p.

Food and Agriculture Organization of the United Nations (2000). Global forest resources assessment 2000. Main report. FAO Forestry Paper 140. 479 p.

Food and Agriculture Organization of the United Nations (1997). State of the world's forests 1997. FAO. 200 p.

de Gier A. and Yousif Alli Hussin (1995). Monitoring forest degradation in part of Indonesia using remote sensing and GIS. International Union of Forest Research Organizations, IUFRO XX World Congress, Tampere, Finland. August 1995. http://www.metla.fi/iufro/iufro95abs/d4pap69.htm

Intergovernmental Panel on Climate Change (IPCC). (1997). Houghton J.T., Meira Filho L.G., Lim B., Treanton K., Mamaty I., Bonduki Y., Griggs D.J. and Callander B.A. (Eds). *Revised 1996 IPCC Guidelines for National Greenhouse Inventories*. IPCC/OECD/IEA, Paris, France.

Intergovernmental Panel on Climate Change (IPCC). (2000a). Penman J., Kruger D., Galbally I., Hiraishi T., Nyenzi B., Emmanuel S., Buendia L., Hoppaus R., Martinsen T., Meijer J., Miwa K., and Tanabe K. (Eds). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. IPCC/OECD/IEA/IGES, Hayama, Japan.

Intergovernmental Panel on Climate Change (IPCC). (2000b). Watson R., Noble I.R., Bolin B., Ravindranath, N.H., Verardo D.J. and Dokken D.J. (Eds) *Land use, Land-use Change, and Forestry: A Special Report*. Cambridge University Press. Cambridge, UK.

Lambin E.F. (1999). Monitoring forest degradation in tropical regions by remote sensing: some methodological issues. *Global Ecology and Biogeography* 8(3/4). Pp.191-198.

Vegetation Subcommittee (1997). Vegetation classification standard. Washington, DC: Federal Geographic Data Committee, Vegetation Subcommittee. 18 p. + 3 appendices.
http://biology.usgs.gov/fgdc.veg/standards/vegstd.htm

GREENHOUSE GASES AND FORESTS

Greenhouse gases (GHGs) play a key role in the Earth's climate. Energy from the sun that passes through our atmosphere warms the surface of the Earth. Some of that energy radiates back towards space from the surface as infrared light. GHGs absorb or reradiate the infrared light, preventing the energy from travelling out into space, thereby trapping heat. Without GHGs, the planet would be too cold to sustain its current life. Increases in GHG levels could make the planet grow warmer. According to the current understandings of world climate, such warming would also change patterns of precipitation, the frequency and intensity of storms and extreme weather, sea levels and a plethora of related parameters of terrestrial ecology. Human understanding of the global climate system is still imperfect, so it is impossible to predict with precision how the climate will change in particular places. However, most scientists studying the subject predict that warming will significantly and for the most part adversely affect human society (IPCC, 2001).

The concentrations of GHGs, notably of carbon dioxide (CO_2), are clearly increasing owing to human activity. Industry now adds about 6.3 gigatonnes of carbon as CO_2 to the atmosphere each year, and the destruction of forests contributes at least another gigatonne. The current concentration of CO_2 in the atmosphere, 370 parts per million (ppm), is about 35 percent higher than it was in pre-industrial times (280 ppm). Although the total amount of carbon in the atmosphere is enormous (around 750 gigatonnes), anthropogenic activities are clearly causing very significant increases (American Petroleum Institute, 1999).

In nature, GHGs are constantly entering and leaving the atmosphere. The oceans exchange CO_2 and other GHGs with the atmosphere and hold CO_2 dissolved or precipitated out in sediments. Actively growing trees and other plants capture CO_2 from the atmosphere, combine it with water through photosynthesis and create sugars and more stable carbohydrates. They may store a significant part of the carbon absorbed for appreciable lengths of time, from years to millennia. Carbohydrates become the building blocks and energy supply for most of life on Earth. Eventually, when plants and animals die, CO_2 returns to the atmosphere. When wood products or other organic materials burn or decompose, they also release CO_2.

The effect of GHGs on climate is truly international. The most damaging effects from many other air pollutants are short term and local, causing most harm near where they are released. Therefore, control of these effects is a local or regional concern. In contrast, GHGs cause global changes to climate. No matter where GHG emissions originate, they disperse throughout the atmosphere. To control GHG-induced climate change, we must curb GHG sources and enhance carbon sinks on a global scale.

Justifiably, most attention has focused on fossil fuels and cement as the major source of greenhouse gases. However, forests have also received attention.

Three classes of forest-related activity can affect GHG concentrations. The first is the establishment, enhancement or protection of forest ecosystems.

Afforestation and reforestation of non-forested lands can increase, and prevention of deforestation can maintain, the amount of carbon held in forests. These are widely acknowledged as potential means of offsetting or reducing a part of anthropogenic GHG emissions. Their relatively low cost, compared with non-forest offset options, may make them economically attractive (Dayal, 2000). Humans can also vary the way they manage existing forests to increase the carbon storage on site. For example, selective cutting schemes, lengthened rotations, reduced-impact logging, and species choice may achieve a higher average level of sequestered carbon. Simply postponing or eliminating harvesting can sometimes be a short- to medium-term means to keep carbon sequestered (Schulze, Wirth and Heimann, 2000).

The second is the enhanced use of forest products. Using wood in buildings and other long-lived objects effectively sequesters carbon for the life of the object. Substituting essentially carbon-neutral wood for energy-intensive materials such as brick, aluminium or steel may significantly reduce the use of fossil fuels, which of course release carbon dioxide when burned.

The third is sustainable production of wood fuel from forests, which can displace fossil fuels. Although burning of biomass fuels releases CO_2, the regrowth of a sustainably managed forest offsets that release. Thus, forest fuels can supply energy virtually without net contribution to GHG levels.

CLIMATE CHANGE AGREEMENTS: ORIGINS AND STATUS

The international community has responded to the challenge of climate change with a series of agreements. The United Nations Framework Convention on Climate Change (UNFCCC) was signed at the United Nations Conference on Environment and Development in 1992 and entered into force in March 1994. As of May 2004, 188 nations had ratified or acceded to the Convention (UNFCCC Secretariat, 2004a). The UNFCCC sets goals and objectives and outlines basic mechanisms for the climate change regime, but lacks many specifics, in particular quantified GHG reduction obligations. It calls for annual Conferences of the Parties (COPs) to work out further details of the international response. The first COP met in 1995; the ninth in December 2003 in Milan, Italy.

The Kyoto Protocol was the product of the third COP (COP-3). The Protocol sets specific reduction targets and timetables for reducing net GHG emissions from industrialized nations. It has not yet entered into force. Article 25, paragraph 1 requires that the Protocol be ratified, approved, accepted or acceded to by at least 55 Parties, including developed nations (listed in Annex I of the UNFCCC) responsible for at least 55 percent of 1990 Annex I CO_2 emissions. In March 2001, after a change of presidential administrations, the United States president declared that the United States was withdrawing its support for the Kyoto Protocol and that he would not seek to ratify it. The United States was responsible for about 36 percent of 1990 emissions from Annex I Parties. As a practical matter, if the United States continues to withhold support, the Russian Federation must ratify the Protocol or it will not enter into force. As of May 2004, 122 Parties had ratified the Protocol, but they represent only 44.2 percent of 1990 Annex I CO_2 emissions (UNFCCC Secretariat, 2004b). In late May 2004, the Russian president stated that the Russian Federation was likely to ratify the Protocol. (For current ratification status, consult the UNFCCC Internet site [unfccc.int].)

The COPs continue to meet and produce agreements and draft agreements for the first session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP 1). The United States has not withdrawn from the UNFCCC and participates in the COPs, attending discussions on the Protocol as an observer. Forest issues have surfaced most prominently in COP-6, COP-6bis, COP-7 and COP-9, dubbed the "forest COP". Meeting in The Hague, the Netherlands, in November 2000, COP-6 failed to reach agreement, mainly over several issues relevant to Land Use, Land-Use Change and Forestry (LULUCF). The Parties took the issues up again in July 2001 in Bonn, Germany (UNFCCC COP, 2001), in a meeting known as COP-6bis. This meeting produced a draft agreement (the Bonn agreement), which the Parties added to and adopted at COP-7 in Marrakesh, Morocco, in November 2001 as the so-called Marrakesh Accords. The decisions of COP-7 can be found in the four main documents produced at COP-7 (UNFCCC COP, 2002a; 2002b; 2002c; 2002d). The central agreement concerning LULUCF is Decision 11/CP.7 (UNFCCC COP, 2002a, pp. 54–63). This agreement is a recommendation, and the Parties to the Protocol must formally adopt it after the Protocol enters into force. However, like the Protocol itself, the agreement represents a working consensus of the Parties on these issues. The next section of this paper discusses forest-related obligations of the Parties as stated in the UNFCCC and the Kyoto Protocol. The subsequent section looks at some of the questions that the UNFCCC and the Protocol left open, and how COP-6, COP-7 and COP-9 have dealt with them.

FORESTS UNDER THE UNFCCC AND THE KYOTO PROTOCOL

Understanding how the climate change agreements may affect forests is a complicated task. First, forests are integral to the global carbon cycle. Almost any reference to sinks or net emissions could have implications for forests. Second, the agreements themselves can be obscure. In the negotiations, consensus has at times been more important than clarity. Where the negotiators encountered controversial issues, they sometimes deferred decisions to later agreements or used ambiguous language. Third, although the later agreements add content to the earlier ones, the documents have no master index or table of cross-references to guide the researcher. As a result, the texts require patient cross-checking and careful scrutiny to understand.

The discussion in this section outlines provisions relevant to forests in the UNFCCC and the Kyoto Protocol. The next section looks at the issues still open after Kyoto and how the Parties addressed them from COP-6 to COP-9. The reader wishing to have a more thorough understanding of the role of forests should investigate the full set of documents, all available on the UNFCCC Internet site (unfccc.int). In addition, the documents on the Intergovernmental Panel on Climate Change (IPCC) site (www.ipcc.ch) address some of the technical issues concerning using, managing and measuring the carbon sink potential of forests.

General obligations that may touch on forests

The UNFCCC casts a broad net over the issue of climate change. Its Article 1 definitions illustrate that breadth. "Climate system" means "the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions". "Reservoir" means "a component of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored." Clearly, forests and wood products are reservoirs. The terms "source" and "sink" also have broad definitions. Sources are processes or activities that contribute GHGs to the atmosphere, and sinks are processes, activities, or mechanisms that remove them. Forests may qualify as either or both depending on whether they are releasing, removing or both releasing and removing GHGs. The term "emissions" is defined without regard to the nature of the source, so that a forest may be a source of emissions just as surely as a factory or a vehicle.

Article 3 of the UNFCCC declares the basic principles of the Convention, and again it paints in broad strokes. Under paragraph 3, it declares that policies and measures to combat climate change should "be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases ... and comprise all economic sectors". Clearly, this language covers forests and forest management.

For most nations looking to adopt implementing legislation, the key provisions of the UNFCCC begin with Article 4, dealing with commitments of the Parties. Article 4 contains two sets of commitments. The first set, in paragraph 1, applies to all Parties. The second set, in the subsequent paragraphs, largely describes commitments of "Annex I" or "Annex II" nations. Annex II of the UNFCCC lists the major nations of Western Europe, plus Australia, Canada, Japan, New Zealand, Turkey and the United States. Annex I lists the Annex II nations plus several European nations that were in transition to a market economy in 1992 when the treaty was written: from the former Union of Socialist Soviet Republics, the Russian Federation, Belarus, Estonia, Latvia, Lithuania and Ukraine; and from Eastern Europe, Bulgaria, Czechoslovakia, Hungary, Poland and Romania.

Under Article 4, paragraph 1 of the UNFCCC, all Parties must:

- develop and update inventories of emissions and removals of GHGs (these include emissions from deforestation and removals from forest growth and also emissions from the burning or decomposition of forest products);
- develop programmes to mitigate climate change, including efforts to address emissions and sinks, which would include forests and their soils;
- promote technologies that lead to lower GHG emissions (this subparagraph of the UNFCCC specifically mentions the forestry sector);
- promote sustainable management of sinks and reservoirs (again, the UNFCCC specifically mentions forests);

Acronyms

AIJ	Activities implemented jointly
AAU	Assigned amount unit
CAP	Common Agricultural Policy (EC)
CCB	Certificate for forest conservation (Costa Rica)
CDM	Clean Development Mechanism
CER	Certified emission reduction
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (United States)
CO_2	Carbon dioxide
COP	Conference of the Parties (to the UNFCCC)
COP/MOP	First session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CTO	Certifiable Tradable Offset
EC	European Community
ECCP	European Climate Change Programme
ERU	Emission reduction unit
FAO	Food and Agriculture Organization of the United Nations
FONAFIFO	National Fund for Forestry Finance (Costa Rica)
GERT	Greenhouse Gas Emission Reduction Trading (Canada)
GHG	Greenhouse gas
GMO	Genetically modified organisms
GPG-LULUCF	IPCC Good Practice Guidance for Land use, Land-use change and Forestry
INAREF	National Forestry Agency, Dominican Republic
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JI	Joint Implementation
lCER	Long-term certified emission reduction
LULUCF	Land Use, Land-Use Change and Forestry
Mt	Megatonne (1 million tonnes)
NGO	Non-governmental organization
OCIC	Office on Joint Implementation (Costa Rica)