

Guide for Classifying Lands for Greenhouse Gas Inventories

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ABSTRACT

Recently, the Intergovernmental Panel on Climate Change has issued new Good Practice Guidance for Land Use, Land-Use Change, and Forestry (GPG–LULUCF), which stipulates different data analysis and reporting procedures for changes in carbon storage and greenhouse gas (GHG) emissions for six land classes: forest, cropland, grassland, wetland, settlements, and other lands. However, the GPG–LULUCF does not include a decision tree to support the identification and classification of lands. This is a critical first step necessary to proceed on land classification for subsequent calculation of GHG inventories. This article provides a useful decision tree and dichotomous key for classifying lands according to the GPG–LULUCF. Countries and the international community will need this tool to unify common criteria for land classification.

Keywords: climate change, land classification, inventory

The World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988. IPCC's main objective is to assess scientific, technical, and socioeconomic information relevant to the understanding of human-induced climate change, potential impacts of climate change, and options for mitigation and adaptation. Among other tasks, the IPCC (1997) develops methodology guidelines for national greenhouse gas (GHG) inventories. In this light, the IPCC established the Task Force on National GHG Inventories at its 14th session (October 1998) to oversee the IPCC National GHG Inventories Program (IPCC–NGGIP). The following are the objectives of the IPCC–NGGIP:

- To develop and refine an internationally agreed on methodology and software for the calculation and reporting of national GHG emissions and removals.
- To encourage the widespread use of this methodology by countries participating in the IPCC and by signatories of the United Nations Framework Convention on Climate Change (UNFCCC).

To this end, the IPCC recently published the *Good Practice Guidance (GPG) for Land Use, Land-Use Change, and Forestry* (GPG–LULUCF; Penman et al. 2003). The origin of the LULUCF is found in the revised 1996 guidelines for reporting GHG inventories, produced by the IPCC. One of the sectors included was land-use change and forestry (LUCF), and the title was imported to the UNFCCC. This sector is composed of land conversions (land-use change) and land management (forestry), given that agriculture was included in the agriculture sector. Discussions leading to the Kyoto Protocol added the land-use component to LUCF and, thus, the new term was *Land Use, Land-Use Change, and Forestry*.

The GPG–LULUCF provides supplementary methods and guidance for estimating, measuring, monitoring, and reporting on carbon stock changes and GHG emissions from LULUCF activities under Article 3, paragraphs 3 and 4, and Articles 6 and 12 of the Kyoto Protocol.

The purpose of the GPG–LULUCF is to assist countries in producing inventories for the LULUCF sector in which uncertain-

ties are reduced as far as practicable. It supports the development of inventories that are transparent, documented, consistent over time, complete, comparable, assessed for uncertainties, subject to quality control and quality assurance, and efficient in the use of resources (Penman et al. 2003). Contents of the GPG–LULUCF include Chapter 1, "Overview"; Chapter 2, "Basis for Consistent Representation of Land Areas"; Chapter 3, "LUCF Sector Good Practice Guidance"; Chapter 4, "Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol"; and Chapter 5, "Cross-Cutting Issues."

Of the five chapters, Chapter 2 is the most important from an inventory and monitoring perspective because it defined the classes of lands on which nations are to report and it is the focus of this article. Chapter 3 uses the land-use categories of Chapter 2 to organize the methodologies and to facilitate: transparent reporting and association of above- and belowground carbon pools (at the higher tiers), while allowing comparison with reporting of the IPCC guidelines (Nabuurs et al. 2003). Chapter 4 describes the supplementary methods and GPG specifically linked to the LULUCF activities in the Kyoto Protocol and gives full consideration to the requirements and methodologies for measuring, estimating, and reporting of activities under Articles 3.3 and 3.4 (Schlamadinger et al. 2003). Chapter 5 describes *good practice* in estimating and reporting uncertainties associated with estimates of emissions and removals in the LULUCF sector and shows how to incorporate the LULUCF sector for the assessment of combined uncertainties across the inventory (Paciornik and Rypdal 2003). Readers

Box 1 – GPG-LULUCF Land Classes (Milne et al. 2003)

- **Forest land** - All land with woody vegetation consistent with thresholds used to define forest land in the national greenhouse gas inventory, sub-divided into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines 3. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
- **Cropland** - Arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions.
- **Grassland** - This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastoral systems, subdivided into managed and unmanaged consistent with national definitions.
- **Wetlands** - Land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
- **Settlements** - All developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.
- **Other land** - Bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

Box 2 –Marrakesh Accords definition of 'Forest' (COP 2002)

'Forest' is a minimum area of land of 0.05 – 1.0 hectares (0.1-2.5 acres) with tree crown cover (or equivalent stocking level) of more than 10 – 30 per cent with trees with the potential to reach a minimum height of 2 – 5 metres (6.6-16.4 feet) at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10 – 30 per cent or tree height of 2 – 5 metres (6.6-16.4 feet) are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.



Figure 1. Row of street trees in a housing development. This area could qualify as forest if the line of trees extended far enough to meet the area threshold and if the strip width threshold were met. If not, then the area would be classed as grassland or settlement.

are encouraged to access the references and read the chapters to understand the specific reporting requirements.

To comply with the GPG-LULUCF, inventory agencies at the national level need information about land area for each of six classes to estimate carbon stocks and emissions and removals of GHG associated with LULUCF activities. The classes are “forest,” “cropland,” “grassland,” “wetlands,” “settlements,” and “other land” for GHG inventory reporting. These classes are defined in Box 1.

When applying the aforementioned categories, inventory agencies are to classify land under only one category to prevent double counting. Thus, the classes are considered mutually exclusive and all-inclusive.

Milne et al. (2003) recognize that the names of these land categories are a mixture of land cover (e.g., forestland, grassland, and wetlands) and land-use (e.g., cropland and settlements) classes. For listings of national definitions of forest, cropland, grassland, and wetlands see the study by Lund (2005a, 2005b).

Inventory agencies are to follow the more-detailed guidance contained in the bulk of the GPG-LULUCF on the preparation of specific emission and removal estimates and, if relevant, the reporting on the activities under the Kyoto Protocol for each of the six types of land classes: forest, cropland, grassland, wetlands, settlements, and other. Different land classes require different analyses and reporting processes.

The GPG-LULUCF contains many decision trees to help the parties in the analysis and reporting process. A decision tree is a flow chart describing the specific ordered steps that need to be followed to develop an inventory or an inventory component in accordance with the principles of good practice (Penman et al. 2003).

Surprisingly, the GPG-LULUCF provides no decision tree to assist in the identification and classification of the lands. This is the most critical step in the whole reporting process because different land classes have different reporting requirements. If we wish for the parties to use the GPG-LULUCF with consistency and comparability, we need a key or flow chart describing the specific ordered steps they need to follow to classify a given piece of land for subsequent carbon stock and GHG reporting.

Note that in Box 1 three of the classes (cropland, grassland, and wetlands) are based on what is considered forestland.



Figure 2. (A) This is a young pine plantation in Manassas, Virginia, in 1994. **(B)** This shows the same location in 2003. The “forest” is now a parking lot for a county hospital and should be classed as a settlement requiring different analyses and reporting than that for forest.

Therefore, to develop a decision key for the aforementioned six classes, we have to understand how “forest” is defined for the Kyoto Protocol. Box 2 defines “forest” in the context of the Kyoto Protocol, as stipulated by the Marrakesh Accords (cf. paragraph 1 of the Annex to draft decision -/CMP.1 [LULUCF] contained in document FCCC/CP/2001/13/Add.1, p. 58).

Remarkably, according to the Marrakesh forest definition there are no exclusions listed and no minimum strip width threshold specified as often done in other definitions of “forest” (Lund 2002). However, buried in Section 4.1.1 of the GPG-LULUCF, Step 1.1 specifies: *In addition to the minimum area of forest, it is good practice that countries specify the minimum width that they will apply to define forest unit and units of land subject to ARD (afforestation, reforestation, and deforestation) activities, as explained in Section 4.2.2.5.1* (Penman et al. 2003). The IPCC does not specify a range of width threshold values.

Thus, nations are free to choose a strip width and an area, crown cover, and tree height thresholds within the Marrakesh ranges specified, but once selected, they are to use the same thresholds in all future reporting. (The USDA Forest Service Forest Inventory Analysis units use threshold val-



Figure 3. Depending on a nation’s definition of tree, an oil palm plantation, such as this one in Papua New Guinea, could be classed as forest or cropland but not both.

ues of 1 ac [0.405 ha] for area, 20 ft [6.1 m] for strip width, 10% stocking for cover, and 13 ft tall [3.97 m] for trees at maturity [Wear and Greis 2002].)

Following the Marrakesh definition, plantations, orchards and groves, and rows of street trees (Figure 1) may be considered as forest if they meet the area, strip width, crown cover, and tree height thresholds. However, some lands with trees that do not make the thresholds (Figure 2) and lands

currently without trees, but are expected to have trees later, may be classed as forest, providing the future tree crown cover and height will meet or exceed the thresholds. Thus, the Marrakesh definition of forest is a combination of land cover and land use.

The stand in Figure 2A did not have enough crown cover to meet the minimum threshold to be defined as “forest.” One would have to make a decision if the trees will make the threshold in the future. If yes,

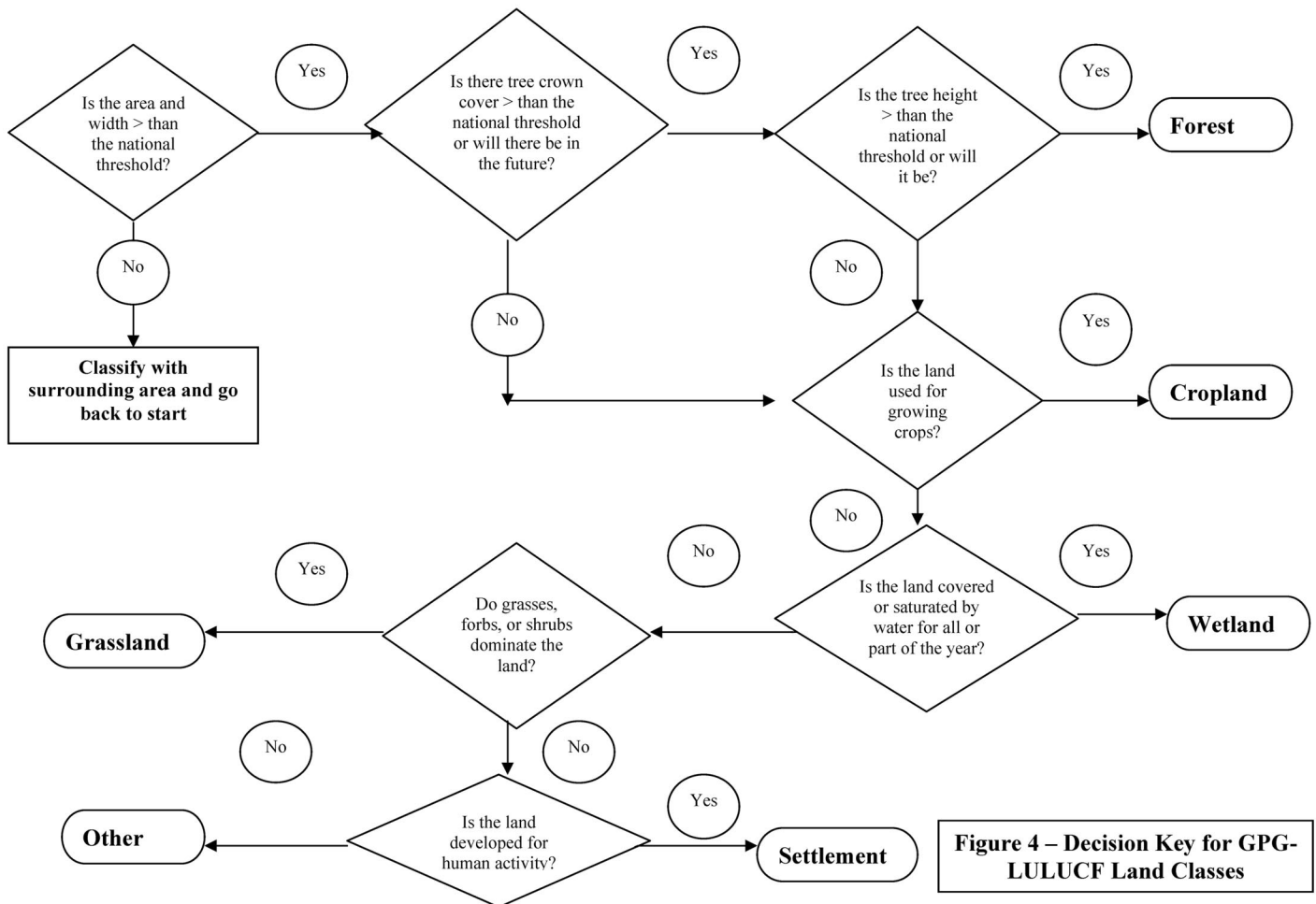


Figure 4 – Decision Key for GPG-LULUCF Land Classes

Figure 4. Decision tree for classifying GPG-LULUCF lands.

then the land would be classed as forest. If judged not to, then the land would be classed as grassland and the appropriate GPG-LULUCF analyses and reports would be completed (see Penman et al. [2003] for analyses to be complete). Today, the “stand” is now a parking lot for a county hospital (Figure 2B).

Neither the Marrakesh Accords nor the GPG-LULUCF define “tree.” Normally, one may assume that a tree is a woody perennial generally with one main stem capable of reaching a height threshold (Helms 1998). However, some national definitions of trees also include bamboos, brushwood, bushes, canes, climbers, coppice, creepers, cuttings, orchids, palms (Figure 3), plants, regrowth, reshoots, shoots, stumps, suckers, transplants, and underbrush (Lund 2005b).

The flexibility in a party choosing thresholds combined with the variety in national definitions of a tree makes comparing LULUCF estimates between nations difficult. However, the main goal is to account for changes in carbon storage and GHG

emissions within a country, not necessarily between parties.

Figure 4 shows a proposed decision tree for classifying lands according to the GPG-LULUCF. One has to use an elimination process to develop a decision key. Thus, for the six GPG-LULUCF land classes we first must determine if the land is forest or not because that decision dictates how the lands may be otherwise classed. Once that is determined we move to whether the land is used for crop production. This step helps separate fields such as rice paddy and cranberry bogs from wetlands. If the land is not used for crops, then we determine if the land is saturated all or part of the year. If it is, then the land is considered wetlands, and the appropriate analyses and reporting are performed. If not, then we determine if grass, forbs, or shrubs dominate the land. If so, then the land is classed as grassland. If not, then we need to determine if the land is used for human activities. If so, then the land is classed as settlement. If not, then the class is other land.

Box 3 has the same classification but in the form of a dichotomous key.

Summary and Conclusion

Land classification is the first step in the analysis and reporting of carbon storage and GHG emissions according to the IPCC’s GPG-LULUCF. The fact that the GPG-LULUCF land classes are a mix of land use and land cover makes decisions a bit confusing (Figure 5).

The lack of a definition of tree compounds the problem. Regardless, this article presents a decision key to assist parties in classifying their lands as to whether they are considered forest, cropland, grassland, wetlands, settlements, or other lands.

The construction of the decision key for use with the GPG-LULUCF is a simple task. The challenge is for parties to gather the data needed for each of the six land classes. Many nations have national forest inventory and agricultural census programs. These may provide some of the data needed for forestland and cropland. However, the

Box 3 - GPG-LULUCF land classification dichotomous key

1. Is the land area and strip width > **national threshold** (threshold must be between 0.05-1.0 hectares (0.12 – 2.47 acres)) - Yes - Go to 2. No - Classify with surrounding area.
2. Does the land have tree crown cover > **national threshold** (threshold must be between 10-30 %) or will it have such tree cover in the future - Yes - Go to 3. No - Go to 4
3. Do or will the trees reach the national height threshold (threshold must be between 2-5 m (6.56-16.4 feet) in height in situ at maturity) – Yes = **Forest land**. No - **Non-forest land** – Go to 4.
4. Is the land used for growing crops - Yes = **Cropland**. No - Go to 5.
5. Is the land covered or saturated by water for all or part of the year – Yes = **Wetland**. No - Go to 6.
6. Is the land dominated by grasses, forbs, or shrubs – Yes = **Grassland**. No - Go to 7.
7. Is the land developed for human activity -Yes = **Settlement**. No = **Other land**.



Figure 5. It is evident from the stacked logs and disturbed soil in this photo that land clearing has taken place. This area could be classed as forest, cropland, grassland, or settlement depending on intended use. However, without additional information, this land would be classed as other land.

national definitions of forest and cropland may differ from that given in Milne and Jallow. (2003). In addition, few countries have national inventory and monitoring programs for wetlands, grassland, settlements, and other lands much less programs to measure changes in carbon and GHG. This means that if nations are to follow the GPG-LULUCF, they may need to modify and expand their current inventory and monitoring programs.

COP could improve the Marrakesh Accord definition of forest with the addition of a definition of tree and the IPCC could improve the GPG-LULUCF by incorporating a decision key for land classification. These, in turn, would improve consistency in reporting among nations.

The United States is listed as an Annex

I country under the UNFCCC. Annex I countries (industrialized countries) are those that agree to reduce their emissions (particularly carbon dioxide) to target levels below their 1990 emissions levels. If they cannot do so, they must buy emission credits or invest in conservation.

The Kyoto Protocol is a proposed amendment to an international treaty on global warming—the UNFCCC. Countries, which ratify this protocol, commit to reduce their emissions of carbon dioxide and other GHG. It also reaffirms sections of the UNFCCC. The United States still has to ratify the Kyoto Protocol. Regardless, the GPG-LULUCF land classification is relevant to all countries as they prepare estimates of emissions and removals from the

LULUCF Sector, whether or not they ratify the Kyoto Protocol (Penman et al. 2003).

Literature Cited

- CONFERENCE OF THE PARTIES (COP). 2002. *Report of the Conference of the Parties (COP) on its seventh session, held at Marrakesh from Oct. 29, 2001 to Nov. 10, 2001*. Addendum. Part Two: Action taken by the conference of the parties, Vol. I. FCCC/CP/2001/13/Add.1 dated Jan. 21, 2002 United Nations Framework Convention on Climate Change (UNFCCC). 69 p. Available online at www.unfccc.int/resource/docs/cop7/13a01.pdf; last accessed Sept. 22, 2005.
- HELMES, J.A. (ED.). 1998. *The dictionary of forestry*. Society of American Foresters, Bethesda, MD. 224 p.
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). 1997. *Revised 1996 IPCC guidelines for national greenhouse gas inventories*, Houghton, J.T., L.G. Meira Filho, B. Lim, K. Tréanton, I. Mamaty, Y. Bonduki, D.J. Griggs, and B.A. Callander (eds.). Vol. 1: Greenhouse gas inventory reporting instructions. 130 p. Vol. 2: Greenhouse gas inventory workbook. 346 p. Vol. 3: Greenhouse gas inventory reference manual. 482 p. IPCC, Meteorological Office, Bracknell, UK. Available online at www.ipcc-nggip.iges.or.jp/public/gl/invs4.htm; last accessed Sept. 22, 2005.
- LUND, H.G. 2002. When is a forest not a forest? *J. For.* 100(8):21–27.
- LUND, H.G. 2005a. *Definitions of agroforestry, forest health, sustainable forest management, urban forests, grassland, pasture, rangeland, cropland, agricultural land, shrubland, and wetlands and related terms* [online publication]. Forest Information Services, Gainesville, VA. Available online www.home.comcast.net/~gyde/more-def.htm; last accessed Sept. 22, 2005.
- LUND, H.G. 2005b. *Definitions of forest, deforestation, reforestation and afforestation* [online report]. Forest Information Services, Gainesville, VA. Available online at www.home.comcast.net/~gyde/DEFpaper.htm; last accessed Sept. 22, 2005.
- MILNE, R., AND B.P. JALLOW (COORDINATING LEAD AUTHORS). 2003. Chapter 2: Basis for consistent representation of land areas. P. 2.1-2.29 in *IPCC good practice guidance for LULUCF*. Institute for Global Environmental Strategies, Kanagawa, Japan. Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Program. 29 p. Available online at www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp2/Chp2_Land_Areas.pdf; last accessed Sept. 22, 2005.
- NABUURS, G.-J., N.H. RAVINDRANATH, K. PAUSTIAN, A. FREIBAUER, W. HOHENSTEIN, AND W. MAKUNDI (COORDINATING LEAD AUTHORS). 2003. Chapter 3: LUCF sector good practice guidance. P. 3.11-3.12. in *IPCC good practice guidance for LULUCF*. Institute for Global Environmental Strategies, Kanagawa, Japan. Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Program. 312 p. Available online at [Journal of Forestry • June 2006](http://www.ipcc-</p>
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- nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm; last accessed Sept. 22, 2005.
- PACIORNIK, N., AND K. RYPDAL (COORDINATING LEAD AUTHORS). 2003. Chapter 5: Cross-cutting issues. P. 5.7-5.81 in *IPCC good practice guidance for LULUCF*. Institute for Global Environmental Strategies, Kanagawa, Japan. Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme. 81 p. www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm; last accessed Sept. 22, 2005.
- PENMAN, J., M. GYTARSKY, T. HIRAISHI, T. KRUG, D. KRUGER, R. PIPATTI, L. BUENDIA, K. MIWA, T. NGARA, K. TANABE, AND F. WAGNER. (EDS.). 2003. *Good practice guidance for land use, land-use change, and forestry*. Institute for Global Environmental Strategies, Kanagawa, Japan. Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme. Available online at www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm; last accessed Sept. 22, 2005.
- SCHLAMADINGER, B., K. BOONPRAGOB, H. JANZEN, W. KURZ, R. LASCO, AND P. SMITH (COORDINATING LEAD AUTHORS). 2003. Chapter 4: Supplementary methods and good practice guidance arising from the Kyoto Protocol. P. 4.1-4.96 in *IPCC good practice guidance for LULUCF*. Institute for Global Environmental Strategies, Kanagawa, Japan. Intergovernmental Panel on Climate Change, National Greenhouse Gas Inventories Programme. 120 p. Available online at www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm; last accessed Sept. 22, 2005.
- WEAR, D.N., AND J.G. GREIS (EDS.). 2002. *Southern forest resource assessment*. USDA For. Serv. Gen. Tech. Rep. SRS-53, Southern Research Station, Asheville, NC. 635 p. Available online at www.srs.fs.usda.gov/sustain/report/index.htm; last accessed Sept. 22, 2005.

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