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Bridging the gap between the estimates of forest management emissions from the national GHG inventories and integrated assessment models via model-data fusion †

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Abstract: Current criteria to define managed forest are inconsistent among countries' reports of GHG emissions to UNFCCC. Integrated Assessment Models used for assessing the countries' mitigation pathways employ a proxy for managed forests that differ from the countries' criteria. It is one of the reasons for a gap of 5.5 GtCO2 yr−1 between the modelled and reported global land-use GHG emissions. Using multiple data, we developed a map of managed forests (0.5x0.5 deg), consistent with official GHG inventories. We applied the map in the G4M model for masking the managed forest area and estimating the GHG emissions from that area.

Keywords: Managed forest map; forest model; forest management emissions; GHG inventory

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1. Introduction

Current criteria to define managed forest areas are still inconsistent among countries' reports of greenhouse gas (GHG) emissions from forestry to the UNFCCC. Integrated Assessment Models (IAM) used for assessing the countries' mitigation pathways employ a proxy for managed forests for modelling purposes that differ from the countries' criteria. This difference in the managed forest definition is one of the reasons for a gap of about 5.5 GtCO2 yr−1 between the modelled global land-use GHG emissions and the one reported by the countries to the UNFCCC. Such inconsistency adds uncertainty to the contribution of the forest sector to climate change mitigation efforts and undermines its monitoring. [1]

The objectives of the study was to develop a harmonized map of managed forests, consistent with official GHG inventories. We developed the map for application in the Global Forest Model (G4M) [2] operating on a 0.5x0.5 deg. regular grid for masking the managed forest area, which is consistent with the estimates of countries GHG emissions' reports to the UNFCCC and estimating the GHG emissions from that area.

2. Materials and Methods

The following input data are used in the study:

Country data on the area of managed forest: Grassi et al. (2021) [1]

Spatial data: Forest cover map used in G4M that is based on GLC 2000 [3]; the layer 'Human impact on forest' from the Nature map [4] (Nature map); road density [5]; mean annual increment [6], travel time to major cities [7] and maps of forest classes and forest uses by Schulze et al. (2019) [8].

We used managed forest area for countries presented in Grassi et al. 2021 [1] as the target values. The managed forest area was derived from the National Inventory Reports from the Annex-I parties, Biennial Update Report submissions from Non-Annex I Parties, Nationally Determined Contributions, other documents communicated by the parties in the UNFCCC process or estimated from the FAO FRA non-primary forests [1].

As a basic map for classification, we used the forest cover map based on GLC 2000 adjusted to the 2000 forest area data from the FAO FRA 2015 [9]. The map is of 0.5x0.5 degree resolution. This map was chosen as it is used in the Global Forest Model (G4M) as initial (year 2000) forest map.

For each country, we collected grid cells containing forest until the sum of the forest area in the collected grid cells matches the managed forest area for that country. The grid cells within the borders of each country were arranged by forest type, starting from the Nature map class 'Short rotation plantations for timber' followed by 'Planted forest'. The Nature map class 'Agroforestry' includes orchards, tree shelter-belts, and individual trees on pastures, it partially overlaps with mosaic classes from GLC 2000 and the classes from the forest uses map by Schulze et al. (2019) [8] 'Primarily used for production' and 'Multiple uses'. Therefore, we collected the cells under the 'Agroforestry' class overlapping with the 'Primarily used for production' class and then with the 'Multiple uses' class. Then the grid cells under the Nature map class 'Naturally regenerating forest with signs of human activities, e.g., logging, clear cuts etc.' followed by 'Naturally regenerating forest without any signs of human activities, e.g., primary forests' (since the protected forests are managed as well) were collected. Another complex class from the Nature map is 'Oil palm plantations' as it partially overlaps with forest classes in GLC 2000 and Schulze et al. (2019) [8] maps. Those overlapping cells were collected after all the other classes. Within each country and Nature forest class the grid cells were sorted by road density (descending), forest productivity (descending) and travel time to major cities.

3. Results and Discussion

Managed forest area estimated from the map after application of the abovementioned method is presented in Table 1 for selected countries and in Figure 1. Globally, we spatially allocated 95% of the managed forest land area that is presented in [1] or estimated from the FAO FRA. Over 75% of the forest is managed. In the Annex-I parties to the Kyoto Protocol, except Canada, 65%, and Russia, 80%, most of the forest land is considered as managed. Among the non-Annex-I parties, Peru has the lowest share of the managed forest, 10%, the other main countries (as presented in [1]) with managed forest area below 50% are Brazil, 45%, Democratic Republic of the Congo, 31%, Ecuador, 39% and Guyana, 43%.

Table 1. Managed and unmanaged forest area estimated from the map, and managed forest area presented in Grassi et al. 2021 [1] or estimated from FAO FRA for selected countries and globally.

Country	Unmanaged, estimated from the map, kha	Managed, estimated from the map, kha	Managed, reported in [1] or estimated from FAO FRA, kha
Argentina	4,886	27,174	27,000
Brazil	283,523	235,120	235,000
Canada	121,584	226,076	226,000
China		176,980	180,000
Colombia	10,767	51,061	51,000
Ethiopia	674	13,030	13,000
India		65,390	70,000
Morocco		1,657	5,632
Mexico	34,831	33,026	33,000
Russian Federation	155,475	654,038	654,000
Thailand	814	16,193	16,000
Turkey		10,183	23,000
Ukraine		9,508	11,000
United States of America	28,337	274,141	274,000
Viet Nam		11,520	14,000
South Africa		9,242	23,000
Global	963,478	3,026,212	3,174,000

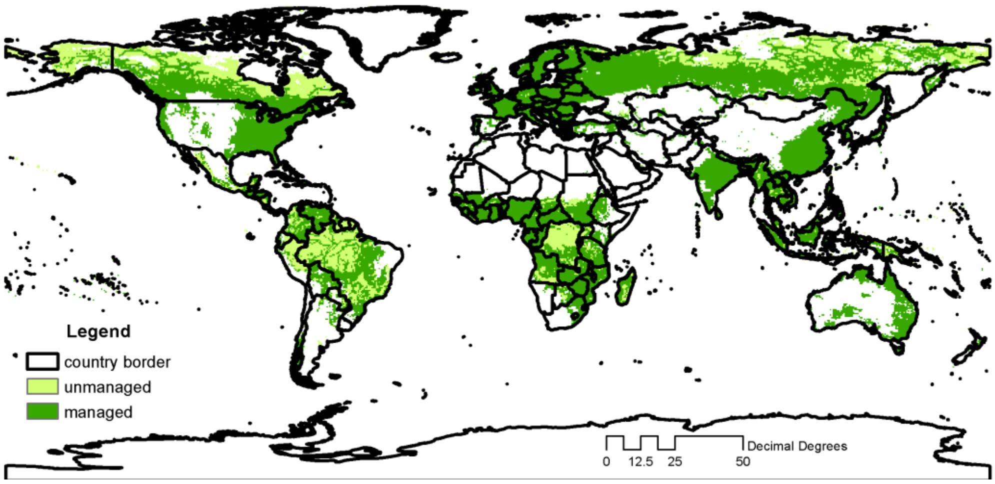

Figure 1. A map managed forest area consistent with the countries' reports of GHG emissions to UNFCCC.

The entire grid cells were classified as managed or unmanaged, therefore, the area of the managed forest land on the resulted map may exceed the country data presented in [1] (e.g., Argentina, Brazil, Canada, Colombia). However, the area of the managed forest on the map is below the area presented in [1] for a number of countries. There are three main reasons for that:

1) our basic map is GLC 2000 adjusted to the FAO FRA forest area in 2000, while the Grassi et al. 2021 [1] data represents 2005-2015 average. In some countries, the forest area

increased after 2000, therefore, our basic map does not contain all forest accounted for in 2005-2015 (e.g., India, Viet-Nam);

2) in the UNFCCC process the countries use national definition of forest that in some cases differ from the FAO definition that is applied in our basic map (e.g., Turkey, South Africa);

3) due to coarse resolution our basic map misses some forest area on the borders and coasts.

The IPCC definition of managed land allows wide interpretation of the term. Therefore, national definitions of the managed land including managed forests differ among countries [10]. In this study, we applied general criteria to all countries, regardless of local forest practices and actual criteria applied in the countries that may result in wrong classification.

A further development of managed forests maps, with consistent definitions at country-level, and country-specific rules for managed/unmanaged forest classification deserves further investigation. Such efforts can support the harmonization of GHG emissions estimates from models and official statistics and improve the design of mitigation policies informed by IAMs. In particular, country specific rules for determining location of the managed forests should be applied and a comparison of the developed map to the national maps of managed forests should be provided where it is feasible.

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