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Projecting global forest area towards 2030 ☆

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ABSTRACT

There is strong interest in gaining an informed view of changes likely to occur in forest area and the impacts of these changes on production forestry and forest conservation. Despite the complexity of underlying causes, it is largely accepted that deforestation is mainly focused in the tropics and driven by conversion to agriculture. Similarly, energy demand and GDP are largely determining wood consumption and production. Based on these assumptions, we built a model predicting natural forests and planted forests' evolution in the next 15 years, and compared the results of the modelling with survey results from country expertise. The results suggest that on a global level, forest resources loss is likely to slow down. The forests that are most at risk of conversion were clearly identified within the tropical domain, while the forest under protected areas showed very little risk of being converted to other land uses in the near future.

1. Introduction

The world's population is growing rapidly: the UN predicts a 15% population increase in the next 15 years to a total of 8.4 billion people (UN 2012). Per capita consumption is increasing as well, especially in fast-growing economies, resulting in an unprecedented demand for resources. In response to increased forest loss over the past decades, international decisions have set global targets like the Aichi targets for biodiversity (CBD, 2010) and incentives to reduce emissions from deforestation and forest degradation in developing countries are being negotiated (UNFCCC, 2014). An informed vision on future forest area dynamics may help guide and prioritize international decisions aimed at reducing forest loss; this paper explores projected forest area change and its potential effect on the production and conservation functions of forests towards 2030.

Deforestation is the result of many processes driven by multiple causes. We can distinguish underlying and direct causes of land conversion; underlying causes can include economic development, demographic trends and technology factors, and direct causes can include cropland, pasture land or urban development expanding on, and replacing, forest land (Geist and Lambin, 2001; Smith et al., 2010). The underlying causes determine the degree of direct causes resulting in land-use change.

Despite the complexity of deforestation causes, it is generally accepted that deforestation is primarily occurring in the tropics (FAO and JRC, 2012) and the largest direct cause of deforestation is agricultural expansion as 70–95% of forests lost in the tropics are converted to agriculture (Holmgren, 2006; Hosonouma et al., 2012).

Hosonouma et al. (2012) used information reported in REDD+ Readiness Preparation Proposals from various countries and the Global Forest Resource Assessment (FRA) (FAO, 2010) to suggest that agriculture (cropland and pasture) is by far the largest direct cause of deforestation; according to their estimations between 70% and 80% of forest conversion is to agriculture in Africa, around 70% in subtropical Asia and >90% in Latin America. Other studies equally indicate agricultural expansion as the largest direct cause of deforestation in Africa, Asia and Latin America (Nepstad et al., 2008; Guitierrez-Velez et al., 2011).

Forest gains, on the other hand, are driven by two main factors: natural forest regrowth on abandoned agricultural land (Baumann et al., 2011) and tree planting for consumption, either as timber (Antweiler et al., 2012) or energy wood. Many studies suggest that wood is indeed increasingly used as an energy source at the global level, not only in developing countries (Smeets et al., 2007; IEA, 2011) but also in developed economies (UNECE and FAO, 2009; USEIA, 2014). As a consequence, the regional and global patterns of wood production have changed in the last few decades, with a rapid and significant increase in the area of planted forests and

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the growing importance of these resources for wood supply (Carle and Holmgren, 2008; Whiteman, 2014). However, technological development in wood processing and the use of other bio-energy sources does not imply that the increased energy demand results in an equal increase in wood demand. For instance, Buongiorno and Zhu (2014) looked at changes in technology and found that wastepaper is increasingly used to replace virgin fibre in pulp and paper production, buffering the effect of increased global bio-energy demand on global wood demand.

In order to capture these different patterns of losses and gains of forest in the next 15 years, we built a model based on several hypotheses: the first is that the changes occurring in agricultural land and natural forest land are meaningfully correlated. This is despite the fact that magnitude of changes occurring in agricultural land and natural forest land are not directly and linearly comparable. Our second hypothesis is that we can use wood consumption projections to build a model predicting planted forest projections. To test the hypotheses we looked at the correlation between past natural forest area change and past arable land area change on the one hand, and wood consumption and planted forests area on the other hand.

Further on, forest area change per country was projected based on a historical trend analysis of FAOSTAT (2013) and FRA country reported data on forest and agricultural area, combined with exogenous global cropland projections to 2030 (Alexandratos and Bruinsma, 2012) and global wood demand projections to 2030 (as in Buongiorno et al., 2012, harmonized with FAO data).

To assess the impacts of forest area changes on production and conservation functions, a global forest map with information on forest functions was produced and the forest area loss projected by the first model was spatially allocated based on an analysis of socio-economic and biophysical characteristics of past forest loss.

Finally, we compared the outcomes of the model with regional change estimates based on country expectations on future forest area changes reported in the global forest resources assessment (FRA) 2015 user survey and provided possible explanations for diverging expectations. The results are presented by region and income level and are limited to the countries that reported data in the FRA 2015 survey, answering to the question, "What is forest area likely to be in the future?"

2. Material and methods

In this paper, the definitions of forests, planted forests and other land uses follows the FRA Terms and definitions (FAO, 2012b). In particular, forest land use excludes any agricultural use (i.e. oil palm plantations are not considered forests), natural forests are comprised of both primary forest and naturally regenerated forest and planted forests are established through planting and/or deliberate seeding.

Three sets of data on forest area change, compliant with the FAO definitions, were used to determine and discuss potential forest projection towards 2030:

- A tabular data country-based model that produces regional and global trends (explained in 2.2–2.5),
- a spatially explicit model using the quantitative projections from the first model and spatially allocating these losses on a global forest map based on a historical trend analysis of locations of past forest loss (2.6),
- a set of country-specific predictions provided as expert judgment for the 2015 Global Forest Resource Assessment (FRA 2015) user survey (2.7).

2.1. Forest projection model: GFRM

The Global Forest Resources Model (GFRM), developed in this study, is based on tabular data per country and projects forest area change using exogenous projections of arable land and wood demand. Because of the strong prevalence of agricultural expansion as the main determinant of past deforestation, we built our modelling choices on the assumption that future forest loss is likely to be strongly determined by future agricultural expansion. Agricultural expansion is approximated with arable land projections up to 2030 by Alexandratos and Bruinsma (2012), which are mainly driven by projections of Gross Domestic Product (GDP) and population expansion, the main exogenous drivers for most global land-use change models (Fischer et al., 2005; Van Vuuren et al., 2007; Schmitz et al., 2014). The arable land projections also include projected changes in agricultural intensification which include policy assumptions that potentially provide an enabling environment and some major assumptions on future commodity trade (Conforti, 2011; Alexandratos and Bruinsma, 2012). The model assumes forest gain to be determined by forest regrowth on a share of abandoned agricultural land and an increase in forest planting driven by wood demand (timber and fuelwood).

The GFRM consists of projections of natural and planted forest as described in Fig. 1.

2.2. Arable land and natural forests

The GFRM projection for natural forest change is a linear relationship between arable land change projection and forest change projection:

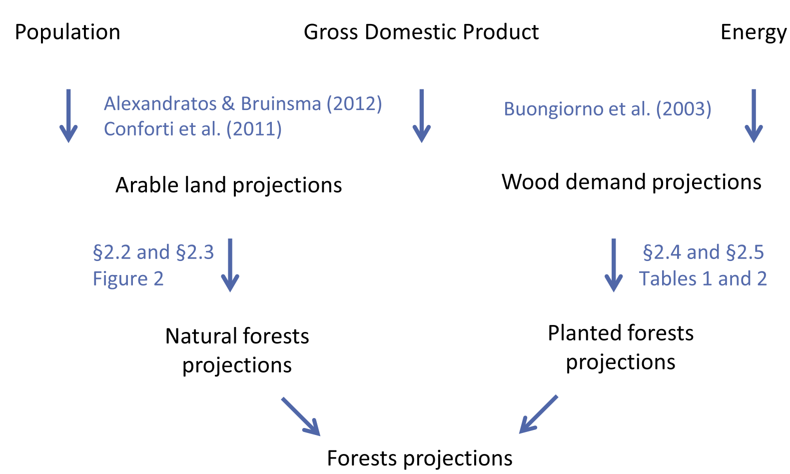

Fig. 1. Schematic representation of the modelling approach used in the study: the Global Forest Resources Model (GFRM).