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Deforestation dynamics and drivers in different forest types in Latin America: Three decades of studies (1980–2010)

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ABSTRACT

Over the last decades there have been a considerable number of deforestation studies in Latin America reporting lower rates compared with other regions; although these studies are either regional or local and do not allow the comparison of the intraregional variability present among countries or forest types. Here, we present the results obtained from a systematic review of 369 articles (published from 1990 to 2014) about deforestation rates for 17 countries and forest types (tropical lowland, tropical montane, tropical and subtropical dry, subtropical temperate and mixed, and Atlantic forests). Drivers identified as direct or indirect causes of deforestation in the literature were also analysed. With an overall annual deforestation rate of −1.14 (± 0.092 SE) in the region, we compared the rates per forest type and country. The results indicate that there is a high variability of forest loss rates among countries and forest types. In general, Chile and Argentina presented the highest deforestation rates (−3.28 and −2.31 yearly average, respectively), followed by Ecuador and Paraguay (−2.19 and −1.89 yearly average, respectively). Atlantic forests (−1.62) and tropical montane forests (−1.55) presented the highest deforestation rates for the region. In particular, tropical lowland forests in Ecuador (−2.42) and tropical dry forests in Mexico (−2.88) and Argentina (−2.20) were the most affected. In most countries, the access to markets and agricultural and forest activities are the main causes of deforestation; however, the causes vary according to the forest types. Deforestation measurements focused at different scales and on different forest types will help governments to improve their reports for international initiatives, such as reducing emissions from deforestation and forest degradation (REDD+) but, more importantly, for developing local policies for the sustainable management of forests and for reducing the deforestation in Latin America.

1. Introduction

The destruction of tropical forests has received worldwide attention because of the well-known, unique role they play in ecological terms, the diversity of functions they provide and, above all, the continuing threat to its existence, which directly affects the net carbon emissions derived from deforestation and degradation (Houghton, 2012). In addition, the deforestation rates are far from being uniform across the world and depend on the different analyses and sources of data used for their calculation. The Food and Agriculture Organization of the United Nations (FAO, 2011) estimated a net global deforestation of 0.20% in the decade from 1990 to 2000, 0.12% between 2000 and 2005 and 0.14% between 2005 and 2010, with a net loss of 5.2 million hectares from the year 2000 to 2010. Instead, (Hansen et al., 2010) indicated a rate of 0.6% of annual forest loss and an estimated loss of global forest area between 2000 and 2005 of 101.1 million hectares. One of the latest published global figures of deforestation indicates global net losses of tropical forests of 6.1 million hectares per year for the 1990–2000 period (0.377%) and 5.9 million hectares per year during the 2000 s (0.384% annually; Achard et al., 2014)

At the continental level, (Achard et al., 2002) reported a deforestation rate of 0.38% for Latin America, 0.43% for Africa, 0.91% for Southeast Asia and an overall rate of 0.52%. Brazil and Indonesia accounted for 20.3% of the loss of tropical forests in 1980, 25.7% during the 1990s and the 40.7% between 2000 and 2005. Since the year 2000, several reports suggest that these tropical regions have significantly reduced their deforestation rate (Achard et al., 2014; Food and Agriculture Organization of the United Nations (FAO, 2010a). In the 1990s, several authors estimated a decrease in the rate of deforestation and an increase in the forest area through planting or natural expansion and

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recovery of existing forests in Asia, Africa and Latin America (FAO, 2010b; Rudel et al., 2009). In Latin America, the largest reported net loss of forests in recent decades occurred from 2000 to 2010 (4 million ha/year), with an increase from 2000 to 2005 (FAO, 2010). A more recent global study (Achard et al., 2014) indicates that the annual net deforestation for humid and dry forests in Central and South America between 2000 and 2010 was 1.92 and 0.92 million of hectares, respectively. These values are higher than those from the previous decade in the case of humid forests (1.86 million of hectares in 1990–2000) and lower than those from dry forests (0.99 million of hectares). The lack of comparable historical national forest inventory data has made these global datasets one of the few available datasets to compare across nations. Yet, the different approaches constitute a challenge for comparing amongst them. Furthermore, most existing studies report the deforestation in different ways (e.g., total deforestation annual rate, total rate, gross, net loss in hectares, among others), which makes the comparison of the dynamics of forest loss complex and, a priori, less direct. A solution to this issue is to use the same standardised deforestation rate, such as the one proposed by Puyravaud (2003).

Addressing the causes of tropical deforestation requires not only reliable figures on deforestation rates but also an understanding of the socioeconomic dynamics of the regional and local scales. The reported causes and agents of forest loss act usually at different scales, and the governments are challenged by the clear limitations that exist in terms of homogeneous information, from both the social and environmental points of view. Furthermore, tropical forests play a vital role in balancing the global greenhouse gas (GHG) emissions due to their ample above- and below-ground carbon storage (Houghton, 2005). For a long time forests and climate change were dealt with on separate international policy tracks, on the one hand on several of the UN Tropical Forestry Action Programmes and national forest programmes, and on the other hand on the UN Framework Convention on Climate Change (UNFCCC) (Buizer et al., 2014). The Kyoto Protocol recognised the importance of forests in climate change mitigation and somehow redefined international climate and forest politics that eventually led into current mechanisms REDD+ (Buizer et al., 2014). In the context of national policies of the countries that signed the Kyoto Protocol (1997), the governments have committed to reduce the drivers of forest change (Kissinger et al., 2012). For the success of current international programmes that aim at reducing emissions from deforestation and to increase the atmospheric GHG removal by forests (e.g., reducing emissions from deforestation and forest degradation −REDD+), a better understanding of the causes of forest loss must be observed as potential opportunities to promote forest conservation and climate change mitigation.

Several advances have been undertaken regarding the explanation of the causes of deforestation patterns in the tropics (Geist and Lambin, 2001). The agricultural expansion in forest frontiers is probably the most cited cause in the literature as the main direct factor of forest loss in the world (Gibbs et al., 2010), followed by other factors such as the conversion of forest to pastures, logging for obtaining energy sources and construction or expansion of infrastructures (Carr, 2004). Behind these direct causes, the understanding of causes and agents of deforestation has evolved to include more distant or underlying drivers of deforestation that involve economic, demographic, technological, cultural and political factors that operate at multiple scales and that differ among regions (Geist and Lambin, 2001; Mather et al., 1999; Meyfroidt et al., 2013). Rudel et al. (2009) identified that between 1960 and 1980 the forces behind the deforestation were social. The results of this study showed an increase in deforestation rates, especially in areas where colonisation schemes promoted the construction of roads and new settlements for rural populations. Hence, it is necessary to recognise the deforestation as a dynamic process associated with social, political and economic changes. These factors change over time, and the trends of forest loss from the 1990s to the present reflect the changes in these causes. More recent processes, such as globalisation, the demand for international markets (increased consumption of corn, sugar cane, palm oil and biofuels) and urbanisation associated with urban population growth, also play a crucial role (Ramankutty et al., 2007; Rudel et al., 2009). Other drivers of change in the tropics are associated with general patterns of land use and conversion of forest to pasture (Ramankutty et al., 2006). In Latin America, geographic, socio-economic factors and biophysical parameters have been proposed as the most important factors of recent changes in the land use (Wassenaar et al., 2007). To a lesser extent (and impact), other factors have been proposed, such as accessibility, demand for domestic and international markets, growth in population density, particularly in lowland transitional areas where the most active deforestation frontiers are found (Armenteras et al., 2011, 2006; Gomez-Peralta et al., 2008; Rudel et al., 2009; Wassenaar et al., 2007).

The majority of recent regional or cross national studies about tropical deforestation have either focused on the general forest/non forest pattern or on a maximum of two forest types (Achard et al., 2014; Aide et al., 2013; Hansen et al., 2013, 2008), e.g., the comparison of woody vegetation and plantations vs. mixed-woody vegetation (Aide et al., 2013) or humid vs. dry tropical forests (Achard et al., 2002, 2014). However, it is well known that different forest types greatly vary from region to region together with the geographical (latitude, altitude, biotic components, microclimate, among others) and socioeconomic factors that affect them. Because of this high variability of forest types, environmental conditions and human dimensions, it seems reasonable to undertake an analysis that would help to compile the deforestation rates and untangle the different dynamics and causes across the different tropical forests types in Latin America. The aim of this work is to (i) analyse deforestation rates in the different forest types and countries, (ii) explore the impact of the Kyoto protocol on deforestation rates and, finally, (iii) evaluate the drivers of deforestation per forest type and country. Based on the previous information, our hypotheses for these objectives are: (i) dry forests have higher deforestation rates than more humid and lowland ones, (ii) deforestation rates have decreased after the Kyoto protocol, and (iii) the expansion of agriculture and pastures remains as the major driver of forest loss across Latin America. We have conducted a systematic and comprehensive review of peer-reviewed publications related to deforestation studies in Latin America for the last 30 yrs (1980–2010). We have compared the deforestation rates and their drivers among different countries and forest types using a standardized formula to calculate the annual rate of change of forest cover (Puyravaud, 2003). For a sub-set of countries, we have also conducted a temporal comparison of deforestation rates taking into account the year of one of the most relevant political agreements concerning environmental policies (i.e., pre- or post-Kyoto Protocol).

1.1. Methodology

1.1.1. Study area

The study area includes most tropical, subtropical and temperate forests of Latin America, from Mexico in the north to Argentina and Chile in the south (see the list of countries included in Table 1). Unfortunately, small countries such as Suriname, Belize or Guyana were not included in the analysis due to their limited availability of information.

1.1.2. Data collection

A comprehensive search was conducted in three databases: a) Scopus, b) Web of Science, and c) Google Scholar. To minimize bias we explicitly stated the hypotheses and the methodological approaches prior to undertaking the research without prior knowledge of the data (Silagy et al., 2002). The first search criterion was the year of publication. We focused the search from 1990 to 2014, considering that even studies published during these years could contain forest cover dates prior to the date of publication. As second criteria, the following keywords were considered: REDD, deforestation, deforestation drivers,