

The rate, extent and spatial predictors of forest loss (2000–2012) in the terrestrial protected areas of the Philippines



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ARTICLE INFO

Article history:

Received 17 March 2016

Received in revised form

31 January 2017

Accepted 7 February 2017

Available online 21 February 2017

Keywords:

Forest loss

Protected areas

Philippines

Logistic regression

Deforestation

ABSTRACT

While studies on deforestation of protected areas (PAs) have been conducted in many parts of the world, no comparative study has been done over an entire country in the tropics. Thus, we conducted a country-wide assessment of forest cover loss in all terrestrial protected areas of the Philippines, covering 198 PAs with a total area of 4.68 million ha. This study utilised Hansen's Landsat-derived global maps of forest cover change from 2000 to 2012, with tree canopy cover data for 2000 as the base year. Correlation and logistic regression analyses were employed to determine the significance and magnitude of the relationships between forest cover and 11 predictor variables. The assessment of forest loss reveals that the terrestrial protected areas are generally effective in reducing forest loss. Over the 12-year period, the average rate (2.59%) of forest clearing in protected areas is marginally lower by 0.1% than the entire country (2.69%). Within the same duration, the average forest loss rate within the 2-km buffer zones of selected protected areas is 1.4 times of those inside PAs. However, there was a significant number of PAs with phenomenal forest cover loss in terms of extent (48,583 ha over 12 years) and rate (up to 21%). We found that spatial predictor variables included in this study have weak or no relationships with forest cover, and hence they are not reliable inputs for predictive modelling. Comprehensive assessments of deforestation are needed at the micro-scale (e.g. single PA level) level and relatively shorter historical timeframe (e.g. less than a decade), to generate useful information for policy formulation, planning, and management.

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1. Introduction

Over the past half century, the world's tropical forest areas have declined considerably. In the late 1970s, tropical deforestation was about 11.3 million hectares per year (M ha y^{-1}) (Lanly, 1982). During the period 1980–1990, it increased to about 15.4 M ha y^{-1} (Singh, 1993). From the latest *Global Forest Resources Assessment 2015* report (FAO, 2015), tropical forest areas have declined by 195 M ha between 1990 and 2015 (Keenan et al., 2015). At present, the same report estimates that there are 1797 M ha of tropical forests worldwide, comprising around 44% of global forest area. While the quests to understand its drivers and preventive measures persist, the continuous depletion of forest resources is no doubt causing various environmental and socio-economic problems.

As in many economically developing countries in Southeast Asia, deforestation in the Philippines has been rampant and rapid. The country's forest cover has declined from 17.1 million hectares or about 57% of the land area in 1937 (Tamesis, 1937) to approximately 8.0 million hectares or 27% in 2015 (FAO, 2015). A study by Carandang et al. (2013) found that logging (identified by 40.58% of informants interviewed), *kaingin* making (shifting agriculture) (16.98%), biophysical factors (climate change, typhoons, floods, landslides) (12.73%), mining (8.49%), and charcoal making (8.15%) are the key drivers of deforestation and forest degradation in the country. Kummer (1991) stressed the importance of elite control and corruption in explaining the rate and pattern of deforestation in the post-war Philippines.

The establishment and management of protected areas (PAs) is one of the strategies being used to combat deforestation. Protected areas serve a variety of functions and they provide substantial benefits to society. They are important in protecting landscapes and seascapes, achieving biodiversity conservation, and delivering essential ecosystem services (Watson, Dudley, Segan, & Hockings,

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2014). Over the past decades, there has been a steady increase in the number and extent of protected areas worldwide. In total, around 20.6 million square kilometres (15.4%) of terrestrial and inland water areas are now covered by protected areas (Juffe-Bignoli et al., 2014). Studies have shown that these lands are generally effective in reducing deforestation within their boundaries, although some protected areas were not significant in reducing forest loss (see review of Campbell et al., 2008; Naughton-Treves, Holland, & Brandon, 2005).

There is a need to understand the drivers of deforestation in protected areas and their surrounding areas. This will allow the generation of scientific information and knowledge essential to policy formulation, conservation planning and land resource management. While deforestation studies in protected areas have been conducted in many parts of the world (e.g. Adhikari, Southworth, & Nagendra, 2015; Pfaff, Robalino, Lima, Sandoval, & Herrera, 2014; Vuohelainen, Coad, Marthews, Malhi, & Killeen, 2012; Sanchez-Azofeifa, Rivard, Calvo, & Moorthy, 2002), no such study has been done over an entire country covering all terrestrial protected areas. This present study attempted a country-wide assessment of forest cover loss in all terrestrial protected areas (PAs) of the Philippines, covering 198 PAs with a total area of 4.68 million ha.

As early as 1904 during the American colonial rule, eight national reserves were established in the Philippines. Subsequent proclamations ensued over the following decades, including a series of legislations that aimed to strengthen the laws on national protected areas in the country. In 1992, the Congress of the Philippines enacted the National Integrated Protected Areas System (NIPAS) Act, which provides a new framework for people-oriented, community-based approaches that aim to balance ecological and socio-economic goals. As of 2014, there are 240 terrestrial and marine protected areas in the Philippines covering 5.45 million hectares (Biodiversity Management Bureau, 2015).

The broad aim of the study was to assess the loss of forests, over a decade, in the terrestrial protected areas of the Philippines. The following are the specific objectives: a) to compare the rate and extent of forest loss in the entire country as against those located in the terrestrial protected areas; b) to determine the significance and magnitude of the relationships between forest cover and selected spatially explicit variables. The study aspired to answer the following key research questions: “Are the rates of forest loss within the protected areas lesser or greater than the forest loss in the entire country?” and “Which of the spatial predictor variables have significant and strong relationships with forest cover within the protected areas?”

2. Methods

2.1. Study area

The study area comprises the land area (i.e. excluding the marine area) of the entire Philippines, covering an extent of 298,170 km² (Fig. 1). It is composed of 7107 islands, in which Luzon, Visayas, and Mindanao are the largest island groups. A tropical country, the Philippines has a climate characterised by relatively high temperature, high humidity and abundant rainfall. The coolest month (January) has a mean temperature of 25.5 °C while the warmest month (May) has a mean temperature of 28.3 °C (PAGASA, 2015). The mean annual rainfall varies from 965 to 4064 mm annually. There are two major seasons: (1) the rainy season, from June to November; and (2) the dry season, from December to May.

The Philippines has a population of over 92 million people based on the 2010 census, with an annual growth rate of 1.9% (National Statistics Office (Philippines), 2012). It makes the country ranked

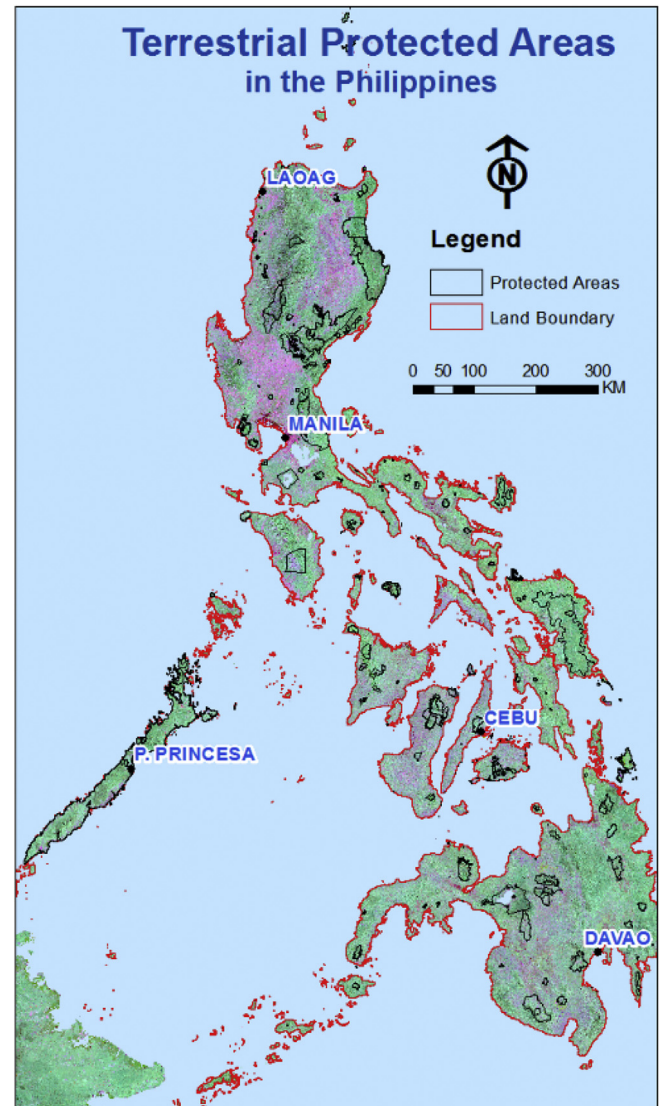


Fig. 1. Location map of the study area showing the terrestrial protected areas.

12th globally among the most populous countries in the world. Based on the latest *Global Forest Resources Assessment* report (FAO, 2015), the Philippines has approximately 8.0 million hectares of forests, corresponding to 27% of the total land area. Of this, about 861,000 ha is classified as “primary forest” (i.e. forests with no clearly visible indications of human activities and the ecological processes are not significantly disturbed), representing a low 10.7% of total forest area. Out of the 8.0 million ha of forests, about 1.86 million ha is classified as “forests within protected areas” (FAO, 2015).

The Philippines is one of world's top biodiversity-rich countries (Mittermeier et al., 1997). Based on the synthesis of Myers, Mittermeier, Mittermeier, da Fonseca, and Kent (2000) from various sources, the country has 7620 vascular plant species (5832 species is endemic) and 1093 vertebrate species except fishes (518 species is endemic). However, the Philippines is also included in the world's most threatened biodiversity hotspots, i.e. areas with exceptional species endemism and experiencing exceptional habitat loss. The same paper (Myers et al., 2000) identified the Philippines as one of the “hottest hotspots”, along with Madagascar and the Sundaland biogeographical region.

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