



## Original research article

## Assessment of carbon stocks of semi-evergreen forests in Cambodia

Kimsun Chheng<sup>a</sup>, Nophea Sasaki<sup>b,c,\*</sup>, Nobuya Mizoue<sup>d,e</sup>, Saret Khorn<sup>a</sup>, Dana Kao<sup>a</sup>, Andrew Lowe<sup>c</sup><sup>a</sup> Forestry Administration, No. 40, Preah Norodom BLVD, Phnom Penh, Cambodia<sup>b</sup> Department of Policy and Management Informatics, University of Hyogo, 7-1-28 Minatojima-minamimachi, Chuo-ku, Kobe 650-0047, Japan<sup>c</sup> School of Biological Sciences, University of Adelaide, North Terrace, Adelaide, SA5005, Australia<sup>d</sup> Faculty of Agriculture, Kyushu University, 6-10-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan<sup>e</sup> Faculty of Forestry, University of British Columbia, 2424 Main Mall, Vancouver, BC, V6T 1Z4, Canada

## ARTICLE INFO

## Article history:

Received 15 October 2015

Received in revised form 13 November 2015

Accepted 13 November 2015

Available online 9 December 2015

## Keywords:

Carbon stocks

Carbon emissions

REDD+

Relative carbon stock

Relative dominance

## ABSTRACT

Understanding carbon stocks relative to tree species is important for managing tropical forests in a way that will result in the carbon emission reductions and biodiversity conservation required under the REDD+ scheme. Here we analyse inventory data from 179 sample plots in semi-evergreen forests of three provinces in Cambodia. Across all study sites, 5,995 trees with a diameter at breast height (DBH)  $\geq 10$  cm, comprising 79 species from 38 families, were analysed. Tree species of the Dipterocarpaceae were most common (10 species), followed by the species of Caesalpiniaceae, Combretaceae and Ebenaceae. Analysis of relative carbon stocks (RCS) suggested that *Lagerstroemia calyculata* Kurz (RCS = 14.3%), *Syzygium* sp. (6.8%), *Shorea vulgaris* (5.0%), *Irvingia malayana* (4.8%), *Anisoptera costata* Kort (4.6%), *Vatica astrotricha* (4.2%), and *Dehaasia cuneata* Blume (3.8%) together accounted for 43.6% of the total average carbon stocks of  $99.8 \pm 4.8$  MgC ha<sup>-1</sup>. We found that carbon stock is highly correlated to basal area ( $R^2 = 0.993$ ) but not to stem density ( $R^2 = 0.153$ ). Using carbon stock values, we estimated the carbon emission due to deforestation of semi-evergreen forests to be 8.3 TgCO<sub>2</sub> year<sup>-1</sup> in Cambodia between 2002 and 2010. These emissions and the loss of 79 tree species in our study sites could be avoided if financial incentives were available for protecting semi-evergreen forests in Cambodia.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## 1. Introduction

Although tropical forests cover only 6% of the Earth's total land surface, they are home to the richest biodiversity on the planet, comprising a major component of our trees, plants, birds, insects and mammals (Laurance et al., 2012). Tropical forests also contribute substantially to the global economy, to local human welfare and to the global carbon budget. Based on 109 case studies from across the tropics, tropical forests are considered important sources of ecosystem services whose annual value has been estimated at US\$ 6120 ha<sup>-1</sup> (TEEB Climate Issues Update, 2009, as cited in Sukhudev, 2010). Unfortunately, the capacity of tropical forests to provide these services is gradually declining each year because of rapid

\* Corresponding author at: Department of Policy and Management Informatics, University of Hyogo, 7-1-28 Minatojima-minamimachi, Chuo-ku, Kobe 650-0047, Japan. Tel.: +81 78 303 2919.

E-mail address: [nopsasaki@gmail.com](mailto:nopsasaki@gmail.com) (N. Sasaki).

<http://dx.doi.org/10.1016/j.gecco.2015.11.007>

2351-9894/© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

deforestation (FAO, 2010; Lambin et al., 2003) and forest degradation, mainly due to uncontrolled and in many cases illegal logging (Asner, 2011; Asner et al., 2009; FAO, 2010; Gaston et al., 1998; Robinson et al., 2013; Tacconi, 2007) and fires (Nepstad et al., 1999; Siegert et al., 2001). Between 2000 and 2005, at least 392 million ha (or 20%) of the total area of humid tropical forests was logged, and approximately 50% of standing humid tropical forests retained <50% forest cover as of 2005 (Asner et al., 2009; FAO, 2010). Reducing deforestation and forest degradation has been at the forefront of negotiations of the Conferences of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) because such reduction will result in carbon emission reduction, protection of biodiversity and improvement of the livelihoods of forest-dependent communities in developing countries.

The adoption of the Bali Action in 2007 and the subsequent recognition of REDD+ (reducing emissions from deforestation and forest degradation, conservation of forests, sustainable management of forests and enhancement of forest carbon stocks) at COP13 paved way for financial incentives for the protection of tropical forests. REDD+ is a results-based financial compensation scheme requiring emission reductions while safeguarding biodiversity. Four of the seven decisions made at COP19 under the Warsaw Framework for REDD+ emphasised the importance of forest carbon monitoring and safeguarding (Decision 9/CP.19). With the requirement for biodiversity safeguards, information on the relationship between tree species and carbon stocks, and how this has been affected by management in developing countries, is important for the successful implementation of any REDD+ activity (Entenmann et al., 2014; Kapos et al., 2012). However, until recently, there was little information available on this relationship. In a review of 24 studies from across the globe, Thompson et al. (2014) found that only one study (from Panama) focused on the relationship between tree species and carbon storage in natural tropical forest. In that study, up to 61 species were found with above-ground biomass of up to 200 MgC ha<sup>-1</sup> (Ruiz-Jaen and Potvin, 2010). In Cambodia, several studies have examined stand structure in evergreen, semi-evergreen and deciduous forests in Kampong Thom province (Kao and Iida, 2006; Kim Phat et al., 2000, 2002a,b; Top et al., 2004) and in evergreen forest in Preah Vihear province (Kao and Iida, 2006); however, measurements were limited to tree species, stem density and stand volume. Sasaki (2006) analysed carbon emissions due to human activities in Cambodia, but the effect of tree species was not considered. Although previous studies provide useful information on the current status of forest stand structure and carbon emissions in Cambodia, information on the relationship between these parameters, i.e. stand structure (tree species, stem density and basal area) and carbon storage, is lacking. This lack of information makes the implementation of REDD+ projects difficult, thus jeopardising carbon emission reductions, local biodiversity and the livelihoods of local people.

The aims of this study were to analyse stand structure and carbon stocks in semi-evergreen forests in Cambodia, and to discuss the policy implications for the successful implementation of REDD+ activities. This paper is structured as follows: forest inventory data from 179 sample plots were analysed according to tree species and diameter at breast height (DBH) classes; the relationships among stem density, basal area and carbon storage were evaluated following Cottam and Curtis (1956) and the policy implications for REDD+ activities and biodiversity safeguards are discussed.

## 2. Study methods and materials

### 2.1. Forests and forest cover in Cambodia

The total 2015 population of Cambodia was estimated to be approximately 15.4 million, increasing from 13.4 million in 2008. Cambodia is a heavily forested country in Southeast Asia, having a total forest area of 10.4 million ha in 2010 (approximately 57.1% of the country's total land area). Forests are socially, environmentally and economically important resources for national development in Cambodia (Kim et al., 2008, 2006; San et al., 2012a,b). Approximately 85% of the Cambodian population lives in rural areas and almost 100% of the total population uses fuelwood for daily cooking. In rural areas, fuelwood is collected from nearby forests (San et al., 2012a), but the distance to forests is increasing as the accessibility to nearby forests decreases. Per capita annual wood consumption in Cambodia has been estimated as approximately 0.66 m<sup>3</sup> (World Bank et al., 1996). As the Cambodian population continues to grow, a greater demand for wood is expected posing further pressure on the remaining forests. Between 2002 and 2010, approximately 0.8% of forest cover was lost annually. The annual deforestation rate accelerated between 2006 and 2010, increasing to 0.9% (Table 1). As shown in Table 1, three major forest types are recognised in Cambodia: evergreen, semi-evergreen and deciduous. Other minor forest types exist, including woody dry shrubland, woody evergreen shrubland, bamboo, forest plantation, flooded and mangrove forests. Semi-evergreen forests have a total area of 1.3 million ha (12.5% of the total forest area) in Cambodia.

The remaining 10.4 million ha of forests are classified under the land-use categories of production forests (36.1% of the total forest area), protected forests (43.1%) and conversion forests (20.8%). Production forests include concession and community forests, where timber may be harvested subject to approval from the Forestry Administration (FA). Protected forests are managed for biodiversity conservation and local development. Conversion forests are forests whose management objectives are not clearly specified. Depending on the need for economic development and settlement of a growing population, conversion forests may be converted to social land concession and/or economic land concession. However, allocation of new economic land concession was banned by the Cambodian government in 2012. Two REDD+ projects were validated in Cambodia, one of which received triple-gold verification for its contribution to emission reductions, improving local livelihoods and biodiversity conservation (Terra Global, 2013).

Download English Version:

<https://daneshyari.com/en/article/4379707>

Download Persian Version:

<https://daneshyari.com/article/4379707>

[Daneshyari.com](https://daneshyari.com)