Mini Focus: Sustainable Landscapes in a World of Change: Tropical Forests, Land use and Implementation of REDD+

Sustainable landscapes in a world of change: tropical forests, land use and implementation of REDD+: Part I

Carbon Management (2013) 4(5), 465–468



> "This is the first of two Mini Focus issues of *Carbon Management*. Articles are based on presentations at a Landscape Ecology Conference sponsored by the International Union of Forest Research Organizations from November 2012 in Conception (Chile)..."



Richard Birdsey*[1], Yude Pan[1] & Richard Houghton[2]

Keywords: carbon sinks ■ deforestation ■ forest degradation ■ monitoring ■ tropical forests

Tropical forests play a critical role in the Earth system; however, tropical landscapes have changed greatly in recent decades because of increasing demand for land to support agriculture and timber production, fuel wood, and other pressures of population and human economics. The observable results are a legacy of persistent deforestation, forest degradation, increased wildfires and loss of biodiversity, allied with losses of original forest lands and high CO_2 emissions in the atmosphere. Besides these long-standing human pressures, tropical regions now have unprecedented vulnerability to climate change.

Over the past two decades, global forests removed from the atmosphere approximately one-third of the carbon emitted globally from the burning of fossil fuels [1]. Over the period 1990–2007, the estimated average carbon sink in global forests was 2.4 ± 0.4 PgC yr^{-1} (2.4 billion tons per year; **Figure 1**). Understanding the causes of the forest carbon sink is necessary to both manage forests for their carbon value and project the future contribution of forests to the carbon cycle, which may be affected by many factors such as drought, natural disturbances and land-use changes.

In the tropics, intact forests (those not affected significantly by land-use changes or harvesting) remove more than 1.0 PgC yr^{-1} from the atmosphere on average, almost as much as the combined removal by temperate and boreal forests **(Figure 1)**. Tropical forests that are affected by land-use change and harvest are even more dynamic, emitting almost 3.0 PgC yr^{-1} from deforestation and forest degradation on average, and taking up approximately 1.6 PgC yr^{-1} in regrowth and recovery. Emissions from land-use change in the tropics appear to be declining significantly from their high of approximately 1.5 PgC yr^{-1} during the 1990s, to a current rate closer to 1.0 PgC yr^{-1} [2].

In contrast to the decadal averages, the magnitude of the global land sink (which is almost entirely attributed to forest land) is highly variable from year to year, ranging from 0.0 to 4.0 PgC yr^{-1} in some years [1,3]. This high variability of the global land sink is inferred from the high interannual variability of the growth rate of CO_2 concentration in the atmosphere, which is correlated with annual or periodic variations in global weather patterns, such as droughts that are associated with El Niño/La Niña and other cycles. Natural disturbances

[1]US Department of Agriculture Forest Service, 11 Campus Blvd., Suite 200, Newtown Square, PA, USA
[2]Woods Hole Research Center, 149 Woods Hole Road, Falmouth, MA, USA
*Author for correspondence: E-mail: rbirdsey@fs.fed.us

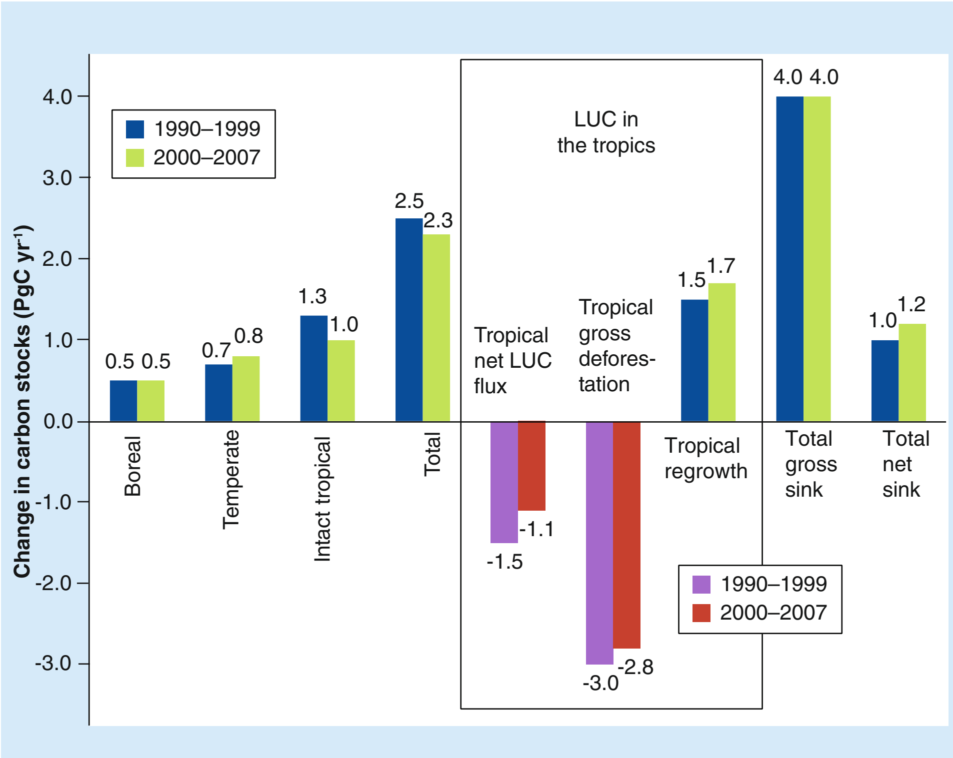

Figure 1. Average annual change in carbon stocks. Negative numbers indicate emissions and positive numbers indicate sinks.
LUC: Land-use change.
Data taken from [1].

also affect the long-term trend and interannual variability in tropical forest carbon emissions and sinks. For example, global fire emissions have increased substantially since 1960, with much of the increase attributed to burning forests and peat soils associated with deforestation in the tropics [4]. Interannual variability in fire emissions is high and is linked to the El Niño/La Niña cycles, which have a particularly large impact on drought in the peatland areas of southeast Asia [5]. There are important interactions between fire and land-use change, not only in the drained peatland areas of southeast Asia, but in Amazonia, where the incidence and severity of wildfire is influenced by the nature of agricultural land management following deforestation [6].

Like wildfire, drought has the potential for highly significant impacts on tropical forest growth. The 2005 Amazon drought reversed a large long-term carbon sink, with the impacts being greater where the drought was most intense [7]. If the incidence of drought increases as projected by several global climate models, reduced carbon uptake and transfer of carbon from live to dead carbon pools may become more significant in the future. Clearly, the interaction between tropical forests and the atmosphere is a strong determinant of the magnitude and variability of the global terrestrial carbon sink.

Tropical forested wetlands, including forested peatlands and mangrove forests, deserve special attention because of their extremely large carbon stocks and vulnerability to climate and land-use change. Globally, CO_2 emissions from drained peatlands constitute approximately 25% of all emissions from land-use change, despite occupying only 2 or 3% of the area of tropical forests; in southeast Asia alone, CO_2 emissions from draining peatlands contribute the equivalent of approximately 2% of current global CO_2 emissions from burning fossil fuel [8]. Because of their high deforestation rate and large emissions, tropical peatlands are increasingly targeted for climate mitigation efforts [9]. Likewise, mangrove forests occupy only a very small proportion of the tropical forest area, but contain very high carbon stocks and are highly threatened by conversion to other land uses such as shrimp farming. Mangroves contain an average of 1023 MgC per ha, much of which is contained in deep organic soils such as tropical peatlands [10]. It is estimated that deforestation of mangroves causes emissions of 0.02–0.12 PgC yr^{-1}, approximately 10% of global emissions from deforestation, even though they account for less than 1% of tropical forest area [10].

REDD+ is a mechanism proposed by the UN to facilitate tropical countries' participation in climate change mitigation. Global initiatives for REDD+ bring together international efforts to implement climate change mitigation while protecting ecosystem services for local residents and indigenous populations, and sustaining economic development. The process involves complex interactions among scientists, activists, decision-makers and local communities. Implementation of REDD+ requires solid science and a robust observation system as a foundation for effective action.

According to the IPCC, conversion of forests to agriculture and grazing land is the principal driver of deforestation; and reducing deforestation is the forestry mitigation option with the largest and most immediate effect on atmospheric CO_2 concentration [11]. REDD+ requirements include monitoring systems that can accurately track the effect of forestry mitigation actions, and monitoring programs to support REDD+ are still evolving as countries grapple with implementing the appropriate methods under varying national circumstances.

> “ …the interaction between tropical forests and the atmosphere is a strong determinant of the magnitude and variability of the global terrestrial carbon sink. ”

This is the first of two Mini Focus issues of *Carbon Management*. Articles are based on presentations at a Landscape Ecology Conference sponsored by the International Union of Forest Research Organizations from November 2012 in Conception (Chile), titled ‘Sustaining humans and forests in changing landscapes: forests, society, and global change’. A special session aimed to highlight studies of tropical land-use changes and deforestation, regional carbon budgets, biodiversity conservation, and forest monitoring; and provide perspectives for implementing mechanisms of REDD+. Invited speakers addressed both the science and policy of sustaining tropical landscapes in a world of change. Some of the questions raised at the conference included:

- What are the most promising monitoring technologies and how can they be used to improve estimation and reporting at landscape scales?
- How can the uncertainty of deforestation and fire emissions estimates be reduced?
- What are the opportunities for sustainable management of vulnerable ecosystems such as mangroves?
- Is there enough avoided carbon emissions from reducing forest degradation to support this as a major part of mitigation strategies?
- What are some approaches to assess biodiversity, carbon and human dimensions at the same time when evaluating REDD+ activities?

Papers in this first Mini Focus issue address many of the key issues for implementing REDD+. Houghton discusses the past trends and future potential of emissions from deforestation and forest degradation, and describes how future management of tropical forests has the potential to temporarily stabilize the concentration of CO_2 in the atmosphere [12]. Mudiyarso *et al.* write about why it is important to include tropical wetlands as a significant component of climate change mitigation strategies, especially in southeast Asia, and how mitigation strategies may also improve local livelihoods [13]. Birdsey *et al.* discuss the evolving approaches to monitoring changes in carbon stocks to support REDD+, and describe the utility of combining remote sensing with field data using different analytical methods [14]. Finally, Schmitt identifies the challenges in classifying tropical forest types and how development of a common classification system could facilitate collaboration among different organizations that evaluate forests, carbon and biodiversity [15]. Besides the papers appearing in this issue, several additional papers related to REDD+ and the themes described in this foreword will appear in the next issue of *Carbon Management*.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

References

1 Pan YD, Birdsey RA, Fang JY *et al.* A large and persistent carbon sink in the world’s forests. *Science* 333(6045), 988–993 (2011).

2 Houghton RA, House JI, Pongratz J *et al.* Carbon emissions from land use and land-cover change. *Biogeosciences* 9, 5125–5142 (2012).

3 Le Quéré CR, Andres J, Boden T *et al.* The global carbon budget 1959–2011. *Earth Syst. Sci. Data* 5, 165–185 (2013).

4 Schultz MG, Heil A, Hoelzemann JJ *et al.* Global wildland fire emissions from 1960 to 2000. *Global Biogeochem. Cycles* 22, 17 (2008).

5 van der Werf GR, Randerson JT, Giglio L *et al.* Interannual variability in global biomass burning emissions from 1997 to 2004. *Atmos. Chem. Phys.* 6, 3423–3441 (2006).

6 Aragão L, Shimabukuro YE. The incidence of fire in Amazonian forests with implications for REDD. *Science* 328, 1275–1278 (2010).

7 Phillips OL, Aragão LEOC, Lewis SL *et al.* Drought sensitivity of the Amazon rainforest. *Science* 323, 1344–1347 (2009).

8 Hooijer A, Page S, Canadell JG *et al.* Current and future CO_2 emissions from drained peatlands in southeast Asia. *Biogeosciences* 7, 1505–1514 (2010).

9 Murdiyarso D, Kauffman JB, Warren M *et al.* *Tropical Wetlands for Climate Change Adaptation and Mitigation: Science and Policy Imperatives with Special Reference to Indonesia*. Center for International Forestry Research, Bogor, Indonesia (2012).

10 Donato DC, Kauffman JB, Murdiyarso D *et al.* Mangroves among the most carbon-rich forests in the tropics. *Nat. Geosci.* 4, 293–297 (2011).

11 Nabuurs GJ, Masera O, Andrasko K *et al.* Forestry. In: *Climate change 2007: Mitigation*. Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA (Eds). Cambridge University Press, Cambridge, UK, 541–584 (2007).

12 Houghton RA. The emissions of carbon from deforestation and degradation in the tropics: past trends and future potential. *Carbon Management* 4(5), 539–546 (2013).

13 Murdiyarso D, Kauffman JB, Verchot LV. Climate change mitigation strategies should include tropical wetlands. *Carbon Management* 4(5), 491–499 (2013).

14 Birdsey R, Angeles-Perez G, Kurz WA *et al*. Approaches to monitoring changes in carbon stocks for REDD+. *Carbon Management* 4(5), 519–537 (2013).

15 Schmitt CB. Global tropical forest types as support for the consideration of biodiversity under REDD+. *Carbon Management* 4(5), 501–517 (2013).