Fact Sheet no. 1

Primary Forests and Carbon

Introduction

Here we provide a summary of key facts about the role of primary forests in storing carbon and climate change mitigation.[1] We draw upon the most recent estimates from reputable scientific publications. Typically, a range of values is provided reflecting the uncertainty in scientific estimates, land use history and the natural variability of ecosystems.

Around 35% of the world's natural forest cover has been lost (Mackey *et al*. 2014) with temperate forests suffering the greatest level of deforestation (WRI 2011). Of the remaining forests, about 60% (approximately 2.337 billion Ha) are subject to industrial logging and degradation (FAO 2010), leaving about 35% (c. 1.277 billion Ha) as intact primary forest.

What is the mitigation value of primary forest?

The mitigation value of forest ecosystems resides in: (1) maintenance of the stored carbon stock as this avoids emissions to the atmosphere; and (2) on-going sequestration of CO_2, further reducing atmospheric concentrations.

- The total global stock of forest carbon has been estimated at a minimum of 862 GtC of which 55% occurs in tropical forests, 32% in boreal forests, and 14% in temperate forests (Pan *et al*. 2011). This estimate, however, is largely based on living and dead biomass carbon, not soil carbon. Recent estimates for the boreal forest biome suggest that the total ecosystem stock of carbon, including living and dead biomass plus soil carbon, likely exceeds the carbon stock of any other forest biome on earth (Bradshaw & Warkentin 2015, Carlson *et al.* 2010).
- The proportion of ecosystem carbon occurring as living biomass, dead biomass and soil carbon is 56:12:32 for tropical forest and for boreal forest 20:20:60. Proportions for

[1] This fact sheet has been compiled and reviewed under the guidance of InAct's independent Technical Advisory Group; http://primaryforest.org/

temperate forests fall between these values (Pan *et al.* 2011). A much larger proportion of ecosystem carbon occurs as soil carbon, in tropical and boreal peat forests (Bradshaw & Warkentin 2015).

- The density of primary forest carbon (tonnes of carbon per ha; tC ha^{-1}) varies with biome and ecosystem type. For example, the average above-ground biomass carbon density is estimated around 248 tC ha^{-1} for tropical moist forest, 498 tC ha-1 for warm temperate moist forest, 642 tC ha-1 for cool temperate moist forest and 97 tC ha-1 for boreal moist forest (Keith *et al.* 2009). When total ecosystem carbon is considered, including below-ground soil organic carbon, boreal regions have the highest carbon densities, with some estimates showing densities 1.5 to 2 times greater than those for cool temperate moist forest (Bradshaw & Warkentin 2015).

Intact primary forests have greater mitigation value than logged, degraded and plantation forests

- Primary forests store 30–70% more carbon than logged and degraded forests (Krankina & Harmon 2006, Bryan *et al*. 2010, Keith *et al.* 2014, Carlson *et al*. 2010). Primary forests store more carbon than plantations for a similar reason: planted trees are harvested every 5-30 years.

- The main reason for higher carbon stocks in primary forests is that most living biomass carbon is found in large, old trees (Stephenson 2014) and in undisturbed soil stocks and peat. Logged forests have lower carbon densities because industrial logging systems are dominated by regenerating stands of younger and smaller trees, and because logging disturbs soils and peatlands (Shearman *et* al. 2012, Cyr *et al.* 2009, Keith *et al.* 2015).

- Primary forests are more resilient to external perturbations including climate change and fire than logged or planted forests, which means that their carbon stocks are more stable (Thompson *et al*. 2009).

Keeping the current forest carbon stock intact and undisturbed from industrial land use, and promoting ecological restoration of degraded forest carbon stocks, is a critically important mitigation action if we are to avoid dangerous climate change.

- Loss of the world's forest by 2100 would emit enough CO_2 to increase atmospheric CO_2 by 50-100 parts per million (House *et al*. 2002). The significance of these potential emissions is evident given that to limit global warming to less than 2°C requires that we limit atmospheric concentrations of CO_2 to around 450 ppm (IPCC 2013) and it has already reached 400 ppm.

- A halt to deforestation and forest degradation alone would reduce emissions by 1.4 GtC per year. Furthermore, allowing logged forests to regrow and age could remove 1-3 GtC per year from the atmosphere (Houghton 2013).

- Natural regeneration and regrowth are as important for carbon sequestration as restoration and reforestation (ISU 2015). Tropical forest regeneration currently sequesters 1.2-1.8 Gt C every year. This rate could be increased significantly if more land was allowed to recover and restoration of tropical forest was prioritized (ISU 2015).

Do primary forests function as carbon sinks?

Contrary to a previously widely held belief, primary forests functions as carbon sinks, i.e., they are carbon positive not carbon neutral

- It has been established that in addition to protecting massive carbon stocks, most primary forests are substantial carbon sinks, continuing to sequester carbon for centuries (Luyssaert *et al*. 2008; Pan *et al*. 2011).

- Primary forests can sequester 2.4 tC ha^{-1} yr^{-1} (Luyssaert *et al.* 2008). In tropical forests, the above-ground living tree biomass is estimated to increase by 0.2-0.9 t C ha^{-1} yr^{-1} (Lewis et al. 2009). This indicates that primary tropical forests sequester 1.3 Gt C every year. Estimates of rates of carbon sequestration in boreal forests are highly variable but indicate that they currently act as a net sink of carbon (Bradshaw & Warkentin 2015).

- While some primary forests may be carbon-neutral, forests are very rarely sources of CO_2 unless they are disturbed (Luyssaert *et al*. 2008). Maintaining forests intact, is therefore critical for protecting carbon stocks while continuing carbon uptake (Mackey *et al*. 2014, Keith *et al*. 2015).

How globally significant are the emissions from deforestation and degradation?

How we manage carbon in the land sector generally, and the role of primary forests in particular, is of central importance to solving the climate change problem.

- Whereas the oceans determine atmospheric concentration of CO_2 over millennial time scales, absorption of carbon by terrestrial ecosystems and surface oceans are the two main natural processes regulating atmospheric concentrations of CO_2 (Lal, 2008). Prior to the industrial revolution, terrestrial ecosystems (including living biomass, dead biomass and soil organic matter) stored six to eight times as much carbon as the atmosphere (Ciais *et al.* 2013). Currently, terrestrial ecosystems store four to five times as much carbon as the atmosphere. About 36% of the additional greenhouse gases in the atmosphere are from emissions due to degradation of terrestrial ecosystems (Friedlingstein *et al.* 2010). Current ecosystem carbon stocks are larger than the stocks of both atmospheric and presently recoverable fossil fuel carbon (Figure 1).

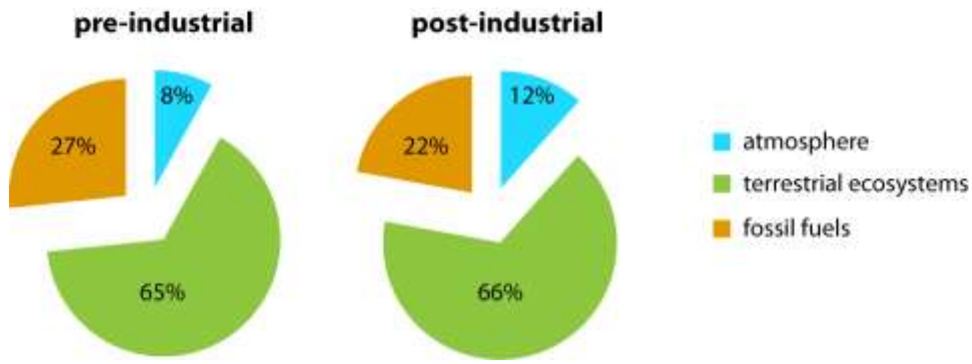

Figure 1 Relative size of carbon stocks in the atmosphere, terrestrial ecosystems and fossil fuels (data from Ciais *et al.* 2013). These values do not include the ocean which accounts for approximately 80% of the total global carbon stock.

- The increase in CO_2 emissions from fossil fuel burning and land use change are the dominant causes of the observed increase in atmospheric CO_2 concentration (IPCC 2013). From 1750 to 2011, CO_2 emissions from fossil fuel combustion and cement production released 375 GtC to the atmosphere, while deforestation and other land use change released 180 GtC. This has resulted in cumulative anthropogenic emissions of 555 GtC (IPCC 2013).

- Every year 0.8-0.9 GtC (as much as 220 tC ha^{-1}) or about 8% of annual global anthropogenic emissions are released into the atmosphere as a result of deforestation (ISU 2015). These emissions are largely irreversible in the short term, as land that is completely cleared of its original vegetation and converted to pasture or other land-uses is unlikely to recover its original vegetation cover and carbon storage capacity.

In addition to deforestation, forest degradation, including road construction, large-scale infrastructure, industrial logging and other industrial extractive activities makes a major contribution to annual global emissions.

- Degradation contributes about 6-13% of annual global anthropogenic emissions (ISU 2015). In 2008, degradation in the Amazon, largely from industrial logging, accounted for an area twice as large as that affected by deforestation (Berenguer *et al*. 2014). Forests degraded by selective logging can increase desiccation and fuel loading resulting in a greatly increased vulnerability to fire and consequently increased emissions (Matricardi *et al.* 2010, Huang & Asner 2010, Cochrane 2003). Extensive road networks associated with degrading activities also often facilitate deforestation (Laurance *et al*. 2014).

Primary forest conservation is a critical component of land carbon mitigation

- Land-based solutions to climate change, including avoided deforestation and avoided forest degradation combined with forest regeneration and restoration can represent a significant solution for climate change mitigation and the stabilization of CO_2 concentrations in the atmosphere. This combination could reduce emissions by 3.45-3.86 GtC every year, representing 24-33% of all mitigation every year (ISU 2015). Re-establishment of forest on previously cleared lands, through reforestation or natural regeneration could yield even greater emissions reductions (Houghton 2013).

- Altogether, avoided deforestation, avoided forest degradation, and forest regeneration and restoration could stabilize the atmospheric concentration of CO_2 while fossil fuels are replaced by renewable fuels over the next few decades (Houghton et al, 2015), thereby providing a reasonable chance of limiting global warming to less than 2°C.

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