

This file has been cleaned of potential threats.

If you confirm that the file is coming from a trusted source, you can send the following SHA-256 hash value to your admin for the original file.

eb4f61683a0a98fc57f7daf39342f7f7e62dd979b3a3858eea01dd77ce7b25a4

To view the reconstructed contents, please SCROLL DOWN to next page.

# Carbon stocks and losses to deforestation in protected areas in Brazilian Amazonia

Euler Melo Nogueira<sup>1,2</sup> · Aurora Miho Yanai<sup>1</sup> · Sumaia Saldanha de Vasconcelos<sup>1</sup> · Paulo Maurício Lima de Alencastro Graça<sup>1,3</sup> · Philip Martin Fearnside<sup>1,3</sup>

Received: 18 June 2016 / Accepted: 27 June 2017  
© The Author(s) 2017. This article is an open access publication

**Abstract** By 2014 approximately 2.2 million km<sup>2</sup> (~43%) of Brazil's Legal Amazonia region had been incorporated into an extensive network of 718 protected areas, which are comprised by 372 indigenous lands, 313 federal, state and municipal (county) conservation units, and 33 Maroon territories (*Quilombos*). Although protected areas occupy vast expanses in Amazonia, their importance as carbon reserves needs to be better understood. In this study, we estimate the total carbon in 2014 held in protected areas in Brazil's "Legal Amazonia" and "Amazonia biome" regions, and the carbon loss in the portions of these protected areas that were cleared by 2014.

Editor: Wolfgang Cramer.

**Electronic supplementary material** The online version of this article (doi:10.1007/s10113-017-1198-1) contains supplementary material, which is available to authorized users.

✉ Philip Martin Fearnside  
pmfearn@inpa.gov.br

Euler Melo Nogueira  
euler.melo.nogueira@gmail.com

Aurora Miho Yanai  
aurorayanai@gmail.com

Sumaia Saldanha de Vasconcelos  
sumaia\_sv@hotmail.com

Paulo Maurício Lima de Alencastro Graça  
pmlag@inpa.gov.br

<sup>1</sup> National Institute for Research in Amazonia (INPA), Av. André Araújo, 2936, CEP, Manaus, AM 69067-375, Brazil

<sup>2</sup> Guanambi Faculty, Av. Governador Nilo Coelho, 4911, São Sebastião, CEP, Guanambi, BA 46430-000, Brazil

<sup>3</sup> Brazilian Research Network on Climate Change (RedeClima), Av. dos Astronautas, 1758, São José dos Campos, SP 12227-010, São José dos Campos, SP 12227-010, Brazil

In 2014, a total of 33.4 Pg C or 57.0% of all carbon stored in Legal Amazonia was held in protected areas and 32.7 Pg C or 58.5% of all the carbon stored in the Amazonia biome was held in protected areas. By 2014, carbon lost due to clearing in protected areas in Legal Amazonia and the Amazonia biome totaled, respectively, 0.787 (or 2.3%) and 0.702 (or 2.1%) Pg C if one assumes that previously each protected area was entirely covered by native vegetation. If the protection of these areas is effective, about half of the carbon in Brazilian Amazonia will be maintained. Carbon in protected areas has strategic value for environmental conservation and for mitigation of climate change because these areas are under lower risk of being emitted to the atmosphere than carbon stored in vegetation located outside of protected areas, although the effectiveness of protected areas varies.

**Keywords** Conservation units · Indigenous reserves · Biomass · REDD · Amazon · Global warming

## Introduction

Amazonia is a large and dynamic reservoir of carbon that holds about 20% of the total carbon contained in the world's terrestrial vegetation (Malhi et al. 2006; Houghton 2007; Saatchi et al. 2007, 2011; Baccini et al. 2012). However, in the Brazilian portion of Amazonia a substantial amount of the carbon that was originally stored has already been lost due to clearing of forest and non-forest vegetation, the area cleared totaling at least 960,000 km<sup>2</sup> (Hansen et al. 2010, 2013; Brazil, IBAMA 2015; Nogueira et al. 2015; Brazil, INPE 2016). Additional carbon has been lost to degradation of standing forest, mapped to be around 92,000 km<sup>2</sup> from 1997 to 2013, after excluding degraded areas that were subsequently converted to deforestation (Brazil, INPE 2014). Almost all

of the carbon that is “lost” from the vegetation is emitted as greenhouse gases such as carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) (Fearnside 1997, 2000). This occurs whether biomass is oxidized via combustion or decay (Barbosa and Fearnside 1996). When biomass is burned a small percentage is left in the soil as charcoal (see Fearnside 2016). When standing forest is degraded, a small part of the carbon in decaying biomass is incorporated into the soil as organic matter (Barros and Fearnside 2016), although these additions to the soil carbon pool can eventually be expected to be released.

Brazil holds roughly two thirds of Amazonia as a whole, regardless of how the region and its Brazilian portion are defined. Two sub-national regions in Brazil are used for different policies and laws related to Amazonia: “Legal Amazonia” and the “Amazonia biome.” “Legal Amazonia” was decreed in 1953 based on geopolitical criteria and roughly one-quarter of this region was originally occupied by savannas and other non-forest vegetation, while the “Amazonia biome” was defined in 2004 by the Brazilian Institute of Geography and Statistics (IBGE) as the area where the predominant original vegetation was Amazonian forest (although it contains a variety of enclaves of other vegetation types). The Amazonia biome is entirely contained within Legal Amazonia (with the exception of a minuscule area in the state of Maranhão); when the distinction between the two regions is not important, we use the term “Brazilian Amazonia.” Information for both Legal Amazonia and the Amazonia biome is needed for policy relevance in Brazil because each of these officially defined geographical areas serves as the basis for a distinct set of policies and government activities.

In Brazil’s “Legal Amazonia” region the original carbon stock of 71.8 Pg C (1 Pg = 10<sup>15</sup> g = 1 gigaton) had been reduced to 58.6 Pg C (a reduction of 18.3%) due to clearing of around 967,000 km<sup>2</sup> of primary forest and non-forest vegetation by 2014 (Cleared areas from: Brazil, IBAMA 2015; Brazil, INPE 2016; Biomass from: Nogueira et al. 2015). The same analysis shows that the “Amazonia biome” had its original carbon stock of 67.2 Pg C reduced to 56.0 Pg C (a reduction of 16.7%) by around 673,000 km<sup>2</sup> of clearing. The term “by” a given year is used in this paper to mean cumulative deforestation or carbon loss from the “pre-modern” status (~1970) up to and including the official deforestation estimate for the year in question, the deforested areas being based on satellite imagery taken in July or August (dry season in most of Amazonia). The “pre-modern” status refers to the condition at the time of the RADAMBRASIL surveys (Brazil, Projeto RADAMBRASIL 1973–1983).

In response to the changes undergone by Brazil’s Amazon forest, large natural or semi-natural areas have been delimited as “protected areas” to maintain endangered species and territories with high biodiversity (“hotspots”) to halt the spread of deforestation and to protect traditional human populations. By 2014, around 2.2 million km<sup>2</sup> of Legal Amazonia (43%)

had been delimited as some type of protected area (Brazil, MMA 2014, 2015a; Brazil, FUNAI 2015a; Brazil, INCRA 2015a). Under Brazilian legislation, protected areas are essentially composed of “conservation units” and territories traditionally occupied by Indigenous peoples or by *Quilombo* communities (Maroon territories). *Quilombos* are formed by descendants of fugitive slaves or by those with presumed African ancestry related to resistance to the historical oppression of slavery in Brazil (Brazil, Decree n° 4887, 20 November 2003; Brazil, PNAP 2006; Matos 2006). Conservation units are classified under Brazil’s National System of Conservation Units (SNUC) into 12 categories, which are divided into “strictly protected” units (fully protected reserves) and “sustainable-use” units (limited-use reserves) (Brazil, SNUC 2000). Conservation units are defined as “strictly protected” when they are intended solely for conservation of biological diversity, with resource exploitation and human occupation being prohibited except for scientific research and restricted educational visitation (e.g., biological reserves, national parks, ecological stations, etc.). Conservation units are considered to be for “sustainable use” when they seek to reconcile conservation with the sustainable use of natural resources. Continued habitation by traditional non-indigenous human populations is allowed, but with restrictions on the use of natural resources (e.g., extractive reserves, national forests, sustainable development reserves, etc.) (Brazil, SNUC 2000). In the case of indigenous lands and Maroon territories, inclusion of human residents is inherent to the purpose of these areas in ensuring the survival and cultural protection of traditional populations, but this is presumed to occur with low-impact use of natural resources by the resident populations (Arruda 1999; Brazil, PNAP 2006; Nepstad et al. 2006).

Although some protected areas that have been legally created are not effectively under protection (e.g., they lack agrarian “regularization,” elaboration and implementation of a management plan, basic infrastructure and hiring personnel), these areas are considered to be one of the most straightforward and reliable means of reducing deforestation and forest degradation (Bruner et al. 2001; Andam et al. 2008). Protected areas would be especially effective at preventing deforestation fires close to roads, where burning is known to be most likely (Laurance et al. 2002; Ferreira et al. 2005; Adeney et al. 2009; Barber et al. 2014). In addition to reducing deforestation at the present time, protected areas remain to reduce deforestation in the future, which is generally not provided by government programs for repression and surveillance of deforestation (Dutschke 2007; Fearnside 2008; Nepstad et al. 2014). Protected areas have a potential role in preventing the passing of climatic tipping points in the Amazon (Walker et al. 2009). Avoiding these regional climatic changes is essential because they would irreversibly affect ecosystem patterns (especially in drier ecosystems), even over a considerable range of deforestation scenarios (Nepstad et al. 2006; Dudley et al. 2010;

Ricketts et al. 2010). Protected areas play a major role in avoiding emissions from deforestation and from degradation resulting from logging and fire (Fearnside 2008).

Carbon stocks currently held in Amazonia's protected areas are under lower risk of being emitted to the atmosphere from deforestation than is carbon stored in vegetation located outside of protected areas. Thus, besides the intrinsic environmental service of each non-emitted carbon atom in a protected area, which is the same as the benefit of any non-emitted carbon atom stored outside of protected areas, there will be an additional value for carbon stored in protected areas reflecting the effectiveness of legal protection in reducing the probability of future emission (Nolte et al. 2013). Carbon stored in protected areas in locations at higher risk or pressure for deforestation has greater value than carbon in remote areas; this is because pressure for carbon emission is immediate, unlike carbon stored in remote protected areas (Fearnside 2008). Carbon loss inside protected areas, as compared to that in the surrounding area, may be used as a measure of reserve effectiveness in preventing deforestation or forest degradation.

The effectiveness of protected areas in preventing deforestation, as indicated by comparing percentages of clearing inside these areas with clearing in a 10-km buffer around them, varies depending on the type, size and administrative level of the area, provided comparisons are within an area with comparable exposure to deforestation. In a study of 80 protected areas in the southwestern portion of the arc of deforestation, Vitel et al. (2009) found that large areas protect better than small ones, that indigenous lands protect better than other categories, and that federal-level conservation units protect better than state-level ones. Sustainable development units had somewhat better results than integral protection units, a counter-intuitive result that is probably explained by the finding by Nolte et al. (2013) in a study of 292 protected areas throughout Legal Amazonia showing that location near or far from deforestation frontiers overshadows any effect from protected-area type. Nolte et al. found that all protected-area types avoid deforestation and that indigenous lands and strictly protected areas are particularly effective in locations with high deforestation pressure.

In spite of the importance of protected areas as carbon reserves (Walker et al. 2014), an aspect that undermines evaluations of environmental benefits of protected areas is lack of consistent estimates of carbon storage. Few estimates are available (e.g., Campbell et al. 2008a, 2008b; Walker et al. 2014); especially lacking are estimates that are based on representative sampling of Brazilian Amazonia as a whole and that include carbon stored in non-forest vegetation. In addition, estimates are lacking of the amounts of carbon lost in protected areas distributed throughout the Amazon that consider the categories of human-use restriction and the level of degradation that has already occurred.

We stress that deforestation is not the only threat to carbon stocks in Amazonian protected areas. Climate change also threatens these stocks, and this impact can be manifest through increasing levels of degradation as the region's climate regime moves to one characterized by a greater frequency of extreme droughts (e.g., Marengo and Espinoza 2016; Zemp et al. 2017). These can kill trees directly by surpassing their tolerance for hydraulic stress and for higher temperatures. These stresses are intertwined, as plants require more water at higher temperatures. Based on projected annual mean temperatures from a variety of climate models, Feeley et al. (2016) found that by 2050 almost all protected areas in Brazilian Amazonia will have "disappearing climates" (as defined by Williams et al. 2007), meaning that, assuming there is no migration of species between protected areas (migration is unlikely for trees on a time scale of decades), many of the present species would not survive. A positive effect of future increases in atmospheric CO<sub>2</sub> is a reduction in the water requirements of trees that makes them more resilient to drought stress. However, higher CO<sub>2</sub> would exacerbate an already apparent increase in lianas, which are favored both by higher CO<sub>2</sub> and by dryer climate (Fearnside 2013; Laurance et al. 2014a, b). Another essential factor is forest fires, which will also be favored by the changed climate. Fires kill trees even if CO<sub>2</sub> is abundant.

In the present study, we will estimate (i) the amount of carbon stored in vegetation in protected areas in Legal Amazonia and the Amazonia biome from a recently published biomass map (Nogueira et al. 2015), including carbon storage in both forested and non-forested vegetation formations. Among the uses for this information is its relevance to efforts to reward avoided greenhouse-gas emissions through REDD+ (Reducing Emissions from Deforestation and forest Degradation) projects. The information is also relevant to decisions on creating new protected areas and on reinforcing those that already exist. We used biomass mapping free of any clearing or non-natural disturbances to estimate (ii) the amount of the carbon reduction caused by clearing in protected areas with various degrees of conservation and land-use restriction. Finally, we use the same biomass dataset and methodological approach to evaluate (iii) how much of the carbon remaining in 2014 in Legal Amazonia and the Amazonia biome was in protected areas, and we discuss the implications of these results for management strategies.

## Materials and methods

### Protected areas in legal Amazonia and the Amazonia biome

In the present study, we analyzed 718 protected areas in Legal Amazonia created from 1959 to 2014, which cover (without

overlapping) 2.18 million km<sup>2</sup>, or about 43% of the region. Of this total, 600 are located in the Amazonia biome, where these protected areas cover 2.03 million km<sup>2</sup> or about 48% of the biome. Vector maps of Legal Amazonia and the Amazonia biome were used to select protected areas that have over 50% of their area inside the boundaries of these regions (Brazil, MMA 2015b). “Vector maps” are composed of areas (polygons) delimited by lines, for example representing the boundary of a protected area, as distinguished from “raster maps” that have information assigned to squares (cells) on a grid. Altogether, without deducting occasional overlapping between protected areas of different types, this study included 372 Indigenous lands (totaling 1.111 million km<sup>2</sup>), 313 conservation units (totaling 1.172 million km<sup>2</sup>) and 33 Maroon territories (*Quilombos*) (totaling 10,212 km<sup>2</sup>) (Table 1), which were listed by April 2015 in the National Register of Conservation Units (CNUC), National Indian Foundation (FUNAI) and National Institute for Agrarian Reform (INCRA) datasets (Brazil, Decree n° 4887, 20 November 2003, Brazil, FUNAI 2015a; Brazil, INCRA 2015a; Brazil, MMA 2015b). The spatially referenced database of protected areas was organized and analyzed using ArcGIS® software by ESRI (2017). Information on Esri® software is available at <http://www.esri.com>.

This study did not include all Maroon territories in Legal Amazonia or in the Amazonia biome because many of these territories are still undergoing the process of recognition or certification. In the present study, we analyzed only the 33 Maroon territories for which land titles had been emitted and for which vector maps were available on INCRA’s website (see Brazil, INCRA 2015a, b; Fundação Cultural Palmares 2015). Similarly, the present study included only Private Reserves of Natural Heritage (RPPNs) for which geographical information was available from the Brazilian Ministry of Environment (Brazil, MMA 2015b).

### Estimates of carbon loss and remaining stock in protected areas

The carbon stored in each protected area was estimated using algebraic maps in ArcGIS software by overlaying the vector map of protected areas in Legal Amazonia and in the Amazonia biome on the biomass maps for these regions available in Nogueira et al. (2015). The same map was used to estimate the total amount of carbon loss caused by clearing in protected areas. Carbon was calculated from biomass (oven-dry weight) using the average carbon content of 48.5% in forest near Manaus measured by da Silva (2007). The map was based on reconstructing the original vegetation types at a scale of 1:250,000, with each vegetation type assigned its corresponding average dry biomass per hectare, which includes both live and dead vegetation components above- and below ground (i.e., roots of trees, but excluding

the soil carbon) (Nogueira et al. 2015). Biomass values were obtained from 2317 1-ha plots sampled in forest as well as from 553 (1-ha each) plots in “contact zones” (ecotones) between two or more vegetation types and 1277 sub-plots of varied size obtained from 39 studies conducted in non-forest vegetation (Nogueira et al. 2008a, 2015). Biomass was estimated mainly from wood volume ( $n = 2860$  plots), for which data were obtained from RADAMBRASIL inventories. Allometric equations were used to estimate biomass in only 10 plots (1 ha each) in forest located in southwestern Amazonia and in some plots or sub-plots covered by vegetation classified as non-forest (see Nogueira et al. 2008a, b, 2015).

In the plots inventoried by RADAMBRASIL, wood volume of all tree boles with DBH  $\geq 31.8$  cm was estimated (Nogueira et al. 2008a). Wood volume of tree boles with DBH  $\geq 10$  cm and  $<31.8$  cm were added using a volume expansion factor (VEF). Based on the estimated wood volume of all trees with DBH  $\geq 10$  cm, biomass was calculated using the average wood density estimated for each plot after weighting by the proportional composition of the species (Nogueira et al. 2007). Other biomass pools were added based on their proportional contribution relative to the above-ground biomass of live trees with DBH  $\geq 10$  cm. These additional components include seedlings, small trees (DBH  $< 10$  cm), dead trees (fallen and standing), roots of trees (but excluding the soil carbon), aboveground necromass, lianas, and palms (Nogueira et al. 2008a; Table 1).

The result is biomass mapped for the whole of Legal Amazonia or for the Amazonia biome prior to the great increases in disturbance that began in the 1970s; this is denoted as “pre-modern biomass” (Nogueira et al. 2015). These pre-modern biomass maps were used to estimate the “original” carbon stock in each protected area in Legal Amazonia and in the Amazonia biome, free of any degradation caused by non-indigenous human use or by non-natural disturbances. This “pre-modern” stock is considered in this study to be equivalent to the “original” stock of the protected areas. This also serves as an indication of a baseline representing the stock when the protected areas were created. The carbon maps from other studies (e.g., Saatchi et al. 2011; Baccini et al. 2012) were not used to estimate carbon reduction in protected areas for two reasons: (1) because they did not report carbon free of degradation (and therefore would underestimate pre-modern biomass) and (2) because they did not provide carbon estimates for the whole of Legal Amazonia.

Carbon that had been held in the areas cleared by 2014 was estimated, thus allowing estimates of the gross reduction of carbon storage in protected areas by clear cutting (i.e., complete removal of forest or non-forest cover). This reduction was estimated for all categories of protected area. Reabsorption of carbon by secondary vegetation in areas abandoned after cutting or after use was not included in the



**Table 1** Protected areas in Brazil's Legal Amazonia region analyzed in this study

Protected area type	Total area (km <sup>2</sup> ) in Legal Amazonia or (Amazonia biome) <sup>a</sup>	Categories of protected area ("Sustainable Use" and "Strictly Protected") <sup>b</sup>	Number of Protected areas in Brazil's Legal Amazonia and (Amazonia biome)	Source
Indigenous lands <sup>c</sup>	1,111,000.89 (1,019,815.76)	Indigenous lands	372 (314)	Brazil, FUNAI (2015a)
		Total	372 (314)	
Federal conservation units	629,689.28 (600,087.99)	Environmental Protection Area (SU)	4 (2)	Brazil, MMA (2015b)
		Areas of Relevant Ecological Interest (SU)	3 (3)	
		Ecological Station (SP)	15 (11)	
		National Forest (SU)	32 (32)	
		National Park (SP)	24 (19)	
		Biological Reserve (SP)	9 (9)	
		Sustainable Development Reserve (SU)	1 (1)	
		Extractive Reserve (SU)	47 (45)	
		Private Reserve of Natural Heritage (SU)	13 (8)	
		Total	148 (130)	
State conservation units	525,395.12 (486,561.27)	Environmental Protection Area (SU)	35 (23)	
		Area of Relevant Ecological Interest (SU)	1 (1)	
		Ecological Station (SP)	7 (7)	
		State Forest (SU)	22 (22)	
		Natural Monument (SP)	2 (0)	
		State Park (SP)	34 (22)	
		Wildlife Refuge (SP)	2 (1)	
		Biological Reserve (SP)	5 (4)	
		Sustainable Development Reserve (SU)	18 (18)	
		Extractive Reserve (SU)	26 (26)	
		Private Reserve of Natural Heritage (SU)	4 (3)	
		Total	156 (127)	
Municipal conservation units	17,812.21 (17,043.19)	Environmental Protection Area (SU)	4 (3)	Brazil, MMA (2015b)
		Area of Relevant Ecological Interest (SU)	2 (2)	
		Natural Monument (SP)	1 (0)	
		Municipal Natural Park (SP)	1 (1)	
		Sustainable Development Reserve (SU)	1 (1)	
		Total	9 (7)	
Maroon territories <sup>d</sup>	10,212.80 (9780.78)	Maroon territory	33 (22)	Brazil, INCRA (2015a)
		Total	33 (22)	
		Grand total	718 (600)	

<sup>a</sup> Refers to surface occupied by all protected areas free of overlapping between areas of the same type, situated inside the boundaries of Legal Amazonia or the Amazonia biome

<sup>b</sup> 'SU' refers to conservation units defined as "sustainable-use" and 'SP' are conservation units defined as "strictly protected"

<sup>c</sup> Includes indigenous lands with diverse official land-tenure status categories: In the case of Legal Amazonia the status categories are: "Under study" (6 areas), "Delimited" (19), "Declared" (28), "Homologated" (officially confirmed) (4), "Regularized" (319), and "Interdicted" (3); these areas harbor at least 157 ethnic groups. See Brazil, FUNAI (2015b) for details about stages in "regularization" of indigenous lands

<sup>d</sup> Includes only Maroon territories with officially recognized land tenure

carbon reduction estimate. Carbon held in the remaining vegetation in 2014 was estimated without considering additional losses in these areas from such processes as selective logging, illegal opening of roads, and forest fires. The area occupied by the original and remaining vegetation was calculated using a coordinate system in the Albers equal-area conic projection.

These areas were then multiplied by the mean carbon per hectare.

Cumulative clearing of vegetation by 2014 in each of the protected areas in Legal Amazonia and the Amazonia biome was obtained from maps available from the Project for Monitoring Amazon Deforestation (PRODES), which

identifies areas as clear-cut if greater than 6.25 ha in area (Brazil, INPE 2016). Cumulative deforestation by 2014 was fully computed for all states in Legal Amazonia. PRODES deforestation monitoring uses images, mainly from the Landsat 5, 7, or 8 satellites (other satellites can be used, such as CBERS 2B, UK2-DMC and ResourceSat) with spatial resolution of 30 m, but resampled to 60 m in the maps provided on INPE's website (Brazil, INPE 2013). In the case of protected areas in the states of Mato Grosso, Maranhão, and Tocantins, areas cleared by 2010 (polygons >2 ha in area) were also identified in non-forest vegetation types (mainly *cerrado*) monitored by the Deforestation Monitoring in Brazilian Biomes Project (PMDBBS) (Brazil, IBAMA 2015). The PMDBBS monitoring used Landsat-5 TM with a resolution of 30 m and CBERS 2B-CCD with a resolution of 20 m (Brazil, IBAMA 2011, 2015). Cumulative clearing of vegetation by 2014 for each protected area is given in the Online Resources (Table S1), including estimates of areas mapped as deforested but that overlap with watercourses.

## Results

### Carbon stocks in protected areas in 2014

In 2014 a total of 33.4 Pg of carbon was held in all of the protected areas in Legal Amazonia and 32.7 Pg C in the Amazonia biome, with average stocks in the vegetation of 158.9 and 166.0 Mg C ha<sup>-1</sup>, respectively (Table S2). The amount of carbon held in these protected areas was equivalent to 57.0% of the total carbon stock in native vegetation in Legal Amazonia in 2014 and 58.5% of the total carbon in the Amazonia biome, when calculated using the same biomass dataset and methodological approaches. Both in Legal Amazonia and the Amazonia biome, most of the protected carbon in 2014 was held in indigenous lands and in federal and state conservation units, which together stored approximately 99% of the total carbon stock in all protected areas analyzed in these regions, without discounting any overlaps between different types of protected areas (Tables S3 and S4). There were substantially lower amounts of carbon in municipal (county) conservation units and in Maroon territories, although the mean stock of carbon per hectare in the vegetation remaining in 2014 was high in all of the protected-area types analyzed (Tables S3 and S4). Carbon densities and protected-area types are shown in Fig. 1.

More carbon is stored in sustainable-use conservation units than in integral protection units, both in Legal Amazonia and in the Amazonia biome, although in the sustainable-use units the magnitude of carbon loss is greater and average carbon loss per hectare is generally smaller, the only exception being state-level conservation units with the “strictly protected” regime in the Amazonia biome (Tables S5 and S6). Among the

categories of conservation units in Legal Amazonia and the Amazonia biome (Fig. S1 in the Online Resources), most carbon is stored in national forests (15.7% or 2.8 Pg C) and state forests (12.9% or 2.3 Pg C), federal, state and municipal parks (~23.5% or 4.2 Pg C) and in extractive reserves (11.5% or 2.0 Pg C). The total remaining carbon stock and mean remaining carbon per hectare in 2014 for each protected area are given in the Online Resources (Tables S7–S9).

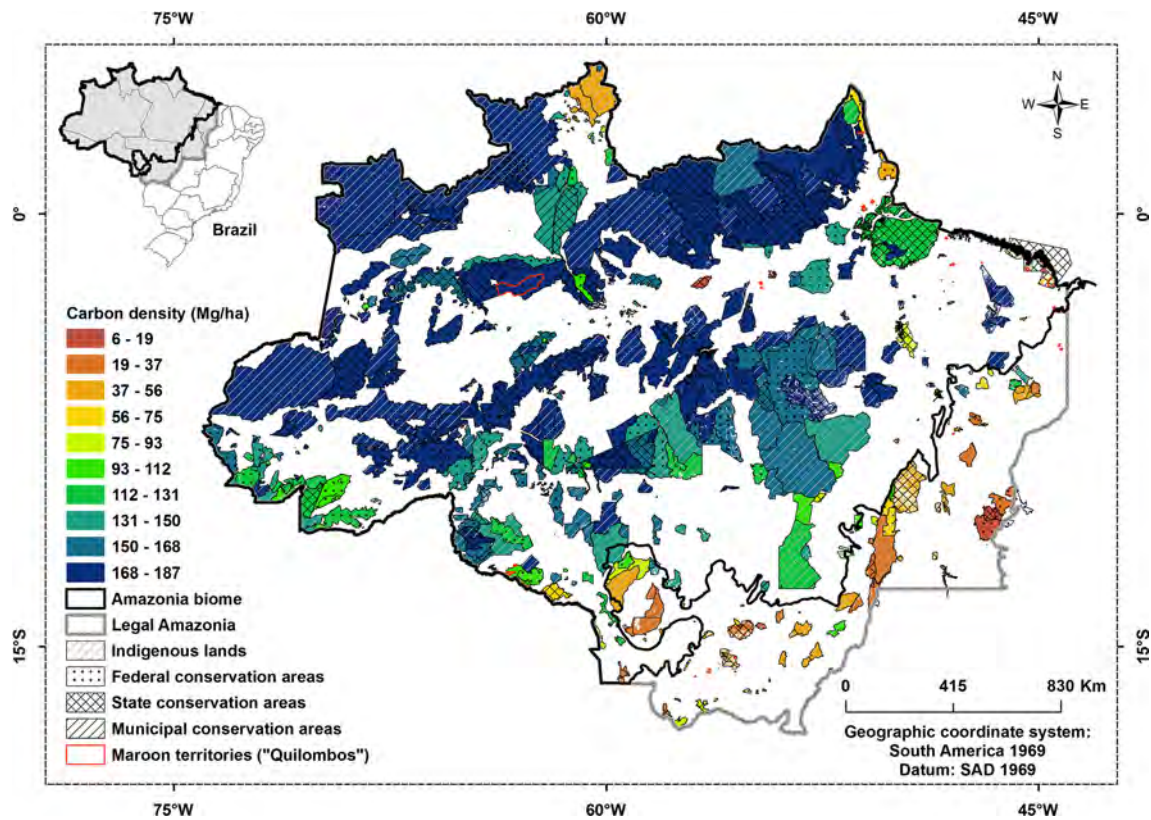
### Carbon stock loss in protected areas

Considering all protected areas without any overlapping, there was a total carbon stock loss of 0.787 Pg C (or 2.3%) in protected areas in Legal Amazonia by 2014 and 0.702 Pg C (or 2.1%) in the Amazonia biome, assuming that previously each protected area was entirely covered with native vegetation without any degradation caused by human use or by non-natural disturbances (Table S2). Considering protected areas situated in Legal Amazonia, loss of vegetation with the highest carbon density occurred in federal conservation units, while municipal conservation units had the lowest per-hectare carbon loss (Table S3). If only the protected areas situated in the Amazonia biome are analyzed, high per-hectare carbon loss (>160 Mg C ha<sup>-1</sup>) are found in all categories of protected area (Fig. 1; Table S4).

Among the types of protected areas analyzed, the largest percentage of carbon loss occurred in the Maroon territories, both in Legal Amazonia and in the Amazonia biome, where about 10% of the carbon stock in the native vegetation was lost, usually in areas with the highest carbon density per hectare (Tables S3 and S4). However, the largest absolute amounts of carbon stock loss occurred in conservation units, mainly in state conservation units (Tables S3 and S4). Among the conservation-unit categories in Legal Amazonia, carbon loss occurred mainly in environmental protection areas (APAs) (60.2% or 0.333 Pg C), in extractive reserves (13.8% or 0.076 Pg C) and in national and state forests (12.1% or 0.067 Pg C). When protected areas in the Amazonia biome are analyzed, carbon loss occurred similarly in APAs (57.6% or 0.290 Pg C), in extractive reserves (14.5% or 0.073 Pg C) and in federal and state forests (13.2% or 0.067 Pg C). Considering all protected areas, the largest carbon reductions occurred in protected areas located in critical regions undergoing deforestation. Total carbon stock loss and mean carbon loss per hectare estimated for each protected area are shown in the Online Resources (Tables S7–S9).

## Discussion

Other maps of Amazonian biomass have been developed by Saatchi et al. (2007, 2011) and Baccini et al. (2012). Mitchard et al. (2014) compared the spatial distribution of biomass in these maps, as well as that of Nogueira et al. (2008a), which is



**Fig. 1** Mean density of carbon ( $\text{Mg C ha}^{-1}$ ) in the protected areas in Brazil's Legal Amazonia and Amazonia biome regions

an earlier version of the forest vegetation portion of the map used in this study, and found that these maps do not agree. Detailed comparisons of the data underlying these biomass maps show that the map used in the present study is based on many more ground plots than are the other studies (Fearnside 2016). For the forest portion of Brazilian Amazonia, the map used in the present study (Nogueira et al. 2015) is based on 1-ha plots at 2317 distinct locations (and an additional 553 1-ha plots in “contact zones” (ecotones) between rainforest and seasonal forest, savanna or *campinarana*), while that of Saatchi et al. (2007) is based on plots at 53 distinct locations of which 28 sampled  $\geq 1$  ha and Saatchi et al. (2011) is based on plots at 96 distinct locations of which 63 sampled  $\geq 1$  ha. The Baccini et al. (2012) estimate in Brazilian Amazonia is based on an undisclosed number out of a set of 283 0.16-ha plots distributed throughout the world's tropical forests. The variance of per-hectare biomass in tropical forest increases rapidly as plot size decreases below 1 ha (Clark and Clark 2000). Even in studies with many carefully measured 1-ha plots in close proximity in the same forest type the variance is substantial. In forests near Manaus, Laurance et al. (1999) found 65 plots in the Biological Dynamics of Forest Fragments Project to have a mean aboveground live biomass of trees, including palms (based on trees  $>10$  cm DBH with a 12% correction for small trees) of  $356 \pm 47 \text{ Mg ha}^{-1}$  with a coefficient of variation (CV) of 13.2%, while in 72 plots in the Ducke Reserve,

de Castilho et al. (2006) found a mean aboveground live biomass for trees, including palms, of  $327.8 \pm 41.9 \text{ Mg ha}^{-1}$  with a CV of 12.8% (based on all trees  $\geq 30$  cm DBH in each 1-ha plot, trees 10–29.9 cm DBH in a 0.5 ha subplot, and trees 1–9.9 cm DBH in a 0.1 ha subplot). For samples at widely separated locations the variance is substantially greater, making widely distributed sampling locations a priority for reducing uncertainty in regional biomass estimates (Fearnside 2016). Note that the RADAMBRASIL dataset used in the present study is much more widely and evenly distributed than are the data underlying other studies (Fearnside 2016).

Information is needed on Amazon forest biomass in a form that can be used in calculating the benefits of avoiding deforestation and degradation in specific territorial units, such as protected areas. A first step is the information presented here on the “original” (pre-modern) biomass of the forests that presently remain standing at these locations (Tables S7–S9). The role that these protected areas play as a bulwark against regional and global climate change faces a wide variety of threats from degradation and from outright deforestation.

## Conclusions

In addition to their value for the conservation of biological diversity, protected areas in Brazilian Amazonia are valuable



because they hold very large amounts of carbon. Protected areas account for most of the carbon that remained stored in the vegetation of Brazil's Legal Amazonia and Amazonia biome regions in 2014. This carbon is especially valuable because it is in areas that are under legal protection; protection reduces the risk of future emission, although these areas have varying levels of permitted access and use of natural resources.

Historically, protected areas have been established following criteria for biological conservation and for maintaining traditional human populations, but changes in global climate make it necessary to incorporate maintenance of carbon stocks as one of the ecosystem services that justifies creating and maintaining these areas. This highlights the importance of carbon estimates in protected areas as a tool for defining development policies for the Amazon region.

**Acknowledgments** We thank the National Institute for Research in Amazonia (INPA: PRJ15.125), the National Institute of Science and Technology for the Environmental Services of Amazonia (INCT-SERVAMB), the National Council for Scientific and Technological Development (CNPq/PCI Program Proc. 304130/2013-3 and 301183/2015-5; CNPq: Proc. 304020/2010-9; 573810/2008-7), the Foundation for Support of Research in Amazonas State (FAPEAM: Proc. 708565), and the National Postdoctoral Program (PNPD/CAPES: Proc. n.º 028176/2009-41) for financial and logistical support. This article is a contribution of the Brazilian Research Network on Global Climate Change, FINEP/Rede CLIMA Grant No. 01.13.0353-00. Three reviewers contributed valuable comments.

**Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

## References

- Adeney JM, Christensen NL, Pimm SL, Freckleton RP (2009) Reserves Protect against Deforestation Fires in the Amazon. *PLoS ONE* 4(4): e5014
- Andam KS, Ferraro PJ, Pfaff A, Sanchez-Azofeifa GA, Robalino JA (2008) Measuring the effectiveness of protected area networks in reducing deforestation. *Proc Nat Acad Sci USA* 105:16089–16094. doi:10.1073/pnas.0800437105
- Arruda R (1999) Populações tradicionais e a proteção dos recursos naturais em unidades de conservação. *Revista Ambiente & Sociedade* 2(5):79–92. doi:10.1590/S1414-753X1999000200007
- Baccini A, Goetz SJ, Walker WS, Laporte NT, Sun M, Sulla-Menashe D, Hackler J, Beck PSA, Dubayah R, Friedl MA, Samanta S, Houghton RA (2012) Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. *Nat Clim Chang* 2:182–185. doi:10.1038/nclimate1354
- Barber CP, Cochrane MA, Souza CM Jr, Laurance WF (2014) Roads, deforestation, and the mitigating effect of protected areas. *Biol Conserv* 177:203–209. doi:10.1016/j.biocon.2014.07.004
- Barbosa RI, Feamside PM (1996) Pasture burning in Amazonia: dynamics of residual biomass and the storage and release of aboveground carbon. *Journal of Geophysical Research (Atmospheres)* 101(D20): 25,847–25,857. doi:10.1029/96JD02090
- Barros HS, Feamside PM (2016) Soil carbon stock changes due to edge effects in central Amazon forest fragments. *For Ecol Manag* 379: 30–36. doi:10.1016/j.foreco.2016.08.002
- Brazil, FUNAI (Fundação Nacional do Índio) (2015a) Download de dados geográficos. *Terra Indígena* (Regularizada, Homologada, Declarada, Delimitada e Área em Estudo). FUNAI, Brasília, DF, Brazil. <http://www.funai.gov.br/index.php/shape>. Accessed 24 April 2015
- Brazil, FUNAI (Fundação Nacional do Índio) (2015b) Modalidades de Terras Indígenas. FUNAI, Brasília, DF, Brazil. <http://www.funai.gov.br/index.php/indios-no-brasil/terras-indigenas>. Accessed 12 May 2015
- Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) (2011) Monitoring Deforestation of Brazilian Biomes Project (PMDBBS), Monitoramento do Bioma Cerrado 2009–2010. IBAMA, Brasília, DF, Brazil. <http://siscom.ibama.gov.br/monitorabiomas/cerrado/index.htm>. Accessed 04 October 2013
- Brazil, IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) (2015) Monitoring Deforestation of Brazilian Biomes Project (PMDBBS). IBAMA, Brasília, DF, Brazil. <http://siscom.ibama.gov.br/monitorabiomas/cerrado/index.htm>. Accessed 12 July 2015
- Brazil, INCRA (Instituto Nacional de Colonização e Reforma Agrária) (2015a) Download de dados geográficos. INCRA, Brasília, DF, Brazil. <http://acervofundiario.incra.gov.br/i3geo/datadownload.htm>. Accessed 14 April 2015
- Brazil, INCRA (Instituto Nacional de Colonização e Reforma Agrária) (2015b) Quilombolas. INCRA, Brasília, DF, Brazil. <http://www.incra.gov.br/quilombolas>. Accessed 11 May 2015
- Brazil, INPE (Instituto Nacional de Pesquisas Espaciais) (2013) Metodologia para o Cálculo da Taxa Anual de Desmatamento na Amazônia Legal. Coordenadoria Geral de Observação da Terra Programa Amazônia (Projeto PRODES), INPE, São José dos Campos, SP, Brazil. [http://www.obt.inpe.br/prodes/metodologia\\_TaxaProdes.pdf](http://www.obt.inpe.br/prodes/metodologia_TaxaProdes.pdf). Accessed 16 June 2016
- Brazil, INPE (Instituto Nacional de Pesquisas Espaciais) (2014) Sistema DEGRAD. INPE, São José dos Campos, SP, Brazil. <http://www.obt.inpe.br/degrad>. Accessed 11 Mar 2017
- Brazil, INPE (Instituto Nacional de Pesquisas Espaciais) (2016) Projeto de Monitoramento do Desmatamento na Amazônia Legal (PRODES). INPE, São José dos Campos, SP, Brazil. <http://www.dpi.inpe.br/prodesdigital/prodes.php>. Accessed 1 March 2016
- Brazil, MMA (Ministério do Meio Ambiente) (2014) Cadastro Nacional de Unidades de Conservação (CNUC), Tabela consolidada das Unidades de Conservação. Atualizada em 27 October 2014. MMA, Brasília, DF, Brazil. [http://www.mma.gov.br/images/arquivo/80112/CNUC\\_Categorias\\_Out14.pdf](http://www.mma.gov.br/images/arquivo/80112/CNUC_Categorias_Out14.pdf). Accessed 31 January 2015
- Brazil, MMA (Ministério do Meio Ambiente) (2015a) Cadastro Nacional de Unidades de Conservação. MMA, Brasília, DF, Brazil. <http://www.mma.gov.br/areas-protegidas/cadastro-nacional-de-ucs/mapas>. Accessed 31 January 2015
- Brazil, MMA (Ministério do Meio Ambiente) (2015b) Download de dados geográficos, MMA, Brasília, DF, Brazil. <http://mapas.mma.gov.br/i3geo/datadownload.htm>. Accessed 17 April 2015
- Brazil, PNAP (Plano Nacional Estratégico para Áreas Protegidas) (2006) Plano Nacional Estratégico para Áreas Protegidas (PNAP), Decreto n.º 5758 de 13 de abril de 2006, Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. [http://www.mma.gov.br/estruturas/205/\\_arquivos/planonacionaareasprotegidas\\_205.pdf](http://www.mma.gov.br/estruturas/205/_arquivos/planonacionaareasprotegidas_205.pdf). Accessed 16 June 2016
- Brazil, Projeto RADAMBRASIL (1973–1983) Levantamento de recursos naturais. Ministério das Minas e Energia, Departamento Nacional de Produção Mineral, Rio de Janeiro, Brazil, 36 vols

- Brazil, SNUC (Sistema Nacional de Unidades de Conservação) (2000) Sistema Nacional de Unidades de Conservação (SNUC), Lei no. 9985 de 18 de julho de 2000. Serviço Brasileiro Florestal (SBF), Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. [http://www.mma.gov.br/images/arquivos/areas\\_protegidas/snuc/Livro%20SNUC%20PNAP.pdf](http://www.mma.gov.br/images/arquivos/areas_protegidas/snuc/Livro%20SNUC%20PNAP.pdf). Accessed 16 June 2016
- Bruner AG, Gullison RE, Rice RE, da Fonseca GAB (2001) Effectiveness of parks in protecting tropical biodiversity. *Science* 291:125–128. doi:10.1126/science.291.5501.125
- Campbell A, Kapos V, Lysenko I, Scharlemann JPW, Dickson B, Gibbs HK, Hansen M, Miles L (2008a) Carbon emissions from forest loss in protected areas. UNEP World Conservation Monitoring Centre, Cambridge
- Campbell A, Miles L, Lysenko I, Hughes A, Gibbs H (2008b) Carbon storage in protected areas: technical report. UNEP World Conservation Monitoring Centre, Cambridge
- Clark DB, Clark DA (2000) Landscape-scale variation in forest structure and biomass in a tropical rain forest. *For Ecol Manag* 137:185–198. doi:10.1016/S0378-1127(99)00327-8
- da Silva RP (2007) Alometria, estoque e dinâmica da biomassa de florestas primárias e secundárias na região de Manaus (AM). PhD thesis, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil
- de Castilho CV, Magnusson WE, de Araújo RNO, Luizão RCC, Luizão FJ, Lima AP, Higuchi N (2006) Variation in aboveground tree live biomass in a central Amazonian forest: effects of soil and topography. *For Ecol Manag* 234:85–96. doi:10.1016/j.foreco.2006.06.024
- Dudley N, Stolton S, Belokurov A, Krueger L, Lopoukhine N, MacKinnon K, Sandwith T, Sekhran N (2010) Natural Solutions: protected areas helping people cope with climate change. A report funded and commissioned by IUCN-WCPA, TNC, UNDP, WCS, The World Bank and WWF, Gland, Switzerland, Washington, DC & New York, USA
- Dutschke M (2007) CDM forestry and the ultimate objective of the climate convention. *Mitig Adapt Strateg Glob Chang* 12(2):275–302. doi:10.1007/s11027-005-9013-6
- ESRI (Environmental Systems Research Institute) (2017) ArcGIS 10.0. GIS software, Desktop. ESRI, Redlands, CA, USA. <http://www.esri.com>. Accessed 3 April 2017
- Fearnside PM (1997) Greenhouse gases from deforestation in Brazilian Amazonia: net committed emissions. *Clim Chang* 35(3):321–360. doi:10.1023/A:1005336724350
- Fearnside PM (2000) Greenhouse gas emissions from land-use change in Brazil's Amazon region. In: Lal R, Kimble JM, Stewart BA (eds) Global climate change and tropical ecosystems: advances in soil science. CRC Press, Boca Raton, pp 231–249
- Fearnside PM (2008) Amazon forest maintenance as a source of environmental services. *Annals of the Brazilian Acad of Sci* 80(1):101–114. doi:10.1590/S0001-37652008000100006
- Fearnside PM (2013) Vines, CO<sub>2</sub> and Amazon forest dieback. *Nature Online Comment*. doi:10.1038/nature11882
- Fearnside PM (2016) Brazil's Amazonian forest carbon: the key to Southern Amazonia's significance for global climate. *Regional Environ Change*. doi:10.1007/s10113-016-1007-2
- Feeley KJ, Silman MR, Franklin J (2016) Disappearing climates will limit the efficacy of Amazonian protected areas. *Divers Distrib* 22(11):1081–1084. doi:10.1111/ddi.12475
- Ferreira LV, Venticinque E, Almeida S (2005) O desmatamento na Amazônia e a importância das áreas protegidas. *Estudos Avançados* 19(53):157–166. doi:10.1590/S0103-40142005000100010
- Fundação Cultural Palmares (2015) Fundação Cultural Palmares, Comunidades Quilombolas. [http://www.palmares.gov.br/?page\\_id=88](http://www.palmares.gov.br/?page_id=88). Accessed 2 June 2015
- Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, Thau D, Stehman SV, Goetz SJ, Loveland TR, Kommareddy A, Egorov A, Chini L, Justice CO, Townshend JRG (2013) High-resolution global maps of 21st-century forest cover change. *Science* 342:850–853. doi:10.1126/science.1244693
- Hansen MC, Stehman SV, Potapov PV (2010) Quantification of global gross forest cover loss. *Proc Nat Acad Sciences USA* 107:8650–8655. doi:10.1073/pnas.0912668107
- Houghton RA (2007) Balancing the global carbon budget. *Annu Rev Earth Planet Sci* 35:313–347. doi:10.1146/annurev.earth.35.031306.140057
- Laurance WF, Fearnside PM, Laurance SG, Delamonica P, Lovejoy TE, Rankin-de Merona JM, Chambers JQ, Gascon C (1999) Relationship between soils and Amazon forest biomass: a landscape-scale study. *For Ecol Manag* 118(1–3):127–138. doi:10.1016/S0378-1127(98)00494-0
- Laurance WF, Albernaz AKM, Schroth G, Fearnside PM, Bergen S, Venticinque EM, da Costa C (2002) Predictors of deforestation in the Brazilian Amazon. *J Biogeogr* 29:737–748. doi:10.1046/j.1365-2699.2002.00721.x
- Laurance WF, Andrade AS, Magrach A, Camargo JLC, Campbell M, Fearnside PM, Edwards W, Valsko JJ, Lovejoy TE, Laurance SG (2014a) Apparent environmental synergism drives the dynamics of Amazonian forest fragments. *Ecology* 95(11):3018–3026. doi:10.1890/14-0330.1
- Laurance WF, Andrade AS, Magrach A, Camargo JLC, Valsko JJ, Campbell M, Fearnside PM, Edwards W, Lovejoy TE, Laurance SG (2014b) Long-term changes in liana abundance and forest dynamics in undisturbed Amazonian forests. *Ecology* 95(6):1604–1611. doi:10.1890/13-1571.1
- Malhi Y, Wood D, Baker TR, Wright J, Phillips OL, Cochrane T, Meir P, Chave J, Almeida S, Arroyo L, Higuchi N, Killeen TJ, Laurance SG, Laurance WF, Lewis SL, Monteagudo A, Neill DA, Vargas PN, Pitman NCA, Quesada CA, Salomão R, Silva JNM, Lezama AT, Terborgh J, Martínez RV, Vinceti B (2006) The regional variation of aboveground live biomass in old-growth Amazonian forests. *Glob Chang Biol* 12:1–32. doi:10.1111/j.1365-2486.2006.01120.x
- Marengo JA, Espinoza JC (2016) Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. *Int J Climatol* 36:1033–1050. doi:10.1002/joc.4420
- Matos H (2006) Remanescentes das comunidades dos quilombos: Memória do cativo e políticas de reparação no Brasil. *Revista USP* 68:104–111. <http://www.revistas.usp.br/revusp/article/view/13486/15304> Accessed 5 July 2017
- Mitchard ETA, Feldpausch TR, Brienen RJW, Lopez-Gonzalez G, Monteagudo A, Baker TR, Lewis SL, Lloyd J, Quesada CA, Gloor M, ter Steege H, Meir P, Alvarez E, Araujo-Murakami A, Aragão LEOC, Arroyo L, Aymard G, Banki O, Bonal D, Brown S, Brown FI, Cerón CE, Chama Moscoso V, Chave J, Comiskey JA, Cornejo F, Corrales Medina M, Da Costa L, Costa FRC, Di Fiore A, Domingues TF, Erwin TL, Frederickson T, Higuchi N, Honorio Coronado EN, Killeen TJ, Laurance WF, Levis C, Magnusson WE, Marimon BS, Marimon Junior BH, Mendoza Polo I, Mishra P, Nascimento MT, Neill D, Núñez Vargas MP, Palacios WA, Parada A, Pardo Molina G, Peña-Claros M, Pitman N, Peres CA, Poorter L, Prieto A, Ramirez-Angulo H, Restrepo Correa Z, Roopsind A, Roucoux KH, Rudas A, Salomão RP, Schiatti J, Silveira M, de Souza PF, Steininger MK, Stropp J, Terborgh J, Thomas R, Toledo M, Torres-Lezama A, van Andel TR, van der Heijden GMF, Vieira ICG, Vieira S, Vilanova-Torre E, Vos VA, Wang O, Zartman CE, Malhi Y, Phillips OL. (2014) Markedly divergent estimates of Amazon forest carbon density from ground plots and satellites. *Glob Ecol Biogeogr* 23(8):935–946. doi:10.1111/geb.12168
- Nepstad D, McGrath D, Stickler C, Alencar A, Azevedo A, Swette B, Bezerra T, DiGiano M, Shimada J, da Motta RS, Armijo E, Castello L, Brando P, Hansen MC, McGrath-Horn M, Carvalho O, Hess L (2014) Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* 344:1118–1123. doi:10.1126/science.1248525

- Nepstad D, Schwartzman S, Bamberger B, Santilli M, Ray D, Schlesinger P, Lefebvre P, Alencar A, Prinz E, Fiske G, Rolla A (2006) Inhibition of Amazon deforestation and fire by parks and indigenous lands. *Conserv Biol* 20(1):65–73. doi:[10.1111/j.1523-1739.2006.00351.x](https://doi.org/10.1111/j.1523-1739.2006.00351.x)
- Nogueira EM, Fearnside PM, Nelson BW, França MB (2007) Wood density in forests of Brazil's 'arc of deforestation': implications for biomass and flux of carbon from land-use change in Amazonia. *Forest Ecol and Manage* 248:119–135. doi:[10.1016/j.foreco.2007.04.047](https://doi.org/10.1016/j.foreco.2007.04.047)
- Nogueira EM, Fearnside PM, Nelson BW, Barbosa RI, Keizer EWH (2008a) Estimates of forest biomass in the Brazilian Amazon: new allometric equations and adjustments to biomass from wood-volume inventories. *For Ecol Manag* 256:1853–1867. doi:[10.1016/j.foreco.2008.07.022](https://doi.org/10.1016/j.foreco.2008.07.022)
- Nogueira EM, Nelson BW, Fearnside PM, França MB, de Oliveira ACA (2008b) Tree height in Brazil's 'arc of deforestation': shorter trees in south and southwest Amazonia imply lower biomass. *For Ecol Manag* 255:2963–2972. doi:[10.1016/j.foreco.2008.02.002](https://doi.org/10.1016/j.foreco.2008.02.002)
- Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Glob Chang Biol* 21(3):1271–1292. doi:[10.1111/gcb.12798](https://doi.org/10.1111/gcb.12798)
- Nolte C, Agrawal A, Silvius KM, Soares-Filho BS (2013) Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proc Nat Acad Sci USA* 110(13):4956–4961. doi:[10.1073/pnas.1214786110](https://doi.org/10.1073/pnas.1214786110)
- Ricketts TH, Soares-Filho B, da Fonseca GAB, Nepstad D, Pfaff A, Peterson A, Anderson A, Boucher D, Cattaneo A, Conte M, Creighton K, Linden L, Maretti C, Moutinho P, Ullman R, Victurine R (2010) Indigenous lands, protected areas, and slowing climate change. *PLoS Biol* 8(3):e1000331. doi:[10.1371/journal.pbio.1000331](https://doi.org/10.1371/journal.pbio.1000331)
- Saatchi SS, Harris NL, Brown S, Lefsky M, Mitchard ETA, Salas W, Zutta BR, Buermann W, Lewis SL, Hagen S, Petrova S, White L, Silman M, Morel A (2011) Benchmark map of forest carbon stocks in tropical regions across three continents. *Proc Nat Acad Sci USA* 108(24):9899–9904. doi:[10.1073/pnas.1019576108](https://doi.org/10.1073/pnas.1019576108)
- Saatchi SS, Houghton RA, Alvalá RCS, Soares JV, Yu Y (2007) Distribution of aboveground live biomass in the Amazon basin. *Glob Chang Biol* 13:816–837. doi:[10.1111/j.1365-2486.2007.01323.x](https://doi.org/10.1111/j.1365-2486.2007.01323.x)
- Vitel CSMN, Fearnside PM, Graça PMLA (2009) Análise da inibição do desmatamento pelas áreas protegidas na parte Sudoeste do Arco de desmatamento. In: Epiphany JCN, Galvão LS (eds) *Anais XIV Simpósio Brasileiro de Sensoriamento Remoto*, Natal, Brasil 2009. Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, pp 6377–6384. <http://martes.sid.inpe.br/col/dpi.inpe.br/sbsr%4080/2008/11.13.14.42/doc/6377-6384.pdf>
- Walker R, Moore NJ, Arima E, Perz S, Simmons C, Caldas M, Vergara D, Bohrer C (2009) Protecting the Amazon with protected areas. *Proc Nat Acad Sci USA* 106:10582–10586. doi:[10.1073/pnas.0806059106](https://doi.org/10.1073/pnas.0806059106)
- Walker W, Baccini A, Schwartzman S, Ríos S, Oliveira-Miranda MA, Augusto C, Ruiz MR, Arrasco CS, Ricardo B, Smith R, Meyer C, Jintiaich JC, Campos EV (2014) Forest carbon in Amazonia: the unrecognized contribution of indigenous territories and protected natural areas. *Carbon Manage* 5:479–485. doi:[10.1080/17583004.2014.990680](https://doi.org/10.1080/17583004.2014.990680)
- Williams JW, Jackson ST, Kutzbach JE (2007) Projected distributions of novel and disappearing climates by 2100 AD. *Proc Nat Acad Sci USA* 104:5738–5742. doi:[10.1073/pnas.0606292104](https://doi.org/10.1073/pnas.0606292104)
- Zemp DC, Schleussner C-F, HMJ B, Hirota M, Montade V, Sampaio G, Staal A, Wang-Erlandsson L, Rammig A (2017) Self-amplified Amazon forest loss due to vegetation-atmosphere feedbacks. *Nat Commun* 8:art. 14681. doi:[10.1038/ncomms14681](https://doi.org/10.1038/ncomms14681)

## ONLINE RESOURCES

### Carbon stocks and losses to deforestation in protected areas in Brazilian Amazonia

Euler Melo Nogueira<sup>a</sup>, Aurora Miho Yanai<sup>a</sup>, Sumaia Saldanha de Vasconcelos<sup>a</sup>, Paulo Maurício Lima de Alencastro Graça<sup>a</sup>, Philip Martin Fearnside<sup>a\*</sup>

<sup>a</sup>National Institute for Research in Amazonia (INPA), Av. André Araújo, 2936, CEP 69067-375, Manaus, Amazonas, Brazil.

\*Corresponding author: Tel.: +55 92 3643 1822; Fax: + 55 92 3642 3028

Email address: pmfearn@inpa.gov.br

<b>Table S1.</b> Cumulative clearing of vegetation by 2014 for each protected area. ....	p. 2
<b>Table S2.</b> Carbon above- and below-ground in protected areas in two regions in Brazilian Amazonia..	p. 25
<b>Table S3.</b> Legal Amazonia: Carbon above- and below-ground in protected areas (Indigenous lands, federal, state and municipal conservation units, and Maroon territories). ....	p. 26
<b>Table S4.</b> Amazonia biome: Carbon above- and below-ground in protected areas (Indigenous lands, federal, state and municipal conservation units, and Maroon territories). ...	p. 27
<b>Table S5.</b> Legal Amazonia: Remaining carbon stock in 2014 and carbon loss due to clearing by 2014 in strictly protected and sustainable-use conservation units. ....	p. 28
<b>Table S6.</b> Amazonia biome: Remaining carbon stock in 2014 and carbon loss due to clearing by 2014 in strictly protected and sustainable-use conservation units. ....	p. 29
<b>Table S7.</b> Carbon estimates in Indigenous lands. ....	p. 30
<b>Table S8.</b> Carbon estimates in conservation units. ....	p. 41
<b>Table S9.</b> Carbon estimates in Maroon territories ( <i>Quilombos</i> ). ....	p. 58
<b>Figure S1.</b> Categories of conservation units. ....	p. 60
<b>Figure S2.</b> Degraded areas (1997-2013) mapped inside the protected areas. ....	p. 61



**Table S1.** Cumulative clearing of vegetation by 2014 for each protected area analyzed in the present study in Brazil's Legal Amazonia and Amazonia biome regions.

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Acapuri de Cima	IL	198.72	198.17	0.55	0.021
Acimã	IL	406.22	403.57	2.66	-
Água Preta/Inari	IL	1397.45	1390.73	6.72	0.149
Alcantara	MT	779.44	137.15	642.29	7.814
Aliança / Santa Joana	MT	76.26	0.05	76.21	-
Alto Rio Guamá	IL	2822.60	1910.83	911.77	0.003
Alto Rio Negro	IL	79764.47	78934.85	829.62	20.160
Alto Rio Purus	IL	2618.36	2596.83	21.53	0.340
Alto Sepatini	IL	260.59	259.51	1.08	-
Alto Tarauacá	IL	1423.74	1412.48	11.26	-
Alto Turiaçu	IL	5294.49	4885.32	409.17	0.159
Anambé	IL	85.95	74.54	11.41	-
Ananás	IL	26.12	26.12	0.00	-
Anaro	IL	304.60	304.60	0.00	-
Andirá-Marau	IL	7905.75	7489.85	415.90	13.906
Aningal	IL	76.67	75.40	1.26	-
Anta	IL	32.63	30.76	1.87	-
Apiaká do Pontal e Isolados	IL	9827.51	9778.54	48.97	0.403
Apiaka/Kayabi	IL	1096.24	1058.40	37.85	0.410
Apinayé	IL	1417.55	1251.62	165.93	0.431
Apipica	IL	6.52	0.40	6.12	0.003
Apurinã do Igarapé Mucuí	IL	732.08	728.03	4.05	0.111
Apurinã do Igarapé São João	IL	182.47	174.80	7.67	0.929
Apurinã Igarapé Tauamirim	IL	1004.66	1001.92	2.75	-
Apurinã Km 124 BR-317	IL	422.89	406.86	16.03	-
Apyterewa	IL	7738.10	7037.12	700.98	-
Araçá	IL	509.38	500.17	9.21	0.007
Arapema	MT	38.29	38.29	0.00	-
Arara	IL	2748.77	2717.87	30.90	0.012
Arara da Volta Grande do Xingu	IL	255.15	238.58	16.57	0.160
Arara do Igarapé Humaitá	IL	874.62	869.75	4.87	-
Arara do Rio Amonia	IL	207.53	195.35	12.17	-
Arara do Rio Branco	IL	1146.60	1136.30	10.29	0.048
Arariboia	IL	4138.09	3897.23	240.86	0.339
Arary	IL	407.27	403.25	4.03	0.056
Araweté Igarapé Ipixuna	IL	9409.30	9364.64	44.65	0.019

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Área de Proteção Ambiental - Baixo Rio Branco	SSU	15647.30	15632.36	14.94	0.936
Área de Proteção Ambiental da Chapada dos Guimarães	SSU	2534.38	1319.95	1214.43	-
Área de Proteção Ambiental da Fazendinha	SSU	1.49	1.47	0.02	-
Área de Proteção Ambiental da Ilha do Combu	SSU	15.03	14.99	0.04	-
Área de Proteção Ambiental da Região do Maracanã	SSU	21.90	4.12	17.79	-
Área de Proteção Ambiental da Região Metropolitana de Belém	SSU	57.43	24.22	33.21	0.510
Área de Proteção Ambiental das Cabeceiras do Rio Cuiabá	SSU	4732.13	3344.56	1387.57	-
Área de Proteção Ambiental das Nascentes de Araguaína	SSU	155.97	117.49	38.49	0.192
Área de Proteção Ambiental das Reentrâncias Maranhenses	SSU	13235.77	6540.05	6695.72	108.207
Área de Proteção Ambiental de Algodal-Maiandeuá	SSU	24.58	23.49	1.09	0.194
Área de Proteção Ambiental de Presidente Figueiredo - Caverna do Moroaga	SSU	4085.57	3705.81	379.76	2.748
Área de Proteção Ambiental de São Geraldo do Araguaia	SSU	267.03	126.46	140.57	0.761
Área de Proteção Ambiental do Arquipélago do Marajó	SSU	45244.26	43829.08	1415.18	24.130
Área de Proteção Ambiental do Igarapé Gelado	FSU	232.83	138.66	94.17	3.587
Área de Proteção Ambiental do Itapiracó	SSU	3.55	1.91	1.65	-
Área de Proteção Ambiental do Lago de Tucuruí	SSU	5682.07	3936.81	1745.27	112.334
Área de Proteção Ambiental do Rio Curiaú	SSU	218.73	203.33	15.40	0.088
Área de Proteção Ambiental do Rio Madeira	SSU	67.58	32.46	35.11	2.802
Área de Proteção Ambiental do Salto Magessi	SSU	78.45	62.22	16.24	-
Área de Proteção Ambiental do Tapajós	FSU	20403.33	19564.12	839.21	1.600
Área de Proteção Ambiental Foz do Rio Santa Tereza	SSU	501.43	248.29	253.15	1.620
Área de Proteção Ambiental Igarapé São Francisco	SSU	300.19	92.00	208.19	-
Área de Proteção Ambiental Ilha do Bananal/Cantão	SSU	15700.08	9107.90	6592.17	5.865
Área de Proteção Ambiental Jalapão	SSU	1349.50	1339.05	10.45	-
Área de Proteção Ambiental Lago de Palmas	SSU	638.59	290.03	348.56	0.573

**Table S1(Continued)**

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Área de Proteção Ambiental Lago de Peixe/Angical	SSU	754.51	629.19	125.32	2.113
Área de Proteção Ambiental Lago de Santa Isabel	SSU	185.85	66.33	119.53	6.502
Área de Proteção Ambiental Lago de São Salvador do Tocantins. Paranã e Palmeirópolis	SSU	84.64	42.53	42.11	2.401
Área de Proteção Ambiental Lago do Amapá	SSU	51.77	16.97	34.79	0.184
Área de Proteção Ambiental Margem Direita do Rio Negro-Setor Paduari-Solimões	SSU	4617.37	3942.23	675.14	23.803
Área de Proteção Ambiental Margem Esquerda do Rio Negro-Setor Aturiá-Apuauzinho	SSU	5683.22	5543.77	139.45	8.029
Área de Proteção Ambiental Margem Esquerda do Rio Negro-Setor Tarumã Açú-Tarumã Mirima	SSU	559.36	449.70	109.66	5.678
Área de Proteção Ambiental Meandros do Araguaia	FSU	3087.42	2834.23	253.19	1.745
Área de Proteção Ambiental Municipal do Aricá-Açu	MSU	754.45	316.42	438.03	0.023
Área de Proteção Ambiental Nascentes do Rio Paraguai	SSU	708.57	416.55	292.02	-
Área de Proteção Ambiental Nhamundá	SSU	2015.97	1976.57	39.40	2.904
Área de Proteção Ambiental Parque Linear do Bindá	MSU	0.06	-	-	-
Área de Proteção Ambiental Paytuna	SSU	560.73	419.70	141.04	3.187
Área de Proteção Ambiental Serra da Tabatinga	FSU	401.64	145.87	255.78	-
Área de Proteção Ambiental Serra do Lajeado	SSU	1118.83	870.31	248.52	0.050
Área de Proteção Ambiental Tarumã/Ponta Negra	MSU	226.32	113.56	112.76	7.577
Área de Proteção Ambiental Triunfo do Xingu	SSU	16784.64	12212.46	4572.18	5.920
Área de Proteção Ambiental Xeriuini	MSU	16691.30	16677.34	13.96	0.502
Área de Relevante Interesse Ecológica Javari Buriti	FSU	131.77	131.77	0.00	-
Área de Relevante Interesse Ecológica Projeto Dinâmica Biológica de Fragmentos Florestais	FSU	31.80	25.09	6.71	-
Área de Relevante Interesse Ecológica Seringal Nova Esperança	FSU	25.74	14.54	11.20	-
Área de Relevante Interesse Ecológico Japiim Pentecoste	SSU	256.54	249.05	7.49	-
Área de Relevante Interesse Ecológico Museu Parque Seringal	MSU	0.01	-	-	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Área de Relevante Interesse Ecológico Parque Ambiental Antônio Danúbio Lourenço da Silva	MSU	0.04	-	-	-
Areões	IL	1802.79	1760.96	41.83	0.557
Aripuanã	IL	7492.72	7464.27	28.44	0.015
Ariramba	IL	103.64	102.65	0.99	0.055
Arquimec	MT	57.91	13.78	44.14	-
Awa	IL	1167.72	757.20	410.52	-
Bacurizinho	IL	2167.77	1944.42	223.35	-
Badjonkore	IL	2220.93	2158.56	62.36	-
Baia dos Guató	IL	192.31	192.04	0.27	-
Bakairi	IL	626.61	558.50	68.10	-
Balaio	IL	2570.45	2554.77	15.68	-
Banawá	IL	1925.99	1918.37	7.62	0.010
Barata Livramento	IL	128.79	125.07	3.72	-
Barreira da Missão	IL	17.74	8.10	9.65	2.213
Barreirinha	IL	23.69	20.47	3.22	-
Barro Alto	IL	19.38	17.76	1.63	-
Batelão	IL	1171.42	1083.36	88.06	-
Batovi	IL	50.42	48.94	1.47	-
Baú	IL	15384.81	15376.78	8.04	0.032
Betânia	IL	1225.90	1195.67	30.23	0.232
Boa Vista	IL	3.37	3.37	0.00	-
Boca do Acre	IL	265.92	249.06	16.85	-
Bom Intento	IL	14.98	14.46	0.53	0.001
Bom Jardim	MT	26.52	15.15	11.37	0.156
Bom Jesus	IL	8.70	8.70	0.00	-
Boqueirão	IL	164.32	157.22	7.10	-
Bragança-Marituba	IL	135.10	123.55	11.55	-
Cabeceira do Rio Acre	IL	785.74	779.63	6.12	-
Cacau do Tarauacá	IL	286.51	280.78	5.73	-
Cacau e Ovos	MT	35.66	33.38	2.28	-
Cachoeira Seca	IL	7340.01	6909.65	430.37	0.927
Cacique Fontoura	IL	323.30	262.84	60.46	0.149
Caititu	IL	3097.08	3081.54	15.54	-
Cajueiro	IL	44.68	44.51	0.17	-
Cajuhiri Atravessado	IL	125.28	112.44	12.84	0.001
Camadeni	IL	1508.85	1507.48	1.38	-



**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Camicua	IL	583.97	578.63	5.33	0.231
Campina de Pedra	MT	17.81	9.26	8.55	-
Campinas/Katukina	IL	335.73	328.45	7.27	-
Cana Brava/Guajajara	IL	1355.58	1151.84	203.75	-
Canauanim	IL	114.52	78.64	35.88	-
Capoto/Jarina	IL	6345.01	6288.86	56.16	0.152
Caru	IL	1708.58	1543.44	165.14	-
Catipari/Mamoria	IL	1149.58	1146.64	2.95	0.058
Cayabi	IL	1108.34	1107.08	1.26	0.001
Chão Preto	IL	126.78	81.54	45.24	-
Coata-Laranjal	IL	11528.81	11449.19	79.61	5.301
Conceição do Macacoari	MT	94.06	89.20	4.86	-
Cué Cué / Marabitanas	IL	8071.98	7945.52	126.46	11.310
Cuia	IL	13.43	8.45	4.98	-
Cuiu-Cuiu	IL	364.35	355.97	8.37	0.071
Cunani	MT	138.84	135.73	3.11	-
Cunhã-Sapucaia	IL	4708.79	4698.14	10.65	1.115
Curiau	MT	31.17	27.08	4.09	-
Deni	IL	15282.13	15224.54	57.60	0.001
Diahui	IL	473.89	455.18	18.71	-
Enawenê-Nawê	IL	7459.06	7431.92	27.14	0.015
Erikpatsá	IL	813.87	802.18	11.69	0.004
Escondido	IL	1689.05	1685.02	4.02	0.009
Espírito Santo	IL	338.40	338.40	0.00	-
Estação Ecológica Alto Maués	FSP	6667.72	6665.31	2.41	-
Estação Ecológica da Serra das Araras	FSP	271.59	266.05	5.54	-
Estação Ecológica da Terra do Meio	FSP	33731.31	33252.97	478.34	0.899
Estação Ecológica de Caracará	FSP	867.98	850.29	17.69	-
Estação Ecológica de Cuniã	FSP	1853.78	1842.33	11.45	0.055
Estação Ecológica de Iquê	FSP	2159.73	2130.73	29.00	-
Estação Ecológica de Jutaf-Solimões	FSP	2895.14	2884.64	10.50	-
Estação Ecológica de Maracá	FSP	1035.36	1009.58	25.78	0.313
Estação Ecológica de Maracá Jipioca	FSP	602.53	593.20	9.32	0.272
Estação Ecológica de Niquiá	FSP	2847.88	2847.57	0.31	-
Estação Ecológica de Taiamã	FSP	115.55	115.55	0.00	-
Estação Ecológica do Grão Pará	SSP	42023.95	42010.29	13.66	0.082

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Estação Ecológica do Jari	FSP	2310.85	2303.69	7.17	0.582
Estação Ecológica do Rio Ronuro	SSP	1026.72	991.03	35.69	-
Estação Ecológica do Rio Roosevelt	SSP	979.66	973.35	6.30	0.103
Estação Ecológica do Sítio Rangedor	SSP	1.26	0.31	0.95	-
Estação Ecológica Juami-Japurá	FSP	8315.24	8314.79	0.45	-
Estação Ecológica Rio Acre	FSP	777.78	777.78	0.00	-
Estação Ecológica Rio Flor do Prado	SSP	85.37	85.37	0.00	-
Estação Ecológica Samuel	SSP	699.35	664.75	34.60	1.202
Estação Ecológica Serra dos Três Irmãos	SSP	879.50	879.35	0.16	-
Estação Ecológica Serra Geral do Tocantins	FSP	6294.73	6280.01	14.72	-
Estação Parecis	IL	21.71	21.53	0.18	-
Estivadinho	IL	20.34	19.53	0.82	-
Estrela da Paz	IL	125.79	116.01	9.78	0.011
Évare I	IL	5487.14	5327.51	159.63	5.516
Évare II	IL	1726.95	1713.40	13.56	0.333
Figueiras	IL	98.55	98.06	0.49	-
Floresta Estadual Apuí	SSU	1827.56	1826.15	1.42	-
Floresta Estadual Aripuanã	SSU	3287.37	3285.75	1.62	-
Floresta Estadual Canutama	SSU	1505.89	1503.45	2.44	0.180
Floresta Estadual de Faro	SSU	6284.29	6266.37	17.92	1.087
Floresta Estadual de Iriri	SSU	4392.39	4355.27	37.12	0.111
Floresta Estadual de Rendimento Sustentado Araras	SSU	10.08	3.05	7.03	-
Floresta Estadual de Rendimento Sustentado Cedro	SSU	25.62	20.49	5.13	-
Floresta Estadual de Rendimento Sustentado do Rio Machado	SSU	970.98	960.53	10.44	-
Floresta Estadual de Rendimento Sustentado do Rio Madeira "B"	SSU	526.14	483.53	42.61	-
Floresta Estadual de Rendimento Sustentado Gavião	SSU	4.34	2.34	1.99	-
Floresta Estadual de Rendimento Sustentado Mutum	SSU	108.55	42.89	65.65	-
Floresta Estadual de Rendimento Sustentado Periquito	SSU	11.35	2.95	8.40	-
Floresta Estadual de Rendimento Sustentado Rio Vermelho (C)	SSU	40.94	29.31	11.64	-
Floresta Estadual de Rendimento Sustentado Tucano	SSU	5.11	3.72	1.38	-
Floresta Estadual de Tapauá	SSU	8814.22	8794.45	19.78	0.473
Floresta Estadual do Amapá	SSU	23702.34	23492.23	210.12	1.260

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Floresta Estadual do Paru	SSU	36100.62	36028.98	71.64	0.194
Floresta Estadual do Trombetas	SSU	31435.55	31366.38	69.17	0.184
Floresta Estadual Manicoré	SSU	834.75	834.20	0.55	-
Floresta Estadual Maúes	SSU	4498.35	4372.11	126.24	16.830
Floresta Estadual Rio Urubu	SSU	270.52	270.51	0.01	-
Floresta Estadual Sucunduri	SSU	4811.02	4810.42	0.60	-
Floresta Nacional Altamira	FSU	7255.22	7092.24	162.98	0.021
Floresta Nacional de Amapá	FSU	4603.58	4595.42	8.16	0.096
Floresta Nacional de Anauá	FSU	2594.01	2593.76	0.25	-
Floresta Nacional de Balata-Tufari	FSU	10800.04	10742.93	57.11	2.006
Floresta Nacional de Bom Futuro	FSU	974.31	837.98	136.33	-
Floresta Nacional de Carajás	FSU	3912.56	3850.70	61.86	0.635
Floresta Nacional de Caxiuanã	FSU	3179.47	3163.90	15.57	1.002
Floresta Nacional de Humaitá	FSU	4731.61	4724.99	6.63	-
Floresta Nacional de Itacaiunas	FSU	1366.99	1164.23	202.77	-
Floresta Nacional de Itaituba I	FSU	2128.69	2122.19	6.50	0.112
Floresta Nacional de Itaituba II	FSU	3977.45	3902.80	74.65	0.065
Floresta Nacional de Jacundá	FSU	2212.00	2175.57	36.44	0.050
Floresta Nacional de Jatuarana	FSU	5696.51	5683.75	12.76	0.133
Floresta Nacional de Macauã	FSU	1763.58	1761.09	2.49	-
Floresta Nacional de Mapiá-Inauini	FSU	3689.49	3684.18	5.31	-
Floresta Nacional de Mulata	FSU	2163.21	2160.16	3.05	-
Floresta Nacional de Pau-Rosa	FSU	9846.81	9807.51	39.29	1.490
Floresta Nacional de Purus	FSU	2561.24	2537.84	23.40	0.065
Floresta Nacional de Roraima	FSU	1696.27	1674.16	22.11	0.905
Floresta Nacional de Santa Rosa do Purus	FSU	2315.38	2280.17	35.21	0.990
Floresta Nacional de São Francisco	FSU	211.48	210.26	1.22	-
Floresta Nacional de Saracá-Taquera	FSU	4412.84	4243.26	169.58	2.045
Floresta Nacional de Tapajós	FSU	5306.22	5047.10	259.12	0.325
Floresta Nacional de Tapirapé-Aquiri	FSU	1965.03	1943.24	21.79	-
Floresta Nacional de Tefé	FSU	8651.22	8538.54	112.68	1.131
Floresta Nacional do Amaná	FSU	5426.61	5383.55	43.06	-
Floresta Nacional do Amazonas	FSU	19415.81	19386.88	28.93	-
Floresta Nacional do Crepori	FSU	7403.96	7376.08	27.89	0.002
Floresta Nacional do Iquiri	FSU	14726.00	14628.63	97.37	0.573
Floresta Nacional do Jamanxim	FSU	13015.55	11588.60	1426.95	0.888
Floresta Nacional do Jamari	FSU	2221.49	2144.57	76.92	3.695
Floresta Nacional do Trairão	FSU	2575.29	2541.50	33.79	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Fortaleza do Castanho	IL	27.53	22.56	4.97	0.294
Fortaleza do Pataua	IL	7.61	6.63	0.98	-
Funil	IL	158.37	121.33	37.04	0.052
Galibi	IL	62.90	60.75	2.16	-
Gavião	IL	83.99	81.45	2.55	-
Geralda Toco Preto	IL	185.16	139.44	45.73	-
Gleba Jamary dos Pretos	MT	146.87	46.62	100.25	-
Governador	IL	421.04	362.18	58.86	-
Grotão	MT	20.70	19.32	1.38	-
Guajahã	IL	50.30	50.30	0.00	-
Guanabara	IL	156.14	149.53	6.62	-
Hi Merimã	IL	6768.27	6763.31	4.96	0.052
Igarapé Capana	IL	1293.05	1291.77	1.28	-
Igarapé do Caucho	IL	121.03	99.75	21.28	0.084
Igarapé Grande	IL	11.90	9.03	2.87	-
Igarapé Lage	IL	1073.23	1017.17	56.06	-
Igarapé Lourdes	IL	1966.14	1912.15	53.98	0.190
Igarapé Ribeirão	IL	478.58	467.11	11.46	-
Igarapé Taboca do Alto Tarauacá	IL	2.87	2.48	0.39	-
Ilha do Camaleão	IL	1.66	1.24	0.42	0.007
Inauini/Teuini	IL	4683.29	4677.46	5.83	-
Inawebohona	IL	3773.16	3731.83	41.34	0.561
Ipiranga do Carmina	MT	14.24	9.18	5.06	-
Ipixuna	IL	2153.26	2151.90	1.35	0.003
Irantxe	IL	455.54	423.27	32.28	-
Itaitinga	IL	1.36	1.36	0.00	-
Itixi Mitari	IL	1822.73	1802.81	19.92	1.230
Ituna/Itata	IL	1369.93	1367.55	2.38	-
Jabuti	IL	142.23	141.89	0.34	-
Jacamim	IL	1925.88	1922.87	3.00	-
Jacareúba/Katauixi	IL	6088.64	6031.86	56.78	0.232
Jaminaua/Envira	IL	805.82	798.58	7.24	-
Jaminawa Arara do Rio Bagé	IL	288.65	287.57	1.08	-
Jaminawa do Igarapé Preto	IL	256.54	254.43	2.11	-
Japuíra	IL	1544.85	1503.08	41.77	0.002
Jaquiri	IL	19.18	19.17	0.01	-
Jarawara/Jamamadi/Kanamati	IL	3889.61	3860.96	28.64	0.134
Jarudore	IL	47.69	1.41	46.28	0.674



**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Jatuarana	IL	50.94	49.22	1.72	0.199
Jauary	IL	248.19	158.83	89.37	0.690
Juininha	IL	703.26	702.25	1.01	-
Juma	IL	384.80	384.33	0.46	0.017
Jumina	IL	417.46	415.87	1.59	-
Kampa do Igarapé Primavera	IL	219.56	218.27	1.29	-
Kampa do Rio Amonea	IL	860.07	856.93	3.14	-
Kampa e Isolados do Rio Envira	IL	2327.45	2312.74	14.72	-
Kanamari do Rio Juruá	IL	6017.46	5991.84	25.62	-
Kanela	IL	1255.76	1241.31	14.46	-
Kanela Memortumré	IL	1003.03	983.63	19.39	-
Karajá de Aruanã II	IL	8.94	8.20	0.74	0.199
Karajá Santana do Araguaia	IL	14.55	13.83	0.72	0.048
Kararaô	IL	3307.48	3306.45	1.03	0.172
Karipuna	IL	1530.07	1523.46	6.62	-
Karitiana	IL	897.22	888.61	8.61	-
Katukina/Kaxinawá	IL	232.40	216.97	15.43	0.724
Kawahiva do Rio Pardo	IL	4106.52	4062.47	44.05	-
Kaxarari	IL	1462.93	1453.05	9.88	-
Kaxinawá Ashaninka do Rio Breu	IL	894.05	882.44	11.61	-
Kaxinawá Colônia Vinte e Sete	IL	1.05	0.22	0.82	-
Kaxinawá da Praia do Carapanã	IL	606.46	589.43	17.04	0.047
Kaxinawá do Baixo Rio Jordão	IL	87.11	81.75	5.36	-
Kaxinawá do Rio Humaitá	IL	1288.08	1282.10	5.98	-
Kaxinawá do Rio Jordão	IL	310.47	308.44	2.02	-
Kaxinawá Nova Olinda	IL	258.08	252.78	5.30	0.146
Kaxinawá Seringal Independência	IL	115.61	112.08	3.52	-
Kayabi	IL	10539.67	10186.80	352.87	0.358
Kayapó	IL	32865.69	32731.28	134.41	0.814
Koatinemo	IL	3878.13	3872.47	5.66	-
Krahó-Kanela	IL	76.99	64.42	12.57	0.002
Kraolandia	IL	3058.32	3038.90	19.42	-
Krenrehé	IL	59.78	55.96	3.83	-
Krikati	IL	1450.67	1095.44	355.22	-
Kulina do Médio Juruá	IL	7271.42	7228.94	42.48	0.145
Kulina do Rio Envira	IL	818.98	815.01	3.97	-
Kulina Igarapé do Pau	IL	455.70	448.70	7.01	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Kumarú do Lago Ualá	IL	799.10	791.88	7.22	-
Kuruáya	IL	1666.23	1663.50	2.72	0.157
Kwazá do Rio São Pedro	IL	168.04	161.29	6.75	-
Lago Aiapua	IL	239.34	234.92	4.42	0.177
Lago Capanã	IL	63.26	63.19	0.07	-
Lago do Beruri	IL	42.74	36.36	6.39	1.475
Lago do Correio	IL	132.20	131.20	1.01	0.298
Lago do Limão	IL	81.96	80.85	1.12	0.071
Lago do Marinheiro	IL	35.79	29.24	6.56	0.624
Lago Jauri	IL	120.29	110.59	9.70	0.022
Lago Comprida	IL	132.46	98.02	34.44	-
Lago dos Brincos	IL	17.80	17.80	0.00	-
Lagoinha de Baixo	MT	25.15	5.21	19.95	-
Las Casas	IL	213.54	181.24	32.30	-
Lauro Sodré	IL	94.84	88.27	6.57	-
Macarrão	IL	434.59	419.44	15.15	0.172
Mãe Maria	IL	628.91	604.07	24.83	-
Malacacheta	IL	285.50	256.99	28.51	-
Mamoadate	IL	3128.91	3119.60	9.32	-
Mangueira	IL	46.34	41.55	4.79	-
Manoa/Pium	IL	439.89	408.02	31.87	0.156
Manoki	IL	2519.31	2113.23	406.08	0.059
Mapari	IL	1573.91	1572.71	1.20	0.040
Maraã Urubaxi	IL	943.00	942.02	0.98	0.033
Maracaxi	IL	7.18	2.40	4.78	-
Maraitá	IL	549.40	549.26	0.14	0.051
Maraiwatsede	IL	1653.46	532.41	1121.05	-
Marajai	IL	9.80	0.01	9.80	0.955
Maranduba	IL	3.75	3.65	0.10	-
Marechal Rondon	IL	1002.96	988.12	14.84	-
Maró	IL	423.89	410.94	12.95	0.026
Massaco	IL	4200.90	4187.64	13.26	-
Mata Cavalo	MT	147.58	65.04	82.54	-
Mata de São Benedito	MT	11.33	0.84	10.49	-
Matintin	IL	217.76	212.77	4.99	0.387
Matões Moreira	MT	55.58	34.29	21.29	-
Mawetek	IL	1155.32	1148.08	7.24	-
Médio Rio Negro I	IL	17761.60	17680.76	80.84	3.677

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Médio Rio Negro II	IL	3157.28	3128.90	28.37	2.286
Mel da Pedreira	MT	26.32	26.32	0.00	-
Menkragnoti	IL	49304.01	49266.48	37.54	1.057
Menkü	IL	1914.46	1379.88	534.58	-
Meria	IL	5.83	1.63	4.20	-
Merure	IL	827.86	811.70	16.17	-
Miguel/Josefa	IL	16.28	7.97	8.31	0.204
Miratu	IL	139.19	120.51	18.68	0.037
Monge Belo	MT	56.55	13.00	43.55	-
Monumento Natural Canyons e Corredeiras do Rio Sono	MSP	14.58	14.54	0.03	-
Monumento Natural das Árvores Fossilizadas	SSP	292.45	276.48	15.96	0.032
Monumento Natural Morro de Santo Antônio	SSP	2.58	2.58	0.00	-
Morro Branco	IL	0.49	0.00	0.49	-
Moskow	IL	141.89	115.64	26.26	-
Munduruku	IL	23859.75	23745.53	114.21	0.576
Munduruku-Taquara	IL	253.14	245.08	8.07	-
Muriru	IL	55.47	48.69	6.78	-
Murutinga/Tracajá	IL	133.06	109.57	23.49	0.219
Nambikwara	IL	10033.32	10009.92	23.40	0.061
Narcisa	MT	6.19	0.16	6.03	-
Natal/Felicidade	IL	3.34	3.34	0.00	-
Nhamundá/Mapuera	IL	10490.11	10365.43	124.68	3.197
Nova Esperança do Rio Jandiatuba	IL	199.08	194.87	4.21	-
Nova Jacundá	IL	4.01	2.56	1.44	-
Nove de Janeiro	IL	2294.25	2285.79	8.46	-
Nukini	IL	319.96	302.15	17.81	-
Ouro	IL	138.01	138.01	0.00	-
Pacaas Novas	IL	2813.04	2767.74	45.30	0.022
Padre	IL	7.97	6.77	1.20	-
Panará	IL	4989.57	4914.16	75.40	0.000
Paquiçamba	IL	242.31	216.48	25.83	3.859
Parabubure	IL	2249.85	2184.20	65.65	0.090
Paracuhuba	IL	9.39	6.42	2.97	0.033
Parakanã	IL	3512.59	3481.05	31.54	-
Paraná do Arauató	IL	59.01	47.21	11.80	-
Paraná do Boa Boa	IL	2450.06	2444.20	5.87	0.002

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Paraná do Paricá	IL	80.07	80.07	0.00	-
Paresi	IL	5625.61	4891.52	734.09	-
Parque do Araguaia	IL	13594.39	13429.60	164.80	0.232
Parque do Aripuanã	IL	16007.91	15958.79	49.12	0.756
Parque do Tumucumaque	IL	30645.39	30605.36	40.03	0.232
Parque do Xingu	IL	26433.29	26048.55	384.74	4.088
Parque Estadual Águas do Cuiabá	SSP	109.62	108.56	1.05	-
Parque Estadual Chandless	SSP	6939.23	6936.29	2.94	-
Parque Estadual Charapucu	SSP	653.49	653.48	0.00	0.004
Parque Estadual Cristalino	SSP	590.20	552.22	37.99	-
Parque Estadual da Serra dos Martírios/Andorinhas	SSP	250.32	237.60	12.72	0.003
Parque Estadual de Águas Quentes	SSP	15.07	9.41	5.65	-
Parque Estadual de Corumbiara	SSP	4298.29	4211.52	86.77	0.072
Parque Estadual de Guajará-Mirim	SSP	2000.87	1994.68	6.19	-
Parque Estadual de Monte Alegre	SSP	56.43	47.63	8.81	0.063
Parque Estadual do Araguaia	SSP	2299.19	2254.23	44.96	2.472
Parque Estadual do Bacanga	SSP	26.23	17.88	8.35	0.744
Parque Estadual do Cantão	SSP	1004.12	943.91	60.21	2.574
Parque Estadual do Guirá	SSP	1046.38	1046.38	0.00	-
Parque Estadual do Jalapão	SSP	1589.71	1585.86	3.85	-
Parque Estadual do Lajeado	SSP	107.50	97.12	10.38	-
Parque Estadual do Matupiri	SSP	5095.99	5092.96	3.04	-
Parque Estadual do Utinga	SSP	11.92	7.31	4.62	0.735
Parque Estadual do Xingu	SSP	953.30	953.30	0.00	-
Parque Estadual Dom Osório Stoffel	SSP	64.21	44.72	19.49	0.006
Parque Estadual Encontro das Águas	SSP	1081.07	1079.68	1.39	-
Parque Estadual Guariba	SSP	711.00	710.90	0.10	-
Parque Estadual Igarapés do Juruena	SSP	2238.16	2221.93	16.22	0.011
Parque Estadual Mãe Bonifácia	SSP	0.77	-	-	-
Parque Estadual Rio Negro Setor Norte	SSP	1481.16	1474.05	7.12	1.115
Parque Estadual Rio Negro Setor Sul	SSP	1555.03	1532.25	22.78	5.690
Parque Estadual Serra Azul	SSP	110.07	108.36	1.70	-
Parque Estadual Serra do Aracá	SSP	18724.51	18691.69	32.82	0.003
Parque Estadual Serra dos Reis	SSP	363.06	342.25	20.81	-
Parque Estadual Serra Ricardo Franco	SSP	1576.38	1198.17	378.21	-



**Table S1(Continued)**

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Parque Estadual Serra Santa Bárbara	SSP	1204.32	1161.69	42.64	-
Parque Estadual Sucunduri	SSP	7961.89	7957.64	4.24	-
Parque Estadual Sumaúma	SSP	0.53	-	-	-
Parque Estadual Tucumã	SSP	810.14	804.27	5.87	-
Parque Estadual Zé Bolo Flô	SSP	0.52	-	-	-
Parque Nacional da Amazônia	FSP	10662.72	10617.66	45.05	0.102
Parque Nacional da Chapada das Mesas	FSP	1599.52	1577.40	22.12	-
Parque Nacional da Chapada dos Guimarães	FSP	326.47	244.29	82.17	-
Parque Nacional da Serra da Cutia	FSP	2834.99	2832.12	2.87	0.008
Parque Nacional da Serra do Divisor	FSP	8369.38	8197.57	171.81	1.750
Parque Nacional da Serra do Pardo	FSP	4453.95	4193.13	260.81	0.023
Parque Nacional das Nascentes do Rio Parnaíba	FSP	4914.34	4901.42	12.92	-
Parque Nacional de Anavilhanas	FSP	3397.36	3386.93	10.44	6.764
Parque Nacional de Pacaás Novos	FSP	7086.70	7078.03	8.66	-
Parque Nacional do Araguaia	FSP	5554.84	5503.38	51.46	0.569
Parque Nacional do Cabo Orange	FSP	5724.25	5714.43	9.82	0.002
Parque Nacional do Jamaxim	FSP	8598.01	8430.38	167.63	1.184
Parque Nacional do Jaú	FSP	23673.40	23633.63	39.77	3.900
Parque Nacional do Juruena	FSP	19565.75	19460.56	105.19	0.846
Parque Nacional do Monte Roraima	FSP	1163.80	1161.77	2.03	-
Parque Nacional do Pantanal Matogrossense	FSP	1358.06	1358.06	0.00	-
Parque Nacional do Pico da Neblina	FSP	22505.17	22438.36	66.81	0.331
Parque Nacional do Rio Novo	FSP	5381.08	5291.86	89.23	-
Parque Nacional dos Campos Amazônicos	FSP	9613.15	9564.04	49.11	0.061
Parque Nacional Matinguari	FSP	17769.24	17644.28	124.96	0.786
Parque Nacional Montanhas do Tumucumaque	FSP	38606.25	38564.97	41.28	0.150
Parque Nacional Nascentes do Lago Jari	FSP	8127.48	8104.82	22.66	0.028
Parque Nacional Serra da Mocidade	FSP	3593.81	3593.72	0.09	-
Parque Nacional Viruá	FSP	2149.53	2149.35	0.18	-
Parque Natural Municipal do Cancão	MSP	3.71	2.54	1.17	-
Patauí	IL	6.15	4.44	1.71	-
Paukalirajausu	IL	674.49	630.15	44.35	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Paumari do Cuniuá	IL	428.13	426.26	1.87	0.036
Paumari do Lago Manissuã	IL	229.71	228.44	1.27	0.160
Paumari do Lago Marahã	IL	1186.84	1176.66	10.18	0.076
Paumari do Lago Paricá	IL	157.93	156.79	1.13	-
Paumari do Rio Ituxi	IL	75.69	74.93	0.76	0.000
Pedras Negras	MT	437.17	435.25	1.92	0.026
Peneri/Tacaquiri	IL	1898.08	1881.38	16.70	0.048
Pequizal	IL	97.93	86.99	10.94	-
Pequizal do Naruvôtu	IL	278.73	227.31	51.43	0.133
Perigara	IL	108.07	104.38	3.70	0.012
Pimentel Barbosa	IL	3275.98	3186.87	89.11	0.011
Pinatuba	IL	296.49	286.13	10.36	0.038
Piqui/Santa Maria	MT	55.88	40.46	15.41	0.029
Pirahã	IL	3469.92	3459.63	10.29	0.283
Pirineus de Souza	IL	284.55	268.09	16.46	-
Piripkura	IL	2424.22	2327.93	96.29	0.348
Pirititi	IL	433.39	430.97	2.42	-
Pitoro dos Pretos	MT	43.06	32.19	10.86	-
Pium	IL	45.62	44.25	1.37	-
Ponciano	IL	43.24	36.79	6.46	0.627
Ponta da Serra	IL	155.52	155.52	0.00	-
Ponte de Pedra	IL	169.65	164.86	4.80	-
Porquinhos	IL	794.09	785.36	8.73	-
Porquinhos dos Kanela Apãnjekra	IL	3012.36	2909.92	102.44	-
Portal do Encantado	IL	430.20	390.45	39.75	-
Porto Limoeiro	IL	49.96	49.73	0.23	-
Porto Praia	IL	47.67	47.60	0.07	-
Poyanawa	IL	244.92	228.94	15.97	-
Praia do Índio <sup>(1)</sup>	IL	0.32	-	0.32	-
Praia do Mangue <sup>(1)</sup>	IL	0.32	0.00	0.32	0.032
Prosperidade	IL	55.73	55.65	0.08	0.052
Quilombola de Jesus	MT	59.71	56.46	3.25	-
Raimundão	IL	42.77	32.18	10.59	-
Raposa Serra do Sol	IL	17376.22	17302.32	73.90	0.121
Recreio/São Félix	IL	2.39	0.15	2.24	-
Refúgio de Vida Silvestre Corixão da Mata Azul	SSP	357.08	325.03	32.05	0.068
Refúgio de Vida Silvestre Metrópole da Amazônia	SSP	63.69	52.46	11.23	0.088

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Reserva Biológica Culuene	SSP	36.14	11.34	24.80	-
Reserva Biológica de Maicuru	SSP	11732.28	11675.90	56.38	0.039
Reserva Biológica do Abufari	FSP	2238.57	2234.72	3.85	0.285
Reserva Biológica do Guaporé	FSP	6156.34	6137.59	18.75	0.016
Reserva Biológica do Gurupi	FSP	2711.87	1934.29	777.59	0.697
Reserva Biológica do Jaru	FSP	3468.60	3369.78	98.82	0.430
Reserva Biológica do Lago Piratuba	FSP	3924.68	3910.91	13.77	0.232
Reserva Biológica do Rio Trombetas	FSP	4077.55	4058.51	19.04	2.123
Reserva Biológica do Tapirapé	FSP	992.72	985.90	6.82	-
Reserva Biológica do Uatumã	FSP	9386.03	9383.87	2.16	-
Reserva Biológica Morro dos Seis Lagos	SSP	382.88	374.55	8.33	-
Reserva Biológica Nascentes Serra do Cachimbo	FSP	3421.91	3155.15	266.76	-
Reserva Biológica Rio Ouro Preto	SSP	547.61	547.46	0.15	-
Reserva Biológica Traçadal	SSP	250.68	250.55	0.13	-
Reserva de Desenvolvimento Sustentável Alcobaça	SSU	224.61	200.84	23.77	10.054
Reserva de Desenvolvimento Sustentável Amanã	SSU	23034.63	22934.74	99.88	12.540
Reserva de Desenvolvimento Sustentável Aripuanã	SSU	2180.95	2179.61	1.34	0.290
Reserva de Desenvolvimento Sustentável Bararati	SSU	1108.12	1105.27	2.86	0.041
Reserva de Desenvolvimento Sustentável Canumã	SSU	227.58	206.16	21.43	0.653
Reserva de Desenvolvimento Sustentável Cujubim	SSU	24219.27	24193.56	25.71	0.070
Reserva de Desenvolvimento Sustentável do Juma	SSU	5807.87	5737.59	70.28	5.154
Reserva de Desenvolvimento Sustentável do Matupiri	SSU	1770.07	1769.90	0.18	0.100
Reserva de Desenvolvimento Sustentável do Rio Iratapuru	SSU	8735.65	8724.63	11.02	0.111
Reserva de Desenvolvimento Sustentável do Rio Madeira	SSU	2796.32	2675.20	121.12	10.105
Reserva de Desenvolvimento Sustentável do Rio Negro	SSU	1029.79	966.72	63.07	14.341
Reserva de Desenvolvimento Sustentável do Tupé	MSU	121.75	93.51	28.24	4.353
Reserva de Desenvolvimento Sustentável do Uatumã	SSU	4234.63	4170.24	64.39	9.332
Reserva de Desenvolvimento Sustentável Igapó-Açu	SSU	3946.22	3894.85	51.37	0.022
Reserva de Desenvolvimento Sustentável Itatupã-Baquiá	FSU	644.41	644.14	0.27	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Reserva de Desenvolvimento Sustentável Mamirauá	SSU	13199.40	13197.58	1.82	0.054
Reserva de Desenvolvimento Sustentável Piagaçu Purus	SSU	8008.71	7988.34	20.38	2.899
Reserva de Desenvolvimento Sustentável Pucuruí - Ararã	SSU	291.65	282.81	8.84	4.646
Reserva de Desenvolvimento Sustentável Rio Amapá	SSU	2143.16	2140.37	2.79	-
Reserva de Desenvolvimento Sustentável Uacarí	SSU	6203.01	6154.51	48.50	0.867
Reserva Extrativista do Rio Cautário	FSU	751.26	741.39	9.87	-
Reserva Extrativista Alto Juruá	FSU	5378.07	5222.58	155.49	0.218
Reserva Extrativista Alto Tarauacá	FSU	1509.23	1473.13	36.09	0.027
Reserva Extrativista Angelim	SSU	83.84	76.26	7.59	-
Reserva Extrativista Aquariquara	SSU	192.76	176.83	15.94	-
Reserva Extrativista Arapixi	FSU	1337.08	1310.56	26.52	1.965
Reserva Extrativista Arióca Pruanã	FSU	838.17	742.89	95.28	0.153
Reserva Extrativista Auatí-Paraná	FSU	1469.49	1452.89	16.60	0.106
Reserva Extrativista Baixo Juruá	FSU	1780.39	1754.02	26.37	0.691
Reserva Extrativista Barreiro das Antas	FSU	1061.11	1060.51	0.60	-
Reserva Extrativista Canutama	SSU	1979.53	1968.50	11.03	0.638
Reserva Extrativista Castanheira	SSU	96.61	92.12	4.49	-
Reserva Extrativista Catuá-Ipixuna	SSU	2123.23	1991.02	132.21	10.689
Reserva Extrativista Cazumbá-Iracema	FSU	7553.46	7471.24	82.22	-
Reserva Extrativista Chico Mendes	FSU	9312.72	8832.33	480.39	-
Reserva Extrativista Chocoaré-Mato Grosso	FSU	27.83	27.53	0.30	0.069
Reserva Extrativista Curralinho	SSU	16.62	15.75	0.87	-
Reserva Extrativista de Cururupu	FSU	1572.35	1350.71	221.64	35.255
Reserva Extrativista do Ciriáco	FSU	81.07	23.82	57.25	-
Reserva Extrativista do Guariba	SSU	1480.84	1479.70	1.14	0.003
Reserva Extrativista do Itaúba	SSU	16.04	15.47	0.58	-
Reserva Extrativista do Lago do Capanã Grande	FSU	3043.07	2998.64	44.43	1.001
Reserva Extrativista do Médio Purus	FSU	6042.32	5998.46	43.85	0.308
Reserva Extrativista do Rio Gregório	SSU	3069.96	3046.80	23.16	0.026
Reserva Extrativista do Rio Jutai	FSU	2755.13	2735.89	19.24	0.338
Reserva Extrativista do Rio Unini	FSU	8496.85	8482.17	14.68	2.410
Reserva Extrativista Extremo Norte do Tocantins	FSU	90.70	5.23	85.47	-
Reserva Extrativista Freijó	SSU	6.29	5.39	0.89	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Reserva Extrativista Garrote	SSU	8.66	8.48	0.18	-
Reserva Extrativista Guariba-Roosevelt	SSU	1376.78	1303.82	72.95	4.434
Reserva Extrativista Gurupá-Melgaço	FSU	1454.16	1430.78	23.38	0.332
Reserva Extrativista Ipaú-Anilzinho	FSU	558.34	375.79	182.55	0.367
Reserva Extrativista Ipê	SSU	8.19	6.58	1.62	-
Reserva Extrativista Ituxí	FSU	7763.23	7746.32	16.91	0.811
Reserva Extrativista Jaci-Paraná	SSU	2003.20	1373.32	629.88	-
Reserva Extrativista Jatobá	SSU	13.39	9.76	3.63	-
Reserva Extrativista Lago do Cuniã	FSU	506.04	503.95	2.08	0.061
Reserva Extrativista Mae Grande de Curuça	FSU	335.96	326.71	9.25	0.462
Reserva Extrativista Mapuá	FSU	937.47	908.35	29.12	1.061
Reserva Extrativista Maracanã	FSU	291.12	286.14	4.98	0.493
Reserva Extrativista Maracatiara	SSU	86.60	75.63	10.97	-
Reserva Extrativista Marinha Arai-Peroba	FSU	600.97	553.38	47.59	3.741
Reserva Extrativista Marinha Caetéperaçu	FSU	408.05	379.75	28.30	1.908
Reserva Extrativista Marinha Cuinarana	FSU	110.36	100.58	9.79	0.173
Reserva Extrativista Marinha de Gurupi-Piriá	FSU	693.81	621.86	71.95	10.445
Reserva Extrativista Marinha de Soure	FSU	295.79	287.37	8.42	0.258
Reserva Extrativista Marinha Mestre Lucindo	FSU	250.57	241.01	9.56	0.183
Reserva Extrativista Marinha Mocapajuba	FSU	202.95	187.37	15.58	0.432
Reserva Extrativista Marinha Tracuateua	FSU	274.84	265.67	9.17	0.053
Reserva Extrativista Massaranduba	SSU	61.75	56.29	5.46	-
Reserva Extrativista Mata Grande	FSU	114.32	8.09	106.22	-
Reserva Extrativista Médio Juruá	FSU	2515.87	2491.43	24.44	0.275
Reserva Extrativista Mogno	SSU	24.13	23.19	0.94	-
Reserva Extrativista Pedras Negras	SSU	1264.74	1262.81	1.92	0.026
Reserva Extrativista Piquiá	SSU	12.79	11.44	1.35	-
Reserva Extrativista Quilombo do Frechal	FSU	93.38	-	-	-
Reserva Extrativista Renascer	FSU	2096.64	1949.22	147.42	0.072
Reserva Extrativista Rio Cajari	FSU	5324.00	5205.95	118.05	0.114
Reserva Extrativista Rio Cautário	SSU	1509.77	1458.02	51.76	0.118
Reserva Extrativista Rio Iriiri	FSU	3989.88	3914.17	75.71	1.807

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Reserva Extrativista Rio Ouro Preto	FSU	2046.32	1856.73	189.59	-
Reserva Extrativista Rio Pacaás Novos	SSU	3504.43	3483.40	21.04	-
Reserva Extrativista Rio Preto-Jacundá	SSU	1197.67	1123.02	74.66	0.262
Reserva Extrativista Rio Xingu	FSU	3030.01	2992.11	37.90	3.303
Reserva Extrativista Riozinho da Liberdade	FSU	3249.03	3195.23	53.80	-
Reserva Extrativista Riozinho do Anfrísio	FSU	7360.83	7324.97	35.86	0.114
Reserva Extrativista Roxinho	SSU	10.39	9.45	0.94	-
Reserva Extrativista São João da Ponta	FSU	34.09	32.53	1.57	0.059
Reserva Extrativista Seringueira	SSU	4.76	4.31	0.45	-
Reserva Extrativista Sucupira	SSU	28.18	27.10	1.08	-
Reserva Extrativista Tapajós Arapiuns	FSU	6742.07	6226.19	515.88	4.500
Reserva Extrativista Terra Grande Pracuúba	FSU	1948.64	1891.63	57.01	0.732
Reserva Extrativista Verde Para Sempre	FSU	12893.12	12502.10	391.01	3.707
Reserva Particular do Patrimônio Natural Aurora Natura	FSU	0.15	0.14	0.01	-
Reserva Particular do Patrimônio Natural Bico do Javaés	FSU	27.62	27.62	0.00	-
Reserva Particular do Patrimônio Natural Catedral do Jalapão	FSU	3.26	3.26	0.00	-
Reserva Particular do Patrimônio Natural Cristalino I	SSU	24.51	23.73	0.78	-
Reserva Particular do Patrimônio Natural Cristalino III	SSU	16.17	15.99	0.18	-
Reserva Particular do Patrimônio Natural Fazenda Bosco	FSU	4.87	4.87	0.00	-
Reserva Particular do Patrimônio Natural Fazenda Calixto	FSU	3.43	3.43	0.00	-
Reserva Particular do Patrimônio Natural Fazenda Loanda	SSU	5.15	4.32	0.83	-
Reserva Particular do Patrimônio Natural Gibeão	FSU	0.31	0.23	0.08	-
Reserva Particular do Patrimônio Natural Ilhas Alexandre Rodrigues Ferreira	FSU	3.02	3.02	0.00	-
Reserva Particular do Patrimônio Natural Irmãos Satelis	FSU	0.41	0.29	0.12	-
Reserva Particular do Patrimônio Natural Klagesi	FSU	0.23	0.19	0.04	-
Reserva Particular do Patrimônio Natural Nova Aurora	FSU	0.19	-	-	-
Reserva Particular do Patrimônio Natural Osório Reimão	FSU	0.09	0.04	0.05	0.000



**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Reserva Particular do Patrimônio Natural Peugeot-ONF-Brasil	SSU	17.60	17.18	0.42	0.005
Reserva Particular do Patrimônio Natural SESC Tepequém	FSU	0.52	0.52	0.00	-
Reserva Particular do Patrimônio Natural Sonhada	FSU	8.87	8.87	0.00	-
Rio Apaporis	IL	1070.44	1065.04	5.40	0.115
Rio Biá	IL	11856.38	11827.60	28.78	0.192
Rio Branco	IL	2363.20	2332.84	30.36	-
Rio Formoso	IL	200.90	188.76	12.15	-
Rio Gregório	IL	2800.27	2761.90	38.37	-
Rio Guaporé	IL	1159.75	1137.21	22.54	0.048
Rio Jumas	IL	94.77	92.88	1.89	0.106
Rio Manicoré	IL	193.34	192.38	0.96	0.139
Rio Mequens	IL	1077.73	1038.62	39.11	-
Rio Negro Ocaia	IL	3401.02	3365.53	35.49	-
Rio Omerê	IL	261.58	217.45	44.14	-
Rio Paru Deste	IL	11943.69	11932.46	11.23	0.182
Rio Pindaré	IL	152.66	63.15	89.51	2.244
Rio Téa	IL	4111.30	4102.27	9.03	0.344
Rio Urubu	IL	275.62	235.48	40.14	1.343
Riozinho do Alto Envira	IL	2600.74	2598.34	2.40	-
Rodeador	IL	23.24	18.90	4.34	-
Roosevelt	IL	2297.15	2247.70	49.45	0.098
Rosa	MT	47.52	47.52	0.00	-
Sagarana	IL	181.86	169.01	12.85	0.011
Sai-Cinza	IL	1249.54	1230.61	18.93	0.534
Sangradouro/Volta Grande	IL	1024.59	1002.12	22.47	-
Santa Cruz da Nova Aliança	IL	59.71	56.56	3.15	-
Santa Inez	IL	301.54	298.36	3.18	-
Santa Maria dos Pinheiros	MT	10.21	1.41	8.80	-
Santa Rosa dos Pretos	MT	75.02	17.36	57.66	-
Santana	IL	358.48	351.84	6.64	-
Santo Antônio do Guaporé	MT	416.90	415.34	1.57	-
São Domingos - MT	IL	63.45	30.84	32.61	0.052
São Domingos do Jacapari e Estação	IL	1347.80	1342.81	4.98	-
São Francisco do Canimari	IL	14.68	13.27	1.41	-
São Francisco Malaquias	MT	10.86	7.18	3.68	-
São Judas Tadeu	MT	24.35	4.91	19.43	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
São Leopoldo	IL	724.06	713.35	10.71	-
São Marcos - MT	IL	1742.11	1714.95	27.17	0.014
São Marcos - RR	IL	6509.39	6457.59	51.80	-
São Pedro	IL	6.15	5.00	1.16	0.061
São Pedro do Sepatini	IL	276.01	275.15	0.86	-
São Raimundo da Pirativa	MT	0.23	0.23	0.00	-
São Sebastião	IL	601.53	595.57	5.95	-
Sapotal	IL	12.65	11.93	0.73	0.493
Saracura	MT	27.94	27.94	0.00	-
Sararé	IL	84.01	81.17	2.83	-
Sarauá	IL	185.85	134.82	51.03	0.062
Sepoti	IL	2514.08	2510.98	3.10	0.000
Serra da Moça	IL	113.60	112.49	1.11	-
Serra Morena	IL	1477.38	1468.77	8.60	-
Seruini/Mariene	IL	1448.83	1446.77	2.06	-
Sete de Setembro	IL	2490.10	2432.23	57.86	-
Setemã	IL	492.53	487.93	4.61	0.128
Sissáima	IL	87.72	59.23	28.50	0.074
Sororó	IL	260.94	247.19	13.75	-
Sucuba	IL	59.77	59.10	0.67	-
Sururuá	IL	361.50	356.04	5.47	-
Tabalascada	IL	130.02	105.96	24.06	-
Tabocal	IL	9.05	7.18	1.87	0.196
Tadarimana	IL	95.43	89.47	5.95	-
Taego ãwa	IL	290.89	201.22	89.67	0.033
Taihantesu	IL	52.62	48.49	4.13	-
Tambor	MT	7 197.75	7188.49	9.25	-
Tanaru	IL	80.70	73.42	7.28	-
Tapirapé/Karajá	IL	660.74	642.48	18.26	0.211
Tembé	IL	10.67	5.64	5.03	-
Tenharim do Igarapé Preto	IL	857.42	847.52	9.90	-
Tenharim Marmelos	IL	4983.70	4962.52	21.18	-
Tenharim Marmelos (Gleba B)	IL	4749.49	4729.60	19.89	0.021
Terena Gleba Iriri	IL	303.76	295.65	8.11	-
Tereza Cristina	IL	290.07	286.76	3.31	0.121
Tikúna de Feijoal	IL	414.97	397.33	17.64	-
Tikuna de Santo Antônio	IL	10.66	0.95	9.71	0.198
Tirecatunga	IL	1304.79	1289.95	14.85	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Torá	IL	506.23	505.40	0.82	0.095
Trincheira	IL	17.42	15.19	2.23	0.118
Trincheira Bacaja	IL	16546.41	16474.01	72.40	0.201
Trocará	IL	216.34	203.28	13.06	-
Trocará - Doação	IL	0.14	0.14	0.00	-
Trombetas/Mapuera	IL	39700.78	39675.73	25.05	0.483
Truaru	IL	60.04	57.04	3.00	-
Tubarão Latunde	IL	1167.47	1148.72	18.75	-
Tukuna Porto Espiritual	IL	29.65	26.10	3.55	-
Tukuna Umariçu	IL	48.55	35.00	13.55	-
Tumiã	IL	1242.40	1236.69	5.71	-
Tupã-Supé	IL	85.85	85.07	0.78	0.429
Turé/Mariquita	IL	1.49	0.89	0.59	-
Turé/Mariquita Ii	IL	6.03	4.11	1.92	-
Tuwa Apekuokawera	IL	117.57	5.14	112.43	-
Uaçã	IL	4700.98	4640.47	60.51	-
Uati-Paraná	IL	1292.08	1280.35	11.73	0.087
Ubawawe	IL	519.13	457.72	61.41	-
Uirapuru	IL	216.65	145.42	71.23	-
Umutina	IL	276.09	262.89	13.20	-
Uneiuxi	IL	9532.35	9526.44	5.91	0.141
Urubu Branco	IL	1676.67	1361.56	315.11	-
Urucu/Juruá	IL	127.51	99.47	28.04	-
Uru-Eu-Wau-Wau	IL	18695.84	18532.27	163.57	-
Utaria Wyhyna/Iròdu Iràna	IL	1775.78	1765.84	9.94	0.062
Utiariti	IL	4097.97	3991.69	106.28	-
Vale do Guaporé	IL	2406.66	2284.67	121.99	-
Vale do Javari	IL	85325.55	85088.22	237.33	0.392
Vista Alegre	IL	131.74	117.10	14.64	1.521
Vui-Uata-In	IL	1215.82	1195.98	19.85	0.220
Waiãpi	IL	6045.25	6025.14	20.11	-
Waimiri-Atroari	IL	25897.17	25866.93	30.24	0.823
Waiwái	IL	4042.78	4007.87	34.91	-
Wawi	IL	1500.34	1409.47	90.88	-
Wedezé	IL	1460.02	1295.05	164.97	0.224
Xambioá	IL	33.38	27.02	6.36	0.057
Xerente	IL	1713.86	1642.88	70.98	0.002
Xikrin do Rio Catete	IL	4360.37	4297.72	62.65	-

**Table S1** (Continued)

Name of Protected Area	Protected area type*	Initial total area**	Area covered by vegetation in 2014	Cumulative clearing of vegetation by 2014	Area mapped as deforested including overlapping watercourses***
Xipaya	IL	1785.46	1784.17	1.29	0.044
Yanomami	IL	94873.78	94628.56	245.22	1.192
Zoe	IL	6688.06	6683.47	4.59	-
Zoró	IL	3546.15	3367.06	179.09	0.024
Zuruahã	IL	2381.22	2368.86	12.36	0.035

\* IL = Indigenous land, MT = Maroon territory, FSP = Federal Strictly Protected conservation unit, FSU = Federal Sustainable-Use conservation unit, SSP = State Strictly Protected conservation unit, SSU = State Sustainable Use conservation unit, MSP = Municipal Strictly Protected conservation unit, MSU = Municipal Sustainable Use conservation unit.

\*\* Total area in each protected area was calculated from vector map available from Brazil, FUNAI (2015), Brazil, INCRA (2015) and Brazil, MMA (2015). For some protected areas the total area calculated from the vector maps may differ from the total area given in other official documents.

\*\*\* The estimates of carbon loss and the stock in the remaining vegetation in 2014 may, in certain protected areas, be affected by the overlapping of classes (*e.g.*, watercourses, forest, non-forest and deforestation), which differ between the carbon map (Nogueira et al. 2015) and the maps of the Project for Monitoring Deforestation in Amazonia (PRODES) and the Project for Monitoring Deforestation of the Brazilian Biomes by Satellite (PMDBBS) (Brazil, IBAMA 2015; Brazil, INPE 2016).

## References

- Brazil, IBAMA (2015) Projeto de Monitoramento do Desmatamento dos Biomas Brasileiros por Satélite – PMDBBS: Cerrado, Monitoramento do Bioma Cerrado 2009-2010. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Ministério do Meio Ambiente, Brasília, DF, Brazil. [http://siscom.ibama.gov.br/monitora\\_biomass/PMDBBS%20-%20CERRADO.html](http://siscom.ibama.gov.br/monitora_biomass/PMDBBS%20-%20CERRADO.html). Accessed 12 July 2015
- Brazil, INPE (2016) Projeto de Monitoramento do Desmatamento na Amazônia Legal (PRODES). Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, São Paulo, Brazil. <http://www.dpi.inpe.br/prodesdigital/prodes.php>. Accessed 1 March 2016
- Brazil, FUNAI (2015) Download de dados geográficos. Terra Indígena (Regularizada, Homologada, Declarada, Delimitada e Área em Estudo). Fundação Nacional do Índio (FUNAI), Brasília, DF, Brazil. <http://www.funai.gov.br/index.php/shape>. Accessed 24 April 2015
- Brazil, INCRA (2015) Download de dados geográficos. Instituto Nacional de Colonização e Reforma Agrária (INCRA), Brasília, DF, Brazil. <http://acervofundiario.incra.gov.br/i3geo/datadownload.htm>. Accessed 14 April 2015
- Brazil, MMA (2015) Download de dados geográficos, Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. <http://mapas.mma.gov.br/i3geo/datadownload.htm>. Accessed 17 April 2015
- Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biology* 21(3): 1271–1292. doi:10.1111/gcb.12798.

**Table S2.** Carbon above- and below-ground in protected areas in two regions in Brazilian Amazonia.

Regions where protected areas were analyzed	Area occupied by protected areas (km <sup>2</sup> )*	Total area deforested in protected areas (km <sup>2</sup> )*	Remaining carbon stock in protected areas in 2014 (Pg C)	Mean remaining carbon per hectare (Mg C)	Pre-modern carbon stock (Pg C)	Carbon loss (Pg C)	Mean carbon loss per hectare (Mg C)**	Carbon loss (%)
				(± uncertainty values)***				
Legal Amazonia	2 186 192.48	58 777.27	33.4 ± 7.3	158.9 ± 34.7	34.1 ± 7.5	0.787 ± 0.181	134.0 ± 30.8	2.3
Amazonia biome	2 034 507.00	42 083.34	32.7 ± 7.1	166.0 ± 36.1	33.4 ± 7.3	0.702 ± 0.155	166.9 ± 36.9	2.1

\* Refers to the total area occupied by all protected areas without any overlap between types or categories. The estimate of the area analyzed encompasses all elements of the landscape in each protected area, including areas not covered by vegetation, provided they are within the bounds of Legal Amazonia.

\*\* The estimate of mean carbon loss per hectare considers only the areas of the surface that originally were covered by vegetation.

\*\*\* The uncertainty values were calculated from the ranges of mean biomass and total area occupied by the vegetation types identified in the protected areas. Some uncertainty values could differ from the true variation because some vegetation types do not have measurements of uncertainties associated with the biomass and carbon estimates (see Tables 1, 2 and 3 in Nogueira et al. 2015).

Reference:

Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biol* 21(3):1271–1292. doi:10.1111/gcb.12798

**Table S3.** Legal Amazonia: Carbon above- and below-ground in protected areas (Indigenous lands, federal, state and municipal conservation units, and Maroon territories). \*

Protected area types	Number of protected areas	Area analyzed in this study (km <sup>2</sup> )**	Total area deforested (km <sup>2</sup> )	Remaining carbon stock in 2014 (Pg C)	Mean remaining carbon per hectare (Mg C)	Pre-modern carbon stock (Pg C)	Carbon loss (Pg C)	Mean carbon loss per hectare (Mg C)***	Carbon loss (%)
				(± uncertainty values)****					
Indigenous lands	372	1 111 000.89	16 967.71	16.9 ± 3.8	156.0 ± 34.7	17.2 ± 3.8	0.241 ± 0.060	142.2 ± 35.1	1.4
Federal conservation units	148	629 689.28	11 471.29	9.8 ± 2.1	161.4 ± 34.6	10.0 ± 2.1	0.182 ± 0.040	158.9 ± 34.6	1.8
State conservation units	156	525 395.12	30 170.65	7.8 ± 1.7	162.0 ± 35.0	8.2 ± 1.8	0.365 ± 0.081	121.0 ± 27.0	4.5
Municipal conservation units	9	17 812.21	580.83	0.246 ± 0.051	147.7 ± 30.8	0.250 ± 0.052	0.0041 ± 0.0009	71.4 ± 15.7	1.7
Maroon territories (“ <i>Quilombos</i> ”)	33	10 212.80	1 211.15	0.148 ± 0.028	166.4 ± 31.1	0.166 ± 0.031	0.018 ± 0.004	148.8 ± 31.4	10.8
Total	718	2 294 110.31	60 401.64						

\* The estimates do not have deductions for overlapping between protected areas of different types, but overlapping between areas of the same type was deducted.

\*\* The estimate of the area analyzed encompasses all elements of the landscape in each protected area, including areas not covered by vegetation, provided they are within the bounds of Legal Amazonia.

\*\*\* The estimate of mean carbon loss per hectare considers only the areas of the surface that originally were covered by vegetation.

\*\*\*\* The uncertainty values were calculated from the ranges of mean biomass and total area occupied by the vegetation types identified in the protected areas. Some uncertainty values could differ from the true variation because some vegetation types do not have measurements of uncertainties associated with the biomass and carbon estimates (see Tables 1, 2 and 3 in Nogueira et al. 2015).

Reference:

Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biol* 21(3):1271–1292. doi:10.1111/gcb.12798



**Table S4.** Amazonia biome: Carbon above- and below-ground in protected areas (Indigenous lands, federal, state and municipal conservation units, and Maroon territories). \*

Protected area type	Number of protected areas	Area analyzed in this study (km <sup>2</sup> )**	Total area deforested (km <sup>2</sup> )	Remaining carbon stock in 2014 (Pg C)	Mean remaining carbon per hectare (Mg C)	Pre-modern carbon stock (Pg C)	Carbon loss (Pg C)	Mean carbon loss per hectare (Mg C)***	Carbon loss (%)
				(± uncertainty values)****					
Indigenous lands	314	1 019 815.76	12 449.67	16.5 ± 3.6	164.5 ± 36.2	16.7 ± 3.7	0.205 ± 0.048	164.6 ± 38.5	1.2
Federal conservation units	130	600 087.99	10 542.20	9.7 ± 2.1	166.5 ± 35.6	9.9 ± 2.1	0.176 ± 0.038	167.1 ± 36.1	1.8
State conservation units	127	486 561.27	19 374.22	7.7 ± 1.7	168.6 ± 36.4	8.0 ± 1.7	0.325 ± 0.070	167.7 ± 35.9	4.0
Municipal conservation units	7	17 043.19	142.91	0.244 ± 0.051	149.8 ± 31.3	0.247 ± 0.052	0.0026 ± 0.0005	182.6 ± 37.4	1.1
Maroon territories (“ <i>Quilombos</i> ”)	22	9 780.78	1 005.30	0.146 ± 0.027	168.2 ± 31.1	0.162 ± 0.030	0.016 ± 0.003	161.9 ± 32.6	10.0
Total	600	2 133 288.98	43 514.30						

\* The estimates do not have deductions for overlapping between protected areas of different types, but overlapping between areas of the same type was deducted.

\*\* The estimate of the area analyzed encompasses all elements of the landscape in each protected area, including areas not covered by vegetation, provided they are within the bounds of Legal Amazonia.

\*\*\* The estimate of mean carbon loss per hectare considers only the areas of the surface that originally were covered by vegetation.

\*\*\*\* The uncertainty values were calculated from the ranges of mean biomass and total area occupied by the vegetation types identified in the protected areas. Some uncertainties values could differ from the true variation because some vegetation types do not have measurements of uncertainties associated with the biomass and carbon estimates (see Tables 1, 2 and 3 in Nogueira et al. 2015).

Reference:

Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biol* 21(3):1271–1292. doi:10.1111/gcb.12798

**Table S5.** Legal Amazonia: Remaining carbon stock in 2014 and carbon loss due to clearing through 2014 in strictly protected and sustainable-use conservation units.\*

Conservation unit type	Strictly protected				Sustainable use			
	Remaining carbon in 2014 (Pg C)	Carbon loss through 2014 (Pg C)	Mean carbon loss per hectare (Mg C)	Carbon loss (%)	Remaining carbon in 2014 (Pg C)	Carbon loss through 2014 (Pg C)	Mean carbon loss per hectare (Mg C)	Carbon loss (%)
Federal conservation units	4.92	0.052	163.1 ± 36.3	1.1	4.93	0.130	155.0 ± 33.4	2.6
State conservation units	1.94	0.013	121.0 ± 32.2	0.7	5.88	0.352	119.3 ± 26.4	5.6
Municipal conservation units	0.00006	0.00002	180.9 ± 40.1	26.3	0.246	0.051	69.6 ± 15.3	1.7

\* The estimates do not have deductions for overlapping between conservation units at different administrative levels (federal, state or municipal), but overlapping between units at the same administrative level was deducted.

**Table S6.** Amazonia biome: Remaining carbon stock in 2014 and carbon loss due to clearing through 2014 in strictly protected and sustainable-use conservation units. \*

Conservation unit type	Strictly protected				Sustainable use			
	Remaining carbon in 2014 (Pg C)	Carbon loss through 2014 (Pg C)	Mean carbon loss per hectare (Mg C)	Carbon loss (%)	Remaining carbon in 2014 (Pg C)	Carbon loss through 2014 (Pg C)	Mean carbon loss per hectare (Mg C)	Carbon loss (%)
Federal conservation units	4.82	0.051	170.0 ± 37.9	1.0	4.92	0.126	163.7 ± 34.9	2.5
State conservation units	1.90	0.012	141.3 ± 37.3	0.6	5.81	0.313	165.2 ± 35.1	5.1
Municipal conservation units	0.00004	0.00002	185.6 ± 41.2	32.5	0.244	0.003	166.8 ± 34.1	1.0

\* The estimates do not have deductions for overlapping between conservation units at different administrative levels (federal, state or municipal), but overlapping between units at the same administrative level was deducted.

**Table S7.** Carbon estimates in Indigenous lands that were analyzed in the present study in Brazil's Legal Amazonia and Amazonia biome regions.\*

Indigenous land**	Total area (km <sup>2</sup> )***	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
Acapuri de Cima	198.72	3260947.71	9241.11	164.55	168.35
Acimã	406.22	7386079.35	47969.51	183.02	180.66
Água Preta/Inari	1397.45	25861715.97	121709.60	185.96	181.07
Alto Rio Guamá	2822.60	35580508.88	16877985.31	186.20	185.11
Alto Rio Negro	79764.47	1379743317.74	14138610.40	174.80	170.42
Alto Rio Purus	2618.36	29537650.93	287028.09	113.75	133.32
Alto Sepatini	260.59	4818122.28	19376.73	185.66	178.86
Alto Tarauacá	1423.74	24643735.66	196702.28	174.47	174.66
Alto Turiaçu	5294.49	90972692.72	7565732.25	186.22	184.90
Anambé	85.95	1375399.75	186468.18	184.52	163.40
Ananás	26.12	138081.13	0.00	52.86	-
Anaro	304.60	903632.08	0.00	29.67	-
Andirá-Marau	7905.75	138013082.27	7308724.03	184.27	175.73
Aningal	76.67	559094.29	17239.17	74.15	136.69
Anta	32.63	127876.07	17597.89	41.57	94.05
Apiaká do Pontal e Isolados	9827.51	131548498.64	671427.33	134.53	137.12
Apiaka/Kayabi	1096.24	17151757.70	586959.47	162.05	155.09
Apinayé	1417.55	18717471.11	2000815.26	149.55	120.58
Apipica	6.52	7358.03	113388.76	185.47	185.13
Apurinã do Igarapé Mucuim	732.08	13140003.98	68694.64	180.49	169.44
Apurinã do Igarapé São João	182.47	2954252.39	123051.42	169.01	160.33
Apurinã Igarapé Tauamirim	1004.66	17161877.91	34184.40	171.29	124.46
Apurinã Km 124 BR-317	422.89	7445579.47	290701.18	183.00	181.38
Apyterewa	7738.10	125444976.63	12777103.36	178.26	182.28
Araçá	509.38	2050910.66	133657.22	41.00	145.12
Arara	2748.77	46852104.04	550958.82	172.39	178.30
Arara da Volta Grande do Xingu	255.15	4391762.78	305211.41	184.08	184.21
Arara do Igarapé Humaitá	874.62	11242965.51	79323.21	129.27	162.86
Arara do Rio Amonia	207.53	2253283.93	139604.47	115.34	114.67
Arara do Rio Branco	1146.60	18772563.69	169596.05	165.21	164.77
Arariboia	4138.09	71073308.23	4468092.21	182.37	185.51
Arary	407.27	7308817.01	74045.73	181.25	183.83
Araweté Igarapé Ipixuna	9409.30	153928459.35	738257.11	164.37	165.34
Areões	1802.79	18184431.48	484428.07	103.26	115.80
Aripuanã	7492.72	128894982.86	481433.52	172.68	169.26
Ariramba	103.64	1836068.20	16471.16	178.86	166.68
Awa	1167.72	14127152.03	7625285.37	186.57	185.75
Bacurizinho	2167.77	25355267.84	2754332.06	130.40	123.32

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )***	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Badjonkore	2220.93	20950491.65	779550.33	97.06	125.00
Baia dos Guató	192.31	1622728.61	2096.74	84.50	77.51
Bakairi	626.61	996626.46	113475.09	17.84	16.66
Balaio	2570.45	46765594.14	290673.40	183.05	185.38
Banawá	1925.99	35427746.99	141542.01	184.68	185.73
Barata Livramento	128.79	631304.84	52594.38	50.47	141.56
Barreira da Missão	17.74	150554.19	137562.59	185.95	142.61
Barreirinha	23.69	379959.67	60078.93	185.65	186.38
Barro Alto	19.38	317858.02	30118.85	179.02	185.24
Batelão	1171.42	15095641.07	1342459.92	139.34	152.45
Batovi	50.42	542786.62	21128.99	110.90	143.30
Baú	15384.81	257159802.46	136433.26	167.24	169.78
Betania	1225.90	19791375.23	552110.11	165.53	182.64
Boa Vista	3.37	5979.59	0.00	17.74	-
Boca do Acre	265.92	4559146.79	311627.41	183.05	184.89
Bom Intento	14.98	184924.35	9125.30	127.91	173.36
Bom Jesus	8.70	27728.47	0.00	31.86	-
Boqueirão	164.32	1102682.69	66140.56	70.14	93.21
Bragança-Marituba	135.10	2290449.92	213861.02	185.39	185.13
Cabeceira do Rio Acre	785.74	8171289.99	86290.80	104.81	141.08
Cacau do Tarauaca	286.51	4169907.94	97691.29	148.51	170.39
Cachoeira Seca	7340.01	118492244.91	7335170.23	171.49	170.44
Cacique Fontoura	323.30	867482.99	222480.41	33.00	36.80
Caititu	3097.08	49308068.92	252634.91	160.01	162.55
Cajueiro	44.68	170437.19	2577.76	38.29	153.10
Cajuhiri Atravessado	125.28	2070162.79	235148.40	184.11	183.12
Camadeni	1508.85	27783891.36	24305.98	184.31	176.71
Camicua	583.97	10577181.89	92100.23	182.80	172.68
Campinas/Katukina	335.73	5780851.72	125396.53	176.00	172.37
Cana Brava/Guajajara	1355.58	17210605.18	3092231.75	149.42	151.77
Canauanim	114.52	875226.93	535226.35	111.30	149.18
Capoto/Jarina	6345.01	70469124.41	719027.87	112.05	128.04
Caru	1708.58	28597930.46	2934812.65	185.29	177.72
Catipari/Mamoria	1149.58	20921835.16	50565.22	182.46	171.64
Cayabi	1108.34	14446504.34	15626.31	130.49	124.02
Chão Preto	126.78	379206.68	151027.15	46.51	33.38
Coata-Laranjal	11528.81	198875615.57	1263224.77	173.70	158.67
Cué Cué / Marabitanas	8071.98	135824479.27	2089814.81	170.94	165.26
Cuia	13.43	157416.58	92415.06	186.23	185.68

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
Cuiu-Cuiu	364.35	6536243.00	151798.36	183.62	181.25
Cunhã-Sapucaia	4708.79	79339208.29	177488.97	168.87	166.73
Deni	15282.13	278088405.28	1038163.18	182.66	180.24
Diahui	473.89	8113814.14	341440.00	178.25	182.50
Enawenê-Nawê	7459.06	57331603.84	295700.23	77.14	108.96
Erikpatsá	813.87	12752876.65	190664.71	158.98	163.17
Escondido	1689.05	30455333.33	72246.58	180.74	179.51
Espírito Santo	338.40	5196327.56	0.00	153.56	-
Estação Parecis	21.71	91767.53	1024.93	42.63	56.90
Estivadinho	20.34	50753.67	1494.07	25.99	18.31
Estrela da Paz	125.79	2118440.04	176936.03	182.61	180.97
Évare I	5487.14	95995805.27	2241271.22	180.19	140.41
Évare II	1726.95	29717030.88	241300.24	173.44	177.96
Figueiras	98.55	454338.38	1615.38	46.33	32.99
Fortaleza do Castanho	27.53	371703.36	86721.86	164.77	174.36
Fortaleza do Patauí	7.61	123660.18	18335.02	186.48	186.48
Funil	158.37	440951.47	122139.52	36.34	32.97
Galibi	62.90	1002153.42	40230.92	164.97	186.48
Gavião	83.99	1518696.20	47325.91	186.47	185.68
Geralda Toco Preto	185.16	2466526.08	620428.09	176.89	135.68
Governador	421.04	3374322.33	680078.19	93.17	115.54
Guajahã	50.30	847429.93	60.91	168.49	173.51
Guanabara	156.14	2632944.88	116649.69	176.09	176.26
Hi Merimã	6768.27	125144274.87	88546.57	185.03	178.49
Igarapé Capana	1293.05	23907867.70	22422.11	185.08	174.96
Igarapé do Caucho	121.03	1617270.98	278917.35	162.13	131.05
Igarapé Grande	11.90	167992.80	53073.49	186.01	185.17
Igarapé Lage	1073.23	16565959.99	926667.68	162.86	165.31
Igarapé Lourdes	1966.14	31982038.38	913981.63	167.26	169.31
Igarapé Ribeirão	478.58	7613041.32	189936.92	162.98	165.67
Igarapé Taboca do Alto Tarauacá	2.87	43592.30	6884.63	176.08	175.75
Ilha do Camaleão	1.66	21605.44	7186.99	174.22	172.07
Inauini/Teuini	4683.29	86554769.00	104504.32	185.05	179.18
Inawebohona	3773.16	22804520.49	425264.75	61.11	102.88
Ipixuna	2153.26	39038929.25	6973.38	181.42	51.59
Irantxe	455.54	3892517.60	122492.65	91.96	37.95
Itaitinga	1.36	11682.60	0.00	86.03	-
Itixi Mitari	1822.73	32457693.51	343454.01	180.04	172.42
Ituna/Itata	1369.93	23076431.55	39671.10	168.74	166.45

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
Jabuti	142.23	336313.25	5121.91	23.70	149.67
Jacamim	1925.88	22587610.77	41804.33	117.47	139.20
Jacareúba/Katauixi	6088.64	85448588.00	820006.51	141.66	144.43
Jaminaua/Envira	805.82	8053676.00	73039.31	100.85	100.85
Jaminawa Arara do Rio Bagé	288.65	4098647.41	11364.14	142.53	105.05
Jaminawa do Igarapé Preto	256.54	4612425.07	37245.86	181.28	176.78
Japuíra	1544.85	24879448.56	691244.85	165.52	165.48
Jaquiri	19.18	316984.50	125.96	165.36	175.00
Jarawara/Jamamadi/Kanamati	3889.61	71246724.79	510715.33	184.53	178.30
Jarudore	47.69	5230.70	162069.28	37.04	35.02
Jatuarana	50.94	900228.19	26607.22	182.90	154.94
Jauary	248.19	1780268.03	938529.05	112.09	105.02
Juininha	703.26	1684828.10	1760.33	23.99	17.39
Juma	384.80	6815286.64	7894.26	177.33	169.83
Jumina	417.46	2907172.18	23747.87	69.91	149.08
Kampa do Igarapé Primavera	219.56	2419143.31	15172.05	110.83	118.04
Kampa do Rio Amonea	860.07	11575475.14	48063.59	135.08	153.09
Kampa e Isolados do Rio Envira	2327.45	30304476.20	203871.99	131.03	138.52
Kanamari do Rio Juruá	6017.46	106589327.34	447979.80	177.89	174.87
Kanela	1255.76	3650349.93	170315.71	29.41	117.79
Kanela Memortumré	1003.03	3866933.35	178135.96	39.31	91.86
Karajá de Aruanã II	8.94	98996.60	7387.12	120.68	100.26
Karajá Santana do Araguaia	14.55	41460.92	7560.26	29.98	105.66
Kararaô	3307.48	54189450.60	14177.36	163.89	137.85
Karipuna	1530.07	24835304.21	107970.65	163.02	163.14
Karitiana	897.22	14091899.72	142614.88	158.58	165.61
Katukina/Kaxinawá	232.40	3807803.53	249819.99	175.50	161.93
Kawahiva do Rio Pardo	4106.52	69040437.45	737241.74	169.95	167.36
Kaxarari	1462.93	25233037.09	171679.81	173.66	173.76
Kaxinawá Ashaninka do Rio Breu	894.05	15711898.81	204729.08	178.05	176.30
Kaxinawá Colônia Vinte e Sete	1.05	3758.89	13828.95	167.89	167.89
Kaxinawá da Praia do Carapanã	606.46	9110722.25	293927.26	154.57	172.50
Kaxinawá do Baixo Rio Jordão	87.11	1446781.16	94486.32	176.99	176.25
Kaxinawá do Rio Humaitá	1288.08	18312016.93	82492.95	142.83	137.83
Kaxinawá do Rio Jordão	310.47	4596468.61	25070.69	149.02	123.82
Kaxinawá Nova Olinda	258.08	4311134.72	86189.93	170.55	162.66
Kaxinawá Seringal Independência	115.61	1972883.35	61424.82	176.02	174.31

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Kayabi	10539.67	131022096.23	5292480.71	128.62	149.98
Kayapó	32865.69	487144147.74	1997755.50	148.83	148.63
Koatinemo	3878.13	63248674.69	92802.14	163.33	163.97
Krahó-Kanela	76.99	370148.13	78776.99	57.46	62.67
Kraolandia	3058.32	10261093.45	70518.31	33.77	36.31
Krenrehé	59.78	187843.51	10859.68	33.57	28.37
Krikati	1450.67	6438568.71	4063196.11	58.78	114.38
Kulina do Médio Juruá	7271.42	129267743.85	742803.42	178.82	174.84
Kulina do Rio Envira	818.98	9220029.08	42649.06	113.13	107.49
Kulina Igarapé do Pau	455.70	5440549.52	77116.69	121.25	110.08
Kumarú do Lago Ualá	799.10	14308247.05	126848.55	180.69	175.65
Kuruáya	1666.23	27867887.05	46673.07	167.53	171.47
Kwazá do Rio São Pedro	168.04	1640198.19	80789.33	101.69	119.67
Lago Aiapua	239.34	2405151.00	74573.12	102.38	168.63
Lago Capanã	63.26	1065654.64	88.51	168.65	12.52
Lago do Beruri	42.74	637430.52	90921.23	175.33	142.36
Lago do Correio	132.20	2252793.69	12526.89	171.71	124.57
Lago do Limão	81.96	1468876.51	19503.86	181.69	174.68
Lago do Marinheiro	35.79	483989.75	109907.01	165.54	167.66
Lago Jauri	120.29	1797987.16	160166.08	162.58	165.15
Lago Comprida	132.46	1498347.48	521793.00	152.86	151.52
Lago dos Brincos	17.80	268918.74	0.00	151.10	-
Las Casas	213.54	314905.17	116055.31	17.37	35.93
Lauro Sodré	94.84	1555730.81	115810.44	176.25	176.26
Macarrão	434.59	7183796.90	209823.14	171.27	138.51
Mãe Maria	628.91	11265376.72	463296.08	186.49	186.55
Malacacheta	285.50	3706210.25	426912.87	144.22	149.73
Mamoadate	3128.91	42784284.55	117875.45	137.15	126.53
Mangueira	46.34	455769.55	68572.06	109.68	143.24
Manoa/Pium	439.89	3641626.39	441538.02	89.25	138.54
Manoki	2519.31	29635697.07	5819674.24	140.24	143.31
Mapari	1573.91	28445672.01	20667.29	180.87	172.60
Maraã Urubaxi	943.00	16470424.26	17538.21	174.84	179.52
Maracaxi	7.18	44429.11	88459.08	185.06	185.06
Maraitá	549.40	6109356.44	1562.12	111.23	111.14
Maraiwatsede	1653.46	5674032.86	14842512.49	106.57	132.40
Marajai	9.80	99.09	163587.74	185.06	167.00
Maranduba	3.75	26802.54	1385.90	73.41	137.45
Marechal Rondon	1002.96	1953791.70	24413.91	19.77	16.45



**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Maró	423.89	7655925.11	240138.83	186.30	185.41
Massaco	4200.90	50355045.10	225178.48	120.25	169.84
Matintin	217.76	3684629.49	81041.41	173.17	162.37
Mawetek	1155.32	21023882.84	129337.47	183.12	178.62
Médio Rio Negro I	17761.60	313141280.34	1412451.48	177.11	174.73
Médio Rio Negro II	3157.28	57102977.92	457444.51	182.50	161.22
Menkragnoti	49304.01	796328187.68	625234.15	161.64	166.57
Menkü	1914.46	18106361.21	6627598.95	131.22	123.98
Meria	5.83	30254.49	77785.54	186.11	185.20
Merure	827.86	3422901.79	46921.45	42.17	29.02
Miguel/Josefa	16.28	68473.88	142154.72	85.94	171.02
Miratu	139.19	2169497.71	344626.19	180.03	184.46
Morro Branco	0.49	2.79	7350.25	149.81	149.81
Moskow	141.89	1323447.64	404869.10	114.45	154.20
Munduruku	23859.75	327895410.79	1437539.90	138.09	125.86
Munduruku-Taquara	253.14	4561546.13	148497.49	186.13	184.10
Muriru	55.47	459450.36	108478.70	94.36	159.97
Murutinga/Tracajá	133.06	1573257.83	431850.60	143.58	183.88
Nambikwara	10033.32	48626663.00	236231.54	48.58	100.96
Natal/Felicidade	3.34	41531.75	0.00	124.18	-
Nhamundá/Mapuera	10490.11	192387005.84	2244126.76	185.60	179.99
Nova Esperança do Rio Jandiatuba	199.08	3589950.24	77625.49	184.22	184.54
Nova Jacundá	4.01	47863.09	26949.52	186.68	186.79
Nove de Janeiro	2294.25	39799339.05	156515.99	174.12	184.97
Nukini	319.96	5426405.76	307932.58	179.59	172.89
Ouro	138.01	393791.35	0.00	28.53	-
Pacaas Novas	2813.04	45979414.10	778560.45	166.13	171.87
Padre	7.97	125812.80	21486.41	185.82	179.10
Panará	4989.57	75778104.11	1140423.61	154.20	151.24
Paquiçamba	242.31	3076234.75	402859.41	142.10	155.99
Parabubure	2249.85	10438802.17	166676.90	47.79	25.39
Paracuhuba	9.39	119040.69	52665.44	185.30	177.53
Parakanã	3512.59	65056592.66	588792.33	186.89	186.68
Paraná do Arauató	59.01	708112.41	204420.57	150.01	173.18
Paraná do Boa Boa	2450.06	43695311.76	107835.90	178.77	183.76
Paraná do Paricá	80.07	1347169.10	0.00	168.26	-
Paresi	5625.61	9510569.39	1271721.66	19.44	17.32
Parque do Araguaia	13594.39	49851310.28	1503589.73	37.12	91.24
Parque do Aripuanã	16007.91	235129237.83	666554.60	147.34	135.69

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Parque do Tumucumaque	30645.39	462068438.90	308039.83	150.98	76.96
Parque do Xingu	26433.29	322130037.35	5048905.80	123.67	131.23
Patauí	6.15	82788.39	31694.67	186.39	185.16
Paukalirajausu	674.49	8231149.70	633076.38	130.62	142.76
Paumari do Cuniuá	428.13	7589784.06	32903.69	178.06	175.89
Paumari do Lago Manissuã	229.71	3970830.87	20062.30	173.82	157.66
Paumari do Lago Marahã	1186.84	20053841.90	147684.69	170.43	145.14
Paumari do Lago Paricá	157.93	2652157.08	19773.88	169.15	174.34
Paumari do Rio Ituxi	75.69	146831.78	12293.67	19.60	160.86
Peneri/Tacaquiri	1898.08	32357219.67	298138.44	171.99	178.51
Pequizal	97.93	1287048.02	162778.00	147.96	148.78
Pequizal do Naruvôtu	278.73	2701637.70	744962.52	118.85	144.86
Perigara	108.07	401571.08	15917.27	38.47	43.04
Pimentel Barbosa	3275.98	13953429.66	399449.35	43.78	44.82
Pinatuba	296.49	5063715.10	190069.53	176.97	183.51
Pirahã	3469.92	61920417.58	179536.50	178.98	174.46
Pirineus de Souza	284.55	1777335.02	202957.26	66.30	123.29
Piripkura	2424.22	38495332.27	1574045.68	165.36	163.47
Pirititi	433.39	8017384.79	44522.15	186.03	184.20
Pium	45.62	180427.51	18721.44	40.77	136.94
Ponciano	43.24	669481.15	108182.70	181.98	167.59
Ponta da Serra	155.52	477858.04	0.00	30.73	-
Ponte de Pedra	169.65	818433.53	15403.81	49.65	32.10
Porquinhos	794.09	6443504.60	105458.07	82.04	120.83
Porquinhos dos Kanela Apãñjekra	3012.36	14620681.74	986949.36	50.24	96.35
Portal do Encantado	430.20	1213944.82	124769.72	31.09	31.39
Porto Limoeiro	49.96	853078.39	4060.68	171.55	175.00
Porto Praia	47.67	708132.41	1175.20	148.76	175.00
Poyanawa	244.92	4113917.06	274820.32	179.69	172.05
Praia do Índio <sup>(1)</sup>	0.32	5832.55	-	-	-
Praia do Mangue <sup>(1)</sup>	0.32	5199.77	-	-	-
Prosperidade	55.73	899360.96	454.73	161.61	58.68
Raimundão	42.77	316830.52	150570.55	98.46	142.22
Raposa Serra do Sol	17376.22	86985663.25	970953.48	50.27	131.38
Recreio/São Félix	2.39	540.24	16747.53	36.61	74.74
Rio Apaporis	1070.44	19633137.55	93399.45	184.34	173.08
Rio Biá	11856.38	215686036.83	508959.58	182.36	176.85
Rio Branco	2363.20	39642059.15	516565.49	169.93	170.17

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )*	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Rio Formoso	200.90	975316.46	71863.17	51.67	59.17
Rio Gregório	2800.27	40001995.32	422784.75	144.83	110.19
Rio Guaporé	1159.75	17476518.44	334328.49	153.68	148.34
Rio Jumas	94.77	1691211.26	33068.74	182.09	174.81
Rio Manicoré	193.34	3519204.43	14799.21	182.93	154.33
Rio Mequens	1077.73	16905793.73	641119.16	162.77	163.93
Rio Negro Ocaia	3401.02	56811229.87	614238.55	168.80	173.07
Rio Omerê	261.58	3316566.98	665625.65	152.52	150.81
Rio Paru DEste	11943.69	221547380.10	201089.74	185.67	179.11
Rio Pindaré	152.66	366923.81	1367970.03	58.10	152.82
Rio Téa	4111.30	71613353.52	128842.89	174.57	142.63
Rio Urubu	275.62	3903126.78	649361.53	165.75	161.78
Riozinho do Alto Envira	2600.74	27475572.33	24206.39	105.74	100.85
Rodeador	23.24	147133.84	64559.51	77.86	148.67
Roosevelt	2297.15	37257026.64	847043.23	165.76	171.29
Sagarana	181.86	1413787.61	224486.44	83.65	174.73
Sai-Cinza	1249.54	20462484.31	336246.16	166.28	177.64
Sangradouro/Volta Grande	1024.59	4940304.59	73264.37	49.30	32.61
Santa Cruz da Nova Aliança	59.71	1025138.98	58422.89	181.24	185.32
Santa Inez	301.54	4051953.55	26853.15	135.81	84.44
Santana	358.48	2039701.67	54327.21	57.97	81.88
São Domingos - MT	63.45	216468.61	135288.95	70.20	41.48
São Domingos do Jacapari e Estação	1347.80	22384598.72	87771.20	166.70	176.19
São Francisco do Canimari	14.68	246994.31	26232.23	186.19	185.93
São Leopoldo	724.06	12416463.75	176669.21	174.06	164.96
São Marcos - MT	1742.11	7684865.98	192122.12	44.81	70.71
São Marcos - RR	6509.39	30812345.55	808838.05	47.71	156.16
São Pedro	6.15	86958.80	19287.48	173.99	166.79
São Pedro do Sepatini	276.01	5091039.23	15217.60	185.02	177.50
São Sebastião	601.53	10697466.86	107487.14	179.62	180.56
Sapotal	12.65	188436.60	4091.03	158.00	56.32
Sararé	84.01	305484.26	41403.49	37.63	146.05
Sarauá	185.85	2485129.35	942029.10	184.32	184.61
Sepoti	2514.08	44995094.90	57560.42	179.19	185.67
Serra da Moça	113.60	324804.37	15008.72	28.87	135.44
Serra Morena	1477.38	23537353.59	135168.41	160.25	157.09
Seruini/Mariene	1448.83	25479822.11	37324.75	176.12	180.85
Sete de Setembro	2490.10	40399503.73	952184.06	166.10	164.56
Setemã	492.53	9016617.90	81622.20	184.79	177.16

Table S7 (Continued)

Indigenous land**	Total area (km <sup>2</sup> )***	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Sissáima	87.72	1101592.33	527901.31	186.00	185.25
Sororó	260.94	4619782.93	256741.25	186.89	186.79
Sucuba	59.77	187747.87	9429.89	31.77	140.04
Sururuá	361.50	6268378.69	96360.24	176.06	176.26
Tabalascada	130.02	625407.61	364564.72	59.02	151.53
Tabocal	9.05	133245.03	30995.37	185.53	165.73
Tadarimana	95.43	1248264.40	82852.99	139.51	139.19
Taego Áwa	290.89	851829.64	359389.91	42.33	40.08
Taihantesu	52.62	350149.48	59720.57	72.20	144.62
Tanaru	80.70	1118632.77	110374.58	152.35	151.67
Tapirapé/Karajá	660.74	5528494.21	151029.71	86.05	82.70
Tembé	10.67	104319.49	93080.31	185.06	185.06
Tenharim do Igarapé Preto	857.42	10872522.33	153567.64	128.29	155.07
Tenharim Marmelos	4983.70	59194114.10	387587.65	119.28	183.00
Tenharim Marmelos (Gleba B)	4749.49	83594032.19	364866.45	176.75	183.44
Terena Gleba Iriri	303.76	4834283.79	132273.45	163.51	163.02
Tereza Cristina	290.07	2188760.13	24814.77	76.33	74.92
Tikúna de Feijoal	414.97	6962877.44	310879.83	175.24	176.26
Tikuna de Santo Antônio	10.66	14702.55	167706.67	154.60	172.67
Tirecatinga	1304.79	4395974.54	30606.40	34.08	20.62
Torá	506.23	8458227.04	9603.85	167.36	116.44
Trincheira	17.42	274326.57	39113.47	180.61	175.64
Trincheira Bacaja	16546.41	298913351.46	1344927.72	181.45	185.77
Trocará	216.34	3757600.55	206319.66	184.85	157.99
Trocará - Doação	0.14	2624.66	0.00	186.89	-
Trombetas/Mapuera	39700.78	738621212.94	454493.50	186.16	181.42
Truaru	60.04	263823.11	33460.37	46.25	111.71
Tubarão Latunde	1167.47	14563889.44	280763.08	126.78	149.76
Tukuna Porto Espiritual	29.65	460014.76	62604.81	176.26	176.26
Tukuna Umariçu	48.55	610717.31	235291.20	174.48	173.70
Tumiã	1242.40	22973857.66	104291.46	185.77	182.63
Tupã-Supé	85.85	1586285.14	6526.07	186.46	83.58
Turé/Mariquita	1.49	16622.98	11092.79	186.44	186.45
Turé/Mariquita II	6.03	76535.26	35662.32	186.25	186.10
Tuwa Apekuokawera	117.57	95696.46	2085030.66	186.22	185.45
Uaçá	4700.98	57412402.59	1077197.76	123.72	178.03
Uati-Paraná	1292.08	22919365.54	208380.73	179.01	177.59
Ubawawe	519.13	2008449.90	213793.08	43.88	34.81
Uirapuru	216.65	288576.06	122318.32	19.84	17.17

**Table S7** (Continued)

Indigenous land**	Total area (km <sup>2</sup> )***	Remaining carbon stock in 2014	Carbon loss through 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Umutina	276.09	3225733.15	183804.22	122.70	139.26
Uneiuxi	9532.35	156268205.27	101251.28	164.04	171.31
Urubu Branco	1676.67	12818558.03	3843141.77	94.15	121.96
Urucu/Juruá	127.51	1447534.15	427988.29	145.53	152.65
Uru-Eu-Wau-Wau	18695.84	251970102.68	2702585.79	135.96	165.22
Utaria Wyhyna/Iròdu Iràna	1775.78	8961094.83	45543.71	50.75	45.82
Utiariti	4097.97	11141108.98	210443.55	27.91	19.80
Vale do Guaporé	2406.66	28941944.51	1770227.97	126.68	145.11
Vale do Javari	85325.55	1501374929.43	3905967.87	176.45	164.58
Vista Alegre	131.74	1943107.86	243038.51	165.93	166.04
Vui-Uata-In	1215.82	22197466.83	336694.26	185.60	169.63
Waiãpi	6045.25	112584340.61	375794.93	186.86	186.87
Waimiri-Atroari	25897.17	475522375.98	527644.29	183.83	174.48
WaiWái	4042.78	69077217.36	610617.99	172.35	174.93
Wawi	1500.34	19083675.98	1310819.74	135.40	144.24
Wedezé	1460.02	3824387.35	522888.05	29.53	31.70
Xambioá	33.38	438518.49	102728.59	162.27	161.51
Xerente	1713.86	6703015.50	241289.98	40.80	33.99
Xikrin do Rio Catete	4360.37	72388527.58	1045713.58	168.43	166.92
Xipaya	1785.46	30895344.72	21156.94	173.16	164.59
Yanomami	94873.78	1697967048.02	4329117.53	179.43	176.54
Zoe	6688.06	122964197.37	85250.95	183.98	185.89
Zoró	3546.15	56165249.96	2965300.39	166.81	165.58
Zuruahã	2381.22	43539205.75	228613.93	183.80	184.95

\* Carbon estimates (both stock and loss) refer to the vegetation remaining in 2014 and to the original vegetation cleared through 2014, respectively, without considering post-clearing recovery of secondary vegetation. The estimates of carbon loss and the stock in the remaining vegetation in 2014 may, in certain protected areas, be affected by the overlapping of classes (e.g., watercourses, forest, non-forest and deforestation), which differ between the carbon map (Nogueira et al. 2015) and the maps of the Project for Monitoring Deforestation in Amazonia (PRODES) and the Project for Monitoring Deforestation of the Brazilian Biomes by Satellite (PMDBBS) (Brazil, IBAMA 2015; Brazil, INPE 2016) (see Table S1).

\*\* Name and geographical information for each Indigenous land were obtained from Brazil, FUNAI (2015).

\*\*\* Total area in each Indigenous land was calculated from vector map available from Brazil, FUNAI (2015). For some indigenous lands the total area calculated from the vector maps may differ from the total area given in other official documents.

<sup>(1)</sup> Carbon values refer to original carbon stock without any carbon loss due to clearing.

## References

- Brazil, IBAMA (2015) Projeto de Monitoramento do Desmatamento dos Biomas Brasileiros por Satélite – PMDBBS: Cerrado, Monitoramento do Bioma Cerrado 2009-2010. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Ministério do Meio Ambiente, Brasília, DF, Brazil. [http://siscom.ibama.gov.br/monitora\\_biomass/PMDBBS%20-%20CERRADO.html](http://siscom.ibama.gov.br/monitora_biomass/PMDBBS%20-%20CERRADO.html). Accessed 12 July 2015
- Brazil, INPE (2016) Projeto de Monitoramento do Desmatamento na Amazônia Legal (PRODES). Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, São Paulo, Brazil. <http://www.dpi.inpe.br/prodesdigital/prodes.php>. Accessed 1 March 2016
- Brazil, FUNAI (2015) Download de dados geográficos. Terra Indígena (Regularizada, Homologada, Declarada, Delimitada e Área em Estudo). Fundação Nacional do Índio (FUNAI), Brasília, DF, Brazil. <http://www.funai.gov.br/index.php/shape>. Accessed 24 April 2015
- Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biology* 21(3): 1271–1292. doi:10.1111/gcb.12798.

**Table S8.** Carbon estimates in conservation units (federal, state and municipality) that were analyzed in present study in Brazil's Legal Amazonia and Amazonia biome regions.\*

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Área de Proteção Ambiental Xeriuni	MSU	16691.30	241008322.66	208964.68	144.51	149.74
Área de Proteção Ambiental - Baixo Rio Branco	SSU	15647.30	229141796.09	256631.07	146.58	171.78
Área de Proteção Ambiental da Chapada dos Guimarães	SSU	2534.38	7130288.03	6806300.69	54.02	56.05
Área de Proteção Ambiental da Fazendinha	SSU	1.49	22339.57	298.12	152.42	152.42
Área de Proteção Ambiental da Ilha do Combu	SSU	15.03	249901.98	628.18	166.70	175.00
Área de Proteção Ambiental da Região do Maracanã	SSU	21.90	69103.32	294833.89	167.88	165.77
Área de Proteção Ambiental da Região Metropolitana de Belém	SSU	57.43	419031.91	604461.64	173.00	182.00
Área de Proteção Ambiental das Cabeceiras do Rio Cuiabá	SSU	4732.13	7789060.10	3442298.53	23.29	24.81
Área de Proteção Ambiental das Nascentes de Araguaína	SSU	155.97	534050.58	142970.23	45.46	37.15
Área de Proteção Ambiental das Reentrâncias Maranhenses	SSU	13235.77	40549480.36	105381363.23	62.00	157.39
Área de Proteção Ambiental de Algodual-Maiandeuá	SSU	24.58	299363.40	15716.28	127.45	144.19
Área de Proteção Ambiental de Presidente Figueiredo - Caverna do Moroaga	SSU	4085.57	68526137.01	6997598.38	184.92	184.26
Área de Proteção Ambiental de São Geraldo do Araguaia	SSU	267.03	1192435.74	2290520.51	94.29	162.95
Área de Proteção Ambiental do Arquipélago do Marajó	SSU	45244.26	514783312.36	24301260.19	117.45	171.72
Área de Proteção Ambiental do Igarapé Gelado	FSU	232.83	2458685.94	1597135.81	177.32	169.61
Área de Proteção Ambiental do Itapiracó	SSU	3.55	32021.95	27633.85	167.89	167.89
Área de Proteção Ambiental do Lago de Tucuruí	SSU	5682.07	31217284.32	30323781.58	79.30	173.75
Área de Proteção Ambiental do Rio Curiaú	SSU	218.73	834918.73	124873.23	41.06	81.08
Área de Proteção Ambiental do Rio Madeira	SSU	67.58	214466.71	519370.31	66.06	147.91
Área de Proteção Ambiental do Salto Magessi	SSU	78.45	297555.45	91164.43	47.83	56.15



**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Área de Proteção Ambiental do Tapajós	FSU	20403.33	346828414.28	13757461.10	177.28	163.93
Área de Proteção Ambiental Foz do Rio Santa Tereza	SSU	501.43	991026.49	796600.50	39.91	31.47
Área de Proteção Ambiental Igarapé São Francisco	SSU	300.19	1110389.24	3145749.82	120.69	151.10
Área de Proteção Ambiental Ilha do Bananal/Cantão	SSU	15700.08	39941505.33	24328300.13	43.85	36.90
Área de Proteção Ambiental Jalapão	SSU	1349.50	1544517.57	16089.80	11.53	15.40
Área de Proteção Ambiental Lago de Palmas	SSU	638.59	736548.13	959363.38	25.40	27.52
Área de Proteção Ambiental Lago de Peixe/Angical	SSU	754.51	1844587.33	387908.32	29.32	30.95
Área de Proteção Ambiental Lago de Santa Isabel	SSU	185.85	369368.10	1768146.83	55.69	147.93
Área de Proteção Ambiental Lago de São Salvador do Tocantins, Paranã e Palmeirópolis	SSU	84.64	180211.02	143400.57	42.37	34.05
Área de Proteção Ambiental Lago do Amapá	SSU	51.77	293477.79	614286.26	172.91	176.55
Área de Proteção Ambiental Margem Direita do Rio Negro-Setor Paduari-Solimões	SSU	4617.37	71575134.43	11902667.52	181.56	176.30
Área de Proteção Ambiental Margem Esquerda do Rio Negro-Setor Aturiá-Apuauzinho	SSU	5683.22	100775166.09	2435765.34	181.78	174.67
Área de Proteção Ambiental Margem Esquerda do Rio Negro-Setor Tarumã Açú-Tarumã Mirim	SSU	559.36	8260338.41	1933751.34	183.69	176.33
Área de Proteção Ambiental Meandros do Araguaia	FSU	3087.42	8984764.13	569906.52	31.70	22.51
Área de Proteção Ambiental Municipal do Aricá-Açu	MSU	754.45	1285948.46	1538720.26	40.64	35.13
Área de Proteção Ambiental Nascentes do Rio Paraguai	SSU	708.57	1665246.31	1061915.64	39.98	36.36
Área de Proteção Ambiental Nhamundá	SSU	2015.97	1398923.73	547334.71	7.08	138.92
Área de Proteção Ambiental Parque Linear do Bindá <sup>(1)</sup>	MSU	0.06	-	-	-	-
Área de Proteção Ambiental Paytuna	SSU	560.73	534737.55	810726.81	12.74	57.48

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Área de Proteção Ambiental Serra da Tabatinga	FSU	401.64	560773.20	884537.36	38.44	34.58
Área de Proteção Ambiental Serra do Lajeado	SSU	1118.83	4175018.37	976469.16	47.97	39.29
Área de Proteção Ambiental Tarumã/Ponta Negra	MSU	226.32	1736124.96	1933334.29	152.88	171.45
Área de Proteção Ambiental Triunfo do Xingu	SSU	16784.64	206264573.38	78813841.77	168.90	172.38
Área de Relevante Interesse Ecológico Japiim Pentecoste	SSU	256.54	4321369.95	132958.73	173.51	177.49
Área de Relevante Interesse Ecológico Javari Buriti	FSU	131.77	2304092.77	0.00	174.86	-
Área de Relevante Interesse Ecológico Museu Parque Seringal <sup>(2)</sup>	MSU	0.01	228.43	-	-	-
Área de Relevante Interesse Ecológico Parque Ambiental Antônio Danúbio Lourenço da Silva <sup>(2)</sup>	MSU	0.04	693.43	-	-	-
Área de Relevante Interesse Ecológico Projeto Dinâmica Biológica de Fragmentos Florestais	FSU	31.80	467238.29	124406.07	186.25	185.31
Área de Relevante Interesse Ecológico Seringal Nova Esperança	FSU	25.74	271188.06	208808.14	186.48	186.48
Estação Ecológica Alto Maués	FSP	6667.72	124137759.60	44564.88	186.24	185.17
Estação Ecológica da Serra das Araras	FSP	271.59	1748344.70	11573.53	65.71	20.88
Estação Ecológica da Terra do Meio	FSP	33731.31	556461028.80	7979765.24	167.34	166.82
Estação Ecológica de Caracaraí	FSP	867.98	15381795.54	316725.94	180.90	179.02
Estação Ecológica de Cuniã	FSP	1853.78	27926635.28	193880.87	151.58	169.33
Estação Ecológica de Iquê	FSP	2159.73	22404299.86	421810.14	105.15	145.45
Estação Ecológica de Jutaf- Solimões	FSP	2895.14	51964662.21	189189.06	180.14	180.15
Estação Ecológica de Maracá	FSP	1035.36	14443978.48	382467.00	143.07	148.33
Estação Ecológica de Maracá Jipioca	FSP	602.53	2385664.29	75212.26	40.22	80.69

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Estação Ecológica de Niquiá	FSP	2847.88	40218268.81	5588.75	141.24	182.87
Estação Ecológica de Taiamã	FSP	115.55	1383718.76	0.00	119.75	-
Estação Ecológica do Grão Pará	SSP	42023.95	767773731.36	253333.37	182.76	185.40
Estação Ecológica do Jari	FSP	2310.85	42775635.28	121262.54	185.68	169.24
Estação Ecológica do Rio Ronuro	SSP	1026.72	14333396.07	536987.07	144.63	150.45
Estação Ecológica do Rio Roosevelt	SSP	979.66	11222520.03	78274.32	115.30	124.19
Estação Ecológica do Sítio Rangedor	SSP	1.26	5284.58	15935.79	167.89	167.89
Estação Ecológica Juami- Japurá	FSP	8315.24	150000340.87	8450.62	180.40	186.48
Estação Ecológica Rio Acre	FSP	777.78	11216830.55	0.00	144.22	-
Estação Ecológica Rio Flor do Prado	SSP	85.37	1468276.22	0.00	171.99	-
Estação Ecológica Samuel	SSP	699.35	10642001.38	553508.52	160.09	159.99
Estação Ecológica Serra dos Três Irmãos	SSP	879.50	14617355.61	1416.49	166.23	91.10
Estação Ecológica Serra Geral do Tocantins	FSP	6294.73	8907351.43	17996.78	14.18	12.22
Floresta Estadual Apuí	SSU	1827.56	27689398.08	18668.00	151.63	131.90
Floresta Estadual Aripuanã	SSU	3287.37	60316231.95	27295.14	183.57	168.54
Floresta Estadual Canutama	SSU	1505.89	26123870.96	39612.70	173.76	162.29
Floresta Estadual de Faro	SSU	6284.29	115557086.42	291177.35	184.41	162.52
Floresta Estadual de Iriri	SSU	4392.39	72113714.86	615379.01	165.58	165.80
Floresta Estadual de Rendimento Sustentado Araras	SSU	10.08	51692.41	119091.55	169.66	169.40
Floresta Estadual de Rendimento Sustentado Cedro	SSU	25.62	334326.47	84400.83	163.14	164.64
Floresta Estadual de Rendimento Sustentado do Rio Machado	SSU	970.98	17418521.75	194665.82	181.34	186.45

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Floresta Estadual de Rendimento Sustentado do Rio Madeira "B"	SSU	526.14	8426277.81	726966.34	174.26	170.62
Floresta Estadual de Rendimento Sustentado Gavião	SSU	4.34	40629.64	34580.79	173.40	173.50
Floresta Estadual de Rendimento Sustentado Mutum	SSU	108.55	716613.62	1103568.46	167.07	168.09
Floresta Estadual de Rendimento Sustentado Periquito	SSU	11.35	48198.59	137008.24	163.40	163.03
Floresta Estadual de Rendimento Sustentado Rio Vermelho (C)	SSU	40.94	497845.70	197242.99	169.87	169.52
Floresta Estadual de Rendimento Sustentado Tucano	SSU	5.11	60661.78	22571.11	162.97	162.97
Floresta Estadual de Tapauá	SSU	8814.22	156302044.92	342173.85	177.73	173.03
Floresta Estadual do Amapá	SSU	23702.34	432409066.87	3742490.74	184.06	178.12
Floresta Estadual do Paru	SSU	36100.62	652597655.22	1178167.99	181.13	164.46
Floresta Estadual do Trombetas	SSU	31435.55	577512572.40	1260427.15	184.12	182.22
Floresta Estadual Manicoré	SSU	834.75	13824663.96	5785.65	165.72	104.81
Floresta Estadual Maúes	SSU	4498.35	78953098.02	2016906.03	180.58	159.77
Floresta Estadual Rio Urubu	SSU	270.52	5026407.37	252.00	185.81	175.03
Floresta Estadual Sucunduri	SSU	4811.02	83865767.83	10409.93	174.34	173.13
Floresta Nacional Altamira	FSU	7255.22	121101992.87	2713206.96	170.75	166.47
Floresta Nacional de Amapá	FSU	4603.58	85587969.26	150761.72	186.25	184.64
Floresta Nacional de Anauá	FSU	2594.01	38003072.75	4412.09	146.52	177.13
Floresta Nacional de Balata- Tufari	FSU	10800.04	189780238.11	963973.65	176.66	168.80
Floresta Nacional de Bom Futuro	FSU	974.31	13474428.52	2212187.55	160.80	162.27
Floresta Nacional de Carajás	FSU	3912.56	67492659.62	1101630.31	175.27	178.09

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Floresta Nacional de Caxiuanã	FSU	3179.47	58255646.41	246901.90	184.13	158.60
Floresta Nacional de Humaitá	FSU	4731.61	84108961.44	122924.58	178.01	185.54
Floresta Nacional de Itacaiunas	FSU	1366.99	21753584.59	3780279.62	186.85	186.44
Floresta Nacional de Itaituba I	FSU	2128.69	38036994.97	116885.09	179.23	179.79
Floresta Nacional de Itaituba II	FSU	3977.45	69947964.80	1283620.32	179.22	171.96
Floresta Nacional de Jacundá	FSU	2212.00	37902603.53	633612.10	174.22	173.90
Floresta Nacional de Jatuarana	FSU	5696.51	102605816.82	230897.74	180.52	180.98
Floresta Nacional de Macauã	FSU	1763.58	18534039.60	25335.06	105.24	101.55
Floresta Nacional de Mapiá-Inauini	FSU	3689.49	65350540.21	92228.96	177.38	173.63
Floresta Nacional de Mulata	FSU	2163.21	30961091.33	46903.65	143.33	153.75
Floresta Nacional de Pau-Rosa	FSU	9846.81	181373056.29	683267.54	184.93	173.88
Floresta Nacional de Purus	FSU	2561.24	47143051.55	428908.27	185.76	183.29
Floresta Nacional de Roraima	FSU	1696.27	29188100.74	339554.02	174.34	153.59
Floresta Nacional de Santa Rosa do Purus	FSU	2315.38	26905438.41	402234.68	118.00	114.24
Floresta Nacional de São Francisco	FSU	211.48	2306795.21	16213.46	109.71	133.34
Floresta Nacional de Saracá-Taquera	FSU	4412.84	78164397.09	3085714.11	184.21	181.97
Floresta Nacional de Tapajós	FSU	5306.22	93631794.26	4768426.33	185.52	184.03
Floresta Nacional de Tapirapé-Aquiri	FSU	1965.03	36317117.99	407245.19	186.89	186.88
Floresta Nacional de Tefé	FSU	8651.22	156100462.55	1736030.69	182.82	154.07
Floresta Nacional do Amaná	FSU	5426.61	99651813.09	781548.64	185.10	181.49
Floresta Nacional do Amazonas	FSU	19415.81	353455174.74	515046.00	182.32	178.02
Floresta Nacional do Crepori	FSU	7403.96	136367099.63	515929.99	184.88	185.01

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Floresta Nacional do Iquiri	FSU	14726.00	263750208.60	1772888.22	180.30	182.07
Floresta Nacional do Jamanxim	FSU	13015.55	193541122.97	23595349.34	167.01	165.36
Floresta Nacional do Jamari	FSU	2221.49	35082615.96	1213740.34	163.59	157.79
Floresta Nacional do Trairão	FSU	2575.29	45427366.06	610388.82	178.74	180.62
Monumento Natural Canyons e Corredeiras do Rio Sono	MSP	14.58	15969.70	30.34	10.98	9.42
Monumento Natural das Árvores Fossilizadas	SSP	292.45	1260314.73	97458.88	45.58	61.05
Monumento Natural Morro de Santo Antônio	SSP	2.58	8519.16	0.00	32.99	-
Parque Estadual Águas do Cuiabá	SSP	109.62	234246.78	1965.76	21.58	18.63
Parque Estadual Chandless	SSP	6939.23	80532667.77	35794.30	116.10	121.78
Parque Estadual Charapucu	SSP	653.49	11421881.41	0.00	174.78	-
Parque Estadual Cristalino	SSP	590.20	9945748.26	624816.39	180.11	164.47
Parque Estadual da Serra dos Martírios/Andorinhas	SSP	250.32	891234.03	145380.49	37.51	114.30
Parque Estadual de Águas Quentes	SSP	15.07	130542.71	70831.00	138.67	125.28
Parque Estadual de Corumbiara	SSP	4298.29	28147094.94	1447985.61	66.83	166.88
Parque Estadual de Guajará- Mirim	SSP	2000.87	27476993.54	100935.73	137.75	163.18
Parque Estadual de Monte Alegre	SSP	56.43	54348.83	11436.04	11.41	12.99
Parque Estadual do Araguaia	SSP	2299.19	7506969.76	211364.13	33.30	47.01
Parque Estadual do Bacanga	SSP	26.23	280832.85	110585.88	157.09	132.45
Parque Estadual do Cantão	SSP	1004.12	10310884.62	147790.47	109.24	24.55
Parque Estadual do Guirá	SSP	1046.38	2533545.55	0.00	24.21	-
Parque Estadual do Jalapão	SSP	1589.71	1997056.55	5048.46	12.59	13.11
Parque Estadual do Lajeado	SSP	107.50	371860.71	34255.51	38.29	33.00

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Parque Estadual do Matupiri	SSP	5095.99	88299793.64	49768.17	173.38	163.83
Parque Estadual do Utinga	SSP	11.92	82065.56	72312.83	112.34	156.59
Parque Estadual do Xingu	SSP	953.30	7202650.89	0.00	75.56	-
Parque Estadual Dom Osório Stoffel	SSP	64.21	439498.56	193801.56	98.28	99.44
Parque Estadual Encontro das Águas	SSP	1081.07	7329284.14	18769.68	67.88	134.86
Parque Estadual Guariba	SSP	711.00	7823296.13	1815.50	110.05	186.89
Parque Estadual Igarapés do Juruena	SSP	2238.16	36670247.11	282221.58	165.04	173.95
Parque Estadual Mãe Bonifácia <sup>(2)</sup>	SSP	0.77	2 547.21	-	-	-
Parque Estadual Rio Negro Setor Norte	SSP	1481.16	25577483.40	81493.56	173.52	114.49
Parque Estadual Rio Negro Setor Sul	SSP	1555.03	28057077.66	316199.45	183.11	138.81
Parque Estadual Serra Azul	SSP	110.07	280683.21	3473.44	25.90	20.39
Parque Estadual Serra do Aracá	SSP	18724.51	336773940.54	586817.13	180.17	178.80
Parque Estadual Serra dos Reis	SSP	363.06	5983412.53	362809.43	174.83	174.32
Parque Estadual Serra Ricardo Franco	SSP	1576.38	9042384.00	4838718.54	75.47	127.94
Parque Estadual Serra Santa Bárbara	SSP	1204.32	2947068.18	243580.48	25.37	57.13
Parque Estadual Sucunduri	SSP	7961.89	126886269.07	66193.04	159.45	155.97
Parque Estadual Sumaúma <sup>(1)</sup>	SSP	0.53	-	-	-	-
Parque Estadual Tucumã	SSP	810.14	12868658.08	76434.05	160.00	130.14
Parque Estadual Zé Bolo Flô <sup>(2)</sup>	SSP	0.52	3 026.29	-	-	-
Parque Nacional da Amazônia	FSP	10662.72	197282461.13	835908.66	185.81	185.54
Parque Nacional da Chapada das Mesas	FSP	1599.52	3364746.61	94299.09	21.33	42.64
Parque Nacional da Chapada dos Guimarães	FSP	326.47	1115405.43	433700.59	45.66	52.78

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Parque Nacional da Serra da Cutia	FSP	2834.99	43139350.88	46629.65	152.32	162.24
Parque Nacional da Serra do Divisor	FSP	8369.38	134865952.55	2810550.65	164.52	163.58
Parque Nacional da Serra do Pardo	FSP	4453.95	62702665.53	4276562.49	149.54	163.97
Parque Nacional das Nascentes do Rio Parnaíba	FSP	4914.34	10866604.49	23352.30	22.17	18.08
Parque Nacional de Anavilhanas	FSP	3397.36	34199570.26	66701.33	100.98	63.92
Parque Nacional de Pacaás Novos	FSP	7086.70	90297652.47	139115.84	127.57	160.55
Parque Nacional do Araguaia	FSP	5554.84	31855001.91	473812.32	57.88	92.08
Parque Nacional do Cabo Orange	FSP	5724.25	33789475.43	152482.79	59.13	155.26
Parque Nacional do Jamaxim	FSP	8598.01	146391035.67	2845290.87	173.65	169.74
Parque Nacional do Jaú	FSP	23673.40	409190314.43	539157.25	173.14	135.57
Parque Nacional do Juruena	FSP	19565.75	286906128.36	1655069.12	147.43	157.33
Parque Nacional do Monte Roraima	FSP	1163.80	17793104.03	28531.77	153.16	140.23
Parque Nacional do Pantanal Matogrossense	FSP	1358.06	9431395.09	0.00	69.45	-
Parque Nacional do Pico da Neblina	FSP	22505.17	391331368.54	1103976.35	174.40	165.25
Parque Nacional do Rio Novo	FSP	5381.08	87205461.21	1536216.75	164.79	172.17
Parque Nacional dos Campos Amazônicos	FSP	9613.15	134658102.94	771459.24	140.80	157.09
Parque Nacional Matinguari	FSP	17769.24	261125456.87	1957962.87	147.99	156.69
Parque Nacional Montanhas do Tumucumaque	FSP	38606.25	719013006.74	767409.97	186.44	185.91
Parque Nacional Nascentes do Lago Jari	FSP	8127.48	147790662.12	420477.65	182.35	185.59
Parque Nacional Serra da Mocidade	FSP	3593.81	57281985.59	1621.29	159.39	173.17
Parque Nacional Viruá	FSP	2149.53	26122887.09	2990.14	121.54	167.48
Parque Natural Municipal do Cancão	MSP	3.71	44935.57	21677.26	177.00	185.59



**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Refúgio de Vida Silvestre Corixão da Mata Azul	SSP	357.08	552146.80	54857.72	16.99	17.12
Refúgio de Vida Silvestre Metrópole da Amazônia	SSP	63.69	898634.06	202845.56	171.30	180.57
Reserva Biológica Culuene	SSP	36.14	110199.23	75987.36	97.19	30.64
Reserva Biológica de Maicuru	SSP	11732.28	217412609.76	1051175.88	186.21	186.45
Reserva Biológica do Abufari	FSP	2238.57	33799206.94	64789.34	151.25	168.19
Reserva Biológica do Guaporé	FSP	6156.34	67122242.99	299316.51	109.36	159.64
Reserva Biológica do Gurupi	FSP	2711.87	36059167.52	14418409.24	186.42	185.42
Reserva Biológica do Jaru	FSP	3468.60	55031530.44	1618344.81	163.31	163.76
Reserva Biológica do Lago Piratuba	FSP	3924.68	21396905.74	142895.86	54.71	103.74
Reserva Biológica do Rio Trombetas	FSP	4077.55	70474123.36	313359.30	173.65	164.58
Reserva Biológica do Tapirapé	FSP	992.72	18425410.33	127486.52	186.89	186.89
Reserva Biológica do Uatumã	FSP	9386.03	168757556.54	40227.84	179.84	186.08
Reserva Biológica Morro dos Seis Lagos	SSP	382.88	6983378.69	155611.71	186.45	186.80
Reserva Biológica Nascentes Serra do Cachimbo	FSP	3421.91	39039993.95	4528277.56	123.73	169.75
Reserva Biológica Rio Ouro Preto	SSP	547.61	8527856.29	2398.86	155.77	162.97
Reserva Biológica Traçadal	SSP	250.68	3943617.89	2283.91	157.40	176.26
Reserva de Desenvolvimento Sustentável Alcobaça	SSU	224.61	1068326.57	255176.98	53.19	107.33
Reserva de Desenvolvimento Sustentável Amanã	SSU	23034.63	398441715.96	1494404.02	173.73	149.62
Reserva de Desenvolvimento Sustentável Aripuanã	SSU	2180.95	38231961.28	18482.11	175.41	137.45
Reserva de Desenvolvimento Sustentável Bararati	SSU	1108.12	18711893.74	50597.96	169.30	177.10
Reserva de Desenvolvimento Sustentável Canumã	SSU	227.58	3347182.94	383727.74	162.36	179.10
Reserva de Desenvolvimento Sustentável Cujubim	SSU	24219.27	437849715.17	452734.37	180.98	176.12

**Table S8 (Continued)**

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Reserva de Desenvolvimento Sustentável do Juma	SSU	5807.87	102424715.99	1108725.89	178.52	157.76
Reserva de Desenvolvimento Sustentável do Matupiri	SSU	1770.07	31513599.59	765.77	178.05	43.63
Reserva de Desenvolvimento Sustentável do Rio Iratapuru	SSU	8735.65	162731719.37	203902.28	186.52	185.00
Reserva de Desenvolvimento Sustentável do Rio Madeira	SSU	2796.32	45756551.76	1941610.89	171.04	160.30
Reserva de Desenvolvimento Sustentável do Rio Negro	SSU	1029.79	16978816.86	872398.76	175.63	138.33
Reserva de Desenvolvimento Sustentável do Tupé	MSU	121.75	1675144.08	443150.18	179.14	156.91
Reserva de Desenvolvimento Sustentável do Uatumã	SSU	4234.63	69171178.10	951305.76	165.87	147.74
Reserva de Desenvolvimento Sustentável Igapó-Açu	SSU	3946.22	72201427.55	953749.04	185.38	185.66
Reserva de Desenvolvimento Sustentável Itatupã-Baquiá	FSU	644.41	11036546.78	4696.84	171.34	175.00
Reserva de Desenvolvimento Sustentável Mamirauá	SSU	13199.40	215065919.75	29495.09	162.96	162.45
Reserva de Desenvolvimento Sustentável Piagaçu Purus	SSU	8008.71	123645162.78	311568.41	154.78	152.91
Reserva de Desenvolvimento Sustentável Pucuruí - Ararão	SSU	291.65	1043832.10	78080.93	36.91	88.34
Reserva de Desenvolvimento Sustentável Rio Amapá	SSU	2143.16	38236197.50	51954.59	178.64	185.98
Reserva de Desenvolvimento Sustentável Uacarí	SSU	6203.01	109804012.03	837175.51	178.41	172.62
Reserva Extrativista Alto Juruá	FSU	5378.07	66908282.39	2141349.71	128.11	137.71
Reserva Extrativista Alto Tarauacá	FSU	1509.23	21702762.84	605196.66	147.32	167.67
Reserva Extrativista Angelim	SSU	83.84	1243246.47	124596.56	163.04	164.21
Reserva Extrativista Aquariquara	SSU	192.76	3092121.51	271966.79	174.87	170.66
Reserva Extrativista Arapixi	FSU	1337.08	23082733.04	427684.81	176.13	161.26
Reserva Extrativista Arióca Pruanã	FSU	838.17	13327812.99	1704869.02	179.41	178.93
Reserva Extrativista Auatí-Paraná	FSU	1469.49	26020305.79	298928.93	179.09	180.10
Reserva Extrativista Baixo Juruá	FSU	1780.39	31860965.08	441805.57	181.65	167.52

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Reserva Extrativista Barreiro das Antas	FSU	1061.11	17940786.12	10469.34	169.17	174.68
Reserva Extrativista Canutama	SSU	1979.53	33518352.57	185156.61	170.27	167.82
Reserva Extrativista Castanheira	SSU	96.61	1501989.16	73855.26	163.04	164.46
Reserva Extrativista Catuá-Ipixuna	SSU	2123.23	36518136.66	2250566.84	183.41	170.23
Reserva Extrativista Cazumbá-Iracema	FSU	7553.46	81960423.68	1037123.80	109.70	126.14
Reserva Extrativista Chico Mendes	FSU	9312.72	103274116.79	6492564.96	116.93	135.15
Reserva Extrativista Chocoaré-Mato Grosso	FSU	27.83	300129.52	3911.72	109.00	132.24
Reserva Extrativista Curralinho	SSU	16.62	253333.48	12410.76	160.85	142.02
Reserva Extrativista de Cururupu	FSU	1572.35	5830764.79	2410374.22	43.17	108.75
Reserva Extrativista do Ciriáco	FSU	81.07	356954.46	871643.15	149.88	152.25
Reserva Extrativista do Guariba	SSU	1480.84	27360330.39	20985.73	184.91	183.97
Reserva Extrativista do Itaúba	SSU	16.04	252093.24	9477.60	163.00	163.98
Reserva Extrativista do Lago do Capanã Grande	FSU	3043.07	52820587.02	702257.75	176.15	158.05
Reserva Extrativista do Médio Purus	FSU	6042.32	105297471.09	774240.15	175.54	176.55
Reserva Extrativista do Rio Cautário	FSU	751.26	11226638.19	123392.35	151.43	125.04
Reserva Extrativista do Rio Gregório	SSU	3069.96	53994332.52	402518.08	177.22	173.78
Reserva Extrativista do Rio Jutai	FSU	2755.13	48217575.21	260006.11	176.24	135.17
Reserva Extrativista do Rio Unini	FSU	8496.85	123929412.47	160485.31	146.11	109.32
Reserva Extrativista Extremo Norte do Tocantins	FSU	90.70	40550.28	1495622.94	77.55	174.98
Reserva Extrativista Freijó	SSU	6.29	88121.11	14619.82	163.37	164.04
Reserva Extrativista Garrote	SSU	8.66	140951.33	2954.67	166.21	165.16
Reserva Extrativista Guariba-Roosevelt	SSU	1376.78	20414313.68	1137847.42	156.57	155.97

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Reserva Extrativista Gurupá-Melgaço	FSU	1454.16	25824283.63	417166.42	180.49	178.40
Reserva Extrativista Ipaú-Anilzinho	FSU	558.34	6720226.33	3296893.84	178.83	180.60
Reserva Extrativista Ipê	SSU	8.19	107224.94	26455.61	163.00	163.65
Reserva Extrativista Ituxí	FSU	7763.23	135952750.18	284113.13	175.51	168.02
Reserva Extrativista Jaci-Paraná	SSU	2003.20	22451152.12	10269651.72	163.48	163.04
Reserva Extrativista Jatobá	SSU	13.39	160663.53	60273.70	164.56	166.26
Reserva Extrativista Lago do Cuniã	FSU	506.04	6986437.54	27952.55	138.63	134.25
Reserva Extrativista Mae Grande de Curuçá	FSU	335.96	2255473.75	111633.38	69.04	120.72
Reserva Extrativista Mapuá	FSU	937.47	15809893.73	496800.61	174.05	170.62
Reserva Extrativista Maracanã	FSU	291.12	2127369.63	68453.46	74.35	137.43
Reserva Extrativista Maracatiara	SSU	86.60	1286028.43	182697.00	170.05	166.49
Reserva Extrativista Marinha Arai-Peroba	FSU	600.97	4002430.87	637049.29	72.33	133.87
Reserva Extrativista Marinha Caetéperaçu	FSU	408.05	2846214.82	336005.31	74.95	118.71
Reserva Extrativista Marinha Cuinarana	FSU	110.36	1172922.68	159676.46	116.62	163.17
Reserva Extrativista Marinha de Gurupi-Piriá	FSU	693.81	4239732.86	783714.68	68.18	108.93
Reserva Extrativista Marinha de Soure	FSU	295.79	1721784.17	110254.96	59.91	131.00
Reserva Extrativista Marinha Mestre Lucindo	FSU	250.57	1859552.18	121455.12	77.16	127.09
Reserva Extrativista Marinha Mocupajuba	FSU	202.95	1685593.15	240203.98	89.96	154.20
Reserva Extrativista Marinha Tracuateua	FSU	274.84	2232085.10	127398.44	84.02	138.90
Reserva Extrativista Massaranduba	SSU	61.75	917409.72	88927.47	162.98	162.99
Reserva Extrativista Mata Grande	FSU	114.32	121225.44	1591330.06	149.81	149.81
Reserva Extrativista Médio Juruá	FSU	2515.87	44135068.05	424826.37	177.15	173.83

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining carbon per hectare in 2014	Mean carbon loss per hectare
					(in Mg C)	
Reserva Extrativista Mogno	SSU	24.13	378342.46	15288.81	163.12	163.28
Reserva Extrativista Pedras Negras	SSU	1264.74	12718751.49	31791.33	100.72	165.19
Reserva Extrativista Piquiá	SSU	12.79	211272.68	24743.53	184.76	183.22
Reserva Extrativista Quilombo do Frechal <sup>(2)</sup>	FSU	93.38	1419198.73	-	-	-
Reserva Extrativista Renascer	FSU	2096.64	31854327.45	2380740.11	163.42	161.50
Reserva Extrativista Rio Cajari	FSU	5324.00	75332338.93	2136443.45	144.70	180.98
Reserva Extrativista Rio Cautário	SSU	1509.77	21841639.46	814979.93	149.80	157.47
Reserva Extrativista Rio Iriri	FSU	3989.88	61143694.56	1226100.70	156.21	161.94
Reserva Extrativista Rio Ouro Preto	FSU	2046.32	29755917.86	3161176.32	160.26	166.74
Reserva Extrativista Rio Pacaás Novos	SSU	3504.43	59191089.96	367549.19	169.92	174.72
Reserva Extrativista Rio Preto-Jacundá	SSU	1197.67	18595789.83	1264426.95	165.59	169.36
Reserva Extrativista Rio Xingu	FSU	3030.01	45019486.22	595846.46	150.46	157.22
Reserva Extrativista Riozinho da Liberdade	FSU	3249.03	46813193.54	924148.32	146.51	171.77
Reserva Extrativista Riozinho do Anfrísio	FSU	7360.83	122380199.93	613672.46	167.07	171.14
Reserva Extrativista Roxinho	SSU	10.39	154125.76	15322.54	163.07	163.28
Reserva Extrativista São João da Ponta	FSU	34.09	426031.84	25696.86	130.97	164.19
Reserva Extrativista Seringueira	SSU	4.76	70297.69	7364.03	163.19	164.52
Reserva Extrativista Sucupira	SSU	28.18	441690.93	17863.84	162.99	164.84
Reserva Extrativista Tapajós Arapiuins	FSU	6742.07	115546785.37	8859338.94	185.58	171.73
Reserva Extrativista Terra Grande Pracuúba	FSU	1948.64	34156598.13	1044412.24	180.57	183.19
Reserva Extrativista Verde Para Sempre	FSU	12893.12	178775725.20	6993238.69	143.00	178.85

**Table S8** (Continued)

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Reserva Particular do Patrimônio Natural Aurora Natura	FSU	0.15	1913.93	210.68	140.68	140.68
Reserva Particular do Patrimônio Natural Bico do Javaés	FSU	27.62	317822.30	0.00	115.07	-
Reserva Particular do Patrimônio Natural Catedral do Jalapão	FSU	3.26	5590.01	0.00	17.17	-
Reserva Particular do Patrimônio Natural Cristalino I	SSU	24.51	443453.40	14586.16	186.89	186.89
Reserva Particular do Patrimônio Natural Cristalino III	SSU	16.17	298911.44	3365.51	186.89	186.89
Reserva Particular do Patrimônio Natural Fazenda Bosco	FSU	4.87	74531.78	0.00	153.10	-
Reserva Particular do Patrimônio Natural Fazenda Calixto	FSU	3.43	3625.68	0.00	10.56	-
Reserva Particular do Patrimônio Natural Fazenda Loanda	SSU	5.15	35221.11	11449.40	81.54	138.45
Reserva Particular do Patrimônio Natural Gibeão	FSU	0.31	3924.24	1417.45	171.30	168.59
Reserva Particular do Patrimônio Natural Ilhas Alexandre Rodrigues Ferreira	FSU	3.02	49882.82	0.00	164.97	-
Reserva Particular do Patrimônio Natural Irmãos Satelis	FSU	0.41	5504.42	2181.58	186.89	186.89
Reserva Particular do Patrimônio Natural Klagesi	FSU	0.23	3514.85	708.15	185.06	185.06
Reserva Particular do Patrimônio Natural Nova Aurora <sup>(2)</sup>	FSU	0.19	3 111.38	-	-	-
Reserva Particular do Patrimônio Natural Osório Reimão	FSU	0.09	592.76	885.00	143.75	186.05
Reserva Particular do Patrimônio Natural Peugeot-ONF-Brasil	SSU	17.60	320174.28	7409.89	186.32	177.03
Reserva Particular do Patrimônio Natural SESC Tepequém	FSU	0.52	897.40	0.00	17.17	-

**Table S8 (Continued)**

Conservation unit**	Administrative (federal, state or municipal) and protection levels***	Total area (km <sup>2</sup> )****	Remaining carbon stock in 2014	Carbon loss by 2014	Mean	Mean
					remaining carbon per hectare in 2014	carbon loss per hectare
(in Mg C)						
Reserva Particular do Patrimônio Natural Sonhada	FSU	8.87	116154.27	0.00	130.96	-

\* Carbon estimates (both stock and loss) are for the remaining vegetation in 2014 and for the original vegetation cleared through 2014 respectively, without considering post-clearing recovery by secondary vegetation.

The estimates of carbon loss and the stock in the remaining vegetation in 2014 may, in certain protected areas, be affected by the overlapping of classes (*e.g.*, hydrography, forest, non-forest and deforestation), which differ between the carbon map (Nogueira et al. 2015) and the maps of the Project for Monitoring Deforestation in Amazonia (PRODES) and the Project for Monitoring Deforestation of the Brazilian Biomes by Satellite (PMDBBS) (Brazil, IBAMA 2015; Brazil, INPE 2016) (see Table S1).

\*\* Name and geographical information for each conservation unit were obtained from Brazil, MMA (2015).

\*\*\* IL = Indigenous land, MT = Maroon territory, FSP = Federal Strictly Protected conservation unit, FSU = Federal Sustainable-Use conservation unit, SSP = State Strictly Protected conservation unit, SSU = State Sustainable Use conservation unit, MSP = Municipal Strictly Protected conservation unit, MSU = Municipal Sustainable Use conservation unit.

\*\*\*\* Total area in each conservation unit was calculated from vector maps was available from Brazil, MMA (2015). Total areas calculated from vector maps for some conservation units may differ from the areas given in official documents.

<sup>(1)</sup> In these protected areas it was not possible to calculate the amount of carbon stored.

<sup>(2)</sup> Carbon values refer to original carbon stocks without any carbon loss due to clearing. In these protected areas a total loss of original vegetation cover may have occurred.

## References

- Brazil, IBAMA (2015) Projeto de Monitoramento do Desmatamento dos Biomas Brasileiros por Satélite – PMDBBS: Cerrado, Monitoramento do Bioma Cerrado 2009-2010. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Ministério do Meio Ambiente, Brasília, DF, Brazil. [http://siscom.ibama.gov.br/monitora\\_biomass/PMDBBS%20-%20CERRADO.html](http://siscom.ibama.gov.br/monitora_biomass/PMDBBS%20-%20CERRADO.html). Accessed 12 July 2015
- Brazil, INPE (2016) Projeto de Monitoramento do Desmatamento na Amazônia Legal (PRODES). Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, São Paulo, Brazil. <http://www.dpi.inpe.br/prodesdigital/prodes.php>. Accessed 1 March 2016
- Brazil, MMA (2015) Download de dados geográficos, Ministério do Meio Ambiente (MMA), Brasília, DF, Brazil. <http://mapas.mma.gov.br/i3geo/datadownload.htm>. Accessed 17 April 2015
- Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biology* 21(3): 1271–1292. doi:10.1111/gcb.12798.



**Table S9.** Carbon estimates in Maroon territories (*Quilombos*) that were analyzed in the present study in Brazil's Legal Amazonia region.\*

Maroon territory ( <i>Quilombos</i> )**	Total area (km <sup>2</sup> )***	Remaining carbon stock in 2014	Carbon loss by 2014	Mean remaining	Mean carbon
				carbon per hectare in 2014	loss per hectare
(in Mg C)					
Alcantara	779.44	1314023.59	10072519.43	95.81	156.82
Aliança / Santa Joana	76.26	180.33	1126588.54	35.34	147.82
Arapema	38.29	22738.78	0.00	5.94	-
Arquimec	57.91	254988.62	816773.34	185.06	185.06
Bom Jardim	26.52	45160.32	183057.95	29.81	161.02
Cacau e Ovos	35.66	457534.52	41790.79	137.06	183.37
Campina de Pedra	17.81	18456.78	15354.80	19.92	17.96
Conceição do Macacoari	94.06	398606.58	40539.54	44.68	83.40
Cunani	138.84	2 041308.44	57339.79	150.40	184.43
Curiau	31.17	153474.37	39232.31	56.68	95.88
Gleba Jamarly dos Pretos	146.87	863042.84	1789269.16	185.11	178.48
Grotão	20.70	63728.30	4559.17	32.99	32.99
Ipiranga do Carmina	14.24	134775.11	74225.56	146.81	146.81
Lagoinha de Baixo	25.15	32960.34	102543.86	63.27	51.41
Mata Cavalo	147.58	214577.36	272286.60	32.99	32.99
Mata de São Benedito	11.33	12362.17	154038.45	146.81	146.81
Matões Moreira	55.58	503717.73	314899.05	146.88	147.94
Mel da Pedreira	26.32	45195.71	0.00	17.17	-
Monge Belo	56.55	144631.11	715226.68	111.27	164.22
Narcisa	6.19	2992.76	111503.88	185.06	185.06
Pedras Negras	437.17	6073574.52	31791.28	139.54	165.19
Piqui/Santa Maria	55.88	607009.24	232577.32	150.01	150.90
Pitoro dos Pretos	43.06	472634.28	159461.36	146.81	146.81
Quilombola de Jesus	59.71	958542.04	56670.44	169.79	174.18
Rosa	47.52	156943.72	0.00	33.03	-
Santa Maria dos Pinheiros	10.21	20750.17	129212.75	146.81	146.81
Santa Rosa dos Pretos	75.02	274180.77	918909.81	157.95	159.36
Santo Antônio do Guaporé	416.90	1127747.74	11260.17	27.15	71.78
São Francisco Malaquias	10.86	87807.99	28709.96	122.22	78.06
São Judas Tadeu	24.35	90899.81	359636.40	185.06	185.06
São Raimundo da Pirativa	0.23	4380.01	0.00	186.48	-
Saracura	27.94	21205.72	0.00	7.59	-
Tambor	7197.75	131655448.35	164892.82	183.15	178.21

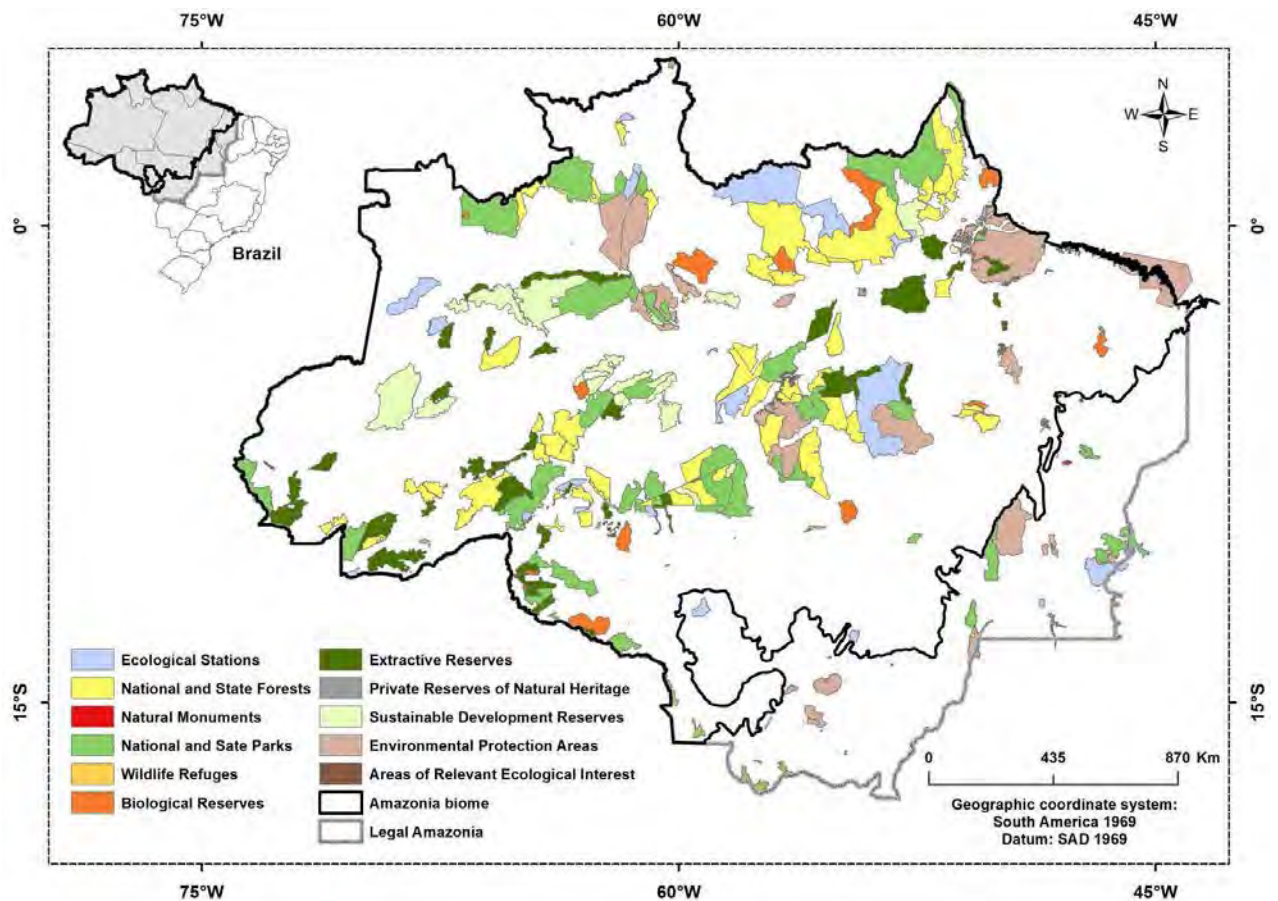
\* Carbon estimates (both stock and loss) refer to the vegetation remaining in 2014 and to the original vegetation cleared by 2014, respectively, without considering post-clearing recovery of secondary vegetation. The estimates of carbon loss and the stock in the remaining vegetation in 2014 may, in certain protected areas, be affected by the overlapping of classes (e.g., hydrography, forest, non-forest and deforestation), which differ between the carbon map (Nogueira et al. 2015) and the maps of the Project for Monitoring Deforestation in Amazonia (PRODES) and the Project for Monitoring Deforestation of the Brazilian Biomes by Satellite (PMDBBS) (Brazil, IBAMA 2015; Brazil, INPE 2016) (see Table S1).

\*\* Name and geographical information for each Maroon territory were obtained from Brazil, INCRA (2015).

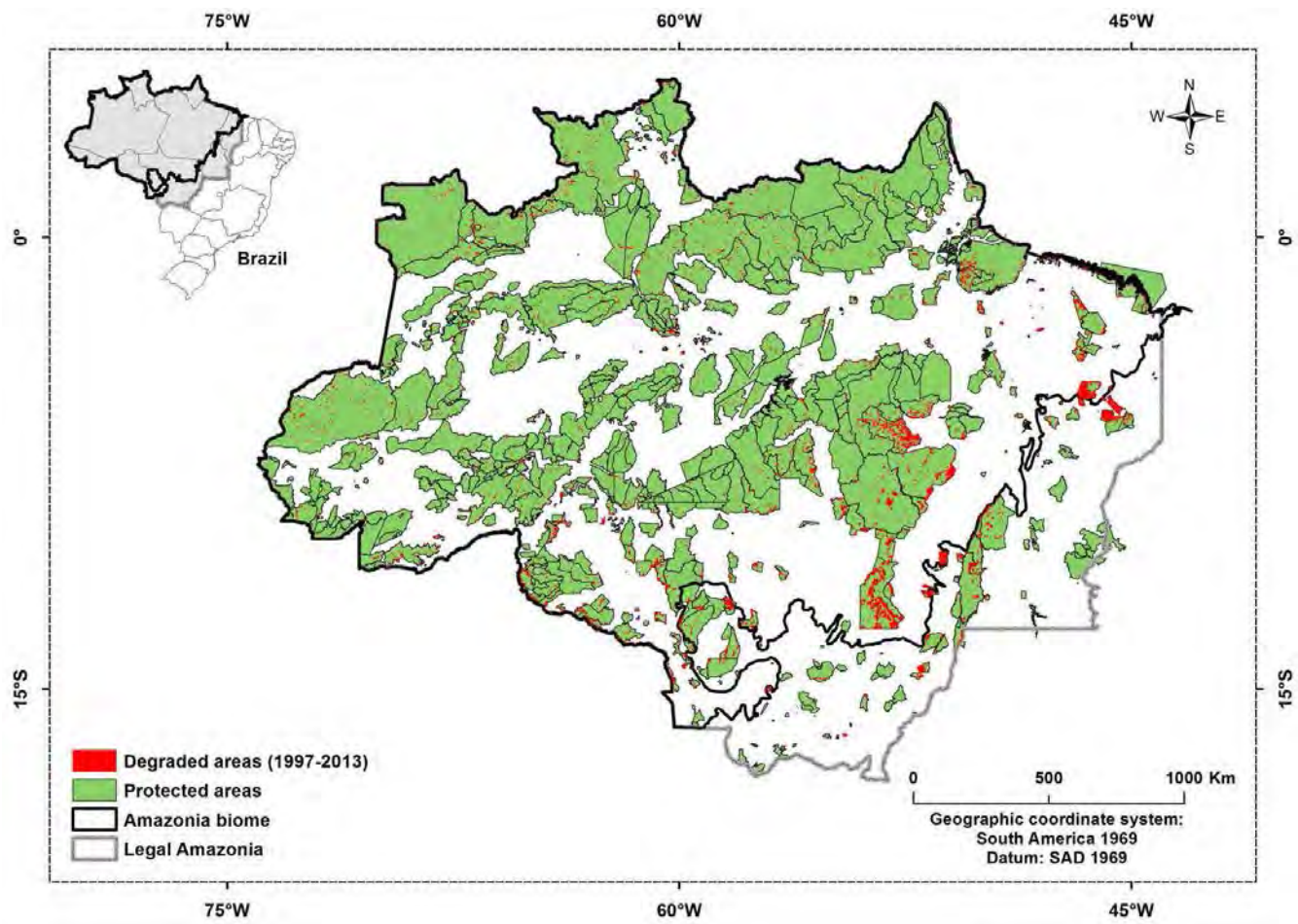
\*\*\* Total area in each Maroon territory was calculated from vector maps available from Brazil, INCRA (2015). Total areas calculated from vector maps for some Maroon territories may differ from the areas given in official documents.

## References

- Brazil, IBAMA (2015) Projeto de Monitoramento do Desmatamento dos Biomas Brasileiros por Satélite – PMDBBS: Cerrado, Monitoramento do Bioma Cerrado 2009-2010. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), Ministério do Meio Ambiente, Brasília, DF, Brazil. [http://siscom.ibama.gov.br/monitora\\_biomass/PMDBBS%20-%20CERRADO.html](http://siscom.ibama.gov.br/monitora_biomass/PMDBBS%20-%20CERRADO.html). Accessed 12 July 2015
- Brazil, INPE (2016) Projeto de Monitoramento do Desmatamento na Amazônia Legal (PRODES). Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, São Paulo, Brazil. <http://www.dpi.inpe.br/prodesdigital/prodes.php>. Accessed 1 March 2016
- Brazil, INCRA (2015) Download de dados geográficos. Instituto Nacional de Colonização e Reforma Agrária (INCRA), Brasília, DF, Brazil. <http://acervofundiario.incra.gov.br/i3geo/datadownload.htm>. Accessed 14 April 2015
- Nogueira EM, Yanai AM, Fonseca FOR, Fearnside PM (2015) Carbon stock loss from deforestation through 2013 in Brazilian Amazonia. *Global Change Biology* 21(3): 1271–1292. doi:10.1111/gcb.12798.



**Fig. S1** Categories of conservation units in Brazil's Legal Amazonia and Amazonia biome regions. In the present study only conservation units that have over 50% of their area inside the boundaries of Legal Amazonia or the Amazonia biome were analyzed.



**Fig. S2** Degraded areas (1997-2013) mapped inside the protected areas analyzed in this study after to excluding areas converted to deforestation by 2014.