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LETTER

Unmasking secondary vegetation dynamics in the Brazilian Amazon

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Abstract

Secondary vegetation (SV) from land abandonment is a common transition phase between agricultural uses following tropical deforestation. The impact of SV on carbon sequestration and habitat fragmentation across tropical forest frontiers therefore depends on SV dynamics and demographics. Here, we used time series of annual MapBiomas land cover data to generate the first estimates of SV extent, age, and net carbon uptake in the Brazilian Amazon between 1985 and 2017. SV increased over time, totaling 12 Mha in 2017, 44% of which was $\leqslant$5 years old. Between 1988 and 2017, 19.6 Mha of SV was cleared, adding 45.5% to the area of primary deforestation detected by the Brazilian monitoring system (PRODES). Rates of SV loss have exceeded PRODES deforestation since 2011. Based on the age and extent of gains and losses, SV was a small net carbon sink during this period (8.9 Tg C yr^{-1}). As SV is not formally protected by national environmental legislation or monitored by PRODES, long-term benefits from SV in the Brazilian Amazon remain uncertain.

1. Introduction

The Brazilian Amazon has lost almost 20% (78 Mha) of its original forests (PRODES/INPE 2018), mainly from deforestation for cattle pasture (Barona *et al* 2010) and agriculture (Sparovek *et al* 2010). However, deforested areas are allowed to regenerate secondary vegetation (SV), either as part of a rotational system to restore soil nutrients (Uhl *et al* 1988, Zarin *et al* 2001) or in response to socioeconomic drivers that alter profitability or the availability of labor, capital, or market access (Laue and Arima 2016, Mukul and Herbohn 2016, Brito *et al* 2019). In the Brazilian Amazon, SV is very dynamic (Nelson *et al* 2000, Vieira *et al* 2014), with cycles of SV growth and re-clearing on decadal time scales. This dynamism complicates efforts to estimate the extent of SV across tropical forest frontiers. However, the potential extent of SV on deforested areas is large. According to official data from the TerraClass project, SV on previously-deforested areas increased from 10 to 17 Mha between 2004 and 2014 (TerraClass 2014), suggesting that 22% of the total deforested area in the Brazilian Amazon by 2014 was in some stage of forest regeneration.

SV may play an important role in climate change mitigation (Chazdon *et al* 2016, Griscom *et al* 2017) and the provision of ecosystem services. Regenerating forests rapidly accumulate carbon in aboveground biomass, with rates of net carbon sequestration up to 20 times higher than old-growth forests (Bongers *et al* 2015). Forest regeneration also increases soil fertility and reduces runoff, soil erosion, and the impact of forest fragmentation on habitat and biodiversity in frontier landscapes (Pereira and Vieira 2001, Feldpausch *et al* 2004, Chazdon *et al* 2009) relative to deforested areas. The benefits of SV accrue over time; thus, the net impact of SV on carbon and other ecosystem services depends on the dynamics and demographics of SV gains and losses.

Four main factors contribute to the growing pressure to deforest SV across the Brazilian Amazon. First, climate change mitigation and other ecosystem services from SV do not have clear economic value to landowners (Vieira *et al* 2014). Second, the Brazilian

Forest Code does not formally protect and regulate land use in areas of regenerating forests. At subnational scales, only Pará State in the Brazilian Amazon has passed regulations governing SV management, including the age at which a regenerating forest can be considered as forest or fallow lands (Vieira *et al* 2014). Third, industry and government efforts to reduce primary deforestation have incentivized the use of existing cleared lands (Britaldo Soares-Filho 2014, Gibbs *et al* 2016), whether or not these areas support SV. Finally, the official deforestation monitoring system for the Brazilian Amazon region, PRODES (PRODES/INPE 2018), along with monitoring systems from independent organizations (e.g. Deforestation Alert System—SAD) ('SAD. ImazonGeo,' n.d.), do not track gains and losses of SV (Assunção and Gandour 2017, Richards *et al* 2017). These satellite-based monitoring systems focus on remaining primary forests (areas never cleared), masking out deforested primary forests (the total removal of vegetation) from further monitoring (Assunção and Gandour 2017, Richards *et al* 2017), even if these areas have high forest cover. Other systems such as the Global Forest Change (GFC) (Hansen *et al* 2013) and TerraClass project (TerraClass 2014) provide information on SV cover, but do not track SV age or separate the contribution from SV to tree cover loss (see supplementary section 3, available online at stacks.iop.org/ERL/15/034057/mmedia). In summary, data gaps on SV prevent a complete accounting of Amazon deforestation, greenhouse gas emissions, and net carbon uptake by SV (Assunção and Gandour 2017; Richards *et al* 2017).

Here, we provide the first assessment of SV—regenerating vegetation on areas that have previously been deforested—extent, age, and dynamics in the Brazilian Amazon, including annual changes in forest cover and forest carbon stocks. Net gains and losses of SV were derived from a new monitoring system for SV dynamics, FloreSer, using MapBiomas land cover data at 30 m resolution from 1985 to 2017. We used the FloreSer maps of annual SV to address three specific questions: (i) What is the annual extent of SV by age class in the Brazilian Amazon? (ii) What are the annual rate of SV loss and the contribution from SV to total deforestation in the Brazilian Amazon? (iii) What is the net carbon balance of SV based on annual gains and losses of SV by age across the Brazilian Amazon? Long time series of satellite data provide essential information on the spatial and temporal patterns of land abandonment to SV and re-clearing needed to quantify a key missing piece of the Amazon forest carbon balance.

2. Methods

2.1. Data

We used annual time series of land use and land cover (LULC) produced by the MapBiomas Collection 3.1 from 1985 to 2017 for the Amazon biome (http://mapbiomas.org). The original LULC classes, obtained with the random forest classifier at 30 m spatial resolution (see the supplementary materials for more detailed information about the LULC classification method), were aggregated into three categories (i) anthropic, consisting of all land use classes with non-native vegetation (e.g. pasture, agriculture, and mosaic classes of agriculture and pasture), with a mean user's accuracy of 85% (table S1); (ii) forest, including all forest formations in MapBiomas, with a mean user's accuracy of 92% (table S1) and (iii) non-forest, including surface water, built-up areas, non-forest vegetation, and clouds. Annual maps of anthropic, forest, and non-forested areas were processed using Google Earth Engine (Gorelick *et al* 2017) (figure S1).

2.2. Mapping of secondary vegetation

We used the time series of annual MapBiomas classification layers to identify SV based on transitions from anthropic to forest classes. All pixels that transitioned from anthropic in year t_i to forest in year t_{i+1} (where, $i = 1, 2, 3\ldots 33$) were reclassified as SV and assigned an age of one-year-old. New cohorts of SV identified based on sequential image pairs were tracked over time. Classes mapped as 'forests' by MapBiomas in 1985 may include both primary and secondary forests, as the previous years were not assessed. Our SV analysis started in 1986, when it was possible to detect transitions from deforestation in 1985 to vegetation in 1986.

2.3. Estimating the age and deforestation of secondary vegetation

For each SV pixel, SV age was estimated based on the number of consecutive years of forest classification following the transition from anthropic land use, up to a maximum of 32 years of age. For SV that returned to anthropic or non-forest cover types, the age at the time of deforestation was used to estimate SV dynamics and associated carbon losses. A pixel may have multiple cycles of SV regrowth and deforestation over the study period; SV age was simply based on the number of consecutive years of forest classification following anthropic land use.

2.4. Carbon modeling

We used a model of carbon accumulation in SV to estimate the net carbon balance of SV based on the extent of SV gains and losses by age. The model was developed using data from the Brazilian Amazon in 1990 (Fearnside 1996). This modeling framework calculates the transition probabilities among land use classes in a Markov Matrix in order to estimate the SV area and carbon stocks. We used a bookkeeping approach to track annual carbon uptake and emissions of SV by age. Therefore, the FloreSer system estimates total annual SV gain and loss by age offering the first

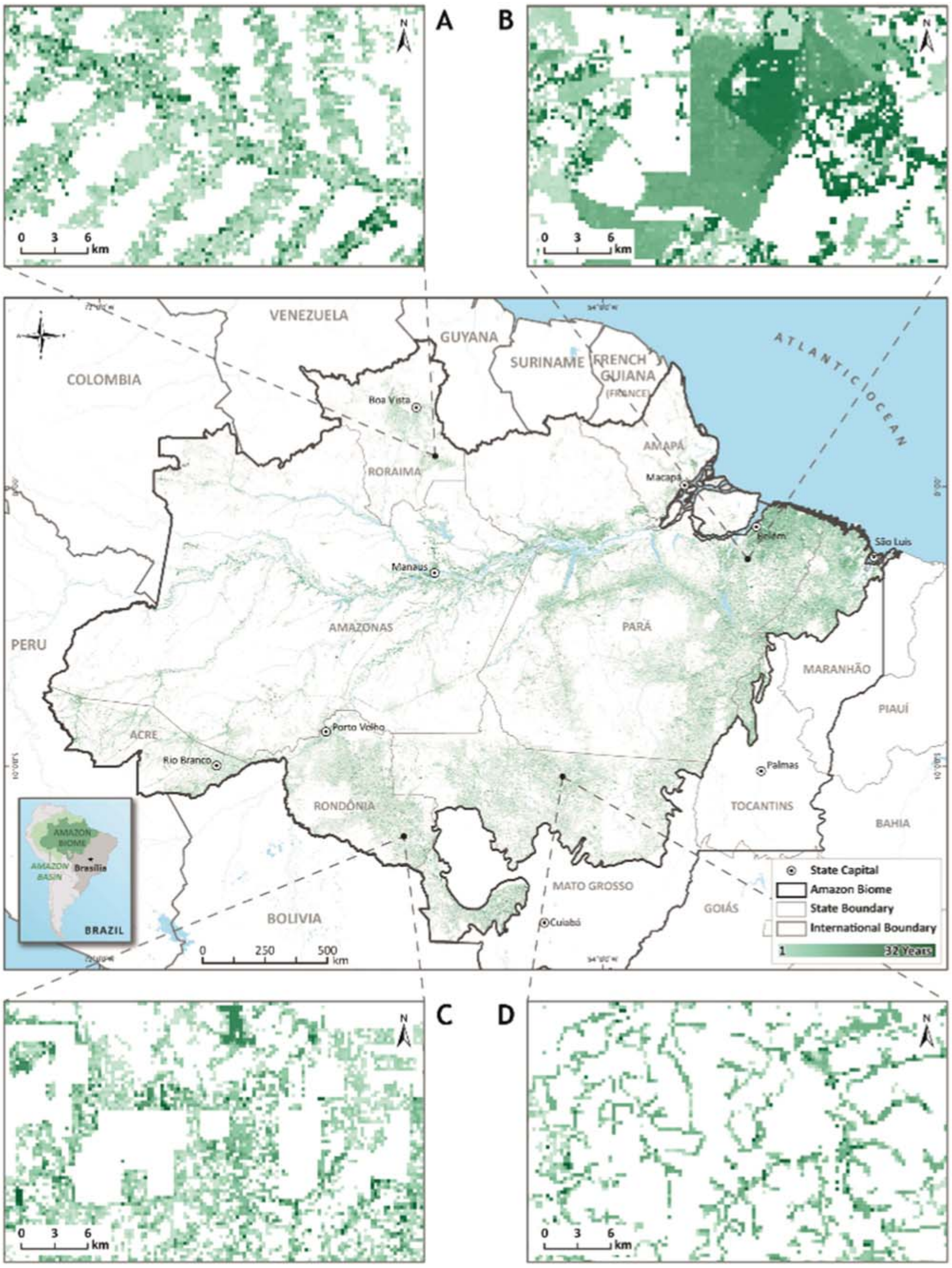

Figure 1. Secondary vegetation distribution across land use frontiers in the Brazilian Amazon in 2017. Zoom panels highlight younger SV regeneration in Roraima State in areas of 'fishbone' deforestation (A), oil palm plantations in Pará (B), patchy regeneration of SV in Roraima (C), and SV along riparian corridors in Mato Grosso (D).

long-term assessment of the annual extent and dynamics of SV for this region.

3. Results

3.1. Annual extent of secondary vegetation

In 2017, patches of SV were distributed along the arc of deforestation, the trans-Amazon highway, and main river corridors in the Brazilian Amazon, with higher concentrations of SV in older frontiers such as eastern Pará State (figure 1). Many factors contribute to the spatial and size distributions of SV, including abandonment or rotational management of pasture and agriculture fields. Forest restoration and forest plantations also contribute to FloreSer estimates of SV in the Brazilian Amazon (figure S2). However, we did not attempt to separate the forest plantations from natural regeneration in this study, although the class 'planted forest' mapped by MapBiomas (86 500 ha) was not included in FloreSer analysis, which reduces the contribution of monucultures to the overall results.

The extent of SV increased from 1985 to 2017, totaling more than 12 Mha in 2017 (figure 2). The net extent of SV increased annually, confirming faster rates of SV gain than loss in every year except 1999–2000. The time series of SV highlights three periods with distinct dynamics. Rapid increases in SV at

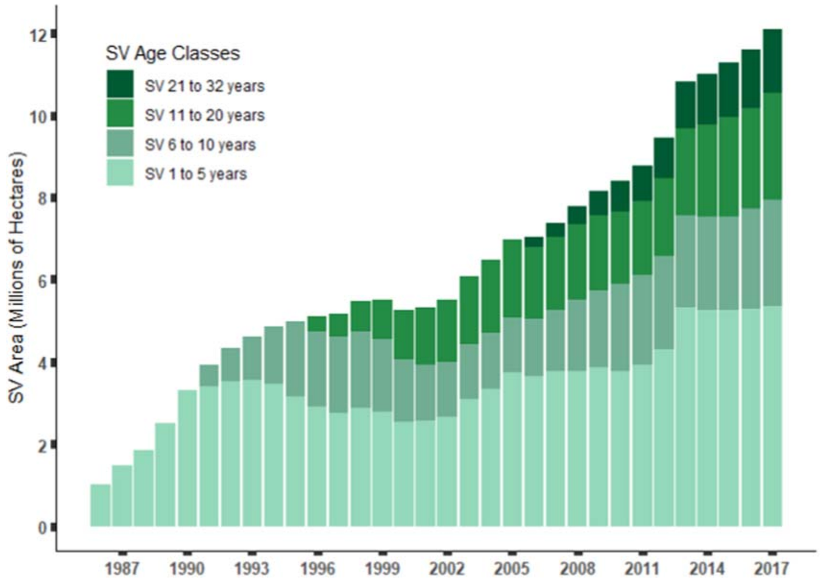

Figure 2. Annual extent of secondary vegetation (SV) by age class in the Brazilian Amazon.

the start of the time series (1986–1993) likely reflect the inability to account for older SV age classes (i.e. before 1986) in SV dynamics during the study period (figure 2; table S2). SV extent stabilized between 1994 and 2002. After 2003, the annual rate of SV expansion increased, doubling the extent of SV from ~6 Mha in 2003 to 12 Mha in 2017, possibly due to a surplus of pasturelands as a result of high deforestation rates between 2000 and 2004. Most SV in the Brazilian Amazon is young. By 2001, the proportion of SV ⩽5 years old stabilized near 50% of total SV extent. In 2017, 65% of SV was ⩽10 years old (7.9 Mha), with only 13% of SV in the oldest age class (1.5 Mha >20 years, figure 2, table S2).

However, there is uncertainty on to which extent an early-regenerating SV (i.e. <5 years old) will turn into an old-second-growth forest. Because of that, we investigated in more details SV for ages from 1 to 5 year old (figure S3, table S3). Our results revealed that 35% of the SV mapped in the first five years could be fallow fields. We also assumed that SV with more than 5 years have a more stable and consistent spatial-temporal signal of regeneration being more likely to be regenerating stages.

SV also occurs in small patches. Increasing the minimum mapping unit in this study from 1 ha, applied by FloreSer, to 6.25 ha, the minimum area of new deforestation in PRODES, decreased the estimated extent of SV in 2017 from 12 to 8 Mha. However, increasing the size of the minimum mapping unit did not impact the trends over time, including the sharp increase in SV extent after 2003 (figure S4).

The distribution of SV by state differed from the extent of historic deforestation. Pará State had the most SV in 2017 (5 Mha, or 42%), with the least SV in Amapá State (0.09 Mha—1%) (figure S5(a), table S4). However, estimates of SV as a proportion of total historic deforestation by state highlight a different pattern (figure S5(b), table S5). Amapá had the highest proportion of deforested areas in SV (54%), followed by Amazonas (43%), Roraima (34%), Maranhão (28%), Pará (22%), Acre and Tocantins (18%), Mato Grosso (11%) and Rondônia (10%).

3.2. Deforestation of secondary vegetation

Deforestation of SV totaled 19.6 Mha between 1987 and 2017 (figure 3(a)). In total, 62% of all SV mapped during the study period was re-cleared by 2017. This rapid re-clearing of SV highlights the dynamic nature of agricultural land use in the Brazilian Amazon. The total SV loss was almost half (45.5%) of the primary deforestation detected by PRODES for the same period (42.9 Mha) (figure 3(a)). Since 2011, the rate of annual SV loss exceeded rates of primary deforestation from PRODES, with annual SV loss 40% higher than deforestation, on average.

The time series of SV deforestation also exhibited three distinct phases (figure 3(a)). From 1988 to 1995, the rate of annual SV loss increased from 0.22 to 0.6 Mha, largely due to the increase in total SV area at the start of the time series. From 1996 to 2013, the average rate of SV deforestation was stable at approximately 0.7 Mha per year, with only minor increases in 2000, 2006, and 2011. Rates of SV loss increased sharply from 2014 to 2017, peaking 1.2 Mha yr^{-1} in 2017. This absolute increase in SV deforestation area is also a higher proportional loss of SV relative to previous years. On average, the deforestation in SV area represents 10% of the total SV detected over time according to FloreSer.

Deforestation of SV primarily impacted the youngest age class (figure 3(b)). During the study period, SV from 1 to 5 years of age accounted for 72% of all SV loss (14.2 Mha). Forests from 6 to 10 years in age

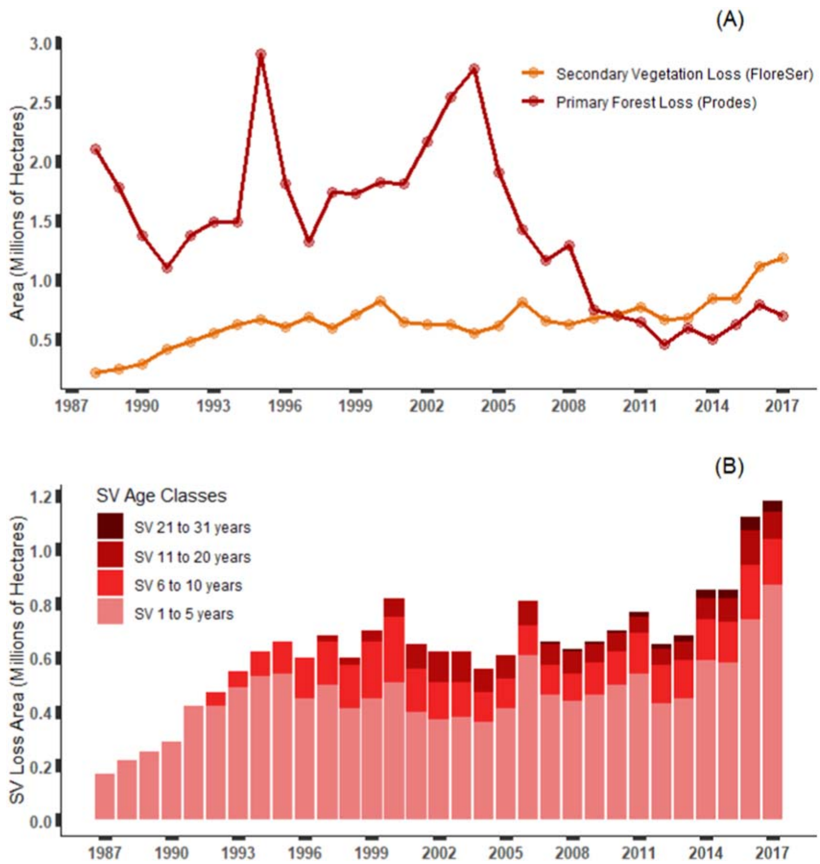

Figure 3. Time series of deforestation in the Brazilian Amazon. (A) Deforestation of primary forest (PRODES) and secondary vegetation (SV, FloreSer) between 1988 and 2017. (B) Annual deforestation of secondary vegetation by age class.

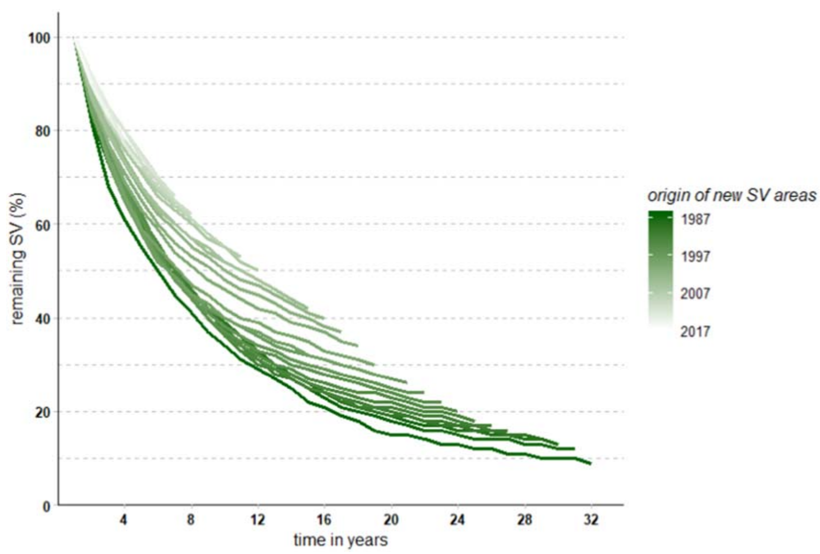

Figure 4. Proportion of new SV areas over time. It shows the permanence of new SV detected by year.

accounted for 18% of all losses, with <10% of deforestation of SV from the oldest age classes (8% from 11 to 20 years, 1% from 21 to 32 years, figure 3(b); table S6). Across the Brazilian Amazon, we estimate that 19% of historic deforestation was in SV in 2017.

The demographics of SV gains and losses highlight the rapid turnover of young regrowing forests in active land use frontiers. Figure 4 tracks the fate of each annual cohort of SV over time. On average, 35% of annual land abandonment to SV was re-cleared within 5 years, 57% within 10 years, and nearly 80% within 20 years. Among the oldest cohorts (21–32 years) only 10%–20% of the original SV extent remained in 2017. These results underscore the dynamic nature of SV

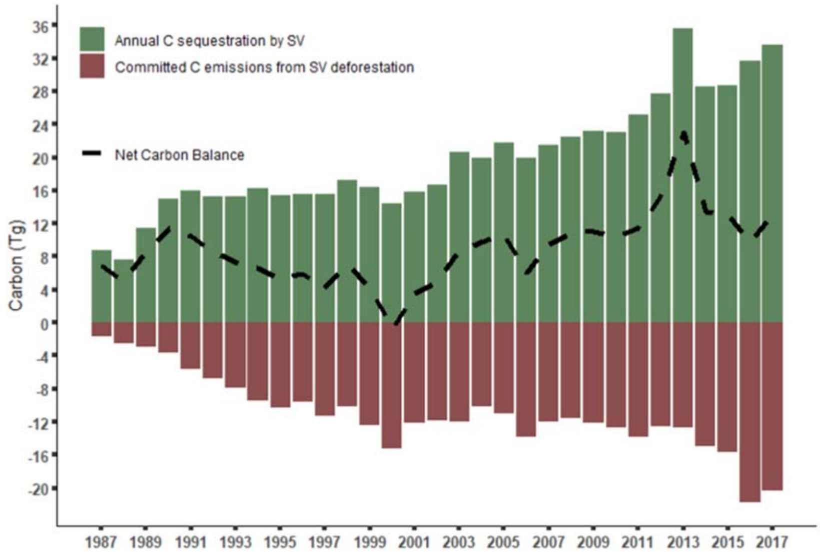

Figure 5. Annual carbon sequestration and emissions by secondary vegetation (SV). SV was a small net carbon sink during the study period (dashed line), based on greater carbon uptake (green) than losses (brown) from deforestation of SV(Fearnside 1996).

and emphasize the need to track SV age to evaluate carbon gains and losses and other ecosystem services. Additionally, there is evidence for longer SV persistence in more recent cohorts (figure 4), consistent with a regional shift from slash and burn to longer rotation management over the study period.

FloreSer results showed that 41% of all cleared SV areas had multiple cycles of deforestation. The number of cycles variated between 2 and 9 deforestations events (table S7). In the most recent year (2017), repeated deforestation of SV was concentrated in younger SV age classes, whereas the first or second deforestation event of SV was broadly distributed across age classes.

3.3. Net carbon balance of secondary vegetation

We estimated that SV stored 299 Tg C in 2017 (figure S6). Average SV carbon stocks per hectare (24.9 Mg C ha^{-1}) were strongly influenced by the distribution of SV by age class (figure 2). SV from 1 to 5 years old accounted for 26% (76 Tg C) of total carbon stocks. Intermediate aged SV (6–20 years) accounted for the largest fraction of total carbon stocks, based in part on the trajectory of rapid forest regrowth that stabilizes between 20 and 30 years in most neotropical landscapes (Fearnside 1996, Foody *et al* 1996, Poorter *et al* 2016).

SV was a small net carbon sink during the study period (figure 5). Carbon accumulation in regrowing forests exceeded carbon losses from SV deforestation by 8.9 Tg C yr^{-1}, on average (figure 5). In contrast to total SV carbon stocks, nearly 50% of annual net carbon gains in SV came from estimated growth in the first year following land abandonment. Combined with the tendency to re-clear younger SV (figure 3(b)), rapid regrowth of younger SV helped offset the total carbon losses from SV deforestation. Potential carbon sequestration in SV is somewhat higher; if 50% of all SV were in the oldest age class (32 years), rather than rapidly re-cleared, the total carbon stock in SV in 2017 would be 387 Tg C, a 29% increase over the estimate based on the observed age distribution.

4. Discussion

We provide the first estimate of the extent, age, and dynamics of SV in the Brazilian Amazon. Long time series of Landsat satellite data provide a robust basis for tracking fine-scale changes in forest cover in dynamic frontier landscapes. By 2017, SV in the Amazon biome totaled 12 Mha (figure 2), suggesting that 19% of the total cleared area in the Amazon according to MapBiomas was under some form of regeneration. The stock of SV was widely distributed across active land use frontiers in the Brazilian Amazon. On average, SV patches were small and young, based on rapid rates of both land abandonment to new SV and deforestation of SV. By looking outside the mask of remaining intact forests that guides official deforestation monitoring efforts, we identified 19.6 Mha of SV deforestation undetected by PRODES between 1988 and 2017. By tracking the extent and ages of forest gains and losses, we estimated that SV was a small net carbon sink during the study period. At <10 Tg C yr^{-1}, small net carbon uptake by SV offsets $<2\%$ of committed carbon emissions from primary deforestation. However, the extent of SV in the Brazilian Amazon is large, and growing. The total extent of SV in 2017 is comparable to the national commitment to reforest 12 Mha by 2030 as part of the Paris Agreement (MMA 2018). The ability to count SV identified in this study towards that national commitment is unclear. One pattern is clear from this study, however; without formal protection of SV at the state or federal level, <20% of newly established SV will be forested in 20 years.

4.1. Dynamics of secondary vegetation

The time series approach to track SV establishment and deforestation highlights the dynamism of SV in active agricultural frontiers. More than 60% of all SV mapped in this study was deforested by 2017. Young forests were the most dynamic class. This dynamism suggests that rotational management systems remain important across the Brazilian Amazon, despite evidence for longer retention of SV in more recent years (figure 4), with continued reliance on fallow periods in ranching and small-scale agriculture. However, other factors may also contribute to the observed dynamics, as short (2–5 year) fallow periods may reflect socio-economic factors such as labor or capital that preclude active management of agricultural lands in all years.

Our findings of a large extent but rapid clearing of SV in the Brazilian Amazon weakens the argument that secondary vegetation is a mechanism for climate change mitigation (Chazdon *et al* 2016, Griscom *et al* 2017). The half-life of SV in this study was 8 years, on average (figure 4). Only 33% of all SV in 2017 was in middle-advanced stages of regeneration (⩾10 years). The lack of older SV impacts ecosystem services, especially carbon storage and biodiversity benefits (Chazdon *et al* 2016, Griscom *et al* 2017) that accrue over time. Importantly, areas that transition in and out of SV are part of the agricultural landscape; fully accounting for the role of SV in productive systems is critical to accurately estimate the potentially available cropland (Lambin *et al* 2013) and the extent of SV that could be maintained for climate mitigation without fundamentally impacting food security (Griscom *et al* 2017).

4.2. Carbon sequestration

Carbon accumulation in SV varies based on climate, soils, prior land use, and the presence of forest fragments nearby (Mesquita *et al* 2001, Feldpausch *et al* 2004, Zarin *et al* 2005, Poorter *et al* 2016, Fearnside 2018). In this study, we modeled carbon sequestration in SV using a look-up table from (Fearnside 1996). This approach does not account for regional variation in SV growth rates from climate or soils or local-scale variation based on prior land use or distance from seed sources. However, our estimates of carbon losses from SV deforestation use the same assumptions. Thus, the finding in this study that SV is a small net carbon sink is based on the demographics of SV, and therefore likely robust to changes in the carbon accumulation profile of SV by age. Importantly, this small net carbon sink does not account for large carbon losses from initial deforestation for agricultural use, only the net balance between carbon gains and losses from SV dynamics. Total carbon stocks in SV were modest (300 Tg C), based in part on the abundance of young regeneration. For context, SV carbon stocks account for <1% of primary forest carbon stocks in the Brazilian Amazon. Potential future carbon sequestration from SV is large, however, if regenerating forests are protected from deforestation. The estimated extent and age of SV in this study provide a robust basis for projecting future C stocks and fluxes for different land use scenarios.

4.3. Recommendations for public policies

Our results have important implications for public policies in Brazil. To date, deforestation of SV has been excluded from national monitoring systems such as PRODES (Assunção and Gandour 2017, Richards *et al* 2017), leading to an underestimate of forest loss and associated carbon emissions. In 2017, deforestation of SV more than doubled the estimated extent of primary deforestation detected by PRODES. Expanding the scope of deforestation monitoring systems to include SV would enable more complete accounting of changes in forest resources and carbon emissions from land use activity (Assunção and Gandour 2017, Vieira *et al* 2014) and provide an objective means to incorporate SV in environmental legislation. Both primary and secondary vegetation must be protected from illegal deforestation to ensure the provision of ecosystem services from the forest. For that purpose, effective monitoring, command and control actions are needed.

Current environmental legislation in Brazil lacks specific provisions for SV. The Brazilian Forest Code (Law n° 12.651, 25 March 2012) restricts the extent of natural vegetation that may be cleared for agricultural use. Under the Forest Code, SV in any stage of regeneration can be used to achieve the required extent of natural vegetation (legal reserve and riparian forests), but the Forest Code does not restrict deforestation or use of SV beyond the requirements for legal reserves. At subnational scales, Pará is the only state to adopt specific legislation that governs deforestation of SV (Vieira *et al* 2014) (Normative Instruction n° 08, 28 October 2015). It regulates the deforestation of SV in early stages of regeneration, based on the age and structure criteria (e.g. basal area), outside legal reserves and riparian forests, within private properties. Similar state-level regulations are needed across the Brazilian Amazon, or action at the federal level, to clarify when regenerating areas are considered forest versus fallow lands, and therefore subject to existing laws.

Estimates of the extent and age of SV also support specific policy efforts to reduce emissions from deforestation and forest degradation and enhance forest carbon stocks (REDD+). The results of this study directly inform decision makers regarding the contributions from forests towards reducing net emissions of greenhouses gases (Bull *et al* 2013, Food and Agriculture Organization of the United Nations 2015), progress towards the zero net deforestation commitments (WWF 2008, GCP 2015), and potential to national commitments to restore 12 Mha by 2030 (MMA 2018). Without SV, national deforestation and greenhouse emissions inventories are incomplete (Pereira and Vieira 2001, Zarin *et al* 2001, Richards *et al* 2017).

4.4. Challenges for mapping secondary vegetation

This study represents the first long-term, consistent analysis of SV across the Brazilian Amazon. We found less SV as a proportion of deforestation than TerraClass, an analysis based on biannual Landsat data from 2004 to 2014 (TerraClass 2014). Our study also detected more turnover of SV than work from GFC that relied on multi-year time series (2000–2013) to track long-term regeneration of SV (Hansen *et al* 2013). However, the data and methodology by FloreSer also have limitations. First, the land cover classes developed by FloreSer were not specifically designed to distinguish among SV types (e.g. monocultures, agroforestry systems, forest restoration projects, fallow areas). Similarly, deforestation of SV was not separated by subsequent anthropic land use. Additionally, this initial version of FloreSer was based on existing LULC maps from MapBiomas, which brings potential biases and errors. It is possible that the spectral confusion between (abandoned) Pasture and Forest can lead to an overestimation of SV with age between 1 and 5 years. Our findings also highlight the important contributions from small patches of young regeneration to SV dynamics during the study period. Future work to quantify the different pathways, patch sizes, and permanence of SV across the Brazilian Amazon is needed to understand the changing drivers of SV gains and losses over the satellite record. Second, the mapping approach in this study did not quantify the quality of SV regeneration. Not all abandoned lands may transition directly to forest, especially after intensive cycles of agricultural use and depletion of soil nutrients from fires (Zarin *et al* 2005). This limitation impacts estimates of carbon accumulation in SV in this study and other uses of FloreSer data to evaluate ecosystem services linked to forest structure such as biodiversity and habitat. Finally, this study used Landsat data at 30 m resolution to track changes in SV. Landsat spatial and temporal resolution is the standard for large-scale mapping efforts, and 30 m data support analyses of large-scale management decisions and larger properties common in the Brazilian Amazon (e.g. $\geqslant$100 ha). However, finer scale information may be needed to evaluate SV dynamics on smaller properties or the contribution of SV to ecosystem services across small watersheds (Soares-Filho *et al* 2014).

5. Conclusion

We identified a large reserve of SV across the Brazilian Amazon, which is poorly mapped by both official and independent monitoring systems. These SV areas were young, on average, based on rapid rates of short-term land abandonment before deforestation. The rapid turnover of SV reduced the total carbon stocks in SV (300 Tg C) and annual net carbon sequestration (8 Tg C y^{-1}). The total SV loss was almost half of the primary deforestation detected by PRODES for the same period. Without changes in protection and management of SV, this reserve of SV is unlikely to provide substantial climate benefits called for by national commitments to reforestation in the Paris Accord. The FloreSer data in this study provide an objective means to track the contribution of SV to total deforestation in the Brazilian Amazon, the greenhouse gas emissions and the net carbon uptake. A better understanding of gain and losses of SV over time is needed to consider changes in environmental legislation for sustainable management of forest resources.

Acknowledgments

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Data availability statement

The data that support the findings of this study are openly available at https://floreser.users.earthengine.app/view/floreser.

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