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Supplementary Materials for

Hidden destruction of older forests threatens Brazil's Atlantic Forest and challenges restoration programs

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1. Land use and land cover on Native Forest Loss and Gain

To evaluate the percentage of native forest gain was formerly attributed to pasturelands or croplands we used the land use and land cover map from 1990. To evaluate the percentage of Native Forest Loss recent land use and land cover we used the map from 2017. We also calculated the mean value of the slope for each land use land cover in younger forest and forest loss areas using SRTM Digital Elevation Data 30 m (*66*) as refence.

We observed that 29% of younger forest was formerly as pasturelands with 11.4 degree mean slope, 32% was Mosaic of Agro-Pastoral Land Uses with 11.5 degree mean slope and 38% was Native Forest that was cleared for at least 3 years and returned as younger forest. We also included the recent (2017) use in forest loss area. We observed that 18% is used as Cropland, 16% used as Monoculture Tree Plantations, 36% as Pasturelands, 28% as Mosaic of Agro-Pastoral Land Uses and 2% used as Urban Infrastructure.

We found that forest gain area happens in areas with the mean value of ~11.5 degree while the Croplands is the use in Forest Loss with the mean value of ~6.1 degree and pasturelands, mosaic of agro-pastoral and Monoculture Tree Plantations has the mean value of ~10 degree with the total mean valeu of 9.8 degree.

Table S1. Past and current land uses/covers (ha) and Mean Slope (degree) in areas of forest gain and loss.

	younger forest		Native Forest Loss	
	Past (1990) land uses/covers in areas of Forest Gain (ha)	Mean Slope (degree)	Current (2017) land uses in areas of Forest Loss (ha)	Mean Slope (degree)
Native Forests	2,382,232	12.0	-	-
Monoculture Tree Plantations	21,042	10.2	999,337	10.8
Pasturelands	1,819,639	11.4	2,280,736	9.9
Croplands	13,378	4.5	1,119,547	6.1
Mosaic of Agro-Pastoral Land Uses	2,103,394	11.5	1,751,966	10.2
Urban Infrastructure	138	-	100,422	6.1
Total	6,339,824	**11.5**	6,252,008	**9.8**

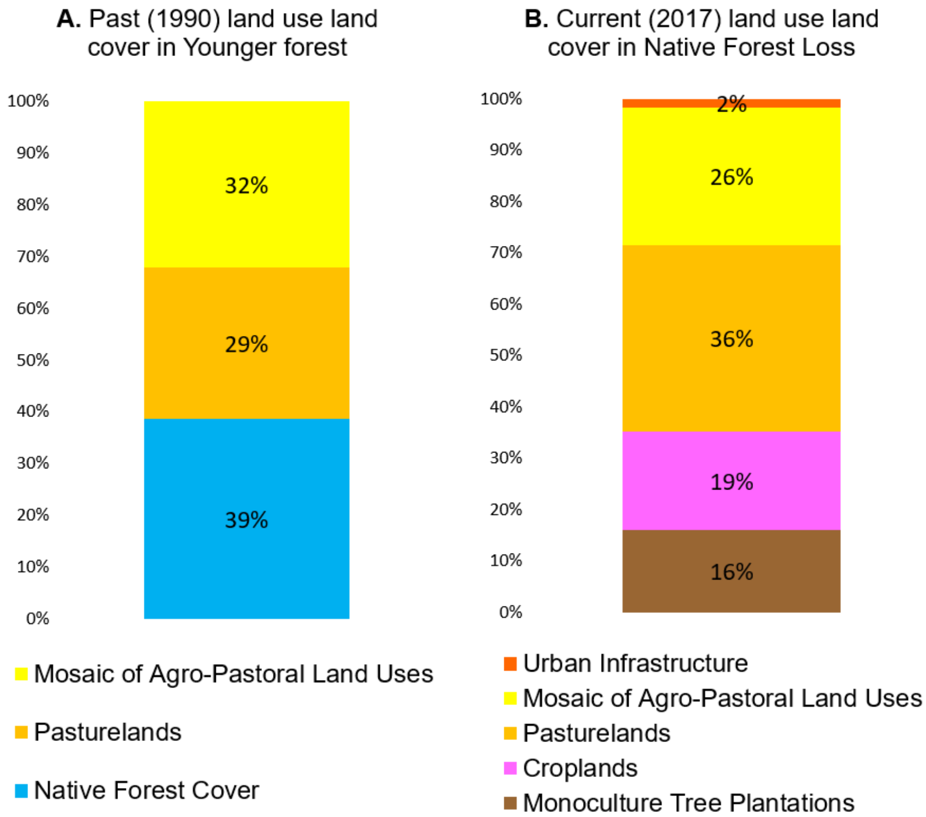

Figure S1. Land use and land cover in native forest loss and gain area. (A) Past (1990) land use land cover (%) in younger forest, and (B) current (2017) land use land cover (%) in areas of native forest loss.

2. Land Cover in Permanent Protected Riparian Areas

Brazil's environmental legislation protects a minimum of 30 m of riparian areas along both sides of rivers and streams, the so called Permanent Protected Areas (PPA) (*27*). The distance is based on the river width and may reach a maximum of 500 m. The map of riparian PPA for the entire Atlantic Forest based on high resolution RapidEye imagery (*57*) was used as reference in our analysis to quantify the land use and land cover in these areas from the MapBiomas Collection 5 in 1990 and 2015. We found an increase of ~292,000 hectare in native forest cover in riparian PPA within the period (Table S2).

Table S2. Area (ha) of each land use and land cover classes in PPAH

Land Use and Cover Classes	Riparian PPA 1990 (ha)	%	Riparian PPA 2015 (ha)	%
Native Forests	*5,754,971*	*45%*	*6,046,668*	*48%*
Pasturelands	*3,723,021*	*29%*	2,893,789	*23%*
Mosaic of Agro-Pastoral Land Uses	*2,766,745*	*22%*	2,755,138	*22%*
Croplands	*403,393*	*3%*	502,040	*4%*
Planted Forest	*111,065*	*1%*	368,888	*3%*

3. MapBiomas Accuracy

We used the MapBiomas Atlantic Forest Biome Collection 5 as the input data source to quantify forest gain and loss for the whole Atlantic Forest between 1985 and 2019 in the present analysis. The data is public available as Google Earth Engine (GEE) asset at:

"projects/mapbiomas-workspace/public/collection5/mapbiomas_collection50_integration_v1"

The land use and land cover maps for Atlantic Forest produced by the Mapbiomas has a global accuracy that vary according to the level of detail of the legend (*63*, *64*, *67*, *68*) (Table S2)

Table S3. MapBiomas accuracy for the Atlantic Forest Biome in Collection 5

Legend Level	Global Accuracy	Allocation Disagreement	Area Disagreement
1	90.7%	7.3%	2.0%
2	86.5%	7.5%	6.0%
3	85.5%	7.8%	6.5%

The legend of MapBiomas Collection 5 with the level of each class is available at:

https://mapbiomas-br-site.s3.amazonaws.com/_EN__C%C3%B3digos_da_legenda_Cole%C3%A7%C3%A3o_5.pdf

The accuracy for the MapBiomas Atlantic Forest maps is consistent across all years (Figure S2), a result of the methodological efforts to produce comparable maps with consistent accuracy for the entire time series (*21*).

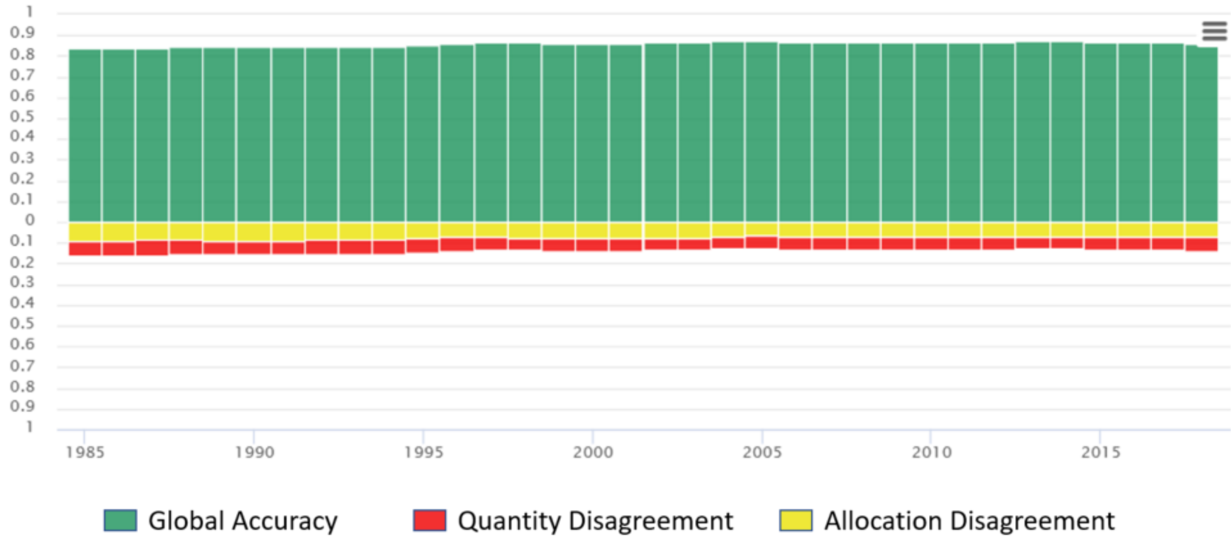

Figure S2. MapBiomas Global accuracy, Quantity and Allocation Disagreement (*63*) *in Atlantic Forest Biome*

The validation was based on over 12.000 points inspected by 3 analysts in a stratified sample design that considered the probabilities of sample weight adjustment (*64*). Detailed information about omission and commission errors for each class can be obtained at:

https://mapbiomas-accuracy-en.shinyapps.io/MapBiomas_Col5_Acc_ENUS/

4. Unbiased land cover area Estimation

The population bias from more than 12.000 reference points was used to estimate the unbiased land cover area for each class according to the good practice guidance (*64*, *65*).

Table S4. Estimate of unbiased area for each land use cover class for the Atlantic Forest Mapbiomas maps (*64*, *65*). NF=Native Forest; Pa= Pasturelands; Crop=Croplands; Mos= Mosaic of Agro-Pastoral Land Uses; MTP= Monoculture Tree Plantations.

	Pixel Area (Millions of hectares)					Population Bias (%)					Estimate of unbiased adjusted Area (Millions of hectares)				
year	NF	Pa	Crop	Mos	MTP	NF	Pa	Crop	Mos	MTP	NF	Pa	Crop	Mos	MTP
1985	33.6	40.3	10.0	17.7	1.1	-0.015	0.051	-0.005	-0.029	0.004	32.0	45.8	9.4	14.6	1.6
1986	33.3	40.3	10.0	17.9	1.1	-0.017	0.053	-0.003	-0.030	0.005	31.4	46.1	9.6	14.7	1.6
1987	32.3	40.8	9.9	18.4	1.2	-0.015	0.052	-0.003	-0.030	0.005	30.8	46.3	9.6	15.2	1.7
1988	31.8	41.5	9.9	18.2	1.2	-0.016	0.048	-0.001	-0.027	0.005	30.0	46.7	9.8	15.4	1.7
1989	31.4	41.9	10.0	18.1	1.3	-0.013	0.042	0.000	-0.025	0.006	30.0	46.4	10.0	15.3	1.9
1990	31.2	42.0	10.1	18.0	1.3	-0.012	0.041	0.001	-0.025	0.006	29.9	46.4	10.1	15.3	2.0
1991	31.1	42.2	10.2	17.6	1.5	-0.014	0.045	-0.001	-0.025	0.006	29.5	47.1	10.1	14.9	2.1
1992	31.0	42.2	10.3	17.7	1.5	-0.016	0.044	-0.000	-0.027	0.007	29.3	47.0	10.2	14.8	2.2
1993	31.1	42.2	10.4	17.5	1.4	-0.016	0.043	-0.000	-0.025	0.007	29.4	46.8	10.4	14.7	2.2
1994	31.0	41.9	10.6	17.5	1.6	-0.016	0.044	0.000	-0.026	0.006	29.2	46.6	10.6	14.7	2.3
1995	31.0	41.6	10.8	17.6	1.6	-0.019	0.045	0.000	-0.026	0.008	29.0	46.4	10.8	14.9	2.4
1996	30.8	41.3	11.0	17.7	1.6	-0.018	0.051	-0.008	-0.024	0.008	28.9	46.8	10.1	15.1	2.4
1997	30.7	41.0	11.1	18.0	1.7	-0.016	0.047	-0.007	-0.024	0.008	29.0	46.1	10.4	15.5	2.5
1998	30.6	40.9	11.1	18.2	1.7	-0.018	0.046	-0.005	-0.024	0.008	28.7	45.9	10.5	15.6	2.6
1999	30.6	41.0	11.2	18.0	1.8	-0.022	0.038	0.006	-0.022	0.008	28.2	45.1	11.8	15.6	2.7
2000	30.5	41.1	11.4	17.7	1.8	-0.019	0.036	0.006	-0.023	0.008	28.4	44.9	12.1	15.2	2.7
2001	30.4	40.7	11.7	17.7	1.9	-0.019	0.034	0.009	-0.023	0.008	28.4	44.3	12.6	15.2	2.8
2002	30.4	40.2	12.1	17.9	1.9	-0.019	0.033	0.007	-0.023	0.010	28.3	43.7	12.8	15.4	3.0
2003	30.3	39.1	12.6	18.5	2.0	-0.020	0.031	0.007	-0.023	0.011	28.1	42.5	13.3	16.0	3.2
2004	30.2	38.5	13.2	18.4	2.1	-0.017	0.040	-0.004	-0.024	0.011	28.4	42.7	12.8	15.9	3.3
2005	30.3	37.6	13.7	18.6	2.2	-0.018	0.038	-0.003	-0.023	0.012	28.3	41.7	13.4	16.1	3.6
2006	30.3	36.9	14.2	18.4	2.4	-0.021	0.033	0.008	-0.024	0.013	28.1	40.5	15.0	15.8	3.8
2007	30.4	35.9	15.0	18.4	2.6	-0.023	0.036	0.005	-0.025	0.013	27.9	39.8	15.5	15.7	4.0
2008	30.4	35.0	15.7	18.3	2.8	-0.020	0.033	0.005	-0.027	0.015	28.2	38.6	16.2	15.4	4.4
2009	30.5	34.3	16.3	18.1	3.1	-0.023	0.034	0.004	-0.025	0.016	28.0	38.0	16.7	15.4	4.8
2010	30.5	33.9	16.6	18.0	3.3	-0.023	0.030	0.006	-0.025	0.018	28.0	37.1	17.2	15.3	5.2
2011	30.6	33.2	16.9	18.0	3.5	-0.023	0.028	0.007	-0.024	0.018	28.1	36.3	17.6	15.4	5.4
2012	30.6	32.6	17.3	17.9	3.7	-0.022	0.029	0.007	-0.024	0.018	28.3	35.8	18.0	15.3	5.6
2013	30.6	31.9	17.7	18.1	3.8	-0.020	0.030	0.006	-0.023	0.017	28.4	35.1	18.3	15.6	5.7
2014	30.6	31.5	18.3	17.7	3.9	-0.020	0.029	0.005	-0.023	0.017	28.4	34.6	18.8	15.2	5.8
2015	30.7	31.0	18.8	17.4	4.0	-0.020	0.031	0.003	-0.024	0.017	28.5	34.3	19.2	14.9	5.8
2016	30.6	30.6	19.0	17.5	4.1	-0.019	0.034	0.001	-0.024	0.015	28.6	34.3	19.2	14.8	5.8
2017	30.5	30.1	19.8	17.3	4.21	-0.017	0.035	-0.002	-0.023	0.014	28.6	33.9	19.6	14.8	5.76
2018	30.5	29.6	20.0	17.4	4.2	-0.018	0.040	-0.004	-0.024	0.014	28.6	33.9	19.6	14.8	5.8

5. Preparation of data for Native Forest Loss and Gain Analysis

MapBiomas land-use and land-cover maps from 1985 to 2019 (35 maps) were reclassified into binary maps. We assigned the value “1” for “Native Forest” and “0” for the "Anthropic". The legend of MapBiomas Collection 5 with the id of each class is available at:

https://mapbiomas-br-site.s3.amazonaws.com/_EN__C%C3%B3digos_da_legenda_Cole%C3%A7%C3%A3o_5.pdf

Each of the simplified aggregation we used for our analysis included the following classes:

- **Native Forests -** This class is the group composed by the MapBiomas id 3 (1.1.1. Forest Formation), which corresponds to the “Native Forest Formation” class.
- **Anthropic** – This class is the group composed by ids 9, 14 (including all sub-classes), 24 and 30 (corresponding to Forest Plantations, Farming (including all sub-classes), Urban Infrastructure and Mining);
- Classes not analyzed in the present study included the ids 4, 5, 10, 23, 25 (corresponding to the Savanna Formation, Mangrove, Non Forest Native Formation (including all sub-classes), Beach and Dune and Water (including all sub-classes). These classes were converted to “NO DATA”. Transitions involving these classes were not considered in the analysis.

The simplified legend with “Native Forest” and “Anthropic” removes confusion between certain specific classes and increases the overall accuracy of the map.

5.1 Post-Classification filter

A post-classification temporal filter based on a moving window was applied to the simplified maps to reduce uncertainty and year-to-year fluctuations in forest loss and gain (*4*). Forest gain was defined as pixels that were classified at least two consecutive years as “Anthropic” followed by at least four consecutive years as “Native Forest” (Figure S3).

t -2	t -1	t	t +1	t +2	t +3
A	A	NF	NF	NF	NF

Figure S3. Forest Gain moving window where t = analyzed year; A=Anthropic; NF = Native Forest

We considered a deforestation episode when a pixel was classified at least two consecutive years as “Native Forest” and then it was classified for at least two consecutive years as “Anthropic” (Figure S4).

t -2	t -1	t	t +1
F	F	A	A

Figure S4. Deforestation moving window where t = analyzed year; F = forest; A=Anthropic

The same rule is applied to identify the re-cut of younger Native Forest.

5.2 Spatial Filter

Forest loss and gain with less than 11 connected pixels (approximately 1 hectare) were considered scattered and excluded from the present analysis. The filter was applied to the accumulated forest gain and forest loss across the entire time series, considering the connection to forest pixels. It could limit the ability to identify the gain and loss of small native forest patches, but it is necessary considering the use of Landsat images with 30 m of spatial resolution.

6. Validation and Comparison with other studies

6.1 Reference points

We used over 12.000 reference points to calculate the accuracy of our simplified map containing only two classes. The points that did not fall within the two simplified classes (native forest and anthropic) were discarded, resulting in over 9,000 validation points for each year (minimum of 9,015 points in 1985).

Our maps had a consistent time-series global accuracy with mean value for all years of 0.938 (the minimum value of 0.912 in 1985). In Figure S5 it is possible to observe the tendency of lower accuracies before 2000, which is expected when classifying Landsat imagery due to the reduced availability of scenes before the year of 2000.

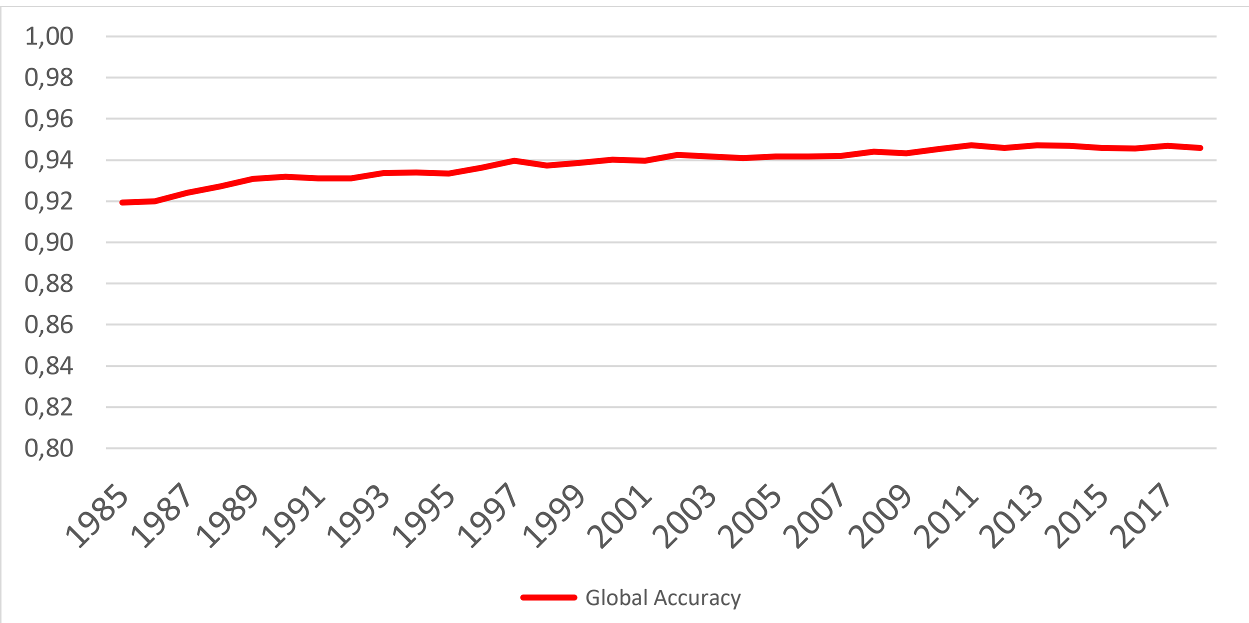

Figure S5. Annual Global accuracy of simplified “Native Forest” and “Anthropic” map

The Google Earth Engine (GEE) script that calculates the accuracy for all years can be visualized at: https://code.earthengine.google.com/21a24122adbd119d3955403f2bce2cd1

The map for 1985 had 9,015 validation points and global accuracy of 0.912 (Table S5)

Table S5. Error matrix for year 1985 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	2703	313	3,016	452,271,821	0.323
	Anthropic	482	5,517	5,999	947,962,421	0.677
	Total	3185	5830	9,015	1,400,234,242	1
		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	0.2895	0.0335	0.3230	452,271,821	0.323
	Anthropic	0.0544	0.6226	0.6770	947,962,421	0.677
	Total	0.343871607	0.656128393	1	1,400,234,242	1
	User's	**0.896**	**0.920**			
	Producer's	**0.842**	**0.949**			
	Overall	**0.912**				

The map for 2018 had 10,153 validation points and global accuracy of 0.946 (Table S6)

Table S6. Error matrix for year 2018 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	2438	173	2,611	407,953,862	0.263
	Anthropic	377	7,165	7,542	1,141,526,956	0.737
	Total	2815	7,338	10,153	1,549,480,819	1
		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	0.2458	0.0174	0.2633	407,953,862	0.263
	Anthropic	0.0368	0.6999	0.7367	1,141,526,956	0.737
	Total	0.282665526	0.717334474	1	1,549,480,819	1
	User's	**0.934**	**0.950**			
	Producer's	**0.870**	**0.976**			
	Overall	**0.946**				

GEE script that displays the confusion matrix and accuracy values for any year can be visualized at: https://code.earthengine.google.com/7dd6fc010cb00770d5548ece5e677c9a

6.2 Native Forest and Monoculture Tree Plantations – Reference points

To determine the accuracy of Native Forest class and its distinction from Monoculture Tree Plantations, we converted the MapBiomas Collection 5 class id = 3 (Natural Forest Formation) and id = 9 (Forest Plantation) to 1 and 0, respectively to create a binary raster, with the remaining Mapbiomas classes converted to "NO DATA". The validation points were also converted to the values 1 (Native Forest) and 0 (Monoculture Tree Plantations). Points that fell into other classes were discarded. An average of 3,152 validation points remained for each year (with a minimum value of 3,022 in 1999). The result is a consistent global accuracy with 0.960 mean global accuracy value for all years. Figure S6 shows the global accuracy for the simplified "Native Forest" and "Monoculture Tree Plantations" maps for all years in the time series. The behavior of the graph indicates that as the amount of Monoculture Tree Plantations increases over our study period, there is an increase in the confusion between native and Monoculture Tree Plantations and a consequent reduction in overall accuracy. Nonetheless, the lowest accuracy value in the whole series was 0.943 in 2012, which is remarkably high given the difficulty to distinguish between these two forest formations using satellite imagery alone.

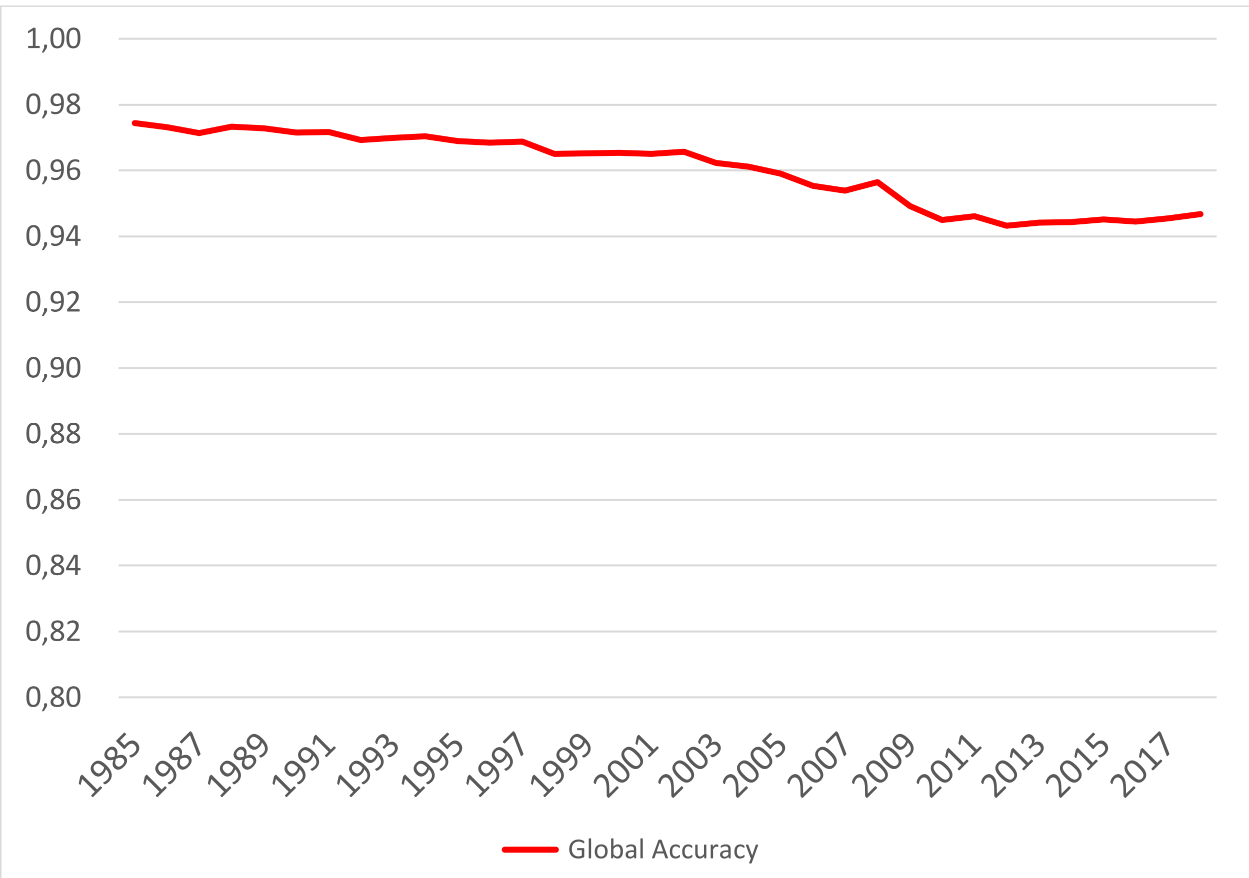

Figure S6. Annual Global accuracy of the simplified map containing "Native Forest" and "Monoculture Tree Plantations" classes only.

Google Earth Engine script used to calculate global accuracy for each year on the fly can be visualized at:
https://code.earthengine.google.com/92effc9eb7544ebf293bbfd826651dc6

The year of 1985 had 2.889 validation points with a global accuracy of 0.979 (Table S7).

Table S7. Error matrix for 1985 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	2.703	20	2.723	452,271,821	0.959
	Monoculture Tree Plantations	54	112	166	19,576,806	0.041
	Total	2.757	132	2.889	471,848,627	1

		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	0.9515	0.0070	0.9585	452,271,821	0.959
	Monoculture Tree Plantations	0.0135	0.0280	0.0415	19,576,806	0.041
	Total	0.96496692	0.03503308	1	471,848,627	1
	User's	**0.993**	**0.675**			
	Producer's	**0.986**	**0.799**			
	Overall	**0.979**				

The year of 2018 had 3,027 validation points with a global accuracy of 0.957 (Table S8).

Table S8. Error matrix for 2018 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	2438	24	2462	407,953,862	0.859
	Monoculture Tree Plantations	137	428	565	67,208,163	0.141
	Total	2575	452	3027	475,162,025	1
		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	0.8502	0.0084	0.8586	407,953,862	0.859
	Monoculture Tree Plantations	0.0343	0.1071	0.1414	67,208,163	0.141
	Total	0.88448472	0.11551528	1	475,162,025	1
	User's	**0.990**	**0.758**			
	Producer's	**0.961**	**0.928**			
	Overall	**0.957**				

The Google Earth Engine script used to produce the confusion matrix for each year can be visualized at: https://code.earthengine.google.com/d85635640aaf83311b7f6a268cb6f8ad

6.3 Global Forest Change v1.7 (GFC) - Forest Loss Analysis

We conducted an annual comparison of forest loss between the Mapbiomas and the Global Forest Change products (*15*) for the period between 2001 and 2015. When not applying any filtering criteria to the GFC product, we found a total forest loss of 4,985 hectares over the period. When filtering the GFC product to include only forests with canopy coverage greater than 70%, a value more compatible with the MapBiomas products, the total forest loss is reduced to 3,433 hectares and the large increase in forest loss rates observed in recent years is reduced. When applying a mask to remove Forest Plantations from the GFC product, the total forest loss in the period decreases to 2,063 hectares, which is comparable to the 2,149 hectares of forest loss we quantified using the MapBiomas products (Figure S7).

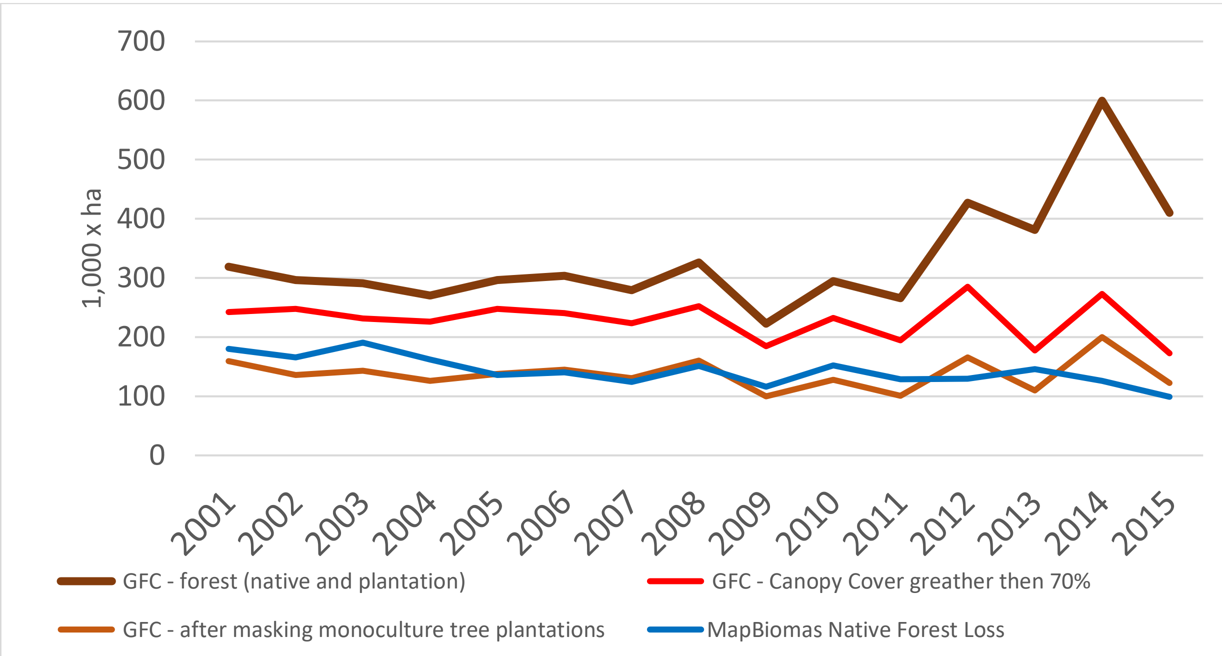

Figure S7. Comparison between quantifications of "native forest loss" based on the Mapbiomas products with the GFC products under three possible scenarios: (1) GFC forest (native and monoculture tree plantations); (2) GFC product after filtering tree canopy cover of 70%; and (3) GFC product after masking monoculture tree plantations.

6.4 Forest loss and gain analysis

Mapping forest cover based on Landsat imagery and monitoring forest loss and gain using supervised classification is a consolidated and well accepted methodology for regional scale studies. Our results reported for the whole Brazilian Atlantic Forest are consistent with previous studies that identified similar forest dynamics for specific regions of the biome (*51*, *60*). The reported accuracy for detection of changes in forest cover based on Landsat guided by specialists varies between 75% and 91% (*69*, *70*).
We created 350 random points in Native Forest Loss and Gain and used visual inspection on annual images Landsat from 1985 to 2018 to verify if they correctly mapped. 289 out of 350 (83%) are correct mapped in Native Forest loss. 257 out of 350 (73%) are corrected mapped in Native Forest Gain.
The Google Earth Engine script used to script with analysis can be accessed at:
https://code.earthengine.google.com/2732e2aa57ca31f166ca366e0a856ca9

6.5 Land use and land cover map of the Atlantic Forest biome (RapidEye 5m) – Native Forest X Anthopic

Rezende et al. (2018) mapped land cover of the Atlantic Forest Biome through supervised classification of RapidEye imagery level 3A (5 m resolution, orthorectified) of the entire base year of 2013 in the unprecedented working scale of 1:10,000 (*57*). Their classification has an overall accuracy of 0.936 and was produced based on 1,970 random points. The final product is available for download in shapefile format at: http://geo.fbds.org.br/

We compared land cover map with the MapBiomas product by was exporting as a GeoTiff image with 30 m resolution and loading it in Google Earth Engine (GEE) as an asset. We generated 5.000 random points across the Atlantic Forest Biome in GEE (3.153 points in the evaluated classes) resulting in a global accuracy of 0.889 (*65*). (Table S9).

Table S9. Error matrix for year 2013 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	868	136	1004	398,316,851	0.311
	Anthropic	215	1,934	2149	881,031,015	0.689
	Total	1083	2070	3153	1,279,347,866	1
		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	0.2692	0.0422	0.3113	398,316,851	0.311
	Anthropic	0.0689	0.6198	0.6887	881,031,015	0.689
	Total	0.3380673	0.6619327	1	1,279,347,866	1
	User's	**0.865**	**0.900**			
	Producer's	**0.796**	**0.936**			
	Overall	**0.889**				

The GEE script used for comparing the two classification can be visualized at: https://code.earthengine.google.com/7dd6fc010cb00770d5548ece5e677c9a

6.6 Land use and land cover map of the Atlantic Forest biome (RapidEye 5m) – Native Forest X Monoculture Tree Plantations

An additional specific analysis for the separation between Native Forest and Monoculture Tree Plantations was developed by comparing MapBiomas map the supervised classification of RapidEye imagery level 3A (5 m resolution, orthorectified) of the entire base year of 2013, for the whole biome, in the unprecedented working scale of 1:10,000 (*57*). To compare the classifications, the classes id = 3 (Native Forest) and id = 9 (Monoculture Tree Plantations) were converted to 1 and 0, respectively and the remaining classes were converted to "NO DATA". We generated 5,000 random points across on the biome's limits (with 1.016 points in the evaluated classes). which resulted in an overall accuracy of 0.948 (Table S10)

Table S10. Error matrix for 2013 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	868	17	885	370,678,954	0.888
	Monoculture Tree Plantations	41	90	131	46,569,372	0.112
	Total	909	107	1.016	417,248,326	1
		Reference				
		Native Forest	***Monoculture Tree Plantations***	Total	Pixels	W_i
Map	***Native Forest***	0.8713	0.0171	0.8884	370,678,954	0.888
	Monoculture Tree Plantations	0.0349	0.0767	0.1116	46,569,372	0.112
	Total	0.9063	0.0937	1	417,248,326	1.000
	User's	**0.981**	**0.687**			
	Producer's	**0.961**	**0.818**			
	Overall	**0.948**				

The Google Earth Engine script used to script to generate the confusion matrices and visualize maps (Figure S8) can be accessed at:

https://code.earthengine.google.com/b266d763a9694e24ec110bb2e57c1de3

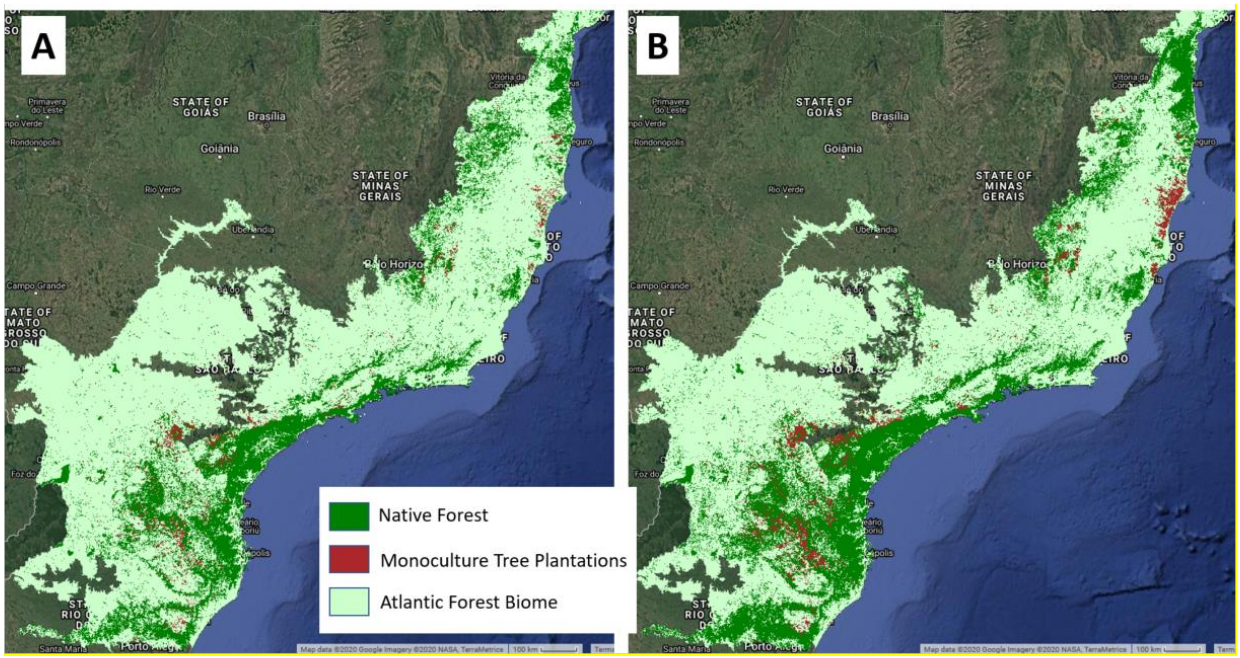

Figure S8. Spatial distribution of Native Forest and Monoculture Tree Plantation for 2013 in Atlantic Forest. (A) produced with 5 m RapidEye resolution (*57*) and (B) MapBiomas data.

6.7 Global Forest Change v1.7

We also used the Global Forest Change (GFC) maps to validate out classification. The GFC product is a time-series analysis of Landsat imagery that characterizes global forest extent and change (*15*).

To compare the GFC maps with the MapBiomas products we first filtered the GFC map to include only forests with continuous canopy cover higher than 70% and considered all other areas as anthropic land use. We also applied a mask to remove overlapping regions from the GFC forest cover map from the MapBiomas Forest Plantations class.

We created 5.000 random points on Google Earth Engine spread across the entire Atlantic Forest Biome (3.604 points in the evaluated classes) to compare the two classifications, resulting in a global accuracy of 0.907 (*65*) (Table S11).

Table S11. Error matrix for 2000 map with sample points and population adjusted based on mapped area proportion (W_i) (*65*).

		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	929	179	1108	371,813,877	0.296
	Anthropic	159	2,337	2496	883,869,688	0.704
	Total	1088	2516	3604	1,255,683,565	1
		Reference				
		Native Forest	***Anthropic***	Total	Pixels	W_i
Map	***Native Forest***	0.2483	0.0478	0.2961	371,813,877	0.296
	Anthropic	0.0448	0.6591	0.7039	883,869,688	0.704
	Total	0.29310782	0.70689218	1	1,255,683,565	1
	User's	**0.838**	**0.936**			
	Producer's	**0.847**	**0.932**			
	Overall	**0.907**				

The GEE script used for comparing the two classification can be visualized at: https://code.earthengine.google.com/8720884bd594d708bc64332ff77c52b4

6.8 Validation of Native Forest and Monoculture Tree Plantations

The separation between Native Forest cover and Monoculture Tree Plantations is a key point in our analysis of forest dynamics in the Atlantic Forest, since Monoculture Tree Plantations (mostly *Eucalyptus spp*) have relatively short cycles of growth and harvest that can inflate quantifications of forest gain and loss over our study period.

By comparing the area calculated from the mapped pixels (Figure S9) with the unbiased adjust area (Figure S10) from the Mapbiomas products, based on more than 10,000 reference points, it is possible to identify an omission in the last year of 1.6 Mha (from 4.2 mapped to 5.8 Mha estimated) in the Monoculture Tree Plantations classification. Nonetheless, both have the same consistent trajectory over time.

The MapBiomas methodology applies a post-classification filter on the Native Forest class to reduce the confusion with Monoculture Tree Plantations and most of the omission in Monoculture Tree Plantations was classified in MapBiomas as "Mosaic of Agriculture or Pasture" (class id=21), which did not affect our forest cover dynamic analysis, as both these two classes were grouped in "Anthropic" class. The confusion between Native Forest and Monoculture Tree Plantations is further discussed below.

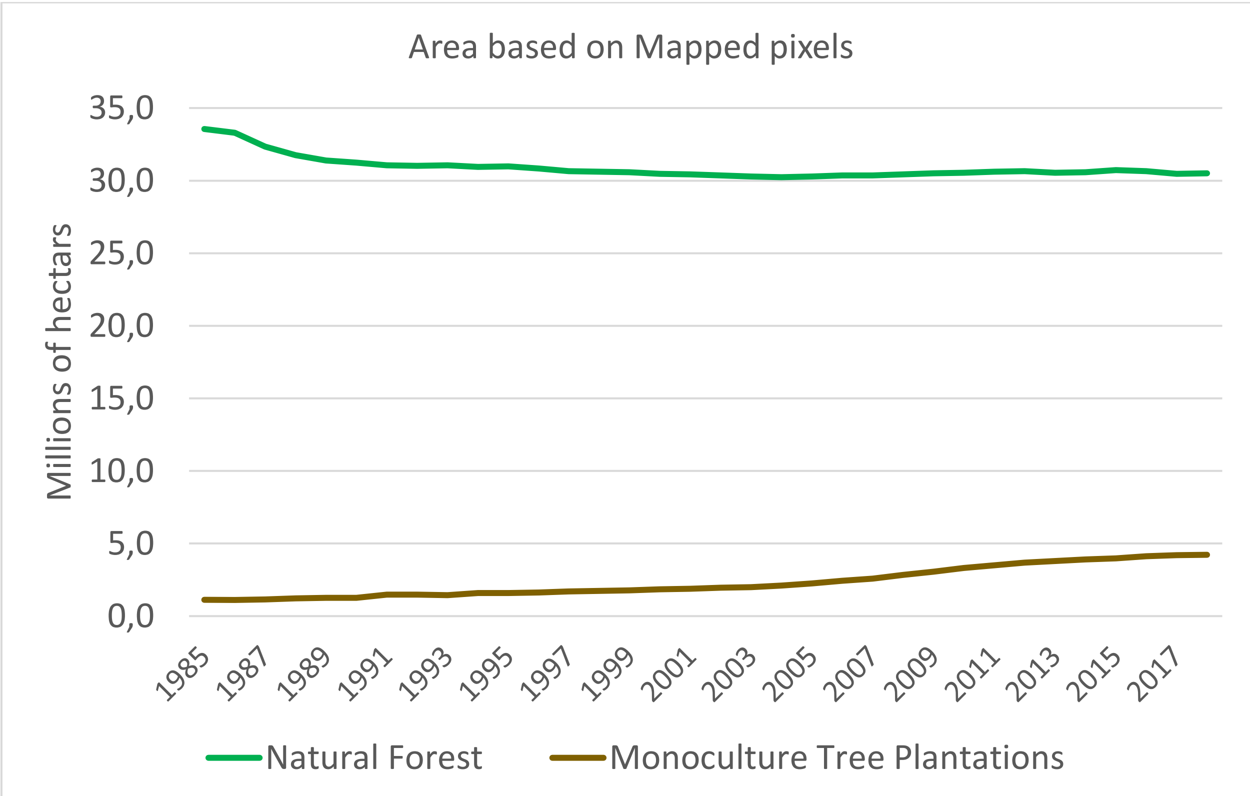

Figure S9. Annual mapped area of “Native Forest” and “Monoculture Tree Plantations” (pixel-count).

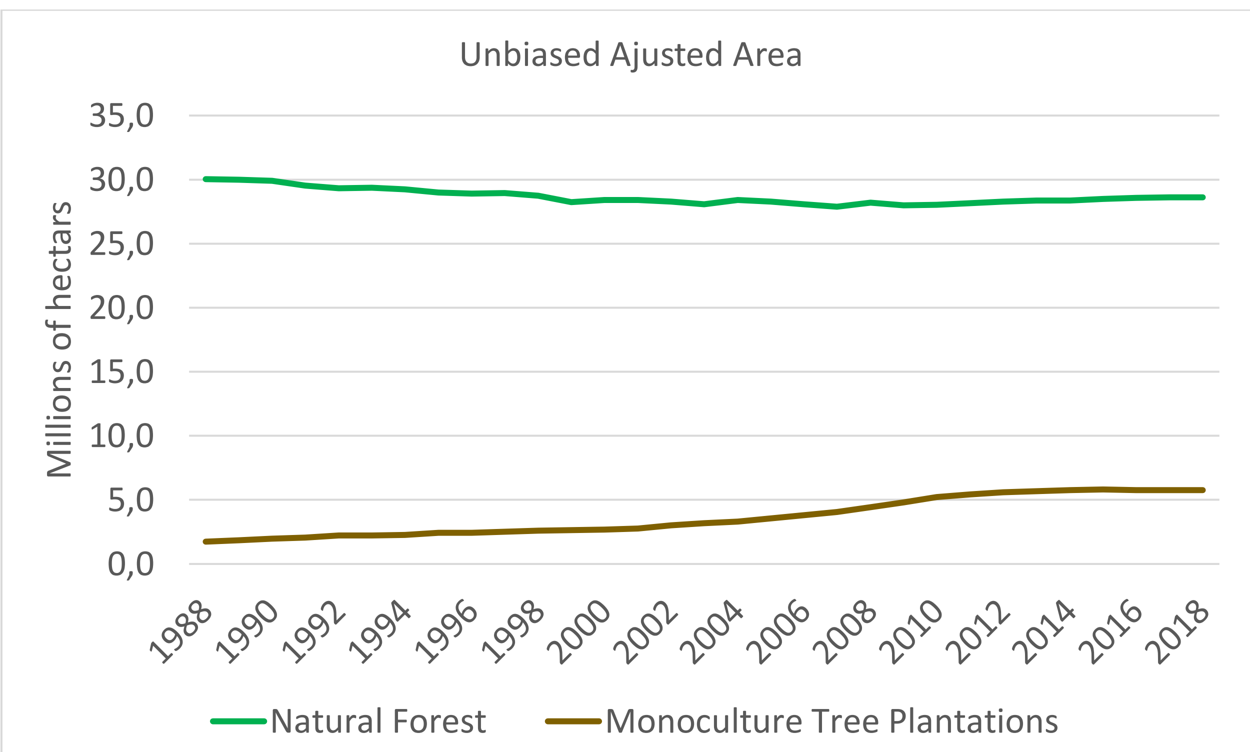

Figure S10. Annual sample-based unbiased area estimation of “Native Forest” and “Monoculture Tree Plantations”.

7. SENSITIVITY ANALISYS

To evaluate the decision of waiting 4 years to define a forest gain and 2 years to define forest loss, we tested other time spans. Forest recovery considering only 2 years of time lapse is much higher than when we consider 3 and 4 years (Figure S11), probably because it includes forest recovery from degradation caused by fire, and some noise in the classification. The values with 3 and 4 years are consistent, and probably more conservative, and for this reason we maintained our initial choice of 4 years. Deforestation rates considering 2 to 4 years of time lapse after the transition show a convergent pattern with similar values towards the end of the time series. Considering that forest loss is an abrupt event and is easier to detect than forest recovery (at the pixel-level), we considered a less conservative time span to calculate deforestation rates: 2 years.

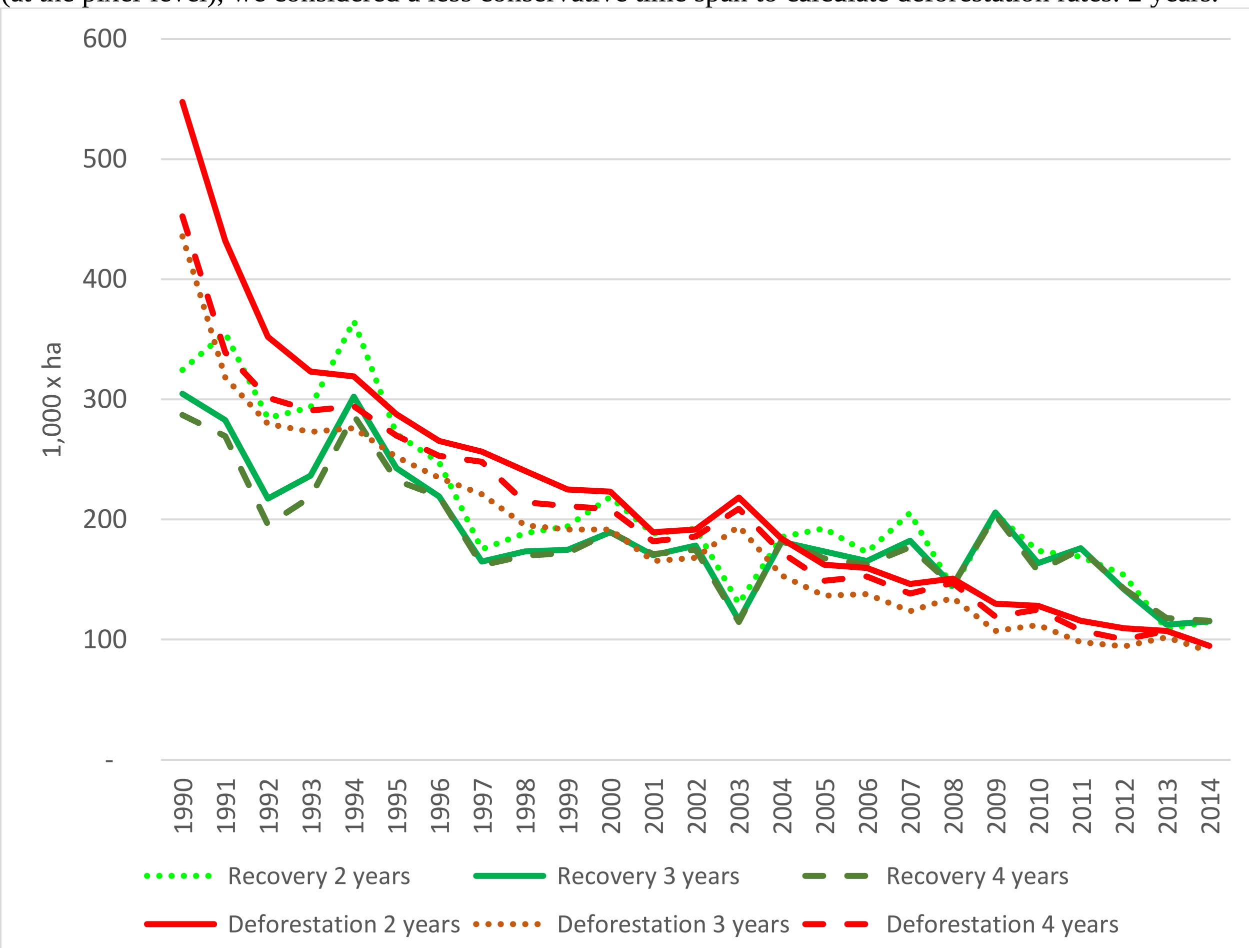

Figure S11: Sensitivity analysis of forest loss and gain considering 2, 3 or 4 years of time lapse.

8. Regional Analysis of Landscape Structure Change

The analysis of landscape structure change between 1990 and 2017 in the 250 km2 hexagons were conducted in Fragstats 4.2.1 (*71*). We calculated the percentage of forest cover and the mean distance to the nearest neighbor to indicate isolation. Since we are dealing with dynamic landscapes with concomitant deforestation and forest gain, we must be cautious when analyzing changes in landscape metrics, such as isolation.

The deforestation process can lead to loss of entire fragments increasing isolation. However, the fragmentation process can split one fragment into two smaller fragments close to each other, and consequently reducing isolation metrics based on the distance to the nearest neighbor.

The forest gain may happen by creating isolated forest patches in the landscape which would lead to an increase in the isolation index if these new fragments are more isolated in the landscapes than the previously existing fragments. However, these increases in isolation metrics cannot be considered as negative changes in the landscape, since it is resultant from forest gain. On the other hand, isolation can be reduced by the recovery of new forest fragments between two existing fragments, reducing the mean isolation in the landscape.

In order to avoid dubious interpretation of landscape dynamics metrics we decided to present the results aggregating forest cover and isolation dynamics in the following classes:

1- Forest cover gain and reduction in isolation: these landscapes increased the forest cover. These landscapes also had a reduction in isolation, probably due to connection of existing patches and reducing the distance between existing patches (by the growth of patches or creating new patches between further patches).
2- Forest cover gain and no reduction in isolation: these landscapes presented forest gain, but isolation was not reduced, or in some cases may have increased. Thus, isolation could have increased due to the creation of new patches isolated in the landscape, leading to increases in isolation metric. However, the increase in net forest cover is beneficial do biodiversity.
3- Stable forest cover and no increase in isolation: these landscapes presented stable net forest cover, and isolation was maintained or reduced. These results must be analyzed with care, because reduction in isolation could be obtained by the division of preexisting patches due to small deforestation and fragmentation processes, which had the forest loss counterbalanced by small forest recover. Thus, some of these landscapes may be increasing their threat to biodiversity due to fragmentation process.
4- Stable forest cover and increased isolation: despite not presenting net variation in forest cover, the landscape structure was altered by increasing isolation. The concomitant deforestation and forest recover processes resulted in the creation of new isolated patches and the loss of fragments between two other existing patches. Thus, forest loss was counterbalanced by forest recovery, but in isolated areas. These processes can represent threats to biodiversity, since it would not be possible to increase isolation in stable forest cover landscapes without losing or reducing the size of old forest patches.
5- Forest cover loss and no increase in isolation: landscapes that suffered net forest loss with no variation or reduction in isolation. These landscapes decreased their conservation potential due to forest loss. In some cases, the isolation could be reduced by splitting one previous patch into two or more smaller patches close to each other, or by losing entire patches that were more isolated than the average isolation in the landscape. Thus, these landscapes also represent a threat to biodiversity due to forest loss and possible fragmentation processes.
6- Forest cover loss and increase in isolation: landscapes that suffered net forest loss and also increase in isolation. These landscapes represent a major threat to biodiversity since forest area was reduced and patches became more isolated. This situation is even more critical, since most of the losses are from older forests. Moreover, the potential of recolonization and the forest recovery quality in isolated patches is smaller than if they were connected to older patches.