MAPBIOMAS

Native Vegetation Loss and Secondary Vegetation – Appendix

Collection 11

Version 1

October, 2026

1. OVERVIEW

This document describes how the native vegetation loss and secondary vegetation products are generated from Collection 11 annual land-cover and land-use (LCLU) maps. The input time series covers 1985–2025 at 30 m spatial resolution across the six Brazilian biomes. The products are derived from the temporal sequence of mapped classes at each pixel, rather than from a separate classification of vegetation loss or secondary vegetation.

The processing consists of three main stages. First, the original LCLU classes are aggregated into three groups: Anthropic, Native vegetation, and Other classes excluded from the target transition analysis. Second, temporal rules are applied sequentially to identify vegetation loss, the establishment and persistence of secondary vegetation, and subsequent secondary vegetation loss. These rules evaluate sequences of annual classes, correct selected short-duration fluctuations, and use the pixel's mapped land-use history to distinguish vegetation trajectories. Specific rules address the beginning and end of the time series, where preceding or subsequent observations are limited. Third, spatial filtering reassigns small patches that do not meet the minimum mapping area of 1 ha.

The resulting annual maps combine land-cover states, such as Anthropic, Primary vegetation, and Secondary vegetation, with transition events such as Regrowth, Loss of primary vegetation, and Loss of secondary vegetation. Regrowth identifies the mapped establishment year of a secondary vegetation trajectory, whereas Secondary vegetation represents its subsequent persistence. Transition events are assigned from 1987 onward, using the initial years (1985 and 1986) as temporal reference.

Primary and secondary vegetation are operational categories derived from the mapped history. Vegetation present at the beginning of the series cannot be distinguished from vegetation that recovered before 1985 on the basis of earlier observations. Likewise, mapped secondary vegetation indicates a trajectory of anthropic land use followed by native vegetation; it does not establish the recovery mechanism, ecological condition, or successional stage. The class aggregation, temporal rules, spatial filtering, and accuracy assessment are detailed in the following sections.

2. METHOD

2.1. Input dataset and class aggregation

The input dataset consists of the annual MapBiomas Collection 11 land-cover and land-use (LCLU) maps for 1985–2025, at 30 m spatial resolution. Each annual map provides the land-cover or land-use class assigned to each pixel. These annual classifications are used to reconstruct vegetation dynamics throughout the observation period.

Before the trajectory analysis, the original LCLU classes are aggregated into three groups: Anthropic, Native Vegetation, and Other. The Anthropic group includes the land-use and non-vegetated classes designated as anthropic in the aggregation scheme. The Native vegetation group includes the forest, savanna, grassland, wetland, and other native vegetation classes considered by the method. The Other group includes classes excluded from the target vegetation-loss and secondary-vegetation transition analysis. Table 1 presents the correspondence between the original LCLU classes and the aggregated groups. This aggregation defines which transitions can be identified by the method.

Native vegetation loss is evaluated for transitions from “Native Vegetation” to “Anthropic”, whereas secondary vegetation establishment is evaluated for transitions in the opposite direction. Changes involving the “Other” group are not interpreted through these same transition rules. The Native Vegetation group initially represents vegetation cover without distinguishing primary from secondary vegetation. This distinction is subsequently assigned through the temporal analysis and historical corrections.

Table 1. *Aggregation scheme applied to the MapBiomas Collection 11 annual LCLU time series to produce the input dataset for classification trajectory analysis.*

AGGREGATED CLASS	ORIGINAL CLASSES INCLUDED	AGGREGATED VALUE
Anthropic	Pasture, Agriculture (Soybean, Sugar cane, Rice, Cotton, Other Temporary Crops, Coffee, Citrus, Palm Oil, Other Perennial Crops), Forest Plantation, Mosaic of Uses, Urban Area, Mining, Photovoltaic Power Plant, Wind Farm, Other non-vegetated areas	1
Native Vegetation	Forest Formation, Floodable Forest, Savanna Formation, Flooded Savanna, Mangrove, Wooded Sandbank Vegetation, Wetland, Grassland, Herbaceous and shrub formation, Salt marsh, Herbaceous Sandbank Vegetation	2
Other	Hypersaline Tidal Flat, Rocky Outcrop, Beach, Dune and Sand Spot, River, Lake and Ocean, Aquaculture, Not Observed, Shallow Coral Reef	7

2.2. Classification Trajectory Analysis

2.2.1. General approach

The aggregated annual maps are analyzed at the pixel level using sequences of annual classes. Instead of treating every difference between two consecutive maps as a confirmed transition, the method evaluates the classes surrounding a candidate change and applies explicit persistence criteria. This approach reduces the influence of selected

short-duration classification fluctuations that may arise from spectral variability, mixed pixels, or uncertainty in the annual maps. Temporal consistency analysis helps identify potentially suspicious land-cover transitions, although it does not establish that every rejected observation is a classification error (Xie et al., 2020).

The analysis uses temporal windows of three, four, or six years, applied through moving windows along the time series. Rules for the final years use windows restricted to the end of the observation period. Processing is sequential; it means that each rule operates on the classifications produced by the preceding rules. The resulting series therefore contains both the aggregated input states and the vegetation-dynamics classes assigned during processing. This sequence is important because a class assigned by one rule can provide the condition required by a subsequent rule.

The processing first corrects isolated vegetation observations between anthropic years and applies specific establishment rules near the end of the series. It then identifies vegetation-loss events, establishes and propagates secondary vegetation states, and reassigns loss events associated with secondary vegetation. Additional corrections use the mapped occurrence of anthropic classes and address remaining unconfirmed secondary vegetation assignments in the final years. Spatial filtering is applied after this temporal processing. Figure 1 summarizes the workflow.

2.2.2. Native vegetation loss

Under the standard loss rule, a candidate event is evaluated using four consecutive annual observations. The required sequence is: Native vegetation – Native vegetation – Anthropic – Anthropic. The first anthropic year is assigned as the vegetation-loss year. If t represents that year, the rule requires Native vegetation in $t-2$ and $t-1$ and Anthropic in t and $t+1$. Thus, the mapped event corresponds to the first anthropic observation in a transition that persists into the following year. For example, a pixel classified as Native Vegetation in 1993 and 1994 and as Anthropic in 1995 and 1996 receives a vegetation-loss event in 1995. The second anthropic observation provides temporal confirmation; it does not shift the event to 1996.

At this processing stage, the loss event is initially assigned to Loss of primary vegetation. Subsequent rules evaluate the vegetation trajectory and historical information to determine whether it should instead be classified as Loss of secondary vegetation. The distinction between these event classes therefore requires more information than the four observations used to detect the loss. This definition refers specifically to transitions between the Native Vegetation and Anthropic groups established in Table 1. Transitions between classes within the Native Vegetation group, such as changes among forest, savanna, and grassland formations, are not considered vegetation loss or secondary vegetation.

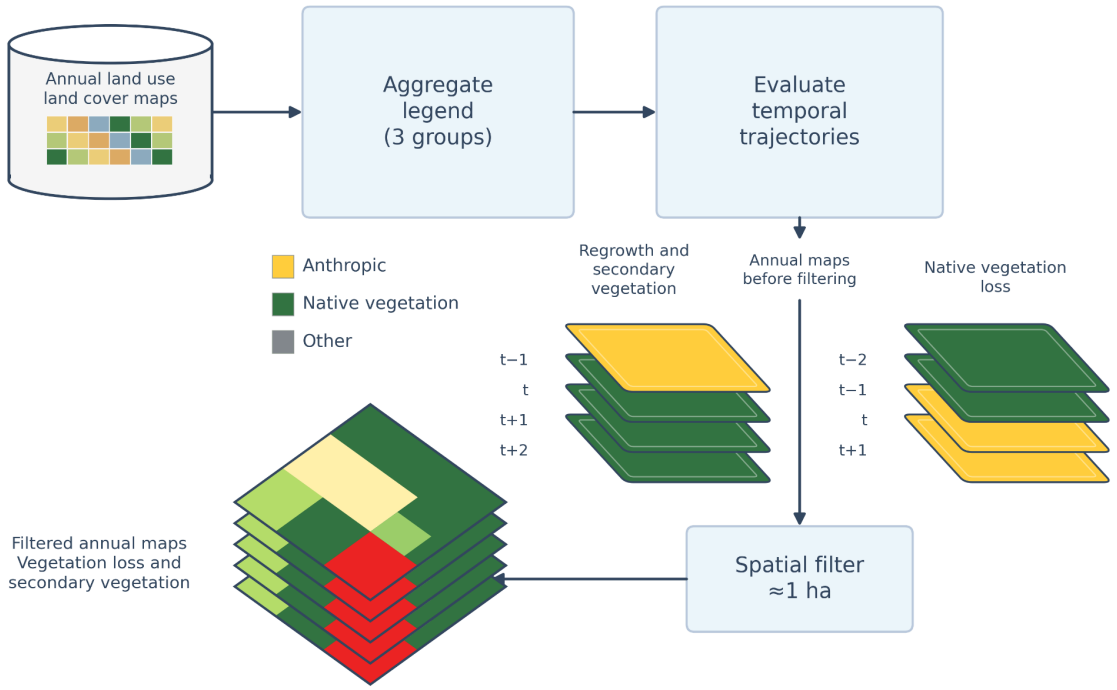


Figure 1. *Workflow used to derive native vegetation loss and secondary vegetation dynamics from the annual LCLU time series. The original classes are aggregated, temporal rules are applied sequentially at each pixel, and spatial filtering is applied to the resulting vegetation-dynamics classes.*

2.2.3. Secondary vegetation establishment and persistence

Secondary vegetation is identified when vegetation is mapped after an anthropic state and satisfies the applicable temporal criteria. Vegetation recovery is a gradual process, and its rate and trajectory can vary with previous land use, disturbance intensity, propagule availability, climate, and other environmental conditions (Aide et al., 2000; Ferreira et al., 2015; Sobrinho et al., 2016; Uriarte et al., 2010). The method therefore requires persistence of the mapped vegetation state rather than interpreting every annual Anthropic-to-Native vegetation change as establishment.

The standard establishment rule uses four consecutive observations: Anthropic – Native Vegetation – Native Vegetation – Native Vegetation. The first vegetation year is assigned to Regrowth, and the following two years are assigned to Secondary Vegetation. If t represents the establishment year, the rule requires Anthropic in $t-1$, $t-2$, and Native Vegetation in t, $t+1$, and $t+2$. For example, an anthropic observation in 2010 followed by vegetation in 2011, 2012, and 2013 results in Regrowth in 2011 and Secondary Vegetation in 2012 and 2013. The establishment year is therefore assigned retrospectively, after the subsequent observations provide evidence of persistence.

Regrowth represents the mapped establishment event within this trajectory. It should not be interpreted as the exact year when ecological recovery began, because vegetation may have started recovering before it was recognized as native vegetation in the annual LCLU maps. Once a secondary vegetation trajectory has been established, additional temporal rules propagate the Secondary Vegetation class through subsequent vegetation observations. These rules maintain the distinction between vegetation that follows mapped anthropic use and vegetation treated operationally as primary.

2.2.4. Correction of short-duration vegetation sequences

Before the main transition rules, a three-year correction addresses an isolated vegetation observation between two anthropic observations: Anthropic – Native Vegetation – Anthropic. The intermediate vegetation year is reassigned to Anthropic, producing: Anthropic – Anthropic – Anthropic. This sequence does not satisfy the standard establishment criterion and therefore does not generate a Regrowth event under that rule.

Two-year vegetation sequences can also be corrected through the interaction of successive rules. In the interior of the series, an anthropic observation followed by two vegetation observations and two anthropic observations can first generate a candidate loss event. A subsequent rule then reassigns the two vegetation years and the candidate event to Anthropic because the preceding vegetation sequence did not satisfy the establishment criterion. These corrections apply to specified sequences. They should not be interpreted as a general rule that all vegetation observations lasting fewer than three years are removed. The result also depends on the surrounding observations, the position in the series, and the order of rule application.

2.2.5. Loss of secondary vegetation

Loss of secondary vegetation is the conversion of native vegetation established after mapped anthropic land use back to an anthropic class. Its identification therefore requires both a vegetation-loss event and a preceding trajectory of secondary vegetation establishment and persistence. Under the standard loss criterion, vegetation must be observed during two consecutive years, followed by two consecutive anthropic observations. The first anthropic year is assigned as the loss year. The event is classified as Loss of secondary vegetation when the preceding vegetation belongs to a secondary vegetation trajectory identified by the method. Specific criteria apply to loss in the final year of the series, as described in Section 2.2.6.

Because the rules are applied sequentially, a vegetation-loss event may initially be assigned to Loss of primary vegetation before the preceding vegetation observations have

been consolidated as secondary. Subsequent correction rules update the vegetation states and the event class to make them consistent with the identified trajectory. One correction evaluates the three-year sequence: Secondary Vegetation – Loss of primary vegetation – Anthropic. The intermediate-year event is reassigned to Loss of secondary vegetation. The event year remains unchanged; the reassignment modifies the type of vegetation associated with the loss. Other sequential rules propagate secondary vegetation through the observations preceding a candidate loss and can also reassign the event. These operations distinguish the detection of a vegetation-to-anthropic transition from the subsequent attribution of that event to primary or secondary vegetation.

2.2.6. Treatment of the beginning and end of the time series

The temporal rules require observations before and after a candidate transition. At the beginning and end of the 1985–2025 series, some of these observations are unavailable. Specific treatments therefore restrict event assignment at the beginning of the series and adapt the persistence criteria at its end. At the beginning of the series, no observations before 1985 are available to reconstruct earlier land use. Vegetation already present in 1985 may therefore include vegetation that recovered before the observation period. Treating it as primary vegetation should not be interpreted as evidence that it was previously undisturbed.

The standard establishment rule is restricted so that its earliest eligible window covers 1986–1989. An Anthropic observation in 1986 followed by Native Vegetation in 1987–1989 assigns Regrowth to 1987 and Secondary Vegetation to 1988 and 1989. The standard loss rule can likewise assign its earliest event to 1987, using Native Vegetation observations in 1985–1986 followed by Anthropic observations in 1987–1988. Thus, 1985 and 1986 provide temporal reference for the first events assigned by these rules.

At the end of the series, the limitation concerns subsequent observations. The standard establishment rule requires vegetation in the candidate year and the following two years, whereas the standard loss rule requires an anthropic observation in the candidate year and the following year. Establishment beginning in 2023 can still satisfy the standard criterion because vegetation observations are available for 2023–2025. Establishment beginning in 2024 or 2025 requires specific six-year windows covering 2020–2025.

For establishment beginning in 2024, the required sequence is: Anthropic – Anthropic – Anthropic – Anthropic – Native Vegetation – Native Vegetation. This sequence assigns Regrowth to 2024 and Secondary vegetation to 2025. For vegetation appearing only in 2025, either of the following sequences assigns Regrowth to the final year: Anthropic – Anthropic – Anthropic – Anthropic – Anthropic – Native Vegetation or Native Vegetation – Anthropic – Anthropic – Anthropic – Anthropic – Native Vegetation. These rules use four or

five consecutive preceding Anthropic observations as evidence when future observations are unavailable. They therefore differ from establishment confirmed through three consecutive vegetation observations. A separate four-year correction addresses a vegetation sequence that returns to Anthropic before satisfying the establishment criterion. Within the 2022–2025 window, the sequence: Anthropic – Native Vegetation – Native Vegetation – Anthropic is reassigned entirely to Anthropic.

Vegetation loss in 2025 is evaluated using a four-year window covering 2022–2025. Three consecutive Primary Vegetation observations followed by Anthropic assign Loss of primary vegetation to 2025. Three consecutive Secondary vegetation observations followed by Anthropic assign Loss of secondary vegetation to 2025. These rules require three preceding vegetation observations but cannot confirm Anthropic persistence in the following year. Finally, a correction reassigns remaining Secondary vegetation observations in 2024 or 2025 to Anthropic when the immediately preceding processed observation is Anthropic. The correction is applied first to 2024 and then to 2025, using the updated 2024 classification. Regrowth assignments produced by the six-year rules are preserved, as is Secondary vegetation in 2025 when preceded by Regrowth in 2024.

Together, these treatments address the unequal availability of temporal evidence at the two ends of the series. Events assigned near the final year have less subsequent evidence than events evaluated under the standard rules and may be revised when additional annual observations become available. Figure 2 summarizes all the temporal rules applied in this product.

2.3. Spatial filtering

Spatial filtering is applied after the temporal trajectory analysis to reduce small mapped patches that may represent residual classification noise. The filter uses different temporal criteria for vegetation loss and secondary vegetation, while applying the same minimum mapping area of approximately 1 ha.

For native vegetation loss, connected patches are evaluated independently in each annual map, considering the Loss of primary vegetation and Loss of secondary vegetation classes. A loss patch must therefore meet the minimum area criterion within the year in which the event is mapped. For secondary vegetation, the filter considers the accumulated spatial occurrence of Regrowth and Secondary vegetation. The accumulated mask combines locations assigned to either class during the entire time series, allowing adjoining areas mapped in different years to form a connected patch. This approach accommodates the gradual spatial expansion of secondary vegetation. An annual occurrence smaller than the minimum mapping area can be retained when it forms part of an accumulated patch that

meets the threshold. The accumulated mask is used to evaluate patch size; it does not replace the annual vegetation-dynamics classifications.

For both groups, connectivity is defined using eight neighboring pixels, including diagonal neighbors. Patches containing 11 pixels or fewer are rejected. At the nominal 30 m resolution, one pixel represents 0.09 ha; 11 pixels represent 0.99 ha. Pixels rejected by the corresponding annual or accumulated spatial criterion are assigned to Other transitions in the evaluated annual map. They remain represented in the product but are excluded from the target loss, regrowth, and secondary vegetation classes. This reassignment does not establish that the corresponding locations had no vegetation change.

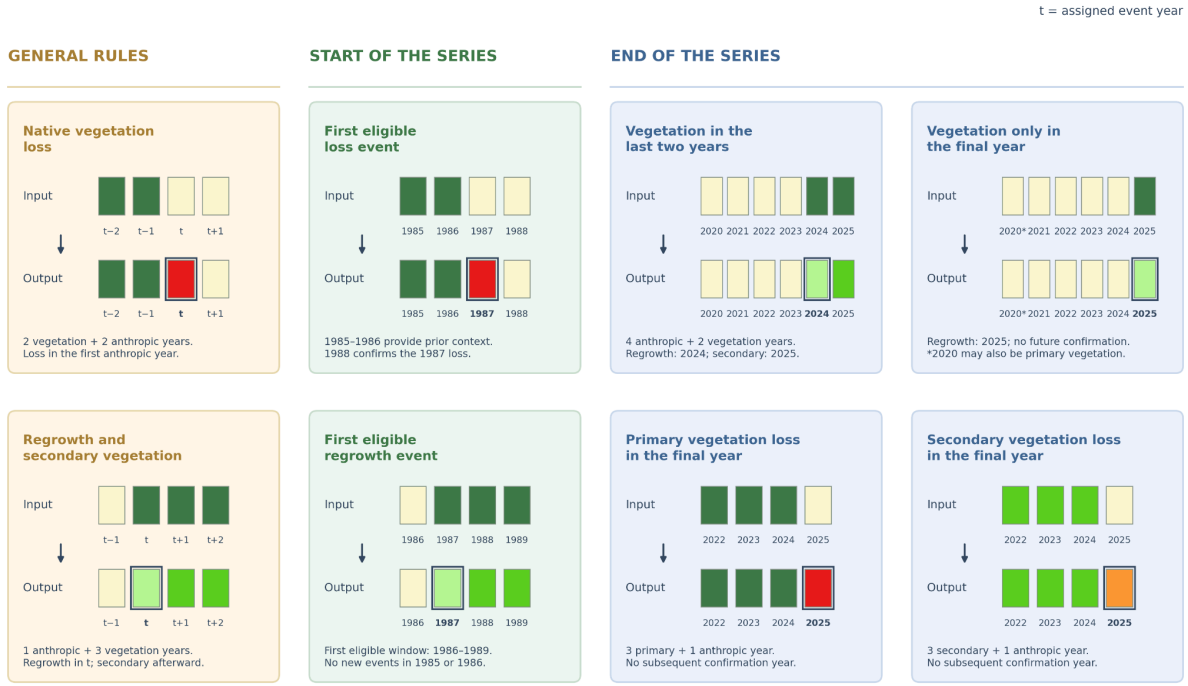


Figure 2. *Temporal rules used to identify native vegetation loss, regrowth, and secondary vegetation. Input and output sequences illustrate the general rules, the first eligible events at the start of the series, and the specific rules applied near its end. Outlined cells highlight the assigned event year. Dark green represents aggregated native vegetation in the input and primary vegetation in the output; yellow represents anthropic cover, light green regrowth, green secondary vegetation, red primary vegetation loss, and orange secondary vegetation loss.*

2.4. Classification scheme and interpretation

The annual vegetation-dynamics maps combine land-cover states and transition events. Anthropic, Primary vegetation, and Secondary vegetation describe the assigned state of a pixel. Regrowth, Loss of primary vegetation, and Loss of secondary vegetation identify

events assigned to particular years. No data and Other transitions represent observations outside these target states and events. Table 2 presents the codes, definitions, and interpretation of all output classes.

Regrowth is the establishment year assigned by the applicable temporal rule; Secondary vegetation represents subsequent vegetation observations maintained within that trajectory. Vegetation-loss classes mark the assigned event year rather than the persistence of anthropic use in every following year. The annual sequence preserves the record of mapped events even when a pixel subsequently recovers or undergoes another conversion. Summing annual loss-event areas therefore measures the area of recorded events and may count the same location more than once when successive loss and recovery cycles occur. This differs from the unique area affected by at least one loss event during the period. Primary and secondary vegetation are operational assignments based on the mapped trajectory. The Secondary vegetation class does not describe ecological condition, successional stage, or recovery mechanism. In particular, a vegetation trajectory following anthropic use should not by itself be interpreted as evidence of restoration success.

Table 2. *Codes and definitions of the land-cover states, transition events, and other classes represented in the annual maps.*

CLASS NAME	CLASS DESCRIPTION	RULE DESCRIPTION	RASTER VALUE	COLOR
Anthropic	Pixels classified as Anthropic in the input data and that did not show any change in the year analyzed	NA	1	#faf5d1
Primary Vegetation	Natural areas from the beginning of the series (1985) to the year analyzed	NA	2	#3f7849
Secondary Vegetation	Areas with a history of Anthropic use followed by a change to the Natural class in the year before the year analyzed	Classified as Natural in the year analyzed and as Regrowth or as Secondary Vegetation in the previous year	3	#5bcf20
Loss of Primary Vegetation	Areas with change from Primary vegetation to Anthropic vegetation in the year analyzed	Classified as Primary Vegetation at least two years before the year analyzed and classified as Anthropic in the year analyzed and the following year	4	#ea1c1c
Recovery to Secondary Vegetation	Areas with a history of Anthropic use followed by change to the Natural class in the year analyzed	Classified as Anthropic at least two years before the year analyzed and classified as Natural for at least two years after the change	5	#b4f792

CLASS NAME	CLASS DESCRIPTION	RULE DESCRIPTION	RASTER VALUE	COLOR
Loss of Secondary Vegetation	Areas with change from Secondary vegetation to Anthropic in the year analyzed	Classified as Secondary Vegetation at least two years before the year analyzed and classified as Anthropic in the year analyzed and the following year	6	#fe9934
Other transition	Areas classified as Other in input data	NA	7	#303149

3. ACCURACY ASSESSMENT

3.1. Validation of native vegetation loss

3.1.1. Purpose and scope

Native vegetation loss is derived from the annual LCLU maps through the temporal trajectory analysis and spatial filtering described in Section 2. Errors in the input classifications may propagate into the derived product, including vegetation-loss events that do not correspond to actual vegetation conversion. The assessment presented here focuses on commission error. Its purpose is to estimate the proportion of mapped native vegetation loss confirmed through interpretation of the Landsat time series. This proportion represents the user's accuracy of the mapped loss class.

Omission error (actual vegetation loss not represented in the product) is not estimated by this assessment. Consequently, the results do not represent overall product accuracy or producer's accuracy. Stable native vegetation points are included as controls to reduce the expectation that every sampled location contains a loss event; their inclusion does not, by itself, provide an estimate of omission.

3.1.2. Sampling design

The reference sample follows a stratified random design defined by three factors: the six Brazilian biomes (Amazônia, Caatinga, Cerrado, Mata Atlântica, Pampa and Pantanal), three native vegetation types (forest, savanna and grassland), and two classes of accumulated loss-patch size (1–3 ha and larger than 3 ha). Within each biome × vegetation type, 50 points are drawn in each patch-size class, plus decoy points on stable native vegetation, for a target of roughly 2,700 points in total. Each biome and vegetation type is analysed independently, because their error behaviour differs markedly.

3.1.3. Response design

Each sampled point is visually interpreted using a Landsat image or composite for each year from 1985 to 2025. The interpreter examines the full sequence to determine whether the location previously supported native vegetation and whether a subsequent conversion is visible. Reference labels distinguish locations with observed native vegetation loss, locations with no observed loss during the series, and locations where native vegetation is not observed. Interpretation is based on the image record rather than on acceptance of the annual map labels. The assessment described here confirms whether vegetation loss occurred at the sampled location during the observation period. Confirmation of an occurrence does not necessarily establish that the mapped event year is correct, nor does it separately validate the attribution of the event to primary or secondary vegetation loss. Figure 3 illustrates the interpretation interface.

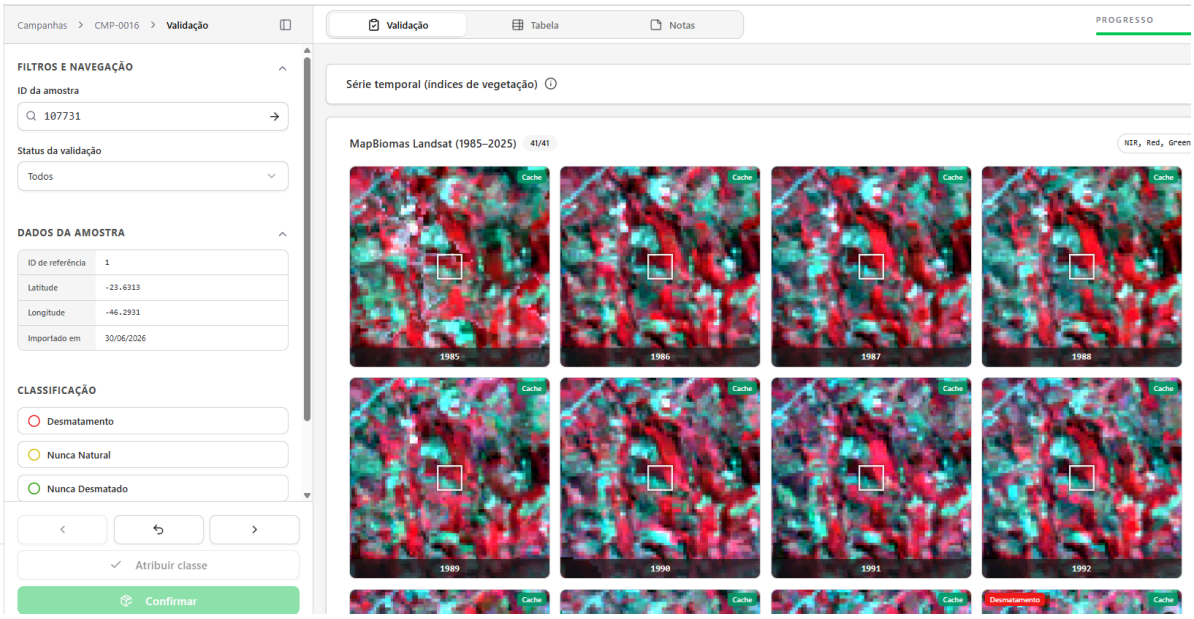


Figure 3. *Validation interface for native vegetation loss. One Landsat frame per year (1985–2025) is shown for the sampled point, and the interpreter assigns a reference label — loss, stable native, or never native — from the full time series.*

3.1.4. Analysis

For each vegetation type, the confirmed rate is the user's accuracy $\hat{U}$, with standard error $SE(\hat{U}) = \sqrt{[\hat{U}(1-\hat{U})/(n-1)]}$ and a 95% confidence interval $\hat{U} \pm 1.96 \cdot SE$ ($n = 50$ per size class). The biome estimate for each native vegetation type combines the two size classes weighted by their mapped loss area, and the national estimate for each vegetation type pools the biomes weighted by area.

3.1.5. Results for forest vegetation loss

Results are most complete for the forest vegetation type, validated in all six biomes (Figure 3, Table 3). Nationally, 82.6% of mapped forest loss is confirmed (95% CI 76.3–88.9%). Confirmation varies widely by biome: it is highest in the Pantanal (95.2%) and the Amazônia (85.0%), and lowest in the Pampa (49.5%), where roughly half of the mapped forest loss is not confirmed — largely reflecting confusion with exotic planted forest. The confidence intervals (±5 to ±10 percentage points at n = 50 per size class) are narrow for the Pantanal and wide and low for the Pampa. Figure 4 and Table 3 present the reported forest-loss results.

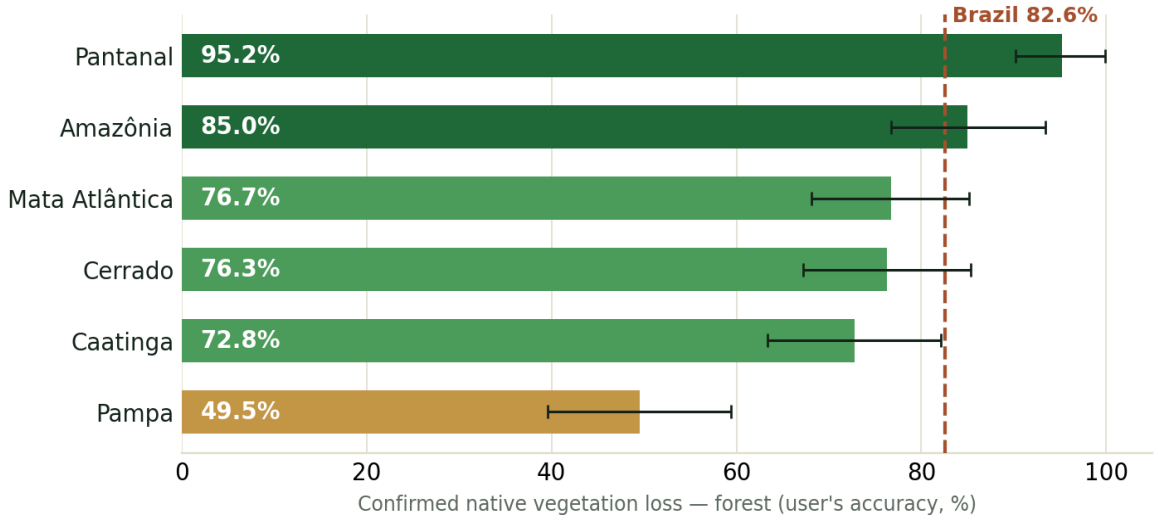


Figure 4. *User's accuracy of mapped forest vegetation loss by biome, with 95% confidence intervals. The dashed line represents the reported national estimate of 82.6%.*

Table 3. *Reported confirmation rates by patch-size category and area-weighted user's accuracy of forest vegetation loss, with 95% confidence intervals.*

BIOME	CONFIRMATION IN 1–3 HA PATCHES	CONFIRMATION IN >3 HA PATCHES	AREA-WEIGHTED USER'S ACCURACY	95% CONFIDENCE INTERVAL
Amazônia (Amazon)	80%	86%	85.0%	76.7–93.4%
Caatinga	78%	70%	72.8%	63.4–82.1%
Cerrado	65%	80%	76.3%	67.2–85.3%
Mata Atlântica (Atlantic Forest)	71%	85%	76.7%	68.1–85.2%
Pampa	49%	50%	49.5%	39.6–59.4%
Pantanal	88%	96%	95.2%	90.2–99.9%
Brazil	—	—	82.6%	76.3–88.9%

3.2. Validation of secondary vegetation

3.2.1. Purpose and scope

The secondary vegetation product is derived from trajectories of mapped anthropic land use followed by native vegetation, subject to the temporal and spatial criteria described in Section 2. Errors in the annual LCLU maps can generate apparent recovery trajectories that are not supported by the image record. The assessment focuses on commission error by evaluating whether sampled mapped secondary vegetation locations show evidence of native vegetation recovery following anthropic land use. User's accuracy represents the proportion of sampled mapped locations for which this trajectory is confirmed. This assessment does not estimate secondary vegetation omitted from the product. It also does not, by itself, validate vegetation age, ecological condition, or the exact establishment year.

3.2.2. Sampling and response design

The design mirrors the native-vegetation-loss validation. Strata are defined by biome, vegetation type, and the accumulated secondary-vegetation patch size in 2025 (1–3 ha and larger than 3 ha), with 50 points per size class within each biome × vegetation type and decoy points on stable vegetation, for a target of about 2,700 points. Each point is interpreted on the Landsat time series and assigned a reference label, and confirmed rates are combined by mapped-area weight to give biome and, ultimately, national estimates with 95% confidence intervals (Olofsson et al., 2013).

3.2.3. Distribution of secondary vegetation

The accumulated secondary vegetation to be validated totals about 32.5 Mha in 2025, distributed very differently across biomes and vegetation types (Figure 4, Table 4). At the national level, the split is roughly 41% forest, 52% savanna and 7% grassland, but this masks strong biome contrasts: secondary vegetation is almost entirely forest in the Amazônia (94%) and Mata Atlântica (82%), almost entirely savanna in the Caatinga (97%), mixed forest–savanna in the Cerrado, and predominantly grassland in the Pampa (87%). This distribution determines which strata carry the most weight in the eventual national estimate. Figure 5 and Table 4 present the distribution of the assessment population. These mapped areas describe the product and are not accuracy-adjusted estimates.

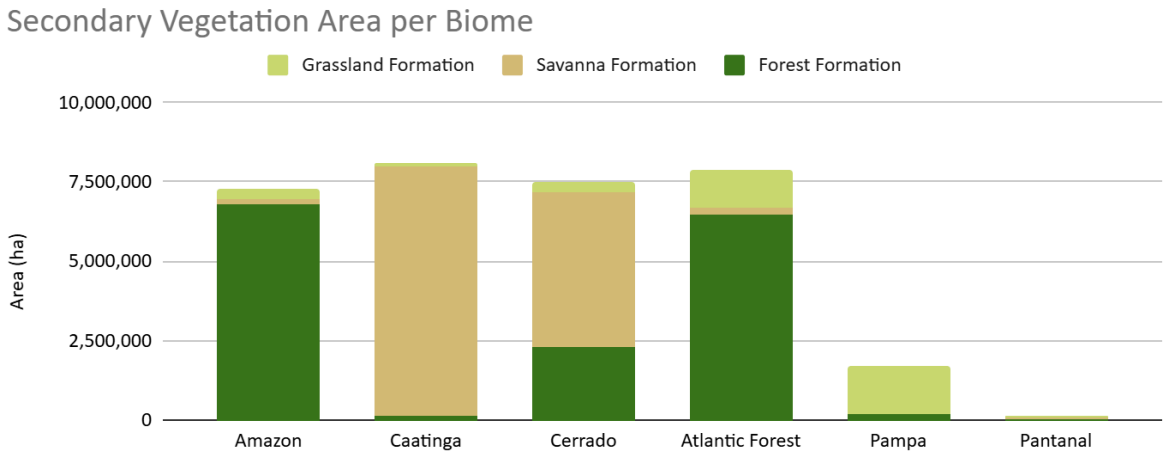


Figure 5. *Mapped secondary vegetation area in the assessment layer consolidated through 2025, by biome and vegetation type.*

Table 4. *Reported mapped secondary vegetation area (in hectares) by biome and vegetation type in the assessment layer consolidated through 2025.*

BIOME	FOREST FORMATION	SAVANNA FORMATION	GRASSLAND FORMATION	TOTAL
Amazônia (Amazon)	6,810,456	132,722	315,332	7,258,510
Caatinga	129,802	7,874,400	77,833	8,082,035
Cerrado	2,302,904	4,888,271	290,042	7,481,218
Mata Atlântica (Atlantic Forest)	6,470,477	192,390	1,208,404	7,871,271
Pampa	213,217	—	1,474,345	1,687,561
Pantanal	10,112	64,348	52,290	126,750
Brazil	**15,936,968**	**13,152,130**	**3,418,246**	**32,507,344**

3.2.4. Preliminary results

Interpretation of the secondary-vegetation sample is underway and only partially complete, so no national estimate is available yet; the figures below (Table 5) are the strata confirmed so far. For forest secondary vegetation, the confirmed rate is 77.9% in the Cerrado (72% for 1–3 ha, 80% for > 3 ha) and 81.6% in the Mata Atlântica (80% and 82%). For savanna secondary vegetation, it is 70.3% in the Cerrado and 65.7% in the Pantanal. Grassland strata and the remaining biomes are still pending.

Table 5. *Reported preliminary confirmation rates and area-weighted user's accuracy for completed secondary vegetation strata.*

VEGETATION TYPE AND BIOME	CONFIRMATION IN 1–3 HA PATCHES	CONFIRMATION IN >3 HA PATCHES	AREA-WEIGHTED USER'S ACCURACY	INTERPRETATION STATUS
Forest · Cerrado	72%	80%	77.9%	done
Forest · Mata Atlântica	80%	82%	81.6%	done
Savanna · Cerrado	72%	70%	70.3%	done
Savanna · Pantanal	64%	66%	65.7%	done
Other biomes/grassland	—	—	pending	in progress

Two features are already apparent. First, confirmed rates for secondary vegetation sit in a similar band to native vegetation loss (roughly 65–82% for the strata measured), consistent with both products sharing the same commission-driven error structure. Second, because the largest secondary-vegetation areas are the forest strata of the Amazônia and Mata Atlântica and the savanna stratum of the Caatinga (Table 4), the eventual national figure will be governed mainly by those still-pending strata — so the current numbers should not be extrapolated to a national accuracy. The completed values are reported here for transparency and will be consolidated once all strata are interpreted.

3.2.5. Interpretation and limitations

The assessments quantify the confirmation of mapped vegetation-loss occurrences and secondary vegetation trajectories. Their scope must be distinguished from evaluation of event timing, primary-versus-secondary loss attribution, vegetation age, or ecological recovery. The confidence intervals describe sampling uncertainty under the stated sampling design. They do not include uncertainty caused by interpreter disagreement, limited image availability, mixed pixels, or residual geolocation differences. Shared dependence on Landsat observations also means that the map and reference interpretation may be affected by some of the same observational limitations.

User's accuracy is the principal metric reported because the assessment targets mapped occurrences. Producer's accuracy, omission error, and overall accuracy are not estimated here. The Kappa coefficient is not reported; interpretation instead focuses on the accuracy measure relevant to the sampled population and its uncertainty (Pontius & Millones, 2011). Secondary vegetation results are preliminary and apply to the strata completed at the reporting date. Forest-loss estimates are available for all six biomes, but do not represent the accuracy of loss across all native vegetation types.

4. CONCLUDING REMARKS

The methodology presented here provides a framework for reconstructing long-term trajectories of native vegetation loss, regrowth, and secondary vegetation from the annual MapBiomas LCLU time series. By combining temporal persistence criteria with the historical trajectory of each pixel, the method distinguishes stable native vegetation, anthropic land use, secondary vegetation establishment, and subsequent vegetation loss while reducing the influence of short-lived classification fluctuations.

Some methodological assumptions should be considered when interpreting the results. Native vegetation present at the beginning of the time series is treated as primary vegetation unless an anthropic history is subsequently observed; therefore, land-use changes that occurred before 1985 cannot be identified. In addition, the Secondary Vegetation class represents vegetation established after a mapped period of anthropic use but does not characterize its ecological condition, successional stage, origin, or quality. Consequently, areas mapped as secondary vegetation may represent different ecological processes, including natural regeneration, restoration, or other forms of vegetation recovery (*e.g.,* Damasceno et al., 2018; Fernandes et al., 2016; Pinheiro & Durigan, 2009).

The reliability of the vegetation dynamics products depends on the quality and temporal consistency of the underlying MapBiomas LCLU classifications, since errors or inconsistencies in the annual maps may propagate into the derived trajectories. The use of temporal persistence criteria and spatial filtering reduces the influence of short-lived classification noise, but does not eliminate uncertainties inherited from the input data.

5. REFERENCES

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