# Panorama of Brazil's Forest Code

CSR
CENTRO DE SENSORIAMENTO REMOTO

LAGESA
laboratório de gestão
de serviços ambientais

UFMG
UNIVERSIDADE FEDERAL
DE MINAS GERAIS

CIT
Centro de Inteligência Territorial

OBSERVATÓRIO
DO CÓDIGO
FLORESTAL

imaflora

NICFI
Norway's International Climate and Forest Initiative

ISA
Instituto Socioambiental

ICV
INSTITUTO
CENTRO
DE VIDA

IPAM
Amazônia

BVRIO
promovendo a economia verde

Amigos
daTerra
Amazônia Brasileira

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# Policy brief

Centro de Sensoriamento Remoto – CSR/UFMG

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# 10 YEARS OF THE NEW FOREST CODE

The Forest Code (FC) is the main legislation regulating conservation on rural private lands in Brazil[1]. In short, it defines where native vegetation must be conserved or can be suppressed and also establishes ways for managing the use of natural resources in areas of native vegetation. The law basically defines two types of conservation areas on private land: Permanent Preservation Areas (APP), land strips along river, water bodies and springs as well as steep slopes and hilltops, and the Legal Reserve (LR)–a percentage (from 80% in the Amazon to 20% in the other biomes) of the property's area where native vegetation must be conserved. For non-compliant properties, the FC also determines the areas needed to be restored to native vegetation at the owner's expense, i.e., LR and APP illegally deforested before 2008.

On May 25th, 2022, the revisions to the FC completed 10 years. A decade past these revisions that relaxed the country's environmental legislation by granting a large amnesty to past illegal deforesters and lowering the needs to recover native vegetation, this anniversary is marked above all by setbacks in public policies aimed at conserving the vast expanses of native vegetation of Brazil.

Apart from the self-registration on the country's Online Rural Environmental Registry (CAR), which has already surpassed 6.5 million rural properties, there was little progress towards the implementation of mechanisms introduced by the 2012 revision aimed at enabling the enforcement of the FC.

CAR (Environmental Rural Registry) is the first of those mechanism. SICAR is a national public database meant to support environmental regularization and to tackle illegal deforestation. Enrolment on the CAR, the first step towards regularization, is mandatory, although a self-report process. The veracity of CAR data must be checked by the state environmental agencies through the so-called "CAR validation", which has experienced continued delays. So far, validation is still carried out as a manual process that has analyzed no more than 0.49% of properties on SICAR. In the absence of validation, fraudulent CAR registries are often used as a tool for land grabbing, thus threatening protected areas and collective lands.

The lack of progress hinders also the implementation of other key mechanisms introduced to help landowners attain compliance, such as the Environmental Regularization Program (PRA), and the Market for Trading Environmental Quotas, also known as Forest Certificates (CRA). In addition to helping solving the country's FC environmental deficit, these mechanisms are essential to further national policies, such as Brazil's Nationally Determined Contribution (NDC), as they can boost large native vegetation restoration programs, providing at the same time monetary return to those who keep or restore native vegetation.

With this in mind, the civil society together with the country's scientific community has made important strides to help the Brazilian states to overcome the CAR validation bottleneck. Advances in computer modeling, the prompt availability of properties' boundaries from the Rural Environmental Registry (CAR), in addition to land use maps for the entire country, have already enabled high spatial resolution analyses[2,3] of the FC balance for numerous properties distributed over large regions of Brazil.

Here we present the results along with the methods of the latest run of our FC model for the country as a whole. The computer model we developed calculates the FC requirements and hence the level of compliance for each one of more than 6.5 million rural private properties (PP) registered on the CAR. For each individual property, the system informs the area requirements for conserving or restoring native vegetation as LR and APP. As a result, the system calculates the deficits (vegetation needed to be restored) or surpluses (vegetation above compliance) of each property. The system also informs on deforestation after 2008 (currently, only available for properties in the Amazon and Cerrado biomes).

Based on these scientific-technological advances, state governments and civil society are now provided with updated estimates of the FC balance as a means to help foster comprehensive public policies aimed at conserving or restoring native vegetation on private lands. The state of Pará has pioneered the application of this technology in order to advance the CAR validation process (the so-called CAR 2.0) as well as to develop SeloVerde–a public and transparent platform that allows tracing cattle and soy from all of the state's rural properties. CAR 2.0 is a science-based system that streamlines the validation process by applying state of art spatially-explicit modelling algorithms, including deep learning, together with high resolution remote sensed data. In turn, SeloVerde platform is a revolutionary technology that supports the due diligence to achieve deforestation-free agricultural supply chains. Both systems are now being expanded to Minas Gerais and other states of Brazil as well.

# BRAZIL

**Bahia is the state with the most PP, totaling about 953 thousand**

## 6.5 million rural private properties

**Mato Grosso is the state with the largest area occupied by rural properties: 64.5 Mha**
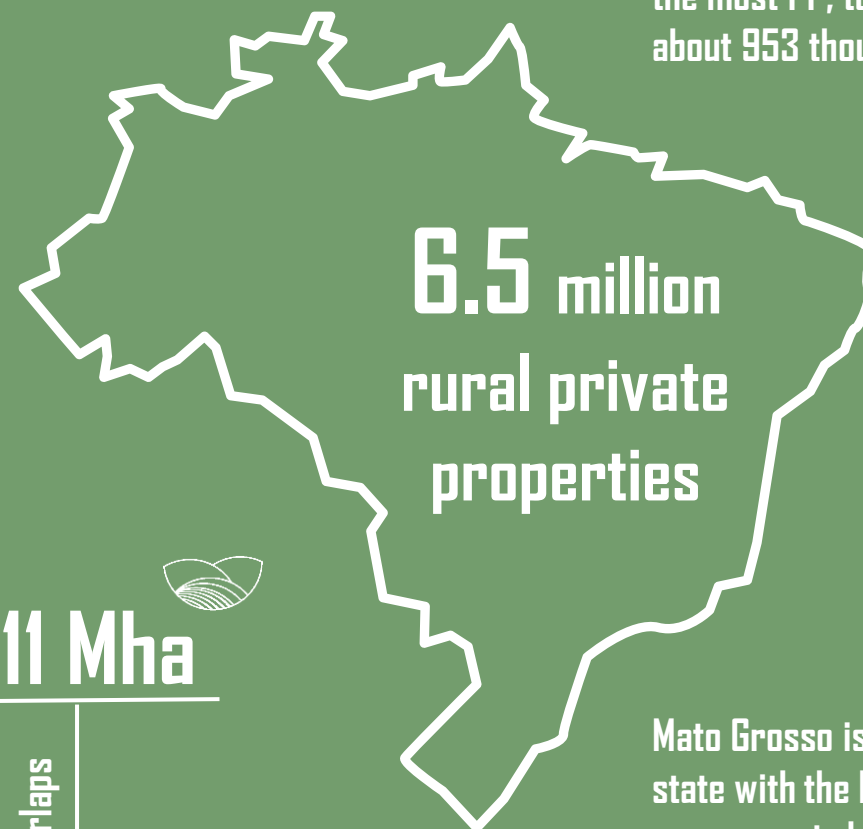
511 Mha

Without overlaps

449 Mha 〉 53% **Brazil's territory**

| 86-104 Mha Legal reserve surplus | 16-20 Mha Legal reserve deficit | 3-4 Mha APP deficit |

# Biomes

The Amazon and the Cerrado are the two largest Brazilian biomes and the ones where the expansion of the agricultural frontier and deforestation are most critical despite their relevance for sociobiodiversity conservation, climate change mitigation and rainfall regulation. Therefore, the conservation of their native vegetation remnants is key to maintain the country's hydroelectric power generation, water supply to main urban centers, and the productivity of agribusiness in addition to many other ecosystem services.

**1.80** million

rural properties

**293** Mha
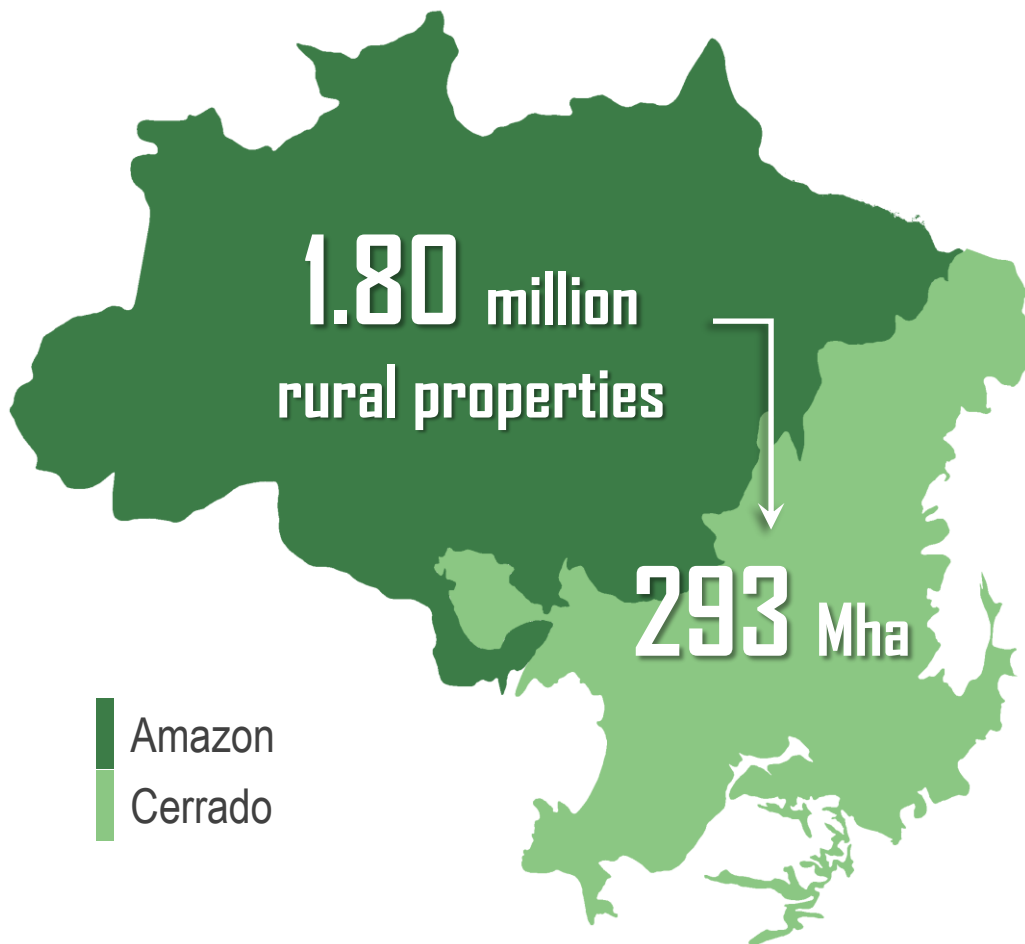
Amazon

Cerrado

## Amazon

Legal reserve
**12** ±2.3 Mha
surplus

**9** ±1.5 Mha
deficit

Rural properties
**0.73**
Million

**141**
Mha

APP
**1.06-1.41** Mha
deficit

Deforestation after 2008
**4.4** ±1.1 Mha

## Cerrado

Rural properties
**1.07**
Million

**152**
Mha

Legal reserve
**33** ±2.7 Mha
surplus

**4** ±0.3 Mha
deficit

Deforestation after 2008
**8.5** ±0.9 Mha

APP
**0.73-0.97** Mha
deficit

## Atlantic Forest

**Legal reserve**

12 ±0.9 Mha
surplus

2.3 ±0.1 Mha
deficit

**Rural properties**

2.63
Million

82.1
Mha
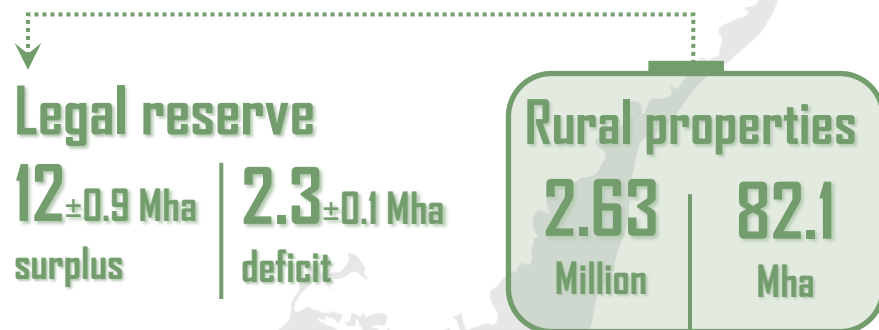
**APP**

1.0-1.3 Mha
deficit

The Atlantic Forest houses the largest cities of Brazil. Only about 15-20% of its forests remain.

## Caatinga

**Rural properties**

1.82
Million

46.4
Mha

**Legal reserve**

19 ±1.2 Mha
surplus

0.1 ±0.01 Mha
deficit

**APP**

0.21-0.28 Mha
deficit

Caatinga is the only biome that occurs exclusively in Brazil, it is home to a great diversity of endemic species.

## Pantanal

**Legal reserve**

6.5 ±0.6 Mha
surplus

0.04 ±0.003 Mha
deficit

**Rural properties**

0.01
Million

13.3
Mha
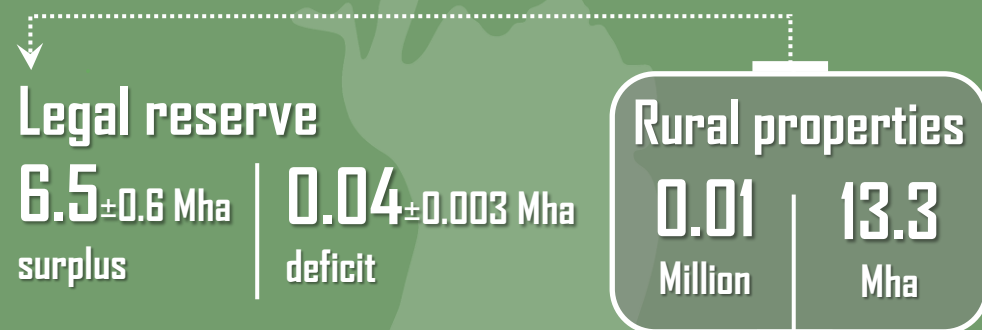
**APP**

0.02-0.03 Mha
deficit

Pantanal forms unique ecosystems that are prone to annual floods and wildfires as well.

## Pampa

**Rural properties**

0.02
Million

15.1
Mha

**Legal reserve**

5.6 ±0.2 Mha
surplus

0.17 ±0.005 Mha
deficit
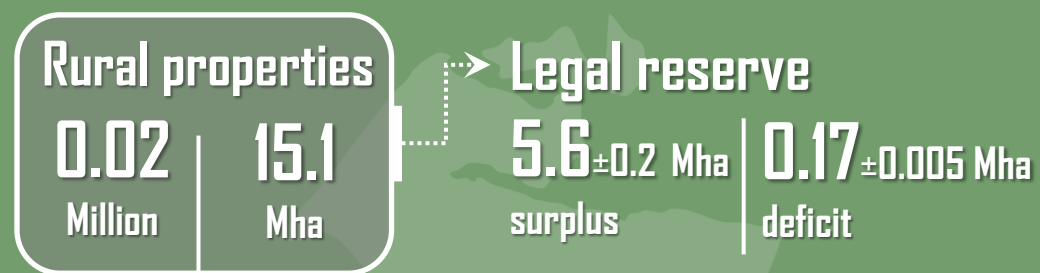
**APP**

0.10-0.13 Mha
deficit

The Pampa biome is mostly converted to agriculture with very little of its natural ecosystem under protection.

# Acre

**0.2%** Water body

**28%** Agricultural land

**71%** Native vegetation

State area
**16.4 Mha**

Private properties

**41,299** Private properties

**34%**

**5.6 Mha**

### Deforestation after 2008

**276±62** thousand ha

**68%** Potentially illegal
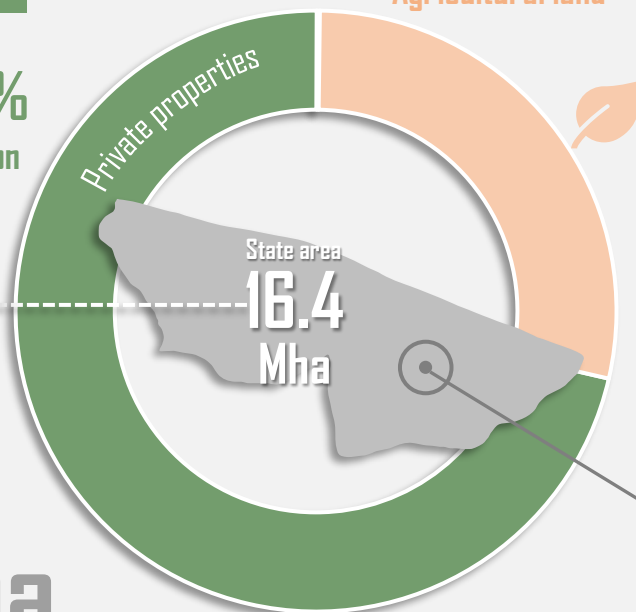
**0.6%**

**31.8-42.2** thousand ha

APP deficit

Legal reserve

**7%** **0.41±0.07 Mha** Surplus
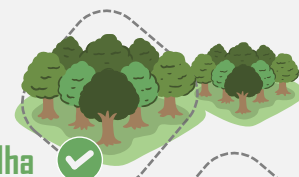
**4.8%** **0.27±0.04 Mha** Deficit

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# Alagoas

**0.4%** Water body

**76%** Agricultural land

**23%** Native vegetation

Private properties

State area
**2.8 Mha**

**106,160** Private properties

**64%**

**1.8 Mha**
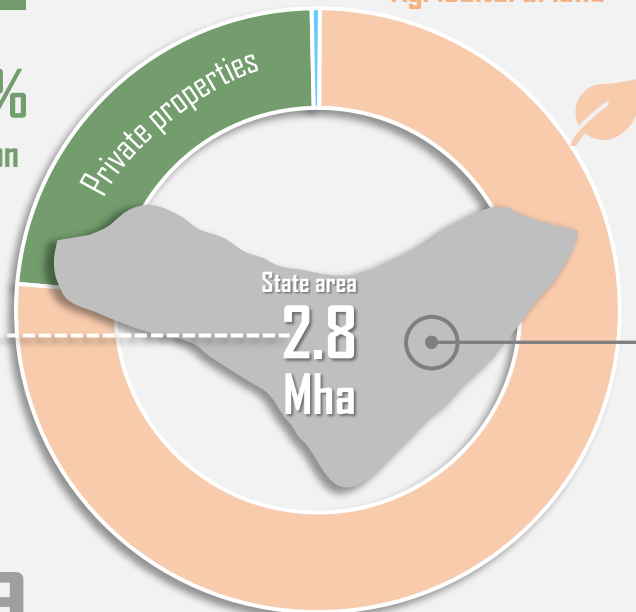
**0.8%**

**14.7-19.6** thousand ha

APP deficit

Legal reserve

**10%** **0.19±0.02 Mha** Surplus
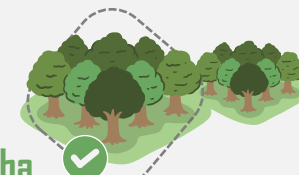
**3.6%** **0.06±0.01 Mha** Deficit

# Amapá

**2%** Water body
**7%** Agricultural land
**91%** Native vegetation

Private properties

State area
**14.2 Mha**
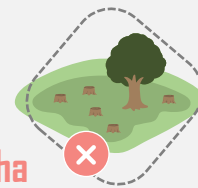
Private properties
**8,493**
**2.4 Mha**

**17%**

## Deforestation after 2008

**8.8±1.9** thousand ha
**14%** Potentially illegal

**0.2%**
**4.6-6.1** thousand ha
APP deficit
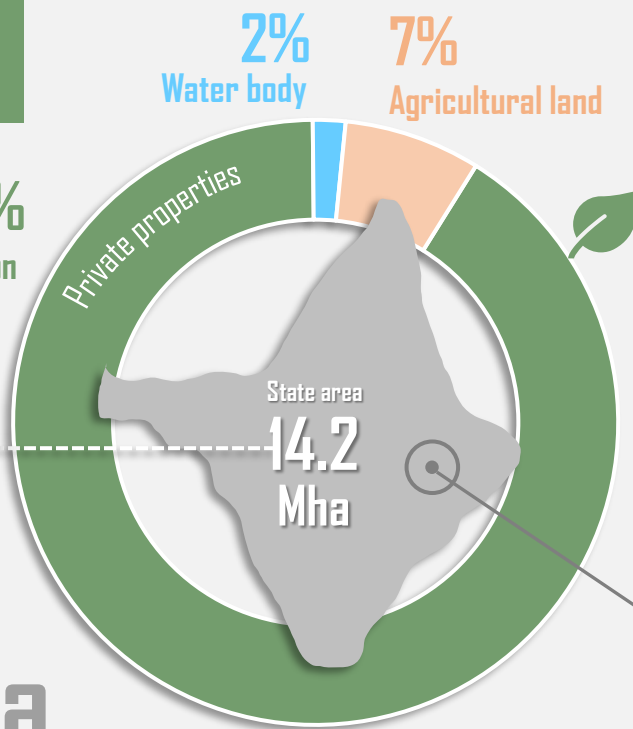
Legal reserve

**25%** **0.60±0.10 Mha** Surplus

**0.2%** **0.01±0.001 Mha** Deficit

# Amazonas

**1%** Water body
**5%** Agricultural land
**93%** Native vegetation

Private properties

State area
**156 Mha**

Private properties
**63,299**
**26.4 Mha**

**17%**

## Deforestation after 2008

**324±179** thousand ha
**68%** Potentially illegal
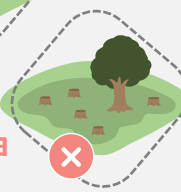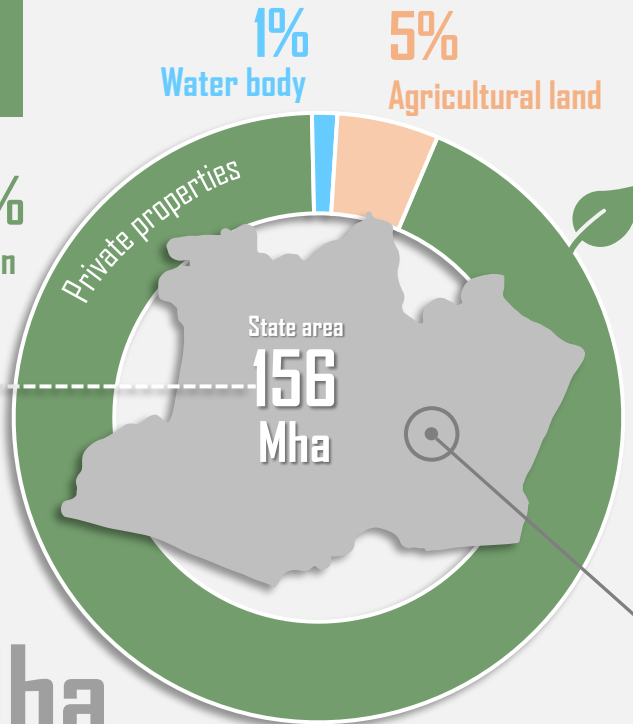
**0.1%**
**32.8-43.6** thousand ha
APP deficit
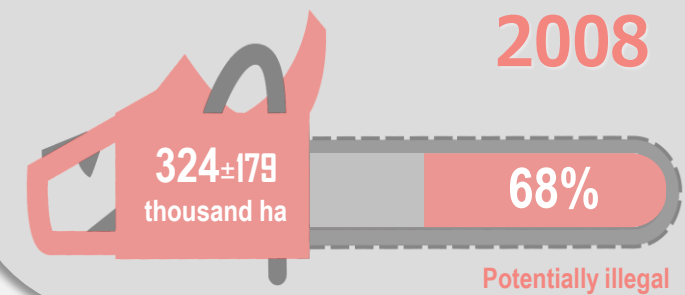
Legal reserve

**13%** **3.48±1.37 Mha** Surplus

**0.9%** **0.24±0.07 Mha** Deficit

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# Bahia

**Private properties**

**952,676**

**31.1 Mha**

55%

**0.3%**
Water body

**45%**
Agricultural land

**55%**
Native vegetation

Private properties

State area
**56.5 Mha**

### Deforestation after 2008

**1.0**±0.02 Mha

**3%**

Potentially illegal

0.5%
**157-209** thousand ha
APP deficit

Legal reserve

37% **11.5**±0.16 Mha Surplus
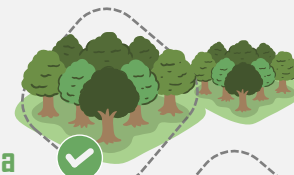
1.1% **0.34**±0.004 Mha Deficit

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# Ceará

**Private properties**

**288,037**

**8.3 Mha**

56%

**1%**
Water body

**29%**
Agricultural land

**70%**
Native vegetation

Private properties

State area
**14.9 Mha**
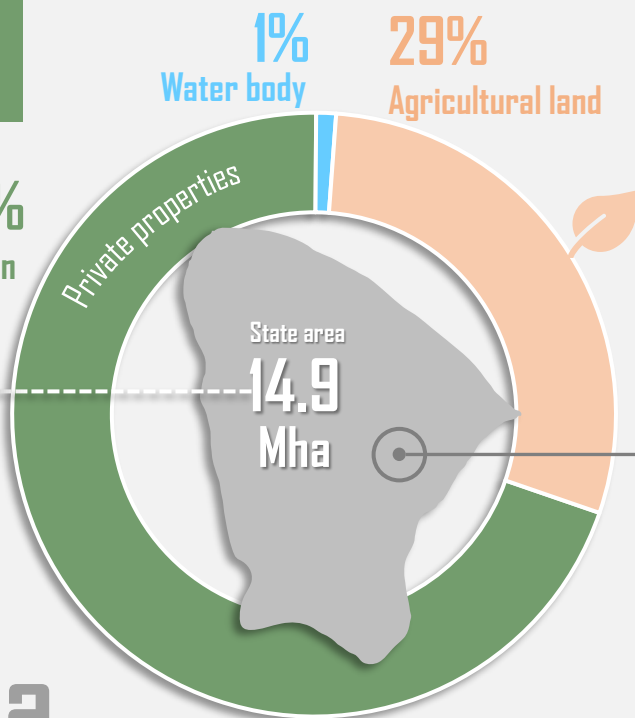
0.5%
**42.9-57.1** thousand ha
APP deficit

Legal reserve

45% **3.75**±0.34 Mha Surplus

0.1% **0.01**±0.001 Mha Deficit

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# Distrito Federal

**0.3%** Water body

**57%** Agricultural land

Private properties

**43%** Native vegetation

Private properties

**16,309**

**83%**

**0.5 Mha**

State area
**0.6 Mha**

**4.2±3.5** thousand ha

**7%**

Potentially illegal
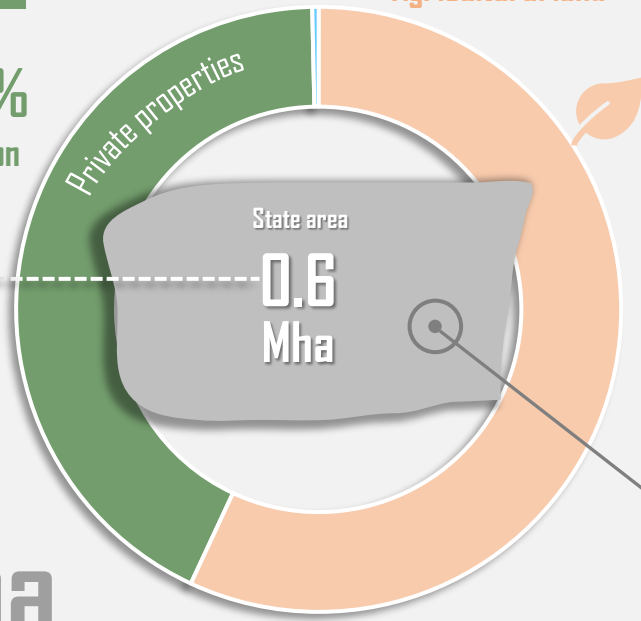
Legal reserve

**0.4%**

**2.1-2.8** thousand ha

APP deficit

**16%** **0.08±0.04 Mha** Surplus

**1.5%** **0.01±0.003 Mha** Deficit

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# Espírito Santo

**0.3%** Water body

**75%** Agricultural land

Private properties
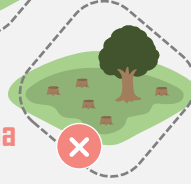
**25%** Native vegetation

Private properties

**104,471**

**72%**

**3.3 Mha**

State area
**4.6 Mha**
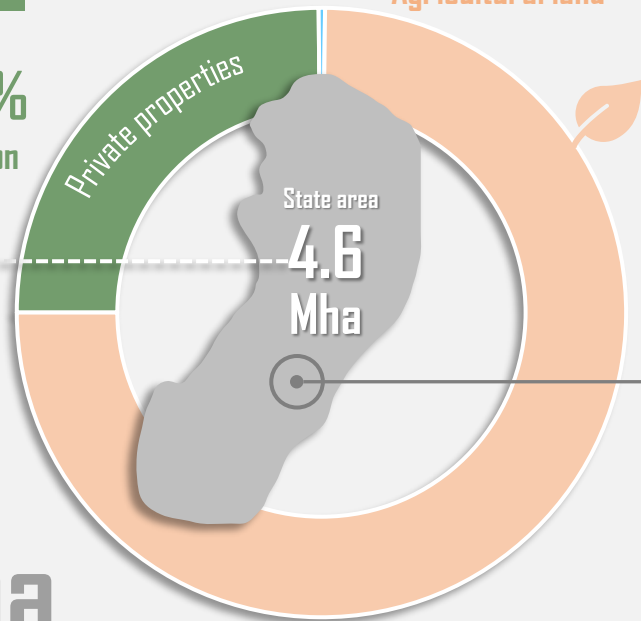
Legal reserve

**2.0%**

**67.3-89.5** thousand ha

APP deficit
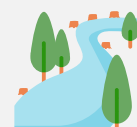
**11%** **0.36±0.02 Mha** Surplus

**3.3%** **0.11±0.01 Mha** Deficit

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# Goiás

**0.3%** Water body
**67%** Agricultural land
**33%** Native vegetation
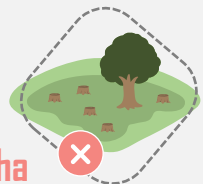
Private properties

Private properties

**188,867** Private properties

**83%**

**28.4 Mha**

State area
**34 Mha**

## Deforestation after 2008

**915±79** thousand ha
**6%**
Potentially illegal

**0.7%**
**205-273** thousand ha
APP deficit
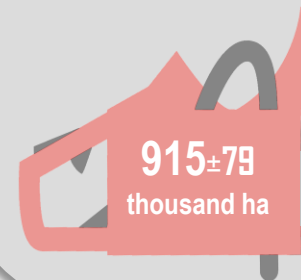
Legal reserve

**15%** **4.19±0.29 Mha** Surplus

**2.0%** **0.56±0.03 Mha** Deficit

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# Maranhão

**0.3%** Water body
**37%** Agricultural land
**63%** Native vegetation

Private properties

Private properties

**244,473** Private properties

**56%**

**18.6 Mha**

State area
**33 Mha**

## Deforestation after 2008

**1.2±0.4** Mha
**26%**
Potentially illegal

**0.5%**
**91-122** thousand ha
APP deficit
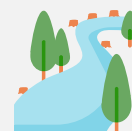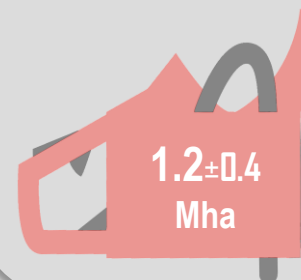
Legal reserve

**20%** **3.70±0.92 Mha** Surplus

**4.9%** **0.91±0.19 Mha** Deficit

# Mato Grosso

**1%** Water body

**44%** Agricultural land

**55%** Native vegetation

Private properties

State area
**90.3** Mha
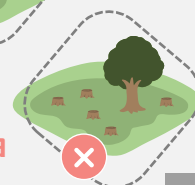
Private properties

**160,733**

**71%**

**64.5 Mha**

## Deforestation after 2008

**1.9±0.4** Mha

**41%**

Potentially illegal
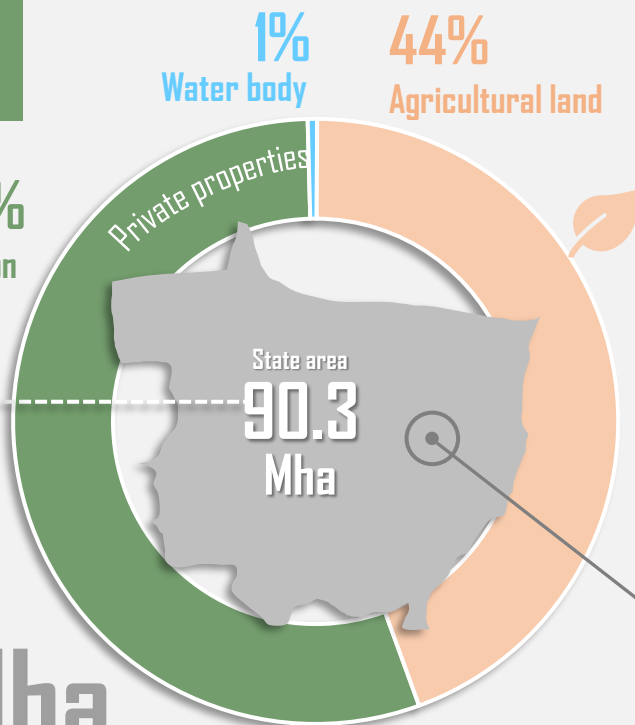
Legal reserve

**0.5%**

**293-390** thousand ha

APP deficit

**11%** **7.18±1.19** Mha Surplus ✓

**7.0%** **4.51±0.64** Mha Deficit ✗

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# Mato Grosso do Sul

**1%** Water body

**60%** Agricultural land

**39%** Native vegetation

Private properties

State area
**35.7** Mha

Private properties

**75,794**

**92%**

**32.8 Mha**

## Deforestation after 2008

**389±14** thousand ha

**7%**

Potentially illegal
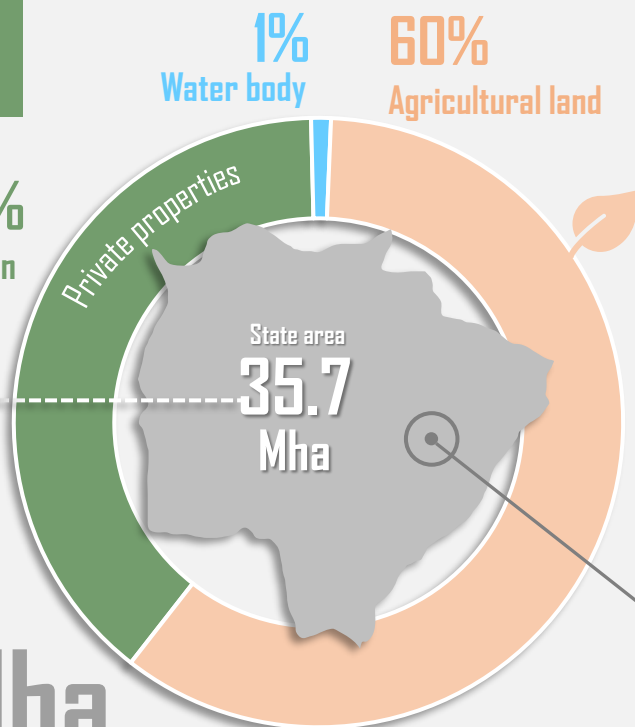
Legal reserve

**0.5%**

**163-217** thousand ha

APP deficit
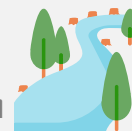
**21%** **6.82±0.20** Mha Surplus ✓

**2.6%** **0.84±0.02** Mha Deficit ✗

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# Minas Gerais

**1%** Water body

**62%** Agricultural land

**37%** Native vegetation

Private properties

Private properties

**930,995**

**78%**

**45.9 Mha**

State area
**58.7 Mha**

## Deforestation after 2008

**866±90** thousand ha

**6%** Potentially illegal
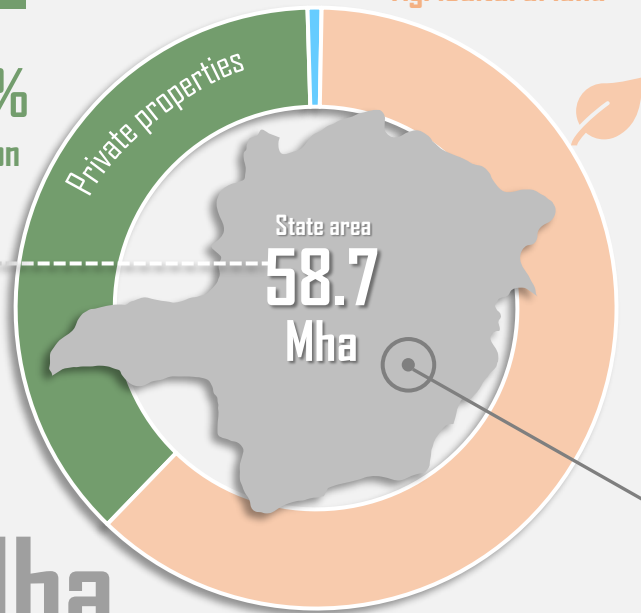
**1.0%**

**448-596** thousand ha

APP deficit

Legal reserve

**19%** **8.92±0.75 Mha** Surplus
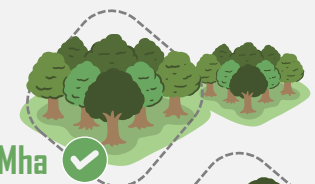
**1.5%** **0.70±0.05 Mha** Deficit

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# Pará

**1%** Water body

**38%** Agricultural land

**61%** Native vegetation

Private properties

Private properties

**260,110**

**38%**

**47.1 Mha**

State area
**124.6 Mha**

## Deforestation after 2008

**2.3±0.4 Mha**

**75%** Potentially illegal
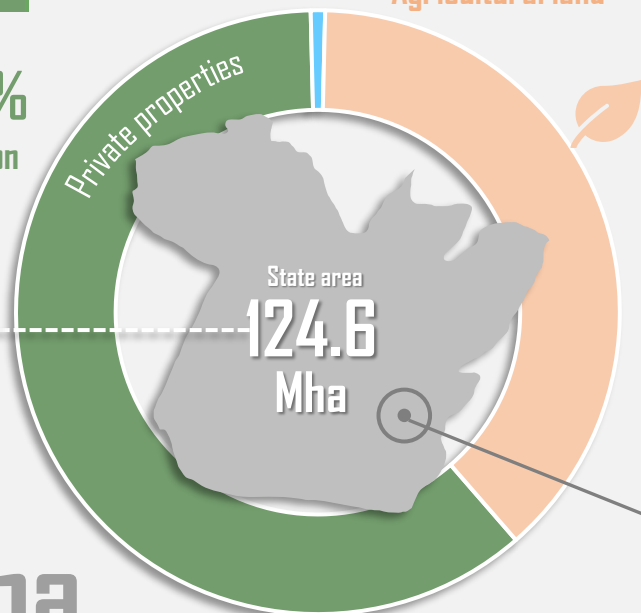
**1.1%**

**504-670** thousand ha

APP deficit
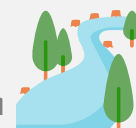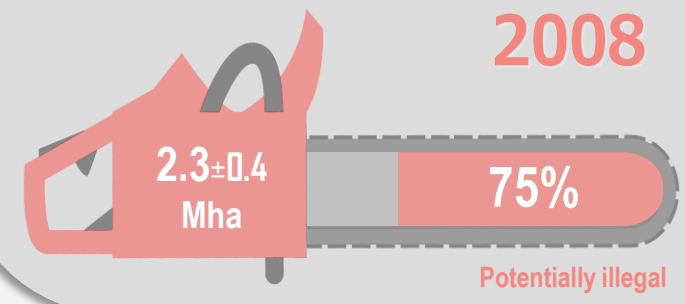
Legal reserve

**7.1%** **3.35±0.42 Mha** Surplus
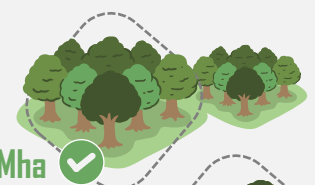
**8.2%** **3.88±0.41 Mha** Deficit
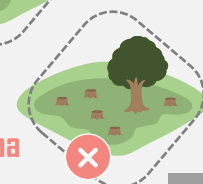
# Paraíba

**Private properties**
161,081

**3.5 Mha**

**1%** Water body
**44%** Agricultural land
**55%** Native vegetation

Private properties

63%

State area
**5.6 Mha**
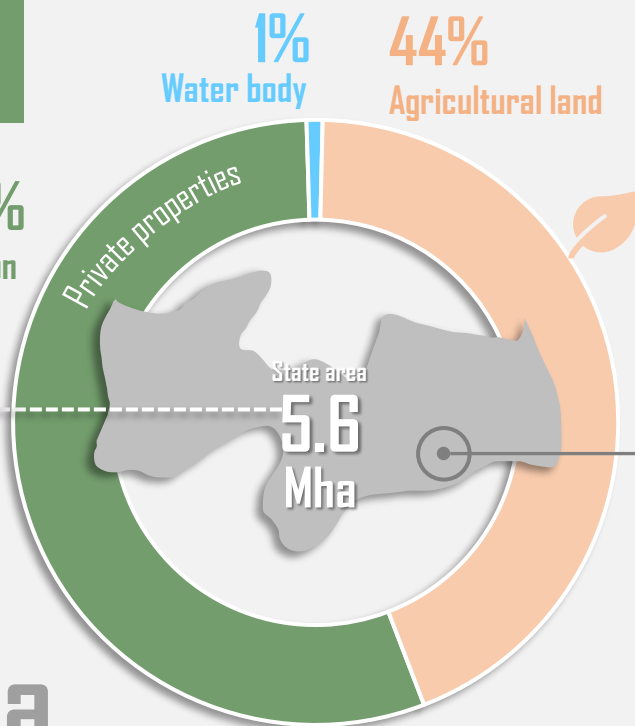
Legal reserve

0.7%
**25.6-34.1** thousand ha
APP deficit

34% **1.21±0.06 Mha** Surplus
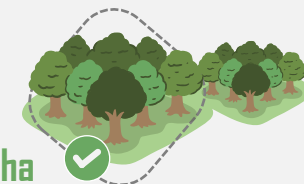
0.6% **0.02±0.001 Mha** Deficit

# Paraná

**Private properties**
481,692

**16.4 Mha**

**1%** Water body
**72%** Agricultural land
**27%** Native vegetation

Private properties

82%

State area
**19.9 Mha**

**Deforestation after 2008**

**5.1±0.5** thousand ha
**4%**
**Potentially illegal**
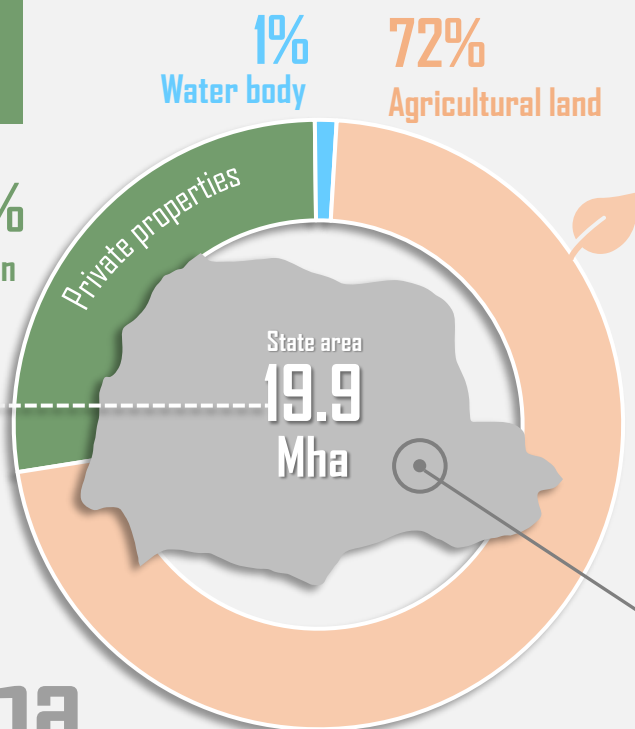
Legal reserve

1.0%
**168-223** thousand ha
APP deficit
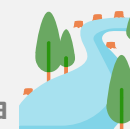
13% **2.10±0.16 Mha** Surplus
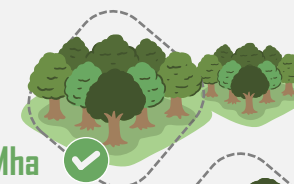
2.5% **0.41±0.03 Mha** Deficit

# Pernambuco

**1%** Water body

**48%** Agricultural land

**51%** Native vegetation

Private properties
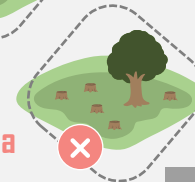
Legal reserve

Private properties

**315,361**

**5.6 Mha**

**57%**

State area
**9.8 Mha**
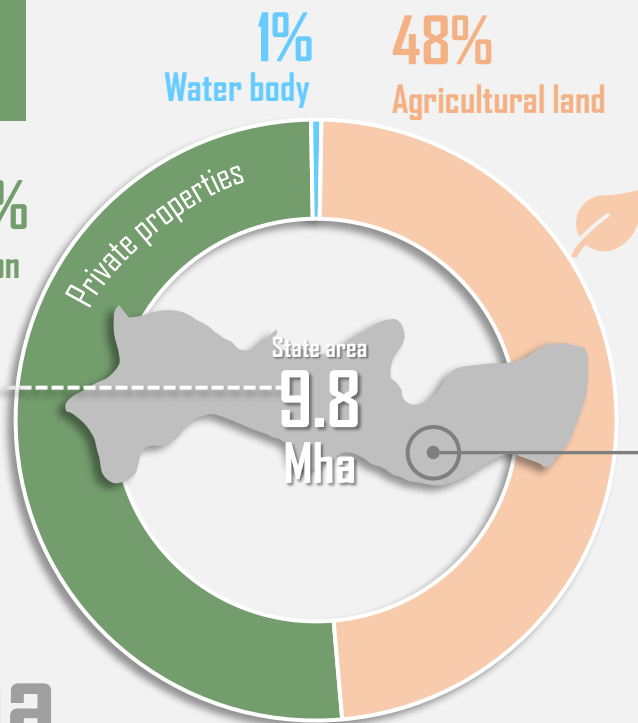
**0.7%**

**41.0-54.6** thousand ha

APP deficit
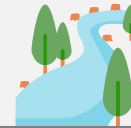
**32%** **1.82** ±0.13 Mha
Surplus
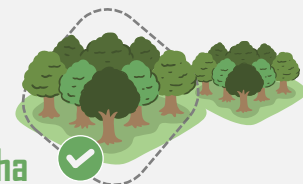
**1.2%** **0.07** ±0.004 Mha
Deficit

# Piauí

**0.1%** Water body

**20%** Agricultural land

**80%** Native vegetation

Private properties

Private properties

**238,884**

**14.7 Mha**

**58%**

State area
**25.2 Mha**
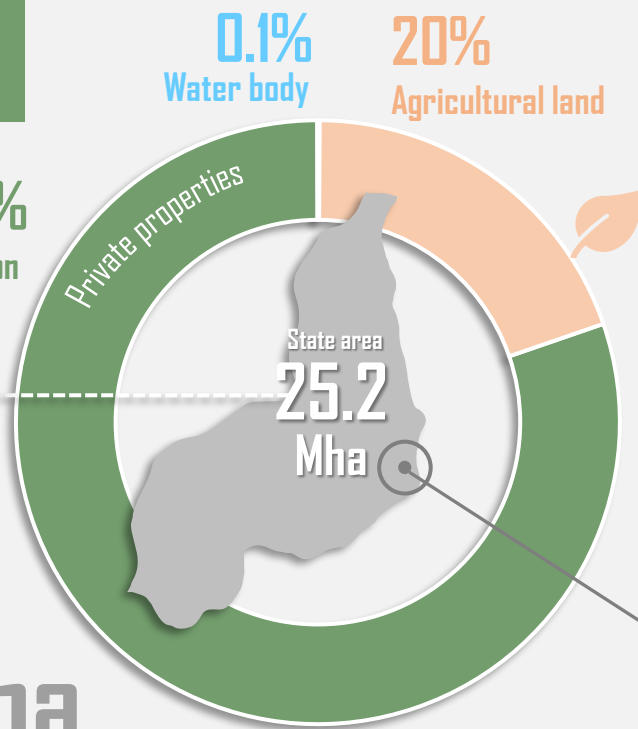
**0.2%**

**28.3-37.6** thousand ha

APP deficit

## Deforestation after 2008

**843** ±163 thousand ha

**2%**

Potentially illegal

Legal reserve

**54%** **7.97** ±1.22 Mha
Surplus

**0.2%** **0.02** ±0.003 Mha
Deficit

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# Rio de Janeiro

**1%** Water body

**69%** Agricultural land

**30%** Native vegetation

Private properties

Private properties

**56,627**

**2.5 Mha**

**57%**

State area
**4.4 Mha**
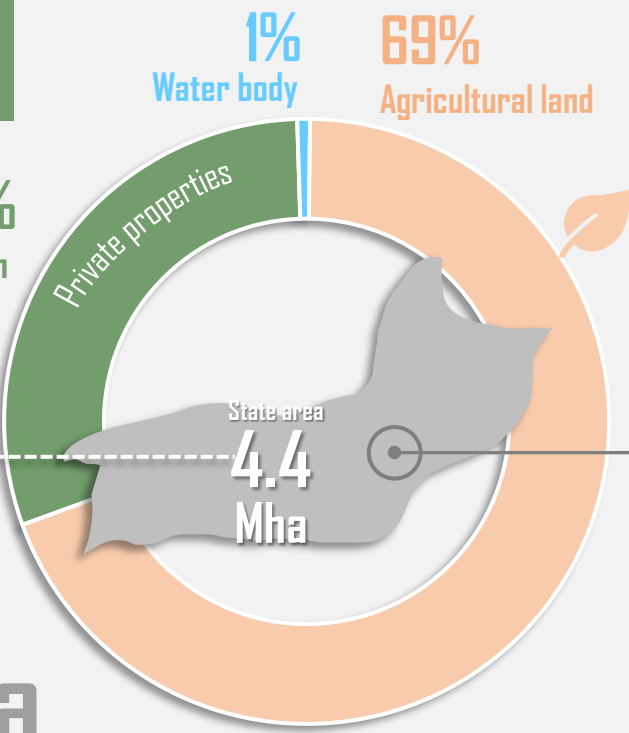
**2.1%**

**50.9–67.7** thousand ha

APP deficit

Legal reserve

**16%** · **0.40**±0.03 Mha
Surplus

**3.2%** · **0.08**±0.005 Mha
Deficit

# Rio Grande do Norte

**2%** Water body

**41%** Agricultural land

**57%** Native vegetation
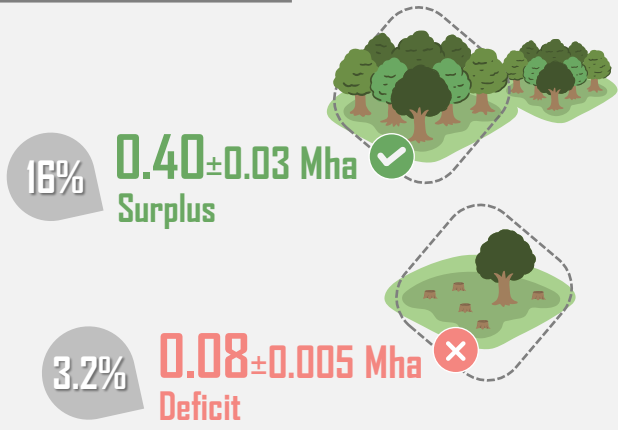
Private properties

Private properties

**83,123**

**3.0 Mha**

**57%**

State area
**5.3 Mha**
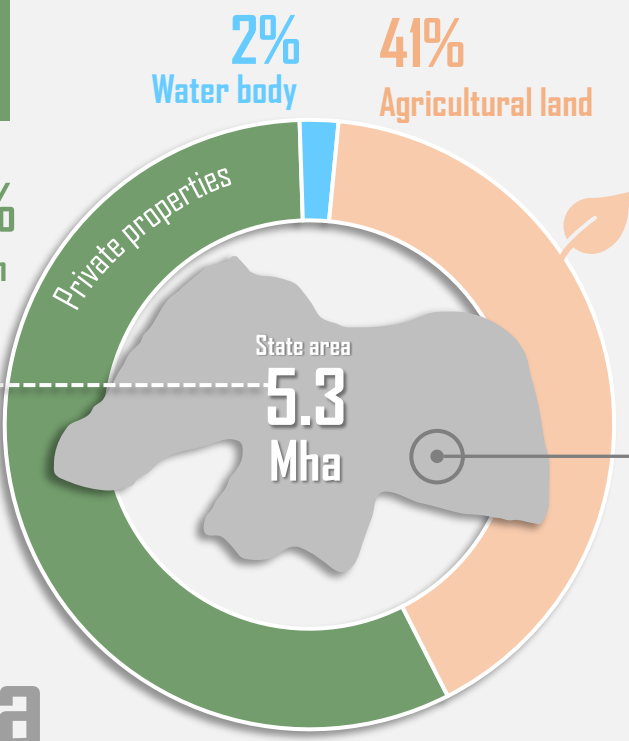
**0.8%**

**22.9–30.5** thousand ha

APP deficit

Legal reserve

**35%** · **1.05**±0.07 Mha
Surplus

**0.3%** · **0.01**±0.001 Mha
Deficit

# Rio Grande do Sul

**1%** Water body

**45%** Agricultural land

**54%** Native vegetation
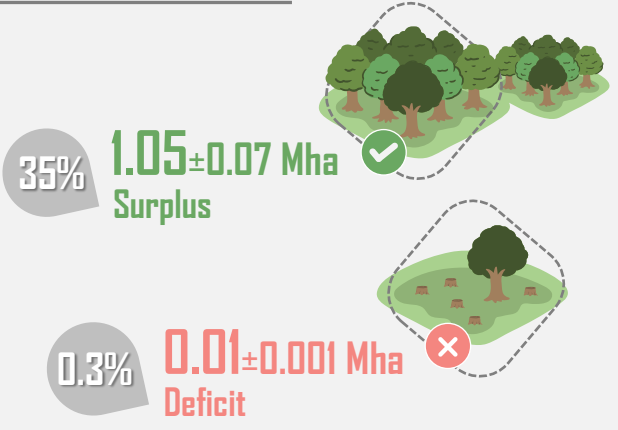
Private properties

Private properties

**593,873**

**81%**

**21.9 Mha**

State area
**26.9 Mha**
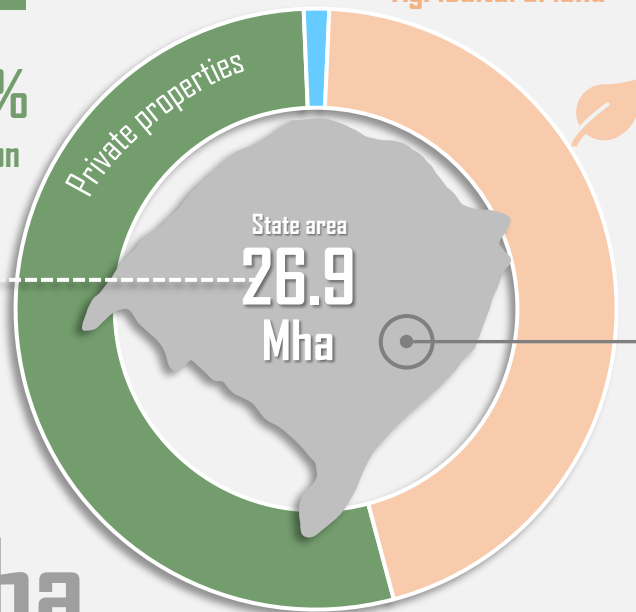
**0.6%**

**138-184** thousand ha

APP deficit

Legal reserve

**33%** **7.19±0.29 Mha** Surplus

**0.9%** **0.19±0.01 Mha** Deficit

# Rondônia

**0.4%** Water body

**59%** Agricultural land

**41%** Native vegetation
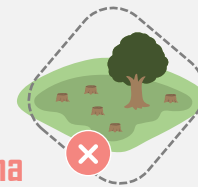
Private properties

Private properties

**139,650**

**50%**

**11.8 Mha**

State area
**23.8 Mha**
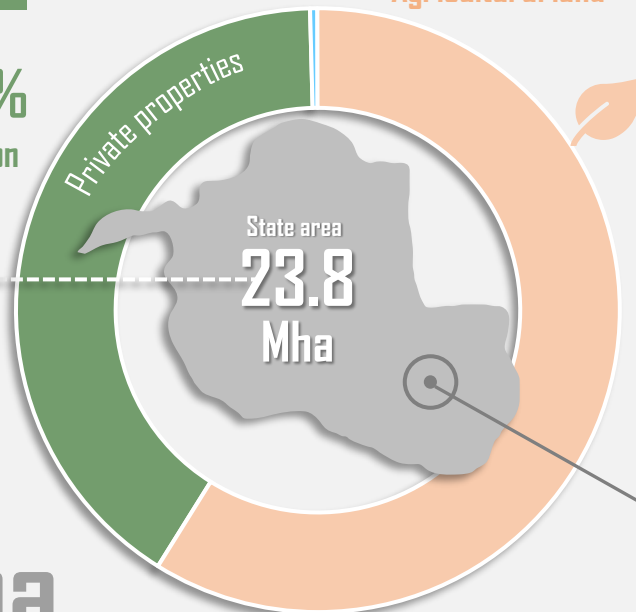
**0.7%**

**88-116** thousand ha

APP deficit

## Deforestation after 2008

**762±87** thousand ha

**86%**

Potentially illegal

Legal reserve

**4.1%** **0.48±0.04 Mha** Surplus

**9.9%** **1.17±0.09 Mha** Deficit

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# Roraima

1%
**Water body**

11%
**Agricultural land**

88%
**Native vegetation**

Private properties

State area
**22.4 Mha**
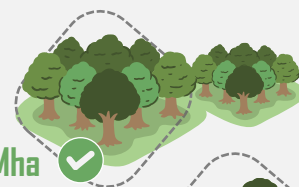
**Private properties**

**20,573**

23%

**5.1 Mha**

## Deforestation after 2008

105±29 thousand ha

**49%**

**Potentially illegal**
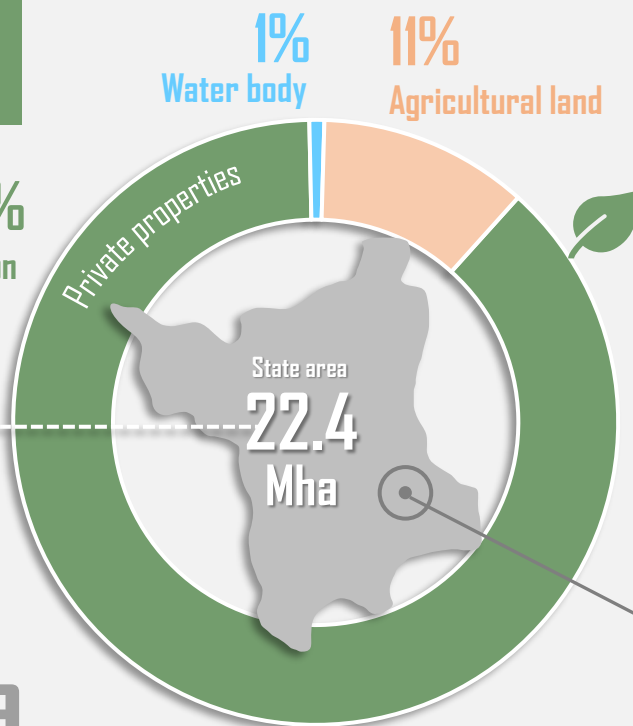
Legal reserve

0.3%

**17.3-23.0** thousand ha

**APP deficit**

20%  **1.03±0.22 Mha**
**Surplus**

1.2%  **0.06±0.01 Mha**
**Deficit**

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# Santa Catarina

1%
**Water body**

51%
**Agricultural land**

48%
**Native vegetation**

Private properties

State area
**9.6 Mha**

**Private properties**

**363,956**

77%

**7.4 Mha**
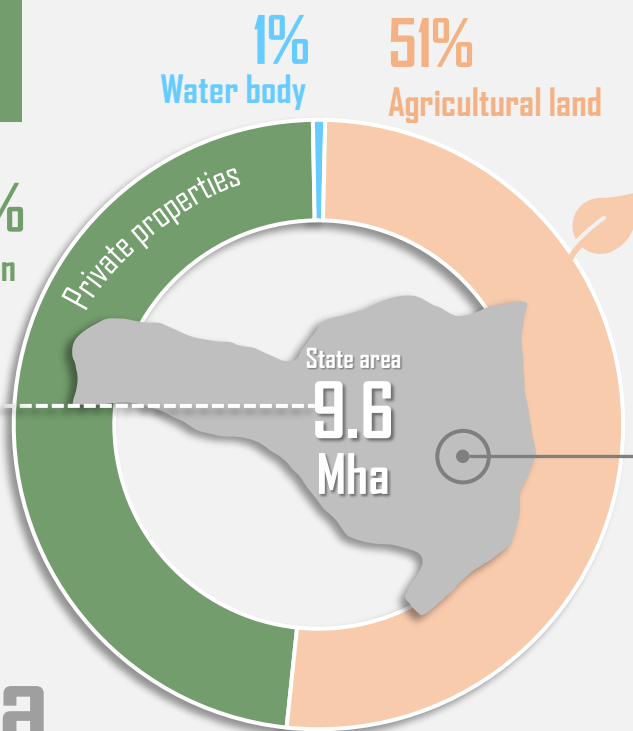
Legal reserve

0.8%

**55.3-73.6** thousand ha

**APP deficit**

28%  **2.04±0.14 Mha**
**Surplus**

0.4%  **0.03±0.002 Mha**
**Deficit**

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# São Paulo

**2%** Water body

**79%** Agricultural land

**19%** Native vegetation

Private properties

State area
**24.8**
Mha
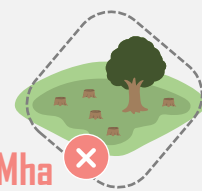
Private properties

**394,766**

**19.8 Mha**

**80%**

**6.8±0.7** thousand ha

**25%** Potentially illegal
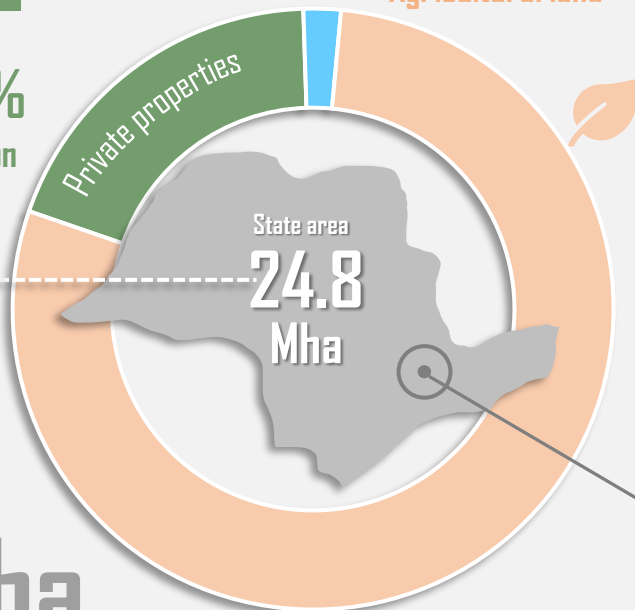
Legal reserve

**1.1%**

**223-229** thousand ha

APP deficit

**8.3%** **1.64±0.14 Mha** Surplus

**5.1%** **1.01±0.08 Mha** Deficit

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# Sergipe

**0.4%** Water body

**77%** Agricultural land

**22%** Native vegetation

Private properties

State area
**2.2**
Mha
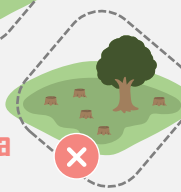
Private properties

**87,246**

**1.4 Mha**

**64%**
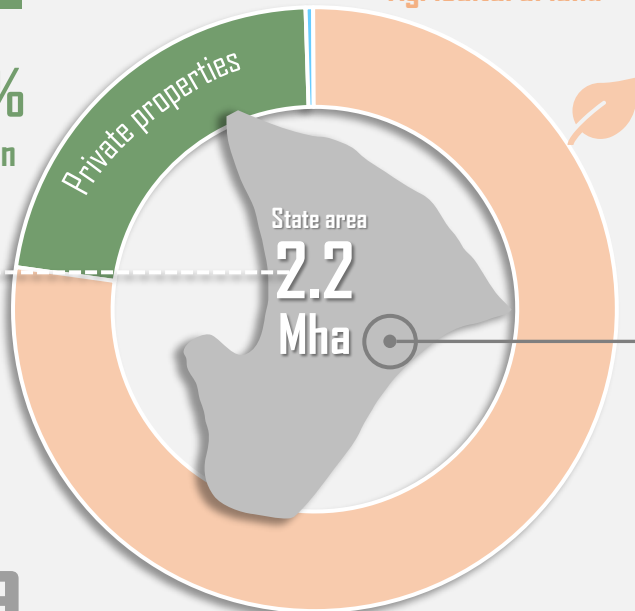
Legal reserve

**0.9%**

**12.1-16.1** thousand ha

APP deficit

**10%** **0.14±0.02 Mha** Surplus

**2.2%** **0.03±0.003 Mha** Deficit

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# Tocantins

**0.3%** Water body

**39%** Agricultural land

**61%** Native vegetation

Private properties

Private properties

**81,952**

**69%**

**19.2 Mha**

State area
**27.7 Mha**

## Deforestation after 2008

**2.0±0.1 Mha**

**8%** Potentially illegal
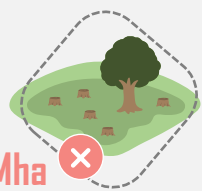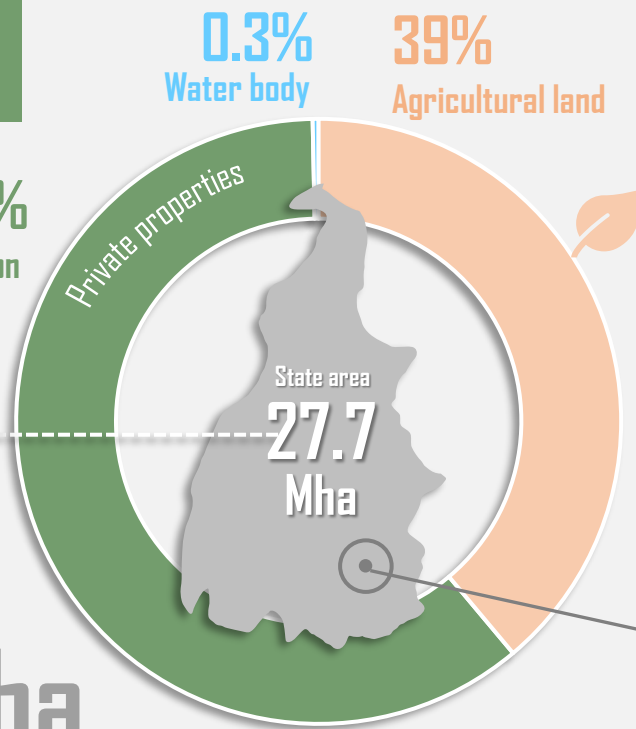
Legal reserve

**0.6%**

**120-160** thousand ha

APP deficit
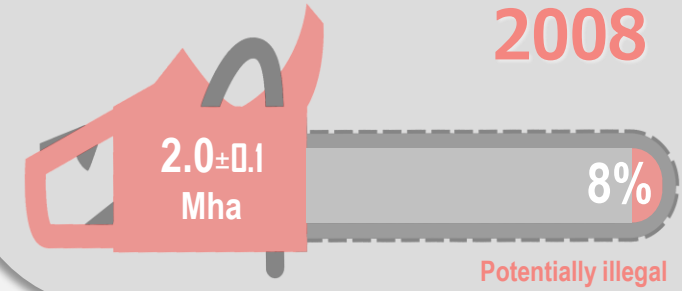
**25%** **4.76±0.12 Mha** Surplus

**4.1%** **0.79±0.02 Mha** Deficit

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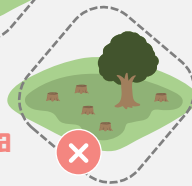
# Ranking top 5

## Legal reserve deficit*
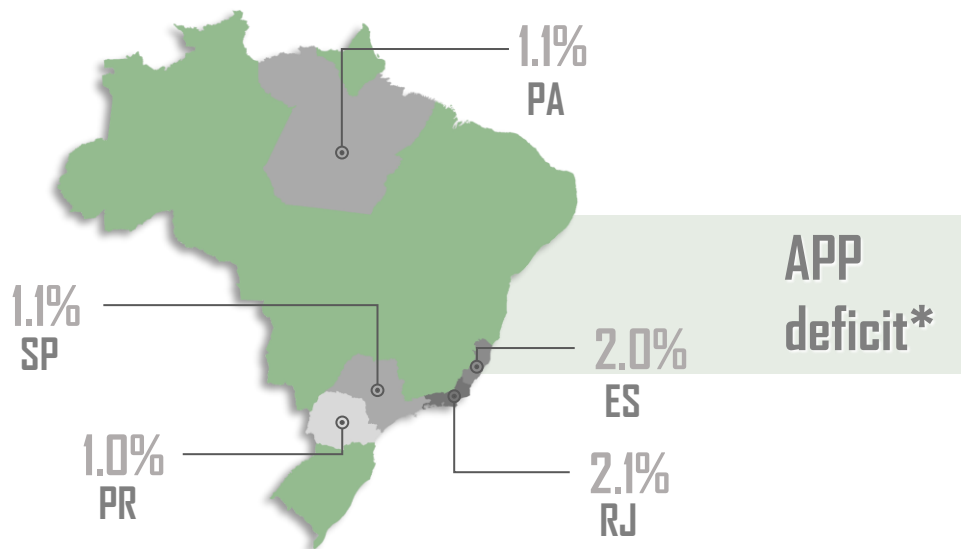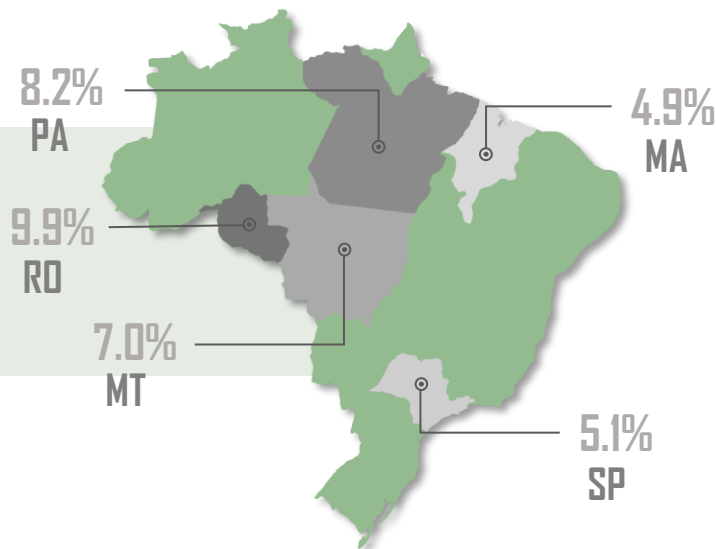
8.2% PA

4.9% MA

9.9% RO

7.0% MT

5.1% SP

## APP deficit*

1.1% PA

1.1% SP

1.0% PR

2.0% ES

2.1% RJ

## Deforestation after 2008*

10.5% **Tocantins** **2,0** Mha

6.5% **Rondônia**

6.3% **Maranhão**

5.7% **Piauí**

5.0% **Acre**

Estimated deforestation at property level, considering a minimum threshold of 6.25 ha.

## Potentially ilegal deforestation after 2008*

5.6% **Rondônia** **658** kha

3.7% **Pará**

3.4% **Acre**

1.6% **Maranhão**

1.2% **Mato Grosso**

Deforestation after 2008 on APPs or within PP with a legal reserve below the minimum required for suppressing vegetation.
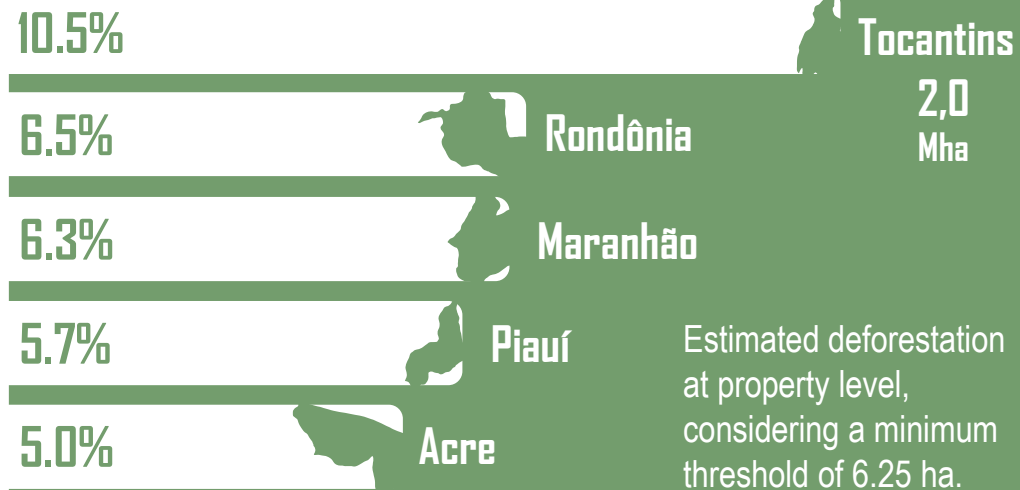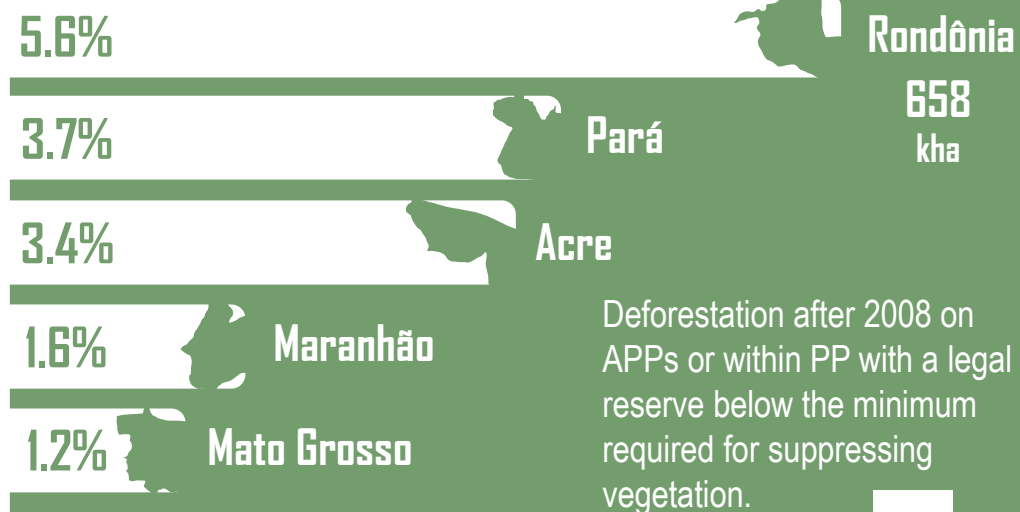
*With respect to the total area of rural properties*

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# Methods

## Datasets

To calculate the FC balance, we employed the CAR database from January 2022. We only analyzed private properties, excluding thus settlement projects and collective lands, such as quilombola (maroon) territories. In addition, the model employs as input maps of state and municipal limits, municipal fiscal modules, the limit of Legal Amazon, vegetation distribution, drainage, land use, deforestation, and protected areas.

We used the map of municipalities from IBGE (Brazilian Institute for Geography and Statistics), so as to assign the municipality geocode to each CAR record. Each Brazilian municipality has a size for the fiscal module[4]. Through the municipality geocode, the size of fiscal module is attributed to the CAR. The FC considers as a small property those from one up to four fiscal modules, a medium property those between 4 and 15 fiscal modules, and as large properties the ones larger than 15 fiscal modules.

Public domain nature conservation units (except for Áreas de Preservação Ambiental–APAs, a land zoning that encompasses mostly private domain) and demarcated indigenous lands[5] are used to calculate the percentage of a municipality and a state occupied by these land use categories, and the resulting numbers are assigned to the CAR via the IBGE geocode.

The boundary of the Legal Amazon has been extended several times as a result of changes in the political division of the country. For our modeling exercise, the limit of the Legal Amazon[6] was used to set the requirements of Legal Reserve (LR).

Vegetation formations from the Radam-Brasil are used to determine the percentage of LR in the Legal Amazon, i.e., 80% for forest formations, and 35% for other vegetation types. Outside of Legal Amazon, the FC establishes the percentage of 20% of the property for LR. When a property overlaps different biomes (i.e., Cerrado and Amazon), a weighted average is applied.

For calculating APP conservation and restoration requirements, we used the drainage maps, including springs and water bodies, from the National Water and Sanitation Agency (ANA).

Our Land-use map is a mosaic composed of water bodies from ANA, land-use categories identifying native vegetation remnants and agricultural areas (so-called "consolidated areas) from Mapbiomas, (collection 6), and maps of annual deforestation from PRODES-Amazon and PRODES-Cerrado[7-11].

## The model

We have applied the rules and definitions of the Forest Code (FC)[1] for each rural private property from the CAR dataset obtained from SICAR—the Online National Rural Environmental Registry System. In doing so, we provide estimates of the FC level of compliance, i.e., landowners' deficits—areas that must be reforested at the owners' expenses, or and surpluses, areas of native vegetation that exceed the FC conservation requirements (Fig. 1).

To this end, we have developed an innovative geoprocessing set of tools that handle big data by employing PostgreSQL and PostGIS extension, and Dinamica EGO 7 freeware[12]. This system takes advantage of full parallel processing[13]. Dinamica EGO parallel execution system uses a variable number of execution threads (called workers) boosted by task-stealing algorithms to provide load balancing and increase the flexibility for running parallel tasks. In theory, all model components can run in parallel, including independent operators, loops, and map tiles[14,15].

Substantive improvements in our computing capacity and modeling tools enabled fine-scale reanalysis of the FC[3,16], making it feasible to estimate the FC balance; i.e., level of compliance, throughout the Brazilian territory at the property-level. These advances allowed us to frog-leap from a 60-meter spatial resolution[3] to a 5-meter (the narrowest APP width for restoration) by using parallel processing and memory allocation optimization. All processing relied on the computing resources of the Center for Remote Sensing[17] of the Federal University of Minas Gerais (Belo Horizonte, Brazil). All calculations can be replicated by downloading the software and opening the FC models (csr.ufmg.br/radiografia_do_car) using Dinamica EGO's user-friendly graphical interface.

To calculate the forest balance (deficit and surpluses), the model first calculates the total area of each property where the law is applicable. Next, the model generates buffer sizes along river, spring and water bodies according to the rules of the FC (Fig. 1). To define the buffer width either for APP conservation or restoration requirements, the model uses the property size (defined in the number of fiscal modules as specified for each municipality) and river width. To calculate riparian APP buffer width to be restored, the model applies a set of rules so-called "escadinha" (little ladder), which specifies the buffer size to be restored according to the property size (defined in the number of fiscal modules as specified for each municipality) and river width.

Thereafter, the model applies the FC rules according to the property sizes to define LR requirements. In the Amazon biome, LR can be reduced by up to 50% in municipalities that have more than 50% of their territory occupied by conservation units and indigenous reserves (Art. 12, II - § 4). The FC exempts small landowners (up to 4 fiscal modules) to restore LR deficit (Art. 67). In addition, the law establishes a maximum percentage of the property for LR restoration (Art. 61-B), depending on the total extent of its riparian APPs (Art. 15). Here we consider the increase in the size of the Legal Reserve (LR) from 50% to 80% established by Provisional Measures 1,511 of 1996 and 2,166-67 of 2001. The FC also establishes that the percentage of LR for forest restoration can be reduced to 50% in the Amazon states that have the ecological-economic zoning approved.

In addition, article 68 of the of FC reviewed in 2012 states that landowners that suppressed native vegetation respecting the legislation in force at the time need not to recover LR to the percentage mandated by the current law, i.e., 80%. Therefore, it corrected conflicting past legislation to bring to legality "properties pushed into illegal status".

The difference in LR definition is the reason that we separated deforestation before 2002 and this year onwards. Deforestation before and after the decree must be analyzed with respect to different specification of LR size. Note that the time of deforestation occurring is also evidence for article 68 of the 2012's FC as specified in Paragraph 1, as follows:

"Owners of rural properties may prove their history of occupation by documents such as the description of historical facts of the region, commercialization records, data, agricultural activities, contracts and bank documents related to production, and by all other means of evidence permitted by law"[18].

The main sequence to obtain the FC balance is depicted in Fig.1. For each property, the model subtracts the total area required for LRs from the areas of native vegetation remnants within each private property and the areas of native vegetation within the customized APP buffer sizes to arrive at the level of compliance. We define a positive result as an environmental surplus and a negative result as an environmental deficit.

Uncertainties in the FC estimates arise from overlaps of properties and different drainage bases.

## Inputs

**rasters 5x5m cells**

Rivers
Land use
Deforestation
Rural properties (CAR)
Biomes
Fiscal modules

DINAMICA EGO

## Model

Minimum APP width (conservation and restoration)

APP width occupied by agriculture (APP environmental debt)

LR percentage required versus observed anthropic use

Required LR percentage (legal compliance level by biome)

APP and LR environmental deficit (conservation and restoration)

Environmental surplus for potential CRA emission (according to biome and fiscal modules)

Potential CRA emission in the Legal Amazon (percentage change of LR, according to Brazilian legislation in 2002)

## Results

↳ **Area of rural properties**
↳ **Number of rural properties**
↳ **Native vegetation**
↳ **Environmental surplus**
↳ **Environmental deficit in APP and LR**
↳ **Demanded area of APP and LR**

*Data by rural property and by municipality.*

*LR = Legal Reserve*
*APP = Areas of Permanent Preservation*
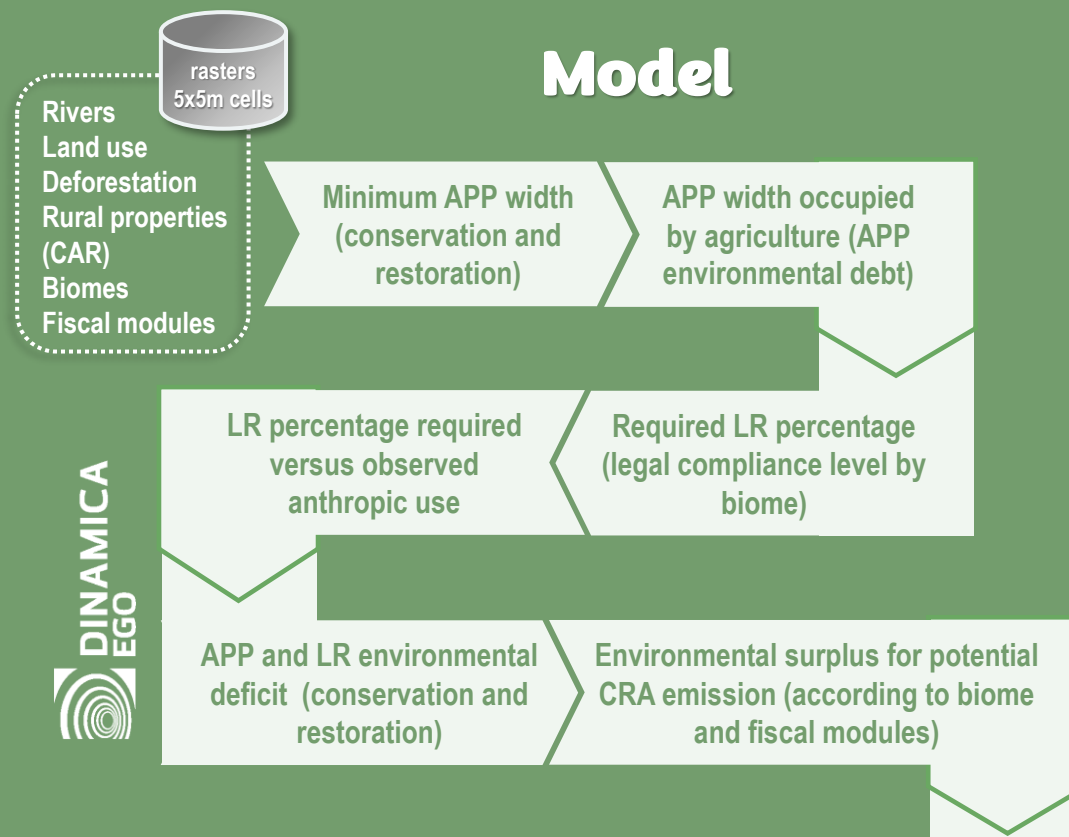*CRA = Environmental Reserve Quota*

**Fig. 1:** Flowchart of the Forest Code compliance analysis model indicating main input data, calculations and results.

## The SeloVerde platform

For traceability purpose the results per property are integrated with annual deforestation maps[10,11], soy cropping maps (Mapbiomas, collection 7), and GTA documents (permit to transport animals). The analyses of FC thus allow us to map potentially legal or illegal post-2008 deforestation—the amnesty deadline for past-deforesters[3] – so as to link deforestation to cattle and soy supply from each cattle ranch or soy farm on the SeloVerde Platform.

## The CAR 2.0

In turn, the CAR 2.0 uses mapping and spatially explicit modeling based on high resolution images to automatically analyze the environmental compliance of each rural property through the methods described above. Properties without overlaps and without significative LR and APP deficits are, as a result, directed to the Canal Verde (Green light channel), a simplified procedure for joining the PRA based on the landowner's self-report, hence without the need to rectify the RL features, hydrography, land use and others features input by the landowner.

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# Panorama of Brazil's
# Forest Code

## Policy brief
## November 2022