

# Brazilian Pampa as part of the INPE's official program for mapping native vegetation removal

Tatiana Mora Kuplich\*, Luciana Soler, Igor da Silva Narvaes, Daniela Peixoto, Patricia Trindade, Greice Silveira, and Claudio Almeida

INPE – Brazilian National Institute for Space Research, [tatiana.kuplich@inpe.br](mailto:tatiana.kuplich@inpe.br), [luciana.soler@inpe.br](mailto:luciana.soler@inpe.br), [igor.narvaes@inpe.br](mailto:igor.narvaes@inpe.br), [daniela.peixoto@inpe.br](mailto:daniela.peixoto@inpe.br), [patricia.trindade@inpe.br](mailto:patricia.trindade@inpe.br), [greice.silveira@inpe.br](mailto:greice.silveira@inpe.br), [claudio.almeida@inpe.br](mailto:claudio.almeida@inpe.br)

\* Corresponding author

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## Abstract

This abstract introduces the background knowledge and the methodological steps for mapping the removal of native vegetation in the Pampa biome, whose main domain consists of grassland vegetation. This work is part of the official governmental program that monitors all Brazilian biomes held by the Brazilian National Institute for Space Research (INPE).

Since 1988, Brazil has running a deforestation monitoring and mapping system for the Amazon biome through the PRODES project (Projeto de Monitoramento do Desmatamento na Amazônia por Satélites) (Almeida et al., 2020). This project provides annual rates and incremental maps of deforestation for the Brazilian Legal Amazon (61% of Brazilian territory). The mapping is, based on visual interpretation of Landsat series images with support of ancillary similar spatial resolution images. The Brazilian government's motivation to support PRODES in these almost 35 years has been environmental and biodiversity conservation and, more recently, as part of the REDD+ (Reduction of Deforestation and Forest Degradation) strategy, the maintenance of carbon stocks. In 2004, the "Action Plan for the Prevention and Control of Deforestation in the Legal Amazonia" (PPCDAm) was enacted by the Federal Government, but this plan has been discontinued in the last four years (from 2019), when inspection of vegetation clearing processes have been weakened or suspended, along with financial cuts.

The methods used to produce the Amazon deforestation maps are based on an incremental system (over areas already mapped that form a "deforestation" mask) using medium spatial resolution (20-30 m) images and visual interpretation by an experienced team. The minimum mapping unit is of 6.25 ha (for the Amazon) and 1ha (for other biomes) and the final mapping accuracy is at least 93%. The need for more frequent and detailed data to assist in monitoring and preventing of further degradation led to complementary projects such as the DETER (Real-Time Deforestation Detection System), but still concentrated in the Amazon biome (Almeida et al. 2021).

The "Action Plan for Prevention and Control of Deforestation and Fires", launched in 2010 by the Ministry of Environment and Climate Change (MMA), intended to reduce the rate of natural vegetation removal and forest fires in the Cerrado biome (Brazilian Savanna), introducing the monitoring and mapping of non-forest physiognomies by INPE's team and expertise. Amazonia and Cerrado biomes cover together around 75% of the area of Brazil.

The inclusion of the remaining Brazilian biomes - Pampa, Mata Atlantica, Caatinga and Pantanal - in INPE's monitoring program took place in 2015 (MMA Ordinance 365/2015). In addition to deforestation and non-forest vegetation removal, the project intended to map forest degradation, fire scars and recovery of degraded areas. In this scenario, the MMA, together with INPE and FUNCATE (Foundation for Science, Technology and Space Applications), found financial support from the Amazon Fund (which includes donations from Norway and Germany), and the "Environmental Monitoring of Brazilian Biomes" Project - the BIOMASBR Program was established.

BIOMASBR is part of the national strategy for REDD+ for the reduction of greenhouse gas (GHG) emissions by deforestation and non-forest vegetation removal in all Brazilian biomes. Its main objective is to support the mapping and monitoring of natural vegetation removal (including deforestation) in Brazil and thus generate strategic information for the territorial management for the whole country, rather than focusing on Amazonia and Cerrado biomes only. This action supports public policies by providing strategic information on the dynamics of land use and land cover. A second objective of the project is to validate the deforestation data produced to define baselines to estimate forest emission reference levels (FREL) for the six Brazilian biomes. With these consolidated data, it is possible to calculate annual GHG emissions by deforestation, forest degradation, non-forest removal and land cover/use conversion in each biome, so that the Brazilian government can apply for payments according to results in reducing GHG emissions.

BIOMASBR Program, even being initially run by FUNCATE, has been based on PRODES methodology adapted to each biome with the constant support from INPE, enabled the formation of research groups in the different regional offices of INPE. The Southern Spatial Coordination (COESU), based in Santa Maria, Rio Grande do Sul, is located in the Pampa biome, in its Brazilian part. Since 2019, COESU has hired research scholarships supported by the BIOMASBR Program, whose studies aimed to learn, modernize and automatize methods of interpretation and mapping of areas of native vegetation removal in the Pampa.

In this context, some results with the use of thermal bands (from Landsat TIRS) for the classification of land cover in the Pampa have already been published and indicated a moderate increase in the accuracy of the classifications with the use of TIRS bands (Trindade et al. 2021). Research is underway with the use of Sentinel 1 SAR (Synthetic Aperture Radar) bands, not subject to cloud cover, for land cover change classification. Machine learning classification algorithms have also been tested for the classification of land cover change in the Pampa region.

The Pampa extends through three countries, Brazil, Argentina and Uruguay, covers around 750,000 km<sup>2</sup> and composes one of the most important temperate grassland regions in the world. In Brazil, Pampa covers 178,000 km<sup>2</sup>, and official land cover mapping initiatives began in 2002, as well as its recognition as a biome that occurred only in 2004. The predominantly grassland vegetation has always favored its use for grazing, but in recent decades grain agriculture (soybeans and rice) has been the major responsible for the conversion and degradation of the Pampa (Overbeck et al. 2007). Forestry was also favored by the flat landscape and covers a significant part of the Pampa.

The recently released maps of native vegetation removal already concluded by the BIOMASBR Program (available at TerraBrasilis platform - [www.terrabrasilis.dpi.inpe.br](http://www.terrabrasilis.dpi.inpe.br), INPE 2022) indicated a total vegetation loss of approximately 34000 km<sup>2</sup> from 2000 to 2021 That represents around 20% of the Pampa remaining native vegetation (INPE 2022) and signals that the Brazilian Pampa native vegetation demands more effective conservation actions for the maintenance of its biodiversity and ecosystem services, in addition to the possibility of carbon stocks and results-based REDD+ payments.

In January 2023, with the start of a new government in Brazil, environmental commitments were renewed. The Decree No. 11,367 of January 1, 2023 establishes the Permanent Interministerial Commission for the Prevention and Control of Deforestation, reestablishes the PPCDAm and provides for the Action Plans for the Prevention and Control of Deforestation in the Cerrado, Atlantic Forest, Caatinga, Pampa and Pantanal. Hopes are for positive actions and the return of lowering (or no) deforestation rates all over Brazilian biomes.

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