**CERRADO PASTURE'S CARBON STOCKS MAPPING DATA, BY MEANS OF A MODEL BASED ON ECOSYSTEM PROCESSES (CENTURY)**

Document elaborated by the Pasture Research Nucleus of the Image Processing and Geoprocessing Laboratory (Lapig) of the Federal University of Goiás (UFG), coordinated by professor Laerte Guimarães Ferreira. This and other methods relative to data production and pastures information are available in the [Atlas of Pastures](#) platform.

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## 1. Contextualization

Cerrado has a unique importance to Brazilian livestock, concentrating the biggest pasture area and cattle herd when compared to the rest of the country. This biome's occupation history is recent, with important transformations happening in the last decades (Parente et al., 2019; Souza et al., 2020). Therefore, understanding this biome's transformations is essential to a better use of the territory, as well as to mitigate the environmental impacts.

Livestock activity, including the transformations of the land's use to pasture, is an important source to Greenhouse Gasses (GG) emission in Brazil (Albuquerque et al., 2020). Therefore, in this system there is a great opportunity to reduce and compensate for the emissions with sustainable actions to stop the liquid emissions (difference between emissions and carbon removal), since terrestrial ecosystems are widely affected by anthropic actions. This way, map and monitor pasture's carbon stock is vital. Currently, many models based on ecosystems models and biogeochemical cycles have been used to simulate chemical elements (Carbon, Nitrogen, Phosphorus), in different scenarios (Smith et al., 1997; Nicoloso et al., 2020). The Century (Soil Organic Matter Model Environment) has shown important results.

Century has been an important model among others to simulate the carbon cycle in scenarios of land's use and coverage, due to its versatility to simulate stocks in the land and in diverse parts of vegetation, regardless the class use, land coverage, and used handling technique, since it is correctly calibrated to the respective uses (Smith et al., 1997). This way, we used an analysis approach to the carbon stock mapping in pasture areas when integrating Century and Geographic Information Systems (GIS). Due to this approach, we were able to map and quantify carbon stock in pasture areas in Cerrado.

## 2. Analyses Approach

### 2.1. *Study Area*

In order to perform the analyses, the pasture identification in Cerrado was based on the map time series of this land's use class in Brazil, between 1985 and 2020, which is available on this platform ([Pasture Atlas]). Here, our reference are the areas classified as pasture in Cerrado, according to maps from 2020. The modeling was done with 1km2 of space detail, therefore the reference map for pasture areas that had originally 30 m of resolution was resampled to the mapping range. During the resampling process, it was used the median criteria, remaining classified as pastures only the 1km$^2$ pixels with over 50% of its area classified as pasture on the reference map. In this resampling process, the total pasture area was ~50,7 Mha (figure 1).

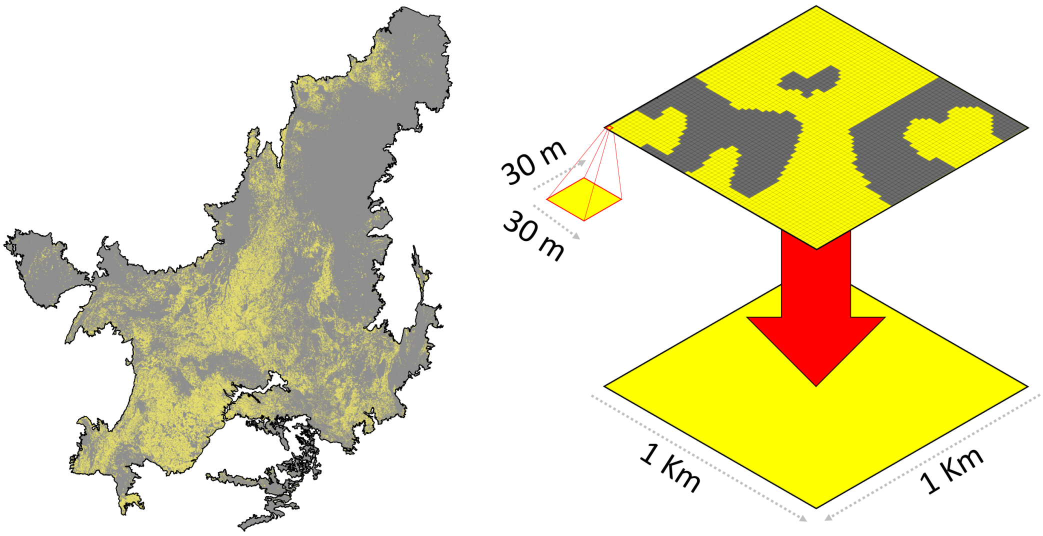


**Figure 1.** Pasture areas in the Cerrado biome, with spatial resolution resampled from 30 m to 1 km$^2$ (summing up approximately 50.7 Mha, in the year of 2017).

## 2.2. *Carbon Stocks Simulation*

Cerrado pasture carbon stock was estimated by Century - Soil Organic Matter Model Environment, based on per-pixel simulations, of 0-20 cm superficial layer (Parton et al., 1987). This model consists of different sub models, such as organic matter dynamic, water, and vegetation production. Becoming necessary the climatic parameters input, as the average air temperature and monthly precipitation, and edaphic parameters, as texture, density, and soil pH. Related variables to the land handling and coverage are also required to the simulations (Leite e Mendonça, 2003). The Century's model environment is composed by the programs that include the sub models and simulation of the exportation structure equations, records of the process description to be simulated, including events that happened on it, such as handling actions, edaphic and local climate parameters records, and local environment parameters records and process that will be simulated by the model (figure 2).

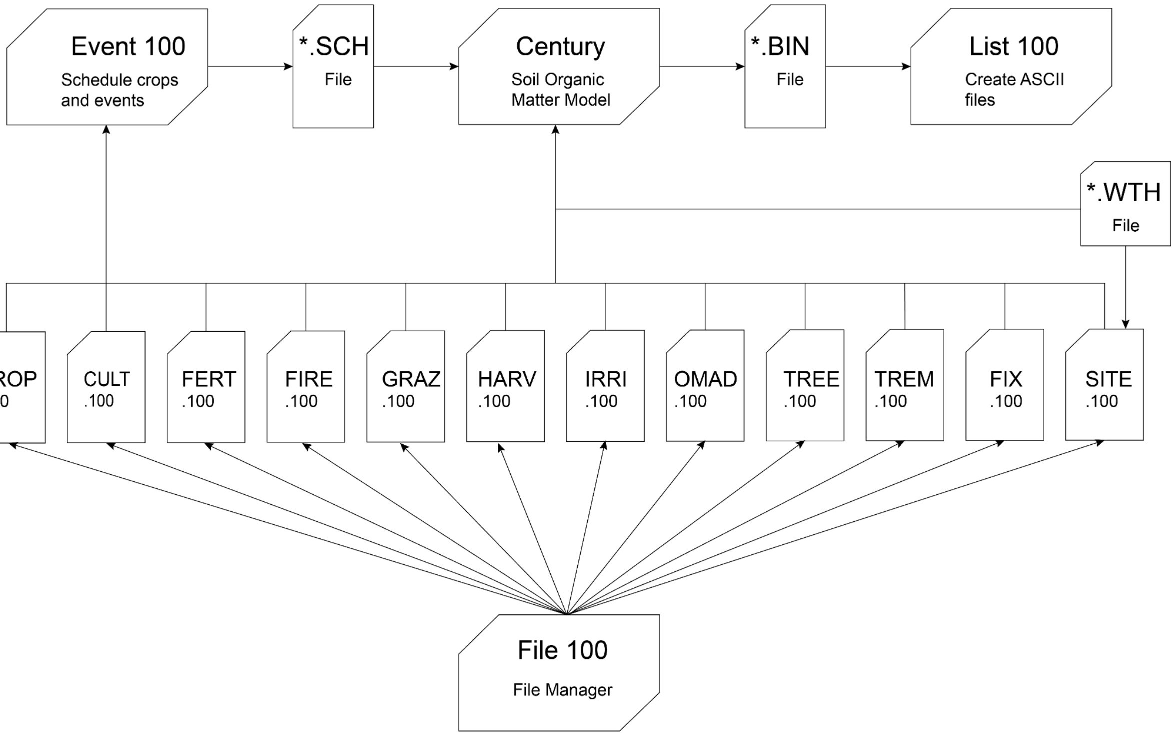


**Figure 2**. Century' model environment, demonstrating the relationship between programs (Century and List 100), and archives structure of simulated description (Event 100), local edaphoclimatic parameters (*.WTH) and parameters of the estimates to be performed (Files *.100).

## 2.3. *Land Use History*

The information regarding the land's use history (e.g., vegetal coverage, adopted handling, usage time) are important to the simulations, because they are factors directly related to the carbon input and output flows and, consequently, its ecosystem storage. To establish the use history, it was considered the changeover year to pasture the one with the highest converted area, because each modeled pixel (1km2) has around 1.1 thousand pixels at the time series maps (30 m x 30 m), which could have been converted to pasture in different years. Thus, we used the mode criteria to identify the changeover year to pasture. The already classified areas as pasture in 1985, this year was established at the beginning of the simulations.

## 2.4. *Soil Physical-chemical Properties*

Soil physical-chemical properties are important to carbon stocks in the soil organic matter, so inputs are necessary to use Century. In this context, to each pixel, the texture (sand, clay, and silt), density, and acidity (pH) are variables used in the modeling process. These variables were obtained from the SoilsGrids database (Hengl et al., 2014; Batjes et al., 2019). SoilsGrids is a global database, with 1 km2 space resolution that provides physical-chemical properties information to the entire world in six depth layers, meeting Century's requirements (figura 3).

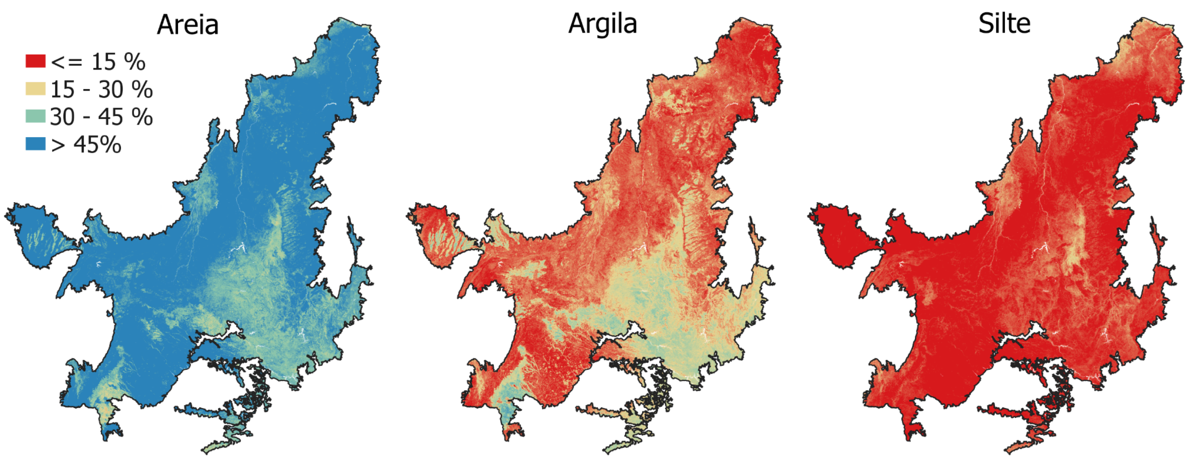


**Figure 3**. Maps of soil texture in the Cerrado, obtained from the SoilGrids database, and utilized for modelling carbon stock in pastures areas in the biome. Maps of density and acidity (Ph) were obtained from the same database.

## 2.5. *Climate data: temperature and precipitation*

Climate seasonality and precipitation and temperature values – maximum and minimum monthly means – are determining to biomass productivity, hence influence the dynamic and carbon storage in areas of pasture. In this study, these variables were obtained from the Terraclimate database (Abatzoglou et al., 2018). Terraclimate database has a monthly time resolution and a 4 km space resolution, covering the period from 1958 until now (figure 4).

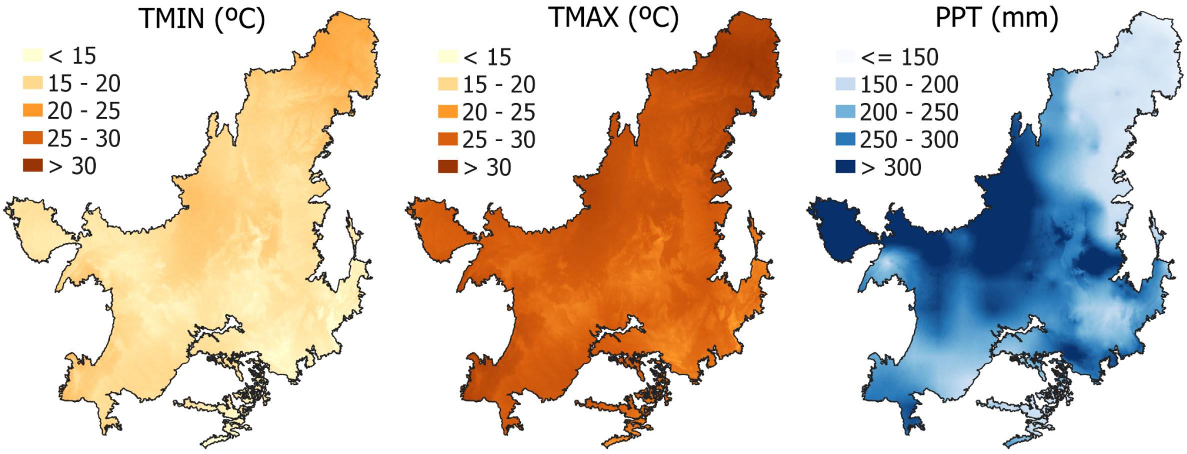


**Figure 4**. Maps of climate variables for the Cerrado, obtained from Terraclimate database, and utilized for modeling carbon stock in pastures areas in the biome (TMIN - minimum temperature; TMAX - maximum temperature; PPT - precipitation; for illustration, it was used data of December 2017).

## 3. Cerrado Pasture's Carbon Stocks

### 3.1. *Cerrado Pastures Carbon Stock Estimate*

In 2019, the total carbon stocks estimated by modeling to Cerrado pasture was 1.69 PgC (Pentagram of Carbon), where 89% is composed by carbon in the soil organic matter (1.51 PgC) (figura 5). Due to Cerrado's wide territory (~2 millions km2), and an important part of it being pasture, especially in the South of this biome (Souza et al., 2020), it is common to find a high variability in the average of carbon stock. Which might be a consequence of the region's edaphoclimatic heterogeneity, combined with different types of handling used in the pastures. Through Century, it was possible to find C stocks in Cerrado up to 20 cm of depth, fluctuating between ~7.0 and 43.6 MgC.ha-1 and ~30.8 MgC.ha-1 mean (figure 5A).

C stock estimated in the aerial biomass was 0.18 PgC and the mean was 4.0 MgC.ha-1, a value close to what Bustamante et al., (2012) estimated, which was 4.1 MgC.ha-1 in Cerrado's pastures. Assessing the alive and dead aerial biomass components proportion brings important inference about the cattle available hay quality, which has a direct relation to the green portion ingested by the animals. C stocks estimated in the aerial biomass fluctuated between ~0.7 and ~1.5 MgC.ha-1 (figure 5B and 5C). Considering the mean C stock values, the alive and dead fraction proportions were, respectively, 58% and 42%. These results were similar to the ones found in a study performed in Rio Vermelho watershed (GO), where average C stocks in the samples of alive and dead biomass were ~1.6 MgC.ha-1 and ~1.1 MgC.ha-1, corresponding to 59% and 41% proportions, respectively.

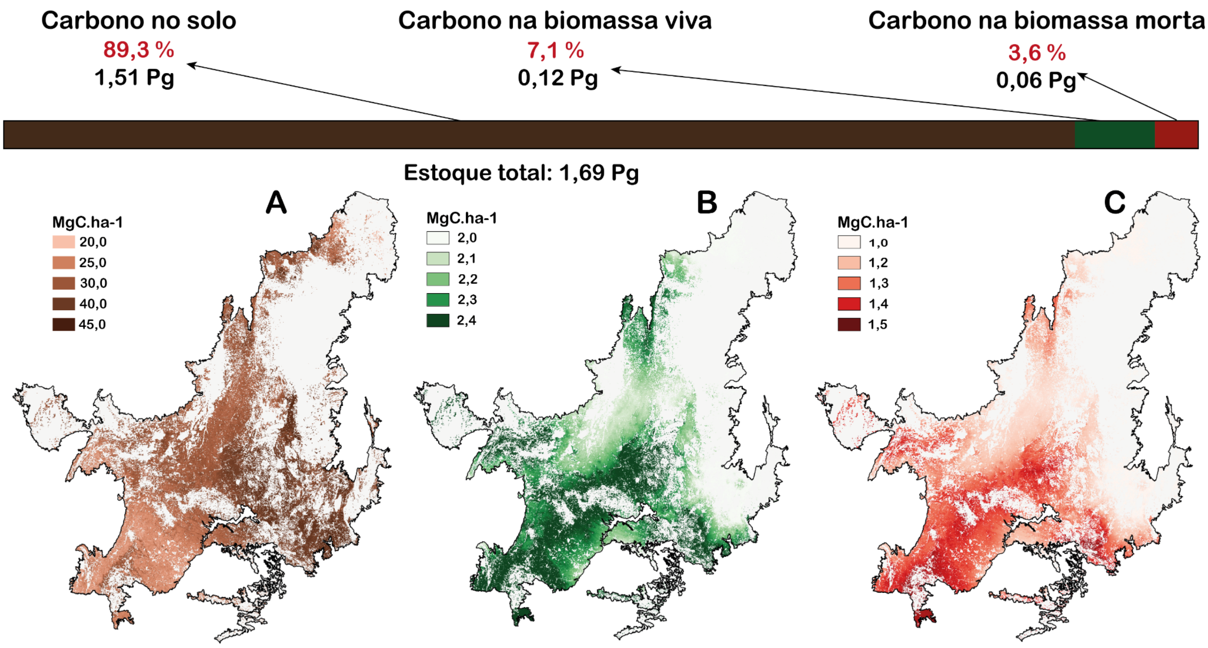


**Figure 5.** Carbon stock estimated in pastures areas in the Cerrado biome in the year of 2019. (A: soil organic matter carbon; B: alive aerial biomass carbon; and C: dead aerial biomass carbon).

## 4. Considerations

- The Century was versatile and robust to estimate Cerrado's pasture carbon stocks, being able to properly reproduce the space patterns characteristics of this biome's seasonal influence.
- Higher stocks estimated to the most fertile groups of soils as Argissolo, the lowest estimated stocks to the sandiest groups of soils, such as Neossolos, and intermediate values to Latossolo areas, indicate that the model was sensitive to edaphic patterns.
- Pasture's age had an important role to carbon stocks, where higher estimates were observed in younger pastures and there was a tendency to reduce the storage as the pasture grew old.
- Climate accuracy database, soil and land use, used to feed the model, affect the model's efficacy to properly simulate the carbon dynamic in the pasture's areas.

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