

The Importance of Brazil's Cerrado

At approximately 200 million hectares (ha), the Cerrado covers nearly a quarter of Brazil's landmass. It is a part of major watersheds and is the country's second largest biome, or area sharing features such as climate and vegetation (Rudorff et al. 2015; Klink and Machado 2005). The Cerrado encompasses a wide range of varied landscapes, including grasslands, savanna, and dry forests. It is a fire-adapted landscape, meaning that fire is beneficial to its ecosystem, in part by helping to maintain a balance between grasslands, savannas, and forests (Batlle-Bayer, Batjes, and Bindraban 2010).

Over the last 40 years, the Cerrado has played a crucial role as Brazil has developed into a world economic power. Many farms and ranches of various sizes are located in the Cerrado, but it is the large-scale farms that supply the majority of the country's commercially raised agricultural products (Haupt 2014). Farms and ranches producing two of the country's most important commodities, soy and cattle, are heavily concentrated in this region.

However, this agricultural success has taken a toll on the biome: more than half of the Cerrado has been cleared of its native vegetation, with most clearance taking place since the 1970s (Lapola et al. 2014). In just the period from 2003 to 2008, deforesting and burning of the Cerrado released 1,449 million metric tons of carbon-dioxide equivalent (MtCO₂-eq) into the air (Bustamante et al. 2012), roughly equivalent to the pollution emitted by 422 coal-fired power plants in a year (EPA 2016). Creation of pasture was responsible for more than half of this clearance (Bustamante et al. 2012).

Rapid land use conversion in the Cerrado has been driven in part by the growth of industrial agricultural operations serving global supply chains (Bustamante et al. 2012). Brazil is now the world's third-largest exporter of beef and second-largest exporter of soybeans; together, these exports added more than \$35 billion to the national economy in 2014 (MIT

2016). Given the huge cost already imposed on the Cerrado, responsible parties should strive to ensure that future agricultural expansion does not further devastate this important region.

Biodiversity

The Cerrado has long been identified as an important area for conservation because many Cerrado species are found nowhere else (Myers et al. 2000) and because it includes one of the most species-rich tropical savannas in the world (Murphy, Andersen, and Parr 2016). It is estimated that more than 3,000 plant species and more than a hundred mammal, bird, reptile, and amphibian species live *only* in the Cerrado (Klink and Machado 2005). Animals such as the jaguar, giant anteater, armadillo, and maned wolf make the biome their habitat.

More than 7,000 species of herb, shrub, tree, and liana (a type of vine) exist in the Cerrado (Klink and Machado 2005). Some plant species, such as the cassava, are important for human consumption, and wild varieties in the Cerrado are an important source of genetic variation (Klink and Machado 2005). Collection of wild fruit, such as pequi, is an important source of income for people living in the Cerrado (Nabout et al. 2011).

Carbon

The majority of the carbon sequestered in the Cerrado is underground, in roots and soil. This is largely because 42 to 71 percent of biomass—or matter in the form of living or recently living organisms—in the Cerrado is underground, an adaptation to fire (Fidelis, di Santi Lyra, and Pivello 2013; Silva et al. 2006). The extensive root systems and specialized underground organs of many Cerrado plant species ensure survival even if fire consumes much of their aboveground structure (Bond 2016; Veldman et al. 2015; Batlle-Bayer, Batjes, and Bindraban 2010).

Even more carbon than is stored in Cerrado biomass is stored in its soil. While estimates of the carbon stored in both above- and belowground vegetation range from 22 to 78 tons of carbon per ha (tC/ha) (Miranda et al. 2014; Bustamante et al. 2012; De Castro and Kauffman 1998), estimates of the

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The Cerrado biome is a mosaic of grassland, savanna, and dry forest. Photo: Wikimedia/Jonathan Wilkins

carbon stored in the soil range from 97 to 210 tC/ha (Bustamante et al. 2012; Batlle-Bayer, Batjes, and Bindraban 2010). The carbon sequestered in soil is relatively secure from fire or drought (Veldman et al. 2015), unless disturbed by agriculture. In some ways, the carbon stored in the Cerrado may be more stable than that stored in other ecosystems, where greater amounts of carbon are usually stored in aboveground vegetation. However, the true carbon content of the Cerrado has long been underestimated because underground carbon is less obvious than that in aboveground vegetation and can also be more difficult to monitor and estimate.

Land Use Change

Brazilian conservation policies aimed at reducing deforestation in the Amazon have been effective in the past, resulting in a 70 percent drop in the rate of deforestation from 2005 to 2014 (Lapola et al. 2014). By national law, only 20 percent of private

land in the Amazon can be cleared, with the rest required to be maintained as intact forest. However, in the majority of the Cerrado, a full 80 percent of land is legally available for development.

While approximately 100 million ha—a full half of the Cerrado—are already under agricultural use, still more land is threatened by conversion. Approximately two thirds of the Cerrado (an area larger than Peru) is estimated to be usable for agriculture, livestock, or forestry (Lopes 1996). As the rate of deforestation in the Amazon decreased, the rate in the Cerrado at first also dropped and then remained relatively steady. But Cerrado deforestation, in terms of both rate and area, began to surpass Amazon deforestation by 2011 (Soares-Filho et al. 2014). Some scholars believe that increased protections in the Amazon forest have led to increased conversion pressure in nearby areas, including the Cerrado, or are likely to do so in the near future (Gibbs et al. 2015; Lapola et al. 2014; Nepstad et al. 2014).

FIGURE 1. Biomes in South America at Risk of Conversion



The Cerrado covers nearly a quarter of Brazil's land mass and is the country's second largest biome. Pictured above are some of the regions at risk of land use conversion.

CATTLE

Brazil is a world leader in cattle production, and global demand for cattle and other livestock products is projected to continue to increase (FAO 2013). An estimated 35 to 55 percent of the Brazilian cattle herd lives in the Cerrado (Arantes, Ferreira, and Coe 2016; Ferraz and Felicio 2010; Silva et al. 2006) and around 60 million ha are under pasture (de Oliveira Silva et al. 2015).

There are both benefits and drawbacks to cattle's presence in the Cerrado. On one hand, cattle can be grazed on native vegetation, providing income to landowners. Careful management of livestock grazing densities and frequencies could actually help maintain native vegetation (Veldman et al. 2015). On the other hand, ranchers often replace native vegetation with nonnative species—in particular African grasses—in order to increase grazing densities (Klink and Machado 2005). Fires fed by these nonnative grasses can burn hotter and last longer than fires fed by native vegetation and can cause soil degradation.

Deforestation is not the only reason the cattle industry is an important contributor to global warming. Other sources of emissions associated with livestock—including enteric fermentation (the bovine digestive process that breaks down plant matter), transportation, and processing—also cause global warming. Between 2010 and 2030, Cerrado beef production is projected to contribute approximately 9 percent of Brazil's total emissions (de Oliveira Silva et al. 2015).

However, there are opportunities to mitigate significantly some of the damage done by the cattle industry in the Cerrado. There are even opportunities to continue its expansion without substantially damaging the environment, such as by implementing integrated crop-livestock systems. The majority of pastureland in the region is degraded (de Oliveira Silva et al. 2015; Bustamante et al. 2012). Pasture could be restored by, for example, improving the quality of the soil. Such restoration plus the avoidance of future land use conversion to pasture could reduce emissions from the beef sector by almost 27 MtCO₂-eq per year (de Oliveira Silva et al. 2015), nearly equal to the emissions of eight coal-fired power plants.

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SOY AND OTHER CROPS

For a long time, the Cerrado's relatively poor soils limited its agricultural potential. The arrival of fertilizer, lime, other chemical applications, and some genetically modified crops, such as soybeans, now allow the Cerrado to support an abundance of agriculture. These modifications, along with its relatively flat area (which eases large-scale, mechanized farming) and proximity to urban centers, have turned the Cerrado into an agricultural powerhouse.

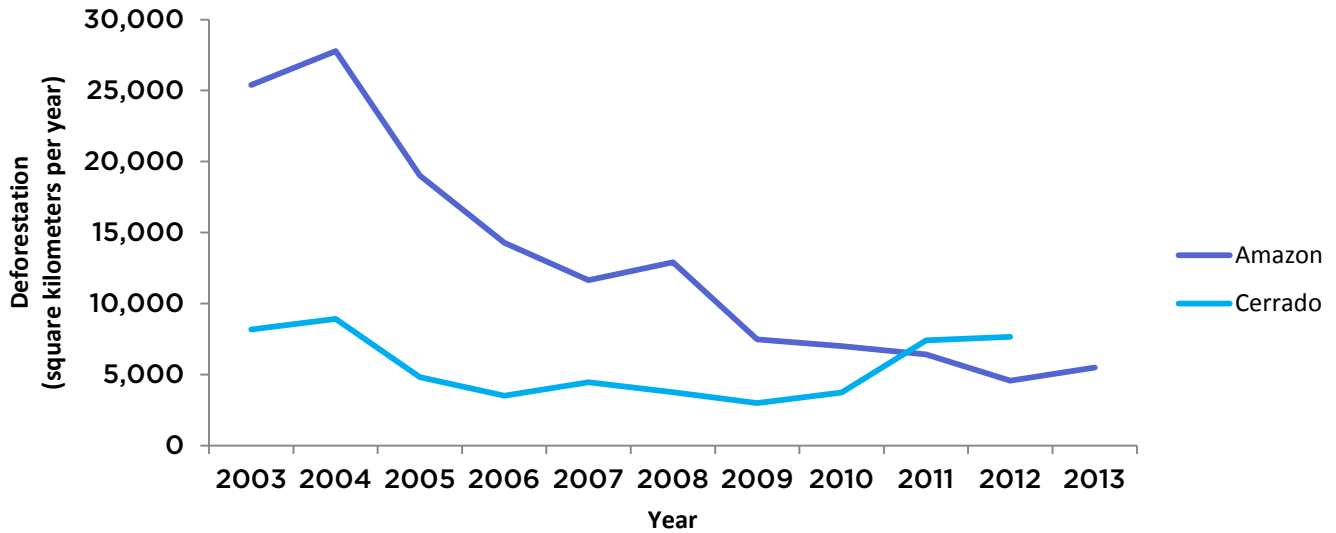
The Cerrado supports an abundance of agriculture, including sugarcane, corn, and cotton. However, perhaps the most important crop grown is soy. Soy can be processed to become a variety of products, including vegetable oil, food, and biofuels. Approximately three quarters becomes animal feed (Brack, Glover, and Wellesley 2016). Its high protein content makes it an ideal feed for pigs, chickens, and cattle. More than half the country's soybean crop is grown in the Cerrado (Rudorff et al. 2015). Soy is also sometimes used as an intermediary crop to improve soils (legumes such as soy put nitrogen back into the soil) (Rudorff et al. 2015).

While an important crop, soy is not the only large-scale agricultural driver of land use change. In the 2013–2014 growing season, more than 17 million ha were used to grow soy, corn, and cotton (Rudorff et al. 2015). Yet there is still significant land available for expansion of crops. More than 42 million more ha of cleared land and 20 million ha of natural vegetation are suitable for cultivation of these crops (Gibbs et al. 2015). In addition, in some parts of the Cerrado, ranchers sell degraded pasturelands to soy producers and then relocate their herds to new areas where they may remove native vegetation to create new pastureland (Grecchi et al. 2014; Persson, Henders, and Cederberg 2014).

FIRES AND AFFORESTATION

Although clearing for pasture and agriculture are the two major drivers of Cerrado land conversion, the Cerrado biome may also have been inadvertently put at risk by some policies designed to mitigate climate change. These policies encourage fire suppression and afforestation (the planting of forests) (Bond 2016; Durigan and Ratter 2016; Veldman et al. 2015). Fires can be natural, often resulting from lightning strikes. However, seminomadic peoples in the region have actively used fire to manage the landscape for thousands of years, and humans are now the main source of fire (Veldman 2016; Pivello 2011). Fires are often used to convert land to agriculture rather than for traditional landscape management (Durigan and Ratter 2016), a practice these policies aim to reduce.

FIGURE 2. Deforestation in the Brazilian Amazon and the Cerrado



In the early 2000s, deforestation in the Brazilian Amazon far exceeded the Cerrado. However, in recent years deforestation in the Cerrado has begun to outpace the Amazon.

DATA SOURCE: SOARES-FILHO ET AL. 2014.

Yet fire suppression, which is implemented in some parts of the Cerrado, can eventually lead to damaging, high-intensity, uncontrolled wildfires because fuel is allowed to build up over unusually long time periods (Durigan and Ratter 2016). Fire suppression may also allow forests and woodlands to overtake grasslands (Geiger et al. 2011). Certainly, Brazilian conservation policies have been strongly biased toward forests (Overbeck et al. 2015). Forests have often been viewed as preferable to grasslands or woodlands because of their assumed higher capacity for carbon storage. But there is growing recognition that the grassland and savanna ecosystems within the Cerrado are themselves stable, old-growth systems that should not be viewed as less important than the forested Cerrado (Veldman et al. 2015). Globally, grassy biomes store a similar amount of carbon as forests (White, Murray, and Rohweder 2000).

The Future

By all accounts, the Cerrado is likely to continue to undergo land use change (Lapola et al. 2014). One study projects a loss of approximately 40 million ha each decade through 2050

(Ferreira et al. 2013). As part of an international commitment, Brazil has promised to reduce Cerrado deforestation by 40 percent from 2010 to 2020 (de Oliveira Silva et al. 2015). However, many of the successes in the effort to reduce deforestation in the Amazon were made possible by monitoring via remote sensing coupled with on-the-ground action. Such monitoring is more challenging in the Cerrado because similarities between different types of crops and between pasture and natural vegetation make them difficult to differentiate when monitored remotely.

Even if clearing land in the Cerrado for crops and cattle pastures were to end immediately, it is important that steps be taken to improve the enormous amount of land no longer covered by native vegetation. Enhancing soil organic matter in cultivated land can increase both carbon sequestration and crop productivity; good pasture management can also increase carbon sequestration (Batlle-Bayer, Batjes, and Bindraban 2010). In addition, natural regeneration, restoration of degraded lands, and implementation of integrated crop-livestock systems are opportunities for carbon sequestration (Espírito-Santo et al. 2016; de Oliveira Silva et al. 2015; Carvalho et al. 2014).

We must make sure to extend efforts made to protect the Brazilian Amazon to other vulnerable ecosystems such as the Cerrado. The Cerrado is a crucial ecosystem, contributing not only to Brazil's economic growth, but also to the livelihoods of many local people and to ecosystem services such as clean air, clean water, and carbon storage. As large-scale farming continues to expand in the Cerrado, threatening remaining native vegetation, more careful attention must be paid to future development and to protecting native Cerrado vegetation when making land use decisions.

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