Without proper management, Brazil's Cerrado becomes disfigured and less resilient to climate change

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A typical Cerrado tree wilting in the shadow of the cerradão's canopy. Credit: Giselda Durigan

A study conducted over a period of 14 years in the Brazilian savanna-like biome shows its typical vegetation rapidly becoming "cerradão"—a biodiversity-poor forest formation—while resistance to drought and wildfires weakens.

The Cerrado, Brazil's savanna biome, is being destroyed at a fast pace, and inadequate management of remnants is transforming large areas of the biome into cerradão, a biodiversity-poor forest formation in which species typical of the Cerrado mingle with generalist species occupying gallery forest and other structures.

Scientists wonder whether areas of cerradão can conserve the biodiversity of the Cerrado. If not, they may evolve into a type of biodiverse forest similar to the Atlantic Rainforest biome, or they may become neither one nor the other.

A long-term study set out to find answers to these questions by investigating changes occurring over a 14-year period in a sample area of cerradão containing 256 plots in Assis Ecological Station, a conservation unit in São Paulo state.

The study is published in the journal *Forest Ecology and Management*.

Designed and supervised by Giselda Durigan, a professor at the State University of Campinas's Institute of Biology (IB-UNICAMP), the study was part of the Ph.D. research of Francisco Ferreira de Miranda Santos, first author of the article. The last author is Ricardo Ribeiro Rodrigues, a professor at the University of São Paulo's Luiz de Queiroz College of

Agriculture (ESALQ-USP) and Santos's thesis advisor.

The study site has been protected from fire for at least 60 years and therefore has not benefited from carefully managed regular burnings with zoning and a rotating fire schedule, now recognized as the best conservation method for the Cerrado.

Despite the long period without disturbance, tree basal area increased and the largest trees continued to grow, but tree density decreased over time. Community diversity increased slightly, owing to a small gain in species richness.

Durigan stressed the hard work done by the researchers. "Studies of forest dynamics take a long time as a matter of course. Changes happen slowly, and it's necessary to wait patiently for the forest to tell its own story. The challenge is understanding how change is influenced over time by extreme heat and cold, excessive or insufficient rain, high winds, or simple competition among trees for light, water and nutrients.

"Besides patience, these studies also require discipline and hard work to collect data on different occasions, as well as inspiration and a sound theoretical foundation to formulate hypotheses and interpret the data," she said.

The size of the study site (over 10 hectares) and the number of trees identified and measured (over 20,000) made the project extremely challenging. "Each measurement activity involved a team of four working for about a year to measure all the trees all over again, to replace lost numbering, and to identify and mark new individuals, despite rain, thorns, ticks, gadflies, armadillo burrows, etc.," she said.

"Santos then spent months in front of a computer to put all this into his Ph.D. in ecology at UNICAMP, organizing a giant database, detecting

inconsistencies, updating species nomenclature, and comparing measurements made at different times to track the history of each tree."

This account is interesting because it helps dispel the false idea that scientific progress is rectilinear. When studies are described in journal articles, they seem straightforward, apart from the difficulties inherent in the technical language used, but a great deal of effort is needed to reach such simplicity. Durigan told how she and Santos together faced the challenge of having to correct errors in the coordinates of the 256 plots that made the research even harder.

"There was only one solution. We had to go back to the site, find certain numbered trees in the dense undergrowth, plot their positions correctly, and compare them with the positions on the map. Eventually, we discovered the errors could be corrected simply by turning the network of coordinates 90 degrees anticlockwise. Everything then fell into place," she said.

As a result of the study, the researchers discovered that 54% of the trees identified in the initial survey had died 14 years later and that some 10,000 new trees had grown to 5 cm in diameter. While 14 years may seem a long time to humans, it is a short period for such a large-scale change in vegetation. In other words, the Cerrado can degenerate rapidly into cerradão once the process has begun.

"The total number of trees decreased in the period. The competition imposed by large trees caused the death of small ones. The outcome of this 'war' was the victory of the largest, which continued to grow, accumulating biomass and carbon. The number practically tripled in the 14-year period. However, the largest trees in areas of cerradão aren't as large as the trees in tropical forest, rarely exceeding 30 cm in diameter," Durigan said.

The study revealed changes not only in the structure of the site but also in its species composition, she added. Forest species and generalists that tolerate shade continued to flourish, while species typical of the Cerrado were unable to get enough sunlight and disappeared.

"The few Cerrado-type trees still alive have no descendants because they don't germinate or even survive in the shade. Many iconic species are vanishing, from the Souari nut [Caryocar brasiliense] and Pequi to the Mangaba [Hancornia speciosa], Curriola [Pouteria ramiflora], Barbatimão [Stryphnodendron adstringens] and Paineirinha [Eriotheca gracilipes]," she said.

What is the significance of these changes from the standpoint of conservation? "First, we can't expect this area to contribute to conservation of the flora in the Cerrado. Cerradão is closed-canopy woodland, and all that shade is a hostile environment for the biome's typical species.

"Although species richness increased by 10%, Cerrado-type tree losses were dramatic and irreversible. Second, the continuous accumulation of biomass in a region of deep sandy soil that can't retain moisture is alarming," she said.

Areas of cerradão are therefore more likely to collapse during long droughts than open areas of the Cerrado. In a time of global climate crisis, extreme events are increasingly frequent. The greater the arboreal biomass, the more rain is intercepted by the forest canopy and the more water is consumed by the trees.

If less water is captured and more is consumed, the stored water will run out sooner. While a five-month drought does not affect trees in open areas, it can lead to many tree deaths in areas of cerradão.

"If climate change in the region led to an increase in and better distribution of rainfall, this new forest would be compatible with local environmental conditions, but the record temperatures recorded there are forcing the trees to consume more and more water as the rainfall decreases, so collapse is increasingly likely.

"If many trees die, the carbon stored in them returns to the atmosphere, and large amounts of dead timber increase the probability of catastrophic fires. Unlike typical Cerrado vegetation, cerradão isn't adapted to fire. If it burns in extreme conditions, it starts functioning as degraded forest," Durigan said.

Rodrigues added other details. "The article reflects the strenuous personal efforts of Ph.D. candidate Santos, whose career as a scientist it solidifies, and is the first to describe the dynamics of a permanent area of more than 10 hectares of continuous cerradão in São Paulo state, with surprising data relating to the speed, intensity and direction of changes in the composition of tree species over a fairly long period," he said.

"It's a major contribution that supports good public policy for conservation and restoration of biodiversity in the challenging context of climate change."

The study confirmed a hypothesis raised some time ago by the researchers but not yet totally tested on this scale. They surmised that the simplistic attitude of merely protecting biodiversity and isolating natural or restored fragments from anthropic disturbance while ignoring the historical and cultural context for sustainable management of natural ecosystems might not be the best solution, and in fact was probably incompatible even with biodiversity conservation.

More information: Francisco Ferreira de Miranda Santos et al, Tree community dynamics in the cerradão (2002-2016): A case of biome shift, *Forest Ecology and Management* (2024). DOI: 10.1016/j.foreco.2024.121698

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