Intensive silviculture accelerates Atlantic rainforest biodiversity regeneration

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The study shows the advantages of herbicide spraying and intensive fertilization in reforestation programs to mitigate the effects of climate change. Credit: Pedro Brancalion

An experiment conducted in Brazil in an area of Atlantic Rainforest suggests that intensive silviculture, including the use of herbicide and substantial amounts of fertilizer, is a more effective approach to promoting the regeneration of tropical forest and biomass gain than the traditional method based on manual weeding and less fertilizer.

The study was supported by São Paulo Research Foundation - FAPESP. The principal investigator was Pedro Henrique Santin Brancalion, a professor of native species silviculture in the Forest Science Department of the University of São Paulo's Luiz de Queiroz College of Agriculture

(ESALQ-USP) in Piracicaba, São Paulo state, Brazil. The results are published in *Ecological Applications*, a journal of the Ecological Society of America.

As Brancalion explained, forest restoration is considered strategic for climate change mitigation, since the vegetation sequesters carbon from the atmosphere as it grows.

"Developed countries such as Norway have put in place programs to help neutralize carbon gas emissions through their economic activities," he said. "Companies issue calls for reforestation proposals to offset part of the emissions from their factories, and many international nonprofits raise funds from companies interested in investing in restoration projects using native species in Brazil."

According to Brancalion, maximizing woody biomass accumulation to obtain early payments for carbon stocks is essential to the financial viability of reforestation programs for climate change mitigation.

Intensive silviculture, traditionally applied in commercial forestry using eucalyptus and pine to maximize productivity and profits, is widely advocated as a promising approach to enhance woody biomass accumulation in restoration plantations. However, Brancalion explained, critics of this approach claim that it may hamper natural forest regeneration and ecological succession owing to competition between colonizing plants and planted trees.

"In several situations, you have to plant native species. How can you ensure these areas with new native trees maximize the carbon stock? We sought answers by conducting a controlled native tree planting experiment," he said.

The experiment was conducted at ESALQ-USP's Forest Science

Experiment Station near the town of Anhembi. The area was donated to the University of São Paulo (USP) in 1974 by CESP, then a major electric power utility, for academic and scientific purposes. Since that time, it has been used for research on the introduction, conservation and genetic improvement of exotic and native tree species, constituting an important germplasm repository for the global forestry sector.

"In this area of Atlantic Rainforest, we investigated the impacts of different silviculture approaches applied to restoration plantations in terms of both woody biomass accumulation and the spontaneous regeneration of native species," Brancalion said.

Experiments involving trees, many of which grow slowly, take a long time to come to fruition. In this case, the study began in 2004 in an area of pasture covered by the exotic signalgrass, Urochloa decumbens, which is widely used for cattle fodder in Brazil.

"We tested three main strategies," Brancalion explained. "In the first, a large proportion of the selected species were pioneer species, which are small to medium in size, hardy and fast growing, and require an abundance of sunlight.

The ideal composition we sought was one that resulted in a large carbon stock while also permitting the regeneration of species similar to those found in native forest rather than a mere stand of trees without regeneration."

Brancalion explained that pioneer species are the first to regenerate in a restored forest. They are fast-growing trees with low wood density and tend to die early, at an age of approximately ten years.

"They play an important role in recolonizing forest clearings and degraded areas, as they rapidly form a forest structure," he said.

"Nonpioneer species grow more slowly and last decades or centuries."

Twenty native tree species were used in the experiment.

Ten were pioneers, including *Cedrela fissilis* (Argentine cedar), *Pterogyne nitens* (amendoim bravo), *Schinus terebinthifolius* (Brazilian peppertree) and *Enterolobium contortisiliquum* (pacara earpod). Others were slow-growing nonpioneer species, such as *Cariniana estrellensis* (jequitibá branco), *Handroanthus impetiginosus* (pink trumpet), *Hymenaea courbaril* (Brazilian cherry), and *Jacaranda cuspidifolia*. Others grow at an intermediate rate, including *Copaifera langsdorffii* (copaíba), *Eugenia uniflora* (pitanga), *Genipa americana* (jenipapo), *Psidium guajava* (guava) and *Syagrus romanzoffiana* (queen palm).

The test for the first strategy consisted of two levels. Level one had an equal number of pioneer and nonpioneer species. In level two, pioneer species accounted for two-thirds of the species, while nonpioneer species accounted for a third.

"The second strategy focused on tree density per hectare planted," said Brancalion. "We wanted to find out whether tree density maximized carbon stocks or whether, on the contrary, a lower density reduced competition among plants and hence enabled trees to grow more and store more carbon."

Tree rows were planted a meter apart in level one and 2 meters apart in level two for densities of 3,333 and 1,666 seedlings per hectare, respectively.

The third strategy focused on weed control and fertilizer use. Level one involved manual weed control and "typical" amounts of fertilizer, while level two involved spraying with herbicide and three times the amount of fertilizer used in level one.

"We collected many measurements over a period of 12 years. The different techniques we tested resulted in very different forests in terms of carbon stocking, which ranged from 25 to 75 tons per hectare," Brancalion said.

Native forest regeneration

Tree density and the ratio of pioneer to nonpioneer species did not significantly affect the carbon stocking rates. The factors that determined optimal results in all cases were herbicide spraying and intensive fertilization.

"The total number of trees and a larger proportion of pioneer species were factors that did not significantly influence biomass accumulation," Brancalion said.

"The second question we set out to answer was whether planting seedlings would trigger a regeneration process that would produce a biodiverse native forest or merely a planted stand. We also wanted to know if bolstering carbon stocks would hamper the regeneration of native species", he said.

"The final outcome was the optimal scenario, featuring synergy between carbon stocking and native species regeneration, which was an excellent result."

More information: Pedro H. S. Brancalion et al, Intensive silviculture enhances biomass accumulation and tree diversity recovery in tropical forest restoration, *Ecological Applications* (2019). DOI: 10.1002/eap.1847

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