Natural History of Ecological Restoration

A natural history notebook and project of the Missouri Botanical Garden

Seedlings planted for Brazilian forest restoration are not representative of tropical tree biodiversity

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A collaborative research project involving MBG’s Center for Conservation and Sustainable Development (http://www.missouribotanicalgarden.org/plant-conservation/plant-conservation/conservation-teams/center-for-conservation-sustainable-development.aspx), the Tropical Silviculture Lab (http://esalqlastrop.com.br/capa.asp?pi=principal) at the University of São Paulo, and the PARTNERS (http://partners-rcn.org/) research coordination network highlights important differences between the native tree flora of the Brazilian Atlantic Forest and the species that are widely planted for ecological restoration projects.

The Brazilian Atlantic Forest is a global biodiversity hotspot (https://en.wikipedia.org/wiki/Biodiversity_hotspot). This designation denotes two things. First, the Atlantic Forest is exceptionally and uniquely biodiverse. Second, the biodiversity of the Atlantic Forest is exceptionally threatened. This once-vast biome historically stretched from northern Argentina to Brazil’s eastern tip in Rio Grande do Norte, but it is now reduced to about 12% of its original size, and most of what remains exists as small, isolated fragments.

During the past decade, a major, multilateral effort has been undertaken to staunch biodiversity loss by doubling the size of the Atlantic Forest through ecological restoration. The Atlantic Forest Restoration Pact (http://www.pactomataatlantica.org.br/the-atlantic-forest) is composed of more than 270 private companies, governments, NGOs, and research organizations. It aims to restore 15 million hectares of Atlantic Forest by 2050.
The Atlantic Forest biome: a global biodiversity hotspot and the site of the most ambitious tropical forest restoration project on the planet. Map imagery from NASA via Wikimedia Commons.

Atlantic Forest restoration projects are characteristically thorough and well-documented. For example, they often include high diversity plantings more than 80 tree species. Yet until recently there had never been a systematic study to evaluate how well these restoration plantings represented the Atlantic Forest biodiversity they aimed to protect.

Dr. Pedro Brancalion is a professor at the University of São Paulo’s agricultural school in Piracicaba, Brazil, where he co-directs the Tropical Silviculture Lab (http://esalqastrop.com.br/capa.asp?pi_principal). Five years ago, he approached me at a meeting of the Society for Ecological Restoration (http://www.ser.org/) in Madison, Wisconsin, and over a beer he told me about a dataset that he thought could shed light on the how well Atlantic Forest restoration projects were conserving tree biodiversity. The dataset consisted of seedling donation records from the NGO SOS Mata Atlântica (https://www.sosma.org.br/). Between 2002 and 2015, the NGO donated more than 14 million tree seedlings to 961 restoration projects. By comparing the species composition in these records to tree species living in mature forests, we could see what elements of biodiversity might be missing and how this could be affecting carbon stocking – an important factor in mitigating global climate change.

Even in high diversity plantings, many of the most threatened tree species were not included.

Last month, Pedro and our collaborative team published a paper in Conservation Letters (https://onlinelibrary.wiley.com/doi/full/10.1111/conl.12454) describing our results. We found that restoration projects in the Atlantic Forest biome had included 416 tree species out of the >2,500 tree species known from mature

and old-growth forest fragments. This is an impressive figure, but the team discovered that it reflects a highly biased subsample of the Atlantic Forest tree flora. The most under-represented species were those with large seeds that are dispersed by animals. Animal-dispersed trees make up as much as 89% of tree species in some parts of the Atlantic Forest and include some of the most threatened species.

The reason that large-seeded, animal-dispersed species are being used less often was probably related to the cost and challenges of collecting and growing seeds. Large-seeded, animal-dispersed trees are more expensive to purchase from nurseries than small-seeded or wind-dispersed species. Because they are energetically expensive to produce and are contained within large fruits, trees tend to produce large seeds in relatively low quantities, with just one or a few seeds per fruit. They are generally found in remote forest areas, and seed collectors have to compete for them with seed-eating animals, like peccaries and agoutis. Once large seeds are collected, they also take up considerably more space in storage and production facilities.

Ficus guaranitica
Seed diameter: 0.7 mm
Est. seedling cost: <$0.01 USD

Caryocar brasiliense
Seed diameter: 30.0 mm
Est. seedling cost: $1.55 USD


The absence of large-seeded, animal-dispersed tree species in restoration plantings has important implications for biodiversity conservation. First, fewer large-seeded trees means less food for large birds, some of which eat mainly large fruits. Second, these species are sometimes overharvested for timber and have difficulty recolonizing forests from which they have been removed. So the fact that large-seeded, animal-dispersed trees are under-represented in restoration projects means that even if the ambitious restoration goals of the Atlantic Forest Restoration Pact are met, the increase in forest cover may not improve dispersal between fragmented populations of the most vulnerable species.

Large-seeded tree species also tend to store carbon more densely than small-seeded species. This tendency is related to large-seeded species growing slowly in the shady understory of the Atlantic Forest and their gradual formation of dense wood, which is rich in carbon. We simulated potential carbon stocking in restored forests and compared it to mature forests, and our results showed that under-representation of large-seeded,
animal-dispersed trees could cause a 2.8-10.6% reduction in carbon storage. Based on the current price of carbon, this loss could represent $17-63 USD per hectare in lost carbon credits.

Many Atlantic Forest restoration projects are quite isolated. A large seed would have a hard time reaching sites like this forest in a sugarcane matrix. Photo by Pedro Brancalion.

Reduced capacity for biodiversity conservation and carbon stocking sounds like bad news, and indeed it is not ideal. However, restoration ecology moves forward by identifying problems and seeking scientifically-based solutions to overcome them. Knowing that large-seeded, animal-dispersed trees are under-represented in restoration plantings means that we can turn our attention to innovative solutions.

For example, new policies could help bridge the gap between Brazil's exceptional tree biodiversity and the relative paucity of species being used for ecological restoration. One way this could happen would be for the Brazilian government to subsidize the cost of producing large-seeded, animal-dispersed tree seedlings. This could be done through financial incentives or potentially by opening some forest reserves for seed harvesting, to make it easier for collectors to acquire these species. Facilitating uptake by reducing costs would be a carrot. A stick could be to legally mandate some representation of these species in future restoration plantings.

Market solutions may also exist. Based on our calculations, adding more large-seeded, animal-dispersed species to restoration plantings would increase carbon storage and carbon credits, offsetting the cost of the expensive seedlings and creating a net gain of $3-32 USD per hectare.

Banner image: *Sterculia striata* ([http://www.tropicos.org/Name/30400014](http://www.tropicos.org/Name/30400014)) (Malvaceae). Photo by Mauricio Mercadante ([https://www.flickr.com/photos/mercadanteweb/8060299675](https://www.flickr.com/photos/mercadanteweb/8060299675)), CC BY-NC-SA 2.0 ([https://creativecommons.org/licenses/by-nc-sa/2.0/](https://creativecommons.org/licenses/by-nc-sa/2.0/)).