MCSC | MIT Climate & Sustainability Consortium

Links Between Biodiversity Loss and Climate Change

Project Overview

How can protecting biodiversity improve nature's ability to remove carbon from the atmosphere?


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Tropical forests are currently earth's largest land-based carbon sink, making them extremely important in absorbing carbon. Much research has been done on the impacts of a changing climate on biodiversity. But what about the impacts of biodiversity loss on climate change? Understanding the links between the two is critical to developing mitigation solutions.

The team for this project includes three researchers from the MIT Department of Civil and Environmental Engineering - Evan Fricke, Research Scientist; César Terrer, TianFu Group Career Development Professor; and Charles Harvey, Professor - and Susan Cook-Patton of The Nature Conservancy. They investigated the influence of seed-dispersing on forest carbon storage using a combination of ecological data sets spanning thousands of tropical forest sites with information about animal biodiversity, movement, and seed dispersal. Their work reveals that biodiversity loss directly weakens one of the planet's most valuable natural climate solutions by slowing forest regrowth and reducing long-term carbon accumulation.

This work aligns closely with MCSC's work in Nature Based Solutions.

Findings & Outcomes

This project demonstrates that protecting seed-dispersing animals is essential for maximizing tropical forest carbon sequestration.

The researchers developed a large-scale index measuring disruption of animal-mediated seed dispersal across tropical forests. Using observations from 3,026 tropical regrowth plots.

Key Findings Include:

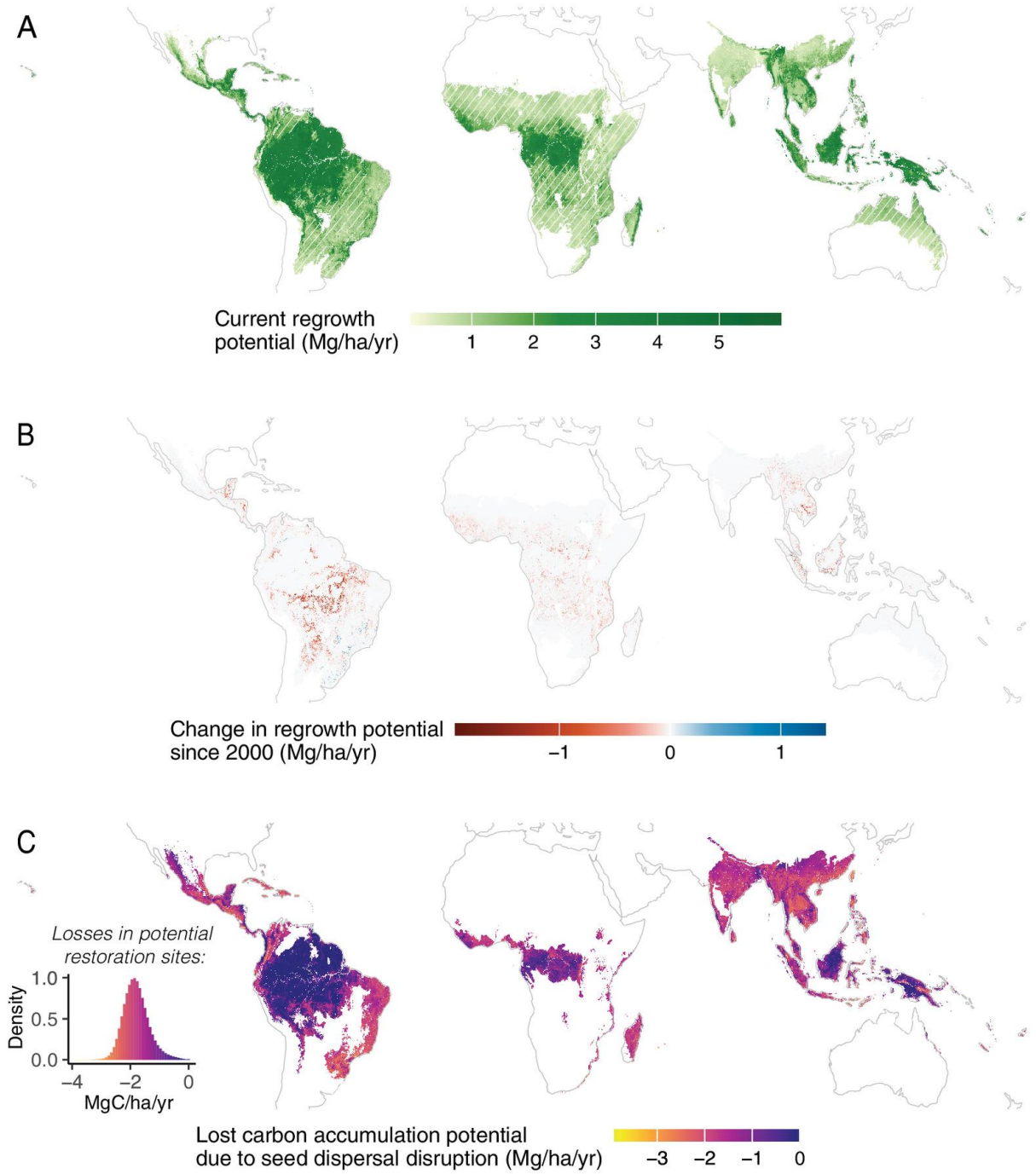
- **81% of tropical trees rely on the animals for seed dispersion;** reduced animal biodiversity and movement can hinder the carbon accumulation potential of regrowing tropical forests.
- Regenerating forests with healthy seed-dispersing animal populations **accumulate up to four times more aboveground carbon** than forests experiencing extreme disruptions.
- Across areas suitable for reforestation, current levels of seed dispersal disruption reduce local **carbon accumulation potential by an average of 57%.**
- Biodiversity loss therefore **limits the effectiveness of natural forest regeneration as a climate mitigation strategy.**

Journal Article: Proceedings of the National Academy of Sciences (PNAS)

The teams' findings were published in, the Proceedings of the National Academy of Sciences (PNAS), in a research article titled "Seed dispersal disruptions limits tropical forest regrowth." The publication demonstrates the previously underappreciated connection of biodiversity conservation and climate mitigation, showing that the decline in animals can decrease carbon storage potential of recovering tropical forests. This shows new evidence that climate and biodiversity strategies should be formed together.

Mapping Carbon Accumulation Potential in Relation to Seed Dispersal

The maps below illustrate current regrowth potential, change in regrowth potential, and lost carbon accumulation potential due to seed dispersal disruption in regions across the world.



Mapping aboveground carbon accumulation potential in light of seed dispersal disruption. (A) The current (c. 2020) regrowth potential of tropical forest and savanna ecosystems while accounting for seed dispersal disruption. Hatching indicates savanna biomes. (B) The cumulative effect of land use change over the period 2000-2020 on natural regrowth potential. (C) the impact of seed dispersal disruption on regrowth potential in tropical forest areas. Values estimate the degree to which current levels of seed dispersal disruption would limit carbon accumulation for regrowing forests at each location. Inset panel shows the distribution of lost carbon accumulation potential across sites identified as potential restoration areas that occur in the tropical forest biomes.

Opportunities for Implementation

Understanding the role of seed-dispersing animals in forest regeneration has the potential to improve the effectiveness of nature-based climate solutions and spur new animal conservation initiatives that seek win-wins for both biodiversity and climate.

First, this work changes the calculus on tree planting vs natural regrowth as the method used for tropical forest restoration. The implications for reforestation cost and biodiversity co-benefits are important.

Natural regrowth, where seeds are planted by animals and other natural mechanisms, is a low-cost option for forest restoration that generally recovers more forest biodiversity. However, natural regrowth has traditionally been unpredictable as a reforestation method, with highly variable carbon storage rates from place to place. In contrast, tree planting leads is the common method that leads to more predictable carbon storage but incurs greater implementation costs and often results in monoculture plantations with much lower biodiversity than natural forests would have. This research shows where natural regrowth can be most successful, and importantly that it can outperform plantation in landscapes with healthy seed disperser communities.

Because seed dispersers influence where natural regrowth potential is high or low, and because the work also identifies where seed dispersers are most effective, the new analysis identifies landscapes where low-cost natural regeneration can outperform tree plantation on both biodiversity and carbon indicators. By reducing the economic costs of reforestation, and increasing the ecological co-benefits, this holds potential to scale up biodiversity-positive forest restoration across the tropics. The key next challenges are to work these scientific findings into policy and practice on the ground.

Second, these findings reveal that natural climate solutions should involve animals, and further that biodiversity projects can pay climate dividends.

The research shows that the amount of carbon can be 4x larger in animal-rich landscapes, but efforts to conserve or restore animals are usually focused on biodiversity outcomes alone. Although biodiversity- or carbon-focused projects are usually separate, projects designed with both outcomes in mind could achieve more in the scope of a single project. Important next steps involve implementing these goals within newly designed natural climate solution projects and collecting on-the-ground data to quantify biodiversity and carbon outcomes.

There are other important implications for how we monitor and how we value—both ecologically and economically—animal biodiversity. Today, biodiversity monitoring aims to track, for example, all animals together rather than isolating animals performing important ecological functions like seed dispersal. Updating such metrics would help managers ensure that conservation or restoration projects maintain or recover from these important ecological roles. Future work could go a step further to assess the contributions that individual animals make in planting trees and amplifying carbon storage, enabling the tracking of important economic and climate-relevant contributions of animal biodiversity.

Together, these findings suggest that forest restoration and conservation efforts could benefit from protecting seed-dispersing animals. Integrating wildlife monitoring with forest restoration and climate programs could help to ensure that forests reach their full carbon sequestration potential.