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The impact of hurricanes on the carbon stock of the juvenile stages of succession in the tropical rainforest in the Caribbean part of Nicaragua

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Abstract

Tropical rainforests significantly impact the global carbon cycle. In juvenile stages of succession, carbon stocks in living tree biomass rise quickly until the forests mature. However, disturbances cause structural changes, releasing stored carbon into the atmosphere. Hurricanes, common in the Caribbean, greatly affect Nicaraguan forests.

We studied the private nature reserve Greenfields, a lowland tropical forest ecosystem protected after Hurricane Joan completely destroyed the land cover in 1988. Hurricane Julia further damaged vegetation there again in 2022. This unique forest allowed us to research: A) Carbon sequestered in woody biomass 27 and 34 years post-Hurricane Joan; B) The decrease in living tree biomass carbon content caused by Hurricane Julia. We established 41 permanent circular research plots (25 m in diameter) in 2015. However, in 2022, we were able to restore 39 of them, and in 2024, due to the terrain's impassability after the hurricane, only 24 could be restored. We measured the position, DBH, and height of all trees (>10 cm DBH) and utilised three different allometric equations to calculate biomass.

The amount of carbon in aboveground live biomass was for Chave's pantropic equation: 83 ± 40 (2015); 90 ± 43 (2022); $35 \pm 18 \text{ t ha}^{-1}$ (2024); for the Breugel Panama's equation for secondary forests: 81 ± 33 (2015); 88 ± 30.5 (2022), and $41 \pm 18 \text{ t ha}^{-1}$ (2024), and the Segura Costa Rica's equation for humid rainforests: 158 ± 61 (2015); 171 ± 62 (2022) and $80 \pm 35 \text{ t ha}^{-1}$ (2024). Between 2015 and 2022, the carbon quantity in dead trees was $10 \pm 35 \text{ t ha}^{-1}$, whereas in 2024, two years after the hurricane, it was $45 \pm 35 \text{ t ha}^{-1}$ (counted by Chave's equation). The findings reveal a considerable reduction in carbon stock within aboveground biomass following Hurricane Julia. During the succession the amount of living biomass is gradually increasing, as well as the amount of dead wood. Our findings suggest that hurricanes significantly influence the carbon dynamics in the forests of the Caribbean region of Nicaragua.

Keywords: Death wood, disturbance, private reserve, rainforest, tree biomass