

Rainforest fragmentation and the dynamics of amazonian tree communities

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INTRODUCTION

Few studies have assessed effects of habitat fragmentation on tropical forest dynamics. I describe results from an 18-year experimental study of the effects of rainforest fragmentation on tree-community dynamics in central Amazonia.

METHODS

Tree communities were assessed in 39 permanent, 1-ha plots in forest fragments of 1, 10, or 100 ha in area, and in 27 plots in nearby continuous forest. Repeated censuses of >56,000 marked trees (≥ 10 cm diameter-at-breast height) were used to generate annualized estimates of tree mortality, damage, and turnover in fragmented and continuous forest.

RESULTS

Forest Dynamics

On average, forest fragments exhibited markedly elevated dynamics, apparently as a result of increased windthrow and microclimatic changes near forest edges. Mean mortality, damage, and turnover rates were much higher within 60 m of edges (4.01%, 4.10%, and 3.16%, respectively) and moderately higher within 60-100 m of edges (2.40%, 1.96%, and 2.05%) than in forest interiors (1.27%, 1.48%, and 1.15%).



Less-pronounced changes in mortality and turnover rates were apparently detectable up to ca. 300 m from forest edges. Edge aspect had no significant effect on forest dynamics. Tree mortality and damage rates did not vary significantly with fragment age, suggesting that increased dynamics are not merely transitory effects that occur immediately after fragmentation, while turnover rates increased with age in most (8/9) fragments (Laurance et al., in press, a).

These findings reveal that fragmentation causes important changes in the dynamics of Amazonian forests, especially within ca. 100 m of habitat edges. A mathematical “core-area model” incorporating these data predicted that edge effects will increase rapidly in importance once fragments fall below ca. 100-400 ha in area, depending on fragment shape (Ferreira e Laurance 1997, Laurance et al., in press, a).

Accelerated dynamics in fragments will alter forest structure, floristic composition (Laurance et al., in press, b), and microclimate, and are likely to exacerbate effects of fragmentation on disturbance-sensitive species.

Forest Biomass

In addition to marked changes in forest dynamics, rainforest fragments in central Amazonia experience a dramatic loss of above-ground tree biomass that is not offset by recruitment of new trees. These losses are highest within 100 m of fragment edges, where tree mortality is sharply increased by microclimatic changes and elevated windthrow. Permanent study plots within 100 m of edges lost up to 36% of their biomass in the first 10-17 years after fragmentation.

Lianas (climbing woody vines) increase near edges but usually compensate for only a small fraction of the biomass lost due to increased tree mortality. Upon decay, the loss of biomass in forest fragments could be a significant source of greenhouse gases such as carbon dioxide and methane (Laurance et al., 1997). These findings suggest that fragmentation of tropical forests is likely to increase emissions of CO₂ and other greenhouse gases above and beyond that caused by deforestation per se.

We estimated committed carbon emissions from deforestation and fragmentation in Amazonia, using three simulated models of landscape change: a “Rondônia scenario,” which mimicked settlement schemes of small farmers in the southern Amazon; a “Pará scenario,” which imitated large cattle ranches in the eastern Amazon; and a “random scenario,” in which forest tracts were cleared randomly.

Local estimates of carbon emissions were up to 42% too low, depending upon the amount and spatial pattern of clearing, when based solely on deforestation. Because they created irregular habitat edges or many forest perforations which increased tree mortality, the Rondônia and random-clearing scenarios produced 2-5 times more fragmentation-induced carbon emissions than did the Pará scenario, for any given level of clearing.

Using current estimates of forest conversion, our simulations suggest that committed carbon emissions from forest fragmentation alone will range from 2.3 to 11.7 million tons per year in the Brazilian Amazon, and from 22 to 149 million tons per year for tropical forests globally (Laurance et al., submitted).



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