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Essays and Perspectives

Synthesis of the first 10 years of long-term ecological research in Amazonian Forest ecosystem – implications for conservation and management



Fernanda V. Costa^{a,*}, Flávia R.C. Costa^a, William E. Magnusson^a,
Elizabeth Franklin^a, Jansen Zuanon^a, Renato Cintra^a, Flávio Luizão^a,
José Luís C. Camargo^{a,b}, Ana Andrade^b, William F. Laurance^{b,c},
Fabricio Baccaro^{e,a}, Jorge Luiz Pereira Souza^a, Helder Espírito-Santo^d

^a Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil

^b Biological Dynamics of Forest Fragments Project, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil

^c Centre for Tropical Environmental and Sustainability Science & College of Marine and Environmental Sciences, James Cook University, Cairns, Australia

^d Postgraduate Ecology Program, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, AM, Brazil

^e Universidade Federal do Amazonas (UFAM), Manaus, Amazonas, Brazil

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ABSTRACT

We present a synthesis of the first 10 years of Long Term Ecological Research project in Amazonian Forest. We elucidate the natural dynamics of forest ecosystem processes and associated biota, and its changes caused by distinct pressures of selective timber extraction and forest fragmentation. We found that, for both plants and animals, densities of individuals and distribution of species assemblages are spatially heterogeneous at the mesoscale, even in relatively undisturbed forests, and that associations with topo-edaphic variables allow prediction of a considerable part of this variation. For biological groups whose dynamics were studied in the short-term, levels of change in species composition and densities were relatively high, and these changes were generally in tune with spatial environmental variation. The impact of selective logging on assemblages and ecosystem processes was normally moderate, and around 19 years were needed for recovering forest biomass and tree size distribution. Continued studies are needed to determine the time required for recuperation of timber stocks and pre-logging floristic composition. Selective logging appears to be compatible with the biodiversity conservation, but reduction and better planning of road access may be more important than planned logging intensities. Habitat-loss' impact on organisms and ecosystem processes is large and long-lasting, since it induces the loss of many taxonomic groups and species, higher tree mortality and accelerated forest dynamics. There was a negative synergy between the impacts of habitat loss and climatic changes, and a better understanding of these processes can only be obtained through long-term research.

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* Corresponding author.

E-mail addresses: fecostabio@gmail.com, fernanda.costa@inpa.gov.br (F.V. Costa).

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Introduction

Growth of human populations and economic activities are transforming tropical forests into a mosaic of altered environments, pastures and isolated forest fragments, with severe consequences for biodiversity (Bierregaard et al., 1992; Laurance et al., 2011). The destruction of Amazonian forests grew exponentially during the 1970s and 1980s (Fearnside, 1987, 1990), and continues to impact dynamics of fauna, flora and ecosystem processes.

Human activities in tropical forest areas range from selective timber extraction with moderate environmental impacts to complete deforestation for agro-pastoral and industrial activities (Laurance and Vasconcelos, 2009). Understanding how and to what extent tropical forest ecosystems respond to different anthropogenic activities provides us an important base for environmental planning, management and monitoring, all essential for the promotion of sustainable development of tropical environments, such as Amazonia.

In response to these challenges, researchers of the National Institute for Amazonian Research (INPA) included Central Amazonia in the Brazilian program for Long Term Ecological Research – LTER (hereafter referenced as LTER-Site #1) established by the Brazilian National Research Council (CNPq). The aim of the program is to collect and organize data on the structure and functioning of the principal Brazilian ecosystems in order to generate a knowledge base to evaluate biological diversity, and subsequently propose plans for sustainable use and conservation. The LTER-Site #1 (Fig. 1) is the oldest

Amazonian site in the Brazilian LTER program, and includes three forest reserves managed by INPA that differ in land use intensity. All sites are covered by evergreen dense terra-firme forest.

The Ducke Forest Reserve (RFD) is located 26 km north of Manaus ($2^{\circ} 55' 47.80''$ S; $59^{\circ} 58' 30.34''$ W), and covers 10.000 ha (10×10 km). This area does not suffer environmental impact within its borders, but is surrounded by urban sprawl from Manaus city. All studies were conducted in permanent plots regularly distributed across the landscape. The Experimental Forest Management Station (ZF2) is located about 90 km northeast of Manaus ($2^{\circ} 38' S$, $60^{\circ} 11' W$), and was submitted to selective logging treatments in 4-ha plots, arranged in three blocks. Each block has one control unlogged plot, three plots logged in 1987, and one plot logged in 1993 to assess the effect of time after timber extraction. The logged plots experienced different intensities of timber extraction. All these plots were established in the upland flat terrain (“plateau”), to minimize topographic effects. The reserves of the Biological Dynamics of Forest Fragments Project (PDBFF) are situated 80 km from Manaus and span about 1.000 km². The study area includes 11 forest fragments (five of 1 ha, four of 10 ha, and two of 100 ha), and expanses of nearby continuous forest that serve as experimental controls. In the early 1980s, the fragments were isolated from nearby intact forest by distances of 80–650 m by clearing and burning the surrounding forest. Most studies performed in PDBFF assessed the effect of fragmentation components – size of fragments and edge effect – on biodiversity, rather than evaluating fragmentation as a landscape process as proposed by Fahrig (2003, 2013).

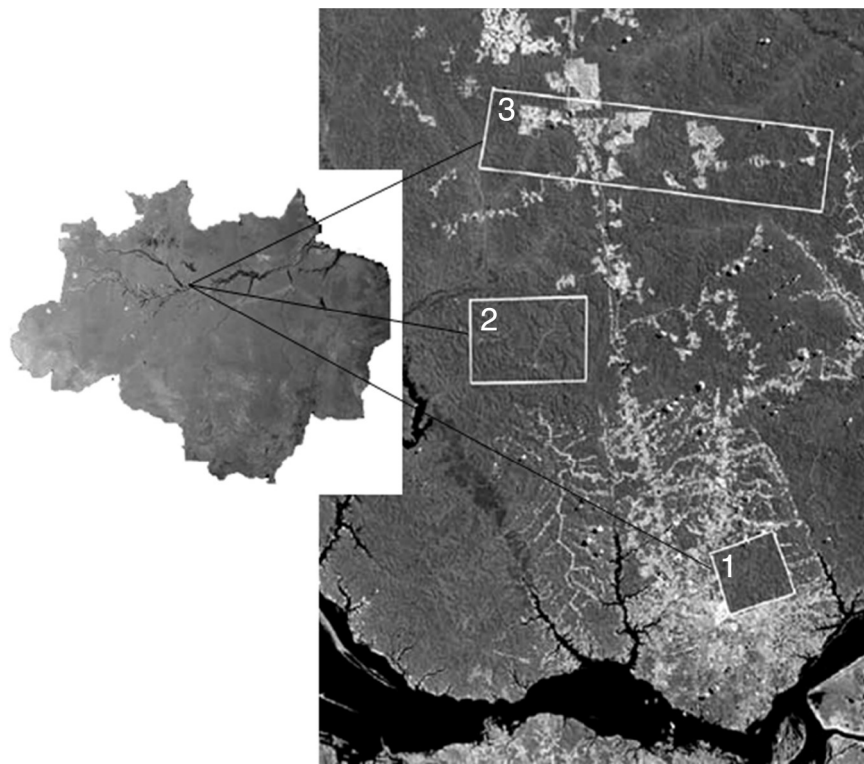


Fig. 1 – Location of LTER-Site #1 in central Amazonia, and the position of the studied areas on north of Manaus city. (1) Ducke Forest Reserve (RFD), (2) Experimental Forest Management Station (ZF2) and (3) Reserves of Biological Dynamics of Forest Fragments Project (PDBFF).

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