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THE BIOLOGICAL DYNAMICS OF FOREST FRAGMENTS PROJECT: 25 Years of Research in the Brazilian Amazon

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The Biological Dynamics of Forest Fragments Project (BDFFP) is the world's largest and longest-running experimental study of habitat fragmentation. On June 28, 2004, researchers, students, and associates of the BDFFP celebrated a watershed event—the 25th anniversary of the project. The event provided an opportunity to showcase the scientific and societal impacts of this landscape-scale investigation into the ecology and conservation of Amazonian forests.

PROJECT HISTORY

Initiated in 1979, the BDFFP is a bi-national, collaborative project between the Smithsonian Institution and the Brazilian National Institute for Amazonian Research (INPA). As one of the longest-term projects evaluating the impacts of human activities in the Amazon, the BDFFP is both a cutting-edge study of forest fragmentation and a model for similar investigations in other regions.

The project owes its genesis to a heated scientific debate in the mid-1970s, concerning the applicability of island biogeography theory to conservation planning. This debate, summarized as "SLOSS" (single large or several small reserves of equal area), eventually helped to galvanize many ecologists to study fragmented and other insular ecosystems. At the time, however, the arguments about SLOSS were more about ecological theory than actual data, because so few data were available.

The SLOSS debate was highly relevant to Tom Lovejoy, at that time the head of programs for World Wildlife Fund-U.S. (and currently President-elect of the ATBC). In late 1976, Lovejoy conceived of a giant experiment in the Amazon to study the implications of fragmentation and its relevance for SLOSS. INPA endorsed the project and, in 1979, the investigation—initially christened the Minimum Critical Size of Ecosystems Project—began in the rainforests near Manaus, Brazil, with

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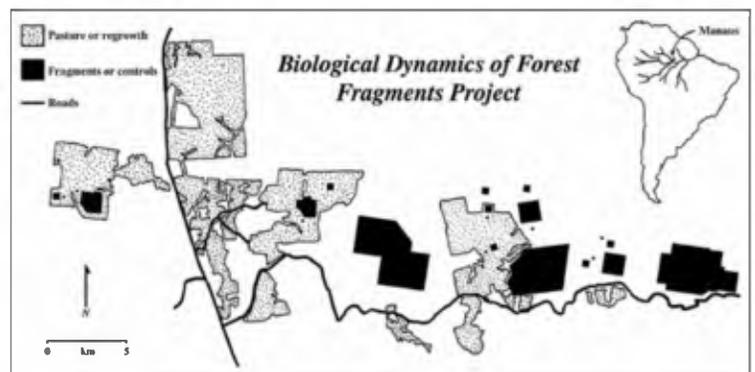


Figure 1. The BDFFP study area near Manaus, Brazil, showing the locations of forest fragments and control sites in intact forest (shaded blocks). Stippled areas are cattle pastures or regrowth forest, while unstippled areas are rainforest. Thick, solid lines are roads.

the fieldwork led by Richard Bierregaard.

Over the past 25 years, BDFFP researchers and students have assessed the impacts of Amazon forest fragmentation on a great diversity of species—trees, birds, primates, small mammals, frogs, insects, and many other plant and animal taxa—as well as on many ecological and ecosystem processes (Box 1). A key feature of the BDFFP is that abundance data were collected for many species prior to experimental isolation of the forest fragments, permitting a far more rigorous assessment of fragmentation effects than would otherwise be possible.

The BDFFP's 1,000-km² study area (Fig. 1) includes a total of 11 forest fragments ranging from 1-100 ha in area within three large cattle ranches, and extensive areas of intact forest that serve as experimental control sites. Despite its acidic, heavily weathered soils, the study area has extremely high tree diversity, averaging over 280 tree species (≥ 10 cm diameter at breast height) per hectare in intact forest. Also present are secondary forests of varying ages and floristic composition that have regenerated on abandoned cattle pastures.

25TH ANNIVERSARY SYMPOSIUM

Today, BDFFP investigators have produced about 450 scientific publications, several books, and nearly a hundred graduate theses (Box 2). A special four-day symposium in Manaus provided an opportunity to see many of the fruits born by these investigations. The symposium brought together current researchers and students with the original investigators whose efforts initiated the project 25 years ago. For those in attendance, it was partly a scientific meeting and partly a giant family reunion.

The meeting was organized in seven sessions, each organized by a research leader. Session 1, organized by William Laurance, described the impacts of fragmentation on forest structure, composition, and dynamics. Session 2, led by Rita Mesquita, summarized studies of forest regeneration in degraded lands of the BDFFP landscape. The third session, coordinated by Richard Bierregaard, described how different animal species respond to forest fragmentation, whereas the fourth session, headed by Heraldo Vasconcelos, described how fragmentation altered ecological processes and species interactions.

The final three sessions focused on practical applications of BDFFP research. Session 5, coordinated by Eduardo Venticinque, described the increasing role of the BDFFP and its GIS laboratory in land-use planning and ecological zoning in Amazonia. Session 6, organized by Domingos Macedo, summarized the many educational programs offered by the BDFFP—from undergraduate and graduate courses to those designed for environmental decision-makers in Amazonia. The final session, led by Regina Luizão, focused on the future management of the BDFFP landscape and its surrounding forests—which are likely to change dramatically in coming years as a result of increasing forest colonization, logging, and other land-uses in central Amazonia.

The plethora of talks illustrated just how far the BDFFP has come, and how much it has evolved, over the past quarter century. Initially, the project had a relatively simple focus on assessing fragment area-related changes in rainforest communities. Today, the BDFFP's activities are far more diverse. It includes a more complex and sophisticated range of studies designed to assess the role of edge, area, isolation, and matrix

effects on plant and animal communities; autecological investigations of key species; diverse studies of forest regeneration; spatial modeling of land-use changes throughout the Amazon

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A three-volume CD of bird calls of Amazonian birds was unveiled at the BDFFP's 25th Anniversary Symposium. The CD was authored by Phillip Stouffer, Luciano Naka, Mario Cohn-Haft, Curtis Marantz, and Richard O. Bierregaard.

BOX 1: IMPACTS OF FOREST FRAGMENTATION

The BDFFP has yielded scores of insights into the effects of habitat fragmentation on rainforest biotas. As expected, many species—large mammals, primates, understory birds, and certain beetles, ants, bees, termites, and butterflies—are highly sensitive to fragment area, and some have disappeared from even the largest fragments in the area. Surprisingly, a few groups, such as small mammals and frogs, have remained stable or increased in species richness after fragment isolation. These taxa have small area requirements, seem insensitive to edge effects, or readily use the mosaic (matrix) of modified habitats surrounding fragments.

BDFFP studies have also revealed the diversity of edge effects in fragmented rainforests. Such changes dramatically affect plant communities and various ecological and ecosystem processes. Edge effects also influence many animals. Species that favor disturbed forest or treefall gaps often increase in abundance near edges, whereas others, including many understory birds, bats, flies, bees, wasps, beetles, ants, and butterflies, have been shown to decline near edges. Such edge-avoiding species may be particularly vulnerable to forest fragmentation.

The matrix of modified habitats surrounding fragments also has important effects on fragment biotas. Fragments bordered by regrowth forest are less vulnerable to edge-related microclimatic changes and have lower tree mortality than do those adjoined by cattle pastures. The matrix also strongly influences fragment connectivity. Among rainforest frogs, birds, small mammals, and bats, matrix-avoiding species have been much more likely to decline or disappear in the BDFFP fragments than are those that use the matrix. Fragments surrounded by regrowth should therefore sustain more sensitive rainforest species than do those surrounded by hostile habitats such as pastures.

Another important finding is that even small clearings are barriers for many rainforest organisms. Many terrestrial insectivorous birds have disappeared from the BDFFP fragments and failed to recolonize even those isolated by only 80 m, despite a proliferation of regrowth around many fragments. Even an unpaved road of only 30-40 m width dramatically alters the community structure of understory birds and inhibits the movements of many species. Clearings of just 15-100 m are insurmountable barriers for certain dung and carrion beetles, euglossine bees, and arboreal mammals. In human-dominated landscapes, habitat fragments are often isolated by much larger distances than these from large forest tracts, suggesting that movement among fragments will be drastically curtailed for many rainforest species.

BOX 2. PUBLICATIONS AND INFORMATION ABOUT THE BDFFP

To learn more about the BDFFP, and to find a full list of the project's many publications and theses, visit the project website (<http://pdbff.inpa.gov.br>). Below are several key books and new resources:

Laurance, W. F., and R. O. Bierregaard, editors. 1997. *Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities*. University of Chicago Press.

Gascon, C., and P. Moutinho, editors. 1998. *Floresta Amazônica: Dinâmica, Regeneração e Manejo*. Ministério da Ciência e Tecnologia, Manaus, Brazil.

Laurance, W. F., and C. Gascon, editors. 1998. *Ecology and Management of Fragmented Tropical Landscapes*. Special Issue of *Biological Conservation* 91:99-247.

Bierregaard, R. O., C. Gascon, T. E. Lovejoy, and R. Mesquita, editors. 2001. *Lessons from Amazonia: The Ecology and Conservation of a Fragmented Forest*. Yale University Press.

Schroth, G., G. da Fonseca, C. Harvey, C. Gascon, H. Vasconcelos, and A.-M. Izac. 2004. *Agroforestry and Biodiversity Conservation in Tropical Landscapes*. Island Press.

Stouffer, P., L. Naka, M. Cohn-Haft, C. Marantz, and R. O. Bierregaard. 2004. *Bird Songs of Amazonia* (Set of three compact disks).

Barbosa Pires, J., and R. Mesquita. 2004. *E Nós Como Ficamos?* BDFFP Publication for Children.

Ferraz, I., and J. L. Camargo. 2004. *Seeds and Seedlings of Amazonia*. BDFFP Publication.

SCHOLARSHIPS AND FELLOWSHIPS

Student Scholarship Program

Bat Conservation International (BCI) announces its 2005 student research scholarship program. About 15 grants ranging from \$500 to \$2,500 will be awarded to research that is directly related to bat conservation and that documents roosting and feeding habitat requirements of bats, their ecological and economic roles, or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply. Application deadline for 2005 scholarships is 15 December 2004. Information and forms are available at <http://www.batcon.org/schol/schol.html>. For questions, contact Sarah Keeton at skeeton@batcon.org or 512-327-9721.

Short Courses on Field Identification of Tropical Plants in Costa Rica

March 14-26, 2005 & June 27-July 9, 2005 (in English). Courses are given in 4 different environments (Life Zones) We offer partial fellowships. Details are available at <http://www.hjimenez.org/>. Direct contact: Dr. Humberto Jiménez Saa. Apdo. 8-5857-1000/ San José, Costa Rica. FAX: (506) 2534963. Phones: (506) 291-0862; 231-1236 (hjimenez@racsa.co.cr).

Oportunidad de beca para estudios de postgrado/ Fellowship opportunity for postgraduate studies:

BECAS MIGUEL DE CERVANTES PARA PROFESORES Y EGRESADOS DE LATINOAMÉRICA (Fecha límite 30 septiembre 2004 / 30 September 2004 deadline) (Sólo castellano / Spanish only) La Universidad de Alcalá convoca 200 becas de postgrado, doctorado/ máster con la colaboración de la Agencia Española de Cooperación Internacional (AECI) y del Grupo Santander. Las becas están destinadas a profesores y egresados latinoamericanos y de otros países hispanohablantes que deseen iniciar estudios de doctorado y máster, y a aquellos que hayan iniciado estudios de postgrado en la Universidad de Alcalá y no cuenten con ningún tipo de ayuda económica. El plazo de presentación de solicitudes finaliza el día 30 de septiembre de 2004. Mayores informaciones: <http://www.uah.es/otrosweb/inves/ProgramasDeApoyo/becascerv.asp>

2005-2006 Kleinhans Fellowship, Rainforest Alliance: Research

in Tropical Non-Timber Forest Products. The Kleinhans Fellowship research area is restricted to Latin America. Applications for projects conducted in the Peten region of Guatemala or Southern Mexico are especially encouraged. Applications must be received before December 31, 2004. A decision will be made by May 1, 2005. For more information: Kleinhans Fellowship homepage at <http://www.rainforest-alliance.org/programs/kleinhans/index.html>

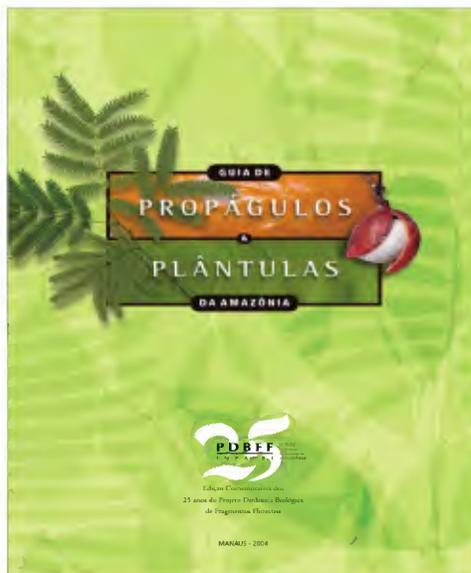
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basin, using the BDFFP's GIS and remote-sensing laboratory; studies of aquatic ecosystems; and long-term investigations of ecological changes in old-growth forests, possibly in response to global-change drivers such as increasing atmospheric CO₂.

Today, education and training also play a major role in the project's mission, to the extent that a number of leading decision-makers in Amazonia received their original graduate training through the BDFFP. The BDFFP also has important influences on conservation policies in Amazonia, via its publications, participation in public meetings, and other public outreach activities. The project's leading role in research and training was the reason it received the prestigious Henry Ford/Conservation International Award for Conservation Achievement in 2000. Another important change is that the Brazilian leadership of the BDFFP has steadily increased over time, to the degree that the last three scientific directors of the project have all been Brazilian. Clearly, the BDFFP has far transcended its original goals and vision. As a model of international cooperation, long-term scientific study, and research and training, the BDFFP has and will continue to make important contributions to our understanding of the ecology and the future of tropical forests.

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LEFT: Also introduced at the BDFFP Anniversary Symposium was the "Guia de Propágulos e Plântulas da Amazônia" (*Seeds and Seedlings of Amazonia Guide*) by Authors Isolde Ferraz and José Luís Campana Camargo.