

Conservation Letter

Human impacts on primate conservation in central Amazonia

Sarah A. Boyle^{1,2}

¹Arizona State University, School of Life Sciences, PO Box 4601, Tempe, Arizona, 85287-4601

²Biological Dynamics of Forest Fragments Project, Instituto Nacional de Pesquisas da Amazônia and Smithsonian Tropical Research Institute, Av. André Araújo 1753 Petrópolis, Manaus AM 69011-970, Brazil. E-mail: Sarah.Boyle@asu.edu

Abstract

Deforestation in the Amazon is a serious environmental, economic, and social concern. This article examines how a colonization plan to bring 180 families to an area north of Manaus, Brazil, would negatively impact the conservation of the six primate species residing in the area. The colonization sites would be located within the Biological Dynamics Forest Fragments Project (BDFFP) study area, the longest-running study of forest fragmentation. An increase in human density in the area would likely increase deforestation and hunting pressure on the fauna, thereby threatening those species that have not fared well in forest fragments. Furthermore, the colonization plan threatens future research at BDFFP and other research sites, as well as the Central Amazonian Conservation Corridor. This would be a great scientific and conservation loss.

Key words: Neotropical primates, Amazonia, agroecosystems, conservation, Brazil

Resumo

O desmatamento na Amazônia é uma séria preocupação ambiental, econômica e social. Este artigo examina como um projeto de colonização para assentar 180 famílias em uma área ao norte de Manaus, Brasil impactaria negativamente a conservação das seis espécies de primatas que habitam a área. Os locais do assentamento estão situados dentro da área de pesquisa do Projeto Dinâmica Biológica de Fragmentos Florestais (PDBFF), o mais antigo estudo sobre a fragmentação da floresta. Um aumento na densidade humana na área provavelmente aumentaria a pressão por desmatamento e caça, ameaçando consequentemente aquelas espécies mais vulneráveis nos fragmentos florestais. Além disso, o projeto de colonização ameaça o futuro da pesquisa no PDBFF e em outros sítios, bem como a integridade do Corredor Central da Amazônia. Isto seria uma grande perda para a ciência e para a conservação.

Palavras-chave: primatas neotropicais, Amazônia, agropecuária, conservação, Brasil

Received: 19 December, 2007, Accepted: 10 February, 2008, Published: 3 March, 2008

Copyright: This is an open access paper. We use the Creative Commons Attribution 3.0 license <http://creativecommons.org/licenses/by/3.0/> - The license permits any user to download, print out, extract, archive, and distribute the article, so long as appropriate credit is given to the authors and source of the work. The license ensures that the published article will be as widely available as possible and that your article can be included in any scientific archive. Open Access authors retain the copyrights of their papers. Open access is a property of individual works, not necessarily journals or publishers

Cite this paper as: Boyle, S. A. 2008. Human impacts on primate conservation in central Amazonia. *Tropical Conservation Science* 1 (1):6-17. Available online: tropicalconservationscience.org

Introduction

The world's forests are disappearing at a rate of 130,000 square kilometers per year [1]. One of the major centers of deforestation is the Amazon Basin, an area that encompasses portions of Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, Suriname, and French Guiana (Fig. 1). The Amazon is the world's largest rain forest, with approximately 50% of its area (4,100,000 square kilometers) located in Brazil [2]. Intensive deforestation of the Brazilian Amazon began in the 1970s, and 70% of the clearing can be attributed to medium-sized and large cattle ranches [3, 4]. Additional clearing for soybean agriculture [4] and selective logging practices [5, 6] have further reduced the amount of intact forest. Activity is primarily concentrated in the "arc of deforestation," located in the southern and eastern areas of the Brazilian Amazon [3], but new highway development plans [4] and colonization projects [7, 8] threaten to increase deforestation across the Amazon.

One of the consequences of deforestation is forest fragmentation, an ever-increasing global phenomenon affecting the persistence of healthy forest ecosystems across the planet [9]. Forest fragmentation occurs when sections of contiguous forest are cleared, thereby leaving a mosaic of patches surrounded by a non-forested matrix. As deforestation for agriculture or urban development continues, the remaining forest becomes increasingly patchy, affecting local climate [10, 11], species richness and distribution [10, 12, 13], predator-prey interactions [14], seed dispersal [15, 16], and habitat suitability [17, 18].



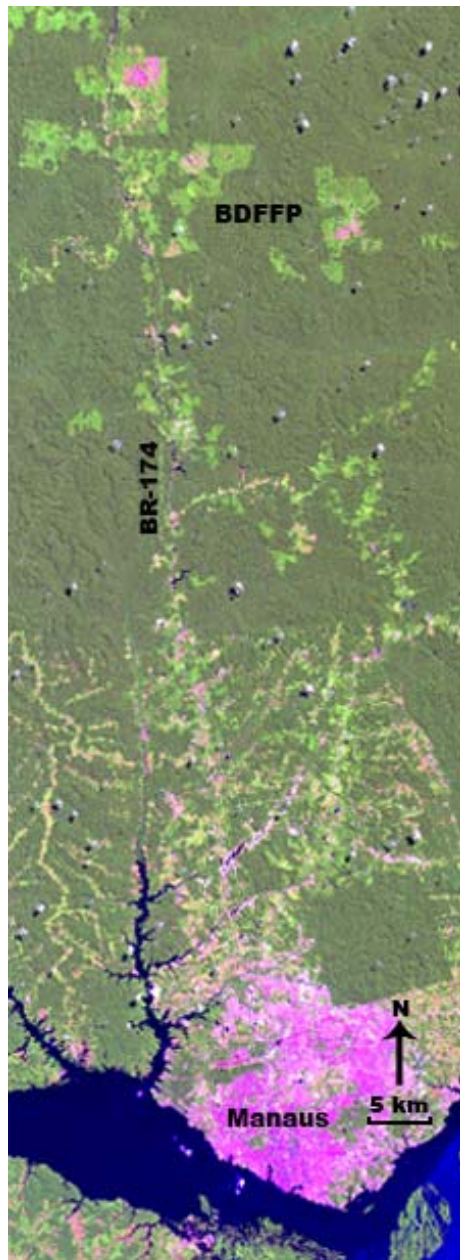
Fig. 1. The Amazon Basin in South America is comprised of areas of Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, Suriname, and French Guiana. Approximately 4,100,000 square kilometers (50%) of the forested area is located in Brazil

Although there is a body of literature examining the effects of forest fragmentation on fauna, flora, climate, and ecological processes, to date there is no consensus as to which factors are primarily responsible for influencing a species' response to forest fragmentation [19-21]. Furthermore, data are lacking for many taxa. For example, in the primate literature the majority of the behavioral ecology research in disturbed habitats focuses on a handful of species, such as howler monkeys (genus *Alouatta*) [16, 22, 23]. Thus, conclusions regarding how primates are affected by habitat fragmentation may not be applicable to underrepresented species in the literature due to differences in the species' behavior and ecology.

Current human practices throughout the tropics threaten the future research and understanding of little-studied taxa, as well as the species' conservation. In this article I illustrate how recent development plans in the Brazilian Amazon may affect the conservation of the nonhuman primates in the region both directly (*i.e.*, deforestation, hunting) and indirectly (*i.e.*, loss of scientific knowledge).

Overview of Conservation Issue

Deforestation of the Brazilian Amazon forest for cattle ranches and soybean cultivation has been coupled with intense development of the transportation infrastructure. As roads are paved and more roads are built, areas that were once remote become easily accessible to humans. Often such developments result in an increase in logging and deforestation [6, 24-26], as well as hunting [18, 27]. In the Brazilian Amazon, two highways, the BR-163 (Santarém-Cuiabá) and BR-319 (Manaus-Porto Velho), are of particular concern [26, 28].



The region surrounding a third highway, BR-174 (Manaus-Boa Vista), which leads to Venezuela (Fig. 2), is the focal area for a controversial plan by the Brazilian federal agency Superintendência da Zona Franca de Manaus (SUFRAMA). The plan calls for at least six colonization projects that would bring 180 families into an area alongside the BR-174, as well as feeder roads such as ZF-3 [7, 8]. The colonization sites would be located approximately 80 km north of Manaus, a large city of approximately 1.6 million inhabitants [29]. Such a project would threaten federally protected areas, a portion of the planned Central Amazonia Conservation Corridor, important research sites operated by the Instituto Nacional da Pesquisas de Amazônia (INPA) and Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), and the existence of the Biological Dynamics of Forest Fragments Project (BDFFP), the longest-running study on forest fragmentation [7].

Fig. 2. Deforestation along the BR-174. Landsat ETM+ satellite imagery from 2006 shows the pattern of deforestation along, and spreading outward from, the BR-174 highway. The BR-174 extends north from Manaus to Venezuela, passing through the BDFFP study area. Dark green areas are forested, light green areas are secondary growth, and pink areas are non-forested

The BDFFP, operated by INPA and the Smithsonian Tropical Research Institute, began in 1979 and has resulted in approximately 600 publications, books, dissertations, and theses by Brazilian and foreign scientists and students on the consequences of forest fragmentation [7]. Gascon and Bierregaard, Jr. [30] and Gascon *et al.* [31] provide a history of the project and a review of the research findings. The study site (Fig. 3), occupies an area of 1,000 square kilometers, and is in the midst of the area slated by SUFRAMA for the colonization projects, even though sections of the BDFFP study area are national protected areas [7, 8]. Already there has been an influx of human inhabitants to the study area (Fig. 4), and BDFFP has suffered from theft, intentional fires, hunting, and logging [7].

Six primate species reside in the BDFFP study area: red howler monkey (*Alouatta seniculus*), black spider monkey (*Ateles paniscus*), brown capuchin monkey (*Cebus apella*), brown bearded saki (*Chiropotes satanas chiropotes*)¹, white-faced saki monkey (*Pithecia pithecia*), and golden-handed tamarin (*Saguinus midas*). Although research at BDFFP has been ongoing since 1979, primate research in the forest fragments has been sporadic, with in-depth behavioral and ecological research only on red howler monkeys [35-40], white-faced saki monkeys [41-43], and bearded saki monkeys [44]. Therefore, there is still much to learn regarding the responses of the primates to forest fragmentation.



Fig. 3. The Biological Dynamics of Forest Fragments Project (BDFFP) is located approximately 80 km north of Manaus, the capital of the state of Amazonas. Forest fragments are located throughout three cattle ranches, or *fazendas*, Dimona, Porto Alegre, and Esteio. Cabo Frio and Km 41 are two continuous forest sites. Fragments are black, clear-cut areas and secondary forest areas are white, and old growth forest is gray. The SUFRAMA colonization plan would settle families within the area of BDFFP

Discussion

SUFRAMA's colonization plan to bring in 180 families to the area has raised serious concern by scientists who foresee the plan having negative ecological, economical, and sociological consequences [7, 8]. Agricultural projects in the Amazon are often not profitable [4], due to the area's low soil fertility. Ranchers near the BDFFP's forest fragments have experienced this firsthand [45]. In fact, one of the main uses of forest in central Amazonia is burning it for charcoal (W. Laurance, pers. comm.). Therefore there is concern that the colonists would not benefit from the colonization plan [8], and there would be increased rates of hunting, logging, and charcoal production. In addition, it is important to note that the plots of land in the SUFRAMA settlement areas would be sold to landowners, some for the purpose of weekend leisure; thus, the settlers are not currently homeless (R. Luizão, pers. comm.).

¹ Currently there are discrepancies regarding taxonomy in the genus *Chiropotes* [32-34]. Prior to the taxonomic revisions, the species found at BDFFP was considered *C. satanas chiropotes*. I follow the original nomenclature here due to the lack of accordance among taxonomists regarding the designation of the *C. satanas* subspecies at the species level.

The possible demise of the BDFFP, a research site that spans three decades, would be a great scientific and educational loss. Approximately three decades of research have been conducted at the BDFFP, yet the BDFFP has also been a source of employment and educational opportunities (*e.g.*, training in science and management) for local residents, for Brazilians from other areas of the country, and for the international community [7, 46]. Past and present BDFFP researchers have also partnered with other agencies to work with the rural population on agroforestry projects (*e.g.*, education, training, distribution of native seedlings), and to provide educational materials on how to make a living without disturbing the protected areas (R. Luizão, pers. comm.). Scientists also credit the cooperation between the local landowners and the BDFFP researchers for the success of the BDFFP project [45]. Therefore, increased human colonization of the study area threatens all aspects of the BDFFP, including the conservation of the primates in the area.



Fig. 4. Settlers within the Biological Dynamics of Forest Fragments Project (BDFFP) study area have illegally cut native forest. Theft, hunting, and intentional fires have also posed problems to the BDFFP. This photograph depicts one settlement in July 2007. Photo courtesy of BDFFP/Carlos da Costa.

The BDFFP is a unique and valuable resource for the study of primates and forest fragmentation. First, censuses of the primates occurred prior to the isolation of the forest fragments, and subsequent censuses of the forest fragments have been intermittently conducted throughout the past three decades [47-50]. These data are imperative to determine the current status of the resident primate populations, to document any patterns of primate immigrations and extinctions that have arisen during the past 30 years, and to relate the presence or absence of the species to predictive variables (*e.g.*, fragment size, distance to continuous forest, and condition of the matrix). Second, the variations in fragment size (1-100 ha) and the configurations of fragments within the surrounding matrix (which varies from pasture to tall secondary growth forest) allow researchers to study the species within the fragments, as

well as their use, or avoidance, of the surrounding landscape. Third, the primates at BDFFP represent six species that vary in body size, diet, home range size, and social structure. Therefore, comparisons of the responses of the species to fragments of various sizes and surrounded by various compositional matrices, are unique opportunities.

The findings to-date have shed light on the variability in responses of the six resident primate species to forest fragmentation (Table 1). Differences between species were apparent upon the initial isolation of the BDFFP forest fragments [47]. Furthermore, since the 1980s, some species (*e.g.*, red howler monkey) have persisted in the various forest fragments, while other species (*e.g.*, black spider monkey, Fig. 5) have remained absent from the majority of the forest fragments [47-50]. Understanding why some species are re-colonizing the forest fragments decades later, and how their use of the fragments' resources differs from that of animals living in continuous forest, is critical for the conservation planning of the species.

Table 1 Primate Presence 2003-2006. The presence of the six primate species is noted for the three size classes of forest fragments: 100 ha, 10 ha, and 1 ha. For each size class, the proportion of fragments in which each species was present is noted. (*) indicates that the species was present in the forest fragment for less than 20 percent of the study.

	100 ha (n=2)	10 ha (n=3)	1 ha (n=4)
<i>Alouatta</i>	100	100	50*
<i>Chiropotes</i>	100	67	25*
<i>Saguinus</i>	100	100	0
<i>Pithecia</i>	100	100	0
<i>Cebus</i>	100	33*	0
<i>Ateles</i>	0	33*	0

Implications for Conservation

Overall there is a lack of knowledge of the Amazon's fauna and flora [51], including the behavioral ecology of many free-ranging primates [52]. If the SUFRAMA colonization plan is put into effect, it could disturb several major scientific research sites in the area, as well as the Central Amazonian Conservation Corridor. More importantly, an increase in colonists could result in the local demise of many plant and animal species, including many of the primates.

Primates are readily hunted in many parts of the tropics, and an influx of settlers to an area would likely bring extra hunting pressure. Human colonization in the eastern Brazilian Amazon has greatly affected the mammal community [53]. All six primate species inhabiting the BDFFP region are hunted in some areas of the Amazon, though hunting pressure varies [54-59].

To preserve biodiversity in areas experiencing human disturbance, it is important to understand how habitat modifications alter species survival over time. For example, primate presence has fluctuated at the BDFFP, thereby creating opportunities to study species that were not present in the forest fragments during the 1980s. Therefore, the continuation of primate research (*e.g.*, censuses, behavioral studies, land cover classifications) at BDFFP is critical to understanding how (and to what extent) the primates use the forest fragments and the surrounding matrix. Unfortunately, the colonization of the area by 180 families, and the subsequent increased human pressure on vulnerable species, is cause for alarm.



Fig. 5. Red Howler monkeys (*Alouatta seniculus*) are more prevalent in forest fragments than the other five primate species at BDFFP. They are commonly found in fragments as small as 10 ha, and intermittently reside in fragments as small as 1 ha. Black spider monkeys (*Ateles paniscus*) have been the least prevalent primate species in the forest fragments at BDFFP. These large-bodied frugivores often face intense hunting pressure throughout the Amazon. Photos by Sarah Boyle.

There is serious conservation concern for the future of the BDFFP primates, in particular those that are virtually absent from the majority of the forest fragments (*i.e.*, black spider monkeys, brown capuchin monkeys), those that appear to be severely isolated from other groups due to their hesitance to cross a young matrix (*i.e.*, bearded saki monkeys), and those that may be currently under hunting pressure in the immediate areas surrounding the BDFFP reserves (*i.e.*, black spider monkeys, red howler monkeys, and brown capuchin monkeys).

There is hope. Researchers and environmental advocates have partnered with like-minded Brazilian agencies to urge SUFRAMA to halt the colonization plans; to release the findings of its 2004 land-use report, which was developed by both SUFRAMA and scientists; and to consult with scientific and research management organizations and government agencies, as well as the public, prior to commencing any forest-colonization plans [7, 8, 60]. As a result of increased media attention regarding the colonization plan, both in Brazil and abroad [7, 8, 60-63], SUFRAMA has temporarily suspended activities related to forest settlement near the BDFFP area (R. Luizão, pers. comm.). Furthermore, reports Luizão, the BDFFP has been invited to submit proposals for funding to develop a formal management plan for both the BDFFP and other regional protected areas. It is crucial that such collaboration and progress continue, due to the importance of the forest that is at risk by the SUFRAMA colonization plan.

Acknowledgements

R. Luizão, W. Laurance, D. Kabelik, B. Lenz, A. Smith, and two anonymous reviewers provided helpful comments to improve this article. The author's research in Brazil was funded by the Biological Dynamics of Forest Fragments Project/Instituto Nacional da Pesquisas de Amazônia and the Smithsonian Tropical Research Institute, Fulbright/IIE, Margot Marsh Biodiversity Foundation, Primate Conservation, Inc., Organization for Tropical Studies, American Society of Primatologists, and Arizona State University. This is contribution number 500 in the Biological Dynamics of Forest Fragments Project technical series.

References

- [1] FAO. 2007. *State of the World's Forests 2007*, Food and Agricultural Organization of the United Nations, Rome. 144 pps.
- [2] Skole, D. and Tucker C. 1993. Tropical deforestation and habitat fragmentation in the Amazon - satellite data from 1978 to 1988. *Science* 260: 1905-1910.
- [3] Fearnside, P.M. and Graça P.M.L. 2006. BR-319: Brazil's Manaus-Porto highway and the potential impact of linking the arc of deforestation to central Amazonia. *Environmental Management* 38: 705-716.
- [4] Fearnside, P.M. 2007. The fractured landscape. *The American Prospect* 18: A11-A13.
- [5] Asner, G.P., Knapp D.E., Broadbent E.N., Oliveira P.J.C., Keller M. and Silva J.N. 2005. Selective logging in the Brazilian Amazon. *Science* 310: 480-482.
- [6] Asner, G.P., Broadbent E.N., Oliveira P.J.C., Keller M., Knapp D.E. and Silva J.N.M. 2006. Condition and fate of logged forests in the Brazilian Amazon. *Proceedings of the National Academy of Sciences of the United States of America* 103: 12947-12950.
- [7] Laurance, W.F. and Luizão R. 2007. Driving a wedge into the Amazon. *Nature* 448: 409-410.
- [8] Blumberg, J. 2007. Up in smoke. *Smithsonian Magazine* 38: 31.
- [9] Lovejoy, T.E. 2006. Protected areas: a prism for a changing world. *Trends in Ecology & Evolution* 21: 329-333.
- [10] Bierregaard Jr., R.O., Lovejoy T.E., Kapos V., Dossantos A.A. and Hutchings R.W. 1992. The biological dynamics of tropical rain-forest fragments. *Bioscience* 42: 859-866.
- [11] Achard, F., Eva H.D., Stibig H.J., Mayaux P., Gallego J., Richards T. and Malingreau J.P. 2002. Determination of deforestation rates of the world's humid tropical forests. *Science* 297: 999-1002.
- [12] Malcolm, J.R. 1997. Biomass and diversity of small mammals in Amazonian forest fragments, In: *Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities*, p. 207-221, (ed) W.F. Laurance and R.O. Bierregaard Jr. University of Chicago Press: Chicago.
- [13] Laurance, W.F., Delamonica P., Laurance S.G., Vasconcelos H.L. and Lovejoy T.E. 2000. Conservation - Rainforest fragmentation kills big trees. *Nature* 404: 836-836.

- [14] Asquith, N.M., Wright S.J. and Clauss M.J. 1997. Does mammal community composition control recruitment in neotropical forests? Evidence from Panama. *Ecology* 78: 941-946.
- [15] Chapman, C.A. and Onderdonk D.A. 1998. Forests without primates: Primate/plant codependency. *American Journal of Primatology* 45: 127-141.
- [16] Estrada, A., Anzures A. and Coates-Estrada R. 1999. Tropical rain forest fragmentation, howler monkeys (*Alouatta palliata*), and dung beetles at Los Tuxtlas, Mexico. *American Journal of Primatology* 48: 253-262.
- [17] Gascon, C., Williamson G.B. and da Fonseca G.A.B. 2000. Ecology - Receding forest edges and vanishing reserves. *Science* 288: 1356-1358.
- [18] Laurance, W.F., Vasconcelos H.L. and Lovejoy T.E. 2000. Forest loss and fragmentation in the Amazon: implications for wildlife conservation. *Oryx* 34: 39-45.
- [19] Harrison, S. and Bruna E. 1999. Habitat fragmentation and large-scale conservation: what do we know for sure? *Ecography* 22: 225-232.
- [20] Kattan, G.H. and Murcia C. 2003. A review and synthesis of conceptual frameworks for the study of forest fragmentation, In: *How Landscapes Change: Human Disturbance and Ecosystem Fragmentation in the Americas*, p. 183-200, (ed) G.A. Bradshaw and P.A. Marquet. Springer-Verlag: Berlin.
- [21] Debinski, D.M. and Holt R.D. 2000. A survey and overview of habitat fragmentation experiments. *Conservation Biology* 14: 342-355.
- [22] Chiarello, A.G. 1994. Diet of the brown howler monkey *Alouatta fusca* in a semi-deciduous forest fragment of southern Brazil. *Primates* 35: 25-34.
- [23] Silver, S.C. and Marsh L.K. 2003. Dietary flexibility, behavioral plasticity, and survival in fragments: lessons from translocated howlers, In: *Primates in Fragments: Ecology and Conservation*, p. 251-265, (ed) L.K. Marsh. Kluwer Academic: New York.
- [24] Laurance, W.F., Cochrane M.A., Bergen S., Fearnside P.M., Delamônica P., Barber C., D'Angelo S. and Fernandes T. 2001. The future of the Brazilian Amazon. *Science* 291: 438-439.
- [25] Nepstad, D., Carvalho G., Barros A.C., Alencar A., Capobianco J.P., Bishop J., Moutinho P., Lefebvre P., Silva J., U. L. and Prins E. 2001. Road paving, fire regime feedbacks, and the future of Amazon forests. *Forest Ecology and Management* 154: 395-407.
- [26] Fearnside, P.M. 2005. Deforestation in Brazilian Amazonia: history, rates, and consequences. *Conservation Biology* 19: 680-688.
- [27] Peres, C.A. and Lake I.R. 2003. Extent of nontimber resource extraction in tropical forests: accessibility to game vertebrates by hunters in the Amazon Basin. *Conservation Biology* 17: 521-535.
- [28] Fearnside, P.M. 2007. Brazil's Cuiabá-Santarém (BR-163) Highway: The environmental cost of paving a soybean corridor through the Amazon. *Environmental Management* 39: 601-614.
- [29] IBGE. 2007. *Contagem de População 2007*. Instituto Brasileiro de Geografia e Estatística: Rio de Janeiro, 311 pps.

- [30] Gascon, C. and Bierregaard Jr. R.O. 2001. The biological dynamics of forest fragments project: the study site, experimental design, and research activity, In: *Lessons from Amazonia: The Ecology and Conservation of a Fragmented Forest*, p. 31-42, (ed) R.O. Bierregaard Jr., C. Gascon, T.E. Lovejoy, and R. Mesquita. Yale University Press: New Haven.
- [31] Gascon, C., Lovejoy T.E., Bierregaard R.O., Malcolm J.R., Stouffer P.C., Vasconcelos H.L., Laurance W.F., Zimmerman B., Tocher M. and Borges S. 1999. Matrix habitat and species richness in tropical forest remnants. *Biological Conservation* 91: 223-229.
- [32] Bonvicino, C.R., Boubli J.P., Otazú I.B., Almeida F.C., Nascimento F.F., Coura J.R. and Seuánez H.N. 2003. Morphologic, karyotypic, and molecular evidence of a new form of *Chiropotes* (Primates, Pitheciinae). *American Journal of Primatology* 61: 123-133.
- [33] Hershkovitz, P. 1985. A preliminary taxonomic review of the South American bearded saki monkeys genus *Chiropotes* (Cebidae, Platyrrhini), with the description of a new subspecies. *Fieldiana* 27: 1-46.
- [34] Silva, J., J. S. and Figueiredo W.M.B. 2002. Revisão sistemática dos cuxiús, gênero *Chiropotes* Lesson, 1840 (Primates, Pitheciidae), in *Livro de Resumos: Xth Congresso Brasileira de Primatologia: Amazônia - A Última Fronteira*, p. 21, Belém: Sociedade Brasileira de Primatologia.
- [35] Neves, A.M.S. and Rylands A.B. 1991. Diet of a group of howling monkeys, *Alouatta seniculus*, in an isolated forest patch in central Amazonia, In: *A Primatologia no Brasil, Volume 3*, p. 263-274, (ed) A.B. Rylands and A.T. Bernades. Sociedade Brasileira de Primatologia: Belo Horizonte.
- [36] Gómez, M.S. 2004. *The effect of home range reduction on the ecology of red howler monkeys in central Amazonia*. Ph.D. dissertation. University of Cambridge, Cambridge.
- [37] Neves, A.M.S. 1985. *Alguns aspectos da ecologia de Alouatta seniculus em reserva isolada na Amazônia Central*. B.S. Monograph. Universidade de São Paulo, Ribeirão Preto.
- [38] Gilbert, K.A. 1997. Red howling monkey use of specific defecation sites as a parasite avoidance strategy. *Animal Behaviour* 54: 451-455.
- [39] Gilbert, K.A. 1994. *Endoparasitic infection in red howling monkeys (Alouatta seniculus) in the central Amazonian basin*. Ph.D. dissertation. Rutgers, New Brunswick.
- [40] Santamaría, M. and Rylands A.B. 2003. Ecología básica de un grupo de *Alouatta seniculus* durante una estación seca en la Amazonía central brasileira, In: *Primatología del Nuevo Mundo: Biología, Medicina, Manejo y Conservación*, p. 96-111, (ed) V. Pereira-Benoga, F.N. Montoya and A. Savage. Centro de Primatologia Araguaiatos Ltda: Bogota.
- [41] Setz, E.F.Z. 1993. *Ecologia alimentar de um grupo de parauacus (Pithecia pithecia chrysocephala) em um fragmento florestal na Amazônia Central*. Ph.D. dissertation. Universidade Estadual de Campinas, São Paulo.
- [42] Setz, E.F.Z. 1994. Feeding ecology of golden-faced sakis. *Neotropical Primates* 2: 13-14.

- [43] Setz, E.Z.F., Enzweiler J., Solferini V.N., Amêndola M.P. and Berton R.S. 1999. Geophagy in the golden-faced saki monkey (*Pithecia pithecia chrysocephala*) in the Central Amazon. *Journal of Zoology* 247: 91-103.
- [44] Boyle, S.A., Smith A.T., Spironello W.R. and Zartman C.E. in press. The behavioural ecology of bearded sakis (*Chiropotes sagulatus*) living in forest fragments of central Brazilian Amazonia, In: *Evolutionary Biology and Conservation of Titis, Sakis and Uacaris*, (ed) A. Barnett, L.M. Viega, S.F. Ferrari, and M.A. Norconk. Cambridge University Press: Cambridge.
- [45] Bierregaard Jr., R.O. and Gascon C. 2001. The Biological Dynamics of Forest Fragments Project: overview and history of a long-term conservation project, In: *Lessons from Amazonia: The Ecology and Conservation of a Fragmented Forest*, p. 5-12, (ed) R.O. Bierregaard Jr., C. Gascon, T.E. Lovejoy, and R. Mesquita. Yale University Press: New Haven.
- [46] Bierregaard Jr, R.O., Laurance W.F., Gascon C., Benitez-Malvido J., Fearnside P.M., Fonseca C.R., Ganade G., Malcolm J.R., Martins M.B., Mori S., Oliveira M., Rankin-De Merona J., Scariot A., Spironello W. and Williamson B. 2001. Principles of forest fragmentation and conservation in the Amazon, In: *Lessons from Amazonia: The Ecology and Conservation of a Fragmented Forest*, p. 371-385, (ed) R.O. Bierregaard Jr, C. Gascon, T.E. Lovejoy, and R. Mesquita. Yale University Press: New Haven.
- [47] Rylands, A.B. and Keuroghlian A. 1988. Primate populations in continuous forest and forest fragments in central Amazonia. *Acta Amazônica* 18: 291-307.
- [48] Schwarzkopf, L. and Rylands A.B. 1989. Primate species richness in relation to habitat structure in Amazonian rainforest fragments. *Biological Conservation* 48: 1-12.
- [49] Gilbert, K.A. 2003. Primates and fragmentation of the Amazon forest, In: *Primates in Fragments: Ecology and Conservation*, p. 145-157, (ed) L.K. Marsh. Kluwer Academic: New York.
- [50] Gilbert, K.A. and Setz E.A. 2001. Primates in a fragmented landscape: six species in Central Amazonia, In: *Lessons From Amazonia: the Ecology and Conservation of a Fragmented Forest*, p. 262-270, (ed) R.O. Bierregaard Jr., C. Gascon, T.E. Lovejoy, and R. Mesquita. Yale University Press: New Haven.
- [51] Peres, C.A. 2005. Why we need megareserves in Amazonia. *Conservation Biology* 19: 728-733.
- [52] Sussman, R.W. 2007. A brief history of primate field studies, In: *Primates in Perspective*, p. 6-10, (ed) C.J. Campbell, A. Fuentes, K.C. MacKinnon, M. Panger, and S.K. Bearder. Oxford University Press: New York.
- [53] Lopes, M.A. and Ferrari S.F. 2000. Effects of human colonization on the abundance and diversity of mammals in eastern Brazilian Amazonia. *Conservation Biology* 14: 1658-1665.
- [54] Alvard, M.S., Robinson J.G., Redford K.H. and Kaplan H. 1997. The sustainability of subsistence hunting in the Neotropics. *Conservation Biology* 11: 977-982.
- [55] de Thoisy, B., Renoux F. and Julliot C. 2005. Hunting in northern French Guiana and its impact on primate communities. *Oryx* 39: 149-157.

- [56] Peres, C.A. 2001. Synergistic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates. *Conservation Biology* 15: 1490-1505.
- [57] de Souza-Mazurek, R.R., Pedrinho T., Feliciano X., Hilário W., Gerônimo S. and Marcelo E. 2000. Subsistence hunting among the Waimiri Atoari Indians in central Amazonia, Brazil. *Biodiversity and Conservation* 9: 579-596.
- [58] Cormier, L. 2006. A preliminary review of Neotropical primates in the subsistence and symbolism of indigenous lowland South American peoples. *Ecological and Environmental Anthropology* 2: 14-32.
- [59] Peres, C.A. 1990. Effects of hunting on western Amazonian primate communities. *Biological Conservation* 54: 47-59.
- [60] ATBC. 2007. *Resolution Supporting Conservation of Critical Ecosystems and Research Sites in Central Amazonia*.
- [61] Mongabay.com. 2007. Scientists demand Brazil suspend Amazon colonization project. *Mongabay.com*. news.mongabay.com/2007/0827-atbc.html.
- [62] Leite, M. 2007. O gringo, a floresta e a escória. *Folha do Meio Ambiente (Online)*. folhadomeio.com.br/publix/fma/folha/2007/08/gringo180.html.
- [63] Lopes, M. 2007. Pesquisadores contra assentamento da Suframa. *Folha do Meio Ambiente (Online)*. folhadomeio.com.br/publix/fma/folha/2007/08/gringo180.html.