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MATA ATLANTICA PROGRAM
TECHNICAL REPORT - QUALITATIVE ASPECTS

Biodiversity Conservation in fragmented landscapes at the Atlantic Plateau of São Paulo, Brazil (BioCAPSP) - II

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Brazilian Coordinator
Prof. Dr. Jean Paul Metzger, Universidade de São Paulo, Instituto de Biociências, Departamento de Ecologia
jpm@ib.usp.br

German Coordinator
PD Dr. Klaus Henle, Klaus.Henle@ufz.de assisted by **Dr. Christoph Knogge;** Christoph.Knogge@ufz.de
UFZ - Helmholtz Center for Environmental Research, Dept. of Conservation Biology

Overall project goals

This project period (2006-2009) represents the continuation of the studies conduced during the first phase of the project (2003-2005) on the effects of forest fragmentation in the Caucaia do Alto region, intensifying the analysis on the influence of the landscape's temporal dynamics and functional connectivity. In order to approach new research questions we extended the study region over two new areas of the Atlantic Plateau of Sao Paulo. In general the project analyzed ***which factors determine in fragmented landscapes the diversity patterns and the distribution of bird, mammal and amphibian species***. It has been shown that these considered groups responded significantly to variations of the landscape structure at the plateau of Ibiúna.

The project was designed to answer the following detailed questions:

- What is the relative importance of forest quantity, spatial configuration and cover for the maintenance of the biodiversity in fragmented landscapes?
- What is the relative importance of the habitat structure in relation to the landscape structure?
- What are the effects of forest fragmentation and anthropogenic perturbations on forest regeneration?
- What is the importance of functional connectivity for the maintenance of species in fragmented landscapes?
- What is the effect of the history of changes in the landscape structure on the communities?
- What is the potential distribution of species representative for the local biota?

The BioCAPSP II Project was structured by several sub-project and organized by cooperating teams as follows:

- **Landscape structure and dynamics**
  Jean Paul Metzger, Milton Cezar Ribeiro, Ana Maria de Godoy Teixeira USP

- **Vegetation structure, dynamics, phenology and the availability of fruit and seed resources**
  Alexandre A. de Oliveira, Cristiane Follmann Jurinitz – USP; Christoph Knogge, Claudia Guimaraes – UFZ

- **Forest growth and regeneration model**
  Sandro Pütz, Jürgen Groeneveld, Andreas Huth – UFZ; Jean Paul Metzger – USP, Luciana Alves - University of Colorado, USA

- **Species composition and richness of amphibians**
  Klaus Henle, Henning Steinicke – UFZ; Jean Paul Metzger, Marianna Dixo – USP

- **Species composition and richness of small and large mammals**
  Simone Sommer, Thomas Püttker, Yvonne Meyer-Lucht – IZW Berlin; Renata Pardini, Adriana de Arruda Bueno, Fabiana Umetsu, Bruno Trevizan Pinotti, Laura R. Capelari Naxara, Karina Espartos – USP

- **Species composition and richness of birds**
  Jean Paul Metzger, Cristina Banks Leite, Paula K. Lira, Danilo Boscolo, Alexandre Camargo Martensen, Cintia Cornelius, Carlos E. Candia Gallardo, Marcelo Awade, Erica Hasui, Rafael Pimentel, Mariane Rodrigues Biz Silva, Soizic Le Saout – USP; Ilse Storch, Miriam Hansbauer, Daniela Vetter – Univ. Freiburg

- **Modelling of the functional connectivity**
  Karin Frank, Guy Pe'er – UFZ; Jean Paul Metzger, Danilo Boscolo – USP

In order to facilitate the presentation, the main outputs of the project will be presented by sub-project, and then we will present a general evaluation of the cooperation.

1 . Main Outputs of the Research

Subproject 1: Landscape structure and dynamics
Jean Paul Metzger, Milton Cezar Ribeiro, Ana Maria de Godoy Teixeira– USP

This first sub-project gives support for all other sub-projects, providing the basic landscape structural data of the project. A complete mapping of the three studied landscapes, including several land use and land cover classes, was used to answer the main research questions, which will be presented below (see other sub-projects). The three studied landscapes present a gradient from low to high forest amount: Ribeirão Grande, with 11% forest cover; Caucaia do Alto, 31%; and Tapiraí, 49% (Figure 1). This was the ideal situation for testing questions related with the effects of a fragmentation threshold (~ 30 % habitat according to the literature), once the three landscapes represent proportions below, near and above the suggested threshold. Beyond this technical output, this group also offers original results related with the dynamic of Atlantic forest, and with its fragmentation pattern.

Regarding the dynamics, we showed that the Atlantic Rainforest loss and recovery are extremely fast. During the first period of 1962 to 1981, the rate of forest regrowth (3% $year^{-1}$) was greater than the rate of deforestation (2%$year^{-1}$), whereas in the latter period of 1981 to 2000, increasing urbanization and the spreading of rural establishments resulted in more deforestation (2.9% $year^{-1}$) than regrowth (1% $year^{-1}$). These dynamics imprinted a heterogeneous landscape, leading to the predominance of progressively younger secondary forests with increasingly less capacity of hosting sensitive forest species. The influence of proximate causes on the dynamics of deforestation and forest regrowth showed consistent patterns, such as higher forest regrowth rates near rivers, on steep slopes and far from dirt roads, whereas losses in young secondary vegetation, and forest were far from rivers, on gentle slopes and near urban areas. The comparison of modeled scenarios suggests that simply the enforcement of current forest laws, which prohibit deforestation on unsuitable agricultural areas and along river margins and establish a minimum of 20% of forest remnant per rural property, may effectively favor forest species conservation in the short term (two decades) without the need of any forest restoration effort.

Regarding the fragmentation pattern, the results revealed a serious situation: more than 80% of the fragments are <50 ha, almost half the remaining forest is <100 m from a forest-matrix edge, the average distance between fragments is large (1 440 m), and nature reserves protect only 9% of the remaining forest and 1% of the original forest. On the other hand, our estimates of existing Atlantic Forest cover were higher than previous ones (7-8%), ranging from 11.4 to 16%. The differences among estimates are mainly related to our inclusion of intermediate secondary forests and small fragments (<100 ha), which correspond to approximately 32-40% of what remains. We suggest some guidelines for conservation: i) large mature forest fragments should be a conservation priority; ii) smaller fragments can be managed in order to maintain functionally linked mosaics; iii) the matrix surrounding fragments should be managed so as to minimize edge effects and improve connectivity; iv) restoration actions should be taken, particularly in certain key areas. The clear differences in the amount remaining and its spatial distribution within each sub-region must be considered when planning for biodiversity conservation.

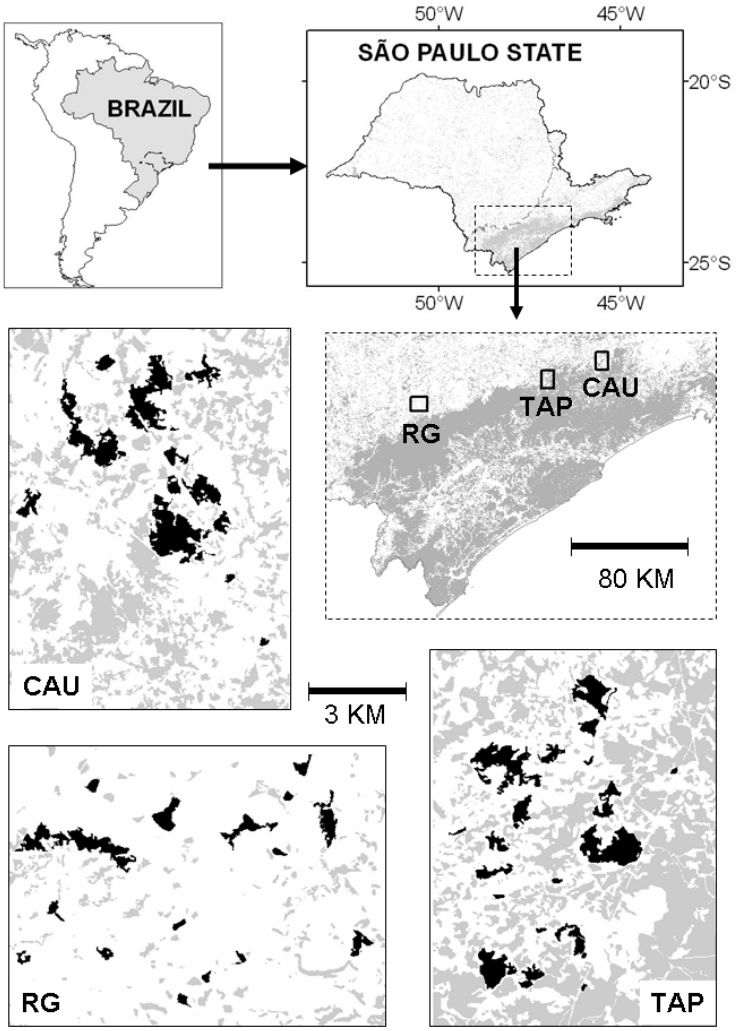


Figure 1. Map of the state of São Paulo. The Atlantic Plateau region is delimited by the grey line, and the locations of the three landscapes are shown. The detailed maps show the remnants (in grey) in each studied landscape and the sampled fragments are highlighted in black.

Subproject 2: Vegetation Structure, Dynamics,

(A) Phenology and the Availability of Fruit and Seed Resources
Christoph Knogge, Claudia Guimaraes – UFZ, Cristiane Follmann Jurinitz, Cristina Leite Banks – USP;

Achieved targets
This part of the sub-project investigated the influence of landscape parameters on the phenology of the production of seeds and fruits in forest fragments compared to continuous mainly undisturbed forests.
We used the results and data as variables (food abundance, habitat quality) for the explanation of the diversity and abundance of birds and would like to perform it also for small and large mammals in the study landscape of Tapirai.
To analyze this causal relationship we used path analysis which may identify the causal correlations. We tested the importance of direct and indirect effects of landscape (patch size and forest cover) on rates of plant species richness and productivity and the abundance and richness of frugivorous birds in seven fragments and three continuous forests during two seasons. The models are still inconsistent, however with significant trends of routes. Patch size has direct effect on the richness of birds and productivity of fruits. However the richness of fruits affects indirectly the bird species. The primacy of effects suggests that birds are most affected by the direct effects of the structure and configuration of the landscape and just indirectly through the availability of fruits, which highlights the habitat conditions in fragmented forests. Birds seem to be able to use all forest fragments as a functionally connected landscape when the degree of forest cover comprises about 50 %.

Applied methodology and developed activities
Data collection on phenology, fruit production and seed rain was conducted over a period of 2 years in 17 forest fragments and 3 sites in a continuous forest using 15 fruit and seed collectors (50X50cm) per sample site. To analyze the causal relationships between fruit availability and bird abundance and richness we used path analysis which may identify the causal correlations. We tested the importance of direct and indirect effects of landscape structure and configuration (patch size and forest cover) on rates of plant species richness and productivity and the abundance and richness of frugivorous birds.
Additionally data on vegetation structure for each sampling site were collected in the field to be integrated into the analysis in order to explain the results of phenology, fruit productivity and bird richness within the context of habitat structure and quality.

Strategy for the dissemination of the results of the research
Currently we are still preparing 3 articles for publication of this particular sub-project. It is planned to integrate the results and raw data into comparative analyses with other sub-projects.

Evaluation of the Bilateral Cooperation and Conclusion
We experienced a constructive integration and productive cooperation between the teams and further analysis with other project partners of BioCAPSP subproject groups are planned if time and financial frame condition allow this cooperation.
This part of the subproject has been developed during the ongoing project and resulted in a scientifically promising study that gives a good base for future analysis and cooperation. The opportunity of this type of new integration of subprojects and support for its flexible integration has been possible within a fruitful and productive cooperation environment that has been created between the involved teams and supervising coordinators.

(B) Tree demography of two Atlantic forest species.

Alexandre Adalardo Oliveirs, Cristiane Jurinitz, Marcel Caritá Vaz, Juliana Lopes Vendrami - USP

Fragmentation is one of the most pervasive threats to biodiversity, changing tropical landscapes by the increase of the heterogeneity and, consequently, their complexity. How plant populations can deal with these changes is one of the major questions to answer in plant ecology. In a fragmented Atlantic Forest landscape in Southeast Brazil (50% of remaining habitat) we studied six secondary forest fragments that differ in size and successional status. For each fragment, we investigated forest structural and functional characteristics in order to know the environmental variation magnitude and relate it with different aspects of tree demography. Our target species were *Guapira opposita* (Vell.) Reitz (Nyctaginaceae) and *Rudgea jasminoides* (Cham.) Müll.Arg. (Rubiaceae), both abundant tree species in Atlantic Forest that differ in the degree of shade tolerance. The six fragments differ in forest structure parameters, such as basal area, tree density, canopy height and openness, litter depth, and in functional parameters, such as litter production, but not in decomposition rate. The canopy openness and the litter depth interact and affect the performance of seedlings in opposite and unexpected ways. Like seedlings, the size distributions of the established individuals (DBH ≥10 mm) are affected in a different way depending on the species. The diameter distribution of the understory species (*R.jasminoides*) is more sensitive to fragment size than successional status, while the subcanopy/canopy species (*G. opposita*) shows the opposite. In despite of all these differences, the population growth rate (λ) for each species did not differ among early and late secondary forests. We conclude that the population structure and the seedling recruitment are affected by both fragment size and structure and attention should be paid particularly on the understory species, which population density and structure are strongly altered in the small fragments.

Sub-Project 3: Forest Growth and Regeneration Model
Sandro Pütz, Jürgen Groeneveld, Andreas Huth – UFZ;
Jean Paul Metzger – USP, Luciana Alves - University of Colorado, USA

Achieved targets
Adaptation of the process and development of individual-based forest growth simulation model (based on FORMIND) to subtropical forests of the Brazilian Atlantic Forests (Plateau of São Paulo). Systematic analysis and disentangling single impacts out of several fragmentation processes on long-term structure, function and biodiversity of subtropical forest fragments. Quantification of the combined impact of human disturbance and fragmentation on carbon loss of forest fragments. Development of a GUI visualisation tool for long-term development of forest fragments. Calculation of potential long-term above-ground carbon loss due to fragmentation for different time scales and forest fragment sizes. New mapping of forest fragments in the Amazon and upscaling the forest model to calculation of biome wide potential long-term above-ground carbon loss due to fragmentation via combining simulation model with the biome wide fragment distribution monitored with satellite image analysis. Exemplary biomes are the Brazilian Atlantic tropical forests and the tropical forests of the Amazon Basin.

Applied methodology
Ecological modelling; statistical analysis, Process-and individual based, dynamic, spatially explicit forest growth model FORMIND; remote sensing analysis; Up-scaling via combining specific FORMIND scenarios with realistic spatially explicit forest fragment distribution maps

Relevance and applicability of the results
Highly relevant: systematic analysis of single fragmentation processes are mostly lacking in habitat fragmentation research; Studying the impact of multiple stressors/drivers on biodiversity is scarce in ecology; The question: "How will the process of species loss, driven by habitat fragmentation and climate change, affect CO2 fluxes and the response of ecosystems to elevated CO2" (Canadell et al. 2007), is considered to be "a next generation question for global change research". The first quantification of biome wide carbon loss due to fragmentation is one important step into that direction.
Canadell, J.G., Pataki, D.E., Pitelka, L.F. (eds.) 2007. Terrestrial Ecosystems in a Changing World. Global Change – The IGBP Series. Springer, Berlin, Heidelberg, New York: 336 pp.

Strategy for the dissemination of the results of the research - Submission to high-level journals.

New projects generated from the original project - Impact of fragmentation on forest regeneration under intensive land use and bioenergy scenarios; Impact of global intensification of bioenergy use on long-term sustainability of tropical landscapes; Impact of global change, represented by fragmentation, climate change, and land use change due to increase in biofuel production on tropical forests in the Amazon Basin

Evaluation of the Bilateral Cooperation
The personal and scientific cooperation has been constructive and satisfying.
The Brazilian collaborating scientists benefit from the modeling expertise of the UFZ, whereas the German scientists benefit from the satellite image analysis and expertise on tropical Biomes.

Conclusion
Due to the cooperation with the institute of Ecology of the University of Sao Paulo, within the project BIOCAPSP the forest growth model FORMIND has made huge progresses in providing a highly integrated modeling approach with respect to impacts of fragmentation on tropical forests, providing now a potentially leading tool for investigating long-term impacts of fragmentation on tropical forest fragments. It includes not only key biological processes of tree

growth, and spatially explicit fragmentation processes (edge effects), but incorporates additionally connectivity to the neighborhood via external seed rain.

Additionally, the project benefitted in an extraordinary manner from the combined use of two specific types of expertise: the remote sensing capacities of the institute of landscape Ecology (USP), and the dynamic modeling capacities of the Department of Ecological Modelling (UFZ). Remote sensing provided large-scale fragment distribution, and the forest model provided long-term carbon loss estimates for different sized forest fragments. Combining these two capacities has shown to yield a classical win-win situation, as similar approaches have not been noticed up to date in the international scientific literature. This approach has the potential to provide further similar benefits with respects to similar research questions in the future.

Subproject 4: Community ecology of frogs in fragmented landscapes of the Mata Atlântica
Henning Steinicke, Klaus Henle – UFZ;
Marianna Dixo, Jean Paul Metzger – USP

Achieved targets
This sub-project was planned as comprehensive study with equal parts of the Brazilian and the German side. The sub-project investigated the influence of landscape parameters on the species composition and abundance of anuran communities with special emphasize on the effect of the presence/absence of forest edges on leaf-litter frogs (Brazilian part) and treefrogs (German part).

Regarding tree frogs, we used studies performed by the Brazilian counterpart to select an appropriate landscape for assessment of fragmentation effects. These studies showed that the landscape of Riberão Grande (about 11% remaining forest cover) with the adjacent continuous area of the Fazenda Paraíso did suit best for our study. The forest fragments and the continuous forest of the Fazenda Paraíso differed in their forest structure. They showed a tendency towards larger numbers of mature trees and lower density of trees in the unfragmented control. Thus, the forest fragments seem to suffer a higher frequency of disturbance. Other important habitat parameters, such as leaf-litter thickness, did not differ strongly between fragmented and unfragmneted sites, presumably becasue the higher density of smaller trees in the highly disturbed fragments compensates the lower biomass production of individual trees. The composition of the tree frog communities in the landscape of Riberão Grande showed very strong differences between the forest fragments and the control transects. The fragments showed a very low species richness and beta diversity. Strictly arboreal species were observed only in continuous forest. The few species found in the fragmented area show a very strong relationship to wetland habitats in and around the forest fragments. In general, arboreal amphibian species showed highest densities around ponds and wetlands. We could not find any impact of forest edges on tree frog species in the fragmented landscape.
These observations lead to the conclusion that tree frog species remaining in the fragmented landscape of Riberão Grande with only 11% forest cover are species not restricted to the habitat forest but con survive in wetlands in the agricultural landscape. Habitat quality is inferior in the forest fragments compared to the continuous area and accordingly forest dwelling species *sensu stricto* have vanished from the forest fragments.

Leaf-litter frogs were sampled by a standardized protocol using pitfall traps at 15 to 20 patches in each landscape, and six sites in adjacent continuous forests landscape. We captured almost 12,000 individuals of 28 frog species, of which > 50% were present in all landscapes. The intensity of fragmentation effects depended on remaining forest cover, being superior in landscapes with higher habitat loss. Species with different ecological characteristics were affected differently, and those species that require an aquatic habitat to complete their development, were strongly and negatively affected by habitat fragmentation and habitat loss. Our data showed that landscapes with 11% of forest cover cannot harbor the leaf-litter anurofauna because in these landscapes some forest species that require water to complete their life-cycle have disappeared. The continuous forest adjacent to these landscapes still maintains a rich frog community and could work as source for fragments of both landscapes. Future efforts should focus on working out ways to increase forest cover and connectivity between continuous forest and fragments to make these landscapes viable again for frog conservation.

Applied methodology and developed activities
The data collection for the study was separated in three parts: 1) field work for leaf-litter frogs, 2) field work for tree frogs, and 3) field work for habitat parameters. All field work was conducted within one year.
Ten forest fragments of sufficient size were selected. A fragment was sufficiently large when the distance from the forest edge to the center of the fragment was at least 100 m. In each fragment two transects with a length of 100 m each were established, following a direct line from the edge to the center. Transects were planned first using GIS (in collaboration with Leandro Tambosi from Lepac/USP) and were then established in the field. Selected fragments were

located in the northern part of the landscape, because the northern and the southern part of the landscape present a strong difference in land use and relief. To limit the variables in the study design, the southern part was not considered in the study. Beside transects in the fragmented landscape two control transects were established in the continuous forest of the "Fazenda Paraíso", an adjacent area of the State Forest Park "Intervales". One of the transects was used for the study of tree frogs and the other for the study of leaf-litter frog communities.
The study sites were checked for tree frogs one after the other, checking first one site for two consecutive nights beginning at dusk and continuing at least until midnight, and then passing to the next site. After finishing all sites the study was continued beginning again at the first site. Tree frogs were surveyed aurally. Calls were recorded for later identification, if individuals could not be captured for species identification. The field work regarding the tree frog communities was conducted from July 2008 until May 2009.
Beside the study on the response of amphibian species to fragmentation, also detailed measures of habitat parameters were made for a multivariate analysis. The habitat assessment was designed together with botanists of the University of São Paulo and the University of Porto Alegre in January 2009. The design accounted for the needs of aural frog surveys and allowed comparability with other botanical studies performed in other fragmented landscapes. At every point of the transect, we measured or estimated leaf-litter depth, number of bromeliads with water tanks and without, as well as number, of trees and diameter at breast height and height of trees within a fixed circle. Furthermore, to obtain data on local differences in precipitation levels, pluviometers were installed and checked daily. The field work regarding habitat parameters was performed during the months February and March 2009.
We analysed the data using univariate and multivariate methods. For the analysis of vegetation structure we generated mixture models to obtain subpixel information about the vegetation structure at the sampling points (in collaboration with Leandro Tambosi from Lepac/USP).

Strategy for the dissemination of the results of the research
Currently we are still preparing 3 articles for publication of this particular sub-project. Part of the data is integrated in other sub-projects and will be published jointly. The results will be further presented in international congresses.

Evaluation of the Bilateral Cooperation and Conclusion
We experienced a very constructive integration and productive cooperation between our two teams. From planning to field work and the analysis of data, the work was almost entirely performed complementary to equal parts to achieve a maximum of comprehensiveness. Further joint analysis and publications are planned, if time allows and funds can be obtained for furtehr cooperation.

Sub-Project 5: Species composition and richness of small and large mammals

Renata Pardini, Adriana de Arruda Bueno, Fabiana Umetsu, Bruno Trevizan Pinotti, Laura R. Capelari Naxara, Karina Espartos – USP
Simone Sommer, Thomas Püttker, Yvonne Meyer-Lucht – IZW Berlin;

A) Consequences of habitat fragmentation on the population dynamics, MHC-diversity and parasite resistance of small mammals (Research group of Prof. Dr. S. Sommer, IZW Berlin)

Achieved targets

Effects of fragmentation on micro-habitat use of small mammals

The Brazilian Atlantic Forest is highly endangered and only about 12% of the original forest remains, most of which consists of small fragments of secondary forest. Small mammals (rodents, marsupials) play a highly important role in ecosystem functioning as they are essential for seed dispersal (regeneration of forests) and represent central food items in the predator cascade. In the Atlantic Forest, small mammals have differential responses to the process of fragmentation and conversion of forest into anthropogenic habitats, and have varying abilities to occupy the surrounding altered habitats.

We investigated the influence of vegetation structure on the micro-scale distribution of five small mammal species in six secondary forest remnants and one control site in the Atlantic Forest. We tested whether the occurrence of important small mammal species is influenced by the availability of micro-scale vegetation structure, aiming to ascertain whether species with different degrees of vulnerability to forest fragmentation (generalist species, not vulnerable: *Akodon montensis*, *Oligoryzomys nigripes* (rodents) and *Gracilianus microtarsus* (marsupial); highly endemic specialist species, vulnerable: *Delomys sublineatus* (rodent) and *Marmosops incanus* (marsupial)) are associated with distinct vegetation characteristics.

Our results indicate the importance of the remaining vegetation structure for the distribution of small mammal species in secondary forest fragments. Generalist species that are not vulnerable to fragmentation occurred at locations with vegetation characteristics of more disturbed forest (open and low canopy, dense understory). Endemic specialist species vulnerable to fragmentation were found at locations with older forest characteristics (close and high canopy). Our results suggest that micro-habitat preferences play an important factor influencing the capacity of small mammals to occupy altered habitats and, consequently, their vulnerability to forest fragmentation at a larger spatial scale. Not only fragment size but also the resemblance of fragments to the original forest structure is essential to ensure the maintenance of biodiversity and ecosystem functioning of the Mata Atlantica.

Effects of fragmentation on small-scale movement patterns of small mammals

Movement distances provide information on diverse population biological parameters and are essential in understanding the ecology of a species. Mean distances moved between successive captures, distribution of movement distances, and the mean maximum distances moved were investigated in generalist and specialist rodent and marsupial species in forest fragments of different size and a control are in the Mata Atlântica. The focus species were the generalist rodents *Akodon montensis* (Thomas, 1902), *Oligoryzomys nigripes* (Olfers, 1818) and the marsupial *Gracilinanus microtarsus* (Wagner, 1842), as well as the endemic vulnerable rodents *Delomys sublineatus* (Thomas, 1903), *Oryzomys russatus* (Wagner, 1848), and *Thaptomys nigrita* (Lichtenstein, 1829) and the marsupial *Marmosops incanus* (Lund 1840).

The marsupials differed significantly from most of the rodents and moved the largest distances. In most species, males moved significantly longer distances than females, especially during the reproductive period. Fragment size had no influence on the movement pattern in any of the investigated species. The results indicate that small mammal species inhabit fragments of different size as long as their ecological demands are fulfilled.

Effects of habitat fragmentation on population density of small mammals

We further investigated the effects of fragmentation on the population density of generalist and specialist species. We tested the hypothesis that rare species, which are more affected by fragmentation than the common species, should decrease in population density with decreasing fragment size while the density of common generalist species should be

unaffected or increase in smaller fragments. The results revealed that generalist species (e.g. *A. montensis*, *O. nigripes*) showed no significant association to any landscape variable while the density of endemic specialists (e.g. *D. sublineatus*) showed a strong tendency to a positive correlation to fragment size as well as a negative correlation to edge density. The results underline the importance of large and connected forest remnants in the Atlantic Rainforest to guarantee an effective protection of endemic small mammal species.

Influence of the remaining habitat amount on a landscape scale on the demography of small mammal species
In addition to fragment size and connectivity, although the total amount of remaining habitat on the landscape level might have a tremendous impact on patterns of biodiversity and demographic processes of populations.
The investigations of the Sao Paulo research group on the influence of the amount of remaining forest on the landscape level (15%, 30%, 50%, control: > 90%) showed that the biodiversity and abundance of endemic species vulnerable to fragmentation was high in a landscape with 50 % or more of remaining forest, independent of fragment size. This was not the case if less forested habitat was available, biodiversity and abundance pattern were positively correlated with fragment size in a landscape with about 30 % of remaining forest. Based on these results, we investigated the demography of small mammals in fragments of similar size but differing in the amount of habitat left at the landscape level using a population modeling approach (software package MARK). Specifically, we investigated on which scale differences of demographic parameters become apparent and thereby influence abundance of the species using model selection by Akaike´s information criterion (AIC). Further, we tested the hypothesis that isolation of small fragments influences immigration of individuals from neighboring habitat patches. For example, for the endemic marsupial *M. incanus* the model selection procedures indicated differences in the survival rate and population growth rate on a landscape scale, comprising higher survival rate and higher population growth rate in fragments in the landscape with 50 % of remaining forest compared to the landscape with 30 % of remaining forest. It also determines the functioning of a metapopulation structure by restricting immigration processes and thus the associated gene flow insuring genetic variability.
These results show the high importance of fragment context for persistence of specialist species in the Atlantic Forest. Thereby, they underline the necessity to consider the amount of remaining habitat in management plans of fragmented landscapes in order to successfully maintain biodiversity.

Influence of the remaining habitat amount on a landscape scale on the spatial genetic structure of endemic rodents and marsupials
Habitat fragmentation decreases the connectivity and gene flow among populations resulting in isolation and decreasing effective population size. The consequence may be a differentiation between the remaining populations through genetic drift, whereas the degree of isolation depends on the landscape structure and the species dispersal behaviour. The use of neutral genetic marker, such as microsatellite analyses provides a detailed pattern of the population structure.
The endemic specialist species, the rodent *D. sublineatus* and the marsupial *M. incanus* occur in fragments of different sizes, but are clearly affected by forest fragmentation and their abundance is positively correlated to fragment size in a landscape with 30% remaining forest. We investigated the effects of landscape structure and fragmentation on the spatial population structure in detail by focusing on 15 microsatellites markers in more than 400 individuals of each species. We established the microsatellite loci by newly developed techniques of genome screening with inter-simple sequence repeat primers and a restriction-ligation approach and an enrichment protocol using genomic DNAs of unrelated organisms for cross-hybridization. We compared the genetic structure of populations inhabiting the landscapes with 30%, 50% and >90% remaining forest cover. No population differentiation could be detected in the two landscapes with higher forest cover (50% and >90%). In the 30% landscape, however, a distinct population structure was visible, indicating restrictions in gene flow between the fragmented populations. Our results provide the first genetic evidence of the consequences of the amount of remaining habitat *at the landscape level* on population genetic diversity patterns.

Effects of fragmentation on the population health (i.e. parasite load) of small mammals: the role of immune genes (MHC) variation on population health and parasite resistance in endemic rodents and marsupials

Parasites are considered to play an important role in the regulation of wild animal populations. The adaptive potential of a species to a changing environment and in disease defence is primarily based on genetic variation. Immune genes, such as the highly variable genes of the Major Histocompatibility Complex (MHC), are thereby of particular importance. The MHC genes are one side of a co-evolutionary arms race between host and their parasites. They are coding for cell surface glycoproteins in vertebrates and their variability is associated with the recognition of foreign antigens and thereby directly linked with parasite resistance and individual fitness.
However, studies in model marsupials used in laboratory investigations indicated very little or even no variation in MHC class II genes. But natural levels of diversity and selection are virtually unknown in marsupials as studies on wildlife populations are absent. We investigated characteristic features of MHC selection, known from Eutherian mammals, birds and fish, for the first time in free-ranging marsupials using two endemic mouse opossums from the Atlantic Forest *(Gracilinanus microtarsus*, *Marmosops incanus)*. We tested whether the depletion at MHC class II in marsupials can be confirmed under natural conditions and examined the evolutionary history of MHC lineages within the group of marsupials. Our study revealed unexpected results: *G. microtarsus* showed extensive levels of MHC diversity within and among individuals, with 47 MHC-DAB alleles and a high extent of sequence divergence. By contrast, the diversity in *M. incanus* was rather low, with only eight observed alleles. However, these alleles revealed high sequence divergence, too. In a phylogenetic comparison alleles of *M. incanus* interspersed widely within the alleles of *G. microtarsus* and four alleles were shared between species, indicating the trans-species mode of evolution in the marsupial MHC class II. We confirmed three characteristic features common at MHC loci of Eutherian mammals, birds and fish for the first time in marsupials: large allelic sequence divergence, positive selection and trans-specific polymorphism. Former assumptions of depleted marsupial MHC II variation need to be revised (Meyer-Lucht et al. 2008).
We investigated possible causes and consequences of the remarkable differences in the MHC class II diversities between the two species of mouse opossums (*Gracilinanus microtarsus, Marmosops incanus*). Since pathogens are assumed to be the main forces in generating MHC diversity, we analysed gastrointestinal parasite burden and functional associations between the individual MHC constitution and parasite load in two species of mouse opossums. In two scenarios we predicted that the species with low MHC diversity would either be under relaxed selection pressure by low parasite diversity ('*Evolutionary equilibrium*' scenario*)*, or there was a recent loss in MHC diversity leading to a loss of resistance alleles and increased parasite burden ('*Unbalanced situation*' scenario). As parasitism is a highly complex and dynamic process dependent on multiple factors, we applied models that are capable to include more that one explaining factor at a time (generalized linear models, GLM). By this means we were able to test for the effects of environmental, biotic and genetic predictors at the same time. Beside well known effects of spatial and temporal environmental variation we detected important associations to the host's MHC genetics. Parasite diversity did not markedly differ between the two host species. However, we did observe considerable differences in the parasite load (parasite prevalence and infection intensity): while *M. incanus* revealed low MHC DAB diversity and high parasite load, *G. microtarsus* showed a tenfold higher population wide MHC DAB diversity and lower parasite burden. These results support the second scenario of an unbalanced situation.

Our findings about the marsupial MHC class II diversity disprove previous assumptions and contribute important insights into the marsupial immunology and the evolution of the MHC within the whole group of mammals. Moreover, we could show for the first time in marsupials that the MHC class II is indeed functionally important in disease defence and thereby for the viability of populations. The fragmentation sensitive *M. incanus* shows a very low MHC diversity and a high parasite load, opposing the situation in the generalist species *G. microtarsus*. It seems probable that the high parasite load in *M. incanus* is a consequence of its low MHC diversity. To summarize, it became apparent that the MHC class II is functionally important in defence against gastrointestinal helminths, which was shown here for the first time in marsupials.
We further investigated the immune status and parasite load in rodent species differing in their sensitivity to fragmentation. *Euryoryzomys russatus* (formerly *Oryzomys russatus*; family Sigmodontinae) and *Delomys sublineatus* are endemic rodent species from the Atlantic Forest sensitive to habitat fragmentation whereas *A. montensis* and *Oryzomys angouya* are considered as generalist species. The classical features of MHC class II organization were detected in all species: typical signals of positive selection including a higher rate of non-synonymous over synonymous substitutions, positively selected amino acid sites and trans-species polymorphism. We compared in a

comprehensive approach immune gene diversity, the MHC expression patterns, and the load with gastro-intestinal helminths between individuals from different landscapes with different amount of forest cover left. All species indicated that levels of immune gene diversity determine population health and the resistance to parasites. We also investigated the effects of other ecological parameters on parasite burden in specialist and generalist small mammal species but no correlation was found.
Our results deepen our understanding of the complex consequences of habitat fragmentation on the population's genetic constitution and diversity, which is the basis for the adaption potential of a species. This link between MHC diversity and disease defence shows the high relevance of our results for conservation issues. The situation in marsupials represents a text-book case of loss of genetic diversity leading to increased disease susceptibility. Our results strongly indicate that the maintenance of genetic diversity in adaptive genetic marker is essential for the long-term viability of the biodiversity.

The role of immune gene expression (MHC) on the health status
In addition to structural sequence variation of immune genes (MHC), also their gene expression might be influenced under environmental stress and thus might be an important component in population health. Medical laboratory studies showed evidence that the functional level is of great importance and should not be ignored. MHC expression can be reduced by regulatory cytokines (e.g. interleukin 10). Helminths are thought to induce a pronounced Il-10 production in hosts that causes an immune tolerance of parasites. We applied quantitative reverse transcription real-time PCR (qRT-PCR) to measure the expression of immune related genes. This method is well established in laboratory model systems but only a few attempts have been made to transfer this knowledge into ecology and evolutionary biology on free ranging populations of wild animals. First we established a SYBR-green qRT-PCR assay upon the European yellow-necked mouse, *Apodemus flavicollis* to see whether gene expression analysis is feasible upon wildlife populations. We transferred our established real-time assay to the Brazilian rodent *Delomys sublineatus*, an endemic species to the Mata Atlantica that is negatively affected by habitat fragmentation. We analysed the gene expression of the MHC DRB gene as well as the expression of the transforming growth factor ß (TGF-ß), interleukin 4 and 10 (Il-4 & 10). We genotyped each individual and looked for effects of certain alleles upon the parasite burden. The laboratory work has just been finished and we are still processing the data.

Applied methodology
Field methods
In all investigations mentioned above grid-based capture-mark-recapture techniques were applied for data collection.

Laboratory methods
In the investigation of parasite load of small mammals, feces were sampled from the traps used to capture the animal. Parasitological data were obtained from non invasive faecal egg counts (FEC).
Genetic analyses are based on DNA extraction, PCR primer design and amplification, molecular cloning, sequencing and genotype screening via SSCP. We further established and used laboratory methods like RNA extraction, reverse transcription and quantitative real-time PCR. We established new techniques to identify microsatellite marker via genome screening with inter-simple sequence repeat primers and a restriction-ligation approach and an enrichment protocol using genomic DNAs of unrelated organisms for cross-hybridization.

Statistical methods
A wide range of ecological, population genetic and modeling statistical software packages were applied, e.g.
R: GLM, GLMM (R Development Core Team 2008)
SPSS 16.0: all other statistical tests
MARK: survival estimation (White & Burnham 1999)
ArcGIS and FRAGSTATS: geographic data analyses
PAML: Test for positive selection (Yang et al. 1997)
GENECONV, LDHAT: Test for recombination and gene conversion (Sawyer 1999, MCVEAN *et al.* 2002)
MEGA, Arlequin: Population genetics, phylogenetic analyses (Kumar *et al.* 2004, Excoffier *et al.* 2005)
Genepop 4.0: Population genetics (Raymond & Rousset 1995)

Micro-Checker: microsatellite analyses (van Oosterhout *et al*. 2004).

Relevance and applicability of the results
The results on the ecology, demography, genetics and population health of small mammals of the Mata Atlântica represent an important contribution to the understanding of the complex influences of human-induced fragmentation process (including habitat loss) on the ecosystem Atlantic forest. In this sense, the main relevance of the results is represented by the information made available as a basis for conservation actions. The results become especially representative in combination with the results of the investigation carried out by the Brazilian counterparts, the knowledge of whom helped in targeting important issues of small mammal ecology initially, as well as during the whole project.
The results become applicable in two ways: 1. Scientific applicability: numerous responses of Brazilian as well as international scientists to the published work showed the high need of such information for scientists working in the Mata Atlântica biome. 2. Applicability in practice: Especially the investigations on demographic and genetic processes, but as well information on parasite loads and microhabitat use, represent useful data-based information for conservation decision-makers. Our results on the minimum numbers of migrating individuals between fragments to ensure long-term sustainability (in combination with results from the Brazilian counterparts) clearly indicate the necessity of maintenance of minimum amounts of forest habitat on a landscape scale for successful conservation of biodiversity.

Impacts of the Project for the involved institutions, the region and the society
For the Institute of Zoo and Wildlife Research the cooperation led to successful capacity building in tropical field-methodologies as well as statistical and educational methods. Besides the contact to direct counterparts the project benefited from knowing experts of the area in the University of São Paulo and elsewhere.
The University of São Paulo benefited from capacity building in genetic and parasitological methodology, both of which have still low representation in the University of São Paulo.

Strategy for the dissemination of the results of the research
Publication in international scientific Journals (already achieved)
Publication in German journals and public media (already achieved)
Making available of results for forest-owners in Brazil (already achieved)
Publication of short film in the Internet (short film already produced)

2. Evaluation of the Bilateral Cooperation (comment)
Quality of the integration/interaction between the teams
The quality of the integration between the teams was remarkably good. Several German and Brazilian students jointly participated in field-work in Brazil and received university degrees (Master, Diplome, PhD) during the course of the project. Further, the Brazilian post-doctoral researcher Dr. Fabiano Fernandes spent one year in the Institute for Zoo and Wildlife Research, Berlin, under the supervision of Prof. Dr. S. Sommer and was trained in genetic procedures which resulted in a permanent position now in Brazil.

B): Species composition and richness of small and big mammals (Research group of Prof. Dr. Renata Pardini, USP)

During the three-year period of the Project, all proposed objectives were achieved. Data concerning the central questions – the effects of forest loss at the landscape on the assemblages of small non-volant and large terrestrial mammals, and on the demography and genetics of small mammal populations – were collected and analyzed. Moreover, a series of complementary datasets was collected simultaneously in the same study regions, encompassing questions such as: the natural history and population dynamics of small mammals in continuous forest, the effects of

forest cover at the landscape scale on the distribution and diversity of small mammals in agricultural areas, the role of riparian corridors as habitat for small mammals, the factors and mechanisms associated with the recovery of the small mammal fauna during forest regeneration, the relative importance of landscape structure and human attitudes for the distribution of large terrestrial mammals in fragmented landscapes, the economic losses and the factors that influence the occurrence of wildlife attacks on livestock, and a guide to identify small non-volant mammals from the Atlantic Plateau of São Paulo.

This information was generated through the engagement of a large number of students (see below), which by itself represents an important contribution of the project to the education and formation of researchers focusing on landscape ecology and conservation biology. As a whole this information represents a relevant advance in our understanding of the factors that influence and the mechanisms that are behind the distribution of species and species diversity in fragmented Atlantic forest landscapes, helping the planning of sustainable landscapes in this biome. In particular, the results from the project are a scientific basis for: (1) the importance of maintaining the Brazilian Forest Code, indicating that severely fragmented landscapes go through a drastic regime shift, with the extinction of the majority of the forest specialist species and the proliferation of generalist species that are known to be agricultural pests and/or reservoirs of pathogens that cause human diseases; (2) the need to include the effects of multiple, correlated factors that are usually not considered in conservation planning, such as roads and domestic dog invasion, which together with the intense persecution and hunting are responsible for drastically simplifying large mammal assemblages even in well-forested landscapes, with potential cascading effects on the whole ecosystem; (3) the total amount of remaining forest at the landscape as a key factor determining the immigration rates and genetic flow among remnants, and thus the landscape connectivity and species persistence in the long run.

The project also allowed and stimulated the establishment of scientific cooperation with other research teams concerning data analysis and discussion (Paulo Inácio Prado – IBUSP, e Toby Gardner – University of Cambridge, Department of Zoology, Conservation Science Group) as well as data collection on the consequences of the proliferation of generalist small mammals on the prevalence of hantavirus (Paulo Sérgio D´Andrea – FIOCRUZ RJ) and on the physiological and behavioral aspects behind the different responses of small mammals to forest loss and fragmentation (Ariovaldo da Cruz Neto, UNESP).

Subproject 6: Species composition and richness of birds

Jean Paul Metzger, Cristina Banks Leite, Paula K. Lira, Danilo Boscolo, Alexandre Camargo Martensen, Cintia Cornelius, Carlos E. Candia Gallardo, Marcelo Awade, Rafael Pimentel, Mariane Rodrigues Biz Silva, Soizic Le Saout – USP;
Ilse Storch, Miriam Hansbauer, Daniela Vetter – Univ. Freiburg

A) Species composition and richness of birds: a systematic review

Research group of Prof. Dr. Ilse Storch, University of Freiburg

Achieved targets

Quantitative review; major questions were the influence of several functional traits (e.g. feeding guild, forest dependency) on a species' sensitivity to forest fragmentation. Effects of forest edges on nest predation rates in tropical birds quantified and described by a meta-analysis; principal question studied was predation rate in relation to distance from forest edge. Close cooperation with Brazilian counterpart; advisory role in bird telemetry studies and provision of technical equipment. Project presented at several scientific conferences and university seminars in 2008 and 2009.

Applied methodology

Systematic review, quantitative review, meta-analysis

Relevance and applicability of the results

The results are relevant for a better understanding of species' responses to forest fragmentation in general and in the (Neo-)tropics and the Mata Atlantica in particular. They will be suitable to assist landscape planning decisions in the Neotropics.

Impacts of the Project for the involved institutions, the region and the society – The project contributed to improving the expertise of involved institutions in landscape fragmentation research and methodology. The results will be suitable to assist landscape planning decisions in the region.

Relevant contribution for scientific and technological development of the project's theme

The research results will improve the understanding of patterns in species' sensitivity to forest fragmentation and impacts of edge effects on nest predation, especially in comparison with temperate regions.

Opportunities of environmental development offered by the project – not applicable

Strategy for the dissemination of the results of the research – Oral and poster presentations at international conferences; presentations for researchers and students at the University of Freiburg (UF) and University of Oviedo (Spain); publication of research papers in international scientific journals.

Strategy for the transfer of the generated or being developed technologies/products to the scientific and civil communities – not applicable

Participation of local associations, NGO's, authorities, public institutions, population in general – not applicable

Mobilization of local population in the construction of a conscience about the necessity to preserve the Environment – not applicable

Prospective analysis of the developed researches – analysis completed for scientific paper on predictors for forest fragmentation sensitivity, meta-analysis to be completed and submitted for publication mid 2010

New projects generated from the original project – none

Interactions with other research areas – none except for within overall BIOCAPSP program

Interaction with the productive sector - none

Evaluation of the Bilateral Cooperation

Quality of the integration/interaction between the teams - UF cooperated closely and without difficulties with the Brazilian partner; research questions and objectives were planned together; UF was available as an advisor and

provided equipment to the Brazilian counterpart's bird telemetry studies. The Brazilian partner and other BIOCASPS team members significantly contributed to revising manuscript drafts by UF.
Benefits derived from the cooperation for the promotion of scientific and technological development of both countries – Network of contacts in both countries established.
Difficulties in the cooperation – none.
Events done in partnership – Workshop of the Mata Atlantica Project, October 2008, Recife, Brazil; Mata Atlantica Symposium during the Joint Meeting of Association for Tropical Biology and Conservation & Society for Tropical Ecology, July 2009, Marburg.
Feasibility of the continuity of the cooperation - UF would welcome continued cooperation as new opportunities arise.
Information on the management
Main problems identified in the execution of the project – Due to the changes within the team (see below) the original time frame was delayed.
Evaluation on the communication with CNPq (comments, critics and suggestions) – not applicable
Changes in original team (consequences) – For personal reasons, Dr. Miriam Hansbauer wished to reduce her workload from originally fulltime to 75% (April 2008) and 12% (August 2008). Dipl.-Forstw. Daniela Vetter took over the main research activity within the project ongoing from April 2008.

Conclusion
Summarized Evaluation of the project performance
The project was an excellent scientific opportunity to review and analyze existent data in the literature concerning forest fragmentation effects. Major limitations to the project were the small size of the team at the UF, changes within the team during the project (see above) and the special position of the project of the UF within the overall program (UF not involved in field work, but working on review articles, and therefore not incorporated in work of other projects as much as it would have been with participating in field work). However, during the project workshop in October 2008 in Recife, Brazil, UF received a substantial amount of support and feedback on their reviews from other project members. The possibility to incorporate these ideas and suggestions definitely improved the outcome of the review. We believe that reviews are an important scientific tool to resume existent data and make it easily available and we are confident that the results of our reviews are an important contribution to fragmentation science.

Summarized Evaluation of the Program
The BIOCAPSP program has been an excellent scientific opportunity for cooperative research. We are confident that the different projects, ranging from field studies to review articles, will yield notable scientific results.

B) Species composition and richness of birds: *field data*
Research group of Jean Paul Metzger, University of São Paulo

B1 - Landscape influences on bird community
(Cristina Banks-Leite, Alexandre Martensen, Erica Hasui, Rafael Guerra Pimentel, Jean Paul Metzger)

In this part of the study, the aim was to answer the following questions: (i) What is the role of ecosystem boundaries and edge effects on natural communities? (ii) Do bird communities show similar patterns of responses to habitat fragmentation in secondary forests as those previously reported for primary forest? (iii) Are edge and area effects on bird species functionally similar and even causally associated? (iv) How does a tropical understory bird community respond to the highly inter-correlated variation in forest cover, patch configuration and habitat quality; and is it possible to set these influences apart? (v) Could differences in sampling protocol alter community estimates or change the magnitude of ecological trends and the probability of detecting them? And (vi), which strategy is more efficient in identifying sites with the highest community integrity, indicator species or structural indicators, such as landscape metrics? To address these questions we used data from more than 7000 birds captured using mist nets in 65 sites from six landscapes with different proportions of forest cover and habitat degradation in the Atlantic Forest of Brazil. The results showed that: (i) edges are ubiquitous features of natural and human-altered landscapes and strongly influence

most species; (ii) even though the bird community in secondary forests is degraded relative to primary communities, birds from these areas show similar responses to edge and area effects found for primary forests; (iii) edge effects are not only functionally similar, but might also be the main drivers of area effects in fragmented landscapes; (iv) the effects of changes in forest cover, patch configuration and habitat quality are highly confounded and without the use of analyses that explicitly model this correlation it is impossible to pull apart the relative influence of each variable; (v) the way the sampling protocol is designed temporally affects the perceived patterns of how species respond to area effects; and finally, (vi) structural indicators generate stronger and more consistent results than indicator species in predicting changes in community integrity. In conclusion, the results show that understorey birds are highly affected by changes in habitat cover, fragmentation and habitat quality in the Atlantic forest, but this influence is strongly dependent on the temporal and spatial context of the study. Also, because of the low consistency of results obtained from short-surveys, and the large explanatory power of models containing landscape metrics, structural indicators should be viewed as the best strategy for identifying sites with high community integrity.

Furthermore, the intrinsic correlation between habitat amount, fragment size, and connectivity make more complex the task to disentangle their effects, and until now, ecologists lack a clear answer about how these variables act individually and jointly in biological systems. In order to obtain a better picture of how habitat amount, fragment size and connectivity influences species persistence in fragmented landscapes, we analyzed and built models for explaining bird richness and abundance, considering the bird community as a whole, as well as divided according their sensitivity to human disturbances. We considered here the data from the fragmented landscapes, in a total of 53 fragments of different sizes (~ 2 to 158 ha), with a wide variation in degrees of connectivity, distributed in 3 landscapes of 10 800 ha each, which varied in the amount of remaining habitat (11, 31 and 44%). We captured nearly 5 000 individuals of 117 species. Simulated species richness accumulation curves in the two landscapes with smaller amounts of habitat were lower and very similar, whereas in the highly forested one was significantly higher, suggesting a threshold effect on species maintenance between 32 and 43% of habitat cover. Changes in habitat amount affect different parts of the community: a reduction in habitat cover in more deforested landscapes favoured less sensitive species, whereas a similar reduction in landscapes with higher habitat cover negatively affected the more sensitive ones. Fragment size and connectivity affected species richness and abundance in all landscapes; however, their importance varied according to the total habitat remaining and species sensitiveness. Local aspects, such as fragment area and corridor connectivity were better in explaining species richness and abundance in the landscape with less amount of forest, suggesting that in these conditions, fragment size has a predominant influence given the low overall connectivity. In the landscape with an intermediate amount of forest, connectivity aspects, especially corridor connections, were more influential on species patterns, indicating that even small fragments could have a higher species richness and abundance if they are well connected. In the landscapes with even higher proportions of habitat (> 40%), species richness and abundance are also influenced by both area and connectivity, but area is relevant especially because of the occurrence of sensitive species unique to this larger amount of habitat landscape. The different effects of fragment area and connectivity along the gradient of habitat amount suggest that different strategies for landscape management for purpose of species conservation should be adopted.

We also tested the role of connectivity on species-area relationship (SAR). This relationship has stimulated the interest of naturalists since the early 1900's and remained central in our understanding of biodiversity patterns. Despite the generalities of the SAR predictions under different landscape configurations, these predictions remain vague. A review of empirical studies had suggested huge variations and frequent underestimations of richness in the remaining patches. One likely reason for these contrasting results is because the model is constructed with solely the patch size to estimate the number of species without considering any configuration aspect. Here, we use the connectivity metric instead the patch area, which better reflects the potential habitat occupied by the community in the landscape. We conducted a meta-analysis from bird species richness in tropical rainforest in order to investigate the connectivity influence on SAR. We used data from similar survey methods (point counts) in 100 fragments localized in the Southeast Atlantic Rainforest of Brazil. Based on graph theory any additional structure or functional areas were considered as connectivity. The relationships between species richness estimation and fragment sizes were evaluated with regression models applying the best fit using linear, logarithmic, power, piece-wise and exponential models. Results pointed out that the regression model using semi-logarithmic multiple regression as the best model, and there was no evidence of

asymptote in the small patches. Connectivity analysis, considering distances as 60 m best explain the influence on species-area relationship. There was evidence to support that the effect of connectivity depends on the size of the fragment. We conclude that incorporating the connectivity effect in the model as functional connectivity may reduce the imprecision of SAR.

Finally, we tested if fragmentation-sensitivity changes according to the relative geographical position. Biogeographical factors, specially the location of populations in relation to the occurrence area of the species, could mediate interpopulational variations in species response to habitat fragmentation. The present study aimed to verify if the biogeographical position of populations can predict bird species sensitivity to habitat spatial distribution, measured as the forest cover and configuration in fragmented landscapes. Considering 21 species present in at least 30 fragments, we established regression models relating the abundance of the species with patch cover and configuration of the patches, and with the population biogeographical position. This position was obtained through species distribution models, with the maximum entropy algorithm (Maxent). We used the Akaike Information Criteria (AIC) to compare the models and verify the relative importance of each variable. Most of the species (n= 10) presented a similar response pattern, being influenced by landscape configuration and also by biogeographical position parameter. Six other species were influenced only by landscape structure, while two species were influenced only by biogeographical position. There were also three other species that were not influenced by any of the used variables. The response pattern to the independent variables seems to be independent of the biological characteristic of the species. The present study showed that the biogeographical position of the populations could be, with the landscape structure, an important factor to determine the abundance of major part of bird species in a fragmented landscape. Such results have implications on the comprehension of bird species persistence in fragmented landscapes, as well to driven effort for conservation plans in regional scales.

B2 – Time lag responses in bird community
(Paula K. Lira, Robert Ewers, Jean Paul Metzger)

Species local extinction sometimes occurs with a substantial delay following landscape change, resulting in the so called “extinction debt”. Extinction debts are especially great in communities in which many species are close to their extinction threshold following landscape change, because the time-lag to extinction is especially long in such species. To evaluate the magnitude of the extinction debt in three 10,000-ha Atlantic Forest fragmented landscapes with different amount of forest cover (11, 31 and 49%), we investigated the effects of historical and current landscape structure on understory bird communities. Results showing that current species richness and abundance is better described by historical than by current landscape structure would give support to the hypothesis of an existence of extinction debt. Birds were sampled in a total of 53 forest fragments distributed across the three landscapes. We estimated species richness and abundance for the entire assemblage, but also subdivided species in two categories according to their published responses to human disturbances: sensitive species, which should reach their extinction threshold in higher levels of forest cover; and generalist species, which should only go extinct in more heavily deforested landscapes. Historical and current landscape structures were evaluated using forest cover maps of three different dates: 1960’s, 1980’s and 2000’s. For each date, landscape metrics representing forest cover and aggregation were estimated, and their influence on the richness and abundance of the three birds’ categories were assessed using structural equation models and variance partitioning. Our results indicate that the temporal scale of response to forest cover change depends on the present amount of forest in the landscape and on the species group considered. Forest cover history seems to be more important in explaining species richness in landscapes with lowers levels than in landscapes with higher levels of forest cover in the present-day suggesting that extinction debts might be especially great in landscapes with lowers levels of forest cover in the present-day. Communities at landscapes with lower levels of forest cover probably have many species persisting below their extinction threshold while most part of the species in communities in landscapes with higher levels of forest cover should be above or at least close to their extinction threshold. These results are congruent with theories suggesting that the probability and magnitude of extinction debt depends on the strength of the landscape change and on some species traits.

Time-lags between landscape modification and species response are widely recognized, but the ecological mechanisms involved in these responses are still poorly understood for animal species. In order to relate time-lag response with life-history characteristics, 26 birds and eight small mammals' species were analyzed in 17 and 20 Atlantic Forest fragments, respectively. We evaluated past and present-day landscape structure around each sampling site using forest cover maps of three different dates. For each date, landscape metrics representing forest cover and aggregation were estimated, and the influence of past and present-day structure on species abundance were analyzed using a model selection framework. There is a large variation regarding the influence of landscape structure on species abundance, including species not sensitive to landscape structure, species sensitive to present-day landscape structure, species sensitive to past landscape structure and species sensitive to past and present-day landscape structure. Life-history characteristics investigated, such as: endemism, forest-dependency, vulnerability to fragmentation and others, had a limited capacity to discriminate species according to their response to past or present-day landscape structure. Only forest-dependency explained partially the different responses of small mammals' species. These results suggest that time-lag responses are controlled by more complex processes, which are still to be revealed.

B3 - Modeling bird response to landscape structure
(Danilo Boscolo, Karin Frank, Jean Paul Metzger)

Habitat loss and fragmentation are currently the most important threats to the conservation of biodiversity. These processes may generate patchy landscapes where several species are forced to survive in small and isolated populations, which are very susceptible to local extinctions. According to the metapopulation theory, if local extinctions in specific patches can be compensated by re-colonization from surrounding populations, a species can persist despite fragmentation. Extinctions and re-colonizations are processes that depend directly on landscape structure. Small patches with low habitat quality have increased extinction probabilities, while poorly connected landscapes with high resistance to the dispersal of individuals have decreased re-colonization rates. Spatially explicit population viability models (SEPVM) allow analyses of the influence of different types of landscapes on the persistence of species, contributing to conservation strategies decision making. The objective here was to identify the factors which affect the persistence of three forest bird species endemic to the Atlantic forest (Chiroxiphia caudata, Xiphorhynchus fuscus and Pyriglena leucoptera) through a SEPVM. Four different fragmented landscapes of the Atlantic plateau of São Paulo were chosen for this study. The playback technique was used to assess the incidence of the birds inside 80 forest fragments in these landscapes. These data were used to derive logistic incidence models to estimate their occurrence probabilities according to the cover and spatial pattern of the surrounding landscape. Furthermore, the movement pattern of the birds between forest fragments was inferred from playback experiments which induced birds to overcome the matrix, and through the translocation of individual birds which were followed by radio-telemetry. The incidence models indicated that the occurrence probability of the birds in places of fragmented habitat depends in large scale on the spatial distribution of forest remnants, being higher where patch isolation is low. This effect becomes even more important in places where habitat patches are not big enough to provide the birds with sufficient resources, forcing them to search for it in nearby forests, which shall not be further away than the birds' aptitude to move through the landscape. Their ability to overcome the inter-habitat matrix, reaching close by forests, was confirmed by the experiments on individuals' movements. The studied species are able to move between nearby forest patches, being even able to use habitat corridors or isolated trees to ease their passage through the landscape. These results indicate that the territories of the studied species can include isolated patches which are connected by birds' movement. Also, the minimum conditions to the establishment of these territories in terms of amount and aggregation of forests varies according to the species. These results, added to bibliographical information on the studied birds' biology, were used to guide the development of an ecologically scaled SEPVM, in which the landscape cells were defined as potential bird territories. This viability model was greatly useful to assess the effects of landscape structural changes on the persistence of small territorial birds' populations. Simulations using both artificial and real landscapes indicated that, in a wide landscape scale, the persistence of these species is largely subjected to the amount of territories the landscape can bear, but not to its aggregation. Nevertheless, increases of forest density lead to a higher amount of possible territories, positively affecting the persistence of the species. The SEPVM developed for the

current thesis allowed the reconciliation of a structural analysis of the landscape to dynamical population modeling, what is considered as a top priority research subject in landscape ecology.

B4 - Corridors, gaps, and dispersal behaviour of Pyrilena leucoptera
(Cintia Cornelius, Marcelo Awade, Carlos Candia-Gallardo, Mariane Rodrigues Biz Silva, Soizic Le Saout, Jean Paul Metzger)

Habitat fragmentation highly affects movement patterns of organisms, resulting in considerable alterations of landscape connectivity and interfering with the spatial distribution and population dynamics of species. Dispersal and routine movements, two different types of movements that act at different spatial scales, can be influenced by the presence of structural elements of the landscape that facilitate or impede movement and by behavioral characteristics of organisms. Projects summarized here aimed to study different aspects of routine and dispersal movements of *Pyriglena leucoptera*, an endemic bird of the Atlantic rainforest. Experimental and modeling approaches were used to understand how different factors influenced the movement patterns of *P. leucoptera* in a fragmented landscape in the Planalto Atlântico of São Paulo in South-Eastern Brazil.

First, playback techniques were used to asses if gap-crossing capacity, by routine movements, is affected by gap width. Gap-crossing probabilities were obtained from this relation, which were then used to parameterize two functional connectivity indices (one binary and one probabilistic) based on graph theory. In a model selection approach, these two indices plus another structural one (*i.e.* patch area) were compared to establish which one is the best to predict *P. leucoptera*'s incidence in forest fragments. Results indicated that at the scale of routine movements, patches are completely isolated when the gap width is higher than 45 m. The species incidence was better described by the probabilistic connectivity index, evincing that it is essential to consider connectivity to understand the spatial distribution of *P. leucoptera*, and this attribute must be viewed in its probabilistic form. This model has a great potential to be used in environmental planning and management.

Second, three sets of translocation experiments were conducted to asses the relative importance of (1) gap-width and sex (2) corridor presence and sex, and (3) gap-width and a previous experience with fragmented landscapes on the dispersal success of *P. leucoptera*. Translocation experiments consisted in releasing individuals into small forest fragments isolated at variable distances (35-350 m) from other forest fragments by an open matrix or a forest corridor (n = 21 experimental landscapes). Capture and release sites were far away (>10 km) to ensure that birds did not know the area, allowing to infer processes related to dispersal rather than to routine movements. Translocated birds (n = 56) were monitored with radio-telemetry to assess the time and direction taken when leaving the release fragments and reaching a nearby habitat fragment.

Third, to quantify the predation risk of individuals while crossing an open matrix a survey of birds of prey and a prey-model experiment were conducted. A taxidermized individual of *P. leucoptera* was placed on a pasture and then slowly pulled with a string towards the forest edge during 1 hour while activity of birds of prey was recorded (n=20); then the same experiment was repeated without the model (n=20).

Finally, a fifth project is in progress to infer the perception of predation-risk by *P. leucoptera* in the matrix, through the study of movement patterns in exotic tree plantations, corn fields, and pastures. The goal of this project is to asses the interaction between risk of predation and visual field, two factors that affect movement decisions when dispersing through a fragmented landscape. Individuals are released in the matrix at a fix distance from a suitable forest fragment and then followed using radio-telemetry until it reaches the forest.

Results of these experiments demonstrated that the probability of dispersing successfully through a non-habitat matrix (e.g. pasture) decreased with increasing gap-distance, but the presence of corridors increased the probability of birds to reach another fragment. Corridors also directed individuals and decreased dispersal propensity (i.e., the time elapsed since release until dispersal). Overall, females were more successful than males when crossing the non-habitat matrix,

but both sexes performed similarly well when corridors were present. Among males though, having a previous experience with a fragmented landscape was important in determining dispersal success. The prey-model experiment demonstrated that the pasture in the region where these studies were conducted is a matrix with significant predation risk (i.e. low quality matrix). This was also supported by the fact that individuals preferred to move through habitat corridors when given the option. Preliminary results of the ongoing project on predation risk-perception revealed that movement patterns and time spent in the matrix varied considerably among the three matrix types, with a higher predation rate in corn-fields. Moreover, different outcomes of translocation experiments with individuals of different origin, suggest that individuals that had a previous experience with fragmented landscapes evaluated the novel environment while dispersing more efficiently than non-experienced individuals that came from the continuous forest population. Thus, considering dispersal capacity as a species specific trait may be misleading because as shown with these experiments movement behavior, and hence dispersal capacity, is sex-biased and is variable among populations for the studied species. Understanding the spatial variation in behavioral patterns and the mechanisms underlying this variation is important for conservation planning in the light of rapid and widespread changes that are currently observed in human-modified landscapes.

Subproject 7: Modelling of the functional connectivity
Karin Frank, Guy Pe'er – UFZ; Cristina Banks-Leite, Alexandre Martensen USP

Achieved targets
1. We obtained better understanding of how animal-landscape interactions determine functional connectivity, for various bird species.
2. We identified how functional connectivity affects sensitivity of species to habitat loss and fragmentation, on several spatial scales and levels – from the local scale (several patches in a landscape), through landscapes (3 landscapes assessed) and to the multi-landscape level (comparing 52 different landscape maps).
3. We assessed the potential effects of corridors on different species in different landscapes, taking into account which types of movements are aided by corridors. We have shown that in landscapes with relatively high forest cover, corridors facilitate both short-range movements and dispersal movements, thereby increasing the capacity of birds to establish home-ranges over more than one patch. In hyper-fragmented landscapes, corridors can no longer facilitate home-range (short-distance) movements, but they become crucial in facilitating dispersal movements and longer-term, larger-scale processes.
4. We analyzed changes in bird communities across a range of landscapes differing in forest cover and fragmentation levels, and showed that connectivity is an inherent component of community structure, necessary for explaining the changes in bird communities in response to forest loss and fragmentation. Without an explicit consideration of functional connectivity, the model could not replicate the observed patterns of species' extinctions, in which communities in hyper-fragmented landscapes crash but not toward complete extinctions.
5. We analyzed the capacity of different connectivity indices, used in the literature, to predict functional connectivity as it emerges from our simulation model. Our analyses indicated that some indices that are used in the literature, such as forest cover, cannot capture functional connectivity at all, while others, such as the landscape-shape index, perform better but depending on the landscapes and the conditions.

Applied methodology
We developed an individual-based, spatially-explicit simulation model which simulates the home-range behaviour of birds as well as dispersal movements, and produces results on both connectivity and abundances. The model can receive inputs from empirical data on: species biology (primarily: sociality); Habitat requirement (niche profile); The response of bird species to edges (avoidance or usage of outside "matrix"); tendency to perform gap crossing between forest fragments; and the home-range size of birds. In the absence of empirical data, the model also allows a range of theoretical explorations.

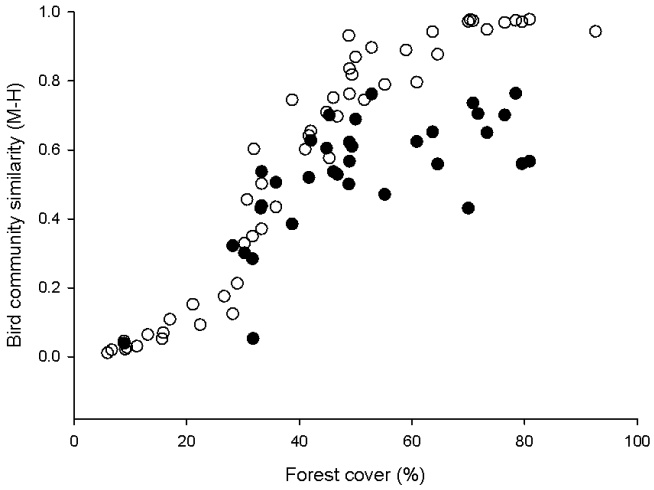
Additionally to the simulation model, we have developed a landscape generator which can produce virtual landscapes differing in forest cover, fragmentation levels and spatial structures. The landscape generator was necessary for any analysis which attempts to separate habitat loss from fragmentation (and hence, structural connectivity), since these two phenomena are highly correlated. The landscape simulator is based on mimicking the processes of habitat loss and fragmentation: simulated "humans" first create roads and then utilise the roads to expand agricultural fields into the remaining forest fragments.

Developed activities
We performed simulations with various levels of specificity:
Theoretical investigations were performed over a several virtual landscapes, where we systematically altered the response of virtual birds to edge and their tendency to perform gap crossing.
In cooperation with Dr. Miriam Hansbauer, and with the assistance of a replacement student (Christian Nawroth), we performed highly detailed parameterization of the model and analysed connectivity and sensitivity of three species of birds in three different fragmented landscapes in Sao Paulo, Brazil (differing in forest cover: 15, 30 and 45% forest cover). We showed that the model successfully replicates the sensitivity of species to fragmentation, but only if connectivity is taken into account.

In cooperation with Dr. Cristina Banks-Leite, Alexandre Martensen and Prof. Jean Paul Metzger, and with assistance of the replacement students Jakob Wernicke and Johanna Kremer, we analysed the potential effect of corridors on connectivity in three landscapes. Analysis was performed by "adding" corridors of different widths to the existing landscape maps: 30, 100 and 200m wide corridors. We then divided bird community into 6 functional types, based on two traits: the response to edge (three types: edge-avoiding, edge-insensitive or birds that penetrate into the matrix) and the response to patch area (two groups: reduced-abundance in small forest fragments versus increased abundance in small patches). We then ran simulations for home-range movements and for dispersal separately. We found that the effect of corridors was not even across landscapes and species. Corridors enhanced connectivity mostly in the landscapes with higher forest cover, and mostly for species that do not avoid edges. There was also a difference between dispersal and home-range movements: in the landscape with lowest forest cover, corridors were long and therefore could only enhance connectivity during the dispersal process but not during home-range movements which are, by nature, short-distanced.

With the assistance of an interim student Lucia Schober, we analyzed the capacity of different connectivity indices, used in the literature, to predict functional connectivity as it emerges from our simulation model. Six virtual landscapes, produced by the landscape simulator, served for our analysis. We used 5 indices from the literature, ranging from simple structural indices such as forest cover and Landscape Shape Index, to the most sophisticated methods used in the literature, namely the use of graph theory. The former indicated that simple approaches, and especially forest cover, cannot predict functional connectivity. Approaces driven from Graph-theory produce far better results since they consider species' biology, but their results are not completely consistent with the model results. Our systematic analysis, however, provided better means of comparing the different indices and making them more comparable.

In cooperation with Dr. Gustavo Zurita (Argentina), we ran simulations for 57 bird species over 52 different landscapes in Paraguay and Argentina, differing in forest cover and fragmentation levels. We then analysed community structure along a gradient of forest covers, from 100% down to 5%. We found that the model is highly capable of reproducing the observed pattern in which forest bird community crashes under a certain threshold of forest loss. However, these results were only obtained if the model explicitly considered mortality due to the lack of connectivity. Thus, we could show that connectivity is an inherent component of bird survival and community structures in fragmented landscapes. In the process, we identified a need to collect further empirical data from landscapes with particularly low forest cover and high fragmentation levels, since it is in these landscapes that connectivity may play the most important role in maintaining forest species. These data have been collected through December 2009 - January 2010, and, as expected, they have strengthened our model and showed that forest bird communities do not crush down to "zero" even in hyper-fragmented landscapes. These results have particular importance for forest conservation and restoration. Analyses are still ongoing and nearing completion, toward the preparation of a manuscript.



The similarity of a bird community in a given landscape to a landscape with 100% forest cover, from empirical data (full circles) vs. simulations (empty circles). The sigmoid function, indicating a crashing of forest communities around 30% forest cover, can only be reproduced when introducing mortality due to the lack of dispersal between forest patches.

On the process of deriving parameters for the simulations, we performed a detailed analysis of the response of multiple bird species to forest edges. We applied a sigmoid function for the distance-effect, and assessed its capacity to predict empirical data from two sources: once from telemetry data (using data from Dr. Hansbauer for 3 bird species) and once from point-count data collected by Dr. Zurita for 57 species, in 38 different landscapes in Paraguay and Argentina. We found that the sigmoid function fits to a wide variety of species, and even produces qualitatively similar results for the similar bird species using two data-sources (radio-telemetry vs. point-counts). The results also affected the niche-profile of many species, indicating that many species which are considered to be using the matrix are in fact merely penetrating into the matrix from the forest, as a distance-dependent behaviour. Analyses are now completed, and a manuscript is toward submission.
Analysis of the landscape simulator indicated that it is capable of reproducing a variety of fragmented landscapes, and especially the patterns produced by human-induced deforestation. The model includes two parameters which give it particular power to mimic fragmentation processes: the number of roads and the size of fields. Higher number of roads produces higher fragmentation levels, whereas larger field-sizes – typical for plantations – produces larger fragments of the remaining forest. We have shown that the model is well capable of reproducing the patterns of habitat loss and fragmentation in arable lands, and its performance is far higher than that of other generators that are used in the literature, such as RULE, that take a fractal-approach for landscape generation. A manuscript describing the simulator and its results has been completed and submitted.

Relevance and applicability of the results
Impacts of the Project for the involved institutions, the region and the society
Relevant contribution for scientific and technological development of the project's theme
Opportunities of environmental development offered by the project
Having validated the model for its capacity to reproduce observed patterns, the model provides unique tools for assessing, a-priori, what can be the potential efficacy of various restoration scenarios on forest animals. Thereby, the model can be used as a decision-making tool or as a tool for project assessment.

New projects generated from the original project
The project led to several directions, which are currently ongoing and are likely to continue developing in the coming years:
It is only with the landscape generator which one could analyse how structural connectivity, separately from forest loss, affects functional connectivity. The generator is currently used for the production of multiple maps, equal in forest cover but differing in spatial structure, in order to expand our analysis of the power of different metrics of structural connectivity to predict functional connectivity.
Cooperation with Dr. Zurita has been identified as a valuable route to continue analysing how bird communities respond to habitat loss and fragmentation, and what are the biological and ecological mechanisms behind these responses. We intend to proceed in this cooperation in the coming years.
The model developed during the Mata Atlantica project has been identified as a valuable tool, which can be implemented toward various projects and ecological questions. These days, we start to develop the model into a dynamic tool for predicting the effects of climate change and land-use change on various animals, belonging to different taxa (mammals, birds, butterflies, reptiles and amphibians) in several countries in Europe. This is within the FP7 cooperated project SCALES.

Feasibility of the continuity of the cooperation
Dr. Banks-Leite visited the Dept. of Ecological Modelling for 6 weeks during May-June 2009, to conduct the analysis of corridor-effect on connectivity. A reciprocal visit of Dr. Pe'er in Brazil was conducted in October 2009. The project produced preliminary results and is currently being completed with the assistance of the interim student Johana Kremer. Results will soon be summarized into a manuscript.
Dr. Gustavo Zurita visited the Dept. of Ecological Modelling for a period of three months, from May-July 2009, for the purposes of analysing bird-responses to edge; analysing the response of bird communities to habitat loss and fragmentation; and comparing the landscape generator to realistic landscape maps in Argentina and Paraguay. A

reciprocal visit of Dr. Pe'er in Argentina was performed in September 2009, to continue simulations and complete the analyses toward the preparation of several manuscripts. One manuscript has been submitted, two more are currently toward submission.
Dr. Hansbauer visited the Dept. of Ecological Modelling several times, to cooperate with Dr. Pe'er and Dr. Zurita on the analysis of bird-responses to edges; and to parameterize the model for the three bird species which she studied in the field using telemetry data. The outcomes of this successful cooperation are currently being summarized within two manuscripts.

CONCLUSION

The project has been completed successfully and achieved all of its original targets. Some of the results, such as the analysis of corridor effects on connectivity, and analysis of the power of different connectivity measures to predict functional connectivity across different landscapes, are still ongoing and being expanded into manuscripts. In addition to the required targets, the project has yielded two results: first, a landscape generator was developed which provides an additional working-tool for various projects and ecological questions. Secondly, a new topic which was not originally included in the main targets – namely the analysis of how functional connectivity affects the response of bird communities to forest loss and fragmentation – developed and produced a fascinating result of particular strength to the project, contributed knowledge which is of high value both to ecological theory and to conservation. Finally, the model developed during the Mata Atlantica project has been identified as an important tool for future projects, and is currently being implemented in various new sub-projects as a longer-term legacy of the project.

2. Evaluation of the Bilateral Cooperation (comment)

Strategy for the dissemination of the results of the research
In General the scientific results are going to be published within the scientific community, mostly in international journals, but also in Brazilian journals.

In order to address the civil communities, the general project and some sub-projects have been presented several times in regional newspapers, journals and also in short documentary style in European wide News - TV Channels (http://www.youtube.com/watch?v=6L_lLZOLz3Q), produced by Esras Films LTD www.eurworldtv.com and financed by the European Comission (http://ec.europa.eu/external_relations/media/).

We gained further outreach through press releases, initiated by the public relation department of the UFZ – Leipzig, for example with striking results that where strategically placed during the Climate Conference in Copenhagen 6. - 18. December 2009 (Press release from December 9 th , 2009; Tropical forests affected by habitat fragmentation store less biomass and carbon dioxide in the long term; http://www.ufz.de/index.php?en=19147) and cited in numerous international newspapers, radio channels, and internet news sites. This same news was also disseminated in the Brazilian press (http://www.usp.br/agen/?p=21297; http://portalexame.abril.com.br/meio-ambiente-e-energia/noticias/mata-fragmentada-absorve-menos-gas-carbonico-enquanto-cresce-546433.html)

During the project we produced material for environmental education and project presentations e.g. the brochure on the natural history of Morro Grande, a DVD on an environmental education project in the reserve Morro Grande, and a DVD documenting the sub-project "Diversity and conservation of small mammals in fragmented landscapes of the Mata Atlântica". These materials are made available to be distributed regionally by local NGOs and project members.

Strategy for the transfer of the generated or being developed technologies/products to the scientific and civil communities
During the project several simulation models for forest growth, landscape connectivity analysis, and meta-population analysis have been developed and adapted to the biome, flora, and fauna that have been studied during the last seven years. There is a certain demand and potential of NGOs, public institutions, and research groups to use this software for the development of landscape and land use management, reserve site selection, and habitat and population management. The distribution and use of this simulation software would require a certain investment of time, people, and financial resources to be adapted and transformed into user-friendly version that would have been possible only within a continuing project financial support.

One of the most important outputs was the strong participation of several members of the Brazilian team in the initiative leaded by BIOTA/FAPESP program to transform scientific results in environmental policy at the São Paulo state level. A large part of this work was sustained by landscape analyses performed by the Laboratory of Landscape Ecology and Conservation, coordinated by J.P. Metzger. As a result, we provided a book with the general guidelines for conservation policy (Rodrigues et al. 2008), and those results support now 21 governmental decrees and resolutions, which defines rules for vegetation removal, restoration, creation of new nature reserves, and an agro-ecological zoning ordinance for sugarcane expansion. This successful experience has now been reported to the Science journal (as a Brevia article), and is under review.

- R. R. Rodrigues, C. A. Joly, M. C. W. Brito, A. Paese, J. P. Metzger, L. Casatti, M.A. Nalon, N. A. Menezes, V. S. Bolzani, V. Bononi. 2008. *Diretrizes para a conservação e restauração da biodiversidade no estado de São Paulo.* Programa BIOTA/FAPESP & FAPESP & Secretaria do Meio Ambiente, São Paulo, SP.

Participation of local associations, NGO's, authorities, public institutions, population in general
During the whole project we collaborated with local nature conservation and community development NGOs like SELVA (Sociedade Ecologica Verde Amarelo). We gave scientific and other inputs, and supported their programs and events in various ways and build up a certain infrastructure and logistic for their future activities in capacity building and environmental education, especially in the region of the Morro Grande Forest Reserve.

Mobilization of local population in the construction of a conscience about the necessity to preserve the Environment
We addressed the local population through locally interacting with NGOs, reserve owning companies (SABESP), and other local leaders. Particularly, during the last 3 years of the project, we provided 50 fellowships for high school students from Cotia municipality in order to train them for environmental education, tourism support, and capacity building for the "eco job market". Most of this students stay in the region, and play an important role in multiplying the scientific knowledge from the project, and in disseminating an environmental conscience.

Prospective analysis of the developed researches
Most of the achieved outputs are still restricted to sub-projects or to PhD outputs. We believe that even without any other data or financial support, there should be in the next years a continuous interaction among team members to integrate data and thus to conclude new and general publications.

New projects generated from the original project
Several ideas of future cooperation and deriving projects have been developed for most of the sub-projects. In parts they have already been started with existing finances (as in the case of a new cooperation between the connectivity modeling project Guy Pe'er - UFZ and a research group from Argentina). Most of the cooperation intentions are, since the termination of the Mata Atlantica program at the end of 2009, still struggling for fundraising for the planned research projects or application of methods, models, and results for landscape and habitat conservation management.

Interactions with other research areas
There are multiples direct and indirect interactions with other areas, some of them are more a result of personal contacts, and other are direct consequences or opportunities created by the project. Some of this interaction are related with conservation actions (with NGOs like IPE, WWF, or with the State Environmental Secretary), and other are developments of scientific research, and include collaborations with several Universities in Canada, US, England, and also in Brazil with FIOCRUZ-RJ and the Federal University of Pernambuco.

Interaction with the productive sector – not applicable

Quality of the integration/interaction between the teams
In this second phase, the interaction between the teams was high and fruitful inside the project, but very low and formal between teams of different projects (São Paulo, Recife, Florianópolis, and Curitiba).

Internally (within the São Paulo project), the teams that were maintained in the second phase were those that collaborated mutually and in a satisfying way in the first phase, and this was the main condition for a successful collaboration. On the other hand, during the first phase, the process of formation of collaborating teams did not receive the necessary amount of consensus between the teams, and thus the effective integration and cooperation was only achieved with a lot of efforts of the coordinators and only after a certain time period. As a result, we consider that much more money and time should be invested in the first stages of the collaboration, when the project is designed and the teams are defined. These first stages are key-moments for a successful collaboration.

Benefits derived from the cooperation for the promotion of scientific and technological development of both countries
For both counterparts the Mata Atlantica research program provided several types of benefits and scientific, data and knowledge transfer. As a consequence, several methods, models, and frameworks for new hypothesis and research questions could evolve substantially. This research program provided an effective environment for scientific capacity building and field research on an unusual large scale.

Difficulties in the cooperation
Most of the difficulties observed in the first phase regarding financial problems, lack of team integration, poor collaboration for some sub-projects, were completely avoided in the second phase. It should be stressed that the successful output of this collaboration was only evident after a long period of financial support and team integration, what highlight the importance of long-term projects and constant evaluations.

Events done in partnership
Several events, like special symposia on international congresses or Mata Atlantica internal workshops integrating all program sites of this research program, have been organized jointly and successfully.

Feasibility of the continuity of the cooperation
Some sub-projects do intent to continue with ongoing or new projects or with the application of results and methods for landscape conservation management, but are dependent on future priorities of the funding agencies.

3. Information on the management (list and comment)

Main problems identified in the execution of the project
As explained before, problems observed in the first phase were adequately avoided or solved in this second phase. We had a more equal investment from both sides, and the lack of equipment support from CNPq was compensated by the German side. All teams had an intensive and fruitful cooperation exchange, which resulted for the moment in 11 joint publications and more than 13 others submitted or in preparation for international journals. Most of these publications represent studies from individual sub-project, and probably more widely integrative studies will only be prepared in a near future, what should increase the number (and the percentage) of joint publications.

Evaluation on the communication with CNPq (comments, critics and suggestions)

In this second phase, we had few exchanges with CNPq and BmBF staff, which were not even present in the annual meetings. We understand that this was mostly related to the relatively few problems faced in this second phase, and to the successful identification of the problems at the end of the first phase.

Changes in original team (consequences)
There was almost no change in the team along the second phase. From the first phase, we only keep the teams that presented a more active and positive cooperation, what allowed a more intense, peaceful, and successful cooperation.

Participation of the executive institution
The executive institutions were quite efficient in providing the logistical and financial support /guarantee for the adequate development of the project, however we feel that they were almost absent from a scientific perspective. We feel also a lack of a more active participation of those institutions regarding a more active role in facilitating or promoting the cooperation among regional projects and teams.

4. CONCLUSION

4.1. Summarized Evaluation of the project performance

After six years of support, we believe we had achieved quite good results. From a scientific point of view, the project produced several manuscripts (43 in international journals, 10 in national journals), some of them in high impact journals (e.g., Oikos, Ecography, Biological Conservation, Landscape Ecology). There are also several other manuscripts submitted (10) or in preparation (41). In addition, scientific results were largely disseminated in numerous international and national events, and more locally in regional newspapers, journals, short documentary, and brochures. Another highly important output of the project is the opportunity provided for training qualified research personnel. Only in the second phase, 24 Brazilian students got their master (15) and PhD (9) degrees, and 7 undergraduate students were trained, and several German students were involved at different levels (post-doc, PhD, and Diploma thesis). Results, processes, methods, models, and procedures developed during the project had also been frequently applied for environmental actions and conservation policy, particularly at the state level, in close collaboration with BIOTA/FAPESP program.

We think that this successful cooperation and their important outputs were only possible due to the long-term support from CNPq and BmBF. It was thus capital to proceed in a second phase to get all the observed results. Without any doubt, several studies and projects will proceed in the future and the integration of data from different sub-projects should result in new relevant publications.

4.2. Summarized Evaluation of the Program - Critics and suggestions

Within this research project it turned out to be difficult to integrate the research teams from all different research sites into one theoretical framework, as the project at each site and even within these sites have been planned and designed mainly independently, thus following a highly heterogeneous range of research questions. Thus in parts we would consider the research program more as a multidisciplinary program of independently working research groups at different sites, what made it relatively difficult to integrate these heterogeneous groups and interests and even worse to integrate the independent results into a common frame of applicable products and recommendations, for example, for policies or conservation management.

This could be avoided in the future if calls of financing agencies would be prepared more carefully, may be during workshops or symposia that may define common framework research questions and topics and provide already in the development of proposals enough opportunities for interactions between the different research teams. These workshops should be carefully prepared setting just some general topics but be widely distributed and open for the scientific community of different disciplines, provide the environment of active participation of researchers of different disciplines, and should have the defined goal of defining a theoretical framework of research topics considering the transdisciplinary approach just from the beginning on. Furthermore, it should have the objective to be able to already define principles for the products and the applicability of results.