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Ecological engineering: from concepts to applications

InBioVeritas – Valuating nature in the southern Mata Atlântica of Brazil

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Abstract

The competence center InBioVeritas was founded in 2007 with the vision to integrate competences for ecological and socio-economic research, sustainable land management and biodiversity conservation in the southern Mata Atlântica. Originating from a successful partnership in a recently terminated Brazilian-German research project (SOLOBIOMA), it is based on long experience and strong commitment of its members. It is concerned with a region of the Atlantic Forest where the largest forest remnants are found in protection areas of different status. However, cumulative effects of land use and climate change are likely to threat conservation and promote further loss of biodiversity in the future.

Keywords: biodiversity; Brazilian Atlantic forest; ecosystem services; socio-economy; sustainable land management

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1. Introduction

The coast of the Brazilian state of Paraná is known for its stupendously species-rich forests. It is part of the Mata Atlântica Biosphere Reserve, one of the hottest hotspots of biodiversity [1]. The region around the small town Guaraqueçaba on which we focus our work represents one of the largest and best-conserved continuous tracts of the Atlantic Forest. It has to be seen in a close urban-rural context with the megacity Curitiba and Brazil's second largest harbor Paranaguá. To the North and South it is connected with similar natural environments, while to the West it is delimited by the Serra do Mar mountain ridge and to the East by estuaries and the Atlantic Sea.

The region encompasses four municipalities with approximately 10,000 inhabitants and a low Human Development Index. It includes the Environmental Protection Area (EPA) Guaraqueçaba (283,000 ha) and two federal protection areas (the National Park Superagüi and the Ecological Station Guaraqueçaba: 38,800 ha) (Fig. 1). Several historic waves of colonization created a patchy landscape of old-growth forests, pastures, agriculture sites, restoration sites and naturally regenerating forests. During the last 40 years, the construction of the road Antonina - Guaraqueçaba in 1970 and subsequent increase of timber and palm extraction (*Euterpe edulis* for palm hearts) had a strong impact on the lowland and lower submontane forests of the region. Asian water buffalo pasturing led to deforestation and created large open grassland, dominated by exotic grasses. However, buffalo farming was never economically lucrative and decreased during the last years. Open land was converted to rice or palm (peach and king palms) plantations or even abandoned, making large degraded areas available for natural or managed restoration of forest. The regeneration of forests from degraded pastures was strongly reinforced by the projects of the Society for Wildlife Research and Environmental Education (Sociedade de Pesquisa em Vida Selvagem e Educação Ambiental - SPVS), described below. This regional Non-Governmental-Organization (NGO) acquired 40 farms of about 400 ha each between 2000 and 2003 for conservation.

The region around Guaraqueçaba has also attracted the scientific community, due to its ecological and social-cultural peculiarities. A series of studies was realized on fauna and flora, some on socio-economy and sustainability, including production of palm heart (palmito) and fruits of *Euterpe edulis*, and on sustainable tourism, but very few on the development of land use technologies. Though, the common lack of feedback from researchers to local people has caused frustration and the feeling that the region persists in a state of abandonment in terms of development [2].

Since 1992 socio-economic studies and diagnostics have been compiled and raised awareness of environmental management needs in the region. At the request of the Brazilian Federal Ministry for Environment all actors in the region which are represented in the council of EPA Guaraqueçaba (municipality leaders, governmental agencies, universities, NGOs) work together on defining land-use regulations for economic activities in the protected areas. The strategic engagement of the NGOs (e.g. Mater Natura, Fundação O Boticário de Proteção à Natureza, SPVS) with governmental environmental agencies (IBAMA, ICMBio, IAP) has resulted in state and federal representatives turning more and more to these organizations for technical support and input on key decisions affecting the EPA. Relevant diagnostic studies for the region have been made by IPARDES (Paraná's institute for economic and social development: macro-zoning of the EPA in 1989) and the SPVS (integrated conservation plan for the region of Guaraqueçaba in 1992). But even though planning strategies exist, administrative deficiencies strongly limit their application and integrated actions for poverty reduction, infrastructure development and better environmental protection.

Since 1991 the SPVS has been continuously working on biodiversity conservation and the improvement of the quality of life of the people in the region. In alliance with the worldwide acting NGO The Nature Conservancy and the companies American Electric Power, General Motors and Chevron, SPVS launched the first climate-action projects in the Atlantic Forest in 1999, through the acquisition of 18,600 ha in the centre of the EPA. Herein remaining forests are conserved and degraded areas ecologically restored. Ecological restoration is based on soil studies, botanical inventories, the production of more than 650,000 seedlings of 40 native tree species in nurseries, application of different planting techniques on 1,500 ha, and biomass and biodiversity monitoring. To estimate carbon sequestration, the aboveground carbon stock and tree growth are measured in permanent plots in different forest strata, pastures and areas under restoration [3]. This is to be considered a pioneer initiative, innovative in the sense of combining biodiversity conservation with global warming mitigation, representing one of the first initiatives of avoided deforestation on a larger scale.

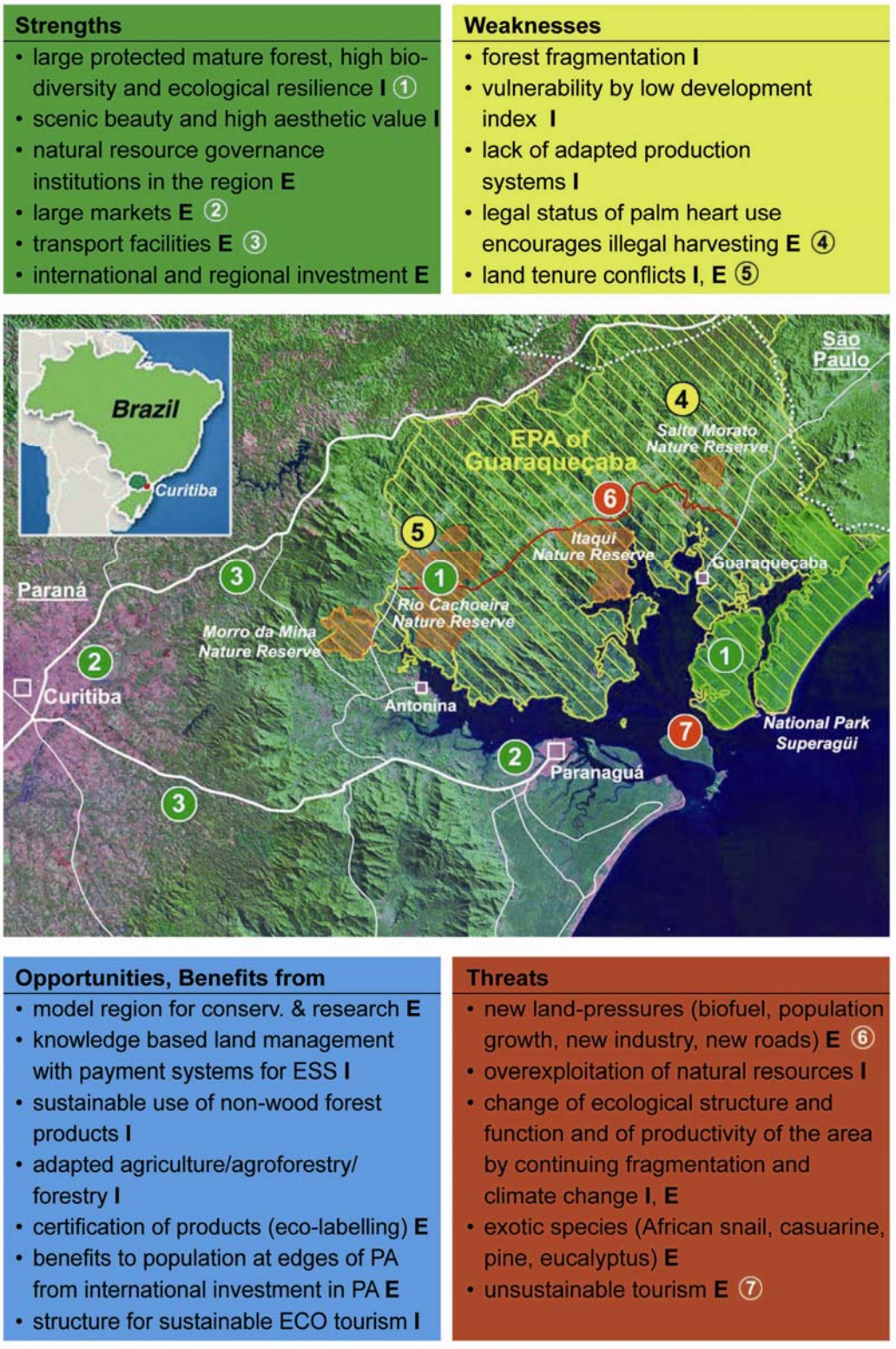

Fig. 1. Map of the region of the Environmental Protection Area (EPA) Guaraqueçaba in Paraná, Brazil. Numbers indicate localities of interest for a sustainable development, based on a SWOT-analysis (**S**trength – **W**eaknesses – **O**pportunities – **T**hreats) (E – extrinsic drivers, I – intrinsic drivers)

One of the prominent results of the projects was the creation of officially recognized private nature reserves (Reserva Particular de Patrimônio Natural - RPPN), which implies a yearly monetary income of nearly two millions of Brazilian Reais (in 2009; approx. 825,000 € or 1,100,000 US$) for Guaraqueçaba and Antonina by the Brazilian system of payment for environmental services (ICMS Ecológico). Unfortunately it is not transparent to what extent this money is being used in awareness of a sustainable development of the region. Therefore, the climate-action projects running now for more than 10 years, are to be considered a model for the REDD initiative (Reducing Emissions from Deforestation and Degradation) [4] rather than a strategy for integrated action within the EPA.

2. Project SOLOBIOMA

Since 2003 the Brazilian-German project SOLOBIOMA studied soils and biogeochemistry, floristics and diversity and function of soil organisms in a-priori classified stages of secondary forest and old-growth forests in the region. Along several chronosequences on two different soil types and in two reserves the scientists tested standard methods within a multi-taxon approach and identified potential indicators from all studied taxa. Main objectives were to describe the diversity, to broaden the understanding of the ecological functions and the recovery of biodiversity in the region and to develop a regionally applicable biological classification system for secondary forests. First results are already published and will be reviewed here briefly:

Monitoring of biogeochemistry in a chronosequence of lowland forests (Restinga) showed that nutrient fluxes were strongly determined by the vegetation. Nitrate, potassium and magnesium increased in throughfall from the youngest to the older stages of the succession and many tree species showed enrichment in foliar potassium content along the succession [5]. The native tree species *Tapirira guianensis* dominated the older secondary forest and influenced calcium contents in throughfall by its high foliar calcium [6]. Microbial respiration in leaf litter also increased along the chronosequence, due to increasing litter quality and enhancing microclimatic conditions inside the forests [7]. In the younger stage litter was dominated by a few species with high degree of sclerophylly (thick leaves, small leaf area, high stomata density, thick palisade parenchyma, strong sclerenchyma), when compared with the species in the older successional stages [8].

Floristic diversity increased along a chronosequence of 20-, 80- and 120-year-old submontane forests. The 120-year-old forest showed highest tree diversity, basal area and volume, while the 80-year-old forest showed higher density and total plant species richness [9]. The a-priori classes of secondary forests proved to be ecologically meaningful and all classes are characterized by indicator species. The age (time after disturbance) of a forest determined species richness and species composition (guild structure). It was estimated that the time necessary to recover the proportion of animal-dispersed, non-pioneer and understory species of mature forests in secondary forests will take one to three hundred years. The recovery of the endemism level of mature forests will probably need more than 1000 years [10].

A similar time scale of up to several hundreds of years was estimated for the total recovery of the richness and composition of ant assemblages (Formicidae) [11]. With more than 170 soil dwelling species, the ant fauna found in a study of 24 sites of young to old secondary and old-growth forests was species-rich, although not as prominent rich as in central tropical regions of the Mata Atlântica or Amazonia. Richness and composition of ant assemblages in secondary forests recovered continuously, but slowly. The soil type had only minor influence on the recovery process. Secondary forests did not act as refuges for many species of old-growth forests. Resource availability and habitat conditions for ants in secondary forests were different to those in old-growth forests; these factors had a strong influence on the structure of ant assemblages [12]. The observed loss of both species and functional diversity in secondary forests offers no reason to believe that the ecological functions provided by ants are buffered against species loss through redundancy [13]. The results emphasize the crucial role of the existent old-growth forests for the conservation of biodiversity and ecosystem functions.

For free-living nematodes extraction methods had first to be tested for applicability under tropical conditions. Only the abundance of nematodes in the leaf litter, but not in the soil, increased with the age of the secondary forests. Nematode abundances in the soil were higher in banana plantations than in forests and mixed agroforestry sites [14]. For the first time microdrilid worms (Enchytraeidae) were assessed during ecological studies in the southern Mata Atlântica. Therefore the first step was a taxonomic study of this group of worms [15]. Ten species were and will be described as new [16]. About 50 species were identified to date, almost twice as much as known until now throughout Brazil. The species richness did increase with the age of the forests, but seemed strongly

influenced by local soil and site conditions. Their abundance and biomass were equally low in all study sites (forests, pastures, agroforestry systems) [17]. In contrast, earthworms accounted for high biomass in soils of all studied sites, although considerable species loss has occurred in the region. To date no autochthonous species could be found and species richness was generally low and varied little between the 51 studied sites representing different soil types, land use and forest stages. The peregrine species *Pontoscolex corethrurus* (Glossoscolecidae) dominated in abundance and biomass. In pastures earthworms were less abundant than in all other sites [18].

Litter inhabiting beetles (Coleoptera) of 35 families had a much lower species density in the young secondary forests than in old-growth forests, but recovered rapidly. Old secondary forests (50 years after abandonment of use as pastures) contributed substantially to the regional conservation of forest beetle diversity. Staphylinidae (predators), Curculionidae (decomposers), Scydmaenidae and Carabidae (predators) dominated in terms of abundance. The composition of beetle assemblages was strongly affected by soil type, litter quantity and litter temperature [19].

Spiders, prominent predators in forests as well as in open land, were sampled with a widely recognized sampling protocol and proved to be species rich (> 400 species). Distribution of the diversity along the chronosequences resembled the pattern found for beetle assemblages. Stages did not differ in richness, but genus composition differentiated the two younger from the older stages, pointing to a strong turn-over.

Decomposition rates were strongly influenced by the leaf species, some species being very recalcitrant to decomposition by soil fauna. Decomposition of all studied leaf species increased with the age of the forest. No clear succession of the soil arthropod fauna in terms of abundance, biomass or structure along the chronosequence could be observed, which could explain this. Decomposition rates were higher in submontane than in lowland forests and earthworm biomass did correlate with the decomposition rates of one rapidly decomposing leaf species [20]. Species composition, but not species richness of litter influenced decomposition rates in a field experiment with a series of leaf mixtures exposed in litterbags. The relationship between the decomposition subsystem and species diversity of litter in the Atlantic Rainforest follows the idiosyncratic response hypothesis and not the rivet hypothesis. For conservation or reforestation management, these results emphasize the need to maintain or restore the assemblages of native tree species (Gießelmann et al. submitted).

Fungal diversity assessed by genetic fingerprinting was high in all stages of forest. This underlines the value even of young secondary forests for the diversity of litter dwelling fungi. However, we also found a high species turnover between successional stages. Thus, secondary forests are not suitable for the conservation of fungi living in old growth forests.

The specimens collected and identified during the project were deposited in Brazilian scientific collections and taxonomic data are made available through the TaxOnline portal (www.taxonline.ufpr.br). The large and growing database of species-level ecological data for the southern Mata Atlântica will be made accessible by implementation of a metadata model developed during the project. In the last ongoing phase of the project the meta- and raw data will be handed over to a Brazilian institution (InBioVeritas, see below).

Horizontal as well as vertical coordination, involvement of stakeholders, using and enhancing existing coordination, collaboration and communication mechanisms are important tasks [21] already tackled in the recently finished project. Videos in Portuguese and German on the biome Mata Atlântica and the project work have been produced and distributed. The approach, objectives and results have not only been presented at scientific congresses and through scientific publications, but also in panels and talks during the Conferences of the Parties (COP) of the Convention on Biological Diversity (CBD) in Brazil (COP 8) and Germany (COP 9) and in expositions at the Natural History Museum Karlsruhe and other locations in Germany. Scientists of all institutions have served written press and other media at the local and regional level. The very positive experience in the partnership and with stakeholders at all levels led the project partners to the foundation of InBioVeritas in 2007.

3. InBioVeritas – the Competence Centre for the Conservation of Biodiversity in the Atlantic Forest (www.inbioveritas.net)

InBioVeritas was founded in the city of Curitiba, Paraná, Brazil by the following organizations: State Museum of Natural History Karlsruhe (Germany, SMNK), Federal University of Paraná (UFPR: Departments Botany, Soil and Agricultural Engineering, Zoology), Society for Wildlife Research and Environmental Education (SPVS) and their representatives signing a letter of intent. In 2008 the NGO Fundação O Boticário de Proteção à Natureza (FBPN)

affiliated as a full member and representatives of several other institutions (Instituto Chico Mendes de Conservação de Biodiversidade ICMBio, federal research institution Embrapa Florestas) expressed interest.

The consortium envisions concentrating existing competences in order to improve and disseminate knowledge on biodiversity of the Mata Atlântica in a planned and coordinated way to be applied for its conservation. The foundation was motivated and based on the following considerations:

- The demand for scientific knowledge on biodiversity has been recognized by the Parties of the Convention on Biological Diversity (CBD), however, it is an extraordinary challenge for the megadiverse countries and those in development to know their own biodiversity.
- The situation of Natural Heritage of the Mata Atlântica is critical, due to continuous anthropogenic interference since centuries and missing integration of the parties interested in the conservation of its biological diversity into regional land use planning as well as in the dissemination of existing knowledge to subsidize practices in conservation management.
- The southern coastal region of São Paulo and the northern coastal region of Paraná represent the major continuous remnant of Mata Atlântica and thus make it imperative to conciliate conservation of biological diversity with regional development in this area.
- The positive results of the developed activities in partnership with members of the projects SOLOBIOMA and Tax online (The Biological Collection Network of Paraná) and the NGO SPVS show how cooperation raises the potential of individual activities and optimizes conservation efforts in the Mata Atlântica.
- The founders of InBioVeritas, together with their partners in the running projects are already well skilled in research on taxonomy, ecology and conservation of the biological diversity of the Mata Atlântica.

Specific objectives of InBioVeritas are therefore:

1) To produce, integrate and disseminate scientific knowledge for the development of models for a rational and sustainable use of natural resources and for subsidizing public politics in conservation of the biological diversity of the Mata Atlântica;

2) To identify and consolidate ongoing initiatives on surveying biodiversity which might be used to define a National Base for Knowledge Administration on the biological diversity of the Mata Atlântica;

3) To develop programs in environmental education, scientific visits and improvement of graduate and post-graduate student formation, subsidized by scientific research;

4) To represent a permanent initiative of valorization of regional conservation organizations, both public and private, on the base of scientific research, educational activities and the search for continuous development in structure and human capacities needed in the protected areas;

5) To standardize proceedings and methods to describe the species richness, diversity and ecosystem functions and services by using standardized protocols that allow future comparisons and integration of the results obtained by projects related to and/or coordinated by the centre;

6) To define politics and procedures for a management of the collected biological material, e.g. for the deposit in scientific collections and accessibility of the non-sensitive data.

4. What is needed for the region?

As in many other regions of the world there is a lack of adequate social and political support, weak law enforcement and absence of a viable financial sustainability mechanism for the EPA Guaraqueçaba. This is accompanied by a chronic deficiency in regional administration, which inhibits the definition of priorities accepted and followed by the different institutions acting in the region. A concrete problem is the low level of training of the personnel responsible for the operational management of the protected areas. Models for generating sustainable income in the local communities are lacking. Research projects carried out in the region by the proponent institutions over the last 15 years revealed a strong need of an integrated management system. Maximizing the efficiency of land use in the forest matrix to minimize the need for additional land is a main goal for the region. Sustainable agroforestry and agricultural systems have to be developed and monitored [22], but today the use of wood and palm products, even by managed extractivism and from secondary forests is severely hindered by restrictive laws. Thus, to date agriculture is not the most viable alternative to biodiversity conservation in forests, which provide a wide range of ecosystem services. These ecosystem services can and must be measured, evaluated

and valorized on local and regional scales. Scientific activities, capacity building and low-scale tourism on the background of a well preserved landscape and biodiversity represent a strong potential of sustainable use creating income by local employments and encouraging investments of low environmental impact.

What is needed is a management concept for the EPA Guaraqueçaba and its surroundings for and with the resident people and the main stakeholders, based on adequate scientific knowledge of the relevant ecosystem services, which will deliver support for decisions on regional planning. The federal and state based environmental governance level depends on external inputs to promote the implementation of legally demanded management plans, and thus asked for support from research institutions and especially from InBioVeritas.

5. How will this goal be tackled?

The region fulfils many criteria for a model region where the valuation of forests, sound decisions on the future management of secondary forests and fallow land, adapted land use systems (forestry, agroforestry and agriculture) and sustainable tourism will contribute to a sustainable socio-economic development of the region, based on the conservation of its natural richness and ecosystem services.

InBioVeritas is therefore applying for funds to realize the following activities:

1. Develop a participative transdisciplinary research approach in a very important nature-oriented region of the Brazilian Atlantic Forest, applicable to other regions within the country and abroad;
2. Execute research on the assessment of biodiversity, ecosystem functions and valuation of ecosystem services (ESS), to enhance the understanding of the provision of these services and their interaction with land use in the socio-economic context of a tropical model region;
3. Quantify the marginal changes in biodiversity, ecosystem functions and services related to land use change under different scenarios of regional development and global change and identify trade-offs between different land use systems in the EPA Guaraqueçaba;
4. Develop tools and a model for sustainable land management considering social differentiation in the region, deliver decision support tools for stakeholders and provide a feedback on results from research into the region by means of educational material, training courses, an image rich “catalogue” that explains achievements, recommendations and a future-oriented (marketable) vision balanced between nature conservation and economic development.

6. Conclusions

InBioVeritas is an approach derived from the practical working level (bottom-up). The founding members and further associates refer to successful research and dissemination activities based on, but also resulting in good partnership. It complements the existing councils, which since many years are trying to address the regional demand from a political point of view. InBioVeritas enriches the discussion in content and integration intensity and aims to show a way out of the impasse of political and legal demand in the absence of thematic and scientific input. Adapted communication and information facilities will assist in the delivery of information and to select the relevant data for regional development. Representatives of the federal governance authorities signalized that they see a concrete progress by incorporating InBioVeritas and its compound expertise in implementing their management plans, which were partially paralyzed since 1992. The new quality seems to be the practical generation of usable results in close unity with recommendations for application in a concrete and given reality of the EPA of Guaraqueçaba. Policy in this sense is a consequence, not a precondition.

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Protection Area with the financial support of General Motors and American Electric Power in partnership with The Nature Conservancy.

References

[1] W.F. Laurance, Biol. Conserv., 142(2009)1137.
[2] A.L. Kasseboehmer, and I.C. Silva, O olhar de pesquisador sobre Guaraqueçaba, Paraná: diagnóstico e análise crítica da produção científica relacionada ao município, Floresta, Brazil, 39(3)(2009)643.
[3] A.R. Ferretti, and R.M. de Britez, J. Nat. Conservat., 14(2006)249.
[4] M.C. Cenamo, M.N. Pavan, M.T. Campos, A.C. Barros, and F. Carvalho, Casebook of REDD projects in Latin America, 1st Ed. (Working Document, V1.0), Manaus, Brazil, 45 pp., 2009.
[5] L.C. Souza, and R. Marques, Fluxo de nutrientes em Floresta Ombrófila Densa das Terras Baixas no litoral do Paraná, Floresta, 40(2010)125.
[6] C.B. Pinto, and R. Marques, Aporte de nutrientes por frações da serapilheira em sucessão ecológica de um ecossistema da Floresta Atlântica, Floresta, 33(2003)257.
[7] M.L.P. Peña, R. Marques, M.C. Jahnel, and A. dos Anjos, Respiração microbiana como indicador da qualidade do solo em ecossistema florestal, Floresta, 35(2005)117.
[8] M.R.T. Boeger, and C. Wisniewski, Comparação da morfologia foliar de espécies arbóreas de três estádios sucessionais distintos de floresta ombrófila densa (Floresta Atlântica) no Sul do Brasil, Revista Brasileira de Botânica, 26(2003)61.
[9] D. Liebsch, R. Goldenberg, and M.C.M. Marques, Florística e estrutura de comunidades vegetais em uma cronoseqüência de Floresta Atlântica no Estado do Paraná, Brasil, Acta Bot. Bras., 21(4)(2007)983.
[10] D. Liebsch, M.C.M. Marques, and R. Goldenberg, Biol. Conserv., 141(6)(2008)1717.
[11] J.H. Bihn, M. Verhaagh, M. Brändle, and R. Brandl, Do secondary forests act as refuges for old growth forest animals? Recovery of ant diversity in the Atlantic forest of Brazil, Biol. Conserv., 141(3)(2008), pp. 733-743.
[12] J.H. Bihn, M. Verhaagh, and R. Brandl, Biotropica, 40(5)(2008)597.
[13] J.H. Bihn, G. Gebauer, and R. Brandl, Ecology, 91(3)(2010)782.
[14] T. Moser, and S. Frankenbach, Methodological adaptation for nematodes extraction in forest soils of the southern Mata Atlântica, PAB, 44(8)(2009)975.
[15] R.M. Schmelz, R.M.C. de la Pena, and J. Römbke, Benefits from ecological study methods to taxonomy of enchytraeids in southern Mata Atlântica, PAB, 44(8)(2009)861.
[16] R.M. Schmelz, R. Collado, and J. Römbke, Zootaxa, 1809(2008)1.
[17] J. Römbke, R. Collado, and R.M. Schmelz, Acta Hydrobiologica Sinica, 31 Suppl.(2007)139.
[18] J. Römbke, P. Schmidt, and H. Höfer, The earthworm fauna of regenerating forests and anthropogenic habitats in the coastal region of Paraná, PAB, 44(8)(2009)1040.
[19] P. Hopp, R. Ottermans, E. Caron, S. Meyer, and M. Roß-Nickoll, Insect Conserv. Diver., 3(2010)103.
[20] P. Schmidt, K. Dickow, A.A. Rocha, R. Marques, L. Scheuermann, J. Römbke, B. Förster, and H. Höfer, Ecotropica, 14(2)(2008)89.
[21] G.A.B. d. Fonseca, W. Sechrest, and J. Oglethorpe, Managing the Matrix, In: T.E. Lovejoy, and L. Hannah, Eds., Climate Change and Biodiversity, (2005)346.
[22] R. Costanza, R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt, Nature, 387(1997)253.