Journal of Coastal Research	SI 39	1156 - 1160	ICS 2004 (Proceedings)	Brazil	ISSN 0749-0208

Landscape Ecology and Effects of Habitat Fragmentation on Biodiversity of Coastal Environments: Case Study of Morraria da Praia Vermelha, SC, Brazil

R. C. Marenzi† and L. C. Gerhardinger ‡

†Laboratório de Implantação e Manejo de Unidades de Conservação, CTTMar, Universidade do Vale do Itajaí, Itajaí, SC. Postal 360, 88302-202, Brazil, marenzi@matrix.com.br

‡ Oceanography student, CTTMar, Universidade do Vale do Itajaí, Itajaí, SC. Postal 360, 88302-202, Brazil, garoupa1@cttmar.univali.br

ABSTRACT

MARENZI, R. C. and GERHARDINGER, L. C. 2006. Landscape ecology and effects of habitat fragmentation on biodiversity of coastal environments: Case study of Morraria da Praia Vermelha, SC, Brazil. Journal of Coastal Research, SI 39 (Proceendigs of the 8th International Coastal Symposium), 1156 - 1160. Itajaí, SC, Brazil, ISSN 0749-0208.

The objective of this study was to develop and apply a landscape ecology study method to a coastal promontory, aiming to understand the processes that involve its formation and its maintenance. This research related the spatial structure of the landscape and the dynamics of tree species (model-species) considered climax indicators of the Atlantic Rainforest and its potentials dispersors (key-species). The study was focused of the Morraria da Praia Vermelha, municipality of Penha, Santa Catarina). The model-species observed were: *Ocotea catharinensis*, *Virola bicuhyba*, *Copaifera trapeziflia*, *Cabralea canjerana* and *Euterpe edulis*. Key-species were: *Ortalis squamata, Ramphastos dicolorus, Melanerpes flavifrons, Myiodynastes maculatus, Pitangus sulphuratus, Turdus rufiventris, Platycichla flavipes* and *Thraupis sayaca*. The situation of the area, considered a coastal fragment for its natural geomorphology, is intensified by the anthropic pressure, resembling it as a vegetation island. On one side it is limited by the Atlantic Ocean and on the other by the quaternary plain. It was observed that model-species are rare, resulting from a selective removal of trees, bird fauna reduction and adverse soil and topographical conditions, together with the distance observed among patches. The situation is further adverse because of the inexistence of connectivity of this area with other habitat fragments. If the adoption of environmental policies does not come soon to consider the restoration, fiscalization and environment education to stop hunting and further fragmentation, the expected trend is a loss of the biodiversity still existing on the studied environment.

ADDITIONAL INDEX WORDS: Landscape ecology; habitat fragmentation; biodiversity conservation.

INTRODUCTION

Landscape appears as a common unit among the several areas of knowledge. A synthesis of physiographic, biological and anthropic phenomena expressed in a portion of the terrestrial surface (NAVEH and LIEBERMAN, 1994).

Landscape ecology studies the inter-relationships among the diverse factors that contributes to formation of the relatively homogeneous units composing the landscape (Rocha, 1995), which enables the agreement between natural and cultural processes in ecosystems with perspective of environmental analysis and planning (MARENZI, 2000).

Being more specific, if we consider that landscape ecology deals with the combination, structure, function and changes on different environments (FORMAN *et al*., 1986), it can contribute to understand the biotic diversity existing on different habitat fragments.

The general objective of the present work was to develop and apply a landscape ecology study method to a coastal promontory, seeking to understand the processes involving its formation and maintenance, considering the possibility of energetic and genetic flow of the species within and the principal components involved.

A coastal promontory is a portion of the coast marked by elevated topography and constituted by crystalline basement whose scarps reach the sea (VILLWOCK, 1987).

These areas still maintains certain naturalness due to its geomorphology and the soil condition, which turns unfeasible agriculture activities and local access.

The construction of roads through the area is only motivated when the scarps are provided with extensive ornamented bays among the rocky coast, whose attractiveness promotes increasing tourism interest.

However, the same situation that privileges the maintenance of natural characteristics on promontories, contributes to the fragmentation of ecosystems therein.

This situation promotes an environmental condition similar to that existent in islands, once it is surrounded by the ocean and coastal plains. This condition requires from species of fauna and flora requires adaptation to a more restricted and anthropoic pressure habitat.

METHODS

The approach intended on this work focused on "Morraria da Praia Vermelha", situated in the municipal district of Penha, Santa Catarina state, Brazil (Figure 1). This area presents a coastal promontory relatively well conservated, but naturally fragmented due to its geomorphology and intensified by anthropic pressure on surrounded areas.

Having on focus the conservation of the biodiversity and the impossibility of analyzing every existent species, several arboreal species were designated as "model-species": *Ocotea catharinenesis* (canela-preta), *Copaifera trapezifolia* (pau-óleo), *Virola bicuhyba* (bocuva), *Cabralea canjerana* (canharana) e *Euterpe edulis* (palmito). These species were chosen mainly by the correlation of its presence to the ecological integrity related to theclimax of Atlantic Rainforest.

The methodology encompassed several field visitations aiming a more detailed knowledge of the study area. Thematic mapping and studies were undertaken to subsidize individual analysis that together permitted understanding the landscape ecology on the study area.

Based on ROCHA (1995), the work involved an inventory and a diagnostic phase, considering local aspects of "Morraria" through the study of the fragment and its surroundings, the last one taking into account anthropic interference.

The inventory considered the Physiographic System (Climate, Geology, Geomorphology, Soil and Hydrology), Anthropic System (Occupation History, Social Environment, Environmental Perception and Legal Protection) and the Biotic System (Vegetation and Fauna).

The diagnostic related the Biotic Interactions, especially those existing among arboreal species (model-species) and

Figure 1. Situation of Morraria da Praia Vermelha as habitat fragmentation.

birds (key-species). It also adopted a Landscape Spatial Structure model adapted to local biodiversity conservation, whose structural arrangements together with information on biotic interactions subsidized the comprehension of the Landscape Functional Pattern in relation to the maintenance of model-species and key-species.

The study of vegetation referred through the caminhamento method (FILGUEIRAS) and to bird fauna through the visual contact method (ZIMMERMANN, 2001).

For the analysis of the landscape spatial structure and the landscape functional pattern it was employed the program *Fragstats Spatial Pattern Analysis*, developed by MCGARIGAL and MARKS in 1994 (ELKIE *et al.*, 1999). This program was designed specifically for landscape fragmentation analysis through the extension *Patch Analyst.*

RESULTS

The birds selected as potential dispersors (key-species) were: *Ortalis squamata* (aracuã), *Ramphastos dicolorus* (tucano-de-bico-verde), *Melanerpes flavifrons* (pica-pau-benedito), *Myiodynastes maculatus* (bem-te-vi-carijó), *Pitangus sulphuratus* (bem-te-vi), *Turdus albicolis* (sabiá-coleira), *Turdus rufiventris* (sabiá-laranjeira), *Platycichla flavipes* (sabiá-una) and *Thraupis sayaca* (sanhaço-cinzento**)**.

The anthropic pressure existent interfere on the maintenance of the biotic diversity, being verified that hunting is still a significant problem.

It was observed that an intense extraction of *Euterpe edulis* (palmito) resulted in only regenerative individuals, and that this species maintains itself on the environment through its dispersal syndrome efficiency.

From the other model-species, *Cabralea canjerana (*canharana), followed by *Virola bicuhyba* (bocuva) are the most expressive within the área, possibly by the fact they are also species from the secondary advanced successional stage.

This can indicate that its presence is recent on the area. *Ocotea catharinensis* (canela-preta) and *Copaifera trapezifolia* (pau-óleo) are nowadays very rare within the area due to selective removal of species, reduction of dispersal birds, difficulties resulting from adverse soil environmental conditions (nutrient debility) and topographic slope (low soil humidity).

All these characteristics area conciliated with the distance observed among forest patches with the same regeneration potentiality. Considering the landscape spatial structure elements: matrix, patches and corridors (FORMAN *et al*., 1981; FORMAN *et al*., 1986; FORMAN, 1995), through the promontory geomorphology situation on the study area, it was defined as the matrix the Atlantic ocean on the oriental phase and urban occupation on the oriental phase.

These are the dominant elements controlling the landscape's functioning and dynamic FORMAN *et al*., 1986; FORMAN, 1995; ROCHA, 1995; MAZZER, 2001).

The Atlantic Ocean, as a natural element, interferes on the vegetation ecology through the marine influence on the vegetation formations, which are the sand coast plain vegetation and mangrove, defined for VELOSO *et al*. (1991) as Marine Influenced Pioneer Formation and Pluvial-Marine Influenced Pioneer Formation, respectively.

The marine influence occurs through the direct tide action (salinity and spatial instability) mainly on frontal dunes (herbaceous vegetation of sand coast plain) and mangrove.

Secondary, the whole sand coast plain (bushy and arborous vegetation) is influenced by the climate (wind intensity and temperature) and soil condition (sandy and low humidity soil).

This influence acts also on the fisionomy of the Atlantic Rainforest (Klein), mainly on oriental vertente. This is visually perceptible as vegetation presented trunks and branches twisted through wind activity.

It is possible to suppose this same interference brings consequence to fauna, mostly in days of intensified winds, when short sized individuals are obligated to shelter on the inner forest.

Further, the oceanic matrix acting as a island should not contribute with dispersion of seeds, therefore limiting the biotic diversity into this context of connectivity.

The other matrix, referred to urban areas, can propitiate larger possibilities of dispersal when comparing to oceanic matrix. This is possible principally considering bird and insect, as they can cross through longer distances even deprived of corridors connecting the Morraria to other segments.

However, other dispersal agents such as large sized mammals are prejudiced by the necessity to move across the actions of humans inhabiting the matrix.

The two factors: distance among fragmented habitats and hunting risk acts as filters or barriers to dispersal (FORMAN, 1995). Thus, dispersal process in area, which contributes to biodiverity, depends basically on the action of bird and insect fauna and intra-fragment dispersal.

The habitat fragment area reaches a total of 762.46 ha and is compounded by 289 polygons, each one delimiting an area equivalent to one typology. These polygons represent 18 typology classes, which were grouped in 174 polygons (landscape patches), meaning 10 classes of patches related to bird habitat, once the focus was on the dispersal of model-species: 1)Forest; 2)Advanced and Median Sucessional Stage; 3)Sand Coast, 4)Arborous Plantation (Bosque), Arboreal Field and Pinus Plantation; 5)Mangrove; 6) Innitial Stage Sucessional, Field and Pasture; 7)Riparian Area; 8)Urban Area; 9)Exposed Soil, Rocky Shore and Sand and 10) Water.

The corridors considered on the landscape referred to the plan of road system and drainage. The road system is formed only by line-corridors, being determined to the area the following categories: road with pavement, which delimits the area; road with bare soil, which penetrates on Morraria; particular road, being considered only the two longest representatives as they

Table 1. *Landscape spatial structure of Morraria da Praia Vermelha.*

Characteristic		Index	
Area (ha)	762,46	Shape	1,89
Patches (n^o)	174	Diversity	4,22
Patch Classes (n^o)	10	Equability	0,82
Perimeter (m)	184253,5	Continuity	3,72
Border Density (m/ha)	241,65		

passed through natural environments; trail, corresponding to six open paths distributed through particular areas, four of them situated in forest environment, of which two giving access to the sea; rocky coastal line accompanying the seafront, interrupted sometimes by the presence of bays.

The drainage system is represented by 45 watercourses, distributed through several vertents. Some of these courses are intermittent, most of them still having its forest, mainly those existing in areas constituted by forest and vegetation on advanced stage.

Table 1 gathers some data that can contribue to a better understanding of the functional pattern of species considered as model and key to conservation of the area. It is presupposed further that these species behavior as a metapopulation in the present environment.

Although a consensus do not exist about the minimum area sufficient to biodiversity conservation, but the necessity of an Minimum Viable Area (MVA) for a Minimum Viable Population (MVP), the establishment of efficiency on the size of an area have to be designated according to the population we want to maintain sustainable. Further, considering that areas larger then 300 ha have high value to conservation, as proposed by CARMO (2000), the area of Morraria assists to this pattern. However it must be taken into account the relationship among the area and vegetation typology, because its composition is limiting on the maintenance or recovery of biotic species.

Ocotea catharinensis (canela-preta) and *Copaifera trapeziflia* (pau-óleo) are found very rarely within the area and *Virola bichuyba* (bocuva) only rarely. This situation makes possible to consider that these species are assuming, as metapopulations, a low-density pattern so that few individuals are sparsely distributed (FERRATTI, 2002), requiring a significant MVA to maintain the population. Although the present data do not make possible to foresee the exact MVA, it is supposed that as larger the area is, better represented these species would be, according to Island Biogeography Theory (FERNANDEZ, 2000).

The same occurs to bird fauna, and specifically to the tucano (resident species), key-species on this study, SICK (1985) stands out the difficulties of conserving it on small reserves due to its unquiet nature, social costumes and migration.

The meaning of the value of border density it's justified when comparing it with other areas sharing the same space. Considering the landscape as a whole, on which border density refers to the relationship of the perimeter to its area, it is possible to compare it with a circular area, which the perimeter is smaller for the same total area. In this case, Morraria da Praia Vermelha gives a border density of 12,83, considering a total area of 762.46 ha and 9784 m of perimeter. Therefore, comparing the resultant value of 241.65 for the studied landscape, a high value is revealed, indicating a significant border effect for the whole area.

However, the shape index is lower then 2, indicating that the shape of the fragment tends to an aggregated surface, offering an elevated efficiency on biodiversity conservation considering a lower interaction to the matrix.

According to KAREIVA (1985), considering two fragments of equal surface, that with the larger perimeter and less compacted shape will have the larger proportion of individuals capable of reaching the border, becoming susceptible of leaving the fragment. CARMO (2000) agrees and complements that convolute or irregular shapes are more effective on increasing the interactions with the exterior environment, its perimeters propitiating exchange with the matrix.

The exchange with the matrix, in Morraria's case, it is not desired as they are negative. This happens because of the adverse marine interference and by anthropic pressure of the inhabited plain. Although the perimeter indicates a significant border effect for the area, the aggregated form preserves the interior of the matrix further.

The model-species, whose pattern of occupation send us to the interior of the forest constituted patches, tends to maintain themselves protected from exterior interference if we do not consider humans entering the area. Species such as *Cabralea canjerana* (canharana), *Virola bicuhyba* (bocuva) and *Euterpe edulis* (palmito), can occupy secondary vegetation areas, and may be further affected by outside disturbs, when present on Advanced and Medium Stages Sucessional.

Considering the possibility of model-species MVP's on Morraria, specifically on forest patches and its borders, it is possible to suppose that the shape of these patches propitiate a efficient dispersal. This would guarantee the maintenance of model-species, and these acting as resource-species can contribute to sustainability of key-species.

The studied landscape heterogeneity refers to the diversity existent, whose index is 4.22. This indicates an elevated richness of kinds of patches if we compare to the value of 2.18 encountered by CARMO (2000) for a tropical landscape on Costa Rica. The index of equability found of 0.82 approximate that found on the same research, equal to 0,92. This index gets closer to the value of 1 when the distribution of kinds of patches are more balanced.

Therefore in the studied area it is possible to consider a tendency to uniformity on the distribution of the patches.

In relation to the diversity encountered for the studied area, it is worth to note that an elevated variety of environments suggests higher biotic diversity. As emphasized by CARMO (*op cit*), the presence of patches in different succesional stages contributes to the maintenance of the diversity of species. This must be considered to large areas, on which the patches are formed through the natural disturbance dynamic of forests, therefore in the sense of an ecosystem evolution. However, considering the biodiversity conservation objective as the maintenance of natural ecosystems, the biotic diversity existent on the interior of the patches should be more significant then the diversity of patches.

Thus, considering that the variety of species tends to increase during the developmental phases of the communities. And this characteristic is dependent on the potential niches and resultant of increased biomass, stratification and other consequences of the biologic organization (DEGRAAF *et al*., 1996; BOTKIN *et al*., 1998; ODUM, 1997), the forest patches on Morraria should present a more expressive biotic diversity and interesting to conservancy.

To GASCON *et al.,* (2001), the diminution on habitat heterogeneity provoke losses of species, as several specialized species can be excluded from the fragments because of its strong association with particular kinds of habitat (FORMAN *et al*., 1986). This is the case of the model-species that, for being climax, demands mature and stable environments, on which human interference do not modify natural conditions.

The continuity index resulted in a value equal to 3.72 for Morraria. If compared to the value of 4.56 encountered for Costa Rica and the analysis of CARMO (2000) about the low values reflecting largest levels of discontinuity or fragmentation, it is possible to consider that Morraria presents low area continuity, therefore it is fragmented. Allied to this fact, the lack of connectivity in the area is expressed through the absence of association with other fragments, depending only on internal connectivity and the activity of insects as pollinators and bird as dispensers.

Mammals, birds and insects, by being mobile, perceive differently the landscapes degrees of heterogeneity. This depends of their vital characteristics and from certain plasticity in function of the landscape organization. On the course of a day they can use different elements from the landscape to satisfy its necessities. Birds in reproductive periods use areas neighboring its nests for feeding (BUREL *et al*., 2002). Thus, the sensibility of individuals of a species to fragmentation depends of its degree of diary activity, within its spatial scale.

However, vegetation species will depend on dispersal processes to its maintenance in the fragments. In the case of model-species, it is possible to suppose that the fragment area may maintain its population due to the following possibilities: recovery of very rare species to rare level *Ocotea catharinensis* (canela-preta) and *Copaifera trapezifolia* (pau-óleo);

interruption on the fragmentation process and removal of these individuals; occurrence of minimum population of key-species. Even considering these possibilities, fragment isolation, allied to its size, can possibly take to a diversity loose of model species and consequently take them to extinction (PRIMACK *et al*., 2002). PIMENTEL *et al*. (2002) said that extinction represents a fail on adaptation to environment variations, either because these changes occurs too fast or because the population its incapable to reply in terms of evolution.

Thus, an efficient dispersal can minimize this tendency (ARGEL-DE-OLIVEIRA, 1998), and for that it is necessary some connectivity among key-species. They can contribute to genetic flow (TERRADAS, 2001) because birds can travel long distances when flying (SICK, 1985; ALMEIDA, 2002). Migrant species have a larger potential to contribute, and this is the case of *Platycichla flavipes* (sabiá-una) and *Myiodynastes maculatus* (bem-te-vi-carijó).

Further, considering the flying capacity is related to wing size (MOERMOND *et al*., 1985), it is possible to presume that *Ramphastos dicolorus* (tucano-de-bico-verde) have a good performance on connectivity among fragments. However, the species *Ortalis squamata* (aracuâ), also considered a large bird, do no fly long distances, once it is habituated to jump from one tree to another (SICK, 1995). Even them it can be efficient on dispersal, as daily activity were registered for this species and it was found that it can move within a ray of 1km (LIESENBERG *et al*., 2002).

Beyond bird's contribution, and more specifically that from key-species to the maintenance of biodiversity, model-species can count on secondary dispersal agents. These are accomplished by other animals by insect pollination (*Euterpe edulis)* or through zoofilic pollination (three other species) (IZA, 2002). Therefore, at all circumstances, biodiversity conservancy is conditioned to connectivity.

This way, corridors must act as connectors among fragments and intrafragments, either to make possible bird activity with lower flight capability, or to other forms of dispersion and pollination.

The actual situation (landscape? configuration?) of Morraria da Praia Vermelha does not maintain connectivity with none other fragment in relation to the existence of connecting-corridors.

Internally, corridors can be acting in several manners, and for model-species it is possible to consider the corridors direct action: trails; coast line; forest; water courses and gravel road. This last one shows the larger negative impact on the border effect, once it has the forest environment through all its margins. Further, the filter and sumidouro function of this corridor acts in the sense of reducing mammal's performance on dispersal.

The distance among fragments and the lack of connectivity among them also contributes to the reduction of local biodiversity. This occurs to such a point that the dispersal process at Morraria depends basically from bird and insect action and from intra-fragment dispersal.

By the time one population decreases, the distance among the species increases, and the pollinators or dispersers shall not visit more them one of these sparse and isolated plants, resulting in a diminution on seed production and consequently natural regeneration.

Lack of connectivity also provokes a situation on which the landscape patches turns subjects to a restricted area, not always of efficient dimensions to conservancy. Ecological corridors, beyond its capability of promoting genetic flow, can minimize the impacts resultant from disturbances and establish a "green belt" to limit urban expansion. It would also signify an important contemplative attraction, increasing the scenic vocation of Morraria.

The spatial structure and functional pattern of the landscape denote as more relevant to biodiversity conservation the existence of two patch classes constituted by forest and advanced and medium succession stages. These classes forms nine individual patches, which are more expressive by its sizes and typologies. Larger areas can maintain a higher genetic flow and more mature formations are more efficient in the sense of maintaining model-species (climax) and a higher biotic diversity coming from the possibility of the existence of potential ecological niches (higher biomass and vegetation strata).

However, the maintenance of model-species is conditioned to the presence of the forest patches.

It is significant within the area the impact coming from the gravel road crossing the Morraria, which acts as a corridor with negative filter and sumidouro function. The corridors represented by the watercourses and forests river are the best contributors to biodiversity conservation as they act as habitat and conductors.

The natural situation of the area as a coastal fragment is intensified by the presence of the two matrices that interferes on the local naturalness. The marine matrix influences more on relation to natural disturbances, while the urbanized plain influences on predatory activities such as hunting, removal of ornamental plants and palm trees. These influences provokes vulnerability conditions to the area that are allied to its geomorphologic and soil conditions.

If the adoption of environmental policies does not come soon to consider the restoration, fiscalization and environment education to stop hunting and further fragmentation, the expected trend is a loss of the biodiversity still existing on the studied environment.

CONCLUSIONS

The natural situation of the coastal promontory, intensified by anthropogenic interference, contributes to the susceptibility of the reduction of arboreal species frequently found on climax stages, mainly *Ocotea catharinensis* (canela-preta) and *Copaifera trapezifolia* (pau-óleo). This can compromise the ecological integrity of the area.

The island behavior showed by Morraria da Praia Vermelha can be common to other coastal promontories in the region, once its geomorphology and landscape matrices are alike. However, only the inventory of particular information to each environment can give a diagnostic on the existent biodiversity situation.

It is unquestionable that the past selective removal of trees contributed to the reduction of arboreal trees, but if these removals ceased long time ago and key-species were observed in the environment, then other factors are also influencing this reduction. Probably one of the factors is the diminution of dispersal species, considering that hunting is still a habit of the community, since no data on bird density do exist. Another reason can be the germination difficulty due to adverse soil condition, related to low humidity, mainly on steeper hillsides.

LITERATURE CITED

ALMEIDA, H. L., 2002. Ocorrência de aves terrestres em uma plataforma a 108 Km de distância da costa do Rio de Janeiro. *XXIV Congresso Brasileiro de Zoologia* (Itajaí. Santa Catarina), pp. 486.

ARGEL-DE-OLIVEIRA, M. M., 1988. Aves que plantam: Frugivoria e dispersão de sementes por aves. *Bolm CEO*, (13), 9-23.

BOTKIN, D.B. and KELLER, E.A., 1998. *Environmental science: earth as a living planet*. New York: J. Wiley Sons. 2a ed., 649p.

BUREL, F. and BAUDRY, J., 2002. *Ecologia del paisaje. Conceptos, métodos y aplicaciones*. Madrid: Mundi-Prensa, 353 p.

CARMO, A.P.C., 2000., Evaliación de um paisaje fragmentada para la conservación y recuperación de biodiversidad. Costa Rica: Centro Agronômico Tropical de Investigación y Enseñanza, Tese Magister Scientiae. 133p

DEGRAAF, R.M. and MILLER, R.I., 1995. *Conservation of Faunal Diversity in Forest Landscapes*. London: Chapman Hall, 633 p.

ELKIE, P.C.; REMPEL, R.S. and CARR, A.P., 1999. *Patch analyst user's manual: A tool for quantifying landscape structure*. Ontario: Ontario Ministry of Natural Resources, 22 p.

FERNANDEZ, F., 2000., *O poema imperfeito: Crônicas de Biologia, Conservação da Natureza e seus Heróis*. Curitiba: UFPr, 260 p.

FERRETTI, A.R., 2002., Fundamentos ecológicos para o planejamento da restauração florestal. *In*: GALVÃO, A.P.M. and MEDEIROS, A.C.S. (eds), *A restauração da Mata Atlântica em áreas de sua primitiva ocorrência natural*. Colombo: EMBRAPA, pp. 21-27

FORMAN, R.T.T. and GODRON, M., 1986. *Landscape ecology.* New York: John Wiley and Sons, 619 p.

FORMAN, R.T.T. and GODRON, M., 1981. Patches and structural components for a landscape ecology. *Bioscience*, EUA, 31 (10), 733-740.

FORMAN, R.T.T., 1995. *Land mosaics: The ecology of landscapes and region.* New York: Cambridge Press, 632 p.

GASCON, C.; LAURENCE, W.F. and LOVEJOY, T. E., 2001. Fragmentação florestal e biodiversidade na Amazônia Central. *In*: GARAY, I; DIAS, B. (Eds), *Conservação da Biodiversidade em Ecossistemas Tropicais*. Petrópolis: Editora Vozes, p. 112-127.

IZA, O. B., 2001. Parâmetros de autoecologia de uma comunidade arbórea de Floresta Ombrófila Densa, no Parque Botânico do Morro Baú, Ilhota, SC. 2002. Florianópolis: Universidade Federal de Santa Catarina. Master's thesis, 76 p.

KLEIN, R. M., 1980. Ecologia da Flora e Vegetação do Vale do Itajaí. *Sellowia*, (32), 387 p.

LIESENBERG, V.; MAAS, C. H.; STACHON, E. and MULLER, J. A., 2002. Aspectos etológicos de Ortalis squamata (Lesson) em um fragmento florestal. *XXIV* ....
Congresso Brasileiro de Zoologia, (Itajai, Santa Catarina), pp. 461.

MARENZI, R. C., 2000. A análise da qualidade visual da paisagem como instrumento da ecologia da paisagem. *Fórum de Debates ecologia da paisagem e planejamento ambiental (*Rio Claro, São Paulo).

MOERMOND, T. C. and DENSLOW, J. S., 1985. Neotropical avian frugivores: patterns of behavior, morphology, and nutrition with consequences for or fruit selection. *Ornithological Monographs*, (36), pp. 865-897.

NAVEH, Z. and LIEBERMAN, A., 1994. *Landscape ecology: Theory and Application*. 2ª ed. New York: Springer-Verlag, 360 p.

ODUM, E., 1997. *Fundamentos de Ecologia*. 3a ed. Lisboa: Fundação Calouste Gulbenkian, 927 p

PIMENTEL, M. R. C.; ROCHA, L. E. C. and SILVA, R. M., 2001. Perda de espécies de aves em fragmentos florestais urbanos. *XXIV Congresso Brasileiro de Zoologia* (Itajaí, Santa Catarina), pp. 424.

PRIMACK, R. B. and ROS, J., 2002. *Introducción a la biologia de la conservación*. Barcelona: Ariel, 375 p.

ROCHA, C. H., 1995. Ecologia da Paisagem e Manejo Sustentável em Bacias Hidrográficas: Estudo do Rio São Jorge nos Campos Gerais do Paraná. Curitiba: Universidade Federal do Paraná, Master's thesis, 176 p.

SICK, H., 1985. *Ornitologia brasileira, uma introdução*. Brasília: Editora de Brasília, v. 1, 474 p.

TERRADAS, J., 2001. *Ecologia de la vegetacion*. Barcelona: Omega, 703 p.

VELOSO, H.P.; RANGEL FILHO, A.L.R. and LIMA, A.J.C. *Classificação da vegetação brasileira adaptada a um sistema universal*. Rio de Janeiro: IBGE, 192 p.

VILLWOCK, J. A., 1987. Processos costeiros e a formação das praias arenosas e campos de dunas ao longo da costa sul e sudeste brasileira. *Simpósio sobre Ecossistemas da Costa Sul e Sudeste Brasileira* (Cananéia, São Paulo), pp. 380-398.

ZIMMERMANN, C. E., 2001. Avifauna da área de influência do Corredor Ecológico do Atlântico Sul (Bioregião de Zimbros, Santa Catarina). *IX Congresso Brasileiro de Ornitologia* (Curitiba, Paraná), pp. 399-320.