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Environmental Analysis and Zoning of Campeche Island (Florianópolis, Brazil): a Landscape Ecology Approach to Insular Management

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ABSTRACT

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Campeche Island is situated about 1,5 kilometres far from Santa Catarina Island (Florianópolis-SC), with a total area of 531.200 m2 and about 4,480 meters of shoreline.Due to encompasses a wide range of natural and archaeological resources, the island was considered as National Heritage by IPHAN since 2000. This study is an application of landscape ecology approach with emphasis in spatial configuration and landscape elements arrangement to improve with relevant information the island management and its environmental conservation. The methodology was shared in four steps of data processing: Inventory, Manipulation; Analysis and Synthesis. At the final, the data integration provides a environmental zoning based on landscape units potentialities and vulnerabilities. In the landscape structural analysis the spatial arrangement demonstrates a strong influence of two functional vectors: wind and water flow. The determination of landscape units was followed by the weighting each attribute showed that the place more vulnerable to these functional vectors and other natural hazards was the eastern steep rocky coast, southern scarps, and the northwest hillslope. The human use and the landscape analysis suggests five classes to the environmental zoning. This compartments requests distinct actions and decisions at the management level to keep an healthy functioning and structuring of the Campeche Island's landscape. The use of Landscape ecology approach was very useful to perform a spatial analysis using ecological criteria, and its application to an island helped to establish the most relevant factors in an environmental analysis to planning and management purposes.

ADDITIONAL INDEX WORDS: *Landscape ecology analysis, insular management, environmental zonning, Ilha do Campeche (Florianópolis-Brazil).*

INTRODUCTION

The Landscape Ecology is a emergent science that unify ecological concepts and landscape classification to apply to environmental planning and management (ZONNEVELD, 1995, FORMAN, 1995). In the Coastal Zone is not usual to see the utilization of the landscape ecology approach by coastal researchers. However, RAY (1991) point out that the principles of this science can help to improve our understanding of the complexity of coastal areas. The author emphasizes the hierarchical nested structure and the detection of landscape patterns as an useful approach to coastal zone biodiversity studies.

The southern brazilian coastal islands are disjuncted areas that become isolated since the start of the holocene period (11.000 years before present). Most of the islands are covered by Atlantic Rain Forest (with some insular adaptations), coastal and marine birds, small mammals including a endemic specie found at the Moleques do Sul Islands (CAVEA MOLEQUENSIS, OLYMPIO, 1995). Some examples of pristine art on the rocks of the cliffs are present as a archaeological heritage as a well (ROHR, 1961).

The landscape structure and dynamic of these areas differs of their continental neighborhoods and some process and patterns can be studied to compare them each other. The island can provide a natural coastal microcosm experiment either to environmental management issues.

The Campeche Island is characterized by natural beauty and archaeological settings, containing a wide range of resources (natural, scenic, social, economic and historical). By this reason some activities like tourism, exploitation of coastal living resources, and others, promote a fast increase of visitors rate and generate environmental impacts and degradation.

This study consists to apply the landscape ecology approach to allow the suitability of areas at the Campeche Island (Florianópolis, SC) through environmental analysis and zoning.

STUDY AREA

The Campeche Island is situated about 1,5 kilometers far from Santa Catarina Island (Florianópolis, SC), and there is 531, 200 km^2 of total area and 8,36 km of shoreline. Its constitution is given by granitic rocks cutted by diabase dykes who cross the islands and controls the shoreline erosion and the interior drainage.

The relief of the island there is a small coastal plain that contains sand beach, marine and aeolian terraces and high lands with some types of slope forms and fluvial depressions. The predominant vegetation is Atlantic rain forest followed by Restinga (brazilian maritime vegetation composed by shrubs and small trees), pioneers cliffs formation and introduced/exotic species by the human presence.

Human history in the island is ancient and after the unknown indian presence, the island was used for support the right whale hunting (17th century). Just in the last century the activities changed for recreational and tourism purposes, but some exploitation activities persists in a small scale like fishing and aquaculture.

METHODS

Data Inventory

Many different types of data composed the initial data set, and it can be separated in three types: Maps; Aerial photographs and data fields.

The map sources used was Topographic (1:10.000 scale) (IPUF, 1990) and Geomorphologic (1:50.000) (IPUF, 1991). This was scanned and digitized "on screen ", and storage as vector file.

Two sets of aerial photographs of the distinct years (1978 and 1995) provided data of geomorphology, geology, vegetation, corridors and hidrography through photo interpretation techniques.

The field data involved sedimentological samples and GPS points for digital cartography purposes. There was about 15

Table 1. *Structure of thematic maps and their respective files format (MAZZER, 2001).*

Thematic Map	*File Format*
Topographic	Grid and Shape
Vegetation	Grid and Shape
Geological	Shape
Geomorphological	Grid and Shape
Corridors	Shape

Fields survey between October 1999 and March 2001.

The literature surveying was a source of data as well, mainly the environmental laws and the Campeche Islands past works.

Data Manipulation

The data from Maps and Aerial photographs was working in the Geographical Information System, Arc View 3.2 software. After scan, digitilize and edit data from both sources, It was georeferenciated with the points from GPS, and the datum conversion according with the Topographic Map (1:10.000) (IPUF, 1990) The data was separated in the thematic maps in the vector and grid (raster) files as described bellow:

The topographic Map generates the Digital Elevation Model (DEM) that produced derivative maps: slope (five classes), aspect and the 3D DEM to improve some terrain analysis and landscape classification.

Another maps were used to perform spatial analysis like overlay, query areas, crossing tables and buffers that is written together the next topic.

Data Analysis

The analysis contents several types of GIS procedures and some application of the Landscape Ecology Principles (FORMAN, 1995) to apply to environmental zoning.

The first part was generate two main analysis maps by overlay:

- **Landscape Structure Map**- resulted of Vegetation + Hidrography +Aspect- this was important to investigate the natural landscape pattern, spatial configuration and convergence points. Through the Landscape Structure Map could be done some patches measurements: patches shape, edges roughness. (based on FORMAN and GODRON, 1986 and FORMAN, 1995).
- **Landscape Units Map**- Resulted from Vegetation Map + Geomorphologic Map. This map expresses the landscape units as ecotopes (HABER, 1990) that support the next analysis: Potential Stability, Anthropic Stability, Vulnerability, (RODRIGUEZ, 1993). This analysis was made with the data modeling from field survey, bibliography (ROSS, 1990, INMET, 2001 and others) and available maps described above. The scheme of the analysis is given below:

Potential Stability:Natural Disturbances * (Slopes +Vegetation +Geomorphology)
Anthropic Stability: Humans Activities* Environmental Impacts
Vulnerability: Anthropic Stability + Potential Stability

Data Synthesis and Environmental Zoning

The data synthesis unite the landscape structure relevant information as a well as terrain analyses like vulnerability and stability determined to each ecotope. Further these information we input the environmental legislation Map (Federal Law n° 4771/65) as additional criteria to define management zones.

The six management zones was determined according to Brazilian National Parks ,and Environmental Protected Areas that was formulated by IBAMA (Brazilian Environmental Protection Agency).

RESULTS AND DISCUSSIONS

Landscape Structure

The results shown in a Landscape Structure Map, presents a large, well connected patch, in the island interior composed by Atlantic Rain Forest that was identified as a landscape matrix. This one shows alongated shape with boundaries among all others patches, which characterize it as a core patch. It have a role of keep the genetic pool and the vital ecossistem function,among other (BATISSE, 1990). The surrounding patch is the second largest patch, but it differs substantially about the shape, and by this way its function in the landscape are very different according to FORMAN (1995).

The other patches there was distinct vegetation like Restinga that representing a further resource to local biota, and the capoeira" that represents naturally disturbed patches for the initial stages of the Atlantic Rain Forest, where each one is associated with past mass movements.

The anthropic patch is composed by several types of exotic/introduced species like coconut three (*Cocus nocifera*), amendoeira (*Terminalia catappa*), jambolão (*Syzigium cumini*), cajuzeiro (*Anacardium occidentale*), mango three (*Mangifera indica*), papaya three (*Caryca papaya*). and so on. Its edges are increasing into a matrix interior characterizing a reduction matrix processes according to FORMAN (1995). The spatial configuration of this patches shows the large matrix (representing 52 %) of island total area, with the natural resource patch type that act as a source of resources and habitat to this biome biota type. Beyond this, this area do a important role in the biotic material flux between coastal highlands and coastal island, like the predicted in the Insular Biogeography Theory (MAC ARTHUR and WILSON, 1967).

The surrounding patch's shape is narrow in general terms but the two convolutions localized at east side (lee side wind) permits some variation in species and promote landscape heterogeneity. This patch is characterized by different edge and boundaries conditions around the island shore. There is a distinct width of this edge in dependence of the different natural factors influence like waves exposure, maritime winds, and so on. At the shelter side the edge appears with slow gradient of species like a strip, while at the exposure side and shore the edge shows more compressed with short gradient.

These set of natural factors determine an peculiar spatial configuration and generating a insular landscape pattern along the main axis of the island, see figure 1.

Landscape Units

A total of 22 landscape units was found at the Campeche Island, as a result of vegetation coverage and geomorphologic compartments, that was used to stability and vulnerability landscape analysis.

Landscape Stability and Vulnerability

The landscape units response in front of natural and human disturbances are given at several ways. At evaluation of this,

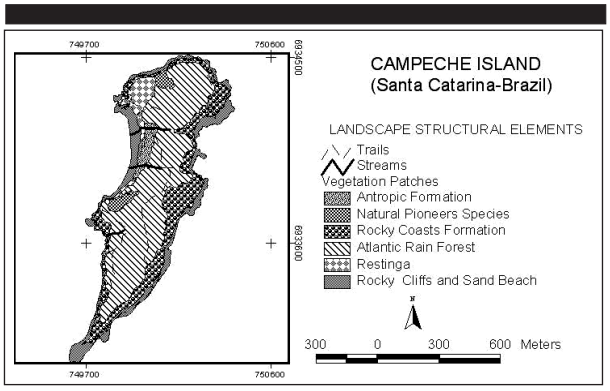

Figure 1. Landscape Structural Elements of Campeche Island (Santa Catarina, Brazil).

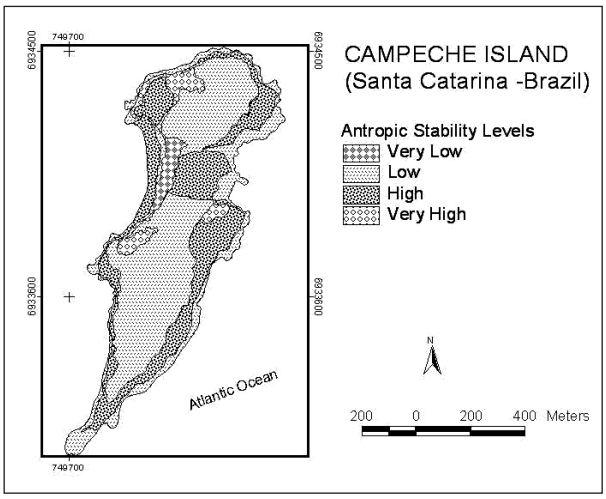

Figure 2. Potential Stability of Campeche Island (Santa Catarina, Brazil).

the two types of stability (potential and anthropic) generate a different maps indicating areas more or less stable in relation to kind of the set of disturbances.

In the figure 2, the less natural stable areas is the shore line, the rocky coasts, high slope areas and the marginal zone of the streams. And the opposite (high natural stability) are associated with the areas covered by Atlantic rain forest (dense vegetation), moderate to flat slope and sheltered shores.

The anthropic stability is directly linked to human uses and impacts and are showed at the figure 3. The less stable areas overlap some natural stable areas that permit the development of human activities without natural disturbances interference as well as the easy access areas. So, some areas with a high range and abundance of natural resource like the Atlantic rain Forest Areas, the streams adjacencies are very unstable in the anthropic perspective. The same occur to the small coastal plain that is aggravated by the soft and permeable substrates with the sewage disposal, surface erosion and buildings structure located there. In addition, a low stability area overlap edges of Atlantic Rain Forest and another types of vegetation, configurating an ecotone of high importance to the island being degradating.

The landscape vulnerability are achieved with the sum of both stability indexes. The figure 4, shows the most vulnerableareas as the coastline, stream adjacencies, part of coastal plain, followed by areas with medium to low vegetation and high slopes and a medium vulnerability, the large area of Atlantic Rain Forest. The low vulnerability areas is composed by core areas with difficulties to access covered by Restinga, Atlantic Rain Forest and some ecotones zones.

This classification is based on the frequency and intensity of the disturbances and its boundaries represents a average of the processes, so it's indicate to a long term planning and management.

Environmental Zoning

The zoning based on the landscape analysis was furthered with environmental legislation issues. The landscape structure data that was relevant to help to delineate some managing zones was the special characteristic like : convergence points (FORMAN, 1995), streams, wetlands, and unusual features like Restinga patch, beyond the vulnerable places that was included in the landscape analysis. Some important nodes of human corridors, as well some edges of landscape units, was considered a zone of restricted use and recuperation respectively. The major remnant, the landscape matrix was destined to a core zone (BATISSE, 1990) and its responsible to keep genetic pools, habitats, plant resources, streams, and protection for the soil erosion

Some zone like the adjacency patch had part of the patch destined to visitation, and some coastal rocks was liberated to sport fishing, but some areas like wave cut platform, and some high slope plunging coast that was restricted human use. The zone overlapping by a legislation map was considered very restricted, and part of coastal plain include beach as well as the important human corridor was destined to controlled use. (Figure 5).

CONCLUSIONS

This analysis comprises physical and ecological aspects of the Campeche Island Landscape, and the zoning shows the final results of this perspective. The whole zoning must contemplate social and economics aspects to get closer to sustainability. However, the purposed zoning can help to initiate the process of insular management indicating the technical priorities for conservation area, to ensure the natural and archaeological heritage contained in the Campeche Island (Florianópolis,SC).

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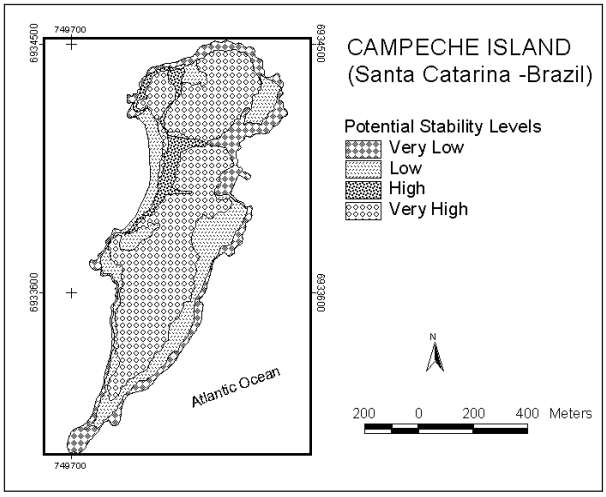

Figure 3. Antropic Stability of Campeche Island (Santa Catarina, Brazil).

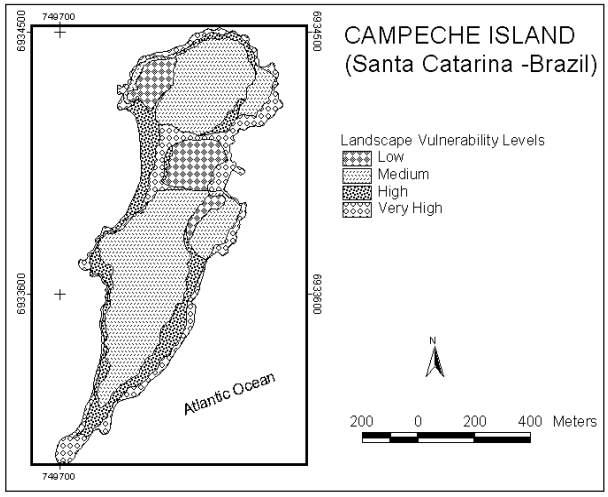

Figure 4. Landscape Vulnerability of Campeche Island (Santa Catarina, Brazil).

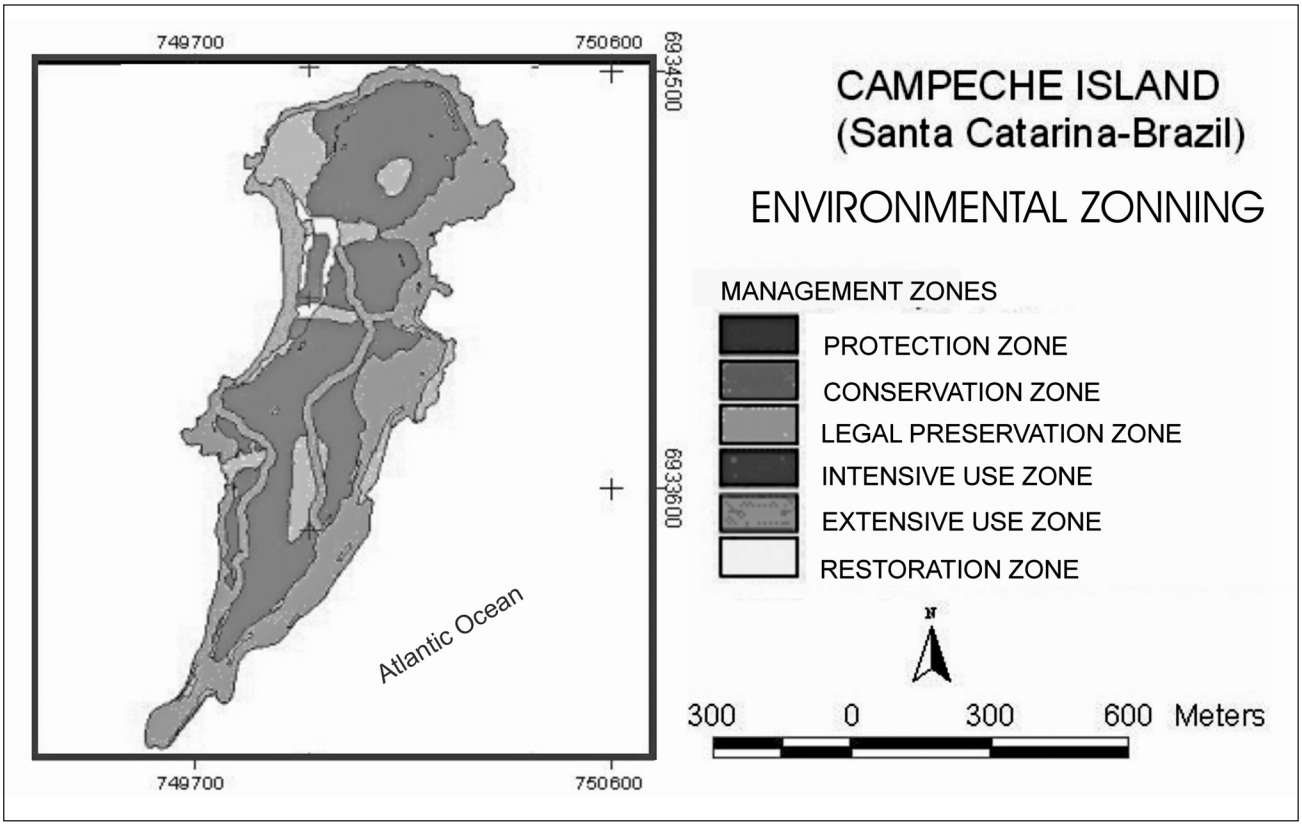

Figure 5. Environmental Zoning of Campeche Island (Santa Catarina, Brazil).

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