

Bridging Natural and Social Sciences: A Framework for Identify Strategies and Actions for the Conservation of Biodiversity

Bergallo HG^{1*}, Uzêda MC², Fidalgo ECC³, Sluys MV¹, Alves MAS¹, Costa TCC⁴, Santos MA⁵, Costa MB⁵, Cozzolino ACR⁵ and Rocha CFD¹

¹Department of Ecology, State University of Rio de Janeiro, Brazil

²Embrapa Agrobiologia, Rio de Janeiro, Brazil

³Embrapa Solos, Rua Jardim Botânico, Rio de Janeiro, RJ, Brazil

⁴Embrapa Milho e Sorgo, Rodovia MG, Sete Lagoas, MG, Brazil

⁵CEPERJ – Statistics State Center Research and Training Public Servants in Rio de Janeiro, Av. Carlos Peixoto, Rio de Janeiro, RJ, Brazil

*Corresponding author: Bergallo HG, Department of Ecology, State University of Rio de Janeiro, Rua São Francisco Xavier, Rio de Janeiro, Brazil, Tel: +55 21 2334-0639; E-mail: nenabergallo@gmail.com

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Abstract

The Atlantic Forest is one of the most diverse areas in the world and considered a hotspot. Several actions are needed for its preservation, among them the implementation of the Biodiversity Corridors. The Atlantic Forest has three biodiversity corridors and the Rio de Janeiro State, which harbors huge species diversity, is in the Serra do Mar Corridor. We developed socioeconomic, political and environmental indicators to present conservation strategies supported by a wide database. These indicators complemented the previous surveys of priority areas which emphasized biotic elements, and their integration allowed the elaboration of strategies for the conservation and management, regionally directed, to support actions to be implemented by the Government. The analysis was done considering three subjects: Anthropic Pressure, Physical and Biotic State, and Present Ability of Response. Data analysis followed a synthesis-aggregation schedule and the resulting database was taken to a workshop, where specialists proposed strategies and actions for the conservation. These strategies were discussed considering vegetation remnant distribution, biological relevance, environmental vulnerability, kind of anthropic pressure in the region and potential for success of the actions proposed, based on the ability of response. Rio de Janeiro State is very diverse in biotic, physical, political, socioeconomic and cultural aspects which demand specific actions for each region. So, depending on the present situation of the natural and anthropic environments and on the present and future sources of degradation, regionally directed actions are applicable. This specificity in conservation actions will enable that the State remnants will be more successfully protected.

Keywords: Knowledge gap; Integrated methodology; Social reality; Pressure-state response model; Conservation targets; Geographical database

Introduction

Linking the conservation to human development is a challenge, especially for some developing countries as Brazil, where conservation usually is not seen to be a service for the society. In such countries, there is a misunderstanding that nature is unleashed of the society and of its productive processes. In this sense, one of the biggest challenges of the modern societies is to develop strategies and technologies to promote the social and economical development, conserving the biodiversity [1]. These authors point that it is essential that the society comprehends that biodiversity provides the basis for the proper survival of human beings. However, this challenge counteracts the disordered human population growth, associated to the economic disequilibrium that produce as ideal model a high standard of consumption, extending the pressure on the natural resources [2].

In Brazil, conservation initiatives date from 1797, and became meaningful in 70's decade of the 20 century, with the creation of many Protected Areas (hereafter UCs - Unidades de Conservação) [3]. However, these initiatives aimed basically the preservation of exuberant landscapes [3] and were defined through an empiric and top

down process of decision. Moreover, the government did not provide the managers with appropriate financial and infrastructural support to the effective implementation of the UCs. It is remarkable that the legal existence of a UC not always reflects the effectiveness of its conservation, and the inadequate surveillance is an example of this lack of effectivity.

In the last 20 years, techniques with scientific endorsement and considerably objectives were developed to identify areas of conservation. The impact of such techniques in the implementation of UCs has been minimal, mainly because managers were unfamiliar with them. Moreover, the low financial resources available, the lack of comprehension on the conservation meanings and the antipathy for the initiatives imposed for the conservation are aggravations for the implementation of UCs [4].

In Brazil, particularly in the Atlantic Forest, these same difficulties reported above have been identified [5]. This has resulted in the government to consider the difficulties of integrally assuming the responsibility for the conservation of biodiversity. These difficulties are evident due to the large territorial country extension and the social-economical and cultural diversity. In this direction, government and society have searched for consolidation of joined initiatives, for example, in the inclusion of private reserves (here after RPPNs) in the legislation of the National System of Protected Areas [6]. The sharing

of responsibilities of conservation among government and society improves the enrollment and compromise of the society in the process of management of the landscape [7].

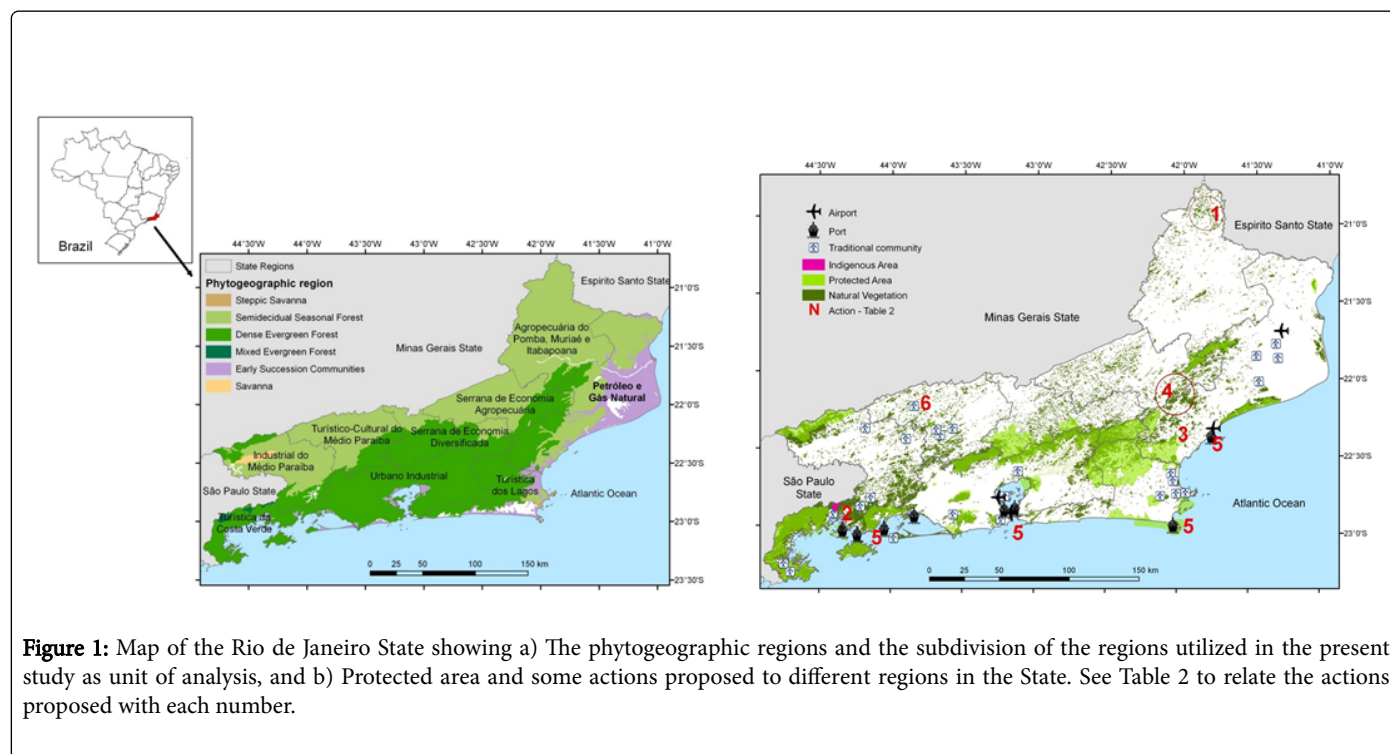
Nevertheless, few are the conservation methodologies that consider as relevant the social-economical and cultural aspects. The most frequently used methodologies include almost exclusively aspects related to biodiversity, and do not involve the society in the decision process [8-10]. Also, these methodologies consider that the information regarding biodiversity is representative for the whole area analyzed. This clearly does not apply to the reality of developing countries, where the production of information and knowledge does not occur evenly. In an analysis of the different approaches used for the conservation, Redford et al. [11] listed 21 different targets coming from 13 conservation organizations, and all are limited to point out environmental aspects, not considering the local social reality.

A recent strategy for the conservation of the Atlantic Forest biodiversity was based in the idea of ecological corridors or biodiversity corridors [12-14]. A biodiversity corridor comprises a unit of regional planning which includes a mosaic of different types of land use, managed in an integrated way. Its function is to connect a net of UCs and other areas with different uses, and thus reverse the critical situation of fragmentation and isolation of forests [15]. The Atlantic

Rainforest has three biodiversity corridors (Serra do Mar, Central da Mata Atlântica and Nordeste) and the Rio de Janeiro State is almost all included in the Serra do Mar Corridor [16].

It is also important to consider that the social, economic and environmental characteristics and the nature of the problems affecting Rio de Janeiro State are not homogeneously distributed, but differ markedly depending on the region. As a result, a regional plan for conservation of the biodiversity in the State must also consider the need of specific strategies and actions of conservation for each particular region. In this way, for an effective conservation in the regional level it is important to integrate information and efforts on biological, physical, economic, social and governance aspects, which compose the tripod, State, Pressure and Response [17,18].

In this study, we developed an integrated methodology for defining strategies and actions for the conservation of the Atlantic Forest biodiversity at Rio de Janeiro State, which combines two approaches: the development of indicators from a model for data aggregation and analysis of spatial patterns of distribution of information. To our knowledge, this is the first time such an approach has been undertaken to delineate strategies for conservation in the Atlantic rainforest hotspot.



Methods

Study area

Rio de Janeiro State, with 92 municipalities, represents 0.5% of the Brazilian territory and harbors about 8.5% of the Brazilian population. Almost all of Rio de Janeiro population (96%) lives in urban areas, being the state with the highest demographic density of the country (328 hab/km²) [19].

The economic and social organization of Rio de Janeiro State is characterized by a high territorial concentration of the population, of

the resources and of the productivity activities delineated along the process of occupation and development of the State. In the last years, Rio de Janeiro State has resumed economic growth with significant changes on its productive structure. A new territorial dynamic associated to this phenomenon occurred with the sprouting of dynamic economic centers to the interior of the State, responsible for new flow of people and services [20].

In the past, Rio de Janeiro State was totally covered by the Atlantic Forest domain [21]. Today, it is the Brazilian State that preserves the highest percentage (21.56%) of Atlantic Forest remnants, in a total area of 946,875 ha [21]. However, great part of continuous vegetation

remnants covers the highlands (especially on hilltops), and comparatively few areas remain in lowlands, edges of rivers and lagoons and in coastal ecosystems [22]. These authors recognized five great blocks of forest remnants in the State, which still have a relatively high degree of connectivity. However, most of the vegetation remnants do not exceed 50 ha in area [23,24] and presently are scattered and isolated [25], with insufficient dimensions to keep viable populations, both genetically and ecologically sustainable [26,27].

Even with such forest fragmentation, the Rio de Janeiro State concentrates one of the most remarkable richness of species and endemism for different animal and vegetal groups [28-32]. Consequently, some areas in Rio de Janeiro State are priority for conservation, and most of them are considered as of Extreme Biological Importance [33].

Przesently, there are 230 public UCs in the State, 19 under federal jurisdiction, 33 under state jurisdiction, 178 municipal and 47 private reserves [34]. Considering only the state and federal UCs, the phytogeographic region having the large protected area is the Mixed Evergreen forest (Floresta Ombrófila Mista) with 75.5% (9965 ha), followed by Steppic Savanna (Savana Estépica) with 46.3% (3148 ha), Dense Evergreen forest (Floresta Ombrófila Densa) with 31.2% (565 552 ha), Early Succession communities with 10.7% (41 099 ha) and the Semidecidual Seasonal forest (Floresta Estacional Semidecidual) with 0.7% (15 199 ha) [24,34]. It is important to consider that not all of the protected area is presently covered by remnants of vegetation. Although the number of UCs can be considered relatively high and cover an expressive area of the State, the UCs cannot be considered representative of the phytogeographic regions found in Rio de Janeiro State (Figure 1).

Strategy of Analysis

The production of information necessary to the definition of strategies and action for the conservation of the Atlantic Forest biodiversity in the Rio de Janeiro State involved a process of collection, systematization, analysis and synthesis of a large georefered dataset, distributed in diverse subjects and areas of the knowledge. The adoption of a method for the integrated analysis of the dataset, in a process of synthesis and aggregation, was necessary to point out actions and strategies regarding conservation, as a support for the decision taking.

The adopted method involved the use of indicators, which have the capacity to reduce the number of measures and parameters used to represent a particular situation, to integrate many variables, to supply synthesis information to represent a situation and to simplify the process of communication of the results to user [35,36]. In this study, we developed indicators to reduce a large set of variables to a unique measure variable associated to a subject of interest. So, the information can be directly assessed by the users or can be integrated to the synthesis relative to the other study subjects.

The grouping of the data for the integrated analysis was made adopting a model of classification of indicators. In this study we used the Pressure-State-Response model developed by OECD [17,18] for the study of global environmental indicators. The model is based on the causality concept: 'the human activities exert pressure on the environment and change its quality and the quantity of natural resources, that is, modifying its state. The society responds to these changes through environmental, economical or sectorial policies (the societal response)'. Although this model can suggest a linear interaction between activities and environment, it must be considered that such relationships are complex.

Based on this model, the data was collected, analyzed and synthesized to characterize the pressures of the human activities on the environment, which threaten the conservation of biodiversity; the state of the environment considering the physical and biotic environment; and the capacity of the society to answer to the human pressures and to act in the conservation of biodiversity.

Therefore, the indicators were chosen in a way to present a representative state of the environmental conditions, the pressures on the environment and the responses of the society (Table 1). Other criteria used in the election of these indicators were:

- It can be located spatially or allow to know its variation in space;
- The component data are readily available or available at a relatively low cost;
- It can be periodically updated, giving priority to those collected in censuses or other systematic surveys;
- The results obtained are simple and easy to interpret; and
- Although applied regionally, they can be potentially applied in the whole Atlantic Forest Biome.

Pressure		
Indicators	Description	Source of data
Tax of poverty	It allows identifying municipalities that are mainly poor. Given by the percentage of people of the municipality with inferior domiciliary income the half wage-minimum, in relation to the total population, effective in August of 2000.	Brazilian Institute of Geography and Statistics (IBGE)
Intensity of poverty	Express the space concentration of low income people for municipality. Given by the absolute number of people of the municipality with domiciliary income less than the half wage-minimum per squared kilometer of the territory, effective in August of 2000.	IBGE
Municipality human development	It allows identifying the level of economic development (per capita income) and of the potential to improve it (longevity and education). Given by the arithmetic mean of three indicators related to the education, longevity and income.	Foundation Center for Information and Data of Rio de Janeiro (CIDE Foundation)
Anthropic pressure	Express force vectors that imply in the reorganization of the anthropic activities in the territory. It is composed for two variables: liquid tax of migration (1991-2000) and average of the annual taxes of growth of the GIP (1998-2004).	CIDE Foundation

Supply of areas for the conservation and preservation	Express the ratio of the municipality covered by forest remainders, secondary vegetation and water bodies.	CIDE Foundation
Intensity of the farming activity	Gotten by means of the integration of 12 constructed indicators on the basis of 17 variables of the farming census of 1995/1996, related to the farming activity. Used indicators: crop area, pasture, fallow area, busy staff in the rural zone, machinery (tractor, machines for plantation, for harvest, utilitarian and trucks in the agricultural business), bovines, milk production, value of the vegetal production, value of the animal production, investments and financings in the agricultural business and balance of the agricultural business (prescriptions and expenditures).	IBGE
Agriculture dynamic	Express the change in harvested area of the main annual crops (rice, sugar cane, beans, manioc, maize, tomatoes) and perennial (banana, coffee, coconut, guava, orange, passion fruit) in the period between 1995/96 and 2004. It allows to verify the stability of the agricultural activity per municipality and the migration of the main crops.	IBGE
Cattle dynamic	Express the change in number of bovine heads in the period between 1995/96 and 2005. It allows verifying the stability of the bovine cattle business per municipality.	IBGE
Presence of settlements	It presents the distribution of the existing settlements in the State, being represented by circles of proportional area to the area of the settlement and classified according to the occupation density	National Institute of Colonization and Agrarian Reform (INCRA)
Evolution of the urban spot	Express geographically the increase of the urban area in the periods: 1958/1967, 1994 and 2001.	IBGE , Directorate of Geographical Service (DSG) , CIDE Foundation
Infrastructure availability	It classifies the municipalities according to its availability of infrastructure for great investments.	CIDE Foundation
Complementary data	Great investments and projects foreseen for implantation per region.	CIDE Foundation
	Identification of encampments and approximate localization.	INCRA
State		
Indicators	Description	Source of data
Threat and endemism	Attributed to each species of the fauna and flora, associating the case of being endemic of Atlantic forest and/or Rio de Janeiro State, and/or it is present in at least one of the lists of Threatened Species [37,38], in the categories, Extinct, Critically Endangered, Endangered and Vulnerable.	Primary data collected by the project, consultation during the Workshop and secondary data obtained in bibliographical revision
Biological importance	Express, for each municipality, the totaling of the indicators of threat and endemism gotten for all the species with occurrence registered in the municipality.	Primary data collected by the project, consult during the Workshop and secondary data obtained in bibliographical revision
Richness of groups with record	It indicates how much a municipality is known on its flora and fauna. Expressed by the number of groups (mammals, birds, reptiles, amphibians, invertebrates, aquatic organisms and flora) withat least one species occurrence for a municipality.	Primary data collected by the project, consultation during the Workshop and secondary data obtained in bibliographical revision
Importance of the vegetation remnants	It classifies the vegetation remnants of Atlantic forest according to its importance for the conservation of biodiversity, considering its insertion in UCs, its size and the possibility of connection with other remnants.	SOS Atlantic Forest Foundation and CIDE Foundation State Forestry Institute (IEF / RJ)
Physical vulnerability of the environment	Developed for watershed by integration of the components: climatic (rain erosivity index), edaphic (soil erodibility index), topographic (average slope and standard deviation of the altitude), hydrologic (draining density and runoff) and morfometric (circular index of watershed).	Embrapa Solos, National Institute of Meteorology (INMET) , SRTM NASA, IBGE , DSG
Complementary data	Cartographic base.	IBGE
	Limits of the phytogeographic regions.	RADAMBRASIL
	Limits of the geomorphologic units.	RADAMBRASIL
	Altitudinal gradients.	IBGE

	Places of occurrence of caves.	Ministry of Environment (MMA)
	Agro-ecological zoning/areas destined to the recovery.	Embrapa
	Marine ecosystems: qualitative evaluation, carried out during the Workshop, of the degree of connectivity between Atlantic forest and the Coastal-Marine systems, establishing 12 compartments in the coast of the State.	MMA
Response		
Indicators	Description	Source of data
Implementation of Ucs	Express the effectiveness of the UCs for the environmental protection. Based in method RAPPAM - Rapid Assessment and Prioritization of Protected Area Management [39]. It integrates the information: existence of creation act and its legality; existence of consulting board and frequency it congregates; existence of management plan; efficiency of the monitoring on the management plan; technician staff enough; existence of environmental and social-economic research, its adequacy and access, aiming at the improvement of the management plan.	Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), IEF ; Municipal city halls ; Questionnaires applied to the managers of protected areas and the Municipal Administrations
Governance	Express the level of organization of the municipalities for the environmental management. It integrates information on the implementation of systems of management with focus in the environment, as Agenda 21, council management plan, advice of environment, intermunicipal trust and committee of watershed, detaching the participation of the society in the process.	Questionnaires applied to the municipal administrations
Social-environment actions	Express the level of mobilization and performance accomplishes of the civil society for municipality. It congregates referring data to the number of operating institutions, with headquarters in the municipality, type of performance (mobilization or execution of projects) and numbers of developed projects or in development.	Questionnaires applied to NGOs and grant sources
Complementary data	Places of occurrence of RPPNs.	Golden Lion Tamarin Association / GeoPlus Database and IBAMA
	Places of occurrence of traditional communities, considered the indigenous areas, quilombolas (community of fugitive negro slaves) and caçaras (simple people of seacost).	INCRA , Institute of Land and Cartography of Rio de Janeiro state , Palmares Foundation , MMA, Association of RJ State Quilombolas
	Priority areas for conservation.	MMA

Table 1: Description and source of data of the indicators used to represent the Pressure, the State and the Response in Rio de Janeiro State.

All data and indicators used were inserted in a geographical database. For the integration of the information, the scale used as reference was 1:250 000. Due to the diverse origin of the data, the area unit that they represent was not always the same (for example, cities, vegetation remnants, watershed, among others). The indicators for the definition of strategies and actions were integrated using as unit of analysis the regions proposed for the Rio de Janeiro State.

In our analysis, we considered that the characteristics of social, economic, environmental and the nature of the questions affecting the Rio de Janeiro State conservation were not homogeneously distributed along the State, but that they differed markedly depending on the region. In this case it was necessary to identify the characteristics for each region of the State. Recently, considering such differences and peculiarities, it was recognized nine regions of the State which aggregate and share similar characteristics: 1) Oil and Natural Gas; 2) Urban -Industrial; 3) Tourist Lakes Fluminenses; 4) Serrana Diversified Economy; 5) Coast Tourist Green; 6) Industrial Middle Paraíba; 7) Tourist -Cultural Middle Paraíba; 8) Serrana Agricultural Economics; 9) Agricultural Dove, Muriaé and Itabapoana [40] (Figure 1a).

After ending the data survey, organizing the dataset, finalizing the selection of indicators and preparing the geographical database, we then organized a Workshop congregating a total of 104 specialists of different areas of knowledge (e.g. ecology, zoology, botany, conservation biology, geography, economy, sociology, agronomy) that had as main goals 1) update the data from the researchers' knowledge, 2) incorporate knowledge on the subject or in several regions, and 3) integrate researchers' analysis of the different areas of knowledge. The adopted logic to analyze the data in workshop can be seen in Figure 2.

Considering the viable strategies and actions to be proposed for the Rio de Janeiro State, we decided to follow a hierarchical analysis based on a comprehensive database framework. The first step was to recognize which were our priority conservation targets. The second step was to choose those strategies that could represent broad conservation policies.

The last step was to list more specific actions within each strategy. We considered strategies to be a more general plan of action or policy, whereas actions were a series of more specific events related to each strategy. Although the strategies were the same for all regions, the actions were specific and directed for each region.

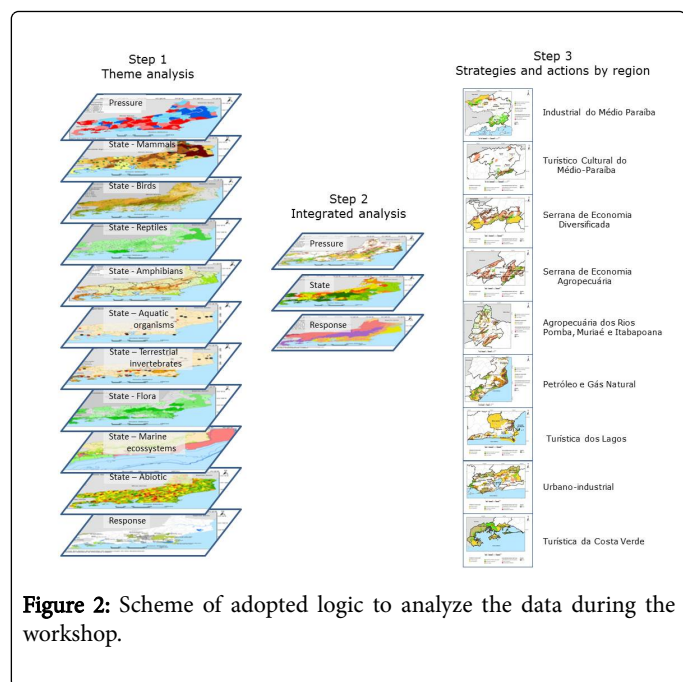


Figure 2: Scheme of adopted logic to analyze the data during the workshop.

Our guiding principles for choosing the conservation targets were: i. habitats and/or species absolutely essential to attain the conservation goals desired, which could not be replaced by any other (irreplaceable); ii. possibility of connection of vegetation remnants in order to strengthen the network of protected areas; iii. ecoregional representativeness of protected areas (UC); iv. promotion of the long term persistence of the conservation target, while maintaining its feasibility and ecological integrity (functionality); v. flexibility of the actions reaching more than one of the conservation targets established; and vi. strengthening the environmental policies to integrate protected and unprotected areas (complementarity).

Knowing that the main vectors of pressure are also the same that generate income and that the production processes and life depend on the maintenance of the quality of ecosystems, the targets set for the conservation are not restricted to biotic aspects, but interact directly with the sustainable use of resources. Our targets were a) Species (enlarge the protection/conservation of endemic and endangered species); b) Landscape (reduce the fragmentation/enlarge the possibilities of connection) and c) Ecological Processes (reducing the damage caused by the pressure of human in ecological processes).

Results

As a result of the implementation of the proposed methodology, we obtained the description of a series of actions driven by the strategies previously outlined. Table 2 shows examples of actions involving all the strategies proposed to the different regions of the state and Figure 1b shows some examples in the map. The actions were proposed by specialist in the Workshop for each of the regions and are based on strategies to reduce the pressure on the environment and expand the response capacity of society for the conservation of biodiversity.

Figure 3 presents the percentage of times that actions regarding a particular strategy were suggested for each region of the state. The strategies, Strengthening of SNUC and Landscape Management, accounted for 52% of the actions proposed for the regions of the state. For the regions of the State that already have UCs, the actions are aimed primarily to increase its level of implementation and to integrate tools for management. In those regions of the State where the vegetation remnant has been left unprotected, the main actions are aimed to create UCs, promote the establishment of corridors and rehabilitation of degraded areas when necessary. In general, these regions have a large deficit of basic information about physical and biotic aspects, being clearly necessary actions relating to "Increase of Knowledge."

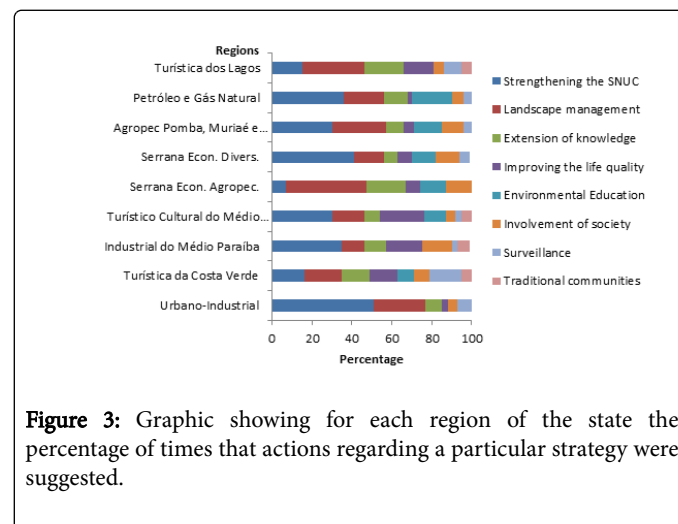


Figure 3: Graphic showing for each region of the state the percentage of times that actions regarding a particular strategy were suggested.

	Examples of action proposed and region
Strategy: Strengthening the SNUC	
Creating and/or increasing UCs	Agricultural Dove, Muriaé and Itabapoana: Stimulate the creation of private reserves aiming to preserve the few remnants of Semidecidual Seasonal Forest. To promote the creation of UCs que possess Wildlife Reserve Area in the remnants of major importance (Figure 1b - point 1)
Extending the level of implementation of UCs	Proposals for the existing UCs in the State: Implement the actions foreseen in the management plans of 13 UCs and to elaborate management plans to 199 UCs
Fortifying the integrated management of UCs: mosaics and corridors	Coast Tourist Green : Promote the integrated management of the existing UCs to support initiatives that aim the strengthening of the mosaic of Bocaina. To construct and to implement new

	models of shared management to UCs and to foment the creation of a net of RPPNs (Figure 1b - point 2)
Identifying forms to extend the economic and social sustainability of the UCs	Oil and Gas: Create alternative forms of administration of the UC União Biological Reserve that promote the sharing of management between the IBAMA and the three municipalities, searching partnerships and financial support in the companies with performance in the area and that they have environmental liabilities (Figure 1b - point 3)
Strategy: Management of the landscape	
Integrating management instruments: plans of basin, council management plan, Agenda 21, management plans of UCs	Industrial urban: Develop integrated management plan for the use of land and natural resources involving the Consortium Intermunicipal in Eastern Guanabara, the Management Committee of the Hydrographic Region of the Guanabara Bay and the Council of Mosaic of the UCs of Central Fluminense Atlantic Forest
Promoting politics of the land use that contemplate increase of the landscape permeability	Agricultural Dove, Muriaé and Itabapoana: Encourage the planting of forests Aimed at Extending the connectivity of vegetation remnants of Semideciduous Forest and the prevention of problems of soil degradation, yet Avoiding extensive areas of monoculture, Which trend to aggravate the rural exodus
Promoting the creation of corridors through recovery of bordering river forest (gallery forest), reforestation in vulnerable, degraded and/or critical areas	Serrana Agricultural Economics: Search for solutions consortium to definition of areas of legal reserve, in order to enhance the connection between remnants. Strengthen the existing orchards, encouraging the production of seeds and seedlings of native species for recovery of degraded areas of the surrounding of the UC Desengano State Park (Figure 1b-point 4)
Retrieving environments degraded by pollution, erosion, mining, among others of importance to the maintenance of the ecological processes	Tourist dos Lagos: Reforest the marginal strip of lagoons and ponds used for water supply
Implementing systems of remuneration/compensation/recognition for environmental services deriving from productive practices compatible with the conservation	Proposal for the entire State: Implement the legislation that standardize the transfer to municipalities the taxes on the movement of goods and services, benefiting those who encourage the implementation of UCs and sustainable use of land
Strategy: Extension of existing knowledge on the socio-economic, cultural and environmental aspects and monitoring of their procedures	
Promoting research in places that have gaps of information that are key to conservation	Promote studies that subsidize conservation actions in the various places of the State in which gaps were identified. Highlight for water resources, for which there is no historical monitoring of adequate quantity and quality of water
Promoting monitoring of the land use and land cover and water resources in appropriate scale	Proposals aimed at monitoring areas of greater momentum in the State due to population densification or to the estimates of deployment of large enterprises
To promote the standardization of the process of obtaining the environmental data and proper documentation of the studies developed	Create a unified database to the State with indicators obtained through standardized methods, in a representative way and updated periodically
Strategy: Improving the quality of life and generate income	
Promote the development of sustainable economic activities.	Cultural tourism in the Middle Paraíba: Stimulate the creation of a regional brand for agricultural products, coupled with a stamp of socio-environmental quality
Search adequacy gears of the development policies aimed at mitigating the negative impacts to the environment.	Serrana Agricultural Economics: Establish policy of attraction and attachment of people through creation of jobs and income
Create policies to stimulate the sustainable local productive arrangements	Serrana Diversified Economy: Encourage the implementation of local productive arrangement based on binomial Tourism-Agriculture
Strategy: Environmental education, training and increased environmental awareness	
To develop public policies to include environmental education in schools	Proposal for the entire state
Promoting educational campaigns	Proposal for the entire state
Training and/or capacitate multiplier agents	Tourist Middle Paraíba: Get the infrastructure in the region for the implementation of courses for the training of local labor and technical courses emphasizing the local productive arrangements
Training environmental agents and improve the technical level of agents operating in that area	Oil and Natural Gas: Insert the local community in the activities of conservation informing on endemic and endangered species in order to match the activity with the fishing conservation
Strategy: Involvement and strengthening of society and local governance	

Create and implement municipal councils of the environment and Agenda 21 with the effective participation of civil society	Stimulate the creation of councils of the environment in 76 municipalities and the implementation of Agenda 21 in 55 municipalities of the State that do not have them
Stimulating the creation of intermunicipalities and / or interstate consortia	Invest in the creation of consortia among municipalities in each region of the State to awaken an identity and create combined shares actions
Create technical capacity in the local civil society for proposing and implementing socio-environmental projects	Cultural Middle Paraíba Tourist: Promote the expansion of articulation and the mobilization of various sectors of civil society organizations through the exchange of experiences
Create integrated lines of funding aimed to local socio-environmental propositions	Tourism Green Coast: Encourage the integration of civil society groups linked to environmental causes, signing agreements of cooperation and agreements between agencies and executers such as academic institutions, NGOs and companies
Strategy: Surveillance	
Fauna and Flora	Proposals for the entire state in an integrated manner, including the actions of environmental education: Monitoring activities of fishing, hunting and gathering, and illegal trade. Control the entry of exotic species by means of transport (ships, platforms, aircraft, trucks) and the introduction of exotic species toward the production (Figure 1b-point 5). Create new Wildlife Sorting Centers in the State to house specimens seized by the surveillance
Other activities	Proposals for the entire state in an integrated manner, including the actions of environmental education and environmental management: Control forest fires, illegal human occupation and the dumping of sewage and excrements of household, hospital and industrial, the use of pesticides and disposal of packaging
Strategy: Traditional Communities	
Identify traditional forms of land use and natural resources compatible with conservation.	Tourism Green Coast: Stimulate specialists to make the diagnosis of knowledge and forms of sustainable use of the elements of nature used by traditional communities who inhabit five indigenous areas and three quilombolas in the region
Recognize and delimit traditional areas of occupation.	Recognize 25 areas occupied by quilombolas and delimit the areas recognized in the State
Involving the communities in the local traditional mechanisms for environmental management	Cultural tourism in the Middle Paraíba: Stimulate the interaction with the rural community quilombola San Jose da Serra, to the construction of collective knowledge aimed to sustainable management of resources (Figure 1b-point 6)

Table 2: List with examples of actions proposed for the eight strategies to be implemented to ensure the conservation of biodiversity in Rio de Janeiro State.

Discussion

The gaps in knowledge observed in the Rio de Janeiro State led us to develop a methodology for the analysis of the landscape that does not require that information is evenly available in terms of sampling and geographical distribution of the biodiversity. The methodologies most frequently used, such as GAP, PCA, IBA and KBA, rely on such evenness to obtain consistent, unbiased results [4,41]. In addition, our analysis took into account political, socio-economic and cultural aspects of relevance to the definition of strategies according to the reality of each region of the State. All aspects previously mentioned were considered with the same weight in the analysis, as far as those relating to biodiversity, so as to propose strategies the most appropriate possible to the regional reality.

The most frequent action needed relate to the strategy of 'Strengthening the SNUC'. This strategy, traditionally, gives priority to the creation of UCs. But in the case of the Rio de Janeiro State, the actions indicated were more frequently driven to the implementation of the UCs already existing. The exception occurred in the regions where the vegetation remnants are still left unprotected, but are representative of the local fauna and flora. In these regions the creation

of new UCs, mainly RPPNs, was considered a priority. The creation of RPPNs results from the involvement and the availability of the owner to transform their area in a reserve, which shares between government and civil society the responsibility on the initiatives aimed to conservation.

The strategy 'Landscape Management' was the second most frequent in terms of actions proposed. The actions most frequently suggested aimed to the increase of landscape permeability through the creation of corridors and/or rehabilitation of degraded environments. This is a most current conservation strategy and seems to be complementary to the strengthening of the SNUC, avoiding the formation of islands of conservation, which has been known to be unviable for the conservation of biodiversity in the long term, since it does not allow the maintenance of ecological processes [42]. The suggested actions were also based on the recognition of environmental services from productive practices compatible with conservation and on the integration of management tools. The recognition and proper compensation for environmental services constitute an important tool in the process of consolidating the management of the landscape [43].

The actions regarding to the strategy of 'Increase of Knowledge' were also numerous due to the gaps on biodiversity, land use, land cover and water resources. Despite efforts in carrying out inventories of fauna along the project, they have proved to be insufficient to provide information to cover all the required demands. Given this, initiatives for the management of the landscape were based mainly on information on the distribution of the remnants in the landscape and on the vulnerability of the physical environment.

The actions regarding the strategies 'Improvement of the Life Quality', 'Environmental Education' and 'Involvement of Society' reflect the methodology built during the project. The actions highlight the importance of human development and inclusion of civil society in the management of the environment, allowing that the adopted strategies reflect the regional socio-economic and cultural differences.

The strategy 'Improvement of the Life Quality' had as main focus the stimulus to the economic development of environmentally friendly practices, respecting the vocation of the region and optimizing available resources. The actions proposed seek to expand the generation of income through the integration of existing activities and the strengthening of local production, predisposing the population to consolidate a culture of local management of the territory.

The actions regarding the strategy 'Environmental Education' have crossed transversally the other strategies and actions proposed, emphasizing the importance of a continuous process and involving stakeholders in formal or informal processes of awareness to environmental issues and their interfaces with political, economic and life quality aspects.

Providing the society with instruments in the decision-making process was the main focus of the actions proposed in the strategy 'Involvement of the Society'. In this strategy, it was considered a priority those actions focusing the participation of citizens as protagonists on decision-making processes. Considering that the ecological processes go beyond the political-administrative limits, it was also highlighted the importance of creating forums for integrated management.

Currently surveillance is done in a diffuse and punctual way, and under the responsibility of many different governmental organs. Although necessary, surveillance is ineffective because it is applied in isolation, without an integrated education planning and environmental management. The strategy 'Surveillance' was thus defined in order to change this situation by proposing integrated actions for the entire state.

The incorporation of traditional communities in conservation strategies demands, a priori, their recognition by the state. The non-recognition contributes to the lack of information about their culture. This situation adversely affected the inclusion of traditional communities in other strategies for conservation. In this case, one of the actions proposed is the deepening of knowledge about their traditions.

Considering the issues raised by Redford [11], all proposed actions are designed to meet where and how conservation should be done, considering always the regional heterogeneity of Rio de Janeiro State. However, the indicator of economic incentive allowed us to include a temporal perspective in the actions, since the economy brings other vectors of pressure allowing us to predict demands and future actions.

Although the watershed's unit of analysis is most appropriate for planning and environmental management [44], it could not be used

due to lack of socio-economic information with this approach. We suggest, therefore, the generation of socio-economic data by watershed, aiming the development of more efficient models of environmental management.

For improvement of our proposed methodology, the detected gaps of information must be filled out allowing to a bigger detailing and understanding of the heterogeneity of the State. The improvement of the environmental management demands a unified database for the State be created, with indicators gotten through standardized, periodically updated, methods, and that allow access to the involved actors in the conservation process.

Conclusion

The proposed methodology has enabled us to reach the following conclusions:

1. Our approach is complementary to the other existing methodologies, and allows its use even considering the considerable shortcomings in the existing information;
2. The equal weight given to the indicators allowed perceiving the role of political, socioeconomic and cultural background in environmental scenario diagnosed;
3. Given the existing huge demands for the conservation and considering the great heterogeneity, the Rio de Janeiro State needs the integration of society in the process of environmental planning and management;
4. The perspective of an increase in the permeability of the landscape allows compatibility between conservation of biodiversity and the carrying out of economic activities;
5. The establishment of compensatory mechanisms for environmental services is essential as complimentary to the SNUC and to the stimulus to productive practices compatible with conservation;
6. The use of integrated instruments of environmental management is fundamental condition for the success of policies to be adopted, and
7. Supplying the gaps of information and creating a dynamic and accessible database is essential to improving environmental management.

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References

1. Meffe GK, Carroll CR (1997) *Principles of Conservation Biology*. Sinauer Associates. pp: 1-265.
2. Martins ARP, Ferraz FT, Costa MM (2006) Environmental sustainability as a new dimension of human development index countries. *BNCES Magazine* 13: 139-162.
3. Mittermeier RA, Fonseca GAB, Rylands AB, Brandon K (2005) A brief history of biodiversity conservation in Brazil. *Megabiodiversity* 1: 14-21.
4. Prendergast JR, Quinn RM, Lawton JH (1998) The gaps between theory in practice in selecting nature reserves. *Conservation Biology* 13: 484-492.
5. Tabarelli M, Pinto LP, Silva JMC, Hirota MM, Bedê LC (2005) Challenges and opportunities for biodiversity conservation in the Brazilian Atlantic Forest. *Megabiodiversity* 1: 132-138.
6. SNUC (2000) National System of Conservation Units. SNIE.
7. Bray DB, Anderson AB (2005) Global conservation, non-governmental organizations and local communities. Perspectives on programs and project implementations in Latin America. Conservation and Development Series. LACC, Florida International University (Miami).
8. Burley FW (1988) Monitoring biological diversity for setting priorities in conservation. National Academy Press (Washington, DC). 227-230.
9. Eken G, Bennun L, Brooks TM, Darwall W, Fishpool LDC, et al. (2004) Key biodiversity areas as site conservation targets. *BioScience* 54: 1110-1118.
10. Granizo T, Molina ME, Secaira E, Herrera B, Benítez S, et al. (2006) Manual de Planificación para la Conservación de Áreas, PCA. TNC and USAID (Quito). 1-206.
11. Redford KH, Coppolillo P, Sanderson EW, Fonseca GAB, Dinerstein E, et al. (2003) Mapping the conservation landscape. *Conservation Biology* 17: 116-131.
12. Sanderson J, Alger K, Fonseca GAB, Galindo-Leal C, Inchausti VH, et al. (2003) Biodiversity conservation corridors: planning, implementing, and monitoring sustainable landscapes. *Conservation International* (Washington, DC).
13. Fonseca GAB, Alger K, Pinto LP, Araújo M, Cavalcanti R (2004) Corredores de Biodiversidade: O Corredor Central da Mata Atlântica. Ibama (Brasília). pp: 47-65.
14. Ayres JM, Fonseca GAB, Rylands AB, Queiroz HL, Pinto LPS, et al. (2005) Os Corredores Ecológicos das Florestas Tropicais do Brasil. Sociedade Civil Mamiará (Brasília). pp: 1-256.
15. Carvalho JC (2005) Iniciativas políticas para a conservação da Mata Atlântica Brasileira. Fundação SOS Mata Atlântica e Conservação Internacional (Belo Horizonte). pp: 133-136.
16. Pinto LP, Bedê L, Paese A, Fonseca M, Paglia A, et al. (2006) Mata Atlântica Brasileira: os Desafios para Conservação da Biodiversidade de um Hotspot Mundial. Rima Editora (São Carlos). pp: 91-118.
17. OECD (1994) *Environmental indicators*. Organization for Economic Co-Operation and Development, Paris.
18. OECD (1998) *Towards sustainable development: environmental indicators*. Organization for Economic Co-Operation and Development, Paris.
19. Fundação CIDE (2006) Anuário Estatístico do Estado do Rio de Janeiro. CIDE (Rio de Janeiro).
20. Oliveira FJG (2007) Reestruturação econômica, planos de desenvolvimento e mudanças territoriais no Estado do Rio de Janeiro. *Revista de Economia Fluminense* 5: 6-17.
21. MMA (2003) Biodiversidade Brasileira. Avaliação e identificação de áreas e ações prioritárias para conservação, utilização sustentável e repartição de benefícios da biodiversidade brasileira. Ministério do Meio Ambiente/Secretaria de Biodiversidade e Florestas (Brasília). 1-404.
22. Rocha CFD, Bergallo HG, Alves MAS, Van Sluys M (2003) A biodiversidade nos grandes remanescentes florestais do Estado do Rio de Janeiro e nas restingas da Mata Atlântica. Rima Editora (São Carlos). pp: 1-160.
23. Fidalgo ECC, Uzêda MC, Bergallo HG, Costa TCC (2007) Remanescentes da Mata Atlântica no Estado do Rio de Janeiro: distribuição dos fragmentos e possibilidades de conexão. *Anais XIII Simpósio Brasileiro de Sensoriamento Remoto*. pp: 3885-3892.
24. Costa TCC, Fidalgo ECC, Santos RF, Rocha JV, Metzger JP, et al. (2009) Diversidade de paisagens no Estado do Rio de Janeiro. Instituto Biomas (Rio de Janeiro). pp: 101-110.
25. Rocha CFD, Bergallo HG, Van Sluys M, Alves MAS, Jenkins C (2006) Corredores ecológicos e conservação da biodiversidade: um estudo de caso na Mata Atlântica. Rima Editora (São Carlos). pp: 317-342.
26. Brito D, Fernandez FAS (2000) Metapopulation viability of the marsupial *Micoureus demerarae* in small Atlantic forest remnants in south-eastern Brazil. *Animal Conservation* 3: 201-209.
27. Brito D, Grelle CEV (2004) Effectiveness of a reserve network for the conservation of the endemic marsupial *Micoureus travassosi* in Atlantic Forest remnants in southeastern Brazil. *Biodiversity and Conservation* 13: 2519-2536.
28. Vanzolini PE (1988) Distributional patterns of South American lizards. *Academia Brasileira de Ciências* (Rio de Janeiro). pp: 317-342.
29. Wege DC, Long AJ (1995) Key areas for threatened birds in the Neotropics. *Birdlife Conservation*, Cambridge.
30. Manne LL, Brooks TM, Pimm SL (1999) Relative risks of extinction of passerine birds on continents and islands. *Nature* 399: 258-261.
31. Costa LP, Leite YLR, Fonseca GAB, Fonseca MT (2000) Biogeography of South American forest mammals: endemism and diversity in the Atlantic forest. *Biotropica* 32: 872-881.
32. Brown KS, Freitas AVL (2000) Atlantic forest butterflies: indicators for landscape conservation. *Biotropica* 32: 934-956.
33. MMA (2000) Avaliação e ações prioritárias para a conservação da biodiversidade da Mata Atlântica e Campos Sulinos. Ministério do Meio Ambiente/Secretaria de Biodiversidade e Florestas (Brasília). pp: 1-40.
34. Fidalgo ECC, Uzêda MC, Bergallo HG, Costa TCC, Abreu MB (2009) Distribuição dos remanescentes vegetais no Estado do Rio de Janeiro. Instituto Biomas (Rio de Janeiro). pp: 91-99.
35. Hammond A, Adriaanse A, Rodenburg E, Bryant D, Woodward R (1995) Environmental indicators: a systematic approach to measuring and reporting on environmental policy performance in the context of sustainable development. World Resources Institute (Washington). pp: 1-58.
36. Winograd M (1995) Marco conceptual para el desarrollo y uso de indicadores ambientales y de sustentabilidad para la toma de decisiones en Latinoamérica y el Caribe, Cali.
37. Bergallo HG, Rocha CFD, Alves MAS, Van Sluys M (2000) A fauna ameaçada de extinção do Estado do Rio de Janeiro. *EdUERJ* (Rio de Janeiro). pp: 1-166.
38. IUCN (2006) *IUCN Red List of Threatened Species*.
39. Ervin J (2003) WWF: Rapid Assessment and Prioritization of Protected Area Management (RAPAM) Methodology. WWF (Gland). pp: 1-49.
40. Saraça CE, Rahy IS, Santos MA, Costa MB, Peres WR (2007) A propósito de uma nova regionalização para o Estado do Rio de Janeiro. *Revista de Economia Fluminense* 3: 18-27.
41. Bencke GA, Maurício GN (2006) Methodological approach. Parte I – Estados do domínio da Mata Atlântica. SAVE (São Paulo). pp: 77-90.
42. Gilpin ME, Soulé ME (1986) Minimum viable populations: processes of species extinction. *Conservation Biology: the science of scarcity and diversity*. Sinauer (Sunderland). pp: 19-34.
43. Grieg-Gran M, Porras I, Wunder S (2005) How can market mechanisms for forest environmental services help the poor? Preliminary lessons from Latin America. *World Development* 33: 1511-1527.
44. Lima WP, Zakia MJP (1996) Monitoramento de bacias hidrográficas em áreas florestadas. *Série Técnica IPEF* 10: 11-21.