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Land use of the environmental protected area of the coastal environment of Serra do Tabuleiro State Park-Palhoça/SC, Brazil: zoning and environmental restrictions

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Abstract The creation of National Parks challenges institutions, technicians and actors involved in the processes of management and protection of natural resources, due to numerous conflicts experienced by local population. The extensiveness of nine municipalities in the Serra do Tabuleiro State Park (PEST—*acronym in portuguese*) within the limits of the Park, along with the development of cities, displays many interests and land conflicts in the Park. This situation forced, in 2009, governmental parties to establish a new demarcation process, aiming the removal of conflict areas and creation of new categories of protected areas. In this context, this paper aims to report the PEST history, collecting environmental characteristics and land use owned by the environmental protection area of surrounding coastal of the Serra do Tabuleiro State Park, in the northeastern portion of the Baixada Massiambu, the locations of the Pinheira and Guarda do Embaú beaches, in city of Palhoça/SC, Brazil. On this regard, a literature research was performed, referring to the uses of the area under study, as well as the legal and territory definitions; then, field visits were performed from March 2012 to March 2014, and finally, data collected were aggregated using geographic information systems, along with data regarding the ecological and legal characteristics of the area. Results displayed 6501 plots of land on the Pinheira and Guarda do Embaú beaches, and of these, 77% had no environmental restrictions, 13% had partial restrictions, and 10% presented total restrictions. Thus, the PEST delimitation demonstrated great ecological significance for human settlement, especially in some detached areas, which should be kept and preserved. This work makes a valuable contribution to the understanding of the Baixada Massiambu problem, mainly related to land use;

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protective measures and environmental recovery can be formulated in this region, taking into consideration aspects such as environmental planning and mechanisms of reorganization discussion for this territory.

Keywords Environmental protected area of surrounding coastal of Serra do Tabuleiro State Park · Demarcations · Socioeconomic conflicts · Environmental restrictions · Environmental cadastre

1 Introduction

The concern with the protection of natural environments through laws has been undertaken for many years. Behind theses protection actions, there is always the recognition of certain special values associated with specific geographical places. The existence of drinking water sources, holy or rare animals, historical events, medicinal plants, or availability of resources are just some examples that historically drove strategies for controlling and limiting the usage of some environments (Miller 1997).

Recently, the rising number of legally protected natural areas is of great importance for our current society and these areas are key strategies for conservation of biological diversity (Milano 2000; Terborgh and Van Schaik 2002). Land cover patterns that characterize natural protected areas determine energy fluxes and material exchanges in the landscape, support biodiversity, provide a wide array of environmental goods and services such as food, clean water, climate regulation, recreation opportunities, upon which human societies depend for their current and future well-being (Costanza et al. 1997, 2007; Daily 1997).

What in the world is termed as "protected area", in Brazil is known as Conservation Unit. The law no 9.985/2000, which created the National System of Conservation Units (SNUC—*acronym in portuguese*), defines conservation areas as:

> Territorial space and their natural resources, including jurisdictional waters, with relevant natural characteristics, legally instituted by the Government, with conservation objectives and limits, under special administration, which apply appropriate safeguards to protect.

Globally, well-connected protected areas networks have the potential to enhance biodiversity within and beyond their boundaries, on land or in the sea (Brudvig et al. 2009; Foley et al. 2010). According to Brandon et al. (1998), protected areas (PAs) remain one of conservation biology's most important approaches for ensuring that representative examples of ecological populations, communities, and ecosystems are maintained for current and future generations. Historically, most PAs were created ambitioning natural environments to not lose their characteristics.

The creation of state-owned or public conservation areas is usually driven by the ecological consciousness and political will of the participants (Mathevet and Mauchamp 2005) but must also confront a variety of ecological and political constraints. Defining the formal boundaries of protected areas is impossible without support from external institutions such as national and international policies, laws, and agreements. Each PA has social and ecosystem characteristics, often including stated management goals, that influence (and are influenced by) governance, affecting economic outputs and social outcomes in the social-ecological system (Ostrom 2009). At the same time, according to Cumming 2016; Cumming and Allen 2017 and Palomo et al. 2014, protected areas are human constructed

environment that reflect human desires and needs and they are intended to govern and regulate human actions.

Xie et al. (2015) suggest that the ecological importance evaluation of a regional space is to emphasize on the harmonious development between production space, living space, and ecological space. They also explain that focus of a regional space evaluation ought to aim on the symbiosis between man and other organisms, and to maintain the natural foundation of urban development using applied principles in ecology.

The evolution of concepts and methods related to protected areas has led to different management categories for these areas and as result some environmental and social conflicts came to light. One of the causes of these conflicts was due to the fact that controlled areas (legally protected) shape the relationship with territory and usually differ from the use already given by the population pre-existent on the area (Silva 2008).

The SNUC groups Conservation Units in different management categories divided into Integral Protection Units, which are intended to preserve the nature, being admitted only the indirect use of the natural resources, and Sustainable Use Units, aimed to reconcile nature conservation with the sustainable use of the natural resources (Fig. 1).

According to Law no 9.985, Parks are Conservation Units that have as definition:

> Territorial space and their environmental resources, including jurisdictional waters, with natural characteristics relevant, legally instituted by the Government, with conservation objectives and limits, under special administration, which apply appropriate safeguards to protect it (Brazil 2000).

Environmental conflict, according to Reis (2002), results from the combination of two major human conflicts: environmental degradation and social conflict. Environmental degradation is a consequence of the absence of an environmental education pedagogy resulting in the indiscriminate usage of natural resources by society under the paradigm of infinite availability of resources. Social conflict is a result of conflict between the institutions involved in environmental issues and the communities that use those ecosystems.

The evolution of concepts and methods related to protected areas, as a consequence of the recognition of different conservation objectives, led to the design of different types or categories of management for these areas. It was from this point on that social and

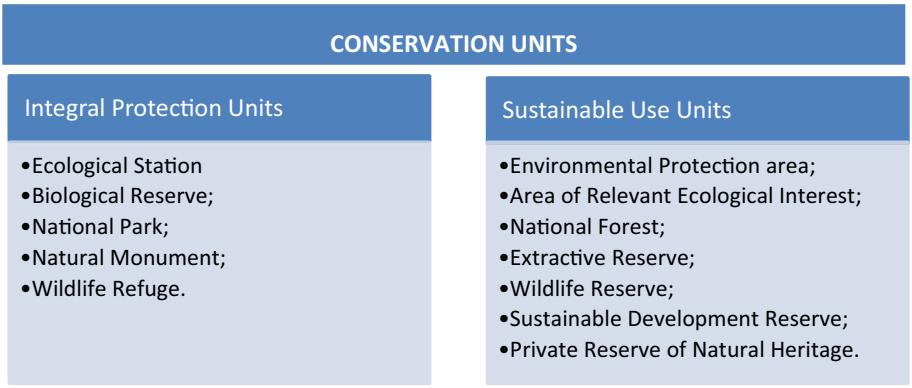

Fig. 1 Groups of Conservation Units. *Source*: Adapted from Brasil. (2000)—Lei no 9.985, de 18 de julho de 2000

environmental conflicts appeared, as a consequence of the establishment of some of these management categories. Among other aspects, this was due to the fact that different socioeconomic, socioenvironmental and cultural relations, in a geographical area, began to be governed by management categories, previously non-existent. These forms of control contributed to the transformation or reconstruction of the territory covered and/or influenced by the area to be protected, often in a divergent way or in conflict with the territory use forms by the pre-existing populations (Silva 2008).

Among the environmental conflicts, there are conflicts of use and occupation of the Conservation Units that, related by Diegues (1995), are of several types: economic and occupational practices (hunting, fishing, extractivism, services, construction and renovation), legal and social (relationship with the inspection and with the Administration, land regularization); degradation of natural resources (fire with agropastoral activities, fires and deforestation); (salary of the employees, garbage and sewage, tourist exploitation, entry into forbidden areas, deforestation for firewood, sale and dismemberment of old property, countryside, camping, etc.).

Despite the large global biodiversity conservation efforts, there are many threats including land-use/cover changes, habitat loss and fragmentation, overexploitation of natural resources, climate change, pollution, invasive species, agricultural intensification, and urbanization (European Commission 2009) as well as tourism development (Aretano et al. 2013; Lim and McAleer 2005; Petrosillo et al. 2007) that can transform the natural disturbance regime and, consequently, increase the potential vulnerability of a natural protected area.

Arterano et al. (2015), propose an integrated use of GIS-based Decision Support System (DSS) with a conceptual linear model of vulnerability to foster conservation strategies in protected areas, by identifying the most vulnerable areas and the most effective management interventions to reduce system vulnerability to fire. The development of such a tool was tested on the natural protected area of Torre Guaceto, through the selection of suitable indicators which enable discrimination among different levels of sensitivity and pressures. Conclusion of this paper displayed that it is desirable that future researches on vulnerability should not only consider the "of what to what", but also consider "for who, where and when" with a focus on the spatial and temporal scale dimensions of vulnerability.

Xie et al. (2015) proposed the identification of the key land usage maintaining ecological security and to put forward some measures for environmental management, based on the GIS technology. They considered characteristics as water security, biodiversity conservation, disaster protection, natural recreation security, and human disturbance. Then, according to the spatial characteristics of ecological importance for different regions, they proposed some zoning regulations and measures for environmental management. Among the Conservation Units in Brazil, there is the Serra do Tabuleiro State Park, which was created in 1975 based on scientific studies addressing (Bertho 2005; Santos 1976; Amaral 1998) its unique natural characteristics (e.g., significant hydric potential, resting forests).

The Park still suffers with the human presence in areas that should be fully preserved, not only due to inappropriate occupation, but also because of lacking of land regulation, resulting not only from irregular occupation of public areas, but also from the existence of areas that still need land regularization. The human presence in and around the Park, together with the inability of the government to offer solutions and forward the demands arising from the creation of conservation areas, increases the risk of damage to the integrity of the area.

There are conflicts of several orders: community versus park administration; Protected area capacity versus rapid population growth; Conflict of interests; Organization versus land regulation; Processes of inconsistency in administrative discriminations versus land registration; Characteristics and fragility of ecosystems versus economic and speculative exploitation; Exodus of the local population versus real estate speculation and conflicts in the performance of the institutions that work in the area.

In 2009, because of the conflicts of the area—especially those related to land use and occupation—it was approved the State Law n. 14661/2009 which modified the boundaries of the Park and reduced its area. The Park was then divided into four parts, and some areas were transformed into a less restrictive protection category:

- Full Protection Conservation Unit—Serra do Tabuleiro State Park;
- Sustainable Use Conservation Unit—Vargem do Braço Environmental Protection Area;
- Sustainable Use Conservation Unit—Vargem do Cedro Environmental Protection Area;
- Sustainable Use Conservation Unit—Surrounding Coastal Zone of Serra do Tabuleiro State Park (Baixada do Massiambu, main theme of this paper).

Most of the occupied areas require regulation because they were occupied without government permission, being object of families without land tenure titles. In this way, there were no relevant legislation that could regulate the situation.

As the occupied areas were part of the Serra do Tabuleiro State Park, and it was created through Decree no 1.260/1975 under the administration of the Santa Catarina State Environment Foundation (FATMA), it would be incumbent upon the State Government to bar population development in those areas. An attempt was made to compensate the families who occupied the area in 1993, where the Administrative Discriminatory Process was established. It was carried out by the State Secretariat of Agriculture and Supply, together with the Public Ministry and FATMA. However, the Discriminatory Process was not finalized, impeding the legitimation of the properties until the present day. The lack of regulatory land tenure by the state government led to the approval of Law no 14.661/2009 that modified the limits of Serra do Tabuleiro State Park, where one of the objectives is to remove several conflicting areas (land conflicts) from the boundaries of the protected area.

In this context, considering the overlay between the Surrounding Coastal Zone of Serra do Tabuleiro State Park (Fig. 6) and the consolidated urban settlements already existent in the region of Baixada do Massiambu, it is important to develop tools to help land regulation, and ways to avoid construction and urban expansion over ecological relevant areas, like sand dunes, mangroves, wetlands, and river margins. One action toward this objective was set by the Environmental Protection Agency of the city of Palhoça (Brazil) (Fundação Cambirela de Meio Ambiente—FCAM) that now is responsible for stating whether energy supply may be authorized or not.

Aiming to provide consistent information for this problem, this paper aims to report the PEST history, collecting environmental characteristics and land use owned by the Environmental Protection Area of Surrounding Coastal of the Serra do Tabuleiro State Park, in the northeastern portion of the Baixada Massiambu, the locations of the Pinheira and Guarda do Embaú beaches, in city of Palhoça/SC, Brazil, in order to discuss the conflicts of the area in the face of the problems of ecological deterioration caused by human activities. It was also identified root causes of ecological deterioration problems, which could be relevant to legal frameworks, implementations or the forces of development, and also

classifies the areas into three categories according to the survey of environmental restrictions.

Regarding the problem presented, this paper proposes to present the main topics of Law no 14.661/2009, which instituted the Serra do Tabuleiro e Terras do Massiambu Conservation Units Mosaic, and also present the main differences between municipal limits and current limits of the Serra do Tabuleiro State Park, according to the State Law no 14.661/2009 and Decree no 3159/2010, and discuss the zoning of the Environmental Protection Area of the Serra do Tabuleiro Surrounding Coastal proposed by the State Decree no 3159/2010.

2 Materials and methods

2.1 Area of study

The Serra do Tabuleiro State Park (PEST) is located between the geographical coordinates 27°42′09″ to 28°07′42″ South latitude and 48°34′09″ to 48°57′13″ West Longitude, having its territorial extension defined in nine municipalities, State of Santa Catarina, Brazil (Fig. 2). The Park was created by Decree no 1.260/1975, amended by Decree no 17.720/82, and idealized by botanists and conservationists Raulino Reitz and Robert Klein (Bitencourt 2000).

The main studies were by Raulino Reitz, who defended the creation of the Serra do Tabuleiro State Park since the 1960s. He sent documentation to the Federal Forest Council, and Miguel Klein, who presented in 1975 during the XXVI Brazilian Congress of Botany,

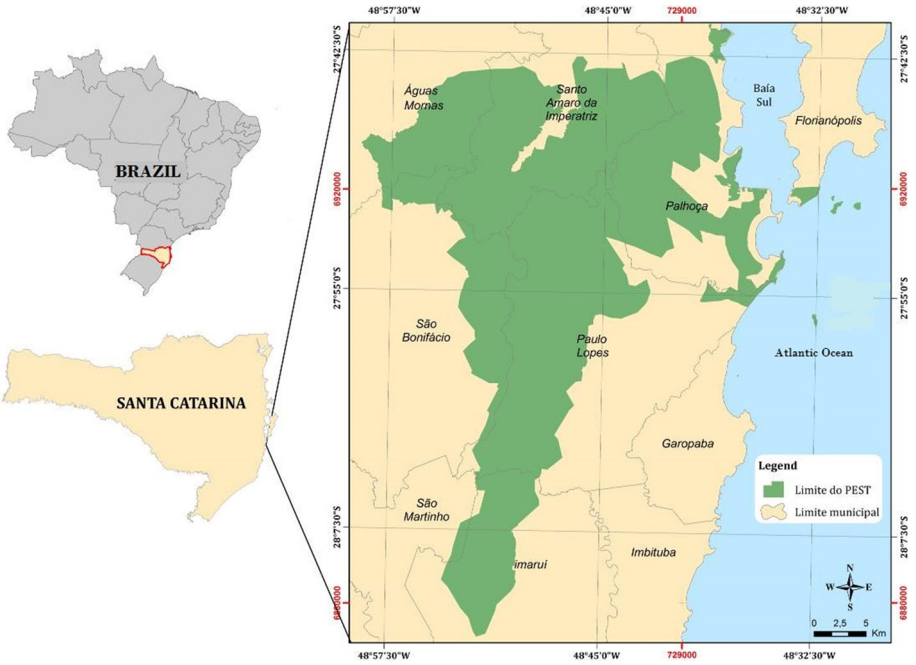

Fig. 2 Serra do Tabuleiro State Park. *Source*: Elaborated by Author

the thesis that the vegetation of Serra do Tabuleiro would only be preserved with the creation of a Forest Park (Bertho 2005), as well as the government of the State of Santa Catarina that, in agreement with FEMA—Foundation of the Environment of the State of Rio de Janeiro, carried out a survey in 1976, and proposed the first master plan for the Park, which considered that rural communities were incompatible with the park's objectives, and the only traditional community should be maintained within a historical-cultural zone was a village of artisanal fishermen—Vila da Pinheira (Amaral 1998), and also, in the year 1976, a research agreement was established between the U FSC—Federal University of Santa Catarina and FATMA—Foundation of the Environment of the State of Santa Catarina to identify the human occupation in the area of the park involving archeology, anthropology, sociology and history (Santos 1976).

According to information provided by the Environmental Foundation of the State of Santa Catarina—FATMA, the Park stands out for presenting five of the six phytogeographic regions of the State: Mangroves, Sandbanks, Dense Tropical Rainforest, Mixed Tropical Rain Forest, and Altitude Fields. Considering their ecological relevance, there are, at least, 27 endemic, rare or endangered species (Oliveira 2005), and it has been recorded ten new species of flora. Natural habitats support species of Brazilian fauna falling into the categories of endangered species of IBAMA (Brazilian Institute of Environment and Natural Resources) and international bodies. According to Oliveira (2005) endangered species include the Macuco (*Tinamus solitarius*), the jacutinga (*Pipile jacutinga*), the purple-breasted parrot (*Amazona vinacea*), the sabi-cica (*Triclaria malachitacea*), pavó-do-mato (*Pyroderus scutatus*), the howler monkey (*Alouatta fusca*), the puma (*Puma concolor*), and others.

The Pinheira Beach is located in the city of Palhoça, 30 km south from the center of the city. The beach is limited in the north by Papagaio Grande Island and in the south by Guarda do Embaú Hill. Originally, this area belonged to the Park area; however, in 1979, through Decree n. 8.857 of September 11, 1979, a strip of 500 m (13,082,968 km^2) was detached from the sea to the mainland, due to the pressures of the tourist expansion process (Fig. 3).

The region encompassed by the beaches of Pinheira and Guarda do Embaú, and it is composed of an alluvial plain, complemented by the addition of a strip of marine decomposition, vasosa and sandy, which presents mobile dunes of quartz sands and fixed dunes of dystrophic quartzose sand. The sedimentary deposits are evidenced by different levels of tidal activity that demonstrate the retreat of the waters and the existence of dunes, indicating the predominance of the northeast wind. The remaining dune cord of the region, formed by the expressive wind action, has been systematically modified by the anthropic action, which compromises its protective function against winds and tides, generating instability of the coast.

According to Murialdo (1999), this region is constituted of the following vegetations: vegetation of beaches and frontal dunes and vegetation of the internal dunes and plains. In the vegetation of beaches and frontal dunes stands out herbaceous vegetation, which has enough resistance to salinity, radiation and wind, as well as poor soil. On the other hand, the vegetation of internal dunes and plains is constituted predominantly by sub-shrub species, and there may be present some herbaceous and shrubs vegetation.

The development of the infrastructure began with the emergence of fishmongers, bakeries, butchers, warehouses, shops, headquarters of the Fishermen's Colony and the construction of the first school. However, this scenario was modified with the implementation of federal highways, and then, with the rise of economic activity, establishment of hotels, restaurants, bars was stimulated. Finally, with urban expansion, mechanical

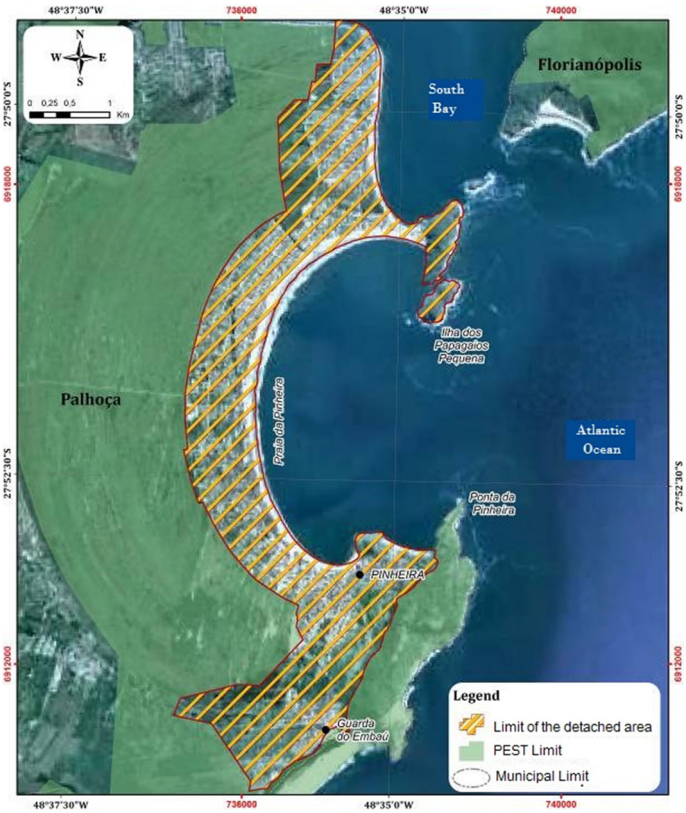

Fig. 3 Serra do Tabuleiro State Park and the detached area from the Park, stated by Decree n. 8857/1979

workshops, confectionery and handicraft shops, stationery stores and magazine stands were settled.

Therefore, for the quality of the beach and the landscape, today, the economy of the region is based on tourism. On the other hand, this activity has motivated a rising anthropic pressure with consequent environmental degradation, as a consequence of intense, disordered and illegal occupation in the dunes and the lack of infrastructure, it has all irreversibly compromised local environment performance and quality.

2.2 Applied research methods

Fieldwork allowed to identify environmental restrictions in the northeast portion of the Serra do Tabuleiro State Park and also enriching the understanding about the occupation history and socioenvironmental characteristics of the region. The objective of the field survey was to counteract the properties identified in the cartographic base of the real estate cadastre of the municipality of Palhoça with the real estate seen in the surveys carried out. Then, the type of use (residence, commercial, agriculture) and the environmental characteristics (vegetation, presence of water bodies and type of soil) were observed. From the identification of the environmental characteristics, mainly, it was defined which characteristics would be considered "environmental restrictions" for the use of the land.

For this purpose, field visits were carried out in the properties of the beach of Pinheira and Guarda do Embaú, in an area of 6 km^2, during the months of March 2012 to March 2014, with the intention of identify the ecological characteristics of the areas (presence of preserved vegetation, presence and type of construction, proximity to water courses, slope of the property and type of soil). After the survey, the ArcGIS software—remote sensing—was used to insert data with the characteristics of the area, where the zoning imposed by Law no 16/1993 and Law no 14.661/2009 were also compiled.

The survey of environmental characteristics and land use and occupation of lands belonging to the Environmental Protection Area of the Coastal Environment of the Serra do Tabuleiro State Park was possible from the elaboration of a synthesis of the main results observed in the development of the work, aiming at the survey Environmental characteristics and land use and occupation in the Environmental Protection Area of the Coastal Environment of Serra do Tabuleiro State Park. During the construction of the land use and occupation map and field maps, 03 (three) use classes were established (Areas with Total Restriction, Areas with Partial Restriction and Areas without Restriction), which are presented in Table 1.

Table 1 Interpretation keys used for the preparation of the field map *Source*: Elaborated by the author

Class	Description	Sample
Total restriction	Areas with environmental restrictions of ecological relevance, in which human settlement will not be allowed	
Partial restriction	Areas that have some restriction to be analyzed as a condition for the provision of environmental authorization for construction, either as a function of location, or because it is limiting to areas of ecological relevance, or due to the presence of environmental restrictions in part of the property	
Without environmental restriction	Areas of consolidated urbanization, with a high occupancy rate, in which streets are present, among other urbanistic attributes	

3 Results and discussion

3.1 Law enforcement problems

The lack of a Management Plan for the PEST carried to a never effectively implemented Area, due to conflicts of political and economic interests, land conflicts in the areas belonging to PEST and the re-boundary of its area, which underwent a series of

Table 2 Legal frameworks of the Serra do Tabuleiro State Park *Source*: Elaborated by author

Legislation	Date	Provision	Objective
Decree no 1.260	November 1, 1975	Creates the Serra do Tabuleiro State Park	Creates the Park with an area of 90,000 hectares
Decree no 1.261	November 1, 1975	Declares the public lands for the purpose of expropriation the land areas destined for the Park	Expropriation of all private lands inserted in the Park
Decree no 2.335	March 3, 1977	Declares as public utility for expropriation purposes the areas of land destined for the Serra do Tabuleiro State Park	Expropriation of islands, lakes, rivers and mangroves
Decree no 8.857	September 11, 1979	Provides for the detachment of areas of the Serra do Tabuleiro State Park and establishes other measures	Detachment of 3625 hectares occupied by 118 small farmers
Law no 5.746	August 11, 1980	Allocates resources for the land regularization of the Serra do Tabuleiro State Park	Allocates resources for damages for expropriations
Decree no 17.720	August 25, 1982	Rectifies the limits of the Serra do Tabuleiro State Park	Rectifies the limits of the Park in function of Decree n. 8,857/1979
Decree no 18.766	December 20, 1982	Declares as public utility for expropriation purposes the areas of land destined for the Serra do Tabuleiro State Park	Expropriation
Decree no 24.598	December 28, 1984	Provides for the implementation of the Serra do Tabuleiro State Park	Create the Implementation Group of the Serra do Tabuleiro State Park
Law no 10.584	November 11, 1997	Disposes of the Ponta do Papagaio area	Turn Ponta do Papagaio into a Special Protection Area
Law no 10.733	April 15, 1998	Changes the wording of the amendment law and Art. 1 of Law 10,584	Detachment of Ponta do Papagaio
Law no 14.661	March 26, 2009	Rectifies the limits of the Serra do Tabuleiro State Park	Create the Mosaic of Conservation Units Serra do Tabuleiro and Terras do Massiambu
Decree no 3.010	February 24, 2010	Declares as public utility for expropriation purposes the areas of land destined for the Serra do Tabuleiro State Park	Expropriation
Decree no 3.159	April 24, 2010	Regulates and defines guidelines for the implementation of the Environmental Protection Area of the Coastal Environment	Deals with administration, Deliberative Council, zoning and Management Plan
Decree no 3.446	August 10, 2010	Rectifies the limits of the Serra do Tabuleiro State Park	Expropriation

modifications. Altogether the Serra do Tabuleiro State Park had fourteen legal marks. Table 2 presents the legal frameworks to which the Serra do Tabuleiro State Park was subjected.

For Amaral (1998), these successive decrees of annexations and detachments of the Park, with consequent alteration of the limits, have entailed difficulties in the precise identification of its limits. According to Gaio (2005), the difficulties encountered for the implementation of the Park have been justified by the lack of financial resources, personnel, political will and also adequate planning. The implementation has not taken place until the present day bringing serious consequences that continually increase the conflicts of interest in the area.

3.2 New zoning of Serra do Tabuleiro State Park and Law no 16/1993

In 2009, it was approved the State Law no 14.661/2009 that redefined the PEST limits, being that some areas that constituted it, were transformed into Sustainable Use Conservation Units, through the institution of the Serra do Tabuleiro e Terras do Massiambu Conservation Units Mosaic.

The Serra do Tabuleiro e Terras do Massiambu Conservation Units Mosaic has an area of 98,400 hectares, and it is composed of four different State Conservation Units, defined and conceptualized as its environmental, social, economic and land characteristics. They are Integral Protection Unit—Serra do Tabuleiro State Park; Sustainable Use Unit—Vargem do Braço Environmental Protection Area, Vargem do Cedro Environmental Protection Area, Environmental Protection Area of Serra do Tabuleiro Surrounding Coastal (Fig. 4).

Through the institution of Mosaic, the total area of the Park fell to 84,130 hectares, with most areas detached from the original area of the Park already occupied with approximately 2500 buildings and also by a majority of squatters and trespassers (FATMA 2006). Already the Environmental Protection Area of Serra do Tabuleiro Surrounding Coastal encompasses an area of approximately 5260 hectares, and it has the following main objectives: sustainable development of coastal communities, environmental protection and ecological value of the remaining areas of rainforest and ridges; environmental preservation, the land occupation, the disciplining of tourist and recreational use, the environmental protection and rehabilitation of occupied areas, and planning of the popular and tourist allotments.

Mosaics also created three Sustainable Use Units, the Environmental Protection Areas (APA): Vargem do Armamento APA was established with an area of 935 hectares and Vargem do Cedro APA with an area of 1.420 hectares. These two Conservation Units have the following objectives: the sustainable development of communities; protection of water sources; the planning of the occupation, land and water use; the disciplining of tourism and recreational use; sustainable forest and agricultural exploitation and protection; the protection of the remnants of mid-Atlantic forest and advanced regeneration; and the development of the agroecological model of rural production and respect for the rural preservationist man, through the payment of environmental services.

The APA of the Coastal Environment, third one, covers an area of approximately 5.260 hectares and has the following objectives: the sustainable development of coastal communities around the PEST; the environmental protection and the ecological value of the remaining areas of Atlantic forest and coastal strands; the harmonization of environmental preservation with the planning, sustainable and rational use of the region's natural resources; the planning of the occupation, land and water use; the disciplining of tourism and recreational use; the protection and environmental recovery of areas occupied by rural

Fig. 4 Serra do Tabuleiro e Terras do massiambu Conservation Units Mosaic and the Environmental Protected Areas. *Source*: Adapted from Diário Catarinense—04/03/2009

and non-rural owners, with a view to preserving the biotic and economic value; the organization of scientific research activities and technological production in the area of sustainable civil construction; and the planning of tourist and popular subdivisions, guaranteeing the implementation of sanitation works and environmental recovery.

The APA of the Coastal Environment is also linked to a zoning, in accordance with the provisions of Article 22 of Decree 3.159/2010, which is composed of the following zones in the study area (Baixada do Massiambu—Palhoça/SC):

1. Special Protection Zone—SPZ: consists of not buildable areas reserved for the recovery and environmental protection, including Permanent Preservation Areas—PPA. Subdivided into subcategories: A, B, C, D, E, F, G, H and I.

The areas designated for special protection zone are nine distinct regions of the Surrounding Coastal Protection Area. The SPZA, SPZD, SPXH and SPZI correspond to areas with preserved vegetation and/or present sand ridges, being that some of them have buildings in their limits. SPZH and SPZI corresponding, respectively, to the Papagaio's tip and Papagaio's Island. These areas have native vegetation, and areas that have been framed buildings in another area: Sustainable Residential Use Zone. This fact comes against in what contained in Law no 16/1993, in which these areas are classified as Permanent Preservation Areas (PPA), and therefore are areas "non aedificandi" with them prohibited

the removal of forest and from other forms of native vegetation, exploitation and destruction of stones, as well as solid waste disposal and any form of land subdivision.

The areas ZPEB, ZPEC, ZPEE, ZPEF and ZPEG corresponds to the Permanent Preservation Areas of watercourses, representing a range of at least 30 (thirty) meters from the banks of the river. However, it is emphasized that in these protective strips from the banks of the watercourses exists buildings, which contrasts with the finality of preserving this region. Only the areas SPZE, SPZF and SPZG are preserved.

2. Sanitation and Public Use Zone—SanitPZ: consists of public domain or private areas, to be reserved for the installation of equipment for public or social interest, for the treatment of water and wastewater storage and treatment of solid waste or the development of leisure and recreation areas. Subdivided into subcategories: A, B and C.

Three of these areas (SanitPZA, SanitPZB and SanitPZC) are located next to watercourses, and therefore, they are ideal for installation of equipment for the treatment of water and wastewater. However, due to this same fact, it is important to emphasize the importance of respecting the limits established by the Permanent Preservation Areas in this region. About the reservation of these areas for storage and treatment of solid waste, this is not ideal, due to the proximity to water course, taking into account the possibility of entrainment of these materials, and the resulting contamination of water resources.

Moreover, the fourth area for Sanitation and Public Use Zone (SanitPZD) is located in an area that has sand bars and should be fully preserved. In addition, according to the Municipal Law no 16/1993, this area is classified as Permanent Preservation Area, only allowing public use whenever necessary.

3. Sustainable Housing Use Zone—SHUZ: consists of public domain or private areas, reserved for the development of real estate and tourism ventures, as well as activities and services for retail and other commercial enterprises of small environmental impact and that does not generate hazardous waste or oily effluents and chemicals.

In general, the areas reserved for the Sustainable Housing Use Zone are characterized by areas which are already highly urbanized. However, the area ZUHB has buildings on the banks of a body of water, the region should be fully preserved, according to Law no 12.651/2012 and Resolution of CONAMA (National Council of the environment) no 303/2002, and the area SHUZC presents occupation in sand ridges, and is limited to allow more families to settle on this region, since it has voids in areas with relevant ecological features. The SHUZL area, despite being quite urbanized, also features buildings on the banks of a water body, as well as having an area of salt marsh wetland bounded to allow the occupation, facts at odds with the established by Law no 12.651/2012.

With the enactment of Law no 14.661/2009, it was found that there was no adequate legislation at the municipal level (Law no 16/1993), objecting order the occupation of areas those are removed from the boundaries of this conservation area and grouped in the Sustainable Housing Use Zone, being that part of these areas follow as Permanent Preservation Areas at the municipal level.

4. Sustainable Economic Use Zone—SEUZ: consists of public or private areas, reserved for the economic development of rural communities and support services to Sustainable Housing Use Zone.

This zone is bounded by three areas located in the northern portion of the Serra do Tabuleiro Surrounding Coastal. Characterized by being small and mostly rural

communities, but having buildings near to the banks of the watercourse, which do not comply with the provisions of relevant laws regarding the Permanent Preservation Areas and, the SEUZC presents areas that must be retrieved to reach the objectives of this zone.

5. Sustainable Industrial Use Zone—SIUZ: consists of public domain or private areas, reserved for the implementation of secondary sector activities and complementary activities.

The Sustainable Industrial Use Zone (SIUZ) is located on sandy ridges and features preserved vegetation, as well as few, and mostly no human interference, related to buildings. It must be observed that industrial activities are potentially polluting activities, classified by Resolution of CONSEMA (Environmental State Council) no 001/2008, and, in most cases, generate waste and toxic effluents on their final stage of production. Thus, the industrial activities should be installed in areas already disturbed, which does not occur in the zoning established, since they are in conservation areas with significant natural features, and even limiting the Special Protection Zone. Currently, at the municipal statement, these areas are Permanent Preservation Areas, according to the zoning provided by current Master Plan.

6. Sustainable Touristic Use Zone—STUZ: consists of public or private areas reserved for construction of tourist complexes that generates jobs and income, linked to environmental compensatory measures designed to the environmental recovery of surrounding area.

The four areas for Sustainable Touristic Use Zone consist of blocks from the Pinheira beach, adjacent to already urbanized areas, partly preserved, with relevant natural features, and that three of these areas (STUZB, STUZC and STUZD) shows traces of strands sandy dunes. It is important to note that Pinheira beachfront is almost urbanized, and the areas reserved for the Sustainable Touristic Use Zone represent the last areas that are still preserved in this region.

7. Regularization Housing Zone—RHZ: consists of public domain or private areas, identified as illegally occupied, demanding for redevelopment measures for sanitation and environmental protection.

Areas located in three of Regularization Housing Zone are densely populated and they are areas which have had their occupation held irregularly, from the legal and environmental standpoint. The RHZA located near a watercourse on Pinheira beach, where buildings border the river banks; the same occurs in RHZC in Guarda do Embaú, where buildings also border on the existing body of water, the Madre River, noting that the houses do not have sewage collection and treatment,

8. Water Abstraction Zone—WAZ: area primarily intended for water use.

The region of Water Abstraction Zone is located in the vicinity of the Madre River in the southern portion of the Serra do Tabuleiro Surrounding Coastal. This region is adequate for this purpose, since that the Permanent Preservation Areas are obeyed, which consists of a range of at least thirty (30) meters from the banks of the river, at the time of installation of the structures needed to capture and water supply of the region.

The distribution areas may be visualized in Fig. 4. The study area is still tied to a municipal zoning, indicated on Law no 16/1993, which provides the zoning of land use and occupation of the territory of Palhoça. In Section X of this Law is discussed about the Permanent Preservation Areas, in which highlights:

> Art 116: The Permanent Preservation Areas are "non edificandi", except for the public uses, it is forbidden to remove the forest coverage and other forms of native

vegetation, exploitation and destruction of stones, as well as the deposit of solid waste and any form of land division.

Among the PPA are highlighted the dunes, where it is forbidden the circulation of any motor vehicle, the change of emphasis, the sand extraction and construction of walls and any kind of fences; the mangroves, where it is forbidden to cut vegetation, the landfills and the prohibition of releasing wastewater pollutants, the water sources, springs, water catchment areas and marginal strips of ponds, streams and water reservoirs, which is prohibited the suppression of any size of vegetation, the release of any effluent and the use of pesticides, insecticides and herbicides; and the beaches, dunes and marshes, not being allowed to build ramps, walls, fences, as well as the extraction sands, or opening roads.

In contrast to the scenarios specified above, it was observed that, with the establishment of the Coastal Environment Protected Area, it was triggered occupation in protected sites. The scenario was observed from the point of view of environmental restrictions provided by federal legal provisions (dunes, mangroves, marginal strips of watercourses, among others), as well as areas that protection was established in the municipal scope by the current Master Plan, and do not have support capacity to receive population density.

3.3 Survey of environmental characteristics and use and occupation of soil

The fieldwork allowed the survey of 6.501 lots on the beaches of Pinheira and Guarda do Embaú, in an area of approximately 6 (six) square kilometers. The classification used for surveying the environmental restrictions visualized in the field works were: Areas with Total Restriction, Areas with Partial Restriction and Areas without Restriction. Of the 6501 surveyed lots, 4.982 properties (77%) had no environmental restrictions, since they were characterized to be settled in areas already urbanized, which where not located within the Permanent Preservation Areas (PPA) and did not limit the Conservation Unit. These areas are those in which the occupation is allowed, as long as guidelines established by the current environmental legislation are followed.

The main constraint scenarios identified in the field and analyzed were: presence of dunes; areas of wetlands; advance of the occupation toward the limits of the PEST, and its respective zone of cushioning, in which the human activities are subject to some rules of occupation; and buildings near the waterways, which configure urbanization in areas of permanent preservation, based on CONAMA Resolution 302/2002, CONAMA Resolution 303/2002 and Law 12.651/2012.

It should be noted that the largest agglomerates of "unrestricted" lots are located in the central part of the Baixada do Massiambu, in the Pinheira beach development (Fig. 5). Also, correlating the field data with the Coastal Environment of the Serra do Tabuleiro State Park Protected Area, on Guarda do Embaú, most of the lots that do not have environmental restrictions are located in the Zone of Habitation Regularization (identified with lines Red in Fig. 5) and Sustainable Housing Usage Zone (identified with pink lines in Fig. 5). In the central part of the Pinheira beach, lots without environmental restriction are also found in the Areas of Sustainable Housing and Housing Regularization.

The areas classified as "Partial Restriction" were those that had some type of environmental restriction, which restricted the total occupation of the lot, such as dunes, wetland areas, Permanent Preservation Areas and Conservation. These areas corresponded to 13% of the total number of lots, totaling 851 lots with this classification and an area of approximately 0.96 km^2.

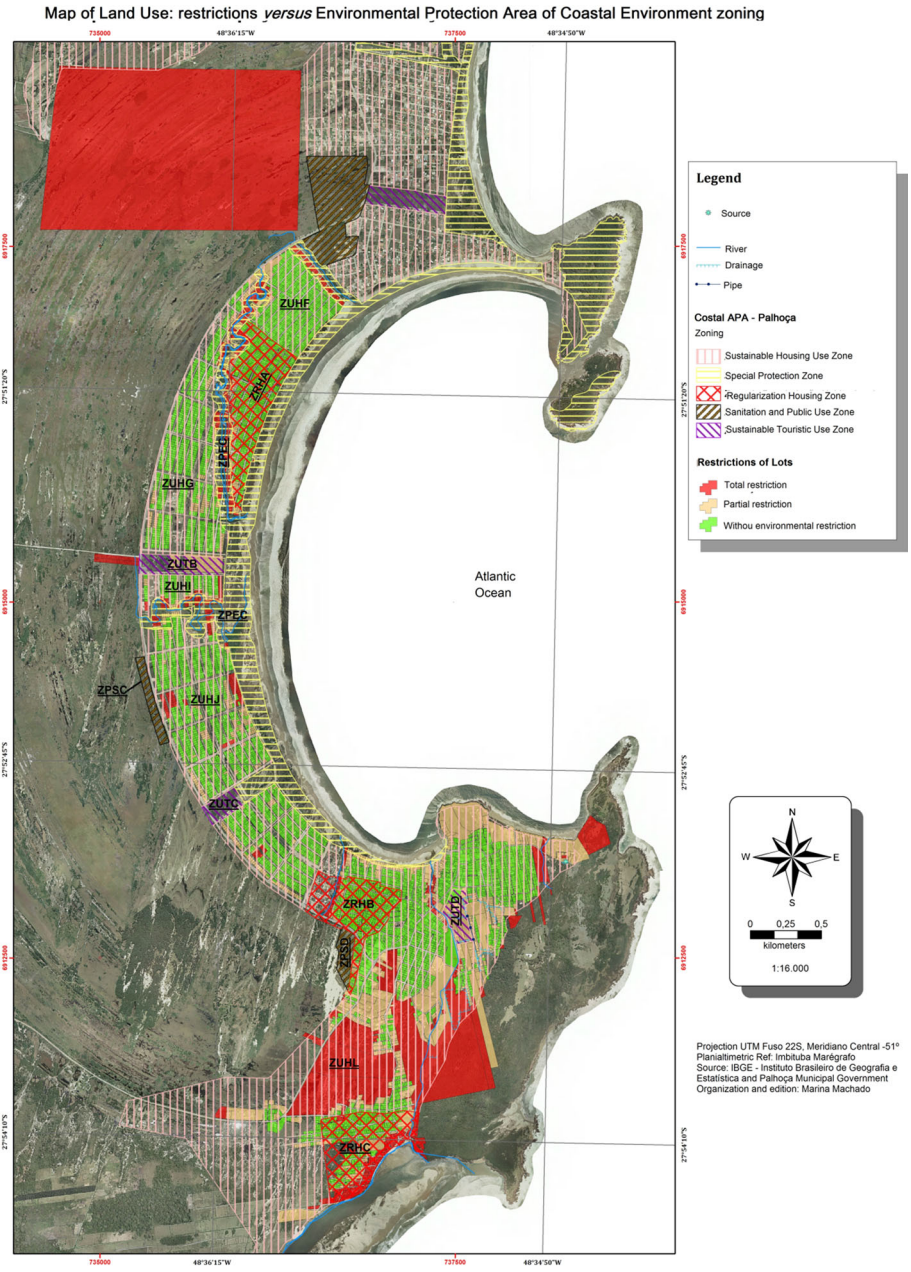

Fig. 5 Map of land use and occupation: restrictions versus coastal environment protected area. *Source*: Elaborated by Author

In the area of the beach of Guarda do Embaú, the partial restrictions found were mostly due to the Permanent Preservation Area of the existing watercourse, the Madre River, which has a width up to the margins of more than 100 (one hundred) meters, and as a

result, the preservation range should be 100 (one hundred) meters. The lot that received the classification CRP 35 is located in the southern portion of Guarda do Embaú and is an example of the existence of buildings near the waterways, in areas of permanent preservation. As an example of the presence of dunes in real estate, we have the lot with classification CRP 11, also in the southern part of Guarda do Embaú. Still, as an example, we have the lot classified as CRP 62 that has a fairly preserved vegetation in Guarda do Embaú. In the region, it was also found an area of sandbank swamp vegetation, which was restricted to the classification of area with "total restriction" and the bordering real estate with "partial restriction" (Fig. 6).

With respect to coastal zone, most of the lots that have partial restrictions on Guarda do Embaú are located in the Sustainable Housing Use Zone, where occupation is permitted, except for areas reserved for preservation. In Pinheira beach were found the same situations already reported for Guarda do Embaú. It is noteworthy that in the region there was a place where rainwater drainage works were carried out to drain the water to the sides of the land, leaving them ready for use. The properties near the drainage area were classified as "partial restraint" lots, in addition to those that the entire land was in a permanent preservation area due to drainage, and which were classified as "total restriction" lots. The drainage ditches found did not have connections that would allow the success of their operation, and still, the buildings did not respect the adequate spacing of these ditches (Fig. 7).

Fig. 6 **a** Lot with partial restraint, in an area of permanent preservation of watercourse; **b** Lot with partial restriction, in an area with dunes; **c** Partially restricted lot, in an area with preserved vegetation; **d** Presence of sandbank flooded, being the property subject to classification of "total restriction", and the bordering lots with "partial restriction". *Source*: Elaborated by Author

Fig. 7 Drainage ditches found on lots on Pinheira beach. *Source*: Elaborated by Author

Another situation also found in Pinheira was the existence of a possible source in the right coast of the locality known as "praia de Cima". It should be noted that the classification of the water body can be affirmed only through a hydrological study that takes into account the temporal analysis of the site. According to Law n. 12.651/2012 perennial springs and water eyes are considered Areas of Permanent Preservation and a radius of at least 50 (fifty) meters must be respected for its preservation (Fig. 8).

In Pinheira beach, lots with partial restrictions were found in the Sustainable Housing Use Zone, in the Sustainable Tourism Use Zone and in the Special Protection Zone. There are two Areas of Sustainable Tourism Use that contain areas with partial restrictions, one of them (STUZd) in the locality of the "praia de Cima", in Pinheira, where lots have some buildings, as well as a preserved vegetation (Fig. 9); and the STUZb that is in the central portion of Pinheira; in this place facilities of an non-operational hotel remain in place. It should be noted that STUZb (Fig. 10) consists of four lots, but three of them are legally registered in the responsible body, and the third does not have real estate inscription, and therefore no uses are allowed, and that despite the installation of the old hotel, there are portions of the area that are still preserved, such as vegetation and dunes, a fact that should be encouraged to preserve and maintain the area, since it is one of the few areas still preserved on the shore of Pinheira beach.

The Special Protection Zones that present lots with partial restrictions refer to the Permanent Preservation Areas of the existing watercourses in the study area, and the

Fig. 8 **a** Possible headwater found in the locality of Cima beach, Pinheira beach; **b** Plumbing system that may be used for collecting water from the possible source observed. *Source*: Elaborated by Author

Fig. 9 Lots that compose the STUZd, some of which are already occupied and others still with preserved vegetation. *Source*: Elaborated by Author

Fig. 10 Lots of SUTZb, place of installation of old hotel *Source*: Elaborated by Author

preservation area does not encompass the entire land, thus being able to the unprotected portion of the lot (Fig. 11). The areas classified as "Total Restriction" were those found within the Serra do Tabuleiro State Park (10% of total covered lots), which had the totality of the Permanent Preservation Area of existing watercourses and which had environmental restrictions on the land use, such as dunes, preserved vegetation, sandbank vegetation, water courses and headwaters.

In Guarda do Embaú, the total restrictions lots presented preserved vegetation (Fig. 12a, b), properties located in Permanent Preservation Areas (Fig. 12c, d), lots with presence of

Fig. 11 Lots of the Special Protection Zone (SPA), which refer to the permanent preservation areas of the watercourses. *Source*: Elaborated by Author

dunes (Fig. 12e–h), and lots within the area reserved for the Serra do Tabuleiro State Park. Contrasting some of the areas with total restrictions in the Guarda do Embaú with the Coastal Environment Protected Area, it can be noted some specific situations of concern: most of the properties located in protected areas of the Madre River are in the Habitation Regularization Zone, identified as irregularly occupied, with undesired occupancy rates, and requiring reallocation measures for sanitation and environmental protection purposes; and large lots, some of them limiting to the Park, are in the Sustainable Housing Use Zone, which is reserved for the development of real estate or tourist initiatives, as well as commercial activities and services and other small environmental impact projects that do not manage hazardous waste or oily and chemical effluents. It should be noted that in the Guarda do Embaú, there is no Special Protection Zone, according to the established zoning, which should exist mainly in the existing preservation areas, as well as in properties that limit the Conservation Unit.

In Pinheira, the total restrictions found also referred to lots within the Park, preservation areas of the watercourses (Fig. 13a, b) and a headwater found in the locality of "praia de Cima", areas with presence of dunes (Fig. 13c–e), with vegetation preserved in the entire land (Fig. 12f) and sandbank swamp area (Fig. 13g, h).

Correlating the restrictions observed in the field, it was noticed that the environmental restrictions are limited to three zones established by Decree n. 3.159/2010, Sustainable Housing Use Zone, the same as in Guarda do Embaú. That these areas permit the installation of projects, as opposed to what has been observed in the fieldwork, since areas with total restriction have the environmental restrictions already described above, in every part of the land; Zone of Housing Regularization, which need corrective measures and occupancy control, also in contrast to what is observed in fieldwork; and most of the Permanent Preservation Areas related to watercourses are located in Special Protection Areas.

It is noteworthy that most of the occupied areas with environmental restrictions are family owned, in a region that was owned by the Santa Catarina government. In the 1970s, the Park had a total population of 217,063 inhabitants; in 2007, this contingent was 584,489, which mean a population growth of more than 169%. In 1993, the Administrative Discriminatory Process was established; it was carried out by the State Secretariat of Agriculture and Supply, together with the State Prosecutor's Office and FATMA, and from September 1996 to August 1998, SDA and FATMA carried out the Registration Funding of PEST. The Registration was carried out, but the Discriminatory Process was not finalized; therefore, inconclusive results were obtained on the actual situation of the deeds. Thus, the

Fig. 12 Areas classified as "Total Restriction" on the beach of Guarda do Embaú. **a**, **b** Area of vegetation preserved; **c**, **d** Areas of permanent preservation related to the preservation belt of the Madre River; **e**–**h** Areas with dunes. *Source*: Elaborated by Author

Fig. 13 Areas classified as "Total Restriction" on Pinheira beach. **a**, **b** Permanent preservation areas; **c**–b Dune areas; **f** Area with preserved vegetation; **g**, **h** Sandbank swamp area. *Source*: Elaborated by Author

necessary information for the procedure of discrimination of the areas and the confirmation of the extremes of the properties were compromised, and the investigation necessary to clarify the real land situation of the region was affected and therefore hindered the legitimization of the ownership of the lands until now (SDS/FATMA 2002).

In addition, the first indemnities in the Serra do Tabuleiro State Park occurred in the years 1980 and 1981 in areas of the municipality of Santo Amaro da Imperatriz and São Bonifácio. In November 1996, new indemnities occurred, from a property of Companhia Madeireira de Santo Amaro da Imperatriz (CIAMA), in the municipality of São Bonifácio. This indemnification occurred as a result of an agreement between the State and the company, covering an area of approximately 4,200 hectares (Gaio 2005). From 1995, and especially in 1997, activities aiming to implement the Conservation Unit highly impacted indirect use of natural resources, such as agroforestry management hunting and exploitation of raw materials. According to SNUC legislation the population residing in the area must be compensated, but according to Ana Cimardi, director of environmental affairs of FATMA in 2005, it is unknown to foresee when or whether if owners will be compensated. Meanwhile, inhabitants of the park must follow an Adjustments of Conduct protocol, committing themselves to restrict their economic activities in the perimeter of the Park (Bertho 2005). In addition, the Park administration has not been able to regularize land occupations until the present day, and with Law 12.651/2012, the indemnification situations were remedied by redefining the limits of the Park.

Territorial conflicts are also perceived in the Amazon (Brazil). Rezende et al. (2017) demonstrated some problems of environmental degradation in the state of Amazonas, Brazil, where about 50% of the territory is under the order of protected area, including 27% Indigenous Reserves and 23% of state and federal management reserves. It could be inferred that the demarcation process and institutionalization of the protected areas are territorial disputes, but along the deployment of the politics and governance, these differences are reduced to the minimum by means of the social participation of stakeholders. However, it was not only in protected areas of Brazil that several conflicts were perceived in the face of the preservation of the restrictive area to the occupation and the local community.

Ruschkowski (2009) studied the occupancy in the Harz National Park, located in the North German low mountain range, to identify and analyze existing and potential conflicts between park management and the local population. Bragagnolo et al. (2016) studied the benefits, needs and constraints related to Pico Natural Park as perceived by local stakeholders through face-to-face semi-structured interviews. Results showed the divergence between the Park's rules and local development, showing inconsistency between local expectations and regional conservation policy. This highlights the importance of public participation prior to any implementation of conservation strategies. Also, in marine zone, these conflicts appears; Xie et al. (2014) applied remote sensing images and environmental and socioeconomic data to analyze the change of land use and land cover in Yellow River Delta, China, and identified the driving forces for these changes from 1986 to 2010. The results show that land use has changed significantly over this period and types of conflicts are land use conflict, oil field exploration and wetland protection conflict, management conflict, and environmental conflict.

4 Conclusion

It was observed that with Serra do Tabuleiro Surrounding Coastal establishment began the occupation in areas of PPA and in areas with other environmental restrictions, showing the inability of the area to support the population density, due to the urban structure already installed. It may also be noted that established zoning displays some inconsistencies, for instance, land use is often linked to areas where environmental characteristics are not considered. It was observed the existence of industrial areas in conservation areas, areas for tourism development, non-urbanized still preserved areas and areas for environmental protection. Moreover, it was observed that the expansion of areas intended for residential and tourist use into areas of relevant ecological characteristics and currently preserved.

A survey of 6501 properties in the Pinheira and Guarda do Embaú areas resulted in a total of 77% of the lots without environmental restriction, 13% with partial restraint and 10% with total restriction. In front of this, it was noticed that with the redetermination of the PEST some detached areas have great ecological relevance and environmental restrictions that prevent human settlement and that they must be preserved, in accordance with the current environmental legislation, as well as the municipal boundaries, which did not changed.

This paper contributes to the understanding of the Baixada Massiambu problem, in regard to land use for, environmental planning, discussing mechanisms of reorganization of the territory, seeking balance between different forms of natural resource use. It has been observed that it is possible to formulate measures of environmental protection and recovery for this region.

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