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Impacts of recreational campsites on salt marsh vegetation structure at Puruba Beach, São Paulo, Brazil

Impactos do campismo recreativo sobre estrutura da vegetação da restinga na Praia Puruba, São Paulo, Brasil

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Abstract

Campsites can impact the vegetation structure by changing the forest composition and causing a loss of vegetation cover and organic matter. The aim of this study was to analyze the impacts of campsites over the vegetation structure of the salt marsh (restinga) in Puruba beach, Ubatuba, São Paulo, Brazil. For this, we estimated canopy cover, herbaceous cover, tree basal area, tree density, *Bromelia antiacantha* Bertol abundance and litter thickness in 20 old campsite areas and 20 control quadrants. We estimated that 26% of the salt marsh area was affected by camping activities. The vegetation structure varied across areas with and without recreation activities. The result shows higher mean values in areas without camping for canopy cover, herbaceous cover, *B. antiacantha* abundance and litter thickness. We found no differences in tree basal area and tree density. This finding can be attributed to the fact that campers are not cutting large trees to make their campsites because they are likely to prefer using areas that have already been opened. This type of behavior makes the herbaceous stratum to be more affected by user intensity and frequency than tree stratum. We did not find a significant relationship between vegetation structure and clearing size of campsites. This result indicates that the recovery rate is slow regardless of the size of impacted area making salt marches areas fragile environments for recreational campsites and some life forms are more negatively affected than others. An alternative to carry on this kind of outdoor activity in Puruba Beach is to implement facilities for users to camp in open areas with easy access to the beach.

Key-words: camping; recreation ecology; vegetation structure; *restinga*

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Introduction

Nature-based tourism activities in Brazil have sharply increased in recent years. Despite being recognized as an important tool for conservation, nature-based activities can damage the environment where they take place if not adequately managed. Camping is a popular outdoor activity in Brazil, but it has the potential to generate negative environmental impacts; mainly because it is often concentrated in small areas over a relatively long period (COLE, 1992; PICKERING, 2010). Reid and Marion (2004) found that the effects of only one night camping is sufficient to cause a significant impact related with cooking and sleeping.

Recreational campsites can cause a negative impact on the environment by changing the vegetation composition, fostering a loss of vegetation cover and organic matter and consequent exposure, causing soil compaction and erosion, damaging and causing a loss of shrubs and trees cover, polluting water, and disturbance to wildlife (COLE, 1987; LEUNG; MARION, 2000). The most significant impacts are those that disrupt the function of ecosystems, occur in large areas, affect rare ecosystems and cause changes irreversible in long-term (COLE, 1990; TWARDOCK et al, 2010).

Different factors influence user impacts on campsites (PICKERING, 2010). Trampling is a major contributor to vegetation cover loss in areas of trekking and campsites because this activity can damage parts of the plant or promote the complete removal from the soil (COLE; MONZ, 2002; SMITH; NEWSOME; ENRIGHT, 2012). The vegetation in campsites are exposed to the direct effect of trampling through mechanical damage and indirect effect in soil alterations of physical and chemical processes that modify plant growth, seedling establishment and, consequently, changes the plant population structure (HAMMIT; COLE, 1998; BARROS, 2003). This is particularly visible with the prevalence of old and middle-aged trees in campsites areas due to a lack of reproduction structure (HAMMIT; COLE, 1998). Impacts of camping are a function of the intensity, characteristic of use and the resilience of the environment. Therefore, analysis of the temporal and spatial variations of the disturbance is important to assess the magnitude and extent of campsites impacts on existing vegetation (MARION; COLE, 1996).

The temporal variation considers the duration and intensity of disturbance. The acute disturbance is defined as a disturbance of short duration but with higher intensity, i.e., several consecutive days of permanence in the same campsite but with low local frequencies of use (COLE; MONZ, 2003). Chronic disturbance is defined as a disturbance that occurs frequently and in the same site but with fewer consecutive days (COLE; MONZ, 2003). Cole (1982) observed that in cases of acute disturbance the loss of vegetation is substantial while in chronic disturbance the additional increase in use was not proportional to an increase in additional impacts. Thus, the impact increases rapidly during the first year, then increases slowly until becomes stable when any impact that could happen has already happened (COLE, 1982, 1995).

The campsite area increases in size and conditions of degradation over time (COLE; HALL, 1992). This spatial variation of the vegetation loss in campsites areas can be described by different models, such as by the multiplication of the percentage of vegetation loss by total disturbed area (COLE, 1982). Some studies show the importance to focus on spatial layout of camping activities to minimize the negative effects caused by campers (COLE, 1995; LEUNG; MARION, 2000).

The type of vegetation is directly related to their speed of recovery after impact. Cole and Monz (2003) showed that in some areas, meadows have recovered completely within a year at the intensities employed, but the local forest, even in areas used for only one night, did not recover completely during the same period. It is apparent that a difference exists between the resilience and resistance among plant species. These differences were also recorded in the work conducted on the same ground plant communities (COLE; MONZ, 2002). The different resistance makes the composition of vegetation tend to turn to the most resistant species (HAMMIT; COLE, 1998).

Places with a predominance of salt marsh vegetation are very popular for the practice of recreational camping since they are close to the beaches sought by bathers. Hence, these ecosystems can be compromised not only by coastal development but also by the inappropriate use of recreationists. This is the case of Puruba beach in the state of São Paulo, Brazil. The salt marsh vegetation in this area was used for camping activities for a long time but the activity is now prohibited. Therefore, the aims of this study was to (1) estimate the percentage of the salt marsh vegetation that was affected by camping activities in Puruba beach, (2) evaluate the changes in vegetation structure in its old campsites areas and (3) examine whether there is a relationship between clearing area of campsite size and its recovery post-camping.

Methods

This research was conducted in Puruba beach, Ubatuba, located on the northern coast of São Paulo (23 ° 21' 14" S 44 ° 56' 03" W). The vegetation in the study area is classified according to criteria proposed by Duarte (2004), which is low non-flooded salt marsh forest in low to medium stages of regeneration. This forest has an aspect of xerophytic vegetation composed of a large number of trees with stems branched from the base. There is a predominance of shrub trees that reach 3 to 5 feet in height, sparse herbaceous, and a large number of terrestrial bromelia, such as *Bromelia antiacantha* Bertol. and *Neoregelia cruenta* (R. Graham) LB Smith.

Puruba beach has an approximate salt marsh area of 11, 200 m². According to reports from local residents this area has been used for camping purposes for more than 10 years, but there were no reports of fires in the salt marsh. We identified an average of 80 tents per season with an average of three tents per campsite. There were more than six campers per group and the average number of days per groups was more than seven days. The campsites faced the ocean and there was no track record of vegetation in the campsite facing the river Puruba. The practice of camping on this site was legally banned in the late '90s.

Data collection occurred in July 2005. With the help of locals, was located 20 sites used as campsites. We measured the size of the campsites and the distance between each site and the beach. Measurements of longer and shorter side of the clearing were converted into area by the the ellipse formula = Pi. A x B (A longer side and B shorter side). This equation approach was done because most of the campsites were shaped in an ellipse. In each of these 20 campsites we demarcated a quadrant of 36 m² (6m x 6m) and 10 meters of distance. We also marked a control quadrant with the same area (Fig. 1). Inside each parcel we distributed nine points of data collection (Fig. 2). We measured: canopy and herbaceous cover, diameter at breast height (DBH), abundance of *Bromelia antiacantha*, litter thickness and density of trees greater than 1 meter. The canopy cover was estimated visually by means of projection of trees, which determined the ratio of the areas covered or not covered and by calculating the coverage percentage of the entire quadrant. The same procedure was performed to measure herbaceous cover, just changing the observation direction at the ground. The basal area was obtained by DBH measurements using the formula: $(DBH^2)*(Pi/4)$. Vegetation data from control and camping areas were compared using Wilcoxon T test ($P \leq 0.05$). A comparison of vegetation structure with the size of gaps from camping activities was analyzed using Gamma correlation.

(A)

(B)

Figure1. Images of study area. (A) old campsite area and (B) control area

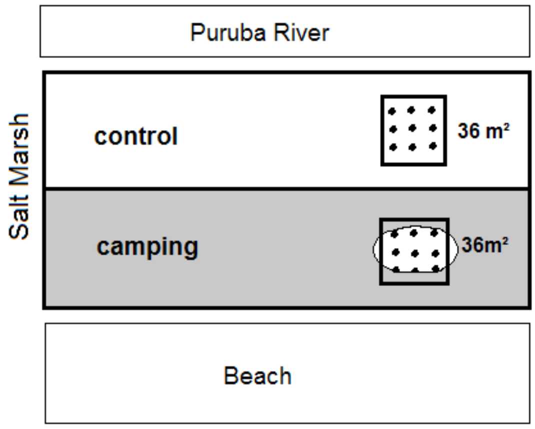

Figure 2. Quadrants' distribution and points of data collection. The gray rectangle represents the salt marsh area used by campers. The white rectangle represents the control area, which has never been used by campers. The small squares represent ours quadrants and the black dots show the distribution of data collection inside each plot.

Results and Discussion

The total estimated area for the salt marsh on the Puruba beach is approximately 11,200 m². The area occupied by the campsites was 2,899 m². This means that approximately 26% of the overall vegetation has been affected by camping activities. This value could, however, be higher than described. Leung and Marion (2000) argue that campsite impacts can influence adjacent areas by increasing in two or three times the area impacted and by continuing to affect vegetation even after the disturbance has ceased (MARION; COLE, 1996), which is the case of Puruba beach campsites.

Results show different vegetation structure between campsites and control areas (Fig. 3) in relation to canopy cover (T = 10, P = 0.00), herbaceous cover (T = 1.50, P = 0.00) and litter thickness (T = 3, P < 0.00). The differences in herbaceous cover and canopy cover confirm previous studies that found differences in the loss of forest cover in comparison between old campsites and areas without campsites (MARION; COLE, 1996) and in trampling experiments (MARION, COLE, 1996; COLE; MONZ, 2002).

No differences between camping and control sites were recorded for the variables basal area and tree abundance. These variables represent the tree vegetation stratum. It can be attributed to the increased resistance of this vegetation stratum in relation to campsite impact. Siles (2003) argues that resistance for recreation activities is directly related to life form; therefore herbaceous species are more affected than trees mainly because the herbaceous cover usually dies after impact while damaged trees are likely to remain alive. During data collection we found a significant number of large trees in campsites areas. Although damaged, these large

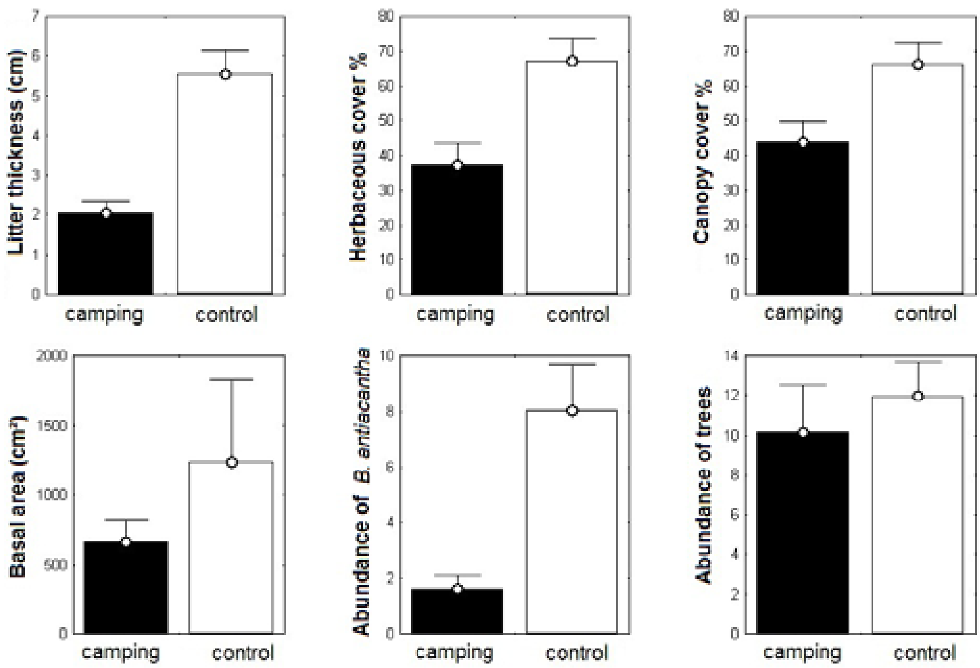

Figure 3: Comparison of variables (Mean and SEM): thickness of litter, herbaceous cover, canopy cover, basal area, abundance of *Bromelia antiacantha*, and abundance of trees in areas used by campers (camping) and areas without use (control).

trees were still representative of the basal area. This was probably the reason for no significant change of this parameter.

Among the variables used to measure vegetation structure, the greatest difference was the abundance of *B. antiacantha* between the camping and control area. There was a dramatically decrease in *B. antiacantha* abundance in the old campsites. As previously stated, the herbaceous stratum was more affected than the tree stratum. In addition, *B. antiacatha* has specific morphological characteristics, such as presence of thorns, which hinder the establishment of campsites. This is why these plants were quite likely to be removed in order to establish these campsites. Another factor that may explain the low density of *B. antiacantha* is the overall low vegetation cover. Since some species need more shading to establish, canopy openness may control vegetation growth. This finding demonstrates that *B. antiacantha* is sensitive to recreation activities. Therefore, more intensive use of these areas for camping purposes can intensify the negative impacts on the species and compromise its conservation. Furtheremore, camping can also change the vegetation community composition among sensitive species, which can favor their substitution for more resistant species (HAMMITT; COLE, 1998).

Characteristics of the vegetation, such as the tolerance of each species to trampling and its resilience, directly affect the magnitude of impact in the environment (MARION; COLE, 1996). In areas managed for conservation purposes but also under intense recreation use, such as campsites, the resistance of the species is more relevant than its resilience (SILES, 2003). Thus, information about species resistance is extremely important for managers of protected areas to more effectively control the impacts of recreation activities on vegetation.

In addition to the direct effects of these anthropogenic activities on plant species, the indirect effects may also hamper the establishment of other vegetation species regardless whether they are resistant or not to trampling. Litter is extremely important in seedling establishment. In the study we found a loss of 3.5 cm of litter in the campsite area. This loss is greater than the findings reported by Marion & Cole (1996) who recorded a loss of 1 cm. This litter loss has direct implication on overall vegetation recovery from the impact. Litter cover not only contributed to the establishment of seedlings by providing nutrients and physical conditions but also reduces erosion. Considering that the soil of these environments contains 95% sand (DUARTE, 2004), the litter loss does not promote erosion and holds a small amount of nutrients that can affect plant establishment.

Regarding the post-impact recovery, there was no correlation between campsite size and structure of vegetation (Tab. 1). This was also observed in studies of natural regeneration of vegetation on salt-marsh forests (MICHELETTI, 2002). Our results indicate that even small campsites can have difficulties to recover even after five years since activities have stopped. The overall rate of regeneration of these campsites may take even longer because the recovery rate is faster at the beginning and suffered decline since the beginning of the disorder (MARION; COLE, 1996).

This is the first Brazilian study exploring biotic and quantitative evaluation of camping impact and the suggested field methods can be used in other sites to improve them and promote future comparisons.

Table 1: Correlation between campsites' size and variables of vegetation structure

Vegetation variables	***N***	***Gamma***	***P***
Abundance of Trees	20	0.15	0.37
Abundance of *B. antiacantha*	20	0.06	0.78
Basal Area	20	0.21	0.19
Canopy Cover (%)	20	0.21	0.21
Herbaceous Cover (%)	20	0.12	0.49
Litter Thickness (cm)	20	0.04	0.80

In conclusion, our study demonstrates that the salt marsh in Puruba Beach is an area not suitable for the practice of camping because of the associated changes in vegetation structure and because of associated slow rate of recovery, which can become even slower with the presence of a chronic disturbance. We recommend, therefore, the use of other sites to establish new campsites in order to accommodate existing tourism demand. This alternative also supports the continuation of tourism as an income generation opportunity for local residents. One strategy would be to implement facilities in other areas where tourists would have an option to practice low--impact camping.

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