Carrying capacity of hiking trails in Natura 2000 sites: a case study from North Atlantic Islands (Azores, Portugal) *

Capacidade de carga de trilhos pedestres inseridos em sítios da rede Natura 2000: um caso de estudo em ilhas do Atlântico Norte (Açores, Portugal)

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ABSTRACT

Tourism has registered a significant growth in the Azores representing already 15.2% of its regional Gross Domestic Product (GDP). Because an increase in the touristic activity may affect the quality of natural habitats, it is very important to evaluate the size of those impacts in order to take sustainable management measures. In this context, hiking trails are one of the most searched activities in the Azores in natural areas, and as such it is important to understand if they are under human pressure.

This study aimed to determine the Tourism Carrying Capacity (TCC) of hiking trails crossing Special Areas of Conservations (SAC) of Natura 2000, in two of the nine Azorean islands, São Miguel and Flores; it also aimed to evaluate the potential of TCC as a management tool for development and planning of a sustainable tourism, for those areas.

The Real Carrying Capacity (RCC) of the trails was determined by the Cifuentes' method, based on the Physical Carrying Capacity (PCC) modified by correction factors (social, precipitation, light and accessibility), selected according to the tourist activity and the conditions of the study area. The correction factor that negatively influenced the RCC the most, for all the trails, was the social factor followed by light. The minor RCC registered (118 visitors/day) was reported to the trail Lagoa do Fogo-Monte Escuro (São Miguel), while the greatest value (557 visitors/day) was calculated for the trail Ponta Delgada-Fajã Grande (Flores). In both trails correction factors social and light, were also the ones that most influenced the RCC. Even considering that the RCC has not yet been achieved in any of the studied trails, and that the Effective Carrying Capacity (ECC) has not been evaluated, it is relevant to keep monitoring those factors, since they are linked to the quality of the visit.

Even though with limitations, including the underlying method and its implementation, it is expected that the results of this study may contribute to improving the sustainable use of hiking trails in natural areas of the Azores. It is also recommended that we proceed with the determination of the tourism carrying capacity for all the hiking trails of the Azores, especially those located in protected areas, and also to carry out an assessment of ECC.

Keywords: Carrying capacity, hiking trails, sustainable management, Azores Islands.

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* Submission: 31 December 2013; Evaluation: 11 February 2014; Reception of revised manuscript: 4 April 2014; Accepted: 23 April 2014; Available on-line: 13 May 2014
1. INTRODUCTION

Outdoor recreation, including nature-based tourism, has long been recognized as an agent of ecological change in natural systems, with the potential to affect soil, vegetation, wildlife, and water quality (Monz et al., 2010). Nature-based tourism is growing at an annual cumulative rate of 7% (THR, 2006), as a response of people’s desire to participate in tours aiming relaxation, discovery, learning and nature escape, that is, getting away from the routine of life, and it is now becoming the main revenue for many countries (Alaeddinoglu & Can, 2011). The European countries are the largest tourist emitters, mainly Germany and the Netherlands (THR, 2006). As this kind of tourism increases, areas such as national parks and other protected areas will be placed under increasing pressure (Marzuki et al., 2011).

Ecotourism is included in nature-based tourism, and it is understood as a strategy for conservation and a tool for economic development, meaning that its activities must take place in harmony with nature. Ecotourism development is being used in protected areas for supporting conservation and generating income. According to Sayan & Atik (2011) protected areas are becoming increasingly important in modern societies since they preserve natural resources and enhance the quality of life. The practice of ecotourism is an effective way to ensure sustainable development for nature reserves and represents one of the most environmentally-friendly alternatives for the economic development of protected areas (Li & Han, 2001), but it can also lead to the degradation of natural resources, when unplanned or poorly planned, especially if management is inadequate. Protection and development should occur simultaneously to ensure the conservation of natural resources and to maintain environmental services provided by protected areas (Maldonado & Montagnini, 2005).
carrying capacity refers to a certain threshold of people activity beyond which damage to the environment will occur (Williams & Lemckert, 2007). The concept is thus dynamic and fluid, neither fixed nor static, and can depend on the speed of change (Simon et al., 2004). However, critics against establishing a numerical carrying capacity argue that it varies depending on the protected area objectives, upon tourism activities, and also because it does not provide a measurement of impacts (McCool & Lime, 2001).

The recent attempts to develop actual carrying capacities in terms of specific numbers of tourists or visitors raise significant questions for the decision-makers that establish policy strategies to tourism development (Saveriades, 2000). The aim of estimating tourism carrying capacity is thus to determine the upper desirable limits of development, i.e. the optimal use of tourism resources. But it also means making decisions about what ought to be done, what recreational opportunities should be provided, and how recreation use should be managed. There are several methods that enable the evaluation of the number of visitors to a PA such as Tourism Carrying Capacity (TCC; Cifuentes, 1992), which takes into account three levels of analysis: Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC) and Effective Carrying Capacity (ECC), where PCC > RCC > ECC.

Other methods include Limits on Acceptable Changes (LAC; Stankey et al., 1985), Visitor Experience and Resource Protection (VERP; US Department of the Interior, 1997), Tourism Optimization Management Model (TOMM; Manidis Roberts Consultants 1997), and Visitor Impact Management (VIM; Kuss et al., 1990). Thus, it is important to evaluate the carrying capacity of PA’s to ensure that they can handle levels of visitation, which enable them to become economically self-sustainable (Cifuentes, 1992; Boo, 1993). It is necessary to define what are the possibilities and limitations of ecological destinations to preserve and not to destroy what visitors come to see.

Islands in general, have geographical, cultural, ecological and economic features that attract visitors, but the fragility and limitations of the destinations make the environment and communities more vulnerable to the pressures of tourism (Kokkranikal et al., 2003). Then carrying capacity becomes one of the main techniques of tourism and recreation planning, and management. Destinations such as the Indo-Pacific Islands, with cheap and open access and weak capacity management, have experienced crowding, crime, pollution and price collapses (Buckley, 2002). But carrying capacity should be used to assist governance decisions based on desired conditions, not rigid numbers, and to encourage actions that reduce impact per visitor rather than simply the number of visitors. Determining how many people could use a given area before unacceptable impact sets in, is becoming critically important to many managers. In this view, studies of carrying capacity and control impacts of visitation are indispensable tools for tourism planning.

Despite the limitations associated to the carrying capacity concept, it has been described as an appropriate tool for management, as it enables the preservation of resources in PA’s. Increasing interest in these areas is focused on the existing natural attractions and covers the visiting of landscapes, the practicing of nature-based sports, among other outdoor activities. The management of PA’s that allows hiking activities can potentially conflict with conservation.

The main goal of this research was to assess the TCC of hiking trails crossing protected areas within Natura 2000 network, using six hiking trails, located in two of the nine islands, as case studies. It is also expected that the estimation of the tourism carrying capacity in these trails will provide stakeholders that explore or manage these trails, with useful data to prevent or minimize impacts that may occur when opening a trail to leisure or interpretative activities.


2. METHODOLOGY

2.1. Study area

Located in the North Atlantic Ocean, along the mid-Atlantic ridge, the Portuguese Azores archipelago consists of 9 islands and several islets of volcanic origin, geographically spread into three groups, between latitudes 37–40°N and longitudes 25–31°W. The archipelago is distant about 1,500 km west from Lisbon and 3,900 km east from the east coast of North America, and has a land surface of 2,333 km² (Pen & Cabral, 1997; Instituto Hidrográfico, 1981) (Figure 1). The Azores, along with Madeira, Selvagens, Canaries, and Cape Verde, belong to the Macaronesia Region, a world biodiversity hotspot that represents 0.3% of the EU territory. The Azorean most important resources are its landscape, endemic flora and fauna, mild climate and friendly people. The archipelago is becoming famous for its natural values, as well as its tourism opportunities at sea and land, both of which are closely related.

In the Azores, SPAs and SAC’s cover 16% of the territory (IGEO, 2009), being instrumental for nature conservation. As these areas are crossed by trails, now used for hiking in ecotourism related activities, it is important to understand how is the relation between each hiking trail and its carrying capacity, in order to evaluate if there is a pressure over the area, with adverse consequences for natural resources.

Our study was conducted on hiking trails located on SAC’s within the frame of Natura 2000, at two of the 9 Azorean islands: São Miguel (SM), the largest island, with an area of 744.55 km², in the eastern group, and Flores (FL), one of the smallest, with 141.02 km², in the western group. São Miguel, the so-called “Green Island” because of its exuberant vegetation, is the largest and most populated island of the archipelago, has the highest touristic flow, and 7% of its land is integrated in Natura 2000 network. On the contrary Flores has 31% of its land covered by Natura 2000 network, but lower touristic flow and population density.
The surveys were done at the following SAC’s: Lagoa do Fogo Nature Reserve (SM), Morro Alto (FL) and Costa Nordeste (FL). These areas are now included in the recently created Island Natural Parks (INP’s), in the category of “protected areas for management of natural resources” (Legislative Regional Decree nº15/2007/A).

The nine islands of the Azores Archipelago account for 69 official hiking trails, some of which are temporarily closed mostly due to landslides related to heavy rains. Unofficial trails also exist and are currently being used by tourists. In São Miguel Island (SM) there are 31 official trails while Flores Island (FL) has only four. All official trails have informative panels (length, difficulty, duration) and directional marks, and the majority are linear. Trail classification, identification, marking, maintenance, supervision and promotion, are responsibility of the Azorean Government. In both islands, all the trails that crossed, or were totally within the mentioned PA’s, were sampled, including the trails used by hikers that are not recognized for the local authorities, but may eventually become official trails in a near future.

A total of 6 hiking trails were investigated in the two islands, three per island. In São Miguel, the trails were sampled at Lagoa do Fogo Nature Reserve (Legislative Regional Decree nº 152/74), once it is among the most important conservation area of the island, presenting geological, biological and landscape values of high touristic relevance. In Flores, three trails were investigated within two PA’s: Morro Alto (two official trails) and Costa Nordeste (one unofficial trail). Morro Alto Reserve is the largest wetland in a high elevation in the Azores, and also the best preserved. Costa Nordeste is dominated by extensive and high coastal cliffs. General characteristics of the trails under investigation are summarized in Table 1.

Sampling

The Azorean protected areas are open, and thus there is no control on the number of visitors or gated input/output points, making it difficult to estimate the real number of tourists. A GPS was used to determine geographical position, altitude and length of the trails. All the trails selected are mainly for hiker use, although motorized vehicles and bikes may also be present in some of them. Fieldwork was performed in the summer of 2009 and 2011. For each hiking trail, an inventory of landscape characteristics and natural resources was generated, including information regarding the trail’s geographical location (georeferenced), biota (birds and vegetation), state of conservation, accessibility and safety. It was decided, due to time and resource constraints and in order to provide an efficient and easy evaluation of the trails, that sampling points would be at intervals of 500 meters.
Methods

Physical, real, and effective carrying capacity were assessed by Cifuentes’ methodology (Cifuentes, 1992), adapted according to specific bio-physical peculiarities and characteristics of the area, as suggested by the IUCN (Ceballos-Lascuráin, 1996). The logic of the method is based on site-specific factors, which reduce the level and quality of visitation, and consider the limiting factors of the areas.

Physical Carrying Capacity (PCC)

PCC is defined as the maximum number of users that can physically fit into, or onto, a specific area.

\[
PCC = A \times \frac{U}{a} \times Rf
\]  

(1)

Where: 
- \( A \) = available area for public use (trail distance)
- \( U \) = Area required per user to walk comfortably (1 visitor per m²)
- \( a \) = Area required per user to walk comfortably (1 visitor per m²)
- \( Rf \) = Rotation factor (number of visits/day)

In order to measure PCC, the following assumptions were done:
- \( Rf \) = Open period ÷ Average time of visit
- Since there are no entrance gates in the PA’s studied, the daily hours of sunshine (daylight) were defined as a parameter, as hiking is done during daylight [average daylight of the summer months (June to September)]: 11.29h in SM and 11.24h in FL. The average time of visit is the average time required to go across the hiking trail.

Real Carrying Capacity (RCC)

RCC is the maximum allowable number of users to the hiking trails, once the correction factors \((Cf)\) derived from the particular characteristics of the site have been applied to the PCC. For the calculation of RCC, PCC was modified by a series of correction factors, such as social \((Cf_{soc})\), precipitation \((Cf_{pre})\), daylight \((Cf_{lig})\) and accessibility \((Cf_{acc})\).

\[
RCC = PCC \times (Cf_{soc}) \times (Cf_{pre}) \times (Cf_{lig}) \times (Cf_{acc})
\]  

(2)

Where: \( Cf \) = correction factor

To measure RCC, the following assumptions must be done: the correction factors are obtained by considering the environment, biophysical and social factors. These factors are closely linked to the specific conditions and characteristics of each site or activity. \( Cf \) is expressed as follows:

\[
Cf = 1 - \frac{M_1}{M_t}
\]  

(3)

Where:
- \( M_1 \) = limiting magnitude of variable
- \( M_t \) = total magnitude of variable

The correction factors

These factors are calculated after fieldwork and are selected based on tourism activities and local conditions of the study area. As a result of the correction factors, values near 0 indicate a limiting factor in the carrying capacity of the trail, while those close to 1 show no limitation. The factors used to calculate RCC are:
- \( Cf_{soc} \) - it refers to the quality of visitation, and the distance required between groups to avoid crowding.
this factor we consider groups of 15 people and a distance of 250m between groups. Regarding the group size, we calculated the carrying capacity for the hiking trails, with a maximum of 15 members per group, according to the directions proposed for ecotourism by The International Ecotourism Society (TIES, 2006) and WWF-Brazil (2003). The distance required per group was calculated through the sum of the distances between groups and the space occupied by each group. Also, the number of groups (NG) that can be simultaneously in the path is generated by the expression:

\[ NG = \text{(Site total(trail) + distance required by each group)} \]

To calculate the Csoc, we first obtain the number of people (P):

\[ P = NG \times \text{Number of people per group} \]

Moreover, the limiting magnitude (Ml) presented by the site was calculated:

\[ Ml = Mt - P \]

Accessibility: it is related to the degree of difficulty presented by the hiking path, according to slope range and soil type. The sum of meters that theoretically may result in difficulty of access for some hikers was considered as an additional correction factor.

**Effective Carrying Capacity (ECC)**

ECC is the maximum number of visitors that a trail can sustain, given the management capacity (MC) available, and adjusting the RCC to the correction factors. Thus, it takes into consideration the infrastructures related to the trails, facilities and equipment, staff (number and qualifications), funding, among others, providing the number of visitants.

**Results and Discussion**

Effective Carrying Capacity (ECC) was not possible to calculate due to the absence of infrastructures related to the trails that would provide the number of visitants. Although it was possible to determine the related correction factors for the Azorean trails, it was impossible to evaluate the MC given the lack of data concerning variables, such as infrastructures, facilities, etc. Thus, the RCC should be considered with care, given the lack of this important indicator for the calculation of TCC.

The trail Ponta Delgada-Fajã Grande (FL) had the largest PCC (44 960 visits/day), because of its relatively easy access and total length. On the contrary, Cedros-Ponta Ruiva (FL) trail, in spite of its easy access, had the lowest PCC (13 113 visits/day), because of its shortest length (Table 2).

After applying the corresponding correction factors to PCC, the Real Carrying Capacity (RCC) was calculated for each hiking trail (Table 3). In the present study, the social correction factor (soc) had the greatest influence on the overall RCC, as it was the most limiting factor (0.057) for all the hiking trails, which led to consider a reduction on the number of visits per day. The same trend was found for the trails located in the protected area of La Tigra National
The Azores are one of the most visited islands in Portugal, especially during the summer months, when most tourists come. However, the carrying capacity of the hiking trails has not yet been attained in either of the studied protected areas (Table 3). Although not always consensual, the carrying capacity assessment remains one of the most useful and applied techniques (Zacarias et al., 2011) for tourism and recreation planning and management, especially if combined with other management tools. These tools may include changing periodically the visiting sites, to allow their recovery or even to adapt visits to season characteristics.

The carrying capacity should facilitate the process of continuous monitoring of tourism by adjustment to plans as needed, and to ensure that tourism development is carried out within the context of the optimum overall capacity level, thus ensuring its sustainability (Saveriades, 2000). Furthermore, the carrying capacity can only be examined in a case-by-case situation because it is sensitive to many variables (e.g. location, type of tourist activity, speed of tourism growth, temporal dimension of technical developments; Simon et al., 2004).

### Table 3. Real Carrying Capacity (RCC) and correction factors, calculated for the hiking trails.

<table>
<thead>
<tr>
<th>Trail Location</th>
<th>Distance (m)</th>
<th>Social</th>
<th>Precipitation</th>
<th>Daylight</th>
<th>Accessibility</th>
<th>RCC (visits/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>São Miguel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Praia-Lagoa do Fogo</td>
<td>6000</td>
<td>0.057</td>
<td>0.950</td>
<td>0.252</td>
<td>0.767</td>
<td>176</td>
</tr>
<tr>
<td>Pico da Barrosa-Ribeira das 3 Voltas</td>
<td>8000</td>
<td>0.057</td>
<td>0.950</td>
<td>0.252</td>
<td>0.844</td>
<td>258</td>
</tr>
<tr>
<td>Lagoa do Fogo-Monte Escuro</td>
<td>6000</td>
<td>0.057</td>
<td>0.950</td>
<td>0.252</td>
<td>0.642</td>
<td>118</td>
</tr>
<tr>
<td>Flores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ponta Delgada-Fajã Grande</td>
<td>12000</td>
<td>0.057</td>
<td>0.945</td>
<td>0.270</td>
<td>0.858</td>
<td>557</td>
</tr>
<tr>
<td>Poça do Bacalhau</td>
<td>7000</td>
<td>0.057</td>
<td>0.945</td>
<td>0.270</td>
<td>0.686</td>
<td>195</td>
</tr>
<tr>
<td>Cedros-Ponta Ruiva</td>
<td>3500</td>
<td>0.057</td>
<td>0.945</td>
<td>0.270</td>
<td>0.671</td>
<td>127</td>
</tr>
</tbody>
</table>

In practice, for the majority of the areas there is a risk of saturation or carrying capacity overload particularly in the peak seasons (Sayan & Atik, 2011). Since the vast majority of visitors come to the Azores during the summer, they most certainly are not willing to go hiking under heavy rain, thus we only considered the days of lower precipitation for analysis. Nevertheless, as in the Azores heavy rain and fog can occur throughout the year affecting tourists’ sightseeing, it should be considered as a limiting factor.

The Lagoa do Fogo-Monte Escuro trail (SM) had the lowest RCC, as a consequence of the correction factors referring to the social and daylight variables. These two factors reduced the RCC considerably, in comparison to the Ponta Delgada-Fajã Grande trail (FL) that had the highest RCC, as it was the least affected by the same correction factors (Table 3); also this latter hiking trail had lower slope gradients and was easier to walk than the first one, therefore it yielded the highest RCC of all the hiking trails.

All hiking trails are located inland, with the exception of the Ponta Delgada-Fajã Grande trail (FL) that develops along the shoreline. As tourism pressures over coastal areas are increasing, the results provided by this trail may be of considerable value for coastal management. This may be emphasised by the fact that most of the studies on Tourism Carrying Capacity on coastal areas address beaches (e.g. Zacarias, 2013)

Most certainly, the real carrying capacity of the trails has not yet been attained in either of the studied protected areas (Table 3). However, as the number of visitors tends to increase in the Azores (SREA, 2013) the probability of approaching the carrying capacity limits may also increase.
In Europe, there are many entrances and roads that cross national parks and PA’s allowing the entrance of both visitors and people who live or work in these areas, along with the traffic (Beunen et al., 2008). Determining the number of users is an important factor to evaluate an area’s carrying capacity, as it can assist the implementation of strategies to help maintain the population and the potential impacts on its surrounding environment (Williams & Lemckert, 2007). Control can be exerted through various methods such as entry restrictions, reducing the number of facilities, pricing, and by enforcing behavioural guidelines (Kokkranikal et al., 2003).

The protected areas in the Azores are open access and there is no control on the number of visitors or a gateway of input/output, making it difficult to assess the real impact concerning the tourists’ visits to these areas. Brown et al. (1997), when comparing two economies highly dependent on tourism, the Maldives Islands and Nepal, demonstrate that from an economic perspective the open access to a great deal of resources which attract tourists to scenic areas, prevents the capturing of significant parts of the potential revenue locally.

As ECC was not evaluated, RCC should not be considered as the existent Tourist Carrying Capacity of each trail, but only an approach to it and an important indicator of its tendency.

CONCLUSIONS

Mostly in vulnerable habitats, the establishment of the area’s touristic carrying capacity may prevent potential anthropogenic impacts over hiking trails, and help decision-makers. With the increase of tourism flow in the Azores, the probability of increasing environmental hazards is also growing and sustainable approaches should be promoted. In this view, it is recommended to establish visitors’ centres, gateways and handrails, at least in those trails located in sensitive areas, allowing the counting of visitors and providing information on the trails, as well as guidance and monitoring along them, in order to prevent major impacts from tourist activity.

Apart from reliable environmental monitoring plans and an effective analysis of the carrying capacity of trails, other approaches could be tested in order to avoid disturbance over protected areas: (i) to increase environmental awareness and awareness about local natural resources; (ii) to work on conditions to limit accessibility in selected places; (iii) to build economic incentives to correct specific deficiencies (e.g. subsidies, eco-taxes); (iv) to manage the presence and to control the tourists on each site; and (v) to invest on environmental conservation and restoration of the areas. The physical limitations (state of conservation, soil, topography and infrastructures) of the trails should be taken into consideration when planning any expansion of the visitation levels, or the addition of official trails, in order to maintain environmental quality, visitor’s safety, and the quality of visitation.

In this study, the ECC was not determined due to the absence of physical and human resources on the sampled trails. As the conditions of infrastructures and equipments available at each hiking trail are very important for the quality of the use, it is recommended to calculate the Effective Carrying Capacity (ECC) in a near future for a complete assessment of the tourism carrying capacity of the trails. Given the results of this analysis, and taking into consideration its limitations, it can be said that the current hiking trails’ capacity has weak points as a result of the scarcity of physical resources (equipments and infrastructures) and human resources (staff), which do not allow an optimal performance of activities in the areas under study.

This research represents the first approach to establish tourism carrying capacity in trails belonging to protected areas of the Azores Natura 2000 network. It is important to assess the real current visitation levels of the hiking trails, not only to understand their meaning but also to decide upon future increases in visitation. The results provided by this approach may also contribute to coastal management, as it was highlighted by the hiking trail located along the shoreline.

It seems clear that there is a need for further multidisciplinary approaches over hiking trails, not only for those under analysis but also for the remaining hiking trails of the Azores, and the future planned.

Finally, it could be interesting to extend the assessment of tourism carrying capacity through time, to have a multi-year evaluation, along with multidisciplinary studies. The pursuit of carrying capacity studies should be encouraged as a way to guarantee the sustainability of the hiking trails in the Azorean protected areas, and a better quality in the experience of the visitors.

ACKNOWLEDGEMENTS

This study is part of the FCT financed project PTDC/ AAC-AMB/104714/2008 (Operational Competitiveness Program COMPETE) and was also supported by a PhD scholar awarded to Rose Emilia by DRCTC (Azorean Government) M3.1.2/F/011/2008. We greatly appreciate the assistance provided by Roberto Resendes from the Biology Department, University of the Azores, and by Pablo Escudero Aznar (Eurodisseia Program).

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