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Meet the editor

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Contents

Preface

National parks are natural areas set aside to protect ecological processes, along with the complement of species and ecosystem characteristics of the area. Apart from protecting natural biodiversity along with their underlying ecological structure and supporting processes, they provide a breathing space and opportunities for learning and spiritual and recreational opportunities. However, all of which must be environmentally and culturally compatible to ensure that the ecological integrity of the ecosystems is protected for the present and future generations. There have been public debates over management objectives of national parks, which often center on the compatibility and on how to strike a balance between conservation of habitats and species biodiversity vs. exploiting them for economic benefits. While the parks are protected, in which ecological functions and native species composition should be intact, they have roles to support economic development through ecotourism that contributes to local and national economies.

The limit of acceptable change is one of the common frameworks that can be used to measure recreational carrying capacity in the national parks, i.e., how much use should or can natural areas be allowed to tolerate? The framework provides a strategy for making decision with regard to what extent the social and environmental conditions are acceptable.

In order to get maximum benefits from national parks, an integrated approach of sustainable management strategic plan should be developed. In developing the plan, inputs and knowledge from the stakeholders and local communities should be valued so that they have equal rights and responsibility in the decision-making. The needs of local communities and indigenous people should also be taken into account as long as these will not adversely affect the primary management objective of national parks.

This book describes the management and conservation strategies of national parks and protected areas in different parts of Europe and Asia and the constraints, opportunities, and challenges to the full realization of the management objectives of the parks. It is divided into five major sections, which include protected area management, fish and wildlife conservation, biodiversity conservation, ecotourism and recreation, and local community participation. The book shows that national parks are useful not only in conserving endangered species and biodiversity but also in providing recreation opportunities, watershed protection, wilderness, and other resources necessary to the socioeconomic development of the local communities. In addition, the sections of the book present information and ideas on useful planning, management, and conservation that link the interests of scientists with practitioners and stakeholders. It is hoped that this book will not only bring greater understanding and appreciation of our natural environments but will also serve as a reminder of our responsibility to ensure their survival and biodiversity and maintain sustainable livelihoods.

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Section 1

Protected Area Management

Chapter 1

Introductory Chapter: Conserving Biodiversity in Protected Areas

Mohd Nazip Suratman

Additional information is available at the end of the chapter

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1. Introduction

Until recently, values and benefits from protected areas have often been taken for granted and underestimated. This book entitled *National Park: Management and Conservation* demonstrates that there are deep necessities in how the wider scientific, environmental, socioeconomic, and cultural values that these natural ecosystems provide should increasingly be recognized. The book highlights various approaches for managing and conserving protected areas to respond to some pressing global challenges today such as climate change, demand for food and energy, over exploitation, and habitat change. For this purpose, the book is published to address these issues and divided into five main sections: (1) protected area management, (2) fish and wildlife conservation, (3) biodiversity conservation, (4) ecotourism and recreation, and (5) local community participation.

The first section concentrates on challenges, constraints, and the way forward in managing protected areas with special references to Croatia, Austria, and the Czech Republic which include some pertinent issues related to transboundary cooperation. It outlines how mutual cooperation between countries can be achieved to share common responsibility in protected area management. An establishment and implementation of protected area management plan and determination of wildlife population in protected areas are highlighted in the second section of the book based on the case studies conducted in Japan and Ethiopia, respectively. Meanwhile, in Brazil, biomarkers were used to assess the exposure to environmental stress in fish population. The third section of the book outlines a progress and historical perspective over hundred years of national parks' existence in Spain since 1918. The establishment of protected areas has promoted toward more sustainable use of forest resources through biodiversity conservation and socioeconomic development. The second chapter of this section highlights the important roles of forest biomass estimated from three forest types in Malaysia

(i.e., lowland dipterocarp, hill dipterocarp, and riparian forests) in sequestering carbon as climate change mitigation. The fourth section discusses the important roles of interpretation as part of management tools for recreation in the national parks of South Africa. The next chapter discusses the growing trend of ecotourism in national parks and how it impacts the natural environment. The final section of the chapter presents the opportunities and constraints for local community involvement in protected area management in Turkey. An assessment and measurement methods to evaluate the effectiveness of stakeholder participatory process are also highlighted.

It can be summarized that the book discusses multifaceted issues pertaining the management and conservation of national parks and protected areas. The proceeding section of this introductory chapter is written on the premise that nature conservation remains the primary aim of protected areas. The chapter demonstrates that there is a profound link between the roles of protected areas and biodiversity conservation based on case studies in Malaysia. While many of protected areas are established worldwide for the conservation of particular species of interest, yet their benefits may be extended to conservation of entire biodiversity pools. In addition, biodiversity conservation, i.e., species, genetic diversity within species, and of habitats, underpins the ecosystem function of protected areas which contribute to many practical and utilitarian benefits.

2. Protected areas

Protected area refers to as geographical space, recognized, dedicated, and managed through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values [1]. The definition of protected area is expanded into six categories. The first category is further divided into two subcategories, i.e., strict nature reserve and wilderness area. Strict nature reserve is designated for the conservation of biodiversity and geological and geomorphological features. In this reserve, visitation, use, and impacts of humans are controlled and limited to ensure that the conservation values are protected. Meanwhile, the wilderness area normally deals with large unmodified or slightly modified areas that retain their natural character and influence. To ensure that natural conditions are protected and preserved, the areas are without permanent or significant human habitation.

The second category refers to national park which consists of large and natural areas that protect large-scale ecological processes with characteristic species and ecosystem. National park also provides scientific, spiritual, educational, recreational, and visitor opportunities. The third category is identified as natural monument or feature. These areas are set aside for the protection of specific natural monuments. These include landform, sea mount, marine cavern, and ancient grove: some geological feature such as cave and living feature such as an ancient grove.

The fourth category is habitat or species management areas in which the management is prioritized to protect particular species or habitat. Active and regular interventions are required to meet the needs of particular species and habitats. In the fifth category, i.e., protected landscape and seascape, interaction of people and nature over time may produce distinct character

of protected area which includes significant ecological, biological, cultural, and scenic value. Safeguarding integrity of this interaction is crucial to ensure the protection and sustainability of the area. The final category refers to as protected areas with sustainable use of natural resources. This involves an integration of ecosystem conservation, cultural values, and natural resource management which involve large and natural area condition. One of the aims for this category is for the use of natural resources that is compatible with nature conservation.

3. Biodiversity conservation

Biodiversity can be defined as the variety of plants, animals, and microorganisms that exist, the genes they contain, and the ecosystems they live in. It provides a variety of goods and services and supports our economy and lifestyles. Man has a moral duty to conserve it to ensure long-term sustainability for human survival and future generations. Trees are an example of critical component of biodiversity. The diversity of life that a tree can support is incredible. For example, in the tropical rainforests, a single tree can house up to 2000 different species of insects, birds, amphibians, reptiles, mammals, fungi, mosses, and epiphytic plants. Unfortunately, natural habitats everywhere are declining. Therefore, the establishment of protected area networks is essential for biodiversity conservation and thus helps to reduce its loss. As habitats are lost, we are also losing various types of precious flora and fauna. No one would have thought, even a few years ago, that some species from the families of Dipterocarpaceae, Grammitidaceae, and Begoniaceae could be extinct, but now they are. Protected areas can be used as complementary measures to achieve sustainable use of biodiversity and protect many threatened and endemic species from becoming vanished.

4. Plant conservation strategy: Malaysia's perspective

In many tropical countries throughout the world, much of the forest has lost as a result from rapid changes in land use and land cover since the last few decades. In Malaysia, for example, the changes in land use cover, particularly to agricultural land, rubber, and oil palm cultivation, are the major contributors of this conversion when the country gained independence. For example, in the 1960s, the 70% of land in Peninsular Malaysia was under natural forest cover; however, 10 years later, only 60.9% of forested area remained due to massive land development schemes during that period [2]. By 1980, the natural forest cover further declined to 49.4% (Forest Statistics, Peninsular Malaysia (1979–1985)) and has now stabilized at 44.5% since 1997 [3] as most of the land more suitable to agriculture has been cleared, leaving hilly, mountainous, and marginal lands and protected areas for wildlife sanctuaries.

Malaysia is well endowed with a great biodiversity with about 12,500–15,000 species of vascular plants [4]. A national strategy for plant conservation has been developed for the country. Part of the strategies includes a publication of *Tree Flora of Peninsular Malaysia* in four volumes since 2005 which described a total of 991 species. Meanwhile, the *Tree Flora of Sabah and Sarawak* was published in seven volumes since 1990 covering a total of 2055 species [5].

Conservation assessments of plants in Peninsular Malaysia initiated in 2005 found that 411 (42.2%) of the taxa to be in conservation concern categories from about 975 species. Based on conservation assessments of vascular plants conducted by Forest Research Institute Malaysia (FRIM), a total of 975 taxa were analyzed. The assessments consisted of families of ferns, lycophytes, gymnosperms, dicots, and monocots.

Table 1 provides a summary of possible threat that encountered by the flora from Peninsular Malaysia. In these assessments, Dipterocarpaceae represents a family for a large timber tree, Begoniaceae and Zingiberaceae represent herbs and understory plants, Nepenthaceae represents climbers, and Begoniaceae and Zingiberaceae represent ferns and lycophytes, respectively. From the assessments, it was found that four species are classified as extinct (EX), which is about 0.4% of the taxa assessed. These include *Oreogrammitis crispatula* Parris, *O. kunstleri* Parris (both are ferns from Grammitidaceae family), *Begonia eiromischa* (woolly-stalked begonia [from Begoniaceae family]), and *Shorea kuantanensis* (Meranti damar hitam [from Dipterocarpaceae family]) [5]. It was possible that the development in their habitats which involved the conversion of land cover was the cause of their extinction.

A total of 97 taxa or nearly 10% of taxa assessed were listed as critically endangered (CR) classification. Other species classified as CR categories are *D. coriaceus* (Keruing paya), *Parashorea globosa* (Gerutu pasir daun besar), and *Hopea bilitonesis*, all of which can be only found in Perak. The *D. sarawakensis* (Keruing layang) is only found in Terengganu, *H. subalata* (Merawan kanching) in Selangor, and *H. auriculata* in Johor, Pahang, and Perak. Meanwhile, 133 (13.6%) of taxa were classified as endangered (EN), 148 (15.2%) were classified as vulnerable (VU), and 29 (3.0%) were listed as rare (RA). Another 182 (18.7%) of the species were classified as near threatened (NT), 327 (33.5%) were listed as least concern (LC), and 55 (5.6%) as data deficient (DD) which means that there is insufficient information for a proper assessment of conservation status to be made. The findings for the percentage of species in each of

Conservation status	Number of taxa	Percentage (%)
Extinct (EX)	4	0.4
Critically endangered (CR)	97	10.0
Endangered (EN)	133	13.6
Vulnerable (VU)	148	15.2
Rare (RA)	29	3.0
Total conservation concern taxa	**411**	**42.2**
Near threatened (NT)	182	18.7
Least concern (LC)	327	33.5
Data deficient (DD)	55	5.6
Total	**975**	**100**

Table 1. Conservation status assessment for selected plants of Peninsular Malaysia in 2012 [5].

the conservation status category are alarming which suggest that initiatives must be made to prevent the endangered and critically endangered species from extinction. Dissemination of published information on conservation status of plants has contributed to grow a level of awareness among stakeholders.

5. Endangered species conservation

Tree species are categorized as endangered when they have limited geographic distribution, small population sizes, and specific habitat requirements. They suffered reductions in their population sizes due to over exploitation in habitats which results in loss in genetic variation within population. In Malaysia, five tree species from the family of Dipterocarpaceae, viz., *D. semivestitus* (Keruing padi), *Vatica flavida* (Resak padi), *H. apiculata* (Resak melukut), *S. hemsleyana* (Chengal pasir daun besar), and *S. macrantha* (Meranti kepong hantu), have been reported to have restricted distribution in the 12.4-ha freshwater swamp forest in part of Parit Forest Reserve at the Universiti Teknologi MARA (UiTM) campus in Seri Iskandar, Perak, Malaysia. Much of the area has been developed into urban settlements leaving small fragments of isolated forests in the area. An ongoing study is conducted to determine the demographic structure of the five endangered species and to map the spatial distribution of the five species [6, 7]. UiTM in collaboration with FRIM monitors the physiology and phenology of trees in the area.

A geographic information system (GIS) was used to analyze the geographic distribution of the endangered species. This was done by overlying the spatial location of endangered species onto the image of habitat areas. The purpose is not only to visualize the present data but also to analyze how the trees are spatially distributed in the landscape. This will allow the researchers to address a critical issue in monitoring the endangered species and in identifying priorities for protected area management with regard to boundaries of reserves.

The spatial distribution of five endangered species is shown in **Figure 1**. From the map, the distribution of four species, i.e., *D. semivestitus*, *S. macrantha*, *H. apiculata*, and *V. flavida*, in the landscape is appeared to be spatially dispersed. However, the spatial distribution of *S. hemsleyana* appears to be more localized compared to other species. It is important to note that many of the species appear to be located at the forest edges. Forest edges are prone to disturbance and experience more dramatic environmental changes. For instance, wind and sun dry out the forest edges which results in elimination of water sources for this sensitive habitat of freshwater swamp forest. Forest edges are also more exposed to vegetation clearing and urban development. Therefore, to address the further decline of biodiversity of tree species, it is essential that conservation plan be incorporated in the campus development plan and more efforts be undertaken to conserve the threatened habitat and species.

From the field survey, for *S. hemsleyana* the highest number of individuals discovered in the study area is recorded (i.e., 198), followed by *D. semivestitus* (35), *S. macrantha* (24), *H. apiculata*, (14) and *V. flavida* (6) (**Table 2**). For *D. semivestitus*, the number of individuals found has reduced from what was previously reported. Chua et al. [8] earlier reported that a total of 53 trees were

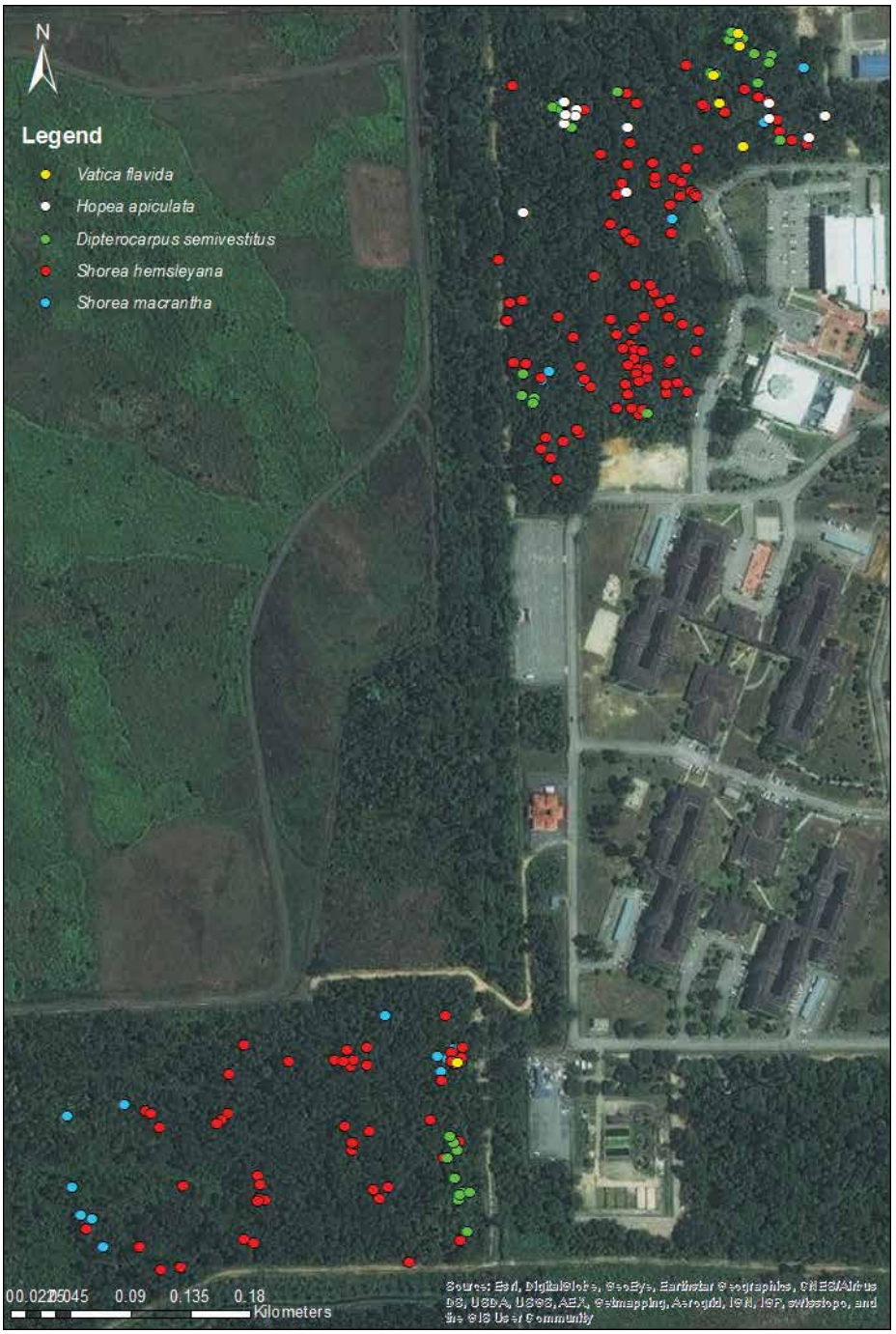

Figure 1. Spatial distribution of five critically endangered species of Dipterocarpaceae at freshwater swamp forest of Parit Forest Reserve, UiTM, Seri Iskandar, Perak, Malaysia [6, 7].

Tree species	Number of individual	Malaysia Red List categories*	Malaysia Red List criteria*
D. semivestitus	35	CR	A4bc, C1
V. flavida	6	CR	A4c, B2ab(ii)
H. apiculata	14	EN	B1b(iii) + c(ii)
S. hemsleyana	198	CR	A4c, D2
S. macrantha	24	EN	B1b(iii) + c(ii)

Notes: CR, critically endangered; EN, endangered

*Based on Chua et al. [8]

Table 2. Conservation status assessment for five endangered species in the freshwater swamp forest of Parit Forest Reserve, UiTM, Seri Iskandar Campus, Perak, Malaysia [6, 7].

located in this area. The loss of 18 *D. semivestitus* individuals was due to an illegal logging in the area which took place in 2012 and lightning strike in May 2014. Historical records reported that the species grows on in two places, Parit Forest Reserve (the study location) and Murabahah district, Central Kalimantan, Indonesia [9]. However, the population in Kalimantan has gone extinct as the area has been converted into oil palm plantations. Therefore, the freshwater swamp forest in Parit Forest Reserve is likely the last population in the world.

As one of 12th mega diversity countries, Malaysia is the home to the most endangered species in the world. The list of threatened species of Dipterocarpaceae has been initiated for Malaysia with a publication of the *Malaysia Plant Red List* [8]. The list has the most comprehensive national threatened tree species under this family thus far, and the first of such is prepared by the Malaysian botanists working together. This Red List is used to classify Peninsular Malaysian Dipterocarpaceae species at high risk of extinction for an assessment at the national level. It covers dipterocarp taxa that are indigenous to Peninsular Malaysia and taxa that are common to the Peninsula and East Malaysia (i.e., Sabah and Sarawak). Based on the *Malaysia Plant Red List*, of the five species, *D. semivestitus*, *V. flavida*, and *S. hemsleyana* are categorized as CR, whereas *H. apiculata* and *S. macrantha* are classified as EN (**Table 2**). Nevertheless, all five species discovered at freshwater swamp forests of Parit Forest Reserve, Perak, are rare and threatened species.

6. Conclusion

In view of the decline in the population of endangered species, conservation measures for the species are urgently needed. Involving stakeholders and local communities in biodiversity conservation efforts can be the key success of a project. This can be achieved by raising awareness of the public and policy makers. The commitments and efforts of stakeholders to support the monitoring and maintenance of ex situ collection are particularly crucial for species that occur on the private land, as demonstrated in the abovementioned case study.

The establishment of protected areas is extremely important in particular for endangered species and sensitive habitats and should be included as one of the key issues of sustainable development elsewhere. However, they need to be better located and actively managed to deal with problems of such as illegal logging, human settlements, unsustainable tourism, encroachment, and challenges in climate change. Unfortunately, in some countries, the protected areas are managed by different networks and governed by different laws with varying degrees of protection status. Therefore, each country should establish uniform national protected areas system operating in the country. Regardless of values and benefits of protected areas, implementation of effective management and conservation strategies aimed at maintaining or restoring these benefits are deemed necessary.

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Chapter 2

Protected Areas and Regional Development: An Austrian Case Study

Grazia Withalm and Michael Getzner

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Abstract

The potential conflicts as well as synergies between the conservation of nature in national parks, Natura 2000 areas, or other forms of on-site conservation, are rarely studied with respect to the marginal (additional) change of regional and local development brought about by conservation policies. This chapter presents empirical evidence on the linkages between Natura 2000 areas and local development in Austrian municipalities. The main result of the empirical analysis is that Natura 2000 is only a minor or even undetectable factor in regional development. Municipalities develop, for instance, according to their location, the territorial capital, the proximity to markets, and infrastructure capital. Natura 2000 rarely influences regional development with one exception; the establishment of Natura 2000 areas might indeed promote tourism. However, as Natura 2000 sites are often overlapping with other categories of protected areas such as national parks, their separate role in development still remains elusive. The main policy conclusions drawn from the results are that protected area management has to develop a coherent and complementary regional strategy to build up networks with all stakeholders (including authorities), and design joint destination marketing policies to attract more visitors while, at the same time, conserving biodiversity effectively.

Keywords: protected areas, national parks, Natura 2000 network, regional development, demography, labor market, tourism

1. Introduction: some economic perspectives on biodiversity conservation

Protected areas including the most prominent categories of national parks according to IUCN's management guidelines [1] and the European Union's Natura 2000 network of protected areas according to the FFH and Birds Directives are often located in peripheral regions,

both within countries and from an international perspective. While other categories of protected areas such as UNESCO's Biosphere Reserves consider sustainable development of the local and regional ecological, social, and economic systems alike, the two aforementioned frameworks do not place an emphasis on regional development nor consider the spatial distribution of costs and benefits of conservation.

However, two main arguments can be made in this context. On the one hand, peripheral regions rich in biodiversity often suffer from slow economic development, which regularly leads to population loss and infrastructure degradation. On the other hand, costs and benefits of conservation and of establishing protected areas may be unevenly distributed within a country. While the general public may enjoy the manifold benefits of conservation such as the existence value of biodiversity (protection of typical landscapes and ecosystems, conservation of flag-ship species) and the contribution to the national natural and cultural heritage, the local population might bear disproportionately high costs in terms of restrictions to economic development (such as land use restrictions for commercial or residential purposes).

The uneven sharing of costs and benefits, of course, has been addressed in various ways including the provisions of the Convention on Biological Diversity (CBD). The CBD, therefore, builds the foundation of benefit and burden sharing, and considers the potentially uneven distribution of costs and/or negative regional economic impacts of conservation. A prominent though often problematic concept that tries to address the securing and provision of biodiversity conservation is the idea of Payments for Ecosystem Services (PES) focusing on a compensation of upstream communities conserving ecosystem services for downstream users.

Besides the debate on the uneven distribution of costs and benefits, a wide range of studies have shown that—from an overall economic perspective—the conservation of biodiversity and the establishment of protected areas in particular is "efficient" in light of the huge benefits of conservation. For instance, Gantioler et al. [2] showed that the economic benefits of the EU's Natura 2000 network, by far, exceed the economic costs. Other publications include studies on single protected areas such as the comprehensive cost–benefit analysis on Austria's Donau-Auen national park [3] that proved that biodiversity conservation in a national park may lead to higher economic benefits even when compared to the construction of a hydro power plant. Other economic and managerial evaluations such as the one of Gesäuse national park [4] as well indicate the effectiveness of biodiversity conservation in protected areas.

One major category of economic costs originating from conservation is opportunity costs of reduced development options. As land is an absolutely scare resource and cannot be increased, any decision of a certain type of land use necessarily leads to a reduction of other potential alternatives. Since the land devoted to nature conservation according to the IUCN's guidelines, and the Flora-fauna-habitat Directive (FFH) and the Birds Directive in Europe is quite substantial, ranging from 9% up to 37% of a country's total land area [5], opportunity costs of conservation might marginally increase in the future. However, these opportunity costs may also be rather small since significant development options in peripheral regions are usually rare (except for single cases of large energy-related projects such as dams or mining). In addition, the costs of establishing and managing national parks and Natura 2000 sites (in terms of "out-of-pocket" expenses) might be substantial especially for low-income regions of countries.

In light of these aspects, it is important to consider the regional effects of biodiversity conservation. First of all, the establishment and operation of protected areas, to be effective, certainly builds on the involvement of stakeholders. As Getzner et al. [6] showed, participation of stakeholders is not only essential for biodiversity conservation but also important for fully exploiting the opportunities of conservation for the regional economy. In general, many studies have dealt with the regional economic perspective and the regional economic effects of protected areas in various contexts [7, 8]. The results generally lean toward the finding that biodiversity conservation in protected areas may lead to positive economic effects in terms of an increase of local and regional production and employment. In most cases, these positive effects are based on increased tourism. Visitors to the protected area might come for a day or spend their vacations in the region; expenditure for accommodation, food, entry fees, consumer goods all lead to higher local and regional demand and thus may support economic development.

However, a major methodological question arises with the exploration of conservation and the regional economic effects. Since visitors might come to the region owing to the landscape or the diverse ecosystems and habitats, the marginal (i.e., additional) contribution of the establishment of the protected area remains uncertain. If the regional economic effects of protected areas are to be ascertained, the underlying causes and consequences have to be carefully distinguished and analyzed.

As mentioned earlier, many studies have explored the regional *economic* effects of protected areas. Usually, this is done by means of collecting data on additional regional spending, and then computing the spatially distributed multiplier effects of spending in several economic branches. Other regional effects are rarely studied (cf. [9]).

In order to shed some light on other aspects of regional development, the Austrian Association of Environmental Organizations (Umweltdachverband) commissioned a study to explore the demographic, labor market, tourism, and agricultural effects of Natura 2000 sites in Austria over a long period (2000–2015) [10]. This chapter presents empirical evidence on the following aspects of regional development in Natura 2000 municipalities:

- Demographic development (population growth or decline);
- Labor market perspectives (change of the number of jobs, unemployment rate); and
- Tourism (overnight stays).

In order to ascertain developments in these three main categories, we employ a comprehensive database of all Austrian municipalities (approximately 2350); data are collected for the abovementioned categories. In order to distinguish between the different types of municipalities, we chose the following classification:

- Share of Natura 2000 areas (more than 50% of the area is devoted to Natura 2000 conservation; less than 50% of the area; and municipalities without Natura 2000 areas within their administrative borders);

- Degree of urbanization of the municipality (urban/city, suburban/intermediate, and rural).

The following section first presents the broad classification of Austrian municipalities, and then discusses the regional development along the selected dimensions.

2. Regional development in Austrian municipalities: exploring the effects of Natura 2000 protected areas

2.1. Number and location of Natura 2000 municipalities

The perspective that protected areas such as Natura 2000 are mostly located in peripheral regions is certainly supported by Austrian data. **Figure 1** presents a map of Austria that classifies Austrian municipalities according to the two variables mentioned earlier. Behind these two variables, a number of hypotheses should be tested by the differentiation between municipalities:

1. The share of land devoted to conservation in Natura 2000 areas is operationalized by three attributes. According to this approach, municipalities are classified into municipalities "with Natura 2000" areas (more than 50% of land lies within a Natura 2000 area), "with little Natura 2000" (from 1 to 50%), and "without Natura 2000." The main hypothesis to be tested here is that municipalities with a large share of Natura 2000 are hindered in their economic, social, infrastructure, and spatial development; that is, owing to the restrictions on the use of land within these municipalities, commercial land use (e.g., forestry and agriculture) is largely banned. Of course, the smaller the share of conservation land, the more insignificant might this restricting effect be.
2. The degree of urbanization is based on a standard classification of Austrian communities; larger cities and towns are classified as "predominantly urban"; municipalities outside the bigger cities and suburbs are classified as "intermediate," while rural municipalities are labeled accordingly. The main hypothesis behind this classification is that—independent of the share of conserved land within municipal boundaries—social and economic development in general might be entirely different between these types of communities. Potential differences or similarities between municipalities may, therefore, be attributed to differences in their economic, social, and spatial structure and location, rather than to conservation according to the Natura 2000 frameworks.

As can be seen from **Table 1**, most municipalities are rural communities (unweighted with respect to their size such as number of residents). About 10% of Austrian municipalities have a share of more than 50% of their land protected under the Natura 2000 framework. Another 36% of communities have some Natura 2000 areas within their boundaries. Given the number of municipalities, the distribution of Natura 2000 areas seems to be rather evenly distributed between these types of municipalities, with a slightly higher share of rural communities with larger Natura 2000 areas.

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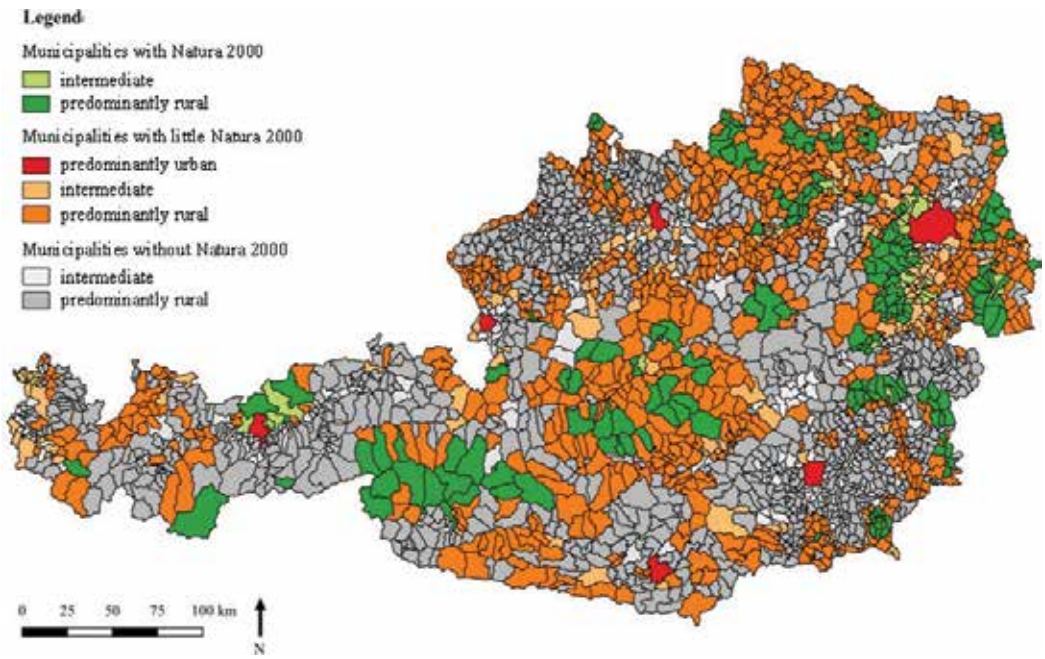

Figure 1. Classification of Austrian municipalities: Share of Natura 2000 conservation areas and degree of urbanization.

	Classification of the share of Natura 2000 areas					
	With Natura 2000		**Little Natura 2000**		**No Natura 2000**	
Degree of urbanization	**No.**	**%**	**No.**	**%**	**No.**	**%**
Urban	0	0.0%	6	0.7%	0	0.0%
Intermediate	32	14.2%	145	17.1%	223	17.4%
Rural	194	85.8%	695	82.2%	1059	82.6%
Total	**226**	**9.6%**	**846**	**35.9%**	**1282**	**54.5%**

Source: Own calculations and computations based on data from the European Commission, Statistics Austria and the European Environment Agency.

Table 1. Classification of Austrian municipalities according to the share of Natura 2000 areas on their land and the degree of urbanization.

As mentioned earlier, **Figure 1** indicates that municipalities with Natura 2000 areas are especially located along the main ridge of the Central Alps in the federal provinces of Tyrol, Carinthia, Salzburg, Upper and Lower Austria. These areas are particularly mountainous areas with high-alpine and forest environments. Mostly, these areas are also peripheral areas with respect to their location and their economic development.

In addition to the location of Natura 2000 areas, the map indicates that many nature conservation categories overlap. For instance, the Central Alps include three national parks (Hohe

Tauern, Gesäuse, and Kalkalpen); furthermore, around Vienna and the federal province of Burgenland, the Donau-Auen, and Neusiedler See national parks are located (and overlapping with Natura 2000 areas). In and around Austria's capital of Vienna, there is also the Wienerwald Biosphere Reserve which also includes a number of Natura 2000 sites.

2.2. Social development: demography and labor market

Taking up the hypotheses presented in Section 2.1, one may assume that Natura 2000 areas might to some extent hinder economic development and thus lead to migration to urban areas. Rural areas, therefore, might suffer from population loss.

Figure 2 presents an empirical picture on the development of the population in the aforementioned categories of Austrian municipalities. Austria's total population grew very slowly from 1990 until about 2000 (at an annual rate of approximately 0.2%). Growth was much higher in the following decade with an annual growth rate of about 0.5% p.a.

As can be seen, population growth was very different between the types of municipalities. The lower dashed line basically mirrors population development in the larger cities, in particular Vienna, which experienced a rapid growth since about 2000. Population grew fastest in intermediate municipalities (between urban and rural); surprisingly, in municipalities with large Natura 2000 areas, population increased by over 15% over the last two decades. This picture is slightly reversed in rural municipalities which saw a slower population growth, or even a slight downward trend.

Regarding the existence of Natura 2000 areas as decisive factors for demographic development, it seems that this conservation framework did not contribute any specifically different

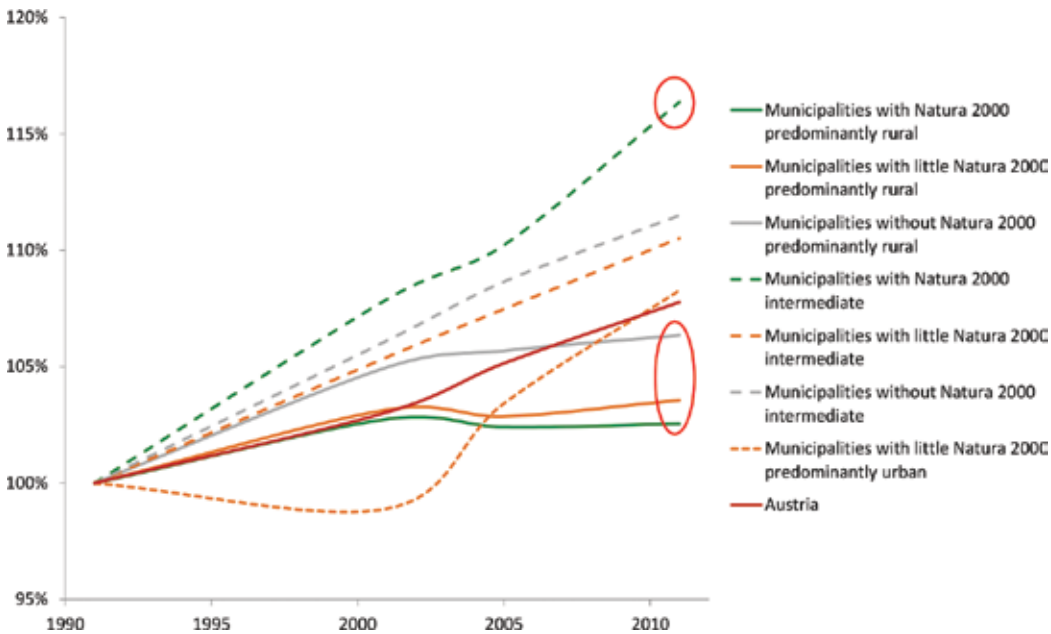

Figure 2. Demographic change: population development in Austrian municipalities (1990–2010).

trend. Municipalities with Natura 2000 both significantly grew faster, and somewhat slower, than communities without Natura 2000. Therefore, demographic development certainly was influenced by many other factors (e.g., location, economic structure, proximity to labor markets, and immigration).

It can therefore be safely concluded that Natura 2000 areas in a municipality on average cannot influence the demographic development which is influenced and determined by other decisive factors which are differentiated according to the degree of urbanization. However, this does not mean, of course, that there might not be single communities where Natura 2000 indeed played a vital role for either emigration or immigration. One the one hand, Natura 2000 may lead to restricted development options, for example, in terms of land use for residential purposes, and might therefore limit the spatial development of a community. On the other hand, Natura 2000 areas may attract new residents since these areas, especially around larger urban areas, are established in ecological and green regions and landscapes.

With respect to the labor market, two indicators were chosen to explore whether there is a recognizable effect of Natura 2000 on the labor market. First, we ascertain potential differences between communities based on the unemployment rate. Second, the number of jobs created in Austrian municipalities between 1991 and 2011 is explored.

Figure 3 presents the results for the unemployment rate (measured by the European Union's standard computation). For rural and intermediate municipalities, the unemployment rate lies between 4 and 5% on average. For the large cities (especially Vienna), unemployment rates are higher with approximately 6–7%. As can be clearly seen, the different classes of municipalities differ marginally regarding the level of unemployment; however, the development of the

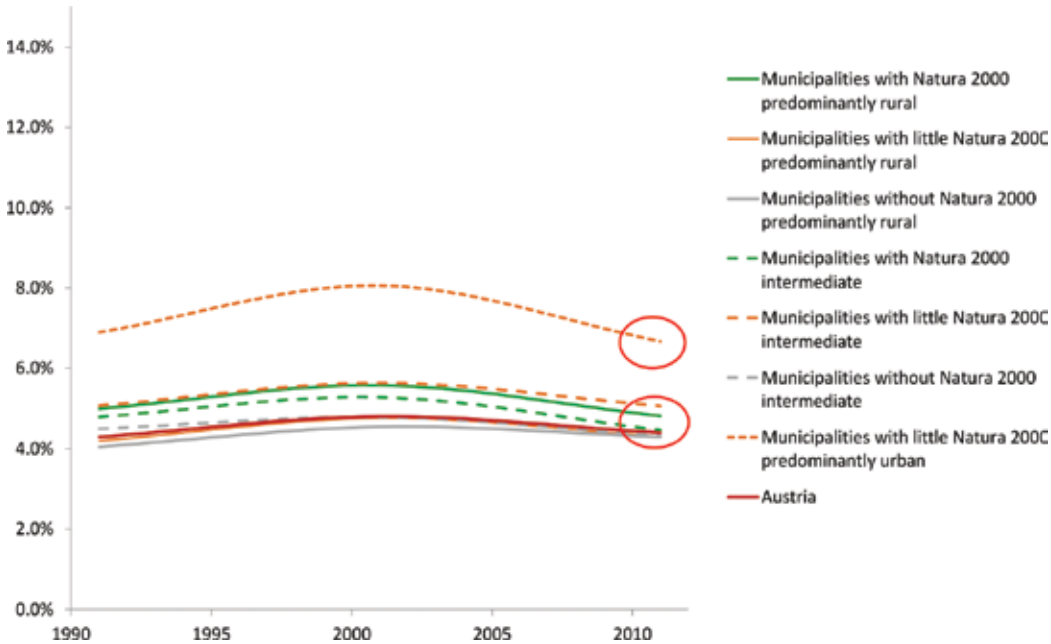

Figure 3. Unemployment rates in Austrian municipalities (1991–2011).

unemployment rate over time is broadly equal, with a peak around 2000, and a reduction in the last decade of the observation period.[1]

Regarding the differences with respect to the share of Natura 2000 areas in municipalities, there is merely no conclusive result to be detected. Again, it seems that the economic structure, the location, and the generally higher unemployment rates in urban areas are one of the driving factors—at least much more important for the determination of the unemployment rate than the existence of more or less nature conservation.

Figure 4 details the picture of the labor market more precisely by considering the number of jobs created over time. It can be clearly seen that the highest concentration of jobs is in urban areas. The growth of jobs in the urban municipalities amounts to about 17% over a decade, however, starting at a much higher level than in other intermediate or rural municipalities.

Growth in Natura 2000 municipalities is certainly comparable to growth in urban areas: municipalities with large Natura 2000 areas exhibit a job growth of 19% (intermediate municipalities) and 25% (rural municipalities).

Employment in municipalities with some Natura 2000 areas grew by about 17% (intermediate) and 37% (one of the largest average increases of jobs). Finally, looking at municipalities without Natura 2000 areas, the figures are comparable with a job growth of 20% in intermediate and 36% in rural municipalities.

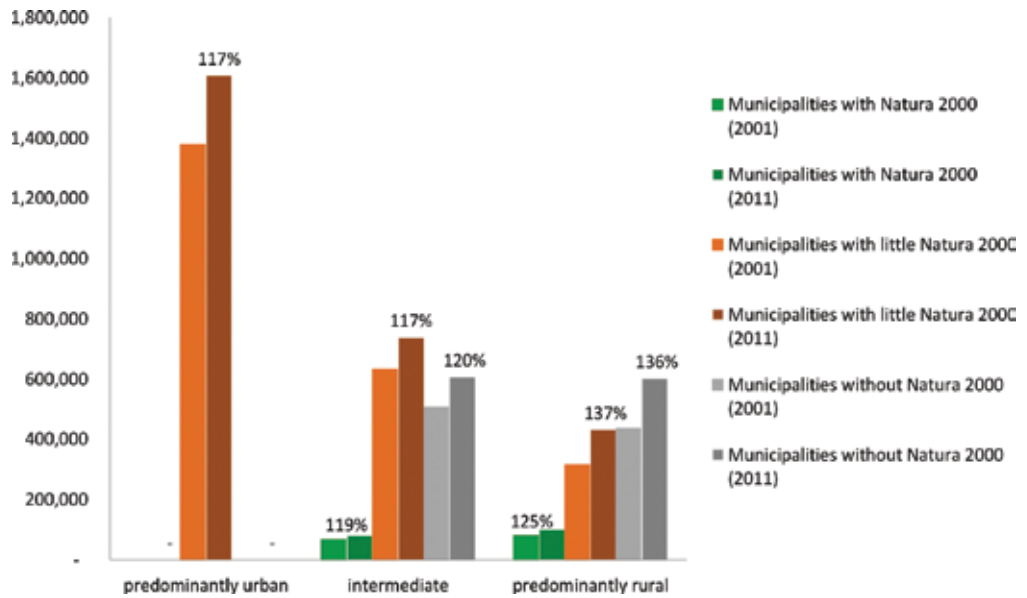

Figure 4. Number of jobs created in Austrian municipalities (2001–2011).

[1]We do not have actual unemployment figures at the municipal level for the most recent years; however, it can be expected that the development between classes of municipalities is largely parallel, but the level of unemployment is certainly higher owing to the financial crisis after 2008.

Job creation, therefore, does not seem to depend on the existence of Natura 2000 areas per se. Some rural areas, of course, also face significant job creation in the tourism sectors—but this can hardly be attributed solely to the existence of Natura 2000.

2.3. Tourism development: the effect of Natura 2000

There certainly is a long-ranging debate on the effects of biodiversity conservation on the regional economy, and more specifically on tourism. The existing empirical studies might be broadly summarized as follows:

- Regional development may certainly be enhanced just by the inflow of money to a region originating from national or international funding sources. As protected areas are located in peripheral regions, the local municipalities often do not have sufficient funds to provide for the establishment and management of park. In most cases, this money inflow per se increases demand for park-related goods and services, and creates (some) local jobs.
- If conservation leads to a change of land use in terms of a total loss of production (e.g., in agriculture, forestry, fishing, and hunting), management plans of national parks, Natura 2000 areas, and nature protection areas provide for a sufficient compensation amounting to the loss of property value. In other words, this means that potential production losses are compensated; income of property owners or rights holders, therefore, may stay the same. (Very often, a significant share of a park's budget is devoted to compensation, and alternative management of the land.)
- Some new regional products might be developed such as new handicraft, certain uses of local resources (e.g., joint marketing of natural and/or ecological products such as organic farming or game meat). In terms of the size of the local economy, the value added is relatively small, though important for building companies and stakeholder networks.
- Finally, the most important potential benefit of establishing and operating protected areas is the tourism sector. As protected areas conserve biodiversity and provide experiences for visitors based on the natural environments, it is safe to assume that protected areas usually attract visitors.

From a methodological point of view, there are some uncertainties that have to be taken into account when the effect of tourism is to be ascertained. First of all, many categories of protected areas such as national parks or even more, Natura 2000 sites, do not emphasize a priori the development of tourism. While national parks at the core provide education and information to visitors, Natura 2000 areas often do not include references to regional tourism. Only when it comes to conserve biodiversity, management plans may provide temporal or spatial bans of access to certain areas.

However, the experiences within a prominent conservation area such as a national park are designed and marketed by the park's management, as well as by tourism boards and the tourism industries. While visitors come to certain areas because of their beauty and pristine natural environments, the label and the management of the park provide for additional attractions. In other words, without marketing and additional efforts, establishing a protected

area by itself may not attract more visitors. Only if concerted actions and strategies are put in place, the destination can be marketed accordingly to raise the number of visitors.

For instance, Getzner [11] provided evidence that the long-term effect of a national park on the number of tourist might lie in the range of 3–5% of annual growth in addition to already existing trends, even with the case of prominent and large national parks.

This chapter presents some evidence that Natura 2000 sites, indeed, lead to an increase in the number of tourists in a region. **Figure 5** presents an index of tourism development over time between 1990 and 2015 for the summer season. Generally speaking, the first decade until about 2000 saw a constant decline in the number of tourists in the summer season; a prominent exception is city tourism, again with Vienna as one prominent destination with a 60% increase in tourism numbers over the last 20 years. Inspecting the graph in more detail reveals that municipalities of all degrees of urbanization, and both with larger or smaller Natura 2000 areas, exhibit higher growth rates than municipalities without Natura 2000 sites.

In other words, nature conservation based on Natura 2000 does not lead to a decrease or stagnation in tourism during the summer season, but rather increases tourism above the Austrian average.

The causal linkages at this level of aggregation are, however, hard to detect. On the one hand, as said earlier, Natura 2000 sites are certainly established in areas of natural beauty, or where other conservation areas are overlapping, such as national parks.

On the other hand, most municipalities without Natura 2000 areas are either rural areas without tourist attractions or are industrial areas and centers.

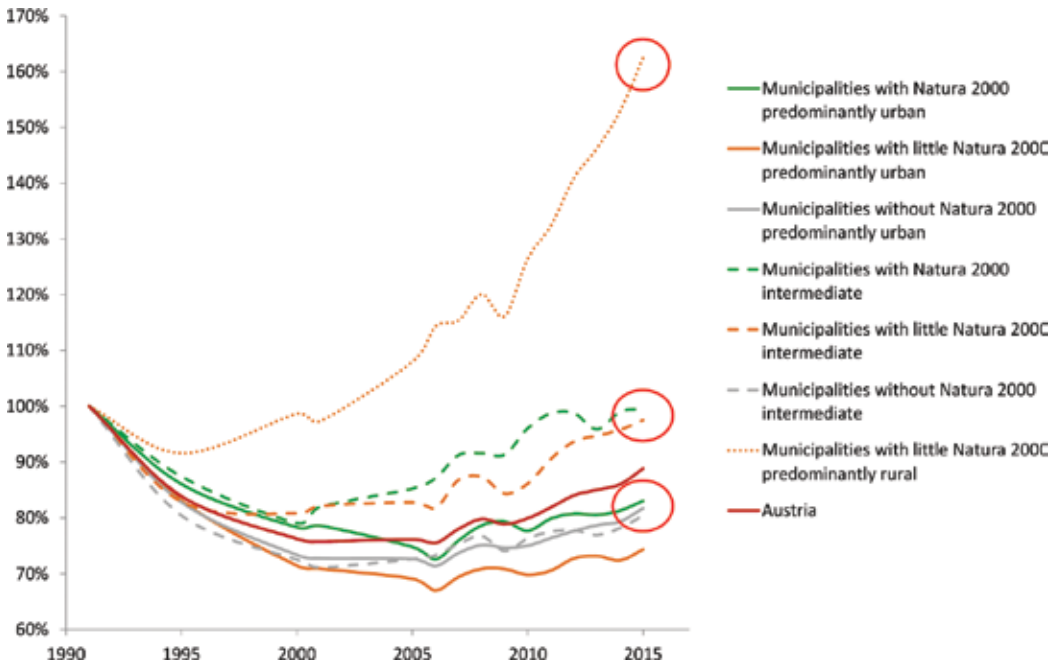

Figure 5. Overnight stays in Austrian municipalities (1990–2016).

It can therefore be concluded that Natura 2000 areas somewhat support tourism development and in certain municipalities may also provide additional attractions in terms of thematic hiking trails, nature trails and educational signposts, or exhibitions dealing with various aspects of conservation.

3. Summary and conclusions

This chapter has briefly highlighted and summarized the potential differences between Austrian municipalities where Natura 2000 areas have been established. The causal linkages between the mere existence of a Natura 2000 area and the regional or local effects are not as strong as it might seem in the first place. Regional and local development is certainly determined by a huge variety of factors such as territorial capital, location and accessibility, available infrastructure, and proximity to markets (factors of production; goods and services). In addition, regions with protected areas are often peripheral regions without much potential for endogenous regional development. Furthermore, many categories of protected areas (such as national parks, biosphere reserves, and nature and landscape conservation areas) overlap with the establishment of Natura 2000 areas. In fact, the Austrian national parks are all managed also according to the Natura 2000 frameworks.

To put it mildly, our study has revealed that Natura 2000 areas do not pose a threat to regional and local development; mostly, demographic, social, economic, and spatial developments are driven by the factors described earlier. This is certainly indicated for the fields of population growth, employment and unemployment, and the number of jobs. One exception can be seen in the tourism development. Data indicate that the establishment and operation of Natura 2000 areas might indeed attract more visitors (in addition to the vast majority who would visit the area even without a protected area on the basis of natural beauty and pristine ecosystems). However, the regional economic impact of protected areas in general may not lead to sufficient private funding or a substantial contribution to the financing of protected areas (cf. [12]).

Regarding management options, the results of this study are mixed. As Natura 2000 does neither harm nor substantially improve regional development, the leeway of management options is very limited. Park management may certainly create visitor experiences based on ecological systems such as nature trails, exhibitions, excursions, and other events. Such options are more feasible in national parks with their aim to educate and inform visitors, while the Natura 2000 framework is first and foremost oriented toward the conservation of species and habitats, and to prevent the further degradation of ecosystems. These objectives may certainly provide the basis for regional development, for example, in terms of increasing visitor numbers, the conservation work has to be complemented by local and regional development strategies. Such strategies may include destination marketing, development of local products based on natural resources, building up networks of local and regional stakeholders, and joint efforts and cooperation between the municipalities and the provincial authorities. Otherwise, it is safe to assume that there is no clear-cut direction of the regional effects of the establishment of protected areas, certainly no “automatism” which may lead to a positive development by merely establishing an area without any further measures or policies directed toward regional development.

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Chapter 3

Development Vision of Protected Areas in the Republic of Croatia: National Park "Krka" as a Trend Leader

Ivan Martinić and Drago Marguš

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.72595

Abstract

This chapter provides an overview of the current state of the park system of R. Croatia. The effectiveness of management, recent achievements and difficulties in the functioning of national parks and parks of the Republic of Croatia are analysed, especially in the light of fulfilling ecological functions, contribution to sustainable development and strengthening local community economies. Attention is drawn to the lack of a comprehensive strategy of national park system, shortcoming of a unique park policy that is necessary for social valuation of a protected areas' role, their stable financing, professionalisation of park functions, professionalisation of workplaces and positioning in relation to other sectors. Through the development vision of the national park system, prospects of improving management are stated, conditions of increasing the efficiency of management are detected and the models of achieving greater financial sustainability are suggested. In the second part, NP Krka is shown as the leader of the trends through protection and management of its area for more than two decades. The practiced approach has positioned them in the very top of the Croatia park system according to the results of the management and quality of the solution. The key features of the NP Krka management concept are highlighted, due to the achieved financial autonomy and the high level of sustainability of NP Krka management. An important upcoming challenge in managing the NP Krka is the need to effectively preserve the biodiversity and ecosystem services of the protected area through the establishment of a higher level of adaptability and flexibility of management, primarily to reduce the impact and effects of climate change, as well as the more pronounced annual growth of visitors and the consequences it brings. An important impulse for the improvement of the management in the NP Krka will be the adoption of a new spatial plan that will define, based on the results of extensive multidisciplinary research, the opportunities for development of acceptable activities in the protected area.

Keywords: protected areas, Republic of Croatia, Krka national park, management, financing, sustainability, tourism

1. Introduction

Protected areas, as the most significant and representative areas with exceptional natural value, are predestined to become model defined natural areas, ensuring permanent harmony between biodiversity conservation objectives and the environment as a whole, while permitting the rational use of space and natural resources, and contributing to the prosperity of the local community in the area surrounding the protected area.

The management of protected areas in the Republic of Croatia largely achieves the targets defined in the Strategy and Action Plan for Nature Protection of the Republic of Croatia (NSAP) [1, 2], the Convention on Biodiversity (CBD), the Aichi Biodiversity Targets,[1] and other relevant national and global programmes [3, 4, 5].

In abiding by the standard success benchmarks for managing protected areas, drafted by IUCN,[2] it can be stated that Croatia has achieved prominent results for most protected area functions [6].

Additionally, according to the assessments of WWF, the Croatian protected areas system has been confirmed as efficient in the sense of protecting biodiversity,[3] and its management success markedly surpasses that of other protected areas in the region [7].

The strategic objectives of the development of a protected areas system in Croatia (hereinafter: Croatian parks system), are defined by the NSAP. The primary objectives are the integral validation of protected areas, improving quality and efficacy of their management, and ensuring active public involvement in the planning and management of protected areas [7].

An overview of the accomplishments achieved over the past 10 years in the management of protected areas in Croatia includes the following:

- Institutional strengthening of nature conservation at the national, county, and local levels, with a strong positioning of the Croatian Agency for the Environment and Nature (HAOP), as the central expert institution for nature conservation, including the function of development and improving park system management,
- Establishment of a common policy system in the operation of public institutions for managing protected areas,
- Accession, ratification and implementation of all international agreements in the field of nature conservation, and the establishment of a national legislative framework in the area of nature conservation that is aligned with the European Union, the *Acquis Communautaire*,
- Successful implementation of a large number of international projects (**Figure 1**).

[1] Aichi Biodiversity Targets 2011–2020; www.cbd.int/sp/targets/default.shtml.
[2] IUCN—International Union of Conservation of Nature.
[3] According to a WWF analysis, a total of 133 biodiversity targets were identified in Croatia; 78 targets (58.6%) are adequately covered by protected areas, 52 (39.1%) have been identified as gaps, and 3 (2.3%) as complete gaps—in the project "Dinaric Arc Ecoregion Gap Analysis".

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Figure 1. Celebration of "Burnumske ide" in Krka National Park—Celebrate full moon nights at the site of the Roman Amphitheatre Burnum from 76/77 AD. (Photo gallery NP Krka).

On the other hand, certain recent analyses of the Croatian parks system [8–10] have indicated that the requirements for further development of the system have only been partially achieved, with the lack of an integral vision, non-standardised management, financing difficulties, sporadic sectoral policies, a backlog of property and legal issues, and so on, are recognised as weaknesses.[4] The system is also marked by a highly unfavourable expenditure structure, in which more than 70% of management costs go towards employee salaries and material costs, and less than 15% of revenues are invested into programmes, including projects to support the local community development.[5]

According to a UNDP report,[6] in order to improve management of the Croatian parks system, the fundamental barriers lie in the systematic weaknesses of the institutional framework, including inefficient management, and the issues of consistency, allocation and efficacy of financing national protected areas. The same report lists that there is not a comprehensive strategic plan for protected areas, only a limited number of standardised policies and procedures for directing the implementation of best management practices. As such, the 19 public institutions (8 national parks and 11 nature parks), currently function completely independent of one another, with limited accountability to the central government bodies for fulfilling national and international obligations concerning nature conservation [11].

According to Martinić,[7] the further development of protected areas in Croatia will require their ongoing revision at the national level [12]. Criteria need to be developed and priorities proposed to proclaim new protected areas, and also to determine priorities for the inclusion of Croatian protected areas into global networks, such as the UNESCO World Heritage List,

[4]See Martinić [9].
[5]See Martinić et al. [10].
[6]See UNDP [11].
[7]See Martinić [9].

the UNESCO Man and Biosphere (MaB) programme, the Ramsar list of internationally important wetlands, the Geoparks network, and so on.

The current operational objectives for the parks system pertain to improving the fundamental management documents, digitising boundaries, resolving property ownership issues and the like. A special objective of the NSAP is the establishment of a representative and functional network of protected areas, with the prior assessment of these protected areas according to the IUCN categories, and an analysis of their representativeness and functionality, in order to determine priorities and means of resolving outstanding issues.

2. Development vision for the Croatian parks system

The development vision for the parks system includes strengthening the credibility of all functions of protected areas in preserving natural and other values in Croatia, while also strengthening the influence of protected areas on sustainable development as a whole. The prominent management challenges involve increasing efficacy in conserving species and habitats, a higher level of adaptability in management, improving spatial planning, and more dynamic and elastic management of space in the sense of visitor reception and permitted activities.

Part of the vision is directed at establishing new intersectoral alliances (among agriculture, forestry, tourism, etc.) to address the values and benefits of ecosystems in protected areas to support human health (**Figure 2**).

More so than in other spaces, in the future, protected areas will be polygons for seeking out and finding "natural solutions" to mitigate and adapt to climate change. In order to strengthen this vision, there are plans to establish[8] a national climate change adaptation centre. The Puljani eco-campus in Krka National Park has been proposed as the future administrative seat of such a centre.

The development of the tourism function of protected areas and national park system, in the spirit of the recommendations of the most recent world parks congress,[9] will lean more heavily on the principle of "connecting people with nature," that is, ensuring that visitation to natural areas is based on strict abidance of reception capacities, as a guarantee of achieving greater authenticity and ensuring a better quality experience during the visit, and preventing the degradation of the values of the protected area. On the other hand, the protected areas in Croatia should in the future serve as drivers of specialised tourism programmes. These programmes should be multi-day thematic visits, achieved in part on partnership with the local population, through accommodation, culinary offer, demonstration of old trades, and so on. In order to achieve this objective, it will be necessary to prepare and adopt a new tourism development strategy in protected areas, taking into consideration broad consultations with

[8]Primarily pertains to initiatives from the ministries responsible for environmental protection and nature, science and education, agriculture and forestry.
[9]Contained within "Promise of Sydney," recommendations of the IUCN World Parks Congress, Sydney, Australia.

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Figure 2. Kopački Rit Nature Park (also called "European Amazon"), the oldest nature park in Croatia and UNESCO "Man & Biosphere" Reserve; situated in the central part of the Danube floodplain, between the Drava River and the Danube River. (Photo: Goran Šafarek).

all interest groups. The key stakeholders are the regional and local authorities, the business sector, associations, and the local population.

An important part of the development vision for the parks system relates to improving the sustainability of financing. The perspectives for sustainable financing stem from social acceptance that the management concept must be based on clear financial mechanisms and diversified sources of funding such as state budget transfers, concessions and other fees, own revenues generated by park administration, domestic and international project funding, and so on. All revenues from fees for protected area services must be reinvested into conservation, maintenance, and development of the system.

To that end, it is necessary to secure the threshold of financial sustainability of the protected area system at the ministry level, which should take into account not only the direct and indirect values of these protected areas but also the non-market and unused benefits, and services ensuing from their functioning [12]. Only such a validation structure for protected areas can cast a light on the significance and true costs of their functioning in the implementation of appropriate protection, conservation, and development.

According to Martinić [13], the generator of improvements to the Croatian parks systems should be the National Parks Agency (NPA). At the national level, this agency should be the leader of forming a single parks policy, and be responsible for presenting the common interests relating to the social validation of protected areas, their stable financing, professionalisation of park functions and tasks, position in relation to other sectors, and other issues.

3. Krka National park as the trend leader

Krka National Park is one of eight national parks in Croatia. The protected area, known for the many lakes and waterfalls, was proclaimed as a national park in 1985. It is situated in central Dalmatia over 109 km^2 of the course of the Krka River, and the lower course of the Čikola

River. The Krka River is marked by seven travertine waterfalls, and its beauty is in this natural karst phenomenon, and the exceptional wealth of flora and fauna, particularly birds.[10] Each year, more than a million tourists from all over the world visit Krka National Park.

For more than a decade, Krka National Park has been among the leaders of the Croatian parks system, both in terms of its overall results and its exceptional accomplishments in specific management aspects. Results include the following:

- Integral validation and a high level of conservation of natural and cultural values, through its approach to applying research results to raise the scope and quality of conservation, and to create new solutions in management and/or development of park products and services.
- Wide ranging contribution to the development of the local community, achieved through employment of local people, hiring local operators for specific park functions (i.e. fire-fighting measures, boat transfers of visitors, etc.), equipping structures of common interest (park branch offices, information centres), and improving the local municipal infrastructure (roads, sewage, etc.).
- Investing ongoing efforts to enhance the visitor experience through dynamic development of organised visitor systems, in which the key elements are a unified visitor management plan, diversified models of ticket sales, synchronised network of entrance points, internal transport system, route directions, and so on (**Figure 3**).
- Ongoing research on the reception capacities of the protected area and constant efforts to unburden the most heavily visited sections of the park, through the development of innovative visitor management solutions and the affirmation of new visitor locations.
- Inclusion in global visitor trends for protected areas through the creative development of a park programme that meets the specific and sophisticated visitor sensibilities, including exhibits, festivals and performances, active education, participation in authentic culinary and wine events, and so on [14–17].

These accomplishments, above all, should be attributed to a strong management concept of Krka National Park, which has achieved financial and overall management sustainability based on good organisation and the application of functional project management models [18]. Such a management approach in the park serves to protect the park resources, and ensures a high level of service for visitors, while placing equal significance on the execution of conservation programmes, enforcement of the law, supervision over concessions and the performance of commercial activities, with high quality information services and visitor safety.

In the management of Krka National Park, the principles of adaptive management are applied. This is based on strictly defined tasks and responsibility of individual services, with the aim of achieving specific project goals. This requires precisely defined procedures, activity leaders and resources, all focused on the clearly defined indicators of goal achievement, and accompanied by dynamic reporting.

[10]More about Krka National Park at: www.parkovihrvatske.hr/nacionalni-park-krka?

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Figure 3. Stairway on the trail towards the "Oziđana pećina" cave in the NP Krka—view of the cascades (known as "necklaces") on the Krka River at the Roški slap. (Photo gallery NP Krka).

To conserve nature and protect biodiversity, intensive inventarisation of species and habitats is performed regularly in the park, encompassing all ecosystem components. Monitoring is regular and, where required, protection measures are implemented. In order to reduce the detrimental impacts of human activities on biodiversity and the environment, the impacts of tourism on the park ecosystems are constantly examined, and mitigation measures implemented.

A study on the preliminary visitor reception capacity was drafted with the aim of reducing the negative impacts of tourism [19]. The study defined the daily visitor quotas for the park in an attempt to ensure more effective visitor management and to prevent degradation of the park values. An important measure was the organisation of new visitor content in areas of the middle flow (Stinice, Roški slap) and upper flow (Burnum, Puljani, Nečven) of the Krka River. Considering the pronounced annual growth in the number of visitors[11] and the increasing seasonal overload of certain park localities, since July 2017, visitor number restrictions have been implemented at Skradinski buk, by far, the most visited site in Krka National Park. The new visitor regime allows for a restriction of the number of visitors to Skradinski buk at one time to 10,000 visitors. In order to inform visitors and to regulate the number of visitors, display screens have been installed at the entrances to the park, indicating the number of available tickets that may be purchased at any time (**Figure 4**). Those visitors arriving during the busiest times are directed to wait, or are redirected to other less burdened areas of the national park.

Krka National Park is the leader of the pack among Croatian protected areas in terms of the number of achieved joint projects with the regional and local authorities. The high level of cooperation with and contributions to the local community is accomplished through the stimulation and development of programmes that bring sustainable solutions and win-win results to successfully respond to development goals and challenges of protected areas, and to the social and economic needs faced by the local and regional community and national authorities. The main framework of these programmes will comprise the new spatial plan of Krka National Park.[12] One of the main professional areas of focus in the new spatial plan will be that the majority of

[11]In 2016, a total of 1,071,561 visitors entered the park, with an annual growth of 12.6% in comparison to 2015.
[12]Adoption of a new spatial plan for Krka National Park is expected by the end of 2017.

Figure 4. Krka National Park; display screen at the Lozovac entrance with information on the current number of tickets available for Skradinski buk. (Photo: TRIS/J. Krnić).

activities surrounding visitors will concentrate on existing visitor sites or those where visitation can have a lesser impact on the most ecologically valuable areas in the protected area.

A special challenge in the management of Krka National Park is the need for an effective response to conserving biological diversity and ecosystem services in light of climate change. Such tasks will certainly increase the requirements for a management model that will focus on the work of the park administration on protecting ecosystem integrity and establishing greater ecosystem elasticity. In the proposed initiative for the establishment of a national centre that would address the issues of adapting park management to climate change, Krka National Park can provide the opportunity of hosting the administrative seat of such a centre at the Puljani eco-campus.

The development of tourism function of Krka National Park is directed at further optimisation of an organised visitor system, to achieve greater authenticity and to improve the quality of the visitor experience. A very important accomplishment in the park management will be the expected inclusion of the park onto the UNESCO World Heritage List in the near future. Krka National Park already meets the general and additional criteria for inclusion onto the UNESCO World Heritage List,[13] particularly the integrity criteria. The strongest support for this inscription is the adopted and successfully implemented Management Plan and the many years of successful management and excellent results.

4. Conclusions

In the contemporary social context, the role and significance of Croatia's protected areas should be viewed through the fulfilment of long-term goals to protect global and national biodiversity and ecosystem process, and to make recognisable contributions to sustainable development and strengthening of the local and regional economies.

In the management of Croatia's protected areas, many of the goals of the main global and national policies and programmes have been accomplished. In terms of international bench-

[13]Criteria for the inclusion of natural properties in the World Heritage List—Chapter D.

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marks of success in managing protected areas, it could be stated that the Croatian parks system is achieving excellent results in best practices of protected area management.

An important hurdle for improving management of the Croatian parks system is the lack of a comprehensive strategic plan for protected areas, systematic weakness of the institutional framework, ineffectiveness in resolving outstanding issues (legal and property relations, spatial planning, etc.), and issues concerning sufficient financing and cost structures.

For the continued development of Croatian protected areas, their ongoing revision is required. At the national level, it is necessary to adopt a strategy to strengthen the credibility with specific instruments to improve management and to define the priorities in resolving outstanding issues in protected area functioning.

The national parks system is expected to strengthen the contribution of developing the local communities, through sustainable and win-win solutions, which will have equal success in responding to the development challenges of protected areas and to the socioeconomic needs of their broader surroundings.

Future priorities in improving the tourism function of protected areas should be placed on optimising organised visitor systems and achieving greater authenticity and quality of the visitor experience.

With the existing management concept of Krka National Park, based on functional and project organisation, a decisive advantage has been gain in management efficacy, which ensures a high level of results of Krka National Park in all fields of management. Many of the key objectives of protected areas have already been accomplished, to the highest level of excellence, and some have been recognised as the best global practice in managing protected areas.

An important management challenge the park still faces is the need for an efficient response to protected biodiversity and ecosystem services through the establishment of a higher level of adaptability and management elasticity, above all to reduce the impacts of climate change and the increasing pressures of growing numbers of visitors and the consequences that these impacts bring.

An important impulse in achieving the management goals of Krka National Park will be the adoption of the new spatial plan, which will set out to define the spatial organisation of park infrastructure and visitation models, and to define the possibilities of developing permitted activities in the park, and their content, positioning, and intensity.

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Chapter 4

Transboundary Cooperation: The Best Way to Share Common Responsibility for Future

Zdenka Křenová and Pavel Kindlmann

Additional information is available at the end of the chapter

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Abstract

The Bavarian Forest National Park (BFNP) and Šumava National Park (ŠNP), established in 1969 and 1991, respectively, are located between Prague and Munich. Their long common border accents the transboundary issue regarding nature conservation, ecological corridors and connectivity. Plans to protect this large forest landscape, dating back to the early twentieth century, were never implemented due to the two World Wars and Iron Curtain. Initially, there were many joint activities. Many common projects (e.g., joint information centre, transboundary public transport system, GPS lynx and deer telemetry) were conducted. Both sides have learned a lot during these 25 years of cooperation. The main obstacles in cooperation are economic differences between the regions, language barriers and different policies and laws. There is only one common ecosystem of mountain forests, common populations of lynx, capercaillie or bark beetle, and the partners have to learn how to share their common responsibility for the future. Step by step, the transboundary cooperation is improving, which is very important in good years, but maybe even more important in bad years. The principle stance of the transboundary partner can buffer threatening in the neighbouring national park and support recovery when the crisis is over.

Keywords: transboundary cooperation, non-intervention management, wilderness, Natura 2000, conservation targets and police, governance

1. Introduction

The Bavarian Forest and Šumava National Parks (BFNP & ŠNP) are located between Prague (Czech Republic) and Munich (Bavaria, Germany), approximately 180 km from each of these two capitals (**Figure 1**). The parks have a fairly long common border, which accents the transboundary issue regarding nature conservation, ecological corridors and connectivity. Plans to protect this large forest landscape date back to the early twentieth century, though

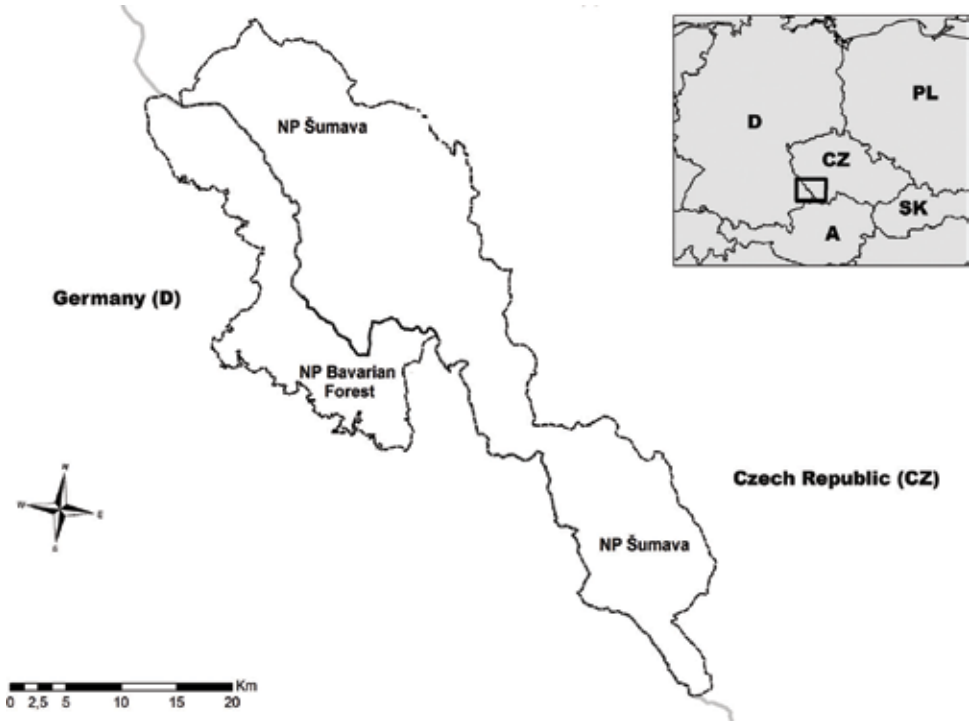

Figure 1. Map showing locations of the Bavarian Forest NP, Germany, and the Šumava NP, the Czech Republic.

they were never implemented, due to the two World Wars and then due to the Iron Curtain, which separated the political power blocs and the human and natural environment of Europe for half a century, from 1945 to 1990.

The management aims for the national parks have not yet been clarified in all aspects. When the Bavarian Parliament voted unanimously to establish the Bavarian Forest National Park (BFNP) in 1969, the first one in Germany, it was thought that this project would probably generate an urgently needed income for the local population through creation of new jobs and support of tourism in this poor region lining the Iron Curtain. Similar reasoning also stimulated the establishment of the Šumava NP (ŠNP) in 1991, immediately after the fall of the Iron Curtain. There is a proverb, however, saying that when the two are planning the same thing, it does not have to be the same.

In this chapter, we are summarising several decades' experiences of management of these two national parks with very similar natural conditions and some social differences. We stress the importance and benefits of transboundary cooperation, which can bring people together and—in addition —improve people's relationship to nature.

2. Nature

A chain of mountains rises along the Czech-Bavarian border in the heart of Europe. More than 2 million hectares of Bavarian and Bohemian forests have remained almost entirely unfragmented

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by roads and free of larger settlements. The Bavarian Forest National Park (Germany) and the Šumava National Park (Czech Republic), located in the centre of this area, with their highest peaks Mt. Rachel (1453 m) and Plechý (1379 m), respectively, represent a densely wooded landscape of great beauty, comprising crystal clear mountain streams, unspoiled marshlands, mires and bog woodlands, and abandoned mountain pastures at higher elevations.

This forest, called Silva Gabreta, is unique because of its almost natural condition and size. It is the last remnant of the 'Hercynian Forest of the Romans' and, looking back, the territory has always been associated with deep forest. The historical presence of the Celtic Boii tribe in the Czech Basin is hinted in the original Germanic name for the mountain range—Böhmerwald (probably 'the forest of Boii'), as well as in the medieval Latin name Silva Bohemica (from Chronica Boëmorum/The Chronicle of Bohemians by Cosmas of Prague, etc.). Any written Czech reference to 'Šumava', which is based on the ancient Slavic 'šuma' [shuma], also indicating forest or dense woodland and still in use (in Croatian, for example), can only be found from as late as the seventeenth century.

In summary, 'Böhmerwald' (Bohemian Forest in English) is used as the name of this transboundary region. Designations 'Bayerischer Wald' (Bavarian Forest in English) and 'Šumava' named the national parks, founded on the Bavarian and Czech sides of the border. Because of the partly nationally sensitive issue, only the country-specific names have been used.

The Bohemian Forest is home and refuge for many endangered species of plants and animals. A stable population of lynx (*Lynx lynx*) is living in the region and observations of wolves (*Canis lupus*) became more and more frequent recently. There are many elements of the northern boreal forest, and capercaillie (*Tetrao urogallus*), Ural owl (*Strix uralensis*), three-toed woodpecker (*Picoides tridactylus*) and other species have an important south-western outpost in the middle of the broad-leaved forest that dominates this part of the continent. In an area of more than 90,000 ha, BFNP & ŠNP today protect a representative example of the Central European highlands and an important part of Europe's natural and cultural heritage.

2.1. Natura 2000

Both national parks form the largest terrestrial Natura 2000 sites in both countries. They are a significant part of the Natura 2000 network, which was established to protect the most endangered habitats and species in Europe, as defined in the 1992 Habitats Directive 92/43/EEC and 1979 Birds Directive 79/409/EEC and 2009/147/EC. More than 25 Natura 2000 habitats have been recorded in this area [1], the following ones being most important: 9410 mountain spruce forests (ass. *Piceion excelsae*); 7110 peat bogs (ass. *Leiko-Scheuchzerion palustris*); 91D0 bog woodlands (ass. *Dicrano-Pinion*); 6230 mountain Nardus meadows (ass. *Nardo-Agrostis tenuis*).

2.2. Bark beetle: spruce forests story

Bark beetle (*Ips typographus*) is the main pest species in any spruce forest. Bark beetles attack mature trees and infestation results in death of the tree [2]. Bark beetle outbreaks are therefore a natural feature of spruce forests in BFNP & ŠNP. Based on historical evidence, large-bark beetle outbreaks occurred many times in the past in this area [3]. The spruce trees we see here now originated partly after a wind disturbance, which was followed by a bark beetle outbreak

[4] and subsequent salvage logging at the end of the nineteenth century. However, now these forests have a natural character [5]. Recently, an extensive bark beetle outbreak occurred in the 1990s and then especially following the windstorm Kyrill during 2007–2012. About 700 thousands of trees were uprooted by Kyrill in 2007 [6].

Bark beetle outbreaks are a key issue in the management of the area, leading to a debate about the appropriate management of bark beetle. Spruce trees are an important habitat in the BFNP & ŠNP, supporting red list species. Broadly, two management approaches are suggested in the management of bark beetle: (1) ***intervention***—includes trap trees, insecticides and salvage cutting [7]; this is practiced in the majority of BFNP & ŠNP, with appropriate intervention in perimeter areas. (2) ***Non-intervention***—no management intervention in forests affected by bark beetle; practiced in non-intervention areas of BFNP & ŠNP (also with appropriate intervention in perimeter areas).

Management '***intervention***' does not always appear to be effective—Grodzki et al. [7] found no significant differences between tree mortality in intervention and non-intervention management areas and the outbreaks in both intervention and non-intervention areas ceased approximately at the same time. Bark beetle outbreaks are a natural phenomenon, but they have been exacerbated by the non-native spruce monocultures that currently exist in BFNP & ŠNP (see Section 3). Non-intervention management results in a more varied vegetation structure and therefore has significant benefits for biodiversity and greater resilience in the longer term [6, 8, 9]. Proponents of intervention may argue for 'one-off' felling to achieve bark beetle management, but in practice this would be a regular sequence of interventions equating to a managed forest environment [2].

It is worth noting recent developments on bark beetle management in Austria, where a recent paper provides guidance on how to deal with bark beetles outbreaks in Austrian national parks and wilderness areas [2]. The proposed management approach will not compromise the non-intervention philosophy in the core zone of these areas, while at the same time providing sufficient protection to surrounding landowners and their managed forests. It is based on a zonation model, which foresees a bark beetle control zone of varying width around the non-intervention zones of the protected areas [2]. It now enjoys a broad support of Austrian conservationists and forest management authorities alike [10].

Similarly, in BFNP & ŠNP, parts of forests were left without interventions, while salvage logging was applied in other areas. It turns out that the effect of salvage logging on vegetation was greater than that of the bark beetle outbreak itself [4, 11]. Bark beetles, together with wind disturbances, were recognised as the main biodiversity drivers in the forests of this region [8].

3. People

Prehistoric humans were active in the Bohemian Forest foothills as far back as 12,000 years ago. Celtic practise of gold panning in the basin of the Otava River in the period 300–50 BC must also be linked with the necessity to cut down the surrounding forests. However, neither of these activities significantly affected the uppermost areas of the Bohemian Forest, i.e., areas

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hosting the mountain spruce forests [12]. The earliest signs of settlement in the vast forest along the Czech-Bavarian border can be found in the eighth to ninth centuries, when Benedictine monks from Nieder Altaich Abbey (founded in 741) were assigned administration of the so-called Northern Forest. Czech rulers soon realised that the extensive and difficult-to-traverse boundary forests were useful as a natural defence of the kingdom. Therefore, for strategic reasons, a significant part of the Bohemian Forest was retained in the possession of the Crown (part of the territory is still called 'Královský hvozd' [The Royal Forest]), as the king wished to have a direct control of the colonisation process by creating settlements for defending gateways to the country [13]. Mass real settlement expanded in the lower parts of the Bohemian Forest only during the High Middle Ages, i.e., from the fourteenth century, with the development of gold and iron ore mining. It can be assumed that during this period there appeared places surrounded by concentrated deforestation activities. However, the forests in higher elevations survived without serious human impact for centuries. In addition to surface settlement, the Bohemian Forest has been, since prehistoric times, affected by historical routes —pathways along which settlements emerged, trails leading along the river valleys via mountain passes and along hillsides. Settlements were founded around inns and comprised all necessary requirements. Any significant impact as regards the highest part of the Bohemian Forest thus only occurred in modern times, with the boom in glass, iron and timber industries dating from the sixteenth to seventeenth century, when the main settlements in the upper part of the Bohemian Forest (Kvilda, Prášily, Walhäuser, etc.) were founded. The development of glassworks was the actual factor stimulating the settlement of difficult-to-access areas, then unsuitable for any other economic use. In particular, glass production in the Bohemian Forest heavily decimated beech forests. Beech ash was used to create pearl ash (potassium carbonate), necessary for the manufacture of glass, while beech wood was also good for making charcoal. Both of these were possible to obtain even in places that were relatively remote and difficult to access for timber transportation. Sites, where remains of local wood-burning fireplaces were found, include the cirque of Plešné Lake, in the altitude of about 1250 m. At that time, the mountain spruce forests at the highest altitudes were affected only by selective logging and some forest cattle grazing [12]. The most intensive use of forests in the highest parts of the Bohemian Forest began in the early nineteenth century, with adapting certain mountain rivers for shipping timber and construction of two navigation canals that enabled timber to be transported from the mixed mountain forests, or some spruce stands, to lower altitudes for sale. Economic exploitation further altered the natural structure of mountain forests in the Bohemian Forest and accelerated the development of spruce plantations, especially at lower altitudes, where these replaced the native mixed deciduous forests. To speed up the growth of spruce in waterlogged areas, people built networks of drainage channels. Many peat bogs and wetlands were drained up to cultivate the landscape. Local people often dug the peat and used it as a litter for cattle or for home isolation. However, one should not imagine that humans logged just any forest in the area. In the middle of the nineteenth century, approximately 25% of forests in what is now the Šumava National Park were still classified as primeval forest [3].

Human needs and technical capabilities were on the rise and the stretch of virgin forest in the Bohemian Forest dwindled century after century. Once again, it was strategic purposes, although largely for reasons of power, which eventually saved a part of Bohemian Forest's

natural beauty. The Iron Curtain, which in the second half of the twentieth century divided Europe for many decades, proved tragic for thousands of human lives, but the natural heritage of the Bohemian Forest benefitted from it. After 1945, most of the original residents were displaced from the Czech part of the Bohemian Forest and many villages in the frontier area were abandoned, often even intentionally destroyed. Some other villages were resettled with newcomers that had no experience of living in a mountainous region, were vetted and subsidised to live in this frontier zone during the socialist era [14]. The number of residents more or less remained the same between 1950 and 1990. The displacement of residents, strictly regulated access and very limited management in the landscape of the boundary zone created excellent conditions for the unhindered development of the area. Before the establishment of the Šumava NP, the local economy was based mainly on extensive forestry and agriculture, whereas tourism suffered, because the area consisted of both a frontier zone and closed military training areas. Also the situation on the Bavarian side of the border was hard during the Iron Curtain years. The young generation escaped to the cities, the region suffered economically and was gradually depopulated.

4. The Bavarian Forest NP

Back in the 1960s, there was a fierce argument between nature conservationists and the tourism industry concerning the future use of the Rachel-Lusen area in the Bavarian Forest. Some argued that new ski runs and lifts in the hitherto unspoilt forested region would bring more visitors and secure incomes. The alternative was creation of a national park, a very old idea dating back to the beginning of the twentieth century. At the end of the 1930s, plans for a Bohemian Forest National Park first began to take shape, whereby the bigger part of the valuable area is on the Czech side of the border. The effort to put the area under protection by the Reich Office for Nature Conservation was stopped abruptly in 1943 in the chaos of the Second World War. On June 11, 1969, the Parliament of the Bavarian state decided unanimously to establish a national park in the Bavarian Forest. Further design and organisation of this first German national park, which was officially opened on 7th October 1970, found its scientific basis in the so-called 'Haber Analysis' of 1968 [15], which described the ecosystem conditions in the new national park [16].

The BFNP was the first protected forest in Central Europe, affected on a large scale by the bark beetle outbreak following several wind throws [17]. Since the 1980s, the park has served as a pilot study area for Central Europe, from which management guidelines have been developed for commercial forests and strictly protected areas with a 'benign neglect strategy' [18]. Periodic windstorms and bark beetle outbreaks have been recognised as a natural phenomenon affecting this forest region for centuries. Scientists reported strong natural regeneration of mountain spruce forests affected by bark beetle over the past several decades [19]. As a result of its consistent implementation of the principle 'Let nature be nature', the Bavarian Forest NP has been recognised internationally by the Council of Europe (with the European Diploma) and the IUCN (World Conservation Union) as a Category II National Park. In accordance with International Nature Conservation Quality Standards, the park has to guarantee that those priority management aims, which target an undisturbed development of nature, are implemented on at least 75% of the park's territory.

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The Bavarian Forest NP was established as the first national park in Germany in area between the Lusen Mt. and Grosse Rachel Mt., Lower Bavaria, on 7 October 1970, then measuring 13,300 ha. Since its expansion on 1 August 1997, it has covered an area of 24,250 hectares. Villages are not part of the BFNP. Zonation is used as a useful tool for management of the BFNP. In accordance with the IUCN rules after appropriate transitional periods, at least three quarters of the surface should be managed in accordance with the primary purpose of protection. In view of this, the following zones with different management purposes are distinguished in the BFNP (**Figure 2**) [16]:

1. **Natural zone**: where natural processes have priority and no human interventions are planned—it covers 58.64% of the BFNP total area;
2. **Development zone**: subdivided into three sub-areas (2a, 2b, 2c)—this zone covers 17.61% of the total area of the BFNP and—step by step—more and more forests are being left to develop naturally here;
3. **Marginal/buffer areas**: covering 22.07% of the total surface area, which allow long-term effective forest protection measures in order to protect neighbouring forests;
4. **Recreation zone** (only 1.68% of the total surface area): this zone secures the function of visitor facilities.

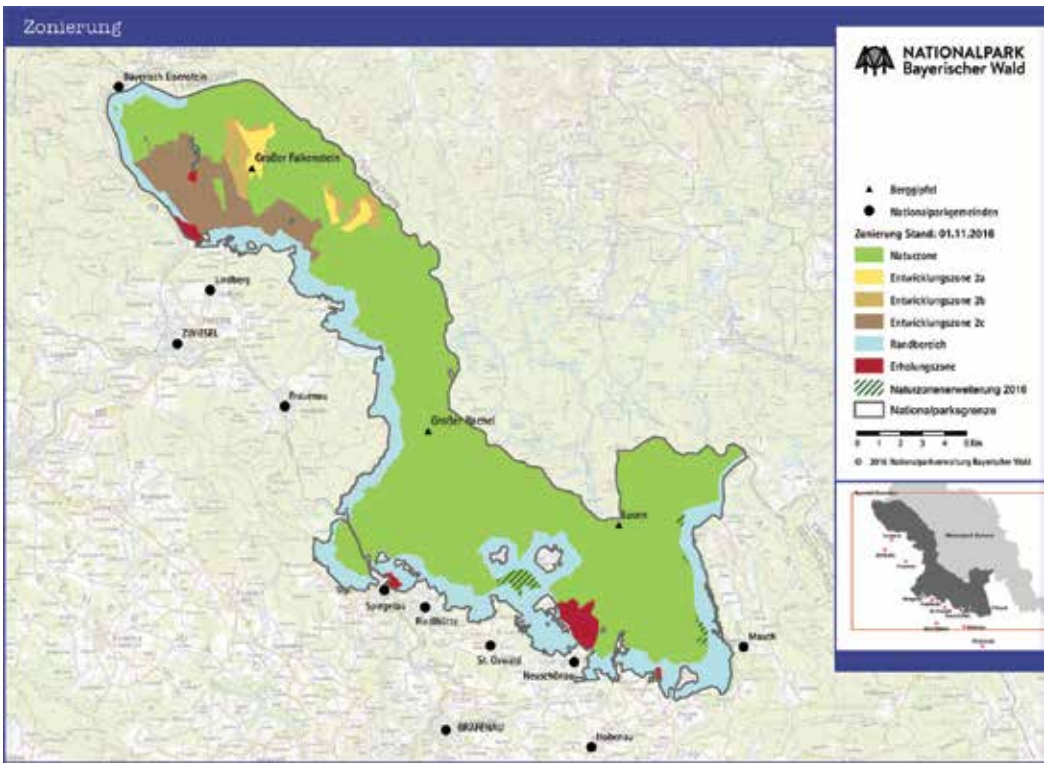

Figure 2. Zonation of the Bavarian Forest National Park.

Since the establishment of the national parks, tourism in the adjoining rural communities has developed from its modest beginnings to a supporting pillar of employment and income. According to the study by Job et al. [20], the BFNP is an important component of the regional economy. With 760,000 visitors per year, the BFNP is the region's most frequented attraction. As much as 67% of guests to the BFNP stay here overnight, the remaining 33% are day guests, local people and day trippers who come from their homes. The seasonal changes of these visitor numbers confirm the seasonal pattern of tourists in the region: most come in the summer and winter seasons and there are lower numbers in the off-peak months [21]. The highest numbers of visitors in the summer season are during July. The majority of the visitors come from Germany. Only 3.9% were foreigners, mainly from neighbouring countries, such as the Czech Republic, Austria or the Netherlands. The share of the tourism held in the BFNP provides the region with an occupation equivalent to 940 people and an additional 200 full-time jobs in the national park authority [20]. A comparison of the costs and benefits of the national park shows that the benefits definitely compensate for the costs that occur. The government spends 12 million Euro per year in the national park. This sum should, however, be seen alongside with the total number of jobs the park creates: 200 employees in the national park administration and 939 full time equivalents indirectly related to the national park—a total of 1139 jobs. Every Euro that the government invests in the national park is more than doubled by the amount spent in the park by its visitors [21].

5. The Šumava NP

Although Czech scholars had a limited access to the Bohemian Forest, which remained largely unexplored until the 1990s, they were aware that it contained many rare organisms and suggested the establishment of the Šumava Protected Landscape Area (Šumava PLA) already in 1963. At that time, there was no political desire for establishing the Šumava NP. However, the idea was not forgotten and preparation of the new national park started very soon after the Velvet Revolution in November 1989. The establishment of the Šumava NP in 1991 was recognised to be a good solution for this marginal region of great natural value. At the same time, in 1990, the former Šumava PLA was included in the list of UNESCO Biosphere Reserves (BR) and the Šumava peatlands became an important Ramsar site [14].

The Šumava NP (68,500 ha) was established in the most valuable parts of the Šumava PLA: in its central parts and along the national border. The remaining area (99,624 ha) of the Šumava PLA became a buffer zone of the NP (**Figure 1**). Unlike many other national parks, including the Bavarian Forest NP, some municipalities and their properties are parts of the Šumava NP. There is currently less than 1000 permanent residents living in six villages located inside the Šumava NP and land administered by 16 other municipalities partly overlaps with the area of the Šumava NP. The original concept assumed that the large area of the highest conservation value and least affected by humans, partly adjacent to the Bavarian Forest NP, would be strictly protected in the newly established NP. Development was to be more strictly regulated in this core zone than in the buffer area of the Šumava PLA, where a mixture of development

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and conservation was welcomed, particularly in the villages neglected for decades. However, this concept was implemented only in the initial years of the Šumava NP [14].

Long-lasting debates on the future of nature conservation in the Bohemian Forest are linked with discussions on zoning of the Šumava NP [22]. Unfortunately, the fact that zoning is just a very important tool of conservation, rather than a goal is currently not included in these discussions. The Article 4 of the Czech Government Regulation No. 163/1991 of March 20, 1991, which established the Šumava NP and set the conditions for its protection, states:

1. Methods and ways of protecting the national park are differentiated according to the division of the national park into three zones, defined according to the natural values.

2. Areas with the most important natural values in the national park are classified as Zone I (strictly natural, particularly natural or slightly amended ecosystems).

The aim was to preserve or restore natural ecosystem processes and limit human intervention into the natural environment to maintain this state. Since the establishment of the Šumava NP, its zonation has undergone significant changes, however (**Figure 3**).

Initially, Šumava NP zonation mostly accepted the international concept of zoning as a basic tool for scaling the value and protection of the NP interior. Fifty-four units of Zone I (**Figure 3a**) included a mosaic of habitats and isolated occurrences of mires, habitats of the highest value, often surrounded by forests, which were partly affected by forestry in the past. Most of the best places, including natural reserves protected long before the establishment of the Šumava NP (e.g., Modravské slatě, Chalupská slať, Jezerní slať, Trojmezná) were included in Zone I. Many of them were maintained without direct human intervention for decades.

In 1995, there was a change in the leadership of the national park, which brought about a change in the concept of NP management [22]. The size of Zone I was reduced and the original 54 units were further fragmented into 135 smaller ones (**Figure 3b**). The main reason was a strong desire for active management, mainly the logging of bark beetle-infested trees. The new definition of Zone I was based primarily on forest typology and this zone included large peat bogs and old forest fragments, which were supposed to be ecologically stable and highly resistant to natural disturbances (primarily bark beetles infestation). However, some units of Zone I were too small for natural processes. Also many valuable habitats, particularly smaller raised bogs and waterlogged spruce forests, were excluded from Zone I and transferred to Zone II, where then standard forestry practices were applied.

Since 1998, cutting of bark-beetle infected tress and cleaning of uprooted ones were allowed in many units of Zone I. This was strongly criticised by experts, representatives from NGOs and international organisations like IUCN and Ramsar Committee. In spring 2004, the Czech Minister of Environment ordered preparation of a new zonation following the international experts' recommendations. The new proposal included extension of Zone I to 39% of the Šumava NP area. Its main goals were respecting natural conditions and minimising negative effects associated with fragmentation of Zone I (**Figure 3c**). Unfortunately, negotiations with local communities and politicians were not successful and this zonation was not officially approved, despite many round-table discussions and public meetings.

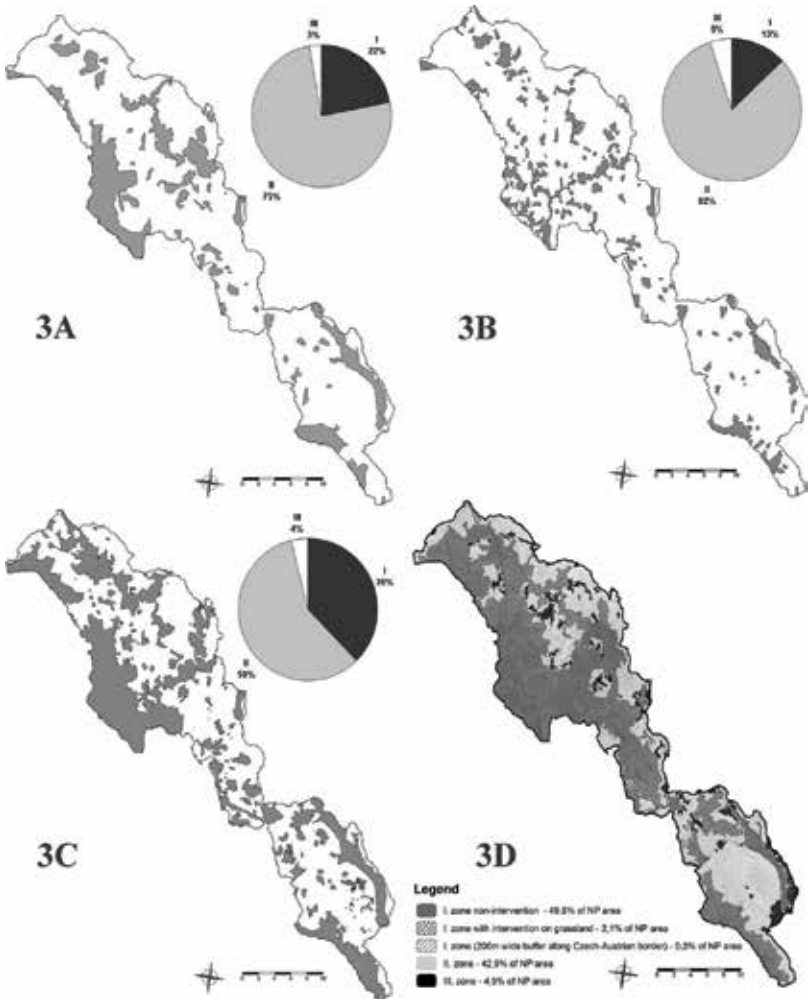

Figure 3. Zonation of the Šumava National Park. A: 1991-1995, B: 1995-now, C: zonation suggested in 2004, not adopted, D: currently suggested zonation.

The ever-repeating picture is that ecologists prefer non-intervention management in the core zone of this NP and argue that logging in these stands of mountain spruce negatively affects biodiversity, while natural disturbances promote biodiversity [8]. On the other hand, traditional foresters who are opponents of the national park concept and various politicians promote logging of bark beetle-infested trees, which results in a reduction in the area of the non-intervention core zone. This controversy resulted in a lack of a long-term management strategy for the Šumava NP.

The history of the ŠNP that lasts more than 25 years reveals several reasons why international (IUCN) standards were not successfully implemented there. Experience of the endless negotiations concerning the new zonation proposal and several other important documents (e.g.,

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new management plan or regulation of visitor numbers and their access to certain places) has shown that local representatives often make obstinate claims, instead of presenting reasoned arguments and objections. They very often alternated their opinion, which caused an increasing lack of mutual trust between them and the NP Authority.

The above-mentioned problems are remarkable examples of the malfunctioning of the council of the Šumava NP, a consultative and initiative body according to the Act 114/1992 (on nature and landscape protection), and the ambiguous attitudes of the Czech Ministry of Environment. The on-going debate intensified after the Kyrill windstorm in January 2007, which uprooted hundreds of thousands of trees in mountain spruce forests. After Kyrill, a non-intervention management approach was finally suggested for some parts of the Šumava NP, but this was not always mandatory and the final decision was often left to local managers and/or owners, as only a part of the park area is owned by state and the remaining part is privately owned.

Ten years after the Kyrill windstorm, at the beginning of 2017, passing the bill on national parks in Czechia [23] is giving a hope that the core zones in the most valuable Czech national park will cover at least 50% of its area in the future (**Figure 3d**). With this new legislation framework, zonation of the national park will recognise four zones:

1. **Natural zone**: covering large areas dominated by natural ecosystems—non-intervention management is planned here;
2. **Close-to-natural zone**: covering part of the national park, where ecosystems were partly affected by human activities;
3. **Zone of concentrated care**: where strongly changed ecosystems exist and long-term active management is planned;
4. **Zone of cultural landscape**: covering built-up areas, designated for their sustainable development.

A new zonation of the ŠNP and new management plan are currently under preparation and successful negotiation with local representatives is a big challenge for the next months.

The Šumava NP is a significant socio-economic factor in the region. Similar results to the BFNP about importance of the national park for the local economy (see Section 4) can be observed also in the Šumava NP, though hard data have not yet been collected. A new transboundary project for monitoring socio-economical aspects is now in progress. Dickie et al. [2] performed a socioeconomic study of the pros and cons of expanding wilderness zones in the Šumava NP. They considered two potential future management scenarios:

1. Adoption of draft Bills that would declassify protected areas and enable developments (e.g., ski lift development) within some of the Park's most valuable habitats for wildlife.
2. Adoption of proposals to expand the wilderness area in the Park's core with associated tourism opportunities and compared their economic impacts for the ŠNP with the scenario of continuation of current management. They arrived at the following conclusions.

5.1. Declassification of the protected areas and enabling developments within some of the Park's most valuable habitats for wildlife

The proposals in the draft Bills have the potential to generate employment through ski lift development, but much of this activity will use imported labour and/or be short-term (e.g., associated with construction work). The financial viability of this development is uncertain for a number of reasons, including: likely requirements to compensate for damage to protected habitats, reduced future snow cover due to climate change, and competition to attract sufficient visitors to use the ski lift. The economic impacts of the adoption of the draft Bills (and, to a lesser extent, of continuing with current management) would also include negative effects on current nature tourism activity and on its long-term potential to expand. Currently, and certainly if the proposed plans in the draft Bill are adopted, the value of the NP as an area of wilderness and high-quality ecosystems would be reduced. This would weaken one of ŠNP's key selling points as a tourism and recreation destination. The opportunity for international branding of the national park based on these ecosystems would be diminished. This damage to ecosystems would go against the views of the 75% of the Czech population who agree that it is important to halt the loss of biodiversity because we have a moral obligation to look after nature.

5.2. Adoption of proposals to expand the wilderness area in the Park's core with associated tourism opportunities

Pro-wilderness development would allow economic opportunities to be pursued to promote nature-based tourism at new locations and activities around an expanded non-intervention zone, while not undermining the ecological integrity of the NP. This tourism offer is in keeping with visitor's preferences, and can exploit global growth in ecotourism activity. The best access points to the Šumava NP's wilderness are currently regarded as being "full" in that further increases in visitors would damage the wilderness experience which draws visitors. Therefore, there is perceived to be demand for a larger number of carefully managed access points to a larger wilderness area.

Local benefits could be enhanced through nature-based tourism development that is spread throughout the communities in and around the park. This would not conflict with the park's wild image that attracts visitors, and this visitor market could grow with support from expanded marketing activity. The potential local economic benefits from the pro-wilderness development option include: maintaining and expanding employment in management of the National Park's habitats, visitor facilities and access points; increased nature-based tourism trade in the villages within and surrounding the ŠNP; increased opportunities to attract financing for local economic development, and for the NP's management, both internationally and locally; a greater proportion of value-added in the tourism offer being generated within the local community, meaning more income can be retained locally and support greater indirect economic activity, and maintaining forestry employment.

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6. Transboundary cooperation

With the legendary summit meeting of Czech, Austrian and German nature conservationists on the Dreisessel peak the discussions about a large forested national park in the heart of the European continent began and have continued until today. Leading nature conservationists such as Hubert Weinzierl, the popular Professor Bernhard Grzimek, and the President of the German League for Nature Conservation (DNR), Wolfgang Engelhardt, supported the idea (http://www.nationalpark-bayerischer-wald.de).

Another 30 years were needed to open the Iron Curtain. With great enthusiasm, the two national park authorities established practical, though informal collaboration from the very beginning in 1991, when the Šumava NP was established [17]. Currently, the main partners involved in transboundary cooperation in BFNP & ŠNP are: Ministry of Environment of the Czech Republic, Ministry of Environment and Public Health of the State of Bavaria, Šumava National Park Authority, and Bavarian Forest National Park Authority. Since 1999, cross-border cooperation has been based on the Memorandum on Cooperation between ŠNP and BFNP, which was signed by the State Ministers responsible for the respective national parks. In the meantime, several supplements were signed, e.g., regarding park management and new cross-border trails.

As already mentioned, there is a long tradition of transboundary cooperation [24]. In order to achieve the common objectives for this integrated area, cross-border cooperation has focused primarily on the following:

- **First joint information centre**: The information centre was built at Bučina, one of the main points of entry to the ŠNP from the BFNP. This was the first joint project. Bilingual displays on the national park concept, development of protected areas, landscape succession, national park regulations and, above all, visitor opportunities are presented there.
- **Transboundary public transport system**: In 1996, the two national parks were enriched as a holiday area with the introduction of public transport systems. In the Bavarian section, 'hedgehog buses' are operating since May 1996, linking all the park's important visitor facilities and sites with the surrounding towns and villages. A public transport system was also established in the ŠNP in the same year. The two services use buses that run on low-emission natural gas or bio-gasoline fuels. The timetables of both public transport systems are coordinated and bilingual.
- **Historical border train station to cross-border information office**: Following the ceremonious inauguration of the restored historical border train station in Bayerisch Eisenstein/Alžbětín by the two former State Ministers, a cross-border information office was set up, offering bilingual information on both national parks and also the Šumava Protected Landscape Area and the Bavarian Forest Nature Park.
- **Coordination and training of ranger services**: Ranger services are coordinated on both sides of the frontier in regular meetings. In addition to providing professional training for

individual rangers, joint courses serve to foster personal acquaintances and understanding of the history and culture of the neighbouring country. In addition, a reference manual with the most important facts and information on both national parks was prepared in the form of a joint bilingual ranger handbook.

- **Successful reintroduction of the Ural owl**: 25 years of experience have shown that efforts to re-introduce the Ural owl were boosted considerably, thanks to the decision to initiate similar projects not only in the ŠNP, but also in the adjacent forested areas of Austria. This is a basic prerequisite for guaranteeing the development of a sustainable population of this owl species through an International Management Programme.
- **Restoration of anthropogenically disturbed habitats**: An artificial drainage channel in the area of a valuable peat bog extending across the state border was returned to nature in the core zone of both national parks in summer 2005.
- **Junior ranger programmes, international youth camps and Czech-German youth forum**: Several times young people from the national park region were given the opportunity to explore the BFNP & ŠNP as part of a cross-border camping programme.
- **Natura 2000 management planning:** BFNP & ŠNP are part of a uniform natural landscape that disregards any political boundaries. Measures to protect endangered and rare habitats and species should ideally be designed on a large-scale basis and in this case, in a cross-border fashion. With this in mind, both national park authorities have been successfully working together on a project promoted by the EU (INTERREG III A) to establish Natura 2000 management plans that include cross-border coordination. Within the frame of this project, a bilingual brochure entitled 'Europas Wildes Herz–Divoké Srdce Evropy' (Europe's Wild Heart) was published in September 2007 [1].
- **Research & LTER & Silva Gabreta journal:** Both NPs are long-term ecological research sites (LTER). There is a long tradition of research and monitoring in the Bohemian Forest. The first forest nature reserve was declared as early as in 1858 to study natural forest development. Long-term databases of ecological data are available (though not all of them computerised). National parks serve as extremely attractive control areas for ecosystem research, especially for scientific long-term monitoring, because they represent permanently protected ecosystems in a process of near-natural development [24]. A transboundary long-term research platform is now being prepared, which should cover most of transboundary ecological and sociological research activities conducted in the region. The most successful recent common research projects include GPS lynx and deer telemetry. Currently, several new transboundary INTERREG projects have been launched, such as (1) biodiversity on the elevation gradient, (2) effect of climatic change on local water regime and (3) effects of forest structure changes on viability of grouse (capercaillie, black grouse, hazel grouse) populations. Results of the regional research are being published in the Silva Gabreta, a peer-reviewed journal jointly published since 1996.
- **Project 'Europe's Wild Heart'**: In 2009, both parks agreed on common management guidelines for a transboundary wilderness area called 'Europe's Wild Heart' [25]. Guidelines for uniform management of the united core zone (present project area of 13,060 ha),

guided tours into the wilderness area, cross-border monitoring and research projects and the establishment of a training and research centre are being prepared. The project [26] has been jointly presented at several international conferences, most recently at the World Wilderness Congress (WILD9) in Merida, Mexico (December 2009). However, Europe's Wild Heart's activities were frozen after 2010, when the new director of the ŠNP was appointed. He introduced not only 'NO-wilderness' concept of NP management, but also allowed salvage logging in the core zones and supported various development projects. For several years, not only the common wilderness project has been stopped, but also other joint activities were scarce. The contemporary director of the ŠNP, appointed in spring 2015, supports common activities and works hardly on improvement of the Czech-Bavarian cooperation.

7. Benefits and challenges

There exist two serious political problems in the Šumava NP, compared with the situation in the Bavarian Forest NP. First, unlike BFNP in Germany, ŠNP never received full political support from the Czech government. This is well illustrated by the fact that there have been as many as 11 directors of ŠNP over a period of 25 years! In contrast, there have been only three directors of the Bavarian Forest NP over the nearly 50 years of its history. Thus the position of the Czech directors is likely to have been untenable. In consequence, both the vision and long-term strategy for the Šumava NP remain uncertain and unclear, whereas its budget has largely depended on the sale of timber.

Second, as a result of heavy lobbying by private owners and foresters, the Czech Parliament approved direct restitution of all the former municipal forests in national parks, which resulted in the Šumava NP losing control over 9.2% of its area (Šumava NP Authority 2013—management plan). Although the new owners are receiving financial compensation for bark beetle damage, they are becoming increasingly vocal about the 'unjust bark beetle control' in surrounding NP forests. Unfortunately, these municipalities manage their forests in a way that does not conform to nature conservation standards [27]. Currently, they are arguing that their forests should not be included in the nature zone or even in the NP.

One of the biggest challenges for both NPs has been the acceptance of natural disturbances (windstorms followed by bark beetle outbreaks), which significantly affected spruce forests in this area. While the Bavarian politicians supported the BFNP managers to follow their NP's motto 'Let Nature be Nature' and intensively supported non-intervention management as an appropriate management in the national park, the same situation has almost threatened the existence of the ŠNP. Since the very beginning of the ŠNP, decisions about its management have been bogged down in never-ending discussions about whether bark beetle infestations should be controlled, or whether a strict 'non-intervention' policy should be adopted. After the Kyrill windstorm (January 2007), the Czech politicians allowed salvage logging in the core zones and only the public blockade and protests of NGOs, scientists, and international conservation community stopped this. Some local representatives and lobbing groups also tried to

open the ŠNP area for different development activities (e.g., ski resorts and new accommodation facilities in the core zone, privatisation of state properties, etc.).

Even during the 'bad' post-Kyrill period, transboundary cooperation and sharing of experience between BFNP and ŠNP were very important and supported conservation targets in the region. Indeed, even when the principles of nature conservation in the Šumava NP have been eroded and the ŠNP Authority has not been very open to transboundary projects, the Bavarian Forest NP has guarded the national park's mission. The BFNP representatives have always behaved very correctly and never entered national affairs. Instead, they transparently declared their conservation principles. It was a very important support for the Czech NGOs, scientists and general public, acting for the Šumava NP. This principle stance of the transboundary partner has buffered some development activities and management proposals threatening the Šumava NP. Recently, a new Nature Conservation Act has been adopted in the Czech Republic and the hope is that this new legislation will prevent similar excesses and will support stability in the ŠNP.

Both the Czech and the Bavarian sides have learned a lot during these 25 years of cooperation, including various lessons they received from both nature and human symbiosis/communication. There are many positive results indicating the strengths of and showing broad benefits from the existence of the transboundary area. These include Natura 2000 sites and their management, understanding the importance of the cross-border perspective of nature protection and research, joint work of rangers, junior ranger programme and environmental education. National park employees, local partners, NGOs, trainees, and volunteers of both countries are involved in many joint activities, including professional projects and various cultural events.

The main obstacles in cooperation of transboundary partners are economic differences between the regions, language barriers, and different policies and laws. Unfortunately, the management strategy of the ŠNP is not yet stable and political turbulence and development pressures are seriously threatening the ŠNP and the transboundary cooperation.

In good years, transboundary cooperation catalyses good things. Projects are better if they are conducted together with partners. Ideas are smarter when prepared with friends. In this region with long and uneasy history, cooperation is very important. There is only one common ecosystem of mountain forests, common populations of lynx, capercaillie or bark beetle in the Bohemian Forest and partners have to learn, how to share their common responsibility for the future. Step by step, the transboundary cooperation is improving, which is very important in good years but maybe even more important in bad years. The principle stance of the transboundary partner can buffer threatening in the neighbouring national park and support recovery when the crisis is over.

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Chapter 5

Challenges in the Management of Plitvice Lakes National Park, Republic of Croatia

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Abstract

Plitvice Lakes National Park is the oldest protected area in the Republic of Croatia and the biggest by its surface. The park is designated as the UNESCO World Heritage Site. Outstanding universal value is recognized within significant natural and geological processes, habitats and biodiversity. Only 1% of the park's large surface is the main focal point for visitors and active tourism. We evaluated management of the park through Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis interpreting internal and external factors. High conservation of biodiversity, investments in different projects and high number of employees are considered as strengths. High number of visitors in small area and lack of visitor management plan, educational programs and marketing strategy are weaknesses. Threats are present through the inadequate management of drinking water supplies, lack of wastewater treatment plant and excessive construction in villages. Our opportunity definitely lies in protected nature and biodiversity. Considering very good status of the park's finances, there aren't any significant barriers for sustainable tourism approach, development of educational programs, various investments and adoption of new management plans. However, these activities must be beyond any potential political influence and they should have continuity in order for the park to be an example of quality management in the years to come.

Keywords: national park, SWOT, Plitvice Lakes, management plan

1. Introduction

Protected areas such as strict nature reserves, wilderness areas, national parks, natural monuments and others are essential for biodiversity conservation. They exist in natural or near-natural ecosystems, and they maintain ecological processes and conserve threatened or

endemic species from becoming extinct. The other important part of protected areas is a benefit for humans regarding the opportunities for recreation and providing the human population with different ecosystem services [1]. There are 202,467 terrestrial and inland water protected areas recorded in the World Database on Protected Areas (WDPA) and they cover 14.7% of the world's extent, which means 19.8 million km^2 [2]. The Conference of the Parties (COP) in 2010 adopted the Strategic Plan for Biodiversity 2011–2020 with a goal to promote effective implementation of the Convention on Biological Diversity, and in this plan, five strategic goals (A–E) with several targets (1–20) known as Aichi Biodiversity Targets were included [3]. The Aichi Biodiversity Target 11 says that "*By 2020, at least 17% of terrestrial and inland water areas, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.*" However, designation of protected areas often changes with regard to the increase or decrease in size or they are not even qualified to be included in the WDPA. Regarding the above stated target, by 2020, an additional 3.1 million km^2 of terrestrial area needs to be protected [2]. According to the former State Institute for Nature Protection (now Croatian Agency for the Environment and Nature) in the Republic of Croatia, there are 409 protected areas of different categories, covering 7547.18 km^2 of total surface, which means 8.56% of the Croatian territory [4].

Management of the protected area is defined through four basic functions: planning, organizing, leading (implementing) and controlling (evaluating). The resources include people, their skills and financial resources. There should be clarity of direction provided by the protected area in a sense that the activity being managed has a purpose and direction. In an organization, the management is undertaken by people with different functions and it is a team effort. Regarding the fact that protected areas constantly face threats such as climate change effects, introduced species, visitor impacts, development and others, there is a great need for active management [5].

1.1. Site description

Plitvice Lakes National Park is the oldest protected area in the Republic of Croatia designated since 8 April, 1949. As a national park, it is listed in the second IUCN category of protected areas regarding the description: "*Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities* [1]." In the Croatian Nature Protection Act, national park is defined by the article 153: "*(1) A national park is a large, predominantly unmodified mainland and/or marine area of outstanding and multiple natural values. It includes one or more conserved or slightly modified ecosystems and is primarily intended for the conservation of autochthonous natural values. (2) A national park has a scientific, cultural, educational and recreational purpose. (3) In a national park only those actions and activities are permitted that do not pose any threat to the authenticity of nature. (4) In a national park all economic use of natural resources is prohibited* [6]." Little is known through the literature that Plitvice Lakes were designated as a national park very early at the beginning of the

nineteenth century in 1928. However, this was only for one financial year until 1929. Since then, the natural values were recognized even though it took almost 20 years for its designation as a protected area.

In 1979, the Plitvice Lakes National Park was inscribed in the UNESCO World Heritage List by criteria vii, viii and ix: "*Criterion (vii): to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; Criterion (viii): to be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; Criterion (ix): to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals* [7]." The National Park is also the only national park in Croatia that is on the UNESCO World Heritage list as natural heritage. The park was recognized for its outstanding universal value (OUV) present in significant geological, biological and ecological processes of which the most important one is the process of tufa formation. The term OUV was formally defined and adopted in 2005 and it means "*cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole* [8]."

The National Park functions as a public institution like most of the protected areas in Croatia. With regard to the type of governance, the park is governed by the government (type A of IUCN governance), which means that the national Ministry of Environment and Energy is the main governing body [9]. As a public institution, the park has an administrative council consisting of five members, the Director and many different services among which the most important one is the Nature Conservation Service managed by the Conservation Manager. Each of the services has its role in managing the protected area or its organizational parts, and the structure of a public institution is rather complex with many different departments (**Figure 1**).

The public institution owns hotels, restaurants, auto camps and buffets. It employs over 600 permanent employees and additional 300–400 seasonal employees during touristic season. In the area of the park, there are 29 settlements with almost 1400 residents. Plitvice Lakes National

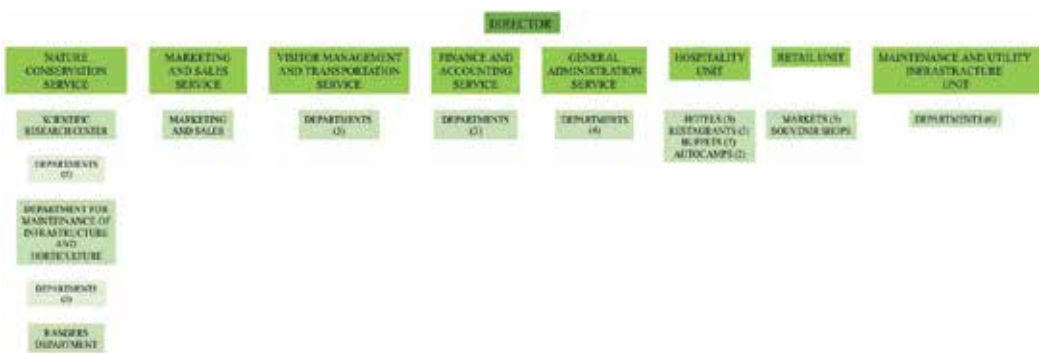

Figure 1. Organizational structure of a public institution of Plitvice Lakes National Park.

Park is financed by sales of the entrance tickets and from visitation and hospitality services. The income is used for management and various investments of the public institution.

Plitvice Lakes National Park is settled in the middle mountainous part of Croatia as a part of Dinaric karst area. The surface of the park is divided between two counties: Lika-Senj County (90.7%) and Karlovac County (9.3%). The total surface of the park is 29,685.15 ha, and by surface, it is the biggest national park in Croatia. The borders of the park were expanded in 1997 for additional 10,000 ha (previously the surface was around 19,000 ha) in order to include the wider catchment area of main tributaries (**Figure 2**).

The entire area of the park is considered a Natura 2000 site (HR5000020) with around 64 Special Protection Areas (SPA) for birds and proposed Sites of Community Importance (pSCI) for flora and fauna species and habitat types regarding the Birds Directive and Habitats Directive. The bigger part of the park's surface is covered with forests (2/3), which consists mainly of European beech and fir forest. The important part of the forest ecosystem is an old-growth forest "Čorkova uvala" covering over 84 ha of surface and considered to be the secondary type of forest (without or with insignificant influence of man). In the area of the park, there are several types of grassland vegetation covering around 1/3 of the total surface. Very important habitat types present in the park are peat habitats (mires and fens), which are rare and endangered on the national level. On only 1% of the total park's surface there is a fascinating freshwater ecosystem of karst springs, small rivers and 16 lakes divided with tufa barriers. Tufa barriers are considered one of the most important OUVs that this park has, and without this specific biodynamic process of tufa formation, there would not be any lakes. Tufa barriers form the cascading system of lakes that are almost a phenomenon for the karst area. The abundance of flora and fauna species is also high in this protected area with over

Figure 2. Map of the Republic of Croatia (A) and Plitvice Lakes National Park with border until 1997 and after the expansion (B).

1400 plant species, 50 species of mammals, 22 species of bats, around 160 species of birds, 320 species of butterflies, 8 species of fish and other representatives of fauna species (**Figure 3**).

1.2. The background

Management plan for the National Park was adopted in 2007 and was developed through the Karst Ecosystem Conservation (KEC) Project that lasted from 2003 to 2007 and was financed by the Global Environmental Fund [10]. The plan is valid until 2017 and that is why the park's management started the process of writing a new management plan that will be finished by the first trimester of 2018. As a part of this new management plan, the park is currently in the process of writing the action plan for visitor management. The new physical plan was adopted in 2014 as the previous plan dated from 1986 ended.

The need to write new a management plan did not come only from the obligation stated in the Croatian Nature Protection Act in the article 181: "*The management of protected areas…shall be carried out according to the management plan. (2) The management plan shall be adopted for a period of ten years. (3) The management plan shall lay down development guidelines, methods of protection implementation, use and management of a protected area, including detailed guidelines for the protection and conservation of natural values of a protected area, respecting the needs of the local population.*

Figure 3. Three large carnivores: bear (*Ursus arctos* L.), wolf (*Canis lupus* L.) and lynx (*Lynx lynx* L.). These species are using the territory of the park and the park's management is financing the project for monitoring their activities in the protected area.

(4) The management plan shall be binding for all physical and legal entities involved in activities in a protected area [6]." Every protected area has to evaluate the effectiveness of management regarding the main objectives and values that are being conserved. Management effectiveness evaluation can enable and support an adaptive approach to management, assist in effective resource allocation, promote accountability and transparency and help involve the community. The evaluation should be seen as normal part of the process of management by which the management becomes adaptive [11].

According to the framework for assessing management effectiveness (**Figure 4**), there are many steps in the assessment [11].

Regarding the framework and the purpose of this article, we are looking now at the context (status and threats) using Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis for the initial assessment or rather a quick summary of Plitvice Lakes National Park management effectiveness regarding the main values of the protected area and all other resources that are present. The main objective of this analysis was to see which management areas can be improved and whether the factors influencing the management come from the microenvironment of the public institution or from external sources.

Figure 4. The framework for assessing management effectiveness [11].

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2. SWOT analysis

SWOT analysis as an acronym for Strengths, Weaknesses, Opportunities and Threats is a business analysis technique used by an organization when deciding on the best way to achieve future growth. Strengths and weaknesses are considered as internal factors that are favorable and unfavorable as the opposite to opportunities and threats that are considered as external factors, again favorable and unfavorable [12]. For evaluating an organization's environment, two types of analysis are performed: internal analysis by which we analyze internal environment (or microenvironment) considering resources that need to be developed and sustained and external environment (macroenvironment) by which we recognize major developments and future implications [13].

Even though SWOT analysis is highly used by different companies or organizations, it can be used for different management assessments in the environment or protected areas. SWOT analysis was used for environmental management status evaluation [14], for ecosystem services in protected areas [15] or for sustainable tourism development in protected areas [16].

For the purpose of this article, before performing SWOT analysis, we grouped factors into four management areas that we found important for the evaluation: *natural and cultural values* (NCV), *visitation, education and marketing* (VEM), *local community and stakeholders* (LCS) and *infrastructure* (I). For each group, we determined internal and external factors.

Additionally, we performed simple matrix analysis of data using the following:

i. Weight (W) that was estimated regarding partially objective point of view for each factor and scored from 0 to 1 (total score for weight should be 1).

ii. Effectiveness factor score (EFS) that was assigned to each factor (1 as fundamental weakness or threat, 2 as minor weakness or threat for unfavorable factors, 3 as strength or opportunity and 4 as great strength or opportunity for favorable factors).

iii. Final score (FS) calculated by multiplying W and EFS.

The analysis was finished by calculating the sum of final scores for internal and external factors. If the final score of internal or external factors is above 2.50, it denotes that favorable factors prevail over unfavorable factors. Similar methodology was performed as in Ref. [16].

2.1. Internal factors

Seen as strengths, we determined 13 factors for natural and cultural values (NCV), 4 factors for visitation, education and management (VEM), 3 factors for local community and stakeholders (LCS) and 3 factors for infrastructure (I). As weaknesses, we determined 7 factors for NCV, 6 factors for VEM, 4 factors for LCS and 4 factors for I.

Natural values of Plitvice Lakes National Park are the most important ones and several factors are seen as strengths for this protected area. The beautiful landscape is in the form of 16 lakes in a cascading system divided by tufa barriers, pristine beech and fir forests that cover almost 80% of the park's surface and grasslands that are considered hot spots for biodiversity.

One of the most important OUVs for the park is most certainly the special biodynamic process of tufa formation that requires a good water quality, different micro- and macroorganisms and certain chemical properties of water. Karst relief with different geological forms like dolines and sinkholes is responsible for special features of this area. Groundwater system is diverse and developed and is considered as a source of water for karst springs that are really valuable and sensitive. Furthermore, biodiversity of flora and fauna species, different habitats and Natura 2000 species is also an important natural value. In the area of the park, there are also some special types of habitat regarding forest with an old-growth forest "Čorkova uvala" and peat habitats like mires and fens. For many years now, natural and geological values of this area have attracted many scientists who found great interest in researching different processes. The park staff within Nature Conservation Service monitor certain flora and fauna species and habitats. Some cultural values, even though there are not many, are also seen as strengths. As a part of material cultural heritage, there are several archeological sites, among which the one that is researched the most is above Lake Kozjak, the "Krčingrad." In some villages, there remains traditional local lifestyle in the form of watermills and sawmills. Intangible cultural heritage is represented through traditional songs, dances, crafts and gastronomy. Plitvice Lakes have always attracted people to visit the area and is recognized with significant touristic attractiveness because beside the beautiful and outstanding landscape there is also a possibility to use the electric boat and panoramic vehicle and walk behind waterfalls and lakes on wooden bridges while visiting the park. The National Park logo is recognized on the national level and is connected with parks of Croatia that unites all protected areas. Important part of visitation system is that the whole public institution is financed through sales of the entrance tickets and from hospitality services. The park also gives significant importance to different educational activities in the form of Junior Ranger program, volunteer program and workshops for children and celebrating important dates in nature protection. The park is also a "driving force" for the entire region. Not only because the park has significant number of local residents employed in different sectors, but also because residents can use apartments that are owned by the park. Because of the high touristic activity in the area, local community can sell their traditional products like cheese, jam and honey and can make additional income for their household. Local community can also use their households to accommodate guests. The park owns significant infrastructure in the form of buildings, hotels, restaurants, auto camps and buffets. One of the strengths is also that, after many years of lobbying, the state road that goes through the park is prohibited for dangerous goods transportation, especially for gasoline and other flammable substances.

There are several internal weaknesses regarding natural and cultural values that were recognized through this process. Allochthonous fish species (pike, chub and rudd) are present in the water ecosystem and can influence biology and lifecycle of other indigenous fish population. Active measures and objectives in management of natural values especially in dealing with succession of grasslands and other important habitats are missing. Succession of grasslands that happens due to several factors like abandonment of traditional agriculture, poor management and unsolved problems with legal property relations can cause a certain biodiversity loss. Lake Kozjak, which is in the core zone of visitation and on which electric boats navigate, is the only water supply for the wider area of the park and the municipality of Rakovica. Beside scientific activity conducted in the area, the park still misses the inventory of some flora and fauna species, habitats and speleological forms. Cultural heritage is missing a plan and vision, and its value is

underestimated and unrecognized. The construction of a visitor center that has been planned for many years now is not built yet, in spite of the fact that it is much needed for additional presentation of natural and cultural values. In visitation part, several factors need to be addressed and the most important one is the high number of visitors in a short period of only several months (especially in July and August). In that period and on some days, almost 14,000–16,000 visitors are present in the small area of the park, mainly on lakes. However, the visitors only stay for a day or for several hours, so this type of transit tourism is also considered as a weakness. The park doesn't have a visitor management plan and marketing strategy. Even though there are several educational activities, the park lacks educational programs. In different sectors regarding capacity, public institution has deficiency of highly educated employees. The demographic structure of local community is old, and the abandonment of traditional agriculture due to depopulation processes is present. Different social activities in closer areas are lacking. There are unsolved problems with legal property relations. Regarding infrastructure, traffic on some roads still goes through the sensitive catchment area. Maybe the main issue is that some villages do not have proper wastewater sewage system and still uses septic tanks. Hotels, restaurants and even buildings do not have energy certificates, and hotels or other facilities cannot be renovated because of complicated documentation and permits that need to be gathered (**Table 1**).

Code		W	EFS	FS
	Strengths			
NCV	Beautiful landscape of lakes and waterfalls, pristine forests and grasslands.	0.035	4	0.14
NCV	The ongoing process of tufa formation is still active and represents one of the main OUVs of the park.	0.050	4	0.2
NCV	Biodiversity of flora and fauna species in different ecosystems (water, forest, grasslands and others).	0.050	4	0.2
NCV	Natura 2000 species and habitats in the area of the park.	0.035	4	0.14
NCV	Presence of old-growth forest "Čorkova uvala."	0.020	3	0.06
NCV	Characteristic karst pastures, meadows and arable land.	0.010	3	0.03
NCV	Peat habitats (mires and fens) are still conserved in the area of the park.	0.030	4	0.12
NCV	Karst relief with variety of forms (dolines, sinkholes, groundwater system and caves).	0.025	3	0.075
NCV	Significant scientific interest for all segments of natural and geological values.	0.030	4	0.12
NCV	Monitoring of different species and habitats.	0.015	4	0.06
NCV	Around 20 archeological localities in the park (the most researched one is above Lake Kozjak, the Krčingrad).	0.010	3	0.03
NCV	Traditional watermills and sawmills in villages.	0.005	3	0.015
NCV	Rich intangible cultural heritage in the form of local songs, dances, gastronomy and traditional crafts.	0.005	3	0.015
VEM	Significant touristic attractiveness of the area with recognizable visitation system (electric boat, panoramic vehicle and wooden bridges).	0.030	4	0.12
VEM	Entrance fees are a significant financial income for the park's economy.	0.045	4	0.18
VEM	Brand and visual identity is recognized on the national level connected with parks of Croatia.	0.025	4	0.1

Code		W	EFS	FS
VEM	Different educational activities.	0.020	3	0.06
LCS	The park employs significant number of local residents.	0.040	4	0.16
LCS	Several small family owned agricultural economies producing different products (honey, cheese and jams).	0.010	3	0.03
LCS	Traditional touristic activity (capacities for private accommodation).	0.005	3	0.015
I	Park owns significant infrastructure (buildings, hotels, restaurants and auto camps).	0.040	4	0.16
I	Residents of several villages have an opportunity to use apartments owned by the park.	0.015	3	0.045
I	State road that goes through the park is prohibited for dangerous goods transportation.	0.025	4	0.1
	Weaknesses			
NCV	Allochthonous species present in the water ecosystem.	0.020	1	0.02
NCV	Lack of active measures and objectives in management of natural values.	0.040	1	0.04
NCV	Lake Kozjak supplies part of the park's area and municipality of Rakovica with drinking water.	0.025	1	0.025
NCV	Succession of grasslands.	0.020	1	0.02
NCV	Inventory of some flora and fauna species, habitats and speleological forms.	0.010	2	0.02
NCV	Unrecognized value of cultural heritage that lacks defined plan and vision.	0.010	2	0.02
NCV	Visitor center for presentation of natural and cultural values is not built yet.	0.020	2	0.04
VEM	High number of visitors in small area of the park (congestion during high season).	0.050	1	0.05
VEM	Visitors stay for short amount of time in the park area (transit tourism).	0.020	2	0.04
VEM	Lack of visitor management plan.	0.050	1	0.05
VEM	Lack of different educational programs.	0.025	1	0.025
VEM	Lack of marketing strategy.	0.030	1	0.03
VEM	Deficiency of highly educated employees.	0.005	2	0.01
LCS	Unsolved problems with legal property relations.	0.020	1	0.02
LCS	Old demographic structure.	0.005	2	0.01
LCS	Abandonment of traditional agriculture.	0.010	2	0.02
LCS	Poor additional social activities for local community in the broader area.	0.005	2	0.01
I	Traffic on some roads in the park still goes through sensitive catchment area.	0.020	1	0.02
I	Wastewater sewage system is missing in some villages (septic tanks).	0.025	1	0.025
I	Hotels and facilities do not have energy certificates.	0.005	2	0.01
I	Lack of complete documentation (permits) for hospitality infrastructure, which causes obstruction for renovation.	0.010	2	0.02
		1	/	/
Total				**2.70**

Table 1. Internal factors of SWOT analysis for Plitvice Lakes National Park with weight (W), effectiveness factor score (EFS) and final score (FS).

The final score was 2.70 meaning that in the analysis of internal factors, the strengths prevail over the weaknesses.

2.2. External factors

As threats for Plitvice Lakes National Park, we determined 6 factors for NCV, 2 factors for LCS and 5 factors for I. As our opportunities, we determined 5 factors for NCV, 5 factors for VEM, 4 factors for LCS and 4 factors for I.

Threats for the Plitvice Lakes National Park are seen through several factors in different management areas. In the area of the park, there is still illegal hunting and fishing present. Even though the Ranger Service is doing their best job in preventing it, it is still present. There is a strong threat from invasive species of crayfish (*Pacifastacus leniusculus* [Dana, 1852]) that were introduced in lower parts of the river Korana outside the borders of the park; however, it can move to upper parts of the river and inside the protected area. Furthermore, the karst area has a high vulnerability and any kind of contamination can end up in the groundwater system and appear at the surface in springs. This possible contamination can come from inadequate and uncontrolled septic tanks. High risk for water contamination also comes from uncontrolled construction and development of houses and buildings in the area that is vulnerable regarding certain loss of water in the underground. Also recognized as a threat is the influence of climate variations and climate changes, especially in water ecosystem regarding changes in water level and temperature. Changes in other ecological factors can also influence different species and other habitats apart from water ecosystem. Villages are getting more and more depopulated as young people move to bigger cities. A certain political instability on local and national level causes changes in the administrative council and in other parts of the organizational structure. Possible concession and privatization of hospitality infrastructure are considered threats. Unsolved issues with water supply system (Lake Kozjak as water supply) and with wastewater system (the lack of wastewater treatment plant) are the main threats regarding infrastructure. There is still uncontrolled traffic of dangerous goods on some roads that pass through sensitive catchment area. The most present threat in recent times has been uncontrolled construction in small villages that does not meet the standards of traditional construction and is developed in villages without basic communal infrastructure.

The opportunities of the park can be seen in several factors that are considered favorable. In cooperation with different national stakeholders and with a continued support from the park's management, the alternative water supply source can be found. Invasive and allochthonous species can be eradicated from the habitats. However, this activity must be based on scientific proposals and research. National protocols or programs for monitoring of Natura 2000 species and habitats are in the process of development. In cooperation with local community and others, there is a possibility for resolving issues regarding legal property relations that will further improve management of certain habitats and resolve issues with some parts of cultural heritage. In the year 2017, the park's management started the process of writing the new management plan that will also include action plan for visitor management. The opportunity of the National Park is definitely present in the fact that this protected area is inscribed in the UNESCO Heritage List and this can be used for promotion of the park. From 2018, new technologies will be adopted, especially regarding online booking that will improve reservation process. Interpretation of natural and cultural values can be better presented through

visitor center (possibility of using EU funds) and through development of educational programs. There is also an opportunity in developing sustainable tourism approach from getting certain certificates. By using EU funds and similar external sources, there is a possibility to stimulate traditional agriculture, where local products can get national certificates for quality. Furthermore, local households can develop an ecotourism approach and be more competitive on the market. Apartments that are used by the park's employees can be repurchased, which will help people to stay in the area of the park. Regarding other infrastructure, the signed agreement between different stakeholders is an opportunity to resolve issues with wastewater system and management. The use of EU funds again can help resolving issues regarding energy efficiency and reconstruction of water supply system. The park can lobby in different institutions that are relevant for decision making about relocation of traffic from some roads. Hotels and other hospitality facilities can get environment-friendly brand (**Table 2**).

The final score was 2.61 meaning that in the analysis of external factors, the opportunities prevail over the threats.

Code		W	EFS	FS
	Opportunities			
NCV	Relocation of water supply system outside the park in cooperation with stakeholders (alternative water supply).	0.035	4	0.14
NCV	Eradication of invasive and allochthonous species.	0.030	4	0.12
NCV	Monitoring of Natura 2000 species and habitats regarding national protocols and programs.	0.040	4	0.16
NCV	Cooperation with local community and others for resolving legal property relations for better management of habitats.	0.030	4	0.12
NCV	Development of new management plan.	0.050	4	0.2
VEM	Interpretation and education about natural and cultural values.	0.040	4	0.16
VEM	World Heritage List of UNESCO can be used for promotion of the NP.	0.025	3	0.075
VEM	Using new technologies for booking, reservation and online ticket sales.	0.035	4	0.14
VEM	Development of visitor management plan.	0.050	4	0.2
VEM	Sustainable tourism approach.	0.040	4	0.16
LCS	Possibility to stimulate traditional agriculture (EU fond).	0.025	3	0.075
LCS	Certification of local products.	0.020	3	0.06
LCS	Development of ecotourism.	0.020	3	0.06
LCS	Possibility for repurchasing of apartments by the employees.	0.020	3	0.06
I	Signed agreement between different stakeholders for resolving wastewater management issues.	0.040	4	0.16
I	Use of EU funds to resolve issues connected with energy efficiency and reconstruction of water supply system.	0.020	3	0.06
I	Possibility for traffic relocation from roads in the park's area.	0.020	4	0.08
I	Getting the environment-friendly (or other) brand for the hotels.	0.025	3	0.075

Code		W	EFS	FS
	Threats			
NCV	Illegal hunting.	0.015	2	0.03
NCV	Invasive species.	0.035	1	0.035
NCV	High vulnerability of karst area (groundwater system).	0.040	1	0.04
NCV	Climate changes and variations and their influence on species and habitats.	0.020	2	0.04
NCV	Uncontrolled construction in the high-risk zone for water contamination.	0.045	1	0.045
NCV	Contamination of natural waters from inadequate and uncontrolled septic tanks.	0.040	1	0.04
LCS	Depopulation of villages.	0.015	2	0.03
LCS	Political instability at local and national level.	0.045	1	0.045
I	Possible concession and privatization of hospitality infrastructure (hotels and restaurants).	0.035	1	0.035
I	Unsolved issues with water supply system.	0.045	1	0.045
I	Unsolved issues with wastewater system.	0.045	1	0.045
I	Uncontrolled traffic of possible dangerous cargo on some roads.	0.020	2	0.04
I	Uncontrolled construction in small villages without the basic communal infrastructure.	0.035	1	0.035
		1	/	/
Total				**2.61**

Table 2. External factors of SWOT analysis for Plitvice Lakes National Park with weight (W), effectiveness factor score (EFS) and final score (FS).

3. Discussion

After performing SWOT analysis, a few important facts about the management of the park became evident. For both the internal and external factors, the final score was above 2.50 meaning that favorable factors (strengths and opportunities) prevail over unfavorable factors (weaknesses and threats). Furthermore, internal factors are stronger than external ones. However, the main problem with the methodology was in deciding about the weight of each factor considering that management of the park is not only directional toward nature conservation, but there are also other different factors that needed to be taken into consideration.

The park's natural value is still very well conserved through biodiversity of different species, important habitats and ongoing process of tufa formation that was significant for forming such landscape of lakes and waterfalls. Recognition of the park by the UNESCO with significant OUVs that are present is definitely a strength of this protected area. Good financial status provides the stable income for the park`s management and allows financing of various projects and developing infrastructure. There are also several other strengths in every management area highlighted in **Table 1**. Among positive external factors, the opportunities for the

park are in sustainable tourism and development of eco-tourism, perhaps not connected to the park's facilities but rather to private households. The park has been a long-time member of EUROPARC Federation and there is an opportunity to be involved in the European charter for sustainable tourism, a type of certificate that is given to protected areas regarding its sustainable tourism management [17]. Regarding eco-tourism, there are still several households that maintain traditional agriculture and production of homemade products that can find their way toward an interested market.

Even though favorable factors prevailed over unfavorable factors in the park's management, they should also be mentioned and addressed. There is definitely a high pressure from tourism in the park. Since the year 2000, there has been a constant increase in the number of visitors to the park (**Figure 5**). The first one millionth visitor was noted in 2011, and in 2016, the park had over 1.4 million visitors per year. The highest visitation is present during summer months in July and August, which brings a lot of pressure to the park's management dealing with congestion and long waiting periods to use the electric boats and panoramic vehicles. In addition, the experience of the protected area is low, with negative effect regarding connection with nature. This issue was recognized previously, through the assessment of visitor and tourism management in the National Park [18].

Infrastructure is also a significant issue for the National Park and it should be resolved in the next several years. There is lack of adequate water supply, considering the fact that Lake

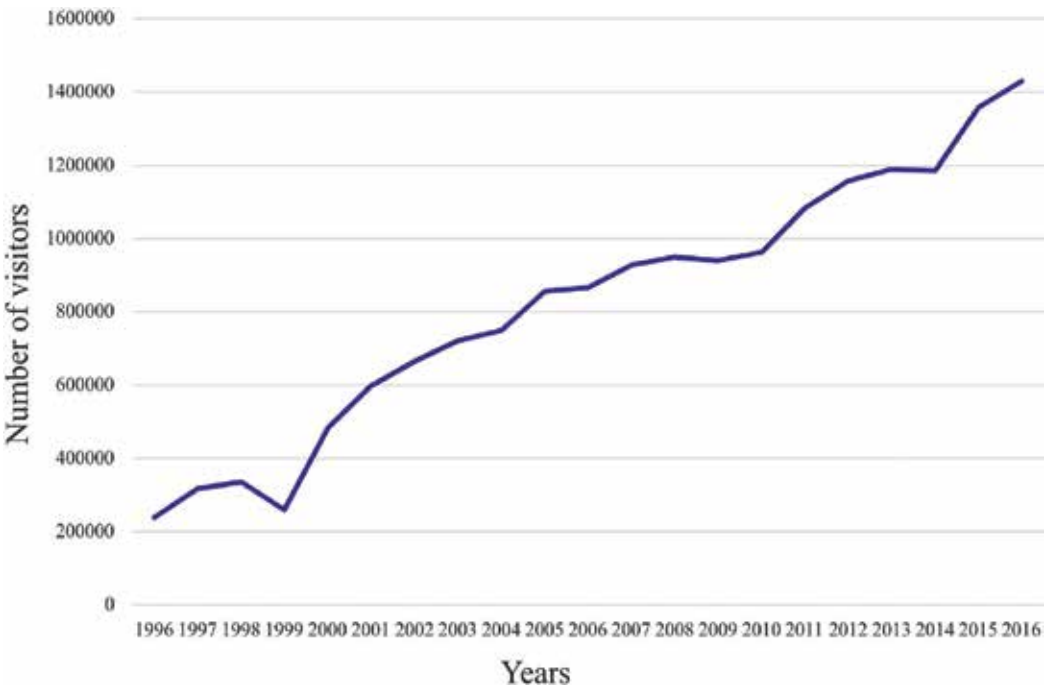

Figure 5. Number of visitors per year in the period from 1996 to 2016.

Kozjak is not suitable as a water supply. Even though the lake is of good water quality [19, 20], there are certain threats still present. The lake is used for navigation of electric boats; however, the important factor that needs consideration is environmental flow. Environmental flow for freshwater ecosystems is a significant part of adaptive management [21]. Furthermore, the management of wastewater sewage system is inadequate, lacking the wastewater treatment plant for entire sewage system. This issue has been a problem for many years considering the fact that investment in this project is rather high and it cannot only be financed solely by the park; it requires additional funding. The positive step for resolving this issue is in the signed Agreement between different stakeholders.

External factors that have a great impact on this protected area are recognized through several important issues. One of the most important issues that has been present in recent times is an uncontrolled construction in small villages like village Plitvica. In a short period of time, many houses have been built mainly with a purpose to be rented to visitors as a private accommodation. However, the area of construction is rather a sensitive karst area were certain amount of water from the stream Plitvica is lost in the underground [22] and there is a lack of any kind of proper communal infrastructure that gives a great concern about the possible water contamination. Regarding that issue, the National Park had Reactive Monitoring Mission by UNESCO that gave recommendations that should be addressed in future management of the park. These recommendations are not only mandatory for the park to adopt, but also for the other national institutions and ministries in Republic of Croatia have the same obligation [23].

During the Homeland War (1990–1995), the area of the park was under the occupation and was depopulated. Afterward, some percent of the population returned and continued to work and live in the area. However, villages remained depopulated, and mostly with older generation of residents. Nowadays, this issue is still present but is more connected with the issue of general moving of population to bigger cities. According to the UN Revision, by 2050, 66% of world's population is projected to be urban [24].

Climate change is also an important external factor that influences not only the biodiversity but also the habitats. For freshwater ecosystem in the park, researchers compared the data of water temperature with time difference of 30 years and concluded that the water temperature rose by 1.5°C in lakes [25]. Even though climate change is a significant threat to declining freshwater population, it seems also that the great impact comes from habitat loss or degradation. Freshwater habitats are strongly affected by different impacts, and according to Freshwater Living Planet Index, the abundance of the populations has declined by 81% between 1970 and 2012 [26].

Rather important, but a highly external factor, is lack of continuity in the political sense where the political influence and changes have certain impact in protected areas either through financing them or designating new protected areas. This is not something that is unusual or new and it has been recognized in other protected areas all over the world. The increasing number of governments are overtly decreasing resources for protected areas, upgrading and upsizing protected areas require persistent political engagement and most conservation problems cannot be solved in 5-year stands [27, 28].

4. Conclusions

Plitvice Lakes National Park has a rather complex management system. The most important part of its management is most certainly the nature conservation and conservation of all the important processes (ecological, chemical and geological) that are present in the protected area. Other important management areas are seen through cultural heritage, tourism and education. However, to be adaptive as a protected area, the National Park has to have good cooperation with local community and different stakeholders. Additionally, the park owns important infrastructure not only for its residents, but also for hospitality services that it provides.

The assessment of management effectiveness for this protected area through SWOT analysis gave an insight into the park's internal and external factors, highlighting that favorable factors still prevail over unfavorable. However, in this changing world with lot of possible threats and weaknesses present through climate change, biodiversity loss, invasive species, uncontrolled construction, insufficiently managed touristic activity, poor infrastructure and ever-changing political atmosphere, every protected area should pay attention to its management to minimize those negative factors.

The future of Plitvice Lakes National Park is situated in well written and adaptive management plan with action plan for visitor management, in developed and applied educational and interpretative programs, in good cooperation with local community and in wise investments in projects, researches and monitoring. In all these activities, the primary end objective should be nature conservation.

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Section 2

Fish and Wildlife Conservation

Chapter 6

Establishment of Management Plan by Sighting Reports of Asiatic Black Bears (*Ursus thibetanus*): A Case Study in Oze National Park, Central Japan

Yukihiko Hashimoto and Tomohito Anrui

Additional information is available at the end of the chapter

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Abstract

In order to make efficient plans for wildlife management, we propose here how to establish the plan for the bear management using sighting reports of Oze National Park (Oze NP), Central Japan. A total of 574 sighting reports gathered from 2004 to 2009 in Oze NP were analyzed. Firstly, analyzing 36 of 236 dangerous bear responses to visitors revealed that bears in Oze NP were not habituated to visitors or their foods. This suggests that all efforts could be put into preventing from making "nuisance bears" in Oze NP. Secondly, in order to determine proper assignation of staffs, the pattern of bear occurrences was analyzed. Bears occurred more frequently in August and relatively frequently in June. Thus, the larger number of staffs should be assigned these months. Core areas were determined by the 50% karnel. Since core area was smaller in August, a few staffs should stand by at Yamanohana area. In June, the number of sighting and core area was larger only in early periods; thus, one staff should stand by at Todengoya and another at Yamanohana area in early June.

Keywords: Asiatic black bear, management plan, Oze National Park, sighting information, *Ursus thibetanus*

1. Introduction

National parks should be managed in a fine balance between wildlife conservation and human activity. Over the decades, conflicts between bears and visitors occurred frequently in some natural parks in Japan [1]. Since staffs and budgets are limited, efficient management plans have to be made. Bear occurrences depend on topology, food availability, vegetation,

bear physiology, and human activity [2]. If it is possible to detect bear occurrence pattern, intensive management action can be planned where and when bears occurred frequently.

In this chapter, using our cases in Oze National Park (Oze NP), we propose how to establish the plan for the bear management using sighting reports. This method we used can be applied in most national park, because sighting reports are not only collected easily and economically but also supposed to have already collected in most national parks.

Two hikers each are injured in the Ozegahara in 1999 and in 2004. Both of these incidents occurred at same spot (**Figure 1**) and about 8 o'clock in the morning in early June. Thus, these incidents may have similar background, and it should be revealed to discuss a proper bear management plan in Oze NP.

Firstly, we will discuss whether the bears in Oze NP are habituated or not. If bears habituated to human or artificial food, these bears are called "nuisance bear," and the risk of conflict between bear and human will be higher [2]. Since prompt action is essential to manage habituated bear, at least one trained staff must be ready at any time in months bears frequently occur. As a result, the larger number of trained staffs is needed than for nonhabituated bears. Thus, firstly the presence of nuisance bear must be detected. In Oze NP, food habit study of the Asiatic black bear revealed that the bears do not use artificial food at all [3]. Besides these studies, we analyzed reactions of bears when they noticed visitors and evaluated the presence of nuisance bear.

Secondly, by analyzing pattern of occurrence of the bears, we discuss on proper staff assignment. In order to decide assignment of staffs, the area where bears frequently occur needs to be determined. Although bears occur anywhere in Oze NP, frequently sighted sites were limited and

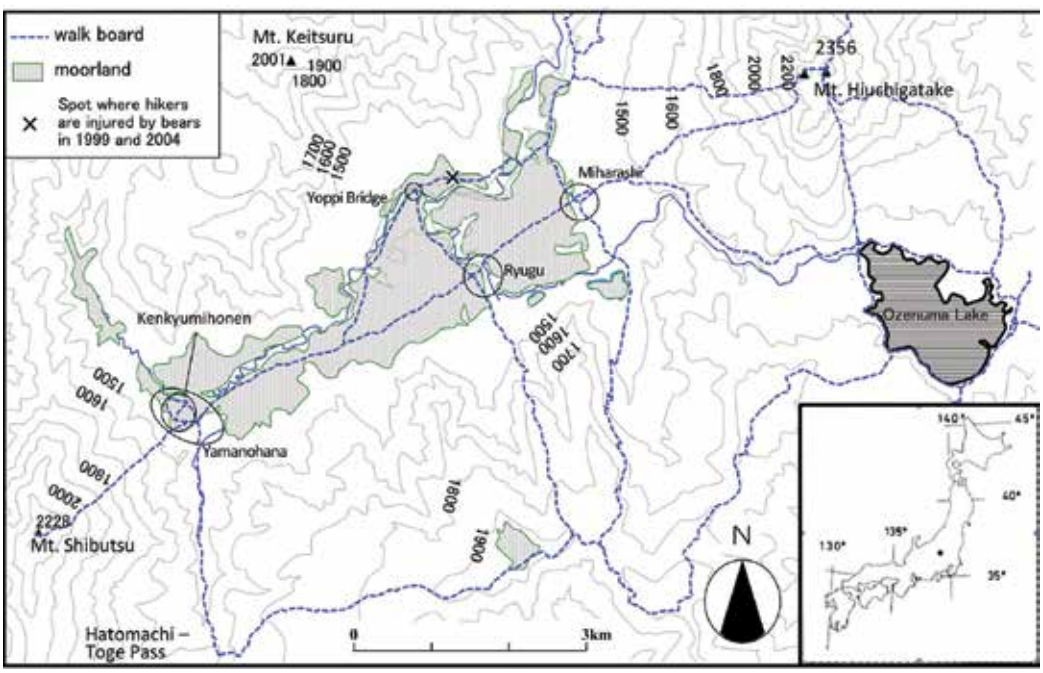

Figure 1. Study area.

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change seasonally. In Oze NP, since no road which vehicles can drive was built, staffs have to arrive on foot at the site where bear management is needed. For prompt action, staffs should choose a place to stand by at with good access of the site. Accordingly, we determined areas where bears are prone to occur frequently by analyzing sighting reports and proposed yearly staff assignment.

2. Study area

This study was conducted in the Ozegahara, Ozenuma Lake and surrounding area of Oze NP (**Figure 1**). Ozegahara is the largest area of moorland in Honshu or the South of Japan, measuring 6 km from northeast to southwest and 2 km from northwest to southeast, with a total area of 7.6 km^2 located at an elevation of 1400 m. Ozenuma Lake is 1.8 km^2 at 1665 m elevation. The area receives heavy winter snow, with mean annual precipitation of 1972.5 mm and a mean maximum snow depth of 342 mm. January is the coldest month, with a mean monthly temperature of −6.5°C, and August is the warmest, with a mean temperature of 17.5°C, according to climate data measured from April 2006 to March 2010 at the Yamanohana Meteorological Station (elevation 1405 m).

Ozegahara consists of fen and marsh, with a raised central bog and transition moorland (valley bogs) in peripheral areas [4–7]. The raised bogs are dominated by *Sphagnum* spp. and cranberry *Vaccinium oxycoccos*. The fens and marshes are dominated by several types of reed communities, and *Phragmites* and *Moliniopsis japonica* communities tend to dominate the transition moorland. Riparian forest extends along streams and rivers in the moorland and provides cover and a corridor for wildlife. Several forest types occur in the area, with

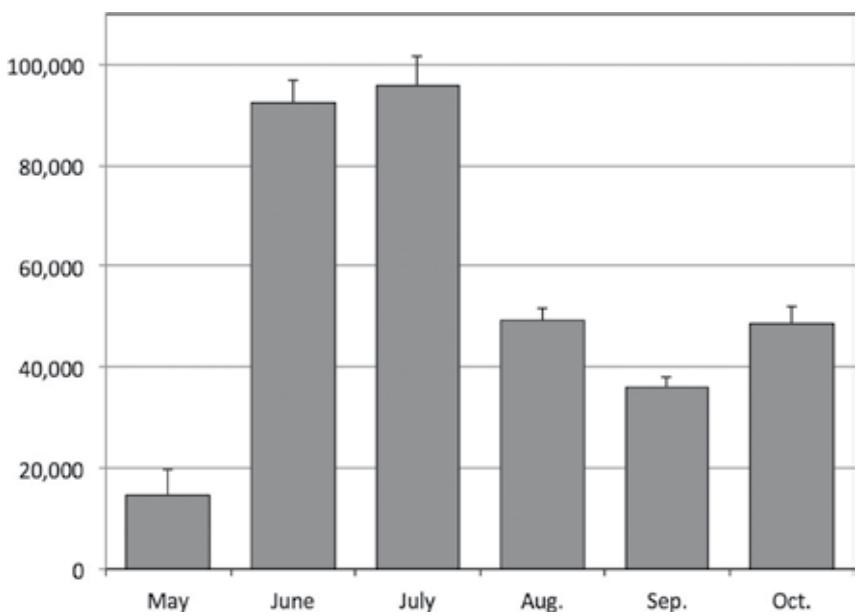

Figure 2. The number of people visit in Oze National Park each month. The number of hikers is from unpublished data provided by the Ministry of the Environment, Japan.

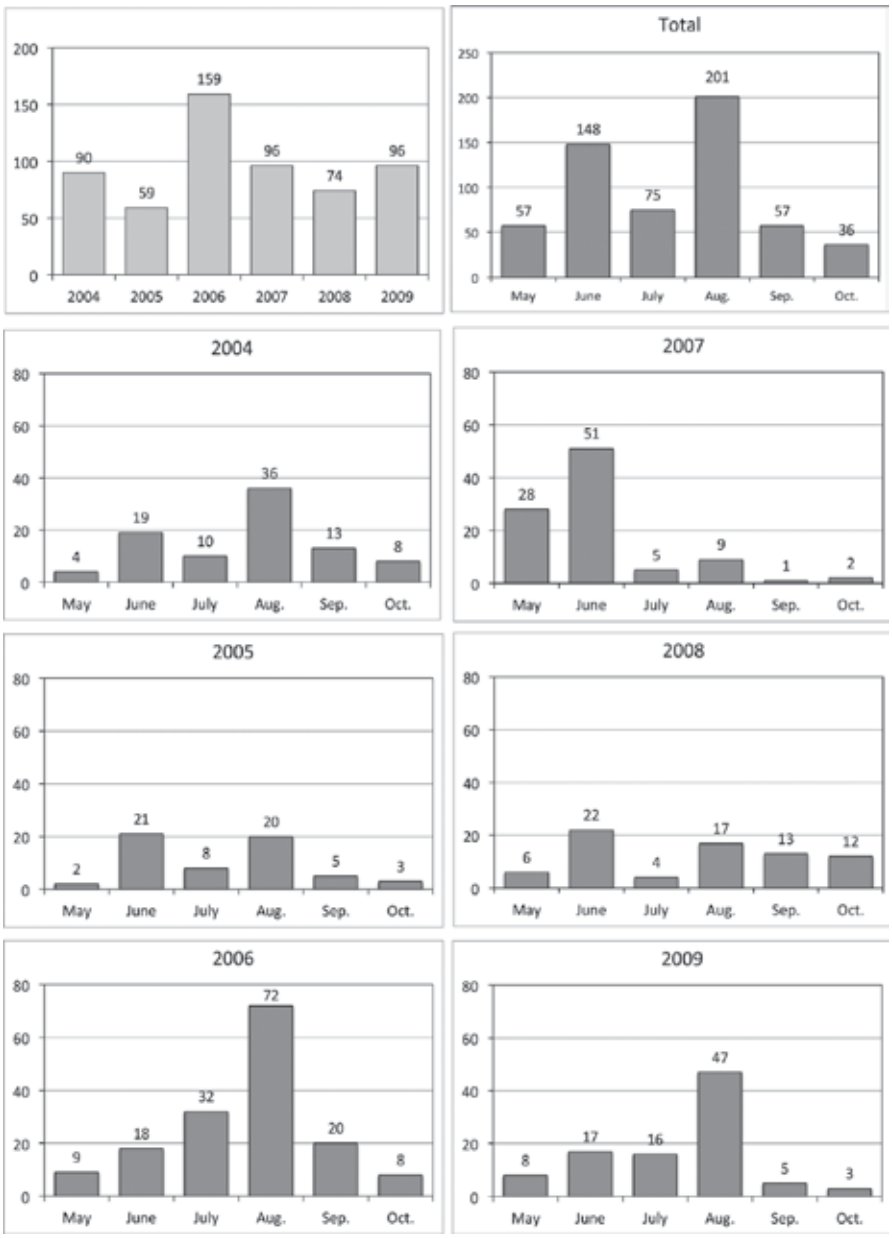

Figure 3. The number of yearly and monthly sighting reports from 2004 to 2009. The number of bear-sighting information is from unpublished data provided by the Oze Preservation Foundation.

the dominant species being *Ulmus davidiana var. japonica*, *Betula ermanii*, *Larix kaempferi*, *Salix bakko*, *Aesculus turbinata*, and *Pterocarya rhoifolia* [5, 6, 8]. The surrounding mountains are high enough to have a timberline and support alpine communities such as *Pinus pumila* scrub. The mountain slopes in the subalpine zone consist of *Abies mariesii* at high elevations and beech (*Fagus crenata*) forests in the foothills (1400–1600 m in elevation) [6, 8].

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The Oze area is celebrated as the "origin of nature conservation in Japan." A dam construction project was undertaken in 1919, but local residents and plant ecologists opposed its construction from the outset, and the plan was finally aborted in 1996. This was the first development project to be halted for nature conservation in Japan. The Oze area has been protected since then and is one of the most famous national parks in Japan, with about 300,000 visitors annually. Blooming skunk cabbages are one of the main attractions for visitors to Oze NP. Many hikers visit in late May to the middle of June to enjoy the scenery of skunk cabbages flushing (Ministry of the Environment of Japan published data; **Figure 2**).

Ozegahara and Ozenuma Lake are designated as special protection areas within the Oze NP and are registered as special Japanese natural treasures and as important international wetlands with the Ramsar Convention. Visitors are restricted to boardwalks to prevent damage to the habitat. Asiatic black bears in the Oze area were hunted by local people until the 1970s; however, they have been subsequently strictly protected by several laws. The park includes 16 lodges, and garbage and waste are managed to prevent environmental damage. Hikers frequently sight Asiatic black bears eating grasses on the moors in June following snowmelt and eating spadices of skunk cabbages from June to August (Oze Preservation Foundation unpublished data; **Figure 3**).

3. Methods

We used data of 574 sighting reports gathered from 2004 to 2009 in Oze NP (**Figure 3**, **Table 1**). Using a questionnaire form, we gathered information about (1) the behavior of bears, (2) the place where bears are frequently sighted, and (3) the month when they are sighted. We interpreted frequent sighting as higher possibility of occurrence of conflicts between bears and visitors. Analyzing reaction of sighted bears, the nature of the bears in Oze NP was decided. Fixed kernel method is used to detecting where the bears are frequently sighted.

Data was collected by interviews and questionnaires. We made the inquiry form and asked witness, including hikers, volunteers, and staffs of visitor centers and hiking lodges to fill the form, and when witnesses come to visitor centers, staffs interviewed them according to the questionnaire. The questionnaire asked about the place where bear was, time, distance to bear, characteristics of bears (size, number, and body feature such as the presence of white patch on the chest), countermeasure of hikers, and bear reaction against witness for each sighting.

To distinguish whether bears are habituated or not, bear reactions were reviewed. We excluded reports when distances between bears and witnesses were longer than 30 m, because even if a bear noticed hikers at a large distance, the bear may not show any behavior. Cases were excluded if reactions of bears were not documented and if possibility that bear did not notice witness was high. If the bear did not show any avoiding behaviors, sneak to hiker, or threaten hiker, we determined it as a problematic response.

If bears occurred and would not move away from the place where distance from wooden board was less than 30 m, and even if they noticed hikers, bear management staffs close the trail and try to make the bears learn to avoid humans by chasing away or using firecrackers. The cases with such management actions were included in the problematic response.

Year	Problematic response				Normal behavior	Total
	Dangerous reaction (Mother and cub)	Chased away	Closing trail	Subtotal		
2004	5 (1)	1		7	23	30
2005	0	0		0	19	19
2006	1	11	1	13	74	87
2007	3	4		7	22	29
2008	2	0		2	21	23
2009	4 (1)	2		7	41	48
Total	15 (2)	18	1	36	200	236

Table 1. The numbers of sighting reports of problematic response gathered from 2004 to 2009 in Oze National Park.

The core area, where bears frequently occur, was determined by 50% kernel of bear-sighting points of relevant period.

All statistics and calculating core areas were performed using R-3.4.1 [9]. Core areas were drawn using QGIS 2.14.

4. Results

4.1. Bear habituation

The numbers of bear-sighting information for analyzing bear habituation were 30 in 2004, 19 in 2005, 87 in 2006, 29 in 2007, 23 in 2008, and 48 in 2009 (**Table 1**). And, the numbers of problematic responses were 7 in 2004, 0 in 2005, 13 in 2006, 7 in 2007, 2 in 2008, and 7 in 2009 (**Table 1**). Among problematic responses, two cases were associated with mother bear accompanied with a cub each in 2004 and in 2009.

4.2. Bear occurrence pattern

4.2.1. Yearly and monthly variation

The number of occurrence of the bears was 95.7 ± 14.0 (from 59 in 2005 to 159 in 2006, **Figure 3**). The number of sighted bears was significantly larger in August than those in May, September, and October (two-way ANOVA, year $F = 1.247$, $p = 0.317$; month $F = 0.005$, $p < 0.05$; Tukey HSD, $p < 0.05$) and marginally larger than those in July ($p = 0.073$). The number of sighted bears was slightly larger in June, when injury incidents occurred, than other months except for August (**Figure 3**), but it was not significant ($p = 0.14$~0.55). The number of sighted bears in August varied yearly; for example, the number was 72 in 2006 but was only 9 in 2007 (Tukey HSD, $p < 0.05$, **Figure 3**).

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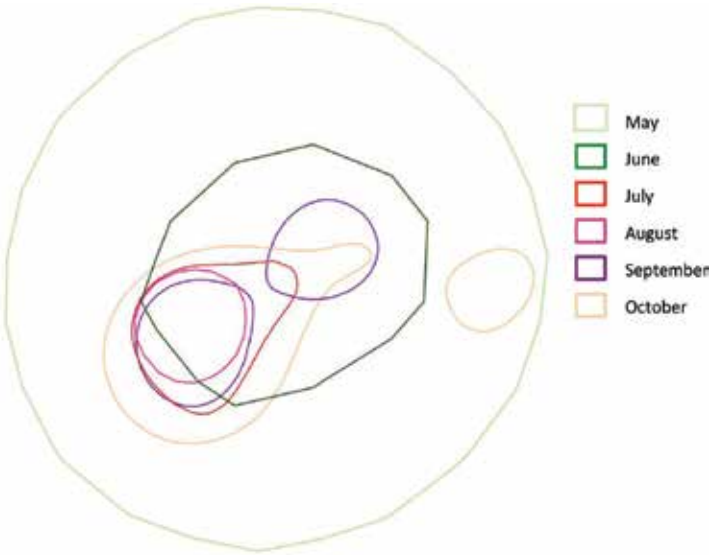

Figure 4. Monthly core areas of bear sighting in Oze NP. The core area, where bears frequently occur, was determined by 50% kernel of bear-sighting points.

4.2.2. Core area of occurrence

The core area, where the sightings were concentrated, of each month was shown in **Figure 4**. The core area was largest in May, became smaller with the month until August. Those in September and October enlarged and had two core areas.

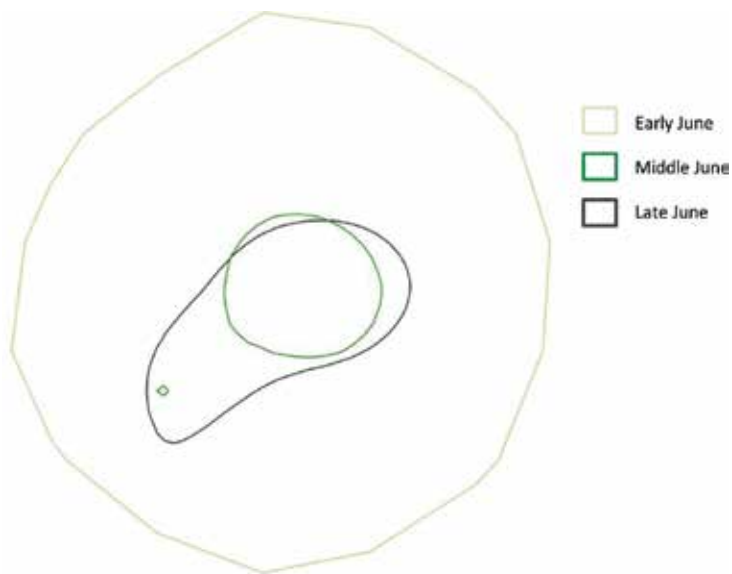

Figure 5. Core area of early, middle, and late June in Oze NP. The core area, where bears frequently occur, was determined by 50% kernel of bear-sighting points.

Human injury incidents occurred in early June. In order to examine the background of the incidents, we separated data of June into early (1st to 10th), middle (11th to 20th), and late (21st to 30th). The number of sighting reports was large in early June and decreased in middle and late June (**Figure 4**). The core area was largest in early June and become smaller in middle and late June (**Figure 5**).

5. Discussion

5.1. Nuisance bear

We found that most of the Asiatic black bears in Oze NP did not habituate to human or artificial foods [3]. But some bears persist of some natural foods near the area where visitors are active.

In 2004, a male bear occurred frequently around Yamanohana area where three hiking lodges and the visitor center are aggregated. This male was live captured and radio collared before released at about 10 km remote site. In 2007, this male bear occurred around Yamanohana and Ryugu areas in Ozegahara (**Figure 1**). This male bear caused all seven cases of problematic response in 2007. Since the bear was radio collared in 2004, we could monitor it and treated it quickly before it came near to the hiking lodge or walk board in 2007.

In 2006, two subadult bears frequently occurred around Yamanohana area in August. All 11 cases of chasing in 2006 were against these bears. They persisted community of skunk cabbage and ate anthotaxy of skunk cabbage exclusively [3]. Although they did not show avoidance of behavior to humans, they did not show any behavior trying to approach humans or artificial foods.

Similarly in 2009, one subadult bear frequently occurred around Yamanohana area in August. Both cases of chasing in 2009 were against this bear. Other situations were also similar to those in 2005.

These results indicates that bears in Oze NP were not habituated to artificial foods, but some of them, usually younger bears, do not mind humans, and if artificial foods were available for them, they would easily habituate. And, we found that such bears could be managed relatively easily if it was radio collared.

But once a bear is habituated, risks for visitors and thus efforts to prevent bear-human conflicts will significantly increase. All staffs engaging habituated bears must be well trained, but such human resource is difficult to secure in Japan. Thus, the most important management action in Oze NP is to prevent making habituated bears. Visitor education not to feed bears by lecture, leaflet, and notice of information calling for attention is the most important action.

5.2. Proper staff assignment

Visitor education should be conducted throughout open season as a routine action mainly by a bear management staff. Added to this, staffs should stand by in months where bears frequently occur.

Bear sighting occurred most frequently in August. Thus, the increase of the number of staffs in this month should be discussed. Mean bear occurrence in August was more than once a day (33.5 ± 8.5). Thus, at least two bear management staffs are needed. Since the core area was small in August (**Figure 4**), staffs may stand by at a single site in or near the core area. From these points, two staffs should stand by at Yamanohana area in August.

Since injury incidents occurred in June and the number of sighting reports was larger although not significant, staff assignment should be discussed. The incidents occurred in early June; the number of siting reports was larger (**Figure 3**), and core area was larger than those of middle and late (**Figure 4**). Thus, increase of staffs in early June should be discussed separately to middle and late June. Since core area was large in early June, the larger area has to be covered. Thus, staffs should stand by each other at separate sites in the core area. From these points, one staff should stand by at Todengoya and another at Yamanohana area in early June. Since the numbers of sighting reports are smaller in middle and late June, additional staffs are not essential, but if needed, added staffs should stand by at Todengoya.

6. Conclusion

We found that the Asiatic black bears in Oze NP did not habituate to humans or artificial foods. This suggests that all efforts could be put into preventing from making "nuisance bears" in Oze NP. Relatively small number of staffs may cover the whole area of the national park. But if bears habituate, not only more possibility of injury accidents which may occur will be higher, but also the cost for bear management will be much higher resulting in employment of a larger number of trained bear management staffs. Daily action of visitor education with bear management staffs is the most important management action. If human injured incidence did not occur in a long period, attentions tend to be neglected. Headquarters of national parks should keep these in mind at any time.

Of cause, these points are similar to other natural parks. Both staffs and visitors of national parks should understand that feeding wildlife, especially carnivorous large animals, results in considerable increase in not only the risks but also financial burdens.

Acknowledgements

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Chapter 7

Genotoxic Biomarkers in Fishes of the Chapada Das Mesas National Park, Brazil

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Abstract

Genotoxic and hematological parameters in *Hypostomus pusarum* and *Mylossoma duriventre* were used as biomarkers to assess the exposure to environmental stressors within the Chapada das Mesas National Park (PNCM). Fishes were sampled at two sites in PNCM: São Romão and Prata Waterfall. Biometric data (length and weight) were recorded, and blood was collected from all fishes for analysis. The abiotic variables were measured in each region: pH, temperature and dissolved oxygen. A drop of blood from each fish was placed on two microscope slides and smeared. The slides were left to dry at room temperature for 24 h and then fixed in absolute ethanol for 30 min. Means and standard deviations (SDs) of the biometric data of *H. pusarum* showed length and total weight bigger than *M. duriventre*. Nuclear morphological changes (NMAs) were identified in the two sampled species for the two collection points. Among the NMAs found, binucleated nucleus (BN), vacuolated nucleus (VC) and micronucleus (MN) were also found in both species; however, in *M. duriventre*, the frequency of MN and NMA was higher than *H. pusarum*. The presented data show that methodologies based on biomarkers will be used in the future park management programs.

Keywords: biomonitoring, freshwater fishes, protected area, cascudo (*Hypostomus pusarum*), pacú (*Mylossoma duriventre*)

1. Introduction

According to Ramelow et al. [1] and Schulz et al. [2], fishes are excellent tools to the aquatic environment biomonitoring because they are used for assessing a lot of environmental disturbing factors such as changes in the rate of growth and sexual maturation. Besides, changes in fish community structure, such as species abundance and diversity, may also reflect the effects of various stressors on the biotic integrity of a river [3].

In this way, erythrocytes of fish have been shown to be a safe tool for the micronucleus test [4, 5]. The micronucleus test is considered an advantageous technique whose analysis is relatively simple. In addition, the simplicity and speed of obtaining peripheral fish blood make the technique even more suitable for the evaluation of environmental contamination [6].

In this context, the selection of species that can reflect the environmental situation of PNCM becomes of great relevance to monitor the interferences that this Conservation Unit has been suffering over the years. Fishes are excellent bioindicators because they are at the top of the trophic chain and reflect the impacts in a given ecosystem through their normal and/or organic composition in the medium or long term [7].

The development and standardization of methodologies capable of predicting the effects of contamination on aquatic organisms are extremely relevant for biomonitoring studies in a Conservation Unit. Among these methodologies, the use of biomarkers of aquatic contamination in fish is particularly important because it shows initial biological responses and may be useful to subsidize monitoring and environmental management actions [8]. Biomarkers are biological responses to stress caused by pollutants and/or physical stressors and can be used to identify early signs of damage to aquatic organisms [9].

Research indicates that when aquatic ecosystems are polluted with organic and inorganic contaminants, fish will inevitably be contaminated [10, 11]. The possible effects of such contaminants on fish can be assessed by using several types of biomarkers, which are defined as the biological responses, as well as the effects caused by the pollutants and which identify signs of initial damage in organisms [12]. Livingstone [13] considers as biomarkers the bodily fluids, cells or tissues, as well as the responses of the exposed organisms, in physiological as well as behavioral or energetic levels, being, therefore, molecular biomarkers, cellular or organisms, being some of them are specific pollutants.

The genetic material of eukaryotic cells of fish species can also be altered by exposure to dissolved chemicals in the water, resulting in the formation of micronuclei, which can be used as biomarkers to assess the degree of contamination in the environment [14]. The micronuclei are derived from chromosomal fragments resulting from breaks that are not incorporated into the main nucleus of the daughter cells after mitosis due to damage introduced into the parental cells [15]. Micronuclei tests have not yet been performed in PNCM and in the water ecosystems of southern Maranhão. Thus, these data may serve to obtain more complete clues of contaminants that may be inducing.

In this way, recognizing the need to provide the sustainable use of natural resources and the environmental quality of the PNCM and to the local communities, as well as the need to know the effect of the possible impacts on the fish of the region, the aim was to contribute with the scientific knowledge related to biomarkers genotoxic in two species of sweet fish (*Hypostomus pusarum* and *Mylossoma duriventre*) in order to subsidize biomonitoring and management programs in the protected areas.

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2. Methodology

2.1. License and statement of ethics committee

Fish collection was done through the research authorization of the Chico Mendes Institute for Biodiversity Conservation—ICMBio (SISBIO, 55361/2017). The protocol of the ethics committee was approved by the State University of Maranhão (13/2017 CRMV-MA) through the Ethics and Animal Experimentation Commission (CEEA).

2.2. Study area

The Chapada das Mesas National Park (PNCM) (**Figure 1**) is a protected area, which is located in the South of Maranhão, between the following cities: Riachão, Estreito and Carolina [16].

The PNCM climate is tropical: humid and hot, characterized by having two defined seasons, one being dry and the other rainy. The rainy season is in the period from November to March, with rainfall concentrated in February [17]. This region contains an extensive and rich hydrographic network with approximately 400 springs and the main water courses that supply the city of Carolina. In addition, the PNCM protects numerous watercourses and springs from several rivers, such as the Farinha River (with numerous waterfalls), Itapecuru, Urupuchete, Corrente

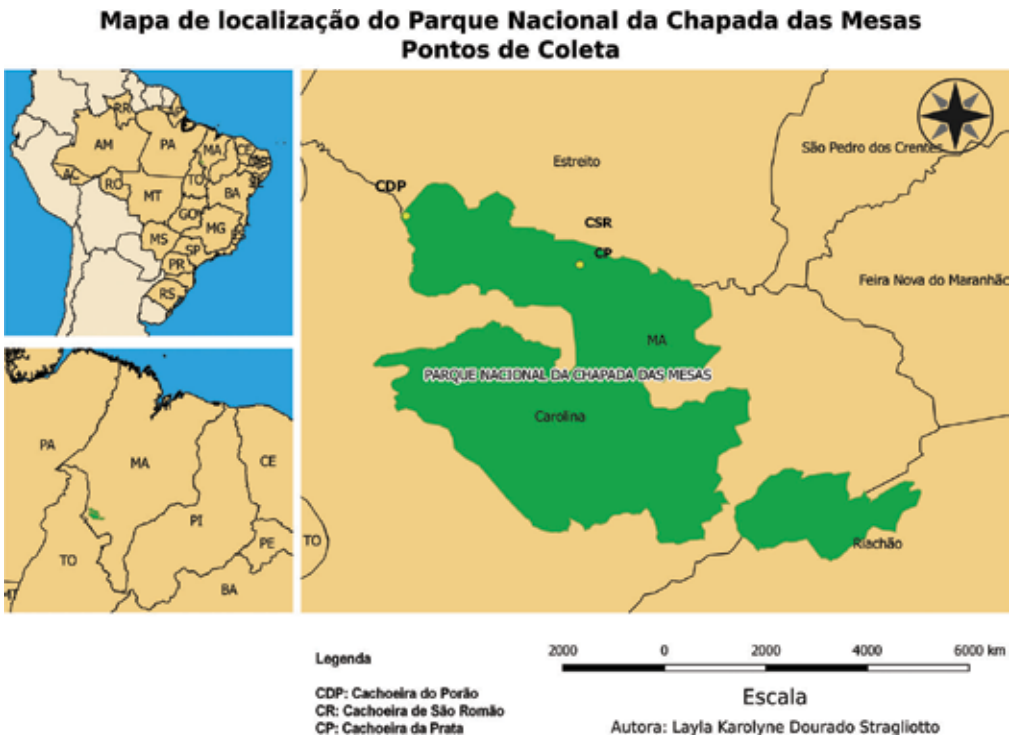

Figure 1. Map of the Chapada das Mesas National Park, Brazil showing the sampling sites. CRS = São Romão Waterfall; CP = Prata Waterfall.

and Lajinha. The hydrographic basin of the Farinha River is one of the main tributaries of the Tocantins river basin, being the most explored from the ecotourism and local point of view.

2.3. Sampling sites and fishes in the PNCM

In total, 32 fishes were sampled in PNCM: [1] São Romão Waterfall (n = 12) and [2] Prata Waterfall (n = 20). The stations were georeferenced by Global Positioning System (GPS). The fishes were collected in the rainy period (March 2017) and in the dry period (June 2017) with fixed nets 22 in the upstream and downstream of the waterfalls. The genera selected for analysis of the biomarkers were *H. pusarum* and *M. duriventre*. The selection of species is related to their habit and their frequency throughout the years in PNCM rivers and waterfalls.

2.4. Environmental parameters

Physicochemical parameters—temperature, pH and dissolved oxygen—were measured at each site during the dry and rainy season when fishes were sampled. The parameters were analyzed using the ASKO multiparameter.

2.5. Micronuclei, morphological nuclear abnormalities and biometric data

Specimens of *H. pusarum* and *M. duriventre* were sampled, transferred to a plastic vat with water and then anesthetized for 5 min in clove solution. Blood was collected from the gills of individual *H. pusarum* and *M. duriventre* (n = 32 from the two sampling sites) using heparinized syringes. A drop of blood from each fish was placed on two microscope slides and smeared. The slides were left to dry at room temperature for 24 h and then fixed in absolute ethanol for 30 min. One set of slides (n = 32) was stained with 10% Giemsa diluted in phosphate buffer (pH 6.8) and analyzed using a light microscope. A total of 2000 cells per slide were analyzed. Micronuclei and morphological nuclear abnormalities in the erythrocytes were deemed indicative of genotoxicity [18].

For each fish specimen, biometric data—total length (TL), fork length (FL), standard length (SL) and total weight (TW)—were recorded.

2.6. Statistical analysis of data

The obtained data were submitted to the normality test, and the obtained results were compared by Student's t-test. For the differences in location between the means obtained for the two collection sites and the biometric data, the multiple comparison test ($P < 0.05$) was used.

3. Results and discussion

3.1. Environmental parameters

The mean values of the abiotic variables recorded in the PNCM throughout the sampled period (rainy and dry season) were measured and are shown in **Table 1**. Temperature and pH remained practically constant in both areas during rainy and dry periods.

Parameters.	São Romão Waterfall	Prata Waterfall	Recommended values
Dissolved O_2 (ppm)[a]	11	12.5	>5 mg/L[b]
pH[a]	7.32	7.45	6.5–8.0[b]
Temperature[a] (°C)	28.0	28.5	28–32°C[b]

[a]Mean value during the dry and rainy seasons.
[b]Resolution No. 357, CONAMA (Brazilian Legislation) 15 March 2005.

Table 1. Environmental parameters analyzed at each sampling location in Chapada das Mesas National Park, Brazil.

These data indicate that all the abiotic factors of PNCM waterfalls are within the values accepted by the National Environmental Council [19]. CONAMA Resolution No. of 17 May 2011, which complements and amends Resolution No. 357/2005 of 17 March 2005, presents specific values that classify freshwater bodies (lentic and lotic) and shows that below recommended levels, these values may cause adaptive changes in the morphology of erythrocytes of bioindicator species (such as fish) and, consequently, a decrease in hematocrit values [16, 20].

3.2. Biometric data

3.2.1. M. duriventre

The results from statistical analysis of the *M. duriventre* biometric in São Romão and Prata Waterfall from PCNM can be observed in **Table 2**.

The biometric data submitted to the normality test for *M. duriventre* indicated that there is not a significant difference between the treatments for the São Romão and Prata Waterfall. According to Pinheiro-Sousa [8], the statistical difference can be related to the environmental conditions of the available resources in two distinct points of a protected area.

In addition, the biometrics data were higher for fish in the dry period in the São Romão Waterfall and in the rainy period for Cachoeira da Prata. This difference between the size

Parameter (mean ± SD)	Means ± Standard deviations (SD)			
	São Romão Waterfall		Prata Waterfall	
	Rainy season	Dry season	Rainy season	Dry season
TL (cm)	7.63 ± 1.02	14.06 ± 5.25	16.5 ± 4.02	13.1 ± 4.62
FL (cm)	6.9 ± 1.08	13.14 ± 5.17	12.25 ± 5.58	13.12 ± 4.78
SL (cm)	6.16 ± 0.90	11.4 ± 4.67	14.2 ± 3.46	11.16 ± 4.01
TW (g)	6.66 ± 4.61	36.4 ± 37.40	93.66 ± 58.73	61.6 ± 59.21

Total number of species sampled = 19; number of species in São Romão Waterfall = 8 and number of species in Prata Waterfall = 11. Biometric data: TL (total length); FL (fork length); SL (standard length) and TW (total weight).

Table 2. Biometric data of *M. duriventre* sampled in the São Romão and Prata Waterfall, Chapada das Mesas National Park, Brazil.

of the individuals shows that the reproductive and growth behavior of the pacú is different for the two areas sampled. Individuals of *M. duriventre* have diurnal habits, are migratory, and in the ebb form schools and migrate upstream to spawn in the confluences of rivers and waterfalls in the reproductive periods. The reproduction is long, covering drought (November) and flood (May), being the most intense spawning between December and February [21] for the Amazonian regions.

Thus, for the PNCM, where two seasons are defined, one of which is dry (May/October) and the other rainy (November/April), the growth and reproduction relationship of *M. duriventre* has a differentiated structure, although it did not indicate a statistical difference between the means and standard deviation analyzed.

3.2.2. H. pusarum

The results from statistical analysis of the *H. pusarum* (cascudo) biometric in São Romão and Prata Waterfall, from PCNM can be observed in **Table 3**.

The biometric data submitted to the normality test for *H. pusarum* also indicated that there is no significant difference between treatments for São Romão and Prata Waterfall. However, taxa of *H. pusarum* captured in the dry season presented higher values of total length (CT) and weight (PT) for the two sampling areas.

In addition, the biometric data were higher for the cascudo than for the pacú. In this case, spawning in females of *H. pusarum* occurs at distinct periods for the different species of the Loricariidae family, offering an adaptive advantage since it reduces the intraspecific competition [22]. Thus, it is probable that the cascudo was captured in all the reproductive cycles for the sampling points of the PNCM, which conferred a greater biometry than the pacú. As *M. duriventre* migrate upstream to reproduce, it was probably not observed in minor individuals (in growth and feeding period) in the São Romão and Prata Waterfall.

Parameter (mean ± SD)	**Means ± Standard deviations (SD)**			
	São Romão Waterfall		**São Romão Waterfall**	
	Rainy season	**Dry season**	**Rainy season**	**Dry season**
TL (cm)	16.95 ± .0.63	15.75 ± 0.77	14.2 ± 6.42	19.99 ± 6.16
FL (cm)	14.1 ± 0.10	12.65 ± 0.77	12.83 ± 5.39	18.86 ± 6.79
SL (cm)	13.05 ± 0.35	11 ± 0.70	11.76 ± 4.57	17.34 ± 6.38
TW (g)	32 ± 28.28	26 ± 2.82	13.66 ± 12.66	128.33 ± 97.22

Total number of species sampled = 13; number of species in São Romão Waterfall = 4 and number of species in Prata Waterfall = 9. Biometric data: TL (total length); FL (fork length); SL (standard length) and TW (total weight).

Table 3. Biometric data of *H. pusarum* sampled in the São Romão and Prata Waterfall, Chapada das Mesas National Park, Brazil.

3.2.3. Micronucleus (MN) and nuclear morphological changes (NMC) in M. duriventre and H. pusarum

Table 4 shows the incidence of micronucleus (MN) and nuclear morphological changes (NMC) in erythrocytes of *M. duriventre* and *H. pusarum* collected at the different sampling points in the PNCM.

Studies applied to resistant aquatic species are considered of great relevance, since the alterations found in any level of biological organization (molecular, biochemical and cellular) can indicate the degree of impact of a given ecosystem [23]. In relation to the genotoxic changes found, a low incidence of MN and NMA was observed for the two species sampled at the PNCM collection points. However, the genotoxic changes found were greater for pacú (*M. duriventre*) than the cascudo (*H. pusarum*).

According to the bioecology of the taxa, the cascudo presents a dermis/benthic habit and, probably, the environmental conditions and the possible environmental impacts of the PNCM in relation to the pacú are probably more resistant. These data are important and highlight cascudo as a bioindicator species more appropriate for biomarker studies in the PNCM. In addition, these data corroborate the general theory of the biomarkers of aquatic contamination that states that benthic species are more appropriate for studies of biomonitoring in relation to species potential sources of pollution in aquatic ecosystems [8].

The **Figure 2** shows a photomicrograph of the changes found in *M. duriventre* and *H. pusarum* for the two areas sampled at different points in the PNCM. Micronucleus (MN), vacuolated nuclei (VN) and binucleated nuclei (BN) were found. In addition, most cells were found in the defense system such as lymphocytes and eosinophils.

The use of hematological and genotoxic parameters in model organisms (such as fish) has allowed to evaluate the quality of aquatic ecosystems and the effect of pollutants as well as changes in their toxic potential after exposure to the environment [24]. According to these

					Rain				
		São Romão Waterfall				**Prata Waterfall**			
Species	**N**	**MN**	**NV**	**NB**	**NE**	**MN**	**NV**	**NB**	**NE**
Mylossoma sp.	9	0	0	50	33	0	8	123	0
Hypostomus sp.	5	0	1	5	0	2	0	7	0
					Dry				
		São Romão Waterfall				**Prata Waterfall**			
Species	**N**	**MN**	**NV**	**NB**	**NE**	**MN**	**NV**	**NB**	**NE**
Mylossoma sp.	10	18	0	75	0	22	15	69	0
Hypostomus sp.	7	4	0	45	0	18	0	38	0

n = total number of fishes sampled; MN = micronucleus; NV = vacuolated nucleus; NB = binucleated nucleus.

Table 4. Frequency of micronucleus and morphologic changes in ***M. pusarum*** and ***M. duriventre*** from the Chapada das Mesas National Park, Brazil.

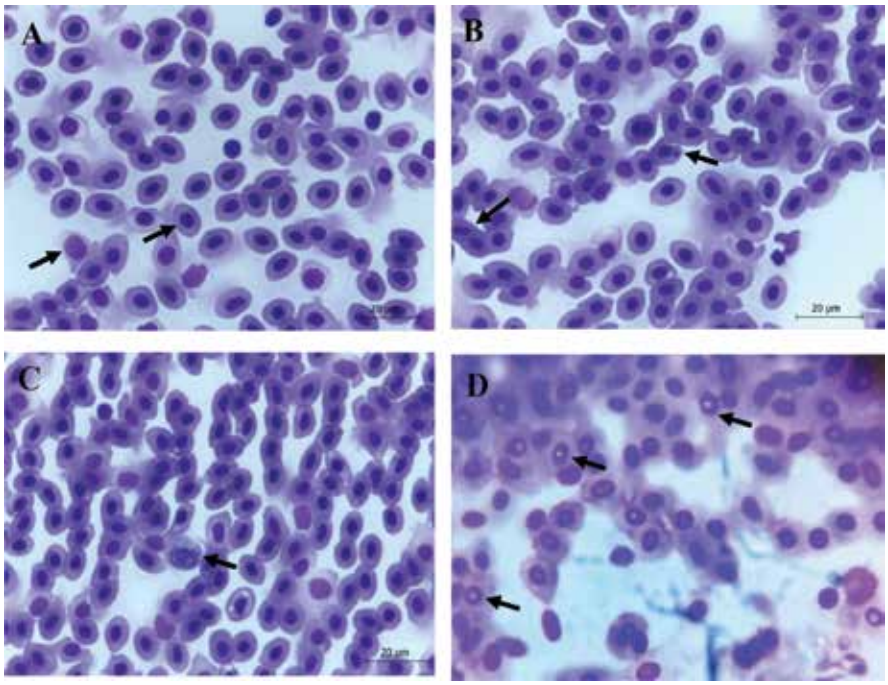

Figure 2. Photomicrograph (×1000) of erythrocytes of *H. pusarum* and *M. duriventre* stained with Giemsa from the São Romão and Prata Waterfall, Chapada das Mesas National Park, Brazil, showing (A) lymphocytes and normal cells—erythrocytes (arrow), (B) binucleated nucleus (arrow) and micronucleus (arrow), (C) eosinophils (arrow) and (D) vacuolated nucleus (arrows).

authors, the biological parameters discussed are verified at the cellular level and provide two types of analyses that reveal damage to the genetic material: the micronucleus test. The increase in the frequency of micronucleated cells is a marker of genotoxic effect that may reflect a exposure to agents with clastogenic mode of action (chromosome breakdown [25]. In the present study, the effect of the antigen on the chromosome number was not significant.

The incidence of NM to the PNCM sampling points was lower than NMA. These data differ from studies performed by Pinheiro-Sousa [8] and Carvalho-Neta et al. [26] who found a higher incidence of MN for the Environmental Protection Area of Maracanã. Thus, despite the low frequency of NMA and MN, especially of micronuclei, it is suggested that the Waterfalls of São Romão and Prata still do not suffer from point sources of pollution.

The presence of nuclear morphological changes (NMA) should be considered as complementary data to micronucleus records and as changes resulting from the induction by cytogenotoxic agents [18, 27] or by induction of pollutants. In fish, several types of nuclear anomalies do not yet have their origin completely understood. However, Carrasco et al. [28] and Galvan [29] have described and photographed some morphological changes found in fish erythrocyte nuclei. These alterations were classified as follows: [1] binucleate nuclei: nuclei that present cuts of two nuclei and nuclear membrane bounded and [2] nucleus vacuolizados: these nuclei present a region that resembles the vacuoles inside. These vacuoles are devoid of any visible material along the nuclear structure [29].

In addition, a large number of defense cells were found in the material analyzed. These include eosinophils and lymphocytes. According to Ranzani-Paiva and Silva-Souza [30], the eosinophils present diverse sizes, relatively small, and can vary according to the quantity or size of granules contained in the cytoplasm. The nucleus is rounded and eccentric with compact chromatin. This type of cell is distributed throughout the connective tissue, especially in the gastrointestinal tract and gills. One of the eosinophils functions is to intervene in the chronic inflammation processes, mainly in cellular defense, as how the fish was analyzed for PNCM.

In contrast, the lymphocytes are predominantly rounded cells, varying in size with the basophilic cytoplasm and without visible granulations, the nucleus has a rounded form, dense chromatin, and its relation with the cytoplasm is elevated [31]. Lymphocytes prevail in the body's defense reaction, but in stress situations, the number of circulating lymphocytes decreases [32]. Pickering [33] reported that lymphocyte decline may be related to. This is an important step in reducing the fish's ability to defend against pathogens. These data indicate that the degree of pacú and cascudo stress is probably low when compared to other studies in Maranhão Conservation Units [8, 26, 34].

Thus, the evaluation of hematology is an important tool for understanding fish sanity of the resources available in PNCM. For *M. duriventre* and *H. pusarum*, these results should be supported by a chemical analysis of the São Romão and Prata Waterfalls to evaluate the degree of impact that this region has been suffering along the process of ecotourism expansion and, of possible, indirectly influenced ventures of the park.

4. Conclusions

Means and standard deviations (SDs) of the biometric data of *H. pusarum* showed length and total weight are greater than *M. duriventre*. Nuclear morphological changes (NMAs) were identified in the two sampled species for the two collection points. Among the NMAs found, binucleated nucleus (BN), vacuolated nucleus (VC) and micronucleus (MN) were also found in both species; however, in *M. duriventre*, the frequency of MN and NMA was higher than *H. pusarum*. Probably, the cascudo (*H. pusarum*), considered a benthic species and resistant to environmental conditions, presented a lower frequency of genotoxic alterations than the Pacú (*M. duriventre*), that is, a species that presents a migratory habit and sensitive to environmental variables. Besides, the frequency of MN and NMA was not significant to indicate possible environmental impacts in the two sampled areas. The presented data show that methodologies based on biomarkers and bioindicator species can be used in future biomonitoring and park management programs.

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Section 3

Biodiversity Conservation

Chapter 8

A Centennial Path Towards Sustainability in Spanish National Parks: Biodiversity Conservation and Socioeconomic Development (1918-2018)

David Rodríguez-Rodríguez and
Javier Martínez-Vega

Additional information is available at the end of the chapter

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Abstract

National Parks (NPs) were the first protected areas (PAs) designated in Spain one century ago. NPs are PAs of exceptional natural and cultural value that are representative of the Spanish natural heritage. Currently, there are 15 NPs in Spain covering almost 400,000 ha, although new site designations are being considered. Spanish NPs' main objectives are closely linked to the sustainability concept: conserving natural and cultural assets in the long term and promoting public use, environmental awareness, research and socioeconomic development. Here, the history of modern nature conservation in Spain is summarized, with special focus on NPs. Moreover, the main monitoring and assessment initiatives in Spanish National Parks are reviewed. Finally, the major results of two current research projects focusing on the sustainability of Spanish NPs, DISESGLOB and SOSTPARK, are provided.

Keywords: protected area, assessment, sustainable development, Spain, history

1. Introduction

Places set aside to conserve natural resources such as forests, plants, animals (chiefly game animals) or waters have existed for centuries. European and Asian kings and noblemen established royal reserves or game reserves in their dominions. Those 'reserves' forbade or restricted access and use of resources to laymen for pleasure and enjoyment of the privileged, who were entrusted management and conservation of such sites. Modern protected areas (PAs)

were initially designated to preserve pristine landscapes when impacts from human development started to be conspicuous and widespread [1]. Aesthetic considerations are largely responsible for the mountainous character of initial PAs. The first widely agreed such PA was Yellowstone National Park (NP), designated in 1872 in north-west United States, although some claims are made that Mongolian Bogd Khan Uul NP, designated in 1783, might have been the first modern PA. Whichever the right chronology, the institutionalization of modern PAs can safely be dated by the end of the nineteenth century. The first such PAs were designated under the category of NP in the United States, Australia, Canada and New Zealand in the last quarter of the nineteenth century. In Europe, Sweden designated the first NP in 1909; Russia, in 1912; and Switzerland, in 1914 [2]. Spain followed few years later, in 1918.

Nowadays, NP is among the most widespread PA categories worldwide and virtually every sovereign state has designated NPs in their territories. NP is one of the six (seven?) PA management categories established by the International Union for Conservation of Nature (IUCN) [3]. Most NPs share some characteristics and aims that are synthesized in the IUCN's definition of 'NP' as 'large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities'. NPs normally restrict most human activities within their borders for nature conservation or restoration, although they are not as stringent as Reserves (IUCN's management Category I), allowing and even promoting controlled educational, research and recreational activities.

2. History of modern nature conservation in Spain

2.1. The pioneers: environmental thinking and nature protection between 1862 and 1936

The deficient state of forests in Spain as a result of unsustainable land-use practices has been acknowledged since the seventeenth century [2]. One of the solutions to preserve forests and associated species, soils and landscapes was the creation of protected, state-owned and managed forests included in the 'Forest Register' in 1862, which in 1896 turned to 'Public Utility Forests', a legal register that persists today. Another solution was the designation of PAs.

In spite of its historical, social and cultural backwardness, Spain was among the first nations in the world to designate NPs, creating a pioneering law on 'national parks' in 1916. Pedro Pidal y Bernaldo de Quirós (1869–1941), a nobleman, mountaineer, environmentalist, senator and personal friend of King Alfonso the XIIIth, was the promoter of the law. According to it, NPs were 'those exceptionally picturesque, forested or wild sites of the [Spanish] territory that the state designates in order to promote their adequate access and to respect the natural beauty of their landscapes, their faunal and floral richness, and their geological or hydrological singularities, avoiding avoiding all destruction or degradation by men effectively. One year later, in 1917, a Royal Decree created two new PA designation categories in the country

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aimed at those natural sites that merited protection but which were not as environmentally exceptional as NPs: 'Natural Site of National Interest' (NSNI) and 'Natural Monument of National Interest'.

The National Park Central Junta was created that year and, in 1918, the history of Spanish NPs began with the designation of the first two NPs in July and August of 1918, respectively: Montaña de Covadonga NP, designated over 16,925 ha in the Cantabrian mountain range in northern Spain and Valle de Ordesa NP, covering 2046 ha in the Pyrenean range in north-eastern Spain [1]. Both were mountainous NPs designated primarily on landscape grounds. Other PAs, chiefly mountainous sites or geologically original sites, were slowly and sparsely designated across the country under different legal categories from 1918, progressively expanding

D.n ALFONSO XIII, por la gracia de Dios y la Constitución, Rey de España;

A todos los que presente vieren y entendieren, sabed: que las Cortes han decretado y Nós sancionado lo siguiente:

Artículo 1.º Se crean en España los Parques Nacionales.

Art. 2.º Son Parques Nacionales, para los efectos de esta Ley, aquellos sitios ó parajes excepcionalmente pintorescos, forestales ó agrestes del territorio nacional, que el Estado consagra, declarándoles tales, con el exclusivo objeto de favorecer su acceso por vías de comunicación adecuadas, y de respetar y hacer que se respete la belleza natural de sus paisajes, la riqueza de su fauna y de su flora y las particularidades geológicas ó hidrológicas que encierren, evitando de este modo con la mayor eficacia todo acto de destrucción, deterioro ó desfiguración por la mano del hombre.

Art. 3.º El Ministro de Fomento creará los Parques Nacionales, de acuerdo con los dueños de los sitios, reglamentará los que vaya creando, y consignará en sus Presupuestos las cantidades necesarias para vías de comunicación y sostenimiento de todos ellos.

Por tanto:

Mandamos á todos los Tribunales, Justicias, Jefes, Gobernadores y demás Autoridades, así civiles como militares y eclesiásticas, de cualquier clase y digni-

Figure 1. Extract from the Spanish law on National Parks from 1916.

site protection at a time when nature conservation was an eccentric idea of the minority elites [2] (**Figure 1**).

2.2. Civil war and economic emergency: 1936–1955

By 1936, the year when the last Spanish civil war started, there were 18 PAs from four categories (NPs, National Sites, NSNIs and Natural Monuments of National Interest) covering 33,500 ha [1]. After the war, economically profitable land uses were promoted by the new authoritarian government at the expense of 'unproductive' nature conservation uses, in a context of extreme economic crisis and resource shortage for many citizens, including food and other basic commodities. Only one new PA (NSNI of Sanabria Lake) was designated (1946) before the new impulse taken by the NP policy, in the mid-1950s. In that decade, three new NPs were designated in peripheral regions: Teide NP (11,866 ha, in 1954) and Caldera de Taburiente NP (3500 ha, in 1954) in the Canary Islands, and Aguastortas y Lago de San Mauricio (9851 ha, in 1955) in Catalonia.

2.3. Economic recovery, nature conservation stagnation: 1955–1970

Another long period of stagnation of nature conservation policies took place between 1955 and 1970, when the socioeconomic progress of the country was significant. The only remarkable conservation milestone from that period was the designation of Doñana NP, thanks to considerable inner and international pressure, in 1969. With 39,225 ha, it was the biggest PA of Spain and accounted for nearly 40% of all protected area in the country by 1970: 103,000 ha [1].

2.4. New times for nature conservation: 1970–1980

In the 1970s, more progressive social thinking, decent life conditions and realization of human impacts on the environment from previous years of massive unsustainable development resulted in a substantial boost of nature conservation policies. The National Institute for Nature Conservation (ICONA), tasked with forest administration and nature conservation activities, including PA management, was created in 1971. In just 2 years (1973–1974), five new PAs were designated, including two NPs: Tablas de Daimiel (in 1973, in central Spain) and Timanfaya (in 1974, in the Canary Islands). In 1975, the first modern law on PAs was passed. It introduced, alongside NPs, new PA categories, most of which are still in force, such as Reserve or Nature Park, and repealed most previous categories, which were subsequently re-categorized. From that year on until 1980, the protected area in Spain nearly doubled, with more than 200,000 ha, which included new PA designations and substantial expansions of existing PAs, such as NPs. Some peripheral protection zones around NPs were additionally designated to buffer the influence of external human uses from surrounding territories [1].

2.5. The administrative transition period: 1980–1989

The Spanish democratic constitution of 1978 established that the autonomous regions (17 regions plus 2 autonomous cities) and not the central government were competent for nature

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conservation policies. The central government retained competency for basic, common nature conservation policies, including NP designation and management. Several heterogeneous and insufficiently coordinated regional nature conservation policies, laws, criteria and PA designations from the early 1980s arose [1]. Numerous PAs were regionally designated across the country using the state's law from 1975 or newly passed regional laws in that decade, although those PAs included just one NP: Garajonay, in the Canary Islands, in 1981. In that decade, the first PAs deriving from European legislation, namely Special Protection Areas (SPAs), for the protection of wild bird species [4] started to be designated after the accession of Spain to the European Economic Community in 1985. In 1989, a new basic law on nature conservation including contemporary (and still relevant) conservation principles and concepts, such as natural resource planning, PA buffer zones, genetic diversity preservation, local socioeconomic development or invasive species' control, was passed. It devoted a specific chapter to NPs. It stated that the designation of NPs will be on grounds of the nation's general interest and based on the representativity of Spanish 'natural (eco)systems'.

2.6. PA expansion and administrative battle for the management of NPs: 1990s

The autonomous regions appealed against the central government's exclusive management of Spanish NPs as stated in the 1989 law and, in 1995, the Constitutional Court established a shared management and financing system of NPs between the central government and regional governments. A new law on nature conservation from 1997 accounted for that judicial decision and established shared designation (NP continued to be designated by the Spanish parliament though with the acceptance of regional parliaments), management and financing of Spanish NPs between the central government and the regional governments where NPs were located. That law also created the Master Plan for NPs, for setting up common management priorities, and the NP Council for the mixed administration of NPs. Three NPs were designated in that decade, alongside many other 'national' and 'European' PAs (including Sites of Community Importance—SCIs-derived from the Habitats Directive, from 1992): Cabrera Archipelago NP (in the Balearic Islands, in 1991. It was the first Spanish NP including some marine area); Cabañeros NP (in central Spain, in 1995); and Sierra Nevada NP (in Andalusia, in 1999). By 1999, there were 611 PAs in Spain covering some 3,332,000 ha. Of them, 12 were NPs [1].

2.7. The consolidation of site conservation and management policies: 2000–2017

As a result of new appeals by regional governments, in 2005, the Constitutional Court sentenced that NP management was an exclusive competency of autonomous regions in Spain and just bestowed basic network coordination competencies to the central government including common managerial priorities and guidelines through the Master Plan for NPs, since then, two specific national laws on NPs acknowledging those changes have been developed (in 2007 and 2014) and a comprehensive law on natural heritage and biodiversity conservation and use was also passed in 2007. Currently, NP management corresponds entirely to the Spanish regional governments where NPs are located. If NPs are located between different regions, their governance is shared between the involved administrations.

In the last two decades, the Spanish terrestrial PA network has largely been completed with plentiful national and European PA designations. Currently, Spain has 1958 'national' PAs that cover 13% of the Spanish terrestrial territory. Three NPs were the last ones to be added to the NP network: Atlantic Islands (in Galicia, in 2002), Monfragüe NP (in Extremadura, in 2007) and Sierra de Guadarrama (in Madrid, in 2013). The 15 NPs existing by the end of 2017 cover 385,000 ha. By 2016, there were also 1865 Natura 2000 sites (SPAs, SCIs and Special Areas of Conservation) which covered 27.32% of the Spanish land territory [5], largely exceeding international PA coverage targets of 17% for terrestrial ecosystems at national scale [6]. From 2010, important effort is being made to also adequately protect marine biodiversity, according to the internationally agreed marine protected area coverage target of 10% [6]. As a result, 39 new marine SPAs were designated across the Spanish Exclusive Economic Zone in 2014. Those, together with other existing marine and coastal PAs, make approximately 12% of the marine environment under Spanish jurisdiction protected by 2017 [7].

2.8. Next steps

Though the Spanish terrestrial PA network can be considered close to completion, considerable effort must still be put in adequately managing those sites, including developing customized management plans and implementing regular surveillance and monitoring of biodiversity and other relevant conservation features consistently [8]. Also, effort should be made to ensure that an adequate representation of the Spanish natural systems established in the law on NPs of 2007 [9], especially steppe, desert and marine systems, is included in the NP network. Work is underway to designate two new NPs in Spain: Sierra de las Nieves NP in Andalusia, which would add to medium and high Mediterranean mountain ecosystem representation in the network, and Mar de las Calmas, in El Hierro, Canary Islands, which would become the first entirely marine NP. Finally, completion of the Spanish marine PA network according to the best available evidence on biodiversity and evolving international targets is still a pending task.

3. The Spanish network of National Parks: attempting sustainability

NPs are 'little transformed PAs of high natural and cultural value whose conservation is priority and in the state's general interest for being representative of the Spanish natural heritage as a result of their exceptional natural values, their representative character, or the singularity of their flora, fauna or geomorphological formations' [10]. The Spanish Network of NPs is an integrated system for the protection and management of the best sample of the Spanish natural heritage. The Network consists of its conforming NPs, their regulations, human and material resources and the institutions that are necessary for its functioning. By September of 2017, the Spanish Network of NPs consisted of 15 NPs. They are scattered across the four biogeographic regions in Spain (**Table 1**) [11].

Thirteen NPs are managed by the governments of the regions in which they are located, whereas the two NPs in Castilla-La Mancha region, Cabañeros NP and Tablas de Daimiel

National Park	Designation year	Area (ha)	Biogeographic region	Main ecosystem protected
Picos de Europa	1918	67,127	Atlantic	High Atlantic mountain
Ordesa y Monte Perdido	1918	15,608	Alpine	High Alpine mountain
Teide	1954	18,990	Macaronesian	High Macaronesian mountain
Caldera de Taburiente	1954	4690	Macaronesian	Canarian pine forest
Aigüestortes i estany de Sant Maurici	1955	14,119	Alpine	High Alpine lakes
Doñana	1969	54,252	Mediterranean	Coastal wetland
Tablas de Daimiel	1973	3030	Mediterranean	Inland wetland
Timanfaya	1974	5107	Macaronesian	Volcanic badlands
Garajonay	1981	3984	Macaronesian	Laurel forest
Archipiélago de Cabrera	1991	10,021	Mediterranean	Mediterranean sea and coast
Cabañeros	1995	40,856	Mediterranean	Mediterranean forest
Sierra Nevada	1999	85,883	Mediterranean	High Mediterranean mountain
Islas Atlánticas	2002	8480	Atlantic	Atlantic sea and coast
Monfragüe	2007	18,396	Mediterranean	Mediterranean forest
Sierra de Guadarrama	2013	33,960	Mediterranean	High Mediterranean mountain

Table 1. Main characteristics of the 15 National Parks in Spain by September of 2017.

NP, are still being managed by the central government through the NP Autonomous Body (OAPN). The overall state's investment in the Spanish NP Network was approximately €89 million in 2015 [12]. The NP Network is funded by the regional administrations for most ordinary expenses and by the central OAPN, which chiefly finances common actions across the Network including monitoring, research, volunteering, local socioeconomic subsidies, training and dissemination. In contrast to some other countries where entrance fees to NPs apply to all visitors or just to foreign visitors, fees do not apply in Spanish NPs and entrance is free of charge although regulated in order not to exceed the carrying capacity of protected ecosystems (**Figure 2**).

The main official aims of Spanish NPs are (1) ensuring the long-term conservation of biodiversity and cultural features; (2) supporting public use; (3) promoting scientific knowledge on their natural and cultural assets; (4) encouraging social environmental awareness; (5) exchanging experience and knowledge on sustainable development; (6) training and capacity building of staff working in NPs; and (7) participating in international programmes and networks. We could probably add an eighth aim, included in the current law on NPs, which deals with 'promoting local socioeconomic development' [10]. For this, a substantial part of the annual budget of the NP Network provided by the OAPN for common actions across the

Figure 2. Location of Spanish National Parks by September of 2017. Numbers indicate order of designation: 1. Picos de Europa; 2. Ordesa y Monte Perdido; 3. Teide; 4. Caldera de Taburiente; 5. Aigüestortes i estany de Sant Maurici; 6. Doñana; 7. Tablas de Daimiel; 8. Timanfaya; 9. Garajonay; 10. Archipiélago de Cabrera; 11. Cabañeros; 12. Sierra Nevada; 13. Islas Atlánticas; 14. Monfragüe; 15. Sierra de Guadarrama.

Network (approximately 58% in 2015) [12] is devoted to subsidies aimed at compensating local dwellers in the municipalities included in NPs for the restrictions to natural or cultural resource use from NPs' regulations and at promoting sustainable economic practices. Thus, the aims of the Spanish NP Network are closely aligned with those of sustainable development: environmental conservation, social equity and economic profitability. But are NPs attaining them?

4. Assessment of the environmental and socioeconomic effects of Spanish National Parks

Regular monitoring, assessment and evaluation are essential to gauge effectiveness of PAs and of any other public initiative or policy. Four types of assessments in Spanish NPs can be identified.

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4.1. Regular inner assessments

Regular censuses or samplings of biodiversity of conservation concern (e.g. endangered species) are regularly carried out in each NP according to their management planning using their own means and staff. Other features of conservation concerns, such as cultural or geomorphological features, are subject to regular surveillance and more sporadic (normally reactive) monitoring.

4.2. External assessments: project calls

The OAPN finances annual calls for research projects on natural values, cultural heritage, socioeconomic aspects and traditional knowledge in NPs since 2002. Those calls are included in the Spanish Research, Development & Innovation Plan. Research priorities in Spanish NPs are established in the NP Master Plan. According to it, funding precedence will be given to projects that monitor global change effects, projects that include more than one NP and projects

Figure 3. OAPN's funded 2015 research call on National Park's advertisement on the Spanish Ministry of Environment's website.

whose results are applicable to the whole NP Network. Eleven 3-year projects were funded under this call in 2015, with an overall budget of 619,000€. The OAPN convenes annual joint dissemination sessions between NP managers and scientists who develop research funded by the OAPN in NPs [13] (**Figure 3**).

In addition to this specific call, other more generic or complementary research calls by the central government or by the regional governments that can be used to fund research in NPs are opened yearly. One example of this is the multi-annual Spanish R + D + I Plan, which funds research projects that can be carried out in NPs through its two main lines: basic science (Excellence Call) and applied science (Societal Challenges Call). The Spanish R + D + I Plan 2013–2016 actually funded two projects on NPs and other PAs that will be mentioned in more detail in this chapter: DISESGLOB and SOSTPARK.

4.3. Institutional assessments: monitoring programmes

As a result of common research priorities identified in the 1999 NP Master Plan, the central and regional governments started developing, from 2008, a NP Monitoring and Assessment Plan. It was endorsed in 2011 and continued to develop according to the mandates in the Law 30/2014, on NPs, that confers the central government (through the OAPN) the competencies for: (1) monitoring and assessment of the NP Network, (2) communication and knowledge exchange among NPs, (3) promoting scientific research and dissemination, and (4) encouraging sustainable development in municipalities in NPs [10]. The NP Monitoring and Assessment Plan is structured in three areas:

4.3.1. Functional monitoring

It assesses the global functioning, coherence and meeting of the overall objectives of the NP Network. It results in yearbooks (by NP and of the network) and in a 3-year report on the status of the NP Network.

4.3.2. Ecological monitoring

It seeks to gather information on the state of conservation and ecological functioning of natural systems in the NP Network according to verified protocols and to assess the current status of biodiversity, its changes and future prospects in a context of global change. So far, the variables that are being monitored relate to forest health, plant phenology, climate change, ecosystem productivity, ecosystem structure, natural system cartography, common bird species, butterflies and marine environment.

4.3.3. Sociological monitoring

It studies the social effect of the NP Network on three target groups: local residents, visitors and the whole Spanish society. Indicators under this area refer to: social perception, socioeconomic data in municipalities included in NPs, effect of subsidies on those municipalities and social impact of the Network (on scientists, PA managers and environmental NGOs).

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4.4. Other assessments

There are plenty of other studies on Spanish NPs carried out by universities and research centers every year—degree, master or PhD theses are examples of such short- or medium-term research effort developed in NPs-. Those studies help to better understand the environmental and socioeconomic status of NPs, although they rarely align with research priorities in NPs but rather with external aims or interests. Moreover, no standardized register of such research is kept and results are rarely put across to NP managers.

Even if the research done in PAs is in accordance to official needs, the results of those studies may be published but are seldom conveyed in an understandable manner to PA managers, yet substantial amounts of primary information (e.g. from internal monitoring programmes), services and/or permission are usually asked from managers by researchers from the onset. Sometimes, lack of collaboration comes from the managers' side [14]. This bi-directional information flow mismatch is common in PAs in Spain [8] and elsewhere [15] and results in that there exists much more valuable information on PAs than that at the disposal of managers and scientists. To prevent this mismatch and make Spanish NP managers aware of some of the most relevant research that affects their sites, the NP Master Plan of 2016 establishes the creation of a public-access research database where results of every authorized study in NPs are communicated to and stored by the OAPN (**Figure 4**).

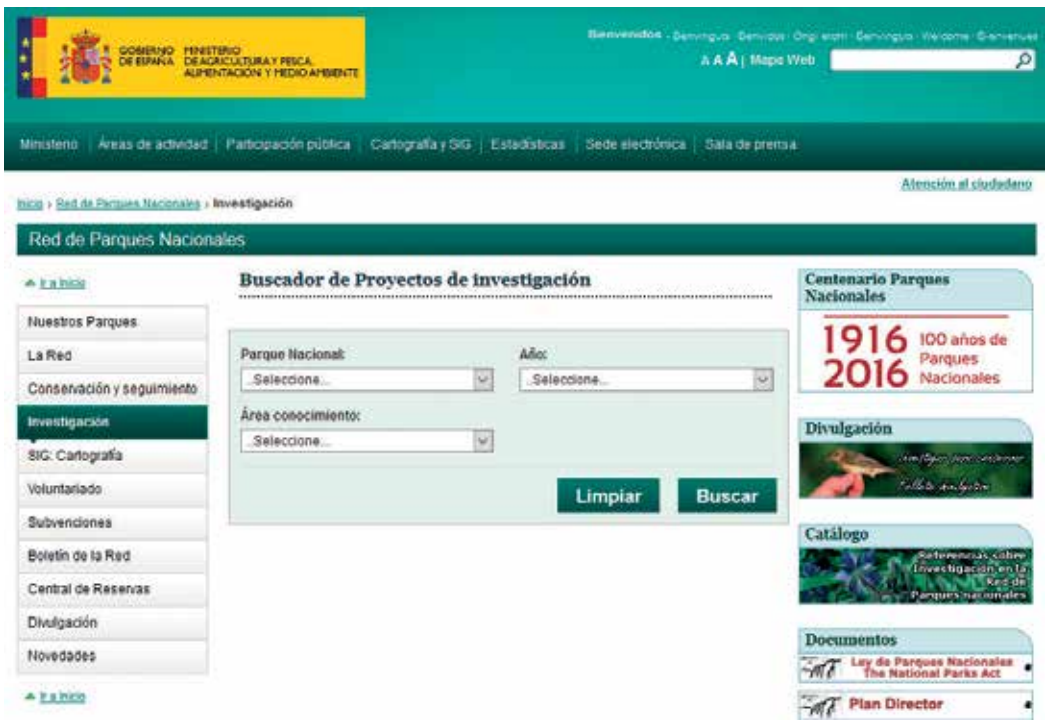

Figure 4. Online national park research project searcher on the Spanish Ministry of Environment's website.

5. Two projects looking at the sustainability of Spanish National Parks: DISESGLOB and SOSTPARK

5.1. DISESGLOB: Design of a methodology to assess the global sustainability of national parks

The DISESGLOB Project forms part of the Spanish Research, Development and Innovation Plan for 2013–2016, whereby the state programmes its scientific research priorities. It was awarded a budget of 25,000€ and its duration was 3 years, from 2014 to 2017. The Project sought to respond to the following research questions: Are NPs effective to achieve their conservation objectives? Are the municipalities in which NPs are designated sustainable? Are NP managers and territorial planners aware of future opportunities and risks to conservation under different scenarios of change? (**Figure 5**).

As a pilot study, different methods were applied to two emblematic NPs: Ordesa NP, designated on the Pyrenean Mountains in 1918, and Guadarrama NP, the last NP of the Spanish network, designated in the Central Mountain Range, between the provinces of Madrid and Segovia, in 2013. Both NPs protect high mountain biodiversity but have clear historical, geographical and socioeconomic differences. Ordesa NP is a long-history, rural, peripheral NP with very low population density and relatively difficult accessibility. In contrast, Guadarrama NP is a new, peri-urban, easily accessible NP located just 40 min away by car from the city of Madrid. Those differences determine different states of, pressures on and responses for conservation features.

Figure 5. Logo of the DISESGLOB project.

5.2. SOSTPARK: Analysis of sustainability of Spanish protected areas: implications for the sustainability of the territory

The SOSTPARK Project is also part of the Spanish Research, Development and Innovation Plan for 2013–2016. It was funded with 193.000€ by the Spanish Ministry of Economy, Industry and Competitiveness for 3 years, from 2015 to 2018 (**Figures 6** and **7**).

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Figure 6. Logo of the SOSTPARK project.

Figure 7. Outline of the SOSTPARK project.

The project seeks to assess the environmental, social, economic and institutional effects of five terrestrial PA networks and one marine PA network with clear legal and managerial characteristics in Spain. The five terrestrial PA networks include nature reserves, NPs, nature parks, SCIs/SACs and SPAs. The environmental effects of those networks were assessed using indicators of two essential natural resources: soil and biodiversity. Their socioeconomic and institutional effects were assessed through indicators such as employment, education or existence of basic infrastructure in PAs and their surrounding areas.

5.3. Environmental sustainability: main results of both projects

Environmental sustainability in 12 of the 15 Spanish NPs, including their statutory peripheral zones, between 2005 and 2011, was assessed by the SOSTPARK project (**Figure 8**). Those NPs represent 85% of the whole NP network area, 83% of the peripheral protection zone area in the network and 87% of the socioeconomic influence zone area of the network by November of 2015. Two indicators of environmental sustainability were analyzed: land use-land cover (LULC) changes and wildfires.

Results show that wildfires were the most widespread pressure in Spanish NPs in the 2005–2011 period (**Figure 8**). Three NPs, and their respective external zones, showed great LULC stability in that period, suggesting effective conservation inside and outside NPs: Ordesa y Monte Perdido NP, Aguastortas y Lago de San Mauricio NP and Caldera de Taburiente NP. The greatest proportion of LULC changes occurred in the statutory zones of Teide NP, Doñana NP, Tablas de Daimiel NP, Cabañeros NP and Sierra Nevada NP. Of these, clearly negative LULC changes occurred in

Figure 8. Location of wildfire area between 2005 and 2012 in each national park network zone included in the study across the Spanish biogeographic regions. NP: National Park; PPZ: Peripheral protection zone; SIZ: Socioeconomic influence zone.

Teide's three statutory zones, including extensive land artificialization in the NP's external zones. It was also the NP most impacted by wildfires, which affected its three zones. Both facts make Teide NP the Spanish NP with the most worrisome recent environmental trends [16] (**Figure 8**).

The DISESGLOB project sought to optimize the System for the Integrated Assessment of PAs (SIAPA) [17], a tool developed to evaluate potential environmental effectiveness of PAs. It was applied to two pilot, emblematic Spanish NPs: Ordesa NP and Guadarrama NP. The SIAPA allows NP managers to easily identify conservation strengths and weaknesses for enhanced PA effectiveness. **Tables 2** and **3** show the summary results[1] of implementing the optimized version of the SIAPA to both NPs [14].

The DISESGLOB project also produced land use-land cover (LULC) scenarios for both NPs and their surroundings between 2006 and 2030, taking into account recent developmental trends [18]. The results show that no major LULC changes are expected inside both NPs. Only inside Guadarrama NP is it likely that some grassland and scrubland areas will become forest areas, following natural succession. However, worrisome changes from agrarian and forest areas to urban areas are expected in the southern part of this NP as a result of easy access and proximity to the city of Madrid (in red in **Figure 9**).

5.4. Socioeconomic sustainability: main results of the DISESGLOB project

Extensive surveys on social perception and valuation of the project's pilot NPs, Ordesa y Monte Perdido NP and Sierra de Guadarrama NP, were conducted on two key stakeholder groups: local residents (n = 401) and visitors (n = 542) [19]. There were similarities and differences between stakeholder groups and NPs. Both samples were mostly made of middle-aged women employed in the tertiary sector in the two NPs, although the proportion of residents

[1]The specific results from which these summary results were obtained can be freely accessed from: http://www.mdpi.com/2076-3298/4/4/68.

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Ordesa y Monte Perdido National Park				
National Park area (ha): 15,608	**Peripheral Protection Zone area (ha): 19,679**			**Socioeconomic Influence Zone area (ha): 89,341**
Designation date: 1918 (1982 re-classified)	**Evaluation date: 2016–2017**			**Evaluation: 1st**
Index/indicator	**Value**	**State**	**Trend**	**Evaluation period**
STATE OF CONSERVATION	0			
Population trends of endangered species or subspecies	2		NA	2012–2015
Changes in the extent of focal habitats	0		NA	2013
Changes in the features for which the PA was designated	0		NA	2012–2015
Visual impact	1		NA	2010
Surface water quality	2		↔	2014–2015
Health of vegetation	1		↓	2012; 2013; 2015
PLANNING	2			
Appropriateness of protection regulation	1		NA	2017
Existence of updated management plan	2		NA	2017
Existence of updated socioeconomic plan	2		NA	2017
MANAGEMENT	1			
Degree of fulfillment of management objectives				
Effectiveness of public participation bodies	2		↔	2012–2015
Existence of sufficient management staff	1		↔	2014–2015
Existence of environmental education and volunteering activities	2		↔	2014–2015
SOCIOECONOMIC CONTEXT	0			
Local population density	0		↓	2015–2016

Ordesa y Monte Perdido National Park				
National Park area (ha): 15,608	**Peripheral Protection Zone area (ha): 19,679**			**Socioeconomic Influence Zone area (ha): 89,341**
Designation date: 1918 (1982 re-classified)	**Evaluation date: 2016–2017**			**Evaluation: 1st**
Index/indicator	**Value**	**State**	**Trend**	**Evaluation period**
Land use changes	1		NA	2006; 2012
SOCIAL PERCEPTION AND VALUATION	2			
Degree of knowledge on the PA	2		NA	2016
Personal importance	2		NA	2016
THREATS TO CONSERVATION	0			
Fragmentation	0		↔	2006; 2012
Density of alien invasive species	0		NA	2016
Density of visitors	1		↓	2014–2015
Activities performed by visitors	0		NA	2016
Climate change	2		NA	1976–2016
Pasture encroachment by woody vegetation	0		NA	2006; 2012
EFFECTIVENESS	1			

Table 2. Summary results of the implementation of the optimized SIAPA in Ordesa National Park.

employed in the primary sector was substantially greater in Ordesa NP. Residents visited Guadarrama NP less frequently than Ordesa NP, whereas visitors to Guadarrama NP visited it much more regularly than visitors to Ordesa NP, most of which were first-timers. The proportion of foreign visitors was five times greater in Ordesa NP, as it is located on the border with France. Both stakeholder groups perceived the conservation state of Ordesa NP to be better than Guadarrama's, something unsurprising given their contrasting geographic and demographic contexts. They, however, coincided in their main perceived threats to both NPs: wildfires, massive visitation and insufficient environmental awareness by visitors. Residents deemed local participation in NPs' management improvable in both cases. Both

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Sierra de Guadarrama National Park[a]				
National Park area (ha): 33,960	**Peripheral Protection Zone area (ha): 62,687**			**Socioeconomic Influence Zone area (ha): 173,632**
Designation date: 2013	**Evaluation date: 2016–2017**			**Evaluation: 1st**
Index/indicator	**Value**	**State**	**Trend**	**Evaluation period**
STATE OF CONSERVATION	1			
Population trends of endangered species or sub-species				
Changes in the extent of focal habitats				
Changes in the features for which the PA was designated				
Visual impact	0		NA	2010
Surface water quality	2		↔	2014–2015
Health of vegetation	1		↑	2014–2015
PLANNING	1			
Appropriateness of protection regulation	2		NA	2017
Existence of updated management plan	0		NA	2017
Existence of updated socioeconomic plan	2		NA	2017
MANAGEMENT	1			
Degree of fulfillment of management objectives				
Effectiveness of public participation bodies	1		↔	2015
Existence of sufficient management staff				
Existence of environmental education and volunteering activities	2		NA	2014
SOCIOECONOMIC CONTEXT	2			
Local population density	2		↑	2015–2016

Sierra de Guadarrama National Park[a]				
National Park area (ha): 33,960	**Peripheral Protection Zone area (ha): 62,687**			**Socioeconomic Influence Zone area (ha): 173,632**
Designation date: 2013	**Evaluation date: 2016–2017**			**Evaluation: 1st**
Index/indicator	**Value**	**State**	**Trend**	**Evaluation period**
Land use changes				
SOCIAL PERCEPTION AND VALUATION	2			
Degree of knowledge on the PA	2		NA	2016
Personal importance	2		NA	2016
THREATS TO CONSERVATION	2			
Fragmentation				
Density of alien invasive species				
Density of visitors	2		↓	2014–2015
Activities performed by visitors				
Climate change				
EFFECTIVENESS	0			

[a]The relatively high proportion of blank boxes relate to indicators that could not be evaluated due to lack of raw data provision by the NP managers.

Table 3. Summary results of the implementation of the optimized SIAPA in Guadarrama National Park.

social groups highly valued the two NPs from a subjective perspective. However, only half of residents and two-thirds of visitors would be willing to pay an entrance fee to those NPs (**Figure 10**). Most residents and visitors who were willing to pay an entrance fee to the NPs considered that 3€ per person per day would be an acceptable fee. Willingness to pay was negatively correlated with the frequency of visits in Guadarrama NP.

On average, approximately 25% of residents and 50% of visitors who were initially reluctant to pay an entrance fee to those NPs would change their minds if measures to ensure equity, such as exemptions to less favored groups, transparency (clear use of collected funds) and accountability (investment of funds in the NP) were implemented. These results provide interesting information on social worries, preferences and attitudes to help NP management, for instance, by considering implementing entrance fees as a response to massive visitation in some NPs, such as Guadarrama NP [12], or by designing evidence-based environmental education programmes.

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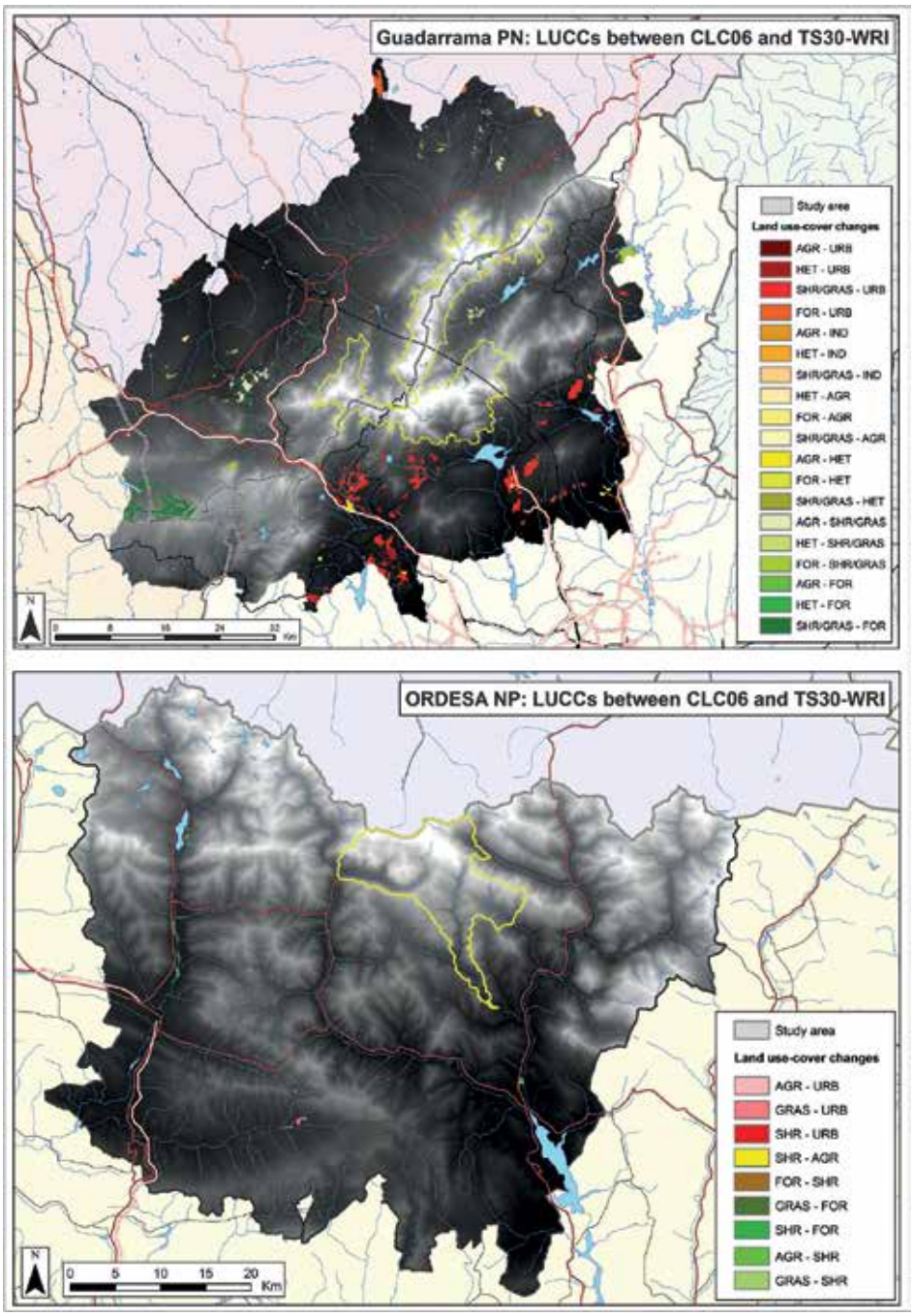

Figure 9. Simulated model of LULCs between 2006 and 2030 in a trend scenario with restrictions and incentives (TS30-WRI) in the Guadarrama NP and its surroundings (above) and in Ordesa NP (below). URB=urban areas; IND = Industrial areas; AGR = Agricultural areas; HET = Heterogeneous agricultural areas; GRAS = Grasslands; SHR = Shrubs; SHR-GRAS=shrubs and grasslands, FOR = Forests. The yellow perimeters represent the boundaries of each NP. Black and white colors represent increasing altitude, ranking from 473 to 3337 m in Ordesa NP's study area, and from 605 to 2462 m in Guadarrama NP's.

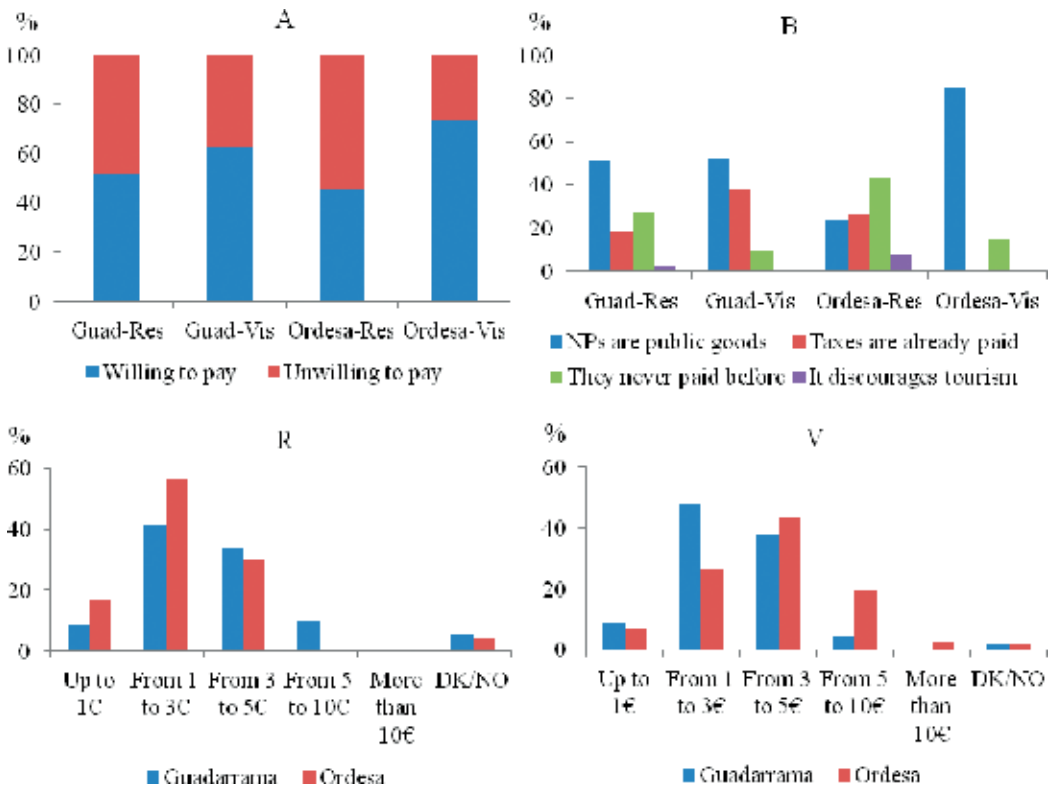

Figure 10. Results on willingness to pay and entrance fee by residents (R) around and visitors (V) to Guadarrama NP and Ordesa NP.

		Guadarrama NP		Ordesa NP	
		NP municipalities	**External municipalities**	**NP municipalities**	**External municipalities**
ESI	Median	0.98	−0.74	0.95	−0.23
	Standard deviation	0.52	0.90	0.14	0.91
SSI	Median	−0.12	−0.12	0.02	−0.15
	Standard deviation	0.51	1.16	1.09	0.93
ECSI	Median	−0.09	−0.34	0.97	−0.56
	Standard deviation	−0.44	1.18	0.54	0.97

The values of the indices rank from +∞ (highest sustainability) to −∞ (lowest sustainability). ESI: Environmental sustainability; SSI: Social sustainability; ECSI: Economic sustainability.

Table 4. Descriptive statistics on the three indices of municipal sustainability by municipality type.

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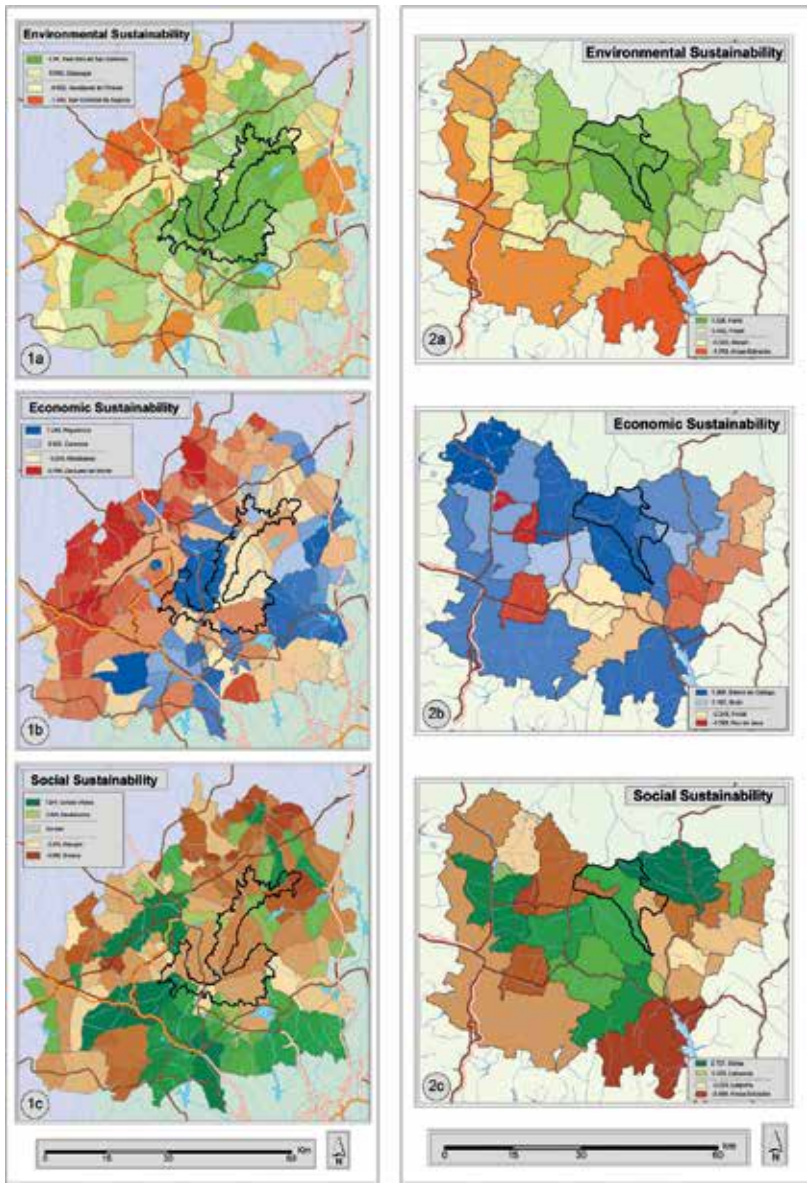

Figure 11. Sustainability maps of municipalities included in Guadarrama NP (left column) and Ordesa NP (right column) and their external municipalities. The values of (a) environmental, (b) economic and (c) social sustainability indexes are shown. National Park boundaries are depicted in black. Maps' legends only show extreme municipal values.

5.5. Global sustainability: main results of the DISESGLOB project

A Municipal Sustainability Assessment Indicator System was developed whereby the municipalities included in Ordesa NP (n = 6) and Guadarrama NP (n = 35) as well as adjacent external municipalities (n = 16 and n = 72, respectively) were assessed according to five environmental

indicators, five social indicators and five economic indicators [20]. Those indicators were subsequently integrated in three indices depicting Environmental Sustainability, Social Sustainability and Economic Sustainability. The results show that, generally, the municipalities included in both NPs were more sustainable than those located outside them (**Table 4**).

Ninety-one percent and 83% of the municipalities included in Guadarrama NP and Ordesa NP were in the first and second quartiles of environmental sustainability, respectively. In contrast, only 29 and 31% of the external municipalities were in those quartiles. In Ordesa NP, 100% and 31% of the municipalities inside and outside the NP were in the first or second quartiles of economic sustainability, respectively. There is not a clear pattern on local social sustainability, though. In Guadarrama NP, external municipalities close to the cities of Madrid (to the south) and Segovia (to the north) showed greater social sustainability (**Figure 11**).

Acknowledgements

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Chapter 9

Biomass and Carbon Stocks Estimation of Lowland Dipterocarp, Riparian and Hill Dipterocarp Forests in Pahang National Park, Malaysia

Nor Farika Zani, Mohd Nazip Suratman, Adzmi Yaacob and Nazlin Asari

Additional information is available at the end of the chapter

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Abstract

Forest biomass estimation at local or global scale is very crucial and served as an important indicator for monitoring and estimating the forest carbon ecosystem especially in the context of climate change. Pahang National Park (PNP) is considered as a primary forest, and therefore, it is expected that more carbon can be absorbed and stored by forest biomass. Despite the multifunctional roles of forest biomass, lack of research had been done with regard to the extent of above-ground biomass (AGB) and below-ground biomass (BGB) in lowland dipterocarp (LDF), riparian (RF) and hill dipterocarp forests (HDF). Therefore, this study was conducted to provide an estimation of the AGB, BGB and carbon stocks with respect to different localities in PNP. A total of 60 plots were randomly set up and each forest type contains 20 plots measuring 20 × 20 m. The diameter at breast height (DBH) and height (H) were used to calculate the AGB and BGB, and the carbon conversion coefficient of 0.50 was used to calculate the carbon stocks. Based on the results, the estimation of biomass within LDF, RF and HDF not greatly varies between different species with the mean total tree biomass (TTB) values of 415.11, 323.33 and 579.05 t/ha, respectively. The estimation of carbon storage demonstrated that HDF attained the highest carbon stocks in TTB with the value of 289.52 t/ha. The information from this study is expected to provide baseline information and an understanding on the role of trees in the natural forest in sequestrating carbon.

Keywords: above ground biomass, below ground biomass, carbon stocks, forest biomass, natural forests, Pahang National Park

1. Introduction

Tree biomass is a product from photosynthesis as a result of carbon sequestration by tree. A tree can absorb approximately 23 kg of carbon per year. Indeed, a tree can increase biomass as an effect of tree growth and loss biomass through mortality that is due to natural death or logging. Tree biomass can be divided into above (AGB) and below ground biomass (BGB) in which the AGB includes the stem, leaves and branch biomass whereas the BGB is the biomass of tree roots. Each component of the AGB varies in biomass density. The estimation of biomass is significantly important for the environment which is a critical aspect of studies of carbon stocks and the effects of carbon sequestration on the global carbon balance. In recent years, carbon dioxide (CO_2) has received much attention from the world because its concentration in the atmosphere has risen to approximately 30% above natural background levels [1]. The need for biomass and carbon stocks estimation is critical and can be measured using destructive or non-destructive sampling method. That is why a field inventory is conducted where the measurement of tree diameter is recorded to estimate the biomass of tree and later the carbon stocks. According to Brown [2], for closed forest such as Pahang National Park (PNP), a minimum diameter of tree to be measured is greater than or equal to 10 cm. However, for open or secondary forest, a smaller minimum diameter should be chosen [2, 3].

Most of the researches focus on the estimation of the AGB rather than BGB because the process to estimate the AGB is easier and less complicated as compared to BGB. In addition, the above ground tree components are the largest contributor of biomass from the total tree biomass (TTB) whereas the BGB only constitutes a small portion of the TTB. Lajuni and Latiff [4] reported the BGB value in their study plots at Khao Chong forest was one tenth of the AGB. Besides, a study conducted by Mohamad [5] in Kenaboi Forest Reserve, Negeri Sembilan found that root biomass in his study plots was six times smaller than the AGB with values of 463.81 and 73.57 t/ha for AGB and BGB, respectively.

Tree biomass and carbon stocks also varied in accordance to forest types and geographical regions. As such, forest biomass and carbon stocks in tropical forest are higher than temperate forest. This might be due to the different in tree species and climatic condition between both forests. Furthermore, in any forest types, tree biomass and carbon stocks in primary forest are higher than secondary forest. Secondary forest is a forest that has been logged or naturally disturbed whereas primary forest is a forest that has never been logged and free from anthropogenic disturbance. In this case, PNP is considered as a primary forest since anthropogenic activities such as logging have never occurred in this forest. Therefore, it is expected that more carbon can be stored by forest biomass in PNP.

Despite the multi-functional roles of forest biomass, lack of research had been conducted with regards to the extent of AGB, BGB and carbon stocks in lowland dipterocarp (LDF), riparian (RF) and hill dipterocarp forests (HDF) in PNP. In addition, information on biomass estimation and carbon stocks from tree inventory data is currently unavailable for protected forest of PNP. Therefore, this study was conducted to provide the estimation of the AGB, BGB and carbon stocks with respect to different localities in PNP. Considering the fact that biomass represents the role of tree as a key indicator of carbon source and sink, the information from

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this study is expected to provide baseline information and an understanding on the role of trees in sequestrating carbon. This study aims to estimate the AGB and BGB as well as the TTB of LDF, RF, and HDF in PNP. This study also aims to estimate the carbon stocks of LDF, RF, and HDF in PNP, and to investigate the interaction between forest and five similar family and five similar species in the study areas.

2. Materials and methods

2.1. Study area and field data collection

This study was conducted in PNP in the state of Pahang. PNP has a tropical climate with an annual rainfall of about 2.260 mm and rich in forest vegetation such as trees, climbers, shrubs, epiphytes and palms. Average temperature throughout the year ranges from 20 to 35°C with more than 80% humidity [6]. There are differences in the soil series in the LDF, RF and HDF mainly due to the variations of parent material between localities [7].

This study was conducted in three types of forests of LDF, RF and HDF of PNP and the location of study area are shown in **Figure 1**. The description for each location is summarized in **Table 1**. A total of 60 plots were set up in which each forest contains 20 plots measuring at 20 × 20 m (0.04 ha). Study plots for LDF were located in Kuala Keniam while plots for RF were scattered; 10 plots were located along Keniam River while another 10 plots were located along Tembeling River near to Kampung Pagi. As for the HDF, data collection was conducted in the Teresek Hill at an elevation around 330 m above sea level.

For the field measurement, diameter at breast height (DBH) tape was used to measure the diameter of sampled trees with DBH ≥ 10 cm which is 1.3 m up from the ground [8]. In the case of big buttressed stems, the tree height was measured just above the upper end of plank buttress [9]. Each tree was permanently tagged using laminated label. Tree height was measured using a clinometer, a device that can be used to measure the slope to points on a tree, which can subsequently be used to determine the tree height. The sampled trees were identified to species level and for unknown species, the botanical specimens (e.g. leaves, flower or fruit) were collected for species identification at herbarium laboratories of Universiti Kebangsaan Malaysia (UKM) and Forest Research Institute Malaysia (FRIM).

2.2. Data analysis of tree biomass

Throughout this study, AGB was estimated using Kato et al.'s function [9] (Eqs. (1)–(4)) while BGB using a function from Niyama et al. [10] (Eq. (5)). According to reference [10], the total root biomass is the summation of coarse and fine roots in which fine root is defined as root with diameter less than 5 mm. The TTB is the summation of AGB and BGB. From the values of measured DBH and tree height; the dry mass of stem, branch and leaves of sample trees were estimated. The equations used to estimate these components are as follows:

$$M_s = 0.0313\,(D^2 H)^{0.9733} \quad (1)$$

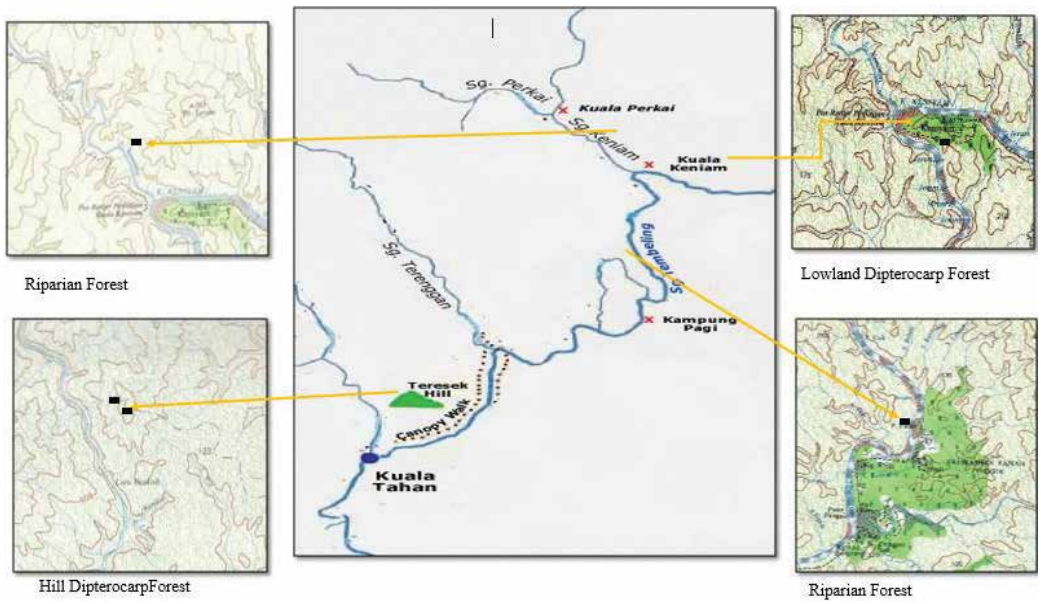

Figure 1. Study areas of LDF, RF and HDF in PNP.

Study area	Forest types	Locality	Coordinates	Slope	Elevation	Soil series
1	Lowland dipterocarp	Kuala Keniam	04° 31.148′ N, 102° 28.100′ E to 0 4° 31.058′ N, 102° 27.934′ E	0–56°	133–139 m above sea level	Telemong
2	Riparian	Along Keniam and Tembeling River	04° 31.507′ N, 102° 28.130′ E to 04°27.690′ N, 102° 29.196′ E	0–40°	102–115 m above sea level	Telemong and Pagi
3	Hill dipterocarp	Teresek Hill	04°23.888′ N, 102° 24.469′ E to 04° 23.872′ N, 102° 24.534′ E	30–79°	292–340 m above sea level	Gol and Tahan

Table 1. Study area, forest types, locality, coordinates, slope, elevation and soil series in PNP.

$$M_B = 0.136\,(M_s)^{1.070} \tag{2}$$

$$\frac{1}{M_L} = \frac{1}{0.124(M_s^{0.794})} + \frac{1}{125} \tag{3}$$

$$AGB = M_s + M_B + M_L \tag{4}$$

$$BGB = 0.0262 \times D^{2.497} \tag{5}$$

$$TTB = AGB + BGB \tag{6}$$

Where, M_S, M_B, M_L were denoted as dry mass of stem, branch and leaves in kg, respectively (Eqs. (1)–(4)). The AGB was computed from the summation of these components as in Eq. (4). The biomass functions developed by Kato et al. [9] can be applied irrespective of tree species since these equations were developed without taking regards of tree species in the study area of Pasoh Forest Reserve [9, 11]. In this study, the dry mass of the tree biomass components was presented in t/ha. The dry mass (kg) for each component was converted into tonne by dividing the values with 1000 then divided with 0.04 ha which is the size of each plot. For an estimation of carbon storage, the biomass value was divided with 0.8 ha which is the total size for each study area. The carbon storage in the forests was calculated in accordance to method from Brown [2] whereby 50% of the biomass in the forest is assumed as carbon.

2.3. Statistical analysis

Means of AGB, BGB and TTB between LDF, RF and HDF of PNP were obtained and analyzed using 3 × 5 factorial two-way ANOVA. The PROC GLM was applied in Statistical Analysis Software (SAS) version 9.3 to study the interaction between forests and five similar family and species based on the highest AGB in LDF, RF and HDF of PNP. The normality of the dataset is test using frequency distribution or histogram. Based on the analysis, the data distribution is normal and the statistical tests are considered as parametric tests.

3. Results and discussions

3.1. The total AGB, BGB and TTB for different types of forests

The total AGB, BGB and TTB for lowland dipterocarp, riparian and HDF are shown in **Table 2**. From the **Table 2**, it appears that HDF recorded the highest AGB, BGB and TTB among study areas. This is because HDF consists of higher trees (n = 579) and number of trees with DBH of more than 80 cm was higher than the other two forests (14 trees/ha) (**Table 3**). Furthermore, dominant family in HDF based on basal area was Dipterocarpaceae with tree count of 58 from 579 trees (**Table 3**). These dipterocarp trees have diameter ranges from 10.8 to 103.5 cm. RF recorded the lowest AGB, BGB and TTB among the three forests as it recorded contains less number of trees (n = 285) and most of trees in RF have smaller diameter. Big-sized trees in RF with diameter more than 80 cm was lower than LDF and HDF (3 trees/ha) thus less contributed to tree biomass of RF.

As comparison with the previous studies, Cairns et al. [12] presented the AGB for 195 sampled trees with diameter of more than 10 cm in dry forest of Mexico's Yucatan Peninsula with value of 191.5 t/ha. Hikmat [13] conducted a study in three virgin jungle reserves in Mata Ayer, Bukit Bauk and Gunung Pulai each in 2 ha plot. A total of 2341, 2702 and 2070 trees with diameter greater than 5 cm were enumerated in Mata Ayer, Bukit Bauk and Gunung Pulai, respectively. From this study, he found that the AGB of each forest was 402.6, 551 and 320.57 t/ha, respectively. The BGB in Hikmat's [13] study was computed following method

Study area	AGB (t/ha)	BGB (t/ha)	TTB (t/ha)
Lowland dipterocarp forest (n = 419)	354.01	61.10	415.11
Riparian forest (n = 285)	276.13	47.21	323.33
Hill dipterocarp forest (n = 579)	493.77	85.27	579.05

Table 2. Total AGB, BGB and TTB in LDF, RF and HDF of PNP.

from [14] in which the root biomass was estimated to be one tenth of the AGB. In this case, the BGB values in Mata Ayer, Bukit Bauk and Gunung Pulai were 40.26, 55.12 and 32.06 t/ha, respectively. The summation of AGB and BGB in the three study areas resulted in total tree biomass of 415.11, 323.33 and 579.05 t/ha. A study at Bangi Permanent Forest Reserve by Lajuni and Latiff [4] revealed that the AGB in 1 ha study plot was 362.13 t/ha derived from 1018 trees of more than 5 cm diameter. Most of trees in their study were distributed in class 5.0–14.90 cm (65.71%) causing the biomass value to be quite low than other studies.

3.2. The analysis of mean of AGB, BGB and TTB between forests

Table 4 shows results from the analysis of AGB, BGB and TTB (t/ha) of lowland dipterocarp, riparian and HDF of PNP. Values presented in **Table 4** are mean values of AGB, BGB and TTB per plot. Result from ANOVA revealed that HDF recorded significantly higher mean of AGB, BGB and TTB than LDF and RF with the values of 499.97, 85.27 and 585.25 t/ha, respectively ($p \leq 0.05$). This is because HDF comprises the highest number of tree and basal area compared to LDF and RF. Family Dipterocarpaceae contributed 10% from the total individuals in HDF. Mostly, dipterocarp trees in this forest especially *Shorea curtisii* have tree height ranges from 30 to 45 m and form the emergent layer of the forest. Even though Dipterocarpaceae was not the highest in term of tree density in the forest, they contributed the most in basal area with value of 13.91 m^2/ha as these trees have larger diameter and height as compared to the other family. This value was the highest compared to LDF and RF. Therefore, this contributed to the higher values of AGB, BGB and TTB in HDF. Generally, basal area indicates the cross section of tree stem at breast height. Therefore, this value can be assumed as proportional to the stem biomass of a tree which also indicates the productivity of a forest [4]. This was supported by a result from Proctor and Newberry [15] in their study in four types of lowland forest in Gunung Mulu. They reported that TTB values in each forest types were in accordance to the value of mean basal area.

As for LDF, family Euphorbiaceae recorded the highest density (90 trees/ha), more than the highest family in HDF. However, the basal areas contributed only 3.10 m^2/ha, considerably lower than family Dipterocarpaceae from HDF. Euphorbiaceae is known as a pioneer species and commonly have small diameter at the range of 10 to 30 cm in this forest. RF on the other hand, recorded the lowest number of trees compared to the other two forests (285 trees). Family Meliaceae recorded 26% (75 trees) from the total of 285 trees in RF and mostly composed of small trees with diameter 10 to 30 cm and seldom can exceed more than 40 cm, thus causing the tree biomass in RF to be lower than LDF and HDF.

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No.	Family	No. of individuals	No. of genera	No. of species
1	Anacardiaceae	25	6	8
2	Annonaceae	12	6	6
3	Apocynaceae	1	1	1
4	Araucariaceae	1	1	1
5	Bombacaceae	3	1	1
6	Burseraceae	43	3	9
7	Celastraceae	4	1	1
8	Chrysobalanaceae	1	1	1
9	Dipterocarpaceae	58	5	12
10	Ebenaceae	3	1	2
11	Elaeocarpaceae	34	1	2
12	Euphorbiaceae	72	7	11
13	Fagaceae	52	2	7
14	Flacourtiaceae	10	3	3
15	Guttiferae	29	5	9
16	Ixonanthaceae	3	1	1
17	Lauraceae	14	6	8
18	Leguminosae	6	4	5
19	Loganiaceae	2	1	1
20	Melastomataceae	9	2	4
21	Meliaceae	4	3	4
22	Moraceae	2	1	1
23	Myristicaceae	23	2	5
24	Myrsinaceae	16	2	2
25	Myrtaceae	64	2	19
26	Olacaceae	1	1	1
27	Polygalaceae	20	1	5
28	Rhizophoraceae	17	2	3
29	Rubiaceae	7	3	3
30	Rutaceae	2	1	1
31	Sapindaceae	4	2	4
32	Sapotaceae	14	2	2

No.	Family	No. of individuals	No. of genera	No. of species
33	Sterculiaceae	7	1	1
34	Theaceae	4	1	2
35	Trigoniaceae	1	1	1
36	Ulmaceae	1	1	1
37	Verbenaceae	10	1	1
	Total	579	85	149

Table 3. Number of families, individuals, genera, and species of HDF in PNP.

Kueh and Lim [16] estimated lower AGB value in comparison with this study. The study was conducted in the logged-over Air Hitam Forest Reserve where the pioneer species such as *Macaranga* spp., *Sapium* spp. and *Endospermum malaccense* were present in high density in the study area with an average DBH of 20.6–25.8 cm. The AGB for Air Hitam Forest Reserve was in the range of 83.69 to 232.39 t/ha. The lower value than the present study might suggest that the forest stand is in an early stage of succession and in the process of recovery after disturbances. Cummings et al. [17] revealed a result from their study in Brazilian Amazon Forest whereby mean of total AGB for open, dense and acetone forests were 313, 377 and 350 t/ha, respectively.

The total AGB of a study from Shanmughavel et al. [18] was 352.5 t/ha while root biomass was 69.9 t/ha. In contrast, Laurance et al. [9] estimated slightly higher AGB at lowland forest of Pasoh Forest Reserve which is 475 t/ha. A review by Malhi et al. [3] on carbon balance of different forest types i.e. Amazonian tropical rainforest, North American deciduous temperate forest and Canadian boreal forest revealed a variation in the AGB value between forests. The AGB value for tropical, temperate and boreal forests were 330–370 t/ha, 155–170 t/ha and 50–60 t/ha, respectively. The heterogeneity in the AGB values between forests was attributed to the climatic factors that affected the soil nutrients in the forest. In this case, due to the seasonality and temperature of boreal forest, nutrient availability is limited by slow decomposition in cold and water-freeze soil. Tropical forest on the other hand, even though has all year warm temperature but have poor soil nutrient and water availability as a result from high soil porosity and heavily leach soil. In general, higher tree biomass is expected on fertile soil simply because there are more resources available for tree growth. According to Laurance et al. [19] a high fraction of forest biomass could be associated with the most fertile soils as well as the tree size. Castilho et al. [20] claimed that texture was strongly associated with the variation in AGB value in their study area at Amazon Forest rather than soil nutrients. Soil texture influences the soil moisture, nutrient availability and nutrient cycling as well.

3.3. The AGB, BGB and TTB distribution according to diameter classes

Figure 2 shows the above ground, below ground and total tree biomass in LDF, RF and HDF of PNP, respectively. Based on **Figure 2**, the total tree biomass in the study areas were not

Biomass (t/ha)	Lowland dipterocarp forest (n = 20)	Riparian forest n = 20)	Hill dipterocarp forest (n = 20)
Above ground (AGB) (t/ha)	356.79 ± 121.01[b]	276.12 ± 35.59[b]	499.97 ± 221.70[a]
Below ground (BGB) (t/ha)	61.19 ± 586.60[b]	47.16 ± 24.58[b]	85.27 ± 160.61[a]
Total tree (TTB) (t/ha)	417.98 ± 200.54[b]	323.28 ± 35.89[b]	585.25 ± 236.06[a]

Notes: Values are expressed as mean ± standard deviation. Means with same letter indicate no significant different.

Table 4. Analysis of AGB, BGB and TTB between LDF, RF and HDF of PNP.

uniformly increased according to diameter class. HDF attained the highest total tree biomass for most diameter class except for diameter class 40.0–69.9 cm. RF achieved the lowest total tree biomass except for diameter class 50.0–69.9 cm whereas LDF only obtained the highest total tree biomass for diameter class 40.0–49.9 cm. With respect to **Figure 2**, lowland dipterocarp, riparian and HDF acquire highest biomass for diameter class of more than 70 cm with biomass value of 83.39, 70.58 and 202.72 t/ha, respectively. The biomass value for class >70 cm dominated 34, 38 and 35% of the total tree biomass in lowland dipterocarp, riparian and HDF, respectively. This indicates that tree diameter is a deciding factor for producing high biomass value in a forest.

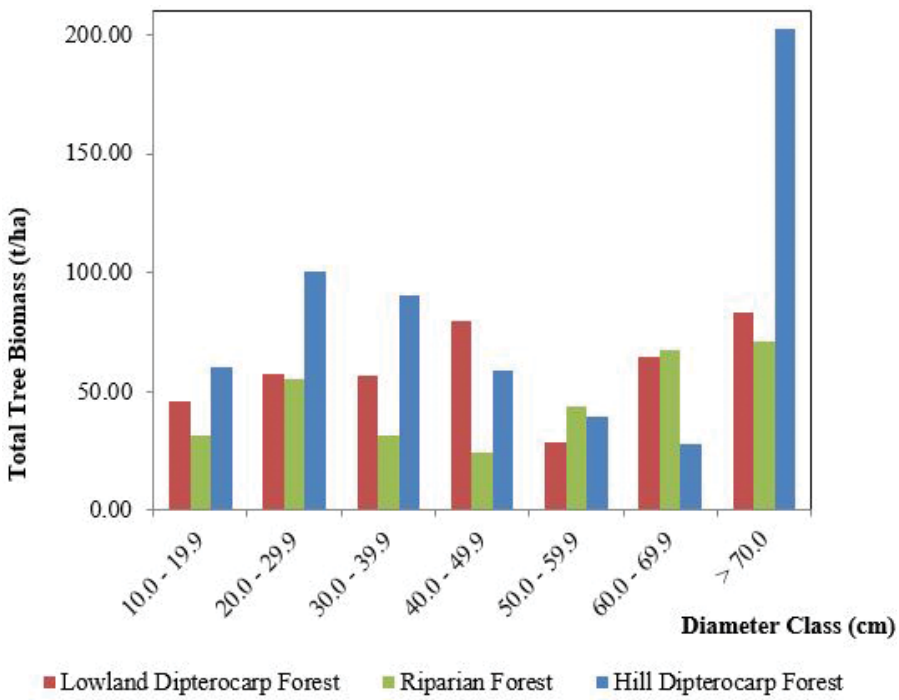

Figure 2. TTB by diameter classes in LDF, RF and HDF of PNP.

As comparison between diameter class, sample trees at class 10.0–19.9 cm recorded the highest number of trees which is 256, 157 and 344 trees in lowland dipterocarp, riparian and HDF, respectively. However, this diameter class recorded lower biomass even though the number of trees was high. Diameter class >70.0 cm recorded the highest biomass though the number of trees was lower which are 5, 6 and 14 sample trees in lowland dipterocarp, riparian and HDF, respectively. Higher biomass value in diameter class >70.0 cm in HDF was due to large trees from family Dipterocarpaceae that constitute 11 trees of the total 14 trees from this diameter class.

A comparison with other studies indicated a similar result whereby a larger diameter class achieved a higher biomass in the study area. For example, a study from Kusin [21] at Jengka Forest Reserve found that trees at diameter class >65 cm dominated 36.64% of the total tree biomass in the study area with the biomass value of 247.12 t/ha. This diameter class comprised of 36 large trees from family Dipterocarpaceae. A study by [13] also obtained a result where large diameter class (≥75 cm) contained higher proportion of AGB in three virgin jungle reserves (VJR) in Peninsular Malaysia. The AGB values for diameter class ≥75 cm in Mata Ayer VJR, Bukit Bauk VJR and Gunung Pulai VJR were 143.21, 184.32 and 24.74 t/ha, respectively. Most of AGB values from his study were higher than the present study because trees with diameter ≥ 75 cm in his study areas were higher of which more than 20 trees.

In contrast, Ewel et al. [22] reported a different result in hill forest of Ibam Forest Reserve, Pahang. The highest AGB value was recorded by diameter class 30.1–35.0 cm (30.51 t/ha), slightly lower than diameter class >70 cm (30.17 t/ha) in his study. The lower AGB value than the present study might be due to the lower number of trees in >70 cm diameter class. Similarly, Kueh and Lim [16] revealed that diameter class of 30.0–39.9 cm recorded the highest TTB in Air Hitam Forest Reserve. The TTB value of diameter class 30.0–39.9 cm was 232.73 t/ha whereas for diameter class >70 cm was 151.54 t/ha. The differences of TTB values between diameter classes in their study were due to the different in tree density. Furthermore, the TTB value in their study for five compartments was higher than LDF and RF from the present study because higher number of trees at diameter > 70 cm (15 trees) compared to this study (five trees). A study by [18] at tropical seasonal rainforest in Xishuangbanna, China found that TTB value for diameter class >70 cm was 115.01 t/ha. This value was higher than LDF and RF but lower than HDF in this study. This might be attributed to the different forest type and environmental factor that cause the biomass to be higher.

3.4. A comparison of similar tree families between forests

In factorial ANOVA experiment, forest and families are considered as two types of treatments. In each treatment, forest for example, consist of three levels; lowland dipterocarp, riparian and HDF while family has five levels; Anacardiaceae, Burseraceae, Dipterocarpaceae, Euphorbiaceae and Leguminosae. Therefore, in this study, the factorial design is 3 × 5 factorial.

Table 5 presents a result of comparison of five similar families based on AGB between lowland dipterocarp, riparian and HDF of PNP. From analysis of variance, there are no significant differences in the mean of AGB values among the forest types ($p > 0.05$) but

Forest (t/ha)	Anacardiaceae	Burseraceae	Dipterocarpaceae	Euphorbiaceae	Leguminosae
Lowland dipterocarp	1.90 ± 2.98 (n = 11)	1.04 ± 1.63 (n = 28)	2.572 ± 5.76 (n = 17)	0.56 ± 0.99 (n = 78)	0.73 ± 0.92 (n = 22)
Riparian	2.51 ± 2.16 (n = 3)	1.83 ± 1.49 (n = 2)	2.96 ± 3.31 (n = 6)	0.60 ± 0.90 (n = 47)	1.15 ± 2.26 (n = 30)
Hill dipterocarp	1.20 ± 2.55 (n = 25)	0.64 ± 0.98 (n = 43)	3.61 ± 4.81 (n = 58)	0.37 ± 0.69 (n = 72)	0.3823 ± 0.33 (n = 6)

Table 5. Means AGB of similar families in LDF, RF and HDF of PNP.

statistically significant in the mean of AGB among families ($p \leq 0.05$). This result indicated that there were no significant main effects of forest types on the values of AGB. There were, however, significant main effects of families on the AGB values, suggesting that families influence the AGB in any forest type in this study.

The non-significant interaction between forest types and tree families is shown graphically in **Figure 3** which indicated by parallel line trend of mean of AGB distribution among families in each forest ($P > 0.05$). This indicates that the five families in the forest types in this study respond similarly towards the forest types.

From **Table 5**, the significantly different value of AGB between families ($p \leq 0.05$) might due to the unbalanced sample trees in each family. Euphorbiaceae dominated the AGB among the five families in lowland dipterocarp, riparian and HDF. This is in agreement with the study by Ewel et al. [23] whereby Euphorbiaceae was the dominant species in alluvium, upland poor soil and intermediate quality soil forests in three young second growth forests in Sarawak.

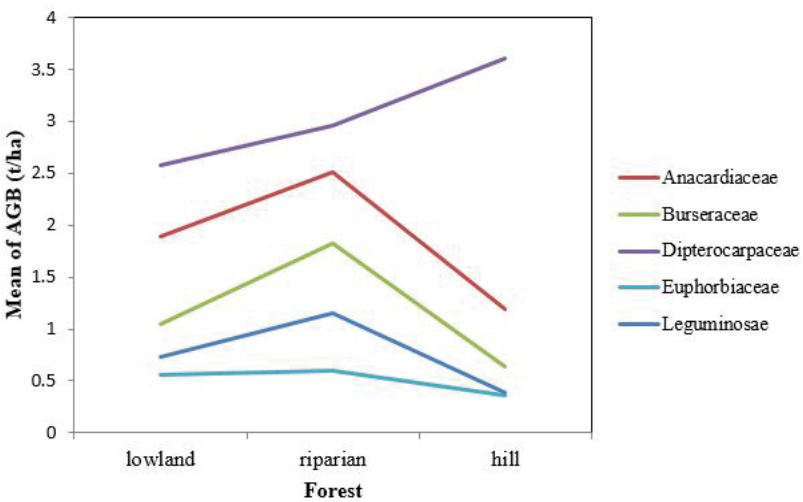

Figure 3. Action between forest types and similar tree families in LDF, RF and HDF of PNP.

Since Euphorbiaceae was a fast-growing pioneer species, therefore most of the biomass in their study was recorded by species in this family.

Zani and Suratman [24] attained a similar result in which there was no significant different detected in the mean of AGB between five transect lines (20 × 100 m) in LDF of Kuala Keniam at PNP. In another study, Rayachhetry et al. [25] observed a similar result in a study to quantify the dry weight of the above ground components of *Melaleuca quinquenervia* trees in three different localities (dry, seasonally flooded, and permanently flooded) at southern Florida. From their study, the effects of locality on the above ground components (total wood, trunk, branch, leaf, seed capsule, and seed) were found to be no significant.

3.5. A comparison of similar tree species between forests

The result of comparison of five similar species between forests namely *Canarium littorale* (Burseraceae), *Elateriospermum tapos* (Euphorbiaceae), *Ochanostachys amentacea* (Olacaceae), *Pimelodendron griffithianum* (Euphorbiaceae) and *Shorea leprosula* (Dipterocarpaceae) based on AGB in lowland dipterocarp, riparian and HDF of PNP is presented in **Figure 4**. **Table 6** shows mean of AGB for five similar species in lowland dipterocarp, riparian and HDF of PNP. From analysis of variance, there are statistically significant differences in the mean of AGB values both in the forest types and species ($p \leq 0.05$). This result indicated there were significant main effects of forests types and species on the AGB value suggesting that the AGB was influenced by the forest types and families.

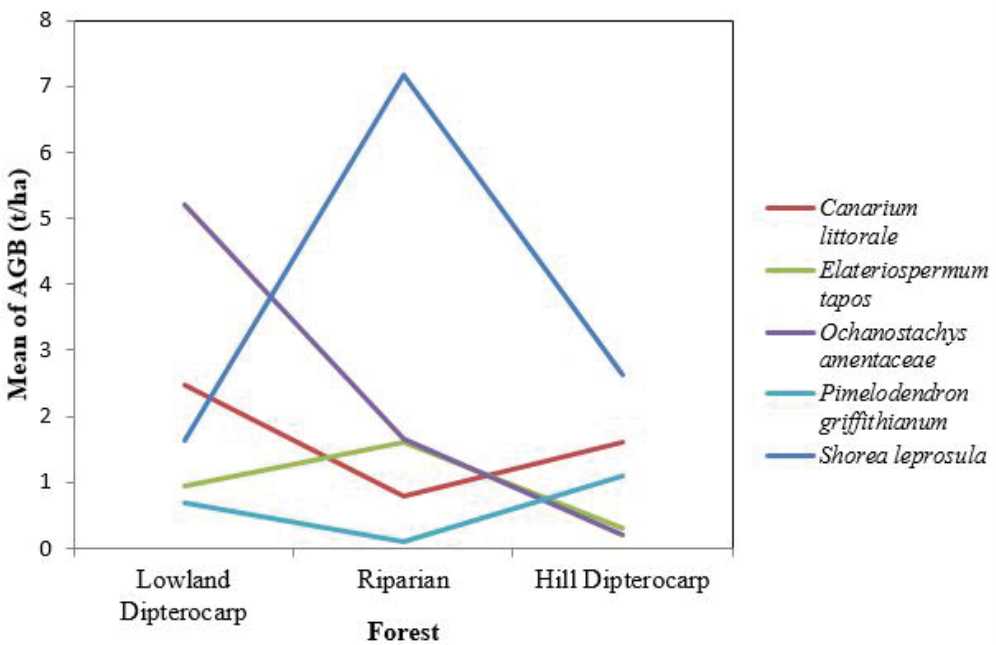

Figure 4. Interaction between forest types and similar tree species in LDF, RF and HDF of PNP.

Forest	*Canarium littorale*	*Elateriospermum tapos*	*Ochanostachys amentacea*	*Pimelodendron griffithianum*	*Shorea leprosula*
Lowland dipterocarp	2.4779 ± 3.05 (n = 5)	0.9387 ± 1.51 (n = 26)	1.6559 ± 1.84 (n = 7)	0.6214 ± 2.15 (n = 4)	0.6894 ± 0.85 (n = 11)
Riparian	0.7770 (n = 1)	1.6045 ± 1.08 (n = 3)	5.2016(n = 1)	0.0908 (n = 1)	7.1628 ± 0.2 (n = 2)
Hill dipterocarp	1.6048 ± 2.52 (n = 3)	0.2989 ± 0.42 (n = 25)	0.1998 (n = 1)	1.1029 ± 1.72 (n = 8)	2.6389 ± 1.87 (n = 6)

Table 6. Biomass and carbon stocks of LDF, RF and HDF of PNP.

Based on **Figure 4**, there was significant interaction between forest and species ($p \leq 0.05$). This indicates that there is a variation in the AGB value among species. That is to say, species behaves differently in different forest types.

Based on **Table 6**, *Shorea leprosula* from family Dipterocarpaceae appeared as the species with the higher AGB value among the five-similar species in lowland dipterocarp, riparian and HDF with the AGB of 0.69, 7.16 and 2.64 t/ha, respectively. Even though the presence of *Shorea leprosula* in each forest was not the highest, *Shorea leprosula* managed to attain higher AGB value due to the large DBH of sample trees. The presence of big trees with diameter of more than 80 cm contributed to the higher AGB values especially in the HDF. The mean AGB of *Shorea leprosula* in RF was higher than LDF and HDF because this forest consists of only two sample trees of *Shorea leprosula* therefore, mean AGB value per tree was higher. In fact, both sample trees of *Shorea leprosula* in this forest have large diameter of 69.0 and 69.1 cm that caused of higher AGB values for *Shorea leprosula* in RF. The higher AGB of *Shorea leprosula* in the RF is anticipated because the species is most common in lowland forest. That is to say, *Shorea leprosula* found in RF might be located at the continuum between lowland and RF. That is why only two trees of *Shorea leprosula* with large diameter were found in the RF plots.

Among the five species, *Elateriospermum tapos* recorded the highest number of trees in LDF and HDF but greatly lower in RF. Based on this result, it might suggest that *Elateriospermum tapos* grows abundantly in LDF and HDF rather than RF. However, mean AGB in RF was significantly higher than HDF ($p \leq 0.05$) but not significant to LDF. This is due to similar reason as stated in the case of *Shorea leprosula*.

The AGB values and tree density varies among five similar species between lowland dipterocarp, riparian and HDF might be due to the environmental factors in the study areas (e.g., soil nutrient, topography, water, light). Each species adapts and respond differently to the limiting factors in the area Shono et al. [26]. For example, *Elateriospermum tapos* favors forest soil that is dry and less preferable on soil that often wet. This might be the reason the tree density of *Elateriospermum tapos* in RF was lower than the other two forests.

These five-similar species that can be found in all forests in this study were due to the adaptability of these species to the environmental factors in the areas. For example, *Shorea leprosula* is a dipterocarp species that can easily adapt to full sunlight and fast growing once the seeds have been germinated whereas C*anarium littorale* was capable to survive in full sunlight and

water stress [26]. According to Pereira Da Silva et al. [27], many factors influence the tree growth in the forest. Usually, tropical tree species exhibits different behavior under different environmental conditions regardless of species or families. Macdicken and Brewbaker [28] agreed with this finding in which they found a significant different between site location and species interactions which indicate different environmental requirements for each species. In support to these findings, Brackand and Wood [29] provided a fact that tree growth was influenced by the environmental factors in the forest. Factors such as climatic, soil, topographic and competition combine to create a site. Therefore, the biomass value in a forest is indirectly affected by these factors because tree biomass value depends on the tree diameter.

3.6. Carbon stocks

Global climate change is the current major threat to the earth. Due to the rapid deforestation and land clearing and conversion that have been actively taking place since 1850 [3] the emission of CO_2 keeps increasing. Referring to the report from National Research Council [30], these activities contribute 17% from the total CO_2 released to the atmosphere. However, it was reported that forests can remove twice the amount that is lost by deforestation. It was estimated that the total carbon pool in the forest ecosystems approximately 1150 Gt, of which 14% in temperate forests, 37% in tropical forests and 49% is in the boreal forests [3].

Table 7 exhibits the carbon storage of lowland dipterocarp, riparian and HDF in PNP. The estimation of carbon storage within each forest was not greatly varies between different species or tree components. The carbon storage in HDF at 289.52 t/ha was higher than LDF and RF. LDF was 207.88 t/ha whereas the lowest was RF at 161.67 t/ha. Meanwhile, above ground carbon in HDF was 246.89 t/ha, in LDF was 177.29 t/ha while RF was 138.07 t/ha, respectively (see **Table 7**).

The carbon storage in HDF was the highest due to the higher biomass in this forest. This is because the tree density in HDF was higher compared to the other two forests types (n = 579).

As comparison to other study, Hikmat [13] found nearly the same result in three virgin jungle reserves (VJR) in Peninsular Malaysia. Carbon storage in Mata Ayer VJR, Bukit Bauk VJR and Gunung Pulai VJR recorded 221.43, 303.16 and 176.33 t/ha, respectively. In another study, [16] estimated carbon storage in Air Hitam Forest Reserve was 89.57 t/ha. This value was considerably lower than the present study because Air Hitam Forest Reserve was recovering from the past disturbances. Therefore, most of the sample trees were composed of small diameter trees with average diameter of 24.0 cm.

Item	Lowland dipterocarp	Riparian	Hill dipterocarp
	Carbon (t/ha)	Carbon (t/ha)	Carbon (t/ha)
Above	177.29	138.07	246.88
Below	30.59	23.61	42.64
Total	207.88	161.67	289.52

Table 7. Biomass and carbon stocks of LDF, RF and HDF of PNP.

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The differences of estimated carbon storage among tropical forests might be due to some limiting factors such as species composition, soil fertility, disturbance history, successional stage and climate Kang et al. [31]. The AGB in the secondary forest would not be the same as the primary forest. Primary forest contains old-growth and large trees since this forest have never been disturbed whereas secondary forest that had been logged or naturally disturbed contains trees with smaller diameter. Therefore, the tree biomass in secondary forest is less than the primary forest. This was supported by Kang et al. [31] who conducted a study to quantify carbon stocks in primary and secondary forests of Bukit Timah Nature Reserve in Singapore. The result from their study revealed that primary forest obtained higher carbon stock than secondary forest with value of 337 and 274 t/ha, respectively. The values in their study were lower than LDF and HDF but higher than RF from this study.

4. Conclusions

In this chapter, the AGB, BGB and TTB of lowland dipterocarp, riparian and HDF have been estimated. Analysis of AGB, BGB and TTB between forests showed that means of AGB, BGB and TTB values in HDF were significantly higher than LDF and riparian ($p \leq 0.05$). The distribution of AGB, BGB and TTB according to diameter class revealed higher AGB, BGB and TTB values in >70 cm class for all forests. HDF was highest in most diameter class except for 40.0–69.9 cm. LDF obtained highest biomass in 40.0–49.9 cm whereas RF for 50.0–69.9 cm. There was no significant interaction between lowland dipterocarp, riparian and HDF and five similar families (i.e. Anacardiaceae, Burseraceae, Dipterocarpaceae, Euphorbiaceae and Leguminosae) with ($p > 0.05$). However, the interaction between lowland dipterocarp, riparian and HDF and five similar species (i.e. *Canarium littorale (*Burseraceae), *Elateriospermum tapos* (Euphorbiaceae), *Ochanostachys amentacea* (Olacaceae), *Pimelodendron griffithianum* (Euphorbiaceae) and *Shorea leprosula* (Dipterocarpaceae) was significant at ($p \leq 0.05$). The estimation of carbon storage in the study areas demonstrated HDF attained the highest carbon value in above ground, below ground and total tree with value of 246.88, 42.64 and 289.52 t/ha, respectively.

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Section 4

Ecotourism and Recreation

Chapter 10

The Roles of Interpretation in the Management of National Parks in South Africa

Kevin Mearns and Elricke Botha

Additional information is available at the end of the chapter

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Abstract

National parks and protected areas are under dichotomy of pressures. On the one hand, they are faced with increasing economic burdens to become independent from state and donor grants, and on the other hand, they need to fulfill their mandate of conserving the environment for future generations. The South African National Parks (SANParks) is no different. Operating costs for managing 19 national parks are roughly 1 billion rand and requires management to generate 80% thereof in order to meet their primary mandate, i.e., conservation. The question thus arises how to balance these important yet opposing priorities. Interpretation is mooted as a possible solution to strive toward this balance. Through interpretation knowledge is instilled in visitors, attitudes and behaviors are changed, and tourists are encouraged to take care of the national parks and to become more responsible citizens. Added to this, interpretation services add to the visitors' enjoyment, create loyalty, extend stays, and increase expenditure and revenue for the park. Interpretation is therefore no longer seen as a 'luxury' but an essential management function of national parks worldwide and this is also the case in SANParks. This chapter reviews recent developments relating to the renewal or redevelopment of interpretation programs within SANParks.

Keywords: interpretation, Kruger National Park, Kgalagadi Transfrontier Park, Addo Elephant National Park, responsible tourism

1. Introduction

Internationally, governments are under tremendous pressure to balance social, economic and environmental expenditure this often results in national parks and conservation areas to often receiving reduced government allocations and subsidies. National parks are under extensive financial pressure to become self-sustaining in terms of their operational expenditure. Tourism is seen as an important means to bolster revenue generation within national parks and conservation

areas in an attempted to achieve long-term economic sustainability [1]. Incredible increases in tourist visitation to natural and cultural protected areas has been observed and in fact encouraged. This increase has created the notion of tourists 'loving national parks to death' and if not managed carefully tourism is in danger of becoming a self-destructive process leading to the destruction of the resources upon which it is based. As far back as 1992 the World Tourism Organization (WTO), realized that growing tourism numbers would become an important problem that conservation areas would need to cope with [2]. Park managers are becoming concerned about increased visitation to fragile conservation areas and national parks as they may severely affect the natural and cultural heritage [3]. Interpretation is proposed as an important solution to mitigate some of the undesirable consequences of tourism in national parks [4, 5]. Not only does interpretation potentially reduce the environmental and social impacts associated with high-levels of tourism it also leads to more satisfied visitors, increase knowledge gains and pro-environmental attitudes and behavior amongst tourists [6–10]. A study conducted in the Canyonlands National Park (Utah) found that interpretation foster intellectual, emotional and stewardship connections [11]. Interpretation may be seen as a form of entertainment or enlightenment that encourages visitors to visit a site, to stay for longer or even to return to a site multiple times [12]. Moreover, interpretation services (depending on their quality) directly affect the psychological experience of visitors. An even more astounding result is the fact that interpretation seemed to have a net positive impact on satisfaction whereas other facilities and infrastructure can only break even or even lead to dissatisfaction [13].

Interpretation has been defined by various authors, however the most widely accepted definition of interpretation is that of Tilden often considered to be the father of interpretation, as 'an educational activity which aims to reveal meaning and relationships through the use of original objects, by first-hand experience, and by illustrative media, rather than simply to communicate factual information' [14]. Tilden's definition emphasizes that interpretation is about communicating meaning and relationships rather than just the transfer of scientific facts. Since Tilden's definition of interpretation, various organizations have embraced their own understanding and definition of interpretation. There is, however, consensus that interpretation is a process of communicating the significance of a place so that visitors will enjoy it more, understand its importance and develop a positive attitude toward conservation. Many national parks historically focused on environmental education over interpretation this is specifically the case in South Africa. Environmental education generally focusses on formalized learning and environmental awareness creation amongst primarily scholars [15]. Interpretation however is aimed at providing visitors first-hand enlightening experiences that lead toward greater understanding, appreciation and protection of park while contributing to greater visitor satisfaction and fulfilled expectations.

Interpretation can be both a program and an activity. 'As a program, it establishes a set of objectives for the things a visitor should understand, and as an activity, it requires skills and techniques to create understanding' [8]. Two types of interpretation exist guided and non-guided or otherwise stated, attended or unattended interpretation [14, 16]. Guided interpretation included guided walks, lectures, discussions and living interpretation, while non-guided interpretation includes self, guided trails, signboards, displays, exhibits and visitor centers.

High quality interpretation has been found to greatly enhance visitor's enjoyment and experience of national parks (experiential outcomes), leading to satisfied visitors returning and

recommending national parks to other potential visitors (economic outcomes) and can enhance understanding and lead to pro-conservation behavior (environmental outcome) [17]. Strong criticism of many interpretation programs has been raised indicating that interpretation programs have predominantly western Eurocentric approach and focus primarily on ecological aspects [18]. Greater sensitivity to culture, a wider range of historical western and nonwestern contexts as well as a focus on sociocultural and ecological heritage in interpretation programs has been proposed [18]. While the basic principles of interpretation are applicable to most circumstances and setting, the cultural appropriateness and inclusivity of interpretation needs to be considered in the implementation of interpretation initiatives.

Interpretation is seen as an important link between the conservation and tourism priorities of national parks (**Figure 1**). Based on the numerous examples provided earlier, this link can be explained as follows: the most important aim of national parks is to conserve the natural and cultural heritage. Interpretation helps the tourists to learn about the park's conservation efforts and in turn creates pro-conservation behavior. The other part of the link is that interpretation satisfies the visitor's need to learn through various innovative mediums and enhances the visit to the park.

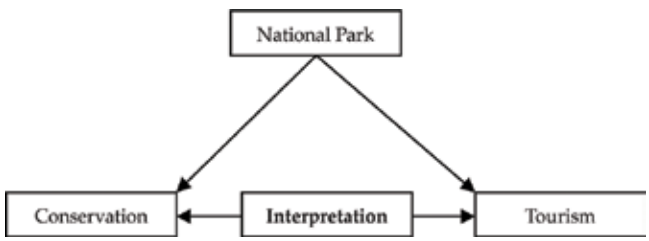

Figure 1. Interpretations link between the tourism and conservation functions of a national park [19].

2. Interpretation and South African national parks

Within South Africa, national parks, along with (special) nature reserves and protected environments fall within the scope of the National Environmental Management: Protected Areas Act (NEM:PAA) (no. 57 of 2003) [20] since these protected areas are organs of state. The South African National Parks Board (SANParks) which is a public entity under the jurisdiction of the Department of Environmental Affairs (DEA) manages national parks. In total, SANParks manages 19 national parks within seven of the nine provinces of South Africa (**Figure 2**). This totals to over 4 million hectares or 67% of protected areas under state management [21].

Due to declining state funding, SANParks is primarily a self-funding entity that has three operational core pillars, namely, conservation, responsible tourism, and socio-economic development [21]. It costs approximately 1 billion rand (i.e., approximately 60 million euros) to run these parks of which 80% of these funds are self-generated through primarily tourism activities offered in the national parks [22]. If the 14% increase in tourist numbers over the 2016/2017 financial year [23] is any indication to go by the need for sustainable practices is desperately needed for the future.

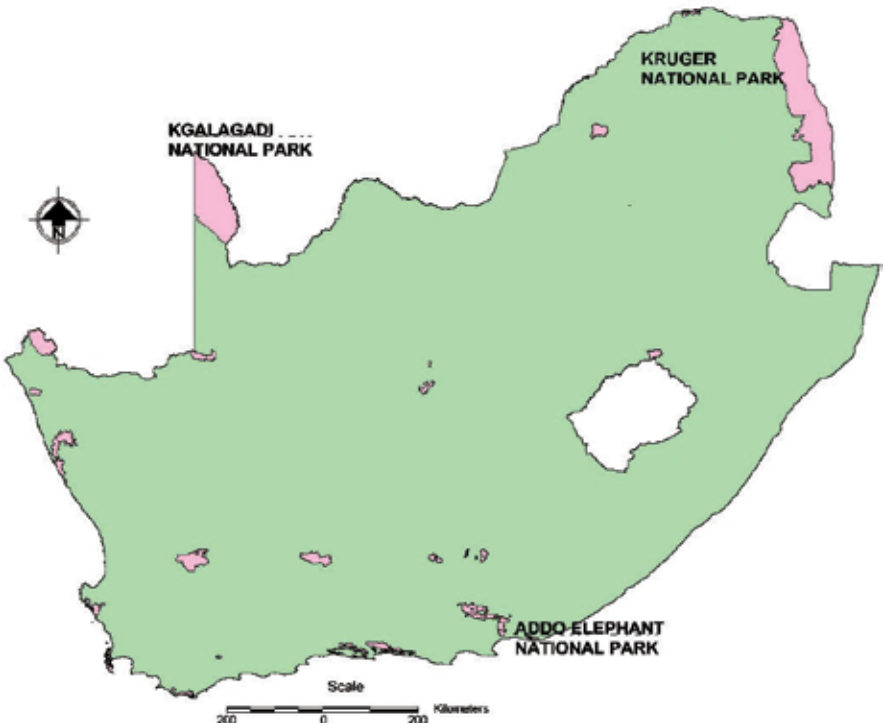

Figure 2. Location of national parks in South Africa, three national parks that will be further discussed are labeled (namely, Kruger National Park, Kgalagadi National Park, and Addo Elephant National Park).

Although the importance and benefits of interpretation for national parks are well reported, SANParks realized that interpretation initiatives were undertaken on an ad hoc basis in the past and not clearly understood by site managers and planners [24]. Since SANParks are mandated to produce park management plans (NEM:PAA, 57 of 2003) [20], it was decided to incorporate visitor interpretation plans into park management plans, in order to address these issues [24].

SANParks has adopted Responsible tourism as a strategy for the rejuvenation and future development is tourism with in the national parks. As far back as 1996, the *White Paper on Development and Promotion of Tourism in South Africa* identified Responsible Tourism as the key guiding principle for tourism development. 'Responsible tourism respects the natural and cultural environment and contributes to local economic development in an ethical manner. It helps conserve fragile cultures, habitats and species by maximising the benefits to local communities and minimising negative social or environmental impacts' [22]. The National Minimum Standard for Responsible Tourism (NMSRT) (SANS 1162) will be used to guide the implementation of the Responsible Tourism Strategy. The NMSRT is based on the three cornerstones of sustainable tourism, namely social-cultural, environmental and economic responsibility [25]. Besides SANParks' the core mandate of conservation, it has an added responsibility to implement and manage nature-based tourism in national parks. According to the NEM: PAA (no. 57 of 2003), this includes educational, recreational, spiritual and scientific opportunities that are not harmful to the environment [20]. The implementation of the

Responsible Tourism Strategy is destined to take SANParks into a new era of sustainable and responsible tourism growth.

For the purpose of this chapter, three case studies within SANParks will be discussed. When one considers the area they occupy, the Kruger National Park, Kgalagadi Transfrontier Park and the Addo Elephant National Park are the three largest national parks in South Africa. Interpretation services within SANParks have recently received attention and is being developed and in some cases redevelopment in several parks. Within the three largest parks, interpretation services are at different levels the details of the development and/or redevelopment are discussed in the next sections.

2.1. Kruger National Park

The Kruger National Park (KNP) is considered to be SANParks' flagship park. This park, covers approximately 2 million hectares of land, the largest park in South Africa [26] and attracted 1,817,724 million guests during 2016/2017 [23]. As the oldest and largest park, it is not surprising that this park has a great deal of interpretation services. The question should be asked whether these interpretation services are a true reflection of the park. Bunn and Auslander critique the history of the park and state that it was predominately subject to a Eurocentric approach and that a local Afrocentric approach to the conservation of the natural and cultural heritage of the Park should be followed [27]. This criticism also needs to filter through to the interpretation activities and services offered in the KNP. In a review of existing interpretation facilities in KNP in 2014 it became clear that there was no clear comprehensive interpretation program and that many of the pre-1994 (better known as the apartheid regime) interpretation initiatives were in need of renewal and redevelopment [15, 28]. As research progresses and more evidence emerges about the rich history of the ordinary people living in and around the park, there is a need that these stories should be told. While better historical accounts of events add to the completeness and comprehensiveness of the history of the park, the complexity of portraying the information is increased. It is against this background that the interpretation services of the park need to be redeveloped and upgraded to be more representative of the past and contemporary history [29].

Planning for interpretation in such a large park may be complex especially if one considers the planning process suggested by Ham, Housego and Weiler [13]. This process is set out as follows: (1) interpretive inventory, (2) interpretive goals, (3) identify visitors, (4) determine outcomes of goals, (5) develop themes, (6) develop media matrices, (7) implementation plan, and (8) evaluation process. Although the information is not captured in line with this process, SANParks' planning seems to be on par in the interpretation documentation. For clarity purposes, these elements will be discussed in the order of Ham et al. planning process [13].

1. As part of the inventory process, SANParks evaluated the status of the current and potential interpretation sites and services against a set of criteria. Interpretation sites and services range from several centers to booklets, maps, personal interpretation (fire camp stories, game rangers), exhibits, historical sites, hides, lookout points, signage and activities. The criteria that these sites and services were evaluated against relate to one internal criterion and four international criteria [30]. The park's first criteria relates to the *placement and condition* of the

current interpretation: is it meaningful to the visitor's experience, is the placement sufficient for a connection to the experience, and are the information outdated or readable? Ham's criteria, or better known as the EROT model which the park used to evaluate the interpretation on the value of *entertainment* (does it hold attention, the use of the visitor's senses activated?); *relevance* (the use of analogies, comparisons or metaphors to make connections); *organized* (is it easy to follow and limited ideas); and *topics and themes communicated* (are the subject matter organized in themes with a beginning and ending) [30]. Some of the outcomes of the audit/inventory indicated that the interpretation in Letaba, Skukuza, and Berg-en-Dal is outdated; no communication of conservation; although some information is available there was no interpretation; stories are missing; and there is too much information on some themes [28]. Based on the criteria explained above, each camp's interpretation has recommendations, allocated periods for improvement, relevant responsible staff/sections and budgets.

2. Authors like Engelbrecht, Kruger and Saayman [31] and Botha et al. [32] reported that visitors to the Kruger National Park expect interpretation services to be delivered in the park and that there is a need to improve on these services. In response to this gap, the Kruger National Park's interpretation plan aims to deliver interpretation services that enhance visitor experience. As such the following visitor experience objectives are set out: (a) learning (protecting the under-conserved; role of KNP as a bank of rare species; inform about animal behavior); (b) emotional (improve emotional enhancement between visitor and park; encourage to care about threats; instill an appreciation of different cultures); (c) behavioral (encourage responsible tourists; acceptable behavior); and (d) promotional (to become involved in volunteer programs; to be ambassadors of the park) [24].

3. Even though visitors to national parks are in majority leisure tourists, other visitors like staff, services providers, community groups, conference groups, schools, concession partners, suppliers (goods and services) and media, to name but a few, also frequent the park. It is within this context that the park also identified these audiences as target audiences [24]. It is perhaps the overnight visitors to the park that contribute financially the most and could therefore be regarded as the main target audience. Botha et al. [19], however, found four interpretation market segments for overnight visitors to the park and suggested to focus interpretation developments on the two largest segments (i.e., Inquisitive and Eager seekers). The issue with these two markets, however, is that these two markets require a variety of interpretation services to add to their park experiences.

4. The outcomes of targeting the above-mentioned audiences are not precisely specified within the interpretation plans. Mention was, however, made to 'balancing conservation and visitor satisfaction,' 'growing the tourism market which in turns generates the revenue support the organization's biodiversity and conservation objectives,' and 'enhancing the visitor experience' [24].

5. Due to the size of the park, differences in biodiversity, rainfall [33], forage [34], animal distribution and consequently tourist numbers and expectations [35] are evident in the park. It is therefore not surprising that over 50 themes are identified in the new interpretation plan of the park. These themes range from history (San Bushmen, development of the park to the Anglo-Boer war), heritage, geology, fauna (land and water), flora, conservation, research, stargazing, code of conduct, and careers in the park [24].

As a following phase, several timeframes (2017–2020) were set out in the inventory phase to indicate by when these interpretation services should be implemented (steps 6 to 7). The Elephant Hall in Letaba, has recently been renovated and launched in March 2017 (**Figure 3a–c**) [23]. This project was a collaborative project between SANParks, Honorary Rangers and the University of Sunshine Coast in Australia.

New interpretation panels will also be erected in December 2017 for the Phabeni Interpretation site (**Figure 4**) [23]. This project took place over several years in collaboration with numerous interpretation, cultural and heritage specialists, external archeologists and SANParks' Honorary Rangers.

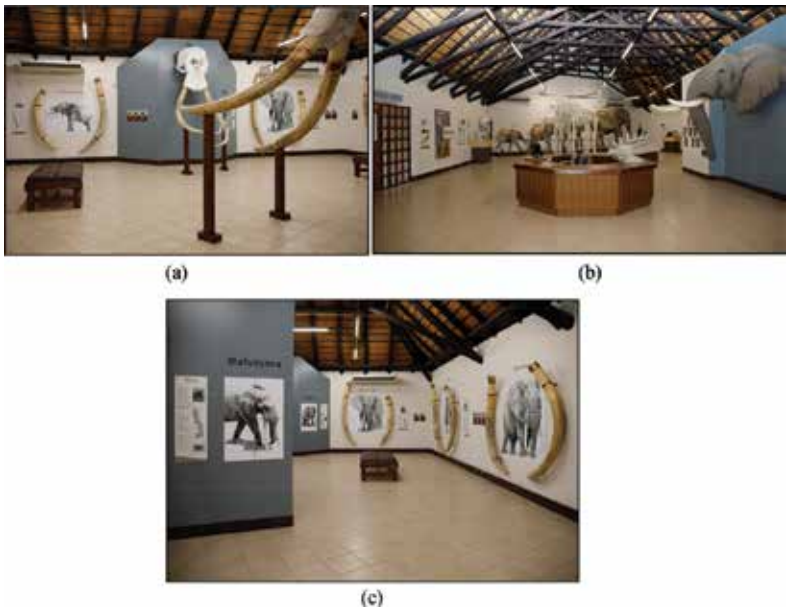

Figure 3. a, b and c. Interior of the Elephant Hall (Letaba) [36].

Figure 4. Interpretation panels at Phabeni [36].

2.2. Kgalagadi Transfrontier Park

The Kgalagadi Transfrontier Park was the first transfrontier conservation area (TFCA) proclaimed in South Africa [37]. Transfrontier conservation areas are relatively large areas, with large-scale natural systems between two or more countries [37]. As such, the Kgalagadi Transfrontier Park borders Namibia to the west and shares the area with Botswana to the east. The uniqueness of this park is also evident in the recent world heritage site status bestowed by the United Nations Educational, Scientific and Cultural Organisation (UNESCO). This status was granted to the park due to the cultural landscape of the Khomani San which dates back to the Stone Age and who still lives in the area [38]. Although the park only attracted 48,221 visitors during 2016/2017 the newly bestowed title will create an increased awareness about the park, leading to more traffic and a need for relevant interpretation services [23].

Due to the smaller size of the park (38,000 km^2), the inventory of interpretation services in the Kgalagadi is less when compared to the KNP. Only one of the three interpretation centers (**Figure 5a** and **b**) is still functional and the other two are used as a storeroom (**Figure 6a** and **b**) or converted for housekeeping (Twee Rivieren). Even though the Nossob center is considered as functional, it needs an upgrade along with Mata Mata. Further to this, the park would like to create a living museum at the South African border gate as well as a new interpretation center at the Twee Rivieren rest camp [39]. The Twee Rivieren interpretation center will be cost intensive and as a result research with external stakeholders currently underway to inform the development process [29]. This research will shed some light on the visitor expectations with regards to themes, media and extent of information required. The park has similar goals and objectives as the KNP but have different themes for interpretation. These themes relate to the UNESCO status (i.e., the Khomani San), the history (Stone Age, wars and transfrontier status), myths and legends, fauna and flora adaptive to the arid conditions, and transfrontier aspects [39]. Many of the interpretation services are planned to be developed in 2018.

Figure 5. a and b. Interpretation at Nossob rest camp [36].

Figure 6. a and b. Interpretation in Mata Mata rest camp [36].

2.3. Addo Elephant National Park

One of the few national parks to include a marine protected area, the Addo Elephant National Park is the only national park to include the big 7 (including the marine animals namely the southern right whale and great white shark). Although this is the case, the park was originally proclaimed to protect the last 11 elephants in the then 2000 hectares area [40]. Today, however, many other species are also being conserved in the 1640 km^2 area. During 2016/2017 the park attracted 265,585 guests to the park [23].

Although this park's management plans indicate that interpretation plans should still be drafted [41], this park already has an impressive interpretation center called the Ulwazi Interpretive Center. The main theme in this center, and not surprising so, revolve around elephants. Information ranges from the evolution of elephants (**Figure 7**), background of the legendary dominant elephant Hapoor that roamed the park (**Figure 8**), and a family tree of all the elephants in the park (below Hapoor on **Figure 8**). Other interesting activities include two parabolic dishes to illustrate how elephants communicate and a jungle gym in the form of an elephant to illustrate how big an elephant can be (**Figure 9**).

Other information is also provided on the surrounding cultures in the park, the environment and other smaller animals like insects and birds.

According to the management plans, future considerations for interpretation services are a historic house in the Kabouga section, Chief Chungwa's gravesite in the Woody Cape section and a number of shipwrecks that are not easily visible from the current visitor access sites [41].

It is clear from the current initiatives in the three largest parks of SANParks that they are in the process to improve their interpretation services. If these initiatives are any indication of the future, the other 16 national parks' interpretation plans will soon also follow and hopefully improve the balance between conservation and the decreased financial support that forces initiatives to increase funding.

Figure 7. Evolution of elephants [36].

Figure 8. Hapoor and the elephant family tree [36].

Figure 9. Interior view of the Ulwazi Interpretation Center [36].

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3. Conclusion

High expectations are placed on national parks namely that they have to enhance local economies, conserve natural and cultural heritage as well as provide an ever-increasing number of visitors with experiences in nature [17]. Washburn explains that '[t]he survival of the national park system in the twenty-first century depends on how it interacts with society and how much society values it. The Interpretation Program is the primary means by which the National Park Service engages diverse publics with their national parks, providing access to meanings, establishes relevance and connects people and communities to national heritage [42]'.

Considering the interpretation initiatives taken by SANParks, one would agree that there is clearly an effort to improve the current situation. SANParks' interpretation plans predominantly focus on the soft interpretation examples [43, 44]. These authors explain that one should consider interpretation on a continuum where the one end, hard interpretation, refer to economical, physical and regulatory strategies to manage visitors and on the other end, soft interpretation, use educational strategies to manage visitors. The question is, therefore, whether national parks should only consider soft/educational interpretation strategies or should they also consider the hard interpretation strategies as part of the interpretation plans? Similarly, interpretation can be categorized into primary, secondary and tertiary interpretation based on easily identifiable characteristics. Primary and secondary interpretation's explanation is similar to that of soft interpretation but what is interesting is that tertiary education is considered to enhance the experience with the more noticeable examples of interpretation. Limited research is available on the correlation between hard and soft interpretation to support the notion of including hard interpretation into the interpretation plans of SANParks. This is probably why SANParks have separate visitor interpretation plans and visitor management plans [24, 39]. But what is clearly noticeable from SANParks' initiatives for visitor interpretation or visitor management plans is the fact that these plans form part of their responsible tourism mandate rather than sustainable tourism mandate [29]. Although similar on minimizing negative impacts, there is a common consensus that responsible and sustainable tourism should not be used interchangeably [45]. Responsible tourism has an emphasis on competitive advantage, involving communities, triple bottom line diversity and promotion of sustainable use of local resources [45]. This is a valuable lesson that other national parks can also take from SANParks. The interpretation plans of SANParks therefore go beyond the message of sustainability but also include an awareness of local cultures (history, stories, legends and myths), incorporating local communities (employment) and more of visitor enjoyment emphasis.

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Chapter 11

Light Intensity and Soil Compaction as Influenced by Ecotourism Activities in Pahang National Park, Malaysia

Mohamad Danial Md Sabri, Mohd Nazip Suratman, Abd Rahman Kassim, Nur Hajar Zamah Shari, Shamsul Khamis and Mohd Salleh Daim

Additional information is available at the end of the chapter

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Abstract

Pahang National Park provides a diversity of flora and fauna, which is popular for ecotourism activities within Malaysia. The ecotourism activities such as trekking and camping may result in some degree of changes to the forest condition in the protected areas. Therefore, a study was conducted to investigate the influences of ecotourism activities on the light intensity and soil compaction in Pahang National Park. A total of 40 plots measuring at 20 × 25 m were established in camping area, trekking trail and natural area of the park. The light intensity and soil compaction were measured using hemispherical photography at nine points and a hand penetrometer at five points, respectively, randomly selected in each plot. The Analysis of Variance shows there was a significant difference in the means of light intensity and soil compaction in three study sites ($p < 0.05$). The light intensity in the trekking trail is significantly greater than in natural area (18.87% vs. 13.13%). The soil compaction in the trekking trail is significantly greater than in natural area and camping area ($p < 0.05$). This may suggest that ecotourism activities especially trekking activity has significantly influenced the trend of forest light intensity and soil compaction in Pahang National Park.

Keywords: ecotourism, forest environment, light intensity, soil compaction, Pahang National Park

1. Introduction

In recent years, national parks and protected areas across the globe have become increasingly popular for recreation and ecotourism. National parks and protected areas are rich with

natural resources and contain geomorphological structure, climate and rich biological diversity, and these areas have an important place in the continuance of the ecological cycle. These attractions may encourage tourist all over places to come and enjoy the nature. According to Lowman [1], ecotourism could be defined as nature-based tourist experiences where visitors travel regions for the sole purpose of appreciating natural beauty. Pahang National Park provides a diversity of flora and fauna and attracts a growing number of local and international visitors. However, many studies revealed that recreational activities have provided various impacts on natural ecosystems. Human activities such as the trampling and camping activities are the most widespread and can readily lead to recreational degradation of natural ecosystems [2–4]. Given the intricacy of protected area ecosystem, ecotourism activities may result in ecosystem disturbance, thus affecting vegetation growth and surface profile.

Disturbance can be natural or in anthropogenic forms which may influence the structure of forest stands. However, natural disturbances, normally, do not influence the forest ecosystem to the greater extent. Conversely, when it comes to the human intervention to forest ecosystem, it will have possible changes to the biodiversity and its surroundings drastically. Thus, study should be considered to produce information and knowledge to manage, to reduce or to sustain the present forest areas. Protected area is believed to be one of the ways to conserve forest area, but somehow ecotourism activity that developed within its place may affect the forest stand patterns. Many studies have suggested that the ecotourism activities provide influences on the richness, diversity and ecological interaction in many forest areas on earth [5–8].

The forest environment is a part and vital for propagation and growth for many kinds of vegetation including herbs, shrubs, bamboo, palm, trees and others. Besides that, vegetation condition in the forest is sensitive toward some levels of disturbance which affect the growth of stand structure within forest ecosystem. Extensive ecotourism activities can cause disturbance which may result in temporal and spatial changes in the morphology of the canopy structure of the forest. A study [9] mentioned that forest stand structure influences the quantity, spectral quality and temporal and spatial variability of solar radiation received by the understory. Some levels of disturbance to the surrounding vegetation may reflect or change the light condition. Forest canopy structure comprises the complex spatial arrangement of foliage, branches and the stem of trees, which influence a wide range of biophysical and ecological processes to the properties of the understory environment in a forest ecosystem [10, 11]. Studies have shown that a strong relationship exists between forest canopy structure and understory light transmittance [12, 13]. In addition, light is one of the most important factors regulating survival and growth of understory trees where light is an essential component in photosynthetic process for trees and other plants.

Among popular activities that occur in Pahang National Park are hiking, trampling and camping. These activities may provide impact to the soil condition and suitability for tree growth. As part of maintenance, trail condition and camping area should be maintained to ensure a minimal ecological disturbance to the protected area and to preserve natural conditions. These were implemented by the park managers to minimize impacts on environment and natural resources. According to Wimpey and Marion [14], formal trails could be developed by the park managers to provide recreational opportunities to visitors, and hence they

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are planned and designed to direct visitors to areas less prone to disturbance. Trails and camping area should be routed, constructed and maintained to concentrate foot traffic and related impacts to minimize the areal extent of trampling damage such as to soil and vegetation. The high use of trails may cause soil compaction and increase in bulk density. Compression of the soil structure leads to a reduction in air and water movement, reduced water infiltration and a decreased water retention, except for coarse-textured soils [6, 15].

A study on ecotourism impact is needed in Pahang National Park which involves environmental factors such as light intensity and soil compaction that result from ecotourism activities. A comprehensive study that scientifically examines the impacts of recreational practices on the light intensity and soil compaction is still lacking. Therefore, a study is required to provide information for the development of effective management plan for recreational activity. Hence, in general, this study aimed at investigating the influence of ecotourism activities (i.e., trekking and camping) on light intensity and soil compaction of Pahang National Park.

2. Materials and methods

2.1. Study area and data collection

This study was carried out in Pahang National Park (approximately latitude 4° 19′ N, longitude 102° 23′ E) near Jerantut, Pahang. The elevation ranges between 120 and 200 m above sea level. Pahang National Park covers a total forested area of 2477 km^2. The topography consists mainly of lowland, undulating and riverine areas. Data were collected in eight locations of forest in Pahang National Park including Kuala Keniyam, Lata Berkoh, Crossing Point, Bukit Terisik, Canopy Walkway, Lubuk Simpon, Jenut Muda and Kuala Terenggan (**Figure 1**). A study by Suratman [16] indicated that the weather in Pahang National Park is characterized by permanent high temperatures ranging from 20°C at night and 35°C in the day with high relative humidity (above 80%). The rainfall at this park is ranging from 50 to 312 mm throughout the year of 2012. The topography consists mainly of lowland, undulating and riverine areas. The overall vegetation in Pahang National Park is lowland dipterocarp forests which are characterized by high proportion of species in the family of Dipterocarpaceae and Euphorbiaceae as dominant families. Hydrologically, Pahang National Park consists of two headstreams of Tahan River and Tembeling River with the presence of riparian tree species mainly Keruing neram (*Dipterocarpus oblongifolius*) along the bank of these two rivers.

This study adopted a standard experimental procedure for studying recreational trampling on vegetation as proposed by Cole and Bayfield [17] with some modifications. Their study has derived conclusions by comparing the vegetation in trampled sites with the vegetation of untrampled site. For study site selection, Department of Wildlife and Protected Parks of Malaysia (DWNP), the custodian of Pahang National Park has listed out a few suggested study sites within this park. Thus, the selected study sites as in **Figure 1** were chosen with respect to the safety concern by the DWNP. With regard to the restriction, the data collection activities were focused to the main recreation areas, i.e., seven sites for trekking trail and three sites for camping

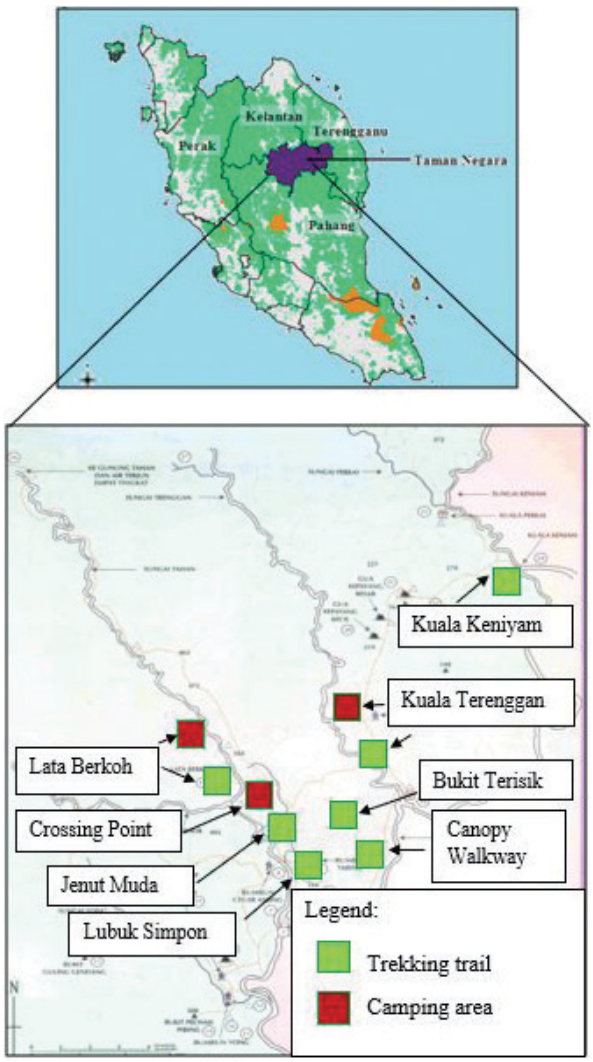

Figure 1. Map of Pahang National Park and distribution of study plots.

area. The imbalance number of study sites between trekking trail and camping area was due to the limited number of camping area within Pahang National Park. On the selected study sites, the plots for trekking activity were established on the middle of the trekking trail sites, while the plots for camping activity were developed on the middle of the camping area sites. In this study, a total of 28 plots for trekking trail and 12 plots for camping area (each plot 20 m $\times$ 25 m in size, as workable units) which consist of 4 plots of each for undisturbed and disturbed area, respectively, were established. Therefore, the accumulated total study area was 2 ha. For undisturbed area, the plots were located 10 m away from disturbed area plots and were selected randomly either on the left or the right side. All undisturbed condition plots were marked as natural areas while the disturbed condition plots either trekking trail or camping area.

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The field measurement activities within 10 study sites of the park began in August 2014 and ended in November 2015. The forest inventory, light intensity and soil compaction measurements were recorded for each site over a 2-week working time of a particular month along the stated field study duration. However, data collection activities were entirely depending on the weather condition of Pahang National Park. Methods of light intensity and soil compaction measurements are explained in the next subsequent section.

2.2. Measurement of light intensity under tree canopy

To determine the light intensity in the forest understory, nine points were laid out randomly in each plot. The measurements of light intensity were made at each point using the hemispherical photography (**Figure 2**). All hemispherical photographs were taken with Nikon Coolpix 4500 digital camera (Nikon, Tokyo, Japan) fitted with a Nikon FC-E8 fisheye converter (**Figure 3**). The camera was mounted on a monopod at the height of approximately 1 m above the ground. The camera and lens were leveled with the aid of a spirit level and oriented to magnetic north. Lhotka and Loewenstein [13] suggested that the measurements were made under overcast conditions, usually in the late morning hours. The digital images were processed based on a procedure developed by Ishida [18]. All images were analyzed to calculate the percentage of diffuse light intensity under the canopy (SOC percentage) using RGBFisheye ver.2.01 (Gifu, Japan).

2.3. Measurements of soil compaction using static cone penetrometer

Measurements of soil resistance were conducted using a hand-held cone penetrometer which is known as static cone penetrometers. This tool was used to measure soil resistance to vertical penetration of a probe or cone as in **Figure 4**. Soil compaction is often characterized by changes in soil bulk density, typically expressed in Mg/m^3 or g/cc. Soil density is also related to soil resistance, which can be measured using a penetrometer much more rapidly than bulk density can be obtained [19]. Some soils are difficult to sample consistently due stony, light-textured or highly friable soils by hammer-type bulk density samplers using corers and rings. Therefore,

Figure 2. Measuring of light intensity through hemispherical photography.

Figure 3. Camera and Nikon FC-E8 fisheye converter.

cone penetrometers are commonly used to measure soil compaction because of their easy, rapid and economical operation [20].

In this study, hand penetrometer Eijkelkamp was used to measure soil compactions. Five points were sampled randomly and assessed in each plot. The measurement of soil compaction using a static cone penetrometer measures the force required to push a metal cone through the

Figure 4. Measuring of soil compaction through penetrometer.

soil at a constant velocity. The force is expressed in Newton (N). The manometer values recorded were then converted into mega pascals (MPa) using the following formula:

$$\text{cone resistance} = (\text{manometer reading})/(\text{base are of cone}) \quad (1)$$

where manometer is in Newton and base area of cone is in cm.

As the penetrometer was being pushed down to the soil, the compaction value was recorded for each sample in a plot in a datasheet. While the methods for static cone penetrometer operation have been standardized, there are some precautions for its usage. Static penetrometer must be moved through the soil at a constant velocity (i.e. pressure); different rates of insertion by different operators can yield variable results [21].

All data in this study were managed using Microsoft Excel worksheets, and all statistical analyses were performed using R Statistical Software Version 3.2.0 and Rcmdr Packages [22].

3. Results and discussion

3.1. Light intensity

Table 1 shows a summary of light intensity percentage for three study sites. From the analysis of variance (ANOVA), it was found that there is a significant difference in the means of light intensity between the three study sites ($p < 0.05$). This suggests that ecotourism activities have significantly influenced to the amount of light penetration within forest understory. Next, a multiple comparison test (i.e., Tukey's test) indicated that there is no significant difference in the means of light intensity between camping area vs. trekking trail and camping area vs. natural area ($p > 0.05$). However, the light intensity in the trekking trail is significantly greater than in natural area (18.87% vs. 13.13%). The mean value recorded for trekking trail is the highest among three study sites (**Table 1**). Therefore, trekking and hiking activities are influencing the trend of light intensity within the forest area of Pahang National Park.

This study also recorded the composition of tree species in all study sites. Information on the uniformity of tree species in all study sites is crucial to the study as ecological adaptions of

Study site	No. of sample	Percentage of light intensity (%)	Minimum light intensity (%)	Maximum light intensity (%)
Camping area	54	$17.06 \pm 11.74^{a,b}$	3.16	49.30
Trekking trail	126	18.87 ± 12.91^{b}	3.39	64.24
Natural area	180	13.13 ± 10.11^{a}	2.35	71.32

Note: All values for percentage of light intensity are mean ± SD. Means with same letter indicate no significant difference at $p < 0.05$.

Table 1. Descriptive statistics for light intensity between camping area, trekking trail and natural area of Taman Negara Pahang.

tree species and its environment could also influence the changes of light intensity in a forest area. The condition of the tree canopy structure that comprises of the complex spatial arrangement of foliage, branches and the stem of trees totally depends on the tree species, ecological interaction of the species and corresponding competitiveness. From the analysis of importance value index (IVI), it was found that the dominant tree species occurred in these three study sites were similar where Perah (*Elateriospermum tapos*) and Meranti tembaga (*Shorea leprosula*) are among the tree species with highest IVI [23]. According to Curtis and McIntosh [24], the tree species with highest IVI exist in the greatest number or the greatest size where they produce the greatest effect on the tree community and its surrounding. Hence, in this study it was observed that tree species was not so much different in natural area; trekking trail and camping area and the value of light intensity shall be compared and pooled as in **Table 1**.

In the current situation, very few published studies have characterized the light intensity in tropical forest resulted from anthropogenic influences using hemispherical photographs. Then, values obtained from this study are discussed and ecologically compared with the other studies elsewhere. Tree requires light to grow, and thus light may influence the regeneration dynamics [25, 26]. The bigger size of canopy openness will then allow some amounts of light penetration directly into the forest floor and trigger the tree seed germination [27]. **Figures 5–8** show the variations in canopy opening as captured through hemispherical photograph from three study sites of Pahang National Park. All the photographs were then analyzed using RGBFisheye software to obtain the percentage value of diffuse light intensity that is captured by the camera.

As comparisons with study by Beaudet and Messier [25] on light transmission recorded in the Duchesnay Forest Station and Mousseau Forest, Québec (Canada), which dominated by tree species of *Acer saccharum*, *Betula alleghaniensis* and *Fagus grandifolia* stands. The description

Figure 5. Digital image taken from hemispherical photograph for natural area.

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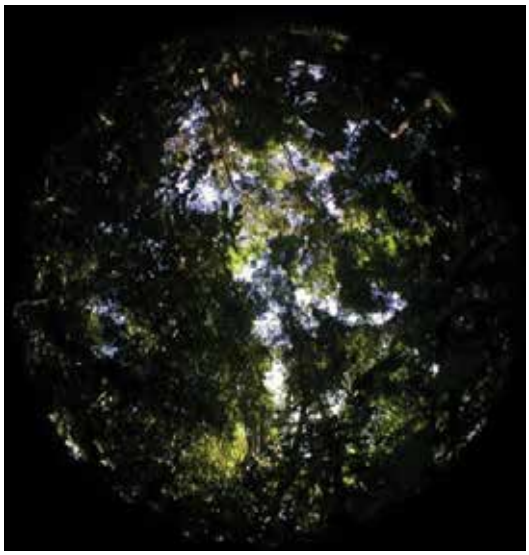

Figure 6. Digital image taken from hemispherical photograph for trekking trail.

Figure 7. Digital image taken from hemispherical photograph for camping area.

about the studied area is that the stands had been logged, using the selection system and while the control area was uncut forests. The gap light index (GLI) values obtained from the previous study were ranged from 3.1 to 37.2% for cut forests and 3.0 to 16.5% in the control forests. The trend GLI values of light transmission for this previous study show the higher percentage in

Figure 8. Digital image taken from hemispherical photograph for open area.

the cut forests than the control forests. Thus, this trend shows that human activity (i.e. cutting forest) is affecting the light condition within a forest area. According to **Table 1**, camping area and trekking trail are slightly higher in the percentage of light intensity than the natural area. Canham et al. [28] also in their study at the United States and Costa Rica found that the GLI values for closed canopy of five study sites were ranged 0.5–5.2% and the GLI values for canopy opening were ranging between 36.8 and 67.6% at the same sites.

In recent study, through the field observation, trekking trail is frequently used by the visitors, and this will affect the tree growth and influence the tree structure. The lack of large tree structures may result in the less number of big canopy and lead to the greater light intensity in the forest understory that is captured by the hemispherical photography, while in camping area, the light intensity remains stable between disturbed and undisturbed conditions. However, there was an argument that the damage on forest stands and its diversity may not be solely affected from human intervention especially in the protected area. Other aspects such as biotic and abiotic elements may have also been contributing factors influencing the situation [29–31], which is not the intention of this study that focused on the physical aspects of human intervention through ecotourism activities to the forest area. Nevertheless, from the statistical analysis, it was found that the ecotourism activities especially to the hiking and trampling activities have caused the canopy openness and allow the greater light penetration to the forest floor.

3.2. Soil compaction

Soil compaction measures the penetration resistance of soil in Pahang National Park as reflected from ecotourism activities. From the analysis, the mean of penetration resistance of

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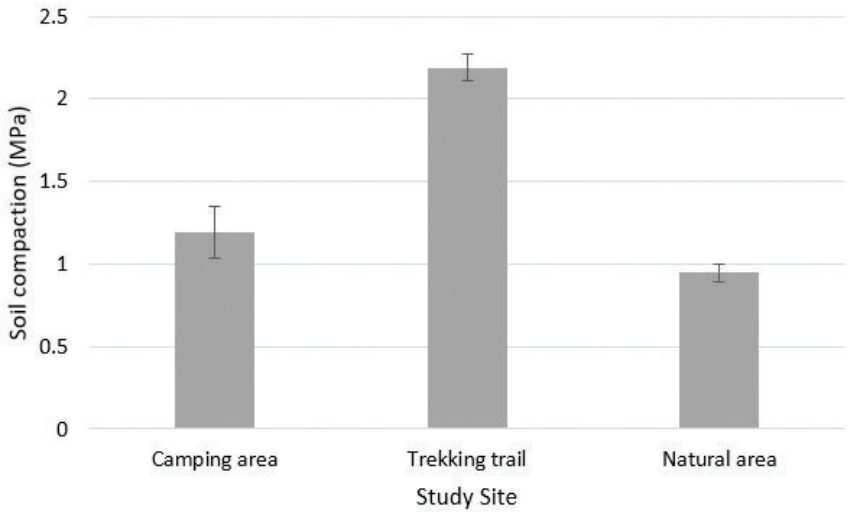

Figure 9. Soil compaction for camping area, trekking trail and natural area of Pahang National Park.

soil for camping area, trekking trail and natural area was 1.19, 2.19 and 0.95 MPa, respectively (**Figure 9**). From ANOVA, it was found that the means of penetration resistance between three study areas were varied significantly ($p < 0.05$). This may suggest that the ecotourism activities have significantly influenced to the soil compaction of Pahang National Park. Therefore, a multiple comparison test (i.e. Tukey's test) was performed indicating that there is no significant difference in the means of soil compaction between camping area and natural area ($p > 0.05$). However, the soil compaction in the trekking trail is significantly greater than in natural area and camping area as shown in **Figure 9**.

All the penetration resistances of soil compaction in this study were comparable with penetration resistance in study by Ampoorter et al. [32] where they found the value of 0.36 MPa at the ground surface to 2.51 MPa at 80 cm depth for undisturbed conditions in two sandy forests of Putte (the Netherlands). According to other previous studies [33, 34], tree root growth for many plants becomes restricted when soil penetration resistance exceeds 2.00 MPa and stops at resistances greater 3.00 MPa. Many previous studies were agreed that a range of 2.00–3.00 MPa of soil compaction is affecting the pattern of tree growth, but study in oak forests in the northern half of France by Wei et al. [35] found the higher soil compaction detected on skid trails, which does not necessarily mean that it will have significant effects on ground flora. This is because flora could survive with penetration resistance to the ground up to 2.5 MPa. Thus, compacted soil may influence the trend of tree development. Eventually, it will affect the tree diversity and species composition within a forest area.

Despite that Pahang National Park is a protected area, the status of soil compaction sounds vital information for management of the park. While this study observed the trekking trail is frequently used by the tourists for purpose of enjoying the nature, jungle trekking, mountain hiking, bird watching, picnic by the river, visiting the cave, wildlife hide, etc. Besides that, a

social study by Ibrahim and Hassan [36] found Pahang National Park is among of popular ecotourism destinations in Malaysia where in 2008 approximately more than 40,000 international tourists arrived at this park. The local, domestic and ASEAN tourists were approximately more than 20,000 who visited Pahang National Park in the same year. Majority of stated tourists were staying at the provided hotel and chalet around of Kuala Tahan. This may suggest that camping areas were the lesser used by the visitors to do their activities within the forest area as their interest to enjoy the nature and get back to hotel or chalet for overnight. Therefore, trekking trail was recorded higher soil compaction than the camping area and natural area. The degree of soil compaction is totally depending on disturbance type and visit frequency [37].

4. Conclusion

Pahang National Park is visited by many local and international tourists, which through their activities would lead to the implications on forest conditions. Therefore, measurement of light intensity and soil compaction assessed in Pahang National Park will surely shed new insight on protected forest management in Malaysia. This study revealed that ecotourism activities have a significant influence on light intensity and soil compaction within three study sites. Based on the findings, there was significant difference between natural area and trekking trail. Study also found there is no significant difference on camping area vs. natural area and camping area vs. trekking trail for light intensity, while in the context of soil compaction, from the multiple comparison test, there was a significant difference between camping area and trekking trail and natural area and trekking trail. No significant difference found between camping area and natural area. Thus, trekking trail was found the most influenced by the ecotourism activities compared to the camping area. And the natural area was classified as the undisturbed condition and used as the control plots. It is clear that to fill the void in our knowledge, study should be done to learn more about the trend of ecotourism influence to the forest area of Pahang National Park. The number of sample for camping area needs to be increased, and relationship between the frequency of visitors and the influences on variables should be looked thoroughly.

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Section 5

Local Community Participation

Chapter 12

Policy and Related Issues Pertaining Community Participation in the Management of Protected Area (PA): A Case of Pahang National Park, Malaysia

Ahmad Naqiyuddin Bakar

Additional information is available at the end of the chapter

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Abstract

With the goal of significantly reducing biodiversity loss, the United Nations General Assembly declared 2011–2020 as the United Nations Decade on Biodiversity. As a signatory to the Convention on Biodiversity, Malaysia is obligated to safeguard the biodiversity through the protection and management of many protected areas (PAs). Achieving sustainability related targets by involving the local communities is an agenda of the day. Inclusivity is the key issue in which various stakeholders are brought to the fore, i.e., the Orang Asli and local villagers; yet, there are others being sidelined. This means, the effective management of these protected areas remained a debatable issue. Hence, this is a systematic inquiry on the governance of protected areas that reiterates the importance of the local communities' participation. Interviews are conducted with local communities that are living in Pahang National Park, specifically in Kuala Tahan vicinity. The data analyzes three features to a community engagement process: (i) the importance of building capacity for indigenous knowledge; (ii) the role of Department of Wildlife and National Parks (PERHILITAN) in facilitating sustainable and resilient communities, and (iii) empowering and harnessing the commitment of all stakeholders to conserve biodiversity. The results suggest that understanding the different needs and concerns of stakeholders are important to achieve sustainability related goals.

Keywords: protected area, PERHILITAN, biodiversity, Taman Negara Pahang, indigenous knowledge

1. Introduction

With regard to the sustenance of biodiversity and more balanced global growth agenda, United Nations declared 2010 to be the 'International Year of Biodiversity'. The priorities identified

by the United Nations General Assembly in 2011–2020 will continue to pursue the overall aim of reducing biodiversity loss, in conjunction with the United Nations Decade on Biodiversity. This commitment has been taken on by the United Nations Environment Programme (UNEP) which call for a fresh forward-looking approach on the international biodiversity agenda with the formation of the Strategic Plan for Biodiversity 2011–2020 [1]. This 10-year framework for action by all countries and stakeholders will be geared towards preserving the present and future biodiversity thereby bringing benefits for all society and economy. The consequences of this initiative have seen the development of biodiversity targets where '[…] by 2020, at the latest, biodiversity values have been integrated into national and local development […] and reporting systems' [1].

Malaysia ratified the Convention on Biological Diversity (CBD) in 1994. As a signatory to the Convention on Biodiversity, Malaysia is obligated to safeguard the biodiversity through the protection and management of many protected areas (PAs). Following that, the first National Policy on Biological Diversity was formulated in 1998. This Policy addresses the impending challenges and concerted efforts that are needed to further develop and validate through new broad-based strategies that will enable the nation to protect its biodiversity in the coming years. Consequently, the National Policy on Biological Diversity 2016–2025 consolidates and ensures the continuity of efforts to conserve biodiversity and use it sustainably in the specific context of areas that are undergoing rapid socio-economic and environmental challenges. It also symbolises Malaysia's strategic response to the Convention on Biological Diversity's Strategic Plan for Biodiversity 2011–2020 [2].

However, the effective management of these PAs remained a debatable issue. Regarding the issue of policy and management, there is arguably lack of strong national leadership on sustainable development which restricts the effective implementation of consistent policies and necessary propagation of biodiversity issues. The existing policy framework for conservation and management of PAs as well as indigenous communities is sound but is not effectively implemented or monitored. Furthermore, there are inconsistent and conflicting policies between the Federal and state authorities and a lack of effective interagency coordination, including Federal-state coordination mechanisms to manage PAs. Furthermore, there is no national framework/system to standardise PA management practices. Given the fact that protected area tourism is lucrative and has become pervasive in society, intense and rapid developments have been undertaken for providing better and exclusive nature experiences. But frequently in the case of PAs, inexorable threats to the environment are unavoidable, where specifically, the development and benefits of the economic benefits (i.e. tourism industry) are enjoyed at the expense of nature and other social impacts. Therefore, there is an urgent need to conduct a systematic inquiry on the policy and governance of PAs that reiterates the importance of the local communities' participation.

This Chapter pursues several lines of enquiry. Considering some of the issues in the management of PAs, the aim of this Chapter therefore is to examine the issue pertaining to the community participation in the PA with particular reference to Taman Negara Pahang. The paper is structured as follows: after this introduction, the second section briefly reviews the concepts of PA. Following this, the third section looks at the Malaysia's PAs and some of the legislations that govern them. In the fourth section, some considerations are given to the research method of the study. The fifth section discussed specifically the case of Pahang

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National Park, in relation to the roles of PERHILITAN. The sixth section puts presents and discusses the analyses of the findings. A very brief recommendations are proposed in the seventh section. Finally, the eighth section considers some way forward for future studies in the area of PAs management.

2. Protected areas

Generally, PAs are framed with a growing need to make the environment and its diversity more sustainable, and to preserve its pristine free from human occupation or at least the exploitation of its resources is contained. More universally adopted definition across literatures has been offered by the International Union for Conservation of Nature (IUCN) in its categorisation guidelines for PAs as follows:

'A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' [3].

In retrospective, even though PAs were generally acknowledged on a national scale, a precise conceptualization and definition remained elusive until 1933, when finally an international consensus on the standards and terminology of PAs was finalised at the International Conference for the Protection of Fauna and Flora in London [4]. The effect the Industrial Revolution had had on the world's natural environment was recognised, and the need to sustain it for future generations was accorded at the 1962 First World Conference on National Parks in Seattle [5].

Since then, it has been a global commitment for the benefit of all citizens, the environment and the society, through regular revisions for the succinct categorisations to regulate and record PAs. The protection of representative examples of all major ecosystem types was endorsed by the Stockholm Declaration of the United Nations Conference on the Human Environment in 1972. This depicts the importance of jointly addressing global challenges among signatories to national conservation programmes. In effect, this also has formed part of the initiatives on conservation biology where this is of mutual benefit for all participating countries in subsequent resolutions – as stipulated by the World Charter for Nature in 1982, the Rio Declaration at the Earth Summit in 1992, and the Johannesburg Declaration 2002.

The world is on track to meet a 2020 target on the expansion of PAs, but more work is needed to ensure areas of importance for biodiversity and ecosystem services are prioritised for protection under equitably managed conditions. Issued by UNEP's World Conversation Monitoring Centre (WCMC) in partnership with IUCN, and funded by the Swiss Federal Office for the Environment (FOEN), Protected Planet is keen to promote increasing cooperation on PA strategic priorities, while providing assistance to governments for accelerating progress with recommendations for action [6]. The report finds that 15.4% of terrestrial and inland water areas and 3.4% of the global ocean are now protected—highlighting growing global awareness of the need to safeguard the natural resources. Consequently, this specifies the priority areas for mutual beneficial cooperation, which will be reflected in the upcoming Sustainable Development Goals. Noting the fact that policy impacts of PAs are different individually and in combination, the conservation of species, ecosystems and the livelihoods should also

respond and adapt to as well as mitigating the impacts of climate change —for example, by reducing risks from natural hazards and providing a carbon sink through forests, 7.8 million km^2 of which are in PAs. The report facilitates how the work will support effectively PAs policy implementation in the countries' efforts in meeting Target 11 of the Convention on Biological Diversity's Aichi Biodiversity Targets. Since 2012, a total area of new PAs totalling of 1.6 million km^2 have been designated. Target 11 calls for effectively and equitably managed conservation areas covering at least 17% of the world's terrestrial areas and 10% of marine areas—the areas aimed at creating new opportunities for biodiversity and ecosystem services—by 2020 [6].

Over the years, the importance of PAs has been at the centre of global concern against the threat of human factors which should be incorporated within environment risk management and the understanding of the necessity to the broader international sustainability and climate change agenda in a sustainable manner. PAs impacts are inherently and increasingly acknowledged not only ecologically, but culturally; taking into account the spectrum of Indigenous and Community Conserved Areas (ICCAs). International programmes for the protection of representative ecosystems remain relatively progressive (allowing specific environmental challenges of globalisation with respect to terrestrial environments to be addressed), with less advances in marine and freshwater biomes [6]. Using the August 2014 version of the World Database on Protected Areas, the protected area coverage was calculated. In 2014, the database underwent a major update, based on the overwhelmingly positive response to a CBD request for parties to the convention. The UNEP-WCMC took step to compile the UN List of Protected Areas and found that until August 2014, 124 countries had submitted new data while 15 were in the process of submitting [6].

3. Malaysia's protected area

Malaysia has established a network of PAs for the conservation of biological diversity. Some of these permanent reserved forests, national parks, wildlife reserves and sanctuaries, nature reserves, bird sanctuaries and marine parks have been established as early as the 1930s. Terrestrial PAs (% of total land area) in Malaysia United Nations Environmental Program and the World Conservation Monitoring Centre, as compiled by the World Resources Institute, based on data from national authorities, national legislation and international agreements [7]. State governments are already gazetting important new areas to encourage further shift towards conservation, for example the Sedili Kecil Swamp Forest in Johor and the limestone hills in Perlis. As for Sabah and Sarawak, these both States have special status when they joined Malaysia in 1963 in which they have jurisdiction on wildlife and forests [8]. Among prominent PA managing authorities in Malaysia include PERHILITAN, Forestry Department Peninsular Malaysia, State Forestry Departments (Peninsular Malaysia), Department of Fisheries Malaysia, Department of Marine Parks Malaysia, Johor National Parks Corporation, Perak State Parks Corporation, Sabah Forestry Department, Sabah Parks, Sabah Wildlife Department, Sabah Foundation (Yayasan Sabah), and, Forest Department of Sarawak.

The National Forestry Act (1984) has earmarked permanent reserved forest located in various parts of the country. In 1992, the National Forestry Policy was revised to take into account the sustainable use of genetic resources, the importance of biological diversity conservation and as well as the role of local communities in forest development. For now, Malaysia has about 14.4 million ha of permanent reserved forests. Taman Negara Pahang or Pahang National Park is an ASEAN Heritage Park [8]. This, in part, explains the reason behind Government's commitment on protection of biodiversity with particular attention to vulnerable to exclusion community. Consequently, Malaysia is currently a party to several multilateral environmental agreements such as Convention on Biological Diversity (CBD), Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention), and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (**Table 1**).

Level	Laws
Federal	Federal Environmental Quality Act 1974
	Fisheries Act 1985
	Pesticide Act 1974
Peninsular	Waters Enactment 1920
	Malaysia Taman Negara (Kelantan) Enactment 1938
	Taman Negara (Pahang) Enactment 1939
	Taman Negara (Terengganu) Enactment 1939
	(The State Parks from the above three Enactments constitute Taman Negara)
	Aboriginal Peoples Act 1954
	Land Conservation Act 1960
	National Land Code 1965
	Protection of Wildlife Act 1972
	National Parks Act 1980
	National Forestry Act 1984
Sabah	Parks Enactment 1984
	Forest Enactment 1968
	Fauna Conservation Ordinance 1963
Sarawak	National Parks Ordinance 1956
	Wildlife Protection Ordinance 1958
	Forest Ordinance 1954
	Natural Resources Ordinance 1949
	Public Parks and Greens Ordinance 1993
	Water Ordinance 1994

Table 1. Partial list of legislation relevant to biological diversity [9].

4. Research methods

A qualitative design was employed. Ref. [10] describe qualitative research as involving "… an interpretive naturalistic approach to the world". The researcher chose this design as it enables one to get quality look at a phenomenon.

Data was generated through unstructured interviews, covert observation and analysing documentations on Malaysia's National Park. An unstructured interview is an interview without any set format but in which the interviewer may have some key questions formulated in advance. In this research, local villagers as well as indigenous communities from Taman Negara Pahang were interviewed to establish circumstances that led them to feel engaged in the development of PA. In this study, the researcher assumed a quasi-covert observation as he mingles in the villages among the communities without status revelation. Seven respondents among local communities and researchers from the area near Taman Negara were purposively sampled for this research as they were the ones residing close to the vicinity.

5. Case study: Taman Negara Pahang

Taman Negara was established in 1938/1939 covering the area of Titiwangsa Mountains, Malaysia, as the King George V National Park. After independence, it was renamed to Taman Negara which means 'national park' in Malay. With standing reputation as one of the world's oldest deciduous rainforest, Taman Negara is estimated to be more than 130 million years old covering a total area of 4343 km^2 [1, 2].

Deforestation not only affect seriously people's health but bring tumultuous impact to environmental ecosystem, contributes to global soil erosion, climate change, drought and flooding [1]. More than half of plants species are found in the rainforest even though it only comprises less than 10% from total forest in the world, As a matter of fact, the native plants and animal species in the world's tropical rainforests are becoming extinct due to deforestation and agricultural expansion. Taman Negara is heralded as the most extensive protected area of pristine, lowland, evergreen rainforest in Malaysia. Thus, Taman Negara foresees the aim 'to utilize the land within the park in perpetuity, for the propagation, protection and preservation of indigenous flora and fauna'. Regarding the legislation of the Taman Negara, in retrospective, during the 1970s the importance of environmental legislation became more recognised at the federal level. The Protection of Wildlife Act, for example, was passed in 1972. Currently most environment-related legislation is sectoral based, meaning that conservation and protection responsibilities cross cut several departments. For example, the National Forestry Act (1984) is concerned with forestry conservation only. Concomitantly, wildlife and national parks management is the responsibility of the Department of Wildlife and National Parks. Under the Federal Constitution, land, water and forests fall under the jurisdiction of each state. Biodiversity conservation requires forests and land to be protected [8].

The history of Taman Negara can be traced back from as far as 130 million years ago, far earlier than of Africa and Latin America. Its location was far enough away from the ice during the ancient

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Ice Ages when most of the Earth was covered with immense glaciers. For many of the planet's tropical rainforests, their evolution only begun at the point when the glaciers receded. Due to this, the Taman Negara is said to be far older than the Amazon or the Congo equatorial forests. Its uniqueness lies on the fact that Taman Negara has been the home of nomadic forest people, and treasured ancient civilisations that have been flourished as well as disappeared in its wilderness. Along with its mystiques, stories and legends, already archaeologists have just developed their interests here. Simultaneously, genetic biologists who study the wealth of life that Malaysia's forest can offer also have made exciting discoveries about new medicinal plants with potential cure for AIDS, cancer, and related illnesses. Standing tall with Gunung Tahan – the country's highest mountain in Peninsular which resides in Taman Negara, this is a homegrown to more than 10,000 species of plants, 300 species of mammals such as the Sumatran Rhinoceros, the Asian Elephant, tigers, sun bear and tapirs; 300 species of fish and over 380 species of birds [2, 11, 12].

In terms of legislation, due to its geographical location sharing by the three states in Peninsular – Pahang, Kelantan and Terengganu, the Taman Negara is governed by those three state's legislation. The Taman Negara Enactment (Pahang) No. 2 of 1939 is enforced in the state of Pahang, the Taman Negara Enactment (Kelantan) No. 14 of 1938 in the state of Kelantan and the Taman Negara Enactment (Terengganu) No. 6 of 1939 in the state of Terengganu. However, the contents of the legislations are rather generic. In terms of size, Taman Negara Pahang is the largest at 2477 km^2, followed by Taman Negara Kelantan at 1043 km^2 and Taman Negara Terengganu at 853 km^2. PERHILITAN as the body entrusted with the responsibility to manage the Taman Negara requires all visitors to obtain permits to enter the area. Beside Gunung Tahan, which is accessible through Kuala Tahan or Merapoh as the entry point [13], visitors can enjoy several other geological and biological spots available in the park. Canopy walkway was erected as one of the iconic symbol of the park - that fast becoming a must visit ecotourism destination in Taman Negara. With regard to richness of flora and fauna, National Park is home ground to some rare mammals, such as the Malayan tiger [13], crab-eating macaque, Malayan gaur (seladang) and Indian elephant. Bird species such as the great argus, red junglefowl, and the rare Malayan peacock-pheasant are still found here in some numbers. Tahan River has been preserved to protect the Malaysian mahseer (ikan kelah in Malay), a type of game fish.

5.1. Department of Wildlife and National Parks (PERHILITAN)

The Department of Wildlife and National Parks (DWNP) or PERHILITAN is an agency tasked with the management of national parks and wildlife reserves in Peninsular Malaysia. The management of these areas is aimed to the long-term conservation of PA while mitigating or reducing conflicts between human and the environment orientated around the planning and implementation of various activities. To ensure optimum benefit to human and prosperity to the environment for the present and future generation, the development of PA was done sustainably [7]. The swiftness of the response to the concern over the loss of biodiversity, in providing for the conversation agenda has been overwhelming. What is now important is how the rebuilding efforts are sustained. PERHILITAN has played a central role in the empowering communities to those living in the vicinity of Taman Negara through the provision of aid for immediate basic needs and also through the actions of many small community based NGOs. Along with other agencies such as Department of Orang Asli Development Malaysia (JAKOA),

this are orientated towards longer-term objectives in providing both a voice as well as practical assistance to specific segments of the population affected by the development. Through a cooperative approach, university researchers can also work along with communities more efficiently than in the past. In the case of nearby villages, the highly satisfactory results are in information for planning, improved local community consultation, improved enforcement and improved stakeholder engagement through the operationalising of formal governance mechanisms. Consequently, these are the strengths of the Taman Negara Pahang.

The networking of community and stakeholder engagement initiatives addressing multiple need of stakeholders including a diversity of communities - are significant achievements. The inclusion of various stakeholders is prerequisite for the project's success, improved technical and logistical capabilities coupled with more effective coordination on the ground have contributed to improvements in the overall park management [8].

6. Discussion

6.1. The importance of building capacity for indigenous knowledge

Communities living in or near the protected area, visitors and other stakeholders of PA will feel a far greater commitment to park management objectives and practices if they have the opportunity to be involved in managing the resource. In Kampung Gol, Kuala Tahan, the villagers, through the Taman Negara Bird Group (TNBG) have indulged seriously on bird watch activities when they collaborated with a group of researcher from Universiti Teknologi MARA (UiTM) – one of the Malaysia's public universities. This indicates an increased sense of ownership, the nature of traditional knowledge and cultural values represent the core for building a strong foundation that will ensure sustained growth. Arguably, therefore, that a first priority for developing efforts should be to exploit tacit knowledge by increasing participation of individuals and other local communities that could have a substantial impact on the process of development. Engage and empower indigenous peoples and local communities living in and around nature tourism sites as active participants in ecotourism planning and implementation so that their livelihoods are improved and the sites are better protected. It includes the incorporation of local knowledge and the power to input into the management process of these local resources which is often more important in supporting and providing the basis of local livelihoods to a majority of the population in a developing region such as Kuala Tahan and surrounding areas nearby Taman Negara.

Biodiversity, or the variety of life on earth, is something that we all critically depend on. It is essential to the well-being of the planet and, in particular, for the human beings who live on it [14]. In an effort to provide clarity, the World Bank explains that indigenous knowledge (IK) is the 'social capital of the poor, their main asset to invest in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives'. The United Nations describe the importance of the local knowledge this way: 'Indigenous Knowledge is the basis for local decision making and problem solving in areas including, but not limited to, agriculture, health care, food preparation, education and natural resource management.

IK is tacit knowledge traditionally held by communities rather than individuals and is commonly embedded in community practices, institutions, relationships and rituals and therefore, difficult to codify' [15]. Generally, (1) the indigenous system is not well connected among various sectors of the economy including universities, private enterprises, government agencies and grassroots innovators. Owing to the inadequacy of scientific and technological research, low investment expenditures and poorly trained labour, the linkage of the traditional knowledge system with the modern knowledge system is inadequate to generate high backward and forward linkages. (2) Because of duality of the economic structure, indigenous peoples have remained isolated from modern sectors of the economy in which most modern technologies are employed. Under such circumstances, building technological capacity to foster growth is limited by lack of skilled labour capable of using, and access to training in, modern technology. (3) The modern knowledge system practised in developing countries is not well integrated into the global knowledge system. In these countries, inadequacy of international standards does not permit rapid improvement in the quality of technology and, therefore, engenders poor quality in products outputted in these countries. (4) The traditional knowledge system is disconnected from the educational and learning systems in developing countries. Accordingly, traditional knowledge systems to continue relying on traditional ideas and primitive practices with little input from modern knowledge. In isolation, the traditional knowledge system cannot promote global competitiveness. Only modern knowledge facilitates productivity through more efficient utilisation of IK. (5) It is not easy to codify and record IK and, therefore, sharing this kind of knowledge among communities and cultures becomes difficult [16, 17]. Most of these ideas are in the form of tacit knowledge stored in the mind of people who live in a given environment influenced by unique features related to their worldview. Some of these ideas have been in existence for thousands of years, which could further be developed in the light of the new knowledge and technologies [18].

Orang Asli in Taman Negara engage in predominately around the tourism industry and other activities that are inter-connected with this important industry such as fresh water fisheries. In developing countries, typical traditional rural communities benefits from a large number of species for medicinal purposes. This localised knowledge has been used by pharmaceutical companies in their search of new drugs, with high biodiversity and long tradition of the use of plants for medicinal purposes [2]. Biodiversity forms an essential part of the cultural life of Malaysia's indigenous people, including food and medicine from plant and animal species. For instance, both the availability of trees, rattans and aquatic plants as well as other natural offer motifs for carving and traditional weaving. The Dayak and Orang Asli, for example, incorporate designs of leaves, seed pods, tendrils, buds and flowers in their traditional carvings of houses. In echoing the cultural consciousness of the value of biodiversity to local community, towns and villages are named after important and useful plants, animals and characteristics found in nature, such that modern-day built-up environments persist [2]. A review conducted into management of PA in Taman Negara Pahang found that communities would show greater commitment to the Park's objectives if they were involved in the management process. The review recommended that all stakeholders should be engaged regularly to discuss decisions that will affect them. Further, PERHILITAN officer should continuously build relationships with all stakeholders, to establish a platform for dialogue, cooperation, and information sharing. Other studies have shown that a strong conservation ethic will arise from the community's

sense of ownership of their heritage and the ability to see the connection between their livelihoods and sustainable resource use. Experience in many locations has demonstrated that involving local stakeholders in community-based resource management requires a great deal of consultative work, trust and commitment. The process requires patience and understanding and it cannot be shortened or rushed. The lack of such consultation in Malaysia in part explains why externally developed management activities in the PAs have had limited success.

It is observed that, the informal sector tends to be larger in rural areas dominated by primary industry including agriculture and fisheries, when considering a broader international context [19]. Also typically elsewhere, the informal sector is of crucial significance to the tourism industry with no exception to Taman Negara Pahang. In the nearby villages, the communities involvement in the informal and agricultural sectors found to account for a conservatively estimated over half of employment. With a high proportion of the local communities dependent on income from the informal sector, the direction of social sustenance centred around livelihood support and social protection, needs to bear in mind underlying conditions impacting upon the target population. This is vital to ensure the effectiveness of any initiatives designed to foster a sustainable environment, which will underpin the long-term viability of both the economy and the natural environment upon which the economy depends. In the light of biodiversity loss such as deforestation, destruction of endangered fauna and flora, water pollution, sedimentation, decimation of water catchments, soil erosion, landslides, and downstream flooding, these problems have been worsened and turned into disasters due to the extremely fragile and sensitive nature of geographical ecosystems, which disrupts the ability of most of those affected as they did prior to the disaster. Organisations such as the Malaysian Nature Society (MNS) and the World Wide Fund for Nature-Malaysia (WWF-Malaysia) have played significant roles in scientific work as well as in advocacy in the conservation of biodiversity in Malaysia for the last few decades [8]. There is an effort to establish a framework for evaluating the effectiveness of PA management and governance, including developing appropriate criteria, methods, standards, and indicators for the National PA system, taking into account the IUCN-World Commission on Protected Areas (WCPA) Framework. For example, community groups have been formed in order to improve participation in local government decision making and rehabilitation initiatives including the rebuilding of the houses which were demolished by the massive flood in 2016. The need to look after our natural environments and their biodiversity is a matter of great urgency as species become extinct at ever increasing and alarming rates, almost entirely as a direct result of human activities [20]. Yet despite evidence of local resilience community resources can be further be optimised with careful planning and plan of action.

6.2. The role of PERHILITAN in facilitating sustainable and resilient communities

Through its role in environmental management, monitoring and reporting, PERHILITAN plays a significant role particularly when they are involved in initiatives that engage with local communities aimed at rebuilding livelihoods to facilitate sustainable and build resilience. A holistic approach focused on long-term solutions to significantly sustaining the PAs management for those living in the National Park is increasingly a focus of PERHILITAN. This agency has become a valuable and ongoing contributor to efforts to conserve biodiversity through its role in local management of the park. In terms of risk, a biodiversity resource such as a natural forest,

may be considered for economic use by one stakeholder but have a different usage for local inhabitants who may see its use as 'an inalienable right' [21]. Benchmarking Australia, under the Environment Protection and Biodiversity Conservation Act 1999, regional communities are obligated to provide lists of endangered and critically endangered species, vulnerable species, and nationally threatened species, populations and ecological communities and key threatening processes [22, 23]. Because the PERHILITAN has been in partnership and networking with various stakeholders as well as with university researchers, it is a leading government agency with local legitimacy. With close and trust based relationships that the PERHILITAN has built with local communities, other agencies can leverage on this unique networking. At the same time, PERHILITAN can become a facilitating conduit for other agencies to deliver aid and coordinate programmes on the ground, through establishing and engaging with the park communities. This positions the PA as pivotal in the park – government relationship. In addition, PERHILITAN, when partnering with local communities, can play an important role especially in context of the local knowledge they are able to offer. Typically, PERHILITAN have a greater understanding of the local area, the community, and the situation on the ground, and are generally the lead agency to champion and drive any initiatives for national park. NGOs on the other hand, with direct links and ties into local communities, have the capacity to ensure that local level stakeholders are included. This governance model of PERHILITAN and NGOs working together, has not only enabled local people to be more directly involved in PA initiatives but foster greater community involvement through actively engaging with local communities. Such an approach provides an additional benefit of enhancing local capacity and building community resilience in the face of challenges that may limit the effectiveness of PA management.

6.3. Empowered and harnessed the commitment of all stakeholders to conserve biodiversity

Conservation of biodiversity and the sustainable use of biological resources are complex and multi-facetted issues, which need to be determined and carried out at the national and local levels [24]. Realising this, the Government adopts a coordinated effort to manage the conservation of biodiversity in Malaysia. The initiative involves partners from the UN based in Malaysia, as well as a wide range of NGOs both at international and the local level who have significant influence on the intended changes and, at times, the capacity to fully determine the intervention approach and under what circumstances, thus having a direct impact on the biodiversity in local territory. However, part of the problem in relation to biodiversity responsibilities in Malaysia is fragmentation, with no single body, or collection of state bodies, assigned to undertake the systematic collection and reporting of biodiversity trends nationwide – pose a challenge for sustainable development. The management of the park is mainly enforcement rather than 'education' with limited funds, limited monitoring capabilities and limited expertise. Furthermore, complication in terms of governance across different authorities could leave communities disempowered when attempting to monitor or question arrangements, uses and conservation of biodiversity resources. Consideration of this in the context of the recent massive flooding seems particularly pertinent. Each sector has its own mandate and aspirations, all parties need to work together so that biodiversity conservation and sector-specific development go hand in hand – as both are crucial components for nation building.

In the National Policy on Biological Diversity 2016–2025, Malaysia outlined multiple insights highlighting to be taken into consideration in addressing biodiversity objectives. It is recognised that natural resource system is subject to depletion, degradation or use which exceeds sustainable yields [25]. Second, in Ref. [26], the anthropogenic factors and their correlation with biodiversity loss of mammals and birds are examined. They found that overuse of natural resources, albeit for survival, can severely degrade resources and eventually deny supply to the very people who need them. It should be noted that wholesale importation of inappropriate Western technologies has caused serious damage to indigenous culture and natural environment by suppressing traditional knowledge, increasing the risk of pollution, disrupting natural habitats and forcing migration [18]. In other words, decisions to promote development must take into consideration local factors that impact human transformation, be they cultural, religious, social, environmental, technological, economic or political. For that reason, the focus on developing and leveraging on local talents is more towards ensuring the local resilience and better protection of their well-being by investing in the strengthening the social capital, traditional knowledge and cultural values.

It should be noted that these indigenous factors are vital for accelerating economic growth and sustaining development. In most developing countries, the failure of development policies to achieve satisfactory levels of development has been correctly attributed to the neglect of local ingredients in the potpourri of development [18]. For instance, recruitment of local key staff with technical knowledge are underrated strategy as they are often less visible, and their rights are mostly ignored by many parties. Thus, relevant authorities or agencies need to employ local people with biology backgrounds as they understand the area ecosystems, threats and mitigation and this will lead to the better management of these vulnerable ecosystems. Learning from the model of Johor National Park Corporation (JNPC), there has been a unique practice in which they employ the local communities as caretaker and rangers to be responsible for environmental monitoring and enforcement that is essential for effective park management. This practice can be expanded to other park authorities at other locations. The importance of the relationship between government and community support for biodiversity safeguarding and management is a key focus underpinning the objective of livelihood sustainability; in fact, it is an important factor in the proper management of ecosystems [27].

In 2004, Malaysia strengthened its management of conservation at the federal level when the restructuring of the ministries led to the formation of the Ministry of Natural Resources and Environment (NRE). In addition, building stakeholder understanding is critical for positive management outcome. If stakeholders, e.g. local universities, local communities, and any other knowledgeable individuals, truly understand the ecosystem threats to the park management they will undertake their own management intervention to mitigate the threats e.g. the establishment of UiTM-PERHILITAN Research Station and the Centre for Biodiversity and Sustainable Development of UiTM will certainly add value to the sustainable practices of the area, as researchers from university who work closely with local communities knew the situation very well, with their own adaptive management intervention. Besides, they also able to supply relevant data voluntarily to local authorities regarding the severity of water contamination or potential landslides at some of the area.

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7. Recommendation

In National Policy on Biological Diversity 2016–2025 Malaysia, a number of issues were to be addressed through all national and state development policies, plans and programmes. This is to ensure that there is an appropriate mechanism that is responsive towards biodiversity and incorporate sufficient safeguards to protect and conserve the biodiversity. All sectoral policies, including those on forestry, energy, agriculture, tourism, transportation, extractive industry and infrastructure, will need to address biodiversity conservation. To facilitate the process of development and strengthen the foundation for knowledge, government should:

- provide knowledge, information, skills and incentive to local people in a manner to increase their participation in the economy. Special programmes should be created to learn more about indigenous people and earn their trust by giving them voice in policy construction and decision makings. Local knowledge helps communities to enforce, implement and monitor the policies, rules, laws and regulations formulated for National Park capable of solving problems directly related to development process.
- adopt practical approach when implementing PA initiatives by considering the local community's readiness to adopt, the options available and how their impact will be assessed before any implementation occurs. Also, this provides a more holistic long-term sustainable initiatives to the specific governance structures to facilitate communication and create synergies while addressing the multiple threats of overfishing, poaching, illegal logging and illegal trade in wild animals, improper sewage, climate change and watershed due to major flooding, etc.
- Encourage initiatives that involve the local community and provide for the long-term sustainability of practical mechanisms, as in international instruments, often call for a designated focal point. Governance models seem to include political/management/technical levels, where political decisions are translated into an action plan carried out through their engagement with local communities and representation of those who are often strong in number supported by national institutions and scientific/technical boards.

8. Conclusion

Malaysia had been aware of the problems of the loss of natural habitats and environmental degradation resulting from economic development and has addressed these problems as early as 1975 and in the Third Malaysia Plan (1976–1980). Long-term initiatives that promote sustainable economic growth for particularly indigenous communities are vital. The approach to conservation that has been in place for over 2 decades is a 'top-down' or centrally managed, rather than a 'bottom-up', community-led model. However, it is increasingly acknowledged that this approach has limitations, particularly as local communities who are vulnerable have not been involved in management of the parks, in a way that is inclusive. In the spirit of facilitating sustainable development, the role of PERHILITAN in the biodiversity conservation

agenda is crucial, as too is the recognition that they are the custodians of vast biodiversity assets provide opportunity to promote an integrated risk management approach to development planning which ties in with the over-arching emphasis on empowering the local communities as advocated by the Malaysian Government, the UN as well as many NGOs. What has emerged as a critical question is how all the initiatives will benefit those living in local communities. Certainly, local populations to benefit, either directly or indirectly, so that any socio-economic activities enhance both the environmental and socio-economic conditions of an National Park area.

Management effectiveness in protected area is the most prevalent issue and widely discussed globally. Effective management of PA as defined by the World Conservation Union IUCN is the efficiency use of human and material resources including national/agency protected area regulations and legislation, policies, international conventions and designations, and management plans and/or agreements associated to those areas, on a planned basis directed to accomplish management objectives. It is also crucial for protected area authorities to involve the local communities – the villagers including the Orang Asli, in the management of the PA. In many instances, water management, climate change, cultural features and natural environment require local solutions for sustaining the use of resources and protecting the local system of production. Therefore, what PA needs are policies that respect the rights of local communities and indigenous peoples, including their right to self-determination, empowering initiatives, a fair share of the economic benefits, and sustained protection for their ecosystems.

Finally, it needs to be noted that this Chapter reports the findings of an exploratory study in which the case study of Taman Negara Pahang has provided some insight as to where future efforts need to be directed to improve the effectiveness of PA management. It is proposed that the next step will be to collect data from a larger sample of respondents. This will allow for further effort could be made to assess the process for community engagement, – for instance to include a more in-depth analysis of the potential influence of the specific activities undertaken within the overall holistic management of PAs. Additionally, there needs to be an assessment of the relationships between adherence to the community participation process presented in this Chapter and the total achievement of sustainability goals for the testament of an efficient PA management.

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Conflict of interest

The author certifies that he has NO affiliation with or involvement in an organisation or entity with a financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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The rapid fragmentation and habitat change in natural environments have created a need for management and conservation, which will ensure areas are protected from anthropogenic interference. These protected areas are necessary to provide adequate location for biodiversity conservation, environmental monitoring, and scientific research where a complete understanding of the natural process and full protection of ecosystems can be attained. This book highlights various approaches for managing and conserving protected areas in temperate and tropical regions to respond to some pressing global challenges today. It is divided into five main sections, viz., protected area management, fish and wildlife conservation, biodiversity conservation, ecotourism and recreation, and local community participation. The book enhances the understanding of the important roles national parks play in the environment and society.

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