Testing Ecotourism Principles in Nicaragua

The cases of the Nature Reserves Mombacho Volcano and Datanlí – El Diablo

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Cover: Landscape view of Apanas Lake from the trail El Leon in NRDE, Jinotega, (photo: H-G. Wallentinus) and tourists hiking in the trail El Crater, NRMV, Granada, Nicaragua (photo: M. Somarriba-Chang).

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Testing Ecotourism Principles in Nicaragua. The cases of the Nature Reserves Mombacho Volcano and Datanlí–El Diablo

Abstract

The purpose of this study is to determine if ecotourism principles are being applied in Nicaragua. The cases studied were the Nature Reserves Mombacho Volcano (NRMV) and Datanlí–El Diablo (NRDE). The research questions addressed were the following:

1. Are the tourism activities contributing to conserving the protected areas and their biodiversity?
2. Is ecotourism promoting awareness in visitors and local people?
3. Are the local communities benefiting from these activities and, if so, how relevant is their participation?

Changes in plant cover, plant species, and medium and large-size mammals were studied along walking trails to determine if tourists had impacted richness, abundance and diversity of these parameters. Data relating to vegetation cover and composition were collected at sites along the trails and comparative pristine (undisturbed) locations in the NRMV in 2005 and 2007. For the large and medium-sized mammals a total of 48 censuses were carried out, 24 at each site. Two methods were used: fixed wide transects and the camera tracker trap technique.

A method for determining the recreational carrying capacity (RCC) of hiking trails in protected areas was tested. To collect the social information individual structured and semi-structured interviews and focus groups were used. The objective of using different tools was to avoid bias by combining quantitative and qualitative interview techniques

The results indicate that there is a significant reduction of vegetation cover along the trails, mostly in a band adjacent to the trails. For tree species richness there were no significant differences between the control and trail-sides, whereas for the understorey species there were significant differences between these comparisons. This indicates an ecological impact on the understorey species composition and richness due to trail use.

In the case of large and medium-sized mammals only a pilot study was completed. It indicates that there are no statistically significant differences between hiking trails within a nature reserve. However, the ordination analyses indicate a difference in the species composition between hiking trails in the most visited reserve.

The results of the Social Carrying Capacity (SCC) indicate that the main constraints for all trails were the spatial and accessibility limiting factors. In broad terms the RCC methodology is a tool for determination of the required physical conditions and management capacities for tourist management.

This study demonstrates that the farmers in the two nature reserve communities are engaged in the protection of the reserves because they are aware of environmental concerns and recognize that their own welfare can be affected.

Keywords: ecotourism principles, plant species diversity, large and medium-size mammals, stakeholder participation, local benefits, recreational carrying capacity, nature reserves Mombacho Volcano and Datanlí–El Diablo.

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Probando la aplicación de los principios del ecoturismo en Nicaragua. Los casos de las Reservas Naturales Volcán Mombacho y Datanlí–El Diablo

Resumen

El propósito de este estudio es determinar si los principios del ecoturismo se han cumplido en sus dimensiones ecológicas y sociales. Los estudios de caso fueron las Reservas Naturales Volcán Mombacho (RNVM) y Cerro Datanlí–El Diablo (RNDE) en Nicaragua. Las preguntas de investigación planteadas en este estudio fueron:

1. Las actividades de turismo de naturaleza están contribuyendo a la conservación de las áreas protegidas y su biodiversidad?
2. Estas actividades turísticas promueven la conciencia ecológica en los visitantes y la gente local?
3. Se están beneficiando las comunidades locales de estas actividades y, si es así, que tan relevante es su participación?

Cambios en la cobertura vegetal, especies de plantas y de mamíferos grandes y medianos fueron estudiados a lo largo de los senderos para determinar si los turistas han tenido un impacto en la riqueza, abundancia y diversidad de especies. Para las especies vegetales se hicieron inventarios, un total de 48 parcelas y subparcelas fueron levantadas. Datos sobre la cobertura vegetal y la composición de la vegetación fueron recolectados en sitios a lo largo de los senderos y en sitios testigos (no disturbados) en la RNVM en 2005 y en 2007. Para los mamíferos grandes y medianos un total de 48 censos fueron realizados, 24 en cada sitio. Dos métodos fueron utilizados: transectos de ancho fijo y trampa cámara automática.

Un método para la determinación de la capacidad de carga recreativa (CCR) de los senderos en áreas protegidas fue probado. La estimación de la CCR considera las condiciones físicas específicas de los senderos, las oportunidades para los turistas de apreciar los atributos naturales del sitio, y las capacidades de manejo del área protegida. Para recolectar la información social se usaron entrevistas individuales estructuradas y semi-estructuradas, y grupos focales. El objetivo de usar diferentes herramientas fue para evitar parcialidad; combinando metodologías cuantitativas y cualitativas.

Los resultados indican que hay una reducción significativa de la cobertura vegetativa a lo largo de los senderos, principalmente en una banda adyacente a los senderos. La riqueza y diversidad de especies arbóreas no muestra diferencia significativa entre los testigos y los márgenes de los senderos, sin embargo para las especies del sotobosque, si hay diferencia significativa entre estas comparaciones. Esto indica un impacto ecológico sobre la composición y riqueza de las especies del sotobosque debido al uso de los senderos.

En el caso de los mamíferos grandes y medianos solo un estudio piloto fue completado. Este estudio indica que no hay diferencias estadísticas entre los senderos dentro de una misma reserva natural. Sin embargo, el análisis multivariado indica

una diferencia en la composición de especies entre los senderos en la reserva natural más visitada (RNVM).

Los resultados de la capacidad de carga social (CCS) indican que los principales limitantes para todos los senderos fueron el factor limitante espacial y el factor accesibilidad. Las capacidades de manejo estimadas para las dos reservas naturales al momento del estudio fueron entre 62 y 74% del óptimo. Por lo cual existe una necesidad de mejorar las capacidades de manejo para permitir mayor numero de visitas a las reservas. En general la metodología aplicada para estimar CCR es una herramienta para determinar las condiciones físicas y las capacidades de manejo requeridas para el manejo del turismo en áreas protegidas.

El presente estudio además demuestra que los productores de las comunidades en las dos reservas naturales están involucrados en la protección de las reservas naturales porque están concientes de los problemas ambientales y reconocen la importancia de las reservas para su propio beneficio. En diferentes formas los productores y comunidades se benefician de las actividades de ecoturismo que ocurren en las reservas, pero no lo suficiente. Sea porque se encuentran excluidos del manejo directo del turismo o porque carecen de los recursos para promover los sitios y mejorar la infraestructura de acceso. La actitud conservacionista de los turistas fue bastante alta y sus expectativas acerca de la reserva natural visitada fueron satisfechas en su mayoría, lo cual indica que ellos también se han beneficiado.

Palabras claves: principios del ecoturismo, diversidad de especies vegetales, mamíferos grandes y medianos, participación de los actores, beneficios locales, capacidad de carga recreativa, reservas naturales Volcán Mombacho y Datanlí–El Diablo.

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Dedication

To my daughter Natalia, my sons Allan Josué and Eduardo Abraham and to my husband Benigno Abraham; for their patience and understanding of the time and effort I devoted to my doctoral studies in Nicaragua, Sweden and elsewhere.

”If you don't go after what you want, you'll never have it. If you don't ask, the answer is always no. If you don't step forward, you're always in the same place”.
Nora Roberts (Eleanor Marie Robertson)

Contents

Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Somarriba-Chang, M. (2010). Vegetation cover and diversity changes due to the use of walking trails in the nature reserve Mombacho Volcano, Nicaragua. Submitted.

II Somarriba-Chang, M., Wallentinus, H-G. and Garmendia, M. (2010). Tracking mammal species along hiking trails in two nature reserves in Nicaragua – a pilot study. Submitted.

III Somarriba-Chang, M. and Gunnarsdotter, Y. (2010). Are the social principles of ecotourism applicable in two Nature Reserves in Nicaragua? Submitted.

IV Somarriba-Chang, M. and Wallentinus, H-G. (Year). Recreational Carrying Capacity in hiking trails. Three case studies in Protected Areas in Nicaragua. Manuscript.

The contribution of Matilde Somarriba-Chang's to the papers included in this thesis was as follows:

I Matilde Somarriba-Chang is the single author of this paper.

II Matilde Somarriba-Chang did the field investigations, made the statistic calculations, and wrote most of the text.
Hans-Georg Wallentinus did the judgments of the distribution pattern observed.
Miguel Garmendia made the design of the monitoring methods and participated in the field investigations.

III Matilde Somarriba-Chang made the field work and wrote the main part. Yvonne Gunnarsdotter reviewed the text and made contributions to improve it, she also took part in the discussion and conclusions sections.

IV Matilde Somarriba-Chang did the field work and wrote the text.
Hans-Georg Wallentinus did the revision of the methodology in cooperation with Matilde. HGW suggested a number of questions for the discussion.

Abbreviations

CANTUR	Camara Nicaraguense de la Pequeña y Mediana Industria Turistica; Nicaraguan Small and Medium Tourism Industry
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza; Tropical Agricultural Research and Higher Education Center
CBD	Convention on Biological Diversity
CCAD	Comisión Centroamericana de Ambiente y Desarrollo; Central American Commission of Environment and Development
FUNCOC	Fundacion Cocibolca; Cocibolca Foundation
HDR	Human Development Report
INETER	Instituto Nicaraguense de Estudios Territoriales; Nicaraguan Institute of Territorial Studies
INTUR	Instituto Nicaraguense de Turismo; Nicaraguan Institute of Tourism
IUCN	International Union for Conservation of Nature
MARENA	Ministerio del Ambiente y de los Recursos Naturales; Ministry of Environment and Natural Resources
NRDE	Nature Reserve Datanli – El Diablo
NRMV	Nature Reserve Mombacho Volcano
SINAP	Sistema Nacional de Áreas Protegidas; National System of Protected Areas
TIES	The International Ecotourism Society
UNA	Universidad Nacional Agraria; National Agrarian University
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO - MAB	United Nations Educational, Scientific and Cultural Organization - Man and the Biosphere Program
UNWTO	United Nations World Tourism Organization
WCPA	World Commission on Protected Areas
WICE	World Institute for Conservation and Environment

1 Introduction

Conservation of biodiversity is a major challenge faced by the world as a whole. Protected areas in developing countries are reservoirs of biodiversity as well as the means for the survival of inhabitants of these rich areas. Nicaraguan protected areas confront these two challenges that have not in all cases been prospering together.

Ecotourism has emerged as an alternative to maintain the conservation of protected areas and to support local communities with social benefits and secondary sources of income. The International Ecotourism Society (TIES) defines ecotourism as "responsible travel to natural areas that conserves the environment and improves the well-being of local people" (TIES, 1990). Therefore, ecotourism requires not only having the natural attractive features but also engaging the responsibilities of business and government with local participation.

There is a broader concept than ecotourism, sustainable tourism, defined by the World Tourism Organization (UNWTO, 1999): "Sustainable tourism development meets the needs of present tourists and host regions while protecting and enhancing opportunities for the future".

According to UNWTO (2002) sustainable tourism should:

1. Make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity.

2. Respect the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance.

3. Ensure viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation

Although the importance of sustainable tourism and ecotourism and how to implement ecotourism have been explained by several authors and organizations (Krüger, 2005), it is relevant to evaluate if the significance and implications of ecotourism are being achieved in practice. My main interest in conducting research in this thematic area came from the question if ecotourism principles are being applied in Nicaraguan protected areas and how they are being achieved in their ecological and socioeconomic dimensions. There has been a lot of promotion of ecotourism (or so called) in Central America and I became concerned about whether this is achievable in a low income developing country as Nicaragua.

With that in mind I approached the Ministry of Environment and Natural Resources in Nicaragua, specifically the Protected Areas POSAF (Programa Socio Ambiental y Forestal) project. This project has been working in several protected areas in the country. They developed their management plans in accordance with the laws and regulations, as well as considering the potential uses of natural resources in a sustainable manner to improve local family livelihoods. The persons in charge of this project helped selecting the two protected areas that are the subject of my study. Because of the natural characteristics and attractiveness for ecotourism, both areas have similar ecosystems and fauna. However, they differ in the social issues, tourism development and the management approach applied (FUNCOC, 2003; MARENA, 2002). They were suitable for the purpose of the questions raised by this research.

1.1 Protected areas on a global scale

The World Database on Protected Areas (WDPA) has registered 104 791 protected areas that cover a total surface of over 20 million km^2.This figure includes all nationally designated sites and covers a broad range of types of protection like forest reserves, private reserves, strict nature reserves and national parks (www.wdpa.org). Although it is a large area, it represents only 12.2% of the world land surface; less than 2 million km^2 of ocean are protected (0.5% of the total ocean surface) (Chape, Harrison, Spalding & Lysenko, 2005).

The literature about the benefits of and reasons for promoting the establishment of protected areas is abundant (Brooks et al., 2004; Bruner, Gullison, Rice & Da Fonseca, 2001, Corcoran & Petermann, 2003; IUCN-WCPA, 2000). Protected areas play a number of key social and economic roles. They give many indigenous and local people vital protection and space where they can continue traditional lifestyles that are now often

impossible elsewhere. A disproportionate amount of the world's drinking water comes from forest protected areas (for instance a third of the world's hundred largest cities draw a substantial proportion of their drinking water from protected areas) (Kalemani & Chape, 2004).

Tropical montane cloud forests are considered rare ecosystems, their potential area in the world is about 380 000 km^2, only 2.5 per cent of all tropical forest (Bubb, May, Miles & Sayer, 2004). The biodiversity attribute of cloud forests is of global relevance, as it also has national and local values. Tropical montane cloud forests have an important contribution in endemism (occurrence of species confined only to the area of concern and found nowhere else), "which is one of the most important components of biological diversity wealth and heritage" (Bruijnzeel & Hamilton, 2000, p 17).

Despite the apparent growth in the number of protected areas worldwide, animal and plant species are still becoming extinct and habitats lost at an alarming rate, and the integrity and viability of many conservation areas are under threat from numerous interventions (Kalemani & Chape, 2004). A gap analysis of the global protected area network found that the current global network has at least 12% of terrestrial vertebrates species not represented in any protected area (gap species). Other taxa with high levels of endemism (plants and insects), would have a higher ratio of gap species, because their smaller range sizes. These results indicate that a network biased towards the tropics (to match their higher level of endemism) would have fewer gap species and a better coverage of biodiversity (Rodrigues, Andelman, Bakarr, Boitani, Brooks, Cowling et al. 2004). On the other hand, in a study comprising 93 protected areas in 22 countries, evaluating the effectiveness of parks at protecting biodiversity, it was found that national parks are effective at stopping land clearing, and to a lesser degree at mitigating logging, hunting, fire, and grazing. This indicates that protected areas in tropical countries are "protecting the ecosystems and species within their borders" (Bruner et al., 2001, p 126).

The management of a protected area requires compromising with the local communities. It has to consider that local communities' livelihoods have been dependent on the resources in the area way before this was 'declared' protected. There are several examples in developing countries about the failure of managing a protected area due to the lack of conservation strategies that consider alternatives for the socioeconomic well-being of the communities in and around the protected areas. Local communities have to renounce some of the natural resource uses due to conservation objectives in the area (García-Frapolli, Ramos-Fernández,

Galicia & Serrano, 2009; Rao, Maikhuri & Saxena, 2003; Wells & McShane, 2004).

1.2 Ecotourism as an alternative to nature conservation and local livelihood improvement

Besides The International Ecotourism Society (TIES) and United Nations World Tourism Organization (UNWTO) concepts given in the introduction, there are others that have defined ecotourism. For instance, ecotourism is considered a type of sustainable tourism in a nature-base tourism setting (Wood, 2002). Ecotourism is also defined as "environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features - both past and present) that promotes conservation, has low negative visitor impact, and provides for beneficially active socioeconomic involvement of local populations" (Ceballos-Lascurain, 1996). According to the World Ecotourism Summit (UNWTO, 2002), ecotourism is sustainable tourism, which follows clear processes that:

- Ensures prior informed participation of all stakeholders,
- Ensures equal, effective and active participation of all stakeholders,
- Acknowledges indigenous peoples communities' rights to say "no" to tourism development - and to be fully informed, effective and active participants in the development of tourism activities within the communities, lands, and territories, and
- Promotes processes for indigenous peoples and local communities to control and maintain their resources.

On a more synthesized approach, Mader (p. 101, 2003) in his analysis of the ecotourism concept in Latin America indicates three criteria to define ecotourism:

- "It provides for conservation measures;
- it includes meaningful community participation, and
- it is profitable and can sustain itself".

These principles can be subdivided and be more specified, as Fennell (2003, p. 25) did by comparing 15 different ecotourism and nature tourism definitions. He identified thirteen principles that included ones as simple as "interest in nature" to the complex principle of being "sustainable". The same author in an analysis of 85 ecotourism concepts applied around the world found that the five variables most frequently encountered in the application of ecotourism concepts are: (1) 'where ecotourism occurs'; (2)

'conservation'; (3) 'culture'; (4) 'benefits to locals'; and (5) 'education' (Fennell, 2001).

Independently of the numbers of principles involved in the definition, they need to be applicable, measurable and evaluated (Fennell, 2003; Krüger, 2005; Mader, 2003). Otherwise they are just nice wishes or theoretical desires. But these goals are difficult to achieve one by one, even more so all together. There has been considerable research and literature developed around the world about the practice of ecotourism. However, it is directed at specific components of ecotourism. On the subject of ecological, social and economic impacts hundreds of studies have been published (Weaver & Lawton, 2007). There is also some research published identifying the adherence to ecotourism principles in developing countries, studying mainly ecotourism potential for ecologic and economic sustainability (Krüger, 2005; Place, 1995; Tsaur, Lin & Lin, 2006; Wallace and Pierce, 1996; among others). Published research specifically evaluating the local participation and benefits in developing countries is quite abundant as well (Lai & Nepal, 2006; Nepal, 1997; Ormsby & Mannie, 2006; Xu, Lu, Chen & Liu, 2009; among others). Particularly in Latin America some cases illustrate the importance of local participation to ensure successful development and eventually sustainability of ecotourism (Hearne & Santos, 2005; Hernández, Bello, Montoya & Estrada 2005; Klak, 2007; Stronza & Gordillo, 2008). Whereas the results vary from place to place, the common denominator is that an ecotourism approach is not a recipe to be followed. It is a way of managing a tourism enterprise, which has to take into consideration the ecological, social, cultural and economic context where it is developed. The principles are guidelines to be applied in accordance with the particularities of every case. The shared goal is: a sustainable way of managing nature-based tourism.

Nature-based tourism is growing internationally at a rate of 10-12% per year. Ecotourism as a broad concept has led to the development of the most diverse products as a function of ecosystem singularities and the resources of the area. The UNEP and IUCN have indicated that most of tourism's expansion is occurring in and around the world's remaining natural areas (TIES, 2007). Because of all the potentially negative impacts of tourism on the environment, it is proposed by TIES that ecotourism should be the exclusive form of tourism operation to be developed in a protected area.

Ecotourism has become a developmental phenomenon in developing countries that is applied as an alternative use of natural areas in a non-consumptive way. This is done particularly under the protected area umbrella, because this type of tourism is allowed under some of the

categories of protected areas (IUCN, 1994). Nevertheless, is ecotourism a form of sustainable tourism as stated in the various definitions mentioned? According to the principles established, ecotourism aims at the three legs of sustainability: ecological, social and economic (Buitelaar, 2001). There are several examples of the social and economic success of ecotourism. As a form of tourism with fewer infrastructure needs and consumer demands, ecotourism is ideal to be developed in poor countries. Local, small businesses and entrepreneurs can fulfill the demands of ecotourism. This has made ecotourism a popular activity in Costa Rica (Narayan, 1998). Also in the ecological arena success stories are found. Research in this area is growing to ensure enough information is available to be able to apply the best management practices for the particular environment and activity being developed in an ecotourism setting, as indicated before.

Although the local sustainability may be accomplished according to the ecotourism concept, there are other kinds of impacts that are not directly caused at the local destination. The impact of traveling from tourist's place of origin to the tourism destination is one of them. These impacts are related to energy use in the form of travel from the home countries to the tourism destinations and the respective green house gas emissions derived. These are considered the greatest magnitude impacts of global tourism (Becken & Simmons, 2002; Gössling, Borgstrom-Hansson, Horstmeier & Saggel, 2002; Høyer, 2000; Hunter, 2002; Hunter & Shaw, 2007). "Air travel has the greatest impact on global warming, it is responsible for around 18% of the energy used and 37% of the contribution of leisure-travel to global warming" (Gössling, 2002, p. 298).

Despite all these consequences on the global environment, none of the ecotourism concepts and principles expresses the need for global ecotourism sustainability. As Fennell and Weaver (2005) indicate: most of the ecotourism definitions support a local approach. Nevertheless, there is a conceptual ecotourism model that discusses the differences between two basic types of ecotourism: 'minimalist' and 'comprehensive' (Weaver, 2005). The comprehensive ecotourism has sustainability objectives with a global scope, is enhancement-oriented and transformational. This is opposed to the minimalist approach that is site-specific, directed to 'maintain' the resource quality (status quo), and non-transformational (Weaver, 2005). The comprehensive ecotourism is certainly a conceptualization embracing a holistic approach of ecotourism sustainability, but unfortunately not widespread as a research subject nor in practice.

Despite that the impacts of traveling to the tourism destinations are not explicitly considered in the ecotourism approach, there is some literature

dealing with the impacts of getting to the destinations (Gössling et al., 2002; Simmons & Becken, 2004). In addition to this there is research applying the ecological footprint methodology to evaluate tourism sustainability. This includes accounting for the global impacts ascribed to an ecotourism destination. Not only the impacts related to green house gas emissions but also the use of energy, production of waste and other environmental problems derived from the tourist activities (Gössling et al., 2002; Hunter & Shaw, 2007).

From all the definitions provided, I suggest that ecotourism should have at least four major principles or criteria to be followed: to minimize local and global ecological impacts, to ensure participation of the locals in the decisions and benefits; to provide an educational experience (awareness) for both the tourists and the locals; and to be economically sustainable, all these under a nature-based tourism experience.

1.3 Objectives and aims

Compliance to ecotourism or sustainable tourism principles in protected areas is necessary because otherwise the conservation of the natural resources and the local communities' livelihoods will be at high risk. The aim of the present research is to investigate if the nature-base tourism developed in Nicaragua's protected areas is in compliance with some of the ecotourism and sustainable tourism principles that are critical to the conservation of the protected areas and the improvement of local livelihoods.

The following research questions were addressed:

1) Are the tourism activities contributing to conserve the protected areas and their biodiversity?
2) Is nature-based tourism promoting awareness in visitors and local people?
3) Are the local communities benefiting from tourism activities and how relevant is their participation?

The objectives of the papers that serve to investigate these questions are:

1) To evaluate the impacts of tourism on the cover, composition and diversity of vegetation along the hiking trails, as well as on the richness, abundance and diversity of large and medium-sized mammals (Paper I and II).

2) To determine if the different groups of stakeholders participate in the benefits of the nature-based tourism (Paper III).
3) To evaluate a method for determination of the recreational carrying capacity of hiking trails used for ecotourism (Paper IV).

1.4 Outline

The thesis is organized as follows. In section two the natural and socioeconomic context of the country and the study areas are described. In section three the methodological approach applied in this thesis is presented. Section four summarizes the findings and their implications are discussed in section five. In the appendix papers a more detailed description of the methodology and results discussed in the thesis can be found.

2 The natural and socioeconomic context

Nicaragua is located in the center of the American continent, in the isthmus named Central America, between 10°42' and 14°59' North and 83°24' and 87°11' West. It has an area of 130 373 km^2, that includes the insular territory and the lakes' and lagoons' surfaces.

Nicaragua is a tropical land with slight variations in temperature and more variability on geographic rainfall distribution. For instance the average temperatures vary from maximums of 25 to 34 °C and minimums of 18 to 24 °C. The mean annual precipitation varies from 800 mm in the northwest and reaches values of 5 000 mm in the southeast of the country (INETER, 2006). Nicaragua is a country of singularities, for example it has the second largest freshwater lake in Latin America, Cocibolca Lake, also called Nicaragua Lake (8 138 km^2) (INETER, 2006). This is the only lake with freshwater sharks in the world (National Geographic, 2009).

Nicaragua has a population of about 6 million inhabitants and the per capita GDP (gross domestic product) in 2007 was 1 023 US dollars (USD). The minimum wage is c. 105 USD per month. The national balance between exports and imports is negative, c. 1 000 millions USD for 2007 (BCN, 2008). In regards to socioeconomic issues, the Nicaragua Human Development Index (HDI) in 2007 ranked 110 of 177 countries (the list includes all UN member states). In Latin America, four other countries have a lower HDI ranking (UNDP, 2007). However this may be considered an improvement from the 1999 report where Nicaragua was ranked 121 and only Haiti (in Latin America) had a lower HDI ranking (UNDP, 1999).

2.1 Protected areas and biodiversity in Nicaragua

Despite all the social poverty, Nicaragua is a rich country when it comes to natural resources; it has 68 different types of ecosystems, of which eleven

are modified by man (Meyrat, 2001). As Nietshmann stated in 1990: "Nicaragua has the largest tropical rain forest north of Amazonia, the most extensive sea grass pastures in the Western Hemisphere, the widest continental shelf, and stretch of coral reefs in the Caribbean, the longest river, largest lakes, richest volcanic soils, and least populous territory in Central America" (as cited in Weaver, Lombardo & Martinez, 2003).

Nicaragua has 72 protected areas with a total surface of 22 088 km^2, embracing 17% of the national territory (figure 1). Some of the categories of Protected Areas allow the possibility of low impact tourism activities in the protected areas, such as ecotourism (MARENA, 2007). The equivalence of Nicaraguan protected areas to IUCN Protected Area categories is shown in table 1. The category of Biosphere Reserve is designated by UNESCO as part of the World Network of Biosphere Reserves (WNBR) (UNESCO-MAB, 2009).

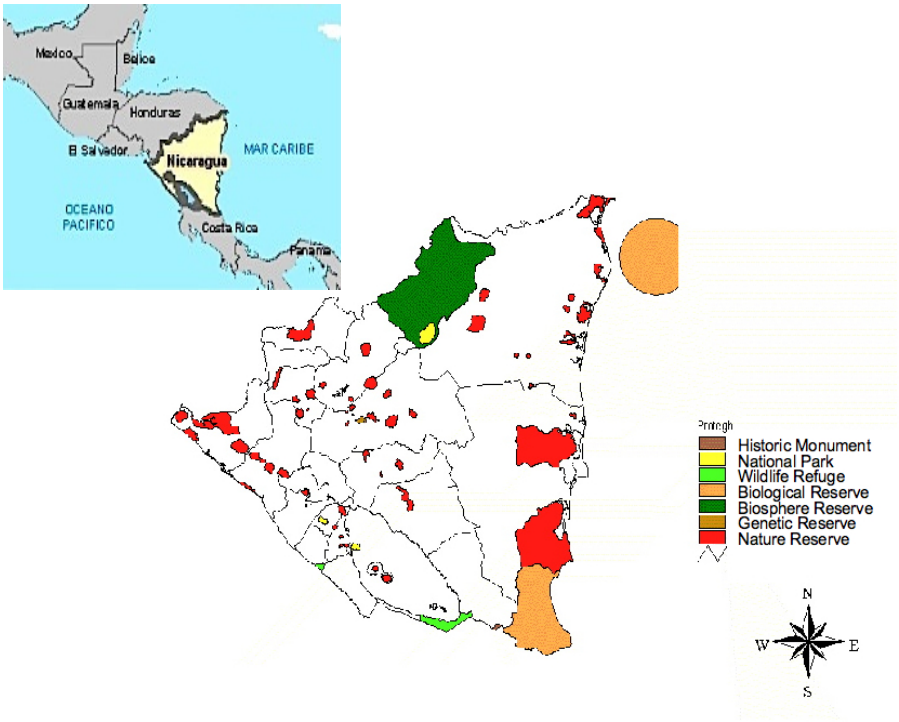


Figure 1. Location of Nicaragua in Central America and the protected areas by management category in Nicaragua (MARENA, 2007).

Table 1. *Protected area categories in Nicaragua and their equivalence to IUCN categories.*

Category	IUCN protected area categories	Main management objectives	Equivalence of Nicaraguan categories
I	(a) Strict Nature Reserve (b)Wilderness Area	Science or wilderness protection	Biological Reserve Genetic Reserve
II	National Park	Ecosystem protection and recreation	National Park
III	Nature Monument	Conservation of specific natural features	National Monument
IV	Habitat/ Species Management Area	Conservation through management intervention	Wildlife Refuge
V	Protected Landscape/ Seascape	Landscape / seascape conservation and recreation	Protected Landscape
VI	Managed Resource Protected Area	Sustainable use of natural ecosystems	Nature Reserve Biosphere Reserve

Sources: IUCN, 1994; Somarriba, et al., 2002; MARENA, 2007.

Nicaragua stands for 36.5% of the ecosystem diversity in Central America (World Bank & CCAD, 2001). The country hosts a diverse number of species as shown in table 2. Nicaragua's forests are refuges for populations of regionally endangered species, such as tapir, harpy eagle, and jaguar, whose survival depends on large areas of undisturbed forests (CBD, 2003). Furthermore, Nicaragua has several species under CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendices I and II. The species covered by CITES are listed in three Appendices, according to the degree of protection they need. Appendix I includes species threatened with extinction. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival (www.cites.org). Nicaragua CITES Appendix I contains 31 animal species and one plant species; while Appendix II contains 219 plant species and 199 animal species. The combined number of species on both lists is 432 species (CITES database, 2008). Therefore it should be a priority to conserve the existing biodiversity within the protected areas and in their surroundings, not only for the benefit of Nicaragua but for the whole Mesoamerican region.

Table 2. Number and status of major taxonomic groups of flora and fauna species in Nicaragua

Group	Total known species	Threatened species
Higher plant species	7,590	39
Mammals	251	6
Birds	676	9
Reptiles	172	8
Amphibians	62	10
Fish	643	21
Corals	58	unknown
Molluscs	1908	2
Insects	8514	Other invertebrates 17

Sources: CBD, 2003; MARENA, 2006; IUCN, 2008.

The effectiveness of the protected areas system in conserving biodiversity in the tropics follows the same pattern as illustrated for the global protected area network in the previous section. Some studies in tropical America support this affirmation. For instance, in Amazonia where reserve networks were designed with the aim to achieve representativeness, following the best knowledge available, there is still no evidence that this has been accomplished. As stated by the authors of that study: "Amazonian reserves cannot be safely assumed to capture all Amazonian species" (Schulman, Ruokolainen, Junikka, Sääksjärvi, Salo, Juvonen, et al. 2007).

The complexity of managing protected areas in developing countries derives from different factors such as land ownership status, land-use pressures, centralized institutional approach and lack of community participation in protected areas decision-making (Wallace & Pierce, 1996; Saalismaa, 2000; García-Frapolli et al., 2009). Most of the land in Nicaraguan protected areas is privately owned. The situation is very different from many other countries in Latin America, for instance Chile, Costa Rica or Cuba, where the land in protected areas is mostly under state ownership (Saalismaa, 2000). From one study done in a protected area in Nicaragua which is dominated by private ownership but where local inhabitants are willing to conserve the area, the main conclusions indicate the need to develop incentives for protection. These could include an exemption on land taxes, and/or alternatives to generate additional income such as organic agriculture and ecotourism (Saalismaa, 2000). Another study in the second biggest protected area in Nicaragua, the Biosphere Reserve Bosawas, illustrates how conflicts of interest between economic development and conservation, or between livelihoods and conservation, undermine the

possibilities for the communities to coexist in harmony with the conservation objectives on a protected area (Howard, 1998).

Some studies developed in the region, such as one in the Yucatan peninsula of Mexico; show that protected areas are not the only option for conservation. Their results revealed that, due to a lesser dependence on agriculture, forest conservation or maintenance was positively correlated to the activities carried out under community-based forestry enterprises and wage labor for the tourism economy, which contributes to reducing the deforestation rate (Ellis & Porter-Bolland, 2008).

2.2 Ecotourism in Nicaragua

In Nicaragua the tourism industry has increased considerably during recent years. For instance, in 2007, the income generated by tourism in general (housing, transportation, fees and other expenditures of international tourists) was 255 millions US dollars (USD), which is an increase of about 11% in relation to the previous year (INTUR, 2007).

According to the Central Bank of Nicaragua (BCN), the national income from exports in 2007 was 1 202 million USD. This indicates the tourism sector represented 21% of the total exports for the country and is higher than the exports earned by coffee (222 million USD), the most important income generator in that year. However tourism expenditures are not accounted for in the national income to calculate the GDP (BCN, 2008). Ecotourism is just a segment of the tourism sector in Nicaragua and stands for approximately 14% of the total tourism in the country (Weaver et al., 2003).

Honduras, Guatemala and Nicaragua have considerable ecotourism potential that has not yet been realized due to a combination of image, infrastructure and political problems (Weaver & Schlüter 2001). The main types of nature-based tourism activities developed in Nicaragua are: agrotourism (also called rural tourism), research or scientific tourism, and ecotourism. The activities include visits to terrestrial landscapes and various types of ecosystems; as well as visits to volcanic, marine, coastal and insular landscapes. All of these involve interaction between the cultural and natural environments (Somarriba, Parra & Acuña, 2002).

By 2007, only 10 protected areas in Nicaragua had an infrastructure for tourism, the ones with good facilities are the National Park Masaya Volcano, Nature Reserve Mombacho Volcano and Wildlife Refuge Escalante Chacocente River. Not all protected areas are self sustainable, particularly the ones managed by the government, because the income from tourists is

used to invest in other social priorities rather than the protected areas. Only two protected areas are considered to have a high degree of self sufficiency: National Park Masaya Volcano (government managed) and Nature Reserve Mombacho Volcano (co-management) (MARENA, 2007). There are several private initiatives to develop nature-based tourism activities; some of them call themselves ecotourism. There is no mandatory certification for ecotourism in place in Nicaragua yet. Law number 306 "Law of incentives for the tourist industry in the Republic of Nicaragua" declares tourism to be a national interest industry, promoting the developing of tourism within a sustainable development and environmental protection policy (La Gaceta, 1999). Several studies have been done in Nicaragua to evaluate the potential for ecotourism development in some protected areas of the country (Barany, Hammet, Shillington & Murphy, 2001; Martinez-Sanchez, 2004; Rosales, 2006). They have not investigated how the ecotourism projects have been developed in terms of the ecological and social impacts on the communities and the country, as much as has been done in the neighboring countries of Costa Rica and Belize. In these countries from 1981 to 2001, at least 27 and 12 studies, respectively, have been reported that relate to ecotourism's socioeconomic or ecological benefits (Krüger, 2005).

2.3 Case study areas

The case studies were carried out in the Nature Reserve Mombacho Volcano (NRMV), Granada and the Nature Reserve Cerro Datanlí-El Diablo (NRDE), Jinotega, in Nicaragua (Figure 2). Both Nature Reserves are cloud forest reserves. A cloud forest is a type of evergreen mountain forest found in tropical areas, where local conditions cause cloud and mist to be frequently in contact with the forest vegetation. These forests support ecosystems of distinctive floristic and structural form and contain a disproportionately large number of the world's endemic and threatened species (Bubb et al., 2004).

2.3.1 The Nature Reserve Mombacho Volcano (NRMV)

The NRMV is located in the department of Granada 10 km from Granada city and 50 km from Managua. The access to NRMV is by an asphalt or paved road. The geographic coordinates are 11° 50' North and 85° 59' West and the highest elevation is 1 345 masl (meters above sea level). The core zone of this reserve is 578 hectares and 6 644 hectares in total (including the buffer zone) (FUNCOC, 2003).

The mean annual precipitation ranges from 1 200 to 1 800 mm, varying according to the altitude. Precipitation can be in the form of mist that is maintained during the day, especially during the rainy season. The mean annual temperature at the base of the volcano is around 27°C and decreases approximately 1°C for every 150 m increase in elevation. The elf forest is located between 1 200 and 1 344 masl. This forest borders on the cloud or misty forest, which is observed from 860 to 1 200 masl. At a lower altitude the semi-deciduous forest, which ranges from 590 masl up to 900 masl takes over. The dry forest is found at the lowest elevation of the volcano (FUNCOC, 2003).

The NRMV is under the system of co-management; Fundación Cocibolca is the NGO in charge of co-managing this reserve under supervision of the Ministry of Environment and Natural Resources (MARENA). Co-management is an administration model for protected areas established in Nicaragua Protected Areas regulations. In this model MARENA, as administrator of the National System of Protected Areas gives the right to administrate a protected area to a Nicaraguan organization without profit aims, such as municipalities, universities, research institutions, cooperatives or indigenous and local communities. The organization acts as co-manager and has shared responsibilities. These responsibilities include the coordination with all the group of stakeholders in the protected area, also implementing the management plan (MARENA, 2007). The fee to enter the core zone for international tourists is 7.00 USD and for nationals is 4.00 USD per person. Tourists can stay at the ecolodge for a fee of 40.00 USD per person, but there is only space for a group of 10 persons at a time (www.mombacho.org/eco.htm).

2.3.2 The Nature Reserve Datanlí-El Diablo (NRDE)

The NRDE is located in the department of Jinotega in the North-Central region of Nicaragua (figure 2), and covers an area of 5 849 hectares. The geographic coordinates are 13° 07' North and 85° 49' West and the highest elevation is 1 650 masl. The access to NRDE is by a macadam road, which during the rainy season is not in an acceptable condition.

The NRDE area has been subject to different types of land use, the forest cover varies as follows: 58% is actually covered by forest, dense forest occupies 49% and the so called "open forest" comprises 9% of the territory. However, forest cover has suffered different kinds of degradation, fragmentation and disturbance. There are four land use types, besides forest land. They are: coffee plantations, pastures, annual crops and fallow (MARENA, 2002).

The NRDE has 45 land owners who have different types of land use on their farms. MARENA is in charge of guiding them to achieve the appropriate practices in accordance with the management plan of the NRDE (MARENA, 2002).

The farmer association, Cooperative Lina Herrera (in the north part of the NRDE) with the support of the United Nations Development Program (UNDP) has built nature-friendly facilities to host up to 25 guests at a time and established three walking trails for tourist use since 2005. The Cooperative has a fee of 10.00 USD per person per night to stay in the cabins and have interpretative and guided walking on the trails (personal communication).

There are five heads of family of the Cooperative Lina Herrera directly working in the ecotourism activities, as tourist guides, their families (wife and children) (figure 3) are involved in the maintenance and sign posting of the walking trails and in providing services to the tourists (cleaning the cabins and preparing meals).

2.3.3 Tourist frequency to the NRDE and NRMV

The tourists to the NRMV have been increasing in number since it opened to the public in 1999. Currently they receive an average of about 30 000 visitors per year. In the NRDE the tourists started to arrive in 2005, having in the past three years an average of only 100 visitors per year (diagram 1).

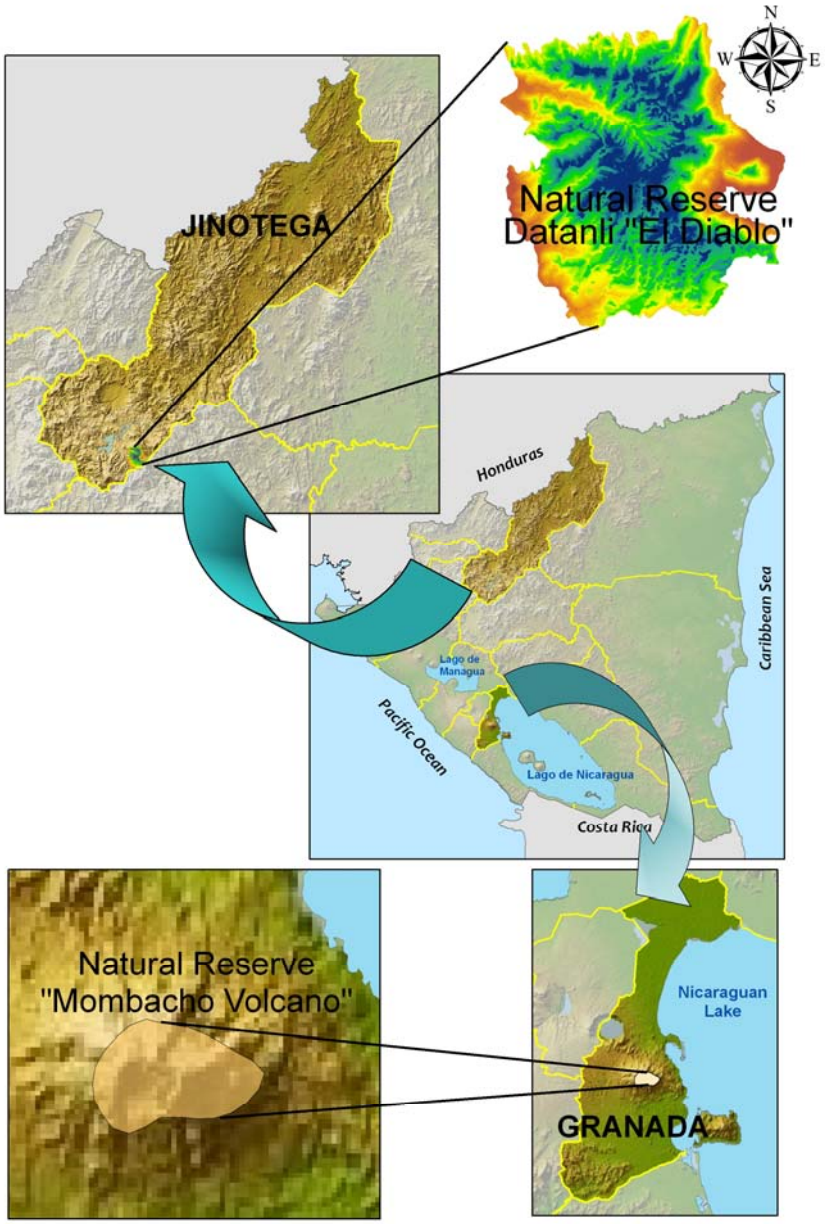


Figure 2. Location of the NRDE and NRMVE in Nicaragua (contribution of F. *Me*ndoza).

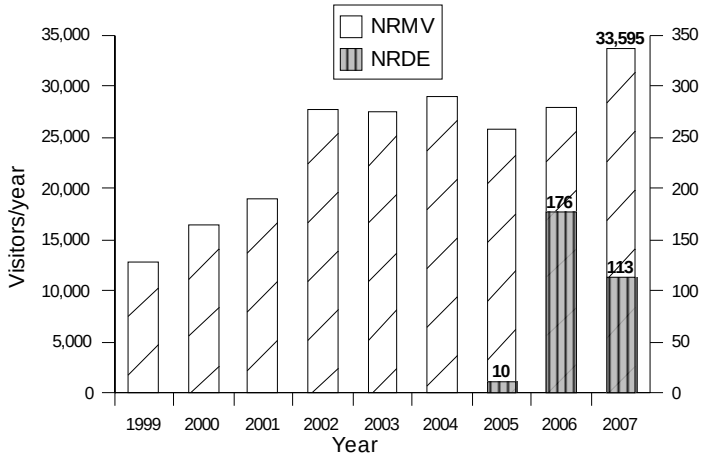


Diagram 1. Annual numbers of visitors to the NRMV (FUNCOC) and to the NRDE (Cooperative Lina Herrera); left Y axis scale is for NRMV data, right Y axis for NRDE data.

Figure 3. One of the local tourist guides and his son in the NRDE, Nicaragua.

3 Methodological approach

The aim of this study is to investigate if the principles of ecotourism are being achieved in the two cases analyzed. In accordance with the concepts of ecotourism and sustainable tourism which are described and discussed in the introduction section, I set the research questions of my study (previously stated). In order to answer these questions I divided the aspects to be studied by their ecological and social attributes. These aspects and how they were addressed in the study are summarized in table 3 and further elaborated in the following sections. To provide a visualization of the context of this study in regards to the global perspective diagram 2 illustrates the different scales of ecotourism sustainability. The diagram describes sustainability not as a state of ecotourism but as an approach to manage it. Dependence of ecotourism sustainability on the scale is indicated for different driving factors (left side of diagram). Besides this, ecotourism may produce dissimilar types of impacts in correspondence to the scale (right side of diagram). The impacts of ecotourism are similar in the type of resources impacted (land, water, flora, fauna) and in the socioeconomic issues raised. But on the other hand, the driving factors differ greatly in scale. In order to measure and manage the impacts very different strategies and techniques are required in accordance with the scale. The present research aimed at providing information on impacts from ecotourism on a local scale and indirectly on a national scale. To study the global scale other methodological approaches are more appropriate as indicated in the previous section. For instance ecological footprint methodology has been used to evaluate tourism sustainability on a broader scale (Becken & Simmons, 2002; Gössling et al., 2002; Høyer, 2000; Hunter & Shaw, 2007). The driving factors indicated in diagram 2 were synthesized from the analysis of different results found in the literature referred to in the present document.

Driving factors

At global level:

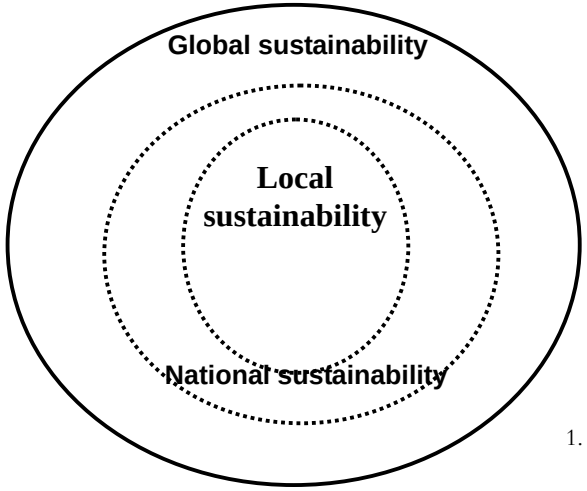
1) Tourist demands from developed countries
2) International policies and regulations
3) Global treaties and agreements
4) Renewable energy development

At national level:

1) National/regional policies and regulations.
2) Institutional support capacity.
3) Infrastructure and socioeconomic networks.
4) Country welfare.
5) Private enterprise commitment.

At local level:

1) Local human capacities.
2) Natural resources management approach.
3) Community organization and social networks.
4) Local entrepreneurship.



The dashes of the circles indicate the "permeability" among the levels (relations beyond the earth are ignored)

Impacts

At the global/national level:

1. Changes in land cover and land use
2. Energy use
3. Biotic exchange and extinction of wild species
4. Exchange and dispersion of diseases
5. Change in perception and understanding of the environment (Gössling, 2002).
6. GHG emissions.

At the local /national level:

1. Ecological impacts: changes in vegetation cover, composition and dynamics, impacts on fauna, soil erosion and trail impacts (Buckley, 2004; Liddle, 1997; Hammit & Cole, 1998; Leung & Marion, 2000, Pickering & Hill, 2007).
2. Waste production and energy consumption (UNEP, 2005; Wiebke & Buckley, 2004).
3. Socio-cultural impacts in the communities (Singh, Timothy and Dowling, 2003).
4. Economic impacts: job creation, fiscal impacts, inflation, income distribution (Lindberg, 2001).

Diagram 2. Sustainability of ecotourism (sustainability NOT as a state but as an approach to manage ecotourism) on different scales, indicating the driving forces and the potential impacts from ecotourism. This research was aiming to evaluate the local sustainability issues (the author)

Table 3. Aspects studied and how they were addressed methodologically.

Ecotourism aspect tested	Questions asked	How was it addressed in the study?
1.Minimizing ecological impact and contributing to the conservation of biodiversity	Is the current visitation management designed to minimize negative impact?	Estimating the recreational carrying capacity and comparing it with the current tourist flow in the most visited nature reserve.
	Is ecotourism affecting the vegetation?	Evaluation of the vegetation cover and plant species richness and diversity at tree and understorey level in a comparative analysis.
	Is ecotourism affecting the fauna?	Monitoring of the richness and abundance of selected fauna species (large and medium size mammals) in a comparative analysis.
2. Promoting ecological awareness for both visitors and the hosts.	Are the locals gaining awareness and knowledge about the relevance of conservation?	Interviewing the farmers and local communities on what are their perceptions of the benefits and threats of being in a protected area?
	Are the tourists looking for ecotourism experiences? How conscious are they?	Interviewing tourists about their expectations, awareness and willingness to contribute to the conservation of the protected area.
3. Providing financial benefits and empowerment for local people	Are the farmers and communities participating actively in ecotourism benefits?	Conversations with the local stakeholders on how they are participating. If there is an interest from their part to be involved in ecotourism. Are they being empowered?
	Are benefits from ecotourism obtained at the national level?	Secondary information about tourist records from FUNCOC and Coop. Lina Herrera. Interviewing tour operators about the social and economic benefits they obtain and how these benefits are transferred or not to national and local people.

3.1 Overview of the research process

The study process began with a consultation with the MARENA-POSAF protected areas project staff about the intention of the study and the questions to be posed. They helped to identify the protected areas to be part of this study, as described in the introduction section and also granted permission to do the research in both of them.

The current tourism policy in Nicaragua aims at promoting the natural and cultural attributes of the different regions in the country. INTUR and MARENA are supporting the development of "touristic routes" that include visiting some protected areas. This has to be done in correspondence with the protected areas management plan and contribute to the biodiversity protection as well as respecting social and cultural resources. Local people's participation is a cornerstone in these activities.

Fulfillment of conservation objectives is related to ecosystems and species conservation. Since I could not evaluate all levels of biodiversity conservation, I chose to evaluate the impact on vegetation along trailsides, and selected a fauna group (large and medium size mammals) to monitor the impact of tourism on those components of biodiversity (papers I and II). The reasons for choosing these two wildlife groups were because the changes on vegetation composition and diversity are determinant for ecosystem conservation and because besides the intrinsic value of the mammals, they provide an essential range of processes (e.g. herbivore, predation, hunting, wallowing) that in turn have the potential to influence the patterns of diversity of other elements of the biota (Owen-Smith, 1988; Terborgh, Estes, Paquet, Ralls, Boyd-Heger, Miller, et al., 1999; Fritz, Duncan, Gordan & Illius, 2002).

The participation of stakeholders and improvement of local livelihoods were examined through a variety of participatory techniques. These were done in cooperation with farmers, community focus groups, tour operators and tourists (paper III).

An interdisciplinary research approach was used to design and analyze the method of study. I consulted several colleagues in Nicaragua with expertise in forest science, dendrology and biology; furthermore I worked in collaboration with key local informants, knowledgeable on the flora and fauna of the two protected areas (papers I and II). The integration of techniques from social science and natural science was used in all the research process. The members of the advisory committee also came from diverse backgrounds (environmental impact assessment, social science and sustainable community development). To explain briefly how each of the

aspects of this research was analyzed they are divided into four methodological components.

3.2 Assessment of changes in vegetation cover and composition along the hiking trails

The purpose of this component of the research was to investigate changes in vegetation cover, plant species richness and diversity along the walking trails as a result of hiking activities. Changes in vegetation can be measured directly by comparing vegetation adjacent to the trail with neighboring undisturbed vegetation of the same basic type. The characteristics of the vegetation which appear to be most sensitive to trailside alteration are species composition and amount of plant cover (Cole, 1978). A picture of a section of a hiking trail is presented to illustrate how the vegetation at the trailside looks (trees and understorey species) (figure 4).

The methodology used to establish the plots along the trailsides is based on systematic transect sampling. Systematic or regular transect sampling selects sample plots at regular intervals. This method is useful for finding out where a variable undergoes rapid changes. This may be interesting if the sampling is along an environmental gradient, such as altitude, rainfall or fertility gradients (Kindt & Coe, 2005). In this case I used the trails as the main transect along which the vegetation was sampled, either for measurement of coverage or for identification of woody and understorey species.

3.2.1 Vegetation cover

The vegetation cover on the trailsides was estimated by taking samples along the hiking trails. This method is known as line-point intercept; it is a rapid and accurate method for quantifying soil cover (by vegetation, litter, rocks and biological soil crusts). With this method, cover is measured along a linear transect line and is based on the number of "hits" on a target species out of the total number of points measured along that line. It is used when precise, repeatable measurements are required (Bonham, 1989; Brady, Mitchell, Bonham & Cook, 1995). In addition, for each sample observation a determination was made as to how far out in the forest proper the disturbances were evident. For both measurements, percentage of cover and disturbed distance, arithmetic means were calculated. Control samples were taken in undisturbed areas of the forest at about 100 m distance from the trails within the forest proper where tourists do not walk.

Figure 4. Hiking trail El Crater, Nature Reserve Mombacho Volcano, Nicaragua.

3.2.2 Plant species composition and diversity

Sampling stations were placed on each trail at an interval of 200 m for El Crater and at 400 m for El Puma, thus providing six stations for each hiking trail. At each station, two sample plots were arranged, one for tree species (10 x 10 m) and a subplot for understorey vegetation, such as shrubs and grasses (5 x 5 m). The sampling design was the same for plots in undisturbed sites within the forest. The species were identified with the help of a farmer who was familiar with the local flora. When the species was unknown a sample was taken to identify it afterwards using the herbarium collection and the expertise of a colleague. All the individuals falling in the delimited area as a whole were counted.

3.2.3 Estimation of Diversity Indexes

The Shannon diversity index H' and Simpson's Index of Diversity (1 – D) (Magurran, 1988) were used to evaluate alpha diversity, which is related to the number of species and the distribution of individuals per species in a community. The beta diversity, related to the differences in species

composition and abundance between sites, was evaluated with Jaccard's similarity index Kj. For more details of the formulas applied see Paper I.

3.2.4 Statistical analysis

A t-test analysis was used to compare the means of the trailside plots with the control plots for each one of the walking trails and for each year, independently. The hypothesis was that there is a difference in the vegetation cover, plant species richness and diversity between trailside plots and control plots.

An ordination analysis for the species abundance was used to identify trends in the data. An ordination is a multivariate analysis technique that arranges group of samples along one or more axes on the basis of their similarity in species composition (Gauch, 1982).

To read about the specific characteristics of the methodology applied for the measurement of vegetation cover, floristic survey at plot and subplot level and calculation of diversity indexes see Paper I methodology section.

3.3 Assessment of changes on large and medium size mammals' richness and abundance along walking trails – A pilot study

This pilot study was done between August 2007 and June 2008. The aim of the study was to test methodology comparison of fauna abundance, richness and diversity along walking trails with different number of visitors. As a side result the study could also give an idea of whether there was a change in occurrence as a result of frequency of use or not. The most visited trail in NRMV is El Crater; El Puma is the least visited trail. During the last four years El Puma was only visited by about 25% of all tourists who visited NRMV (FUNCOC personal communication). This is because in the case of El Puma, tourists must be accompanied by a guide when walking the trail. For the NRDE, the most visited trails are El Campanero and El Leon, and the least frequently visited is El Congo.

Two methods for sampling along the trails were used: 1) wide fixed transects (Ojasti, 2000) of 20 x 700 m in an area where I tracked and sighted species; and 2) camera trapping. Both methods are non-invasive. The sampling was done at two times of the day: at dawn, at dusk or at night. A total of 24 monitoring walks were performed at each site (Paper II).

In order to standardize the abundance results, an index of abundance for each species was estimated, number of individuals found per kilometer. This

index has been used in two Costa Rican protected areas (Carrillo, Wong & Cuarón, 2000) and in a comparative study of the Andean forest and reforested areas in Colombia (Sánchez, Sánchez-Palomino & Cadena, 2008).

A collector's curve or species accumulation curve was estimated (Colwell & Coddington, 1994). The collector's curve helps to determine if the sampling is sufficient or if a number of species are likely to remain undetected. The statistical program used to estimate the collector's curve was PAST (Paleontological Statistics Software Package for Education and Data Analysis) (Hammer, Harper & Ryan, 2001).

The Shannon diversity index H' and Simpson's Index of Diversity (1 – D) (Magurran, 1988) were used to evaluate alpha diversity, which is related to the number of species and the distribution of individuals per species in a community. The beta diversity was investigated with Jaccard's similarity index. For more details on the methodology applied see Paper II.

3.4 Identifying the degree of stakeholders' participation in ecotourism initiatives

The purpose of this part of the research was to explore if ecotourism is contributing to strengthening ecological awareness and to stimulating the local participation (two principles of ecotourism), in these two reserves. To collect the information from the group of stakeholders involved in this study, I used structured and semi-structured interviews, as well as focus group technique (Jennings, 2005).

The groups of stakeholders involved in this study were:

1. Farmers and communities living in the core and buffer zones of the nature reserves
2. Tour operators
3. Tourists

The most important group of stakeholders involved in this study is the first group. Tourists and tour operators are stakeholders that provide an important context to the local community. The managing organizations of MARENA and FUNCOC are also viewed as stakeholders though information about them has been gathered indirectly through written and electronic material available as well as researcher observations (Paper III).

3.4.1 Farmers and communities living in the core and buffer zones of the nature reserves

This is the most important group investigated because they are the ones with more at stake in the protected area management and ecotourism taking place in the nature reserves. The conceptualization of community in this sense is taken from social and geographical science, which implies the symbiotic relations between people and their habitat (Singh et al., 2003). This is particularly relevant for this research, because the relationship of people with the environment is "reflected in their lifestyles and economic activities" (Singh et al., 2003, p. 7).

The sampling for the farmers was based on the number of farms in each reserve, for instance in NRMV 18 farm interviews were performed, representing 38% of the total number of farms and in NRDE 16 farm interviews were carried out, representing 33% of the farms in NRDE. The individual interviews were applied to farmers and the focus groups were done at the community level (figure 5).

The objective in using different tools to obtain this information was to avoid research bias and to be able to confirm the perceptions expressed by the group of stakeholders, particularly the local people living in the nature reserves. This approach combines quantitative (structured interviews) and qualitative interview (focus group) techniques (Jennings, 2005). The community group differs from the farmers because in the community focus group the farmers participated as part of the families that live in the protected areas. Since some of the farmers were interviewed individually, the focus group tried to gather informants that were not part of the individual interviews as well as ones who were interviewed.

During the group discussion, the participants were divided into subgroups to make their involvement in the discussion more active and the researcher facilitated the group discussions, with the help of two research assistants. Afterwards a representative of each subgroup presented their responses to the question guideline I provided them with. In the plenary session a common opinion for the whole group was discussed and agreed.

Figure 5. Farmer presenting the perspectives of the focus group discussion in front of the 'plenary' for consensus in the NRDE community workshop.

3.4.2 Tour operators

A sampling of 29% of the tour operators that have tours to Mombacho registered by the Nicaraguan Institute of Tourism (INTUR, 2005) were interviewed. A total of ten tour operators, six in Managua and four in Granada were interviewed. The structured interview instrument applied was short and designed to gather general information on the tour operation, national personnel hired, portion of the tour operator's income generated from tourism to NRMV. Because tour operators' managers do not like to give much information on their business, it was explained to them this was solely for research purposes.

3.4.3 Tourists in NRMV

Due to the difficulties to find a sufficient number of tourists to interview at a given time in NRDE, the interviews were only applied in the NRMV. A total of 100 interviews of tourists visiting NRMV were done, three of them were discarded though due to lack of information provided in the second part of the interview. The interview instrument was designed to gather information about the profile of tourists, their expectations of the visit in

terms of the natural and cultural potential that the site offered to them (attitude towards the nature reserve) and at the end, if these expectations were fulfilled.

3.4.4 Analysis of the quantitative and qualitative information

The results from the interviews were categorized in accordance with the variables studied, then analyzed in terms of frequency of responses by the selected categories, mean comparisons using the unpaired t-test for quantitative data, Mann-Whitney or Kruskal-Wallis test for the rank scale data and contingency table analysis (Fisher's test) for the categorical data. The qualitative information from the interviews and workshops was recorded and transcribed. The quotations from local people used in this paper have been translated into English. The results of individual farmers' interviews and community responses were compared within the same reserve and between the two nature reserves in this study (Paper III).

For more information about the specific characteristics of these three groups and detailed methodology see Paper III.

3.5 Estimation of the recreational carrying capacity

The purpose of doing this study as a component of the whole research project was to determine if the two protected areas were being managed in accordance with the minimal parameters of visitor management. The use of carrying capacity is a potential strategy to reduce recreational impacts in protected areas (Kuss, Graefe & Vaske, 1990). Furthermore, it is valuable to know the carrying capacity of the hiking trails used for tourism, as an ecological indicator and a management strategy to be applied for tourist management.

The main objective in this part of the study was to evaluate, and if possible to improve, a method for determining the recreational carrying capacity (RCC) of hiking trails used for ecotourism. The method was originally introduced by Cifuentes (1992). This particular method provides a means to establish the maximum number of visitors that hiking trails can sustain at any selected point of time, before they exceed an upper limit where the visitors' impact on each other could reduce their enjoyment of the area. This does not automatically mean that flora and fauna are affected at a significant level.

The methodology for calculation of the RCC considers three consecutive steps: calculation of Spatial Capacity (SC), calculation of Social

Carrying Capacity (SCC) and calculation of Recreational Carrying Capacity (RCC).

The RCC framework applied in this study is based on Cifuente's (1992) methodology used in hiking trails of many protected areas of Latin America, such as Manuel Antonio National Park, Corcovado National Park, Monumento Nacional Guayabo and National Park Tapantí Macizo de la Muerte (Costa Rica) (Cifuentes, Mesquita & Méndez, 1999; Tobar, López & Morales, 2003), Galapagos National Park, Ecuador, El Guácharo National Park,Venezuela (Méndez, 1999) and La Tigra National Park, Honduras (Maldonado & Montagnini, 2005). There are a few applications in other continents, like one in Van Vihar National Park, India (Shanker, 2006).

3.5.1 Calculating the Spatial Capacity (SC)

The spatial capacity (SC) is the maximum number of persons that can be admitted during a day, just considering the space available along the trails. The figure is given by the relationship between the available space on the walking trail and the number of hours available to visit the site. Cifuentes (1992) called this the Physical Carrying Capacity, but in order not to confuse this with the physical attributes of the trails, this research suggests naming it Spatial Capacity.

Cifuentes presented two equations to calculate SC:

$$SC = [A/ap] * f \text{ and } f = H/tw$$

Where: A: is available area, ap: is the area used per person; f: frequency of potential visits per day; H: opening hours for tourism and tw: required time to walk the trail.

This frequency of potential visits per day formula has an error, it needs a correction factor. This factor is equal to the time needed to walk the trail. This is because the last visitor allowed on the trail must have a fair chance to exit the trail before the reserve closes for the day .Furthermore, in the original Cifuentes methodology the time required to walk the trail was given by the managers of the reserve. This figure can be biased by the guides to shorter or longer time. Therefore it is proposed to apply a factor to account for steepness/accessibility to give a more unbiased figure. A theoretical value for the time needed to walk the trail (tw) is equal to the second formula given below.

The second Cifuentes formula f = H/tw will, for reasons of clarity, be replaced by two formulas:

f = (H-tw)/tw; tw = [Lma/0,5 + Lmb/0,75+(L-Lma-Lmb)]/v/1000*time factor.

Where v = is the mean walking velocity in km/h, which should be the normal pace to watch wildlife and scenery. Lma is the length of the trail with very high steepness, (Lmb) with high steepness and L the total length in meters (one way in the case of dead end trails). In the calculations done in this paper the velocity (v) is set to 1,5 km/h. On steep slopes the walking velocity is set to 75% of normal speed and on very steep slopes to 50% (Naismith's Rule). The time factor is for a special case when the trail is not a circuit. In those cases Cifuentes calculates with a correction only half way. This is to simplify the calculations too much, because on the way back steep slopes can retard the return velocity to the same degree as in the opposite direction, especially among elderly people or those who are not fit. It is probable that people are walking faster on the way back, because they have already seen most of the interesting things on their way to the turning point. An appreciation of the return velocity might be that it is double the velocity up to the turning point, in our calculations thus 3 km/h (Aitken, 1977; Langmuir, 1984 as cited in Fritz & Carver, 1998). If so, the total walking time for one way should be multiplied with 1,5 because the way back takes 50% of the way up. In all other cases the time factor is one since the total length of the trail is already accounted for in the calculations.

3.5.2 Estimating the Social Carrying Capacity (SCC)

The social carrying capacity is the maximum number of visits that is possible after applying a series of correction factors considering the critical minimum conditions of the site that could restrict the tourists from fully enjoying the site. The limiting factors are defined according to the particular characteristics of the site, considering physical, social and managerial variables. The SCC is estimated after applying the limiting factors to the SC.

The general equation applied is:

SCC = SC * spat LF * prec LF * inun LF * clos LF

The limiting factors (LF) for the cases studied are:

- Spatial (called "social factor" in Cifuentes, 1992) (spat LF)
- Precipitation (prec LF)
- Inundated sections (inun LF)
- Closing times (clos LF)

When the trail is not a circuit and tourists have to return on a "dead end" path, they will meet people walking in the opposite direction. This will require longer separation between groups to avoid disturbance. The corrected dead end factor goes from 1 when a trail is a circuit, in a strongly curved trail it might be enough to double this distance, whereas in a straight trail it should maybe be increased four to six times. Therefore this factor will duplicate or sextuplicate the distance between groups.

Precipitation, inundated sections and closing time limiting factors were calculated by applying the following equation:

$$LFx = 1 - Lmx/Tmx$$

Where: LFx: Limiting Factor of variable "x",
Lmx: Limiting magnitude of variable "x" and
Tmx: Total magnitude of variable "x".

The spatial limiting factor accounts for the distance between groups as well as for the number of persons per group. The formula is as follows:

$$Spat\ LF = (Ls/Tm)$$

Ls: Limiting space occupied
Tm: Total length of the trail

To determine most of the factors field surveys are necessary. For more details on the calculation of each one of the limiting factors, please refer to Paper IV.

3.5.3 Estimating the Management Capacity (MC) of the reserves

The management capacity is defined as the possibilities the administrators of a protected area have to develop the activities and be able to reach the objectives of the management plan. It is calculated as the mean value provided from the integrated condition of infrastructure, equipment and personnel. The MC of the protected area is represented as a percentage of the optimum management capacity; it is a measurement of the management effectiveness of the protected area.

The equation for calculation of MC is:

$$MC = \sum[(\text{existing values} / \text{optimum values}) \star 100]/3$$

Where: MC: is the management capacity of the protected area in per cent.

For the estimation of the Management Capacity variables such as legal frame, policies, equipment, competence of the staff, funding, infrastructure, and existing facilities are included. The variables considered for this study were selected based on the priorities of the Management Plans of the two Nature Reserves (FUNCOC, 2003; MARENA, 2002). A workshop with the park rangers and managers was done in each nature reserve to get feedback for the estimation of the management capacity.

3.5.4 Recreational Carrying Capacity

The RCC is the maximum number of visits that should be allowed considering the social carrying capacity of the hiking trails and the managing capacity (MC) of the reserve. This is the critical level for recreational purposes, because it considers the social variables that if exceeded will affect the tourists' enjoyment of the area negatively.

The equation used was:

$$RCC = SCC * MC/100$$

Where:
RCC: Recreational Carrying Capacity
SCC: Social Carrying Capacity
MC: Management Capacity of the protected area as a decimal fraction of the optimum.

For further details on the methodology applied, see Paper IV.

3.6 Methodological shortcomings

3.6.1 In the ecological dimension

In the survey of plant species along the walking trails the species composition was not studied in terms of their specific ecological relevance. For instance, the evaluation of the presence of umbrella and keystone species (Mills et al., 1993; Simberloff, 1998) would be required to measure the significance of ecological impacts of vegetation changes. With more time and expertise involved, it would be possible to study this aspect in depth.

Regarding the fauna monitoring, the group of large and medium-size mammals was selected because this group is one of the most vulnerable to ecosystem disturbance and change, due to their dependence on larger spaces and forms of life. However, the time of monitoring was reduced due to

limitations in procurement of the equipment which was done only in the later part of the PhD studies. Unfortunately, when the cameras were installed, five out of eight of them were stolen shortly thereafter. These incidents made this part of the thesis just a pilot study, because it would require many more hours of monitoring with the cameras to have conclusive results.

3.6.2 In the socioeconomic aspects studied

The stakeholders were identified as accurately as possible, they are:

1) Organizations:
   a. Ministry of Environment and Natural Resources (MARENA)
   b. Fundacion Cocibolca (FUNCOC), an NGO managing the NRMV
   c. Cooperative Lina Herrera, a farmer association managing ecotourism in the north zone of NRDE
2) Communities: Farmer households in NRMV and NRDE
3) Visitors: Tourists mainly from Nicaragua, Europe, USA and Canada
4) Tour operators: Tour operators in Managua and Granada

I did not interview MARENA or FUNCOC personnel in regard to their perception of the community participation, instead I used the written information they provided us about the reserves and the results from the management capacity workshops to make the cases. The adherence to ecotourism principles by tour operators was not evaluated. Also it was not part of the study to quantify the economic and financial benefits, because this requires additional time and expertise, something which was not available to the researcher.

The number of visitors estimated with the recreational carrying capacity methodology should not be used as a definitive restriction, but as an approximation that lets us know if it is desirable to reduce the visitor flow. The figure can also be used to support administrative decisions to decrease the number of visitors per day that are admitted to a site. This is especially pertinent when there are certain pressures for allowing many more visitors than the site could handle without negative social or even ecological effects.

4 Results

Papers I to IV contain detailed descriptions of the data and methods used, results obtained, discussions, and conclusions for different studies carried out. But, in this section I provide the main results as a basis for the discussion in the next section.

4.1 Changes in vegetation cover and diversity

The investigation was done in 2005 and 2007. This study was performed only in the Nature Reserve Mombacho Volcano (NRMV), because there had recently been a similar study in the Nature Reserve Datanlí- El Diablo (Fransson, 2007). The results from this reserve did not show any differences between trailside and control. This was valid both for tree and understorey species.

4.1.1 Vegetation cover

The results indicate that there is a statistically significant ($p < 0.001$) reduction of vegetation cover along the trails, mostly in a band adjacent to the trails compared to the control plots in both trails (table 4 and Paper I). The average disturbed distance from the trails towards the undisturbed forest ranges from 0.93 to 1.17 m for both trails, which is not a considerable impact in terms of the total area of the reserve. This represents a total area of 1.65 hectares, or about 0.28 % of the total area in the core zone (Paper I).

Table 4. Percentage of vegetation cover for El Crater and El Puma trails, Nature Reserve Mombacho Volcano, Nicaragua.

Variables measured	El Crater				El Puma			
	trailside mean	control mean	trailside SD	control SD	trailside mean	control mean	trailside SD	control SD
Percentage of vegetation cover	27.9	69.2*	19.1	21.9	30.1	58.1*	19.2	23.6
Vegetation disturbance extension (m)	0.98	-	0.37	-	1.09	-	0.54	-
Trail width (m)	1.08				0.74			

NS: No significant difference * Significant difference ($p < 0.001$) between trailside and control. n = 12 for El Crater and n = 34 for El Puma, per side.

4.1.2 Plant species richness and diversity

For plant species richness and Shannon's diversity index of the tree species, the differences between the control and trailside are not statistically significant for either El Crater or El Puma sites. Likewise, no significant differences were observed between the results for 2005 and 2007 measurements.

For the understorey species differences in species richness in the 2005 subplots compared to analogue controls (table 5) are considered statistically significant for both El Crater ($t = 3.712$, $p = 0.0004$) and for El Puma trailsides ($t = 3.372$, $p = 0.0013$). For 2007, comparing subplots with controls in the El Crater area differences are not quite significant ($t = 1.859$, $p = 0.0675$), whereas for the subplots in the El Puma area the differences are considered significant ($t = 2.289$, $p = 0.0236$). This indicates an ecological impact on the understorey species composition and richness due to trail use (table 5).

The results for Simpson's index of diversity are consistent with those of the Shannon diversity index outcomes for both groups of species, tree and understorey species. The levels of taxonomic similarity between different sites and years are characterized by Jaccard's similarity index. Comparing the El Puma trail and its control plots for tree species, Jaccard's coefficients were different in 2005 compared to those in 2007 (0.43 and 0.64, respectively),

whereas for the El Crater trail Jaccard's value is the same when comparing trailside with control, for both years.

Table 5. *Plant species richness, Simpson's and Shannon's indices along the walking trails and within undisturbed areas in the understorey subplots (5 x 5 meters) for herbs, shrubs and tree saplings.*

Sites	Species richness in 150 m2	Number of individuals in 150 m2	Percentage of the total number of species found	Simpson's Index of Diversity	Shannon Diversity Index
El Crater trailside subplots 2005	37**	177	55.2	0.94***	3.12***
El Crater control subplots 2005	19	796	28.4	0.77	1.82
El Puma trailside subplots 2005	35**	274	52.2	0.86NS	2.61***
El Puma control subplots 2005	19	446	28.4	0.84	2.22
Total number 2005	67		100		
El Crater trailside subplots 2007	35NS	412	57.4	0.94***	3.06***
El Crater control subplots 2007	25	585	40.9	0.87	2.45
El Puma trailside subplots 2007	36*	457	59.0	0.93**	2.99***
El Puma control subplots 2007	23	723	37.7	0.89	2.56
Total number 2007	61		100		

NS: No significant difference * Significant difference ($p < 0.05$) **Significant difference ($p < 0.01$) ***Significant difference ($p < 0.001$) for comparison between trailside subplots and control subplots.

In the understorey species case, comparing El Crater subplots trailside with control subplots had the lowest Jaccard's coefficients in both years (0.33); hence, these two exhibit the lowest floristic similarity value for all the

understorey species by location and year. Regarding changes in species composition (dissimilarity) these are higher for El Crater than for El Puma in 2007 but not in 2005.

4.1.3 Ordination Analysis

The Principal Component Analysis (PCA) results showed that the first two axes explain approximately 87 and 92% of the variance for El Crater and El Puma tree plots, respectively. Therefore the two-dimensional solution of a bi-plot graph is adequate. Variability in tree species abundance between trailside and corresponding control analogues is not evident on the bi-plot graph since the separation between trailsides and controls is very mild.

However, the results of the PCA in the case of subplots show that the differences in the composition of species between the trailside and the corresponding control groups in both trails are quite evident. For instance, in the El Crater case species abundance along the trailside in 2007 was very different from the control for same year and from the other two sets in 2005 (diagram 3). Some specific cases illustrate the species composition alteration, for instance the abundance of *Cenchrus pilosus* Kunth, a Poaceae very common in disturbed places, not originally from cloud forest ecosystems, which is considered a weed in Nicaragua as well as in many countries. The same is valid for murruca (*Oplismenus burmannii* (Retz.) Beauv). It is also considered a weed in coffee plantations in Nicaragua (Blanco, et al. 2003).

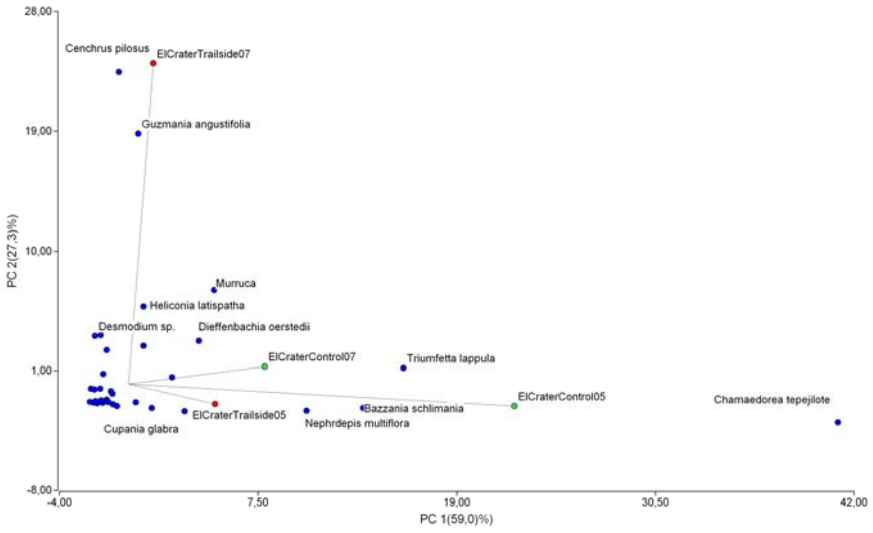


Diagram 3. PCA Biplot for El Crater Subplots 2005 and 2007, trailsides differ with control in both years, but in 2007 the angle of separation is wider.

4.2 Fauna along the trails

The trails are managed differently in regard to tourists' influence, in NRMV El Crater trail is the one receiving all the visitors entering to the core zone (c. 33 000 per year), while the El Puma trail only receives c. 7 500 per year. In the NRDE the trails Campanero and El Leon have the main influence of visitors (c.100 per year), the trail El Congo is practically only visited by researchers because the trail has not the appropriate conditions to hike on yet. This implies a greater activity in the trails most visited as compared to the others, particularly in the NRMV case. Therefore it would be expected to see differences in the behavior of animals and the probability of observing them. Furthermore, in NRDE the trail Campanero is the easiest to hike and lies closer to the farmers' gathering or working areas. Therefore the impact of people should be more pronounced than in the other two trails.

4.2.1 Mammal species richness

There were a total of 51 individuals identified of twelve species of large and medium-sized mammals. The most abundant orders were Artiodactyla and Carnivora with two families each. The most abundant families were Cebidae, Didelphidae and Felidae, with two species each. In the NRDE I found seven of the twelve species. In the NRMV I monitored eight species. Five species were found only in NRMV; four only in NRDE and three species were in common. Comparing the species richness for the two nature reserves, a contingency valuation analysis (Chi-square) showed that there was no significant difference in species richness between trails and reserves.

4.2.2 Mammal species abundance

The most abundant of the 12 species registered during the monitoring were collared peccary (*Tayassu tajacu*) (10), southern opossum (*Didelphis marsupialis*) (8), mantled howler monkey (*Alouatta palliata*) (8), Central American agouti (*Dasyprocta punctata*) (7), white-tailed deer (*Odocoileus virginianus*) (5) and white-nosed coati (*Nasua narica*) (5), other species being represented by two or fewer individuals. The mean abundance index for the NRDE was 2.8 and for NRMV 1.5 individuals/km (diagram 4). Nevertheless, statistical analysis does not reflect differences between the abundance indices of the walking trails between the two reserves ($p= 0.300$). On the other hand when comparing the species found along the walking trails of the same nature reserve, there is generally a higher probability of finding a given species in the walking trails less frequently used for tourism. In the case of NRMV the trend is similar (diagram 5) (Paper II).

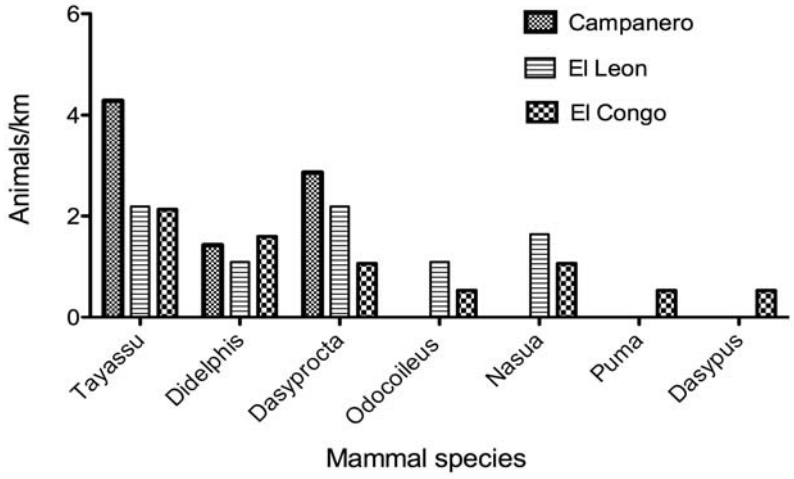


Diagram 4. Average abundance index of species (individuals/km) found in the NRDE. Tayassu= T. tajacu; Didelphis = D. marsupialis; Dasyprocta = D. punctata; Odocoileus = O. virginianus; Nasua = N. narica; Puma = P. concolor; Dasypus = D. novemcinctus

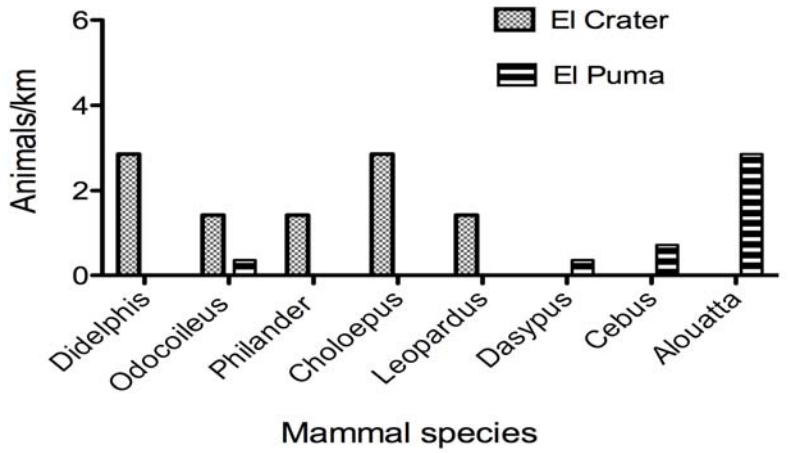


Diagram 5. Average abundance index of species (individuals/km) found in the NRMV. Philander = P. opossum; Choloepus = C. hoffmanni; Leopardus = L. pardalis; Cebus = C. capucinus; Alouatta = A. palliata.

4.2.3 Mammal species diversity and similarity

According to the Shannon diversity index (H'), NRMV is more diverse than NRDE, but the difference is not significant (table 6). In the NRMV reserve I found a significant difference between El Cráter and El Puma walking trails (T17gl = 2.31, P<0.05). El Cráter showed higher diversity compared to El Puma. The Jaccard's similarity index between trails within the NRDE is high, especially between El Leon and El Congo; in contrast to the NRMV Jaccard's similarity index (less than 0.25).

Results of research on monitoring mammal populations in other Latin American protected areas indicate that medium-sized mammals can be very elusive, they need significant sampling efforts. Only four out of 43 medium-sized Neotropical mammals require a sampling effort of 250 km or less, the others will require more effort. They also recommend the use of automatic cameras to increase the chances of detecting them as compared to sighting and tracking them (Emmons 1984; Glanz 1990; Janson & Emmons, 1990; Wright et al.1994 and Chiarello, 1999 as cited in Carrillo et al. 2000). This information indicates that the results of this part of the thesis can be considered preliminary pending confirmation of whether the few individuals and species monitored could be attributed to insufficient sampling efforts, rather than to the impact of tourism activities.

Table 3. *able 6. Diversity indices by nature reserve and walking trails therein (Paper II).*

Nature Reserve	Shannon diversity index (H')	Simpson index of diversity (1 - D)	Walking trail	Shannon index (H')	Simpson index (1 - D)
Datanlí - El Diablo	1.72	0.80	Campanero	1.06	0.64
			El Congo	1.81*	0.80
			El León	1.53	0.82
Mombacho Volcano	1.74 NS	0.75	El Cráter	1.55*	0.78
			El Puma	0.98	0.51

* p< 0.05 NS: No significant difference

Of the 12 species monitored, four of them only inhabit forested areas with little disturbance or areas like forest (coffee plantations) in cloud areas. These are considered specialist species. Specialist species can only live in a narrow range of environmental conditions or have a limited diet (Ownsend et al., 2003, p.54). Four are generalist species that can even be found in

agricultural and urban or suburban environments. Generalist species "widely explore the environment and are less susceptible to landscape fragmentation" (Lyra-Jorge et al., 2008, p.1574). And the rest are not exclusive to forested areas, but are not found either in agricultural or urban areas. The more generalist species are *D. marsupialis, P. opossum, D. punctata* and *D. novemcinctus* that can be found in a wide set of different types of habitats, varying from forests to extremely altered forest environments used for farming or urban/suburban land.

The results of the Detrended Correspondence Analysis (DCA) comparing between the trails in the two nature reserves had a gradient length ranging from 0.00 to 1.23. This indicates low variability on the extremes (species shared by both ends of the gradient). However, the large and medium-sized mammal's species in the trails in NRDE are grouped together while the species in the trails in NRMV showed a diverging pattern (diagram 6) (Paper II).

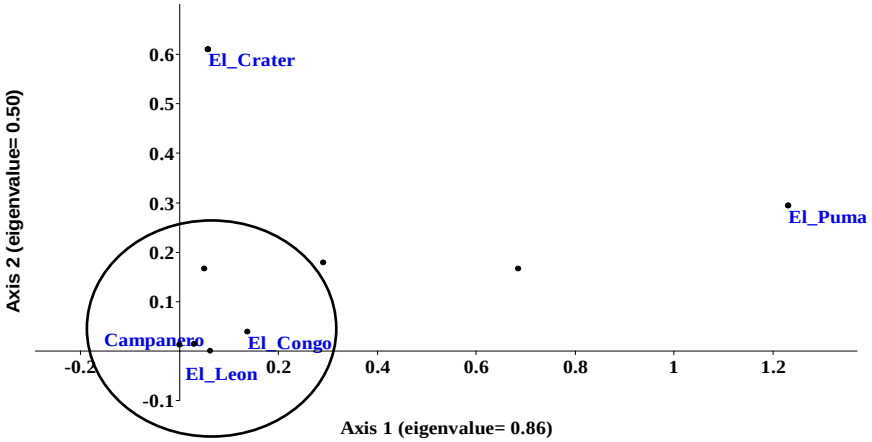


Diagram 6. Detrended correspondence analysis, showing the mammals' species ordination in the hiking trails in NRDE, where the grouping of the trails indicates similarities among the trails, contrasting with the trails in NRMV where they are completely apart from each other. Observe the species distribution (black points) in relation to the trail grouping.

4.3 How do farmers relate to the nature reserves and ecotourism?

The average farm size varies in the two reserves. In Mombacho (NRMV) there are no farms smaller than 21 hectares, an indication that there are no poor small farmers in this area. The results show that the land use consists mainly of coffee plantations and forest, the smaller the farm size the higher percentage of coffee plantations (diagram 7). With increasing farm size the proportion of land devoted to forest increases. This was tested with a linear regression analysis which gave an R^2= 0.63, indicating there is a positive correlation between farm size and forest surface.

In Datanlí - El Diablo (NRDE) the average farm size is smaller (diagram 8). They were grouped into four farm size classes, consisting of below 10 hectares, between 11 and 70, between 71 and 210, and more than 210 hectares. In this case the percentage of land devoted to cultivated maize and beans in the two smaller classes of farm size is approximately 10%, and there is no land allocated to this use in the other two classes of farm size. The bigger farm size classes have a great proportion of land devoted to forest. In this case the linear regression gave a better fit: R^2= 0.96. The smaller farms show the highest diversity in land use (diagram 8).

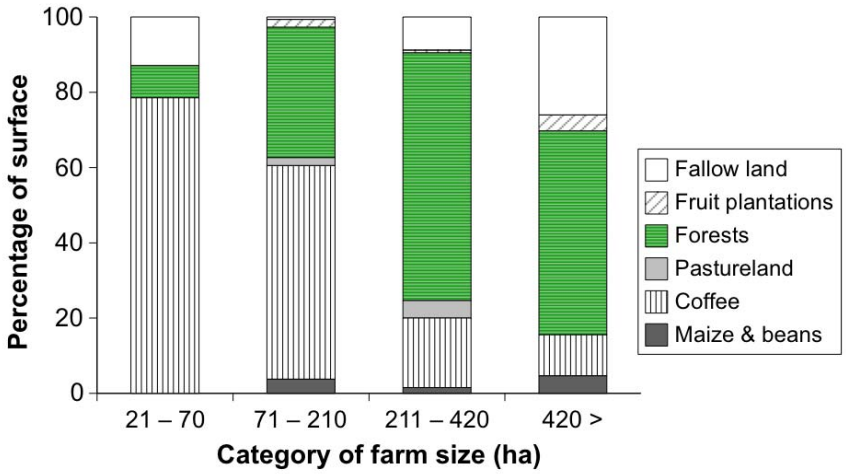


Diagram 7. Land use categories by farm size classes in the NRMV.

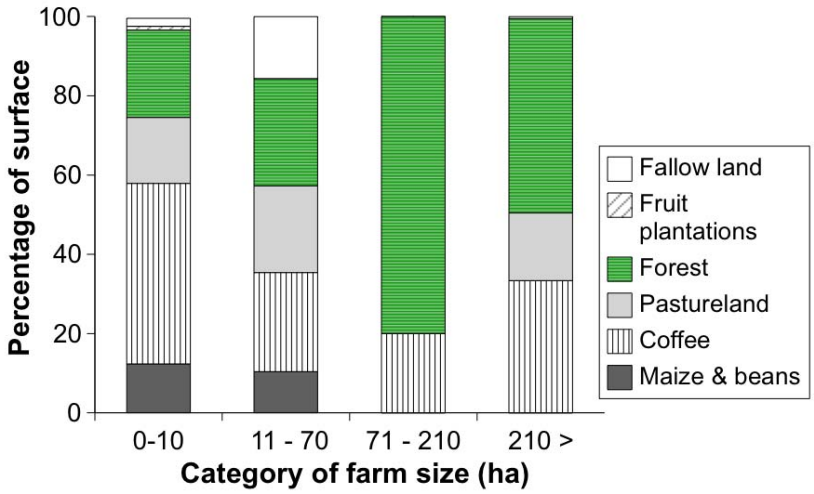


Diagram 8. Land use categories by farm size classes in the NRDE.

These results indicate that in Mombacho the farms are used mainly for coffee production and there is a considerable amount of forest land. Many farmers have their main economic activity in the city and do not live on the farm and therefore they do not cultivate staple crops. The bigger farms require maize and beans to feed the farm workforce, so called coffee pickers. In Datanlí - El Diablo, the smaller farms have a more diverse land use, such as maize and beans, pastureland and coffee plantations. This suggests that in the Mombacho case the farmers do not depend on the farm to survive whereas in Datanlí the small-size farmers depend on crop production for subsistence. The predominant category of land use in both nature reserves indicates that the farms do not depend on tourism as a source of income.

In NRDE there is a greater variety of topics for which the organizations provide the farmers with technical assistance. They are trained in waste management, tourism management, fire control and animal husbandry which are not mentioned at all in NRMV. This indicates a broader array of technical capacity being developed by farmers in NRDE or it could be they already know about this in NRMV. The objective of the organizations providing these capacities is to empower local communities to manage the natural resources in a sustainable manner. This result infers that the farmers in NRDE could have a broader experience concerning ecological issues, which is supported by the results of focus group discussions.

The results of the farmers' interviews show few differences between the two groups according to how they perceive potential benefits of tourism (diagram 9). The median ranking among the types of potential benefits within each nature reserve present no significant differences when applying the Kruskal-Wallis test. Both groups of farmers realize tourism is a source of income and it is important for economic welfare, in general, but they also realize that it is a means to protect wildlife in the reserves. Nevertheless, for the farmers in NRDE the social aspects have first priority, e.g. receiving more support from the government (not mentioned in NRMV) and improvement of infrastructure in the zone seems more relevant for NRDE dwellers than for the NRMV group. On the other hand, employment is not even mentioned by the farmers in NRDE, whereas for the NRMV farmers it has a medium average relevance (diagram 9).

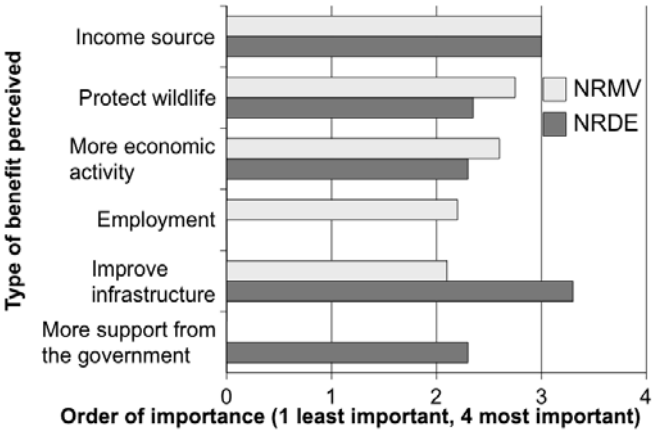


Diagram 9. Benefits ranked in order of importance by farmers in the NRMV and NRDE.

In regards to the potential threats of tourism, the farmers have definitively a different perception on some aspects and a similar one on a few. In NRMV the farmers are more concerned about social and cultural impacts, namely, massive tourism, drugs and delinquency, and cultural distortions, as well as environmental degradation received the highest priority (diagram 7). Whereas the NRDE farmers are concerned about the socioeconomic sphere, namely the rise of local prices, external intervention and lack of tourists as threats while these were not even mentioned in NRMV. Furthermore, even though the ecological impacts are relevant for NRDE, they are of greater importance to NRMV farmers.

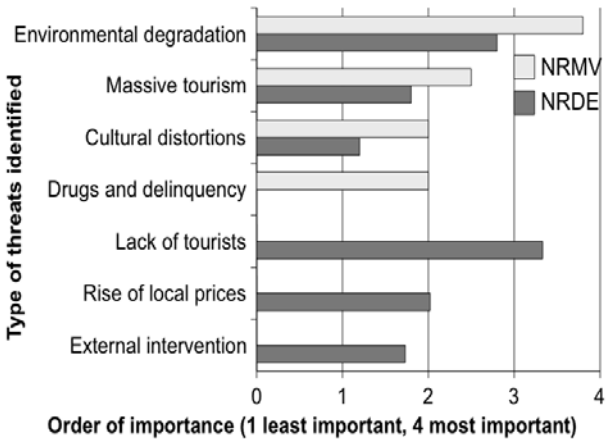


Diagram 10. Threats ranked in order of importance by farmers in the NRMV and NRDE.

4.4 How do communities relate to the nature reserves and ecotourism?

The issues at the focus group discussions with participating farmers living in both nature reserves can be summarized in three main aspects: 1) What do they think of the ecological importance of the reserve? 2) Which are the potential benefits and threats of tourism for the protected area? 3) Who benefits currently from tourism in the reserve?

On the issue of ecological importance of the nature reserve, the participants at NRMV agreed with the following statements:

"The reserve is important because it protects the environment, fauna and flora, although not 100%." "It provides us with water, a nice climate and natural beauty."

"There is not enough protection." "There is a lot of illegal hunting and a lot of deforestation going on." "It does not seem like it is a reserve; the wild animals are very scarce now."

In the case of NRDE, the community participants agreed that the ecological importance of the reserve was:

"The protected area is important because it is the lung and source of life for the communities of Venecia, Pueblo Nuevo, San Esteban and Apanás Lake, because they get water from the Reserve."

"For the owners it is important because it is an opportunity to keep the forest and other natural resources from being exploited."

"For the people in general it is important but hard to keep, especially for the ones that live in the upland areas, they have to follow the law applied to the Protected Areas in the country."

The participants at NRDE also asserted the following in regard to the nature reserves:

"MARENA does not allow the owners to use the resources they are protecting and they are very strict about giving permission to use the wood, for instance."

"This nature reserve is providing an environmental service to the communities and this is not 'compensated' to the farmers with a payment for environmental service."

The second last statement of NRDE participants, regarding MARENA and the use of resources, is a common reaction in protected areas where there have been inhabitants for generations, and it is known as the "tragedy of enclosure" (Bryant & Bailey, 1997). This situation is created by denying "grass roots" participants access to common resources.

In regards to negative impacts both communities are concerned with ecological and social aspects. The only negative economic impact of tourism is pointed out by the focus group in NRMV, and presented as "not enough participation of the communities". In NRDE it is not mentioned and the inhabitants are instead concerned that "there won't be enough tourists visiting the reserve" so they will not get the positive economic impacts expected. The reason for not being concerned about the participation of the communities in the NRDE is related to the fact that in this reserve the farmers are actually managing the ecotourism activities (Farmers' Cooperative) compared to NRMV where Foundation Cocibolca (FUNCOC) is the organization that manages these activities in the core zone of the reserve. The participants in the focus group in NRMV expressed their current concern at the limitation they see in the way ecotourism is managed. This is especially important for some members of the community in NRMV who do not have land to cultivate; they only have a small area where they have a house and subsist as part of the labor force on the big coffee farms.

4.5 How do tour operators take part in ecotourism benefits?

The results of the tour operators' survey illustrate the provenience of the tourists. The majority come from the USA and Canada (36%), followed by Latin America (24%) and European tourists (19%); the rest are from other continents such as Asia, Africa and Oceania (21%). It is noticeable that national tourists do not use tour operators. However, there are a large number of national visitors that go to Mombacho Volcano, as the results of the tourist survey show.

An indicator of the economic importance of tourism locally and nationally is employment. For instance from the ten tour operators interviewed it was found that they have 67 persons directly working in the tourism business, in diverse positions (table 7). Additionally the survey provides information on gross annual income earned by the tour operators, on average roughly 110,000 USD per operator. In Granada and Managua, tour services provided that are related to NRMV constitute between 32% and 44% of total gross income, respectively.

Table 7. Number of employees hired by the ten tour operators interviewed in Managua and Granada.

Managers	Tourism agents	Drivers	Tourist guides	Administrative personnel	Maintenance personnel
10	23	11	11	9	3

4.6 How do tourists comprehend the NRMV and ecotourism?

The tourists interviewed at the NRMV were mainly from Europe (39%), USA and Canada (29%) and Nicaragua (27%). The academic level of the tourists interviewed was very high, 78% of them had a university degree of whom 19% had a graduate, either master or doctoral, degree. The explanation for this could be that educated people may be more aware of the importance of conserving ecosystems, or perhaps they just simply have more opportunities to travel to exotic natural environments, such as Nicaragua. This result is consistent with results found in other studies around the globe. For example, in North America 75% of general and 96% of experienced ecotourists had degrees or at least some college education. In the UK, 61% of frequent ecotourists were educated to degree or postgraduate levels (Wight, 2001).

The tourists were asked what their expectations were when they arrived at the NRMV. The most popular expectations were looking at natural beauty (34%) and wildlife watching (20%) (diagram 11). After their visit to the walking trails at the top of the nature reserve, the tourists were surveyed

and asked about their favorite experiences. It was noted that the expectations they had originally of watching wildlife were not fulfilled, since only 4% of them said this was the experience most enjoyed (diagram 12). A small proportion of the tourist also expected to have a cultural experience (2%), but that was not mentioned afterwards. On the other hand after the visit, viewing the landscapes increased as one of the most appreciated experiences; it was 30% after the visit compared to only 13 % prior to the visit. These results suggest that tourists had their own perceptions before visiting the area and the majority of their expectations were fulfilled with the visit, except by watching wildlife and having a cultural experience.

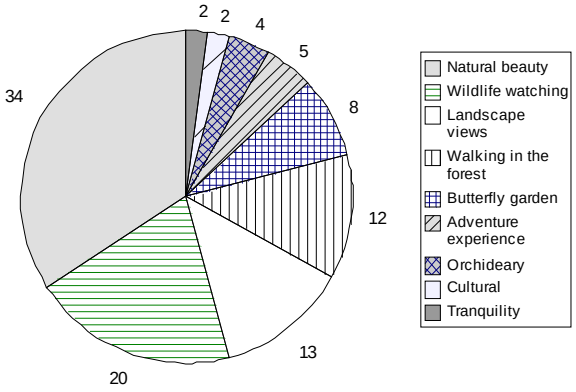


Diagram 11. Expectations of the tourists when they arrive at the NRMV, percentage of tourist's responses.

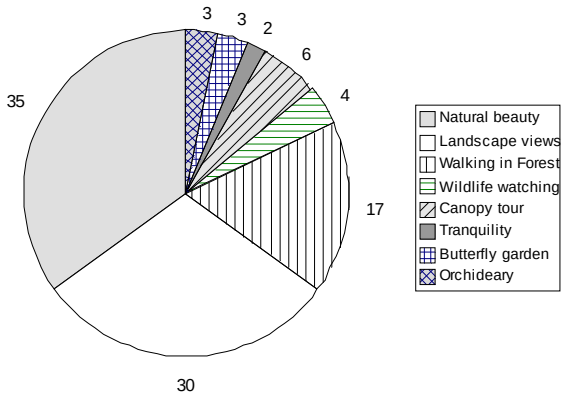


Diagram 12. Experiences the tourists liked the most after they walked on the trails in the NRMV, percentage of tourist's response.

The potential threats of tourism to the nature reserve, as viewed by the tourists, were of an ecological and economic kind. The highest percentage of negative responses (23%) was "having the potential for being overcrowded". This was followed by "leaving trash in the reserve" (20%) and then about an equal proportion for tourists who would "damage the vegetation" and the possibility of "having a small number of tourists" (reducing the income to manage the nature reserve).

The question about the willingness to pay an additional sum devoted to protect this reserve was in general well received by the tourists. Only 19% of them were not willing to pay anything, but 23% were willing to pay at least 1 USD and 58% of the interviewees were willing to pay 2 to 10 USD in addition to the current entrance fee to protect this reserve.

The results indicate that the tourists visiting the NRMV have ethical motives and are committed to the conservation of natural ecosystems. Their concern for the nature reserve could be considered as an indicator of their educational experience while visiting the reserve that somehow increased their level of awareness and concern for care and conservation of natural ecosystems, like NRMV.

4.7 Estimation of recreational carrying capacity

4.7.1 Nature Reserve Mombacho Volcano

The variables to calculate the spatial capacity for the trails El Crater and El Puma are indicated in table 8. The Recreational Carrying Capacity for the trail El Crater was estimated to be between 370 to 680 visitors/day, while in the trail El Puma it is 230 to 430 visitors/day (Table 9). To determine if the estimated RCC in this study was exceeded by the current number of visitors to NRMV, the number of tourism visits (records of Fundación Cocibolca) were compared. I found that the estimated RCC had not yet been exceeded by the total number of visits registered per year. Whereas the pattern shown by the nature reserve records indicates a tendency for the number of visitors per day in peak periods to increase.

4.7.2 Nature Reserve Datanlí – El Diablo

The variables to calculate the spatial capacity for the trails in NRMV are indicated in table 8. The RCC for the trail El Leon was estimated to be between 380 to 690 visits/day, while in the trail El Congo it should be limited to 350 to 640 visits/day (Table 9). The main constraints for the SCC are the spatial and the accessibility limiting factors. These two factors reduce

the RCC considerably in comparison to the Campanero trail (450 to 820 visits/day) (Table 9). This difference is caused because more space is needed between groups of visitors and these trails are more difficult to hike. The Campanero trail has lower slope gradients and it is easier to walk than the other two trails. Therefore it yields the highest RCC of the three trails.

Table 8 Nature Reserve's hiking trail lengths, average hiking time, opening hours and visits per day; variables to estimate the spatial capacity (SC).

Nature Reserves	Hiking trails	Length (m)	Hiking time (hours)	Opening hours/ day	Number of potential visits/ day	Spatial capacity (SC) (visitors/day)
Mombacho Volcano (NRMV)	El Crater	1400	1.03	8.0	6.74	9436
	El Puma	4000	3.19	8.0	1.51	6045
Datanlí- El Diablo (NRDE)	El Congo	2575	2.38	10.0	3.20	8236
	El Leon	1720	1.57	10.0	5.37	9229
	Campanero	1200	1.02	10.0	8.84	10603

Source: Paper IV.

Table 9. Spatial carrying capacity (SC), Social carrying capacity (SCC), Management carrying capacity (MC) and Recreational carrying capacity (RCC) of hiking trails in NRMV and NRDE, Nicaragua.

Nature Reserves	Hiking trails	Spatial capacity (SC) (visitors/day)	Social carrying capacity (SCC)	Management capacity (MC)	Recreational carrying capacity (RCC) (visitors/day)
Mombacho Volcano (NRMV)	El Crater	9436	505-925	74	370-680
	El Puma	6045	321-589	74	230-430
Datanlí- El Diablo (NRDE)	El Congo	8236	561-1029	62	350-640
	El Leon	9229	610-1118	62	380-690
	Campanero	10603	720-1320	62	450-820

Source: Paper IV.

5 Discussion and Conclusions

The goals of ecotourism in protected areas are to conserve natural resources, enhance local livelihoods and promote environmental awareness among tourists and local communities. Nevertheless the capacity to achieve those goals needs to be fostered at the local level (Ezebilo & Mattsson, 2009; Xu, Lu, Chen & Liu, 2009). There is a certain skepticism in the international research community about the ecotourism concept, because "unless ecotourism is well planned and monitored and, in addition, seeks wide participation of local communities, the pursuit of maximizing economic benefits may actually accomplish the opposite, namely to harm the ecosystem and deprive the local communities even further" (Muller, 2000, p. 250). Thus, by answering the research questions set out for this thesis, it would be possible to understand if ecotourism is accomplished or not:
Are the tourism activities contributing to conserving the protected areas and their biodiversity?
Is nature-based tourism promoting awareness in visitors and local people?
Are the local communities benefiting from tourism and how relevant is their participation?

The two cases studied, NRMV and NRDE have great similarities in relation to natural characteristics. Both are cloud forest reserves, relatively well conserved and of a small size compared to other protected areas in Nicaragua. However, socio-economically, they differ in important ways. The NRMV has a distinguishable core zone above 850 m.a.s.l. that is administrated by a foundation, FUNCOC, and the buffer zone comprises privately owned land, mainly with coffee plantations (upland) and annual crops (lowland). FUNCOC has implemented nature-based tourism in the core zone since 1999.

In contrast, the NRDE has farmers owning land in the buffer zone as well as in the core zone. The main land uses, as in NRMV, are coffee plantations and annual crops, but on smaller land holdings. This reserve is under the responsibility of MARENA. Some farmers have a cooperative group that began to do some nature-based tourism after 2005, with the financial support of UNDP.

5.1 Ecotourism contributions to minimize impacts on biodiversity in nature reserves

To sustain ecotourism it is essential to ensure the sustainability of both the natural and cultural environments of the tourism site (Wearing, 2001). Nevertheless, ecotourism may have a variety of direct and indirect negative impacts on native flora and fauna. The characteristics of the vegetation which appears to be most sensitive to trailside alteration are species composition and amount of plant cover (Cole, 1978). The impacts of ecotourism on wildlife fauna are, in many cases, much less significant than major habitat changes associated with agriculture, forestry or extractive industries (Mattson, 1997; Green & Catterall, 1998 cited in Buckley, 2004). In other cases, wildlife species that only survive in protected areas can be disturbed by ecotourists, especially during critical periods such as breeding and migration. This could have considerable effects for the conservation of the species concerned (Buckley, 2004).

According to the results in this thesis, the impact on flora and fauna is limited to:

1) Loss of vegetation cover in a narrow band immediately adjacent to the trails;
2) Changes in richness, diversity and composition of the understorey plant species; and
3) Difference in mammal species composition comparing the two trails in the NRMV case only (Papers I and II).

The impact on vegetation cover is mainly the result of the construction and maintenance of trails in the NRMV, although trampling by tourists may play a role in the loss of vegetation cover when tourists leave the trails. Other studies evaluating plant species richness and diversity on recreational sites have shown that large changes in plant community cover were correlated with large changes in species composition (Hall & Kuss, 1989; Nepal & Way, 2007). These changes in species composition, particularly in understorey species, are probably due to light intensity differences between

the more open trail areas and the control undisturbed subplots (Cole, 2004). Also, the effect of trampling needs to be considered as a trailside impact. It has been found by other authors that "differences in resistance and resilience to trampling can result in changes in species richness" (Pickering & Hill, 2007, p 796). As a result, species that are more susceptible to trampling are replaced by more tolerant species. This effect can be seen in two ways, either by increasing the plant diversity with new exotic species (Hall & Kuss, 1989) or by decreasing plant diversity because native and non-ruderal species are reduced (Potito & Beatty, 2005). In any case, the managers of tourism in protected areas should be aware of these changes to prevent negative consequences for the particular ecosystem.

In a study covering eight protected areas in Costa Rica and Belize, it was found that prevalent trail impacts included effects on vegetation cover, organic litter loss, soil exposure and damaged trees. The authors also found that many visitor impacts on trails in protected areas were reduced as a result of trailside reinforcement and using surfacing materials on trails (Farrell & Marion, 2001). The NRMV trails in our study are well maintained and have wood steps protecting the steepest segments of the trail. This provides the tourists with a well demarcated path. This is most likely the reason why the extent of damage on vegetation cover is still restricted to a narrow band.

The difference in composition of mammal species found along the two trails in NRMV could partly depend on the larger number of visitors along El Crater throwing edible things around them, as well as on the change in flora, giving a number of animal species an opportunity to feed on species that are normally found in other ecosystems. In turn these animals attract different carnivores. Along El Puma the visitors have a guide with them and maybe not so many things are thrown along the trail. Also the visitors are fewer and therefore trampling and disturbance is not so evident. In the NRDE there is no evident difference in the composition of mammal species among the trails, which is what I expected given the low influence of tourists there. Furthermore, the results of a study of mammal populations in two Costa Rican protected areas indicate that an abundance index similar to the one I used reflects changes in mammal abundance but conveys no information on the actual size of the wildlife population (Carrillo et al. 2000). Since the two nature reserves in the present study are relatively isolated in regard to natural corridors, it is relevant to discuss the possibilities of species loss due to the lack of a sufficient area to conserve them, particularly for large and medium-sized mammals. The reason I could not detect more individuals of given species found in these two sites is probably due to populations that are too small. Small and isolated populations, as is

the case in our two nature reserves, have a great risk for inbreeding (Keller & Waller, 2002).

Critics against establishing a numerical carrying capacity argue that carrying capacity varies depending on the protected area objectives, upon tourism activities, and also because it does not provide a measurement of impacts (McCool & Lime, 2001). Nevertheless, the carrying capacity methodology presented in this research does take into account these criticisms and considers the management objectives of the nature reserve and the characteristics of the tourism settings. The RCC is estimated for the specific conditions of each reserve and the tourist activity evaluated. The Limits of Acceptable Change (LAC) approach to carrying capacity, as contrasted to the RCC used herein, does not take into consideration many of the constraints noted above (McCool and Lime, 2001; Manning, 2007). The RCC methodology is applicable with basic information usually available and applicable by the reserve managers. For determining RCC, we modified the methodology of Cifuentes (1992) to incorporate important social considerations. For instance, as a rule a trail is a circuit, i.e. it returns to the starting point. However, in some cases the visitors must walk back over the same path covered previously to return to the starting point (dead end). This creates a space limitation for visitors due to the probability of encountering other tourist groups on the return. Therefore it was important to take this factor into account. The use of RCC as a tool for tourism management does not preclude the need to monitor ecological changes in the reserves. Further, the RCC methodology can be applied as a range in capacities rather than a single value and hence provides a useful tool in determining ecotourism strategies and management implications.

The Recreational Carrying Capacity (RCC) has not yet been exceeded in either of the nature reserves. However, the pattern of tourist frequency in the NRMV indicates a trend for the number of visitors to increase during daily peak periods to near RCC limits. If the trend in visit numbers continues to increase during these periods in the future, it will be necessary to restrict the number of visits during those times (Somarriba, Garnier & Laguna, 2006; Paper IV).

5.2 Ecotourism helps promote conservation awareness for visitors and local people

There are several illustrations of how local communities in Latin American countries appreciate the tangible and intangible benefits of a protected area (Bollanda, Drew & Vergara-Tenorio, 2006; Stronza & Gordillo, 2008). Also

among both tourists and local farmers conservation awareness was also found to be rather high in the two study sites in Nicaragua. Local inhabitants in both nature reserves are conscious of the importance of the protected areas. They appreciated the reserves as "the lung and source of life for the communities", and also for their "natural beauty" (Paper III). The farmers in the two communities studied appreciate the benefits of natural resource conservation promoted by ecotourism. They are engaged in the protection of the reserves both because of their environmental concerns and because their own welfare is at stake.

However, in NRDE the farmers consider the regulations imposed on them for the use of the natural resources within the reserve, as too strict. They would prefer to have more decision making authority on the nature reserve than MARENA currently concedes to them. As established in our results, this "tragedy of enclosure" (Bryant & Bailey, 1997) is exemplified in several other cases in Latin America (García-Frapolli et al., 2009; McShane & Newby, 2004 cited in Wells & McShane, 2004). Managing protected areas gives rise to social and economic conflicts. Many of these conflicts are related to the fact that different groups have different perspectives on the use and management of the natural resources within a particular protected area. When the management decisions are made, if the local people's interests are not taken into account conflicts arise (García-Frapolli et al., 2009; Hernández et al., 2005; Molnar, 2004). Prior studies in developing countries indicate that the community attitudes toward protected areas are related to education, stewardship, participation, costs, and benefits perceived by the local people (Lai & Nepal, 2006; Ormsby & Mannie, 2006; Stronza & Gordillo 2008; Xu et al., 2009). Thus, it is very relevant that those who live in and around nature reserves are made aware of the opportunities of living in a protected area, and not just the usual regulatory limitations imposed upon them because they live there.

In our study, the farmers' dependence on the nature reserves is more evident in NRDE than in NRMV. This is due to the fact that the farms are smaller in NRDE where farmers depend on crop production and coffee plantations as their main source of income. These farmers also have other food production for subsistence (meat, milk, eggs). On the other hand, in NRMV the farms are larger and engaged mainly in coffee production. Owners of big farms in NRMV have alternative careers in town and landless families work as the labor force for big farms or in town, as a livelihood strategy. However, ecotourism is seen as a supplemental income for the farmers as well as for the communities in both nature reserves. Since Wallace (1992), this vision of ecotourism as a complementary activity has been

considered a dependable strategy for local inhabitants. Additionally, because the fluctuation of ecotourism demand worldwide, it is not advisable for farmers to depend only on ecotourism as main source of income.

There are no studies in Nicaragua regarding how owners in protected areas depend on the reserves for income generation. However, there are several studies in Central America, mostly from Costa Rica, that verify the economic benefits of ecotourism. Those studies conclude that the revenues generated go mainly to foreign investors located at the sites or in nearby cities with more capacity to supply local business (Klak, 2007; Place, 1995; Brandon, 1996; Stonich, 1998). Unfortunately, also in the case of the two studied sites in Nicaragua, the main economic benefits do not go to the local farmers and communities, despite the fact they are the ones who are burdened with regulatory compliance imposed by governmental authorities in protected areas.

The other group of stakeholders, the tourists visiting NRMV, showed concern for the conservation of the ecosystems and indicated their willingness to contribute to their conservation (81% of them). They have some expectations when entering the reserve (see results) and after their visit, survey responses indicate that everything but wildlife watching had been fulfilled. This indicates that they had benefited from this ecotourism experience. Several studies in Costa Rican protected areas have shown that tourists were willing to pay fairly high entrance fees for protecting the natural areas (Besleme & Aguilar 1994; Burnie, 1994; Hearne & Salinas, 2002). This implies for Nicaragua that tourist awareness of a need to protect natural reserves may be an unused potential to support protected areas where the national budget for biodiversity conservation is not a country priority.

Another important awareness aspect as viewed by the tourists was the potential threats of tourism to the nature reserve. The threats were mostly related to tourism management. The two highest percentages of responses in tourist surveys were "potential for being overcrowded" (23%) and "inappropriate waste management" (20%). Tourists were concerned to a lesser frequency about the "damage to the vegetation" and the possibility of "having a small number of tourists". The results illustrate that about one fourth of the tourists were concerned about overcrowding while one eighth had the opposite concern of not enough tourists (reducing the income to manage the nature reserve). Overcrowding is a potential problem, but at the present time not of sufficient magnitude to cause a higher frequency of tourists to identify it as a problem. These results are consistent with the fact that the RCC has not been exceeded in the NRMV.

In a study of eight protected areas in Central America, ecotourists were concerned that their activities did not result in a negative impact on the area visited, but managers frequently failed to communicate to the tourists how to apply low impact practices or regulations (Farrell & Marion, 2001). The lack of effective education and interpretation programs is a common deficiency in tourism enterprises in the developing world.

5.3 Ecotourism and evidence for promotion of local participation

Another important aspect of ecotourism is that a great proportion of the tourism benefits should go directly to the stakeholders and places where ecotourism takes place (Weaver & Schlüter, 2001). In our two cases, the different circumstances for the communities lead to differences in their perception of opportunities and obstacles regarding ecotourism. The NRMV is being managed by FUNCOC that has the capacity to market and manage attendance of large numbers of tourists. Ecotourism has a great economic potential for the farmers but they do not currently participate in the management of the core zone in the nature reserve (where the main tourism takes place) and therefore they perceive that they do not benefit appropriately from the tourism. However, some of the local inhabitants are employed by FUNCOC as park rangers and support staff, hence they do receive some of the benefits of ecotourism in the area. This lack of direct participation of the local communities in nature-based tourism enterprises is common in many protected areas in developing countries (Bruyere, Beh & Lelengula, 2009; Lai & Nepal, 2006; Ormsby & Mannie, 2006; Stronza & Gordillo, 2008; Xu et al., 2009).

Moreover, it has been demonstrated that tourism in protected areas has yielded economic benefits, but these benefits are mostly received at national and global levels, while local communities have received limited economic benefits. Generally, this is because the local people do not have the training and investment opportunities to establish or participate in the tourism business as easily as foreigners do (Bookbinder, Dinerstein, Rijal, Cauley & Rajouria, 1998; Ezebilo & Mattsson, 2009; Nepal, 1997; Nyaupane et al., 2006; Xu et al., 2009). This is so in the case of the NRDE farmer's cooperative that does not have the capacity to develop ecotourism business, and also for the communities in NRMV that do not take part in the ecotourism enterprises already established there. Therefore, it should be a priority for protected area managers and decision makers at all levels to develop conservation strategies in a benefit-sharing approach with local

communities; this would provide an incentive for farmer participation and not leave the impression that they only share the costs of conservation.

Farmers in NRDE perceive the benefits of tourism activities directly, but the tourists are too few. The farmer cooperative is engaged in this endeavor, but does not have the capacity needed to attract increased numbers of tourists to the area. Better transportation, other infrastructure development, and marketing are needed for capacity building. These are matters that need governmental support (Paper III). This seems to be a frequent limitation in Latin America. A study done in three ecotourism projects in the Amazonian region of Peru, Ecuador and Bolivia also identified a need to develop strong local institutions to support the communities engaged as owners and managers of the ecotourism projects (Stronza & Gordillo, 2008). This situation is exemplified also in a protected area in Nicaragua, the Biosphere Reserve Bosawas. Here, institutional weakness, lack of coordination between institutions, over-centralization of political power, and lack of resources and political will at all levels have all collectively contributed to a mismanagement of this protected area (Howard, 1998; Stocks, McMahan & Taber, 2007).

According to an analysis of 251 case studies on ecotourism around the world (25% in Central America), the benefits of ecotourism could be grouped into four categories:

1) More effective conservation of protected areas because of a higher incentive to do so.
2) Increased revenue creation for local communities, which subsequently leads to changes in the land-use pattern from consumptive to non-consumptive land use.
3) Revenue creation on a regional or national scale, leading to shifting priorities at various levels of the administration.
4) Change in the attitude of local communities towards the protected area in their vicinity which in turn reduces poaching, illegal timber cutting and other consumptive land uses (Krüger, 2005).

Comparing this framework of benefits indicated by Krüger (2005) with our two case studies, the benefits 1 and 4 are in process for both cases because it is evident that the ecosystems are fairly well conserved, the negative impacts on biodiversity are not yet extensive, and there is a local concern for avoiding consumptive land uses. While benefit 2 (increased revenue creation for local communities) is in process for NRDE but will need external support to accomplish it, in the NRMV it is only an idea given to the managers as part of the results of this study. Benefit 3 (revenue

creation on a regional or national scale) is being met based on the tour operators income generation, employment of local workers, and evidence from national records of income derived from tourists visiting Nicaragua. Nevertheless, there is a strong need for a study to document the revenue creation that is specifically ecotourism derived.

On the other hand, from those same 251 cases, it was found that the three main reasons for tourism to be unsustainable were:

1) Too many tourists leading to habitat alteration and pollution;
2) Lack of local community involvement which leads to consumptive land-use; and
3) Not enough control and management of properties and resources leading to unsustainable practices that can spread (Krüger, 2005).

Once more, the second and third reasons for unsustainable tourism are the main limitations in our cases as well. This indicates the great importance on paying attention to accomplishing a real participation in the management of ecotourism for the local community.

5.4 In conclusion is ecotourism an alternative for protected areas in Nicaragua?

As was stated in the references and confirmed by the case studies presented, there is not a given answer to the question of ecotourism being an alternative for protected areas in Nicaragua. Minimization of ecological impacts and conservation of biodiversity are somehow achievable goals with appropriate technical support, personnel and infrastructure for tourist management. Full participatory benefits for local communities in ecotourism are difficult to accomplish when there is insufficient institutional support and technical expertise to manage such an enterprise. In our study I illustrate a conservationist organization working for more than 10 years, sustaining the nature reserve management objectives, promoting conservation awareness for the tourists and communities, generating economic benefits to maintain the reserve, and indirectly providing profit to the national economy, but local communities are not participating enough in the ecotourism enterprise. In the other case studied, NRDE, besides granting appropriate ecological management to the reserve, the local owners and farmers are accomplishing real participation in the ecotourism project. However, they lack the enterprise and networking expertise to market and promote the ecotourism in a competent manner. Additionally, the area where this reserve is located does not offer good accessibility, and the national government is not

providing sufficient assistance in this regard. As a consequence, the economic benefits derived from ecotourism so far are marginal.

Despite all the complexity of developing ecotourism, there have been successful examples reported. Very close to Nicaragua in Costa Rica, the Santa Elena Rainforest Reserve is a case where ecotourism has made positive contributions to the local community (Wearing & Larsen, 1996). Nevertheless, some researchers have characterized Costa Rica as an unsustainable ecotourism model. This is because the prioritization of economic growth is independent of community and ecological matters. Examples of unsustainable ventures in Costa Rica include the construction of very large-scale tourism complexes, hotels with golf courses in semiarid regions, the severe degradation of hydrologic systems, the massive clearing of rainforest and the displacement of locals in favor of touristic access to natural areas (Mowforth & Munt, 2003 in Klak, 2007, p. 1049). These extensive types of impacts at national level in the destination country along with the global impacts of traveling to the tourism destination should be acknowledged and managed. It is difficult to assign the responsibility of the production of GHG emissions, it could be assigned to the country of origin of the tourists because they are the ones producing the emissions, it could be to the destination country because it is the one earning from tourism. On the other hand, it can also be argued that the cost should be carried by the countries selling the fuel since they are acquiring the economic profits of using it (Gössling et al. 2002). The last suggestion particularly appeals to me, following the principle of "who contaminates pays", or in other words, internalizing the costs of 'producing' fuel and paying for the cost of its consumption in the market price. Nevertheless, there are some alternatives to mitigate the impacts of green house gas emissions, such as "clean" energy sources (solar, wind), reduction of consumption patterns, sustainable transportation systems and carbon neutral traveling.

Summarizing this work, it may be concluded that conservation of biodiversity is possible within an ecotourism framework. The impacts on flora are not extensive and can be managed with appropriate ecological considerations. In the case of the fauna group studied the results are not definitive and it requires an additional period of monitoring to confirm if there is a reduced abundance of some species or more sampling effort is needed. Because, due to their intrinsic conditions cloud forests are located in highland areas and surrounded by drier and warmer environments, some connectivity to similar type of ecosystems is needed in order to maintain fauna in a sufficient population size. As O'Grady, Brook, Reed, Ballou,

Tonkyn & Frankham (2006) indicate populations of threatened mammals with reduced genetic diversity have elevated extinction risk.
Concerning the local communities, they have different levels of it is not just participation, but it is not just their own participation that is required to make ecotourism enterprises a success. Applying ecotourism in protected areas in a developing country such as Nicaragua is a tradeoff situation. When the local communities are in charge of running the ecotourism business, they may lack marketing expertise and the networking abilities to make it as economically successful as it might otherwise be. It is a trade-off between local participation and the ability to succeed as a business, because the local stakeholders do not usually have the same economic and political power as the government, organizations or private tourism enterprises may have.

Ecotourism as a process developed in valuable natural and cultural areas needs to be understood in order to be appropriately managed. Taking the results of the two cases, I would say that ecotourism is an alternative to conserve biodiversity and at the same time contributes to local livelihoods, but it needs an institutional framework for support. In the case of NRMV, the managers find it easier to manage the tourism operation in compliance with the protected area management plan without much community involvement. The involvement of communities in ecotourism would just add to their work load. If an institutional framework was established for ecotourism management as it is for protected area management in Nicaragua, the managers would be compelled to integrate the representatives of the communities in the ecotourism business, as they do integrate the communities in conservation issues. Additional support is also needed for small enterprises to succeed in ecotourism, as in any other business, as this requires investment, networking and marketing, capacities not always locally available. Moreover, the government institutions in charge of protected areas need to change the "tragedy of enclosure" management approach to a sustainable use approach. This, under the umbrella of ecotourism, can ensure the conservation of natural and cultural resources.

The results of this research demonstrate the importance of ecotourism studies in developing countries, especially under Nicaraguan natural and socioeconomic conditions that are similar to and at times different from other cases in Latin America. To address the complexity of ecotourism management an interdisciplinary research approach is required. Therefore, the research was designed to integrate ecological and social dimensions of ecotourism. While the importance of this kind of study is unquestioned, it continues to be a challenge to obtain quantitative data sets to test hypotheses under these natural and social systems. To this end this study has obtained as

complete data sets as possible. While in some cases the results are not as definitive as I may have liked, they represent the best that could be achieved under the constraints of the research. I am pleased to have been able to conduct this pioneering work to better understand the issues involved in natural and social sciences and for the practitioners of these disciplines.

5.5 Future research proposed

It is recommended that monitoring of vegetation cover, plant and mammal species abundance and diversity be continued on some periodic basis to compare with baseline observations presented herein. As indicated in section 3.6.1, studies on umbrella and keystone species would be of great value for conservation of this unique ecosystem. Because of the intrinsic conditions of cloud forests it is necessary to investigate the need or not of establishing a biodiversity corridor for these two nature reserves in order to avoid major risks of extinction by inbreeding, specially for large range mammal species.

While it was not part of this study to quantify the economic and financial benefits of ecotourism, such a study would be most welcome and important to verify total revenues generated by this specific enterprise. Furthermore, as was stated previously, the concerns in regard to the global sustainability of ecotourism have not been addressed in this research. Nevertheless, this is an important issue to be dealt with in future research.

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