The carrying capacity of trails in the Iztaccíhuatl-Popocatépetl National Park

Gandhi González Guerrero, Dr.,

María Eugenia Valdez Pérez, Ms.,

Rafael Morales Ibarra, Mr.,

María de Jesús Osorno Corona, Miss,

Centro Universitario Tenancingo, Universidad Autónoma del Estado de México, Tenancingo, México

Correspondence details: Centro Universitario Tenancingo, Universidad Autónoma del Estado de México, Carr. Tenancingo-Villa Guerrero Km 1.5, Edo. de México, C.P. 52400.

Corresponding author. Gandhi González-Guerrero is a lecturer at the Tenancingo University Centre of the Autonomous University of the State of Mexico. She completed her PhD in Development Studies at the University of East Anglia. Her research interests are on the subjects of rural development, tourism and policy instruments with focus on participation and community involvement. She has published papers in journals and congress proceedings. E-mail: gandhoo@hotmail.com

María Eugenia Valdez Pérez is a lecturer at the Tenancingo University Centre of the Autonomous University of the State of Mexico. She holds a Master's degree on Geography and is currently studying a PhD in Science. Her research interests are on the subjects of natural resources. E-mail: mevaldezp@gmail.com

Rafael Morales Ibarra is a lecturer at the Tenancingo University Centre of the Autonomous University of the State of Mexico. He holds a Master's degree on Economics and is currently studying a PhD in Economics. His research interests are on the subject of microeconomics and small enterprises.

María de Jesús Osorno Corona is currently concluding her BA dissertation on Tourism at the Tenancingo University Centre of the Autonomous University of the State of Mexico.

The carrying capacity of trails in the Iztaccíhuatl-Popocatépetl National Park

Abstract

As conservation sites, Protected Natural Areas (PAs) arguably have a greater need for the estimation of their carrying capacity than other destinations. The Iztaccíhualtl - Popocatépetl National Park in Mexico has eight trails, which are offered as attractions. These paths have different purposes, emphasizing different aspects within the Park. Some of the paths are also used as educational tools within the subject of conservation. This document focuses on two of such trails and uses the methodology of carrying capacity to estimate the ideal number of visitors to each trail. The document concludes arguing the advantages and disadvantages of trails in National Parks. It also discusses the advantages and disadvantages of the methodology of carrying capacity as a tool for the management of visitor flow.

Key words: carrying capacity, trails, National Parks

Introduction

Protected Areas (PAs) contribute to conservation objectives at the national and international level. Apart from conservation objectives some categories of PAs, such as National Parks, have also meant to be used for recreation. However, recreation and conservation objectives are not always compatible, for which it has been sought to lower the impacts caused the tourism activity in general. Carrying capacity is one of the tools that have been proposed to manage visitor flow and thus monitor and control impacts. Since PAs including National Parks have conservation objectives by definition, they have arguably greater need for managing impacts than other types of destinations.

Protected Natural Areas

A Protected Area is a place that for its environmental value and singularity is especially set apart for conservation purposes. It is 'an instrument of environmental policy legally defined for the conservation of biodiversity' (CONANP 2008). The total area of PAs in a region or country can be used as an indicator for measuring biodiversity conservation efforts (Marcer et. al. 2010). The World Commission on Protected Areas (2010) states three benefits that can be obtained from PAs: preservation of biodiversity, protection from extinction and climate change, and support for the livelihood of human communities.

According to Bartlett et. al. (2010), the closure of areas for their protection followed two different patterns. The first one – called direct- with the purpose of having an impact on the use and conservation of resources; and the second one – indirect- founded on the spiritual and cultural needs of the communities. The later patter specially linked to indigenous communities and the places that hold significance for them (Lockwood 2009).

The protection of areas can be traced back two thousand years to India for the purpose of conservation; and in Europe a thousand years ago, for the purpose of hunting (Eagles, et. al. 2002). In more recent times Yellowstone National Park is considered the first PA, decreed in 1872 (West Sellars 1997), although in 1864 a policy movement by the US Congress meant the establishment of Mariposa Grove in the Yosemite Valley as a reserve, to become part of the Yosemite National Park in 1890 (Eagles & McCool 2002).

The first PA in Mexico was a National Park, which was decreed in 1917. Up to October 2013 there have been a further 175 proclamations of Protected Natural Areas, of which 67 are National Parks. To date there are six categories of PAs in Mexico – Biosphere

Reserves, National Parks, Natural Monuments, Natural Resource Protection Areas, Flora and Fauna Protection Areas and Sanctuaries.

Tourism in Protected Natural Areas

Due to its economic importance, the tourism activity is a priority for many countries (WTO 2013); and its diversification is linked to its success in attracting different types of tourists. Even though today it is a common understanding that PAs are set to fulfil conservation objectives, an important factor in the creation of the Yellowstone National Park was profit-seeking (West Sellars 1997). It is thought that the economic interest of the railroad companies in the tourism potential of the National Parks started what might be referred to as a movement to be repeated the world over (Ibid.). Yellowstone was decreed as "a public park or pleasuring ground for the benefit and enjoyment of the people" (Eagles, et. al. 2002: 6).

As National Parks began to be established also in Australia, Canada, South Africa and New Zealand towards the end of the 19th century, 'park visitation and tourism became a fundamental element of the park phenomenon' (Eagles & McCool 2002: 48). Thus, historically, National Parks and Protected Areas have had both – conservation and recreational purposes (Cessford & Muhar 2003; Bartlett 2010). In practice this has meant the generation of impacts to National Parks, as the concentration of tourists and the intensive use of resources damage not only the environment but also the experience of the tourism activity (Puente Santos, et. al. 2011).

Generally speaking, in the last decades there has been a movement in tourism towards lowering the impacts caused by the activity. In the case of National Parks and other

Protected Areas this movement takes greater relevance as these areas are especially reserved for the conservation of natural resources. As mentioned by Wall (1997: 46), visitors to natural areas can be potentially more damaging to the environment than the mass tourist as the latter's "needs and wastes can be more readily planned for and managed". This points to the need for 'planned extension and organised demand' of tourism in protected areas (Dinca & Irina 2011), for which tools such as the carrying capacity can be used.

Carrying capacity

Due to the importance of controlling and managing visitor flow in National Parks, different monitoring processes have been used. Cessford and Muhar (2003) make a review of different techniques used in visitor monitoring and divide them into four categories– direct observation, on-site counters, visit registrations and inferred counts. The techniques listed include: camera recording, field observers, active optical, magnetic sensing, visit registers, fees, interviews and indicative counts, among others. The purpose of these monitoring options is to inform planning and management.

Another tool that has been used is carrying capacity. This is the estimated maximum amount of visitors that a site can receive per day without causing considerable damage to the ecosystems or to visitors' satisfaction (Prato 2009). This tool aids tourism planning. It has a behavioural component that has to do with the "quality of the recreational experience" and a biophysical component; although it is ultimately considered an ecological concept that reflects the results of the people-nature interaction (Simón, et. al. 2004: 277).

Carrying capacity studies have been conducted for example in Costa Rica (Cifuentes 1999), Great Britain (Simón, et. al. 2004), Spain (Roig i Munar 2003; Tudela Serrano & Giménez Alarte 2008), Mexico (Segrado, et. al. 2008; Puente Santos 2011), Colombia (Botero 2008) and Argentina (Rosell 2007; Martín Varisto, et. al. 2009). These studies have the purpose of providing a baseline to regulate the tourism activity, as it is often practiced without control or regulation with important implications for biodiversity (Puente Santos, et. al. 2011).

However, carrying capacity studies encounter several problems. Simón, et. al. (2004: 277) list a number of challenges that are faced. These include the subjectivity of the concept, as it can be based on perception. Linked to this is also the dynamism and fluidity of the concept, which means that the concept need to adapt not only to context and circumstances but also to changes in them. Puente Santos et. al. (2011) mention the lack of sociocultural indicators in the currently used methodologies. Despite these and other challenges, it can be argued that carrying capacity is a starting or orientation point that needs to be complemented with other tools to better inform tourism monitoring and planning.

Methodology

Research site

The research site is the Iztaccíhuatl-Popocatépetl National Park (IPNP), which is located in the Centre of Mexico. This park was decreed in 1935. The initial decree stated that the area above 3000 MSL would constitute the National Park. An amendment in 1948 increased the MSL to 3600 establishing an area of 25,679 hectares for the IPNP (DOF 1935; 1948).

The IPNP falls within the boundaries of three states – Mexico, Morelos and Puebla, comprising 13 municipalities among them. The Park is managed by the CONANP (National Commission for Protected Natural Areas) – a government department created in 2000 to manage all PAs with federal decree in the country. In contrast to many PAs in Mexico and around the world, this National Park does not seem to have ownership claims by private owners or communities.

The management programme for the IPNP was first published in 2013. One of its stated objectives is to promote the development of tourism and leisure activities. At the same time, the document acknowledges that there is a lack of control in the tourism activity, which is reflected in damage to the areas and litter in the park (CONANP 2013).

The IPNP offers visitors eight trails that vary from 270 metres to 6 kilometres in length. All trails have educational purposes covering a range of topics. For the purpose of this document two trails were chosen: Yolotxochitl and Alpine Trail. Yolotxochitl is approximately half km. from the main building. Its length is 270 m. and the time calculated for its visit is from 15 to 30 minutes. Its purpose is to show and explain the importance of water catchment through trenches. The Alpine trail is 6 km long and its visit is calculated to last from 1.5 to 2.5 hours one way. Its purpose is to highlight the role of the mountains as water producers. It includes some history while considering pre-hispanic cultures and their sustainable use of forest and water resources.

The tourist carrying capacity for each these trails is calculated based on the methodology proposed by Cifuentes (1992; 1999). This methodology is explained in the following section.

The methodology of tourist carrying capacity

The methodology followed for the study is that proposed by Cifuentes (1992; 1999). This methodology entails the calculation of four carrying capacities that together make up the Tourist Carrying Capacity (CCT).

The first carrying capacity is the Physical Carrying Capacity (CCF). The CCF refers to the maximum amount of people that could be accommodated in a given space in a day without considering comfort, quality of experience or environmental impact (Puente Santos et. al., 2011; Tudela Serrano & Giménez Alarte 2008).

The second carrying capacity is the Real Carrying Capacity (CCR). Within this carrying capacity four factors are considered: the social factor (FSoc), erodability (FCero), accessibility (FCacc) and seasonality (FCct). The FSoc refers to the minimum space required per visitor and distance between groups. The FCero entails calculating the impacts generated by considering type of soil and gradient. The FCacc determines the degree of difficulty that visitors experience during their visit due to the gradient. The FCct refers to the season in which the place remains opened.

The third carrying capacity is the Management Capacity. This carrying capacity considers the administrative part of the space focusing on three variables: personnel, infrastructure and equipment. These variables are rated according to four criteria: a) existent and optimum amount, b) use and conservation status, c) location, distribution and accessibility to the equipment, and d) functionality.

The fourth carrying capacity is the Effective Carrying Capacity (CCE). This carrying capacity brings together the calculations of the previous carrying capacities to determine the maximum amount of visitors that a given space can receive. The result is the Tourist Carrying Capacity.

The Carrying Capacity of the Yolotxochitl and Alpine Trails

As explained in the previous section, the methodology proposed by Cifuentes (1992; 1999) was followed to estimate the CCT of two trails of the Iztaccíhuatl-Popocatépetl National Park. Thus the results are presented in the following sections.

1. The Physical Carrying Capacity (CCF) is calculated as follows:

$$CCF = \left(\frac{S}{SP}\right)(NV)$$

Where:

S= Trail length

SP= Space required by visitors (1 m. and 4 m.)

NV= Times that the area can be visited by the same person in one day. NV is calculated as follows:

$$NV = \frac{Hv}{Tv}$$

Where:

Hv= Opening times

Tv= Time needed for the visit

Given these equations, the results for the chosen trails are thus calculated:

Trail	Equations	CCF
Yolotxochitl	$NV = \frac{540\ min.}{30\ min.} = 18\ times$ $CCF = \left(\frac{270\ m.}{1\ m.}\right)(18) = 4860\ visitors$	4860 visitors
Alpine	$NV = \frac{540\ min.}{180\ min.} = 3\ times$ $CCF = \left(\frac{6000\ m.}{4\ m.}\right)(3) = 4500\ visitors$	4500 visitors

The space required by visitors is given by Cifuentes (1992) in 1 linear m. considering the trail is one-way. Such is the case of the Yolotxochitl trail – there is one entrance and one exit. Segrado, et. al. (2008) consider that the ideal distance between people should fall between 3.5 and 7.25 linear m. and that the minimum space should be of 2 linear m. Puente Santos et. al. (2011) suggests a 4 linear m. distance to allow for the consideration of a two-way visitor influx. This is the case of the Alpine trail – a two-way influx. For this reason a different measure was used for each trail. Thus, for Yolotxochitl the CCF is 4860 visitors per day considering one person can visit the trail 18 times in a day and for the Alpine trail 4500 considering the possibility of visiting the trail three times in a day.

2. Real Carrying Capacity (CCR)

The Real Carrying Capacity is made up by the Social Factor (Fsoc), Erodability (FCero), Accessibility (FCacc) and Seasonality (FCct). Each factor is calculated in the following sections.

2.1) Social Factor (Fsoc)

The Fsoc is estimated using the following criteria:

Trail	Persons per group (PG)	Distance between groups (DG)	Space required per person (SP)
Yolotxochitl	20	50 m.	1 m.
Alpine	4	50 m.	4 m.

For PG an average was estimated. As it can be observed, the Yolotxochitl trail receives larger groups. This can be explained by the location and the length of the trail. School groups visit this trail while the other one is more visited by small groups of friends. For both trails a distance of 50 m. between groups is considered.

For the Fsoc, it is necessary to first calculate the *distance required per group* (DRG):

$$DRG = (DG) + [(SP)(PG)]$$

Trail	Equations	DRG
Yolotxochitl	$DRG = (50) + [(1)(20)] = 70\ m.$	70
Alpine	$DRG = (50) + [(4)(4)] = 66\ m.$	66

With this information it can then be estimated the *groups* that can be simultaneously found in a trail.

$$Groups = \left(\frac{S}{DRG}\right)$$

Trail	Equations	Groups
Yolotxochitl	$Groups = \left(\frac{270}{70}\right) = 3.86$	3.86
Alpine	$Groups = \left(\frac{6000}{66}\right) = 90.91$	90.91

After the groups, it is calculated the *people* (P) that can be found simultaneously in each trail:

$$P = (Groups)(PG)$$

Trail	Equations	People
Yolotxochitl	$P = (3.86)(20) = 77.2$	77.2
Alpine	$P = (90.91)(4) = 363.6$	363.6

The Fsoc also requires the calculation of the *limiting magnitude* (Ml) – the part of the trail that is kept free given by the distance between groups and the space between persons.

$$Ml = (Mt) - [(P)(SP)]$$

Trail	Equations	Limiting Magnitude
Yolotxochitl	$Ml = (270) - [(77.2)(1)] = 192.8$	192.8
Alpine	$Ml = (6000) - [(363.6)(4)] = 1454.4$	1454.4

Finally, the Fsoc is estimated by dividing the *limiting magnitude* (Ml) by the *trail length* (S):

$$FSoc = 1 - \frac{Ml}{S}$$

Trail	Equations	FSoc
Yolotxochitl	$FSoc = 1 - \frac{192.8}{270} = 0.29$	0.29
Alpine	$FSoc = 1 - \frac{1454.4}{6000} = 0.75$	0.75

The FSoc thus considers factors relating to group size and space needed per group to estimate a reducing factor that for the Yoloxochitl trail is 0.29 and for the Alpine trail is 0.75.

2.2) Erodability (Fcero)

As mentioned earlier, erodability is estimated by considering the relation between the soil type and the gradient. There are six types of soil in the Park. According to their characteristics they were classified as low, medium, high and very high susceptibility to erosion.

Soil	Susceptibility to erosion	Weighing
Phaeozem (PH)	Medium	0.5
Cambisol (CM)	Medium	0.5
Regosol (RG)	High	1

Andosol (AN)	High	1
Arenosol (AR)	High	1
Leptosol (LP)	Very high	1.5

In the case of gradient, three ranks are considered by Cifuentes (1999):

Gradient	Erodability	Weighing
Less than 10%	Low	Non-significant
Between 10% - 20%	Medium	1
More than 20%	High	1,5

Within these ranks, only the last two are considered as having erodability risks. This calculation helps to limit the number of visitors according to impacts related to erodability.

Trail	Equations	Erodability
Yolotxochitl	$FCeroS = \frac{(270)(1)}{270} = 1$ $FCero = Non - significant$	1
Alpine	$FCeroS = \frac{[(1900)(1) + (2600)(1) + (1500)(1.5)]}{6000} = 1.13$ $FCero = 1 - \frac{[(2100)(1) + (500)(1.5)]}{6000} = 0.53$	1.13+0.53= 1.66/2= 0.83

The type of soil in the Yolotxochitl trail is arenosol, thus presenting a high susceptibility to erosion having a weight of one in pondering. The gradient of the Yolotxochilt trail falls below 10%, for which it is non-significant for this estimation.

The Alpine trail has three types of soil: andosol arenosol and leptosol. Thus presenting from high to very high susceptibility to erosion having a weight of 1.0 and 1.5 in pondering. Regarding the gradient falls between the three ranks proposed by Cifuentes (1999).

2.3) Accessibility (Fcacc)

Accessibility relates to the difficulty with which visitors can move along the trail. This is considering the gradient in the following ranks

Gradient	**Difficulty**	**Weighing**
Less than 10%	None	Non-significant
Between 10% - 20%	Medium	1
More than 20%	High	1,5

The Fcacc is thus calculated as follows:

$$FCacc = 1 - \frac{[(ma)(1.5)] + mm}{mt}$$

Where:

Ma= metres with high difficulty

Mm= metres with medium difficulty

Mt= total metres of the trail

Trail	Equations	FCacc
Yolotxochitl	Non-significant	-
Alpine	$FCacc = 1 - \frac{[(500)(1.5)] + 2100}{6000} = 0.53$	0.53

The gradient of the Yolotxochilt trail falls below 10%, for which the difficulty is non-significant for this estimation. According to the data, the gradient of the Alpine trail presents none medium and high difficulty giving an FCacc of 0.53.

2.4) Seasonality (FCct)

This factor considers the months in which the site remains closed to the public. It is calculated as follows:

$$FCct = 1 - \frac{Ml}{Mt}$$

The park does not close except for warning of volcanic activity and excessive snow during the winter months. This is difficult to calculate as it varies per year. However an approximate period of a month will be considered for both trails.

$$FCct = 1 - \frac{1}{12} = 0.92$$

Once the four factors have been calculated, the CCR is estimated as follows:

$$CCR = (CCF)[(FSoc)(FCero)(FCacc)(FCct)]$$

Trail	Equations	CCR
Yolotxochitl	$CCR = (4860)[(0.29)(1)(0.92)] = 1296.65$	1296.65
Alpine	$CCR = (4500)[(0.75)(0.83)(0.53)(0.92)] = 1365.89$	1365.89

As it can be observed the FCacc for the Yolotxochitl trail was not considered, as it was not significant. According to the results, the Real Carrying Capacity of the Yolotxochitl trail is 1297 visitors and for the Alpine trail 1366 visitors.

3. Management Capacity (CM)

Once the CCR has been estimated, it is necessary to calculate the CM. The CM will consider the variables: infrastructure personnel and equipment, using four criteria to evaluate them – quantity condition location and functionality. This information will reflect the capacity of the space to receive visitors based on the basic elements needed for visitor service. The information was obtained by observation and though interviews with management. The variables were evaluated according to the following information:

Mark	Value
Unsatisfied	0
Little satisfaction	1
Medium satisfaction	2
Satisfied	3
Very satisfied	4

For estimating CM, the following formula is used. The result can be converted to percentage to explain the Management Capacity.

$$CM = \left(\frac{Infraestructure + Personnel + Equipment}{3}\right)(100)$$

Trail	Equations	CM
Yolotxochitl	$CM = \left(\frac{0.75 + 0.74 + 0.63}{3}\right) = 0.71$	0.71
Alpine	$CM = \left(\frac{0.75 + 0.74 + 0.63}{3}\right) = 0.71$	0.71

According to these results, the trails have a Management Capacity of 71%. This means that as regards infrastructure personnel and equipment there is a lacking capacity of 29% in quantity condition location and/or functionality. Both trails have the same capacity since both belong to the same management.

4. Effective Carrying Capacity (CCE)

The CCE is estimated by as follows:

$$CCE = (CCR)(CM)$$

Where:

CCE= Effective Carrying Capacity

CCR= Real Carrying Capacity

CM= Management Capacity

Trail	Equations	CCE
Yolotxochitl	$CCE = (1296.65)(0.71) = 920.62$	921 Visits/day
Alpine	$CCE = (1365.89)(0.71) = 969.78$	970 Visits/day

Thus, according to the estimation the Effective Carrying Capacity or Tourist Carrying Capacity is of 921 visits per day for the Yolotxochitl trail and of 970 visits per day for the Alpine trail. This is the estimated number of visitors that, by definition, would not cause considerable damage to the ecosystems or to visitors' satisfaction (Prato 2009).

Discussion and conclusions

The Tourist Carrying Capacity (CCT) is a tool that facilitates the estimation of the number of visitors per day to a place. According to this tool, the Yolotxochitl trail can receive 921 and the Alpine trail 970 visits per day. These numbers are calculated based on the characteristics of each trail such as length, soil type and erodability. But there are also elements that they have in common such as those needed to estimate Management Capacity.

Also related to Management Capacity, it is noteworthy that it is only evaluated through the managers' perspective. It is proposed that interviews with visitors could also be conducted to obtain a mean from both perspectives in aspects that can be known by both groups.

This particular methodology to calculate CCT, although useful to estimate an approximate number of visitors, does not consider certain aspects. For example, Holden (2008) states that important for the estimation of carrying capacity are also economic, social and psychological aspects. As the methodology was developed for its application on PAs, it could be argued that particularly economic and social aspects are not relevant. However, as mention by Eagles and McCool (2002) and Eagles, et. al. (2002) PAs have evolved to incorporate local communities that have traditionally been part of them in the planning and decision making processes. It has also been sought that local communities benefit from the tourism activity (Ashley, et. al. 2001). Further, there are costs related to the management of these areas. Thus, economic and social aspects become relevant in the carrying capacity of PAs for which the available methodologies could be further developed to incorporate these aspects.

Carrying capacity studies have limitations. Simón, et. al. (2004) mention the issue of unrealistic implementation. As carrying capacity depends on the possibility of establishing limits of visitation, this may not be straightforward in public areas such as PAs. Furthermore, in the particular case of PAs there is a history of the exclusion and the eviction of native people (see Nepal and Weber 1995; Anderson and James 1998; De Merode 2005; Hayes 2006). In this sense, carrying capacity studies have the risk of repeating exclusion processes by setting a limited number of visitors and in the long term become accessible only to the better off (see West Sellars 1997). Under these circumstances the preservation of resources would be far from a 'democratic movement'.

Nevertheless, there is a need for impact measurement in PAs because of their vulnerability. As leisure and tourism have been regular features since the beginning of their creation, the purpose of conservation of resources may have at times been threatened by intensive use due to a lack of control and monitoring. In this regard carrying capacity can be seen as tool, which complemented with other monitoring tools such as those reviewed by Cessford and Muhar (2003), can inform tourism planning. Thus, despite their limitations, carrying capacity studies are not only helpful but necessary to provide a basis on which to further research on limiting visitors' impact to natural areas.

References

Anderson, T. L., & James, A. (1998). Introduction: Parks, politics and property rights. In K. Brandon, K. H. Redford & S. E. Sanderson (Eds.), *Parks in peril. People, politics and protected areas* (pp. 520). Washington: Island Press.

Ashley, C., Roe, D., & Goodwin, H. (2001). *Pro-poor tourism strategies: Making tourism work for the poor. A review of experience* (Report No. 1). Nottingham: Overseas Development Institute.

Bartlett, C. Y., Maltali, T., Petro, G., & Valentine, P. (2010). Policy implications of protected area discourse in the Pacific islands. *Marine Policy*, 34(1), 99-104.

Botero Saltarén , C., Hurtado García , Y., González Porto , J., Ojeda Manjarrés , M. & Díaz Rocca , L. H. (1999). Metodología de cálculo de la capacidad de carga turística como herramienta para la gestión ambiental y su aplicación en cinco playas del caribe norte Colombiano. *Gestión y Ambiente,* 6(19)

Cessford, G., & Muhar, A. (2003). Monitoring options for visitor numbers in national parks and natural areas. *Journal for Nature Conservation, 11*(4), 240-250.

Cifuentes, M. A., et. al. (1992). *Determinación de capacidad de carga turística en áreas protegidas*. Turrialba.

Cifuentes, M. A., et. al. (1999). *Capacidad de Carga Turística de las Áreas de Uso Público del Monumento Nacional Guayabo, Costa Rica*: WWF.

Comisión Nacional de Áreas Naturales Protegidas. (2008). Que son las AP? (Vol. 2008). México: CONANP.

Comisión Nacional de Áreas Naturales Protegidas. (2013). *Programa de Conservación y Manejo del Parque Nacional Iztaccíhuatl-Popocatépetl-Zoquiapan*. México: CONANP

De Merode, E. (2005). Protected areas and decentralisation in the Democratic Republic of Congo. A case for devolving responsibility to local institutions. In K. Homewood (Ed.), *Rural resources and local livelihoods in Africa* (pp. 36-57). New York: Palgrave Macmillan.

Dinca, G. E., & Irina, A. (2011). Tourism–A vulnerable strength in the protected areas of the Romanian Carpathians. *Procedia-Social and Behavioral Sciences*, *19*, 190-197.

Eagles, P. F., & McCool, S. F. (2002). *Tourism in National Parks and Protected Areas. Planning and Management*. Oxon: CABI.

Eagles, P. F., McCool, S. F., & Hyanes, C. D. (2002). *Sustainable tourism in Protected Areas. Guidelines for planning and management*. Gland: IUCN.

Hayes, T. M. (2006). Parks, people and forest protection: An institutional assessment of the effectiveness of protected areas. *World Development, 34*(12), 2064-2075.

Holden, A. (2008). *Environment and Tourism*. London & New York: Routledge.

Lockwood, M. (2009). Good governance for terrestrial protected areas: A framework, principles and performance outcomes. *Journal of Environmental Management, 91*(3), 754-766.

Marcer, A., Garcia, V., Escobar, A., & Pons, X. (2010). Handling historical information on protected-area systems and coverage. An information system for the Natura 2000 European context. *Environmental Modelling & Software*, 25(8), 956-964.

Nepal, S. K., & Weber, K. E. (1995). Managing resources and resolving conflicts: National Parks and local people. *International Journal of Sustainable Development and World Ecology*(2), 11-25.

Prato, T. (2009). Fuzzy adaptive management of social and ecological carrying capacities for protected areas. *Journal of Environmental Management, 90*(8), 2551-2557.

Puente Santos, E. D., Pérez Ramírez, C. A. & Solís Barrón, C. I. (2011). Capacidad de carga en senderos turísticos del centro de cultura para la conservación Piedra Herrada, México. *Quivera,* 13(2)

Roig i Munar, F. X. (2003). Análisis de la relación entre capacidad de carga física y capacidad de carga perceptual en playas naturales de la isla de Menorca. *Investigaciones Geográficas (Esp),* (31) Rosell, M.P. & Del Pozo, O.M. (2007). Reserva natural isla de Puan. Propuestas metodológicas de Conservación. *Aportes y Transferencias* 11(1)

Segrado, R., Palafox, A. y Arroyo, L. (2008) Medición de la capacidad de carga turística de Cozumel. *El Periplo Sustentable*, (13)

Simón, F. J. G., Narangajavana, Y., & Marqués, D. P. (2004). Carrying capacity in the tourism industry: a case study of Hengistbury Head. *Tourism Management*, 25(2), 275-283.

Tudela Serrano, M. L. & Giménez Alarte, A. I. (1999). Determinación de la capacidad de carga turística en tres senderos de pequeño recorrido en el municipio de Cehegín (Murcia). *Cuadernos de Turismo,* 6(19)

Wall, G. (1997). Sustainable tourism - unsustainable development. In S. Wahab & J. J. Pigram (Eds.), *Tourism, development and growth. The challenge of sustainability* (pp. 33-49). London: Routledge.

West Sellars, R. (1997). *Preserving nature in the National Parks. A history*. New Haven and London: Yale University Press.

World Commission on Protected Areas. (2010). *50 Years of Working for Protected Areas. A brief history of IUCN World Commission on Protected Areas*: IUCN.

World Tourism Organization. (2013). Tourism Highlights. Retrieved 10-10-2013, 2013, from http://dtxtq4w60xqpw.cloudfront.net/sites/all/files/pdf/unwto_highlights13_en_lr.pdf