

Protected Areas: When Good Intentions are not Enough

**A Thesis Presented for the
Master of Science
Degree
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DEDICATION

I dedicate my work to my family for its unstoppable support and love.

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I would like to thank my advisor Dr. Dan Simberloff for his guidance, support and help. Also I want to thank to all my field assistants: Ludovico Zeller, Isabela Zeller, Emmanuel Imizcoz, Lucila Amione, Flavia Casinelli, Marlene Zaracho, Edgardo Balverdi, Ana Paula Blazina, Thais Efron, Maria Celeste Lado, Florencia Mallou, Laura Barbieri, Sofia Jones, Julieta D'Amario, Carolina Mansilla Ferro, Maria Belen Dri, Antonio Navarro, Sabrina Ignacio, Mauro Ricci, Carolina Alonso, Natanael Griffa, Francisco Molina; and lab assistants: Brianna Jacobs and Isabella Ritchie. Finally, this project would not have been possible without the support of the following institutions: University of Tennessee, Ecology and Evolutionary Biology Department, Administracion de Parques Nacionales, Prefectura Naval Argentina, and British Ecological Society.

ABSTRACT

Despite the exponential growth of PAs worldwide in number and area over the last 50 years, evidence of biodiversity protection effectiveness in many cases is not convincing, and further studies at the local level are needed. Most research conducted in PAs has focused on the geological, biological, or ecological aspects of the site, while few studies have examined the policymaking process itself. However, the political history of a country with respect to environmental protection could inform us as to whether PA designation is based on a strong conservation commitment or, on the contrary, it is essentially a propaganda effort yielding what are globally known as “paper parks.” Argentina has a long history of environment protection despite being a developing country, and in 1906 it was the first Latin American nation to set land aside to protect the environment. Later Argentina declared this land a National Park in 1922. A succession of democratic governments interrupted by military regimes has modified parks and promulgated several laws that changed conservation priorities over time. This history shows that the conservation/protection goal of PAs was not always clearly manifest in government policies and actions. Despite the increasing number of PAs (47 by 2017) and the increase in area covered (4,441,808 ha total), most of these lands face the same challenges as other PAs in many developing countries: low budget, lack of field staff, absence of strategic planning, poor political support, and corruption, to mention the most obvious. To understand the impact of these problems on biodiversity, we aimed to determine if protected area designations conserve small mammal communities in Argentina’s first National Park (Nahuel Huapi National Park-NHNP). We compared small mammal communities in unprotected areas and areas with three protection levels: Strict Natural Reserve, National Park and National Reserve. We conducted a capture-mark-recapture study on 20 plots, five in each type of area. This study yielded no clear evidence that the NHNP protection system is conserving small mammal communities. However, higher abundances recorded inside the Strict Reserve suggest direct human interaction negatively impacts this assemblage.

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INTRODUCTION

Anthropogenic landscape modification has grown dramatically over the last century in response to human needs. Human population growth has pushed the boundaries of those human-altered landscapes farther into natural ecosystems. This situation has led to land impoverishment and an unprecedented loss of biodiversity around the world. One of the strongest measures taken to stop this process has been the creation of protected areas (PAs).

The United States is recognized as the first country to establish a PA (Wright and Mattson, 1996). Yellowstone National Park, created in 1872, constituted the first large protected natural area with the main function of preserving the natural heritage for the enjoyment of present and future generations. However, it was not until 1916 that the United States Congress finally enacted the National Parks Service Act in order to unify management policies applied to the 35 National Parks declared by this time (Wright and Mattson, 1996). While some countries rapidly incorporated the concept of PAs and created their own PAs, other countries joined this conservation strategy later in the 20th century according to the World Database on Protected Areas (WDPA). In many developing countries, lands set aside to create PAs have been understood as a luxury that society could not afford (Adams et al., 2004). In many cases, areas that have been declared PAs within the stricter categories of protection (1-4 IUCN categorization) have residents that must be removed, which escalates the conflict (Brockington et al., 2006).

Despite the exponential growth of PAs worldwide in number and area over the last 50 years (Chape et al., 2005), evidence of biodiversity protection effectiveness in many cases is not convincing, and further studies at the local level are needed (Barnes et al., 2016; Carey et al., 2000; Chape et al., 2005). Most research conducted in PAs has focused on the geological, biological, or ecological aspects of the site, while few studies have examined the policymaking process itself (Hopkins, 1995). However, the political history of a country with respect to environmental protection could inform us as to whether PA designation is based on a strong conservation commitment or, on the contrary, it is essentially a propaganda effort yielding what are globally known as “paper parks.”

Argentina has a long history of environment protection despite being a developing country, and in 1906 it was the first Latin American nation to set land aside to protect the

environment. Later Argentina declared this land a National Park in 1922 (APN, 1991). The number of Argentinian PAs has increased since then, and now there are 47 National PAs (Neme, 2016). However, there is no clear evidence that these PAs are effectively protecting the natural and cultural heritage.

For my dissertation, I proposed to investigate the evolution of the Argentinian protected areas system and the effectiveness of the first Argentinian National.

CHAPTER I

**ARGENTINIAN NATIONAL PARKS SYSTEM DEVELOPMENT: LEGAL,
POLITICAL AND ECONOMIC FRAMEWORK, WITH PARTICULAR FOCUS ON
NON-NATIVE SPECIES**

A version of this chapter will be published by María Daniela Rivarola and Daniel Simberloff.

María Daniela Rivarola conducted a search literature in order to gather all the information needed and wrote the whole article. Dan Simberloff proposed the idea, revised and edited the article.

Abstract

Protected Areas (PAs) are key to avoid habitat destruction and biodiversity loss. Most research conducted in PAs has focused on the geological, biological, or ecological aspects of the site, while few studies have examined the policymaking process itself. However, the political history of a country with respect to environmental protection can inform us as to whether PA designation is based on a strong conservation commitment or, on the contrary, is at least partially a propaganda effort yielding what are globally known as “paper parks.” Argentina was the first country in Latin America setting land aside to protect it. Its first national park was created in 1922, and the first law concerning PAs was promulgated in 1934. Since then, a succession of democratic governments interrupted by military regimes has modified parks and promulgated several laws that changed conservation priorities over time. This history shows that the conservation/protection goal of PAs was not always clearly manifest in government policies and actions. Despite the increasing number of PAs (47 by 2017) and the increase in area covered (4,441,808 ha total), most of these lands face the same challenges as other PAs in many developing countries: low budget, lack of field staff, absence of strategic planning, poor political support, and corruption, to mention the most obvious. Since the return to democracy in 1983, new laws have been promulgated based on sound foundation, inspired by knowledge and experience gathered in other countries. However, the existence of a law does not guarantee its enforcement. Environmental NGOs, the scientific community, and a growing concerned citizenry nowadays constitute the most important forces supporting the conservation function of PAs and environmental conservation in general in Argentina.

*Siglo veinte, cambalache
problemático y febril!...
El que no llora no mama
y el que no afana es un gil!
¡Dale nomás!
¡Dale que va!
¡Que allá en el horno
nos vamo a encontrar!
¡No pienses más,
sentate a un lao,
que a nadie importa
si naciste honrao!
Es lo mismo el que labura
noche y día como un buey,
que el que vive de los otros,
que el que mata, que el que cura
o está fuera de la ley...
Tango Cambalache, Enrique Santos Discepolo, 1934*

Introduction

Protected areas (PAs) constitute in many cases the principal strategy for nature conservation. The number and ecoregion representativeness of PAs around the world have increased markedly during the last decades, reaching 233,938 PAs in 245 countries by August 2017 according to the World Database on Protected Areas (WDPA). While some countries have a long history of developing PAs (United States, Spain, Canada, etc.), others have developed environmental policies including protected areas later (Gabon declared its first PAs in 2002 [(Oxford Business Group, 2011), while Afghanistan did it in 2009 [(BBC News, 2009)]]). Most research conducted in PAs has focused on the geological, biological, or ecological aspects of the site, while few studies have examined the policymaking process itself (Hopkins, 1995). However, the political history of a country with respect to environmental protection could inform us as to whether PA designation is based on a strong

conservation commitment or, on the contrary, it is essentially a piece of propaganda globally known as a “paper park”.

Political stability as established in developed countries rarely lasts long in developing ones. Problems of governance in countries across Latin America, Asia, and Africa (where most global biodiversity is concentrated) are similar. Public institutions often controlled by corrupt and authoritarian leaders make incompetent economic and political decisions. The scene is repeated over and over: explosive population growth, environmental degradation, growing poverty, human suffering in urban as well as rural settlements, exploitation by greedy self-serving functionaries, to mention a few recurring factors. Research on the last five centuries concludes that most of these countries face perennial poverty, corruption, ethnic conflicts, environmental abuse, and other societal ills because of governance failures (Jreisat, 2002).

In order to understand the success or failure of PAs, it is important to look at the policymaking process and conservation management approach, because political participation and national attitude toward environmental protection will often confront economic interests and corruption, a situation that could be exacerbated in developing countries (Hopkins, 1995).

Argentinian National Park System: The Beginning

Vast areas of Argentina were unexplored or poorly known at the end of the 19th century. To remedy this situation, the national government organized several expeditions. The French-Argentinian landscape architect Carlos Thays was ordered to travel and study the virgin jungles surrounding the Iguazú Waterfall at the border with Brazil (Fig.1). Meanwhile, 900km² in northwestern Patagonia (Fig.1) was contested between Chile and Argentina for years (Lacoste, 2002). The Argentinian government sent Dr. Francisco Pascasio Moreno to explore the Andean fringe of Patagonia at the boundary with Chile to find a solution and to define the international border.

The experience must have been astonishing for both of them. Iguazú Waterfall consists of 275 individual waterfalls (Fig.2), with the highest one 80 m tall, surrounded by



Thays's expedition

Moreno's expedition

Figure 1. Map of Argentina. Thays was sent to the Iguazu Falls area, located in the northeast frontier with Brazil and Paraguay. Moreno was sent to the Andean fringe (northern Patagonia) bordering Chile. Human settlement in that area was first known as Nahuel Hua

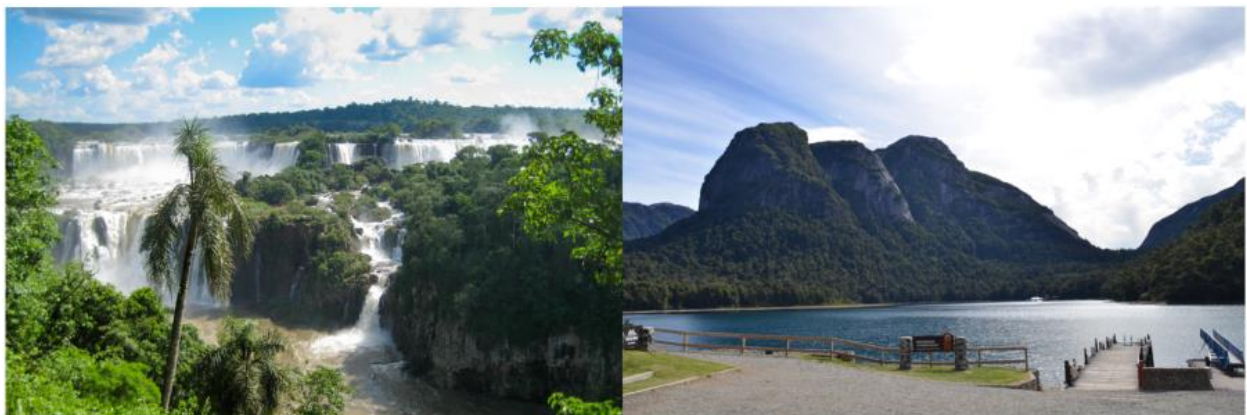


Figure 2. (left) Iguazu Water Falls. Argentina; (right) Puerto Blest, original area donated by Moreno to the National State in 1902

Atlantic forest with more than 2,000 plant species (Izquierdo and Clark, 2012). Aware of this richness, Thays proposed in 1902 the protection of 250 km^2 of land surrounding the Iguazu Waterfall (APN, 2013). The Andean fringe, on the other hand, is shaped by snow-capped mountains, dense evergreen forests, and crystal lakes. Moreno successfully intervened in the process delimiting the international border. To honor him, the national government recognized his efforts with a grant of 75 km^2 of pristine land on the west coast of Nahuel Huapi lake, an area known as Puerto Blest (Fig. 2), bordering Chile. Despite the honor and value, Moreno donated this land back to the Argentinian government, with the main goal to preserve the beautiful landscape for present and future generation to enjoy ¹.

The nation and certainly the region were unprepared to develop any management or conservation program for that pristine area, given that in 1902 the Argentinian government had created by presidential decree under the Home Law (“Ley del Hogar”) the Nahuel Huapi Colony on the southeastern shore of Nahuel Huapi Lake. The goal of the colony was to populate the area after the dispute between Chile and Argentina. Lands were granted gratis to people willing to settle in that beautiful but harsh and isolated place.

The government accepted Moreno’s donation in 1904. By 1907 there were still 430 km^2 planned for human settlement but not yet claimed. To avoid ownership conflicts, the government decided to incorporate the unclaimed land into the land donated by Moreno (Schlüter, 1994). Colonists (mainly European) arrived gradually but continuously in the Nahuel Huapi Colony. They brought agriculture and livestock (including horses, sheep, goats, cattle, and pigs, Fig. 3). Extensive planned fires were common in order to remove forests in preparation for agriculture and ranching. There was also indiscriminate felling of trees for commercial purposes (Fig. 4), hunting, fishing, and even introduction of wild non-native species, both intentionally and unintentionally, that would have strong negative effects on several native species (extinctions, range reductions, displacement) (Veblen et al., 1992).

¹ “With this donation, I manifest my desire that the current physiognomy of the covered perimeter will not be altered, and the only modifications realized will be in response to the needs of educated visitors, whose presence in these places will be always beneficial to the region, definitely incorporated to our sovereignty, whereof rapid and meditated use must contribute to the good destiny of the Argentinian Nation” Moreno, E., 1979. *Reminiscencias de Francisco P. Moreno*. Eudeba, Buenos Aires.



Figure 3. Domestic introduced pig freely grazing on Nahuel Huapi Lake shores, Puerto Blest, Argentina, 1920-1930.



Figure 4. Sawmill in Puerto Blest, Argentina, in the heart of the land donated by Moreno. Beginning of the 20th century.

It took the government more than 10 years to provide an appropriate administrative framework for this protected area, and on April 8, 1922, President Hipólito Yrigoyen created the Parque Nacional del Sud (Southern National Park). He had a more comprehensive vision than Moreno about what a protected area should achieve, as the introduction of the Act explicitly states: “It is considered imperative to avoid the destructive exploitation of our forests, but also to preserve the beautiful natural landscape, along with its flora and fauna...”.

Yrigoyen proposed to use the natural physiognomy of the landscape to redefine the new protected area. As a result, lakes, hillsides, mountains, rivers, and forests would now be units of conservation, increasing the protected area to a total of 7,800 km^2 . In order to consummate the creation of the national park, he entrusted Dr. Emilio Frey, engineer and geographer, to monitor and guide the project for the benefit of the region, alongside with improvement for touristic development (APN, 2013). Although well-intentioned, this Act had some inconsistencies. For instance, one article strictly prohibited all kinds of extractive activities (like felling trees), while another stated that a certain amount of felling and log removal would be allowed, by permission of the director, with no clear specification of how much, where, and what factors should guide the director’s decision (APN, 2013).

Residents of San Carlos de Bariloche (the final name given to the town; henceforth denoted “Bariloche”), in a spontaneous action, formed a Pro-Southern National Park Commission (then formalized by the Alvear-Le Breton decree on April the 14th 1924 as the National Parks Commission) with the main goal of protecting the park and implementing the work needed to improve its accessibility (Biedma, 2003).

The remoteness of the area made this process very slow. The few tourists arriving in Bariloche at the beginning of the 20th century had to travel across Chile, from Santiago de Chile to Puerto Montt, then cross the Andes mountains, arriving in Puerto Blest (heart of the land donated by Moreno), and finally sailing across Nahuel Huapi lake to Bariloche; the entire trip took eight days. The first tourists from the east arrived in 1917, by means of a precarious journey, using horses and narrow, badly maintained roads. In 1931, the lawyer Exequiel Bustillo settled in Bariloche. He had a profound impact on the development of the region. He deeply believed that this land would become the most desirable destination for both national and international tourists, as he said: “the tourism must jointly advance with a rationale for conservation of nature, and the colonization program must be profoundly considered. This

is the pathway to follow to turn this wonderful place into one of the most attractive and important centers of the world” (Biedma, 2003).

Bustillo was designated president of the National Parks Commission on 1934, the same year that the train finally arrived in Bariloche, establishing an easy connection with Buenos Aires. With all the pieces of the transportation puzzle in place, and using his presidency as a platform, along with his influence in Buenos Aires, Bustillo promoted the creation of the first law concerning national parks. National Law 12103 of National Parks was finally promulgated in 1934, along with the creation of “Dirección Nacional de Parques Nacionales” (National Parks National Directorate, DNPN), and it designated the first two national parks in Latin America: Nahuel Huapi National Park (once Southern National Park, Fig. 5) and Iguazú National Park (following architect Thays’s recommendation, Fig. 6).

The law 12103 was inspired by the United States and Canadian National Park Systems and included the legislation necessary to enable the establishment and development of an independent institution with the main purpose of preserving and conserving lands (López Alfonsín, 2015). This law explicitly promoted the creation of new protected areas, as stated in Article 7 “It will be possible to proclaim as Park or Reserve those portions of National Land, that for their extraordinary beauty, or scientific interest, are worthy to be conserved for the use and enjoyment of future generations.” The law promoted conservation along with beautification and touristic development as a strong economic venue. Because those protected areas also included private lands, in order to minimize or mitigate their impact, Article 14 established the authority of the DNPN in controlling and monitoring to forestall harmful exploitation, industrial development, construction, and modification of watercourses.

Article 2 established that the board of DNPN would consist of a president -designated by the Senate - and eight members – chosen by the President of the Republic-. Furthermore, Article 4 bestowed on the DNPN the power to grant up to two stipends (for the DNPN president and secretary) in the event that the nature and economic importance of their duties justified it. The DNPN was administered autocratically, enabling faster resolution of issues, and had autonomous control of its budget, allowing it to function independently of the government. With Bustillo as president of DNPN, there was a burst of energy in Bariloche (Fig. 7). In only ten years, he promoted touristic development by leading the construction of



Figure 5. Map of Nahuel Huapi National Park

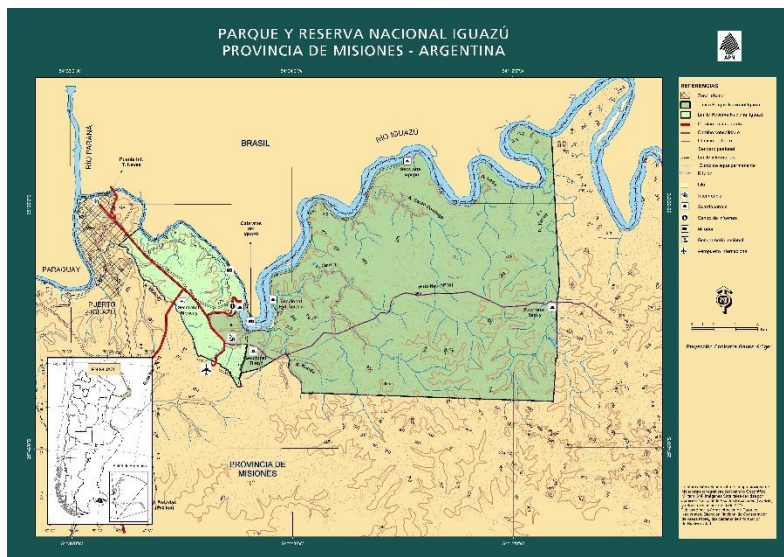


Figure 6. Map of Iguazu national Park

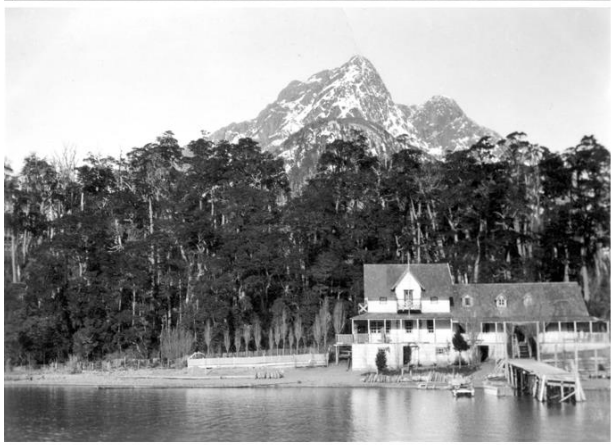
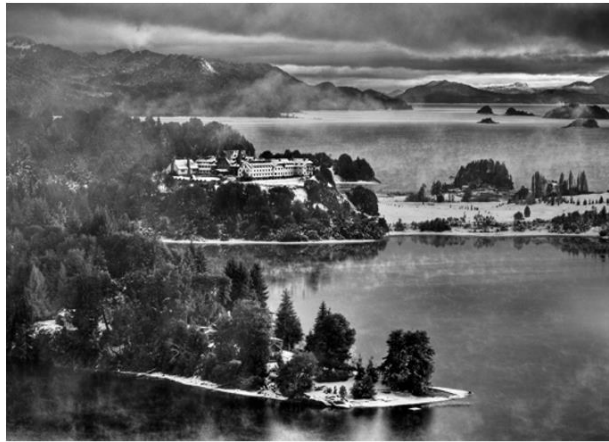


Figure 7. Main achievements of Bustillo during his period as president of the DNPN (1934-1944). Top Left: Llao Llao Hotel. Top right: Civic Center (Bariloche downtown). Center left: Cathedral. Center right: Puerto Blest Hotel. Bottom left: Regional Hospital. Bottom right: Launching the ship Modesta Victoria.

three emblematic hotels (Isla Victoria Hotel, Puerto Blest Hotel and Llao Llao Hotel twice, since the first version had been completed in 1937 but had burned to the ground in 1939 and was rebuilt in 1940). Additionally, he led the paving of the route linking Bariloche and the Llao Llao Peninsula and the launching of the Modesta Victoria, a tourism ship that still sails today in Nahuel Huapi Lake. To consolidate the city, he built the Civic Center and the regional hospital. Finally, amidst these remarkable projects, he built the Cathedral and the Saint Edward Chapel (Biedma, 2003).

Article 10 of law 12103 promoted scientific and historical research along with all those activities aligned with the main goal: conservation. In response, soon the Biological Research Stations at Puerto Radal and Puerto Anchorena (both on Isla Victoria, the main island in Nahuel Huapi Lake) were established, focusing their studies on tree phenology (Oyola-Yemaiel, 1996). The national nursery garden established a few years previously on Isla Victoria, where more than 120 non-native plant species had been introduced as an experimental garden (Relva and Nuñez, 2014), along with some game species like red deer, fallow deer, and wild boar, was also ceded to DNPN (Oyola-Yemaiel, 1996).

The DNPN also promoted the creation of other protected areas in the Andean fringe of Patagonia between 1934 and 1940: Lanín, Lago Puelo (this area was preserved during this period and was finally declared a protected area in 1971), Los Alerces, Perito Moreno, and Los Glaciares National Reserves (Fig. 8). At the beginning of the 1940s, more than 23,200 km^2 had already been protected in Argentina. The law established that creating a protected area had to be followed by nearby urban development. To that end, schools, hospitals, roads, and bridges were promoted by the DNPN in the vicinity of every new National Park or Reserve.

Law 12103 was an important first step toward land conservation in Argentina; however, it had some weak points. The annual budget was mainly supported by the national government but was also self-generated by the DNPN through selling timber and sale or lease of lands. Contrary to the current conception of land protection, it was possible to declare lands as reserves for mining exploration. DNPN could assign locations for human settlements and rural areas (for agriculture and livestock) inside protected areas.

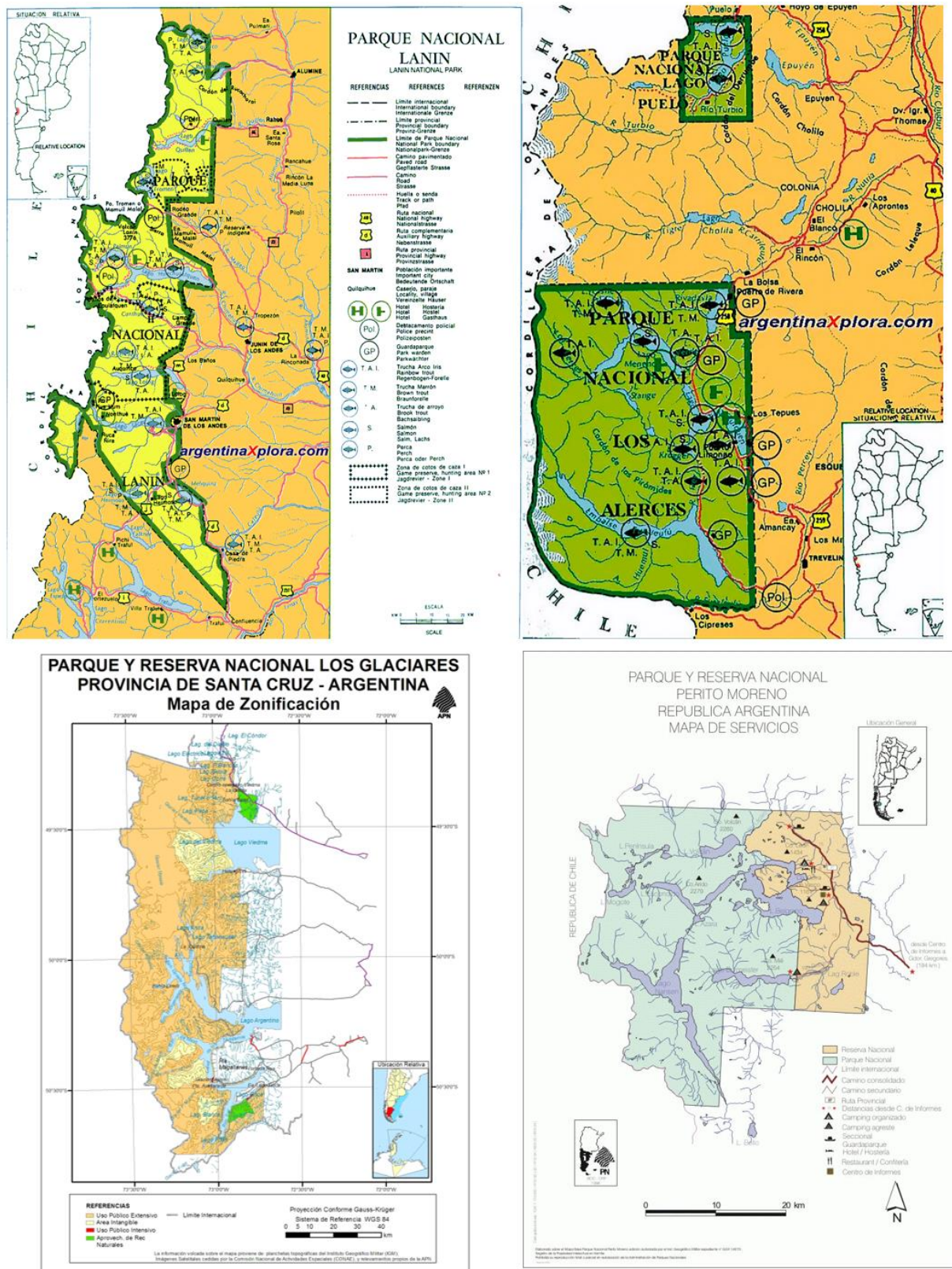


Figure 8. National Parks created by Moreno. Lanín National Park (top left), Lago Puelo National Park and Los Alerces National Park (top right), Glaciers National Park (bottom left) and Perito Moreno National Park (bottom right)

Finally, it is important to note that, even though throughout the body of the law the words “park” and “reserve” are repeatedly used, no distinction between them or explanation is provided.

The rapid creation of these protected areas reflects the reigning priorities at the beginning of the conservation movement in Argentina: geopolitical importance (proximity to the international border), landscape value for tourism, and preference for protecting forest over arid or non-forest environments (Martin and Chehébar, 2001).

Evolution of the Argentinian National Park System: History of Its Political and Legal Framework

The conservation movement had begun in the American continent. The Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere was adopted in Washington D.C. on October 12, 1940 (deposited in the Organization of American States General Secretariat, OAS Treaties Series N0.31, UN Registration 03/03/53, No.485, Vol.161). Thirteen countries signed the convention in 1940. Argentina signed in 1941 jointly with other five countries. Finally, the last four countries that adopted the Convention would signed in later years. The preamble establishes the common goal: to protect and preserve their natural habitats with their flora and fauna, including migratory birds. Lands should be preserved based on their extraordinary beauty, striking geological formations, or historic or scientific value.

In its first article, the Convention defines the distinctions between:

- a. National Park – area under public control in which aesthetic beauty will be accessible for enjoyment by the general public-
- b. National Reserve – protected area where some use of resources can be made under government control-
- c. Nature Monument – region, object or living species that deserves strict protection based on its aesthetic, historical, or scientific value-
- d. Strict Wilderness – natural area in pristine condition, with no path for motorized transportation and no commercial development permitted-

- e. Migratory birds – species that at any season travel across different countries that are members of the present convention. The Contracting Governments shall adopt appropriate measurement for the protection of migratory birds to prevent extinction. A rational use of these species could be made through adequate measures.

The Convention promoted the urgent creation of new protected areas, in which case the contracting country had to notify the Pan American Union of such establishment. This multilateral agreement set the basis for an international approach regarding nature conservation.

Argentina followed the Convention guideline, and the number and surface of Argentinian National Parks and Reserves has increased, reaching 47 protected areas covering almost 4,441,808 ha by 2017 (Fig. 9), which represents 1.7% of the national area. Nevertheless, the process was not a continuum, and the political and economic instability due to a succession of legitimate democratic governments interrupted by military regimes switched priorities over time (Table 1), which had a huge impact on the country as whole; and the conservation process was not an exception.

Law 12103 had created the Argentinian National Park System as an autocratic institution, with the required independence to grow and consolidate. However, this autocracy changed over time. In 1944, President Pedro Ramirez (military) promulgated Decree 18637, which modified Law 12103, granting the Executive Power the ability to

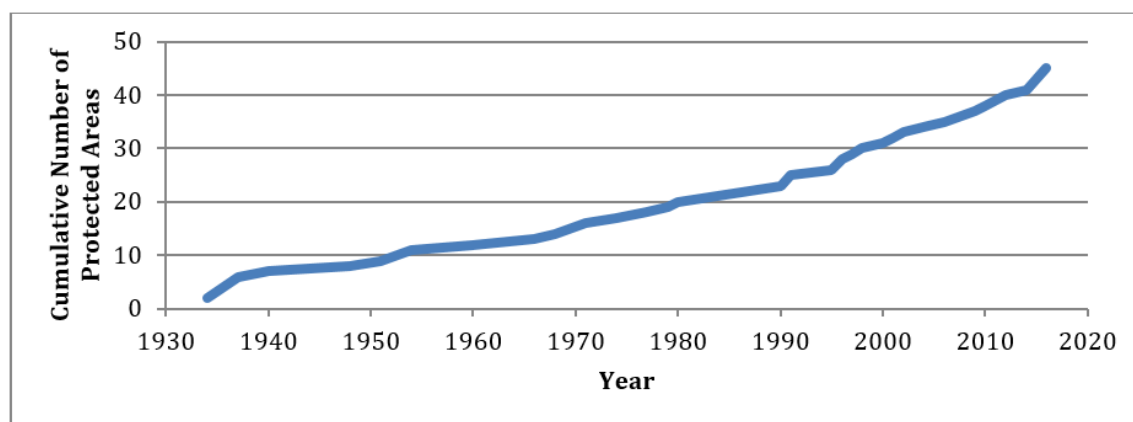


Figure 9. Cumulative number of National Parks created in Argentina since 1932

Table 1. Presidents of Argentina since 1932. Democratic elected presidents were interrupted for military regime. The Ministry in charge of the Protected Areas changed over time. The number of Protected Areas created during each period is indicated.

Period	President	Regimen	Ministry regulating PAs	Number of PA created
1932-38	Agustin Justo	Democratic	Ministry of Agriculture	6
1938-42	Roberto Ortiz	Democratic	Ministry of Agriculture	1
1942-43	Ramon Castillo	Democratic	Ministry of Agriculture	0
1943-43	Arturo Rawson	Military	Ministry of Agriculture	0
1943-44	Pedro Ramirez	Military	Ministry of Agriculture	0
1944-46	Edelmiro Ferrel	Military	Ministry of Agriculture	0
1946-55	Juan D. Peron	Democratic	Ministry of Agriculture	4
1955-55	Eduardo Lonardi	Military	Ministry of Agriculture	0
1955-58	Pedro E. Aramburu	Military	Ministry of Agriculture	0
1958-62	Arturo Frondizi	Democratic	Ministry of Agriculture	1
1962-63	Jose Maria Guido	Military	Ministry of Agriculture	0
1963-66	Arturo Illia	Democratic	Ministry of Agriculture	1
1966-70	Juan Carlos Ongania	Military	Ministry of Agriculture	1
1970-71	Roberto Levingston	Military	Ministry of Agriculture	1
1971-73	Alejandro Lanusse	Military	Ministry of Agriculture	1
1973-73	Hector Campora	Democratic	Ministry of Agriculture	0
1973-73	Raul Lastiry	Democratic	Ministry of Agriculture	0
1973-74	Juan D. Peron	Democratic	Ministry of Agriculture	1
1974-76	Isabel Martinez de Peron	Democratic	Ministry of Agriculture	0
1976-81	Jorge R. Videla	Military	Ministry of Agriculture	3
1981-81	Roberto E. Viola	Military	Ministry of Economy (Secretary of Agriculture)	0
1981-81	Carlos A. Lacoste	Military	Ministry of Economy (Secretary of Agriculture)	0
1981-82	Leopoldo F. Galtieri	Military	Ministry of Economy (Secretary of Agriculture)	0
1982-82	Alfredo O. Saint-Jean	Military	Ministry of Economy (Secretary of Agriculture)	0
1982-83	Reynaldo B. A. Bignone	Military	Ministry of Economy (Secretary of Agriculture)	0
1983-89	Raul R. Alfonsin	Democratic	Ministry of Economy (Secretary of Agriculture)	0
1989-99	Carlos S. Menem	Democratic	Ministry of Economy (Secretary of Natural Resources and Environment)	10
1999-01	Fernando de la Rúa	Democratic	Ministry of Tourism	2
2001-01	Federico R. Puerta	Democratic	Ministry of Economy (Secretary of Tourism)	0
2001-01	Adolfo Rodríguez Saa	Democratic	Ministry of Economy (Secretary of Tourism)	0
2001-02	Eduardo Camano	Democratic	Ministry of Economy (Secretary of Tourism)	0
2002-03	Eduardo A. Duhalde	Democratic	Ministry of Economy (Secretary of Tourism)	1
2003-07	Nestor C. Kirchner	Democratic	Ministry of Economy (Secretary of Tourism)	2
2007-15	Cristina E. Fernandez de Kirchner	Democratic	Ministry of Tourism	8
2015-present	Mauricio Macri	Democratic	Ministry of Environment and Sustainable Development	2

promote the settlement of new cities in regions near international frontiers despite the previous establishment of protected areas.

The succeeding democratic government promulgated Forests Law 13273 in 1948, which established as policy the defense, improvement, and expansion of forests, including those inside protected areas as well as those outside (federal and private lands). The Law classified forests under five categories: protected, permanent, experimental, special woods, and productive; with different regulations applied to each category.

In 1956, under a military regime, Decree 6325 reestablished the Law 12103 in its original version.

In 1958, still under a military regime, Decree-Law 654 modified ten articles of Law 12103. The main points are:

- a) The Executive Power would now choose all members of the DNPN (previously this function was shared between the president and the Senate)
- b) The original Law promoted the creation of National Parks or Reserves. The present Decree also included the creation of Natural Monuments, Protection Zones, and Virgin Regions.
- c) It added an educational role to the functions of a protected area.
- d) Article 16 of the original Law was committed “to protect, conserve and encourage fauna and flora.” This Decree expanded the concept, and in this article incorporated the prohibition of the introduction of any non-native species. Furthermore, it committed to provide the resources needed to eliminate those non-native species that had already been introduced, with the exception of sport fishing species (several trout species, mainly).
- e) It ratified the Forest Law; forest use could be only authorized in Natural Reserves.
- f) It allowed local factories to be established in Natural Reserves.
- g) It banned creation of new cities inside any already declared protected area.
- h) It ratified the first eight National Parks/Reserves created since 1934, which had ended up included in the four new provinces created in 1953 (Law 14294) and in 1955 (Law 14408).

In 1970, a new military regime presided over by Carlos Onganía changed Law 12103 one more time, replacing it with Law 18594. It abolished 29 of the 32 articles in the previous Law. It diminished the autonomy of the DNPN, which no longer had authority to fund or to promote the development of the National Park Services, as Decree 637/1970 had allowed. Moreover, article 21 imposed a presidential appointee (inspector) as head of the National Park Services. This person could be anyone, no matter her/his background or expertise. As could easily have been predicted, the position was occupied by military appointees. Article 23 of Law 18594 dismantled the DNPN and replaced it with a National Consulting Commission on National Parks, National Monuments, and National Reserves. The new commission was formed for the benefit of stakeholders who acted on behalf of their particular interest. Even during military regimes, several presidents led the country for short periods (Table 1). A new president meant a new head for the National Park Services. This institutional instability negatively affected conservation programs and policies (Oyola-Yemaiel, 1996).

Article 25 of Law 18594 established the Park Ranger Corps as a uniformed public force. A park police force had existed since 1934. The School of Park Rangers was created in 1965 and established in Nahuel Huapi National Park. However, this Law formalized Park Ranger Corps authority and made it possible for them to enforce regulations in the protected areas (preventing hunting, timber, and any illegal action).

In 1971, Law 19292 divided the existing protected areas located in the western Patagonian fringe into National Parks and National Reserves. The National Park would be the inner land of the existing protected area and the surrounding area would change its status to National Reserve, within the original limits (Table 2).

Table 2. National Reserves created in 1971 by Law 19292 from the original National Parks along the Andean fringe of Patagonia. The area under each category is expressed in ha.

Protected Area	National Park (area in ha)	National Reserve (area in ha)
Lanin	273,778	195,007
Nahuel Huapi including Los Arrayanes	590,082	235,288
Los Alerces	315,049	72,290
Lago Puelo	22,759	8,427
Los Glaciares	602,287	188,377
Laguna Blanca	9,350	3,000
Perito Moreno	124,878	31,952

Law 18594 was modified by Law 20161 in 1973 under the military regime of Lanusse. This Law resembled in some ways the original Law 12103 but still contained administrative restrictions.

Finally, in 1980, the current Law 22351 regarding the National Parks, Natural Monuments, and National Reserves was promulgated. This law was based on the original National Parks Law 12103 and on recommendations extracted from the 10th General Assembly of the IUCN (1969) and from the Second World Conference on National Parks (1972). The new law consists of 37 articles arranged under seven titles:

- Title I, National Parks, Natural Monuments, and National Reserves. It states the geographical area requirements and characteristics to be considered protected area, clarifies ownership by the national state over those lands, defines human settlement restrictions, and defines the legal authority over the flora and fauna.
- Title II, National Parks Administration. One of the most important changes needed due to the institutional role in conserving nature and taking care of the visitors was to restore institutional autonomy. The name National Parks Administration (Administration de Parques Nacionales – APN) proposed under Title II of this law seemed logical for an institution that administers and manages National Parks, National Monuments, and National Reserves, but also builds and maintains touristic infrastructure and promotes and supports scientific research for the better protection of the ecosystem. Under this title the APN directorate is defined, along with its duties and attributions.
- Title III, Direction and Administration. States sanctions and legal actions for transgressions of regulations.
- Title IV, Reconfirming Status of Protected Areas under the Law. Lists the 31 Protected Areas existing at that time (16 National Parks, one Natural Monument and 14 National Reserves).
- Title V, National Park Rangers. The control and vigilance of National Parks, Natural Monuments, and National Reserves is delegated to the Corps of National Park Rangers. The Executive Power will establish their duties and obligations.

- Title VI, Special Dispositions. In case of National Security issues involving a protected area, the Ministry of Economy and Ministry of Defense will work together with the APN.
- Title VII, Transitory Dispositions. Repeals Laws 18594 and 20161, and Decrees 2811/1972 and 637/1970; and gives 180 days to the APN to propose a new structure and regulations.

In its extensive forewords the authors justified, point by point, each improvement proposed with respect to the previous law. Article 5 subsection g says “The introduction, transplant or propagation of exotic flora and fauna is forbidden”. However, it is interesting that the forewords used as a harmful example the introduction of beaver (*Castor canadensis*) to Tierra del Fuego. They explained the forest devastation as a consequence of flooded lands, and also the change in water quality from clear and high level of oxygen to cloudy and poor in oxygen which, as they say, affects survival of salmon and trout, species that are themselves non-native and harmful for natural ecosystems, but with greater economic importance for the local economy.

In 1983, Argentina finally recovered its democracy, which has been uninterrupted since then. Former president Raul Alfonsín took over a country in ruins. In 1986, Alfonsín opened the inaugural session of the Conference of National Parks and Protected Areas held in Bariloche, where he declared: “Since the industrial revolution and the following demographic explosion, the relationship between man and biosphere has deteriorated, with harmful consequences for the future of the humanity. It is imperative for us to move forward following the directions proposed by the International Union for Conservation of Nature toward correct natural resources management, in order to get the best benefit for current and future generations.”²

Decree 2148 promulgated in 1990 created a new management category following the IUCN guidelines, Strict Natural Reserve, with the main purpose of conserving Argentinian biological diversity (Art. 1). Lands would be chosen based on their biological value and ecoregion representativeness (Art. 2). The Strict Natural Reserve goal is to preserve native communities and their biotic and abiotic interactions as a whole, in order to guarantee the

² Alfonsín, Raul. Discursos Presidenciales. t. 10, Buenos Aires: Secretaria de Informacion Publica, 1986, p. 57.

maintenance of biological and ecological processes (Art. 3). Human access other than that required for management/control or scientific research is forbidden. The same day, 19 Strict Natural Reserves were created (Decree 2149/90) subdividing existing National Parks (Table 3).

Table 3. Strict Natural Reserves created in Argentina on 10/10/1990 under decree 2149. Provinces where each area is located are indicated with a blue dot.

Strict Natural Reserve	Province	
Iguazu	Misiones	
San Antonio	Misiones	
El Palmar	Entre Rios	
Pilcomayo	Formosa	
Chaco	Chaco	
Colonia Benitez	Chaco	
Calilegua	Jujuy	
Baritu	Salta	
El Rey	Salta	
Lihue Calel	La Pampa	
Otamendi	Buenos Aires	
Laguna Blanca	Neuquen	
Lanin	Neuquen	
Nahuel Huapi	Neuquen-Rio Negro	
Lago Puelo	Chubut	
Los Glaciares	Santa Cruz	
Perito Moreno	Santa Cruz	
Bosques Petrificados	Santa Cruz	
Tierra del Fuego	Tierra del Fuego	

Decree 453 followed in 1994, creating two new management categories: Wild Natural Reserve and Educational Natural Reserve. Wild Natural Reserves would be those large areas with little or no alteration at all that provide a good representation of local biological diversity. The goals are to promote biological conservation, to avoid or reduce anthropogenic alterations, and to preserve the continuity of the natural communities and as a buffer zone protecting Strict Natural Reserves. The Educational Natural Reserves, on the other hand, would be those areas adjacent to Strict Natural Reserves and/or to Wild Natural Reserves that provide opportunities for developing environmental education programs.

Also in 1994, there was an important legal change in Argentina. There were no constitutional norms or provisions that regulate natural resources or make specific references to the environment. A new reform of the National Constitution (promulgated in

1853, then modified in 1860,³ 1866, 1898, 1957 and finally in 1994) changed that. Article 41 of the 1994 Argentinian National Constitution Reform states:

“Todos los habitantes gozan del derecho a un ambiente sano, equilibrado, apto para el desarrollo humano y para que las actividades productivas satisfagan las necesidades presentes sin comprometer las de las generaciones futuras; y tienen el deber de preservarlo. El daño ambiental generará prioritariamente la obligación de recomponer, según lo establezca la ley. Las autoridades proveerán a la protección de este derecho, a la utilización racional de los recursos naturales, a la preservación del patrimonio natural y cultural y de la diversidad biológica, y a la información y educación ambientales. Corresponde a la Nación dictar las normas que contengan los presupuestos mínimos de protección, y a las provincias, las necesarias para complementarlas, sin que aquellas alteren las jurisdicciones locales. Se prohíbe el ingreso al territorio nacional de residuos actual o potencialmente peligrosos, y de los radiactivos.”⁴

Also in 1994, National Law 24.375 “Convention on Biological Diversity” was promulgated in agreement with the commitment adopted by Argentina after the Earth Summit held in Rio de Janeiro, Brazil (CBD, 1992). Later, in 1997, decree 1347/97 created the National Advisory Commission for the Conservation and Sustainable Use of Biological Diversity (CONADIBIO for its initials in Spanish) as the authority charged with fulfilling this commitment.

On February 2, 2000, then-president Fernando de la Rúa ordered by Decree 175/2000 that Hernán Santiago Lombardi, Secretary of Tourism, be appointed as APN controller and take charge of APN operations, in response to the urgent need of regularize the normal function of the institution. A year later, Decree 214/2001 restored APN autonomy and designated a new directorate in charge.

³ This reform abolished slavery in the National Territory. Every slave would be free upon arriving to Argentina.

⁴ “All inhabitants enjoy the right to a healthy, balanced environment, suitable for human development and for productive activities to meet present needs without compromising those of future generations, and have a duty to preserve it. In the case of environmental damage, priority to the obligation to rehabilitate, as established by law. The authorities shall provide for the protection of this right, the rational use of natural resources, the preservation of natural and cultural heritage and biological diversity, and environmental information and education. It is up to the Nation to dictate the rules that contain the minimum protection budgets, and to the provinces, those necessary to complement them, without those altering the local jurisdictions. The entry into national territory of current or potentially hazardous waste and of radioactive waste is forbidden.”

An important legal instrument that goes beyond the APN was enacted in 2002: Law 25675 Ley General del Ambiente (Environment General Law) proposed the minimum budget needed to achieve sustainable environmental management, in order to protect and preserve biological biodiversity and to progress toward sustainable development. This law mandates the elaboration of an annual environmental report. According to this law, the National Governmental Environmental Politics must:

- a. Guarantee the preservation, conservation, recovery, and improvement of the quality of both natural and cultural resources.
- b. Promote improvement of the quality of life for present and future generations.
- c. Encourage social participation in the decision-making process.
- d. Promote sustainable and rational use of natural resources.
- e. Maintain the equilibrium and dynamics of ecological systems.
- f. Secure biological diversity conservation.
- g. Prevent and avoid harmful anthropogenic effects.
- h. Promote social change toward sustainable development.
- i. Organize and integrate environmental information and make it accessible.
- j. Establish a federal coordination system in order to implement environmental policies at national and provincial levels.
- k. Establish adequate mechanisms to minimize environmental risks, to prevent and mitigate environmental emergencies, and to repair damage caused by environmental pollution.

Finally, a more specific law was signed in 2007. Law 26331 “Ley de Presupuestos Mínimos de Protección Ambiental de los Bosques Nativos” (Law of minimum budget for the environmental protection of native forests). The first article states that the minimum environmental protection budget needed for the enrichment, restoration, conservation, sustainable use, and management of native forests, along with the criteria used for its distribution, will be guaranteed. In its definition of “native forest”, it includes the associated fauna as well as the soil, subsoil, atmosphere, climate, and hydrological resources. The minimum forest size to be regulated under this law must be 10 ha.

During the 20th century, a long legal process toward biodiversity protection and conservation took place in Argentina; however, the political instability along with changes

in government parties' affiliations hindered this process. Nevertheless, to a certain extent, environmental concerns were included in the national political agenda with higher frequency in recent years.

APN, from theoretical proposals to practical application

The National Parks created since 1934 responded to different interests. As noted above, several of the earliest National Parks were created as a means of national delimitation, to avoid international conflicts with neighboring countries. Bustillo himself explained several years after the creation of the National Parks in the Andean fringe that he was inspired by the regional needs and the national urgency to occupy the frontier that until then had been purely nominal (Hopkins, 1995). Eighteen ecoregions have been described in Argentina (Burkart et al., 1999); but just three ecoregions had been represented at beginning of the establishment of a national protected areas system: Patagonian Temperate Forest, Patagonian Steppe, and Upper Parana Atlantic Forest.

The original political motive gave way to a more purely conservation motive. Over time, new PAs were established in underrepresented ecoregions (Fig. 10); however, this process was more opportunistic and did not follow an organized plan based on previous studies regarding biodiversity representation or vulnerability (Burkart R. et al., 2007; Rodriguez-Cabal et al., 2008). This shortcoming may be associated with the unbalanced representativeness of some ecoregions in the protection system (Table 4). Despite the increment in the number of PAs in Argentina, the size of the protected areas never reached the huge area of those original lands designated in the Andean fringe (Table 5). The importance of these National Parks was soon recognized internationally, and several of them were also designated as World Heritage Site, RAMSAR site, or Biosphere Reserve for the UNESCO (Table 5).

In 2001 the new APN administration issued the 1st Plan de Gestion Institucional para los Parques Nacionales Argentinos (Institutional Management Plan for Argentine National Parks). This plan constitutes the first long-term strategy to overcome difficulties related to the fact that institutional policies were generated by changing national government administrations (López Alfonsín and Berra, 2012). The plan recognized the non-transferable

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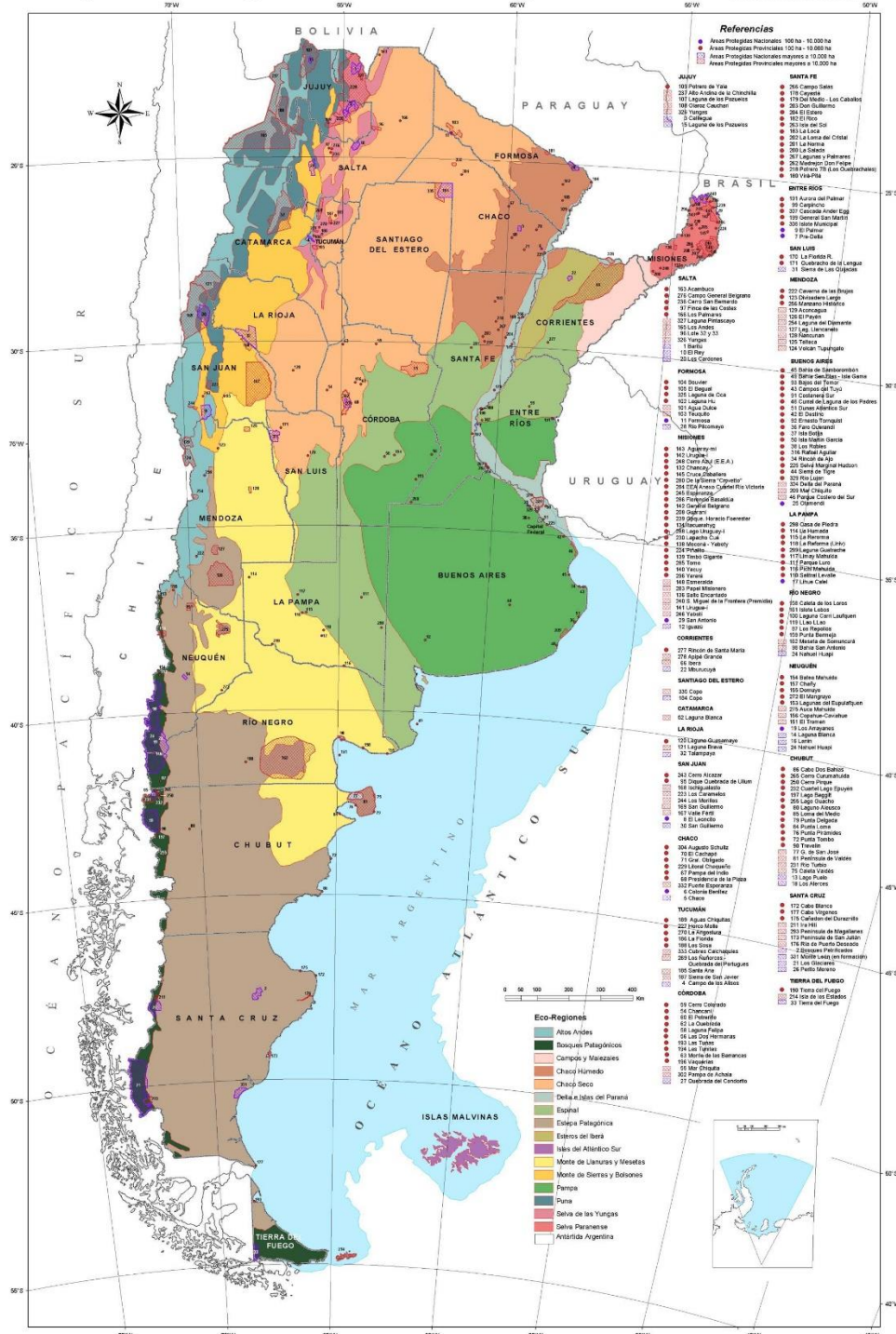


Figure 10. Federal System of Protected Areas and Ecoregions of Argentina. National and Provincial Parks are indicated. Purple dot: National Park, area between 100 and 10,000 ha. Red dot: Provincial Park, area between 100 and 10,000 ha. Purple figures: NP, area >10,000ha. Red figures: Provincial Park, area > 10,000 ha. Extracted from SIB (Biological Information System), APN.

Table 4. Argentinian ecoregions and their representativeness in federal protection system (APN). Information extracted from SIFAP (Federal System of Protected Areas), SIB (Biodiversity Information System), APN, 2017.

Ecoregion	Total area (ha)	Protected Area (ha)	Number of PAs	Percentage protected
High Andes	12274505	42604	5	0.34%
Antarctica	96559700	0	0	0%
Patagonian forest	6452891	2131308	11	33.02%
Field and weeds	2675777	0	0	0%
Humid Chaco	11883797	65406	4	0.55%
Dry Chaco	49184341	353322	6	0.71%
Paraná River Delta and Islands	5617359	10792	3	0.19%
Espinal	29835847	8213	1	0.02%
Patagonian steppe	54278956	512077	10	0.94%
Iberá wetland	3926945	172086	2	4.38%
South Atlantic islands	1216340	0	0	0%
Argentinian Sea	96509501	302082	5	0.31%
Monte Plains and Plateaus	35360046	32500	1	0.09%
Monte of mountain range	11656586	323821	5	2.77%
Pampa	39628852	3040	1	0.00%
Puna	9267113	210356	4	2.26%
Parana forest	2707016	68100	3	2.51%
Yungas	4757050	267136	10	5.61%

Table 5. Argentinian National Parks created from 1934 to 2016

Creation	Region	PA Category	PA Name	Surface (ha)	Ecoregion	International Category
1934	Northeast	National Park	Parque Nacional del Iguazú	67,620	Parana Forest	World Heritage Site
1934	Patagonia	National Park	Parque Nacional Nahuel Huapi	712,160	Patagonian Forest, Patagonian Steppe	
1937	Patagonia	National Park	Parque Nacional Lanín	412,003	Patagonian Forest	
1937	Patagonia	National Park	Parque Nacional Los Alerces	263,000	Patagonian Forest	
1937	Patagonia	National Park	Parque Nacional Los Glaciares	726,927	Patagonian Forest, Patagonian Steppe	World Heritage Site
1937	Patagonia	National Park	Parque Nacional Perito Moreno	127,119	Patagonian Forest, Patagonian Steppe	
1940	Patagonia	National Park	Parque Nacional Laguna Blanca	11,251	Patagonian Steppe	RAMSAR site
1948	Northwest	National Park	Parque Nacional El Rey	44,162	Yungas Forest	
1951	Northeast	National Park	Parque Nacional Río Pilcomayo	50,417	Humid Chaco	RAMSAR site
1954	Northeast	National Park	Parque Nacional Chaco	14,981	Humid Chaco	
1954	Patagonia	National Park	Parque Nacional Bosques Petrificados de Jaramillo	78,543	Patagonian steppe	
1960	Patagonia	National Park	Parque Nacional Tierra del Fuego	68,909	Patagonian Forest	
1966	Central Home	Natural Reserve	Parque Nacional El Palmar	8,213	Espinal	
1968	Northeast	Natural Reserve	Reserva Natural Formosa	9,005	Dry Chaco	
1971	Patagonia	National Park	Parque Nacional Lago Puelo	27,675	Patagonian Forest	
1971	Patagonia	National Park	Parque Nacional Los Arrayanes	1,840	Patagonian Forest	
1974	Northwest	National Park	Parque Nacional Baritú	72,439	Yungas Forest	Biosphere Reserve
1977	Patagonia	National Park	Parque Nacional Lihue Calel	32,500	Monte Plains and Plateaus	
1979	Northwest	National Park	Parque Nacional Calilegua	76,306	Yungas Forest	Biosphere Reserve
1980	Northwest	Natural Monument	Monumento Natural Laguna de los Pozuelos	16,000	Puna	Biosphere Reserve, RAMSAR site
1990	Central Home	Natural Reserve	Reserva Natural Otamendi	4,088	Paraná River Delta and Islands	RAMSAR site
1990	Northeast	Natural Reserve	Reserva Natural Educativa Colonia Benítez	8	Humid Chaco	
1990	Northeast	Strict Natural Reserve	Reserva Natural Estricta San Antonio	480	Parana Forest	
1991	Central Home	National Park	Parque Nacional Predelta	2,608	Paraná River Delta and Islands	

Table 5. Continued

Creation	Region	PA Category	PA Name	Surface (ha)	Ecoregion	International Category
1991	Center	National Park	Parque Nacional Sierra de las Quijadas	73,785	Dry Chaco, Argentinian Northwest Monte and Thistle of the Prepuna	
1995	Northwest	National Park	Parque Nacional Campo de los Alisos	16,177	High Andes, Yungas Forest	World Heritage Site
1996	Center	National Park	Parque Nacional Quebrada del Condorito	37,344	Dry Chaco	
1996	Northwest	National Park	Parque Nacional Los Cardones	65,000	High Andes, Argentinian Northwest Monte and Thistle of the Prepuna, Puna, Yungas Forest	
1997	Center	National Park	Parque Nacional Talampaya	215,000	Argentinian Northwest Monte and Thistle of the Prepuna	
1998	Center	National Park	Parque Nacional San Guillermo	166,000	High Andes, Argentinian Northwest Monte and Thistle of the Prepuna, Puna	Biosphere Reserve, World Heritage Site
2000	Northeast	National Park	Parque Nacional Copo	118,119	Dry Chaco	
2001	Northeast	National Park	Parque Nacional Mburucuyá	17,086	Iberá Wetlands	
2002	Center	National Park	Parque Nacional El Leoncito	89,706	High Andes, Argentinian Northwest Monte and Thistle of the Prepuna, Puna	
2004	Patagonia	National Park	Parque Nacional Monte León	62,169	Patagonian steppe	
2006	Northwest	Natural Reserve	Reserva Nacional El Nogalar de los Toldos	3,275	Yungas Forest	
2009	Central Home	National Park	Parque Nacional Campos del Tuyú	3,040	Pampa	RAMSAR site
2009	Patagonia	Interjurisdictional Park	Parque Interjurisdiccional Marino Costero Patagonia Austral	104,812	Patagonian steppe, Argentinian sea	
2010	Central Home	National Park	Parque Nacional Islas de Santa Fé	4,096	Paraná River Delta and Islands	
2012	Patagonia	Interjurisdictional Park	Parque Interjurisdiccional Marino Isla Pingüino	159,526	Argentinian sea	
2012	Patagonia	Interjurisdictional Park	Parque Interjurisdiccional Marino Makenke	68,796	Argentinian sea	
2014	Northeast	National Park	Parque Nacional El Impenetrable	128,000	Dry Chaco	
2015	Patagonia	National Reserve	Parque Nacional Patagonia	53,000	Patagonian steppe	
2016	Patagonia	Natural Reserve	Reserva Natural Silvestre El Rincón	15,000	Patagonian Temperate Rain Forest	

Table 5. Continued

Creation	Region	PA Category	PA Name	Surface (ha)	Ecoregion	International Category
2016	Patagonia	Natural Reserve	Reserva Natural Silvestre Isla de los Estados y Archipiélago de Año Nuevo	52,736	Patagonian Temperate Rain Forest	

function of the national state in developing and managing the protected area system by the creation of a Protected Areas National System (SNAP-Sistema Nacional de Areas Protegidas).

The plan included:

- 1- The administrative control and patrol of the system.
- 2- The establishment of people and equipment in each unit.
- 3- Inspection of the quality and safety of the services offered.
- 4- Monitoring of the environmental and cultural patrimony.
- 5- APN intervention with people residing in the PAs.
- 6- Land-use planning favoring non-degrading activities.
- 7- Designing and implementing non-native species control and eradication programs.
- 8- Wildfire prevention and control.

The main goals proposed in this plan accounted for:

- ✓ Broader integration of politics and management of the protected areas in Argentina, at the national (SNAP), provincial, municipal and private levels.
- ✓ Inclusion of underrepresented ecoregions in protected areas.
- ✓ The National Park Strategy must be part of the National Strategy for Biodiversity Conservation, an international agreement formulated during the Earth Summit held in Rio de Janeiro, Brazil (CBD, 1992).

Finally, the plan listed particular goals:

- 1- To implement a concept of “equilibrated development”, in which resources would be equally distributed between units.
- 2- Each National Park will have adequate infrastructure.
- 3- Decentralize organization at the regional level.
- 4- Evaluate performance of each unit.
- 5- Better training/ professionalization of the people working in each unit.
- 6- Recovery of the economic autocracy, to generate new income by arrangements with national/international organizations (public and or private).
- 7- Sustainable tourism development.
- 8- Maintaining a positive image of the National Parks in the public eye.

- 9- In order to eradicate the “APN elitist vision,” open a discussion with the general public to reach consensus regarding best practices needed to achieve the main goal of natural resources conservation.

The Environment and Sustainable Development Secretary enacted in 2003 resolution 91/2003, which created a document called “Estrategia Nacional sobre Diversidad Biologica” (National Strategy on Biological Diversity), with the main purpose of accomplishing the Convention on Biological Diversity’s goals and objectives. Title VI of this extensive document addresses Protected Areas. Its main purpose is to fortify the Protected Areas System as a base to conserve the Argentinian natural heritage in the long term. Particular goals pursued included:

- ✓ to improve the ecosystem representation of each ecoregion (unrepresented or poorly represented for the current PAs),
- ✓ to increase the creation of PAs with different management categories,
- ✓ to strengthen the capacities of the entities in charge of the administration of PAs,
- ✓ to strengthen the management capacity of PAs in order to effectively meet the objectives set at the time of their creation
- ✓ to promote a closer relationship between society and PAs.

APN began the 21st century with clear goals and good objectives. During the first 16 years of the century, 15 new PAs were created in comparison with 30 created over a period of 66 years. However, the APN did not have all the support needed to succeed fully. The creation of new PAs was not followed by the required investment. By 2004, there were 300 park rangers distributed over 34 National Parks, most of them without transportation and poorly equipped. The illegal traffic of flora and fauna reached alarming points and could not be countered by the system with its low level of performance (Traetta, 2004).

Adverse conditions affect Argentinian PAs at different levels, including provincial, municipal, and private PAs (owned by NGOs, universities, and people), some of which are in an even worse situation. According to a 2005 study, 44% of the total surface declared as protected area do not have control on the ground, 37% have insufficient control, and the remaining 19% have at least the minimum acceptable control (Burkart, 2005). Furthermore, 78% of those PAs have partial protection, which means that human settlements, cattle

grazing, and logging are allowed under the control of the APN, control that is often weak or nonexistent owing to lack of people on-site (Burkart, 2005).

An emblematic case that shows the distance between theory and practice occurred recently in NHNP. On March 2016, a huemul deer (*Hippocamelus bisulcus*) – a species declared a National Monument and endangered according to the IUCN Red list - was seen by a farmer when it was being chased by the farmer's dogs near his house. Despite being outside NHNP, the farmer contacted the nearest park ranger working in the southern region of NHNP. This park ranger went to the farm immediately and contacted the main office located in Bariloche. People from the Conservation Department went to the site, although this took several hours. Meanwhile, the huemul deer was kept captive, tied by his neck to a pole (Fig. 11). After 15 hour of captivity under this highly stressful condition, the deer finally died. The entire procedure was unclear and disorganized, as well as the decisions post-mortem since the animal was buried there with no further analysis or necropsy (Llorente, 2016). It took more than a year for the APN to decide on whether sanctions were appropriate in this case. In August 2017 they suspended two persons responsible for what happened, one of them for seven days and the other for three days. In fact, according to the APN Central House (located in Buenos Aires), two "Huemul Safety Protocols" exist. However, for the people in the Bariloche office - including those first responders- there are none, and furthermore, they have neither the expertise nor the equipment and supplies needed to work on such cases (Llorente, 2017).

In recent years, APN has incorporated different tools to evaluate management effectiveness of each of the 47 PAs under its jurisdiction: Environment Management Plans (EMP), Annual Operational Planning (AOP) and Management Effectiveness Measurements (MEM).

- 1- The EMP provides a basic description, characterization, and updated diagnostic to establish the mission and goals of the PA in a long-term conservation plan. By the end of 2016, 11 PAs had an EMP, 10 PAs were updating their EMP, four APs had sent their EMP to the APN for approval, 10 PAs were elaborating their EMP and 12 had no EMP (Neme, 2016).
- 2- AOP are elaborated and evaluated for people working at each AP, in coordination with Regional and National APN offices. This provision was being implemented



Figure 11. Huemul deer found in the proximity of NHNP. It was kept tied by its neck waiting for APN managers decisions. Picture extracted from local newspaper (Llorente, 2016)

more quickly than that establishing EMPs: 56% of the APs had an AOP by 2009 and the percentage rose to 90% by the end of 2016 (Neme, 2016).

- 3- MEM provide periodic information regarding PA management effectiveness. This evaluation has been done four times, in 2011, 2012, 2013 and 2016. APN used internationally proposed ranges (Leverington et al., 2010) to evaluate the outcomes as: inadequate management (score < 33%), basic management with major deficiencies (33-49%), basic management with minor deficiencies (50-67%) and sound management (>67%). During the period 2011-2013 most of the PAs were under basic management with minor deficiencies (Fig. 12), however, a substantial number of PAs scored under 49%.



Figure 12. MEM evaluation results from the PAs in Argentina. Extracted from (Neme, 2016)

Environmental Working Plans (EWP) are administrative legal instruments to formalize and manage protected natural areas. EWPs go beyond the environmental diagnosis and must include short, medium, and long-term goals, and programs related to scientific research, environmental education, and preservation. However, no information is available about which PA units have a EWP, whether they have been approved, or even whether they have been implemented (Neme, 2016).

Conservation under corruption

The alternation between democratic government and brutally repressive military dictatorships was not the only reason for political and economic instability in Argentina. Despite the continuity of legal democratic governments since 1983, critical situations have never been absent in the modern Argentinian history. Corruption at all levels pervades the country affecting every institution. For example, in 1983, Dr. Jorge H. Morello was appointed President of the APN. The drastic dismissal of more than 300 APN employees in December 1983, replaced presumably by Morello's own people, has been cited as an example of the "imperialism" of the park system acting on behalf of "the elites" (Hopkins, 1995).

This example is not exceptional; often presidents choose ministers irrespective of their experience or expertise, and most of the time based on their own interests. As an example, at the beginning of his term in 1989, former President Menem designated the Engineer Maria Julia Alsogaray as Secretary of Natural Resources and Sustainable Development. Substantial opposition arose from different sectors with a long history in environmental issues, arguing that she was unprepared for that position (YBF, 1991). In the event, this opposition proved to be correct. Not only did Alsogaray perform poorly during her tenure, but she also served her own interests. The main scandals include a huge, ineffectively managed fire affecting Nahuel Huapi National Park, Lanin National Park and Lago Puelo National Park in 1996. The fire finally died out thanks to rain and the volunteer work of hundreds of local residents, but it destroyed not only more than 20,000 ha of native forest and steppe, but also houses and hotels, and it left innumerable human victims. Its cost was estimated at 2,686,500 U\$S. Interestingly, a year earlier the National General Audit had suggested the need to develop a wildfire prevention campaign, with an estimated cost of 1,000,000 U\$S, which Alsogaray had ignored (Anonymous, 1996). However, the most evident example of Alsogaray's corruption was her plan to clean the Riachuelo (a heavily polluted waterway along Buenos Aires' industrial Southside). In 1993 Alsogaray obtained a loan of 250 million US\$ 250 million from the Inter-American Development Bank (IABD) for the purpose of cleaning the Riachuelo. The loan was obtained based on a compromise agreement reached between the state and 65 factories, responsible for 90% of heavy metal contamination, to build treatment systems to produce a non-toxic waste. The state had also

to provide a system of home waste disposal to stop the discharge of wastewater directly into the river. Despite her promise to clean it in 1000 days, the clean-up never happened and today the Riachuelo is still the most contaminated watercourse of America, and one of the most contaminated rivers in the world. US\$ 1million was used to removed a few sunken ships, while more than US\$150 million were redirected to social programs, US\$7 million were paid as fines to the IABD as a penalty for not using the loan as agreed upon, and US\$90 million were never found. In the meanwhile, those factories continue disposing toxic waste into the river, and more than 500,000 people live along the river banks, 30% with no access to clean water and 55% without sewers (Lipcovich, 2006).

APN is an autocratic institution. Communications between the President of the Republic and the APN were mediated for a Ministry. Historically the relation was between the APN and the Ministry of Agriculture; however, that relationship also changed over time (Table 1). In 1999, during his first year in office, former president de la Rúa put the APN under the Ministry of Tourism control. The direct relationship between APN and the Ministry of Tourism looks incompatible with the original National Parks goal of conserving nature and providing a place of enjoyment for present and future generations. Severing the tie between APN and the Secretary of Environment and Sustainable Development meant also a disconnect with its basic environment concerns, such as implementing the National Biodiversity Strategy, coordinating the Federal Council of Environment (COFEMA) that integrates environmental management between the provinces and the national government, to mention a few examples (Burkart R. et al., 2007). The main purpose of a PA can be jeopardized when confronted with the economic interests of the Ministry of Tourism. Friendship and political favors between the former Minister of Tourism Enrique Meyer and Martin Olavarria, director of Turisur S.R.L. (tourism company that provides transportation in Nahuel Huapi Lake and owns the Puerto Blest Hotel) resulted in irregularities, landscape alterations, and temporary removal of the park ranger in charge of 35,000 ha in the area of Puerto Blest (*personal communication*).

Isla Victoria, the main island in Nahuel Huapi lake, has large populations of non-native game species (wild boar, red deer, and fallow deer). APN has long conducted a control program with the purpose of reducing the population. However, at the same time, different agreements of doubtful legality allow politicians, businessmen, and officers of different

national institutions to come to the island and hunt those animals for weeks, in a sort of tourist safari, apparently in exchange of some benefit (*personal communication*).

The APN remained under the Ministry of Tourism until December 11, 2015, when the new administration promulgated Decree 12/2015, which transferred the APN to the newly created Ministry of Environment and Sustainable Development.

In this time line, it is possible to see how Argentinian political instability has had repercussions for the National Parks System, as for the country as a whole. The uncertainties associated with this chaotic history can be hard to understand for people who have not experienced it. This political environment has generated inadequate information, a scarcity of trained people, sudden cutoffs of funds, fluctuations in trade and prices of exportation/importation products, and often unclear organizational relationships, inflation, and hyperinflation that made it impossible to plan a successful budget evaluation (Hopkins, 1995).

Despite the legal framework established in the 20th and 21st centuries to protect Argentinian biodiversity, clear evidence points to poor performance. A study published in 2013 that evaluates forest loss since 2000 at the global level found that Argentina (fig. 13), along with Brazil, Indonesia, Malaysia, Cambodia, Cote d'Ivoire, Tanzania, and Paraguay, has one of the highest percentages of forest loss (Hansen et al., 2013).

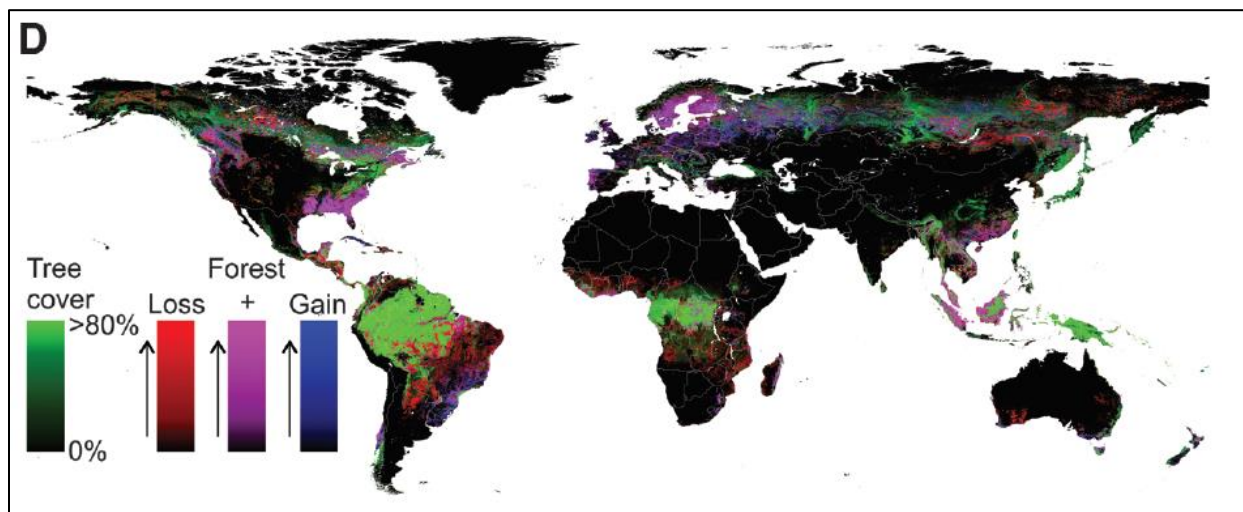


Figure 13. Forest loss and gain enhanced for improved visualization. Extracted from Hansen et al (2013).

Native forest reduction caused by wildfires has increased over time. An area of 28,394 km^2 of native forest, which constitutes 9.44% of the native forest estimated in 2001, has been destroyed by wildfires. Firefighters and inspectors are not properly trained to identify causes of wildfires; consequently, most such fires remain classified as “unknown origin.” Furthermore, many of these wildfires can be ascribed to a deliberate intention to remove forest in order to allow a different use to that land, in opposition to the Forest Law 26.331 (Egolf, 2016).

In a country where democracy cannot be taken for granted, and laws continually change, it is hardly possible to implement a long-term and effective plan for biodiversity conservation. Despite the enormous Argentinian biodiversity and rich natural resources, conservation has never been a priority for any government. As mentioned above, Law 25675 (Environment General Law), enacted in 2002, mandated an Annual Environmental Report in which authorities must inform the National Congress about the general environmental status and what consequences human activities may have had or may have in the future on the environment; nevertheless, the Annual Environment Report was written for the 1st time ten years after the law was enacted, and the 2nd and last one in December 2016.. Worldwide scientists’ efforts have played a main role in the enactment of conservation regulation since the early history of conservation, leaving the clear lesson that states will act just when their economic interests are jeopardized (Grove, 1992). Argentina is not an exception; the main effort toward the creation/implementation of conservation policies in Argentina has been driven by a small group of dedicated park administrators, ecologists and biologists, conservationists and environmentalists (Hopkins, 1995).

Public awareness, development, and influences of NGOs on the conservation of the Argentinian biodiversity

Public and governmental environmental consciousness in developing countries began later than in developed ones. The 1972 Stockholm conference on the human environment (UN General Assembly, 1972) had an important impact and changed that situation; while just 11 developing countries had governmental agencies with environmental management responsibilities by 1972, the number increased to 102 by 1980 according with

a survey conducted by the Center for International Environmental Information (Leonard and Morell, 1981).

Governmental awareness in environmental issues had begun earlier in Argentina, although the impact of such awareness was at least doubtful as explained above. Nevertheless, a monumental change occurred, and in 1977, one of the most important Argentinian nongovernmental organizations concerned with environmental protection, Fundación Vida Silvestre Argentina-FVSA (Argentinian Wildlife Foundation), was created. In its 40 years, FVSA has accomplished a number of successes (Table 6).

The creation of the FSVA took place during the last military regime, so it is not surprising that few people would show any empathy for the foundation at that time. Other NGOs with environment goals were created over time, however, it took a long time for public environmental awareness to develop in Argentina. This changed in 1991 after two dramatic events. Thousands of migrating penguins arrived on the coast of Chubut province covered in petroleum; the obvious ship oil spill was never determined by the authorities. This inefficacy along with the high penguin mortality raised an immediate environmental concern on the general population. The second event that jarred the public beyond the environmental groups was an agreement between the national government and a New Jersey company (Environmental Development Corporation) also signed in 1991. Under this agreement, the American company would export 540,000 tons of “de-watered” household and industrial sewage per year from New York to San Antonio port (Rio Negro province), where this material that would be treated and transformed into fertilizer. The Argentinian branch of Greenpeace led a strong campaign against this agreement, and the people working along with those NGOs won the dispute and finally the agreement was cancelled (Hopkins, 1995).

The number of environmental NGOs began to growth, as also did NGOs with different concerns. In 1999, the National Government enacted Decree 916/99, which establish the Mandatory National Registration of Non-Governmental Organizations. Nowadays, there are 73 NGOs working in favor of PAs and 61 NGOs with biodiversity/environmental concerns registered in Argentina.

NGOs develop outreach programs; most of them focus on child education as a means to achieve adult awareness; however, they also work jointly with local communities and conduct their own research projects (Fig. 14).

Table 6. Argentinian Wildlife Foundation achievements

Year	Accomplishment
1979	Creation of Campos del Tuyú Wildlife Reserve, 3.040 ha on the Pampa ecoregion
1982	Launch the Journal "Vida Silvestre", awarded several times for its work of awareness on environmental issues
1985	Launch the campaign with the credit card Diner Club "One purchase= One squared meter", which increased in 2,000 ha the Campos del Tuyú Wildlife Reserve
1980-1989	Funded studies on two emblematic Patagonian species: the huemul deer (<i>Hippocamelus bisulcus</i>) and the maca tobiano (<i>Podiceps gallardoi</i>). Promotion of the creation of new PAs and impulse to declare the huemul deer as National Monument
1987	Launch program "Refugios de Vida Silvestre" (Wildlife Refuges) with the goal of creating refuges in private lands. By 2014, 16 Wildlife Refuges have been created covering 177,000 ha
1988	Join the WWF
1990	Take the first environmental case to trial, case related with illegal fauna commerce. The accused was convicted.
1998	Creation of Uruguay-I Wildlife Reserve, 3,245 ha of Parana forest ecoregion. After that, FVSA promoted the enactment of the law "Corredor Verde" (Greenway) that has saved more than 1,000,000 ha of Parana forest
1995	Publish 1 st book regarding Argentinian environmental situation
2000/2002	Promote the creation of two PA in Salta province (8,000 and 13,000 ha)
2001	Purchase of Monte Leon Land (funded by Patagonia Land Trust) and creation of Monte Leon National Park, 62,169 ha along the Patagonian Atlantic cost
2005	Creation of San Pablo de Valdes Wildlife Reserve, 7,360 ha along the Patagonian Atlantic cost. Location later declared Natural Heritage from UNESCO
2007	Promotion, along with other NGOs, to the enactment of the Law 26331 Law of minimum budget for the environmental protection of native forests
2009	Impulse the Misiones province government commitment to "Deforestation Zero" by 2020, in order to save 1.1 million of ha of Parana forest ecoregion
2010	Help to the creation of three new PAs on the Argentinian Sea: Patagonia Austral, Makenke and Isla Pinguino, covering 400,000 ha
2011	Develop pilot program of sustainable cattle grazing on 8,500 ha in the Pampa ecoregion
2012	Promote the Red de Comercio Forestal (Forest Trade Network) with other organizations to generate a sustainable use of this resource
2013	Impulse the creation of new PA, Banco Namuncura (Burdwood) in the South Atlantic
2014	Promote the creation of "Red Argentina de Reservas Privadas" (Argentinian Private Reserves Network), recording 61 private reserves with 17 NGOs between their members. Work along with APN to create the National System of Marine Protected Areas (Law 27.037), which facilitate the creation of new PAs on the Argentinian Sea.
1977-2017	In order to develop public awareness on environmental concern, the FVSA has never stop training educators and open public through workshops, courses, and different activities across the country.

NUESTROS PROYECTOS

PROYECTOS DE INVESTIGACIÓN

Estos son nuestros **proyectos**, mediante los cuales fomentamos el **estudio, la conservación, manejo y protección de la naturaleza.**



**FUNDACIÓN
VIDA SILVESTRE
ARGENTINA**



Figure 14. Outreach projects developed by NGOs. Top, Huellas (Footprints) is developing research projects on several species. Middle, FVSA conduct educational workshops and campaigns. Bottom, Amigos del arbol y el bosque (Tree and Forest Friends) works in Salta province closely with local community.

The government at different levels (nation, province, region, and city) and the APN have joined this effort to reach the community to bridge the gap between conservation advocates and the public. Schoolbooks, magazines, TV shows, documentaries, workshops, courses, open audience talks, are some of the strategies used toward this end (Fig 15).



Figure 15. Outreach projects developed by the government and the APN. Left (top and bottom) TV shows about different PAs, their biodiversity and relevance. Top right, Drawing National Contest "One day in a National Park". Bottom right, APN presentation in a National Science Fair.

Conflicts of interest delay the process. National and international companies prioritize their financial performance over human and environmental rights. According to the Observatorio de Conflictos Mineros de America Latina (Observatory of Mining Conflicts in Latin America), 27 mining conflicts have been recorded in Argentina since 1989 (compared to 37 for Chile, 37 for Peru, and 39 for and Mexico). Most of these companies are developing their mines along the Andes (Fig 16), precisely where a rich mass of continental water is reserved as glaciers. Local people along with several NGOs worked together to achieve enactment of a law to protect this natural resource; on October 10, 2010, National Law 26639 (Regimen de Presupuestos Minimos para la Preservacion de los Glaciares y del Ambiente Periglacial; Regime of Minimum Budget for the Preservation of Glaciers and the Environment Periglacial) was finally promulgated. This law not only mandates a minimum



Figure 16. Mining conflicts registered in Argentina since 1989

budget but also urges the creation of a National Inventory of Glaciers, with the purpose of identifying priority areas for conservation. By December of 2015, only 10% of the glaciers were registered in the inventory. In his Environmental Annual Report for 2016, the Minister of Environment and Sustainable Development Sergio Bergman proudly announced that after his first year in office, the ministry had raised that number to 40% and the plan is to complete it by the end of 2017 (Neme, 2016). On November 27, 2017, federal judge Sebastian Casanello prosecuted former members of the ex- Secretary of Environment and Sustainable Development (Ministry of Environment and Sustainable Development since December 2015), and the former director of the Instituto Argentino de Nivologia, Glaciologia y Ciencias Ambientales (Argentine Institute of Snow Science, Glaciology, and Environmental Sciences) for “breach of duty of public official” directly related to the mining projects Veladero and Pascua Lama (San Juan Province). On September 12 and September 13, 2015, 1,125,000 l of water contaminated with cyanide leaked from those mines; local people and NGOs created a campaign named “Jachal no se toca” (do not touch Jachal) asking for justice and remediation, denouncing the fact that the people designated to protect those glaciers had acted in favor of the Canadian mining company Barrick Gold . A new leak occurred on September 8, 2017; this time public pressure prevailed and led to the outcome described above (Iglesias, 2017).

The American company Monsanto entered Argentina in 1956. The biggest change impact occurred in 1996, when genetically modified soybean was introduced, as part of a plan to use a neoliberal agro-export strategy for socio-economic development. This strategy dominated during former president Kirchner’s administration, and today 90% of arable land is planted with transgenic soybean resistant to the herbicide Roundup (Fig 17) (Finnegan and Lieblin, 2017). Argentina ranks third among all nations in production and exportation of soy. However, despite the economic success, this development has produced socio-environmental damage. While Monsanto claims that its product is safe when properly used, public health of communities within and around genetic modified soybeans farms tell a different story (Arancibia, 2013). The number of cases of cancer increases every year, affecting people of all ages but mainly children. Local residents, environmental activists, rural physicians, scientists, agronomists, and lawyers have been asking the government to ban glyphosate-based herbicides such as Roundup without success (Arancibia, 2013). Deforestation to open lands for soy production has been another consequence that



Figure 17. Area where genetic modified soybean is produced in Argentina. Extracted from (Leguizamón, 2014)

affects unprotected and protected lands. An emblematic case happened in 2004, when 60% of the Pizarro Protected Area (Province of Salta, north-west Argentina) was sold by Salta's provincial authorities to be converted to agricultural use, specifically for soybean production. Fortunately, scientist, NGOs, indigenous and local residents began a legal complain that lasted one and half year; which they finally won and the protection status was restored to that land, constituting the first victory of its kind in Argentinian conservation history (Hufty, 2008).

More than 30.3% of the Argentina's population lives in poverty according to the World Bank report 2016, which renders difficult any negotiations with the government, which still sees increasing the economy to diminish national poverty rates as mutually exclusive with protecting the natural heritage of Argentina. Unfortunately, the scientific community has not convinced them that poverty and environmental degradation are intimately related (Adams et al., 2004).

Conclusions

For more than a century, Argentina has had laws and regulations that addressed the National Protected Area System. The vision of environment protection evolved in a positive direction over this period, reaching all the levels: government, APN, NGOs and people in general. The long list of laws, and their modifications owing to changes in priorities of different national administrations (including democratically elected governments and military regimes), have followed an irregular pattern, where good judgment has prevailed in some cases but counterproductive decisions have been made as well. Frequently international assessments and the experiences of other countries were adduced in order to promote enacting stronger and better laws. NGOs and public awareness have had a huge influence in this process. The return to democracy uninterrupted for more than three decades has doubtless helped as well. However, Argentina's immense natural richness is at the same time the best gift and the worse enemy. Just as many people cannot believe that their actions affect the planet on a global scale (Elsasser and Dunlap, 2013), many Argentinians do not realize that despite the vast territory, every action has a consequence.

No one could ever believe that Nahuel Huapi Lake, with its 530 km^2 of surface area and its 83.35 km^3 of clear water, could be contaminated; unfortunately, there is evidences that contamination is happening (Ribeiro Guevara et al., 2002). The problem exceeds the capacity of local actors to deal with it. National and international corporations and corrupt politicians constitute the biggest threat of all. Good laws exist, they cover almost every aspect of the problem, but they are not enforced when a powerful enough stakeholder wishes otherwise. Argentinians are jaded by seeing this happen repeatedly. Irregularities are on the front page of newspapers day after day. A radical change is needed from top to bottom; laws must be followed and enforced without exception in order to eliminate the rotten root.

Protected areas in Argentina are receiving more attention, and they are no longer seen as unnecessary luxuries as they might have been seen in the past. Education is the key component for the nation to keep on this track, and the enormous effort from scientists, environmentalists, the APN, NGOs, and some politicians on the elaboration of a great variety of outreach projects to generate public environment awareness proves that the change is possible. Argentinian nationalism and pride for the fatherland, freedom from dictatorships, and education are the tools that will help to achieve the necessary change.

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CHAPTER II

**CATEGORIZATION AND EFFECTIVENESS OF PROTECTED AREAS:
COMPARATIVE STUDY OF SMALL MAMMAL COMMUNITIES IN
NAHUEL HUAPI NATIONAL PARK, ARGENTINA**

A version of this chapter will be published by María Daniela Rivarola, Christy Leppanen and Daniel Simberloff.

María Daniela Rivarola conducted a search literature in order to gather all the information needed and wrote the whole article, designed and carried on the fieldwork, analyzed the data and wrote the article. Christy Leppanen revised and edited. Dan Simberloff revised and edited the article.

Abstract

Protected Areas constitute the cornerstone of most conservation strategies, but an increasing number of publications question their effectiveness. This study aimed to determine if protected area designations conserve small mammal communities in Argentina's Nahuel Huapi National Park (NHNP). We compared small mammal communities in unprotected areas and areas with three protection levels: Strict Natural Reserve, where human activity is forbidden; National Park, where recreation can be authorized; and National Reserve, where tourism and extractive uses may be permitted. We conducted a capture-mark-recapture study on 20 plots, five in each type of area. In 2015 (20,600 trap/nights, 727 individuals, >2102 captures, 10.20% success), we trapped seven native rodents: *Abrothrix hirta*, *A. olivacea*, *Oligoryzomys longicaudatus*, *Geoxus valdivianus*, *Chelemys macronyx*, *Irenomys tarsalis*, *Loxodontomys micropus*, and the endemic marsupial *Dromiciops gliroides*. In 2016 (21,000 trap/nights, 532 individuals, 1894 captures, 9.02% success), we captured the same species with the exception of *C. macronyx*. *Abrothrix hirta*, *D. gliroides* and *O. longicaudatus* were the most common species in all areas during both seasons. Assemblage species richness did not vary among protection levels. However, greatest abundances were in the highest protection level (Strict Reserve) and lowest abundances in the lowest level (National Reserve) in the NHNP system. *Dromiciops gliroides* abundances were higher in National Park and Strict Reserve compared with National Reserve and outside protected areas. This study yielded no clear evidence that the NHNP protection system is conserving small mammal communities. However, higher abundances recorded inside the Strict Reserve suggest direct human interaction negatively impacts this assemblage.

Introduction

Protected areas (PAs) can be traced back more than 2000 years; however, Yellowstone National Park, created in 1872, is recognized as the first PA of the modern era (Wright and Mattson, 1996). Concern about nature's protection spread around the world during the second half of the 20th century resulting in exponential growth in the number of PAs and total area protected worldwide (fig. 18). But what does “protected area” really mean? The World Commission on Protected Areas defines PAs as areas especially dedicated to protecting and maintaining biological diversity; therefore, PAs constitute the cornerstone of most conservation strategies.

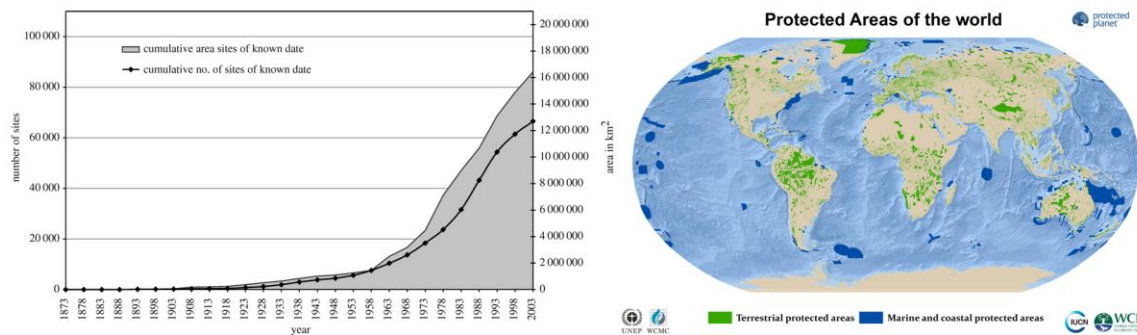


Figure 18. Protected areas. (Left) Global increase in numbers of protected areas over time (Chape et al., 2005). (Right) Source: IUCN and UNEP-WCMC (2016). The World Database on Protected Areas (WDPA) [online], April 2016, Cambridge, UK: UNEP-WCMC. Available at www.protectedplanet.net.

During the tenth meeting of the Conference of the Parties, Convention on Biological Diversity, in Nagoya, Japan (CBD, 2010), the parties agreed on a Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. Target 11 proposes global conservation of 17% by area of land and inland water and 10% of coastal and marine areas, through protected areas by 2020 (CBD, 2010). Interestingly, the wording of this target also states that those protected areas must be effectively and equitably managed. Debate about PA effectiveness began in the late 20th century and an increasing number of recent publications question their success (fig. 19) (Barnes et al., 2016; Bruner et al., 2001; Carey et al., 2000; Chape et al., 2005; Coad et al., 2015; Coetzee et al., 2014; Gardner et al., 2009). A comprehensive study evaluated changes in abundance of 31 plant and animal guilds in 60

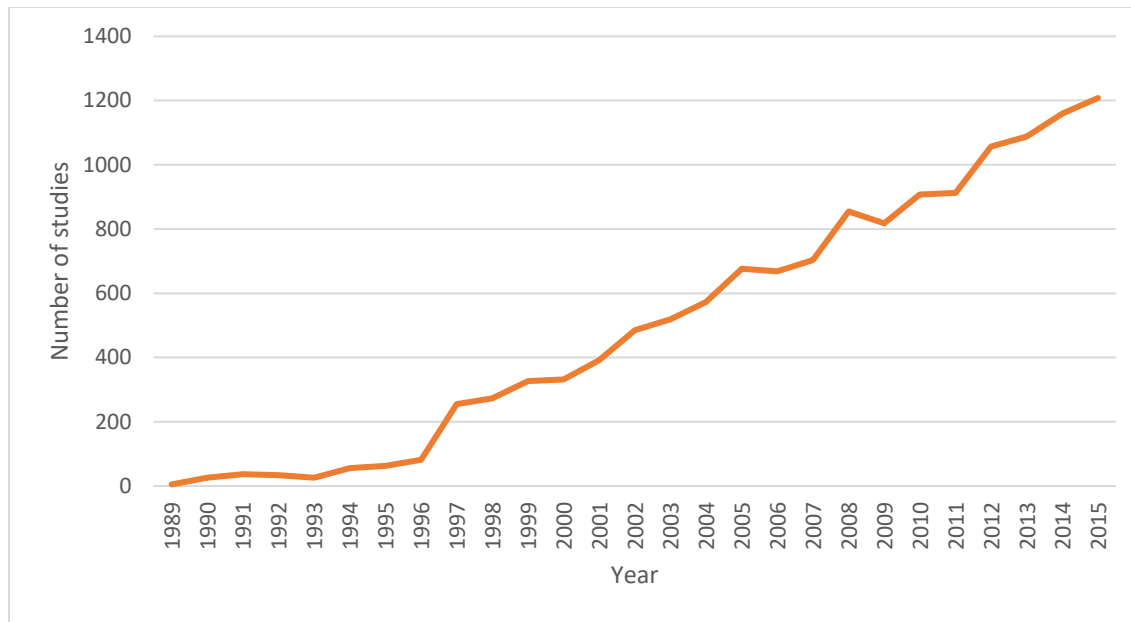


Figure 19. Number of studies investigating effectiveness of protected areas worldwide. Data obtained through Web of Science with search criteria used by Coetzee et al. (2014).

PAs distributed in tropical forest across the world. After summarizing first-hand knowledge of 262 researchers working in those locations for at least 20-30 years, the authors concluded that, while 30 of those PAs were performing relatively well, the other 30 showed taxonomic and functional biodiversity impoverishment (Laurance et al., 2012).

Among vertebrates, most conservation studies have focused on mammals; and among mammals, primarily large mammals (Amori and Gippoliti, 2000). Many conservation organizations have a large mammal emblem (WWF, Rainforest Action Network, NRDC, National Wildlife Federation) precisely because these charismatic species suffer obvious impacts related to human activities. A study conducted in Africa evaluated changes in 583 large mammal populations (belonging to 69 species) distributed across 78 PAs and concluded that population abundances declined 59% between 1970 and 2005 (Craigie et al., 2010).

Clearly, evaluating PA effectiveness is crucial for the best use of funds destined for conservation and biodiversity protection goals (Carey et al., 2000); however, a second challenge must be faced, how to evaluate effectiveness? Two main methods have been proposed in recent publications, monitoring (Barnes et al., 2016; Coetzee et al., 2014; Gardner et al., 2009) and scoring (Bruner et al., 2001; Rusch, 2002). Monitoring is a detailed site-level assessment using quantitative information gathered from direct measurement in

an individual PA. Scoring is a more superficial but quicker site-level system using qualitative, perception-based data gathered through extensive questionnaires answered by people who work in the PA, and because it may be applied in multiple sites, scoring provides a more general and comparable overview of the overall status or achievements met by PAs (Hockings et al., 2006). Both methods have been widely used, and despite their differences, one method is not considered universally better than the other (Hockings, 2003); on the contrary, the chosen method should be related to the main goals of the PA and the budget and time available for the study.

Socio-economic country status is recognized as one driver that may influence the biodiversity conservation outcome of PAs (Bruner et al., 2004). South America is the world's most biodiverse continent (Sarukhan and Dirzo, 2001); at the same time, most South American countries are beset by socio-economic problems and political corruption (Gingerich, 2013). A meta-analysis of 86 globally distributed studies found that species abundance and species richness inside South American PAs were lower than outside PAs (Coetzee et al., 2014).

The first South American National Park is Nahuel Huapi National Park (NHNP), established in 1934 (although the creation process began in 1906) and located in the northwestern part of Patagonia in Argentina. Its original 750,000 ha would be subdivided in 1968, when 473,352 ha were re-designated as National Reserve. Finally, in 1990, 75,436 ha were designated as a new category, Strict Natural Reserve. Uses and activities allowed in each category differ (Martin and Chehébar, 2001):

- a. Strict Natural Reserve: Category I, World Database of Protected Areas (WDPA 2017): These areas are surrounded by National Park. Human activity, apart from scientific research, is forbidden.
- b. National Park: Category II, World Database of Protected Areas (WDPA 2017): Neither extractive use nor touristic infrastructures are allowed. Recreational use can be authorized.
- c. National Reserve: Category IV, World Database of Protected Areas (WDPA 2017): These areas, where tourist infrastructure is allowed, are considered buffer zones between protected and neighbor unprotected lands. Extractive use (e.g., forestry, livestock) may be authorized.

NHNP, including what is now Strict Natural Reserve, National Park, and National Reserve, aims to protect an extreme ecological gradient composed of high Andean forest, Valdivian temperate forest, and steppe. More than 1,000 km from the nearest other forests (Pearson, 1983), NHNP's isolated forests may be associated with unique outcomes of local evolutionary histories and ecological processes. From an evolutionary perspective, species found in these forests have several possible origins. First, species may have evolved in situ from tropical or sub-tropical relatives, such as hystricognath rodents related to African forms (Huchon and Douzery, 2001; Perez and Pol, 2012). Second, they may be relicts of temperate taxa from earlier dispersal events, such as *Dromiciops gliroides* (Microbiotheria), more closely related to Australian marsupials than to American marsupials (Martin, 2010; Nilsson et al., 2004). Dispersal through a tropical filter, such as cricetid rodents that arrived from North America, provides a third possible origin (Leite et al., 2014).

On the other hand, the area has been isolated from other continents for millions of years. Its last connection with Africa was 100 million years ago, and its complete separation from Antarctica was 30 million years ago (Pitman III et al., 1993). Isolation is sometimes associated with higher invasibility owing to decreased habitat saturation (Gillespie et al., 2008), as was found in Patagonia where fewer species were recorded; those species represented a higher rate of endemism and greater susceptibility to extinction might be expected, e.g., in comparison with vertebrate diversity in temperate forests of North America (Barnosky et al., 2001). However, while large and medium-sized mammals are poorly represented, small mammal diversity equals that found in temperate forest elsewhere (Pearson, 1983). Finally, these forests present one of the highest rates of pollination and seed dispersal by birds, with a few species providing a vital ecological service to many others (Aizen and Ecurra, 1998).

Valdivian temperate rainforests are described in the Global 2000 World Wildlife Fund (WWF) Conservation Science Program as one of the most biologically valuable ecoregions that must be protected and preserved (Olson and Dinerstein, 1998). An effectiveness evaluation of PAs in the Argentinian portion of the Valdivian temperate rainforest was conducted by Rusch (2002) to determine if these PAs were truly protective, or on the contrary, if they should be seen as “paper parks”, a term widely used to refer to PAs with legal designation but without implementation of protective measures on the ground (Erwin,

1991). In her study, Rusch (2002) applied a scoring method to stakeholder, technician, and field technician interviews to evaluate 36 PAs (covering a total of 1,706,306 ha) in Neuquén, Rio Negro, and Chubut provinces that included all PA categories found in the area: 13 National PAs, 17 Provincial PAs, five Municipal PAs, and one private PA. Rusch (2002) assigned PA effectiveness to the following categories according to the percentage of estimated optimal protection: Very satisfactory (>91% of the optimal), Satisfactory (76-90% of the optimal), Fairly satisfactory (51-75% of the optimal), Minimally satisfactory (36-50% of the optimal) and Not satisfactory (<36% of the optimal). Thirteen of the 36 PAs were classified as “Fairly satisfactory” (1,250,653 ha), 11 as “Minimally satisfactory” (430,139 ha), and 12 received the lowest score of “Not satisfactory” (25,514 ha). The NHNP system received an average value of 66.75% of the optimal score, falling in the “Fairly satisfactory” category.

The main problems detected were:

- Inadequate planning.
- In those cases where planning did exist, a low rate of applying such plans.
- Low external financial support.
- Lack of field technicians.
- Lack of equipment needed for fieldwork.
- Low general public awareness (35% of optimal)
- Low political support (23% of optimal)

The author also mentioned differences in perceptions between people who worked in the field and those who worked in offices. Their answers to the same question often differed, e.g., when they were asked to describe the existence of planning tools, office workers bestowed higher scores than field workers, who in many cases did not know about the existence of any planning at all.

Human settlements established in the region before creation of NHNP challenge the conservation-human society interface. While some rural settlers descend from 19th century colonists, indigenous peoples have inhabited Patagonia for centuries. Both groups' economies depend strongly on livestock grazing, which generates an obvious conflict with natural area protection (Raffaele et al., 2014). The government has worked with each

community to transform activities from detrimental to low-impact tourism. While some groups have agreed to a certain extent, others still refuse to make this change. Additionally, tourism constitutes a risk in itself. Patagonia has won popularity nationally and internationally, with the number of visitors increasing annually and generating a service demand such that economic-ecosystem conflicts are common and the infrastructure and workforce of NHNP are insufficient (Martin and Chehébar, 2001; Monjeau et al., 2005). Furthermore, the low employment rate in neighboring cities has caused an increase in the number of people re-establishing in rural settlements. The Curruhuinca Community is an example of this demographic process. While 403 people were distributed in 42 settlements in 1985, by 1998 the number had increased to 600 people in 108 settlements (Martin and Chehébar, 2001).

Boundaries of NHNP are clear on paper but often not on the ground, particularly with respect to each of the categories of protection. Furthermore, NHNP is not isolated from surrounding land-use that has penetrated the PAs. The introduction of nonnative species is recognized as one of the biggest threats (Schmitz and Simberloff, 1997; Simberloff, 2013). Plants, vertebrates, and invertebrates introduced intentionally and unintentionally over the last century have generated impacts to the resilience of these forests that we are still trying to understand (Arbetman et al., 2012; Barrios Garcia Moar, 2012; Correa et al., 2012; Franzese and Ghermandi, 2014; Nunez et al., 2013; Rodriguez-Cabal et al., 2013; Simberloff et al., 2002; Svriz et al., 2013). On the other hand, wildfires also have a tremendous impact on this ecosystem. Forests around the world have evolved with different natural wildfire regimes; to a certain extent fires are needed and beneficial for the health of ecosystems. In Patagonian forests, a combination of natural and unnatural, human-induced factors cause and increase wildfire severity, affecting thousands of hectares every summer (Raffaele et al., 2014). Finally, other threats reported in NHNP include epidemiological risk (rodent-borne diseases, like hantavirus), establishment of new transportation routes crossing NHNP, and impacts to the hydrological regime and aquatic environments, to mention the most relevant (Monjeau et al., 2005).

Many problems, failures, and threats have been clearly identified in NHNP; however, no clear evidence shows to what extent natural communities inhabiting this area have been affected. Some species have received special consideration, such as the native huemul deer

(*Hippocamelus bisulcus*), a conservation emblem declared a Natural Monument in 1996 by National Law 24702 and holding the highest level of protection inside and outside of PAs. Populations are closely followed and studied, and conservation and management plans have been proposed (Vila et al., 2006). Another good example is the southern otter, *Lutra provocax*, studied for decades (Cassini et al., 2010; Chehébar, 1985). One small mammal has received growing attention, the endemic marsupial *Dromiciops gliroides*, which is the only living species of the order Microbiotheria. It is more closely related to Australian marsupials than to those of the Americas and is a key disperser of fleshy fruits seeds of many Valdivian forest native trees (Amico et al., 2009). Municipal Ordinance 2112-CM-10, promulgated in 2010, declared *D. gliroides* as species with special value that deserves higher protection.

In an ecosystem with low vertebrate diversity like NHNP, small mammals (particularly rodents) are highly important. Whether they are herbivores, granivores, or omnivores, they directly affect forest dynamics. Furthermore, they constitute the main food source for many other native species (Raffaele et al., 2014). Nevertheless, conservation priorities in Argentina align with those found elsewhere (Fisher, 2011). Most conservation studies worldwide have focused on charismatic large species, while small mammals (mainly rodents) have attracted less research attention, despite their vital ecosystem roles (Fisher, 2011). On the contrary, damage to crops, vectoring of animal-borne disease, and their popular reputation as vermin have resulted in a lack of support for rodents in conservation agendas (Amori and Gippoliti, 2003). Additionally, because rodents are small with high fecundity and most species are herbivorous, the general perception is that they occur in high density and require little area, leading to the belief that they can persist in a fragmented landscape and maintain resilience to local extinction. This situation is true for certain species of rodents but not for all of them (Lidicker, 1989). A study conducted in northern Patagonia in which contemporary small mammal communities were compared with communities present 500 years ago found species extinctions and distribution contractions, as well as increases in population densities for some opportunistic species (Teta et al., 2014).

Different threats may act differently on different species. Despite their evolutionary and ecological importance, the conservation status of small mammal communities has never been evaluated in NHNP. While the scoring method of management evaluation is useful to generate a general overview, small species need to be considered directly through

monitoring because assuming management actions for iconic species will benefit them as may well lead to incorrect conclusions and inappropriate management decisions (Barnes et al., 2016). The main goal of the present study is to determine to what extent the NHNP protection system is affecting small mammal communities' conservation. We propose two hypotheses:

1. There is a direct human impact on conservation of small mammal communities. The communities inhabiting Strict Reserve Areas will have higher biodiversity and richness as a consequence of isolation and a lack of human intervention. However, small mammal communities inhabiting National Parks and Natural Reserves will be impoverished owing to a lack of control and poor PA delimitation that increases human contact.
2. There is an indirect human impact on conservation of small mammal communities. NHNP categories are associated with direct human use and designate activities that are allowed within each area. However, many threats related to human activities result in impacts beyond those areas. e.g., the spread of invasive species, wildfires, or grazing by wild or semi-wild livestock. These threats likely affect small mammal communities in all categories.

Methods

Study site

We conducted our study in Nahuel Huapi National Park (NHNP) located in northwestern Patagonia, Argentina, in the foothills of the Andes Mountains (40° 57' 14.81" S, 71° 32' 11.02" W). Average temperatures range from 3°C for the coolest (July) to 15°C for the warmest (January) months, with nightly frost present almost year round. Precipitation is greatest in autumn and winter, averaging 1,800 mm annually, but with water availability occurring along an west-east gradient, with western points getting more than 2,000 mm and the eastern fringe as little as 150-200 mm of precipitation annually. The area lies within the

southern temperate forest in the biogeographic region of the sub-Antarctic province; but the Patagonian Steppe Ecoregion is also represented along the eastern, drier fringe (Mermoz and Martin, 1986). The canopy, approximately 40 m tall, is dominated by *Nothofagus* (*N. dombeyi*, *N. pumilio*, *N. antartica*) (Nothofagaceae) and the evergreen *Austrocedrus chilensis* (Cupressaceae). The understory is dominated by bamboo *Chusquea culeou* (Poaceae) and several species of bushes and smaller trees: *Lomatia hirsuta* (Proteaceae), *Schinus patagonicus* (Anacardiaceae), *Maytenus boaria* (Celastraceae), *Aristotelia chilensis* (Elaeocarpaceae), *Luma apiculata* (Myrtaceae) and *Azara microphylla* (Salicaceae) (Mermoz and Martin, 1986). Species with the highest representation in the lower strata are *Berberis buxifolia* (Berberidaceae), *B. serratodentata* (Berberidaceae), *Ribes cucullatum* (Grossulariaceae), *Acaena ovalifolia* (Rosaceae), *Vicia nigricans* (Fabaceae), and *Fragaria chiloensis* (Rosaceae), among others (Dimitri, 1977). Nonnative plant species with conspicuous presence in NHNP are Douglas fir (*Pseudotsuga menziesii*) (Pinaceae) and *Rosa* spp. (Rosaceae). There is a tight relationship among elevation (from 3554 m a.s.l. to 500 m a.s.l.), water availability, and dominant species (fig. 20). To reduce variability in our study owing to these factors, we conducted our study entirely in forest dominated by *N. dombeyi* (coihue or southern beech), between 500 and 700 m a.s.l.

Sampling method

The best way to evaluate PA effectiveness would be by comparing communities before and after the PA was implemented. However, in most cases, information about community status prior to PA creation is unavailable. In lieu of such a comparison, a widely used strategy is to compare communities inside and outside of PAs (Coetzee et al., 2014). We thus conducted a capture-mark-recapture study to evaluate similarities and differences among small mammal communities across different levels of protection and outside of the NHNP protection system. We established 20 plots (60 x 60 m) at least 1 km apart, five each in the Strict Reserve, National Park, National Reserve, and outside PAs (fig. 20). The five plots outside PAs were located along the southern border of NHNP because to the west of NHNP is Chile, to the north is another protected area (Lanin National Park), and to the east is another ecoregion (Patagonian Steppe).

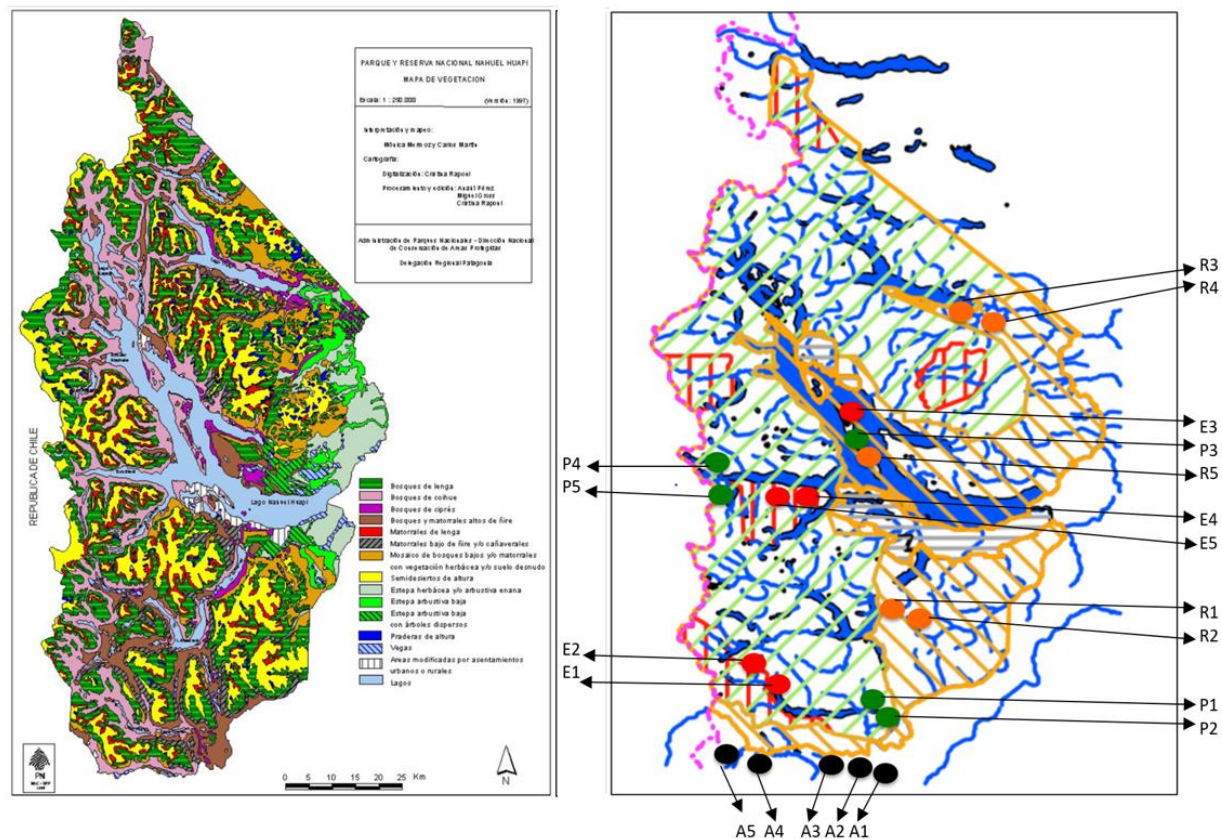


Figure 20. (Left) Map of dominant vegetation across Nahuel Huapi National Park, Argentina; light pink corresponds to forest dominated by *N. dombeyi*. (Right) Protection categories applied in NHNP. Red (E): Strict Reserve, Green (P): National Park, Orange(R): National Reserve. Dots indicate sampling plots, with number or replicate assigned, with colors matching protection category. Black dots (A) show sampling area outside the NHNP system.

We used a star design for each plot, in which we established 25 trap stations 10 m apart (Fig. 21). We georeferenced the central trap station of each plot using a GPS (Garmin GPS60). We activated two trap types at each station, a Sherman trap (10 x 10 x 29 cm) on the ground and a Tomahawk trap (30 x 14 x 14 cm) 1 m in vegetation above the ground (fig. 21). We baited the Sherman trap with oat and peanut butter (Pearson and Pearson, 1982) and the Tomahawk trap with apple and banana slices (Rivarola, 2010). We conducted a monthly capture session during three months of the austral summers of 2015 and 2016, January-February-March and February-March-April, respectively. We activated traps four consecutive nights and checked them twice a day, at sunrise and at sunset, resulting in a total capture effort for the entire study of 41,600 traps/day. Trap success was calculated as the number of small mammals caught divided by the number of active traps. We identified to species level each individual captured. After sex was determined, we classified rodent reproductive status as *active* (scrotal testicles) or *inactive male* (abdominal testicles), or *active* (pregnant, lactating, open vagina, recently fertilized) or *inactive female* (lacking previous characteristics). Before releasing individuals at the trapped location, we marked marsupials with Passive Integrated Transponders (known as PIT-Tags, TXP148511B model, Biomark 8.5 mm X 2.12 mm, 134.2 kHz ISO, 0.067g) by subcutaneous implantation on the back; rodents were marked with ear-tags (National Band and Tag Company, style 1005-1). We handled all captured animals following UTK-IACUC protocol # 2409-0116 (Institutional Animal Care and Use Committee, University of Tennessee, Knoxville, Tennessee) and the safety norms promulgated by the University of Tennessee's Occupational Health Program.

Data analysis

To compare biodiversity between communities along different levels of protection, we used the following key biodiversity attributes (Magurran and McGill, 2011):

- ✓ Assemblage Species Richness (S): total number of species present in a defined area
- ✓ Assemblage abundance: total number of individuals trapped for all species
- ✓ Species abundance: abundance of each species separately
- ✓ Shannon-Wiener Diversity Index (H'): an index that takes both number of

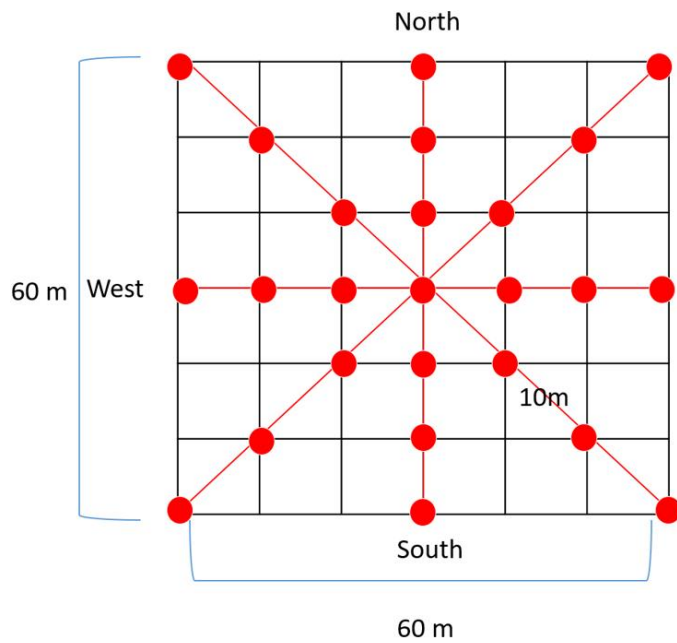


Figure 21. Sampling design. (Left) Plot with star design. Each red dot represents a capture station. (Right) Each capture station has two traps, a Sherman trap on the ground and a Tomahawk trap approximately 1 m above the ground.

species and relative abundances of different species into account

$$H' = - \sum p_i \ln(p_i)$$

Where p_i is the relative abundance of species i and is calculated as follows:

$$p_i = \frac{n_i}{N}$$

Where n_i is the number of individuals of species i , and N is the total number of individuals trapped for all species combined

- ✓ Sex ratio (number of females/number of males) for the three most common species
- ✓ Proportion of sexually active individuals per population (number of sexually active females or males/total number of females or males * 100) calculated independently for males and females during the three capture sessions per season, to capture variation through time.

We used non-parametric Kruskal-Wallis tests to compare each of these indices across different levels of protection. We could not use ANOVA because normality (evaluated with a Shapiro test) and homogeneity of variance (evaluated with Barlett's test) were not satisfied (Ott and Longnecker, 2010). Additionally, when we found significant differences between a variable and levels of protection, we conducted post-hoc analyses (Tukey's Honest Significance Differences Test with 95% confidence level).

Results

In 2015, we had a capture effort of 20,600 traps/night, with 727 individuals identified and over 2102 total captures resulting in a capture success rate of 10.20%. In 2016, we had a capture effort of 21,000 traps/night, with 532 individuals identified, 1894 total captures, and a capture success rate of 9.02%. In 2015, we trapped eight native species, seven in the

Order Rodentia (Suborder Myomorpha, Family Cricetidae, Subfamily Sigmodontinae) – *Abrothrix hirta*, *A. olivacea*, *Oligoryzomys longicaudatus*, *Geoxus valdivianus*, *Chelemys macronyx*, *Irenomys tarsalis*, *Loxodontomys micropus* – and the endemic marsupial *Dromiciops gliroides* (Order Microbiotheria, Family Microbiotheriidae). In 2016, we captured the same species that were captured in 2015 with the exception of *C. macronyx*. The species with greatest representation in communities across the four different levels evaluated were *A. hirta*, *D. gliroides* and *O. longicaudatus*, consistently for both seasons (fig. 22 and 23).

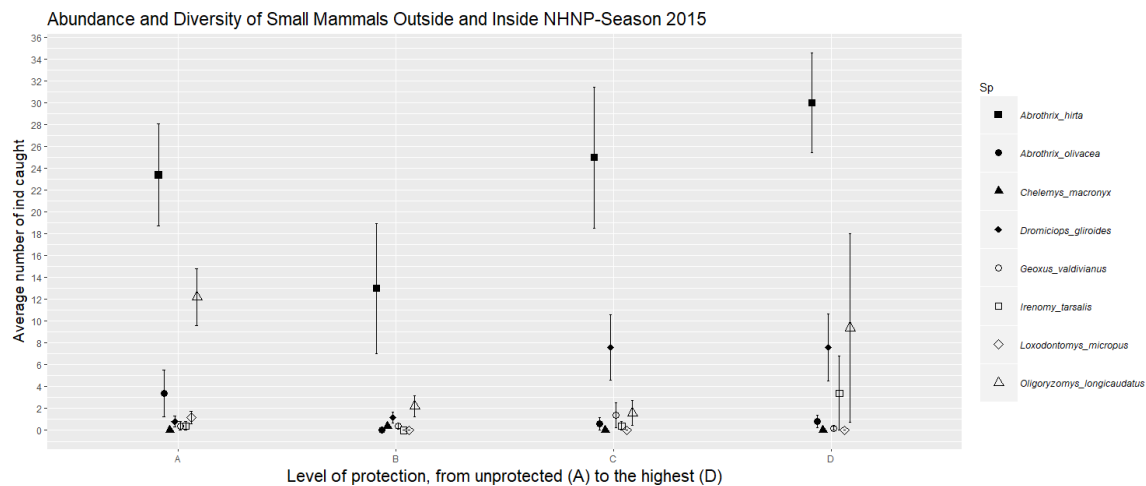


Figure 22. Diversity and average abundance of small mammals caught across different levels of protection in Nahuel Huapi National Park during the summer season 2015. (A) outside NHNP, (B) National Reserve, (C) National Park, (D) Strict Reserve.

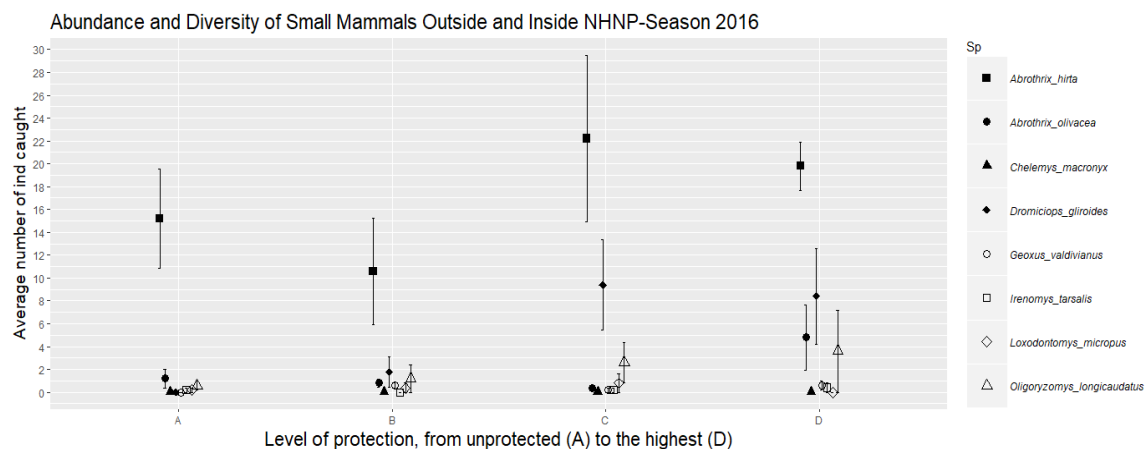


Figure 23. Diversity and average abundance of small mammals caught across different levels of protection in Nahuel Huapi National Park during the summer season 2016. (A) outside NHNP, (B) National Reserve, (C) National Park, (D) Strict Reserve.

Assemblage species richness did not vary among protection levels in 2015 or 2016 (Table 7). However, there were statistical differences between assemblage abundance with the greatest abundances found in the highest protection level (Strict Reserve) and lowest abundances in the lowest protection level (National Reserve) in the NHNP system consistently for both years (Table 7, fig. 24). Comparison of Shannon-Wiener diversity indices did not indicate differences in diversity (Table 7). Finally, abundance by species across the NHNP system and outside PA differed in only two instances, *D. gliroides* and *L. micropus*. A Kruskal- Wallis test on abundance of *D. gliroides* vs protection level reported a significant p value in 2016 (Table 7); however, the subsequent conservative Tukey test did not indicate any significant difference between any pair; thus application of those results should be interpreted with caution (fig. 25). *Loxodontomys micropus* was trapped in only three plots outside the protected area in 2015 (Table 7, fig. 26); nevertheless, this difference did not persist in 2016, when this species was trapped in one plot at each level of protection except for the Strict Reserve (fig. 26). The difference found in 2015 might be associated with a false positive due to our multiple-testing analysis, where the probability of obtaining false significant results (or significant by chance) is approximately 0.43. We ran Bonferroni, Benjamini-Hochberg, and Benjamini-Yekutieli tests that indicated the statistical difference obtained through the Kruskal Wallis test was, indeed, not supported. However, despite the lack of statistically significant differences in *D. gliroides* abundances across the four levels of protection, abundances appeared greater in National Park and Strict Reserve in comparison with National Reserve and outside PA (fig. 25). To further evaluate these unequal abundances, we thus combined capture numbers from the Strict Reserve and National Park under the category “High protection”, while National Reserve and NHNP were grouped under a “Low-no protection” category. We ran a t-test for each season, finding a consistent difference between these two groups (Season 2015, $t=3.2188$, $df=9.4882$, $p\text{-value}=0.0098$; Season 2016: $t=2.8567$, $df=10.16$, $p\text{-value}=0.0168$, fig. 27).

The analysis of sex ratio (number of females/number of males) calculated for the three most common species: *A. hirta*, *O. longicaudatus* and *D.gliroides*, did not show any difference with respect to the level of protection, during either season 2015 or season 2016 (Table 8). Worth nothing is that the number of males was higher than the number of females in most cases.

Table 7. Comparison among small mammal communities across different levels of protection in the NHNP system and outside. Each diversity variable (column 1) was analyzed for each season of data independently (top season 2015, bottom season 2016) by means of Kruskal-Wallis's Test because ANOVA's assumptions were not satisfied. Mean $\pm$ standard error is indicated in each cell. * indicates statistical significance.

	Outside NHNP	National Reserve	National Park	Strict Reserve	KW chi ²	Df	P-value
Assemblage	3.8 $\pm$ 0.66	3.0 $\pm$ 0.74	3.0 $\pm$ 0.54	3.2 $\pm$ 0.37	0.853	3,16	0.8368
Species	2.2 $\pm$ 0.49	3.0 $\pm$ 0.32	2.8 $\pm$ 0.66	3.0 $\pm$ 0.54	4.1315	3,16	0.2476
Richness							
Assemblage	41.8 $\pm$ 8.45	17.2 $\pm$ 5.91	36.6 $\pm$ 7.86	51.4 $\pm$ 8.26	7.6316	3,16	0.0542*
abundance	17.0 $\pm$ 3.99	15.4 $\pm$ 5.55	35.8 $\pm$ 7.08	37.6 $\pm$ 3.75	9.2491	3,16	0.0261*
Shannon-	0.95 $\pm$ 0.13	0.59 $\pm$ 0.23	0.59 $\pm$ 0.15	0.67 $\pm$ 0.16	2.5076	3,16	0.4739
Wiener	0.43 $\pm$ 0.16	0.68 $\pm$ 0.12	0.58 $\pm$ 0.18	0.87 $\pm$ 0.06	4.0859	3,16	0.2523
Diversity Index							
<i>A. hirta</i>	23.4 $\pm$ 4.69	13.0 $\pm$ 5.98	25.0 $\pm$ 4.46	30.0 $\pm$ 4.57	4.1562	3,16	0.2451
	15.2 $\pm$ 4.37	10.6 $\pm$ 4.65	22.2 $\pm$ 7.27	19.8 $\pm$ 2.11	2.9045	3,16	0.4066
<i>O.</i>	12.2 $\pm$ 2.59	2.2 $\pm$ 0.97	1.6 $\pm$ 1.12	9.4 $\pm$ 8.66	7.1228	3,16	0.0681
<i>longicaudatus</i>	0.6 $\pm$ 0.4	1.2 $\pm$ 1.2	2.6 $\pm$ 1.78	3.6 $\pm$ 3.6	0.5515	3,16	0.9074
<i>D. gliroides</i>	0.8 $\pm$ 0.49	1.2 $\pm$ 0.49	7.6 $\pm$ 2.99	7.6 $\pm$ 3.07	5.7734	3,16	0.1232
	No capture	1.8 $\pm$ 1.32	9.4 $\pm$ 3.95	8.4 $\pm$ 4.16	8.417	3,16	0.0381*
<i>A. olivacea</i>	3.4 $\pm$ 2.13	No capture	0.6 $\pm$ 0.6	0.8 $\pm$ 0.58	2.3911	3,16	0.4953
	1.2 $\pm$ 0.8	0.8 $\pm$ 0.37	0.4 $\pm$ 0.24	4.8 $\pm$ 2.85	1.4184	3,16	0.7012
<i>G. valdivianus</i>	0.4 $\pm$ 0.4	0.4 $\pm$ 0.24	1.4 $\pm$ 1.16	0.2 $\pm$ 0.2	0.8742	3,16	0.8316
	No capture	0.6 $\pm$ 0.24	0.2 $\pm$ 0.2	0.6 $\pm$ 0.4	4.3244	3,16	0.2285
<i>C. macronyx</i>	No capture	0.4 $\pm$ 0.24	No capture	No capture	6.3333	3,16	0.0965
	No capture	No capture	No capture	No capture	-	-	-
<i>I. tarsalis</i>	0.4 $\pm$ 0.4	No capture	0.4 $\pm$ 0.4	3.4 $\pm$ 3.4	1.1333	3,16	0.7690
	0.2 $\pm$ 0.2	No capture	0.2 $\pm$ 0.2	0.4 $\pm$ 0.4	0.1333	3,16	0.7690
<i>L. micropus</i>	1.2 $\pm$ 0.58	No capture	No capture	No capture	9.9805	3,16	0.0187*
	0.2 $\pm$ 0.2	0.4 $\pm$ 0.4	0.8 $\pm$ 0.8	No capture	1.1385	3,16	0.7678

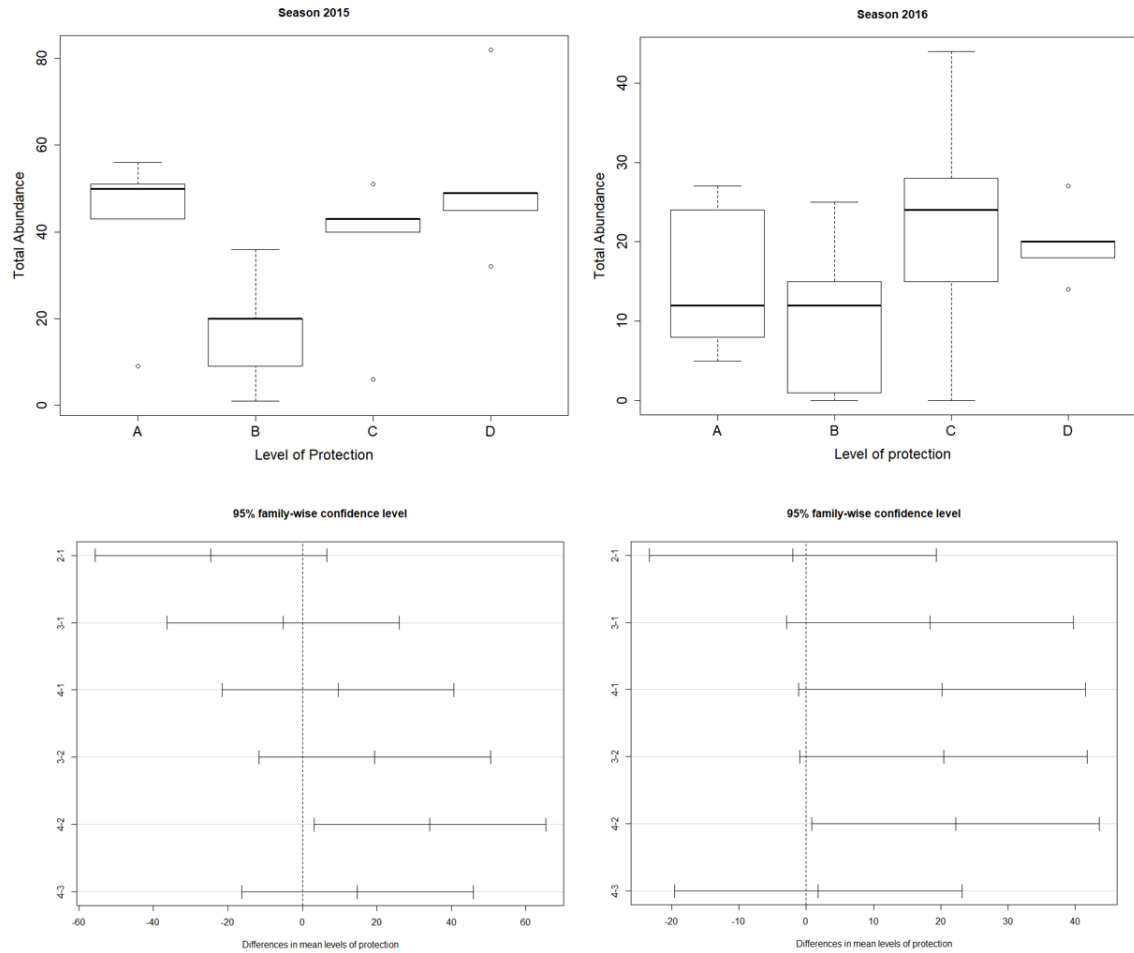


Figure 24. Total abundance of small mammals captured in sites with different levels of protection in NHNP. Top left corresponds with 2015 while top right with 2016. (A) outside PA, (B) National Reserve, (C) National Park, (D) Strict Reserve. Results from Tukey's HSD test are shown at the bottom for each year, respectively. Differences between group 2 and 4 (National Reserve and Strict Reserve) were found in both years ($p=0.02879$ for 2015 and $p=0.03987$ for 2016).

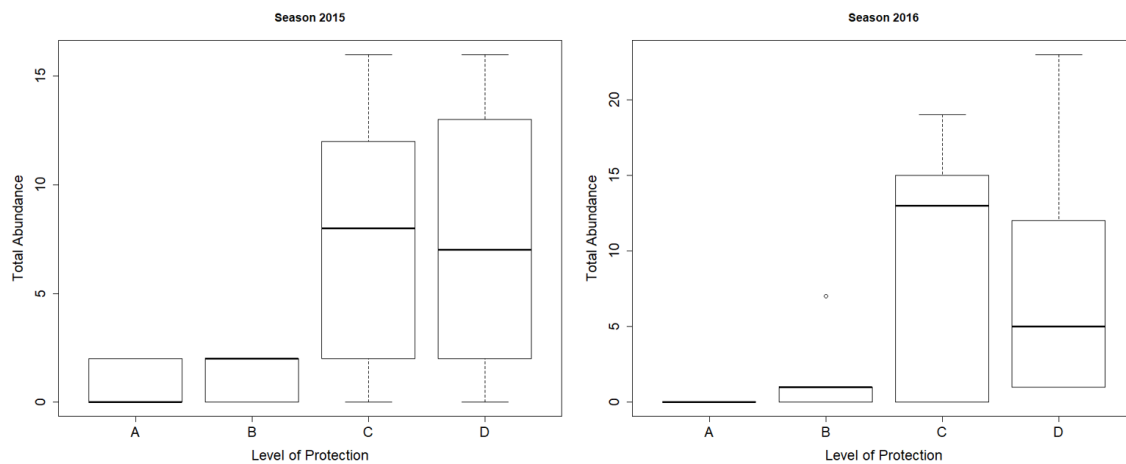


Figure 25. Abundance of *Dromiciops gliroides* at each level of protection NHNP. (Left) 2015, (Right) 2016. (A) outside PA, (B) National Reserve, (C) National Park, (D) Strict Reserve.

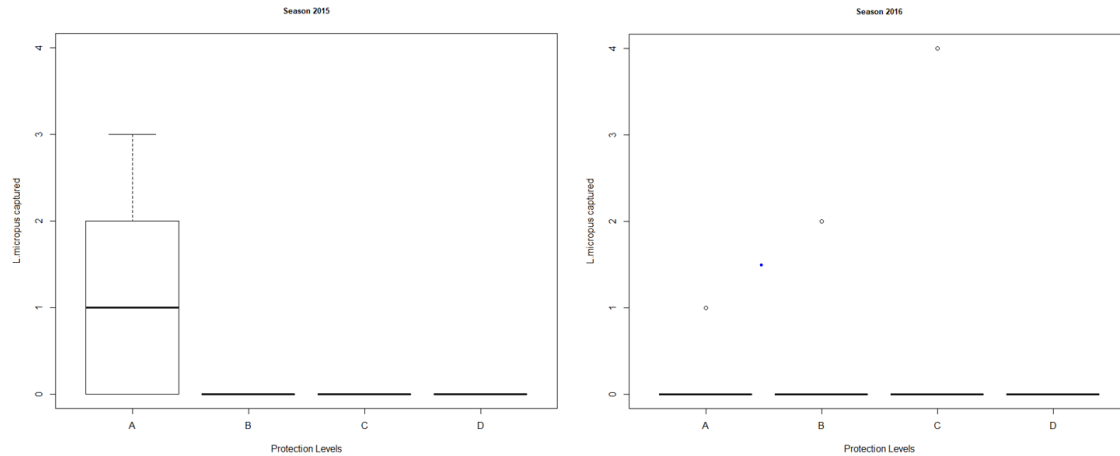


Figure 26. Number of *Loxodontomys micropus* caught at each level of protection during 2015 (left) and 2016 (right). While there was a statistical difference in 2015, it did not appear in 2016. (A) outside PA, (B) National Reserve, (C) National Park, (D) Strict Reserve.

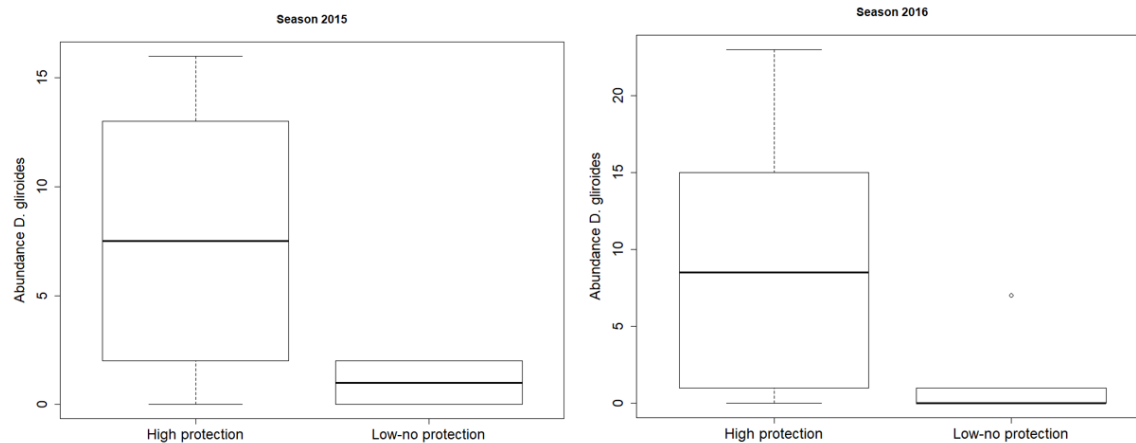


Figure 27. Grouped abundance of *Dromiciops gliroides*. High protection combines Strict Reserve + National Park captures. Low-no protection combines National Reserve + outside PA captures.

Table 8. Sex ratio comparison for the three most common small mammals species at each level of protection in the NHNP system and outside. Each season of data was analyzed independently (top season 2015, bottom season 2016) by means of Kruskal-Wallis's test because ANOVA's assumptions were not satisfied. Mean $\pm$ standard error is indicated in each cell.

Sex Ratio= #females/ #males	Outside NHNP	National Reserve	National Park	Strict Reserve	KW χ^2	Df	P-value
<i>A. hirta</i>	0.942 $\pm$ 0.20 0.649 $\pm$ 0.13	0.417 $\pm$ 0.1 7 0.224 $\pm$ 0.1 1	0.509 $\pm$ 0.1 4 0.880 $\pm$ 0.2 8	0.793 $\pm$ 0.0 9 0.549 $\pm$ 0.1 3	7.5168 5.8698	3,16 3,16	0.0571 0.1181
<i>O. longicaudatus</i>	1.000 $\pm$ 0.38 0 $\pm$ 0	0.333 $\pm$ 0.2 1 0.2 $\pm$ 0.2	0.400 $\pm$ 0.4 0 0.124 $\pm$ 0.0 8	0.183 $\pm$ 0.1 8 0.314 $\pm$ 0.3 1	3.9603 2.3443	3,16 3,16	0.2658 0.5041
<i>D. gliroides</i>	0.2 $\pm$ 0.2 No capture	0 $\pm$ 0 0.4 $\pm$ 0.4	0.56 $\pm$ 0.20 0.418 $\pm$ 0.1 9	0.547 $\pm$ 0.2 50.542 $\pm$ 0. 27	4.98 d92 4.4766	3,16 3,16	0.1726 0.2144

Sexual status in rodents is more clearly determined by external characteristics than in marsupials. For this reason, we evaluated the sexual status of the two most commonly captured rodents: *A. hirta* and *O. longicaudatus*. Since this status may change from month to month, we analyzed them independently for each capture session (January, February, and March) and per gender. There was no difference between proportion of individuals sexually active and level of protection (Table 9) with the sole exception of males of *A. hirta* for the January capture session in both years. Post-hoc Tukey test analysis for data from 2015 supported the difference between a higher proportion of males sexually active in the Strict Reserve than outside NHNP (fig. 28, Tukey test p-value 0.0144 between Strict Reserve and outside). Nevertheless, this conservative analysis run with the 2016 data did not indicate a significant difference between any pair; closest was the p-value between Strict Reserve and National Park (p-value= 0.0607); thus these results should be interpreted with caution.

Discussion

While scoring effectiveness evaluations provide insights that help to detect the main factors that may be affecting a PA, quantitative population data from monitoring allows much stronger inference. This monitoring study yielded no clear evidence to support the view that the NHNP protection system, with its different protection categories, is effectively conserving its small mammal communities. However, the higher assemblage abundance recorded consistently in both years inside the Strict Reserve suggests that direct human interaction negatively affects this assemblage as a whole.

In an attempt to minimize the effect of landscape variability on species presence/absence, we restricted the distribution of our 20 plots to forest dominated by *N. dombeyi*, between 500 and 700 masl. By doing so, we aimed to connect community and population variation with levels of protection. Pearson (1983) described nine species in the most comprehensive study (> five consecutive years) of small mammals conducted in the northern Patagonian forests. In the present study, we recorded eight of those species, with the sole exception of *Aconaemys fuscus*, the distribution of which occurs north of NHNP (Roach, 2016). Nevertheless, in our study, these species were unevenly recorded across our 20 plots,

Table 9. Analysis results of proportion of sexually active individuals in relationship with the level of protection. Individuals captured during 2015 and 2016 in NHNP and outside PA.

Species and gender	Capture date	Kruskal-Wallis test results
<i>A. hirta</i> male	January 2015	K-W $\chi^2=8.4827$ Df=3 p-value=0.03702*
	February 2015	K-W $\chi^2=2.0273$ Df=3 p-value=0.5668
	March 2015	K-W $\chi^2=2.3865$ Df=3 p-value=0.4962
	January 2016	K-W $\chi^2=8.7699$ Df=3 p-value=0.03251*
	February 2016	K-W $\chi^2=3.3036$ Df=3 p-value=0.3471
	March 2016	K-W $\chi^2=3.3893$ Df=3 p-value=0.3354
<i>A. hirta</i> female	January 2015	K-W $\chi^2=2.1158$ Df=3 p-value=0.5487
	February 2015	K-W $\chi^2=0.0527$ Df=3 p-value=0.9968
	March 2015	K-W $\chi^2=1.0987$ Df=3 p-value=0.7774
	January 2016	K-W $\chi^2=4.4454$ Df=3 p-value=0.2172
	February 2016	K-W $\chi^2=4.4408$ Df=3 p-value=0.2176
	March 2016	K-W $\chi^2=3.029$ Df=3 p-value=0.3872
<i>O. longicaudatus</i> male	January 2015	K-W $\chi^2=1.9439$ Df=3 p-value=0.5841
	February 2015	K-W $\chi^2=2.0273$ Df=3 p-value=0.345
	March 2015	K-W $\chi^2=2.3865$ Df=3 p-value=0.4962
	January 2016	K-W $\chi^2=2.11$ Df=3 p-value=0.5497
	February 2016	K-W $\chi^2=1.944$ Df=3 p-value=0.5841
	March 2016	K-W $\chi^2=2.11$ Df=3 p-value=0.5497

Table 9. Continued.

Species and gender	Capture date	Kruskal-Wallis test results
<i>O. longicaudatus</i> female	January 2015	K-W $\chi^2=2.2258$ Df=3 p-value=0.5487
	February 2015	K-W $\chi^2=0.0527$ Df=3 p-value=0.9968
	March 2015	K-W $\chi^2=1.0987$ Df=3 p-value=0.7774
	January 2016	K-W $\chi^2=3$ Df=3 p-value=0.3916
	February 2016	K-W $\chi^2=4.4$ Df=3 p-value=0.2214
	March 2016	K-W $\chi^2=2.11$ Df=3 p-value=0.5487

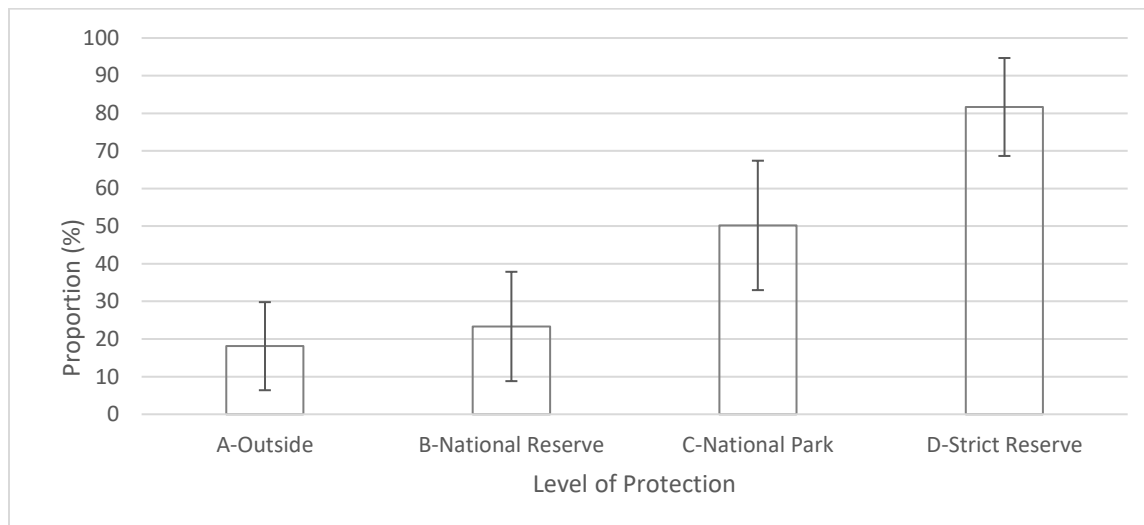


Figure 28. Proportion of males of *Abrothrix hirta* sexually active captured in January during 2015 in NHNP and Outside the PA.

without a clear relationship with the level of protection for each plot. This may be because the lack of control and enforcement across NHNP does not guarantee the reality of the protection category (see Chapter 1). On the contrary, the uneven species distribution could also be related to variation at the local scale, e.g., in understory vegetation composition, food availability, and shelter, variables that we measured and that will be evaluated separately.

The species most frequently recorded in this study was *A. hirta*, which was not only the most abundant but also the most widely distributed, present in 18 of 20 plots (absent both seasons in plots R5 and P3 on Isla Victoria, Fig. 20). This result agrees with previous studies (Christie, 1984; Pearson and Pearson, 1982). Although a typical forest species, it can also be found in the steppe if sufficient ground cover and bushes are present (Pearson, 1983). This plasticity along with its omnivorous feeding behavior could be associated with its dominance in the communities. This species has been reported active during morning, afternoon, and night (Pearson, 1983); while in our study it was most frequently captured during the day, it was not unusual during night trapping. Nevertheless, most of those nocturnal captures were recaptures of individuals trapped the previous day. We did not find a relationship between sex ratio and level of protection, but in all the cases males were more abundant than females. Sex ratio for the species was previously evaluated for spring and autumn, and in both seasons males were more abundant (59% in autumn and 57.9% in spring) (Pearson, 1983). We evaluated the proportion of males and females sexually active through the summer. The only relationship between this variable and level of protection was found in January (2015) for males: there were more sexually active individuals within the Strict Reserve than outside NHNP. However, this difference was not maintained the following months or during the second year, which makes it fruitless to speculate on whether this observation is relevant to population growth and the level of protection. It is known that while some individuals might be sexually active in October, the majority reach that stage during November and December, and the reproductive season extends to March (Pearson, 1983).

Oligorizomys longicaudatus has been described as scarce within dense forest (Pearson, 1983). However in our study it was the second most abundant species trapped during 2015 (n=127), when it was found in 15 of 20 plots (absent in R1, P2, P4, E1 and E2, Fig. 3). Its numbers dropped drastically in 2016 (n=40) and it was captured in only six plots

(A1, A3, R5, P1, P3 and E3, Fig. 3). As there was no relationship between abundance and level of protection, this decline could be related to a natural process, and annual fluctuations are not unusual (Murua et al., 1986). Their numbers have also been reported higher in autumn and spring than in summer (Sage et al., 2007). The sex ratio for this species in the area has been reported to be slightly biased toward males (Murua et al., 1986; Pearson, 1983), which coincides with our findings. Most individuals of this species breed during November and December; however, there is evidence of breeding in autumn and early spring. Furthermore, offspring can reproduce when one month old (Pearson, 1983). This reproductive process seems to happen equally across the area; we found no relationship between the proportion of individuals sexually active and the level of protection.

The marsupial *D. gliroides* is the only species reported in this study that is listed as Near Threatened in the IUCN Red List (Martin et al., 2015). Its population is declining mainly owing to habitat changes, like forest conversion to agriculture and habitat fragmentation. It is remarkable that in our study *D. gliroides* was the third most abundant species in 2015 (n=86), when it was trapped in 13 of 20 plots (absent in A2, A3, A4, R3, R5, P3 and E1, Fig. 20), and the second in 2016 (n=98), documented in 11 of 20 plots (absent in the five plots outside NHNP, R1, R3, P2 and P3, Fig. 20). It is important to note that despite the lack of statistical support of the relationship between level of protection and abundances of this species, most individuals were trapped in plots located with high level of protection (Strict Reserve and National Park). Our combined analysis between high protection (Strict Reserve + National Park) vs low-no protection (National Reserve + outside NHNP) was statistically significant (Season 2015, $t=3.2188$, $df=9.4882$, $p\text{-value}=0.0098$; Season 2016: $t=2.8567$, $df=10.16$, $p\text{-value}=0.0168$), highlighting the importance of the existence of protected areas for this species. Although abundant, these populations were markedly smaller than populations previously reported in the area, where a single population of 152 individuals was reported with a capture effort of 800 traps/night (Rivarola, 2010). Fragmentation and agriculture are not the only threats to this species. The first long-term study tracking population changes in this species demonstrated how sensitive it is to other natural processes like massive flowering of bamboo and the subsequent mouse outbreak, volcano eruption, and other changes associated with human activities, such as climate change that has entailed drier summers in this area (Oliver et al., 2017). Rivarola (2010) reported a sex

ratio slightly biased toward males (51.8 %). In the present study, we found no relationship between sex ratio and level of protection. Low capture number in plots outside NHNP and National Reserve does not allow us to speculate about the sex ratio. However, the sex ratio in those plots established in National Park and Strict Reserve was biased towards males as well.

Abrothrix olivacea inhabits areas with thick grass, marshes, and forest with sufficient ground cover vegetation (Pearson, 1983). They prefer microhabitats with vegetation cover from above because it protects them from predators (Murua et al., 1986). With some degree of variation, all of our 20 plots had good ground cover vegetation. However, this species was captured in only five plots (n=24) in 2015, but in ten plots in 2016, and the number of captures almost doubled (n=36). This change in presence/absence highlights the importance of long-term studies needed to understand variation in species distributions, and also of looking more closely at those variables that might affect the occurrence of this species, beyond the level of protection.

Irenomys tarsalis occupies dense forest with understory dominated by the bamboo *Chusquea culeou* (Pearson, 1983). Those plots that had bamboo as a dominant species had flowered in 2010 (Herrero, 2013). *Chusquea culeou* undergoes vegetative growth most of the time; but after 50-70 years, it flowers synchronously (thousands of hectares at once), produces a massive amount of seeds, and then dies. Recovery is a slow process because this mass mortality allows seedlings from tree species (mainly *Nothofagus*) to spread (Giordano et al., 2009; Marchesini et al., 2009). This could be the reason for our low capture rate for the species (n= 21 in 2015 and n=4 in 2016). Furthermore, *I. tarsalis* abundance has been reported to increase from summer (1 individual captured with a trapping effort of 1936 traps/night) to fall (10 individuals captured with the same trapping effort) (Garcia et al., 2013); it could be worthwhile to follow the population during autumn. In the present study, the species was recorded in five plots in 2015, mostly under high level of protection (A2, P2, E3, E4, E5, Fig. 20), and in only three plots in 2016, with no relationship with the level of protection (A5, P1, E3, Fig. 20).

During 2015, 12 individuals of *G. valdivianus* were caught, distributed in six plots (A5, R3, R4, P1, P4, E5, Fig. 20), while in 2016 the number of captures dropped to 7 individuals, also distributed in six plots (R1, R3, R4, P5, E4, E5, Fig. 20). This is the only species whose

diet is based solely on invertebrates (Pearson, 1983); further studies about invertebrate diversity and abundance in each plot could help us to understand its distribution (data to be analyzed for another publication).

Loxodontomys micropus is bigger than the mammals mentioned above; its weight based on 151 captures ranges from 10.5 to 105 g (Pearson, 1983). It is mainly herbivorous and prefers forest with sufficient ground vegetation. Despite the apparently suitable condition of our 20 plots, we trapped only six individuals in 2015, all of them in plots outside NHNP (A2, A4, A5, Fig. 20). Because all of our replicates outside NHNP are located along the southern border owing to certain restrictions (Lanin National Park along the northern border, Chile along the western line, and landscape change to steppe to the east), this occurrence could be related to a preference for a southern distribution. However, in 2016 our captures changed despite the fact that we trapped almost the same number of individuals (n=7); this time they had a wider distribution (A5, R2, and P2). A study conducted in Chile in mature and second growth forest reported ten individuals with a trapping effort of 1936 traps/night (Garcia et al., 2013). Further studies are needed to determine the reason for the low abundance recorded in our study with a total trapping effort of 41,600 traps/night.

Finally, *C. macronyx*, which resembles a large vole with front claws used for digging, has been found mainly in lenga forest (*N. pumilio*), where 45 individuals were captured in Chile with a trapping effort of 1936 traps/night (Garcia et al., 2013), but it has never been trapped in *N. dombeyi* forest (Pearson, 1983). In the present study, in 2015 we trapped two individuals in two plots where, as mentioned above, the dominant species was *N. dombeyi*. These plots were the northernmost samples we took (R3 and R4, Fig.3), both in the National Reserve category. It is worth mention that the area was still heavily covered by volcanic ash (from the Cordon Caulle eruption in June 2011). Research on ash chemical composition and its effect on arthropods has demonstrated its insecticidal action (Buteler et al., 2011). Although *C. macronyx* is omnivorous, it is believed that invertebrates constitute most of its diet (Sage et al., 2007), so it is interesting that we found them in that particular area and nowhere else. Nevertheless, it has been reported in higher abundance (still low captures success) in areas where more than 50% of the ground is unvegetated (Pearson, 1995). To

increase capture probability, traps must be set near their burrow entrances instead of randomly distributed in a grid as we did (Ojeda R., *personal communication*).

Small mammal populations commonly undergo cycles of different length in response to biotic and abiotic factors (Armas et al., 2016). The lack of this information for the communities in this area renders tenuous our conclusion regarding NHNP effectiveness and highlights the importance of long-term studies and monitoring programs regularly scheduled within PAs.

Climate change is a major threat in the area (Kelt and Meserve, 2014) and might be responsible for the unusually dry summers in 2015 and 2016. Rain has a strong effect on small mammal activity rate and capture probability in the area. In our study, during 2015, there was one plot (A4) in which, despite good vegetation cover and an adjacent marsh area, capture success was extremely low during the 1st and 2nd trapping session (0 and 9 captures respectively); however, during the last season it rained all the week and the number of captures rose to 58.

Our study does not support our hypotheses beyond the assemblage abundance, as mentioned above. However, it is notable that the sampled area, with its different categories of protection, did not actually differ as much as one might expect from the names of the categories, in terms of anthropogenic impacts. For instance, we could find cattle (domestic, semi-wild, or wild) in almost every plot. For those plots that belong to the National Park, we asked the park ranger about what measures were implemented to reverse that situation, and, at the moment, they lacked support or instructions to remove the cattle. Those areas where we found more diversity and abundance were located in zones with more difficult access, which might imply that it is not the category of protection but just the inaccessibility that is preserving these communities, as has happened in other PAs in different countries (Struhsaker et al., 2005). The number of park rangers is extremely low, and in most cases they do not have the equipment needed to patrol the area and enforce laws. In most of the sampled areas, there was just one park ranger to patrol more than 300 km² (0.3 park ranger per 100 km²), and in case of a day off or sickness, the area remained with no authority or representation from the APN, even for months. This situation greatly affects the performance of the PA. A study conducted in 93 PAs distributed in 22 tropical countries determined that

PAs that perform well have at least three park rangers per 100 km², and low effectiveness PAs have 0.4 park rangers per 100 km² (Bruner et al., 2001).

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CONCLUSIONS

- ✓ Argentinian National Park System (APN) has a long and strong history
- ✓ General trend progressive toward international biodiversity conservation
- ✓ Rapid growth in number and areas protected with better representation of ecoregions
- ✓ In-kind collaborations to supplement budget shortfalls
- ✓ Stronger outreach campaigns
- ✓ Rangers with strong commitment to conservation
- ✓ Conservation plan only for endangered species. Field technician with no equipment, training
- ✓ Decision-makers chosen by the National Government may be biased
- ✓ Institutional corruption
- ✓ Low budget
- ✓ Limited staff prioritized to visitor needs not patrolling/monitoring
- ✓ Political and economic instability, institutional corruption and absence of a rightful government commitment, lead to the partial failure of the APN. Education and generation of public environment awareness is the path to follow.
- ✓ Small mammal abundance significantly higher in Strict Natural Reserve
- ✓ Two dominant species: rodent *Abrothrix hirta* and marsupial *Dromiciops gliroides*
- ✓ *A. hirta* was well represented across the entire area.
- ✓ *D. gliroides* was more abundant inside National Park and Strict Reserve than elsewhere, suggesting that the presence of the protected area plays a fundamental role in conserving this endangered species.

- ✓ There is no clear evidence of a consistent difference between small mammal communities across the different protection levels.

VITA

Maria Daniela Rivarola was born in Ayacucho, Buenos Aires province, Argentina. She obtained her degree in Biological Sciences in Universidad Nacional del Comahue, located in Bariloche, northern Patagonia, where she developed a strong love and bond with the native forest and its fauna. Maria won a scholarship funded by the European Union to conduct undergraduate studies during eight months in Sweden (Swedish University of Agricultural Sciences, Umeå- SLU). She has participated in several studies monitoring small mammal populations and communities both in Argentina and Chile. Maria has presented her research in national and international conferences along with scientific publications in high impact journals. Currently, she resides with her husband and two daughters in Knoxville, TN.