Figure 1. Map of the Magellanic sub-Antarctic ecoregion showing the full extent of the broadleaf evergreen rainforests (green) and the Magellanic moorland (gray), from Cape Horn (56ºS) to Penas Gulf (47ºS) in Chile. The satellite image below illustrates the location of the Omora Ethnobotanical Park, and the Cape Horn Biosphere Reserve area (enclosed by the light blue dashed line). Omora Park is the biocultural research, education, and conservation center of this biosphere reserve, and it is situated on Navarino Island (55ºS), south of Tierra del Fuego. Modified from Rozzi et al. 2008a. Photo Adam Wilson.

Figure 2. *Front page.* Glacier Italia, one of the numerous in the Cape Horn Biosphere Reserve that flows down from the Darwin Cordillera to the sea. Photo Jordi Plana.

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THE OMORA PARK LONG-TERM ORNITHOLOGICAL RESEARCH PROGRAM: STUDY SITES AND METHODS

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In January 2000, we initiated a Long-term Ornithological Research Program at Omora Ethnobotanical Park in the world's southernmost forests: the sub-Antarctic forests of the Cape Horn Biosphere Reserve. In this chapter, we first present some key climatic, geographical, and ecological attributes of the Magellanic sub-Antarctic ecoregion compared to subpolar regions of the Northern Hemisphere. We then describe the study sites at Omora Park and other locations on Navarino Island and in the Cape Horn Biosphere Reserve. Finally, we describe the methods, including censuses, and present data for each of the bird species caught in mist nets during the first eleven years (January 2000 to December 2010) of the Omora Park Long-Term Ornithological Research Program.

THE MAGELLANIC SUB-ANTARCTIC ECOREGION

The contrast between the southwestern end of South America and the subpolar zone of the Northern Hemisphere allows us to more clearly distinguish and appreciate the peculiarities of an ecoregion that until recently remained invisible to the world of science and also for the political administration of Chile. So much so, that this austral region lacked a proper name, and it was generally subsumed under the generic name of Patagonia. For this reason, to distinguish it from Patagonia and from sub-Arctic regions, in the early 2000s we coined the name “Magellanic sub-Antarctic ecoregion” (Rozzi 2002).

The Magellanic sub-Antarctic ecoregion extends along the southwestern margin of South America between the Gulf of Penas (47ºS) and Horn Island (56ºS) (Figure 1). Its mountainous terrain includes steep slopes, and along the Andes, the Darwin Cordillera in Tierra del Fuego and numerous high summits on other islands there are ice fields with glaciers that flow down to the sea (Figure 2). Its forests are characterized by the dominance of an evergreen broadleaf tree species, the Magellanic Coigüe or Evergreen Beech (*Nothofagus betuloides*), and for being embedded in a matrix of moorlands and wetlands, known as the Magellanic tundra complex (Pisano 1977, 1980,

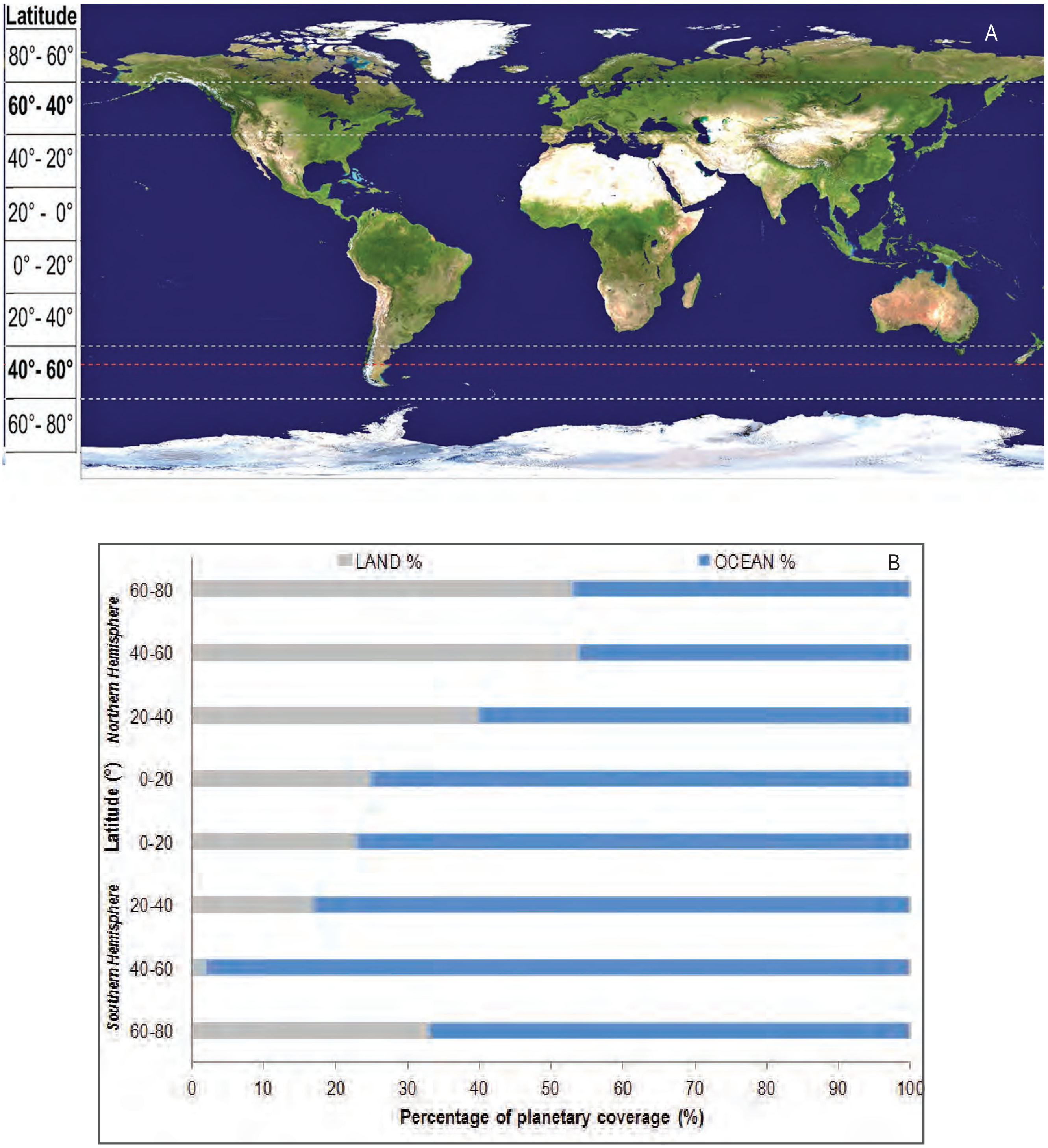

Figure 3. A. World image showing that the Magellanic sub-Antarctic forests extend nearly 10 degrees further south than the temperate forests of Stewart Island, New Zealand (47ºS, indicated by the dashed red line). Therefore, the world's southernmost forests in the sub-Antarctic Magellanic ecoregion have no eco-geographical equivalent in the Southern Hemisphere. The sub-Antarctic forests also contrast with the boreal forests, because while the former span a narrow strip of land in southwestern South America the latter cover a vast cross-continental area in the Northern Hemisphere. The white dashed lines enclose the latitudinal bands at 40–60º in both hemispheres to illustrate the conspicuous difference in land:ocean ratios at this latitudinal range (Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes, based on "The MODIS Rapid Response System"). B. The Southern Hemisphere has a clear prevalence of oceanic surface over land surface. The prevalence of oceanic surface reaches a maximum at the 40-60°S latitudinal band where the proportion of land:ocean areas is 2%:98%. In contrast, in the Northern Hemisphere, there is a prevalence of land surface at temperate and subpolar latitudes, which reaches a maximum at the 40-60°N latitudinal band where the proportion of land:ocean areas is 54%:46%. Data from Rozzi *et al*. 2012.

Arroyo *et al.* 2005). Its climate is hyperhumid with cool temperatures and an annual rainfall that is greater than 1000 mm in most areas, and greater than 5000 mm in the western areas (Tuhkanen *et al.* 1990).

As compared to names used in earlier literature, such as “antiboreal” region (Koehler 1912, Ekman 1935, Wace 1965), “Westpatagonia” (Skottsberg 1924), "Subantarctic subregion" (Cabrera 1973, Morrone 2000), “Magellanic rainforests” (Veblen *et al.* 1983), and “Magellanic subpolar rainforests” (Mittermeier *et al.* 2002, 2003), the term “Magellanic sub-Antarctic ecoregion” (Rozzi 2002, Rozzi *et al.* 2012) has the advantage of clearly distinguishing this ecoregion from:

(i) Patagonia in southeastern South America, which is dominated by low shrub steppe, has a flat relief, and a semi-arid climate (Cabrera & Willink 1973).

(ii) Sub-Antarctic oceanic islands in the Southern Hemisphere (*e.g.*, Diego Ramirez Islands, South Georgia and the South Sandwich Islands), which completely lack forests (Pisano 1972, Pisano & Schlatter 1981a,b).

(iii) The sub-Arctic region in the Northern Hemisphere, which is characterized by its boreal forests dominated by evergreen conifers and deciduous broadleaf trees, and have a continental climate (Chapin *et al.* 2006).

Omora Park is located near the southern end of the Magellanic sub-Antarctic ecoregion, south of Tierra del Fuego, along the Beagle Channel on the northern coast of Navarino Island (Figure 1). Due to the inter-hemispheric contrast between sub-polar areas (sub-Arctic and sub-Antarctic), the Long-Term Ornithological Research (LTOR Program) developed at Omora Park and the Cape Horn Biosphere Reserve is not only of regional significance, but of global significance for the following reasons.

WORLD RELEVANCE OF THE OMORA PARK LONG-TERM ORNITHOLOGICAL RESEARCH (LTOR) PROGRAM IN THE MAGELLANIC SUB-ANTARCTIC FORESTS

1. *The LTOR-Omora Park has no eco-geographical equivalent worldwide*

The forests of Cape Horn are not only the most southern of the planet, but neither do any latitudinally equivalent forests exist in the Southern Hemisphere. Omora Park is located at 55ºS, near the southern end of the Magellanic sub-Antarctic ecoregion, approximately 10 degrees of latitude further south than New Zealand southernmost forests on Steward Island at 47ºS or Tasmania's forests at 43º37'S in South Cape Bay (Figure 3A). The forests of New Zealand and Tasmania are temperate forests. Therefore, there is no eco-geographically equivalent ecoregion to the Magellanic sub-Antarctic ecoregion in the southern Hemisphere. In addition, the Magellanic sub-Antarctic ecoregion has conspicuous geographic, climatic, and biological contrasts with the subpolar forests of the Northern Hemisphere. This confirms that the LTOR-Omora Park, including its mist-netting and bird banding program, is conducted in an ecoregion that has no equivalent elsewhere.

2. *Omora Park has an oceanic climate that contrast with the continental climate of sub-polar study sites in the Northern Hemisphere*

The sub-Antarctic ecosystems of southwestern South America strongly contrast with their latitudinal counterparts in the Northern Hemisphere for geographical reasons. In the Southern Hemisphere, in the latitudinal band 40-60ºS, the proportion of land:ocean areas is 2%: 98%, whereas in the latitudinal band 40-60ºN the proportion of land:ocean areas is 54%: 46% (Figure 3B). At a global scale, this marked difference in the proportion of terrestrial *versus* oceanic areas creates a strong macro-climatic contrast between the temperate and sub-polar regions of the north and south hemispheres.

In the Southern Hemisphere, the climate in temperate and sub-Antarctic ecosystems is moderated by the vast expanse of ocean that creates an oceanic climate characterized by very low thermal fluctuations between seasons, with winters that do not have extremely cold temperatures and mild summers (Figure 4A). This feature was well described by Rockwell Kent (the celebrated illustrator of the American frontier of Alaska) who concluded his book *Voyaging Southwards from the Strait of Magellan* (Kent 1924) by stating that “the forests are luxuriantly green, with stately trees, and violets starring their dark floors; and in them live the gentlest of wild creatures. It is a peaceful and friendly wilderness, neither intemperately hot or cold” (p. 184).

In contrast, in the Northern Hemisphere the high proportion of land at high latitudes generates a continental type of climate, which is characterized by great annual temperature ranges, with very cold winters and warm summers (Arroyo *et al.* 1996, Lawford *et al.* 1996). For example, during the years 2009-2012 the annual temperature range recorded at the northernmost forested site of the US Network of Long-Term Ecological Research (LTER), Bonanza Creek in Alaska (64º42'52"N, 148º08'43"W) was 47.9ºC. The mean temperatures of the coldest (January) and the warmest month (July) were 19.2ºC and -28.7ºC, respectively (http://www.lter.uaf.edu/bnz_bcef.cfm) (Figure 4B). For the same period of time, the annual temperature range recorded by the microclimate station of the Chilean Long-Term Socio-Ecological Research network (LTSER-Chile) at Omora Park, 10 m above sea level, was 8.9ºC. The annual temperature range is calculated

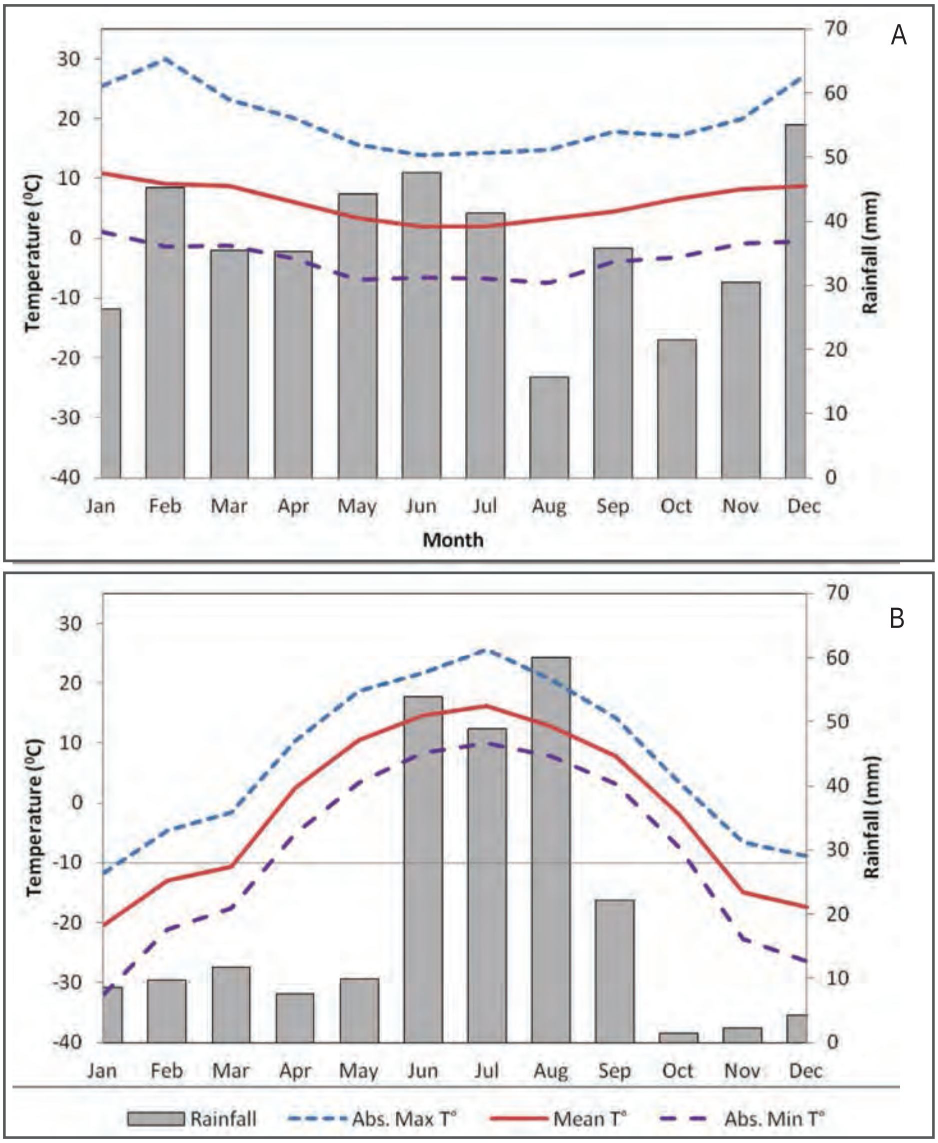

Figure 4. Average monthly rainfall (bars), mean monthly temperature (red central line), absolute maximum temperature (blue dashed line) and absolute minimum temperature (purple dashed line) at (top) the Omora Park Station, LTSER Chile, and (bottom) at Bonanza Creek in Alaska (LTER, (64º42'52"N, 148º08'43"W) for the period January 2009–December 2012. Data from LTSER-Chile (http://www.ceazamet.cl/index.php?pag=mod_estacion&e_cod=CNPW&p_cod=ceazamet), and LTER-Bonanza Creek (http://www.lter.uaf.edu/bnz_bcef.cfm).

Figure 5A. The Magellanic Woodpecker (*Campephilus magellanicus*) is the largest woodpecker in South America. About ten family groups are found in Omora Park, which offers protection to this species that is classified as Endangered in south-central Chile, and as Vulnerable in southern Chile and Argentina. The Magellanic Woodpecker is a congeneric species of the Ivory-billed (*Campephilus principalis*) and Imperial (*C. imperialis*) woodpeckers of North America. In contrast to the Magellanic Woodpecker, both North American species are probably extinct today due to habitat degradation and hunting pressure. Photo Jordi Plana.

as the difference between the mean temperature of the warmest month (10.8ºC, January) and the mean temperature of the coldest month (1.9ºC, June and July) (http://www.ceazamet.cl/index.php?pag=mod_estacion&e_cod=CNPW&p_cod=ceazamet) (Figure 4A). Therefore, the annual temperature range recorded at Bonanza Creek is 6.4 times greater than in Omora Park. In addition, during the years 2009-2012 the lowest temperature recorded at Bonanza Creek (-32ºC in January 2012, Hollingsworth 2005) was 25ºC colder than the lowest temperature recorded at Omora Park (-7.5ºC in August 2011).

As compared to Omora Park, seasonality, as characterized by thermal regimes and patterns of rainfall, is much more marked in Bonanza Creek. Whereas at Omora Park rainfall is evenly distributed throughout the year (Figure 4A), at Bonanza Creek there is a concentration of rainfall in the summer (Figure 4B). We have included the climatic comparison between Omora Park and the Bonanza Creek LTER site for two reasons:

(a) Bonanza Creek contains forests that are representative of the northernmost subpolar or boreal forests in the Americas. In this sense Bonanza Creek represents a kind of “inter-American mirror image” of the southernmost forests at Omora Park.

(b) In 2010, a formal agreement of long-term collaboration was signed between the University of Alaska Fairbanks that administrates Bonanza Creek and the University of Magallanes and the University of North Texas that co-administrate Omora Park. In the next years we plan to develop comparisons between the forest avifauna of both sites.

It is important to note, however, that in sites located on the west coast of Alaska and other coastal sites in sub-polar zones of the Northern Hemisphere, the maritime influence results in lower seasonal fluctuations in temperature and rainfall than those recorded at Bonanza Creek. Nevertheless, the oceanic climate characteristics of these boreal sites are less than those recorded in southwestern South America (Alaback 1996). Additionally, in the Magellanic sub-Antarctic ecoregion all forests are subjected to strong oceanic climatic conditions and no forests are subjected to continental climatic conditions. In contrast, in the Northern Hemisphere most boreal forests are subjected to strong continental climatic conditions (Arroyo *et al.* 1996). Given these marked inter-hemispheric climatic differences, in future ornithological research at Omora Park we plan to conduct comparative sub-Antarctic—sub-Artic studies that may generate new insights about the impacts of global climate change on the biology and population dynamics of the subpolar forest birds.

3. *The Omora Park long-term ornithological studies are conducted under conditions of minimal direct human impact*

Southwestern South America includes a vast and remote area of forest that was recently identified as one of 24 world’s most pristine ecoregions (Mittermeier *et al.* 2002, 2003). The archipelago of Cape Horn is one of the few island groups in South America that has remained free of direct modern human impact (Silander 2000). Under these conditions, the Omora Park and the Cape Horn Biosphere Reserve represent a natural refuge for species that are threatened in other areas of their range, such as Magellanic Woodpecker (*Campephilus magellanicus*) (Figure 5A).

The Magellanic Woodpecker is the largest woodpecker in South America. It is also a congeneric species of the two world's largest woodpecker species: the Ivory-billed (*Campephilus principalis*) and the Imperial (*C. imperialis*) woodpeckers. These two species that inhabited the temperate forests of North America are presumed to be extinct today or are Critically Endangered (IUCN 2013). The causes of their extinction include hunting pressure and drastic habitat loss of the temperate forests in North America. In contrast, at the southern end of the Americas the Cape Horn Biosphere Reserve preserves extensive contiguous old-growth forest. For this reason, Navarino Island hosts relatively large populations of *C. magellanicus*, a species that is threatened in the rest of Chile.

The logging of native forests and the replacement of native forests by plantations of monocultures of exotic fast-growing trees such as *Eucalyptus* and the Monterrey Pine (*Pinus radiata*) in south-central Chile and Argentina has drastically affected the populations of the Magellanic Woodpecker over most of its range. Today, the Magellanic Woodpecker is considered a threatened species. It is classified as an Endangered species in the administrative regions O'Higgins and Maule of Chile (33-37ºS), and as a Vulnerable species in the administrative regions Bío-Bío to Magallanes (38ºS-56ºS) in Chile (Glade 1993, Hunting Law, SAG 2012), as well as in Argentina (Ojeda 2004). Therefore, the populations of Magellanic Woodpecker in Omora Park as well as in other sites of Navarino Island and the Cape Horn Biosphere Reserve are particularly important for the preservation of this species that has global relevance for the conservation of birds and biodiversity.

Other birds of special interest for conservation include the Rufous-legged Owl (*Strix rufipes*) and the Chilean Hawk (*Accipiter chilensis*). Like the Magellanic Woodpecker, the Rufous-legged Owl is an indicator species of old-growth forests (Figure 5B). It is also a congeneric species of the Spotted Owl (*Strix occidentalis)*, which has played a central role in the conservation debate of old-growth forests in the Pacific Northwest in the USA and Canada (Martínez & Jaksic 1996). The Rufous-legged Owl is frequently sighted at Omora Park, but it is considered to have sparse populations in Chile. At the national level, it is classified as an Inadequately Known species (SAG 2009; the Chilean Hunting Law uses an earlier version of IUCN categories). The Chilean Hawk is another raptor species that nests in the forests of Omora Park, which is of conservation concern at the national level. The Chilean Hawk is classified as a Rare Species in Chile (SAG 2009, Figure 5C). For these endangered birds, including the largest survivor of the genus *Campephilus*, the forests of Omora Park and the Cape Horn Biosphere Reserve provide a critical protected area. In addition to a conservation area, Omora Park provides a *natural laboratory* for the study of the biology and ecology of the bird assemblages of the sub-Antarctic forests under conditions with a minimal degree of direct modern human disturbance.

Figure 5B. The Rufous-legged Owl (*Strix rufipes*) is a resident species in the old-growth forests of Omora Park. It is the species of owl with the highest conservation priority in Chile (SAG 2009). Photo José Tomás Ibarra.

Figure 5C. The Chilean Hawk (*Accipiter chilensis*) is frequently observed at Omora Park. In Chile it is classified as a Rare Species (SAG 2009). Photo José Tomás Ibarra.

4. *Omora Park fills a global gap in long-term ornithological and ecological studies*

The ornithology of Magellanic sub-Antarctic forests has been little studied, as compared to the ornithology of temperate and boreal forests of the Northern Hemisphere (Jarvinen & Vaisänen 1977, Jaksic & Feinsinger 1991, Meserve & Jaksic 1991, Willson 1991, Rozzi 2002, Brommer 2004, Brommer *et al.* 2012). Within the South American temperate forest biome, Magellanic sub-Antarctic forests have been also overlooked. Ornithological studies in the area of Cape Horn have been limited to short periods, mainly during the breeding season of the austral summer (see Jiménez and Rozzi, Epilogue in this book). Ecological studies and a few long-term mist-netting program have been conducted in the Mediterranean and temperate forests of south-central Chile, as well as in the relict fog forests of Fray Jorge National Park (*e.g.*, García 1982, Erazo 1984, Egli 1987, 1996, Armesto & Rozzi 1989, Armesto *et al.* 1987, 1995, 2001, Correa *et al.* 1990, López 1990, Sabag 1993, Rozzi *et al.* 1995, 1996, Smith-Ramírez & Armesto 1998, Gantz & Rau 1999, Cornelius *et al.* 2000, de Santo *et al.* 2001, Kelt 2001, Reid *et al.* 2004, Díaz *et al.* 2005, Tomacevic & Estades 2006, Ibarra *et al.* 2010). However, not a single year-round ornithological study was conducted in the Magellanic sub-Antarctic forests before the Omora Park Long-Term Ornithological research program was started. Moreover, in previous comparisons of bird assemblages of temperate and subpolar forests of North and South America, no mention was made of the Magellanic sub-Antarctic forests (cfr. Jaksic & Feinsinger 1991, Willson 1991, Willson *et al.* 1994).

Not only the ornithology, but the ecology of the austral Magellanic Region has also been understudied (Figure 6). Long-term ecological research networks and environmental observatories have conspicuously overlooked this region. For example, in 2010 the International Network of Long-Term Ecological Research (ILTER, www.ilternet.edu), the largest global network of ecological monitoring, included 543 sites in 44 countries. However, 509 of these sites (93.7%) are located in the Northern Hemisphere. Most sites of the ILTER network are located in boreal and temperate latitudes of the Northern Hemisphere with 69% of ILTER sites located at latitudes > 40°N (Figure 6). Less than 10% (n = 34) of ILTER network sites have been established within the tropical latitudes between 20°N and 20°S, where most of the diversity of birds and other groups of organisms is found (Myers *et al.* 2000). In the Southern Hemisphere as a whole, there are only 34 sites (6.3%), and until 2010 there was a complete absence of ILTER sites in temperate and sub-Antarctic latitudes in the Southern Hemisphere (Figure 6). This blind spot in the ILTER network involved the omission of the full temperate biome in South America, including its Magellanic sub-Antarctic ecoregion (Rozzi *et al.* 2012).

Other international networks of long-term global monitoring and ecological research have also omitted the 40-60ºS latitudinal range in the Southern Hemisphere. For example, FLUXNET has over 500 sites with meteorological towers continuously operating on five continents to record the flow of carbon dioxide in terrestrial ecosystems, but these sites are currently restricted to the latitudinal range between 70ºN and 30ºS (Sundareshwar *et al.* 2007). The Global Lakes Ecological Observatory Network (GLEON) includes 27 observatories in the five continents, but these sites are concentrated between 69ºN and 38ºS. GLEON omits the 40-60ºS latitudinal area, and includes a lake observatory in Antarctica at 77ºS (www.gleon.org). Terrestrial transects established by the International Geosphere-Biosphere Programme (IGBP) do not include any point in temperate and sub-Antarctic forests (Koch *et al.* 1995, Steffen *et al.* 1999). Therefore, the geographical area of temperate and sub-Antarctic forests of South America represents a blind spot in all the major systems of long-term ecological monitoring, including long-term ornithological studies.

The LTOR- Omora Park aims to contribute to address the geographical gap in long-term studies in the Southern Hemisphere (Rozzi *et al.* 2008b). To this end, Omora Park was one of the founding sites of the recently created Chilean Network of Socio-Ecological Long-Term Research Sites (LTSER-Chile) (Figure 7A). The three founding sites of the LTSER-Chile network span the whole latitudinal range of the South American temperate forests biome. These sites include a coastal fog forest in a matrix of semiarid scrublands at Fray Jorge National Park (30°S) (Gutiérrez *et al.* 2010), Valdivian and North Patagonian forests on Chiloé Island at the Senda Darwin Biological Station (42°S)

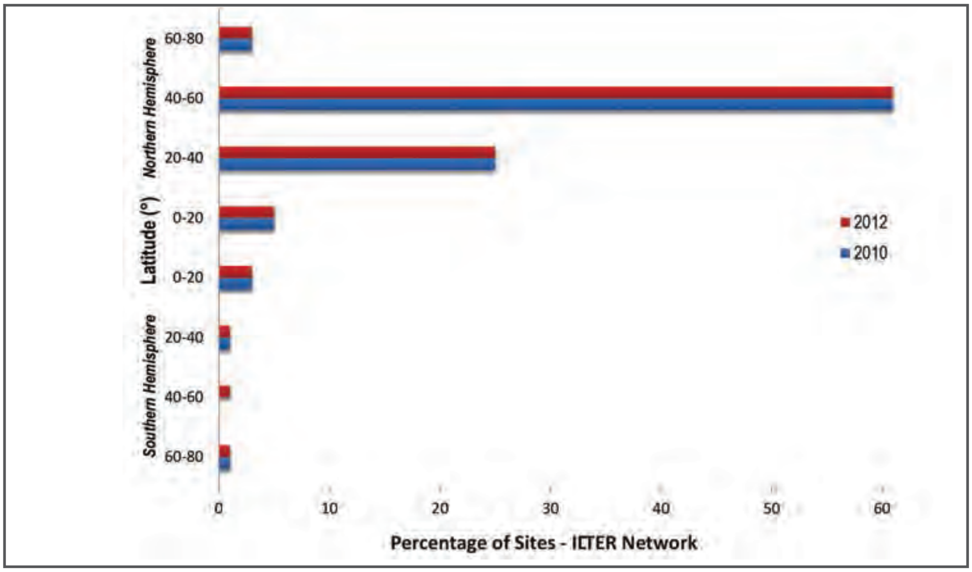

Figure 6. Relative percentage of study sites in the International Long-Term Ecological Research (ILTER, www.ilternet.edu) network at different latitudinal intervals. There is a very low proportion of sites in the Southern Hemisphere, especially in the latitudinal band of 40° -60° S that include the Magellanic sub-Antarctic ecoregion. Notice that the latter has ILTER sites only since 2011. Modified from Rozzi *et al*. 2012.

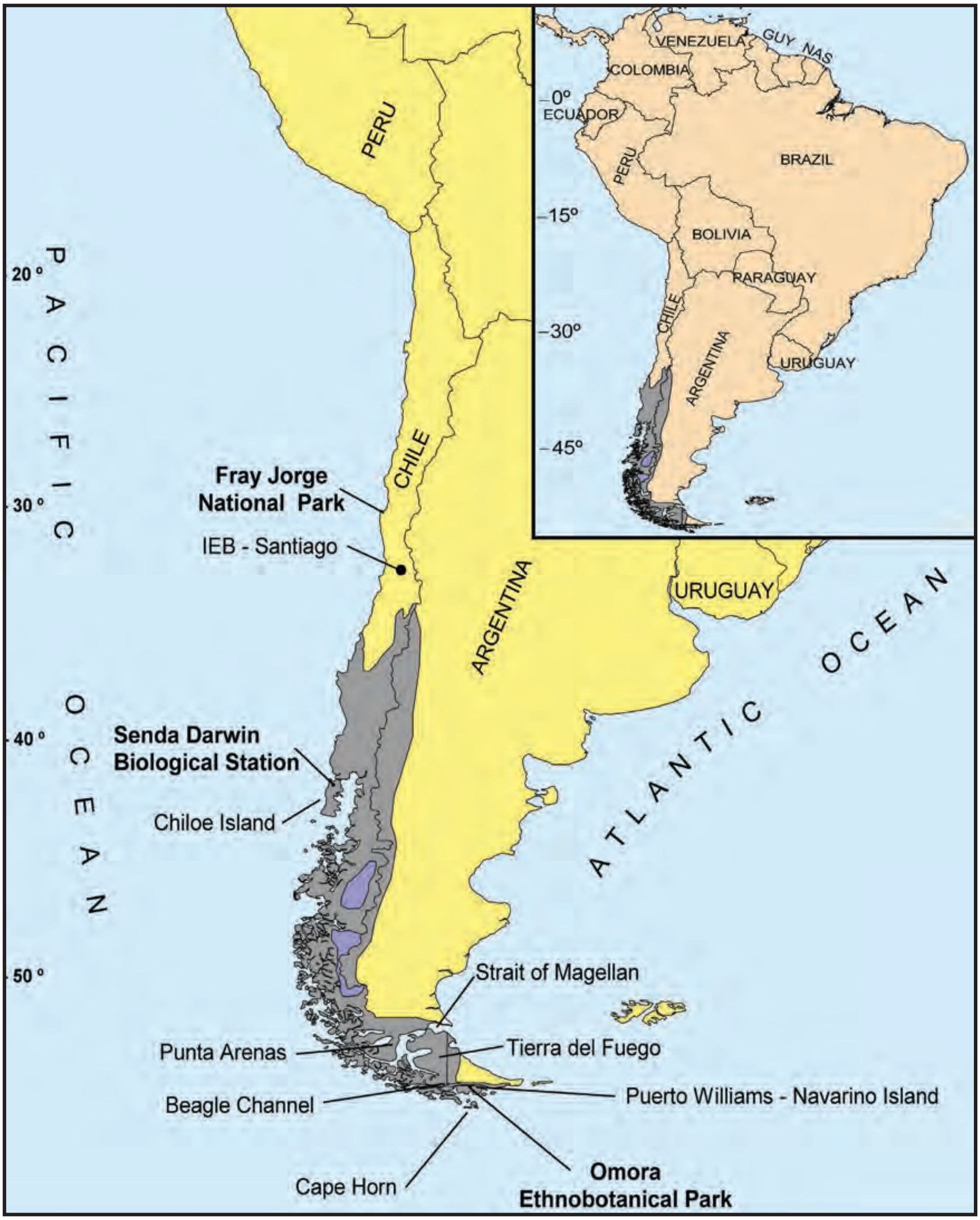

Figure 7A. Map showing the location of the three founding sites of the Chilean Long-Term Socio-Ecological Research (LTSER-Chile) network, and the area covered by the South American temperate forest biome (*sensu* Armesto et al. 1998; grey area on the map). The sites include (i) Fray Jorge National Park (30ºS), which protects a fog, relict, temperate forest on coastal slopes north of the current distribution area of the biome; (ii) Senda Darwin Biological Station (41ºS), which protects North-Patagonian and Valdivian rainforests on Chiloe Island near the latitudinal center of the biome; (iii) the Omora Ethnobotanical Park (55ºS), which protects Magellanic sub-Antarctic forests near the southern end of the biome. Along the 25 degrees of latitude span of LTSER-Chile, there is a distinct gradient of temperature, rainfall, and anthropogenic impact. However, the species composition of forest birds retains a significant number of common species across the three LTSER-Chile sites. Modified from Rozzi *et al.* 2008b.

(Carmona *et al.* 2010), and Magellanic sub-Antarctic forests at Omora Park (Rozzi *et al.* 2010). The forest avifauna present in these three LTSER-Chile sites includes a number of common species (cfr. Cornelius *et al.* 2000, Reid *et al.* 2002, Vergara & Armesto 2009). In the next years, the LTOR - Omora Park Program plans to conduct comparative ornithological studies across LTSER–Chile sites in the South American temperate forest biome.

In 2011, the LTSER-Chile network joined the ILTER network. This has opened opportunities for both ecological and ornithological collaborative and comparative long-term studies with sites around the world. At a planetary scale, it is important to note that the LTOR-Omora Park Program is located at the closest LTSER-Chile site to Antarctica, separated by only 950 km from King George Island where the Chilean Antarctic Scientific Base Julio Escudero is found (Figure 7B). Omora Park has established a formal collaboration with the Chilean Antarctic Institute that administrates Julio Escudero Scientific Base. Navarino Island and King George Island are strategic and complementary locations for monitoring the impacts of global climate change on the biota.

5. *Climate change, latitudinal and altitudinal gradients at LTOR – Omora Park*

Climate change affects with great intensity both polar and subpolar regions, including the Magellanic sub-Antarctic ecosystems ecoregion. The LTSER-Chile network provides an ideal platform to investigate and monitor latitudinal changes in bird species distribution and migration patterns. In addition, the LTOR - Omora Park program provides an ideal setting to investigate and monitor these patterns along altitudinal gradients. Magellanic sub-Antarctic basins are characterized by altitudinal gradients with steep slopes and heterogeneous topographies where a mosaic of bogs, forests, shrublands, scrublands, and alpine vegetation is found (Pisano 1980). Along the altitudinal gradient of the Róbalo River basin protected by Omora Park, marked microclimate variations and temperature gradients from the the Beagle Channel to the Dientes de Navarino Mountains (1000 m) are associated with well- defined altitudinal vegetation zones (Figure 8). The temperature data recorded in the Omora Park suggest that in the Magellanic sub-Antarctic ecoregion the moderating effect exerted by the ocean on temperature is strong near the coast, but it rapidly disappears with altitude, especially above the tree line (Contador *et al.* 2013, Méndez 2013). At the elevation of the coast the mean annual temperature is 6ºC, while above the treeline at 728 m it is 0ºC (Méndez *et al.* 2013). Hence, temperature decreases ca. 1ºC per 100 m along this gradient.

In the Cape Horn Biosphere Reserve (CHBR) there is also a distinct rainfall gradient with annual precipitation decreasing from > 5000 mm in the west to < 500 mm on Navarino Island in the east (see below). The hundreds of islands and islets in the CHBR host a heterogeneity of habitats, temperatures, and rainfall in a relatively small area; an ideal setting to study the responses of biota to climate change (Rozzi *et al.* 2007, Mansilla *et al.* 2012). The study and monitoring of bird migration, distribution and temporal patterns represents a valuable approach for investigating the impact of climate change on the biota. LTOR-Omora Park provides an opportunity to investigate potential impacts of climate change on birds at multiple geographical scales, from local to regional and to inter-hemispheric comparisons.

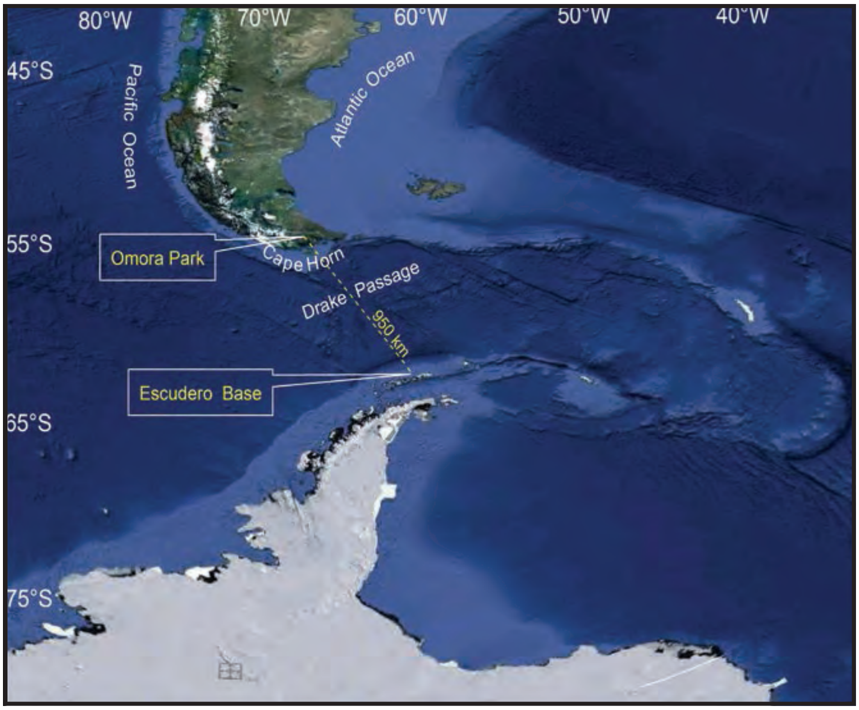

Figure 7B. The Cape Horn Biosphere Reserve has the world's closest forest ecosystems to Antarctica. Omora Park is separated by only 950 km from the Chilean Scientific Base "Julio Escudero" on King George Island, adjacent to the Antarctic Peninsula. Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes, based on “The MODIS Rapid Response System.”

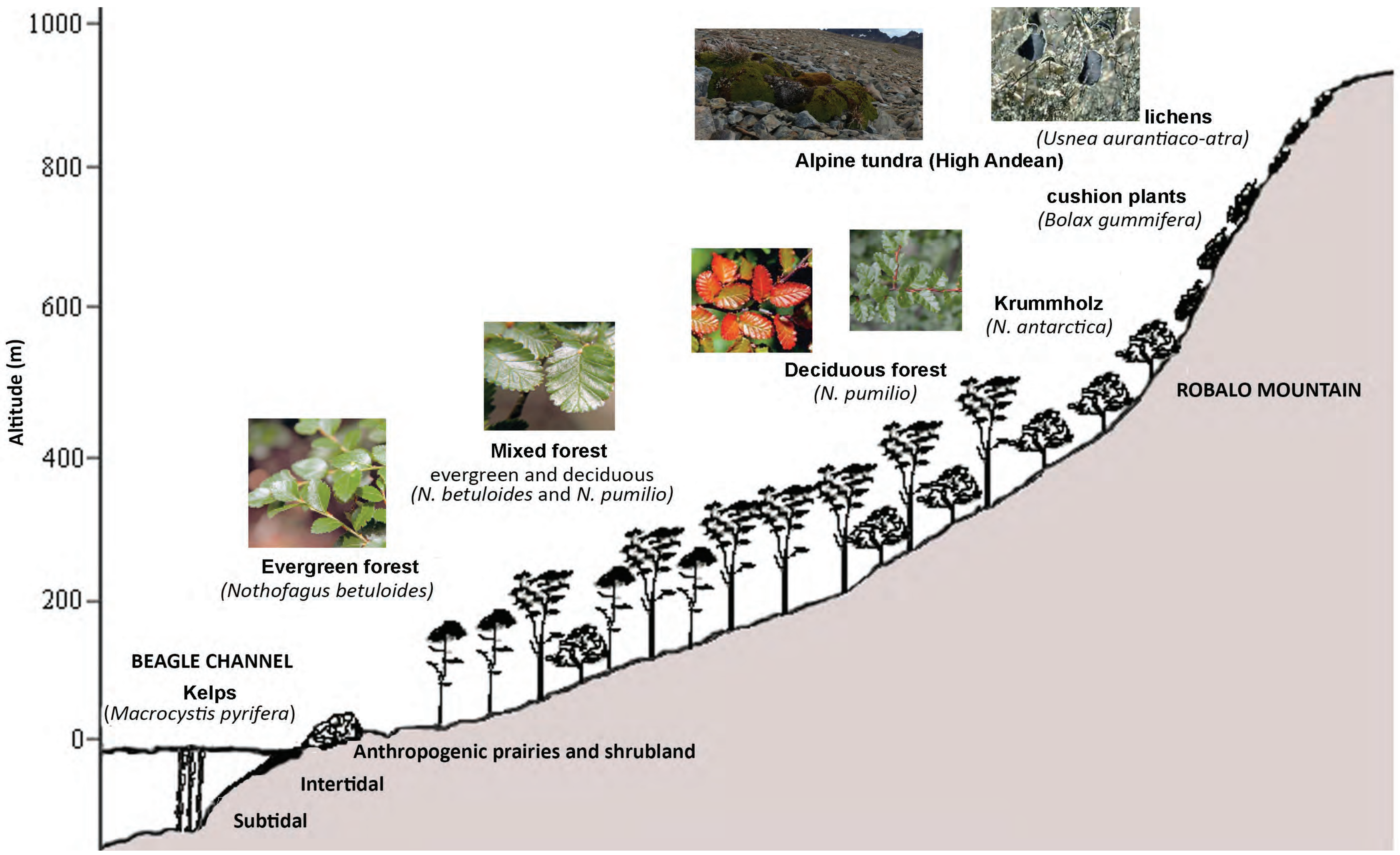

Figure 8. The Omora Ethnobotanical Park altitudinal vegetation profile includes, from the coastal area to the summit: (i) Anthropogenic pasturelands and scrublands, adjacent to a very productive intertidal zone where numerous birds feed; (ii) Evergreen broadleaf forests dominated by the Magellanic Coigue or Evergreen Beech (*Nothofagus betuloides*); (iii) Mixed evergreen and deciduous forests dominated by *N. betuloides* and Lenga or High Deciduous Beech (*Nothofagus pumilio*); (iv) Deciduous forests dominated by *N. pumilio* and Ñirre or Low Deciduous Beech (*N. antarctica*); (v) High Andean habitats above the treeline, dominated by cushion plants (*e.g.*, *Bolax gummifera*) at lower altitudes and by lichens (*e.g.*, *Usnea aurantiaco-atra*) at higher altitudes. Modified from Rozzi *et al*. 2006a).

STUDY SITES AT OMORA PARK

The Omora Ethnobotanical Park is a public-private protected wilderness area that was created in 2000 to conduct long-term interdisciplinary ecological research, environmental education, and biocultural conservation (Figure 9). A pivotal element of our biocultural conservation initiative was the identification of the Green-backed Firecrown (*Sephanoides sephaniodes*), or Omora in the Yahgan language, as a flagship species. The focus on the hummingbird was appealing to the diverse stakeholders who live in Puerto Williams. Directing the attention toward this unique bird helped the Omora initiative to integrate biological and cultural diversity, as well as ecological, anthropological, social, cultural, aesthetic, economic, and ethical dimensions into its international sub-Antarctic Biocultural Conservation Program (Rozzi *et al.* 2008c). The main functions of Omora Park are:

a) Protection of the Róbalo River watershed that provides drinkable water for the citizens of Puerto Williams, the world's southernmost city and capital of the Antarctic Province of Chile.

b) Conservation of the Magellanic sub-Antarctic biodiversity at a Priority Site for Biodiversity Conservation identified by the Chilean National Commission for the Environment (CONAMA) in 2002.

c) Interdisciplinary Research, Education, and Conservation at the southernmost site of the LTSER-Chile network, which also functions as a "natural laboratory" for the Cape Horn Biosphere Reserve and the Sub-Antarctic Biocultural Conservation Program (www.chile.unt.edu).

In terms of land tenure, the Chilean Ministry of National Land granted the park jointly to a state institution, the University of Magallanes, and to a private non-profit organization, Omora Foundation, as a renewable 50-yr free concession of 1069 ha (54º56'-54º59'S, 67º38'-67º42'W; Figure 10). The altitudinal profile extends from the coast rising through peat bogs, forests and shrubs (0 to 400 m approximately) to the high Andean zones that include cushion plant formations and abundant lichens and mosses (400-900 m approximately) (Figure 8).

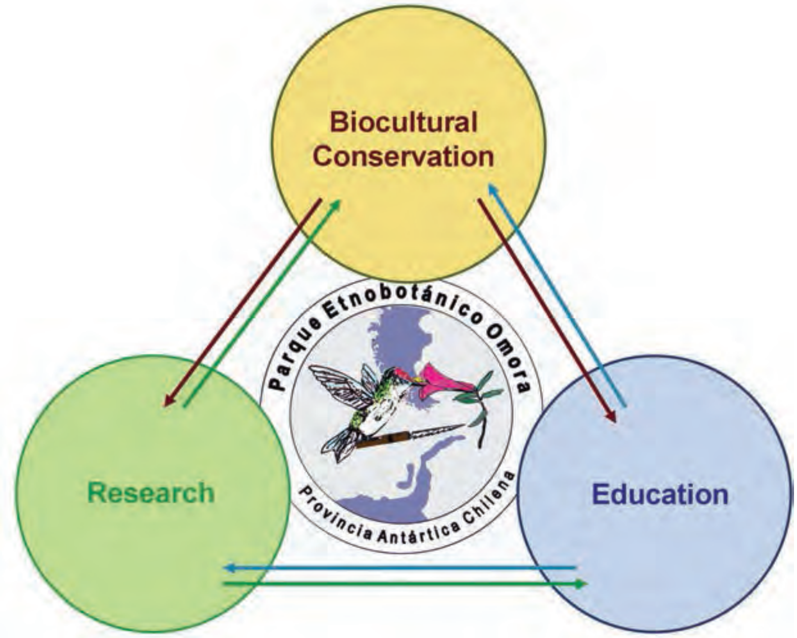

Figure 9. Three main domains of action of the Omora Ethnobotanical Park initiative: (1) interdisciplinary ecological research, (2) formal and informal education, including school, university, and training courses; and (3) biocultural conservation linked with sustainable tourism. At the center, the logo of Omora Park illustrates the goals of integrating biological and cultural conservation through the image of the Green-backed Firecrown (*Sephanoides sephaniodes*), or *Omora* in the Yahgan language. From the cultural point of view, *Omora* is depicted with a harpoon, a hunting tool traditionally used by the Yahgan indigenous people. From a biological point of view, the Green-backed Firecrown is the only hummingbird species that reaches the extreme southern tip of the continent, a very interesting fact given the rigorous climatic conditions in Cape Horn. On the logo, the Green-backed Firecrown is depicted feeding on a flower of Coicopihue (*Philesia magellanica*), a flower that produces large volumes of a sugar rich nectar. The high quality and quantity of nectar meet the high energy requirements of this hummingbird (Massardo *et al*. in preparation).

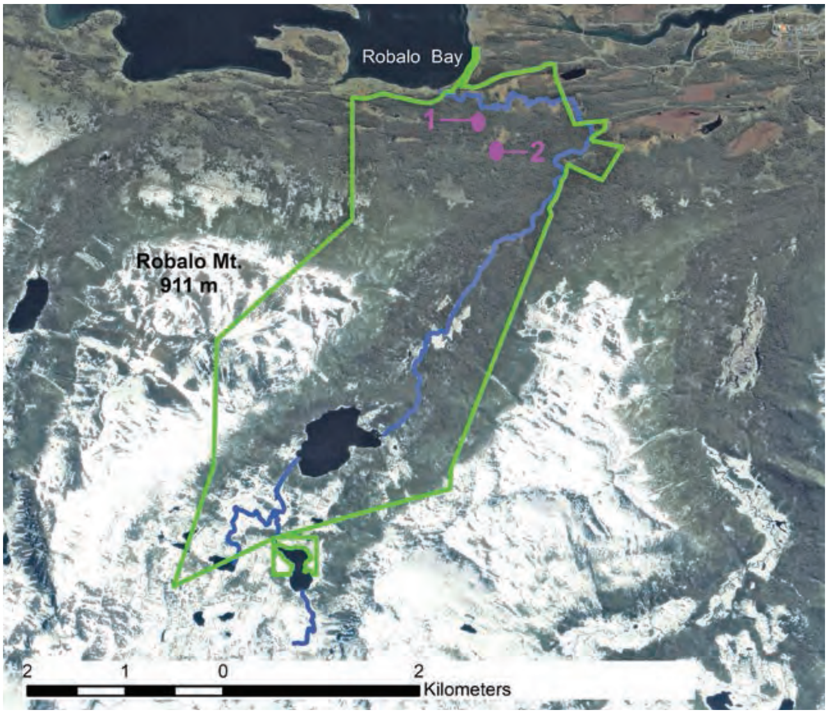

Figure 10. The Omora Park covers 1069 hectares of the Róbalo river watershed, which provides drinkable water to the city of Puerto Williams (upper right in the satellite image). The pink dots show the location of the permanent long-term mist-netting sites of forest birds (1, Canelo site) and forest edge birds (2, Notro site). Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes, based on a Quick-Bird image taken in 2003.

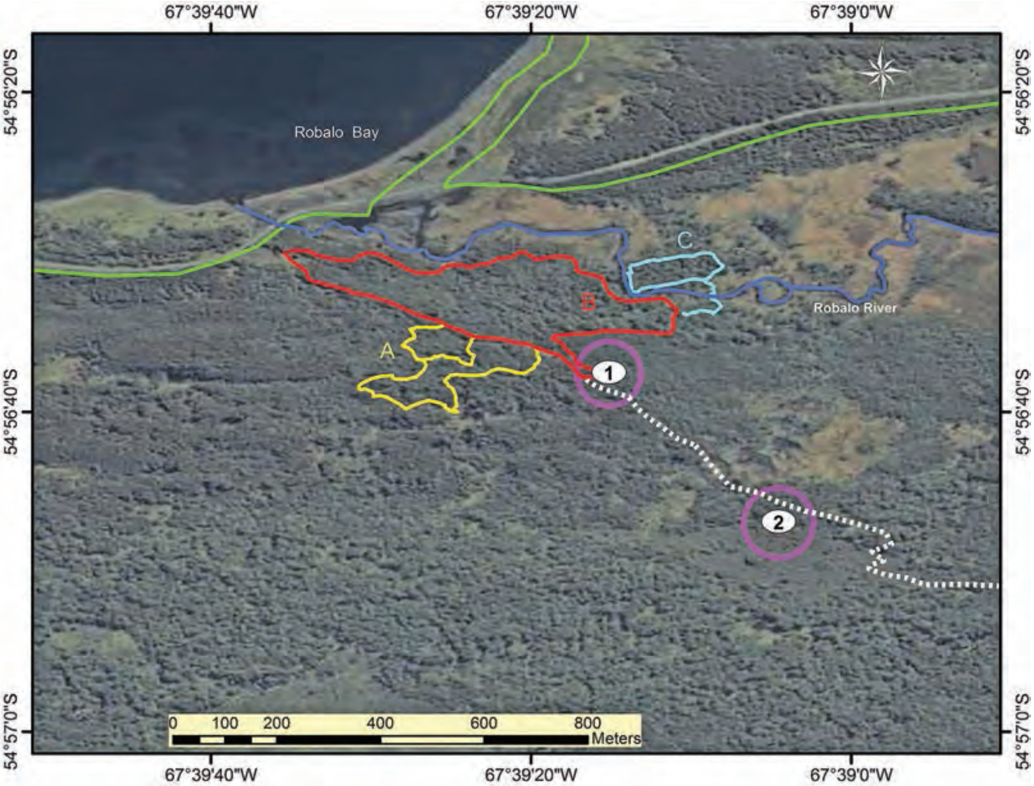

Figure 11. Close-up of the two long-term bird mist-netting sites at Omora Park: (1) "Canelo site" is a broadleaf evergreen forest site located within a large patch of old-growth forests dominated by Magellanic Coigue (*Nothofagus betuloides*), and Winter's Bark or "Canelo" (*Drimys winteri*); (2) "Notro site" is a forest edge site located at the ecotone formed by a patch of mixed evergreen and deciduous forests (dominated by Lenga (*Nothofagus pumilio*) and by a shrubland dominated by Firebush or "Notro" (*Embothrium coccineum*), Winter's Bark (*Drimys winteri*), Fashine (*Chiliotrichum diffusum*), Box-leafed Barberry (*Berberis buxifolia*), and Prickly heath (*Gaultheria mucronata*). The figure also illustrate the three main interpretive trails used for educational and ecotourism activities at Omora Park, which include bird watching. These trails are: A = Ecotourism with a Hand-Lens in the Miniature Forests of Cape Horn; B = the Southernmost Forests of the World; C = Underwater with a Hand-Lens in the cleanest freshwaters of the planet. Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes, based on a Quick-Bird image taken in 2003.

The high Andean (or alpine) zone above the tree line on the summits of Róbalo Mountain and Dientes de Navarino Range, are inhabited by two bird species with a restricted geographic distribution, and specialized habitat requirements: the Yellow-bridled Finch (*Melanodera xanthogramma*) and the White-bellied Seedsnipe (*Attagis malouinus,* a Rare species according SAG 2012). The bodies of freshwater, such as Róbalo Lake, provide breeding habitat for the Flying Steamer-Duck (*Tachyeres patachonicus*). As mentioned above, the forests are dominated by *Nothofagus* species and provide old-growth forest habitats for three bird species of conservation interest: Magellanic Woodpecker, Rufous-legged Owl, and Chilean Hawk.

The permanent long-term mist-netting sites for forest interior birds are located at lower altitudes (Figure 11). They include two sites: 1) Canelo site located in forest interior habitats, within a large patch of old-growth forests dominated by Evergreen Beech or *Magellanic Coigüe* (*N. betuloides*), and Winter's Bark or *Canelo* (*Drimys winteri*); 2) Notro site located at the forest edge of mixed evergreen and deciduous forests, adjacent to a scrubland dominated by Firebush or *Notro* (*E. coccineum*) (Figure 11). At these two sites, bird-banding has been conducted monthly since 2000 (see Rozzi 2002). Other study sites at Omora Park, including high Andean habitats, have been used to conduct occasional supplementary mist-netting.

Outside Omora Park, on the northern coast of Navarino Island the main complementary study site is Guerrico Hill (54º55'S, 67º54'W), a gentle, north-facing slope (Figure 12), where bird-banding has been conducted at least once a year since 2000. Guerrico is a critical study site to assess site fidelity of migratory birds because it is separeted from Omora Park by only 25 km. Guerrico is dominated by a patch of *E. coccineum* adjacent to a fire regenerated forest of Evergreen Beech and High-deciduous Beech or *Lenga* (*N. pumilio*), and to the main dirt road along the northern coast of Navarino Island. The mist-netting sites have experienced a range of anthropogenic influences, mostly from timber harvest, and clearing and burning for pastureland. As in Omora Park, the landscape near Guerrico and other areas of Navarino Island includes natural and anthropogenic disturbance on north-facing slopes. The land's history of use generated a mosaic of habitats, which include:

(a) Anthropogenic park formations characterized by large trees of *N. betuloides* and *N. pumilio*, growing among burned trunks, logs, snags, regenerating saplings, and abundant shrubs of *Berberis buxifolia*, *B. ilicifolia*, and *Ribes magellanicum* that produce berries during spring and summer (November-February);

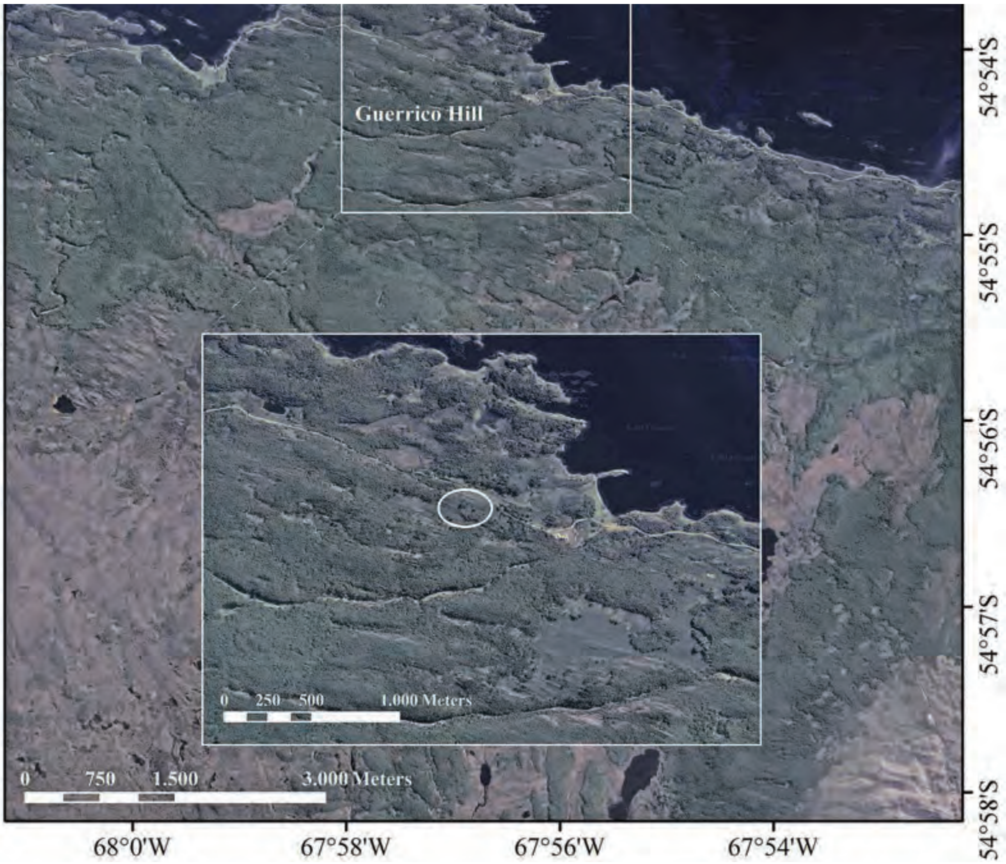

Figure 12. Aerial photograph of the Guerrico study site on the northern coast of Navarino Island. The 10 x 10 km view shows the landscape mosaic with patches of forests on the north facing slopes of the Navarino mountain range. Inset: Detail of the *Embothrium coccineum* study site, which is surrounded by patches of *Nothofagus betuloides* and *N. pumilio* forests, deforested areas, and a beaver pond on the left top corner. Image prepared by Gerardo Soto.

Nº	A) Navarino Island sites	Nº	B) Beagle Channel West sites	Nº	C) Almirantazgo Sound sites	Nº	E) Cape Horn Archipelago
1	Omora Park	19	Yendegaia Bay: Ferrari Cove - Serka Glacier	35	Bahia Sound Cien Cascadas	53	Hoste Island: Hardy Peninsula - Orange Bay
2	Guerrico	20	Holanda Glacier: Olla Cove shore & Eastern hills	36	Cien Cascadas Bay	54	Hoste Island: Hardy Peninsula - Lort Bay & Cannelliert Point
3	Mejillones Bay	21	Frances Mountain: Forested slopes west of Olla Cove	37	Ainsworth Bay: West area	55	Bayly Island: Washington Channel
4	Puerto Inutil	22	Alemania Glacier: Glacio-fluvial riparian forest	38	Ainsworth Bay: Marinelli Glacier	56	Wollaston Island: Kendall Cove
5	Wulaia Bay	23	Pia Glacier: East Arm	39	Ainsworth Bay: East area	57	Wollaston Island- Eliana Cove: Bravo Channel
6	Douglas Bay	24	Pia Glacier: West Arm	40	Parry Fjord: Morro Point	58	Herschel Island: Martial Cove
7	Grandi Sound	25	España Glacier: lowlands forests	41	Parry Fjord: Southwest Arm	59	Hermite Island: Maxwell Port
8	Windhond Lake	26	Garibaldi Sound: lowland forests	42	Parry Fjord: Southeast Arm	60	Hermite Island: Saint Martin Cove
9	Windhond Bay	27	Ventisqueros Sound: 2da Angostura West- lowland forests	43	Parry Fjord: Barría Point	61	Hornos Island: Southwest Peninsula: Espolón Point
10	Puerto Toro	28	Ventisqueros Sound: Verde Point - lowland forests	44	Parry Fjord: Blanca Bay		
11	Holger Islets	29	Chair Island: tundra - lowland forests	45	Almirantazgo Sound: Maria Cove (Caleta)		
12	Eugenia Cove	30	Gordon Island: Morning Cove - Romanche Bay	46	Paralelo River		
13	Picton Island: Piedras Cove	31	Gordon Island: Fleuriais Bay	**Nº**	**D) West Areas Biosphere Reserve**		
14	Nueva Island: Pescado Cove	32	Hoste Island: Mil Cascadas Fjord	47	de Agostini Sound: East Coast		
15	Button Island	33	Hoste Island: Coloane Bay	48	de Agostini Sound: West Coast		
16	Mascart Island	34	Hoste Island: Fouque Fjord	49	Martinez Sound – Escandallo Fjord		
17	Ponsonby Sound: Narrow Passage to Carfort Channel			50	Courtney Sound: Edwards Peninsula		
18	Ponsonby Sound: Narrow Passage to Beagle Channel			51	London Island: Horacio Mountain		
				52	Basket Island: Basket Cove & Murray Bay		

Table 1. Key to the numbers on the map of the Cape Horn Biosphere Reserve (CHBR, Figure 13), that identify each of the sites where bird censuses (transects and/or species lists) have been conducted during the breeding season (spring-summer) and non-breeding season (autumn-winter). 61 sampling sites were identified within 5 major areas of the CHBR: Navarino Island (18 sites), North-west Arm of the Beagle Channel and neighboring areas (16 sites), Almirantazgo Sound (12 sites), West Areas of the CHBR (6 sites), and the Cape Horn Archipelago area (9 sites).

(b) Open areas covered by low shrubby Ericaceae, *Gaultheria mucronata* and *Empetrum rubrum*, that produce berries between September and March, with some fruits available during the whole year;

(c) Recently burned sites dominated by *Chiliotrichium diffusum*;

(d) Naturally or anthropogenically-disturbed areas dominated by thickets of the Protecaeae *E. coccineum* which produces red tubular flowers rich in nectar twice a year, in late spring in November-December and in early fall in March; and

(e) Areas of different sizes covered by continuous old-growth forests dominated by *N. betuloides* and *N. pumilio*, with an understory of several species that produce fleshy fruits, such as *D. winteri*, and *Maytenus magellanica*.

In addition to forest burning, wood-cutting, and livestock ranching, the forests of Navarino Island have been subjected to the disturbance effects of the introduced beaver (*Castor canadensis*) since the 1950s (Sielfeld & Venegas 1980). Many of the deforested areas and ponds near the *E. coccineum* sites seen in the aerial photograph, reflect the effects of beavers, which today occupy almost every available watershed in the island, modifying drastically the hydrology and adjacent forest structure.

To complement and expand the range of study sites on Navarino Island, in the years 2000-2003 mist-netting was also conducted at Mejillones Bay (54°55´S, 67°54´W), and three sites on the western coast of Navarino Island: Puerto Inútil (54º59'S, 68º13'W), Wulaia Bay (55º03'S, 68º09'W), and Douglas Bay (55º05'S, 68º09'W). These are the first six study sites listed in the column “Navarino Island sites” in Table 1; their locations are shown in Figure 13. Beyond Navarino Island, we have conducted bird censuses on other islands to better capture the rich diversity of habitats of the Cape Horn Biosphere Reserve.

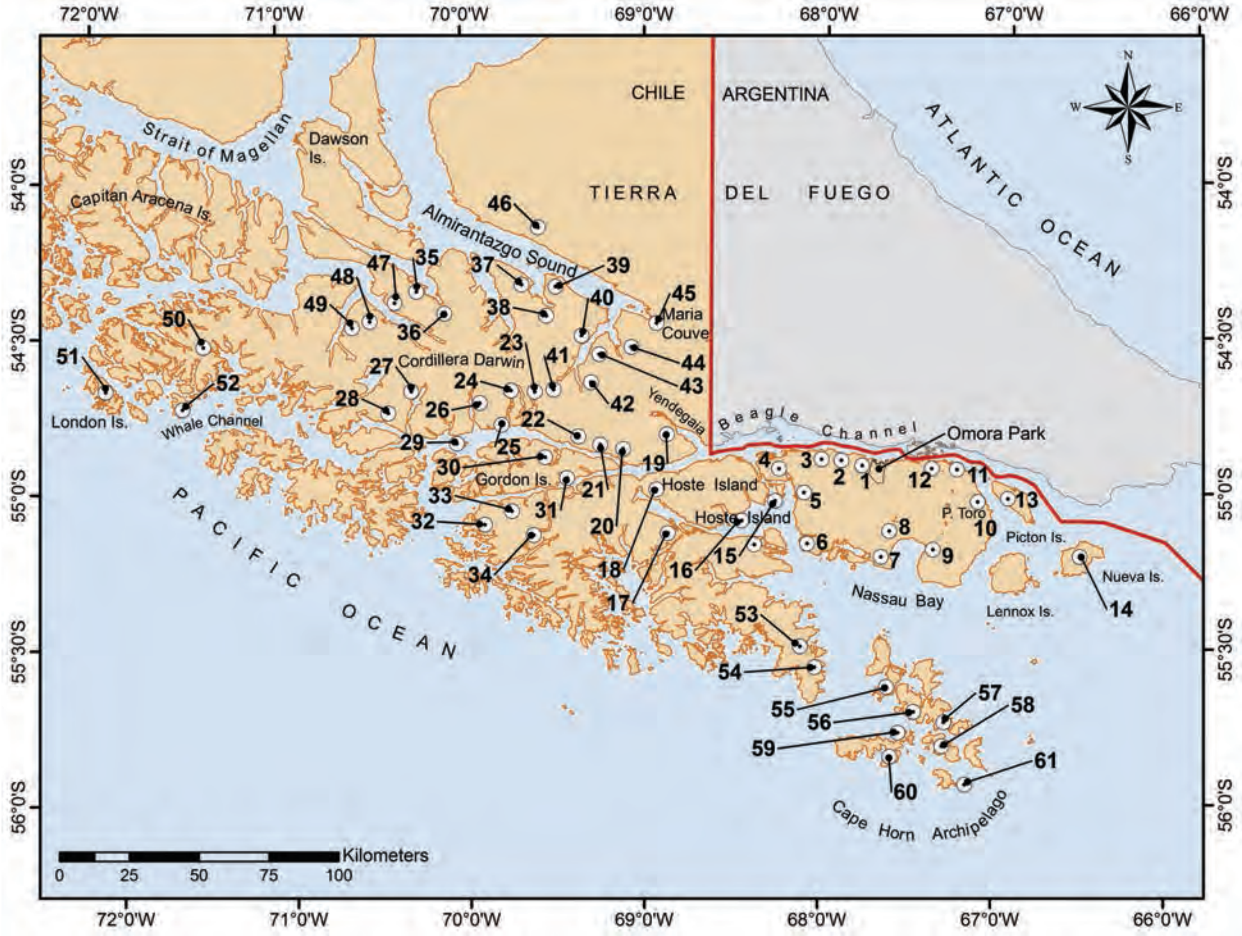

Figure 13. Map of the Biosphere Reserve Cape Horn showing the sites in which at least two bird surveys have been conducted, one during the breeding season (spring - summer) and one in the non-breeding season (autumn-winter), during the decade January 2000 - December 2010. The names of the sites are listed in Table 1. Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes.

Figure 14. The presence of Neotropical trees and birds, such as the Winter's bark (*Drimys winteri*) and the White-Crested Elaenia (*Elaenia albiceps*), is one of the most surprising attributes of the world's southernmost forests. The White-Crested Elaenia eats the fruits of Winter's bark before its migration from Cape Horn to the Amazonian forests each autumn. Photos José Tomás Ibarra (top) and Ricardo Rozzi (bottom).

MOSAIC OF HABITATS AND STUDY SITES IN THE CAPE HORN BIOSPHERE RESERVE

At the landscape scale, Cape Horn offers a remarkable diversity of habitats with a rich biodiversity that derives its uniqueness to a great extent from the variety of its biogeographical relationships (Moore 1983). The biota of Cape Horn has affinities with five contrasting biogeographic regions.

1. ***Gondwana***. Today, the genus *Nothofagus* is only found in the Southern Hemisphere, in Australasia (eastern and southeastern Australia, New Zealand, New Guinea, and New Caledonia) and southern South America (Chile, Argentina). Fossil trees are also preserved in Antarctica (Veblen *et al.* 1996). In most islands of the Cape Horn Biosphere Reserve, dense old-growth forests dominated by species of *Nothofagus* grow on the slopes protected from the wind. The presence of this genus provides a living example of the Gondwanic connections that southern South America had with Antarctica, New Zealand, and Australia, until the late Cretaceous 75 million years B.P.

2. ***Neotropical***. *Drimys* is a Neotropical genus whose species are distributed throughout South and Central America reaching southern Mexico (Arroyo *et al.* 1996). The southernmost representative of this genus, the Winter's Bark or *Canelo* (*D. winteri*), grow in the broadleaf evergreen forests of Cape Horn near the coast. In coastal forests, the Winter's Bark is a dominant tree that is characterized by its large leaves. It also produces fleshy fruits, which are consumed by the Austral Thrush (*Turdus falcklandii*) and the White-crested Elaenia (*Elaenia albiceps*), which feeds on them before its migration each autumn from Cape Horn to the Amazonian forests (Figure 14, Jiménez *et al.*, in preparation). In the coastal broadleaf evergreen forests it is also possible to observe parrots and Hummingbirds that reflect the biogeographical connections that the forests of Cape Horn have with the Neotropical forests of South and Central America.

3. ***Andean***. Above the tree line, in Omora Park it is possible to observe birds of the genera *Attagis* (seedsnipes) and *Meladonera* (finches) that are distributed northward along the high Andes. The cushion plants of the genus *Azorella* that grow above the treeline as well as near the coast at Omora Park and other places in the Cape Horn Biosphere Reserve. These plants grow about 4000 m altitude in the high Andes of Bolivia, Peru, and northern Chile and Argentina (Armesto *et al.* 1980). Both the bird and cushion plants are examples of the connections that the biota of Cape Horn has with the biota of the high-Andean Puna.

4. ***Antarctica***. On the rocks of the coast in the Cape Horn Biosphere Reserve, the bright orange lichens *Caloplaca hookeri* and *C. sublobata* (Goffinet *et al.* 2012), and the penguins *Eudyptes chrysolophus* (Macaroni Penguin) and *Pygoscelis antarctica* (Chinstrap Penguin), are an example of the close connections between the terrestrial and marine biota of the Magellanic sub-Antarctic ecoregion and the Antarctica.

5. ***Bipolar***. The abundance of low shrubs of Red Crowberry or Diddle-dee (*Empetrum rubrum*) is an example of long dispersal between the sub-Antarctic and subarctic regions, which generates a "bipolar distribution." The genus *Empetrum* has only two species: *E. nigrum* restricted to Alaska and other subarctic zones, and *E. rubrum* restricted to Cape Horn and other sub-Antarctic zones (Donoghue 2011, Popp *et al*. 2011).

Two other factors that contribute to the great heterogeneity of habitats in the Cape Horn Biosphere Reserve (CHBR) are the complex physical geography and the strong west-east gradient of rainfall (Rozzi *et al.* 2006a,b,c). In the western and southern areas of the CHBR toward the Pacific Ocean are innumerable islands with peninsulas, bays, steep mountains, narrow valleys, and fjords. In the northern area of the CHBR, the most dominant characteristic of the physical geography is the Andean Cordillera system that bends eastwards along the southwestern extension of Tierra del Fuego giving origin to the Darwin Cordillera, also known as the Fuegian Andes. This cordillera creates an abrupt alteration in the topography that generates abrupt changes in climate over short distances. The highest peaks of the Darwin Cordillera are found to the west on Mt. Sarmiento (2404 m) and in the Darwin Cordillera (Mt. Luis de Saboya 2469 m, Mt. Darwin 2438 m) (Figure 15). The altitude of the mountains diminishes eastwards and southwards. On Navarino Island the highest peaks are the "Dientes de Navarino" (1195 m) where the Róbalo River is born. At Omora Park, the highest altitude is the summit of Róbalo Mountain (920 m). In the Cape Horn Archipelago, only Wollaston Island has peaks above 500 m.

The high altitude of the Darwin Cordillera combined with the prevailing winds carrying high moisture from the Pacific Ocean, creates a remarkable rainfall gradient from the west to the east. When the westerlies arrive on the western coast and the Darwin Cordillera their moisture condenses and precipitates as rain on the lowlands and as snow on the mountains. It is not possible to give a detailed and reliable map of the distribution of the precipitation, but the main features have been well synthesized by Tuhkanen *et al.* (1990). In less than 300 km the annual rainfall decreases approximately an order of magnitude, from over 3000 mm in the west to less than 500 mm in Puerto Williams and Omora Park (Figure 16). The combination of biological, orographic, climatic, and other factors gives origin to a terrestrial ecosystem mosaic that includes a complex of (I) forests, (II) scrublands, (III) moorlands and wetlands, and (IV) high-Andean habitats. Among the forests, four main types are present at Omora Park and in other areas of the Cape Horn Biosphere Reserve.

Figure 15. Mount Darwin peak (top left), one of the three highest peaks of the Darwin Cordillera. Photograph of Alemania (Germany) Glacier taken from the North-West Arm of the Beagle Channel, illustrating the diversity of high-Andean, moorland, and forest habitats in the Cape Horn Biosphere Reserve (top). A closer view of the evergreen Magellanic sub-Antarctic forest (bottom). Photos Ricardo Rozzi.

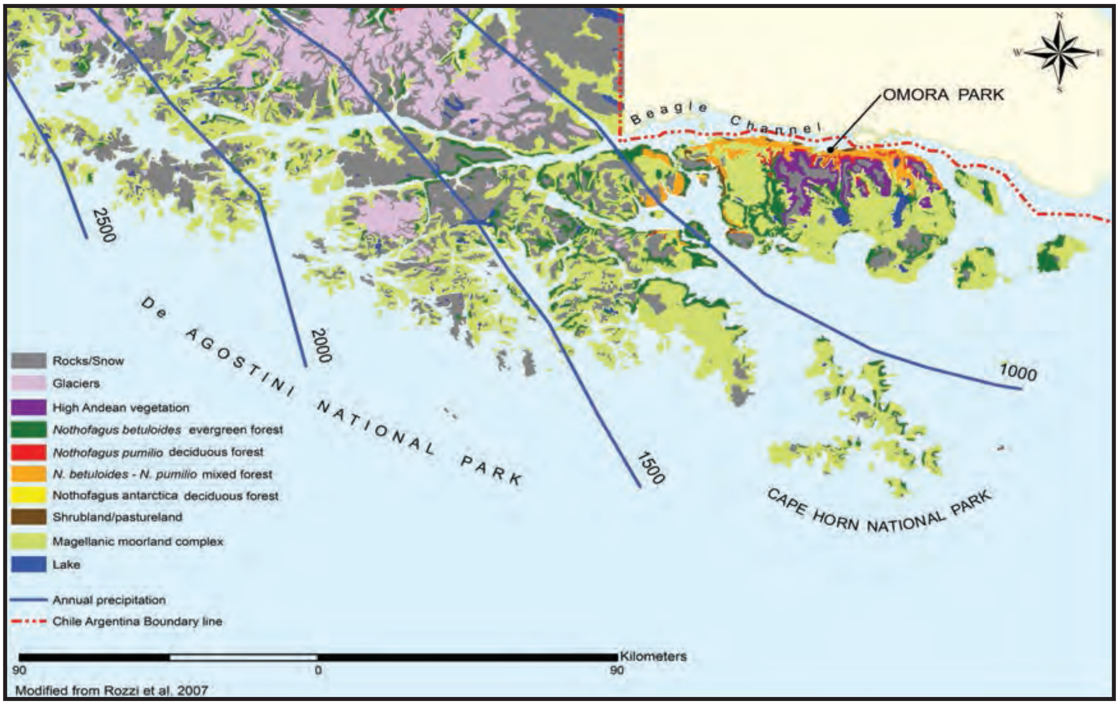

Figure 16. West-east rainfall gradient within the Cape Horn Biosphere Reserve (CHBR). The overlap of the annual precipitation curves and the land-cover depicting the major habitat types distinguishes two main ecologicalclimatic zones within the CHBR: 1) A hyper-humid zone dominated by tundra and Magellanic broadleaf evergreen rainforests (*Nothofagus betuloides* and *Drimys winteri*), which is located in the southwest area of the CHBR with over 1000 mm annual rainfall. 2) Less humid zone, located northeast of the 1000 mm isohyet, which encompasses a mosaic of habitats, including mixed evergreen and deciduous forests (*N. betuloides* and *N. pumilio*), as well as pure stands of deciduous forests dominated by *N. pumilio*. Omora Park is located within the second zone, and therefore it includes a mosaic of evergreen and deciduous forests, as well as high Andean vegetation. (Modified from Engel 1969 and Tuhkanen *et al*. 1990). (Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes).

I. Main Sub-Antarctic Forest Types

I.1) Sub-Antarctic Magellanic broadleaf evergreen rainforest. Along the coastlines of the Magellanic islands the high oceanic influence buffers temperature fluctuations, enabling the growth of broadleaf evergreen forests at lower altitudes. These forests are dominated by the endemic tree species that defines the sub-Antarctic Magellanic ecoregion: the Evergreen Beech (*N. betuloides*). It grows together with other evergreen species such as Winter's Bark (*Drimys winteri*), and Pickwood (*Maytenus magellanica*). The understory of these forests varies in association with the rainfall gradient (Pisano 1977, Rozzi *et al.* 2006b). In the most humid areas (>2000 mm annual rainfall) the understory is dominated by liverworts (*e.g.*, *Gackstroemia magellanica*, *Schistochilla lamelata*) and lichens (*e.g.*, *Pseudocyphelaria* spp.). In intermediate humid areas (1000-2000 mm annual rainfall) the understory is dominated by mosses, woody ferns (including *Blechnum magellanica* and *Gleichenia pinnatifolia*) (Figure 17A), and shrubs that include the "Coicopihue" (*Philesia magellanica*), an endemic plant with large red tubular flowers that produces abundant nectar. *Philesia magellanica* flowers almost all year round, and it is a key species to sustain the populations of the Green-backed Firecrown hummingbird (*Sephanoides sephaniodes*) that are present in the area until the end of fall (May) (Rozzi 2002, Massardo *et al.* in preparation). On the less humid areas (<1000 mm annual rainfall), such as at Omora Park, the woody ferns (*B. magellanica* and *G. pinnatifolia*) and *P. magellanica* are absent; instead, the understory is dominated by shrubs that produce abundant berries: Holly-leafed Barberry (*Berberis ilicifolia*), Box-leafed Barberry (*B. buxifolia*), and Wild Currant (*Ribes magellanicum*). The physiognomy of these forests is complex and multi-stratified; trunks and large branches are profusely covered by mosses, liverworts, and lichens (Pisano 1977, 1980). The Thorn-tailed Rayadito (*Aphrastura spinicauda*, Figure 17B) and the White-crested Elaenia (*Elaenia albiceps*) occupy a wide variety of habitats, but they are particularly abundant in the broadleaf evergreen coastal forests.

I.2) Deciduous Lenga forest. In areas of good drainage that receive less than 1000 mm annual rainfall, such as Navarino Island, including Omora Park, High-deciduous Beech (*N. pumilio*) forests dominate the majority of the hill slopes (Figure 17C). This type of forest has the tallest trees in the Magellanic sub-Antarctic ecoregion. *Nothofagus pumilio* has straight trunks, and the understory is dominated by low shrubs, such as the Dwarf Pickwood (*Maytenus disticha*), herbs, including orchids (*Gavilea lutea*), and mosses. The Magellanic


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Woodpecker (*Campephilus magellanicus*) inhabits evergreen and deciduous forests, where they frequently feed and nest. Cavities made by woodpeckers on Lenga trees are often used for nesting by the Austral parakeets (*Enicognathus ferrugineus*; Rozzi *et al.* 2006a,b).

I.3) Mixed evergreen-deciduous forest. This forest combines evergreen and deciduous species where *N. pumilio* and *N. betuloides* co-dominate. It extends over the areas that are more sheltered and have relatively good drainage, and where annual rainfall is between 550 mm and 1000 mm (Pisano 1977, Moore 1983, Rozzi *et al.* 2006a,b).

I.4) Deciduous Ñirre forests. Small forest stands dominated of *Ñirre* or Low Deciduous Beech (*N. antarctica*) are found in wet areas with poor drainage. The trees reach heights of only up to 15 m. However, they are abundantly covered with mosses, liverworts, and lichens such as “old man’s beard” (*Usnea* sp.) (Rozzi *et al.* 2008a, Goffinet *et al.* 2012).The trunks often host abundant ascomycetous fungi of the genus *Cyttaria*, particularly *C. darwinii* or Darwin’s Fungus. The floor of wet areas is usually covered by the Dwarf Gunnera or Devil’s Strawberry (*Gunnera magellanica*) (Figure 17D). Occasionally, *N. antarctica* grows also in krumholtz formations together with *N. pumilio* at the treeline near the mountain summits.

II) Scrublands

Among scrublands, the woodland dominated by the Firebush (*E. coccineum*) is a particularly important habitat type for our bird studies (Figure 17E). The Firebush is a small evergreen tree in the family Proteaceae that produces tubular red flowers with abundant nectar. It flowers twice a year, in spring and fall, and the flowers are visited by diverse species of birds, including the Green-backed Firecrown and nectar robbers such as the Patagonian Sierra-Finch (*Phrygilus patagonicus*), and the Austral Parakeet (*E. ferrugineus*, Figure 17F). The Firebush grows among a dense cover of shrubs of *Chiliotrichum diffusum*, *Baccharis* spp., and *Berberis buxifolia*. In these thickets we have captured large number of Patagonian Sierra-Finches (*P. patagonicus*, Figures 17G, 17H). In wetter and windier areas, such as on Horn Island, scrublands are dominated by dense thickets of low shrubs of Box-leafed Barberry (*B. buxifolia*), Holly-leafed Barberry (*B. ilicifolia*), and Prickly Heath (*Gautlheria mucronata*). This habitat type is characteristically used by the Magellanic Tapaculo (*Scytalopus magellanicus*) on the islands that are more exposed to the Pacific Ocean.

III) Moorlands: The Magellanic Tundra Complex

Vast areas of the Cape Horn Biosphere Reserve are dominated by mires. Edmundo Pisano (1977) calls the set of different types of mires the “Magellanic tundra complex.” Pisano distinguishes the following four main types: (i) *Sphagnum* tundra or peatlands, formed by two species of mosses, *Sphagnum magellanicum* and *S. fimbriatum*. In the peatlands, dwarf trees of *N. antarctica* and *N. betuloides*, and dwarf woody plants with berries (*e.g.*, *Myrteola numularia*) grow. (ii) Cushion plant bogs, saturated zones with poor drainage dominated by cushion plants of the genera *Astelia*, *Azorella*, *Laretia*, *Donatia*, and *Bolax*. Small Juncaceae such as *Rostkovia magellanica* and *Juncus stipulates*, which typically grow around ponds found embedded in the layer of cushion plants. (iii) Graminoid bogs, commonly associated with cushion bogs areas there are zones dominated by grass-like plants, “graminoid,” such as *Schoenus antarcticus*, *Tetroncium magellanicum* and *Uncinia kingie*. (iv) Rush wetlands, extensive wetland zones dominated by the rush *Marsippospermum grandiflorum*, which provide a critical habitat for birds such as the South American Snipe or Magellan Snipe (*Gallinago paraguaiae*, Figure 18A).

IV) High-Andean Habitats

Above the tree line, high Andean habitats are characterized by a high diversity of mosses and lichen species that grow on the rocks or associated with cushion plants or low shrubs. The high Andean habitats have three distinct altitudinal levels: i) a lower zone dominated

Figure 17. *Front page.* A. Understory of a coastal broadleaf evergreen rainforest site at the North-West Arm of the Beagle Channel, which receives 1500 mm of annual rainfall. Its understory is characterized by the presence of the woody ferns *Blechnum magellanica* and *Gleichenia pinnatifolia*. B. The Thorn-tailed Rayadito (*Aphrastura spinicauda*) is particularly abundant in the broadleaf evergreen coastal forests of the Cape Horn Biosphere Reserve. C. High-deciduous Beech or “Lenga” (*Nothofagus pumilio*) forests dominate the slopes with good drainage that receive less than 1000 mm of annual rainfall, such as the slopes of Róbalo Hill at Omora Park. The photograph taken in May 2002 on the equatorial facing slopes of Omora Park shows the dominance of the red color of the Lenga leaves during autumn. D. Low Deciduous Beech (*Nothofagus antarctica*) or "Ñirre" forests are found in wet areas. The trunks are characteristically covered with mosses, while the floor is usually covered by the Dwarf Gunnera or Devil’s Strawberry (*Gunnera magellanica*), which plays a key ecological role in nitrogen fixation. E. The red tubular flowers of the Firebush (*Embothrium coccineum*) produce abundant nectar. F. The Firebush is an evergreen tree (Proteaceae) with flowers that are visited by a diversity of bird species, including nectar robbers such as the Austral Parakeet (*Enicognathus ferrugineus*). G. The Firebush blooms twice a year and its flowers are visited by another abundant nectar robber: the Patagonia Sierra-Finch (*Phrygilus patagonicus*), which is the bird most frequently captured in the mist-nets. A banded female is shown in the picture. H. Ornithologist Steve McGehee working at the “Notro” or Firebush site in Omora Park. Photos A, C, and D Ricardo Rozzi, B Paola Vezzani, E John Schwenk, F-H Steff van Dongen.


A


B


C


D


E

by low shrubs (*e.g.*, *Empetrum rubrum*); ii) an intermediate zone dominated by cushion plants (*e.g.*, *Bolax gummifera*; iii) a high zone dominated by mosses and lichens on rocky substrates (Rozzi *et al.* 2006a, Méndez 2013, Méndez *et al.* 2013). On the Darwin Cordillera, and Hoste Island the high Andean habitats include glaciers, several of which descend into the ocean. The lateral moraines of the glaciers are rapidly colonized by *Nothofagus antarctica* and *N. betuloides* trees (Figure 18B). The Rufous-collared Sparrow (*Zonotrichia capensis*) is a habitat in the CHBR that inhabits all types of habitats, including the margins of glaciers (Figure 18C). However, glaciers are no longer present in the high-Andean habitats on Navarino Island (Figure 18D) and the Cape Horn Archipelago (Figure 18E).

As mentioned above, to capture the heterogeneity of habitats we included 61 study sites widely distributed throughout the CHBR (see Figure 13 above). To capture the degree of human impact on species composition and population dynamics of birds in zones under different protection regimes in the CHBR, the study sites were located in core, buffer, and transition zones (Figure 19). Forest ecosystems of the island territory of Cape Horn are embedded in a mosaic of habitats that has remained largely free of the direct impact of modern society into the 21st century. Thus, the Cape Horn habitats provide a baseline to study sub-Antarctic forest bird assemblages under conditions similar to those that were present prior to the European colonization.

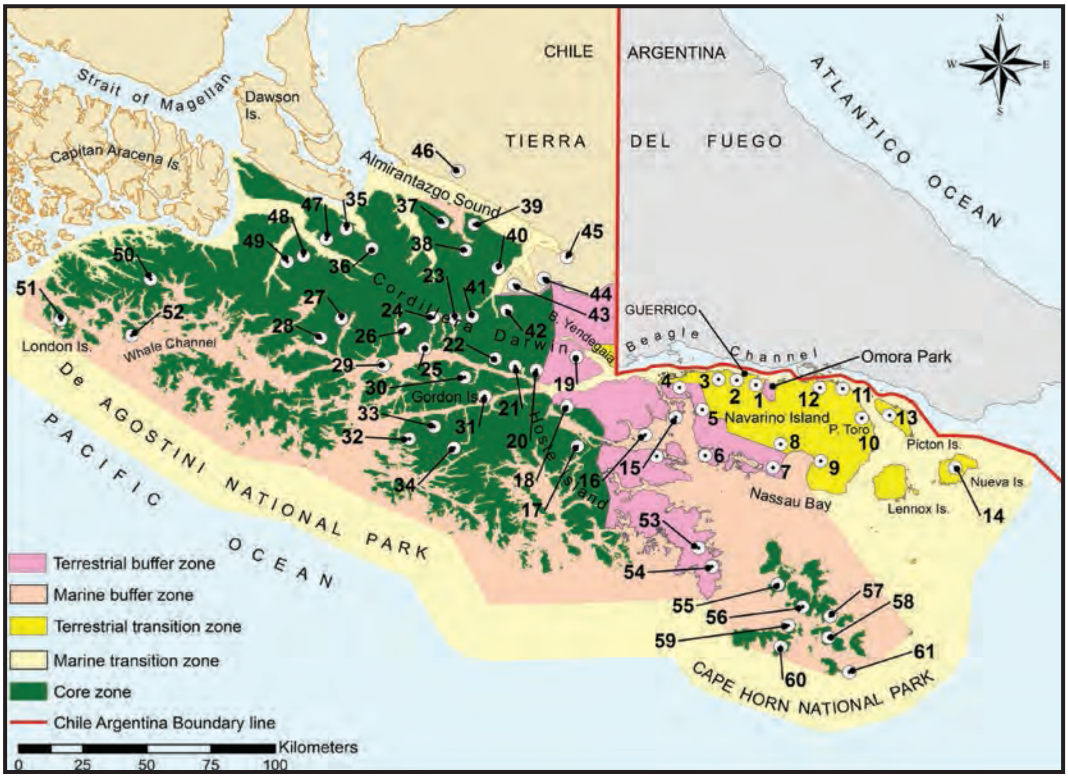

Figure 19. Zoning map of the Cape Horn Biosphere Reserve (CHBR) that illustrates its core zones (green), buffer zones (pink), and transition zones (yellow). The core zones include two national parks: Alberto de Agostini and Cape Horn. The buffer zones include the Omora Ethnobotanical Park. The transition zones include the main complementary long-term ornithological study site, Guerrico Hill, which is located on the northern coast of Navarino Island, 25 km west of Omora Park. Numbers on the map identify each of the 61 sites in which at least two bird surveys have been conducted, one during the breeding season (spring - summer) and one in the non-breeding season (autumn-winter), during the decade January 2000 - December 2010. Sampling sites are located within 5 major geographic areas of the CHBR: (i) Navarino Island (18 sites), (ii) West Arms Beagle Channel (16 sites), (iii) Almirantazgo Sound (12 sites), (iv) West Areas of the CHBR (6 sites), and (v) the Cape Horn Archipelago area (9 sites). The names of the locations are listed in Table 1 (page 16). Figure prepared by Omora Park & GIS Laboratory, CERE-Universidad de Magallanes.

Figure 18. *Front page.* A. The South American Snipe or Magellan Snipe (*Gallinago paraguaiae*), one of the species that nests in the wetland habitats dominated by the rush *Marsippospermum grandiflorum*. B. Glacier and later moraine at Parry Glacier in the northern zone of the Cape Horn Biosphere Reserve (CHBR), showing the recolonization of broadleaf evergreen forests dominated by *Nothofagus betuloides*. C. A Rufous-collared Sparrow (*Zonotrichia capensis*) in the high-Andean habitats of Marinelli Glacier; this bird is the most generalist species in terms of habitat use in the CHBR. D. The summit of Robalo Mountain at Omora Park is free of permanent ice; however, the Robalo River watershed clearly shows a glacier geomorphology. E. Pyramid Hill is the highest peak on Horn Island, and its east-facing slope has the world's southernmost forested watershed. Photos A Jordi Plana, B-D Paola Vezzani, E Ricardo Rozzi.

Figure 20. (top) The Long-Term Ornithological Research Program at Omora Park began in 2000 involving the participation of local and international bird lovers, such as Germán González and Nicolás Seguel, members of the Yahgan Indigenous Community of Mejillones Bay, who collaborated with US ornithologist, Steven McGehee. (bottom) Since the beginning, we also received the help from regional teachers, such as Teresita Gómez, and researchers who study forest birds in temperate and forests of North and South America, such as Dr. Mary Willson. Photos Ricardo Rozzi.

Figure 21. (top) Cristián Celis completed his veterinary thesis (Universidad de Chile) that investigated the presence of ectoparasites on the Magellanic Woodpecker (*Campephilus magellanicus*); he used a model of the woodpecker to attract and capture birds at Omora Park. (bottom) High-school students from Puerto Natales learn in the field about the ecology of sub-Antarctic forest birds, such as the Patagonian Sierra-Finch (*Phrygilus patagonicus*). Photos Adam Wilson and Steff van Dongen.

METHODS

For eleven years, between January 2000 and December 2010, we have conducted standardized monthly mist-netting at the Omora Ethnobotanical Park, and with less intensity on other sites of Navarino Island and the Cape Horn Biosphere Reserve. This program has involved many people, including national and international scientists, members of the Yahgan indigenous community, graduate and undergraduate students from the Universidad de Magallanes and other Chilean and foreign universities, teachers and students from the schools of Puerto Williams and other schools in the Magellanic Region, and other regions from Chile, Latin America, and abroad, professionals from Chilean public agencies, family, and personnel of the Chilean Navy, as well as volunteers (Figure 20). In November 2000 we formalized the participation of a regional, a national, and an international advisor in the Omora Park Long-Term Ornithological Research Program (LTOR):

- At the regional scale, Professor Claudio Venegas, who has led the ornithological studies at the Instituto de la Patagonia, University of Magallanes, for three decades, advised the LTOR-Omora Park team during the planning and implementation phases of our long-term ornithological program.

- At the national scale, Juan Carlos Torres-Mura, ornithologist at the Laboratory of Ornithology at the National Museum of Natural History, Santiago, Chile, continuously provided advice about field methodologies and participated in many field campaigns for bird censuses and mist-netting.

- At the international scale, Dr. Christopher Elphick, ornithologist at the University of Connecticut, provided essential advice for the design of the type and size of bands used for each bird species, the acquisition of bands and mist-nets, and the design of the initial sampling methods.

At Omora Park, field work and mist-netting was conducted and/or coordinated during the years 2000-2002 by Ricardo Rozzi, 2003 by Silvina Ippi and Ricardo Rozzi, 2004-2005 by Steven McGehee and Ricardo Rozzi, 2006-2008 by Ximena Arango, and 2009-2010 by Sebastian Dardanelli. The sampling methods for point-count censuses along transects and preparation of checklists in the Cape Horn Biosphere Reserve were designed and/or conducted by Ricardo Rozzi and Juan Carlos Torres-Mura, in collaboration with Steven McGehee. After the time period covered by this book, the general direction of the long-term ornithology research program was passed from Ricardo Rozzi to Jaime Jimenez in January 2011. Concomitantly, during the years 2011-2012 the field work and mist-netting at Omora Park was conducted and/or coordinated by Ronnie Reyes and Cristián Celis, and since 2013 by Omar Barroso and Ana Piñeiro. In addition to bird censuses along transects and mist-netting studies, Chilean and foreign researchers, graduate, and undergraduate students, as well as high-school students have conducted a number of special studies at LTOR-Omora Park (Figure 21).

Mist-Netting

Mist-netting sample effort. We used two sizes of mist-nets with a mesh size of 30 mm: 6 m long by 2.4 m height and 12 by 2.4 m (Figure 22). Each sampling day, mist-nets are checked every 15 to 30 minutes. To standardize the sampling effort for each site, we considered the size of the net and the exposure time. The products of the net-area (m^2) and the number of hours of net display (h), based on the set up time and removal of each net, were calculated for each net and sampling day. During the 2000-2010 period we conducted mist-netting for a total of 764 days with an accumulated mist-netting effort of 497,852.36 m^2/h. At each mist-netting site, information about the habitat, temperature, and weather conditions was recorded each day.

In 2003, we initiated a protocol of six sampling days per month at Omora Park: three days at the forest interior (“Canelo site”) and three days at the forest edge with a scrubland patch (“Notro site”) (Figure 11). For this reason, the numbers of mist-netting days per year since 2003 were higher, and the goal was 72 days of mist-netting each year; however, weather conditions and logistics during winter months impeded this regularity in some years (Figure 23). Most years, some mist-netting was also conducted at the other complementary study sites, mainly at the Guerrico site on Navarino Island. Mist-netting at Guerrico site was conducted every year for a period of three days at least once during the reproductive season (November-March).

Bird bands. In 2000, captured birds were banded with aluminum bands of uniform size with a 2.78 mm internal diameter, modifiable through folding one end of the band over the other upon placement on the bird’s tarsus. These bands were numbered 1-500 and followed by the letters RR00 (*i.e.*, Ricardo Rozzi year 2000).

Later, in January 2001 we began using bands of a specific diameter for each bird species. Following the advice by ornithologist Christopher Elphick, the appropriate band size was determined for each species based on a leg gauge designed by the North American Banding Program (http://www.pwrc.usgs.gov/bbl/), of the United States Geological Survey and the Canadian Wildlife Service, and measurements of the tarsus of at least three individuals of each of the bird species captured at Omora Park.

Finally, in 2008 Chile´s Agriculture and Livestock Bureau (SAG, *Servicio Agrícola y Ganadero de Chile*), Ministry of Agriculture, launched a national initiative for bird banding in which the Omora Park team participated. During this same year we began using bands

Figure 22. (left) Mist-nets deployed at a forest-edge site on Guerrico in the northern coast of Navarino Island. (top right) A Thorn-tailed Rayadito (*Aphrastura spinicauda*) captured in a mist-net. (bottom right) Omora Park ornithologist, Dr. Ronnie Reyes, carefully handling the captured Rayadito. Photos Adam Wilson.

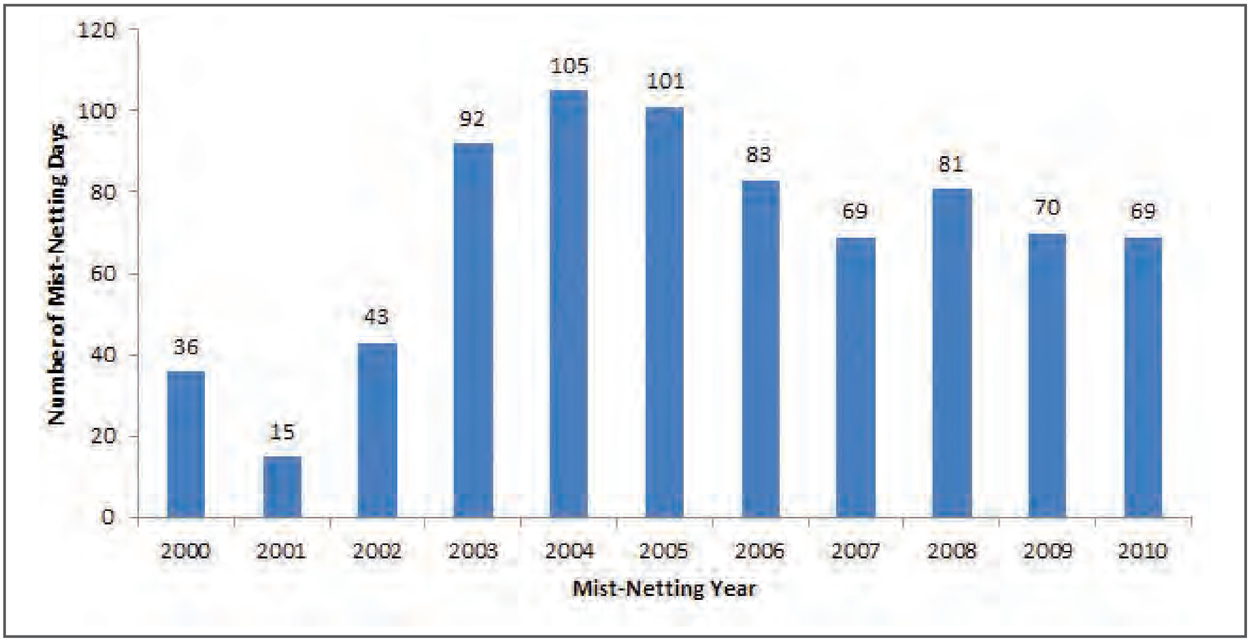

Figure 23. Bird monitoring effort quantified as the number of mist-netting days per year at Omora Park and complementary study sites on Navarino Island, conducted from January 2000 to December 2010.

provided by SAG. Occasionally, we also have used additional color bands to facilitate the identification of individuals (Figure 24). The Green-backed Firecrown or *Omora* Hummingbird (*Sephanoides sephaniodes*) required a species-specific methodology. This species requires special care, and captured individuals were initially banded with small, blue-plastic rings that were sequentially numbered, and later with a small band cut from a numbered aluminum sheet that was sanded to remove sharp edges. These bands were placed on the legs of hummingbirds using special pliers.

Analyses of captures, recaptures, and longevity of species. The information gathered from mist-nets recorded all captured individuals, including occasional cases of individuals that escaped and were not banded. It also includes all known recaptured individuals. Total Captures (TC) is the value that sums up all capture events of all captured birds. For each species we calculated its:

A. *Relative Percentage of the Total Captures (RTC).* We used the ratio: TCSn/TC, where TCSn is the sum of all capture events for species n, and TC of all captured birds. In the descriptive section of each captured species in Chapter 2, species are ordered from the highest to the lowest RTC value. The RTC value for each species is presented as "% of total captures" right to the photograph of the species. The total number of captures for each species is also recorded right to the photograph in Chapter 2.

B. *Total Number of Different Individuals Captured and Banded (TCB).* We calculated this value based on the number of captured birds that (i) were not previously banded and that (ii) we succeeded in banding for the first time. Therefore, TCB does not include multiple recaptures nor individuals that escaped before they were banded. This criterion enables TCB to be used as a basis for the estimation of the percentage of banded individuals that were recaptured. In Chapter 2, TCB for each species is presented as "Different individuals captured," to the right of the photograph of the respective species.

C. *Total Number of Different Individuals Recaptured (TRDI).* We calculated this value as the total number of individuals that were recaptured at least once. We did not distinguish between one or multiple recaptures of the same individual.

D. *Percentage of Recaptured Individuals (%RI).* We calculated this value using the ratio: % RI = (TRDI/TCB) * 100. In Chapter 2, the %RI value for each species is presented as "% individuals recaptured," right to the photograph of the respective species.

E. *Maximum Recorded Longevity (years) (MRL).* We estimated this value based on the individuals that had the longest period between their first capture and banding event, and the last recapture event. This value represents a preliminary estimate of maximum longevity. This preliminary estimate provides the first available information on longevity for bird species in the sub-Antarctic forests of Navarino Island.

Morphometric measurements. Each captured bird was identified, banded, and the following morphological measurements were taken (Figure 25; see Pyle *et al.* 1987 for more details):

a) *Total length*, defined as the length between the tip of the tail and the tip of the bill with the bird extended and supported dorsally over an ornithological ruler with 1 mm accuracy.

b) *Tail length*, defined as the length of the extended wing from the base to the tip of the longest primary feather, measured with an ornithological ruler with 1 mm accuracy.

c) *Tarsus length*, measured with a caliper with 0.1 mm accuracy.

d) *Wing length*, defined as the length of the extended wing from the wrist to the tip of the longest primary feather, with the wing extended flat over (flat, *i.e.*, arch) an ornithological ruler with 1 mm accuracy.

f) *Bill length*, defined as the length of the exposed culmen, measured with a caliper with 0.1 mm accuracy.

g) *Bill depth*, defined as the height of the upper and lower mandibles measured perpendicular to the bill´s length and at the anterior end of the nostrils, using a caliper with 0.1 mm accuracy,

h) *Bill width*, defined as the width of the culmen, measured perpendicular to the bill´s length and at the anterior end of the nostrils, using a caliper with 0.1 mm accuracy,

i) *Weight*, measured with an electronic scale with 0.01g accuracy or a Pesola scale of 30 g and 0.5 g accuracy for the majority of the species. For larger species we used a 100 g Pesola scale with 0.5 g accuracy and for hummingbirds a 10 g scale of 10 g with 0.1 g accuracy.

Figure 24. (top) Numbered aluminum bands provided by SAG and color bands on the legs of a captured White-crested Elaenia (*Elaenia albiceps*). (bottom) The captured Elaenia, banded and ready to be released by Omora Park ornithologist Dr. Sebastián Dardanelli, who carefully holds the bird from its legs. Photos Jaime Jiménez and Sebastián Dardanelli.

Figure 25. (top) “Notro site” bird-banding station at Omora Park, where each captured bird is identified, banded, and subjected to morphological measurements by ornithologists, such as the Omora Park field technician Omar Barroso and the student Aquiles Gutierrez. (bottom) One of the measurements, wing length, taken on a Patagonian Sierra-Finch (*Phrygilus patagonicus*). Photos Jaime Jiménez and Steff van Dongen.

When possible, the gender (color dimorphism and presence/absence of incubation patch and cloacal protuberance) and age (adult or juvenile; through feather development and color) of each captured individual was estimated.

Diet information for each species. We have collected the feces of birds that defecated during the mist-netting and banding handling for subsequent diet analysis. Feces samples were preserved and dried in paper envelopes. To identify the seeds and invertebrates found in bird feces, we prepared a reference collection of seeds of all plant species with fleshy fruits, as well as the main Gramineae. To identify the invertebrates found in bird feces, we mounted reference collections of the most common insect taxa, as well as other invertebrates, present in the canopy and soil of forest, scrublands, and riparian habitats. We identified the contents of feces by using dissecting microscopes,

To study the diet of potential pollinators, for captured individuals of *Elaenia albiceps* and *Sephanoides sephaniodes* that visit the flowers of *Embothrium coccineum* and of other plant species with red-tubular flowers, in the period 2000- 2002 we sampled pollen grains removed with Scotch tape from above and below the beak of the bird. Tapes were later stored on microscope slides. In order to determine the taxa of pollen, we prepared a reference collection of pollen grains of plants with red tubular flowers that are present at Omora Park and/or the Cape Horn Biosphere Reserve. We identified the pollen on slides by examining the samples under a compound microscope.

The study of diet is under way. Hence, only preliminary information is provided in the description of each species; our original preliminary information is also complemented with information from the literature.

Bird capture rates per month. In order to assess the seasonal variations in the number of captured birds in the mist-nets, we summed the number of individuals of each species captured each month, and standardized this number with the mist-netting effort: Total number captured birds/[net-area (m^2) x number of hours of net display (h)] x 10^4. Then, we calculated the monthly mean (± SE) based on the standardized monthly data for each month between 2003 and 2010. These data are represented in a histogram for each species.

CENSUSES OF FOREST BIRDS IN THE CAPE HORN BIOSPHERE RESERVE

In addition to mist-netting sampling methods, at Omora Park and other study sites on Navarino Island, we have conducted censuses along transects with observation-listening stations at different sites across the Cape Horn Biosphere Reserve (CHBR). At each site we conducted a transect of at least 10 observation-listening stations separated by at least 100 m, and at each station we:

(i) Recorded the bird species heard or seen during 5 minutes within an approximate of 50 m radius;

(ii) Counted the number of individuals of each species at each station;

(iii) Recorded the types of activity, habitat, and microhabitat used by each of the observed individuals;

(iv) Documented the habitat type at the counting point, the weather conditions, and the time of day.

During the course of the transects, and our entire stay at each of the sites, we also prepared lists of bird species recorded. Preliminary distribution maps were prepared for each species based on information gathered during forest bird censuses in spring/summer and late fall/winter at 61 sites broadly distributed throughout the CHBR (Table 1; Figure 13). For the preparation of the distribution maps of species within the CHBR, expeditions were considered developed in five main sectors:

1. Navarino Island (18 sites), including Picton Island, as well as Button Island, Mascart Island in the area of Murray Channel and sites in Ponsonby fjord in Hoste Island.

2. North-west Arm of the Beagle Channel and neighboring areas (16 sites), including sites at both the North-West and the South-West arms of the Beagle Channel, as well as neighboring fjords (Yendegaia Sound, Pia Sound, Ventisqueros Sound) and islands (Chair Island, Devil Island).

3. Almirantazgo Sound (12 sites), including neighboring fjords (Parry Sound, Ainsworth Bay, Brooke Sound), valleys (Paralelo River), and Caleta Maria (Maria Cove) at the eastern end of Almirantazgo Sound.

4. West Areas Biosphere Reserve (6 sites), including neighboring islands (London, Baskets).

5. Cape Horn Archipelago area (9 sites), including the islands of the Wollaston or Cape Horn Archipelago, as well as two sites on the eastern coast of Hardy Peninsula (Orange Bay, Lort Bay).

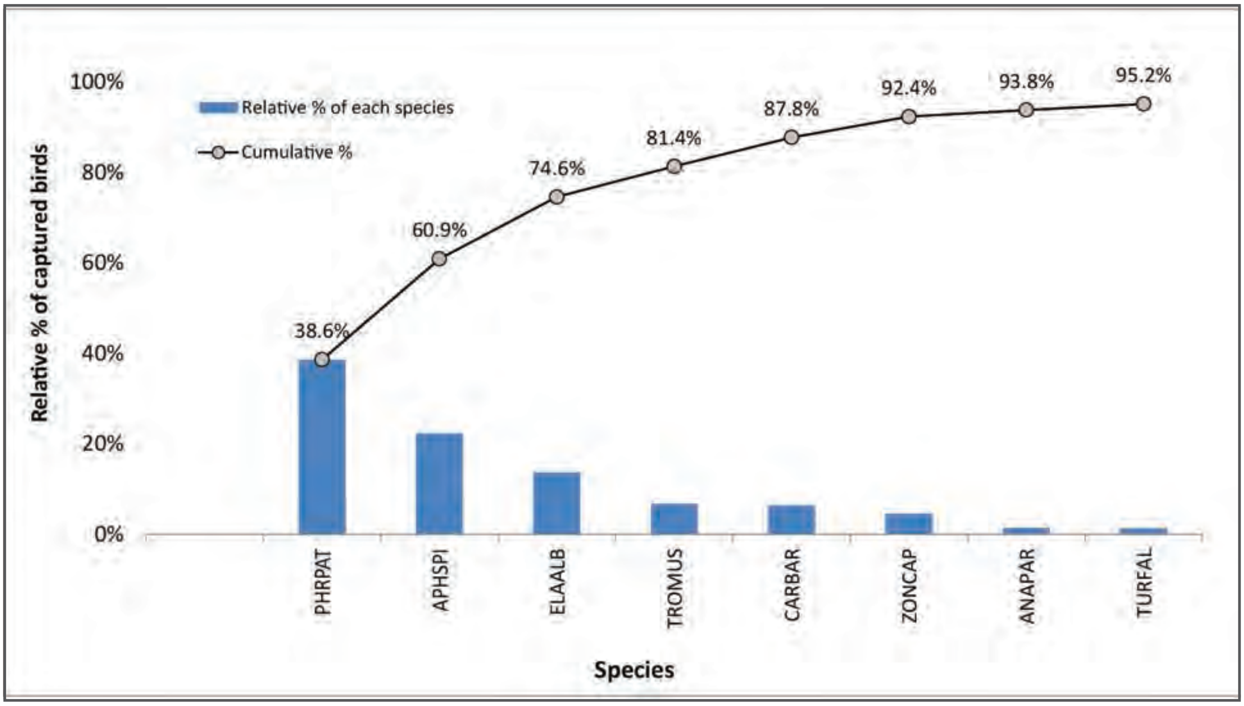

Figure 26. Cumulative Relative percentage of captured forest bird species. A total of 8,887 birds belonging to 26 species have been captured with mist-nets. It is noteworthy that three species -*Phrygilus patagonicus* (PHRPAT), *Aphrastura spinicauda* (APHSPI), and *Elaenia albiceps* (ELAALB)- accounted for 75% of all captures. More than 95% of the captured birds, was represented by only eight species, including in addition to the former three species: *Troglodytes aedon* (TROMUS), *Carduelis barbatus* (CARBAR), *Zonotrichia capensis* (ZONCAP), *Anairetes parulus* (ANAPAR), and *Turdus falcklandii* (TURFAL).

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SANTIAGO DE CHILE, MIÉRCOLES 28 DE NOVIEMBRE DE 2001

PLAGA | Depredador llega a Navarino:

¡Cuidado con el visón!

Alertan al SAG sobre la aparición de este carnívoro que come y destruye todo a su paso, y piden que se lo controle urgentemente.

PUNTA ARENAS.— Primero llegó el castor y ahora último apareció el visón. Dos plagas que son vistas con bastante antipatía en Magallanes. La primera especie lleva décadas y ya está adaptada, pero hasta hace poco nadie había visto visones.

Pese a ser tan cotizado por su sedoso pelaje café en el mundo de la moda, su presencia a orillas del canal Beagle ha alarmado a las autoridades.

Éstas decidieron adoptar medidas urgentes para controlar esta plaga que por años ha causado enormes perjuicios en las regiones de Los Lagos y Aisén.

Los habitantes de isla Navarino ya han tenido suficiente con el castor que incluso ha alterado el ecosistema de Puerto Williams, desviando los cursos de agua.

De extenderse el visón por la isla podría traer consecuencias negativas para desarrollar un atractivo turístico en torno a Puerto Williams, donde habitan aves nativas tales como el carancho, la caranca, caiquén, martín pescador, carpintero negro o pato juarjual.

El visón depreda directamente las aves nativas y de corral, como también coloniza áreas, destruye y come todo lo que halla a su paso. Esta especie fue introducida en Argentina en 1946, y ahora cruzó a nado el canal Beagle con intenciones de conquistar Navarino.

SU DAÑINA PRESENCIA EN C 7

DEPREDADOR.— El visón es muy cotizado por su pelaje, pero en isla Navarino su explosiva proliferación podría causar un gran daño al ecosistema.

EL TIEMPO HOY

SANTIAGO
9°/27°
Mayormente despejado, tornándose cálido.

Arica	17/23	Parcial
Iquique	15/22	Parcial
Antofagasta	14/21	Parcial
Copiapó	12/26	Despejado
La Serena	12/19	Parcial
Valparaíso	7/21	Despejado
Curicó	7/25	Despejado
Chillán	5/23	Despejado
Concepción	7/20	Despejado
Temuco	5/19	Parcial
Puerto Montt	6/14	Despejado
Punta Arenas	4/12	Parcial

EL MERCURIO

NACIONAL

C7

Isla Navarino:

Alerta para evitar una plaga de visones

Este carnívoro depredador cruzó a nado el Canal Beagle y amenaza a la rica avifauna de Puerto Williams.

ROLANDO MARTÍNEZ

PUNTA ARENAS.— El avistamiento de algunos visones cerca de Puerto Williams, en la Isla Navarino, fue suficiente para que el gobernador de la Provincia Antártica, Eduardo Barros, alertara al Servicio Agrícola y Ganadero y pidiera análisis para definir una oportuna política que evite plagas como las ocurridas en áreas de las regiones de los Lagos y Aisén.

No quiere que este carnívoro, depredador de aves nativas y de corral, se convierta en otro verdugo del ecosistema de Navarino, tal como ha ocurrido con el castor, que desde hace tres décadas ha generado una plaga suficiente para alterar cursos de aguas naturales con la construcción de pequeñas represas, con una población que bordea los 80 mil ejemplares.

El visón (Mustela vison) es una especie exótica. En 1946 la Sociedad Argentina Privada del Sur introdujo cerca de mil ejemplares en Isla Tierra del Fuego de Argentina, cerca de Tolhuin, sector noroeste del lago Fagnano, con el objeto de desarrollar una industria peletera. Al fracasar el proyecto, los animales se multiplicaron y salieron del cautiverio.

Se sabía que su población, no cuantificada, permanecía circunscrita en Tierra del Fuego con registros de avistamiento en el lado chileno, según explicó el encargado de Protección de Recursos Naturales del SAG en Magallanes, médico veterinario Nicolás Soto.

Se estima que el animal debió cruzar a nado el Canal Beagle (7 kilómetros) hasta llegar a Isla Navarino en el afán de conquistar nuevos territorios. Le gusta habitar lugares húmedos cercanos al agua y vive aislado o bien en pequeños grupos confinados en riberas de ríos.

De aspecto alargado: de 50 a 60 centímetros, cabeza ancha, orejas y patas cortas, con 12 centímetros promedio de alzada, se desplaza con facilidad en la tierra y el agua.

El macho pesa de 800 a 1.500 gramos, mientras que la hembra varía de 600 a 1.000 gramos. Su pelaje es de amplia gama: va del café oscuro, con algunas manchas blancas en el vientre y otras en la barbilla, al gris y al blanco. La ley de caza lo considera muy dañino y, por tanto, no hay problemas para su captura durante todo el año.

Temor a la plaga

El ecólogo Ricardo Rossi, promotor del parque botánico Omora (picaflor en lengua yagán) a 2 kilómetros de Puerto Williams —donde conviven bosques de lenga, coigüe y ñire como escenario para la crianza de unas 25 especies de aves—, precisó que es necesario adoptar las medidas preventivas. Le preocupa que una eventual plaga afecte directamente las aves de la zona.

El gobernador Eduardo Barros apuesta a un desarrollo turístico de Puerto Williams y su entorno, que se conjuga a través de extensas áreas vírgenes y abundante variedad de aves. De allí la necesidad de preservar todo con cuidado.

El profesional del SAG Nicolás Soto reconoció que hay detección de visones en la zona, pero los primeros diagnósticos evidencian que la situación aún no es relevante, pero hay que evaluar medidas.

BREVES

SESMA:

Autorizan piletas en Santiago

El Servicio de Salud Metropolitano del Ambiente (Sesma) autorizó el funcionamiento de las piletas de la comuna de Santiago como recintos de baño. Tras la polémica del año pasado, el municipio cumplió con los requerimientos que solicitó el director del Sesma, José Concha, al alcalde Joaquín Lavín en una reunión realizada en octubre. Paralelamente, cuarenta piscinas inspeccionadas por el Sesma presentaron anomalías.

ARMADA:

Dan de alta a guardiamarina

Figure 27. The Omora Park Long-Term Ornithological Research Program gave the first alert about the arrival of the North American mink (*Neovison vison*) to Navarino Island on November 25, 2001. Ricardo Rozzi, together with the Governor of the Chilean Antarctic Province, Mr. Eduardo Barros González, immediately contacted the regional and national offices of the Chilean Agriculture and Livestock Bureau (SAG). Two days after the detection the news were published on the cover of the national newspaper “El Mercurio” on 28th November, 2001.

Only those sites that were sampled at least once during the breeding season (October to March) and once during the nonbreeding season (April-September) were used for the maps. Based on this information, we prepared presence/absence maps for each forest bird species recorded in the Cape Horn Biosphere Reserve. The maps for each species are presented in Chapter 2. On the maps, the colors indicate whether a given bird species was recorded in both seasons (= green), only in the breeding season (= yellow), or neither (= white) at each sampling site. Therefore, maps characterize the broad distribution and migratory patterns of each species. As mentioned above, the study sites represent a representative sample of the different types of habitat, climatic, and geographical conditions, as well as the degree of modern human impact in the Cape Horn Biosphere Reserve.

CONCLUDING REMARKS

The purpose of this chapter has been to introduce the main attributes of the study sites at Omora Park and other places in the Cape Horn Biosphere Reserve, from the perspective of their relevance at a global scale and specifics at the local scale. Before concluding this chapter, however, we would like to point out some general results that will help to put the next chapters and the book as a whole into context.

1. A total of 8,887 birds belonging to 26 species were captured with mist-nets. It is noteworthy that three species (*Phrygilus patagonicus*, *Aphrastura spinicauda*, and *Elaenia albiceps*) accounted for 75% of all captures, and 8 species for >95% of all the captured birds (Figure 26). The results of the long-term mist-netting and banding program at Omora Park are presented for each species in Chapter 2.

2. 69.2% of the 26 species captured with mist-nets are year-round residents at Omora Park. Only eight species, *i.e.* 30.8%, migrate during winter. This represents a marked contrast with the bird assemblages of temperate and subpolar forests in the Northern Hemisphere, where as many as 82% of the species are migrants (Newton & Dale 1996, Willson *et al.* 1996).

3. The eight most abundant species are habitat generalists. They were found on sites close to the Pacific Ocean, as well as in the interior islands of the archipelagoes south of Tierra del Fuego.

4. In the Cape Horn Biosphere Reserve we also detected a species distribution pattern that approximately corresponds to the limit of distribution of the High-Deciduous Beech or Lenga (*Nothofagus pumilio*) in areas that receive less than 1000 mm of annual rainfall, and which are less exposed to the strong winds along the Pacific coast. Among the species restricted to the sheltered areas with well-developed old-growth forests are the Magellanic Woodpecker (*Campephilus magellanicus*), the Austral Parakeet (*Enicognathus ferrugineus*), and the Rufous-legged Owl (*Strix rufipes*). A few other species migrate from the western and southern islands exposed to the Pacific to the more sheltered sites on Navarino Island and Beagle Channel in the northern central area of the CHBR.

5. Among the birds captured with mist-nets, only one species was exotic: the House Sparrow (*Passer domesticus*), captured at Omora Park and in Puerto Williams. Additionally, the Rock Dove (*Columba livia*) was recorded in checklists in Puerto Williams. Both species were restricted to the city of Puerto Williams. Therefore, we have not recorded any invasive exotic bird species in the Cape Horn Biosphere Reserve.

6. In November 2001 we detected the presence of the North American mink (*Neovison vison*) on Navarino Island. This detection was immediately notified to the Governor Office in Puerto Williams and the regional and national offices of the Chilean Agriculture and Livestock Bureau (SAG), as well as the general public via national and regional media (Figures 27 and 28). This early alarm triggered actions that have continued until today to control the spread of this introduced mammal, which represent a high threat to the avifauna of the Cape Horn Biosphere Reserve. Part IV of this book presents research articles on this topic generated during the first decade. More recently, it has been documented that mink represents one of the main concerns of local residents (Schüttler *et al.* 2011), and that this predator might even threaten the large, charismatic Magellanic Woodpecker (Jiménez *et al.* 2013).

The Cape Horn Biosphere Reserve is part of the Man and the Biosphere Program (MaB) of UNESCO that began in 1970 as an alternative to preservationist approaches to biological conservation, which excluded humans from protected areas. MaB had the intention of instead promoting a perspective that would reconcile social, cultural, recreational, and ecological needs (Guevara & Laborde 2008). A fundamental element of the MaB Program's method was the establishment of an international network of biosphere reserves. This network has come to include a mosaic of world unique sites that correspond with the planet's major ecosystems through the development of research programs, monitoring, education, conservation, and to promote social and environmental sustainability through the worldwide Biosphere Reserve Network. In 1996 the MaB Program defined the Seville Strategy (UNESCO 1996), whereby biosphere reserves must achieve three complementary functions:

a) biodiversity conservation,
b) sustainable social and economic development, and
c) logistical support for research, education, and monitoring.

2 CRONICA

La Prensa Austral

Martes 27 de noviembre de 2001

Piden intervención del Sag

Preocupa presencia del visón en Williams

- Gobernador de la provincia Antártica advirtió que este animal carnívoro podría ocasionar serios trastornos al ecosistema de esa zona.

Inquietud existe en la provincia Antártica por la detección de un visón, animal carnívoro que de masificarse podría causar serios trastornos ecológicos y económicos al ecosistema de la isla Navarino. De ahí que la Gobernación de la provincia Antártica y la Fundación Omora solicitaron al Servicio Agrícola y Ganadero (Sag) la implementación de urgentes medidas de control frente a la presencia de esa especie en la región y particularmente en esa zona.

Junto con recalcar la necesidad de controlar la introducción de especies exóticas en la región, el gobernador Eduardo Barros indicó que el ecólogo Ricardo Rozzi, presidente de la la Fundación Omora, confirmó la presencia del primer visón (Mustela visón) capturado en la isla Navarino. Dijo que esto significa un serio riesgo ecológico y económico para la provincia, por los estragos que el carnívoro ha provocado en las regiones de Los Lagos (Décima) y Aisén (Undécima).

Según explicó Rozzi, el visón es un depredador voraz de aves de corral y nativas. Podría afectar seriamente la avifauna subantártica presente en la isla, considerando que hasta ahora ha evolucionado en ausencia de mamíferos carnívoros terrestres.

El investigador recalcó que el diagnóstico del visón y la gravedad de su presencia en la isla Navarino fue ratificada por el jefe del Subdepartamento de Vida Silvestre del Sag, Agustín Iriarte.

Desde la Tierra del Fuego argentina el visón fue introducido a la región.

Especie introducida

El director regional del Sag, Carlos Rowland, confirmó la inquietud planteada por representantes de la provincia Antártica por la presencia de un ejemplar de visón. Dijo que la institución establecerá una estrategia a seguir una vez analizada la información existente.

El médico veterinario Nicolás Soto, encargado regional del Departamento de Protección de Recursos Naturales del Sag, indicó que el visón no es una especie nativa de Magallanes, pues ingresó en la década del '40, a partir de la introducción de visones y castores realizada en Tierra del Fuego argentina con fines peleteros. Dijo que en general el visón no revierte mayor peligrosidad, aunque ataca principalmente a las aves y algunos animales silvestres.

Respecto a la posible presencia de esa especie en el continente, manifestó que no existen antecedentes que comprueben esa teoría. Ello, a pesar de que algunas personas han señalado haber visto visones en el sector del Parque Chabunco. A juicio de Soto, habrían sido confundidos con animales parecidos como el quique y el chingue en su estadio juvenil.

Por otro lado, recordó que según la ley de caza el visón es una especie de la fauna silvestre perjudicial o dañina. Puede ser cazada o capturada en cualquier época del año, en todo el territorio nacional y sin limitación de número de piezas o ejemplares. Para ello los interesados deben contar con el correspondiente permiso de caza otorgado por el Sag.

Figure 28. *La Prensa Austral* is the regional newspaper with the largest circulation. In the November 27th 2001 issue the detection of the American mink in the northern coast of Navarino Island is reported.

The LTOR Program at Omora Park aims to contribute to these goals of the MaB Program, which are also the goals and responsibilities of Omora Park as the interdisciplinary research center of the UNSECO Cape Horn Biosphere Reserve. This book provides a first synthesis of ornithological research in Cape Horn that contributes to fill the gaps in the understanding of the autecology of sub-Antarctic bird species and their ecological interactions, and offers a baseline for future ornithological, and ecological research, education, and conservation, including policy, education, tourism, and environmental decision making. This book has the goal of making this body of information available to the local community, particularly the education community, and the Indigenous Yahgan Community, and to Chilean authorities and public agencies, including the Chilean Antarctic Provincial Government, the Chilean National Forestry Corporation (CONAF), the Chilean Ministry of the Environment, the Ministry of National Lands, the Chilean Navy, the Municipality of Cape Horn, the Corporation for the Promotion of Production (CORFO), the National Tourism Service (SERNATUR), the Agricultural and Livestock Bureau (SAG), the National Corporation for Indigenous Development (CONADI), the National Fisheries Service (SERNAPESCA), and the Undersecretary for Navy Affairs Office of the Ministry of Defense.

It is only through coordinated inter-institutional collaboration that we will consolidate Cape Horn as a world center for sub-Antarctic research in the context of global environmental change, and as a bird watching and nature destination providing economic and environmental sustainability in the CHBR. Bird watching is one of the fastest growing areas in nature tourism, and Cape Horn offers a unique site to develop innovative themes and activities for sub-Antarctic scientific tourism that integrates science, ethics, arts, and education at the southern end of the Americas. The alliance of research, education, and sustainable tourism can significantly help conserving one of the planet's most unique forest ecosystems of the world, contributing to the well-being of both humans and birds in the precious habitats of the Magellanic sub-Antarctic ecoregion.

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