BOSQUE 32(2): 155-164, 2011

The forests of Robinson Crusoe Island, Chile: an endemism hotspot in danger

Los bosques de la isla Robinson Crusoe, Chile: *hotspot* de endemismo en peligro

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SUMMARY

Robinson Crusoe Island (RCI), part of Juan Fernández Archipelago, contains more endemic plant species per area than any other island system of the world (1.9 species/km²). Currently, exotic plants are invading all habitats on the island with higher or lower intensity. As two-thirds of the vascular plant species are threatened by extinction, the island has a high conservation priority. Protection of the island's biodiversity is of utmost importance both locally and globally. Using already published information, the main vegetation types defined for RCI were reviewed, considering plant species richness on the International Union for Conservation of Nature conservation categories, amount of invasive exotic plants, and the occurrence of land bird species. The highest number of endemic and endangered plant species was found in the upper and lower montane forest, in which only highly threatened and threatened bird species live. Furthermore, the scientific literature about Juan Fernández Archipelago was reviewed in order to identify missing data needed for effective conservational efforts. So far research in Juan Fernández and RCI has been mainly focused on Botany, usually dealing with taxonomical aspects of singular plant taxa. Detailed studies of ecology, structure, dynamics, processes and services of the forests on RCI are missing in scientific literature. It appears as highly important to fill this knowledge gap in order to be successful in future conservation and restoration initiatives.

Key words: conservation, IUCN red list categories, invasive species, Juan Fernández Islands.

RESUMEN

La isla Robinson Crusoe, parte del Archipiélago Juan Fernández, contiene más especies de plantas endémicas por área que cualquier otro sistema insular en el mundo (1,9 especies/km²). Actualmente los hábitats de la isla son invadidos por plantas exóticas con mayor o menor intensidad. Dos tercios de las especies de plantas vasculares se consideran en peligro de extinción, por lo que la isla representa una prioridad de conservación para la biodiversidad a escala local y global. Utilizando información ya publicada, se revisan los principales tipos de vegetación definidos para la isla Robinson Crusoe, considerando la riqueza de especies en categorías UICN (Unión Internacional para la Conservación de la Naturaleza), la cantidad de plantas exóticas invasivas y la ocurrencia de especies de aves terrestres. La mayor proporción y número de especies de plantas endémicas se ubicaron en el bosque montano alto y bajo de la isla, donde habitan en mayor abundancia especies de aves endémicas altamente amenazadas. Adicionalmente, para percibir necesidades de información para la conservación, se analizaron los principales temas de publicaciones científicas desarrolladas sobre el archipiélago Juan Fernández. Hasta hoy la investigación en Juan Fernández se ha centrado en botánica, normalmente, en temas relacionados con aspectos taxonómicos de especies de plantas singulares. Estudios en ecología, estructura, dinámica y procesos de los bosques de la isla Robinson Crusoe han sido escasamente tratados en publicaciones científicas. Es urgente abarcar, comprender y vincular estos temas hacia iniciativas de conservación y restauración aplicada.

Palabras clave: conservación, categorías UICN, lista roja, especies invasivas, archipiélago Juan Fernández.

INTRODUCTION

Plants and animals that somehow have arrived on islands adapt and may evolve in those isolated ecosystems in a unique way. Adaptive radiation following migration helps species to occupy different environmental or ecological niches. Therefore, the high number of endemic species on islands can, at least partly, be explained by speciation through mutation and selection (Cronk 1997). The evolution of species in isolation without much intraspecific competition results in a major susceptibility of island biota to invasive species and human impact (Loope and Mueller Dombois 1989).

Although islands cover only about 2 % of the terrestrial surface, their contribution to global biodiversity is substantial. Around 14 % of all mammals and more than one quarter of bird species occur on island ecosystems (Myers *et al.* 2000). Similar patterns can be observed for vascular plant taxa (Hahn *et al*. 2005). Because of their small land areas and high levels of endemism, islands are likely to offer high returns for species conservation efforts and therefore warrant a high priority in global biodiversity

conservation (Kier *et al*. 2009). Nine of the world's 25 biodiversity hotspots for conservation priorities are mostly or completely made up of islands (Myers *et al.* 2000).

Juan Fernández Archipelago Biosphere Reserve (Chile, South east Pacific at 33º S) is one of those biodiversity hotspots. Composed by three oceanic islands, the archipelago accounts for less than 100 km² of land mass, which represents about 0.01 % of Chile's territory. However, the islands concentrate more than 5 % of Chile's endemic vascular plants (Marticorena 1990). One family, twelve genera and 135 species of plants are endemic to Juan Fernández Islands (Danton and Perrier 2006). Particularly Robinson Crusoe Island, the only permanently inhabited island of the archipelago, presents more endemic plants per area than any other island of the world (93 species in 4,794 ha *i.e*., 1.9 endemic species/km²; Stuessy 1992). In addition, almost one third of the Chilean endemic avifauna can be found on Juan Fernández archipelago (Rau 2006).

The extinction of some plant species illustrates the conservation issues that the flora of Juan Fernández is faced with. *Santalum fernandezianum* Phil. (Santalaceae), a tree of precious wood, became extinct in 1913, and Asteraceae, *Robinsonia berteroi* (DC.) Sanders, Stuessy *et* Martic in 2004. The flora of Robinson Crusoe Island is especially endangered. Only about 20 % of the island's vegetation remains fairly undisturbed (Greimler *et al.* 2002a). At present, exotic animals and weeds invade all habitats on this island (Danton and Perrier 2006). The future of native flora and avifauna appears to be uncertain if conservation and restoration activities are not successful in the middle and long term (Dirnbörk *et al*. 2003, Hahn *et al*. 2005).

To implement restoration initiatives it is advisable to know the habitats of the most endangered species as well as their biology, ecology and dynamics. Thorough research of this kind seems to be lacking even though plants have been studied and collected on the islands since 1823 (Skottsberg 1956).

In this literature review the objectives are: i) to identify in which vegetation types of Robinson Crusoe Island the most endangered vascular plant and threatened land bird species are found, and ii) to analyse on which aspects of nature and vegetation of the Juan Fernández Islands past research has been focused on. The idea is to pinpoint areas of conservation interest highlighting information gaps for conservation.

ABOUT THE NATURAL HISTORY OF JUAN FERNÁNDEZ ISLANDS

Study area. Juan Fernández Archipelago National Park and Biosphere Reserve comprises three islands located between 680 and 860 km west of central Chile. Robinson Crusoe Island is the closest one to the continent (47.9 km², 33º 37' S, 78º 51' W). San Juan Bautista, on Robinson Crusoe Island, is the only settlement on the archipelago housing *ca.* 700 permanent residents. The climate is Mediterranean with an oceanic influence presenting an average temperature of 15.2 ºC and an annual precipitation of 957 mm (Hajek and Espinosa 1987).

The Juan Fernández Islands belong to the few places in the Pacific that remained untouched by humans until their discovery by European sailors in the late XVI century (*e.g.* Galápagos Islands, Revillagigedo Archipelago, Bonin Islands). Polynesians did not reach further than Easter Island and the Native Americans stayed on and near the South American mainland (Hahn *et al.* 2009). Juan Fernández is characterized by its biogeographical isolation. The lack of neighbouring islands within 500 km, the long distance to the mainland, the cool Humboldt Current flowing northwards parallel to the South American continent, and the mainly southerly to westerly winds form an environment that sustains a discrete floristic region, neither entirely belonging to the Neotropical nor to the Subantarctic flora (Hahn *et al.* 2009).

Robinson Crusoe Island vegetation types. Vegetation on Robinson Crusoe Island comprises *ca*. 3,750 ha of surface, composed mainly of grasslands, shrublands and forest formations (Greimler *et al.* 2002a). Vegetation is related to the Valdivian coastal formations of southern Chile and has some common characteristics with the subtropical islands communities of the New Zealand region as well as the Hawaiian Metrosideros-forest (Skottsberg 1953, Mueller-Dombois and Fosberg 1998). There are eight main vegetation types on Robinson Crusoe Island that comprise *ca*. 3,133 ha obtained by excluding minor scattered vegetation units (see Greimler *et al.* 2002b):

i) Endemic upper montane forest (753.5 ha extension, 350-650 m a.s.l.). Is located on steep slopes, dominated by the endemic tree species: *Myrceugenia fernandeziana* (Hook. *et* Arn.) Johow (Myrtaceae) and *Drimys confertifolia* Phil. (Winteraceae). The fern species: *Dicksonia berteroana* (Colla) Hook. (Dicksoniaceae) and the treelet *Coprosma oliveri* Fosberg (Rubiaceae) are frequent on the understorey. The palm tree *Juania australis* (Mart.) Drude ex Hook. f. (Arecaceae), the tall forb *Gunnera peltata* Phil. (Guneraceae) and species of the Asteraceae genus *Robinsonia* are common in this vegetation type.

ii) Endemic lower montane forest (441.9 ha of extension, 220-410 m a.s.l.). It comprises woodlands dominated by *M. fernandeziana*. *Fagara mayu* (Bertero ex Colla) Engl. (Rutaceae) and *D. confertifolia*. The endemic trees *Rhaphithamnus venustus* (Phil.) B. L. Rob. (Verbenaceae), *Coprosma pyrifolia* (Hook. *et* Am.) Skottsb. (Rubiacea*e*) and *Boehmeria excelsa* (Bertero ex Steud.) Wedd. (Urticaceae) occur with less abundance in this vegetation type (Vargas *et al.* 2010).

iii) *Ugni molinae* Turcz. (Myrtaceae) shrubland (232.2 ha of extension, 200-600 m a.s.l.). It is a hard leaved shrub community occurring along the ridges and upper slopes of Robinson Crusoe Island, mainly on the NE side. *Ugni molinae,* introduced from the mainland, dominates this

formation with some endemics like *Ugni selkirkii* (Hook. *et* Am.) O. Berg (Myrtaceae) or *Blechnum cycadifolium* (Colla) Sturm (Blechnaceae).
iv) *Rubus-Aristotelia* shrubland (718.3 ha extension, 140-420 m a.s.l.). This vegetation type is formed by dense pure thickets of the exotics: *Rubus ulmifolius* Schott (Rosaceae) and *Aristotelia chilensis* (Molina) Stunz (Eleocarpaceae). It is located mainly near the lower border of montane forests. The previous endemic montane forests, today invaded by *R.ulmifolius* and *A. chilensis*, were included in this vegetation type (Gremler *et al.* 2002b)
v) *Acaena argentea* Ruíz *et* Pav. (Rosaceae) vegetation (439.3 ha, < 400 m s.l). It is located especially on the western part of the island, where the exotic *A. argentea* colonizes eroded areas. Few introduced grasses and herbs are scattered within this matrix; native species are infrequent.
vi) Grasslands (248.7 ha extension, 20-450 m a.s.l.). Native grasslands and grasslands with *A. argentea* associations defined by Greimler *et al.* (2002b) were bundled together in this vegetation type. The natives Poaceae *Nassella laevissima* (Phil.) Barkworth and *Piptochaetium bicolour* (Vahl) E. Desv. are common in this unit.
vii) Weed vegetation (175.6 ha, 15-450 m a.s.l). This vegetation type corresponds to grasslands occurring on the eastern part of Robinson Crusoe Island. It is dominated by European species such as *Rumex acetocella* L. (Polygonaceae), *Vulpia sp*. and *Avena barbata* Pott ex Link (Poaceae).
viii) Exotic plantations (123.9 ha, 110-170 m a.s.l.). These are located in the surroundings of San Juan Bautista town to provide wood for the local community. They are composed by pure and mixed stands of *Eucalyptus globulus* Labill (Myrtaceae), *Cupressus goveniana* Gordon (Cupressaceae) and *Pinus radiata* D. Don (Pinaceae).

Land bird species. From a biogeographic point of view, the birds on Robinson Crusoe Island (N = 41 species) correspond to the temperate, subantartic, and neotropical taxa. Robinson Crusoe Island shares species with Chilean mainland, Easter Island, Desventuradas, Chiloé and Mocha islands (19 % similarity) (Hahn *et al.* 2009). Most birds are non-breeding visitors (28 species) that mainly rely on marine environments (22). Some regular breeders (11) are endemic to the Archipelago (46 %).

Most breeding birds on Robinson Crusoe Island are land bird species (N = 8) that range from widespread taxa such as *Columba livia f. domestica*, *Passer domesticus* and *Turdus falcklandii ssp. magellanicus* to more local species like *Asio flammeus suinda*, *Sephanoides sephaniodes, Falco sparverius ssp. fernandensis*, *Anairetes fernandezianus* and *Sephanoides fernandensis* (Hahn *et al.* 2005, 2006, 2009).

Natural history research on Juan Fernandez archipelago and Robinson Crusoe Island. The most comprehensive study about the natural resources of Juan Fernandez was compiled between 1920 and 1953 by Carl Skottsberg. The Swedish scientist co-authored "The natural history of Juan Fernández and Easter Island", referring to the algae, fungi and vegetation communities of the islands (Skottsberg 1953). In 1896, Johow published a review of the flora of Juan Fernández archipelago (Johow 1896), a work that has never been updated. Stuessy and collaborators helped to estimate the age of the islands (*ca.* four million years for Robinson Crusoe Island; Stuessy *et al.* 1984), and Castilla, together with several scientists (Castilla 1987) compiled a broad inventory for the Archipelago (and other oceanic islands) with respect to their geology, meteorology, marine biology, fishery, ornithology, entomology, and vegetation.

More specialized papers are dealing with genetic and breeding aspects of noteworthy plant species (Bernardello *et al*. 1999, 2001, Anderson *et al.* 2001). A map defining the vegetation types of Robinson Crusoe Island was produced by Greimler *et al*. (2002b). Danton and Perrier (2006) developed a complete catalogue of the vascular flora of the archipelago. Hahn *et al.* (2005, 2006, 2009) characterized the bird communities on the islands.

CONDUCTED ANALYSIS

Endangered plant species in the main vegetation types. All analyses and results presented in this review are based on the main vegetation types of Robinson Crusoe Island (Greimler *et al.* 2002a; 2002b) and the catalogue of the island flora detailed by Danton and Perrier (2006).

After sampling 106 vegetation plots (releves) all over Robinson Crusoe Island using the Braun- Blanquet cover abundance scale, Greimler *et al.* (2002b), identified 15 vegetation types on the island. The main vegetation types consider the eight largest plant communities (sampled through 97 plots, Greimler *et al.* 2002a). The total richness of vascular plant species present in each releve (97) was estimated. Endemic, native, and exotic plant species were counted, and the richness of "endangered" and "invasive exotic" taxa was evaluated. For the main vegetation types the total number of species in each category was obtained for each plot, and then averaged.

Native and endemic species were classified using the criteria of the endangered species red list of the International Union for Conservation of Nature (IUCN) provided by Danton and Perrier (2006). These categories were simplified to improve interpretation: a) "critically endangered" and "endangered" were regarded as those species that present an extremely high or a high risk of extinction in the wild; b) "vulnerable" were considered those species that are menaced in the wild, and c) "least concern" was attributed to species that are at low risk of endangerment.

The grade of invasiveness of exotic species was assessed using two categories *sensu* Danton and Perrier (2006): a) "dangerous invasive" *i.e.* exotic species already naturalized in the wild which endanger the survival of native species and b) "species with naturalization risks", *i.e.*

exotic species that present a certain risk of naturalization in the wild. Some exotics could not be classified because of c) "insufficient information".

To stabilize the sample effort among vegetation types, we used 999 non parametric bootstrap pseudo-replicates, re-sampling the original data sets (with replacement) to calculate the confidence intervals (95 %) for the mean species richness on each defined category. This was especially useful for the analysis of vegetation types with an insufficient number of plots. Analyses were done using the R project statistical program (R development Core Team 2010, Canty 2002).

Land birds habitat types and conservation status. We considered land bird species given they directly interact in the vegetation communities and some taxa present serious conservation problems (Hagen *et al.* 2005). Moreover there is good information available (Hahn *et al.* 2005, 2006, 2009). For all land bird species analyses we used the avifauna distribution lists detailed by Hahn *et al.* (2005, 2006, 2009).The authors sampled plots and line transects for visual and acoustic recognition of birds based on vegetation, estimating species abundances (Hahn *et al.* 2005). Six land bird habitat types were identified on Robinson Crusoe Island (Hahn *et al*. 2005). The land bird habitat types differ slightly from the main vegetation types (Greimler *et al*. 2002b). Upper and lower montane forests are bundled into one bird habitat type. Also, grasslands, *A. argentea* vegetation, and weeds assemblages are grouped in "grasslands and weed vegetation" (Hahn *et al*. 2005, 2009). The "settlement area" considered by Hahn *et al.* (2005) was excluded because this presented no floristic records (Greimler *et al.* 2002b), thus only five bird habitat types were considered in the analysis.

The number of breeding land bird species in each main vegetation type was evaluated taking into account the vegetal formations employed as habitats by land bird species. Abundances categories for each land bird species were defined using the population estimations of Hahn *et al*. (2006).

To consider the conservation status of land bird species, we took the geographical classification of Hahn *et al.* (2009). Not only ecological factors (*e.g.* reproduction, competition, predation, etc.) but also geographical features can provide information about the conservation value and need for a given bird taxon (Hahn *et al.* 2009, Walter 2004). Each bird species was independently ranked in regard to its conservation status based on six geographical parameters: history, area, dispersion, vagility, isolation and location (see eigenplace index: Walter 2004, Hahn *et al*. 2009).

To simplify the conservation status interpretation for land bird species three geographical conservation classes were defined: a) "highly threatened", *i.e.* bird species with restricted habitat and low abundance, b) "threatened", *i.e.* bird species geographically restricted but with higher vagility and abundance, and c) "not threatened", *i.e.* bird species with a wide distribution and larger dispersion potential and population.

Research about Juan Fernandez Islands. Based on Thomson-Reuters Web of Science (Web of Science 2010) we compiled the different scientific subjects studied about Juan Fernandez and Robinson Crusoe Island to identify the most studied topics related to the vegetation of Juan Fernández Islands. Although there is a lot of information apart from this citation system scattered among books, undergraduate theses, internal reports and local studies (*i.e.* grey literature); the data provided by this platform is a proxy for quality qualitative scientific information available for the islands. Even if some studies are missing, the Web of Science provides an excellent account of the current literature (de Bello *et al*. 2010).

We employed the specific keywords: "Juan Fernandez Islands", "Juan Fernandez archipelago", and "Robinson Crusoe Island" searching for the title for each scientific paper. We compiled the results by attributing the main thematic subject to each paper based on standard definitions (Web of Science 2010). We considered six broad thematic disciplines: botany, conservation, marine biology, zoology, medicine, and "other sciences". The latter included papers dealing with geology, climatology, architecture, and literature.

Botanical studies were subdivided in subjects dealing with taxonomy, morphology, physiology, vegetation sciences, forestry, and ecology (Sitte *et al.* 2002). Conservation papers included studies on scientific divulgation, applied ecology research, invasive exotic species, and endangered species propagation.

RESULTS

Endemic and endangered plant species in the vegetation types. The associations accommodating most endemic species were the upper and lower montane forest, followed by the *Ugni molinae* shrubland (figure 1A). The upper and lower montane forests contained in average more than 75 % and 65 % of endemic species respectively. The other vegetation types had lower total numbers and proportions of endemics (0 – 40 %). The average number of exotic species was noticeably higher in the weed vegetation, grasslands, and exotic tree plantations (figure 1A).

Except for the exotic plantations, all vegetation types contained species that were considered as endangered or vulnerable. The montane forests (upper and lower) and the *Ugni molinae* shrubland were the only associations that held a considerable number of endangered and critically endangered plant species. Around one quarter of native and endemic species in these associations were classified as critical endangered and endangered, or vulnerable (figure 1B).

Most exotic species found in the main vegetation types

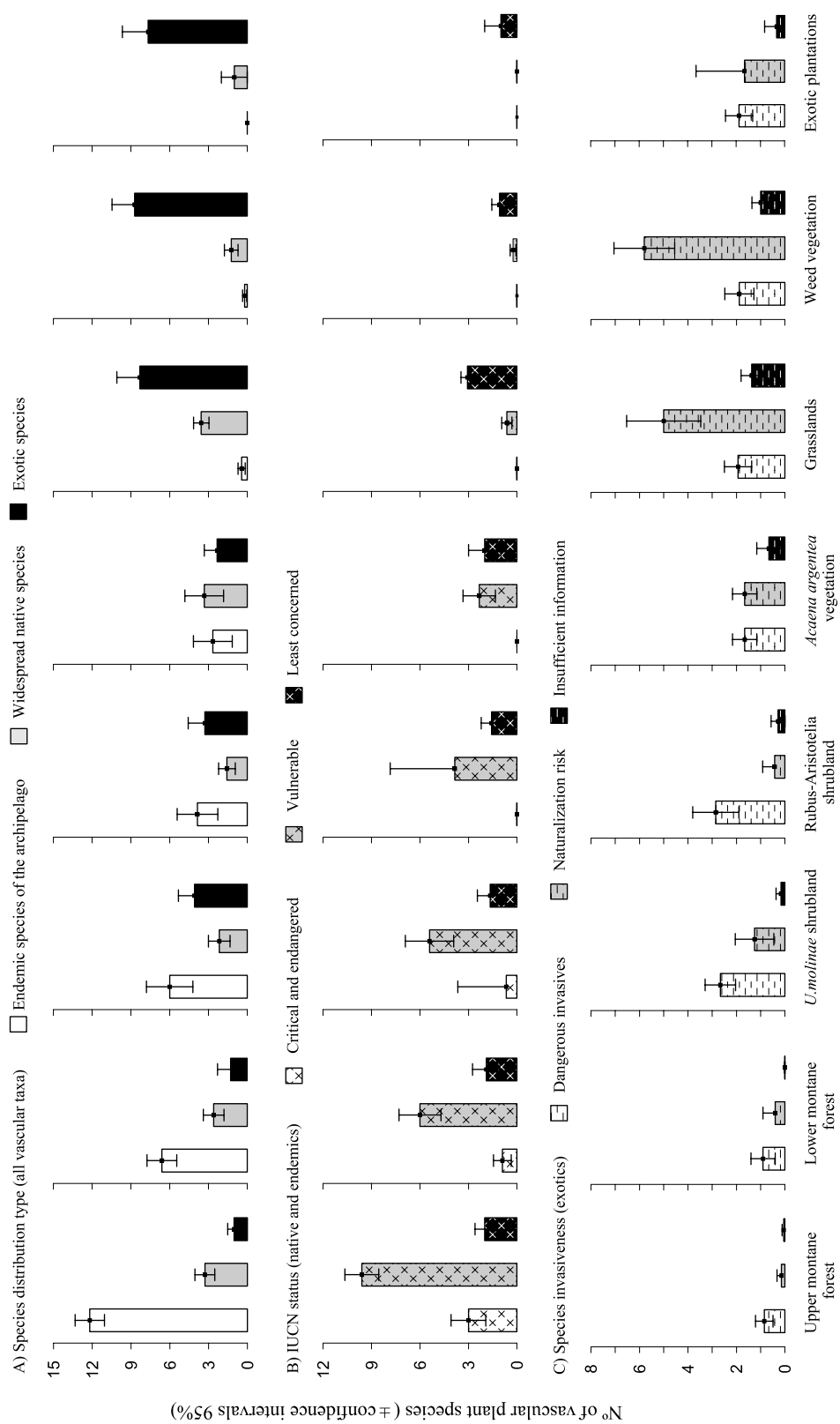

Figure 1. Mean species richness in the main vegetation types of Robinson Crusoe Island with respect to their distribution type (A), conservation status (B) and amount of invasive exotics (C) *sensu* Greimler *et al.* (2002b) and Danton and Perrier (2006). Confidence intervals (95 %) calculated after 999 bootstrap simulations for each vegetation type.
Riqueza promedio de especies en los principales tipos de vegetación de la isla Robinson Crusoe con respecto a su distribución (A), estado de conservación (B) y cantidad de especies exóticas invasivas (C) *sensu* Greimler *et al.* (2002b) y Danton y Perrier (2006). Intervalos de confianza (95 %) calculados luego de 999 simulaciones *bootstrap* para cada tipo de vegetación.

of Robinson Crusoe Island were classified as with naturalization risk or as dangerous invasive. Despite a lower average frequency of exotics, the proportion of dangerous alien species was the highest in the *Rubus-Aristotelia* shrubland and in the upper montane forest (*ca.* > 70 %). Species on the Weed and Grassland vegetation types were mostly exotics classified as "with naturalization risks" (figure 1C).

Land bird habitat types and conservation status. The resident land bird species on Robinson Crusoe Island (8) are distributed homogenously throughout the different habitats, usually living in more than one vegetation type. Bird species tend to prefer the habitat provided by exotic plantations, montane forests, and the *Rubus-Aristotelia* shrubland. Exotic bird species (2) accumulate around 10 % of the total bird population on Robinson Crusoe Island. Native land bird species (3) accumulate *ca.* 60% being present in all habitat types. Endemics birds (3) concentrate *ca.* 30 % of the total land bird population (figure 2).

Endemic and native birds presented their highest abundance in the upper and lower montane forests (> 2400 individuals). Although endemic bird species were present in exotic vegetation types such as the *Rubus-Aristotelia* shrubland and forest plantations, their abundance on them was very low (< 800 individuals).

Focus of studies on Juan Fernández archipelago and Robinson Crusoe Island. The amount of information is relatively large considering the small area of the islands. A total of 108 articles covering diverse scientific topics referring to the Juan Fernández Islands were found (figure 3). Most of the studies were about botany (51 papers) and marine biology (14), but research papers in geology, climatology, architecture and literature have also been published (included in other sciences, figure 3).

Within the fields of botany and conservation, most pa-

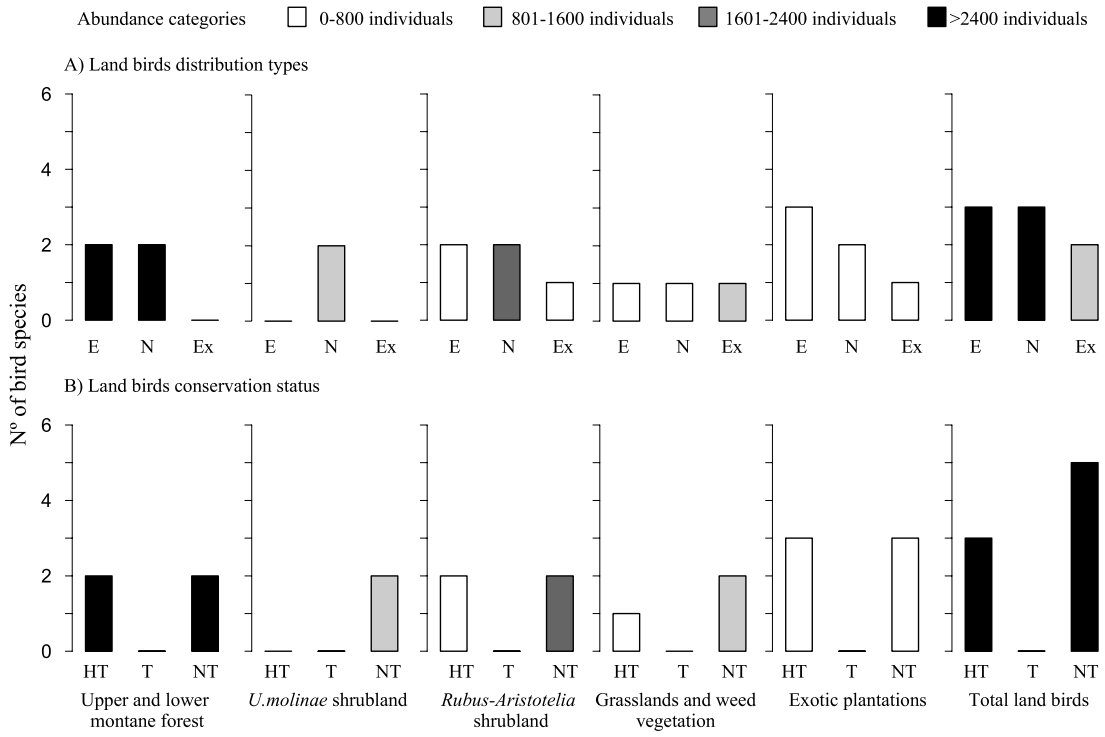

Figure 2. Number of resident land bird species in the most important vegetation habitat types of Robinson Crusoe Island. First line considers bird distribution types: E = endemic species, N = Native species (widely dispersed), Ex = exotic species. Second line includes the geographical conservation status: HT = highly threatened, T = threatened, N = non threatened. The colours of the bars represent abundance classes on each category. Data *sensu* Hahn *et al.* (2005, 2006, 2009).

Número de aves terrestres residentes en diferentes tipos de hábitat de la isla Robinson Crusoe. La primera fila considera el tipo de distribución de las aves: E = especie endémica, N = especie nativa (ampliamente distribuída), Ex = especie exótica. La segunda fila incluye el estado de conservación geográfico: HT = altamente amenazada, T = amenazada, N = no amenazada. Los colores de las barras representan clases de abundancia en cada categoría. Datos *sensu* Hahn *et al.* (2005, 2006, 2009).

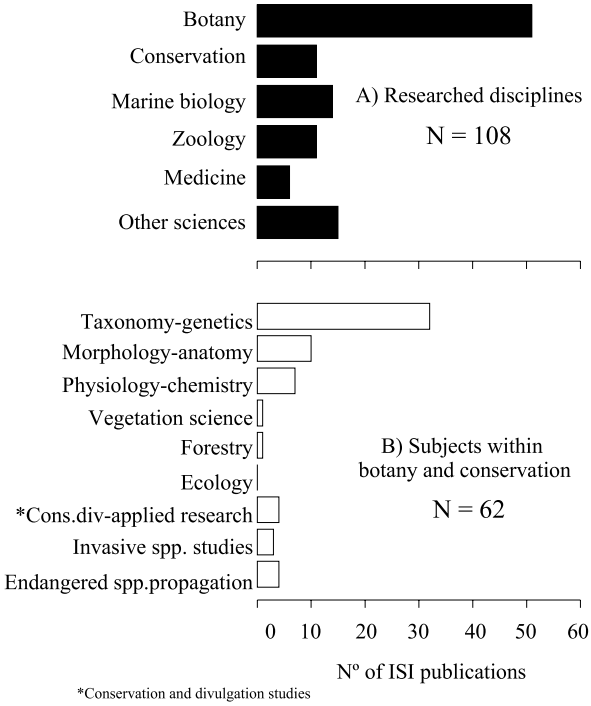

Figure 3. Research papers on scientific subjects on Juan Fernández Archipelago (Web of Science 2010).
Trabajos de investigación en temas científicos acerca del archipiélago Juan Fernández (Web of Science 2010).

pers deal with taxonomical and genetic aspects of fauna and flora (32). Specific topics that could present some interest, like: ecology and forestry have been scarcely treated in ISI journals[1], and there is only one specific paper referring to vegetation sciences. Conservation research has been focused on scientific divulgation, endangered species propagation and invasive species studies.

DISCUSSION

Forest: conservation hotspot. The most critical areas for plant conservation on Robinson Crusoe Island are the montane forest formations. They concentrated the highest number and proportion of endemic and endangered plant species. In addition, they constituted the most important habitat type for two of the three endemic land bird species of Robinson Crusoe, including the highly threatened hummingbird *Sephanoides fernandensis* and the Juan Fernández Tit tyrant *Anaerites fernandezianus* (Hahn *et al*. 2005). Almost all of the exotic plants occurring on these vegetation types are dangerously invasive which might affect the survival of native vascular species by competition or direct suppression (Danton and Perrier 2006), disturbing also the nesting habitat of endemic bird species (Hagen *et al.* 2005).

Around 70 % of plant species of the upper and lower montane forest were endemic. The proportion of endemic plants was considerably higher than that of other similar ecosystems such as the coastal Valdivian forest in Chile (*ca.* 50 % of endemism) or the woodlands of Polynesian and Micronesian regions (*ca.* 57 %) which are both considered priority areas for biodiversity conservation (Biodiversity Hotspots 2010).

In four of the eight main vegetation types found on Robinson Crusoe Island more than half of native species were ranked as vulnerable, endangered or critically endangered. This agrees with Ricci (2006) who assesses the majority of the native flora of the archipelago as in danger of extinction. A similar condition can be found for the vegetation of Hawaii and Canary Islands where 40 % and 20 % of its endemic taxa (respectively) are classified as endangered (Loope and Mueller-Dombois 1989). Consistently, one third of all known endangered plants occur on oceanic islands (Francisco-Ortega *et al*. 2000).

On Robinson Crusoe Island, bird species seem to prefer well structured vegetation, higher than 3m meters without much preference for plantations or montane forests. Most bird species on the island occur in exotic plantations (six from eight) but generally in low abundance (< 800 individuals). Forest plantations are located near San Juan Bautista town. This area, in a small spot, presents a mosaic of gardens, thickets and exotic plants of high feeding potential for birds (Hahn *et al*. 2005). This is normal in central Chile, where pine plantations on the surroundings of coastal fragmented forests hold most of native bird species (Tomasevic and Estades 2007).

Among vegetation types, the richness of land bird species did not differed greatly. However there were divergences considering land bird species population: endemic and threatened bird species were more copious in the montane forest. Native and endemic bird populations depend on the conservation of the original vegetation of Robinson Crusoe Island (Hahn *et al.* 2005, Hagen *et al*. 2005). The native land bird species (*S. sephanoides* and *T. falcklandii*) were the only widespread distributed within all the Robinson Crusoe Island habitat types presenting the highest populations. Especially the abundance of *T. falcklandii* is currently considered as a huge conservation problem given its interaction on the dispersion of the most invasive exotic weeds (*R. ulmifolius, A. chilensis* and *U. molinae*). This might have helped the success and speed of a plant invasion process in Robinson Crusoe Island, with deplorable effects on the native biodiversity of the island[2].

Conservation status and information needs. The loss of biodiversity is a problem that occurs on a local or regional scale but presents a negative global impact that may affect important ecosystem processes (Wardle and Zackris-

[1] Thomson Reuters ISI (Web of Science 2010).

[2] C. Smith-Ramírez. Personal communication.

son 2005). It is thought that biodiversity loss may have already surpassed the boundaries of safe operating space for human sustainability, making urgent to advocate for its protection and restoration (Rockström *et al*. 2009).

Juan Fernández Archipelago has been considered of high priority for Chile's biodiversity conservation due to its conservation risk, its limited area and high levels of endemism (Biodiversa 2009). Despite the importance of the archipelago, there are only few studies referring to ecological or structural characters of the island's forests (Vargas *et al*. 2010). Although specific studies dealing with the woodlands of the archipelago (Danton 2006) even assigned a name for Juan Fernández forest formations ("Myrtisilva (-ae)") there is no information about the patterns, heterogeneity, functions or dynamics of these ecosystems. This knowledge, however, might be necessary as reference state for active conservation (Hobbs 1996).

Conservation literature about Juan Fernández Archipelago is dominated by case studies of noteworthy species. Different reasons, like the large distance to mainland, and the interest mainly related with conservation, far away from economical direct profitable activities, might explain the low scientific attention towards these forests (Anderson *et al.* 2001, Bernardello *et al.* 2001), that lack of studies with integrated ecological research scope.

Similar forest relicts in continental Chile such as Fray Jorge National Park (*ca.* 10,000 ha) are covered in less scientific publications, but *ca.* 30 % of the papers refer to the ecological forest characteristics (Web of science 2010, Gutiérrez *et al*. 2008). Similar temperate forests of southern central Chile, that are less interesting in terms of endemism and endangered species, have been widely studied (Veblen *et al*. 1981, Donoso 1993, Armesto *et al*. 1998). Forests on other oceanic islands such as Canary (Fernandez-Palacios and Arévalo 1998), Azores (Elias and Dias 2009), Hawaii (Mueller-Dombois 1987) and Bonin (Kawakami and Okochi 2010) have also attracted more scientific attention.

The forests of Robinson Crusoe Island are the only woodlands in Chile (and possibly in the world[3]) that are formed exclusively by endemic tree species. If appropriate actions to save the forests are not taken soon, they will be lost. Conversion of these forests into novel formations dominated by alien species would occur in less than 80 years (Dirnböck *et al*. 2003). It is of primary importance to focus the research on the forest areas to reverse the degradation process. It seems paramount to define realistic goals to ensure the maintenance of the most endangered species as well as implement and document restoration activities.

Beyond the conservation of a single plant or bird species, it is more important to preserve the ecosystems in which those particular species live (Franklin 1993). On Robinson Crusoe Island there could be a relationship among conservation of the montane forest, freshwater production and conservation of marine life near the coast (Danton and Perrier 2009). In this context, the conservation of the endemic forest of Robinson Crusoe Island would guarantee not only the preservation of the habitat of the most endangered plants and birds, but also the sustainability of fishery which is the most important economical activity of the local community.

[3] P Danton. Personal communication.

CONCLUSIONS

The forest of Robinson Crusoe Island congregates the most endangered species of endemic vascular plants, and threatened land bird species in an area of less than 900 ha (upper and lower montane forest). These vegetation units can be considered especially attractive for conservation within the whole Juan Fernández Archipelago which is itself a priority area for biodiversity preservation. These woodlands may offer elevated returns for species habitat restoration in the aim of the conservation of most taxa. Scientific attention has not been focused on holistic ecological research including the forest ecology. There is little knowledge about population dynamics of native and exotic plant species or the role of dispersal vectors of invasive species. Either, there are no papers available dealing with restoration including proper monitoring and evaluation. However those matters are of utmost importance in order to protect this endemism hotspot.

ACKNOWLEDGMENTS

Special thanks go to Josef Greimler (University of Vienna, Austria), Ingo Hahn (University of Münster, Germany), Philippe Danton and Christophe Perriere (Robinsonia Association Grenoble, France) who kindly facilitated their data bases. Without them this review wouldn't have been possible. Thanks to Katja Seis, Dimitriois Samaras, Osvaldo Vidal and Jan Bannister (Freiburg University) who contributed with good tips and comments to previous versions of the manuscript. We are especially grateful to Mr. Iván Leiva, and all the CONAF functionaries on Robinson Crusoe Island and to the residents of Juan Fernández who have always been very supportive. Special thanks to Cecilia Smith-Ramírez for her collaboration and input on the further research for conservation on the Juan Fernández. Thanks to Michael Werner (Western Australia University) for English checking. We appreciate the contribution of two anonymous reviewers. This work was funded by CONICYT Presidente de la República scholarship (Chile), the Georg Ludwig Hartig Stiftung and the Badischen Landesverein für Naturkunde und Naturschutz (Germany).

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Recibido: 14.10.10
Aceptado: 16.05.11