



The MaB Reserve of Ñacuñán, Argentina: its role in understanding the Monte Desert biome

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Temperate and semi-arid regions of Argentina are undergoing rapid habitat conversion as a result of several human activities (i.e. grazing, logging, agriculture, etc.). These arid ecosystems contain many endemic species and have played an important role in the evolution of South American biota. The Man and Biosphere Reserve of Ñacuñán (12,800 ha) is located in the central region of the lowland Monte Desert. The reserve is a stand within a highly disturbed matrix characterized by deforestation (i.e. mesquite, *Prosopis*) and overgrazing. Major vegetational and animal communities recovered after the reserve was fenced in 1972, and Ñacuñán thus provides critical data describing the recovery of biotic and abiotic components of the Monte Desert when anthropogenic assaults are minimized. Indeed, the Reserve of Ñacuñán protects many distinctive habitats of the Monte Desert, including mesquite forest, or algarrobal, and several representative animals of the South American biota (i.e. tinamous, rhea, marsupials, edentates and caviomorph rodents). Several research projects on community ecology, herbivory, disturbances, ecology and ecophysiology have been or are being developed in the reserve. Although the town of Ñacuñán lies within the reserve, the link between the research community and the local people has not been strong, persistent or effective. The reserve is the most important site in Argentina for monitoring the ecological health of the Monte Desert and for developing indicators of desertification. Its potential is great for long-term ecological research and for strengthening the infrastructure of science. Sustainable development in the next millennium requires integrating the activities of the research, local people, ranch landowners and governmental sectors so as to infuse science-based proposals into management and conservation initiatives.

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Introduction

The arid and semi-arid biomes of Argentina are undergoing rapid habitat conversion. In the extensive Chaco-Monte-Patagonia lowland, deserts are experiencing the serious damaging effects of human activities, especially overgrazing by goats, sheep and cattle;

clear cutting for fuel; and land clearing for agriculture, mining and oil exploration (Schofield & Bucher, 1986; Roig, 1991).

The extensive deforestation and selective extraction of hardwood and clear cutting of mesquite forests (*Prosopis flexuosa* and *P. caldenia*) in the lowland Monte Desert, including the Espinal, began in the late 19th and early 20th centuries and continues today. Estimates for 1869 reveal that Argentina had 15 million ha of *P. caldenia*; today, *P. caldenia* occupies no more than 108,000 ha. Together, anthropogenic activities during the past 150 years have led to pronounced desertification, disruption of habitats and changes in the biodiversity and geographic ranges of many species in extensive portions of the temperate southern cone (Roig, 1991).

The drylands of South America were an important setting for evolution of the temperate biota of the continent. A large proportion of the dryland species are not found elsewhere in the New World (several marsupials, edentates, caviomorph and murid rodents). In part, this degree of endemism is a consequence of evolution in isolated drylands in the southern part of the continent since the Oligocene (Patterson & Pascual, 1972; Webb, 1978; Ojeda & Mares, 1982; Reig, 1986; Ojeda *et al.*, 1997).

The Biosphere Reserve of Ñacuñán in the lowland Monte Desert of Argentina contains an important segment of the biotic diversity, landforms and disturbance regimes of the arid lands of South America. Combating desertification requires identifying biophysical and socio-economic indicators (i.e. early warning signals) and maintaining an open dialogue between scientific and local communities. In this paper we present an overview of the Reserve of Ñacuñán in this context.

The Reserve of Ñacuñán

The Man and Biosphere Reserve of Ñacuñán (34°02'S, 67°58'W) is located in Mendoza Province, Department of Santa Rosa, Argentina (Fig. 1). The area belongs to the Monte Desert phytogeographic province (Morello, 1958). Geomorphologically it is an undulating plain (540 m a.s.l.) formed from fine-grained soils derived from the Andean Cordillera, 100 km to the west (Tanquilevich, 1971). The climate is semi-arid and strongly seasonal, characterized by hot, humid summers and dry, cold winters. Average annual precipitation is 326 mm (Ojeda, 1989). High annual and inter-annual variation in monthly precipitation, especially in the late spring and summer (November–March), is an important climatic feature of Ñacuñán (Fig. 2(a,b)) (Campos, 1997; Gonnet, pers. com.; Ojeda, pers. obs.). Mean temperatures are lower than 10°C in winter and above 20°C in summer.

The reserve was created by provincial law in 1961 to protect the algarrobal or mesquite forest of *Prosopis flexuosa* DC., one of the most conspicuous habitat types of the area. The reserve consists of 12,800 ha and is crossed from north to south by a railway that runs parallel to Road No. 153. The railway station and town of Ñacuñán lie within the reserve.

In 1966 the Department of Renewable Natural Resources of the Government of Mendoza Province began to support a scientific infrastructure (i.e. research station), and in 1970 the Argentine Institute for Arid Zone Research (IADIZA) became responsible for managing the reserve and the biological station (Roig & Roig, 1971). In 1986 Ñacuñán was incorporated into the UNESCO Man and Biosphere Reserve Network (InfoMAB, 1992).

Biological importance of the Ñacuñán Reserve

The region of Ñacuñán is a diverse mosaic of habitats. The major plant communities include the mesquite forest (*Prosopis flexuosa*, 'algarrobal') and creosotebush (*Larrea divaricata* Cav. and *L. cuneifolia* Cav., 'jarillal'). To a lesser degree, sand dune ('medanal') and saltbush (*Atriplex lampa* Gill. ex Moq., 'zampal') communities are also represented in the reserve area (Roig, 1971).

The mesquite forest is the most complex habitat. The tree stratum is characterized by *F. flexuosa* and *Geoffroea decorticans* (Gill. ex Hook.). Dominant shrubs are *L. divaricata*, *L. cuneifolia*, *Lycium* spp., *Condalia microphylla*, *Capparis atamisquea*, *A. lampa* and *Verbena* spp. The most important grasses are *Digitaria californica*, *Pappophorum caespitosum*, *Aristida* spp. and *Setaria*.

The creosotebush-grass habitat interdigitates with mesquite forest. The main features of the creosotebush-grass habitat are the absence or low density of trees and high cover of shrubs and grasses. In clay soils, low cover dominated by *L. cuneifolia* ('peladal') essentially produces a monoculture (Roig, 1971). Two strata characterize this habitat: shrubs and bare ground.

The fauna of Ñacuñán is well known (Table 1). Representative desert vertebrates of the reserve include the red tegu lizard (*Tupinambis rufescens*), boa (*Boa constrictor*),



Figure 1. Location of the Monte Desert Biosphere Reserve of Ñacuñán in Mendoza Province, Argentina.

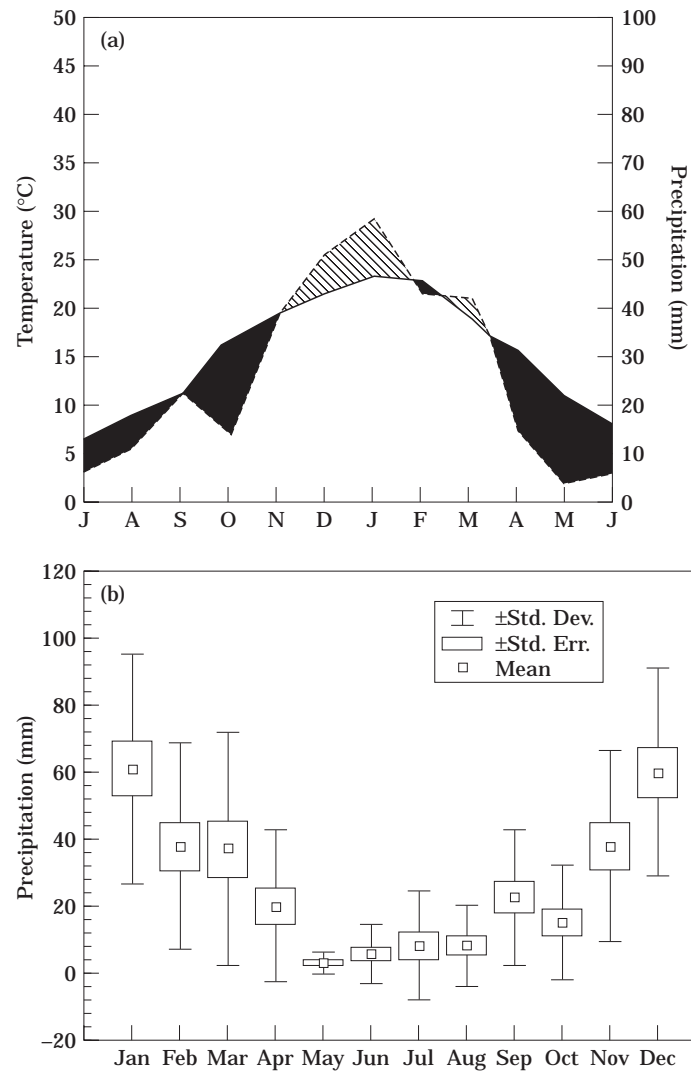


Figure 2. (a) Climatogram of Nacuñán based on temperature (—) and precipitation (---) showing periods of water deficit (■) and water surplus (▨). (b) Variation in monthly precipitation (mean, standard deviation and standard error) in the Biosphere Reserve of Nacuñán for the period 1980–1996.

Table 1. Faunal biodiversity in the Reserve of Nacuñán

	Amphibia	Reptilia	Aves	Mammalia
Order	1	2	16	5
Families	2	10	36	11
Genus	3	16	107	14
Species	3	21	134	29

greater rhea (*Rhea americana*) and the elegant-crested tinamou (*Eudromia elegans*). The reserve was once part of the range of the guanaco (*Lama guanicoe*) (Contreras, 1979). Several threatened vertebrate species are protected here, among them the desert tortoise (*Geochelone chilensis*) (Reptilia), the lesser pichiciego (*Chlamyphorus truncatus*), the pampas cat (*Felis pajeros*), the Patagonian hare (*Dolichotis patagonum*) and the red vizcacha rat (*Tympanoctomys barrerae*) (IUCN, 1996; Ojeda & Diaz, 1997).

In Argentina the drylands have the greatest number of endemic mammal species (Ojeda *et al.*, 1997). The Reserve of Nacuñán includes the distributional ranges of many species of Monte, Patagonia and Chacoan origins. Ancient mammalian lineages (marsupials, edentates and hystricognath rodents) are well represented in the area. Among these species are the fairy armadillo (*Chlamyphorus truncatus*), screaming pichy (*Zaedyus pichiy*), red vizacha rat (*Tympanoctomys barrerae*), Patagonian hare (*Dolichotis patagonum*), Patagonian cavy (*Microcavia australis*), plains viscacha (*Lagostomus maximus*) and gopherlike tuco-tuco (*Ctenomys eremophilus*).

In Latin America, wildlife (Table 2) plays an important role as a source of food, medicine and commercial and sport hunting (Ojeda & Mares, 1982; Mares & Ojeda, 1984).

Table 2. Use of faunal resources in Nacuñán

Common name	Scientific name	Use
Reptiles		
Red tegu lizard	<i>Tupinambis rufescens</i>	skin, food
Turtle	<i>Geochelone chilensis</i>	food, pets
Birds		
Greater rhea	<i>Rhea americana</i>	feathers, food, skin
Crested tinamou	<i>Eudromia elegans</i>	food, sport hunting
Lesser tinamou	<i>Nothura maculosa</i>	food, sport hunting
Doves	Several species	food, sport hunting
Parrot	<i>Cyanoliseus patagonum</i>	pets
Parakeet	<i>Myopsitta monacha</i>	pets
Mammals		
White-eared opossum	<i>Didelphis albiventris</i>	skin, food
Hairy armadillo	<i>Chaetophractus vellerosus</i>	food, carcasses for handycrafts, guitars, etc.
Screaming armadillo	<i>Zaedyus pichiy</i>	food and carcasses
Plains viscacha	<i>Lagostomus maximus</i>	skin, food, sport hunting
Patagonian hare	<i>Dolichotis patagonum</i>	skin, food, sport hunting
Common skunk	<i>Conepatus suffocans</i>	skin
Gray fox	<i>Dusicyon griseus</i>	skin
Geoffroy's cat	<i>Felis geoffroyi</i>	skin
Pampas cat	<i>Felis pajeros</i>	skin
Jaguarundi	<i>Felis yagouaroundi</i>	skin
*European hare	<i>Lepus europaeus</i>	sport hunting, food, skin
*European wild boar	<i>Sus scrofa</i>	sport hunting, food

*Exotic species.

The MaB Reserve of Ñacuñán as a research and control area

The main sources of disturbance in this area consist of livestock grazing and its associated infrastructure (i.e. water points, fences, trails, human settlements), along with logging, intentional fires and invading species such as the European hare, *Lepus europaeus* (Lagomorpha), and the wild boar, *Sus scrofa*. Cattle grazing is one of the most important economic activities in Ñacuñán. Intensive grazing began in the middle of the 19th century and peaked at the beginning of the 20th century. Currently the number of cattle has decreased by about 50% from the peak (Fig. 3). This decrease probably reflects a decline in the region's carrying capacity as a result of overgrazing.

The Reserve of Ñacuñán has been protected for more than 25 years. The surrounding matrix has a conspicuously larger proportion of bare ground and lower vegetative cover than the reserve (Fig. 4). Thus, Ñacuñán constitutes an appropriate reference-research laboratory for developing ecological indicators and thresholds of desertification (Ojeda, 1989; Gonnet, pers. com.). Observations of small mammal responses to simplification in vegetative structure due to fire perturbations have shown that at the end of the first year, species diversity decreases from an original set of five species (unburned habitat) to one (burned habitat) (Ojeda, 1989; Fig. 5). Understanding the structure and function of the Monte Desert ecosystem (Mabry *et al.*, 1977; Orians & Solbrig, 1977; Simpson, 1977) will, in turn, provide the proper data for wise management of public and private lands. Ñacuñán data are included in important physical and biological data bases.

Research projects have been funded by several organizations such as the National Council for Science and Technology (CONICET), Man and Biosphere Program, National Science Foundation (NSF), National Geographic Society and other governmental institutions. Results of these studies have been presented in a wide range of journals, books and doctoral dissertations. Research focuses on various aspects of this arid ecosystem, from climatic and geomorphological descriptions (Tanquilevich, 1971; Estrella & Heras, 1973; Estrella *et al.*, 1979) to studies of flora and fauna. Faunal studies comprise topics such as insect ecology (Claver, 1990; Claver & Fowler, 1993; Debandi, unpubl. data; Lagos, unpubl. data) and vertebrate community composition

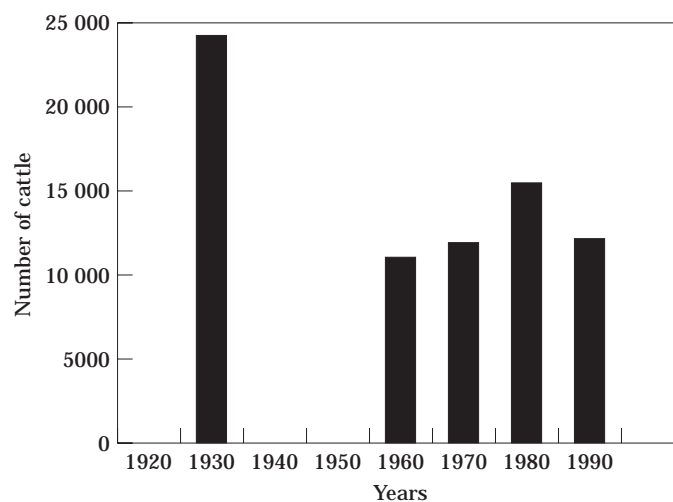


Figure 3. Number of cattle in the Santa Rosa Department of Mendoza, Argentina, since 1930.



Figure 4. Landsat image of Ñacuñán Biosphere Reserve, Mendoza, Argentina.

and ecology (Contreras, 1979; Contreras & Roig, 1979; Marone, 1990*a,b*, 1991, 1992; Navarro, 1991; Videla & Puig, 1994).

Ñacuñán offers a unique situation for research on ecological, physiological and behavioral desert adaptations. Some of the most specialized desert mammals, such as the endemic red vizcacha rat, *Tympanoctomys barrerae* (Octodontidae), inhabit the reserve (Ojeda *et al.*, 1989). This highly adapted hystricognath rodent feeds on halophytic vegetation of high salt content (Ojeda *et al.*, 1996) and is convergent with other world desert rodents such as *Dipodomys microps* (Heteromyidae) of North America and *Psammomys obesus* (Muridae) of Africa (Mares *et al.*, 1997; Ojeda *et al.*, pers. com.). Research on renal morphology and water balance are under way for several species of murid and hystricognath Monte Desert rodents (Diaz, unpubl. data; Diaz & Ojeda, pers. com.). Ecological studies of small and medium-sized mammals of the Monte Desert biome have shown the importance of herbivory and omnivory (Kufner & Pelliza de Sbriller, 1987; Kufner & Durañona, 1991; Campos, 1997; Borruel *et al.*, in press; Tognelli *et al.*, pers. com.), seed dispersal (Campos & Ojeda, 1997; Fig. 6), habitat preferences (Kufner & Chambouleyron, 1991, 1993; Tognelli *et al.*, 1995; Giannoni *et al.*, 1996; Gonnet, pers. com.) and effect of disturbances and conservation (Maldonado-Curti, 1989; Ojeda, 1989; Gonnet, pers. com.). Studies of vegetation are mostly concerned with productivity (Guevara *et al.*, 1973; Braun *et al.*, 1978; Guevara *et al.*, 1978; Braun & Candia, 1980; Candia, 1980; Cavagnaro & Dalmasso, 1983; Cavagnaro *et al.*, 1983; Dalmasso *et al.*, 1983; Cavagnaro, 1988; Monge, 1989; Passera *et al.*, 1992; Seligman *et al.*, 1992; Passera *et al.*, 1996; Marone & Horno, 1997), nutritive value of forage species (Wainstein & González, 1971*a,b*), physiology (Seligman *et al.*, 1992) and phytosociology (Roig, 1971, 1980; Rossi, unpubl. data). Social studies of the inhabitants of the town of Ñacuñán and surrounding ranchlands have also been addressed (Guevara, 1978*a,b*; Abraham & Wuilloud, 1988; Guevara *et al.*, 1990; Daniele, 1991; Daniele *et al.*, 1993).

The reserve plays an important role in the ecological training of graduate and undergraduate students. Since 1983 several intensive field courses on desert ecology, inventorying and monitoring biodiversity have been offered by the staff of the Arid Zone Research Institute (InfoMAB, 1992).

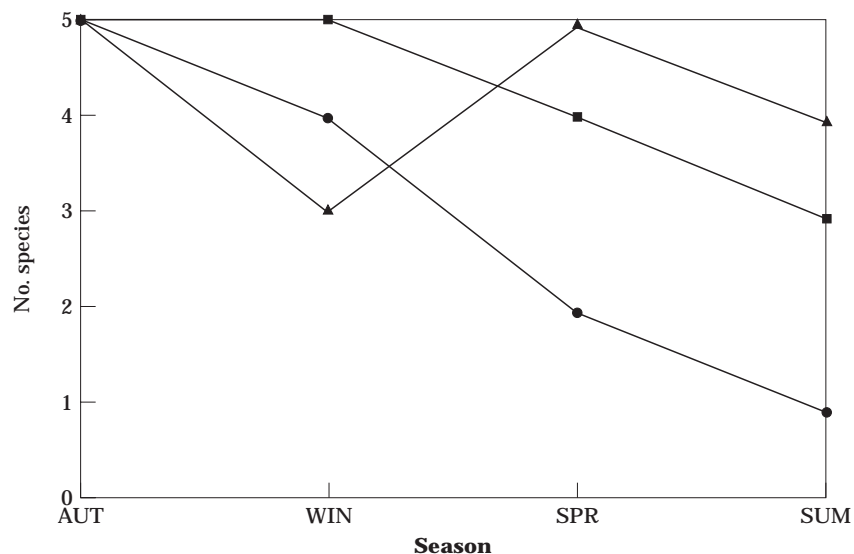


Figure 5. Small mammal species diversity during the first year following perturbation by fire in the Reserve of Ñacuñán in three situations: unburned (control) (▲), edge of burn (■) and burned (●) (after Ojeda, 1989).

History and problems to be addressed

The reserve was established from public lands for which no title deeds existed from colonial times. In fact, no records of these lands existed before 1907, when they were sold at auction. They remained private property until 1937. Under private ownership (1907–1937) the land underwent intensive deforestation, which coincided with the advent of the railway in 1908. Native forests of *P. flexuosa* were logged, mainly to produce charcoal for fuel (Roig & Roig, 1971). In 1937 the area returned to public domain, and its vegetation was overgrazed until the area was fenced in 1972. The area's indigenous population (Araucanian origin) was small and devoted to hunting and fruit collection. Settlement by Europeans dates to the middle of the 16th century. Livestock grazing on extensive open fields was the main land use.

The relationship between the indigenous population and Europeans was precarious. In fact, a state of war against Spanish colonists began during the middle of the 17th century. By the end of that century the colonists began to secure the lands. By building forts, they finally controlled the land by the early 18th century (Prieto & Abraham, 1994). Significant human-induced changes in the ecosystem accompanied the consolidation of Spanish settlements. In the middle of the 19th century livestock grazing began to dominate the landscape (Roig & Roig, 1971; Prieto & Abraham, 1994).

Seventy-eight people inhabit the town of Ñacuñán. Some lost their jobs when the railway was privatized in 1993. About 54% of these inhabitants are temporary workers, 33% are public employees, 9% are retired and 3% are ranchers (IADIZA, 1995a; Torres & Delugan, pers. obs.). Firewood extraction and subsistence hunting have been common practices by ranchers and townspeople.

Scientific research on the reserve is not well integrated with the activities of the local population and ranchlands. The ranchers and the scientific community seldom communicate. So irrational land use prevails here as in most of Argentina's arid lands. Rotational grazing patterns are not used, and the entire area is continuously grazed. Watering points are few and inadequately placed. For example, the District of Santa

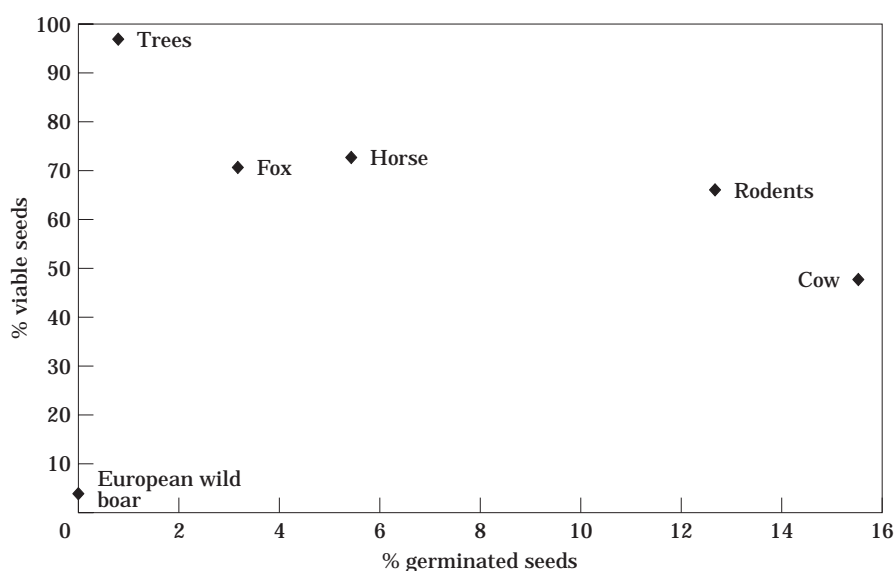


Figure 6. Dispersal of mesquite (*Prosopis flexuosa*) seeds by native, exotic and domestic mammals in the Monte Desert. Relationships between viable and germinated seeds that had passed through the digestive tract of different dispersers (after Campos & Ojeda, 1997).

Rosa, where the reserve is located, has only one watering point per 7631 ha (Guevara *et al.*, 1978). Cattle must walk long distances for water and are likely to lose weight in the process. To make quick profits, ranchers usually over use the land at the expense of productivity. The results are losses of biodiversity and wildlife biomass and changes in species composition and soil properties. Clearly, Ñacuñán contrasts sharply with the surrounding matrix. A comparative study showed that seed crop and finch abundance decrease with high-intensity cattle grazing on the reserve (Fig. 7(a, b)). On the other hand, medium-size herbivorous mammals more often occupy open vegetation patches created by range practices (Fig. 7(c)) (Gonnet, pers. com.).

Environmental education activities are few, only temporary, and not performed within long-term programmes. As a result, most of the population is unaware of the reserve's existence and its objectives. Inhabitants of the reserve and of the associated ranchlands have limited economic opportunities. To survive they must hunt and extract wood from the reserve. They view both activities as typical of a pastoral existence. Most of the population ignores the restrictions on hunting and logging in the reserve. Those who are aware of them believe that these restrictions on the use of natural resources are the products of senseless and whimsical decisions. Moreover, a management plan for the reserve has not yet been implemented although a proposal exists to this effect (IADIZA, 1995*b*).

Another problem in linking the reserve with its local community is the location of the reserve headquarters in the city of Mendoza, 200 km from the reserve. As a result, administrators, research staff and local people seldom interact. Among the most important needs are a clear definition of roles of the sectors participating in the reserve (administrators and research staff of the Argentine Institute for Arid Zone Research (IADIZA), the federal and state governments and the local people), stronger financial support, park rangers, several infrastructure facilities (e.g. vehicles, more laboratory facilities) and an administrative-interpretation centre in the town of Ñacuñán. This administrative centre would help facilitate science-based decisions concerning the reserve and the development of stronger linkages and partnerships among science, local people and ranch landowners.

The participation of the town of Ñacuñán should be promoted. Local people must be empowered as promoters of the reserve's activities, visitor guides, control people, assistant managers and research field assistants. Indigenous people can make a living by implementing small-scale programmes to rear desert wildlife in captivity (i.e. tinamous, Patagonian hare, plains vizcacha), either for consumption or hunting.

Overview

The Reserve of Ñacuñán is the most important reference site in Argentina for monitoring the ecological health of the Monte Desert. Field stations serve as points of reference and sites for long-term research. Such sites are particularly critical for developing and calibrating biophysical indicators of desertification and identifying their thresholds. These concerns were among the concluding remarks of several discussion groups in the desertification workshop held in Tucson, Arizona (U.S.A.) in May 1997. Desert research stations play a vital role in defining sustainable alternatives that eventually must be incorporated into local land use practices.

The Biosphere Reserve of Ñacuñán represents a large-scale experiment that continues to demonstrate the recovery of desert biotas after excluding cattle for 25 years. The real challenge is to demonstrate that the Monte Desert can be sustainably managed. Moreover, Ñacuñán supports the infrastructure of science by disseminating techniques in field ecology and wildlife management, identifying and monitoring biodiversity and quantifying the role of habitat complexity and seed-dispersal by herbivores on community structure and ecosystem processes. The next step is to

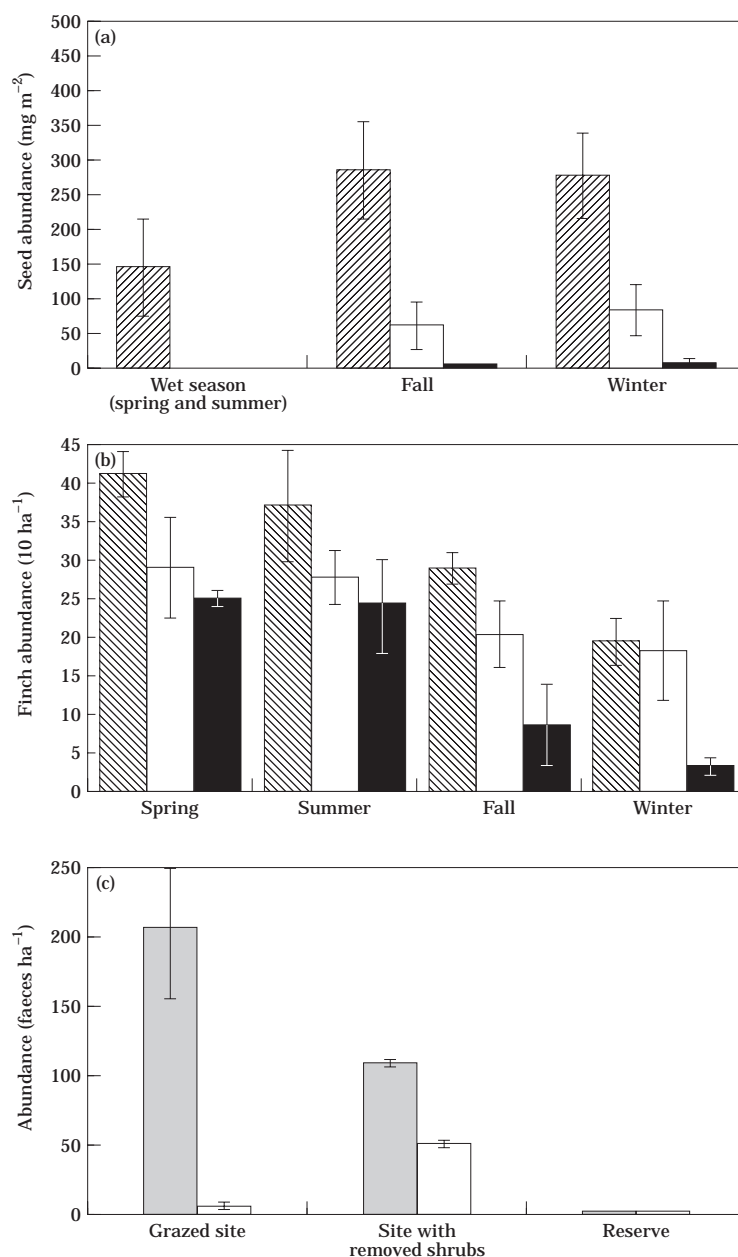


Figure 7. (a) Seasonal variation in the abundance of herb seeds at three different intensities of cattle grazing in Ñacuñán. Samples were taken in 30 m^2 plots between November 1995 and September 1996. Bars represent the standard error (Gonnet, pers. com.). (▨) = Ñacuñán Reserve; (□) = grazed site excluded from cattle; (■) = continuous grazing. (b) Seasonal variation of finch (Fam. Emberizidae) abundances at three intensities of cattle grazing in Ñacuñán. Abundance was counted with 30 circular plots of fixed radius (40 m) between November 1995 and September 1996. Bars represent the standard error (Gonnet, pers. com.). (▨) = Ñacuñán reserve; (□) = grazed site excluded from cattle; (■) = continuous grazing. (c) Average abundance of the Patagonian hare (*Dolichotis patagonum*) (▨) and European hare (*Lepus europaeus*) (□) in three habitats in the region of Ñacuñán. Bars represent the standard error. Abundance was estimated between December 1995 and February 1996 by counting fresh faeces on six belt transects ($1000 \times 25 \text{ m}$) at each site (Gonnet, pers. com.).

integrate the ecological understanding with the culture of the local population and ranchlands. We must integrate indigenous knowledge, expertise and wisdom into scientific structure and incorporate the local people (rangers, managers, assistants, volunteers) as part of the reserve's diverse activities (Kaus, 1993). Community involvement at all levels cannot be overlooked if we want to develop a sustainable land use programme for the Monte Desert biome.

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