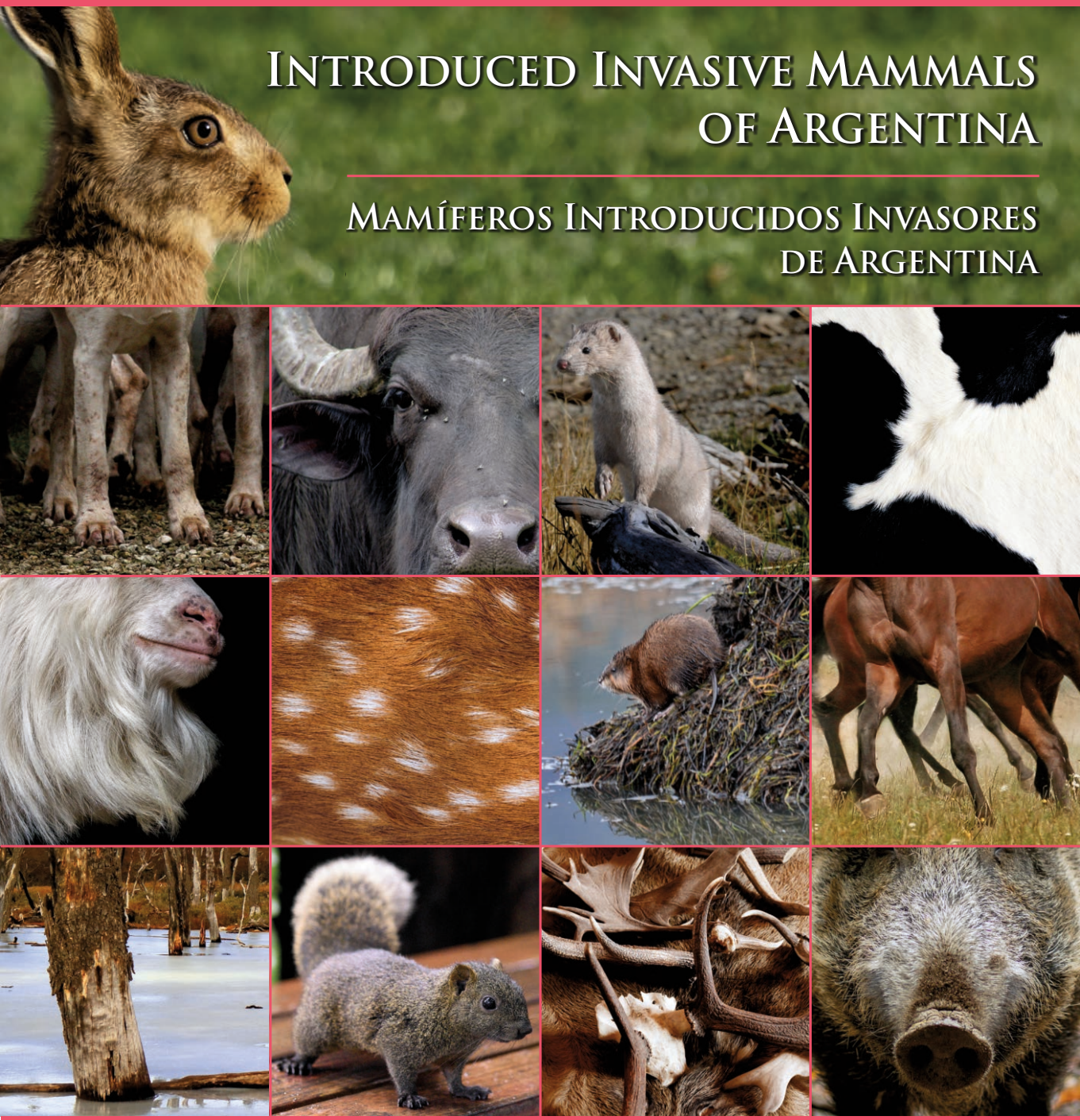
SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas

Volume 3

Introduced Invasive Mammals of Argentina

Mamíferos Introducidos Invasores de Argentina



Alejandro E. J. Valenzuela, Christopher B. Anderson, Sebastián A. Ballari and **Ricardo A. Ojeda**, Editors

The Argentine Society for the Study of Mammals (Sociedad Argentina para el Estudio de los Mamíferos – SAREM) was created in 1983, and currently has about 300 members from several countries. SAREM is an interdisciplinary society of natural sciences professionals whose main goals are the promotion of scientific and technical research, the consolidation of national collections and research centers, and the publication and diffusion of research on living and/or extinct mammals. SAREM has organized scientific meetings for mammal researchers since 1994, publishes the journals *Mastozoología Neotropical* and *Notas sobre Mamíferos Sudamericanos*, and has edited books on the systematics, distribution and conservation of the mammals of southern South America, including *Libro Rojo de los mamíferos amenazados de la Argentina* (first ed. 2000, second ed. 2012) and *Mamíferos de Argentina. Sistemática y distribución* (2006), as well as contributing to the *Libro Rojo de los mamíferos y aves amenazados de la Argentina* (currently out of print).

» Dr. Alejandro E. J. Valenzuela

Alejandro E. J. Valenzuela is a biologist in the Argentine National Scientific & Technical Research Council (CONICET) and professor at the National University of Tierra del Fuego (UNTDF). He works doing ecological research applied to native wildlife conservation and invasive species management, but also supporting managers and decision-makers to generate conservation strategies.

» Dr. Christopher B. Anderson

Christopher B. Anderson is an ecologist in the Argentine National Scientific & Technical Research Council (CONICET) and a professor at the National University of Tierra del Fuego (UNTDF). Originally from the USA, he has spent his professional career studying the integrated ecological and social dimensions of environmental problems in southern Patagonia.

» Dr. Sebastián A. Ballari

Sebastián A. Ballari is an ecologist and wildlife biologist manager in the Argentine National Scientific & Technical Research Council (CONICET). With an emphasis on the conservation of native ecosystems and their natural processes, his interests include the study of introduced invasive species, wildlife management in protected areas, and effects of global change drivers.

» Dr. Ricardo A. Ojeda

Ricardo A. Ojeda is a biologist at the Argentine Institute of Arid Zones Research (IADIZA) and the Argentine National Scientific & Technical Research Council (CONICET). His main research interests are the ecology of small desert mammals, biogeographic patterns, integrative taxonomy and biodiversity conservation.

Introduced Invasive Mammals of Argentina

EDITED BY

Alejandro E. J. Valenzuela
Instituto de Ciencias Polares, Ambiente y Recursos Humanos (ICPA), Universidad Nacional de Tierra del Fuego (UNTDF)
& Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
avalenzuela@untdf.edu.ar

Christopher B. Anderson
Instituto de Ciencias Polares, Ambiente y Recursos Naturales (ICPA), Universidad Nacional de Tierra del Fuego (UNTDF)
& Centro Austral de Investigaciones Científicas (CADIC), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
canderson@untdf.edu.ar

Sebastián A. Ballari
Parque Nacional Nahuel Huapi (CENAC),
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
s.ballari@conicet.gov.ar

Ricardo A. Ojeda
Instituto Argentino de Investigaciones de Zonas Áridas (IADIZA),
Centro Científico Tecnológico (CCT) – Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) – Mendoza
rojeda@mendoza-conicet.gob.ar

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SAREM – Sociedad Argentina para el Estudio de los Mamíferos
Av. Ruiz Leal s/n, Parque General San Martín. CP 5500, Mendoza, Argentina
www.sarem.org.ar

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Introduced invasive species are a major driver of local to global environmental change, including important negative impacts on biodiversity, ecosystem processes, economies, health and other social values. At the same time, however, different social actors can hold diverse representations of these species, particularly of introduced invasive mammals (IIMs). Such divergent values and perceptions can lead to conflicts regarding the management of IIMs, but also invite researchers and managers to be reflexive regarding their own work at a more fundamental level. Therefore, it is key that we advance towards a holistic understanding of IIMs and develop strategies to manage them based on solid technical information and plural perspectives regarding their multiple values. Despite a rich history of initiatives in Argentina to study and manage IIMs, until now there has not been an opportunity to assess the state-of-the-art knowledge in our country. This book seeks to provide rigorous, relevant and legitimate information to support research, policymaking and management decisions regarding IIMs in Argentina. With this objective in mind, the book presents a series of chapters selected to highlight priority topics concerning the conceptualization and implementation of IIM research and management. Then, fact sheets are provided for the different IIMs found in Argentina. Finally, beyond the realm of academic inquiry, the timing of this publication is ideal to re-enforce policy and decision-making, such as the recently approved National Invasive Exotic Species Strategy, which seeks to implement actions and enhance institutional capacities related to invasive species management in Argentina, and the Convention on Biological Diversity's new Global Biodiversity Framework, which also addresses biological invasions as part of broader efforts to attain the 2050 Vision for Living in Harmony with Nature.

Dr. Alejandro E.J. Valenzuela
Dr. Christopher B. Anderson
Editors, Vol. III SAREM Series A

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Foreword

Biological invasions by introduced species are one of the great changes rapidly transforming the globe today, with innumerable impacts on economics, human health, ecosystem services, and biodiversity. Mammals are among the most impactful of invasive species, transmitting diseases to humans, livestock, and native animals, trampling native grasslands, voraciously devouring vegetation from groundcover to saplings of forest trees, fouling water, causing erosion, and preying on and outcompeting native animals. They were among the first species humans introduced worldwide and in Argentina, both deliberately (*e.g.*, livestock) and inadvertently (*e.g.*, rats and mice). They have been introduced for sport (*e.g.*, deer, boar) and companionship (*e.g.*, cats, dogs), or simply as attractive ornamentals (*e.g.*, squirrels). Some that are meant to be kept in captivity, such as cats, dogs, and squirrels, escape and establish feral populations.

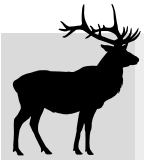
Argentina looms large in the history of biological invasions by introduced mammals. The earliest permanent European settlers of Buenos Aires in 1580 discovered huge herds of feral horses already on the pampas, and soon after, Vázquez de Espinoza described feral horses in Tucumán that were "in such numbers that they cover the face of the earth…". Many sheep were in Tucumán as well at that time, and of course later sheep were enormously numerous in Patagonia, effecting huge changes in the vegetation and driving land degradation and desertification to this day. When Charles Darwin visited the La Plata region in 1832 during the voyage of the Beagle, he reported that "…countless herds of horses, cattle, and sheep, not only have altered the whole aspect of the vegetation, but they have almost banished the guanaco, deer and ostrich. Numberless other changes must likewise have taken place; the wild pig in some parts probably replaces the peccari; packs of wild dogs may be heard howling on the wooded banks of the less-frequented streams; and the common cat, altered into a large and fierce animal, inhabits rocky hills."

Approximately 40 mammals have been introduced to South America, of which 25–30 have established populations; most of these are in the Southern Cone. In Argentina, I count 23 successfully introduced mammal species, including feral cats, dogs, and cows. Many, such as rats, rabbits, boar, and goats, are widely distributed around the world. By contrast, the hairy armadillo has been introduced nowhere else but from the mainland of Patagonia to Tierra del Fuego Island. Strikingly, except for the rats and house mouse, all these mammals were brought to Argentina deliberately; this is very different from, say, introduced insects. A few of these invasive mammals, like the squirrel, were not intended to be released, but I hesitate to term such invaders truly "accidental," because the people who brought them should have realized that escapes or later releases were almost inevitable. Of course, almost all of these mammals were introduced before the late twentieth century, which was when most scientists and the public began to recognize the extent and importance of impacts of introduced species. However, the squirrel and armadillo introductions were recent enough that potential impacts should have been foreseen. Things could be worse, of course—mammals deliberately brought to Argentina that either were released, but did not establish persistent populations or have not yet escaped from hunting preserves include reindeer, silver fox, mule deer, African buffalo, white-tailed deer, Père David's deer, thar, barbary sheep, wisent, mouflon, chamois, and ibex.

The technology of eradicating introduced invasive mammals has made enormous strides in the last thirty years—at least 31 mammal species have been eradicated from islands worldwide, including relatively large islands like South Georgia. Both Norway and ship rats have been eradicated hundreds of times, and house mice about 100 times. Most large mammals, such as deer and horses, are technologically easier eradication targets—many can simply be tracked and shot, for instance. However, mammals more than any other introduced species pose the complication that many people—especially hunters—simply do not want to eradicate them, and many animal welfare advocates, even those recognizing the damage some invaders cause, object to eradicating them by the only currently feasible means—killing them, humanely if possible. Even rat eradication has been impeded on animal rights/animal welfare grounds, and free-ranging dog and cat populations frequently are seen more as animal welfare issues than as conservation problems to broad sectors of some societies. In Argentina, the problem of implementing feasible eradication programs for invasive mammals is epitomized by the rather schizophrenic attitude taken by the National Parks Administration (Administración de Parques Nacionales – APN) towards red deer. The APN's conservation imperative is supported by the section of Law #22,351 that forbids propagating introduced animals, yet red deer, known to damage native species and ecosystems, are managed in Lanín National Park to foster ongoing hunting, and even to improve the size and quality of the deer for better hunting trophies. Additionally, there is often inconsistent and inadequate funding for managing and eradicating invasive mammals in protected areas, almost always constituting a supervening impediment even when a rational and effective goal is stated.

Argentine scientists have participated heavily in the rapid growth of modern invasion science since its inception in the 1980s, and they and overseas colleagues have conducted substantial research on the biology and impacts of many of the introduced invasive mammals in Argentina, as well as other invasive species. Some of the threats posed by these mammals have even become widely known to the general public in Argentina and beyond—the spread of the beaver from Tierra del Fuego to the mainland has been an international news story. *Introduced Invasive Mammals of Argentina* is therefore an exciting and timely addition to the literature on invasions in southern South America for both the Argentine public (and its political representatives and environmental managers) and scientists worldwide. The many authors assembled for this book explore how these biological invasions happened in the first place, how they spread, what they do to biodiversity, ecosystems, and human enterprises, what has been done about them so far, what can be done about them now, and what might be done with them in the future. The editors and authors are to be congratulated for an excellent exposition of the Argentine part of a growing global phenomenon.

Daniel Simberloff
Nancy Gore Hunger Professor of Environmental Studies
Department of Ecology and Evolutionary Biology
University of Tennessee
Knoxville, TN 37996



Cervus elaphus
red deer, ciervo colorado

Jo Anne M. SMITH-FLUECK[1] and Werner T. FLUECK[2]

[1] Fundación Shoonem and DeerLab, Argentina, and Laboratorio de Teriogenología "Dr. Héctor H. Morello", Facultad de Ciencias Agrarias, Universidad Nacional del Comahue, Cinco Saltos, Río Negro. j.smith@deerlab.org

[2] CONICET; Argentine National Park Administration, Bariloche, Argentina, and Swiss Tropical and Public Health Institute, University of Basel, Switzerland. wtf@deerlab.org

Resumen. El ciervo colorado europeo, un cérvido de gran tamaño, fue introducido por primera vez en Argentina entre 1902 y 1906. Actualmente se ha confirmado su presencia en al menos 14 provincias, con más de 150.000 ejemplares silvestres. Se organizan en grupos familiares, formados por una hembra y sus descendientes de los últimos dos o tres años, o en grupos de machos, cuyos tamaños dependen del tipo de hábitat, perturbaciones, densidad poblacional y la estación del año. Machos y hembras permanecen separados la mayor parte del año, hasta la época de celo (marzo-abril), seguida de un período de gestación de 235 días, y el nacimiento de una cría por año. Presentan un sistema de apareamiento flexible: los machos dominantes muestran territorialidad y los subordinados exhiben otras estrategias. Su dieta es mixta y varía según el hábitat, la estación y la competencia interespecífica; son muy adaptables a una amplia gama de condiciones ambientales, lo que facilita su dispersión, que en Patagonia se ve acelerada por las grandes extensiones de terreno con baja densidad humana, las plantaciones de pinos, las introducciones (legales o ilegales) de ciervos en nuevos lugares, y los escapes de cotos. Pueden ser residentes todo el año o migrantes estacionales. Se estima que en un futuro podrían ocupar toda el área cordillerana de Patagonia, desde Mendoza hasta Santa Cruz, incluyendo una variedad de hábitats, desde bosques húmedos valdivianos hasta la estepa patagónica. Adicionalmente a los impactos ecológicos ocasionados por el ciervo colorado, es importante tener en cuenta su papel epidemiológico en relación con las especies autóctonas y el ganado. Además, su presencia ha provocado la caza furtiva dentro de las áreas protegidas. Se presentan opciones de gestión para mantener/reducir el tamaño poblacional, que tienen en cuenta a todos los grupos sociales interesados y utilizan estrategias científicas de gestión adaptativa.

General description of the species

The red deer (*Cervus elaphus*) is a large cervid, with stags reaching shoulder heights up to 150 cm. Only males possess antlers, 5 tines or more on one antler in prime stags, which are cast each year in late winter. The adult coat is basically solid, reddish-chestnut in summer and greyish-brown in winter; calves are born with spots.

Biology

Adult females at Parque Nacional Nahuel Huapi (PNNH) averaged 119.2 kg while the five largest males averaged 291.6 kg (Smith-Flueck and Flueck, unpublished data). Dental formula is 0.1.3.3 / 3.1.3.3. The Patagonian rutting season is March to April. Females are seasonally polyestrous; a cycle lasts 18 days with one to two days of receptivity. Gestation lasts 235 days with one calf per year. Females reach sexual maturity at approximately 16 months of age, but this can vary considerably depending on local conditions. The males can begin reproducing at two years of age, but generally begin much later due to competition with older males. Males reach their maximum development at 12–14 years of age (Fig. 1). In Patagonia, free-ranging males and females have reached 25 and 20 years of age, respectively (Smith-Flueck and Flueck, unpublished data).

Behavioral ecology

A mixed feeder, the red deer diet varies considerably according to habitat, season, and competition with other herbivores. They are most active foraging during dawn and dusk. In disturbance-free areas, they can be seen resting and foraging in the open during

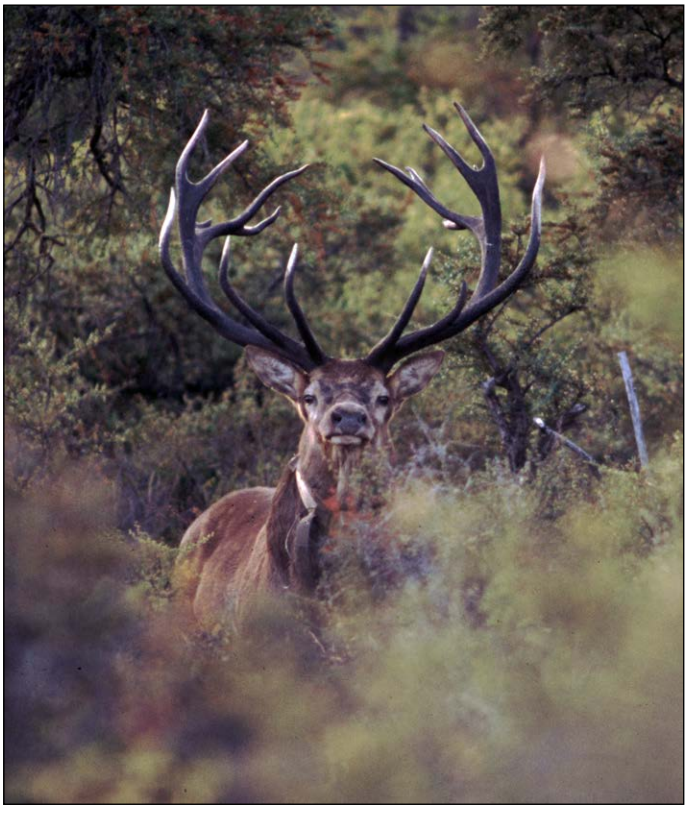


Figure 1. Mature red deer stag in Patagonia, Argentina. (Photo: Jo Anne Smith-Flueck).

daylight hours. The basic social unit is a family group formed by one female and her descendants of the last two to three years. Young males disperse to then form groups with similar aged males. The sexes remain apart most the year. During the rut, the stags vocalize frequently with loud deep bellows that signal their status (Hurtado *et al.*, 2012). The mating system in Patagonia is flexible, with prime males being territorial while non-prime males exhibit various other semblances of mating strategies. Mobile harem defense, as described in Europe, was not observed (Smith-Flueck and Flueck, 2006). The social organization of the stags during the rut determines the frequency and severity of male fights. Inappropriate hunting practice can result in injuries and deaths by a modified social structure. Group size depends on habitat type, disturbance, population density, and season. A gregarious species, their numbers can reach hundreds in open areas. In contrast, in forest habitat, group size is commonly three to five animals. They can be year-round residents or seasonal migrants, sometimes migrating long distances between summer and winter ranges. They easily jump fences, run quickly from predators, and are also exceptional swimmers.

History of the invasion, patterns of expansion and current distribution

The first individuals arrived to Argentina from Europe between 1902–1906 at Reserva Provincial Parque Luro in La Pampa province. In 1922 a few from this stock were brought to the Andean pre-cordillera in Neuquén province. By 1952, deer were culled from this population to reduce competition with livestock. By 1959, this deer was officially declared a "pest" species in Neuquén (Flueck and Smith-Flueck, 1993).

In 1926, red deer were liberated in southern Neuquén province on Huemul Peninsula inside PNNH (Hurtado *et al.*, 2012). The expansion was then aided by further liberations (Flueck and Smith-Flueck, 1993). Three principal ones were at: 45° S (1945); 44° S (1966) (Smith-Flueck and Flueck); and 42°53' S (1979) (Smith-Flueck, 2003). By April 1995, the deer from the latter liberation site had spread a minimum of 15 km further northeast, entering Parque Nacional Los Alerces. It was estimated they would join the population expanding south from Río Negro by 1996 (Smith-Flueck, 2003). The estimated distribution of red deer in Patagonia by 2002 was 51,500 km²; using known rates of dispersal, the range was predicted to reach 206,500 km² by 2050 (Flueck *et al.*, 2003) (Fig. 2). This estimate did not consider further introductions, escapees, nor the influence of introduced pine plantations as corridors.

The highly adaptable behavior of red deer facilitates their dispersal over a large range of environmental conditions. Their expansion in Patagonia is further accelerated by the vast tracts of land with low human density, the pine plantations, the introductions (legal or illegal) of deer to new sites, and escapees from enclosures. In New Zealand, the distribution of red deer recently expanded due to illegal translocations (26%) and escapees (38%) (Nugent *et al.*, 2001).

Red deer will eventually inhabit the entire western cordillera of Patagonia, from Mendoza to Tierra del Fuego (Flueck *et al.*, 2003), and could reasonably extend east to where the precipitation gradient falls to 150mm/yr or less. Today, the North Patagonian population extends continuously along the western portion of the provinces of Neuquén, Río

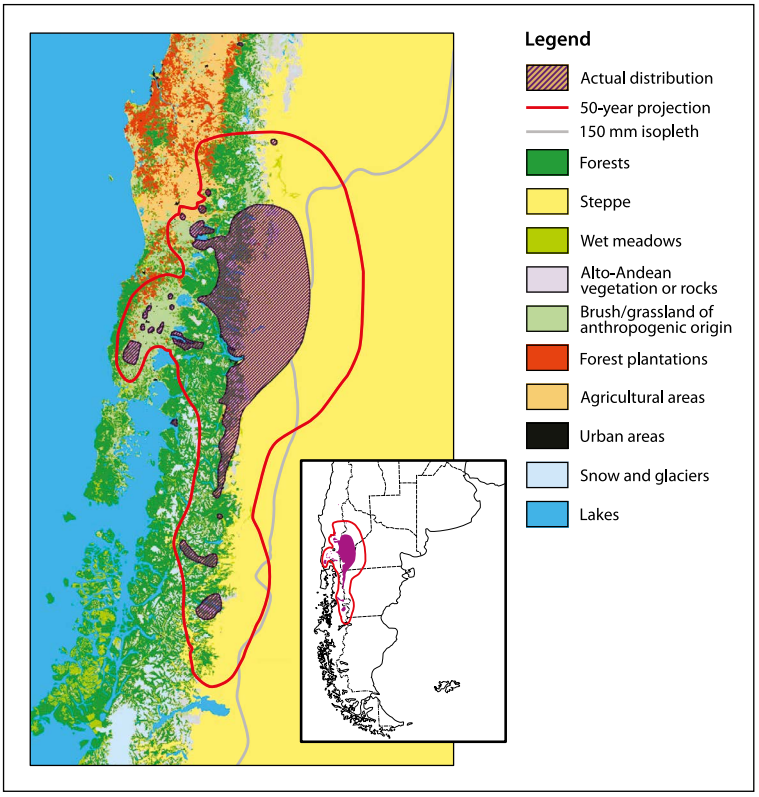


Figure 2. Red deer distribution in Patagonia (as of 2002), including Chile, is 37°42'S – 54°55'S and 73°36'W – 69°50'W (not contiguous). Provinces confirmed to have free-ranging red deer are the following nine: La Pampa, Neuquén, Río Negro, Chubut, Mendoza, San Luis, Tucumán, Salta, and Jujuy. Provinces with red deer in captive and/or semi-captive centers (deer farms or hunting reserves) include: Buenos Aires, Entre Ríos, Corrientes, Santa Fe, La Rioja, and Córdoba. Additionally, they were introduced in 1973 to Staten Island (AR) and in 2000 to Tierra del Fuego, Chile, for farming and hunting. Although not confirmed, red deer may also already be in Catamarca, Chaco, CABA, Formosa, San Juan, Santa Cruz, Santiago del Estero and Tierra del Fuego.

Negro and northern Chubut, including portions of three large national parks (Nugent *et al.*, 2011). North of Patagonia, they recently escaped two enclosed hunting reserves in the district of La Carrera, Tupungato, in Mendoza province, and are now free-ranging (F. Cuevas, pers. comm.). Currently, they are found in 14 continental provinces (Fig. 3), by way of introductions, deer farms, and hunting reserves, with six of these possibly having animals still only in captive facilities (Flueck, 2010). Lastly, they were introduced in 1973 to Staten Island and in 2000 to the Chilean side of Tierra del Fuego Island for farming and hunting (Flueck and Smith-Flueck, 2012a).

Impacts

There is no evidence in New Zealand, Chile or Argentina that an equilibrium has been reached between deer and the host ecosystems they inhabit (GISD, 2015). In

Argentina, they inhabit a variety of habitats from dense rain forest to ecotone to grassland steppe. Within this habitat gradient, they have altered the floristic composition, forest understory and stand structure, and impaired tree regeneration (Veblen *et al.*, 1992). Evidence of extensive dietary overlap between red deer, livestock, native guanaco (*Lama guanicoe*) and endangered native huemul (*Hippocamelus bisulcus*) suggests these herbivores might compete under limiting environmental conditions (Bahamonde *et al.*, 1986; Smith-Flueck, 2003; GISD, 2015). Regardless, several populations of huemul disappeared before red deer occupancy or while founding populations of the introduced were still at very low densities, despite the red deer being blamed as one of the main causes of the huemul's current endangered status (Smith-Flueck, 2003; Smith *et al.*, in press). The potential epidemiological role for various diseases of red deer is important to consider in conservation and the livestock industry (Flueck and Smith-Flueck, 2012b; Smith-Flueck and Flueck, 2017).

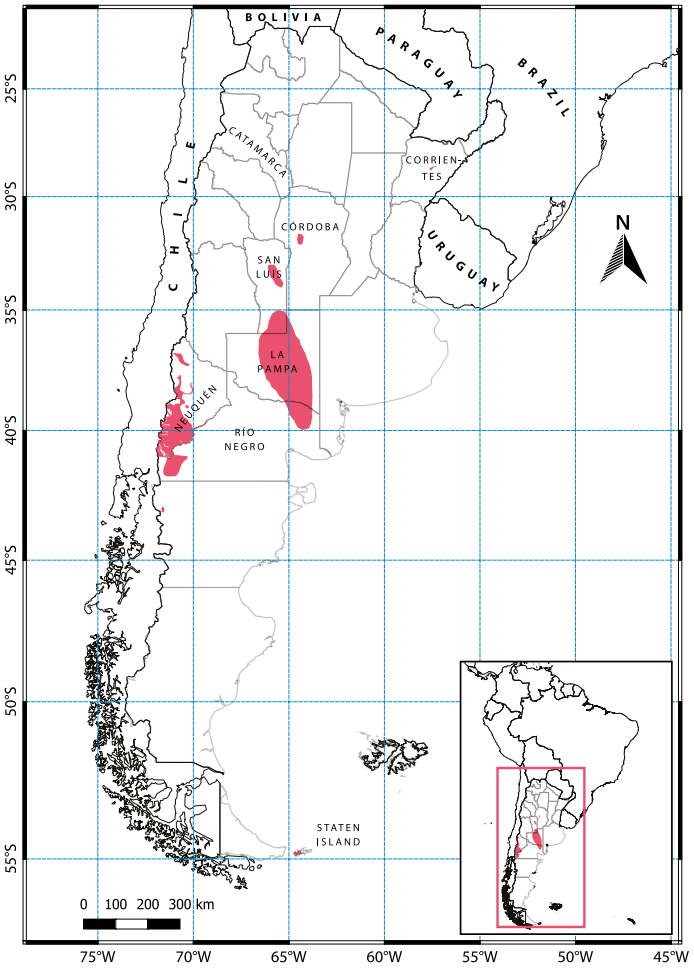


Figure 3. Feral distribution of *Cervus elaphus* in Argentina. Modified from Relva *et al.* (2019). (Mapping: Alfredo Claverie and Ian Barbe).

Management

History of management in Argentine National Parks (APN)

Well-established red deer populations, if appropriately managed, can provide a sustainable economic asset for humans (Flueck *et al.*, 1995). Several provinces and national parks have established hunting regulations for red deer, but not based on population ecology (GISD, 2015). Red deer are often considered a pest, at least in national parks, yet, ironically, there are strict hunting-focused regulations in most jurisdictions limiting the hunting season and restricting the number, sex, and antler size of animals (Nugent *et al.*, in press). Red deer in protected areas are mainly under the jurisdiction of APN. Recreational sport hunting of red deer, principally implemented as a means to control poaching, has been practiced in Parque Nacional Lanín (PNL) and PNNH since 1955 and 1987, respectively. Basic guidelines for red deer management in the parks were first outlined in Resolution #454/1986, where the importance to reduce the density and avoid an expansion were recognized. In 2004, these same guidelines were incorporated into the APN management strategies for red deer (Res. HD #18/04), where they recognized the impossibility to maintain a sport hunting program without population management, and considered sport hunting the tool of choice by which to accomplish this.

Social-cultural aspects

Many landowners and inhabitants inside the parks perceive red deer as competing with traditional livestock activities. Deer do not produce a secure financial income for these stakeholders, and instead have introduced problematic poaching. For social and economic reasons, they cannot justify investing in some form of management, and thus only take opportunistic advantage of hunting mature trophy males for profit. Only where densities have reached high levels on some private lands have red deer been culled.

Of all national parks, PNNH and PNL have the greatest presence of red deer. The zonification of "national reserve," where people live and some own land legally, makes up 46% of the surfice of these two protected areas. These lands, mostly in the lower elevations of the parks, are winter range for the red deer. These inhabitants can play an important role as the lower zone is most suitable for managing the population (Flueck and Smith-Flueck, 1993), given its importance as winter range, road infrastructure, and high conservation value. Although density reduction is the most important objective to achieve (*e.g.*, Res. HD #18/04), populations regrow regularly beyond carrying capacity due to various factors. For one, harvest of females and young animals has been discouraged (Relva and Sanguinetti, 2016), even prohibited in NPNH (Mendez, 2007). PNL, recognizing this, initiated a control hunting program in cooperation with hunting clubs, resulting in reducing deer density more effectively (Sanguinetti *et al.*, 2014), but only lasting five years. Recreational sport hunting alone achieves little in the way of conservation and benefits only a small sector of the society. Like in New Zealand, it does not control population size, and to the contrary, contributes to higher densities (Flueck *et al.*, 2005; Nugent *et al.*, 2011). Even commercial trophy hunting cannot be maintained, as it is self-limiting, unless scientific population

management is part of the program (Nugent *et al.*, 2011). A promising option would be to incorporate landowners in a control program, adopting an integrated approach, whereby APN works with all interest groups. In New Zealand, a consortium of landowners joined forces to develop the successful "Regional Strategy for Managing."

The current hunting system of national parks

When analyzing stags on private lands bordering APN, 69% were misclassified and shot too young (Smith-Flueck and Flueck, unpublished data). The average age for stags hunted in national parks was 7.99 years (SE=0.21, n=255), and the most frequently hunted age class was 6.5 years. Given that stags reached their maximum body size between 12–16 years of age, most of the hunted stags never got to reach their full-antler potential.

Population size in Patagonia overall was estimated at 100,000 red deer, based on a conservative estimate of 2 deer/km², given that densities in the ecotone have reached 100 deer/km² and 40–50 deer/km² in the steppe habitat (Flueck *et al.*, 2003). In APN, few deer get culled compared to New Zealand. With 250,000 deer on 65,000 km², the New Zealand government provided 65,000 hunting permits (free of charge): 42,000 deer were harvested. Meanwhile, by 2007 our estimation had increased to 150,000 deer on 51,500 km² in Patagonia, but only 600 permits were issued, mostly sold through an auction. Such low levels of harvests explain die-offs occurring due to various dry years, which had reduced carrying capacity (Flueck, 2001a,b).

Adaptive management

To maintain a constant population density, when recruitment rate is high and sustained by an adequate food base, an annual population harvest of 30–35% is required (Challies, 1989). Adaptive management is then used, which involves annual monitoring and measurements of various parameters to identify dynamics in population density, body condition, and vegetational cover. Harvest numbers should be adjusted accordingly. If density, environmental impact and physical condition are shown to have responded as anticipated, one can then assume the harvest figures used for that season were adequate. The main priority is to maintain the deer density at a certain level below the current carrying capacity. The acceptable density for red deer in a particular environment will also depend on sympatric introduced herbivores, whose densities will influence model parameters, and thus, the amount to harvest.

Management options available:

1. ***Recreational sport hunting.*** Studies have shown in New Zealand and Patagonia that such hunting does not control density. The funds generated from the sale of hunting rights through public auction need to be reinvested in deer management (Nugent *et al.*, 2011).
2. ***Recreational public hunting.*** This cannot be carried out on fiscal park nor private lands.

3. ***Commercial hunting.*** Properly designed this would be viable (*e.g.*, New Zealand), pending on public acceptance, and would require harvesting female deer.
4. ***Laisser-faire.*** This does not address conservation, nor does it optimize the current sport hunt by not allowing stags to reach their full potential with well-developed antlers. Practiced when long-term costs of control programs to reduce perceived deer impacts may not be practical.
5. ***Integrated management.*** Landowners would be provided with an incentive to implement management strategies—preferably as a collective—by having access to general funds generated from the recreational sport hunting that is now practiced in the fiscal zones.
6. ***Private concession.*** A report elaborated for APN included a design of hunting units for a concession and successful examples from Europe (Flueck and Smith-Flueck, 2001).
7. ***Professional control hunting.*** This provides results if the deers' activity patterns and social behavior are not modified. Thus, the Judas method was recommended to APN (Flueck,1991), as being feasible, less expensive than other options and with minimal collateral impact. Ideally, implementing this strategy would be combined with scientific studies to monitor the effects on deer population dynamics and social behavior, as well as the effects on the ecosystem (Flueck *et al.*, 1995).
8. ***Stricter enforcement of illegal poaching activities.***

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