

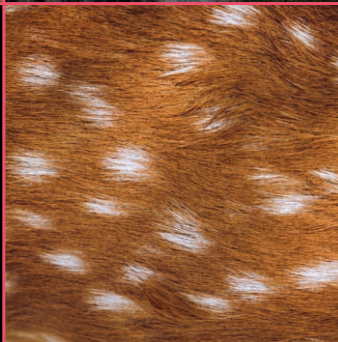


SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas

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



SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas

Copyright ©
SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas
Buenos Aires, Argentina

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

Introduced Invasive Mammals of Argentina / Alejandro Valenzuela ... [*et al.*]. – 1ª ed. –

Mendoza : Sociedad Argentina para Estudio de los Mamíferos SAREM, 2023.

Memoria USB, PDF

ISBN 978-987-98497-9-8

1. Mamífero. 2. Animales Exóticos. I. Valenzuela, Alejandro.

CDD 599.0982

Board of Directors

President: Pablo V. Teta (Museo Argentino de Ciencias Naturales “Bernardino Rivadavia,” MACN–CONICET, Buenos Aires, Argentina)

Vicepresident: Javier A. Pereira (Museo Argentino de Ciencias Naturales “Bernardino Rivadavia,” MACN–CONICET, Buenos Aires, Argentina)

Secretary: María Cecilia Ezquiaga (Centro de Estudios Parasitológicos y de Vectores, CEPAVE–CONICET, La Plata, Argentina)

Treasurer: Agustín M. Abba (Centro de Estudios Parasitológicos y de Vectores, CEPAVE–CONICET, La Plata, Argentina)

Board Members:

Guillermo Cassini (Museo Argentino de Ciencias Naturales “Bernardino Rivadavia,” MACN–CONICET, Buenos Aires, Argentina)

Valentina Segura (Unidad Ejecutora Lillo, CONICET–Fundación Miguel Lillo, Tucumán, Argentina)

Alternate Board Members:

Agustina A. Ojeda (Instituto Argentino de Investigaciones de las zonas áridas, IADIZA–CONICET, Mendoza, Argentina)

Soledad Leonardi (Instituto de Biología de Organismos Marinos, IBIOMAR–CONICET, Puerto Madryn, Argentina)

Auditors:

Mauro Schiaffini (Centro de Investigación Esquel de Montaña y Estepa Patagónica, CIEMEP–CONICET & FCNyCS, Esquel, Argentina)

José Coda (Instituto de Ciencias de la Tierra, Biodiversidad y Ambiente, ICBLA–CONICET, Córdoba, Argentina)

Alternate Auditor:

M. Laura Guichón (Instituto de Investigaciones en Biodiversidad y Medioambiente, INIBIOMA–CONICET–UNCo & Centro de Ecología Aplicada del Neuquén, CEAN, Junín de los Andes, Argentina)

SAREM Series A Editorial Committee

Editor-in-Chief: E. Carolina Vieytes (Museo de La Plata, Universidad Nacional de La Plata, La Plata, Argentina)

Associate Editors:

David Flores (Unidad Ejecutora Lillo, CONICET–Fundación Miguel Lillo, Tucumán, Argentina)

Cecilia C. Morgan (Museo de La Plata, Universidad Nacional de La Plata, La Plata, Argentina)

English Style Editor:

Christopher B. Anderson (Instituto de Ciencias Polares, Ambiente y Recursos Naturales, Universidad Nacional de Tierra del Fuego & Centro Austral de Investigaciones Científicas–CONICET, Ushuaia, Argentina)

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the Publisher.

Cover collage: Gabriela F. Ruellan

Cover photo credits: Kev on Pixabay (European hare) | Dorota Kudyba (dogs and horses) | Ruediger50 on Pixabay (water buffalo) | Sergio Anselmino (American mink) | Gabriela Ortega (cow hide) | efPercy05 on Pixabay (goat) | suksao on Freepik (chital) | Guillermo Deferrari (muskrat) | J. Cristóbal Pizarro (North American beaver damage) | Peter Chou (Pallas's squirrel) | Public Domain Pictures (red and fallow deer antlers) | marco on Pixabay (wild boar)



SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas

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

CONTENTS

LIST OF REVIEWERS.....	VII
FOREWORD.....	IX–X
DANIEL SIMBERLOFF	
1 INTRODUCED AND INVASIVE MAMMALS: CONCEPTUAL AND HISTORICAL PERSPECTIVES FOR ARGENTINA.....	1–30
S. YASMIN BOBADILLA, ANDREA DEL PILAR TARQUINO-CARBONELL AND RICARDO A. OJEDA	
2 RECONCEIVING BIOLOGICAL INVASIONS AS A SOCIO-ECOLOGICAL PHENOMENON USING THE CASE STUDY OF BEAVERS IN PATAGONIA.....	31–51
CHRISTOPHER B. ANDERSON AND J. CRISTOBAL PIZARRO	
3 CHARISMA AS A KEY ATTRIBUTE FOR THE EXPANSION AND PROTECTION OF SQUIRRELS INTRODUCED TO ARGENTINA.....	53–73
M. LAURA GUICHÓN, MARIELA BORGNA, VERÓNICA BENITEZ AND A. CECILIA GOZZI	
4 HUNTING AS A DRIVER OF MAMMAL INTRODUCTIONS.....	75–93
SEBASTIÁN A. BALLARI, M. NOELIA BARRIOS-GARCÍA, JAVIER SANGUINETTI, HERNÁN PASTORE AND M. FERNANDA CUEVAS	
5 IMPACT OF INTRODUCED INVASIVE HERBIVORES IN PATAGONIAN FORESTS.....	95–110
M. NOELIA BARRIOS-GARCÍA, CAROLINA QUINTERO, YAMILA SASAL, SEBASTIÁN A. BALLARI, AGUSTÍN VITALI AND MARIANO A. RODRIGUEZ-CABAL	
6 MANAGEMENT OF FERAL HORSES AS INVASIVE MAMMALS: BIODIVERSITY CONSERVATION VERSUS CULTURE?.....	111–126
ALBERTO L. SCOROLLI	
7 PROGRESS OF BIOLOGICAL INVASION GENETICS AND THE MANAGEMENT OF INVASIVE MAMMALS IN ARGENTINA.....	127–141
MARTA S. LIZARRALDE, MARIANA FASANELLA, SEBASTIÁN POLJAK AND MAGALI GABRIELLI	
8 DISEASE RISKS FROM INTRODUCED MAMMALS.....	143–172
MARCELA M. UHART	
9 EXOTIC SPECIES IN THE FORMAL EDUCATIONAL SPHERE IN ARGENTINA.....	173–191
CLAUDIA M. CAMPOS, GONZALO M. BERMUDEZ, GABRIELA B. DIAZ AND ALFREDO VILCHES	
10 MEDIA REPRESENTATIONS OF INTRODUCED INVASIVE MAMMALS: A COMPARISON BETWEEN TRENDS IN ARGENTINA AND TIERRA DEL FUEGO PROVINCE.....	193–205
VALERIA CAR, NATALIA ADER, CHRISTOPHER B. ANDERSON AND ALEJANDRO E.J. VALENZUELA	
FACT SHEETS ON THE INTRODUCED INVASIVE MAMMALS OF ARGENTINA	
<i>Antilope cervicapra</i> blackbuck, antílope negro.....	209–213
SEBASTIÁN A. BALLARI	
<i>Axis axis</i> chital, ciervo axis.....	215–221
JUAN F. TELLARINI, MARIANO L. MERINO AND JAVIER A. PEREIRA	
<i>Bubalus arnee bubalis</i> wild water buffalo, búfalo asiático.....	223–229
LUCÍA I. RODRÍGUEZ-PLANES, SEBASTIÁN CIRIGNOLI, DIEGO VARELA, MARTA S. KIN AND MARTÍN MONTEVERDE	

<i>Callosciurus erythraeus</i> Pallas's squirrel, ardilla de vientre rojo	231-242
A. CECILIA GOZZI, VERÓNICA BENITEZ, MARIELA BORGNIA AND M. LAURA GUICHÓN	
<i>Canis lupus familiaris</i> domestic feral dog, perro doméstico asilvestrado.....	243-248
IAN BARBE, ALFREDO Ñ. CLAVERIE AND ALEJANDRO E.J. VALENZUELA	
<i>Castor canadensis</i> North American beaver, castor americano	249-254
CHRISTOPHER B. ANDERSON AND CATHERINE ROULIER	
<i>Cervus elaphus</i> red deer, ciervo colorado.....	255-263
JO ANNE M. SMITH-FLUECK AND WERNER T. FLUECK	
<i>Chaetophractus villosus</i> large hairy armadillo, peludo	265-271
SEBASTIÁN POLJAK, MAGALI GABRIELLI, JULIETA SÁNCHEZ AND MARTA S. LIZARRALDE	
Rodentia: Muridae commensal rodents, roedores comensales	273-286
<i>Mus musculus</i> house mouse, ratón doméstico	
<i>Rattus norvegicus</i> Norway rat, rata parda o noruega	
<i>Rattus rattus</i> black rat, rata negra o de los tejados	
REGINO CAVIA AND ISABEL E. GÓMEZ VILLAFañE	
<i>Dama dama</i> fallow deer, ciervo dama.....	287-291
M. NOELIA BARRIOS-GARCIA	
<i>Felis sylvestris catus</i> domestic feral cat, gato doméstico asilvestrado.....	293-299
IAN BARBE, ALFREDO Ñ. CLAVERIE AND ALEJANDRO E.J. VALENZUELA	
Feral livestock, ganado cimarrón.....	301-309
<i>Equus ferus caballus</i> feral horse, caballo cimarrón	
<i>Equus africanus asinus</i> feral donkey, burro orejano	
<i>Bos primigenius taurus</i> feral cattle, vaca	
<i>Capra aegagrus hircus</i> feral goat, cabra	
ALBERTO L. SCOROLLI	
Lagomorpha European hare and rabbit, liebre y conejo europeos	311-317
<i>Lepus europaeus</i> European hare, liebre europea	
<i>Oryctolagus cuniculus</i> European rabbit, conejo europeo o de Castilla	
ALEJANDRO E.J. VALENZUELA	
<i>Lycalopex gymnocercus</i> Pampa fox, zorro gris.....	319-322
ALEJANDRO E.J. VALENZUELA	
<i>Neogale vison</i> American mink, visón americano	323-328
ALFREDO Ñ. CLAVERIE, IAN BARBE, L. ALEJANDRO VILLAGRA AND ALEJANDRO E.J. VALENZUELA	
<i>Ondatra zibethicus</i> muskrat, rata almizclera.....	329-333
GUILLERMO A. DEFERRARI	
<i>Sus scrofa</i> wild boar, jabalí.....	335-340
M. FERNANDA CUEVAS	

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

6 | MANAGEMENT OF FERAL HORSES AS INVASIVE MAMMALS: BIODIVERSITY CONSERVATION VERSUS CULTURE?

MANEJO DE CABALLOS CIMARRONES COMO MAMÍFEROS INVASORES: ¿CONSERVACIÓN DE BIODIVERSIDAD VERSUS CULTURA?

Alberto L. SCOROLLI¹

¹ GEKKO (Grupo de Estudio en Conservación y Manejo), Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, 8000ICN Bahía Blanca, Buenos Aires, Argentina. scorolli@criba.edu.ar

Abstract. Feral horses (*Equus ferus caballus*) are large, herbivorous mammals considered invasive in many countries. Their populations are managed to reduce impacts on biodiversity, and conflicts often arise between government agencies and horse defenders. In Argentina, feral horse management has been inconsistent. In Parque Provincial Ernesto Tornquist (PPET), a grassland ecosystem reserve in the Pampas region, the feral horse population was reduced by 50% in 2006–2007. The management goal was to eradicate the species. In 2011, a conflict arose between the park's authorities, university researchers and a group of horse protectionists. This chapter describes the process surrounding this conflict, analyzes the arguments of the opposing sides, and compares the experience with invasive species conflicts in other countries. A *Facebook* group, which later transformed into a non-governmental organization with the goal of protecting the feral horses of PPET, attacked researchers and government authorities studying and managing this invasive population. The conflict persisted for two years and caused management efforts to be suspended. Researchers provided evidence of the feral horse's Eurasian origin, taxonomic status, and demographic rates that would lead to rapid recovery after control efforts ended. Impact on biodiversity was quantitatively studied and significant changes were reported. Argentine legislation clearly states that invasive mammals should be managed. Horse protectionists invoked the following aspects justifying their opposition: the horse's cultural and historical role in Argentina, aesthetic value, genetic uniqueness, and the horse as a reintroduced “native” species (based on paleo-records). There are important differences with the management of feral horses in other countries. Argentine governmental agencies were passive and did not have a management plan or any court-based legal process. Important challenges that were identified include: having an official science-based management plan, providing more substantiated evidence, attaining active government participation, and including human dimensions of this biological invasion from a socio-ecological perspective.

Resumen. El caballo (*Equus ferus caballus*) es un mamífero herbívoro de gran tamaño miembro de la familia Equidae y del orden Perissodactyla, originario de Eurasia, fue domesticado aproximadamente hace 5.000 años. Cuando los caballos domésticos escapan del control del ser humano o son liberados se denominan cimarrones. Fueron introducidos en Argentina en el siglo XVI por los colonizadores españoles. Rápidamente se volvieron cimarrones y se dispersaron ampliamente en varias regiones del

país, como la Pampa, Noreste y Patagonia. En el siglo XIX prácticamente se extinguieron en estado silvestre por la aparición de las estancias y el uso del alambrado para dividir la tierra. Actualmente existen varias poblaciones de caballos cimarrones en áreas poco pobladas de las regiones de Cuyo y Patagonia. También habitan en áreas protegidas como los Parques Nacionales Los Glaciares y Bosques Petrificados de Jaramillo en la provincia de Santa Cruz. La mayor población conocida, y la más estudiada, se encuentra en el Parque Provincial Ernesto Tornquist (PPET) en el sudoeste de la provincia de Buenos Aires.

El caballo cimarrón es considerado una especie introducida invasora en varios países. Dado su potencial impacto sobre la biodiversidad a altas densidades poblacionales son considerados un serio problema de conservación y su manejo resulta una prioridad. Usualmente, el manejo implica la reducción del tamaño de las poblaciones para minimizar el impacto causado. Es frecuente el uso de métodos letales y de captura viva con posterior adopción de los animales. En varios países, como EE.UU., Australia y Nueva Zelanda, el manejo de caballos cimarrones ha sido muy conflictivo y controversial. En la Argentina, el manejo ha sido esporádico y no organizado. Solo se ha manejado la población de caballos del PPET. Esta área es considerada de gran valor para la biodiversidad por conservar una muestra del ecosistema de pastizal serrano y numerosas especies endémicas. Este capítulo describe el conflicto que generó dicho manejo y analiza los argumentos propuestos por los grupos involucrados. Además, compara el conflicto con situaciones similares ocurridas en otros países y propone algunos desafíos pendientes para el futuro manejo de los caballos cimarrones en Argentina.

Los caballos fueron introducidos en el PPET en 1942. El grupo original era de raza Criolla Argentina, derivada de caballos andaluces-bereberes. Estos caballos rápidamente se asilvestraron, ocupando una amplia zona de la reserva. Su población creció paulatinamente hasta aproximarse a la capacidad de carga del ecosistema, alcanzando una densidad muy alta (35 caballos/km² en 2002). En ese período, los caballos cimarrones estuvieron limitados por alimento. La mortandad por inanición fue alta y el impacto sobre la biodiversidad significativo. Durante 2006 y 2007, las autoridades del área protegida manejaron la población de caballos cimarrones reduciendo un 50% su tamaño. Se capturaron mediante corrales 220 animales, la mayoría fueron relocalizados y 80 fueron eliminados por decisión del cuerpo de Veterinarios Equinos del Ejército. Este manejo fue implementado sin asesoramiento técnico y sin conocimiento del público. En 2011, un grupo de defensores de los caballos inició una serie de protestas contra las autoridades a cargo del PPET y los científicos que estudiaron a los caballos y asesoraron al gobierno. El conflicto, de tono muy agresivo, duró dos años. El escenario principal fueron las redes sociales, pero también tuvo lugar en los medios locales y regionales. Se formó un grupo de *Facebook* con más de 5.000 miembros, que luego fundó una organización no gubernamental, la Asociación Civil Cimarrón Equino (ACCE). Su misión es proteger a todas las poblaciones de caballos y burros cimarrones del país. Los investigadores de la Universidad Nacional del Sur (UNS), institución local, participaron del conflicto brindando evidencia de los siguientes argumentos: los caballos cimarrones son una especie introducida invasora, causan impacto sobre la biodiversidad, su demografía sugiere que crecen rápidamente y se recuperan fácilmente del control poblacional. Los defensores de los caballos cimarrones se opusieron al manejo. Presentaron argumentos asignando a los caballos cimarrones los siguientes valores: importancia cultural e histórica, estética, composición genética única, estatus de especie «nativa» reintroducida (en términos paleo-históricos), y parte del ecosistema. Las autoridades del PPET decidieron suspender el manejo en 2012, finalizando así el conflicto, pero no resolviendo el problema socio-ambiental de fondo.

Existen interesantes paralelismos entre el conflicto en Argentina y los ocurridos en otros países. Los actores involucrados son similares y los argumentos se repiten. Algunos rasgos particulares de este conflicto son: ausencia de un plan de manejo basado en evidencia científica, escasa participación del gobierno en las discusiones e inexistencia de procesos legales. En el año 2013 los investigadores de la UNS presentaron oficialmente una propuesta de Estrategia de Manejo de los caballos cimarrones en el PPET. Si bien aún no ha sido implementada, recientes conversaciones con las presentes autoridades y también con el Presidente de ACCE auguran un futuro promisorio. La dimensión humana del conflicto es un aspecto crucial a tener en cuenta para arribar a una posible solución en el manejo de caballos cimarrones. Algunos autores han propuesto recientemente que los problemas de conservación, incluyendo el manejo de especies invasoras, sean abordados desde una perspectiva socio-ecológica. Esto implica el estudio de los valores y las actitudes de los distintos actores de la sociedad en pos de soluciones más efectivas y éticas. Existen importantes desafíos a futuro para un mejor manejo de las poblaciones de caballos cimarrones en la Argentina: difundir ampliamente las evidencias científicas, lograr una participación activa y transparente de las autoridades, contar con planes de manejo de caballos cimarrones basados en ciencia y con amplia participación del público, y con inclusión de profesionales de las ciencias sociales. Además, se debería integrar esta especie en la Estrategia Nacional de Especies Exóticas Invasoras (Ministerio de Ambiente y Desarrollo Sostenible).

El manejo de caballos cimarrones como mamífero invasor en la Argentina es complejo y con múltiples aspectos. Para hallar una solución en el futuro, este problema debe ser tratado de manera estratégica y colaborativa. Si bien hay importantes desafíos por delante, existen evidencias y antecedentes de la voluntad de llegar a un manejo participativo y basado en ciencia está disponible.

Introduction

Horses (*Equus ferus caballus*) are large, herbivorous mammals and members of the family Equidae in the order Perissodactyla (Bennet and Hoffman, 1999). Horses originated in North America four million years ago and migrated through the Bering Isthmus to Eurasia and through the Panama Isthmus to South America during the Great American Biotic Interchange (GABI); later, they dispersed widely (Mc Fadden, 2005). By the end of the Pleistocene, all horses in America had become extinct (Alberdi and Prado, 2004; Mc Fadden, 2005). When domestic horses escape from human control or are liberated in natural areas, they can revert to a form of life similar to that of wild equids and are termed “feral” (Berger, 1986; Douglas and Leslie, 1996).

During European colonization of the Americas, horses were re-introduced to the continent. In Argentina, the first horses were brought by Spaniard colonizer Pedro de Mendoza, when he founded Buenos Aires in 1536. The first settlement was destroyed by indigenous inhabitants of the area, and when Pedro de Garay founded a new settlement in the same place, he discovered there were already thousands of feral horses descended from the original introduction (Cabrera, 1945). During the 16th century, many other horses entered Argentina from Chile and Peru, accompanying the colonists that established the first Euro-colonial cities. These horses, and many others that escaped, founded the first feral horse populations, which expanded rapidly to inhabit the Pampean region, northeast and central Argentina and the Andes mountains region (Cabrera, 1945). These early introductions were

of horses of Andalusian-Barb ancestry, and they later became the Argentine Criollo horse breed.

Horses as introduced invasive species

Introduced invasive species are defined as those species that are transported outside of their native range, establish populations and cause environmental damage (CBD, 2017). Introduced invasive mammals are present worldwide and are deemed by some sectors of society to be a serious biodiversity conservation problem (Lever, 1994; Long, 2003; White *et al.*, 2008). In particular, feral ungulates are a highly successful group of invasive species, and their management has motivated considerable effort and investment in many countries, including Australia (Bradshaw *et al.*, 2007), New Zealand (Parkes and Murphy 2003), and the United States of America (USA) (Douglas and Leslie 1996; Witmer *et al.*, 2007).

Horses were introduced by humans outside their native range in many countries on every continent except Antarctica (Lever, 1994; Long, 2003). Feral horses are considered invasive in many of these countries (Lever, 1994; Long, 2003), including Argentina (Novillo and Ojeda, 2008; InBiAr, 2017). They are especially abundant in Australia and the western USA, and at high population densities, they have large impacts on the environment through overgrazing and trampling (Dobbie *et al.*, 1993; Beever and Brussard 2000a; Dawson *et al.*, 2006).

Feral horse populations in Argentina are mainly distributed in the Andean zone of the Cuyo and Patagonia regions, but their geographic location, size and origins remain understudied (Scorolli, 2016). Some populations occur in natural protected areas, like Parque Nacional Bosque Petrificado de Jaramillo and Parque Nacional Los Glaciares, both of which are in Santa Cruz province, and the largest and most-studied population is found in Parque Provincial Ernesto Tornquist (PPET), located in the Pampas region of southwestern Buenos Aires province (Merino *et al.*, 2009; Scorolli, 2016).

Feral horse management is often very conflictive and controversial (Dobbie *et al.*, 1993; Symanski, 1996; Beever and Brusard, 2000b; Dawson *et al.*, 2006; NRC, 2013). Where the species is considered invasive, management is usually aimed at reducing the population size or density to minimize damage (Nuñez *et al.*, 2016). These goals are achieved in different ways, including lethal methods or live capture and subsequent adoption by the public. Conflicts usually arise between governmental agencies or authorities and non-governmental organizations (NGOs) or horse protection groups, as has occurred in the USA, New Zealand, Canada and Australia.

In Argentina, feral horse management has been inconsistent and relatively unorganized. Formal efforts have only been initiated in one natural protected area: PPET (Scorolli, 2016). The conflict that arose between a group of horse defenders and government authorities when management of PPET's feral horses was attempted has been briefly described elsewhere (Scorolli, 2016, 2018). The aim of this chapter is to elaborate on these previous descriptions to analyze the values involved and arguments offered by the opposing groups and add a comparison with conflicts that have arisen in other countries. These findings provide insights to potential solutions and highlight gaps and challenges for future feral horse management in Argentina.

The conflict over management

The management and conflict of horses in a protected area

PPET is a natural provincial protected area, consisting of 6,770 ha located in the Ventana Hills of the Pampas region in southwestern Buenos Aires province (38°00' S and 38°10' S; 61°45' W and 62°8' W). Its main goal is to preserve the biodiversity of the hill-grassland ecosystem (Fiori *et al.*, 1997). The area has a rich plant community with more than 600 species (Long and Grassini, 1997), and the presence of endemic plant and animal species brings special value to this reserve (Kristensen and Frangi, 1995).

Domestic Argentine Criollo horses were introduced to the area in 1942, but soon became feral and increased their population without management. They were studied for the first time in 1995 (Scorolli, 1999). In 2002, their density was extremely high, at 35 horse/km², and the population was approaching carrying capacity (Scorolli and Lopez Cazorla, 2010). Researchers studied their demography and population dynamics (Scorolli and Lopez Cazorla, 2010), as well as their impacts on vegetation (Loydi and Distel, 2010), the bird community (Zalba and Cozzani, 2004) and interactions with introduced invasive plants (de Villalobos *et al.*, 2011). In 2006, government authorities in charge of the protected area, based on an assessment from previous years made by university researchers, decided to initiate management efforts for this feral horse population (Scorolli, 2016, 2018). The goal, defined by a provincial government decree (PEPB, 2006), was to eradicate the population. The Universidad Nacional del Sur (UNS) was not involved nor consulted, and the plan proceeded without public knowledge (Scorolli, 2016, 2018). Feral horses were trapped with mobile-corrals, and in two years of management, 220 horses were captured. Most of them were relocated, and 80 were euthanized by the Army Equine Veterinary Division (Scorolli, 2016, 2018). At this time, during a political speech made by the former provincial governor in a meeting of the local ranchers' society (Asociación Rural), some public protests and verbal attacks were made on the authorities. In 2011, a group of horse defenders initiated a series of protests in the local and regional media against the described management actions. They attacked the authorities and also the researchers who had provided the evidence that promoted control (Scorolli, 2016, 2018). The horse defenders opposed this goal, denying the impacts on biodiversity and opposing the labeling of horses as an introduced invasive species. When biologists responded to these criticisms with scientific evidence, the conflict escalated. A *Facebook* group was created that in only a few months reached 5,000 members. Members posted messages and gave radio interviews, uploaded videos and wrote notes in online newspapers (Scorolli, 2016, 2018). The group consolidated and later founded an NGO called Asociación Civil Cimarrón Equino (ACCE – the Wild Horse Civil Association) with the explicit goal of conserving all feral equine populations, including horses and donkeys (*Equus africanus asinus*), in Argentina (ACCE, 2011).

The controversy persisted for two years and also involved conservation NGOs and PPET park rangers. Government agencies remained almost silent during this time, perhaps because they were finishing their mandate period (Scorolli, 2018). After the election, the new responsible authorities, who were staff from a newly created environmental agency called the Organismo Provincial para el Desarrollo Sostenible (OPDS – the Provincial Agency for

Sustainable Development), contacted the ACCE group. They promised them a participatory meeting and even agreed to give them control of the feral horses, but this never happened. Finally, managers made the decision to stop feral horse management and the conflict ended. However, the socio-ecological problem of feral horses as a biological invasion continues today (Scorolli, 2018).

The arguments of researchers

Feral horses as invasive species. Domestic horses originated in Eurasia approximately 5,000–6,000 BP (Pennisi, 2001; Olsen, 2016) and are considered an introduced species in Argentina (Novillo and Ojeda, 2008; InBiAR, 2017). In PPET, they were established in the 1940s, and the population expanded to occupy all available areas in the reserve. They are the dominant large herbivore, and in 2001–2002 were found to have reached very high densities and cause significant environmental impacts (Scorolli and Lopez Cazorla, 2010).

There is some uncertainty about the current taxonomic status of feral horses (Groves, 2002). The modern horse species was first described by Linnaeus from a domestic specimen type (Bennett and Hoffman, 1999). The taxonomy and phylogeny of the *Equus* genus is complex and still not fully understood (Groves, 2002). It is not completely clear who was the domestic horse's ancestor (Kefena *et al.*, 2010). The Eurasian tarpan (*E. ferus ferus*) is one candidate, but insufficient evidence supports this claim. The Mongolian wild horse or takhi (*E. ferus przewalskii*) is the only true wild horse at present. However, recent research strongly suggests that it is not the domestic horse's ancestor, but rather these are two separate lineages (Orlando *et al.*, 2013). Some authors consider that the scientific nomenclature *E. caballus* should be retained for both the domestic form and feral populations of horses (Gentry *et al.*, 2004).

Demography and population dynamics. Feral horses in many countries have few if any predators. They show moderate fecundity, very high survival rates, and their average annual population growth rate worldwide is 18% (Ransom *et al.*, 2016). These life history characteristics allowed feral horses to recover rapidly, even after population size reductions, and clearly limits the efficacy of inconsistent control methods (NRC, 2013). There is evidence that the PPET population shows density-dependence and has been food-limited, with annual mortality as high as more than 80 horses, dying mostly from starvation (Scorolli and Lopez Cazorla, 2010). After two important population reductions, one of 30% caused by mass-mortality in 2002 and another of 50% by management in 2006–2007, the population recovered its initial size in just four to five years (Scorolli, 2016, 2018).

Impact on biodiversity. Feral horses are considered to be a problem species by environmental scientists and managers in many countries, and their environmental impacts were studied in the USA (Beever and Brussard, 2000a, 2004; Beever and Herrick, 2006), New Zealand (Rogers, 1991) and Australia (Dawson *et al.*, 2006; Cherubin *et al.*, 2019; Robertson *et al.*, 2019). In PPET, important evidence was obtained from 2000 onwards about the impacts on the grassland bird community (Zalba and Cozzani, 2004), vegetation composition and

structure (Loydi and Distel, 2010; de Villalobos and Zalba, 2010; Loydi *et al.*, 2010; Loydi *et al.*, 2012; de Villalobos, 2016), impact of dung-piles as dispersers of introduced invasive plants (Loydi and Zalba, 2009), and facilitation of introduced invasive trees like pines (*Pinus halepensis*) (de Villalobos *et al.*, 2011). Habitat modification would also be expected to affect the population of endemic animals, such as rodents and lizards, but this has not been studied.

Legal framework. Argentina has ratified the Convention on Biological Diversity (CBD, 2017), and as part of this multi-lateral treaty has obligations concerning biodiversity conservation and invasive species management. Also, the Administración de Parques Nacionales (APN–National Parks Administration) published a report that presents its official position about the need to prevent and control invasive species in national parks (APN, 2007). The Argentine National Fauna Conservation Law (#22,421) and Resolution #376/97 from the Secretaría Nacional de Ambiente y Desarrollo Sostenible (SAyDS–National Secretary of Environment and Sustainable Development) similarly made pronouncements against invasive species in any area of national biodiversity value, particularly protected areas. Plus, a provincial law in Buenos Aires province about Natural Protected Areas (#10,907) clearly states that introduced species should be managed.

Even when some “post-modern” critics suggest that expert opinion, including that of scientists, is almost without any value to society (Symanski, 1994, 1996), the legal normative framework represents the legitimized norms, standards or compromises that guide the actions of a nation's policies and inhabitants. To institutionalize further its position with regards to introduced and invasive species, Argentina is also developing and implementing a National Invasive Exotic Species Strategy with the financial support of the Global Environment Facility (GEF), administered through the Food and Agriculture Organization (FAO) and broad participation of government and academic institutions (FAO, 2016).

Arguments from horse protectionists

Cultural and historical value. The members of ACCE claim, as one of the main arguments against management, that feral horses are a very important part of Argentine rural culture and history. Popular culture is defined as a group of practices and manifestations that express the way of life in a place or country (RAE, 2017). It is true that Argentine Criollo horses have played a vital role in the rural way-of-life throughout history since European colonization (Brailovsky and Foguelman, 1991; Taboada, 1999; Dowdall, 2003). Historically, Argentina and the Pampas have been famous around the world for their livestock, and still today Argentina is often considered a “horse nation,” where livestock breeding is a traditional and economically important activity.

Many travelers and historical chroniclers, such as Faulkner, Paucke, Dobritzhoffer, Azara, D'Orbigny, and Darwin, referred in their works that in the rural landscape of the past, feral horses were incredibly abundant and mostly used as a source of tamed animals for work and as a renewable resource that produced meat and fat for consumption and leather for export (Taboada, 1999). Later, when the era of ranches consolidated, feral horses were

viewed by ranchers as a problem or a pest, because the big herds often destroyed fences, infrastructure, and even “stole” domestic horses, causing considerable damage to commercial ranching activities (Brailovsky and Foguelman, 1991; Taboada, 1999).

Indigenous peoples also have intensely used feral horses since the 18th century; they ate their meat, used their fat, and traded live animals and hides (Alioto, 2011; Pedrotta, 2016). During the 18th and 19th centuries, hundreds of thousands of Argentine Criollo horses were used in the independence war against Spain, as well as in wars against neighboring countries and in Argentina's own fierce civil war (Cabrera, 1945; Taboada, 1999). Many domestic horses died in the battles during this period. The ACCE proposes that feral horses must be honored as war heroes or “patriots.”

The domestic Argentine Criollo horse was, and still is, highly valued by rural people, but that is not the case of feral horses. However, this distinction between domestic and feral is apparently poorly understood in many social contexts. At present, only 10% of the Argentine human population lives in rural areas (INDEC, 2010). Therefore, most of the public's experience with feral horses is indirect. Only in PPET is it possible for tourists to have some



Figure 1. Herd of feral horses in Parque Provincial Ernesto Tornquist, Argentina.

contact with feral horses, but this possibility is reduced by the deteriorated conditions of the inner roads that cross the area.

Aesthetic value. The value assigned to a species due to its beauty or symbolism is frequently a reason for its protection and conservation (Pearson, 2016). Feral horses are viewed as beautiful animals by most people (Fig. 1), and aesthetic value is one of the reasons for their protection in many countries (Dawson *et al.*, 2006; NZ DOC, 2012; NRC, 2013; ITRG, 2016).

Genetic uniqueness. The ACCE also proposes to value PPET's feral horses based on a supposed unique genetic composition. The breed that was the reported source of this population is Argentine Criollo, from the famous horse breeder Emilio Solanet in Ayacucho. This is the most common breed in rural Argentina. However, there has yet to be any genetic study of the PPET feral horses that could help to clarify this purported value.

Reintroduction of a “native” species. Some researchers in the USA and Europe have proposed “rewilding” as a conservation restoration tool to reintroduce large mammals that went extinct during the Pleistocene by bringing back the same or ecologically similar species to their former habitat (Donlan *et al.*, 2006; Donlan, 2007). This proposal has been highly criticized (Rubenstein *et al.*, 2006; Rubenstein and Rubenstein, 2016), but in a recent work by Naundrup and Svenning (2015), the potential area suitable for reintroduction of horses was analyzed for Argentina and a large part of South America.

During the Pleistocene in Argentina, there were horses of the genera *Equus* and *Hippidion* (Alberdi and Prado, 2004). The *Equus* species found in Argentina included *E. neogeus*, perhaps somewhat similar to the *E. caballus* of the Pleistocene (Prado and Alberdi, 1994), but different from the domestic breeds that were artificially selected by humans for millennia. The factors that caused the Pleistocene extinction of horses in the Americas are still not entirely known and have been the subject of great debate among paleontologists (Alberdi and Prado, 2004; Prado and Alberdi, 2017). Recently, some evidence suggested vegetation change was one of most probable causes (Sánchez *et al.*, 2006; Prado and Alberdi, 2017). If the vegetation change since the Pleistocene has been as significant as many ecologists believe (Beever and Brussard, 2000b; TWS, 2011), and present plant communities evolved without horses, then the reintroduction as part of a “rewilded” landscape restoration strategy would need to be carefully analyzed.

“Wild” species that “belong” to the ecosystem. Many horse defenders consider feral horses to be an integral part of the ecosystems where they now have populations (NRC, 2013; ITRG, 2016) and even playing crucial functions that benefit the habitat and other species (Kirkpatrick and Fazio, 2010; Downer, 2014). In Argentina, ACCE indistinctly uses the terms “wild” and “feral” for naming these horses. The word *cimarrón* (the most used synonym of feral in Spanish) indicates an animal that has escaped from domestication, but the term is sometimes used to mean wild or untamed. In Argentina, *cimarrón* has been used for centuries to name escaped horses or cattle (Taboada, 1999) and is widely known and

unambiguously used by the rural people. Most horse protectionist groups prefer the term “wild” for feral horses and invoke their rights as a wild “native” species that is part of the ecosystem. They even propose to treat them as threatened fauna, not controlling the population nor allowing their culling, but instead caring for their welfare and even giving them veterinary care or supplementary food if needed (HSU, 2010; ACCE, 2011; ITRG, 2016).

Comparison between conflicts in different countries

There are many differences and variations between the conflicts that have occurred around the topic of feral horse management in Argentina and other countries. Some interesting parallels and common arguments exist (Table 1). The conflict in PPET had some particular features that could be mentioned, including that no legal court processes have yet occurred, and that the OPDS (Currently Environment Ministry of Buenos Aires province) has not written a formal management plan, despite the UNS having been proactive in conducting research that has provided sufficient results to elaborate one.

Table 1. Comparison of feral horse management conflicts in different countries.

Feature of conflict	Countries				References
	Argentina	Australia	USA	New Zealand	
Long-term duration (decades)		x	x		1, 2
Short-term duration (some years)	x			x	3, 4
Government, scientists and horse defenders involved	x	x	x		1, 2, 3
Gave rise to legal processes			x		2
Science-based management plan		x	x	x	6, 7, 8, 9
Participatory planning		x	x		5, 6, 8
Protests against goals, lethal methods and scientific evidence	x	x	x	x	3, 10, 11

References: **1.** Dawson *et al.*, 2006; **2.** National Research Council, 2013; **3.** Scorlli, 2016; **4.** New Zealand Department of Conservation, 2012; **5.** Independent Technical Reference Group, 2016; **6.** Parks Victoria, 2021; **7.** Office of Environment and Heritage, 2017; **8.** United States Bureau of Land Management, 2011; **9.** United States Bureau of Land Management, 2015; **10.** Asociación Civil Cimarrón Equino, 2011; **11.** Humane Society of United States, 2010.

Challenges for the future

A crucial aspect of feral horse management success is addressing the problem's human dimensions (Dawson *et al.*, 2006; Nimmo and Miller, 2007; NRC, 2013). Recent reviews have highlighted the surprising paucity of studies that quantify this issue (Nimmo and Miller, 2007; Linnell *et al.*, 2016). Only some such research exist, including Bhat-tacharyya *et al.* (2011) in Canada, Chapple (2005) in Australia, and Rikoon (2006) in the

USA. Recently, in the Argentine portion of Tierra del Fuego, the perceptions about threats to nature were studied, including free-roaming horses (Mrotek *et al.*, 2019). It would be very important to evaluate in other regions of Argentina how different social actors perceive this type of conflict and the underlying issues (see Anderson and Pizarro, this volume; Car *et al.*, this volume; Guichón *et al.*, this volume).

The polarized situation of ecologists *vs.* horse defenders is perhaps not an accurate reflection of reality, and it could be more productive to look for solutions that incorporate multiple perspectives (Estévez *et al.*, 2015). In this context, some authors have remarked on the importance of managing the environment, and in particular biological invasions, from a socio-ecological perspective (Knight, 2019; see also Anderson and Pizarro, this volume). This framework applied to addressing the feral horse conflict provides an interesting venue and a potentially positive direction for the near future. A correct diagnose of values and risk perception of the different stakeholders involved in the conflict, as proposed by Estévez *et al.* (2015), could be an important first step in the right direction.

Recently, the university researchers involved in the conflict have officially presented OPDS authorities with a draft management proposal for feral horses in PPET (Scorrolli, 2016, 2018). The document focuses on technical aspects with the main goal being to reduce the feral horse population size through corral live trapping and relocation or adoption of the captured horses. The proposal considers adaptive management to be a key issue, with careful monitoring of both ecosystem and social responses. A public debate of the management strategy, including participation of diverse stakeholders, has not yet happened, but clearly is needed and expected. At present, this proposal has not been implemented, but recent conversations with authorities, and also with the President of ACCE, are promising. Some challenging tasks, however, are urgently needed to improve feral horse management, including:

- Better communication of scientific evidence to the general public.
- More effective participation and transparency by governmental agencies and authorities.
- Further debate with and participation of different citizen social groups in the planning process and communication strategy.
- Greater engagement of the public regarding biodiversity's multiple values.
- Enhanced integration of knowledge (*e.g.*, values, opinions, perspectives) gained from other stakeholders to improve feral horse management plans.
- Inclusion of feral horse management plans in the current National Invasive Exotic Species Strategy (ENEEL).

Conclusions

Managing feral horses as an introduced invasive mammal in Argentina is a complex and multi-faceted task. If we are to arrive at a solution in the future, this issue should be treated in a more strategic and collaborative context that recognizes and incorporates its human dimensions, beyond merely expecting society to accept ecologists' statement

of scientific values. Clearly, many challenges remain, but the basis for a sound, participative, knowledge-based management plan is already available. There is a clear path forward regarding the expansion of this issue to understand it as a social-ecological system (see also Anderson and Pizarro, this volume).

Acknowledgements

Thanks to the Secretaría de Ciencia y Tecnología of Universidad Nacional del Sur (UNS) and the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) for the financial support to the projects PGI 24/B213 and PIP 112 201201 00413 CO. Special thanks as well to Dr. Jason I. Ransom for critically reading the manuscript and providing valuable suggestions.

References

- Administración de Parques Nacionales de Argentina (APN). 2007. [*Lineamientos estratégicos para el manejo de especies exóticas en la APN*. Administración de Parques Nacionales, Buenos Aires, 45 pp. Unpublished.]
- Alberdi, M.T. and Prado, J.L. 2004. *Caballos fósiles de América del Sur. Una historia de tres millones de años*, 269 pp. INCUAPA, Facultad de Ciencias Sociales UNCPBA, Olavarría.
- Alioto, S.L. 2011. *Indios y ganado en la frontera. La ruta del río Negro (1750–1830)*, 248 pp. Centro de Documentación Patagónica, Departamento de Humanidades, Universidad Nacional del Sur, Bahía Blanca. Prohistoria Ediciones, Rosario.
- Anderson, C.B. and Pizarro, J.C. This volume. Reconceiving biological invasions as a socio-ecological phenomenon using the case study of beavers in Patagonia, pp. 31–51.
- Asociación Civil Cimarrón Equino (ACCE). 2011. *Objetivos de creación de la asociación*. <https://www.facebook.com/groups/caballostorquinst>.
- Beever, E.A. and Brussard, P.F. 2000a. Examining ecological consequences of feral horse grazing using exclosures. *Western North American Naturalist* 60: 236–254.
- Beever, E.A. and Brussard, P.F. 2000b. Charismatic megafauna or exotic pest? Interactions between popular perceptions of feral horses (*Equus caballus*) and their management and research. In: T.P. Salmon and A.C. Crab (eds.), *Proceedings of the 19th Vertebrate Pest Conference*, pp. 413–418. University of California, Davis.
- Beever, E.A. and Brussard, P.F. 2004. Community- and landscape-level responses of reptiles and small mammals to feral horse grazing in the Great Basin. *Journal of Arid Environments* 59: 271–297.
- Beever, E.A. and Herrick, J.E. 2006. Effects of feral horses in Great Basin landscapes on soil and ants: direct and indirect mechanisms. *Journal of Arid Environments* 66: 96–112.
- Bennett, D. and Hoffmann, R.S. 1999. *Equus caballus*. *Mammalian Species* 628: 1–14.
- Berger, J. 1986. *Wild horses of the Great Basin. Social competition and population size*, 326 pp. The University of Chicago Press, Chicago.
- Bhattacharyya, J., Slocombe, D.S. and Murphy, S.D. 2011. The “wild” or “feral” distraction: effects of cultural understandings on management controversy over free-ranging horses (*Equus ferus caballus*). *Human Ecology* 39: 613–625.
- Bradshaw, C.J.A., Field, I.C., Bowman, D.M.J.S., Haynes, C. and Brook, B.W. 2007. Current and future threats from non-indigenous animal species in northern Australia: a spotlight on World Heritage Area Kakadu National Park. *Wildlife Research* 34: 419–436.
- Brailovsky, A. and Foguelman, D. 1991. *Memoria verde. Historia ecológica de la Argentina*, 375 pp. Editorial Sudamericana, Buenos Aires.
- Cabrera, A. 1945. *Caballos de América*, 405 pp. Editorial Sudamericana, Buenos Aires.

- Car, V., Ader, N., Anderson, C.B. and Valenzuela, A.E.J. This volume. Media representations of introduced invasive mammals: a comparison between trends in Argentina and Tierra del Fuego province, pp. 193–205.
- Chapple, R. 2005. The politics of feral horse management in Guy Fawkes River National Park, NSW. *Australian Zoologist* 33: 233–246.
- Cherubin, R.C., Venn, S.E., Driscoll, D.A., Doherty, T.S. and Ritchie, E.G. 2019. Feral horse impacts on threatened plants and animals in sub-alpine and montane environments in Victoria, Australia. *Ecological Management and Restoration* 20: 47–56.
- Convention on Biological Diversity (CBD). 2017. *What are Invasive Alien Species?* <https://www.cbd.int/invasive/WhatareIAS.shtml>.
- Dawson, M.J., Lane, C. and Saunders, G. 2006. *Proceedings of the National Feral Horse Management Workshop*, 83 pp. Invasive Animals Cooperative Research Centre, Canberra.
- De Villalobos, A.E. 2016. Efectos de los caballos cimarrones sobre la composición florística y la estructura de los pastizales naturales en las Sierras Australes bonaerenses. *Ecología Austral* 26: 264–274.
- De Villalobos, A.E. and Zalba, S.M. 2010. Continuous feral horse grazing and grazing exclusion in mountain pampean grasslands in Argentina. *Acta Oecologica* 36: 514–519.
- De Villalobos, A.E., Zalba, S.M. and Peláez, D.V. 2011. *Pinus halepensis* invasion in mountain pampean grassland: effects of feral horses grazing on seedling establishment. *Environmental Research* 111: 953–959.
- Dobbie, W.R., McK. Berman, D. and Braysher, M.L. 1993. *Managing vertebrate pests: feral horses*, 123 pp. Bureau of Rural Sciences, Australian Government Publishing Service, Canberra.
- Donlan, C.J. 2007. Restoring America's big, wild animals. *Scientific American* 296: 70–77.
- Donlan, C.J., Berger, J., Bock, C.E., Bock, J.H., Burney, D.A., Estes, J.A., Foreman, D., Martin, P.S., Roemer, G.W., Smith, F.A., Soulé, M.E. and Greene, H.W. 2006. Pleistocene rewilding: an optimist agenda for twenty-first century conservation. *American Naturalist* 168: 660–681.
- Douglas, C.L. and Leslie, D.M. 1996. Feral animals on rangelands. In: P.R. Krausman (ed.), *Rangeland wildlife*, pp. 281–291. The Society of Range Management, Denver.
- Dowdall, C.R. 2003. *Criollo. El caballo del país*, 271 pp. Vazquez Mazzini Editores, Buenos Aires.
- Downer, C. 2014. The horse and burro as positively contributing returned natives in North America. *American Journal of Life Sciences* 2: 5–23.
- Estévez, R.A., Anderson, C.B., Pizarro, J.C. and Burgman, M.A. 2015. Clarifying values, risk perceptions and attitudes to resolve or avoid social conflicts in invasive species management. *Conservation Biology* 29: 19–30.
- Fiori, S.M., Scorolli, A.L. and Zalba, S.M. 1997. [*Propuesta de plan de manejo para el Parque Provincial Ernesto Tornquist*. Universidad Nacional del Sur, Bahía Blanca, 80 pp. Unpublished.]
- Food and Agriculture Organization of the United Nations (FAO). 2016. *Estudio de nivel de conocimiento y percepción social sobre las especies exóticas invasoras*. Solicitud de Proposición. http://www.fao.org/fileadmin/user_upload/FAO-countries/Argentina/ToR/Invitacion_a_Licitar_FAOAR-2016-002.pdf.
- Gentry, A., Clutton-Brock, J. and Groves, C.P. 2004. The naming of wild animal species and their domestic derivatives. *Journal of Archaeological Science* 31: 645–651.
- Groves, C.P. 2002. Taxonomy of the living Equidae. In: P.D. Moehlman (ed.), *IUCN Equid Action Plan*, pp. 271–297. IUCN, Morges.
- Guichón, M.L., Borgnia, M., Benitez, V.V. and Gozzi, A.C. This volume. Charisma as a key attribute for the expansion and protection of squirrels introduced to Argentina, pp. 53–73.
- Humane Society of United States (HSU). 2010. *Our vision for wild horse and burro management on federal lands in the U.S.* <https://www.humanesociety.org/resources/our-vision-wild-horse-and-burro-management-federal-lands-us>.
- Independent Technical Reference Group (ITRG). 2016. [*Final report of the Independent Technical Reference Group: supplementary to the Kosciuszko National Park wild horse management plan*. Office of Environment and Heritage NSW, Sydney, 70pp. Unpublished.]
- Instituto Nacional de Estadísticas y Censos (INDEC). 2010. *Censo Nacional de población, hogares y viviendas*. Presidencia de la Nación, Argentina. <https://www.indec.gov.ar/indec/web/Nivel4-Tema-2-41-135>.
- Invasiones Biológicas en Argentina (InbiAr). 2017. *Invasiones biológicas en Argentina*. <http://www.inbiar.uns.edu.ar/base-dados-nacional>.

- Kefena, E., Mekasha, Y., Han, J.L., Rosenbom, S., Haile, A., Dessie, T. and Beja-Pereira, A. 2012. Discordances between morphological systematics and molecular taxonomy in the stem line of equids: a review of the case of taxonomy of genus *Equus*. *Livestock Science* 143: 105–115.
- Kirkpatrick, J.F. and Fazio, P.M. 2010. *Wild horses as native North American wildlife*. The Science and Conservation Center. Zoo Montana, Billings.
- Knight, A.R. 2019. How can the social sciences work with ecology in informing feral horse policy and management in south-eastern Australia? *Ecological Management and Restoration* 20: 9–12.
- Kristensen, M.J. and Frangi, J.L. 1995. Una isla de biodiversidad. *Ciencia Hoy* 5: 25–34.
- Lever, C. 1994. *Naturalized Animals*, 354 pp. Poyser Natural History, London.
- Linnell, J.D., Kaczensky, P. and Lescureux, N. 2016. In: J.I. Ransom and P. Kaczensky (eds.), *Wild equids. Ecology, management and conservation*, pp. 121–132. Johns Hopkins University Press, Baltimore.
- Long, J.L. 2003. *Introduced mammals of the world. Their history, distribution and influence*, 589 pp. CSIRO Publishing, Collingwood.
- Long, M.A. and Grassini, C.M. 1997. [Actualización del conocimiento florístico del Parque Provincial Ernesto Tornquist. Ministerio de Asuntos Agrarios de la Provincia de Buenos Aires y Universidad Nacional del Sur, Bahía Blanca, 199 pp. Unpublished.]
- Loydi, A. and Distel, R.A. 2010. Floristic diversity under different intensities of large herbivore grazing in mountain grasslands of the Ventania System, Buenos Aires. *Ecología Austral* 20: 281–291.
- Loydi, A., Distel, R.A. and Zalba, S.M. 2010. Large herbivore grazing and non-native plant invasions in montane grasslands of central Argentina. *Natural Areas Journal* 30: 148–155.
- Loydi, A. and Zalba, S.M. 2009. Feral horses dung piles as potential invasion windows for alien plant species in natural grasslands. *Plant Ecology* 201: 471–480.
- Loydi, A., Zalba, S.M. and Distel, R.A. 2012. Vegetation change in response to grazing exclusion in montane grassland, Argentina. *Plant Ecology and Evolution* 145: 313–322.
- Mc Fadden, B. 2005. Fossil horses: evidence for evolution. *Science* 307: 1728–1730.
- Mrotek, A., Anderson, C.B., Valenzuela, A.E.J., Manak, L., Weber, A., Van Aert, P., Malizia, M. and Nielsen, E.A. 2019. An evaluation of local, national and international perceptions of benefits and threats to nature in Tierra del Fuego National Park (Patagonia, Argentina). *Environmental Conservation* 46: 326–333.
- Naundrup, P.J. and Svenning, J.-C. 2015. A geographic assessment of the global scope for re-wilding with wild-living horses (*Equus ferus*). *PLoS ONE* 10: e 0132359. doi: [10.1371/journal.pone.0132359](https://doi.org/10.1371/journal.pone.0132359).
- National Research Council (NRC). 2013. *Using science to improve the BLM Wild Horse and Burro Program: a way forward*, 436 pp. The National Academies Press, Washington.
- New Zealand Department of Conservation (NZDOC). 2012. *Kaimanawa Wild Horses Working Plan 2012–2017*. <http://www.doc.govt.nz/about-us/science-publications/conservation-publications/threats-and-impacts/animal-pests/kaimanawa-wild-horses-working-plan-2012-2017>.
- Nimmo, D.G. and Miller, K.K. 2007. Ecological and human dimensions of management of feral horses in Australia: a review. *Wildlife Research* 34: 408–417.
- Novillo, A. and Ojeda, R.A. 2008. The exotic mammals of Argentina. *Biological Invasions* 10: 1333–1344.
- Núñez, C.M., Scorlli, A.L., Lagos, L., Berman, D. and Kane, A. 2016. Management of free-roaming horses. In: J.I. Ransom and P. Kaczensky (eds.), *Wild equids. Ecology, management and conservation*, pp. 133–148. Johns Hopkins University Press, Baltimore.
- Merino, M.L., Carpinetti, B.N. and Abba, A.M. 2009. Invasive mammals in the National Parks System of Argentina. *Natural Areas Journal* 29: 42–49.
- Office of Environment and Heritage, New South Wales (OEH). 2017. *Kosciuszko National Park Wild Horse Management Plan*. <http://www.environment.nsw.gov.au/protectsnowies>.
- Olsen, S. 2016. The role of humans in horse distribution through time. In: J.I. Ransom and P. Kaczensky (eds.), *Wild equids. Ecology, management and conservation*, pp. 105–120. Johns Hopkins University Press, Baltimore.
- Orlando, L., Ginolhac, A., Zhang, G., Froese, D., Albrechtsen, A., Stiller, M., Schubert, M., Cappellini, E., Petersen, B., Moltke, I., Johnson, P.L.F., Fumagalli, M., Vilstrup, J.T., Raghavan, M., Korneliusen, T., Malaspinas, A.-S., Vogt, J., Szklarczyk, D., Kelstrup, C.D., Vinther, J., Dolocan, A., Stenderup, J.,

- Velazquez, A.M.V., Cahill, J., Rasmussen, M., Wang, X., Min, J., Zazula, G.D., Seguin-Orlando, A., Mortensen, C., Magnussen, K., Thompson, J.F., Weinstock, J., Gregersen, K., Roed, K.H., Eisenmann, V., Rubin, C.J., Miller, D.C., Antczak, D.F., Bertelsen, M.F., Brunak, S., Al-Rasheid, K.A.S., Ryder, O., Andersson, L., Mundy, J., Krogh, A., Gilbert, M.T.P., Kjær, K., Sicheritz-Ponten, T., Jensen, L.J., Olsen, J.V., Hofreiter, M., Nielsen, R., Shapiro, B., Wang, J. and Willerslev, E. 2013. Recalibrating *Equus* evolution using the genome sequence of an early Middle Pleistocene horse. *Nature* 499: 74–78. doi: [10.1038/nature12323](https://doi.org/10.1038/nature12323).
- Parkes, J. and Murphy, E. 2003. Management of introduced mammals in New Zealand. *New Zealand Journal of Zoology* 30: 335–359.
- Parks Victoria. 2021. *Protection of the Alpine National Park: Feral Horse Action Plan 2021*. <https://www.parks.vic.gov.au/projects/feral-horse-action-plan-2021>.
- Pearson, R.G. 2016. Reasons to conserve nature. *Trends in Ecology & Evolution* 31: 366–371.
- Pedrotta, V. 2016. Estrategias indígenas de captura y manejo del ganado cimarrón en las sierras septentrionales bonaerenses: las construcciones de piedra Cerro Guacho I y Cerro Guacho II. *Arqueología* 22: 269–289.
- Pennisi, E. 2001. Horses domesticated multiple times. *Science* 291: 412.
- Poder Ejecutivo de la Provincia de Buenos Aires (PEPB). 2006. *Se aprueba la carta de intención entre el Ministerio de Asuntos Agrarios y el Comando de Remonta y Veterinaria del Ejército Argentino (junta y retiro de animales —caballos cimarrones— Parque Provincial «Ernesto Tornquist»)*. Decree #721/2006. <http://www.gob.gba.gov.ar/legislacion/legislacion/06-721.html>.
- Prado, J.L. and Alberdi, M.T. 1994. A quantitative review of the horses *Equus* from South America. *Paleontology* 37: 459–481.
- Prado, J.L. and Alberdi, M.T. 2017. *Fossil horses of South America: phylogeny, systematics and ecology*, 150 pp. Springer, Cham, Switzerland.
- Ransom, J.I., Lagos, L., Hrabar, H., Nowzari, H., Usukhjargal, D. and Spasskaya, N. 2016. Wild and feral equid population dynamics. In: J.I. Ransom and P. Kaczensky (eds.), *Wild equids. Ecology, management and conservation*, pp. 68–86. Johns Hopkins University Press, Baltimore.
- Real Academia Española (RAE). 2017. *Diccionario de la lengua española*. <http://dle.rae.es/?w=diccionario>.
- Rikoon, J.S. 2006. Wild horses and the political ecology of nature restoration in the Missouri Ozarks. *Geoforum* 37: 200–211.
- Robertson, G., Wright, J., Brown, D., Yuen, K. and Tongway, D. 2019. An assessment of feral horse impacts on treeless drainage line in the Australian Alps. *Ecological Management and Restoration* 20: 21–30.
- Rogers, G.M. 1991. Kaimanawa feral horse and their environmental impacts. *New Zealand Journal of Ecology* 15: 49–64.
- Rubenstein, D.R. and Rubenstein, D.I. 2016. From Pleistocene to trophic re-wilding: a wolf in sheep's clothing. *Proceedings of the National Academy of Sciences USA* 113: E1. <http://www.pnas.org/content/113/1/E1.full.pdf>.
- Rubenstein, D.R., Rubenstein, D.I., Sherman, P.W. and Gavin, T.A. 2006. Pleistocene Park: does re-wilding North America represent sound conservation? *Biological Conservation* 132: 232–238.
- Sánchez, B., Prado, J.L. and Alberdi, M.T. 2006. Ancient feeding, ecology and extinction of Pleistocene horses from the Pampean Region, Argentina. *Ameghiniana* 43: 427–436.
- Scorolli, A.L. 1999. [Demografía y áreas de actividad de una población de caballos cimarrones en el Parque Provincial Ernesto Tornquist. MSc Thesis, Universidad Nacional del Sur, Bahía Blanca, 45 pp. Unpublished.]
- Scorolli, A.L. 2016. Manejo de caballos cimarrones: la situación en la Argentina. *Mastozoología Neotropical* 23: 325–333.
- Scorolli, A.L. 2018. Feral horse management in Parque Provincial Ernesto Tornquist, Argentina. *Human-Wildlife Interactions* 12: 102–110.
- Scorolli, A.L. and Lopez Cazorla, A.C. 2010. Demography of feral horses (*Equus caballus*): a long-term study in Tornquist Park, Argentina. *Wildlife Research* 37: 207–214.
- Symanski, R. 1994. Contested realities: feral horses in outback Australia. *Annals of the Association of American Geographers* 84: 251–269.

- Symanski, R. 1996. Dances with horses: lessons from the environmental fringe. *Conservation Biology* 10: 708–712.
- Taboada, G. 1999. *El caballo criollo en la historia argentina. Siglos XVI a XIX*, 256 pp. Editorial Planeta, Buenos Aires.
- The Wildlife Society (TWS). 2011. *Final Position Statement: feral horses and burros in North America*. <http://wildlife.org/wp-content/uploads/2014/05/Feral.Horses.July.2011.pdf>.
- U.S. Department of Interior, Bureau of Land Management. 2011. *Details of the BLM's proposed strategy for future management of America's wild horses and burros*. 32 pp. https://www.blm.gov/sites/blm.gov/files/Proposed_WHBStrategy.pdf.
- U.S. Department of Interior, Bureau of Land Management. 2015. *Wild Horses and Burros Program*. <http://www.blm.gov/wo/st/en/prog/whbprogram.html>.
- White, P., Ford, A.E.S., Clout, M.N., Engeman, R.M., Roy, S. and Saunders, G. 2008. Alien invasive vertebrates in ecosystems: pattern, process and the social dimension. *Wildlife Research* 35: 171–179.
- Witmer, G.W., Pitt, W.C. and Fagerstone, K.A. (eds.) (2007). *Managing vertebrate invasive species: proceedings of an International Symposium*, 488 pp. USDA–APHIS, Fort Collins.
- Zalba, S.M. and Cozzani, N.C. 2004. The impact of feral horses on grassland bird communities in Argentina. *Animal Conservation* 7: 35–44.

INTRODUCED INVASIVE MAMMALS OF ARGENTINA

Introduced Invasive Mammals (IIMs) are a major driver of global and local environmental change, including negative impacts on biodiversity, ecosystem processes, economies, health and other social values. However, as complex social-ecological systems, invasive species cannot be conceived solely as “negative,” nor merely as “biological” invasions. This book presents conceptual and practical perspectives from 49 authors with expertise in communication, ecology, education, genetics, history, philosophy, social sciences and veterinary medicine to better understand and manage IIMs in Argentina. It concludes by providing updated information on Argentina's IIM assemblage, which includes 23 species.

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



SAREM Series A
Mammalogical Research
Investigaciones Mastozoológicas

