

Consejo Nacional de Investigaciones Científicas y Tecnológicas and
Centro de Ecología Aplicada del Neuquén, Argentina

The current distribution of red deer (*Cervus elaphus*) in southern Latin America

By W. T. FLUECK, JO ANNE M. SMITH-FLUECK and C. M. NAUMANN, Bariloche

1 Introduction

The spread of exotic species into foreign habitats may result in economic losses and ecological impacts, but also may provide benefits derived from a novel renewable resource. Of primary concern is how the exotic may influence the persistence of native species and affect native biodiversity and ecosystem functions (D'ANTONIO et al., 2001). Red deer (*Cervus elaphus elaphus*) is known to effectively naturalize in new environments. In fact, exotic red deer are considered to be one of the World's 100 Worst Invasive Alien Species (IUCN SSC Invasive Species Specialist Group 2002, www.issg.org). Red deer expansion into the southern cone of Latin America began less than a century ago, and has yet to reach a state of equilibrium (FLUECK and SMITH-FLUECK, 1993). Negative ecological impact has been described for both Chile and Argentina (RAMIREZ et al., 1981; VEBLEN et al., 1989). However, neither economic loss nor changes to native biodiversity or ecosystem functions have been quantified. Competition between red deer and native ungulates has been suggested, such as in the case of guanaco (*Lama guanicoe*) (BAHAMONDE et al., 1986; FLUECK, 1996). The native Patagonian huemul deer (*Hippocamelus bisulcus*), has also been assumed to be displaced by red deer (CRESWELL, 1972; LEVER, 1985). A recent study identified high dietary overlap between red deer and huemul, particularly in autumn. Ninety-two percent of the annual diet of huemul consisted of plants consumed by both cervids during at least 2 seasons (SMITH-FLUECK, 2003). Huemul is severely endangered with an estimated population size of 600 in Argentina and 1,500 in Chile, with a 99% decline according to REDFORD and EISENBERG (1992).

The distribution of red deer and their movement behavior raise concerns over their potential epidemiological role for various diseases such as foot and mouth disease, brucellosis and tuberculosis (LONGHURST et al., 1952; THORNE et al., 1979; RHYAN et al., 1995; FLETCHER, 2001). Alternately, well-established red deer populations have provided an economic asset and an increased interest for appropriate management of the resource (FLUECK et al., 1995a; FLUECK and SMITH-FLUECK, 2001). Increased and updated knowledge regarding the current distribution of red deer in southern Latin America is necessary for addressing these issues.

Because red deer easily cross the Andean mountain range (FLUECK and SMITH-FLUECK, 1993; FLUECK et al., 1995a), management decisions must be based on the entire red deer distribution, and so far distributions of red deer had only been addressed at a local scale. Thus, we present the current distribution of red deer in the southern cone of Latin America, specifically for the foothills and mountain range of the Andes and the Patagonian steppe of Chile and Argentina.

2 Materials and Methods

We determined the current extent of the red deer distribution in Argentina by updating of previous accounts (MASSOIA and CHEBEY, 1993; FLUECK and SMITH-FLUECK, 1993; FLUECK et al., 1995a), based on interviews and confirmations in the field. Several areas investigated in 1992/93 were resampled for signs of red deer and private landowners and land administrators were consulted about the present distribution of red deer. In Chile, the current distribution of focal populations is based on distributions reported by WOLLENHAUPT (1983) and ORTIZ (1992a, 1993). In addition, SCHILLING (Nat. Assoc. of Deer Breeders in Chile, pers. comm.) provided current information on new sightings. For eight populations, WOLLENHAUPT (1983) could estimate the annual rates of expansion which were used to adjust the size of the current distributional areas. For additional populations in similar habitat the rates of neighboring populations were used. Rates of spread averaged 1 km/year and the approximated distributions were considered sufficiently accurate for the scale used in this analysis.

The topographical contour map for this region was prepared by the U.S. National Imagery and Mapping Agency (www.nima.mil). The interval of isopleth lines used in this analysis is 305 m. Contours were used to determine the most likely distribution of red deer in certain areas, but they are not indicated on figure 1 due to the large scale of the map.

To determine types of habitat already occupied by red deer, we used a digital vegetation map for the Valdivian Rainforest eco-region of Chile and Argentina (LARA et al., 1999), covering the area between 35° and 48° S, and from the Pacific Ocean to 70° W. The Chilean portion was mapped from information provided by the Chilean National Vegetation Mapping project completed in 1997 at scales of 1:50,000 and 1:250,000. The Argentine portion was based on visual interpretation of Landsat TM images, and other available maps (forestry, National Parks) covering some areas in detail. LARA et al. (1999) integrated these data bases into a GIS using ERDAS Imaging 8.3 software. Although the unit on their map was 1 hectare, the vegetation classification was coarser. The habitats classified in the vegetation map of LARA et al. (1999) were: alerce forests, *Fitzroya cupressoides*; Araucaria forest, *Araucaria araucaria*; Guaitecas Cypress forest, *Pilgerodendron uviferum*; Cordilleran Cypress forest, *Austrocedrus chilensis*; Roble-Rauli-Coihue forest, *Nothofagus obliqua*, *N. nervosa*, *N. dombeyi*; Rauli-Tepa-Coihue forest, *Nothofagus nervosa*, *N. dombeyi*, *Laureliopsis philipiana*; Valdivian Rainforest complex; Lenga forest, *Nothofagus pumilio*; Nire forest, *Nothofagus antarctica*; Roble-Hualo forest, *Nothofagus obliqua*, *N. glauca*; Magellan Coihue forest, *Nothofagus betuloides*; alto-Andean vegetation; Patagonian steppe; wet meadows and riparian wetlands; brush and grassland of anthropogenic origin – e.g. forests cleared for livestock; agricultural areas and forest plantations. These habitat types were reduced to forest, suitable non-forested areas, Patagonian steppe, unsuitable habitat and lakes. All types of forests were considered habitable based on known red deer presence. We adapted this digital vegetation map for use in ArcView and added the new layers consisting of the deer distribution and topographical contours.

3 Results

Currently red deer established in most forested habitat types encountered between about 34° and 55° S (figure). Of all differentiated habitat types, only the Guaitecas cypress and roble-hualo forests – hypothesized to provide adequate habitat for this species (WOLLENHAUPT, 1983) – apparently have not yet been occupied by red deer. The potential to yet

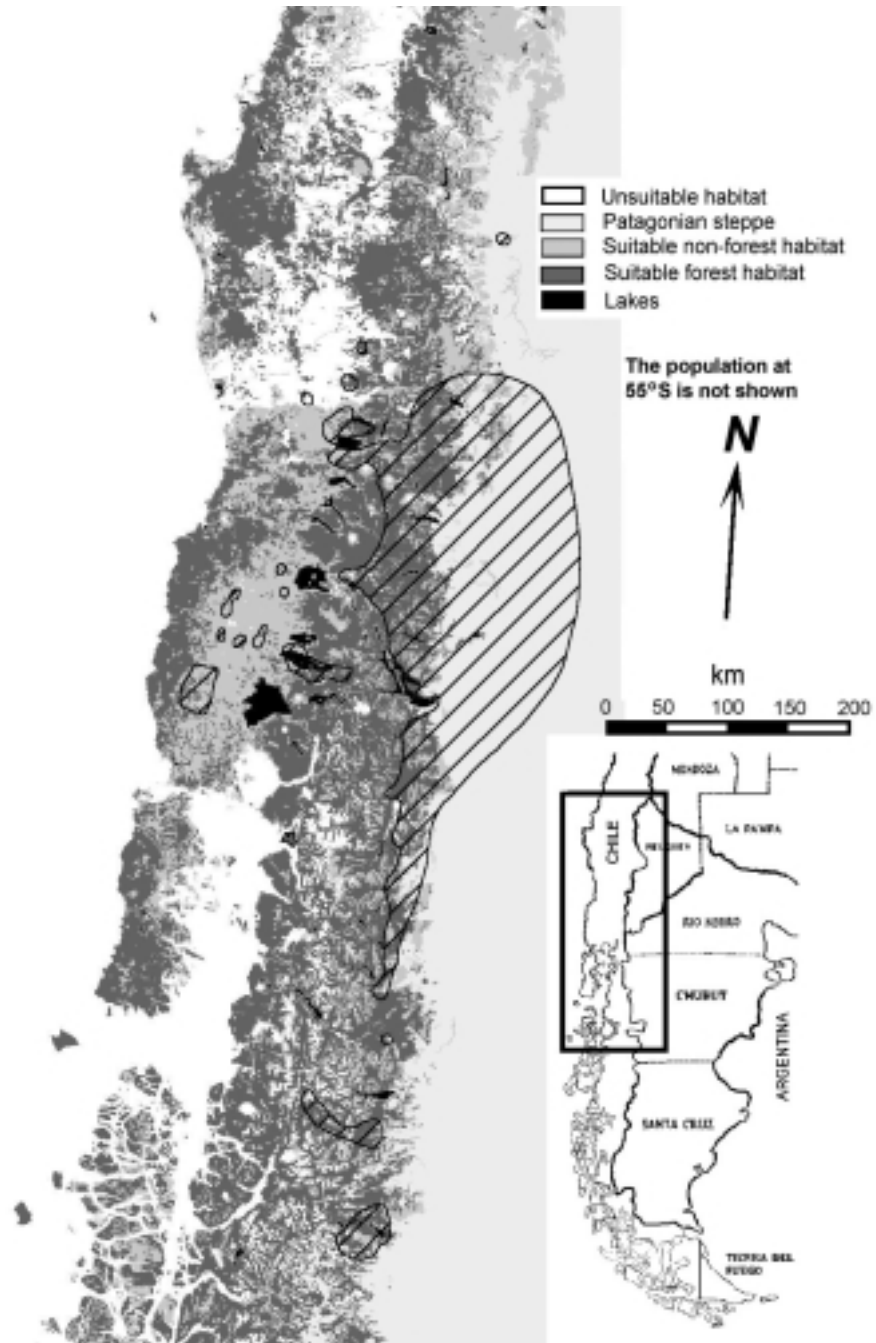


Fig. Current distribution of free-ranging red deer populations in southern Latin America.

invade these habitat types is supported by the fact that the native Patagonian huemul deer once inhabited these environments (SMITH-FLUECK, 2000). We estimate that the current area occupied by red deer in the Patagonian steppe and the Valdivian Rainforest eco-region of Chile and Argentina amounts to nearly 51,500 km². This distributional area includes 424 km² of unsuitable habitat like permanent snow, glaciers, urban and intensive agricultural occupation, plus 826 km² of lake surface. The areas physically available and likely used by red deer comprises 50,238 km² and consists of: 29% forest habitat; 57% Patagonian steppe habitat; and 14% of non-forested habitat such as wet meadows and riparian habitat, brush or grasslands of anthropogenic origin, and high altitude vegetation above the tree line. Whereas ORTIZ (1992b) estimated red deer in Chile to occupy 3,400 km² in 1990, the present calculations show all areas occupied to total 7,700 km².

The present distribution of red deer has the following environmental characteristics: it covers the latitudes between 37° 42' S and 54° 55' S (noncontiguous); the longitudes between 73° 36' W and 69° 50' W (noncontiguous); and altitudes between <300 m and >2,450 m.

4 Discussion

Numerous introductions of red deer in southern Chile and Argentina occurred in the foothill areas of the Andes, which has allowed interchange of this species across the continental divide principally through the many low passes that provide easy corridors, often containing continuous plant cover due to the low elevations (FLUECK and SMITH-FLUECK, 1993; FLUECK et al., 1995a). The plasticity of red deer in colonizing new areas in southern Latin America reflects the history of their invasion in New Zealand, where all vegetation types and a wide range of elevations were used (DAVIDSON and KEAN, 1960). Furthermore, the precipitation gradient in the Valdivian rainforest and Patagonian eco-regions compares with that of New Zealand, where red deer use areas receiving up to 5,000 mm of precipitation (DAVIDSON and KEAN, 1960). The red deer's adaptability and high reproductive potential favor its dispersion to the point where they are currently found in most available habitat types in Patagonia, between about 39° S and 55° S, ranging from temperate rain forest to the tree-less steppe. Low human density allows for rapid colonization which is accelerated through forest plantations. Many enclosures established for farming or hunting are outside of the current distribution of free-ranging populations and are not indicated in the figure. Additional releases and accidental escapees can be anticipated from this increasing number of enclosures. As there are no major barriers, red deer may eventually colonize much of the southern cone of Latin America. Within the present distribution, red deer may currently number 100,000 animals at an average density of about 2 deer/km². This appears to be a conservative estimate considering that favorable ecotonal habitats have revealed densities around 100 deer/km² whereas in steppe areas they reached 40–50 deer/km² (AMAYA, pers. comm.; FLUECK et al., 1995b).

In time, these southern populations of exotic red deer might join other centers of liberations, particularly in Argentina. The area considered in this study borders the Pampean savannah to the east, which already contains a large expanding red deer population in the provinces of La Pampa and San Luis (FLUECK and SMITH-FLUECK, 1993), and the forests of Tucuman to the north, which also contain an expanding red deer population (GRAU et al., 1995). These latter authors also suggested that red deer in Tucuman are expanding into high elevation forests and alto-Andean grasslands where they could impact the native guanaco, taruca (*Hippocamelus antisensis*) and brocket deer (*Mazama* spp.), and due to a lack of natural barriers are expected to invade high altitude forests of Catamarca, Salta, Jujuy

as well as Bolivia. Aside from the invasion by the Tucuman population, red deer were released in the 1970's in Salta and Jujuy, where they have already become established (FLUECK and SMITH-FLUECK, 1993).

The present analysis provides the first approximation of the current extent of the red deer presence in southern Chile and Argentina. The habitat characteristics and lack of natural and anthropogenic barriers suggest that the invasion will continue. This will have direct consequences for the native biodiversity, and conservation efforts for native species like the Patagonian huemul deer. For conservation efforts to be viable, they must contemplate not only the current presence of red deer, but also the future arrival. The presence of red deer in several national parks in both countries manifests a need to implement sound management to protect the park's ecosystems. The likely effects of red deer on native forests, small rodent and bird communities are also of concern (CASEY and HEIN, 1983; PUTMAN et al., 1989). The epidemiological role of red deer in regards to several infectious and parasitic diseases is a concern for Chile and Argentina because these diseases are not only important economically but affect conservation efforts of endangered native ungulates. The current tendency to consider red deer as an economic asset suggests that the expanding populations will likely increase this interest in the species as a renewable resource. It needs to be seen if these interests can be directed towards managing or regulating the populations, instead of accelerating the invasion by additional uncontrolled liberations.

Acknowledgments

We thank several land owners and administrators for contributing information and permitting access to their land. We also thank G. D. ELLIOTT and R. PRIBISH for assistance with field work, and two anonymous reviewers for their constructive advice.

Summary

Spread of exotic species into natural areas is a major component of global change, drawing attention to economic losses, ecological impacts, plus potential benefits to be gained from a novel resource. Red deer, *Cervus elaphus*, known to effectively naturalize in new environments is considered one of the world's 100 worst invasive alien species. Negative ecological impact has been described for both Chile and Argentina, and competition with native ungulates like guanaco, *Lama guanicoe*, or the Patagonian huemul, *Hippocamelus bisulcus*, has been suggested. This report provides the current distribution of red deer in Chile and Argentina with respect to habitat types to permit informed decisions to manage the invasion. Information on the distribution was gathered through interviews, literature and field confirmations. Digital maps were used to analyze habitat use and estimate sizes of occupied areas. Red deer were introduced <100 years ago to both sides of the Andean foothills and now extend between 37° 42' S – 54° 55' S and 73° 36' W – 69° 50' W (noncontiguous). Practically all available habitat types have been invaded, amounting to >50,000 km². The current distribution involves 29% forest habitat, 57% Patagonian steppe habitat and 14% of non-forested habitat such as wet meadows, brush and grasslands of anthropogenic origin, and vegetation above the tree line. Habitat characteristics and lack of natural and anthropogenic barriers suggest that the invasion will continue unabated, thereby continuously increasing the geographical area occupied by red deer. This will have direct consequences for the native biodiversity and conservation efforts.

Key words: Red deer, *Cervus elaphus elaphus*, invasion, exotic species, Chile, Argentina, distribution

Zusammenfassung

*Die gegenwärtige Verbreitung von Rotwild (*Cervus elaphus*) im südlichen Lateinamerika*

Die Ausbreitung exotischer Arten in Naturgebieten ist ein wesentliches Element globaler Veränderungen. Wirtschaftliche Verluste, ökologische Schäden, aber auch Vorteile durch die neuartige Ressource stoßen auf Interesse. Rotwild, *Cervus elaphus*, das für seine effektive Anpassung an neue Umgebungen bekannt ist, wird als eine der weltweit 100 schlimmsten invadierenden exotischen Arten betrachtet. Ökologische Schäden durch Rotwild wurden bereits für Chile und Argentinien beschrieben, und Konkurrenz mit einheimischen Huftieren wie Guanako, *Lama guanicoe*, oder dem Patagonischen Huemul, *Hippocamelus bisulcus*, wurde vermutet. Dieser Beitrag schildert die gegenwärtige Verbreitung von Rotwild in Chile und Argentinien bezogen auf Habitattypen, um besser informierte Entscheidungen im Hinblick auf das Management der Invasion zu ermöglichen. Daten zur Verbreitung wurden durch Interviews und Bestätigungen im Feld gewonnen. Zur Analyse der Habitatnutzung und zur Berechnung der genutzten Flächen wurden digitale Karten herangezogen. Die Ansiedlung von Rotwild erfolgte vor < 100 Jahren auf beiden Seiten des andinen Vorgebirges und die (nicht geschlossene) Verbreitung erreicht nun 37° 42' S – 54° 55' S und 73° 36' W – 69° 50' W. Praktisch alle existierenden Habitattypen, mit einer Gesamtfläche von > 50,000 km², wurden besiedelt. Die derzeitige Verbreitung verteilt sich auf 29 % Waldfläche, 57% Patagonische Steppe und 14 % unbewaldete Fläche wie z. B. Nasswiesen, Busch- und Grassland anthropogenen Ursprungs, und Vegetation oberhalb der Baumgrenze. Die Eigenschaften der Habitattypen und das Fehlen von natürlichen oder anthropogenen Barrieren lassen vermuten, dass die Invasion uneingeschränkt weitergehen wird, wodurch das Verbreitungsgebiet des Rotwilds kontinuierlich zunehmen wird. Das wird direkte Auswirkungen auf die einheimische Biodiversität und Naturschutzbemühungen haben.

Schlüsselwörter: Rotwild, *Cervus elaphus elaphus*, Invasion, exotische Arten, Chile, Argentinien, Verbreitung

Résumé

References

- BAHAMONDE, N.; MARTIN, S.; SBRILLER, A.P., 1986: Diet of guanaco and red deer in Neuquen Province, Argentina. *J. Range Manage.* **39**, 22–24.
- CASEY, D.; HEIN, D., 1983: Effects of heavy browsing on a bird community in deciduous forest. *J. Wildl. Manage.* **47**, 829–836.
- CRESWELL, M., 1972: European red deer in Argentina. *Deer* **2**, 937–938.
- D'ANTONIO, C.; MEYERSON, L.A.; DENSLow, J., 2001: Exotic species and conservation. In: Soule, M.E.; Orians G.H. (eds.) *Conservation Biology: Research priorities for the next decade*. Washington, DC: Island Press, pp. 59–80.
- DAVIDSON, M.M.; KEAN, R.L., 1960: Establishment of red deer range in the Tararua mountains. *N.Z. J. Forestry* **8**, 293–324.
- FLETCHER, J., 2001: Foot and mouth disease in British deer. *Deer* **12**, 54–57.
- FLUECK, W.T., 1996: Zwischenartliche Beziehungen zwischen freilebenden Guanaco (*Lama guanicoe*) und angesiedeltem Rotwild (*Cervus elaphus*) in Argentinien. *Z. Jagdwiss.* **42**, 12–17.
- FLUECK, W.T.; SMITH-FLUECK, J.M., 1993: Über das in Argentinien angesiedelte Rotwild (*Cervus elaphus*, L., 1758): Verbreitung und Tendenzen. *Z. Jagdwiss.* **39**, 153–160.
- FLUECK, W.T.; SMITH-FLUECK, J.M., 2001: Consideraciones acerca de una concesión experimental para la caza de ciervo colorado en el parque nacional Nahuel Huapi: Evaluación de los cotos fiscales de caza de ciervo colorado, Cerro Buque y Lago Nuevo, parque Nacional Nahuel Huapi. Report to the Administración de Parques Nacionales, Argentina. 42 pp.
- FLUECK, W.T.; SMITH-FLUECK, J.M.; RUEGG, K.A., 1995a: Management of introduced red deer in Patagonia. In: BISSONETTE, J.A.; KRAUSMAN, P.R. (eds.) *Integrating people and wildlife for a sustainable future. Proceedings of the first International Wildlife Management Congress*. Bethesda, MD, USA: The Wildlife Society, pp. 525–528.
- FLUECK, W.T.; SMITH-FLUECK, J.M.; RUEGG, K.A.; BONINO, N., 1995b: Datos preliminares sobre la densidad del ciervo colorado (*Cervus elaphus*) introducido en la Patagonia, Argentina. III Congreso Latinoamericano de Ecología, Merida, Venezuela, 24–29.
- GRAU, A.; HALLOY, S.; DOMINGUEZ, E.; GONZALEZ, J.A.; VIDES, R., 1995: Ciervos introducidos: estudio de su impacto ambiental en el noroeste Argentino. *Serie Conserv. Natur., Fund. Miguel Lillo, SECYT, Argentina* **10**, 1–13.
- LARA, A.; RUTHERFORD, P.; MONTORY, C.; BRAN, D.; PEREZ, A.; CLAYTON, S.; AYESA, J.; BARRIOS, D.; GROSS, M.; IGLESIAS, G., 1999: Mapeo de la eco-region de los bosques Valdivianos. *Fundacion Vida Silvestre, Buenos Aires. Boletin Técnico No. 51* pp. 1–27.
- LEVER, C., 1985: *Naturalized mammals of the world*. Longman Inc., New York. 477 pp.
- LONGHURST, W.M.; LEOPOLD, A.S.; DASMANN, R. F., 1952: A survey of California deer herds. Their ranges and management problems. *Calif. Dept. Fish and Game, Game Bull.* **6**, 1–136.
- MASSOIA, E.; CHEBEY, J.C., 1993: *Mamíferos silvestres del archipiélago Fueguino*. LOLA, Buenos Aires.
- ORTIZ, C. R., 1992a: Current status of introduced red and fallow deer populations in Chile: the need of management. In: BROWN, R. D. (ed.) *The biology of deer*. New York: Springer Verlag, pp. 30–36.
- ORTIZ, C.R., 1992b: Sociobiological control of deer in practice experiences in Chile. In: ORTIZ, C. R. (ed.) *International seminar on native and introduced deer in Chile*. Osorno, Chile: Asociacion Nacional de Criadores de Ciervos, pp. 99–105.
- ORTIZ, C.R., 1993: Red deer management in Chile. *Deer* **9**, 35–38.
- PUTMAN, R.J.; EDWARDS, P.J.; MANN, J.C.; HOW, R.C.; HILL, S.D., 1989: Vegetational and faunal changes in an area of heavily grazed woodland following relief of grazing. *Biol. Conserv.* **47**, 13–32.
- RAMIREZ, C.; GODOY, R.; ELDRIDGE, W.; PACHECO, N., 1981: Impacto ecológico del ciervo rojo sobre el bosque de Olivillo en Osorno, Chile. *Anales Mus. Hist. Nat. Valparaiso* **14**:197–215.
- REDFORD, K.H.; EISENBERG, J.F., 1992: *Mammals of the Neotropics: The Southern Cone. Volume 2. Chile, Argentina, Uruguay, Paraguay*. Chicago and London: The University of Chicago Press.
- RHYAN, J.; AUNE, K.; HOOD, B.; CLARKE, R.; PAYEUR, J.; JARNAGIN, J.; STACKHOUSE, L., 1995: Bovine tuberculosis in a free-ranging mule deer (*Odocoileus hemionus*) from Montana. *J. Wildl. Dis.* **31**, 432–435.
- SMITH-FLUECK, J., 2000: The current situation of the Patagonian huemul. In: DIAZ, N.; SMITH-FLUECK, J. (eds) *The Patagonian huemul: a mysterious deer on the brink of extinction*. Buenos Aires: L.O.L.A., pp. 67–146.

- SMITH-FLUECK, J.M., 2003. The ecology of huemul (*Hippocamelus bisulcus*) in Andean Patagonia of Argentina and considerations about its conservation. Doc. Diss. (in Spanish), Univ. Nac. Comahue, Argentina, submitted.
- THORNE, E.T.; MORTON, J.K.; RAY, W.C., 1979: Brucellosis, its effect and impact on elk in western Wyoming. In: BOYCE, M. S.; HAYDEN-WING, L. D. (eds) North American Elk: Ecology, Behavior and Management. Laramie, Wyo. USA: The University of Wyoming, pp. 212–220.
- VEBLEN, T.T.; MERMOZ, M.; MARTIN, C.; RAMILO, E., 1989: Effects of exotic deer on forest regeneration and composition in northern Patagonia. *J. Appl. Ecol.* **26**:711–724.
- WOLLENHAUPT, H., 1983: Die Ansiedlung, Bestandesentwicklung und Status des Rothirsches (*Cervus elaphus* L., 1758) in Chile. Diss., Georg-August-Universität in Göttingen, Germany. 225 pp.

Authors' addresses: W.T. FLUECK, PhD, CONICET, C.C. 176, 8400 Bariloche, Argentina. email: deerlab@infovia.com.ar, JO ANNE M. SMITH-FLUECK, MSc, PhD cand., Universidad Nacional del Comahue and DeerLab, C.C. 176, 8400 Bariloche, Argentina, C.M. NAUMANN, MSc, PhD, Instituto Andino de Educación Superior, Luisa Runge 875, 8400 Bariloche, Argentina

