

Rehabilitation of *Nothofagus pumilio* forests in northern Chilean Patagonia

Alejandro Huertas-Herrera*, Fernanda Rivas,
Macarena Luco, Mónica Toro-Manríquez

*alejandro.huertas@ciep.cl

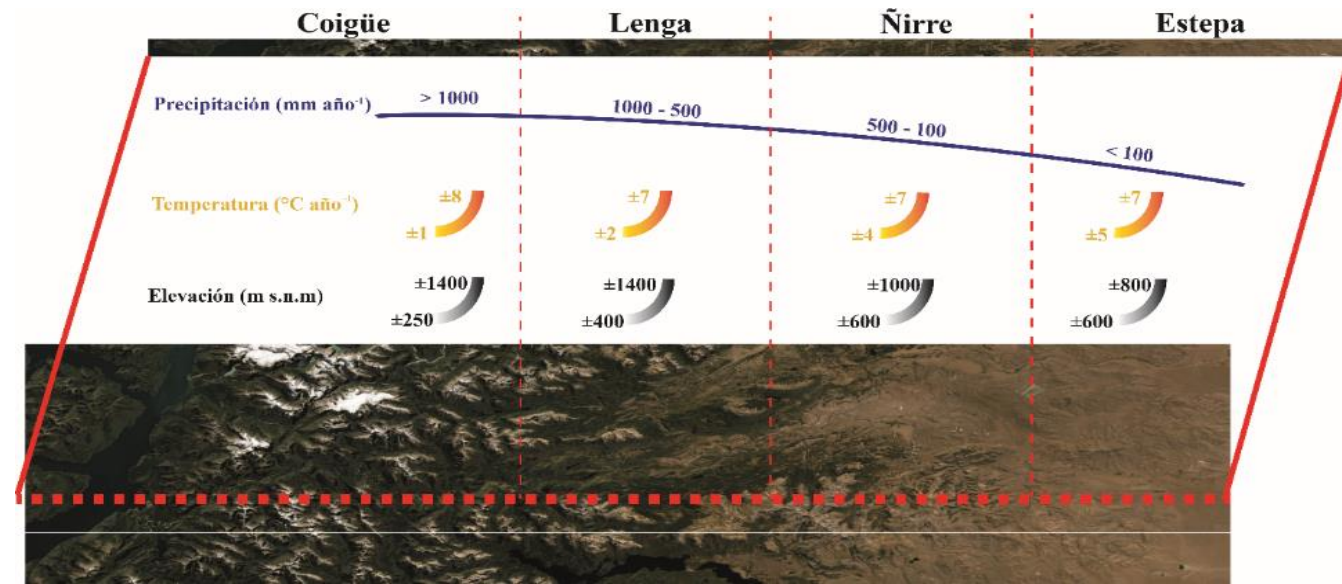


FOREST LANDSCAPE RESTORATION: RESILIENT SOCIOECOLOGICAL LANDSCAPES IN THE MAKING



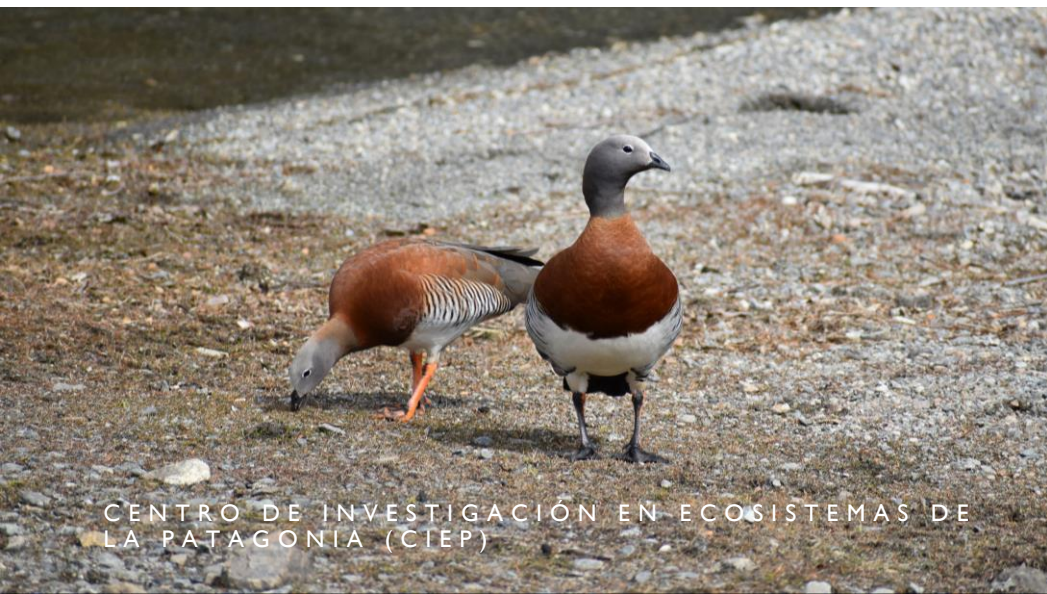
Native forests in northern Chilean Patagonia

CENTRO DE INVESTIGACIÓN EN ECOSISTEMAS DE LA PATAGONIA (CIEP)





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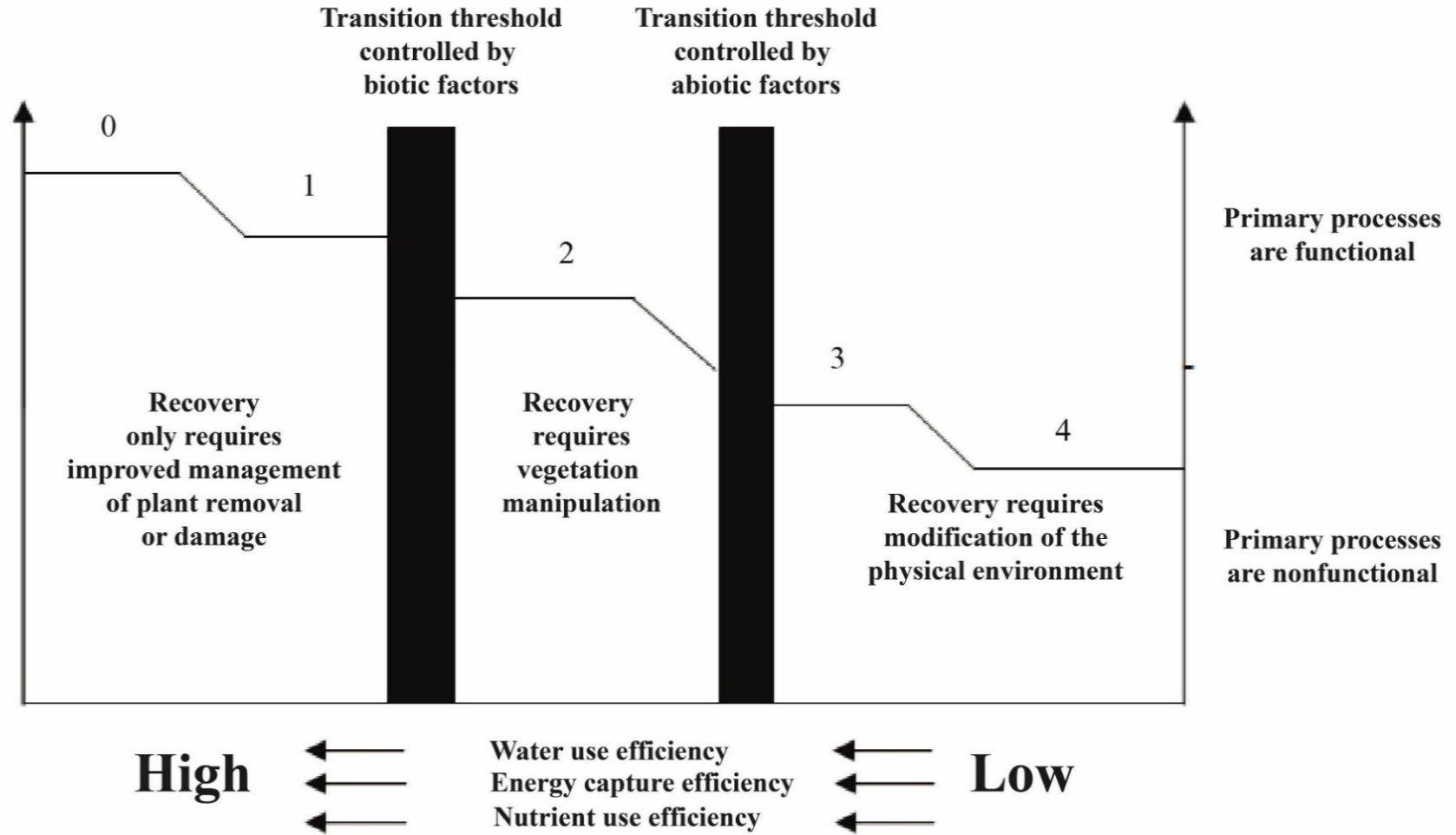


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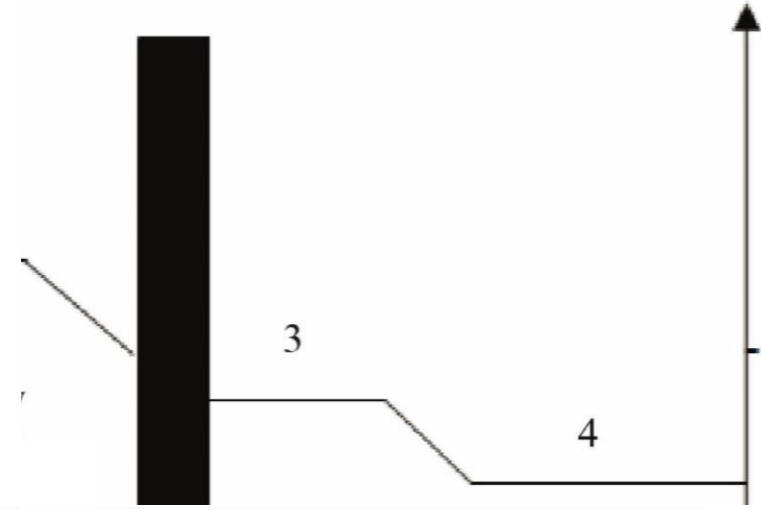




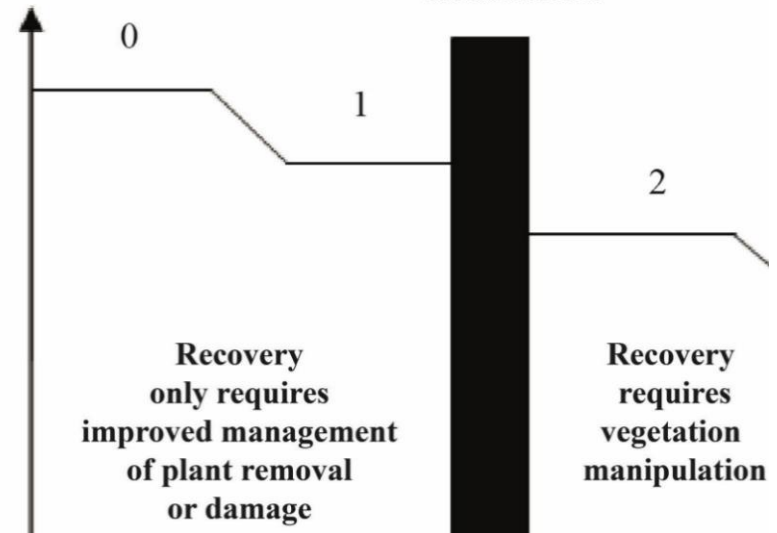
Theoretical model of the degradation of natural ecosystems, where the numbers indicate the levels of degradation (adapted from Whisenant 1999).



**Transition threshold
controlled by
abiotic factors**



**Transition threshold
controlled by
biotic factors**





Forest nursery





Rehabilitation of *Nothofagus pumilio* forests in Chilean Patagonia: can fencing and planting season effectively protect against exotic European hare browsing?

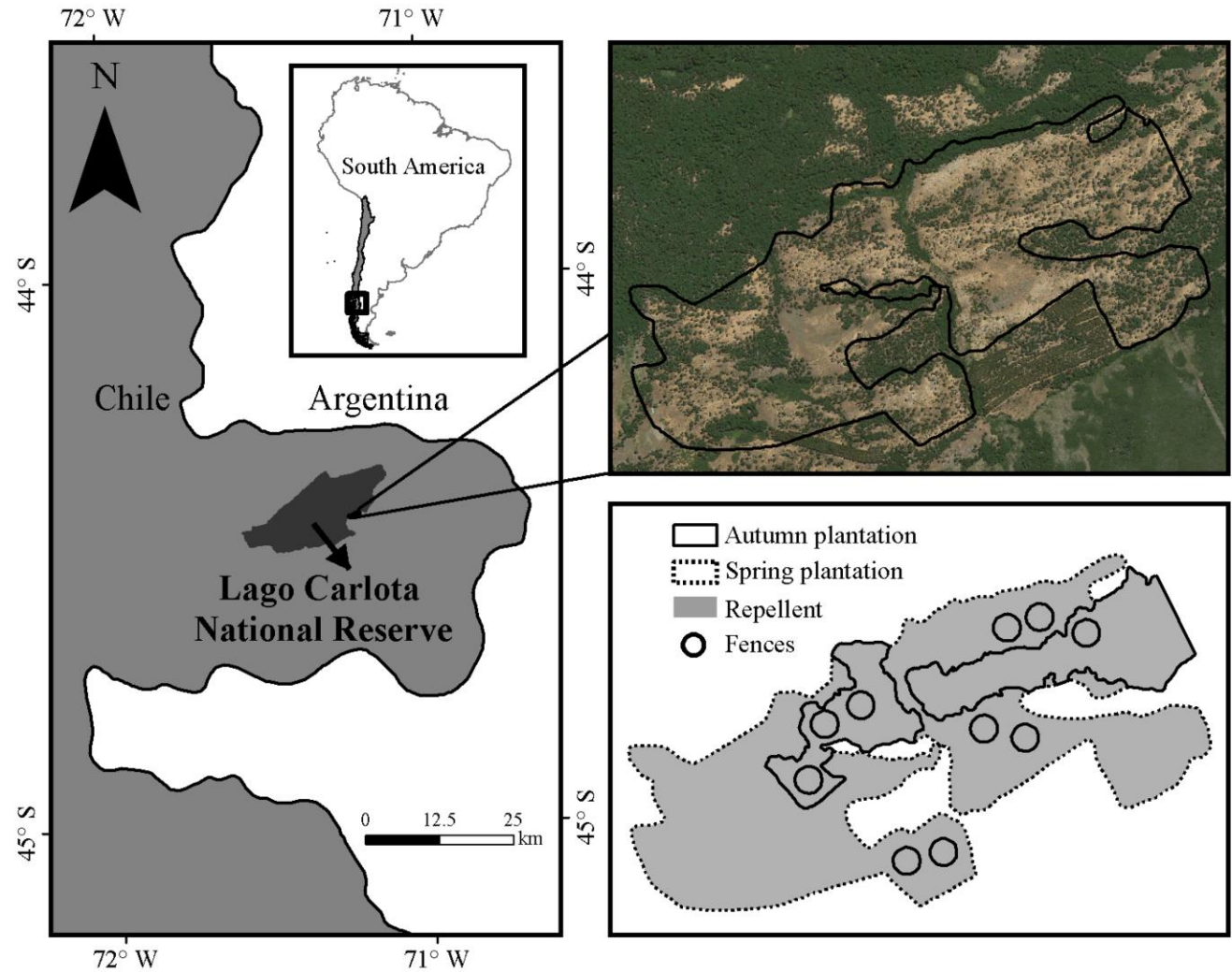
Alejandro Huertas Herrera^{1,2} · Álvaro Promis³ · Mónica Toro-Manríquez^{1,2} · María Vanessa Lencinas⁴ · Guillermo Martínez Pastur⁴ · Matías Río⁵

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Abstract

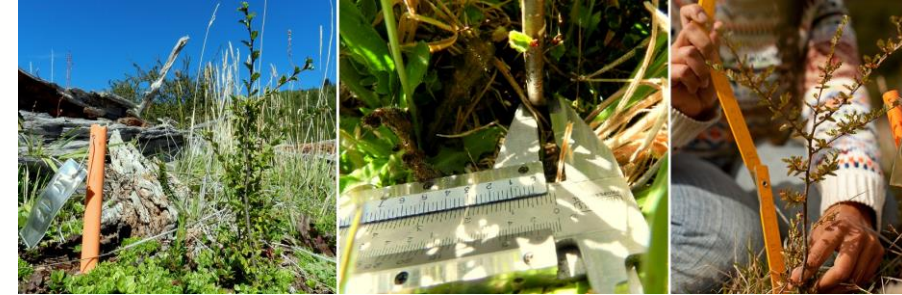
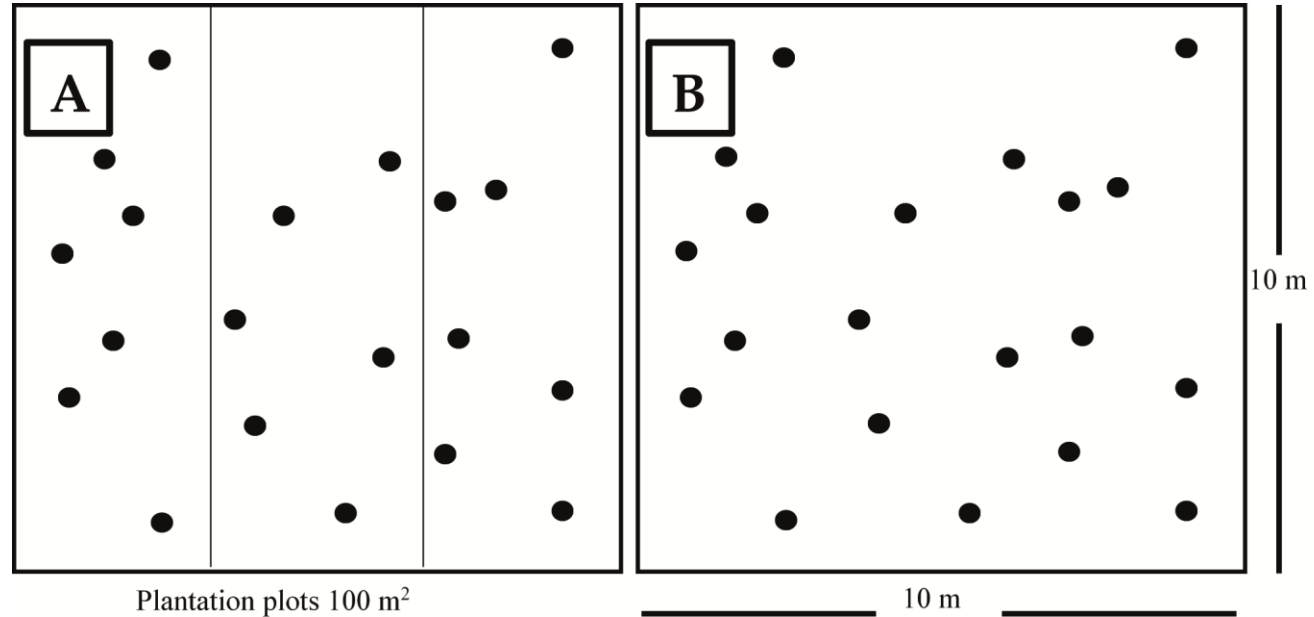
In forests affected by heavy fires and continuous grazing of exotic herbivorous mammal species, *Nothofagus pumilio* (lenga) cannot recover naturally. The main factors that hinder the natural recovery of these forests and the feasibility of native tree plantations are the exotic herbivorous pressure, like that produced by *Lepus europaeus* (European hare), and the environment degradation degree by anthropic disturbances. The objective of this study was to evaluate different plantation efforts to recover *N. pumilio* forests degraded by fires in Chilean Patagonia. The plantation actions also included wire fences for sapling protection in 100 ha, where 60 ha were established during autumn (May 2012), and 40 ha were established during spring (October 2012). In March 2013 we recorded the height annual growth (cm year^{-1}), the section browsed at each sapling, the modification of plant form (number of new branches), and the vigor expression. We evaluated the data using one- and two-way ANOVAs, Cohen's *d* effect size, and chi-square analyses. We measured a total of 872 plants, where 42% presented damages caused by European hare browsing. These results indicated that the wire fences were not completely useful to stop the damage on saplings (Cohen's *d* effect size = <0.2). We also found that autumn plantations were more susceptible to damage than those established during spring. European hares predominantly browsed on a particular sapling section: the apical buds. As a consequence, the browsed saplings had lower height growth than undamaged ones. These outputs highlight the need to explore and implement alternative actions for the rehabilitation of these degraded deciduous forests, to achieve the objectives of sustainable management or to recover the natural ecosystem functions.

Keywords Native tree plantations · Saplings · Wire fences · Herbivory control · *Lepus europaeus* · Aysén Region

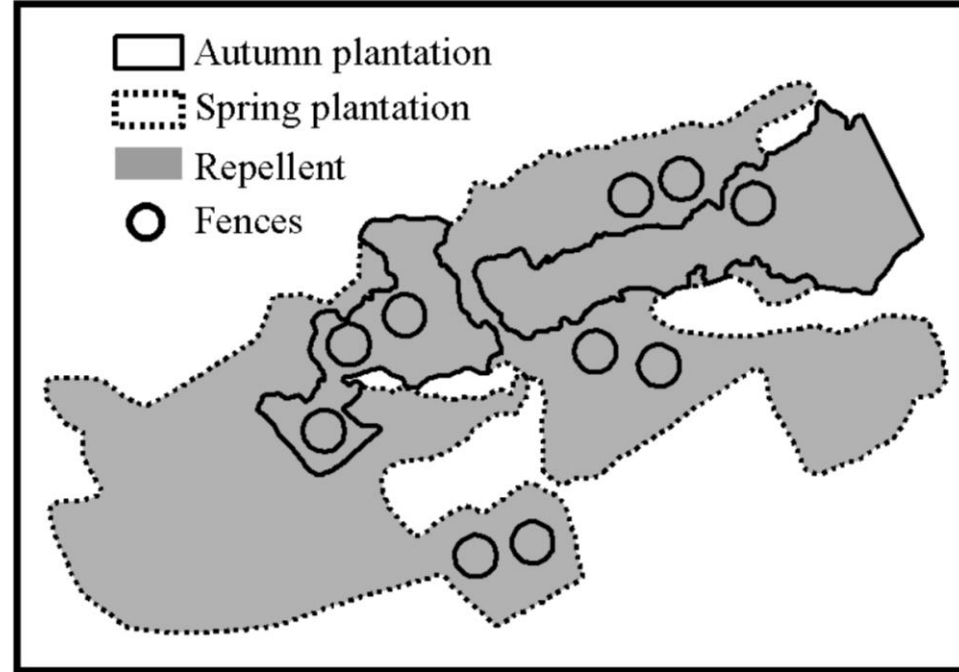


100 ha of burned forests within the reserve were selected for the native tree plantation

This is a remote area



100 ha were planted with *N. pumilio* saplings in 100 m² plots (with 20 saplings each). These saplings were 2-3 years-old, 3.8-4.5 mm (4.2 mean \pm 1.4 standard deviation) in diameter at root collar (DRC) and 15-20 cm (15.1 mean \pm 4.5 standard deviation) in height (H). The individuals presented similar shapes (only one stem and erect stem) and a root/shoot mass ratio higher than 2:1.



Planting was carried out during two seasons to assess the best planting period. All plants were treated with a hare-repellent substance (Pomarsol[®] Forte 80% WG Product Thiram of Bayer CropScience fungicide and repellent for lagomorphs) with Bond[®] sticker (200 L for approximately 52,000 plants). For their application, the repellents were hand-sprayed.

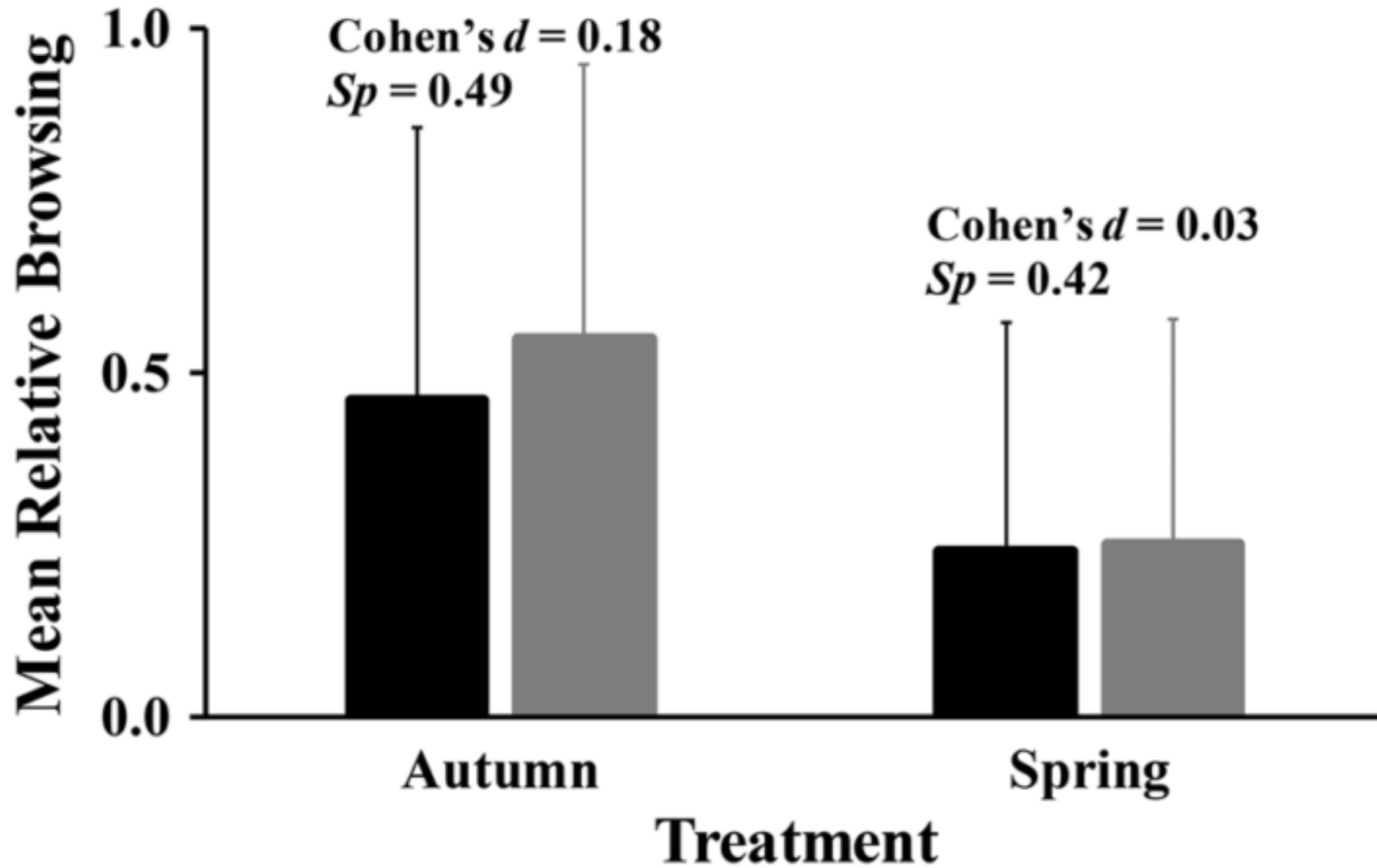




Table 1 Two-way ANOVAs and the average percentage value of plants for the factors of the period (autumn and spring) and fencing (unfenced and fenced) on the response variable plant damage severity

Factors	Type	No damage	Low damage	Medium damage	High damage	Very high damage	Total cut off
A: Period	Autumn	49.1 a	11.0	17.0 a	8.8 a	8.4 a	5.9
	Spring	70.0 b	18.3	4.9 b	2.8 b	2.0 b	1.9
	F	11.65	3.79	22.50	8.88	7.18	2.21
	(<i>p</i>)	(0.004)	(0.072)	(<0.001)	(0.009)	(0.018)	(0.159)
B: Fencing	Unfenced	61.4	16.3	10.4	4.9	4.1	2.9
	Fenced	57.1	13.1	11.5	6.6	6.2	4.9
	F	0.45	0.71	0.19	0.78	0.85	0.12
	(<i>p</i>)	(0.513)	(0.412)	(0.666)	(0.393)	(0.372)	(0.372)
A x B	F	0.577	0.00	0.19	1.85	0.44	1.56
	(<i>p</i>)	(0.462)	(0.945)	(0.666)	(0.195)	(0.517)	(0.232)

F, Fisher test; (*p*), probability. Letters indicate differences using Tukey's test ($p < 0.05$). The text in italics is used to differentiate between the value of the statistical parameter (F and *p*) and other values. Medium damage, high damage, and very high damage were arcsine square root transformed to accomplish ANOVA assumptions, but the transformed data are not shown

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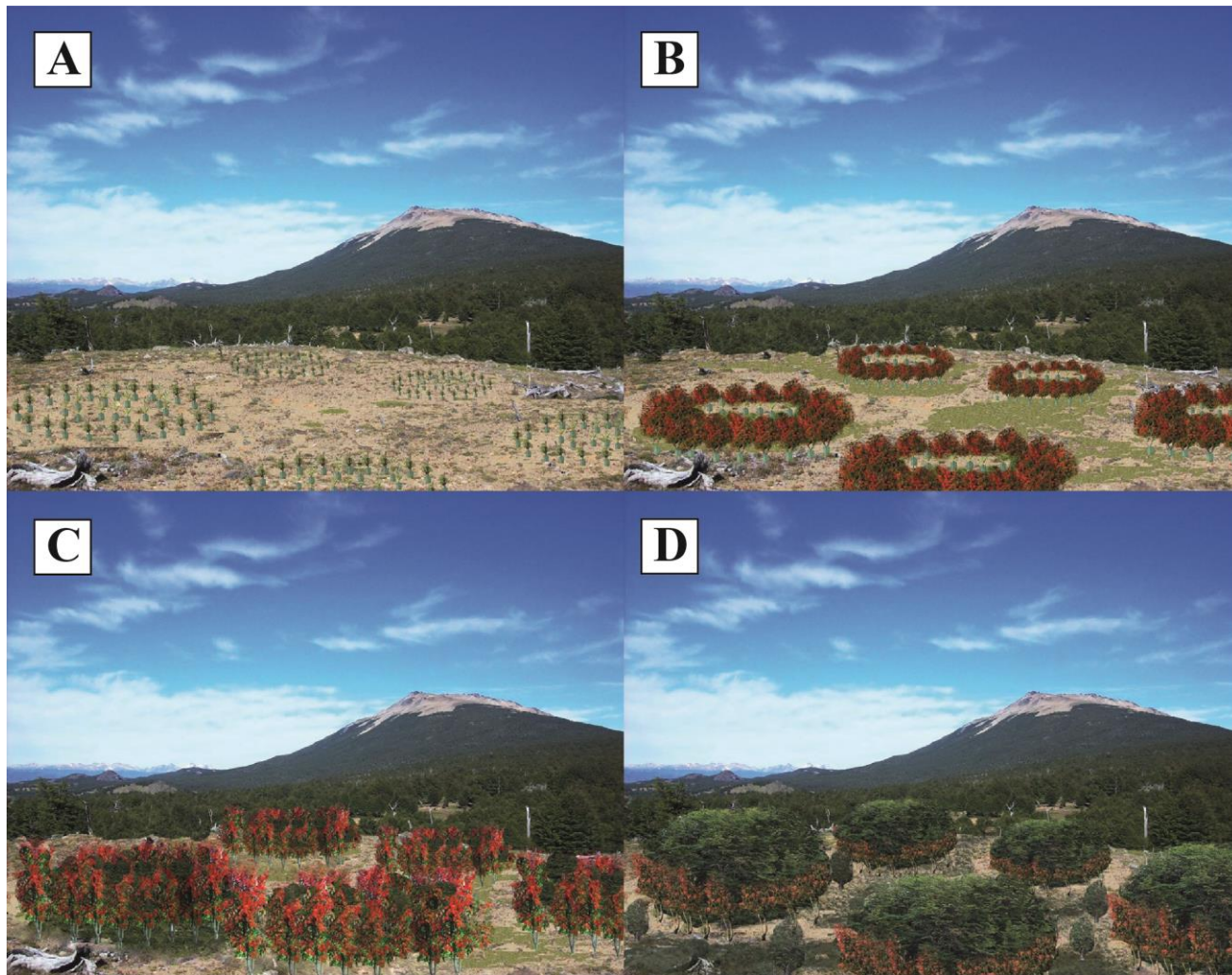
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 **Pato Salinas Dillems** @pato_salinas · 7h
Dentro del programa de restauración en Torres del Paine, estamos probando propagar Ñirres (*Nothofagus antarctica*), a través de acodos aéreos (airlayering). El objetivo es generar individuos de mayor desarrollo para ser posteriormente plantados en otras áreas del parque.



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Visual simulation of the stages of development expected with the establishment of cluster planting: (A) establishment of the cluster planting where peripheral (notro) and inner (lenga) individuals are protected with shelters; (B) plantation in 5 years, the notro reaches between 3 to 4 m height, while the lenga reaches 1 m height; (C) plantation in 25 years, the notro reaches 6 to 7 m height, while the lenga reaches 4 m height; (D) plantation in 50 years, the notro reaches 8 m height, while the lenga reaches between 7 to 8 m height, natural regeneration of both species and the initiation of understory is expected.



ELSEVIER



Relationships among livestock, structure, and regeneration in Chilean Austral Macrozone temperate forests

Alejandro Huertas Herrera^{a,*}, Mónica D.R. Toro-Manríquez^a, Jaime Salinas Sanhueza^b,
Fernanda Rivas Guíñez^{a,c}, María Vanessa Lencinas^d, Guillermo Martínez Pastur^d

^a Grupo Ecología Forestal, Centro de Investigación en Ecosistemas de la Patagonia (CIEP), Camino Baguales s/n Km 4, Coyhaique, Chile

^b Instituto Forestal (INFOR) Sede Patagonia, Camino Coyhaique Alto Km 4.5 Coyhaique, Chile

^c Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Avenida Vicuña Mackenna (4860) Santiago, Chile

^d Laboratorio de Recursos Agroforestales, Centro Austral de Investigaciones Científicas (CADIC CONICET), Housseay 200 (9410) Ushuaia, Argentina

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ABSTRACT

A Macrozone is a socioecological region with shared geographic and demographic characteristics. Within the Chilean Austral Macrozone (43° to 56° SL), the native temperate forests serve as a crucial resource, offering multiple ecosystem services to local communities. These forests significantly support animal husbandry practices involving cattle, horses and sheep. However, introducing these exotic species affects natural regeneration and compromises their long-term sustainability. This study proposes a new classification of the temperate forests in the Chilean Austral Macrozone based on structure parameters and determine their relationships with animal husbandry and natural regeneration. Data were obtained from Chile's National Forest Inventory (NFI) (2001–2010), including 195 inventory plots (500 m²) with 21 tree species. We redefined the forest categories described in NFI according to the proportional basal area of each tree species at each plot. We used two levels of analysis: forest composition (Level 1), which includes general categories such as mono-specific (dominated by a single tree species), bi-specific (dominated by two tree species), and multi-specific forests (dominated by multiple tree species), and forest type (Level 2), which includes specific species (e.g., *Nothofagus pumilio*) or species groups (e.g., *N. pumilio* - *N. dombeyi*) with economic relevance. We evaluated the data using univariate and multivariate analyses. We found 18 forest types in the Austral Macrozone, in contrast to the three traditionally recognized forest types used in the NFI (e.g., lenga, evergreen, coihue de Magallanes). Livestock was observed in all forest types, where *Nothofagus* forests showed that regeneration in *N. antarctica* and *N. pumilio* were higher with livestock than without livestock breeding (Hedges' $g > 0.51$). The natural regeneration of the studied forests was influenced by animal husbandry, environmental variables (bioclimatic and topographic factors), and forest structure. Our data suggested the importance of using more forest types than the three classics to generate tools or recommendations that are more focused on the particularities of each one. The classification must be based on forest parameters obtained during NFI. The proposed forest type classification reflects the complexity and richness of the forests in a better way, which could improve forest management and the development of public policies related to climate change and sustainability. Finally, although livestock pressure was observed in all forest types, the impact over some areas (e.g., *N. antarctica*) needs special attention in the forest management and conservation planning for the Chilean Austral Macrozone.

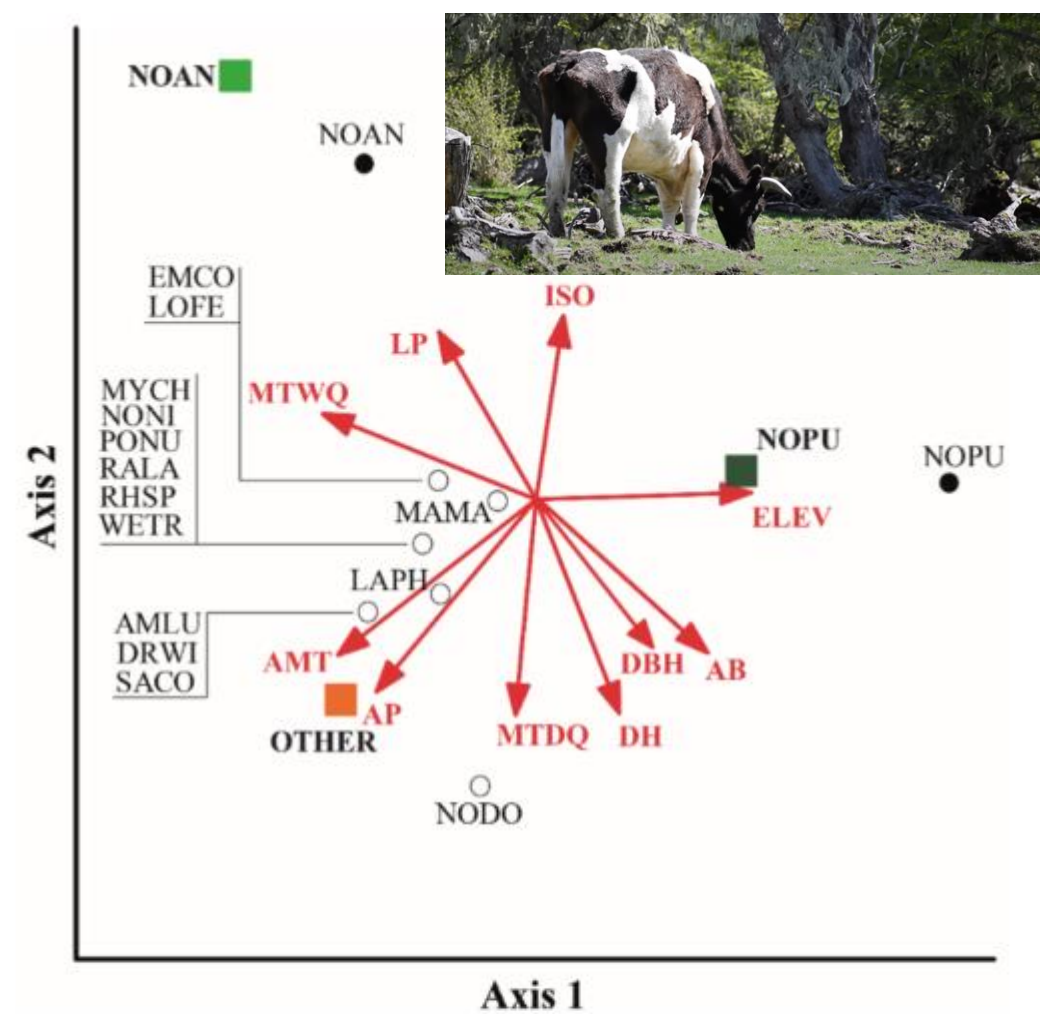


Fig. 8. PCA analysis illustrating the relationships between natural regeneration (white dots = evergreen, black dots = deciduous), forest types (coloured squares), and environmental variables (red arrows) using dummy variables. NOAN = *Nothofagus antarctica*, NODO = *N. dombeyi*, NOPU = *N. pumilio*, OTHER = other deciduous and evergreen or both species, AMT = Annual mean temperature, AP = Annual precipitation, BA = Basal area, DBH = diameter at breast height, DH = Dominant height, ELEV = Elevation, ISO = Isothermality, LP = Livestock pressure, MTDQ = Mean temperature of the driest quarter, MTWQ = mean temperature of wettest quarter. The species codes are shown in Fig. 4.



A low-angle, upward-looking photograph of a dense canopy of trees. The leaves are in various stages of autumn, showing shades of orange, yellow, and brown. The tree trunks and branches are dark and silhouetted against a pale, overcast sky. The overall mood is serene and contemplative.

Obrigado!
Thanks!
Gracias!

