Seasonal diet of *Lama guanicoe* (Camelidae: Artiodactyla) in a heterogeneous landscape of South Patagonia

Dieta estacional de *Lama guanicoe* (Camelidae: Artiodactyla) en un paisaje heterogéneo de Patagonia Sur

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SUMMARY

Large diversity of habitat types, plant species assemblages, and silvopastoral activities in *Nothofagus spp.* forests condition the food availability for native herbivores. This work evaluates the seasonal diet of *Lama guanicoe* linked to plant life forms and habitat types in sub-Antarctic forests. The study evaluated vegetation availability and habitat types by floristic surveys (n = 206) in Tierra del Fuego, and seasonal diet of *L. guanicoe* by a micro-histological analysis of feces (n = 4 in four areas, during four season). Open lands showed the highest plant richness, while lowest values corresponded to primary *Nothofagus pumilio* forests. *Nothofagus pumilio* (21.6 %), *Carex spp.* (17.2 %), *Misodendrum spp.* (10.6 %) and *Deschampsia spp.* (8.6 %) were the most frequent items found in feces. Significant differences were seasonally found in diet composition and trophic niche breadth: grasses were all consumed along the year, while tree browsing decreased and the proportion of shrubs increased in winter. This study highlights the widespread use of different habitats by guanaco, including harvested forests. In summer and spring *Nothofagus spp.* forests were the main source of food for guanacos, depending more on open lands during winter. The knowledge of plant-native herbivores interactions in productive landscapes could improve the management plans towards an ecologically sustainable strategy.

Key words: grasses, guanaco, landscape, plant assemblage, tree seedlings.

RESUMEN

La heterogeneidad de hábitat, distintos ensambles de especies vegetales y las actividades productivas en bosques del género *Nothofagus* condicionan la disponibilidad de alimento para los herbívoros nativos. Este trabajo evalúa la dieta estacional de *Lama guanicoe* vinculada a la vegetación, los tipos de hábitat y el manejo forestal en Tierra del Fuego. Se realizaron censos de vegetación (n = 206) y se estudió la dieta de *L. guanicoe* mediante recolección de heces y análisis micro-histológico (n = 4 en cuatro áreas, durante las cuatro estaciones). Las áreas abiertas tuvieron la mayor riqueza específica, mientras que los valores más bajos correspondieron a bosques primarios de *Nothofagus pumilio*. La dieta de *L. guanicoe* incluyó 25 especies y 13 géneros de plantas y un musgo (*Sphagnum spp.*). *Nothofagus pumilio* (21,6 %), *Carex spp.* (17,2 %), *Misodendrum spp.* (10,6 %) y *Deschampsia spp.* (8,6 %) fueron los ítems más frecuentes en la dieta. Se registraron diferencias estacionales tanto en la composición como en la amplitud del nicho trófico: el consumo de pastos fue continuo durante todo el año, el ramoneo de árboles disminuyó en invierno y aumentó el consumo de arbustos perennes. Este estudio confirma que el guanaco utiliza una amplia variedad de ambientes, incluyendo bosques cosechados. En verano y primavera los bosques de *Nothofagus spp.* fueron los principales sitios de alimentación para los guanacos, dependiendo más del alimento en áreas abiertas durante el invierno. El conocimiento de las interacciones planta-herbívoros nativos en paisajes con manejo agro-forestal podría mejorar los planes de manejo hacia un uso ecológicamente sustentable.

Palabras clave: ensamble de plantas, guanaco, pastos, paisaje, plántulas leñosas.

INTRODUCTION

The multiple-use character of forests means that many different and sometimes conflicting goals exist (*e.g.* timber production, silvopastoral, tourism and recreation, conservation of wildlife habitat) regarding their management (Luque *et al*. 2011). In South Patagonia, *Nothofagus spp.* forests are considered one of the world's largest and most pristine temperate forests (Mittermeier *et al*. 2003). On the other hand, forest harvesting takes an important role in the socio-economic development of southern Patagonia, mainly in Tierra del Fuego.

In Tierra del Fuego (Argentina), landscapes are forested mosaics where timber-quality forests of *Nothofagus pumi-*

lio (Poepp. *et* Endl.) Krasser 1896 (lenga) are interspersed along with other habitat types (Lencinas *et al*. 2008) such as open lands (grasslands, peatlands) and associated low timber-quality forests of *N. antcarctica* (Forster f.) Oersted 1871 (ñire). Each habitat type presents a characteristic assemblage of plant species and vegetation formations. At the same time, harvesting and silvopastoral practices of *Nothofagus spp.* forests modify the original composition of understory plants compared to primary unmanaged forests (Martínez Pastur *et al*. 2002). That includes tree seedlings and saplings, which are key components to ensure the maintenance of the tree layer. This landscape heterogeneity and different plant assemblages offer a variety of food resources for native ungulates (Raedeke 1978, Pulido *et al*. 2000, Cavieres and Fajardo 2005).

Populations of native large herbivores are affected by environmental changes, in terms of spatial and temporal heterogeneity in food availability (Raedeke 1978), as well as the presence of competitive livestock with which they share the habitat in productive systems (Soler *et al*. 2012). In this way, native herbivores perceive and respond to variation in plant quality and quantity across multiple spatial scales (Edenius *et al*. 2002).

Historically, the sub-Antarctic forests have been inhabited by guanacos (*Lama guanicoe,* Müller 1776), the only one large native herbivore (Raedeke 1978, Muñoz 2008). It is a generalist species and the most abundant free-ranging ungulate throughout Patagonia, but it is commonly sharing habitats with domestic herbivores (*i.e*. cattle and sheep). Despite their preference for open habitats (Puig *et al*. 1997), guanaco does move into the forest, consuming not only *N. pumilio* seedlings and saplings (Pulido *et al*. 2000) but also other plants growing there. Although this native herbivore has coexisted with *Nothofagus spp.* forests for centuries (Raedeke 1978, Pulido *et al*. 2000, Muñoz 2008), several authors affirm that regeneration of these forests can be inhibited by guanaco browsing (Pulido *et al*. 2000, Cavieres and Fajardo 2005). It has been also reported that livestock browsing creates serious problems for natural regeneration growth of *N. pumilio*. However, we consider there has been no quantitative evaluation of the impact of ungulate browsing on *Nothofagus* species. Even less information exists about the role of different functional groups of plants in the diet of native ungulates, under different scenarios of *Nothofagus spp.* forest management and livestock.

In this study we investigate the seasonal diet composition of guanacos, linked to the available vegetation during summer season in different habitat types of Tierra del Fuego (Argentina). To achieve this goal, we addressed the following questions: i) what is the assemblage of plant species and different vegetation community types across the landscape?, ii) is the herbivores' diet determined by the availability of life-form groups of plants in space and time?, iii) how is the relationship between diet and the use of different habitat types in this landscape?

METHODS

Site description. The study was conducted in an area of 100 km², "Los Cerros" ranch (figure 1) in the central zone of Tierra del Fuego Island, Argentina (54°20' S, 67° 52' W). The climate is characterized by short, cool summers (mean: 14 °C), and long snowy and frozen winters (mean: -7 ℃). Precipitation is near 700 mm per year. The growing season of vegetation extends for about five months (November to March), but tree leaves fully expanded during January and February, with signs of early senescence during March (Moore 1983).

We classified this area through high definition satellite images (Quickbird images, March 2008) into a GIS, and checked in the field during the vegetation surveys. Open lands occupied 28.7 % of the area (grasslands 24.9 % and peatlands 3.8 %), while *Nothofagus spp.* forests occupied 71.3 % (*N. antarctica* forests 19.4%, primary *N. pumilio* forests 42.7 % and harvested *N. pumilio* forests 9.2 %). The *Nothofagus spp.* managed stands selected for this study were harvested (1-5 years) using a variable retention method (Martínez Pastur *et al.* 2009), which included non-harvested aggregated retention areas (30 % of the stand) and harvested areas with dispersed retention (70 % of the stand).
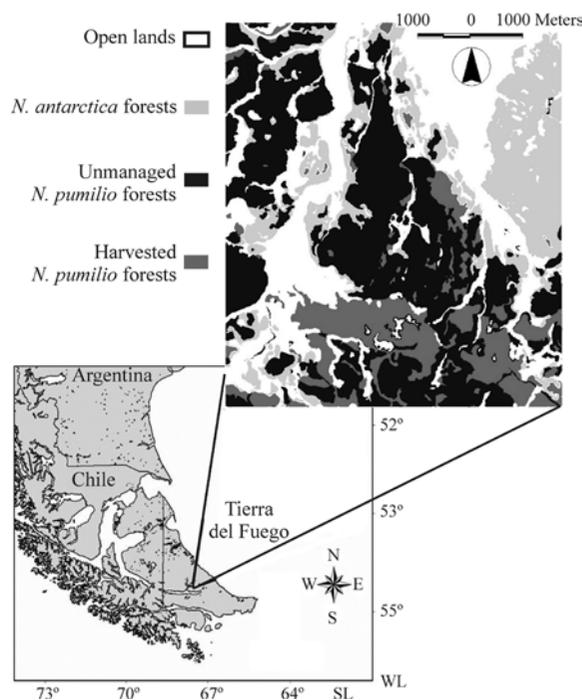

Figure 1. Study area in central Tierra del Fuego showing different habitat types: white = open land, pale gray = *N. antarctica* forest, black = primary unmanaged *N. pumilio* forest, dark gray = harvested *N. pumilio* forest.

Área de estudio en el centro de Tierra del Fuego, donde pueden observarse los distintos ambientes estudiados: blanco = áreas abiertas, gris claro = bosque de *N. antarctica*, negro = bosque sin manejo de *N. pumilio*, gris oscuro = bosque cosechado de *N. pumilio*.

Montes *et al*. (2000) estimated a density of 2 individuals km^{-2} for guanacos populations in this area. During the pre-breeding season (October-November) guanacos are concentrated mainly in the forest-steppe area, but in winter they seek shelter and tend to spend more time in the coastal regions associated with forest (Montes *et al*. 2000). On the other hand, livestock density is about 12 individuals km^{-2} (cattle) in the study area, corresponding mainly to Hereford breed. The traditional grazing management is based on winter and summer extensive grazing ground (400-1,000 ha approximately), where each grazing ground includes mixed habitat types (*N. antarctica* forests, grasslands, and peatlands) (Ormaechea *et al*. 2009). Livestock movements depend on ranching management decisions, but usually are free-ranging, feeding along grasslands in the steppes and occasional browsing of forest plant species (Somlo *et al.* 1997).

Vegetation analyses. During summer season (2007 and 2008), floristic surveys were conducted in the study area. Based on existent GIS data and the different management schemes in the study area, four habitat types were defined as: 1) open lands (*i.e.* peatlands and grasslands) (OL): 2) *Nothofagus antarctica* forest (Ñ); 3) unmanaged *N. pumilio* forest (PF), which has not been previously logged; 4) harvested *N. pumilio* forest (HF).

A total of 206 vegetation surveys were conducted, according to the heterogeneous distribution at the landscape and resulting in unequal number of replicates (OL = 30; Ñ = 70; HF = 80; PF = 26). Surveys were randomly distributed in the habitats, and the Braun Blanquet sampling method was applied following Pauchard *et al*. (2000) for estimations of vegetation availability in circular plots of 30 m radius (2,827 m²). Vascular plants (Dicotyledonae, Monocotyledonae, and Pteridophytae) were taxonomically classified at species level following Moore (1983). Then, species were grouped according to their life form as: tree seedlings and saplings (trees less than 1 m height), shrubs, erect herbs, prostrate herbs, caespitose grasses, and rhizomatous grasses. Species richness was calculated as the total number of species per habitat type, and relative frequency of each species was calculated as a proportion of one species within the plot and divided by the total proportion of the vegetation cover in each plot.

Fecal collection and micro-histological analyses. Feces samples were collected during spring (October 2007), summer (January 2008), autumn (April 2008) and winter (August 2008). We identified four sampling sectors within the ranch as current use latrines, independently of the vegetation sampling points because the latrines are located mainly in *Nothofagus* spp. forests, and rarely found guanacos latrines in open lands (*e.g.*, peatlands or grasslands) in this region. Also considering that guanacos walk long distances at day looking for food or water, they could feed in several sites far from latrines. In each sector

(approximately 1 ha), five fresh dung piles were collected and pooled, resulting in one sample by sector by season (n = 16 samples). Botanical composition of feces was determined by identifying plant epidermal and no epidermal fragments according to the micro-histological analysis method (Sepúlveda *et al*. 2004). Pool samples were oven-dried at 60 ºC for 48 h, ground to < 1 mm in a Cole-Parmer analytical mill (USA), depigmented with alcohol 70º, colored with safranin and mounted on five microscope slides of 24 × 40 mm in glycerin-jelly. Twenty random field observations per slide were performed; thus, a total of 100 fields per pool sample were obtained. Quantification of the species components was achieved through the frequencies of each species. Plant epidermal fragments were identified using 100 × magnifications, based on their morphological characteristics at species or genus level, and classified in the different life forms, also including bryophyte (B) or hemiparasitic shrub (HS) categories. *N. pumilio* and *N. antarctica* were differentiated through the stoma distribution patterns in the epidermis, swelling of cuticle and trichomes (Ragonese 1981).

Data analyses. All data were tested for normal distribution using the Shapiro-Wilks test. The plant life forms groups were also tested for homogeneity of variance with Levene's test ($P < 0.05$). One-way factor ANOVAs were performed to evaluate differences in: i) the vegetation cover classified by life forms in different habitat types, ii) the proportion of plant life forms constituting the seasonal diet. A post-hoc Tukey's test was used for all mean comparisons ($P < 0.05$). No corrections were made to consider the differential digestibility of plant species (Bonino and Pelliza Sbriller 1991). In addition, differences in the frequency of plant species in the diets across seasons were analyzed using a Chi square test.

Diet was characterized by three indices. The trophic niche breadth was determined by Levins's standardized index (B_{st}, Krebs 1989), which ranges from 0 (preference for only a few resources) to 1 (all available resources used equally):

$$B_{st} = \frac{(B-1)}{(B+1)} \qquad [1]$$

In this formula, *B* is the Levin's trophic niche breadth:

$$B = \frac{1}{\Sigma \mathrm{p}i^2} \qquad [2]$$

where p*i* is the proportion of a single food item in relation to the overall consumption. Diet selection was analyzed considering vegetation cover in the field during summer as an estimation of food availability, according Ivlev's selectivity index (*S*, Krebs 1989):

$$S = \frac{\mathrm{r}i - \mathrm{p}i}{\mathrm{r}i + \mathrm{p}i} \qquad [3]$$

where ri is the relative abundance of plant group i in the guanacos feces, and pi is the cover of that group in the field. S varies between -1 (strong avoidance) and 1 (strong selection); while values from -0.09 to 0.09 mean indifference (Krebs 1989, Borgina *et al.* 2010). Finally, we performed an index to graph the relationship between plant species found in guanaco's feces and vegetation census (plant cover at the landscape). Seasonal differences in the niche breadth were tested with one-way ANOVA.

RESULTS

Vegetation composition. A total of 113 species of vascular plants were recorded during the vegetation census, where 71 species were dicots (Appendix 1), 39 monocots (Appendix 2) and three ferns (Appendix 3). The most abundant species at the landscape level were: *Galium aparine* (17.6 %), *Poa pratensis* (11.9 %), *N. pumilio* (9.7 %), *Cotula scariosa* (8.5 %), *Osmorhiza depauperata* (7.1 %), *Empetrum rubrum* (4.0 %), *Carex curta* (3.3 %), *Taraxacum officinale* (3.3 %) and *N. antarctica* (2.0 %). Despite this, 58 species presented less than 0.1 % cover at the landscape level (40 dicots, 17 monocots and one fern). Richness was higher in open lands (83 species) than in woodland sites (HF= 63, Ñ= 57 and PF= 26 species). The most abundant species found in each habitat type were: *E. rubrum* and *C. curta* in open lands (14.1 % and 11.7 %, respectively); *G. aparine* and *O. depauperata* in harvested *N. pumilio* forests (16.1 % and 13.0 %, respectively), *C. scariosa* and *P. pratensis* in *Nothofagus antarctica* forests (22.1 % and 17.5 %, respectively); and *G. aparine* and *N. pumilio* seedlings in unmanaged *N. pumilio* forests (33.8 % and 21.2 %, respectively) (Appendices 1 to 3).

Significant differences were found for the cover of plants functional groups for each habitat type (table 1). Cover of shrubs, caespitose and rhizomatous grasses were higher in open lands, while tree seedlings and saplings were higher in unmanaged *N. pumilio* forests. The groups of herbs were higher in forested areas (PF, HF and Ñ).

Seasonal diet analyses. Guanaco's feces samples contained 37 taxa of vascular plants and 1 moss (*Sphagnum*). A total of 25 plants were identified at species level and 13 at genus level (table 2). The species and genera recognized in the feces potentially included 58 of the 113 species identified during the vegetation census. *Nothofagus pumilio* (21.6 %), *Carex spp.* (17.2 %), *Misodendrum spp.* (10.6 %) and *Deschampsia spp.* (8.6 %) were the most frequent taxa found in feces all year round (table 2). Rhizomatous grasses and tree seedlings and saplings were the main components of the feces, with 28.1 % and 23.9 % mean annual percentages, while prostrate herbs was the least frequent group with 6.7 % mean annual percentage (*e.g. Arjona spp., C. scariosa, Gunnera magellanica, Nanodea mucosa, Ranunculus* and *Vicia magellanica*).

Niche breadth ($F = 3.61$, df = 3, $P = 0.045$) was significantly higher in winter (0.49) and lower in spring (0.31), with intermediate values for autumn (0.43) and summer (0.41). The consumption of some plant species showed seasonal differences: a) *Rubus geoides* ($\chi^2 = 15.02$, df = 3, $P = 0.001$) was exclusively consumed during spring (5.0 %); b) *Geum magellanicum* ($\chi^2 = 32.20$, df= 3, $P < 0.001$) and *N. antarctica* ($\chi^2 = 8.62$, df = 3, $P = 0.03$) were significantly higher in summer (10.7 and 5.3 %, respectively); c) *Plantago barbata* ($\chi^2 = 30.40$, df = 3, $P < 0.001$) and *Berberis buxifolia* ($\chi^2 = 3.96$, df = 3, $P = 0.050$) were significantly superior during autumn (10.3 and 5.0 %); and d) *Juncus scheuzerioides* ($\chi^2 = 16.62$, df = 3, $P = 0.001$) was significantly more consumed during winter (7.5 %). Finally, *N. pumilio* was consumed all around the year (23.5 % - 31.7 %), but decreased during winter ($\chi^2 = 28.25$, df = 3, $P < 0.001$) when this item represents less than 1 %.

Table 1. One-way ANOVA for coverage (%) of tree seedlings and saplings (T), shrubs (S), erect herbs (EH), prostrate herbs (PH), caespitose grasses (CG), rhizomatous grasses (RG), at different habitat types: open lands (OL), *N. antarctica* forests (Ñ), primary unmanaged *N. pumilio* forests (PF), harvested *N. pumilio* forests (HF).
ANDEVA de un factor para evaluar la cobertura (%) de plántulas de *Nothofagus* spp. (T), arbustos (S), hierbas erectas (EH), hierbas postradas (PH), pastos cespitosos (CG) y pastos rizomatosos (RG), en diferentes tipos de hábitat: áreas abiertas (OL), bosques de *N. antarctica* (N), bosques primarios de *N. pumilio* (PF) y bosques cosechados de *N. pumilio* (HF).

Habitat	Life forms					
	T	S	EH	PH	CG	RG
OL	5.84[ab]	20.56[b]	10.36[a]	8.36[a]	18.13[c]	36.73[c]
Ñ	1.48[a]	1.48[a]	21.26[bc]	41.68[b]	11.73[b]	22.34[b]
PF	21.33[c]	0.04[a]	17.13[ab]	46.80[b]	3.22[a]	10.83[a]
HF	6.86[b]	0.51[a]	26.35[c]	47.43[b]	4.85[a]	14.62[a]
F (P)	41.75 (< 0.01)	31.95 (< 0.01)	11.03 (< 0.01)	44.68 (< 0.01)	19.49 (< 0.01)	19.23 (< 0.01)

Note: F = Fisher test; *P* = probability. Letters a,b,c mean significant differences at *P* < 0.05. Normality and homoscedasticity of residuals were previously tested.

Table 2. Relative frequency of plant species (±SD) in the diet of *Lama guanicoe* during spring (SP), summer (SU), autumn (AU), winter (WI). Origin: native (N) or exotic (E) species. Life form: tree seedlings and saplings (T), shrubs (S), erect herbs (EH), prostrate herbs (PH), caespitose grasses (CG), rhizomatous grasses (RG).

Frecuencia relativa de las especies vegetales (± DE) presentes en la dieta de *Lama guanicoe* durante la primavera (SP), verano (SU), otoño (UA), invierno (WI). Origen: especies nativas (N) o exóticas (E). Formas de vida: plántulas de *Nothofagus spp.* (T), arbustos (S), hierbas erectas (EH), hierbas postradas (PH), pastos cespitosos (CG) y pastos rizomatosos (RG).

Species	Life form	Origin	SP	SU	AU	WI
Acaena spp.	EH-PH	N	1.1 (0.6)	-	1.4 (0.9)	3.3 (1.6)
Agrostis spp.	RG-CG	N	6.1 (2.4)	5.6 (2.0)	3.9 (2.3)	7.1 (2.8)
Alopecurus magellanicus	CG	N	3.1 (0.6)	4.4 (2.5)	-	3.9 (1.8)
Arjona spp.	EH	N	-	0.3 (0.3)	-	-
Berberis buxifolia	S	N	2.5 (0.7)	0.6 (0.4)	6.6 (1.4)	2.0 (0.8)
Blechnum penna marina	EH	N	0.3 (0.1)	0.7 (0.3)	-	2.3 (1.2)
Bromus unioloides	CG	N	-	-	0.3 (0.3)	-
Calceolaria biflora	EH	N	-	0.3 (0.3)	-	-
Carex spp.	RG	N	23.2 (0.8)	14.2 (3.6)	15.4 (2.0)	16.0 (1.3)
Cerastium spp.	PH	E-N	0.8 (0.5)	2.0 (1.1)	4.2 (2.1)	1.7 (0.7)
Cotula scariosa	PH	N	0.1 (0.1)	0.7 (0.7)	-	1.5 (1.0)
Deschampsia spp.	CG-RG	N	8.7 (1.9)	5.4 (1.1)	7.4 (0.3)	13.4 (2.2)
Empetrum rubrum	S	N	2.3 (0.8)	2.8 (1.6)	0.1 (0.1)	5.0 (0.9)
Epilobium australe	EH	N	0.7 (0.7)	0.3 (0.3)	0.3 (0.3)	0.2 (0.1)
Erigeron myosotis	EH	N	0.6 (0.3)	-	-	-
Erodium cicutarium	PH	E	-	-	0.4 (0.3)	-
Festuca magellanica	CG	N	1.6 (0.7)	3.2 (1.4)	2.5 (1.3)	5.9 (0.9)
Galium spp.	PH	E-N	1.1 (1.1)	0.7 (0.4)	2.3 (0.8)	0.9 (0.5)
Gaultheria pumila	S	N	-	-	-	2.0 (1.0)
Geum magellanicum	EH	N	-	10.7 (2.6)	-	-
Gunnera magellanica	PH	N	1.5 (0.8)	0.4 (0.3)	-	0.7 (0.3)
Hordeum sp.	CG	N	-	-	-	1.5 (1.5)
Juncus scheuzerioides	RG	N	-	-	1.6 (0.8)	7.5 (2.0)
Luzula alopecurus	CG	N	0.1 (0.1)	0.6 (0.3)	-	-
Misodendrum spp.	S	N	8.1 (3.0)	8.8 (2.2)	10.1 (0.3)	15.2 (5.6)
Nanodea muscosa	PH	N	0.2 (0.2)	-	-	-
Nothofagus antarctica	T	N	-	5.3 (2.2)	0.3 (0.2)	3.7 (1.3)
Nothofagus pumilio	T	N	30.1 (2.8)	23.5 (2.9)	31.7 (6.2)	0.9 (0.9)
Osmorhiza spp.	EH	N	0.5 (0.2)	0.6 (0.6)	-	0.1 (0.1)
Plantago barbata	EH	N	-	0.1 (0.1)	10.3 (5.6)	-
Ranunculus spp.	EH-PH	N	0.1 (0.1)	1.1 (1.0)	-	-
Rubus geoides	S	N	5.0 (1.9)	-	-	-
Rumex acetosella	EH	E	0.3 (0.2)	-	-	-
Senecio allophyllus	EH	N	-	1.1 (1.1)	-	1.0 (1.0)
Senecio magellanicus	EH	N	0.4 (0.4)	1.2 (0.7)	0.5 (0.3)	2.0 (0.7)
Trisetum spicatum	CG	N	0.5 (0.5)	0.3 (0.3)	0.7 (0.7)	-
Vicia magellanica	PH	N	-	0.7 (0.4)	-	-
Sphagnum sp.	Moss	N	1.1 (0.4)	4.5 (2.1)	-	2.0 (0.4)

According to Ivlev index, herbs groups were avoided (-0.36 for erect and -0.66 for prostrate), while tree seedlings and saplings were slightly selected (0.60) (figure 2). Consumption proportion for the grasses group (0.04 for caespitose and 0.08 for rhizomatous) and shrubs (-0.01) equaled their availability.

Linking diet composition and vegetation type. Most plant life forms were grazed or browsed all around the year (*e.g.* shrubs, prostrate herbs and caespitose grasses; figure 3). Tree seedlings and saplings were browsed in all seasons, but significantly decreased during winter ($F = 14.42$, df =3, $P < 0.001$). Cover of these seedlings was most abundant in unmanaged *N. pumilio* forests (21.3 %) and harvested *N. pumilio* forests (6.9 %), but also appeared in open lands (5.8% of *N. antarctica*; table 1). Erect herbs were more grazed in summer, but feeding decreased to a minimum during spring, and was mainly found in harvested *N. pumilio* forests and *N. antarctica* forests. The rhizomatous grasses were more grazed during winter, and lower feeding on this group occurred during summer. These grasses were mainly found in open lands. Finally, the *Sphagnum sp.* present in peat bogs was consumed throughout the year (except in autumn), as well as the hemiparasitic *Misodendrum spp.* which was also relatively constant between seasons, but it tended to increase during winter (non-statistically significant).

When the relationship between plant species found in feces (table 2) and vegetation census (Appendices 1 to 3) was analyzed, it was possible to observe a feeding preference defined as a ratio between cover at landscape level and occurrence in feces (figure 4). For example, species of *Agrostis, Deschampsia, Carex* or *Nothofagus* were plants

Figure 3. Seasonal foraging of different plant life forms by *Lama guanicoe*: tree seedlings and saplings (T), shrubs (S), erect herbs (EH), prostrate herbs (PH), caespitose grasses (CG), rhizomatous grasses (RG), hemiparasitic shrubs (HS), bryophytes (B). Values below the X-axis represent Fisher test (F) and the probability (*P*). Letters a, ab, and b on the bars showed differences by Tukey test at $P = 0.05$.
    Consumo estacional por parte de *Lama guanicoe*, de las diferentes formas de vida de plantas: plántulas de *Nothofagus* spp. (T), arbustos (S), hierbas erectas (EH), hierbas postradas (PH), pastos cespitosos (CG), pastos rizomatosos (RG), arbustos hemiparásitos (HS) y briófitas (B). Los valores al pie del eje X indican el F (*P*) de la prueba de Fisher. Letras en las barras indican diferencias por la prueba de Tukey $P = 0,05$.

Figure 4. Relationship between plant species found in *Lama guanicoe* feces and their average cover at landscape level. Species or genera above the line are preferred for feeding, and below are avoided. Only the most relevant species or genera are named.
    Relación entre las especies vegetales encontradas en las heces *Lama guanicoe* y su cobertura promedio a nivel de paisaje. Las especies o géneros por encima de la línea son preferidas para la alimentación y las de abajo son evitadas. Sólo se mencionan las especies o géneros más relevantes.
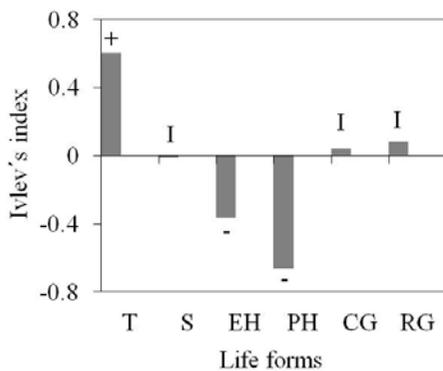

Figure 2. Ivlev's selectivity index for plant life forms: tree seedlings and saplings (T), shrubs (S), erect herbs (EH), prostrate herbs (PH), caespitose grasses (CG), rhizomatous grasses (RG). + = selection; − = avoidance; I = indifference. The index was calculated based on the plant availability during the summer.
    Índice de selectividad de Ivlev para las diferentes formas de vida vegetal: plántulas de *Nothofagus* spp. (T), arbustos (S), hierbas erectas (EH), hierbas postradas (PH), pastos cespitosos (CG) y pastos rizomatosos (RG). + = Selección; - = evitación; I = indiferencia. El índice fue calculado en base a la disponibilidad de plantas durante el verano.
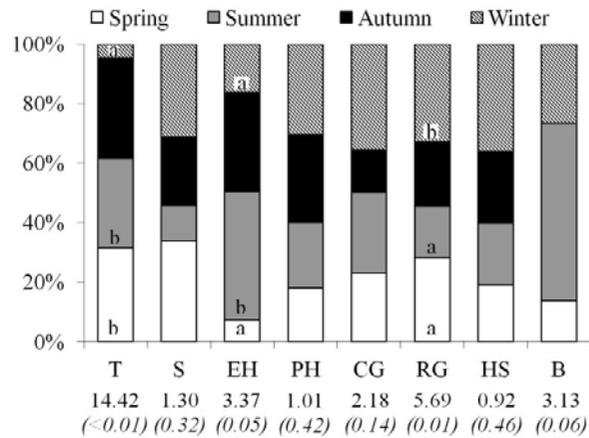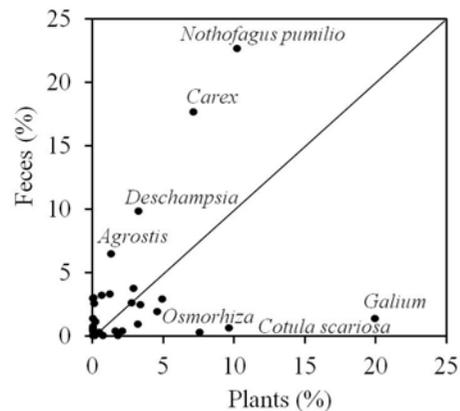
highly consumed regardless of their cover at the landscape level, while other species, *C. scariosa, Galium spp.* or *Osmorhiza spp.*, were avoided and occasionally consumed along the year.

DISCUSSION

Plant species composition across the landscape. Plant diversity greatly changed at the landscape level, but most of them (in our study, 59 species) are shared between at least two different habitats. Open lands presented more exclusive species (40 species) than the ones presented by the other environments. Many plant species found in grassland and peatlands are adapted to extreme conditions such as strong wind, long periods of drought and radiation, and evapotranspiration. Collantes *et al.* (1999) described the abundance of *E. rubrum* and other cushion shrubs associated with acidic, poor nutrient soils, or the dominance of sclerophyllous tussock grasses (*e.g., Festuca spp., Carex spp.*) along xeric steppes. However, on moister grasslands of Tierra del Fuego, the most important factor affecting long-term productivity is possibly the occurrence of life-form shifts in the plant communities, which could be attributed to grazing disturbance (Collantes *et al.* 1999) replacing palatable grasses by unpalatable species for native wildlife.

Nothofagus spp. forests supported a relatively low richness of understory plant species, and all of them could be found in other habitats. However, unmanaged *N. pumilio* forests offer the greatest proportion of tender seedlings and saplings, palatable for the herbivores, while the presence of shrubs and grasses are poor. We observe that in harvested forests, the diversity and cover of understory plant species (*e.g.* grasses and herbs) absent from the original condition increased, becoming more similar to other communities. The environmental changes due to forest harvesting also allow the establishment of alien species (Martínez Pastur *et al.* 2002). Many of these plants have adapted to environmental conditions of southern Patagonia, extending their distribution in different habitat types of Tierra del Fuego (Moore 1983), including several palatable grasses (*e.g. Hordeum comosum* or *Poa pratensis*) that also appear in the diet of native herbivores. It could reflect the successful adaptation of both exotic plants and the herbivores feeding on them.

Seasonal diet composition and main feeding sites. The food habits of guanacos in central Tierra del Fuego were characterized by: (1) the dominance of grasses (particularly *Carex spp.*) and tree seedlings and saplings (*Nothofagus spp.*); (2) the small contribution of herbs groups (Dicotyledons); (3) clear seasonal variations; and (4) intermediate values of selectivity which could indicate an intermediate feeder (Baldi *et al.* 2004). Similar botanical composition of the diet has been described by previous authors for guanaco populations in South Patagonia Argentina (Bonino and Pelliza Sbriller 1991), where grasses and tree leaves represented together almost half of the total bulk of the diet. Although Bonino and Pelliza Sbriller (1991) and Baldi *et al.* (2004) described a wide variety of plant species in the guanaco diet, in our study some groups of plants were proportionally less consumed than their

availability (as it was measured during summer). However, it is not possible to describe a preference-avoidance pattern for guanacos in Tierra del Fuego, since this would require evaluating forage availability during all studied seasons. Certain selectivity patterns have been previously described for the guanaco diet (Puig *et al.* 1997) and other camelids in continental desert habitats (*Vicugna vicugna*, vicuña; Borgina *et al.* 2010). Also, other factors that determine the herbivores diet are the biomass and quality (crude protein and digestibility) of forage (Baldi *et al.* 2004). For better understanding, in future studies our results should be complemented with these variables.

The proportion of the different plant functional types consumed greatly changed along seasons. Despite the continued use of caespitose grasses, guanacos increased the percentage of rhizomatous grasses and shrubs, and decreased the percentage of trees and erect herbs in their diet from spring to winter. While the consumption of deciduous trees decreases in winter, the feeding of shrubs increases due to the high abundance of evergreen species such as *E. rubrum*. Our results agree with previous work on the guanaco diet in other parts of their range. For example, in the arid and semi-arid Patagonian steppe of Chubut Province (Argentina), guanacos changed their diet from mainly Monocotyledons plants in spring to Dicotyledons plants (woody and herbaceous combined) in summer, when annual grasses are less available (Baldi *et al.* 2004). Seasonal changes of dietary composition also occur in domestic herbivores such as sheep or cattle (Baldi *et al.* 2004, Soler *et al.* 2012). Even the dietary similarities between sympatric guanacos and sheep in Patagonia generate a potential condition for interspecific competition, mainly during those seasons when forage is scarce (Baldi *et al.* 2004). In response to this competition, mainly involving sheep, seasonal displacements steppe-to-forest of guanaco populations have been described for Tierra del Fuego (Raedeke 1978, Cavieres and Fajardo 2005). Thus, guanacos would make use of the forest as a feeding place but also as a refuge or sleeping area (Montes *et al.* 2000). Beside this, during summer guanacos also use high elevation grasses and tree-line forests (Raedeke 1978). More studies of guanacos related to competition with domestic herbivores, habitat use and impact over selective behavior feeding must be conducted to bring new tools to promote integrated management of ecosystems and conservation planning at landscape level for the species.

This study also reports the use of *Sphagnum spp.* and *Misodendrum spp.* as food source. The moss could be incidentally consumed in bogs where *Carex spp.* cover is abundant. In the second case, *Misodendrum spp.* is a hemiparasitic and evergreen shrub that could be eaten with the branches of its host (*Nothofagus spp.* trees) mainly in winter. Because the snow accumulation in winter (1-1.5 m, even into the forest) almost completely cover seedlings and saplings (< 1.3 m high) at the forest floor (in harvested or unmanaged stands), we suggest that guanacos could brow-

se on low-height mature trees or secondary stands with accessible branches for guanacos (*e.g. N. antarctica* forests). Also considering the ground level increase. This may be a possible explanation why tree consumption decreases but the frequency of *Misodendrum spp.* increases in the winter diet. Ortega and Franklin (1987) affirm that trees were rarely used by guanacos during winter in Torres del Paine National Park (Chile), while Bonino and Pelliza Sbriller (1991) detected similar proportion of tree consumption through the year in Tierra del Fuego (Argentina). According to our results, grasslands and *Nothofagus spp.* primary forests would be the most common feeding sites for guanacos in Tierra del Fuego. However, this pattern is not uniform throughout the year. *Nothofagus spp.* forests appear to be the main source of food for guanacos during summer and spring, depending more on open areas during the winter season.

Implications for forest management. Increasing demands for forest supplies and energy will continue to set up pressures on valuable forest systems. Measures to achieve this include attaining larger shares of natural regeneration and tree retention (*e.g.* Martínez Pastur *et al*. 2009) in order to incorporate elements of natural forest structures and dynamics in managed forests. These actions will have both direct and indirect consequences for the ungulates. For example, food resources at the stand scale are likely to be affected immediately (Edenius *et al*. 2002). Because the guanaco is an endemic component inhabiting Tierra del Fuego for more than 8,000 years, we consider that historically they have not been an impediment for the regeneration of *Nothofagus spp.* forests. Even the natural regeneration cycle, which has evolved with guanaco browsing, is 300-500 years (Muñoz 2008). The effect of native ungulates as a limiting factor on early growth of *Nothofagus spp.* regeneration has been reported by several authors (Pulido *et al.* 2000, Muñoz 2008). But there has been no quantitative evaluation of the impact of browsing on the stems growth-form and productive consequences.

The apparent forestry problem appears with silvicultural practices, where seedlings are thicker and higher than in primary forests and other palatable exotic species increase in number and biomass (Martinez Pastur *et al*. 2002, Soler *et al*. 2012). Many areas are being subjected to multiple threats simultaneously, and the interactions among them could lead to serious problems. For example, in southern Chile, Echeverría *et al*. (2007) documented positive feedback between the effects of habitat fragmentation, intensity of browsing by livestock and harvesting of trees for timber. As forest patches decline in area, they become more accessible to both people and livestock, progressively eliminating old-growth forest areas from the landscape (Luque *et al*. 2011). Conducting studies about the real use of *N. pumilio* harvested stands by guanacos and quality of food in different habitats types must be essential before formal recommendations. For the moment, the results reported in this paper should be considered in the planning of productive activities related to *Nothofagus spp.* forests-grasses mosaic.

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Appendix 1. Percent coverage (±SD) of dicotyledons plants obtained from vegetation surveys in open lands (OL), *Nothofagus antarctica* forests (Ñ), primary unmanaged *N. pumilio* forests (PF), harvested *N. pumilio* forests (HF). Life form: tree seedlings and saplings (T), shrubs (S), erect herbs (EH), prostrate herbs (PH).
       Porcentaje de cobertura (±DE) de plantas dicotiledóneas, a partir de los censos de vegetación en áreas abiertas (OL), bosques de *Nothofagus antarctica* (N), bosques primarios de *N. pumilio* (PF) y bosques cosechados de *N. pumilio* (HF). Formas de vida: plántulas de *Nothofagus spp.* (T), arbustos (S), hierbas erectas (EH) y hierbas postradas (PH).

Species	Life form	Feces	Habitat			
			OL	Ñ	PF	HF
Acaena magellanica (Lam.) Vah	PH	G	1.6 (0.5)	0.9 (0.3)	0.8 (0.5)	1.4 (0.2)
Acaena ovalifolia Ruiz *et* Pavón	PH	G	0.8 (0.4)	1.8 (0.4)	0.8 (0.3)	5.7 (0.7)
Acaena pinnatifida Ruiz *et* Pavón	EH	G	0.1 (<0.1)	<0.1 (<0.1)	-	<0.1 (<0.1)
Achillea millefolium L.	EH	N	1.0 (0.9)	0.4 (0.2)	-	0.2 (0.1)
Adenocaulon chilense Less.	EH	N	-	-	-	0.1 (<0.1)
Agoseris coronopifolium (D'Urv.) Chambers ex D.M. Moore	EH	N	<0.1 (<0.1)	-	-	<0.1 (<0.1)
Arenaria serpens Humb., Bonpl. *et* Kunth	PH	N	0.1 (<0.1)	-	-	-
Azorella lycopodioides Gaudich.	S	N	1.6 (1.2)	-	-	-
Azorella trifurcata (Gaertner) Hooker f.	S	N	0.7 (0.4)	-	-	<0.1 (<0.1)
Berberis buxifolia Lam.	S	G	1.8 (1.0)	1.3 (0.3)	<0.1 (<0.1)	0.1 (<0.1)
Berberis empetrifolia Lam.	S	G	0.1 (<0.1)	-	-	-
Bolax gummifera (Lam.) Sprengel	S	N	2.1 (1.2)	-	-	-
Calceolaria biflora Lam.	EH	S	<0.1 (<0.1)	0.1 (<0.1)	-	<0.1 (<0.1)
Caltha sagitata Cav.	PH	N	3.4 (1.2)	-	-	-
Capsella bursa pastoris L. Medicus	EH	N	-	0.1 (0.1)	-	0.2 (0.1)
Cardamine glacialis (Forster f.) DC.	EH	N	-	0.4 (0.1)	1.7 (0.5)	1.8 (0.3)
Cerastium arvense L.	PH	G	0.4 (0.2)	0.4 (0.1)	0.2 (0.2)	1.1 (0.4)
Cerastium fontanum Baumg.	PH	G	0.1 (<0.1)	0.7 (0.2)	0.7 (0.3)	5.7 (0.7)
Chiliotrichum diffusum (Forster f.) O. Kuntze	S	N	0.1 (<0.1)	-	-	-
Cirsium vulgare (Savi) Ten.	EH	N	-	-	-	0.2 (0.1)
Colobanthus quitensis (Kunth) Bartl.	PH	N	0.2 (0.1)	-	-	-
Coronopus dydimus (L.) Sm.	PH	N	<0.1 (<0.1)	-	-	-
Cotula scariosa (Cass.) Franchet	PH	S	0.6 (0.2)	22.1 (2.0)	9.0 (3.0)	3.0 (0.6)
Draba magellanica Lam.	EH	N	-	<0.1 (<0.1)	-	-
Dysopsis glechomoides (A. Richard) Müller Arg.	PH	N	-	0.2 (0.1)	1.0 (0.6)	6.5 (1.2)
Empetrum rubrum Vahl exWilld.	S	S	14.1 (4.5)	-	-	-
Epilobium austral Poeppig *et* Hausskn.	EH	S	-	-	-	<0.1 (<0.1)
Erigeron myosotis Pers.	EH	S	0.3 (0.2)	-	-	-
Euphrasia antarctica Bentham	EH	N	0.1 (<0.1)	-	-	-
Galium antarcticum Hooker f.	PH	G	-	0.5 (0.2)	-	-
Galium aparine L.	PH	G	-	8.9 (1.4)	33.8 (1.4)	16.1 (3.8)
Galium fuegianum Hooker f.	PH	G	-	0.5 (0.1)	-	0.5 (0.1)
Gaultheria pumila (L. f.) Middleton	S	S	<0.1 (<0.1)	<0.1 (<0.1)	-	-
Gamochaeta spiciformis (sch. Bip.) Cabrera	EH	N	0.1 (<0.1)	<0.1 (<0.1)	-	<0.1 (<0.1)
Gentiana postata Haenke	EH	N	0.1 (<0.1)	-	-	-
Gentianella magellanica (Gaud.) Fabris ex D.M.Moore	PH	N	0.3 (0.1)	<0.1 (<0.1)	<0.1 (<0.1)	0.1 (<0.1)
Geum magellanicum Comm. Ex Pers.	EH	S	0.2 (<0.1)	<0.1 (<0.1)	-	-
Gunnera magellanica Lam.	PH	S	0.1 (<0.1)	-	-	-
Hieracium antarcticum D'Urv.	EH	N	-	<0.1 (<0.1)	-	-

Appendix 1 continued

Leucanthemum vulgare Lam.	EH	N	0.5 (0.4)	<0.1 (<0.1)	-	0.2 (0.1)
Nanodea muscosa Banks. ex C.F. Gaertner	PH	S	0.4 (0.2)	-	-	-
Nothofagus antarctica (Forster f.) Oersted	T	S	5.8 (2.2)	1.4 (0.3)	0.2 (0.1)	0.2 (0.1)
Nothofagus pumilio (Poepp. *et* Endl.) Krasser	T	S	-	0.1 (<0.1)	21.2 (2.4)	6.7 (0.8)
Osmorhiza chilensis Hooker *et* Arn.	EH	G	-	0.4 (0.1)	-	<0.1 (<0.1)
Osmorhiza depauperata Phil.	EH	G	<0.1 (<0.1)	8.3 (1.6)	10.1 (1.1)	13.0 (0.9)
Oxalis magellanica Forster f.	PH	N	<0.1 (<0.1)	-	-	-
Plantago barbata Forster f.	EH	S	<0.1 (<0.1)	-	-	-
Polygonum aviculare L.	EH	N	<0.1 (<0.1)	-	-	-
Pratia longiflora Hooker f.	EH	N	<0.1 (<0.1)	-	-	-
Pratia repens Gaudich.	EH	N	0.1 (0.1)	-	-	-
Primula magellanica Lhem.	EH	N	<0.1 (<0.1)	-	-	-
Ranunculus biternatus Sm.	PH	G	-	0.1 (<0.1)	<0.1 (<0.1)	1.0 (0.5)
Ranunculus fuegianus Speg.	PH	G	<0.1 (<0.1)	-	-	-
Ranunculus maclovianus D'Urv.	EH	G	-	-	-	<0.1 (<0.1)
Ranunculus uniflorus Phil. Ex Reiche	PH	G	0.2 (0.1)	-	-	
Ribes magellanicum Poiret	S	N	<0.1 (<0.1)	0.2 (0.1)	-	0.3 (0.1)
Rubus geoides Sm.	S	S	-	-	-	0.1 (<0.1)
Rumex acetosella L.	EH	S	0.4 (0.2)	1.4 (0.3)	0.2 (0.1)	2.9 (0.6)
Sagina procumbens L.	PH	N	-	-	-	0.3 (0.1)
Schizeilema ranunculus (D'Urv.) Domin	PH	N	0.1 (0.1)	4.0 (0.6)	-	0.8 (0.3)
Senecio magellanicus Hooker *et* Arn.	EH	S	0.5 (0.3)	-	-	<0.1 (<0.1)
Senecio vulgaris L.	EH	N	-	-	-	<0.1 (<0.1)
Stellaria debilis D'Urv.	PH	N	-	-	-	<0.1 (<0.1)
Stellaria media (L.) Vill.	PH	N	-	0.9 (0.5)	0.9 (0.4)	2.5 (0.6)
Taraxacum gillesii Hooker *et* Arn.	EH	N	-	0.2 (<0.1)	-	-
Taraxacum officinale Weber	EH	N	1.8 (1.0)	2.6 (0.5)	4.3 (0.9)	4.5 (0.5)
Thlaspi magellanicum Comm., ex Poiret	EH	N	<0.1 (<0.1)	<0.1 (<0.1)	-	<0.1 (<0.1)
Trifolium repens L.	EH	N	4.9 (2.5)	0.3 (0.1)	-	0.7 (0.4)
Veronica serpyllifolia L.	PH	N	0.1 (<0.1)	0.2 (<0.1)	<0.1 (<0.1)	0.5 (0.1)
Vicia magellanica Hooker f.	PH	S	-	0.1 (0.1)	-	0.1 (<0.1)
Viola magellanica Forster f.	PH	N	-	0.4 (0.1)	0.1 (0.1)	1.5 (0.5)

Note: items identified in faeces at species level (S), genus level (G), or without presence (N).

Appendix 2. Percent coverage (±SD) of Monocotyledons plants obtained from vegetation surveys in open lands (OL), *Nothofagus antarctica* forests (Ñ), primary unmanaged *N. pumilio* forests (PF), harvested *N. pumilio* forests (HF). Life form: caespitose grasses (CG), rhizomatous grasses (RG), erect herbs (EH).
Porcentaje de cobertura (±DE) de plantas Monocotiledóneas a partir de los censos de vegetación en áreas abiertas (OL), bosques de *Nothofagus antarctica* (N), bosques primarios de *N. pumilio* (PF) y bosques cosechados de *N. pumilio* (HF). Formas de vida: pastos cespitosos (CG), pastos rizomatosos (RG) y hierbas erectas (EH).

Species	Life form	Feces	Habitat			
			OL	Ñ	PF	HF
Agropyron pubiflorum (Steudel) Parodi	RG	N	<0.1(<0.1)	-	-	-
Agrostis magellanica Lam.	RG	G	0.7 (0.7)	-	-	-
Agrostis perennans (Walter) Tuck.	CG	G	2.2 (1.0)	0.2 (0.1)	-	0.1 (<0.1)
Agrostis uliginosa Phil.	CG	G	-	-	-	0.4 (0.3)
Alopecurus magellanicus Lam.	CG	S	1.6 (0.7)	0.1 (<0.1)	-	0.1 (<0.1)
Alopecurus pratensis L.	CG	N	0.1 (0.1)	-	-	-
Bromus unioloides Humb., Bonpl. *et* Kunth	CG	S	0.1 (<0.1)	1.6 (0.3)	-	0.4 (0.1)
Calamagrostis stricta (Timm) Koeler	RG	N	0.8 (0.3)	-	-	-
Carex capitata L.	RG	G	<0.1 (<0.1)	-	-	-
Carex curta Gooden	RG	G	11.7 (3.5)	-	-	-
Carex deciduas Boott	RG	G	2.3 (1.1)	-	-	-
Carex fuscula D'Urv.	RG	G	0.3 (0.1)	-	-	-
Carex gayana Desv.	RG	G	3.7 (2.7)	-	-	-
Carex macloviana D'Urv.	RG	G	0.1 (0.1)	-	-	-
Carex magellanica Lam.	RG	G	1.5 (0.5)	-	-	-
Carex sorianoi Barros	RG	G	<0.1 (<0.1)	-	-	-
Carex subantarctica Speg.	RG	G	0.4 (0.4)	-	-	-
Dactylis glomerata L.	CG	N	-	0.1 (0.1)	-	-
Deschampsia antarctica Desv.	CG	G	1.0 (0.9)	0.2 (<0.1)	-	0.2 (0.1)
Deschampsia flexuosa (L.) Trin.	RG	G	4.4 (2.0)	2.9 (0.7)	-	0.2 (0.1)
Elymus agropyroides C. Presl	RG	N	0.1 (<0.1)	<0.1 (<0.1)	-	<0.1 (<0.1)
Festuca gracillima Hooker f.	CG	N	1.3 (1.3)	-	1.0 (0.5)	0.6 (0.2)
Festuca magellanica Lam.	CG	S	0.5 (0.2)	5.4 (0.6)	1.5 (0.7)	0.5 (0.1)
Holcus lanatus L.	CG	N	-	0.2 (0.1)	-	-
Hordeum comosum C. Prsel	CG	G	4.0 (1.6)	0.1 (<0.1)	-	0.1 (<0.1)
Hordeum secalinum Schreber	CG	G	-	-	-	0.2 (0.1)
Juncus scheuzerioides Gaudich.	RG	S	0.3 (0.2)	-	-	-
Luzula alopecurus Desv.	CG	S	0.2 (0.1)	0.1 (<0.1)	-	<0.1 (<0.1)
Phaiophleps biflora (Thunb.) R.C. Foster	EH	N	<0.1 (<0.1)	-	-	-
Phleum alpinum L.	CG	N	4.0 (1.6)	2.1 (0.3)	0.2 (0.1)	1.0 (0.2)
Phleum pratense L.	CG	N	0.4 (0.3)	-	-	-
Poa annua L.	CG	G	-	0.1 (<0.1)	-	0.3 (0.1)
Poa nemoralis L.	CG	G	-	-	-	<0.1 (<0.1)
Poa pratensis L.	RG	G	9.5 (2.5)	17.5 (1.2)	10.7 (2.1)	12.9 (1.5)
Tetroncium magellanicum Willd.	RG	N	<0.1 (<0.1)	-	-	-
Triglochin concinna Davy	RG	N	0.5 (0.3)	<0.1 (<0.1)	-	-
Triglochin palustris L.	RG	N	0.4 (0.2)	-	-	-
Trisetum spicatum (L.) K. Richter	CG	G	2.7 (1.0)	1.6 (0.3)	0.5 (0.2)	1.0 (0.3)
Uncinia lechleriana Steudel	RG	N	-	1.9 (0.3)	0.1 (<0.1)	1.5 (0.4)

Note: items identified in faeces at species level (S), genus level (G), or without presence (N).

Appendix 3. Percent coverage (±SD) of Ferns according to the vegetation surveys in open lands (OL), *Nothofagus antarctica* forests (Ñ), primary unmanaged *N. pumilio* forests (PF), harvested *N. pumilio* forests (HF). Life form: erect herbs (EH), prostrate herbs (PH).
Porcentaje de cobertura (±DE) de Helechos a partir de los censos de vegetación en áreas abiertas (OL), bosques de *Nothofagus antarctica* (N), bosques primarios de *N. pumilio* (PF) y bosques cosechados de *N. pumilio* (HF). Formas de vida: hierbas erectas (EH) y hierbas postradas (PH).

Species	Life form	Feces	Habitat			
			OL	Ñ	PF	HF
Blechnum penna marina (Poiret) Kuhn	EH	S	0.1 (<0.1)	6.7 (1.3)	-	2.0 (0.5)
Cystopteris fragilis (L.) Berhn.	EH	N	<0.1 (<0.1)	0.1 (<0.1)	0.8 (0.3)	0.3 (0.1)
Lycopodium magellanicum (P. Beauv.) Swartz	PH	N	0.1 (<0.1)	-	-	-

Note: items identified in faeces at species level (S), genus level (G), or without presence (N).