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IMPORTANCE OF HARESFOOT CLOVER (*TRIFOLIUM ARVENSE)* AS A NITROGEN FIXER IN SEMI-ARID GRASSLANDS OF NEW ZEALAND

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Abstract

The aim of the study was to determine the distribution of annual haresfoot clover (*Trifolium arvense*) in a depleted indigenous short tussock grassland catchment in the dry sub-humid MacKenzie Basin, South Island, New Zealand. Haresfoot clover was present on all landscapes, and widely distributed on lower sunny aspects, suggesting that it is an important component of the nitrogen cycle in these environments even in the absence of fertiliser application. The study was conducted during an atypically moist summer when a bloom of the annual clover occurred. Nitrogen inputs will vary with landscape and spring/summer rainfall and it is likely that significant pulses occur in wetter years.

Keywords: legumes, nitrogen, nitrogen fixation, *Trifolium arvense*, haresfoot clover, tussock grasslands

Introduction

The South Island tussock grasslands have a history of exploitive pastoral farming whose sustainability in the absence of nutrient input has been questioned (Martin et al., 1994). Depletion of soil nitrogen by grazing and burning is considered as a key factor, although information on N inputs and outputs in undeveloped tussock grassland environments is limited. Nitrogen (N) nutrient balances that have been constructed (e.g. McIntosh, 1997;

Metherell, 1997) depend to a large extent on assumptions and extrapolations from other environments. The scarcity of natural nitrogen-fixing legumes in New Zealand tussock grasslands, led Martin et al. (1994) and McIntosh (1997) to assume minimal inputs of N. However, this assumption neglects the potential importance of naturalised *Trifolium* spp. For example, haresfoot clover is an annual clover frequently recorded in semi-arid environments (Gaur and Lowther, 1980, Palmer, 1972; Williams, 1980).

The aim of this study was to use GPS and GIS to map the occurrence of haresfoot clover in a tussock grassland landscape to provide quantitative data of its frequency of occurrence in the landscape, extent of cover, and to indicate factors affecting the distribution of the plant. The incidence of haresfoot clover together with its N-fixation role can used to predict the sustainability of similar undeveloped tussock grassland in New Zealand.

Material and Methods

The catchment was initially surveyed into land classes based on topography, soil depth, and plant associations; the boundaries of land classes were mapped using GPS. The natural vegetation is a short tussock association (*Festuca novae- zelandiae, Poa seta, Poa colensoi, Rytidosperma spp*) with the scrub *Melicytus alpinus* along the gully floor. The catchment has been invaded by mouse-ear hawkweed (*Hieracium pilosella)* in the past few decades, and the gully floor by sweet briar (*Rosa rubiginosa*). The unfertilised catchment has been periodically grazed with Merino sheep.

The distribution of haresfoot clover was measured from detailed analyses of 5 m by 5 m quadrats at 25 m intervals along band transects directed through land classes e.g. from the valley floor to ridge tops on sunny and shady aspects. The position of the transect lines and quadrats were also located by GPS, and were superimposed on land classes and vegetation maps. Percentage cover was calculated using sums of estimated areas of patches of haresfoot clover (sometimes <10 cm^2) within the quadrats.

Results and Discussion

Haresfoot clover was present on all six classes of land. However, the plant was most successful on sunny lower slopes where other vegetative cover was limited. *Rytidosperma spp* and *P. colensoi* were the main grasses and *H. pilosella* the main dicotyledon. Haresfoot clover was least successful on the low shady aspect land unit where *H. pilosella* forms a veritable low growing flatweed carpet (Table 1). Here the haresfoot clover was present in only 4 of 9 quadrats along the 225 m transect, and mean cover was less than 0.1% of the quadrat area with the range of areas covered by haresfoot clover varying from 1 cm^2 to 225 cm^2. There was negligible haresfoot clover in the small gully floor land class unit because of competition from rank growth of exotic adventive grasses such as browntop (*Agrostis capillaris),* Yorkshire fog (*Holcus lanatus)* and sweet vernal (*Anthoxanthum odoratum)* under the shrub dominants.

The distribution of haresfoot clover is uneven within all land classes, as can be seen from the standard deviations (sd) shown in Fig 1. For example, on the lower sunny slopes the percentage cover of haresfoot clover ranged from 4 to 68% over the 225 m transect (mean 18.4 %). This probably reflects the differing reserves of seed in the soil and/or the ability of microsites to retain moisture in the soil to enable germination of the seed and plant establishment.

The records were made during summer 1999/2000 which was characterised by greater than average summer rainfall. Mean annual rainfall at the nearest long term recording station varies between years from 270 to 780 mm. Haresfoot clover is a prolific seeding plant, which is extending its range by natural invasion. As an annual in a dry environment, haresfoot clover can go practically unnoticed or be seen as an insignificant part of the flora for periods of years. This may help explain the conclusions drawn by Martin et al. (1994) And McIntosh (1977). However, in seasons when ideal soil moisture conditions occur at the same time, as the soil temperatures are suitable for seed germination and plant growth, its true importance is seen. Blooms of growth such as we observed are believed to result in significant pulses of nitrogen inputs into the ecosystem, which are vital to its sustainability.

The importance of this result is that haresfoot clover growth, and hence nitrogen fixation, is occurring in the absence of fertiliser, in an environment known to be deficient in sulphur. It brings into question the conclusions that grazing of unimproved tussock grassland is unsustainable because of N depletion (Martin et al. 1994, McIntosh 1997).

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Table 1 - Mean percentage cover (exclusive of haresfoot clover) on different land class units.

Cover	**Land class units**					
	Top of catchment	**Mid shady**	**Mid sunny**	**Low shady**	**Low sunny**	**Front face**
Bare ground	19.3	26.25	41.0	22.52	39.0	20.9
Non-endemic herbs (especially *H. pilosella*)	65.8	57.8	50.9	75.9	34.7	42.3
Native herbs	0.8	2.2	0.3	0.5	0.9	0
Non-endemic leguminous herbs	trace	1.1	0.2	0	0	0.2
Native grasses	4.1	6.3	1.6	0.1	14.0	9.6
Native tussocks	8.6	7.5	6.3	2.2	0.5	0.02
Non-endemic grasses	0.4	1.3	0.3	0.3	0.1	10.2
Native shrubs	1.0	0.3	3.5	0	3.3	0.6
Non-endemic shrubs	0	0.1	0	0.1	2.1	0.6

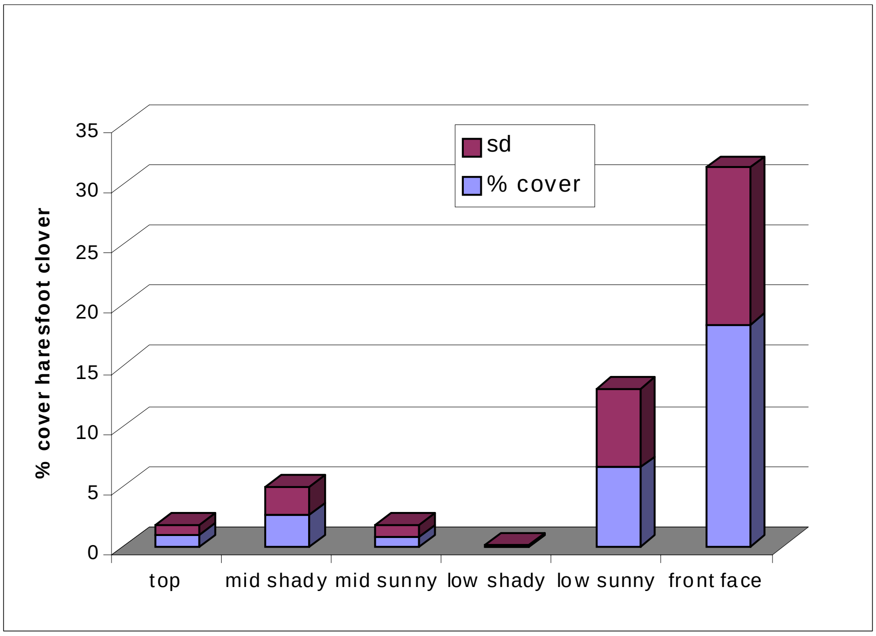

Figure 1 - Percentage cover of haresfoot clover on different land class units.