Mapping Nitrogen Fixing Shrubs in Dry Unimproved Tussock Grassland

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MAPPING NITROGEN FIXING SHRUBS IN DRY UNIMPROVED TUSSOCK GRASSLAND

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Abstract

Global Positioning System (GPS) was used to both map the positions of individual nitrogen-fixing shrub plants and record individual plant height and breadth dimensions, within a small catchment of dry sub-humid unimproved short tussock grassland. The distributions of different species of shrubs varied with different landscape units within the catchment. The information will provide the base data for a first approximation of the role of the shrubs in the nitrogen balance of the ecosystem, which is pivotal to the sustainability of pastoral farming in the tussock grasslands.

Keywords: *Carmichaelia petriei*, *Discaria toumoutu*, legumes, nitrogen, nitrogen fixation, *Sophora prostrata*, tussock grasslands.

Introduction

The sustainability of dry and semi-arid tussock grasslands is greatly influenced by inputs of nitrogen (N) into the ecosystem. Martin et al. (1994) believed grazing the grassland to be unsustainable in the absence of fertiliser nutrient inputs. It appears that indigenous shrub legumes such as native broom (*Carmichaelia petriei*), and kowhai (*Sophora prostrata*), and other N-fixing shrubs such as matagouri (*Discaria toumoutu*) and tutu (*Coriaria arborea*) were important N fixers historically (Wardle 1991). In the 150 years following European settlement, burning and grazing have reduced the numbers of N-fixing shrub plants in the grasslands. The present scarcity of legumes in New Zealand tussock grasslands, led Martin et al. (1994) and McIntosh (1997) to assume minimal current inputs of N. However, Boswell et al. (2000) believe that a volunteer non-endemic annual (haresfoot clover, *Trifolium arvense*) may be an important N-fixer in parts of the ecosystem.

As part of an effort to understand N cycling in these grazed natural grasslands, we have determined the incidence of individual shrub legume plants on different parts of the landscape within a small catchment. Because of the repeatability of patterns of plant distribution especially affected by sunny and shady aspect on the broken high country landscape, we can extrapolate the findings to other catchments in the same range of mountains and probably to other ranges with a similar climate. Knowledge of the occurrence of different species indicates where future effort in measurement of N-fixation should be directed in order to determine their importance in ecosystem nitrogen balances.

Material and Methods

Our technique involved an initial survey of the catchment into land classes based on aspect, steepness, soil depth, and plant associations; and mapping the boundaries of land classes using GPS. The catchment is known as Tomahawk Gully in the Benmore Range, MacKenzie Basin, South Island New Zealand. The gully runs approximately NW to SE so that one side has a sunny aspect facing NE and the other has a shady aspect facing SW. The catchment is approximately 0.4 km wide; the line of the drainage flow extends over 1.3 km; it has a narrow gully floor and has steep sides (>30^{o}); and rises from approximately 500 m asl to 850 m asl.

The natural vegetation is a short tussock association (*Festuca novae- zelandiae, Poa cita*, *Poa colensoi*, *Rytidosperma spp*) with the scrub *Melicytus alpinus* along the gully floor. The catchment has been invaded by the flat weed mouse-ear hawkweed *Hieracium pilosella* in the past few decades, and the gully floor by sweet briar (*Rosa rubiginosa*).

The distributions of N-fixers, including shrubs, clovers (especially haresfoot clover), and lichens within 5 m by 5 m quadrats at 25 m intervals along transects across land units from the valley floor to ridge top, were initially identified and quantified (Boswell et al. 2000). This technique proved unsuitable for the shrubs we were interested in. On the shady side of the catchment, the positions of individual shrubs (mainly native broom) within a 20 m wide transect from the valley floor to ridge top were located by GPS. Similarly the individual native broom shrubs were also mapped in a 20 m wide transect in the top of the catchment. Plant dimensions (height and two width/breadth dimensions) were also recorded on the GPS files for subsequent biomass and N balance estimations. Kowhai was associated with rocky outcrops near ridge tops in the sunny face of the catchment land units. The shrub was surveyed in detail on a representative part of the ridge, with individual plants again mapped by GPS and plant dimensions recorded. One small area of very old matagouri plants and other individual plants were mapped wherever they were seen in and outside of the sampling areas.

Results and Discussion

Fig. 1 shows the land units identified within the catchment and the distribution of individual or dense associations of kowhai, and matagouri plants in the catchment. Locations of the wide band transects from which data for the distribution of the more regularly dispersed native broom was obtained are also shown.

Kowhai was mainly associated with rock outcrops at the top of the sunny aspect of the catchment. A total of 98 plants were recorded in a single well-defined ridge top location (see Fig.1). Mean plant size (height 58 cm, 53% in the range 40-80cm; mean volume 0.122 m^3, 52% in the range 0.01-0.1 m^3) was much less than the mature matagouri plants. The biggest kowhai shrub recorded was 1.6 m tall and had a volume of 1.15 m^3. Kowhai appears more susceptible to sheep browsing than matagouri. The estimated maximum kowhai plant population for the catchment (Table1) was calculated from the plant density recorded in the sample, and the area of rock outcrops on the extended ridge of the sunny aspect.

Matagouri occurred as a single patch (0.015 ha) of a few old trees about 2.5 m tall, grouped shrubs, and sparsely scattered outlying plants. Three plants close by the patch, on the lower sunny face were 1 m-2 m tall and 0.9 m-2 m across. The mean volume of these shrubs was 1.8 m^3. Two plants were recorded within the 20 m wide (0.5 ha) transect area on the lower shady face were taken as representative of plant density on this landscape unit. Other plants mapped were taken as isolated groups or single plants. Three plants were mapped in the upper part of the gully floor land unit, and a group of three and a separate single plant in the top of the catchment. The spiny growth habit of matagouri protects it from grazing. We believe the low density of matagouri reflects a past history of burning and seedling grazing.

Native broom was not recorded on the lower sunny slopes. Twenty-six individual plants were recorded within the 20 m wide transect on the lower shady slope, and 46 plants in a similar transect at the top of the catchment. Native broom occurs more frequently on the higher parts of the slopes e.g. within about 40 m of the ridge tops on the shady slope. Low plant heights (mean 33 cm, 54% of plants between 5 and 20 cm) and small individual plant volumes (mean 0.06 m^3, 51% of plants < 0.01 m^3) reflect close-grazing by sheep. The species has the potential to grow over 2 m tall (Poole and Adams 1980) but only one plant approached this in the experimental catchment.

GPS offers a useful technique for the measurement of the spatial distribution, frequency, and size of individual N-fixing shrub plants and groups of plants with identifiable boundaries; especially in ecosystems featuring difficult terrain. The survey showed they occur in localised sites within the catchment, especially near the tops of the ridges. Repeat surveys offer the capability of charting the survival of individual plants or groups of plants over time, and mean changes in physical size of the shrubs. Net growth or browsing depredation by merino sheep and/or rabbits, will provide one of a suite of indications of ecosystem sustainability.

The low numbers of matagouri plants counted, and higher numbers of kowhai plants belied conventional thinking of their respective importance in such tussock grassland. Constraints put upon extrapolation from the published indicative figures for N-fixation by matagouri (Daly 1969) and tutu (Silvester et al 1979) make them unsuitable for modelling; while N-fixation in kowhai and native broom has never been measured. This study reinforces the requirement for such measurements. Shrub distribution suggests N-input to the ecosystem may be spatially limited but may be significant within small areas of the catchment. The effectiveness of shrub-N to the ecosystem will be limited by the extent of N transfer by browsing merino sheep, hares and rabbits either directly from the shrubs, or from understory plants which benefit from the shrub N-fixation.

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Table 1 - Mean densities of N fixing shrubs on different land units (plants/ha)

Species	Land Unit					Estimated total plants in catchment (49.2 ha.)
	Front face (sunny)	Sunny slope	Shady slope	Top of catchment	Gully floor	
Native broom	nil	nil	52	26	nil	1189
Matagouri	nil	n/a (patch <0.02 ha)	4	4 plants, two locations	5 plants, one location	95
Kowhai	98 plants in defined area		nil	30 (estimated)	nil	98-130
Areas of generic land units (ha)	2.21	17.73	19.56	6.62	1.94	

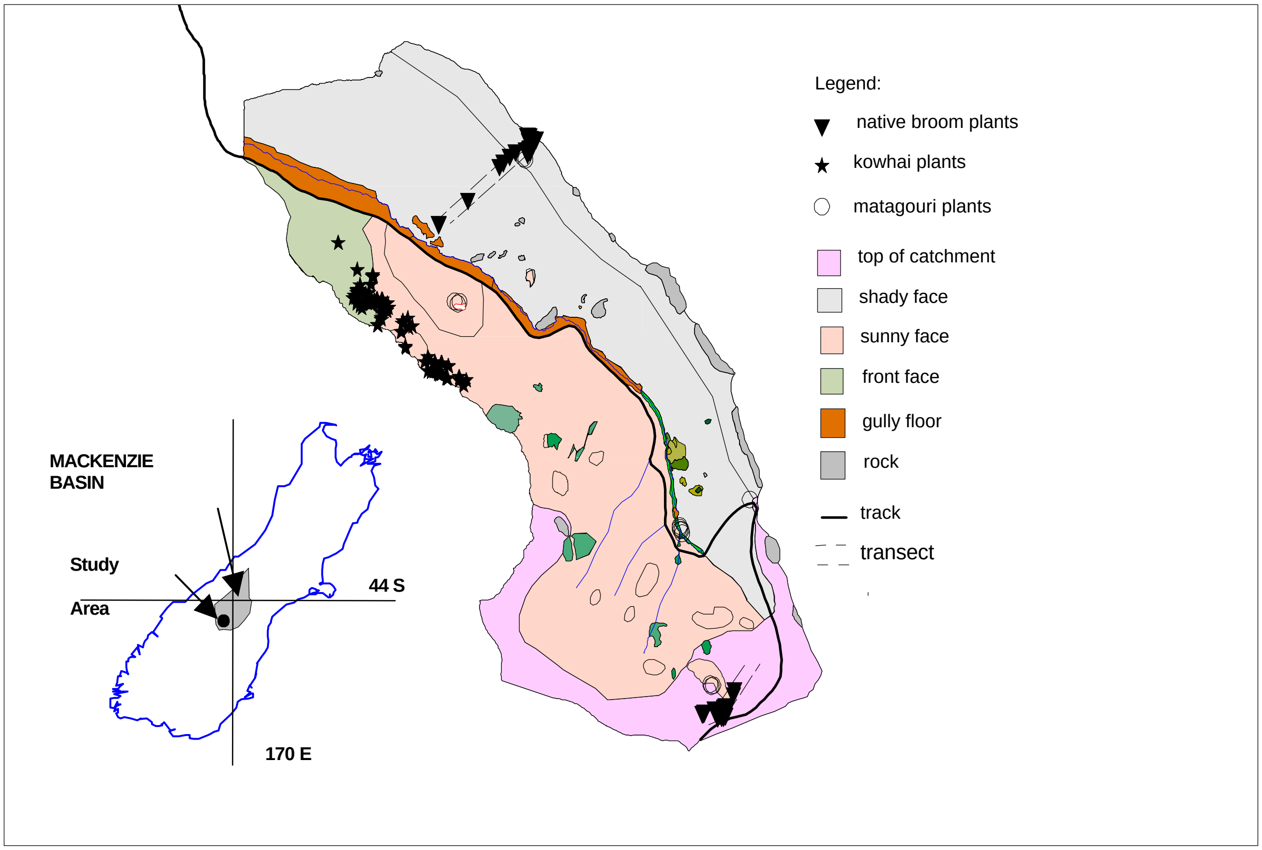

Figure 1 - Map of Tomahawk Gully showing generic land units, GPS plotted locations of individual kowhai and matagouri plants, and native broom in belt transect sampling locations (Inset shows location of catchment area in the South Island of New Zealand).