The roles of legumes in achieving sustainable farming on Longslip Station, Omarama – past, present, and future

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Abstract

The role of legumes for increasing pasture production and quality to ensure the long-term sustainability prospects for a high country sheep and cattle farm, with reference to options, impediments and future directions. The currently available pasture legumes have serious shortcomings in the face of drought, low soil fertility, aluminium toxicity and competition from *Hieracium* species. I describe a vegetation study in the Caucasian mountains in the search for more persistent, diverse, aluminium-tolerant and fertiliser-efficient pasture species.

Keywords: caucasian clover, high country, *Hieracium,* oversowing and topdressing, sheep, sustainability, *Trifolium repens, Trifolium trichocephalum*

Introduction

In humid temperate regions symbiotically fixed leguminous nitrogen is the basis for high producing quality pastures. This requires a vigorous leguminous component, to be well adapted to the local conditions. While the low legume content is a feature of New Zealand hill pastures (Suckling 1966), the indigenous tussock grasslands of the South Island are almost devoid of legumes and consequently are low producing in their natural state (Leamy *et al.* 1974; McLeod 1974). Better legumes are therefore important to improve the naturally low soil N status (Scott & Maunsell 1974) and to directly transfer N to grasses and thus increase total forage production.

In order to achieve biophysical and financial sustainability on Longslip it is necessary to establish high-producing pastures which are competitive, resilient, characterised by inherently affordable inputs and adapted to meet the requirements of livestock. Stock also need to be bred to live in harmony with the environment, soils, pastures, input costs and markets. I am pursuing this objective by breeding and selecting Merinos that have a high degree of footrot resistance under intensive moist conditions (Patterson & Patterson 1989, 1991).

Longslip physical resources

Longslip is a 15 150 ha pastoral lease in the middle of the South Island high country at latitude 44° south in the mid Ahuriri valley near Omarama. Longslip was taken up for sheep grazing in 1859 and has been in the Patterson family for nearly 50 years. Longslip is characterised by a highly variable annual rainfall of 700–940 mm, and a growing season of up to 200 days. Altitude varies from 650 to 1905 metres a.s.l., with pronounced gradients of increasing moisture regime and decreasing temperature with altitude. Soils are mainly high country yellow-brown earths on schist parent materials with a pH range of 4.8–6.0, characterised by high levels of latent aluminium. Soils are deficient in phosphorus, sulphur and molybdenum for vigorous growth of traditionally used legume species. For animal production there is a pronounced selenium deficiency and a cobalt response in young sheep. The low levels of sodium in the herbage requires feeding salt blocks, to encourage stock to eat more roughage, especially pre-lamb ewes.

Climatic variation drives the Longslip farming system. The probabilities of receiving enough rainfall to sustain pasture growth on a month-by-month basis for the growing season is highly variable, ranging from 10–80%. Pasture growth is sustained by the soil water store built up over winter. In spite of the relatively high rainfall, cool temperatures in many years will delay the onset of spring growth and prevent a flush of autumn growth following the dry months of summer. September, November and February stand out as being particularly dry (Rabbit and Land Management 1992).

Longslip development

Over the past 18 years, 30% of Longslip has been oversown and topdressed and 900 ha direct drilled with white and alsike clovers and cocksfoot. The flats have reverted to thick *Hieracium*. Over the past 3 years, 500 ha have been cultivated, limed and sown into traditional pasture mixtures, lucerne and caucasian clover. Fertiliser inputs have averaged 80 kg/ha/annum of 28% sulphur super. This has raised and maintained Olsen P values from 12 to 18 and sulphate-sulphur above 8.

I try to avoid traditional set stocking of large blocks covering diverse soil landscape units at the same time every year (Patterson 1983). To achieve this in excess of 300 km of new permanent fencing has increased the number of blocks from 7 to 70, which has directly lead to better utilisation and greater flexibility, so that enough stock can be run to take advantage of good years, but not too many to risk being devastated in less than favourable years. The main advantages of increased subdivision are control over the timing and severity of grazing, improved utilisation and strategic spelling especially to minimise snow risk by enabling stock to be held on sunny faces.

Unimproved pastures produce from 50 to 700 kg/ha/annum of low-quality feed, with virtually no legume component, depending on site (Patterson 1994). Dry matter production from improved pasture under grazing varied from 2000 to 6000 kg /ha/annum of high quality feed, with up to at least 35% legume composition, over a 3-year period (TGMLI, unpub. data). N fixation by legumes has increased the above-ground N pool from 1 to 20 kg/ha on unimproved to 60 to 180 kg/ha (Patterson 1994).

It is important that sufficient stock are wintered to ensure reasonable utilisation of the feed grown, both to promote vigorous pastures and high animal performance per hectare. This ensures a cash surplus for continued fertiliser application and a return on investment. I wean at 12 weeks of age so the lambing country can be spelled from mid January to mid June, after which it is used for ewe and hogget wintering.

Output has gone from 7000 sheep producing 21 000 kg of wool to 17 000 sheep producing 75 000 kg of wool. Lambing % has increased from 30 to 50% to 80 to 95%. Cattle numbers have recently increased from 100 to over 500 today.

Wool price and favourable seasons drive the economics of the development of Longslip, and given this uncertainty stocking rates above 3 s.u./ha are required to justify such development today (Ogle & Patterson 1996).

Table 1 shows the vegetation trends measured by point analysis on seven hill sites on Longslip before (1978) and after oversowing and topdressing (1984 and 1992). The increase in the clover component and decrease in bare ground have proved to be the best means so far to limit invasion by *Hieracium* species.

Table 1 Effect of oversowing and topdressing in 1980 on vegetation cover % on Longslip (Patterson 1994).

Component	Native	o/sn ’84	o/sn ’92
Litter	29	19	12
Rock	3	1	1
Bare	14	3	4
Tussock	9	6	6
Sweet vernal	14	28	18
Browntop	1	1	12
Other grasses	10	4	12
Natives & weeds	19	3	16
Clover	1	35	17
Hieracium spp.	rare	trace	2

The legacy of traditional pastoralism

In today’s environment it is tempting for some commentators to point to the fact that we have imposed a very intensified form of European style farming, where an alternative may be to harvest in a sustainable manner from what was already there. The thrust of this argument seems to be living in harmony with the natural ecosystem and leaving it as intact as possible. This might be quite achievable if a return to hunting and gathering were possible, as practised 10 000 years ago when an estimated one million people inhabited the earth (Jordan 1995). Also the notion that removing all farming from the high country will automatically result in the vegetation reverting to its original condition is unsubstantiated. A more realistic proposition for sustainable land management is the production of income to enable the means to finance weed and pest control for instance and to sustain people with land and livelihood.

Historically 130 years of farming in this manner with nil or very low inputs, without refined management regimes or a diverse range of plant species with the required attributes in a marginal environment in terms of climate and soil fertility, has resulted in a cover dominated by *Hieracium pilosella* with high levels of bare ground. *H. pilosella* has a mat growth habit that makes it difficult for sheep to graze, and spreads by stolons that are largely unaffected by grazing. In addition it gains competitive advantage owing to its ability to capture and store cations in its extensive root system and by making the soil more acidic and thus creating aluminium toxicity (alupathy) for other plants. This gives it the resilience to fill in bare ground created by exploitive pastoralism. Even today 80% of the high country is still unimproved, relying on adventive species to provide forage (Martin 1994). To rely on plant invaders for producing forage is not always predictable. I believe that the full impact of *Hieracium* is still to come.

Developing with evolving knowedge

My development of Longslip was undertaken in an era of expanding knowledge and know-how, in a time of uncertainty. Development has relied on pasture species suited to low country in the hope that they will be permanent and self-rejuvenating in the high country. Even here regular use of the plough, fertiliser, resowing and a high level of grazing management expertise are essential to maintain productivity and feed quality. Furthermore, soils at these lower altitudes, are deeper, hold more moisture and are more fertile relative to the soils of the high country.

The ecological threshold predisposing much of the high country to *Hieracium* invasion was probably exceeded in the relatively early stages of pastoralism. In the early stages of *Hieracium* ingress, increasing the level of fertility and providing plenty of competition for light can control the invasion (Scott & Sutherland 1993). In acid fluvial-glacial outwash soils on Longslip direct drilling in the early stages, let alone the later stages, of ingress by *Hieracium* species has not proved to be successful in the long term. It is an unrealistic expectation for traditional species that have been domesticated under cultivation, to be successfully direct drilled into and dominate thick *Hieracium*. To succeed, plants will need to be specially selected and bred over many generations for this demanding role. In contrast the large herbage seed industry is based on the principle that our pasture species prove temporary. Thus by using traditional pasture species (lupins are an exception), we are pre-empting the need for renewal or be lost to low-producing more open pastures ripe for weed invasion with time. So in a lot of cases, especially when fertility levels drop, these temporary solutions endorsed by the herbage seed industry are the crux of the problem today.

I strongly believe that there is a need for more dominant, competitive, persistent, fertiliser-efficient, acid- and aluminium-tolerant legumes which can spread by vegetative means. For this reason I am evaluating rhizomatous legumes such as caucasian, zigzag and sulphur clovers as well as *T. trichocephalum*, creeping Lucerne's and specialist acid tolerant rhizobia.

In my view, traditional cultivars of white clover have severe limitations in achieving sustainable farming on Longslip owing to their low productivity after an initial establishment boom. They also persistent poorly, with low production under moisture stress, *Hieracium* competition, low fertility and at altitudes above 1100 metres.

Locating more suitable montane legumes

Attempting to locate legumes more suited to Longslip has taken me to North and South America and Bol'shoy Kavkaz (Caucasus) Mountains. The Bol'shoy Kavkaz region is one of the three centres of origin of the genus *Trifolium*. It has a diverse and dynamic ecosystem (often in excess of 100 species/hectare). The literature highlights the agronomic potential of legumes from this region (Yates 1993; Virgona & Dear 1996). One of these, caucasian clover is particularly noted for its persistence compared to traditional clovers (Yates 1993). However the currently available genotypes of Caucasian clover are no more efficient than white clover in terms of phosphorus nutrition (Spencer & Hely 1982) and react similarly to lucerne in acid soils (Barnard & Folscher 1988; Espie, pers. comm.). This is supported by my observations on Longslip.

One of my aspirations is to introduce to the South Island high country, clovers and other forages from the Bol'shoy Kavkaz mountains. They have evolved since the last ice age in conjunction with herbivory and *Hieracium* species. To achieve this goal, last year I initiated a joint study with the Georgian Department of Botany to investigate legume forage species in similar bioclimatic zones and soils in the greater Caucasus region to those in the South Island high country. This study is a systematic investigation emphasising the contrasting ecology and supported by the relative abundance of *Trifolium ambiguum* (a persistent rhizomatous zonal polyploid) and a regular companion *T. trichocephalum* (tap-rooted and widely adapted) in the Bol'shoy Kavkaz mountains. These adapted ecotypes are a unique source of germplasm, valuable for immediate sowing, without requiring delays for local selection and breeding.

Our study focused on plant communities, particularly the comparative abundance of *Hieracium* species, Caucasian and white clover, in terms of dry matter production, soil properties, nitrogen cycle, landscape, climatic factors, rabbits and past cultural impacts (grazing intensity and fire). My initial involvement was a self-funded 5-week study in the Bol'shoy Kavkaz mountains which has demonstrated the potential, established working contacts with authorities and scientists, who are keen to collaborate provided that it is a funded joint project.

There is a striking contrast between the performance of legumes in their natural habitat in the Bol'shoy Kavkaz mountains and in New Zealand under similar rainfall, mean annual temperatures and soils (pH 4.9 to 8.1). In the Bol'shoy Kavkaz legumes form a large part of the sward, and although this is part of the *Hieracium pilosella* natural range, it is very rare; typically no fertiliser is applied and caucasian clover grows at up to 3200 metres a.s.l. Caucasian clover is dominant in nearly all of the nine plant communities studied, while white clover is increasingly rare above 2300 metres above sea level. In a meadow at 2000 metres a.s.l. Caucasian clover made up 51% and white clover 10% of the 6900 kg/ha of dry matter measured. Georgian shepherds refer to *Trifolium ambiguum* as sheep's clover in recognition of its value as a forage for sheep.

On Mount Kazbegi (5043 metres a.s.l.) in the central part of the greater Caucasus (43° north), there is an apparent absence of the hexaploid genotype of caucasian clover but the widespread presence of a triploid form not previously reported in the literature.

Sustainability impediments

This paper concentrates on the limitations of pastures in the high country but there are also other impediments to sustainable farming. The Land Act 1948 and the Resource Management Act 1991 are both impediments to sustainable farming practices as the best method of living in harmony with them is to do as little as possible. Rabbit control is in effect a 70 cents/kg tax on every kg of wool that I produce. Wool is traded as a commodity and is subject to violent price fluctuations and corrections. Raw wool constitutes only 3% of the retail price of a jersey or a woollen carpet (Roche 1995).

Summary

The high country vegetation is characterised by a loss of species, increasing bare ground and invasion by *Hieracium* species. Removal of the native tussock plant communities has occurred without replacing them with satisfactory alternative vigorous and diverse communities of exotic plants. The species currently used for pasture improvement are not as successful as they could be. The Bol'shoy Kavkaz mountains have a diverse range of pasture plants well adapted to the task. The need to apply lateral thought in a systems approach on a level playing field to achieve sustainable farming in the high country is more urgent than ever. Farmers need practical research, generating superior, resilient and low input pastures, that can be readily and reliably integrated on a large scale, to achieve long-term ecological, physical and financial sustainability. The results of Caucasian clover experiments in the high country and in my on-farm trials in particular are encouraging.

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