Integrated pastoral management strategies for *Hieracium* control

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Abstract

There are four main options for controlling *Hieracium:* agricultural development, herbicides, biological control and grazing management. Grazing management appears one of the most feasible current strategies for limiting *Hierucium* spread on low-input land. Exclosure studies in Canterbury and Otago show grazing can reduce *Hierucium* flower density 40-fold, limiting expansion by seed. Autumn recruitment from seed varied from 46 to 95 seedlings /m^2 , suggesting this may be an important dispersal mechanism in wet summers. Low-intensity spring-summer grazing significantly reduced plant number and ground cover of upright *Hieracium* species, but not prostrate species. Conversely, high-intensity grazing may assist establishment. In a 16-year grazing trial in Otago, *Hierucium* cover, and that of similar flatweeds, was greatest at high stocking rates. Farming with *Hierczcium* in the future will require development of grazing strategies integrating the requirements for the optimal management of different *Hieracium* species.

Keywords: *Hieracium,* hawkweed, high country, grazing-management-

Introduction

Hieracium species are one of the most serious issues facing high country farming, because *Hieracium* excludes forage species. Some runs have reduced stocking rates by up to 30% and the sustainability of low-input pastoralism is now being questioned (South Island High Country Review Committee 1994). Nature conservation values in tussock grasslands are also threatened (McMillan 1991). The eventual cumulative gross annual revenue loss from pastoral production is estimated at $45 million (Kerr 1993), plus the other unquantified environmental costs of tussock grassland degradation.

Hieracium species came from Europe, probably as contaminants in pasture seed mixes. They were first reported in the 1880s as botanical novelties, their weed potential being recognised in 1920 in the lowlands (Allan 1920). They evidently spread into the high country some time after this and by the early 1960s two species were widespread, though generally of low abundance, with some localised high density areas (Connor 1992). Colonisation rapidly increased and today four species occupy over 15 million ha in the South Island. Of this land 42% is roughly estimated to have either a dominant (508 000 ha), conspicuous (1005 000 ha) or common *(4 823 000* ha) *Hieracium* component (Hunter 1991), mainly in Marlborough, Canterbury and parts of Otago. Hieracium also has the potential to become a similar problem in the North Island. The cause of this expansion is debated (Hunter *et al.* 1992). Some regard it as a symptom of gradual land degradation under pastoral systems (Treskonova 1991). Others view it as an invasive weed particularly well adapted to the low-fertility grazed tussock grassland environment in the high country (Scott 1993a).

Species and distribution

Ten species of *Hieracium* occur in New Zealand, forming two distinct subgenera: those with stolons, reproducing sexually or asexually (apomixis) and those without stolons, reproducing asexually (Webb *et al.* 1988). The four species that constitute the main problem are:

H. pilosella (mouse-ear hawkweed) is the most widespread species and the worst weed. It occurs in Marlborough, Canterbury, Westland, Otago, and Southland and in the vicinity of Rotorua, the volcanic plateau, around Lake Waikaremoana, the Kaimaniwa and Ruahine Ranges, and Hawke's Bay. Strongly stoloniferous, it forms tight prostrate patches and mats which can comprise almost complete ground cover over extensive areas, displacing both indigenous and adventive grassland species.

H. praealtum (king devil hawkweed) is widespread in Canterbury and parts of Marlborough and Otago and is also found in the volcanic plateau, Nelson, and Westland. More upright in habit than *H. pilosella,* it is less stoloniferous, more shade-tolerant and is more abundant on very dry and moist sites.

H. caespitosum (field hawkweed) occurs extensively in Marlborough, parts of Canterbury and Otago and is present in Westland. It is similar in growth form to *H. praealtum.*

H. lepidulum (tussock hawkweed). It is widespread in Otago, and in locally in Canterbury and Marlborough. It is also found in Taranaki and Nelson. It differs from the preceding species, being non-stoloniferous, tap-rooted and spreading by seed. It is shade-tolerant, extending from forest margins through to open grasslands.

Control

There are four pastoral management strategies for controlling *Hieracium:*

Agricultural development

Sowing improved pasture species and applying fertiliser can suppress *Hieracium* with the appropriate grazing management. Scott et *al.* (1990), working at two sites in the Mackenzie basin, showed *H. pilosella* remained dominant at nil or low fertiliser inputs. On a deep, moderately productive soil, it was reduced by legume introduction and high fertiliser application within 2 years, and was rare by 6 years. On a shallower, less productive soil, the legume sward took 5-6 years to begin decreasing the *Hieracium* content. Two further trials at Mt. John, Lake Tekapo, monitored for 9 years, similarly showed *Hieracium* decreased or disappeared under high fertiliser and sown pasture species, particularly with irrigation, but became an increasingly important component with decreasing fertiliser inputs (Scott 1993b). Alsike (*Trifolium hybridurn)* or white clover *(T. repens*) were the most effective legumes at the high fertility levels while lupin *(Lupinus polyphyllus)* was the best sown legume at moderate and low fertility levels.

Approximately 200 000 ha of the South Island high country may be suitable for such development, requiring investment of around $40 million, assuming costs of $200/ha (McMillan 1991). Variability of spring rainfall strongly influences this success of this approach in low rainfall areas. Agro-forestry also appears a feasible alternative land use.

Biological control

Biological control, probably available within 2-5 years, is likely to be important for constraining *Hieracium* on the agriculturally unimprovable land. A rust, ***Puccinia** herracia var. piloselloidarum*. specific to stoloniferous species of *Hieracium*, and a powdery mildew, *Erysipe cichoracearum,* look promising. The best rust strains can achieve 80% infection (Jenkins, pers. comm.). The rust causes a low intensity infection throughout the year in Europe and is likely to be most effective in the higher rainfall runs when introduced.

Insects that attack *Hieracium* are also being investigated. A European gall-forming wasp, ***Aulacidea pilosellae,*** and three moths, *Oxptilis* spp., have been identified, among others, as potential biological control agents (Scott 1985; Syrett & Sarospataki 1993). Native species, broad-nosed weevils, *Niceana cervinata* and *N. cinerea,* have recently been shown to feed on *H. pilosella* and *H. praealtum* seedlings, causing up to 54% mortality in a laboratory experiment (Evans *et al.* 1994).

Herbicides

Hieracium species are tolerant to herbicides and a complete kill is seldom achieved (Meeklahet *al.* 1981). Mortalities vary from 20-85%, depending on formulation,.application rate and time of application. Hi-ester 2-4, D at 1 l/ha with clopyralid 0.5 l/ha and a penetrant, a mecoprop/MCPA/dicamba mixture at l-3 kg a.i. /ha have produced the best results. Late spring-early summer is the best time for treatment or if in autumn, using a glyphosate/penetrant combination at 1 kg a.i /ha. Application costs are high, between $55-100/ha, and repeated applications, in early (September) and late spring (October/end November) and autumn (February/ March) are usually necessary. This effectively limits their practical use to localised spot control or in combination with pasture introduction. Boron is reported to reduce *Hieracium pilosella* in low rainfall areas in central Otago and its practical application is being investigated (Miller 1994).

Grazing management study

No firm conclusions were reached regarding the role of grazing management at a recent *Hieracium* workshop convened by the New Zealand Ecological Society (Hunter *et al.* 1992). This objective of the present study was to investigate how grazing affects *Hieracium* and its application for practical management.

Methods

Exclosures rabbit fenced in 1947 at the Lindis Pass and in 1978 and 1980 at Flock Hill Station, Canterbury, were assessed in 1994 and 1992 respectively for *Hieracium* abundance. The Lindis site was a degraded snow tussock *(Chionochloa rigida*) grassland and the Flock Hill sites were unfertilised fescue tussock grasslands. Two sets of paired 10 x 10 m plots were located 2 m inside and adjacent to the Lindis exclosure and species ground cover was assessed in 10 randomly located 50 x 50 cm quadrats. At Flock Hill, *Hieracium* abundance was assessed at the 2 sites (850 and 1500 mm mean annual precipitation respectively). *Hieracium* density and cover was measured in 100 contiguous 1 m^2 quadrats inside and outside the first exclosure and in seventy two 24 m^2 plots in the second, using a randomised block design. The number and flowering status of *H. lepidulum* plants were also counted. The grazing history for the Lindis site is not known, but was probably low-intensity periodic set stocking (c. 0.1 SU/ha/yr). Grazing intensity at Flock Hill was low, 0.1-0.5 SU/ha/yr.

At Tara Hills Research Station, Omarama, long-term effects of grazing on the botanical composition of oversown hill tussock pasture was investigated in November 1993 on 9 grazing management treatments initiated in 1978 (Allan 1992). In addition, *Hieracium* inflorescence removal and establishment from seed was assessed in grazed tussock grassland at two sites, 490 m on a flat outwash surface and at 1100 m on a flat ridge crest. *Hieracium* seedlings were counted in 25 contiguous 10 x 10 cm grid squares in 10 randomly located 50 cm square quadrats per site in March 1994.

Results

Light grazing in the Lindis Pass and both Canterbury sites consistently increased the cover of the prostrate mat-forming *H. pilosella* but had the opposite effect on the four species with an erect or semi-erect growth habit (Table 1). The Lindis exclosure was probably fenced before *Hieracium* reached the site, while invasion is just starting at the dry Flock Hill site, hence the lower cover values relative to the wetter Flock Hill site where *Hieracium* has been present for about 40 years. Similarly, grazing reduced the number of plants of the erect species but did not affect *H. pilosella* (Table 2). Flowering of *H. lepidulum* was spectacularly reduced, plant number decreased 4 times but flowering decreased by 45 times (Table 2).

At Tara Hills cover of all the flatweed species, dandelion *(Taraxacum offininale)*, cats-ear (*Hypochoeris radicata)*, *H. pilosella* and *H. praealtum*, was consistently greatest at high stocking rates, intermediate at the medium treatments and least at low stocking rates. Dandelion, the most abundant flatweed, had 5.1, 2.4, and 0.7 % cover respectively ($P < 0.001$), and *H. pilosella* 0.5, 0.3 and 0.1%, though the very low abundance gave an insufficient sample size to adequately assess statistical differences.

Bud removal in *H. pilosella* resulted in 65% of the rosettes producing stolons ($P < 0.001$) but elongating bud and flower removal resulted in only 24% and 21% compared with 23% for the control. Inflorescence removal had no significant effect on *H. praealtum* stolon production. Appreciable seedling establishment occurred by late autumn, varying from 32 to 348 seedlings/m^2 (Table 3). The seed source at both sites was predominantly *H. pilosella,* with lesser amounts of *H. praealtum,* though seedlings were too small to attempt any differentiation.

Table 1 Grazing effect on *Hieracium cover (Mean cover % ±* Standard Error).

Species	Site		Grazed	Ungrazed	Sig.
H. caespitosum	Flock Hill		0.0 ± 0.0	0.01 ± 0.0	ns
H. xstoloniferum	Flock Hill		0.02 ± 0.04	0.15 ± 0.0	ns
H. lepidulum	Lindls		1.6 ± 0.5	3.0 ± [illegible]	. [illegible]
	Flock Hill	850 mm	0.0 ± 0.0	0.02 ± [illegible]	. [illegible]
	Flock Hill	1500mm	0.02 ± 0.4	0.3 ± 1.0	***
H. praealtum	Lindis		3.6 ± 0.6	11.1 ± 1.8	.**
	Flock Hill	650mm	0.01 ± 0.0	0.17 • 0.0	***
	Flock Hill	1500 mm	0.3 ± 0.2	2.5 ± 0.8	***
H. pilosella	LIndis		10.6 ± 2.3	0.6 ± 0.3	. [illegible]
	Flock Hill	850 mm	0.06 ± 2.2	0.04 ± 0.6	. [illegible]
	Flock Hill	1500mm	10.0 ± 1.8	2.2 ± 0.6	. [illegible]

Table 2 Grazing effect on *Hieracium* plant number and flowering at Flock Hill (Mean ± Standard Error).

	Grazed	Ungrazed	Significance
No. plants /m^2			
H. pilosella	1.0 ± 0.4	1.0 ± 0.6	ns
H. lepidulum	0.2 ± 0.0	0.8 ± [illegible]	. [illegible]
Flowering %			
H. lepidulum	0.8 ± 0.0	36.1 ± 1.2	.**

Table 3 Mean seedling establishment at Tara Hills (Mean no. /m^2 ± Standard Error).

Site	Autumn	Significance
Flats (490 m)	95 ± 29	
Hill (1100m)	46 ± 9	0.01

Discussion

The most urgent requirement for *Hieracium* management concerns low-input land, particularly those areas where *Hieracium* is present at relatively low abundance. In this context these results, showing that low-intensity grazing can reduce the flowering, cover and plant numbers of erect growing *Hieracium* species, have important management implications for both pastoral farming and nature conservation. Grazing management appears a feasible low-cost strategy for slowing *Hieracium* spread on low-input land that can be immediately implemented.

Makepeace (1985a) observed that both ***H. pilosella*** and ***H. praealtum*** produced enormous numbers of seeds, but considered the probability of successful establishment to be negligible, about 1 in 230000. This, together with his observation that inflorescence removal promoted vegetative growth, has formed the basis for previous management recommendations where seeding has been considered a minor factor in ***Hieracium*** control. During the 1993-94 season, with an abnormally wet summer, ***Hieracium*** successfully established large numbers of seedlings (Table 3). Similarly Watt (1962) noted ***H. pilosella*** seedling establishment in England occurred in years with higher than average spring rainfall. Seedling survival over winter averaged 40% (Espie unpub. data) and the current density suggests that seeding can be a major factor in ***Hieracium*** spread. This may help explain ***Hieracium*** expansion in the high country, providing evidence for the hypothesis that reduced rabbit densities in the 1950s and a series of warm wet summers allowed widespread flowering with subsequent establishment from seed and vegetative expansion. Further research is required.

The initial results from the Tara Hills inflorescence study suggest that it is bud removal, rather than flower removal, that promotes stolon growth in ***H. pilosella.*** The results refine Makepeace's (1985b) observation that removal of 'the uppermost shoot parts . ..' promoted stolon production. If flower removal does not, as' previously thought, always result in increased vegetative growth, then spring-summer grazing during flowering may offer a low cost tool for reducing seedling establishment of ***H. pilosella*** and other ***Hieracium*** species.

The effect of different grazing intensities on ***Hieracium*** abundance was relatively minor in a pasture improvement trial (Scott ***et al.*** 1990). Conversely, in an Otago paddock survey, grazing was a management factor linked with higher ***H. pilosella*** cover (Foran ***et al.*** 1992), consistent with the results from the Tara Hills study. It is clear that grazing will not control ***H. pilosella*** once it has become established, as its prostrate habit is adapted to grazing pressure. Grazing, however, can reduce the density and abundance of the upright ***Hieracium*** species (Table 2). This agrees with evidence from farmers and from fenceline effects, where many set-stocked summer grazed blocks carry less ***Hieracium*** than adjoining blocks that were spelled or conservatively grazed. A different strategy is required for limiting ***H. pilosella.*** A 'tall pasture' management system, resulting in accumulation of standing herbage is required as ***H. pilosella*** cover was lowest under low stocking rates where herbage accumulated in the Tara Hill grazing trial (Allan 1992).

Tara Hills is typical of many high country properties, where ***Hieracium*** species are generally of low abundance but are gradually increasing (Espie & Allan 1994). Strategies for future economic sustainability include genetic diversification into a super-fine flock, to provide the basis for producing a high value product with market demand. Management for long-term pastoral viability will entail conservative stocking levels, both for improved per animal performance and for periodic destocking of fertilised hill blocks for extended periods to allow herbage accumulation to limit ***H. pilosella.*** These blocks would then be intensively mob stocked to reduce the ***H. praealtum*** and other upright species. The goal will be to maintain a balance that keeps the ***Hieracium*** content to an acceptable minimum as a pasture component but to prevent it gaining dominance. Improving production from low-altitude blocks will be necessary to provide the forage and management flexibility lost from the hill country.

Conclusions

Pastoral improvement and intensive development of the more productive land resources is a proven method for controlling ***Hieracium.*** While biological control holds promise for the future, the balance of low-input land will require new management strategies designed to co-exist with, but minimise, the impact of ***Hieracium.*** Different species of ***Hieracium*** will require different management. Low-intensity grazing during spring and early summer is recommended to reduce ***Hieracium*** seed spread to other areas and limit the abundance of upright ***Hieracium*** species. Grazing strategies that allow accumulation of standing herbage are necessary for limiting ***H. pilosella.***

REFERENCES

Allan, H.H. 1920. A note on weeds. ***The magazine of the Agricultural and Pastoral Association 1: 39-40.***

Connor, H.E. 1992. Hawkweeds, ***Hieracium*** spp., in tussock grasslands of Canterbury, New Zealand, in 1960s. ***New Zealand journal of botany 30: 247-***261.

Espie, P.R.; Allan, B.E. 1994. Management and spatial vegetation change at Tara Hills 19851993: Implications for High Country Systems Sustainability. ***Proceedings of the New Zealand Conference on Sustainable Land Management, Lincoln University, April 1994:*** In press.

Evans, A.A.; Barratt, B.I.P.; Fergusson, C.M. 1994. Susceptibility of legume and Hieracium species seedlings to feeding by native broad-nosed weevils (Coleoptera: Curculionidae). ***Proceedings of the 47th Weed and Pest Conference:*** In press.

Foran, B.D.; Bates, J.; Murray, P.; Heward, G.; Pickens, D. 1992. A paddock based survey of management factors relating to mouse-ear hawkweed (*H. pilosellu)* dominance in Central Otago. *New* Zealand *Ecological Society Occasional Publication No. 2* p 64-68.

Hunter, G.G. 1991. The distribution of hawkweeds (*Hieracium)* in the South Island, indicating problem status. *Journal of the New Zealand Mountain Lands Institute 48:* 21-3 1.

Hunter, G.G.; Mason, C.R.; Robertson, D.M (Eds). 1992. Vegetation change in tussock grasslands, with emphasis on hawkweeds. *New Zealand Ecological Society Occasional* Publication No. 2 105 pp.

Makepeace, W. 1985a. Some establishment characteristics of mouse-ear and king devil hawkweeds. New *Zealand journal of botany 23:* 91-100.

Makepeace, W. 1985b. Growth, reproduction and production biology of mouse-ear and king devil hawkweed in eastern South Island, New Zealand **New Zealand journal** ***of*** **botany 23: 65-78.**

McMillan, G. 1991. Hawkweed Report. *Journal of the New Zealand Mountain Lands Institute 48: 8-20.*

Meeklah, F.A.; Mitchell, R.B.; McMillan, H. 1981. Chemical control of mouse-ear hawkweed. *Proceedings of the 34th Weed and Pest Conference:* 132-136.

Miller, N.W. 1994. The direct control of Hieracium using fertiliser and trace element products. *Proceedings of the 55th New Zealand Grasslands Association Conference:* In press.

Scott, D. 1985. Hawkweeds in run country. *Tussock grasslands and Mountain Lands Institute Review* 42: 33-48.

Scott, D. 1993a. Time segment analysis of permanent quadrat data: changes in *Hieracium* cover in the Waimakariri in *35* years. *New Zealand journal of* ecology 17: 41-57.

Scott, D. 1993b. Response of *Hieracium* in two long term manipulative agricultural trials. New *Zealand journal of ecology 17*: 41-57.

Scott, D.; Robertson, J.S.; Archie, W.J. 1990. Plant dynamics of New Zealand tussock grassland infested with *Hieracium pilosella. Journal of applied ecology 27*: 224-241.

South Island High Country Review Committee, 1994. Final report from the working party on sustainable land management, Government Printer, Wellington, 184p.

Syrett, P.; Sarospataki, M. 1993. Prospects for biological control of hawkweeds with insects. *Proceedings of the 6th Australasian Grasslands Invertebrate Ecology Conference, AgResearch, Hamilton,* pp 426-432.

Treskonova, M. 1991. Changes in the structure of tall tussock grasslands and infestation by species of *Hieraciumin* the Mackenzie country, New Zealand. *New Zealand journal of ecology 15*: 65-79.

Watt, A.S. 1962. The effect of excluding rabbits from grassland A (xerobrometum) in Breckland 1936-*1960, Journal of ecology 50:* 181-198.

Webb, C.J.; Sykes, W.R.; Gamock-Jones, P.J. 1988. Flora of New Zealand vol. 4. Christchurch, Botany Division DSIR, 1365 p.

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