How Resilient Are Our Alpine Grasslands To the Impacts of Introduced Species?

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Introduction

Picture an alpine grassland and most people will imagine spectacular, rugged scenery, dramatic weather and range-upon-range of endless mountain landscapes. Less known is the fact that alpine plant communities contribute 13% of the total native flora of New Zealand (Wardle 1991) with 93% of these species endemic to New Zealand and its subantarctic islands (Mark and Adams 1995). Endemism is particularly high in the regions of North West Nelson and Fiordland. On the mainland of New Zealand alpine grasslands represent the major vegetation type above treeline, although they also extend down to lower altitudes on slips and some previously forested sites. The stature and composition of alpine grasslands varies with altitude and site conditions. In communities immediately above treeline tall snow tussocks in the genus *Chionochloa* intermix with subalpine shrub species such as snow totara (*Podocarpus nivalis*) and various turpentine shrub species in the genus *Dracophyllum*. Above this zone typically there are dense tall snow tussock grasslands, which grade into communities dominated by shorter-statured snow tussock species and cushion-forming herbaceous species at higher altitudes (Wardle 1991). The strange, distinctive form of alpine plants is a striking feature of the alpine flora. The dramatic spiky appearance of the spaniards (*Aciphylla* species) is one of the most visible examples. Alpine grasslands represent our least modified grassland type. Some people consider them to be our only major native grassland type as many sites now inhabited by lower-altitude short-tussock grasslands were once covered by forest.

Together these features highlight the distinctiveness and significance of alpine grasslands for long-term conservation. However, like many other ecosystems in New Zealand, the unique features of these grasslands and their long-term survival are threatened by introduced species. There are three main threats: introduced animals, introduced herbs and grasses, and introduced tree species. Each of these is discussed in detail.

1. THREATS FROM INTRODUCED ANIMALS

Impact on species composition

For many decades in the 20th century, until the 1970s, alpine grasslands were heavily grazed by introduced red deer. Deer numbers declined after this period as commercial helicopter hunting became popular and the deer retreated back behind the cover of the forests (see Hickling 1986). A few studies have documented the impact of deer on alpine vegetation. In North Fiordland, research by Rose and Platt (1987) found that deer impact was higher in the tall snow tussock grasslands dominated by mid-ribbed snow tussock (*Chionochloa pallens*) than shorter-statured grasslands dominated by curled snow tussock (*C. crassiuscula*) and the southern species *C. acicularis*. The preference of tall snow tussock grasslands reflects the high number of preferred plant food species in this community. Preferred food species include mid-ribbed snow tussock and broad-leaved snow tussock (*C. flavescens*) and a range of large-leaved herbaceous species such as Haast's carrot (*Anisotome haasti*), the mountain daisy *Celmisia verbascifolia* and gentian (*Gentiana*) species. This study found a significant recovery in the presence and abundance of preferred food species from the mid-1970s to mid-1980s as deer numbers reduced dramatically with helicopter hunting (Rose and Platt 1987). Similarly, a long-term study of alpine grasslands in the Harper-Avoca, two major catchments of Craigieburn Forest Park in Canterbury, has shown a recovery of snow tussock species and large-leaved mountain daisy and spaniard species from high deer numbers in the 1950s and 1970s (Newell and Rose *unpubl. data*). These studies show that grazing significantly reduces the abundance of some native species. However, no one has examined whether deer grazing reduces the number of native species (species diversity) in alpine grasslands. In the Harper-Avoca comparisons of data collected in the mid and late 1970s with data collected in 2000 suggest that species diversity has increased in the 20-year period since deer numbers were last high.

The long-term impact of other introduced animals on alpine grasslands is less well documented. One would expect the preferred food species to be negatively affected. In some areas snow tussock and other native grass species make up more than 50% of the diet of tahr and nearly 20% of the chamois diet (Parkes and Thomson 1995). Native grasses are also a major component of the hare diet (Flux 1976). Woody subalpine species are also a major dietary species for chamois and hare. Hares browse on woody species such as porcupine shrub (*Melicytus alpinus*) and matagouri (*Discaria toumatou*) (Flux 1976) while snowberry (*Gaultheria depressa*) and native broom (*Carmichaelia* species) are favourites for chamois (Parkes and Thomson 1995).

Impact on regeneration of alpine tussock grasslands

The long-term survival of alpine grasslands is, in part, dependent on the ability of the major tussock species in the community to complete their life cycle. This means a tussock must flower and produce viable seed that will germinate and develop into seedling tussocks, which in turn grow into mature tussocks and flower. Any mechanism or animal that affects part of this cycle potentially can have a huge impact on the long-term survival of the community. The impact of deer on regeneration is inconspicuous and requires long-term studies to monitor details of tussock growth and regeneration.

Research on the regeneration and population structure of montane and alpine grasslands suggests that introduced animals are having a negative impact on tussock regeneration. Comparisons of areas with and without grazing have shown a significant reduction in the number of snow tussocks per hectare and fewer flowering stems per tussock in grazed tussock grasslands. Similarly, grazed grasslands have reduced health, with a higher proportion of dead tussocks to live tussocks per unit area than non-grazed grasslands. Grazing also alters the age structure of a tussock population, with a higher ratio of large, old tussocks to young juveniles and seedlings in grazed communities (Rose and Platt 1992; Newell and Rose *unpubl. data*; Rose and Allen *unpubl. data*). These results have been consistent for grasslands grazed by sheep, tahr and hare. There is every reason to suggest that the impact of other introduced animals such as deer and chamois would be similar.

2. THREATS FROM INTRODUCED HERBACEOUS SPECIES AND GRASSES

The invasion of introduced herbs and grasses into lower altitude, montane short-tussock grasslands has been well documented (e.g. Scott et al. 1988; Rose et al. 1995). Anecdotal reports suggest that these species have started to invade alpine grasslands, but there have been very few quantitative data to document this invasion or to identify whether the invasion patterns parallel those described for montane short-tussock grasslands.

Permanent grassland plot data from the Harper-Avoca provide a unique opportunity to compare invasion patterns in montane and alpine grasslands. Over 30 40-m long transects were set up in montane and alpine grasslands in 1955 and 1960 and these were remeasured in 1965, 1975, 1980 and 2000. The invasion patterns of the two grassland types are broadly similar. In montane grasslands sheep's sorrel (*Rumex acetosella*), hawksbeard (*Crepis capillaris*), catsear (*Hypochoeris radicata*), and the grass Yorkshire fog (*Holcus lanatus*) decreased significantly between 1965 and 1990 (Rose et al. 1995). Similarly, in alpine grasslands there was a significant decrease in sheep's sorrel and mouse-ear chickweed (*Cerastium fontanum*) between 1960 and 2000. However, catsear abundance did not change in alpine grasslands and Yorkshire fog was only ever present in a very small number of transects (Newell and Rose *unpubl. data*). In montane grasslands three hawkweed species (field hawkweed (*Hieracium caespitosum* also including king devil *H. praealtum*), mouse-ear hawkweed (*H. pilosella*), tussock hawkweed (*H. lepidulum*)) increased from 1965 to 1990. Purging flax (*Linum catharticum*) and brown top (*Agrostis capillaris*) also increased over this period (Rose et al. 1995). By comparison, the three hawkweeds were the only introduced herbs and grasses that increased in alpine grasslands between 1960 and 2000 (Fig. 1).

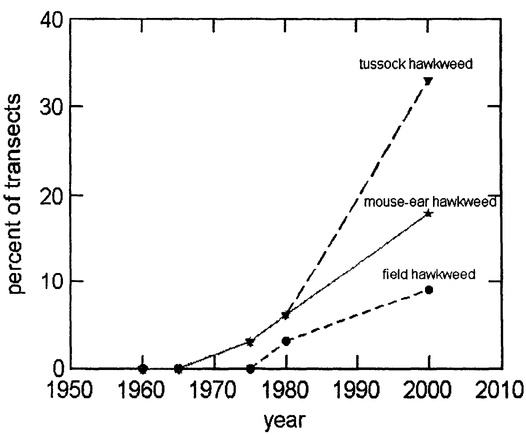

Fig. 1 Percentage of transects that field hawkweed (*Hieracium caespitosum/H. praealtum*), mouse-ear hawkweed (*H. pilosella*) and tussock hawkweed (*H. lepidulum*) occurred in (a different symbol has been used for each species) on the 33 Harper-Avoca alpine grassland transects set up in 1955 or 1960 and remeasured in 1965, 1975, 1980, and 2000.

Figure 1 shows the pattern for hawkweed invasion in the Harper-Avoca alpine transects. Hawkweeds were not present in 1960 or 1965. Both tussock and mouse-ear hawkweed were present in 1975 with all three species present in 1980. Tussock hawkweed has the highest rate of invasion from 1980 to 2000 with more than a 5-fold increase in the number of transects invaded (6 to 33%) whereas mouse-ear presence trebled over this period (6 to 18%). As a comparison, in montane grasslands mouse-ear hawkweed had invaded most transects by 2000 (Newell *unpubl. data*). In the Harper-Avoca mouse-ear and tussock hawkweed invasion is highest in alpine grasslands adjacent to montane grasslands and lower in areas above native forest. However, changes in the spatial distribution of these two species since 1975 indicate that they are moving further into isolated areas (Newell *unpubl. data*). At their current rates of invasion, tussock hawkweed and mouse-ear hawkweed will respectively have invaded approximately 60% and 30% of transects by 2020. However, we must be concerned about abundance of hawkweeds per transect not just their presence. At this point hawkweeds mostly occur with very low abundance on a 40-metre transect. With time abundance may increase dramatically and changes on one subalpine tussock transect illustrate a possible pattern. In 1980 tussock hawkweed was found on 4% of the 15-cm circular sample points along this 40-m transect. The sobering fact is that by 2000 tussock hawkweed was recorded on 42% of the circular sample points. This is a serious concern.

It is also important to consider the type of alpine grassland habitat that hawkweeds invade. Hawkweeds invade a range of established and disturbed alpine habitats in the Harper-Avoca. Both tussock and mouse-ear hawkweed invade open intertussock mats dominated by native mat-forming and small herbaceous species such as snowberry and *Anistome aromatica*. Tussock hawkweed is also successful in low-light situations, invading small openings in dense snow tussock grasslands and also the dense litter layer surrounding the base of each snow tussock. In disturbed situations both mouse-ear and tussock hawkweed invade the dense mat daisy (*Raoulia*) cushions along creek margins with *H. lepidulum* also found on recent slip sites (*pers. obs.*).

The invasion of hawkweeds into alpine grasslands deals a multiple blow. These are aggressive, fast-growing species that may out-compete native species and alter the composition of established vegetation. Their presence on disturbed sites and sometimes dominance at this initial phase of the successional cycle suggests that hawkweeds could change the successional pathway of vegetation on disturbed sites. Hawkweeds may also alter regeneration patterns of established alpine grasslands. There is a strong overlap between sites invaded by hawkweeds and those where snow tussock seedlings establish, suggesting that snow tussocks must now compete with hawkweeds for successful regeneration. This may have a negative impact on the regeneration and long-term sustainability of snow tussock grasslands. The final blow is the genetic adaptability of tussock hawkweed. Genetic research by Hazel Chapman at Canterbury University shows that this species has high genetic variation within a single population. This suggests that tussock hawkweed will adapt quickly to many different habitats and situations that arise.

3. THREATS FROM INTRODUCED TREE SPECIES

In some areas of New Zealand introduced trees are spreading across the high-country landscape. Alpine grasslands are not resistant to invasion by these species. In a series of trials in the Craigieburn Range Peter Wardle and others have shown that several introduced tree species are able to grow successfully well above the natural New Zealand treeline. Introduced woody species appear to be better adapted to the environment than our native woody species at treeline, having a higher level of winter hardiness at treeline (Wardle 1985) and greater ability to cope with this harsh environment (Wardle 2002). Lodgepole pine (*Pinus contorta*) can spread vigorously above treeline and is the most serious threat to alpine communities. Tree-statured lodgepole pines are able to grow more than 100 m above our natural treeline and this species can establish and grow in a stunted form approximately 200 metres above treeline (Wardle 1985).

Currently invasion by introduced tree species is a less widespread threat than that associated with introduced animals and introduced herbaceous and grass species. However, the threat is high in the places such as Craigieburn Forest Park where introduced tree species have been planted extensively. If left unchecked introduced trees will not only change the visual appeal of alpine grasslands but also the existence of some subalpine communities above the natural treeline. The worst-case scenario would see a new treeline formed by introduced tree species approximately 150 m above our natural treeline. This zone would overlap strongly with the distribution of native mixed alpine tussock and shrub communities. It is possible that the alpine tussock shrub zone could be totally replaced by a forest of introduced species.

LOOKING TO THE FUTURE: 2100 AND BEYOND

If we are committed to conserving alpine communities long-term we must ask "what will be the biggest problem facing alpine grasslands in the future?" All three threats discussed here have the potential to be a serious problem. However, the impact of introduced animals and herbs is likely to be geographically more widespread and would affect a broader range of alpine communities. The geographic distribution of introduced tree species is reasonably restricted. Where present, introduced trees would probably only impact an area of 200 m or so above the natural treeline.

However, there are several confounding factors that must be taken into account. At present there is little money in hunting deer commercially by helicopter. This may result in an increase in deer numbers as well as their movement back into alpine grasslands as the reason to hide under forest cover recedes. Prior to the helicopter hunting era, deer numbers were higher in alpine grasslands than in the forests below (see Hickling 1986). This suggests that the composition and regeneration of alpine grasslands could again be badly affected by heavy deer browsing. However, next time the impact may be different. Next time there would be a group of fast-growing introduced hawkweeds inconspicuously waiting in the wings for any decline in native species cover and tussock vigour. Invasion would be rapid and possibly irreversible.

The small number of long-term studies monitoring alpine grasslands is also a serious concern. Effective management must be integrated with long-term monitoring. Without these studies it is impossible to pre-empt future problems and actively manage them before they reach crisis stage. This is particularly true for introduced herbs, which are often inconspicuous in their early stages of invasion. Additionally, the impact of hares in alpine grasslands has not been well quantified. Observations over the last 15 years in the Harper-Avoca suggest that hare numbers are considerably higher than they were a decade ago. However, there is no quantitative information to measure hare numbers or hare impact on grasslands.

The current funding favours control of introduced animals and not plants. As a consequence our understanding of the characteristics of introduced plants and their invasion patterns is often limited in comparison to their furry counterparts. We also need more funding for the removal of introduced tree species. Much of the important work currently undertaken is privately funded and these are quietly moving our knowledge forward. For more than 10 years the Hieracium Control Trust has funded Landcare Research to work on hawkweed biocontrol. This firstly meant identifying appropriate insects that feed on hawkweeds in their native European habitats and choosing insects for biocontrol of hawkweeds in New Zealand that would not attack our native plants. Five biocontrol insects have been brought into New Zealand and these attack mouse-ear hawkweed, king devil and field hawkweed. Landcare Research staff rear these insects and release them annually throughout New Zealand. The search for a biocontrol agent for tussock hawkweed is currently underway. In addition, the Miss E. L. Hellaby Indigenous Grasslands Research Trust is currently funding three postgraduate students to improve our understanding of the ecology and genetic characteristics of tussock hawkweed.

Commitment is required on multiple fronts to ensure that alpine grasslands survive in a pristine, natural state well into the future. The degree of commitment by managers to monitor grasslands long-term and to control invasive plants and animals will directly affect this outcome. We also need a commitment from keen volunteers to continue to support wilding pine control days. A commitment must be made to fully understand the characteristics of the invading species to provide effective management and control for these species.

Tussock hawkweed, with its genetic adaptability and ability to invade a wide range of habitats, is perhaps our most serious concern. The degree to which commercial helicopter hunting does or does not carry on in the future is an unknown, but it must also be considered as increased deer numbers could have a huge impact on the long-term sustainability of alpine grasslands.

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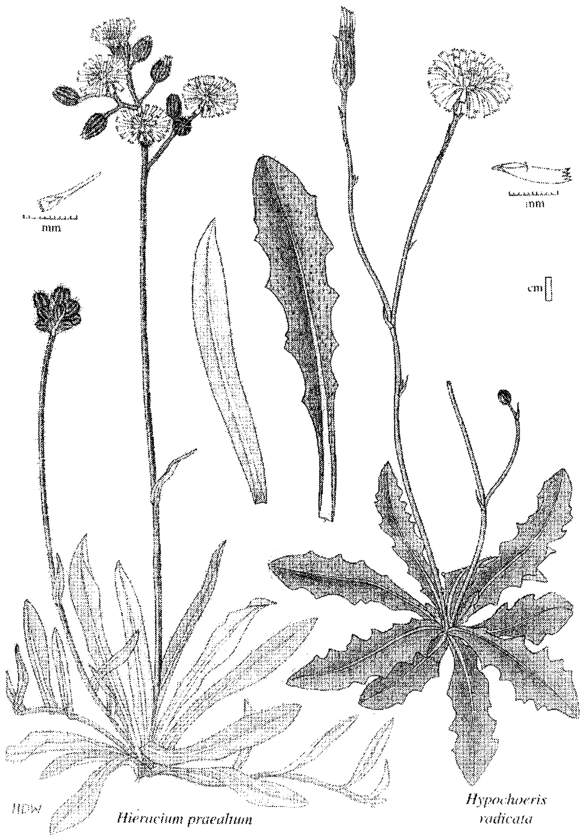

Kingdevil (*Hieracium praealtum*) and catsear (*Hypochoeris radicata*), both with dandelion-like orange-yellow flowers, are now abundant exotic weeds of montane, subalpine and alpine grasslands. (del. Hugh Wilson).