The impact of browsing on wilding conifers in the South Island high country

Nick J. Ledgard[1] and David A. Norton[2]

Abstract

Browsing by domestic and wild animals is likely to have a major influence on the survival of young seedlings of wilding conifers in the South Island high country. But to be successful wildings must be browsed before they reach 2 years of age after which they become sufficiently woody and robust to make it difficult for animals to cause complete defoliation, and hence mortality. Palatability to browsing animals varies with species, with Corsican pine (*Pinus nigra*) being the least preferred. Sheep are more effective in suppressing wildings than cattle. Low grazing pressures of >0.5 sheep stock units/ha can have a significant impact on seedling establishment and early growth rates, particularly where seed rains are light. The use of fertilisers can increase grazing levels and hence wilding control. The impact of wild animals is variable. Rabbits are generally more effective than possums or ungulates, and the consequences of improved rabbit control after the 1940s and the arrival of rabbit haemorrhagic disease in 1997 have almost certainly led to higher wilding numbers. Although wilding control can be enhanced by increasing browsing levels, perhaps aided by fertiliser application, both can impact negatively on native conservation values by promoting the grazing of native plants and their suppression by the enhanced vigour of competitive exotic grasses. Two case studies at Mt Dewar and Flock Hill Stations show how changes in farm animal stocking levels have led directly, although inadvertently, to increased wilding numbers. The opportunities for wilding spread can be expected to increase as sheep populations continue to decline, wild animal control improves, and tenure review leads to formerly grazed land being retired into the public conservation estate. There is a case for the more strategic deployment of browsing to control wildings, but this must be used with due consideration of potential adverse impacts on other values.

Introduction

The natural regeneration of introduced conifers, or wilding spread, continues to cause concern over large sections of New Zealand, particularly in the eastern South Island hill and high country. It is currently estimated that over 500,000 ha of land are 'affected' by wilding trees (North *et al*, 2007). The background to wilding spread, the reasons for concern, the major influencing factors, prevention and control strategies, and the history of research in the area, have been well addressed (e.g., Hunter and Douglas 1984; Ledgard, 1988, 2004, 2006a). Domestic and wild exotic mammals are common and wide-spread in New Zealand, so their browsing is likely to be a major influence on the survival of young wilding seedlings (Ledgard 2004). This article utilises information gathered from a number of research trials together with two case studies to provide more detail on the impact of browsing animals on wilding conifer establishment in the South Island high country.

Background

Introduced conifers have been grown in New Zealand for over 100 years. Although successful natural regeneration was first reported in the late 1800s (Smith 1903; Guthrie-Smith 1953), the first real upsurge in wilding establishment beyond planted stands in the high country was only noted in the late 1940s (Hunter and Douglas 1984). These authors suggested that this could well be connected to the lowering populations of sheep (*Ovis aries*) and rabbits (*Oryctolagus cuniculus*) at that time. Domestic stock numbers in the high country reached an all-time low during the 1950s (O'Connor 1980); in parts of inland Otago the carrying capacity of sheep in 1951 was only 10% of what it had been in 1881. In addition, plagues of rabbits were finally countered in the 1950s with the introduction of the "Killer Policy" in 1947. Many woody weeds, such as sweet briar (*Rosa rubiginosa*) spread in response to the reduced browsing levels (Molloy 1964) and it is likely that conifers responded similarly (Benecke 1967).

Livestock and introduced animal numbers (particularly rabbits) continued to fluctuate in the latter half of the twentieth century in response to changing farm prices and government subsidies (Kerr 1992). Most recently, browsing levels have been reduced for longer periods by the arrival of the rabbit haemorrhagic disease (RHD) in 1998 and changes in land tenure (O'Connor 2003; Mark and Dickinson 2004; Norton 2004) which has resulted in substantial areas being put into the conservation estate and retired from grazing. These factors, together with a reduced incidence of burning by land managers (Basher *et al*, 1990) have led to improved opportunities for the establishment of wilding conifers.

Research Trials

Age of Browsing

Browsing probably kills most wildings soon after they have germinated but after that they are harder to kill by grazing as they become more woody. In a simulated browsing trial, Crozier and Ledgard (1990) found that young conifers could be readily killed by removal of all green foliage before age 2. However, beyond this age shoots

[1] *Scion, PO Box 29237, Christchurch, Email: nick.ledgard@ensisjv.com*

[2] *Rural Ecology Research Group, New Zealand School of Forestry, University of Canterbury, Private Bag 4800, Christchurch 8140*

had become sufficiently woody and robust to make it much harder for browsing animals to remove all needles and hence cause mortality. In these circumstances, whilst grazing animals remain present, conifers can be 'hedged' and kept below 0.5 - 1.0 m tall for many years, but only require a few years of lighter or zero grazing to move above browse height and begin normal growth.

Relative Palatability

Palatability to browsing animals varies between species. This was shown by Crozier and Ledgard (1990) who exposed seven conifer species to sheep browsing 10 months after they had been planted as seedlings in unimproved grasslands. After one year Corsican pine (***Pinus nigra***) was the least preferred species, followed by Douglas-fir (***Pseudotsuga menziesii***), Scots pine (***Pinus sylvestris***), European larch (***Larix decidua***), contorta and ponderosa pine (***Pinus contorta*** and ***P. ponderosa*** respectively), with radiata pine (***P. radiata***) the most browsed species. Hunter and Douglas (1984) and Beauchamp (1962) also noted that Corsican pine wildings were 'infrequently browsed', and the relative frequency of this species in the high country (compared to elsewhere) could well be related to it being a less preferred species for animal browsing.

Domestic Animals

Following well-reported accounts of the spread of contorta pine in the Central Plateau area of North Island (Wardrop 1964), Benecke (1967) explored the effect of different levels of browsing pressure by sheep in controlled plots on Tara Hills Station, inland South Canterbury. He found that seedling survival after 27 months in ungrazed and unimproved (no inputs of seed or fertiliser) tussock grassland was 94%; whereas survival in grazed tussock grassland (0.6 and 0.3 sheep/ha), was substantially lower (23% and 59% respectively).

Cattaneo (2002) assessed the survival and growth of wildings either side of a retirement fence on Flock Hill Station, upper Waimakariri Basin. The seed source was 6 km away, so the rain of seed over the relatively small study area either side of the fence is likely to have been very similar. Below the fence, extensive low-density grazing was present (< 0.5 sheep stock units (SU)/ha), whilst there was no sheep grazing above. Sheep grazing significantly affected the overall numbers and height of wildings (Table 1), with wilding density 67% lower and mean wilding height 85% lower in the grazed area below the fence. Contorta pine was the most common conifer present, representing 93% of all wildings in the grazed area and 63% in the ungrazed area. Other species present were dwarf mountain pine (***Pinus mugo***), Scots pine and Douglas-fir, but their numbers were too low for a meaningful assessment of browsing on their survival and growth.

Table 1. Mean (±1 SE) wilding numbers and heights within lightly grazed (<0.5 SU/ha) and ungrazed grasslands on Flock Hill station. (from Cattaneo 2002).

	Grazed	Ungrazed	P-value
Wilding number	28.9 ± 8.7	67.3 ± 13.7	0.044
Wilding height (cm)	11.2 ± 2.3	75.6 ± 15.1	0.015

Gibson (1988) compared the influence of sheep and cattle on wilding numbers on 'The Hossack' Station, located immediately east of Hanmer Forest, north Canterbury. Hanmer Forest was planted in the early 1900s, mainly with Corsican and ponderosa pine, and some European larch, with radiata pine and Douglas-fir added from the 1950s on. All species would have been seeding heavily within 20 years of planting. The prevailing strong winds blow from the north-west directly towards 'The Hossack'. Prior to 1974 the station ran predominantly sheep but in 1974 there was a major change from sheep to cattle (***Bos taurus***), with low numbers of sheep only grazed on a short-term basis. Gibson (1988) documented a dramatic increase in seedling establishment dating from 1974, especially on grassland areas where wildings had been virtually non-existent prior to this date. Corsican pine was the dominant species, with a few older trees present amongst kanuka/manuka shrubland (pre-dating 1974), but with the vast majority of seedlings (including all the larch, radiata pine and Douglas-fir) younger than 10 years old (ie., post-dating the 1974 change in grazing management).

Wild Animals

As indicated above, rabbits can have a significant effect on the establishment success of young woody species. Davis *et al* (1996) conducted two trials to determine the effect of excluding rabbits, birds and insects from young radiata pine seedlings during their first year of growth from seed. Rabbits were clearly the major cause of seedling failure (Fig. 1) at the two experimental sites. There is no information on the impacts of hares on wilding conifers.

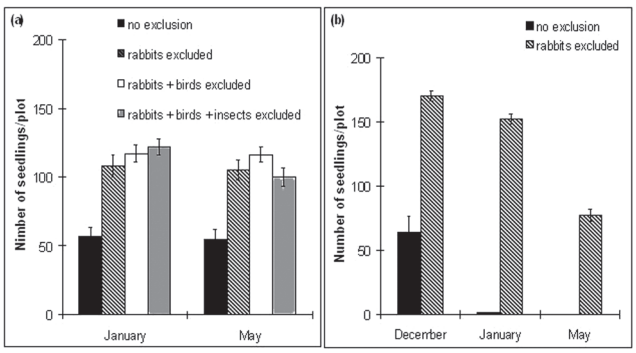

Figure 1. The effect of rabbits, birds and insects on first-year survival of radiata pine sown on two sites (a and b) near L. Tekapo in the Mackenzie Basin. (From Davis et al, 1996)

No formal trials have been carried out on the impact of possums on wilding establishment and growth, but they can be a serious problem in plantation forests at least locally (Butcher 2000). Possums appear to readily eat the bark of 2-year wilding conifers, thereby killing off branch tips and preventing cone and seed production (Nick Ledgard *pers. obs.*). In areas of scattered outlier wilding conifers, especially where there is not a wide range of food sources, such browsing could have a major impact on seed production and hence the rate of wilding spread. Further study on the impact of possums on wilding spread rates could be useful.

As with possums, no quantifiable data has been collected on the effect of browsing by wild ungulates (deer, goats, pigs etc) on wilding spread. However, there is circumstantial evidence to indicate that where numbers of these (especially goats) are high, wilding spread is being at least partially controlled by their browsing. In autumn, stags are known to seek out lone conifers for antler rubbing, and where contorta pine is present amongst a range of other conifers, it is often the preferred species (Nick Ledgard *pers. obs.*).

Browsing and Fertilisers

The use of fertilisers is a well accepted farming practice for increasing stock carrying capacity and has often been used to assist control of woody species such as gorse (Ulex europaeus) and broom (*Cytisus scoparius*). However, any depression of wilding conifer establishment under such management should not be attributed to a higher level of browsing alone. In the absence of any grazing, the improved vegetation vigour resulting from fertiliser addition, and hence the increased competition for light, moisture and nutrients can decrease wilding establishment success significantly.

In his contorta pine establishment trial, Benecke (1967) included an improved (fertilised) grassland treatment and even with zero grazing no seedlings lasted more than 15 months. Davis (1989) successfully direct drilled pine seed into unimproved short tussock grassland but had no success in improved grasslands unless a herbicide was applied. In another trial carried out in unimproved grassland at Mt Barker (Ledgard 2006b) one application of fertiliser (in the form of diammonium phosphate, applied at the rate of 100kg N/ha) increased dry matter production from 255 g/m^2 to 544 g/m^2 two years after application. Over four years the increased vegetation cover had a significant ($P <$ 0.01) negative effect on seedling emergence of all wilding species. The average suppression was 42%, ranging from 28% (maritime pine - P. *pinaster*) to 70% (contorta pine). There was also a negative relationship between seed weight and amount of suppression, with contorta pine having the lightest seed.

Although browsing and grazing pressure, perhaps enhanced by the use of fertilisers, can certainly reduce wilding establishment success and early growth rates, they can also be accompanied by negative impacts on native plants. Animals which browse wildings can also consume

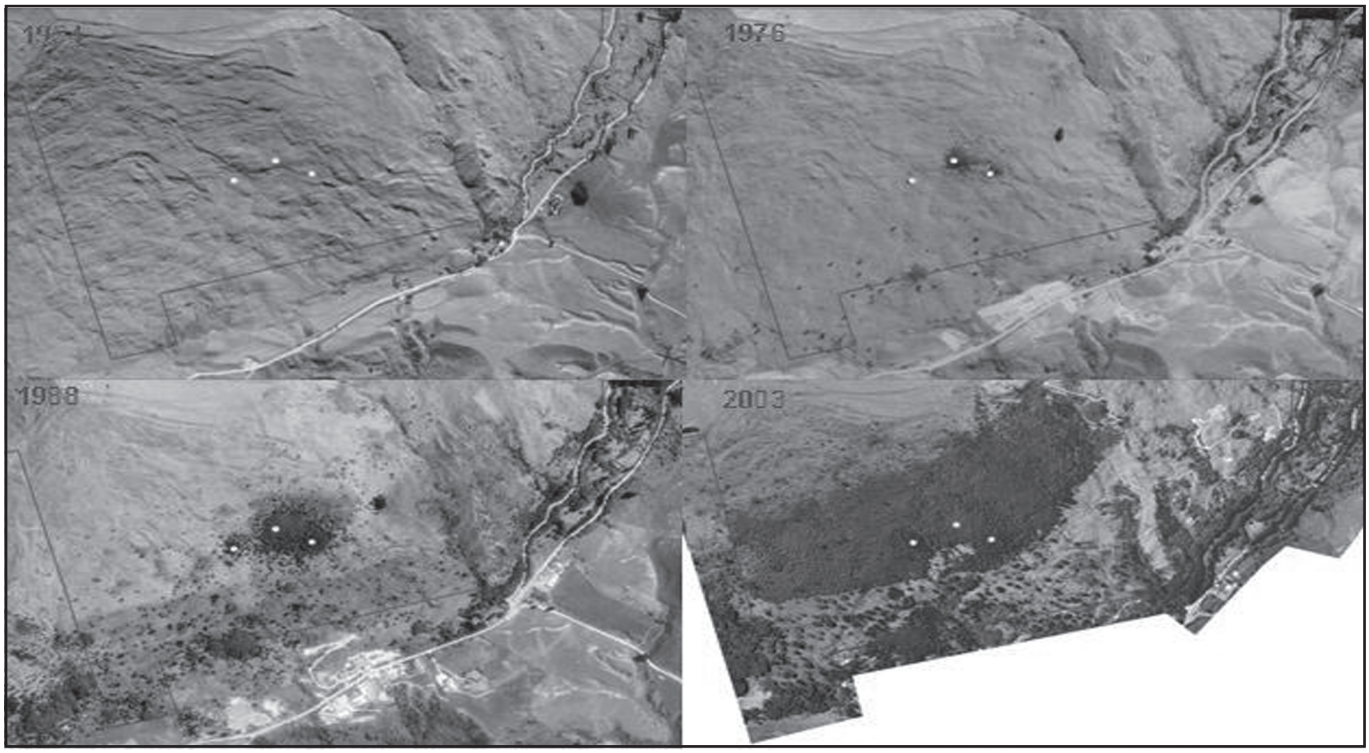

Figure 2. Aerial photo sequence of Mt Dewar station. The three original wildings are marked with white dots. It is suspected that the big increase in wilding numbers occurring between 1988 and 2003 was brought about by a major lowering of stock numbers (3000 down to 1000 SU) in the early 1990s, accompanied by a cessation of fertiliser use.

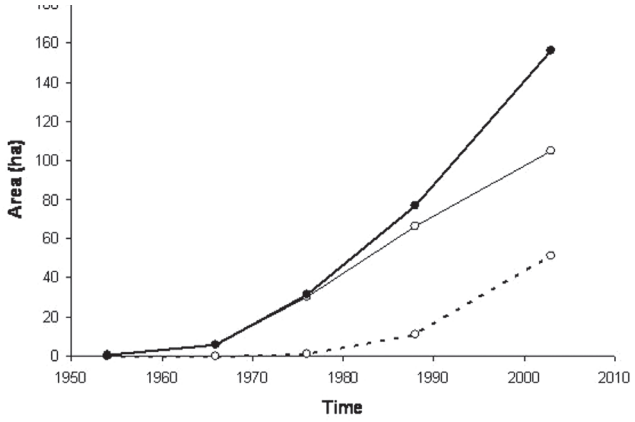

Figure 3. Area of scattered (grey line), dense (- - - - -) and combined (dark line) wilding conifers in the area illustrated in Fig. 2, Mt Dewar Station.

native vegetation, sometimes in preference to the conifers, as although palatable conifers are often not the most preferred food (Crozier and Ledgard 1990). In addition, if fertilisers are used to enhance grazing pressure, they may not only increase the likelihood of damage to native plants by browsing, but they can also promote the vigour of competitive (usually introduced) grasses which can smother or out-compete resident native species and prevent the recruitment of new seedlings (Rogers 1996; Widyatmoko and Norton 1997; Ledgard and Davis 2004).

Case Study Examples

Mt Dewar Station, Queenstown area

Mt Dewar Station is a 1,796 ha property situated just above Arthurs Point on the road between Queenstown and Arrowtown, south-western Otago. Historically, it has been an extensively grazed, and largely unimproved sheep farm. Up until the early 1990s the property carried around 3000 SU, but at that time stocking rates were reduced to around 1000 SU and no further fertilising was carried out. The first wildings (only three) are visible in aerial photos taken in 1954 (Figs 2 & 3), most likely originating through wind dispersal from the adjacent Arthurs Point settlement. The 1976 and 1988 photos show how wilding spread increased gradually by means of fringe spread around these outliers plus recruitment (mostly in the form of scattered trees) from outside seed sources. By far the biggest increase in wilding numbers (Fig. 3) occurred between 1988 and 2003, and it seems highly likely that the lower stocking rates, coupled with a cessation of fertiliser use from the early 1990s, contributed significantly to the spread of wilding conifers on this property.

Flock Hill Station, upper Waimakariri Catchment

Flock Hill Station is a 13,946 ha property bordering the main road (SH 73) between Christchurch and Arthurs Pass. As with most high country farms, its traditional use has been the extensive grazing of mainly sheep plus some cattle on unimproved grasslands. The major area affected by wildings is close to SH 73 on south-western boundary of the property. The source of wildings is conifer stands just across the highway planted on slopes and ridges reaching up to the Craigieburn Range. The main spreading species is contorta pine, but seven other conifer species can be found as wildings on Flock Hill. Immediately across the road directly under the rain of seed blown by the prevailing north-west winds from these planted conifer stands are the Flock Hill flats. A major increase in wilding numbers occurred all over the Flock Hill flats in the early 2000s, most likely due to the virtual removal of grazing for a period during this time (Fig. 4).

Although grazing pressure on the Flock Hill flats was low (<0.5 SU/ha) up until the zero grazing period in the early 2000s, it was still sufficient to significantly reduce wilding establishment from the regular influx of seed from a Craigieburn source approximately 1-2 km upwind. For many years this was illustrated by an 'island' of wildings growing within a small area fenced from sheep grazing in the early 1980s, whereas none were present in the surrounding grazed area. However, once the trees within the fence had

Figure 4. Photos showing the increase in wilding numbers on Flock Hill flats between 2001 (left) and 2006 (right), at the start of which period sheep grazing was ceased for a time.

Figure 5. For many years, light sheep grazing (<0.5 stock units/ha) has been sufficient to stop wildings establishing below a retirement fence (bulldozed line in mid-picture) on Flock Hill station. Now however, despite continued grazing below the fence, wildings are establishing (not visible in photo), due to the increased seed rain arriving from above.

matured and begun to produce their own cones and the local seed rain increased significantly, then the light grazing of the surrounding land was not sufficient to stop a major local increase in seedling establishment on the downwind side of the fenced area.

The same sequence of wilding invasion occurred in the area studied by Cattaneo (2002). The site was first invaded by wildings growing from seed which had blown in from a source 6 km away. Hence the seed rain was light and irregular and seedling establishment was significantly decreased by low grazing pressure below the grazing retirement fence. However, this was not so above the fence, where wildings soon established (Figure 5). Since these trees began to produce cones, resulting in a major increase in the local seed rain, the same grazing pressure below the retirement fence has not been sufficient to stop a significant increase in seedling numbers (not yet visible in Fig. 5).

Conclusion

Browsing by domestic farm stock and wild animals (notably rabbits) has been a major influence on wilding establishment in the hill and high country of the South Island - even if it has usually been inadvertent (not deliberate) as far as land management is concerned. Without such browsing, there is no doubt that the area of affected land would be significantly greater than it is today. However, in the future, if more land is retired from grazing and wild animals are kept under control, browsing pressures are likely to decline still further and hence the opportunities for wilding establishment will increase. A corollary to this is to explore the strategic use of grazing and fertilisers to limit the opportunities for successful wilding establishment. Grazing alone may be sufficient to control wildings where seedling numbers are low but in areas of high seed rain grazing in combination with fertiliser application is likely to be required. However, such use will not be simple as the positive impacts in terms of reduced wilding numbers will have to be balanced against the potential negative impacts on native plants through the greater risks of browsing damage and the enhanced vigour of competitive species (especially introduced grasses) where fertilisers are used. Alternatively, removal of seed sources will obviously remove the pressure of seed rain irrespective of grazing levels. However, these different management options have different costs associated with them (both in terms of action and inaction) and it seems clear that those involved in the long-term management of the South Island high country need to seriously consider the role of grazing and grazing-removal on wilding conifer distribution and abundance.

Acknowledgements

Our thanks to Murray Davis and Hamish Cochrane for helpful comments on this article.

References

Basher, L.R., C.D. Meurk,C.D. and K.R. Tate. 1990. The effects of burning on soil properties and vegetation. A review of the scientific evidence, relating to the sustainability of ecosystems and land use in the eastern high country: Departement of Scientific and Industrial Research Land Resources Technical Record No. 18: 93 pp

Beauchamp, R.R. 1962. Regeneration of Mackenzie trees. *The Press*, Christchurch, July, 1962. Reprinted in Tree Grower, 4. 67-68

Benecke, U. 1967. The weed potential of lodgepole pine. Review 13, *Journal of the New Zealand Mountain Lands Institute*, Lincoln University, Canterbury, New Zealand: 36-43

Butcher, S. 2000: *Impacts of possums on primary production*. In Montague, T.L. (Ed). The Brushtail Possum Biology, Impact and Management of an Introduced Marsupial. Manaaki Whenua Press, Lincoln. 105-110.

Cattaneo, M. 2002: Effects of microsite characteristics, competition and grazing on *Pinus contorta* and *Pseudotsuga menziesii* seedling estalishment. Unpublished M.For.Sc. thesis, School of Forestry, University of Canterbury. 154 pp

Crozier, E.R. and N.J. Ledgard. 1990: Palatability of wilding conifers and control by sheep browsing. In Basset, C., L.J. Whitehouse and J.A. Zabkiewicz. (Eds) "Alternatives to the chemical control of weeds". Proceedings of International Conference, Rotorua, July 1989. Ministry of Forestry, Forest Research Institute Bulletin No 155: 139-143

Davis, M.R., L.J. Grace and R.F. Horrell. 1996. Conifer establishment in the South Island high country: influence of mycorrhizal inoculation, competition removal, fertiliser application, and animal exclusion

during seedling establishment. *New Zealand Journal of Forestry Science* 26: 380-394

Davis. M.R. 1989: Establishment of conifer plantations in the South Island high country by direct drilling. *New Zealand Journal of Forestry*, 34(3): 21-24

Gibson, R. 1988. Change from sheep to cattle promotes conifer spread. Review 45, *Journal of the New Zealand Mountain Lands Institute*, Lincoln University, Canterbury, New Zealand: 26-28

Guthrie-Smith, H. 1953. *Tutira - the story of a New Zealand sheep station*. William Blackwood and Sons Ltd, Edinburgh and London: 444 pp

Hunter, G.G. and M.H. Douglas. 1984. Spread of exotic conifers on South Island rangelands. *New Zealand Journal of Forestry Science* 29: 78-96

Kerr, I.G.C 1992. The high country in transition - some implications for occupiers and administrators. Review 49, *Journal of the New Zealand Mountain Lands Institute*, Lincoln University, Canterbury, New Zealand: 32-50

Ledgard, N.J. 1988. The spread of introduced trees in New Zealand's rangelands - South Island high country experience. *Tussock Grasslands and Mountain Lands Institute Review* 44: 1-7

Ledgard, N.J. 2004: Wilding conifers - New Zealand history and research background. In Hill, R.l., S.M. Zydenbos and C.M. Bezar. (Eds) "Managing wilding conifers in New Zealand - present and future". Proceedings of a workshop held in conjunction with the annual general meeting of the NZ Plant Protection Society in Christchurch on August 11, 2003. ISBN 0-478-10842-7 Published by NZ Plant Protection Society: 1-25

Ledgard N.J. 2006a: Mitigating worries with wildings. *New Zealand Journal of Forestry*, 50(4): 20-23

Ledgard, N.J. 2006b: Determining the effect of increasing vegetation competition through fertiliser use on the establishment of wildings in unimproved high country grassland. *New Zealand Journal of Forestry* 51(3): 29-34

Ledgard, N. and M. Davis. 200): Rehabilitation of mountain beech (*Nothofagus solandri* var. *cliffortioides*) forest after fire. *New Zealand Journal of Ecology* 28: 125-135

Mark, A.F. and K.J.M. Dickinson. 2004. South Island high country in transition: issues, options and initial outcomes with the tenure review process. In: Kearsley, G.; Fitzharris B. (Editors), Glimpses of a Gaian world, pp. 285-308. School of Social Science, University of Otago, Dunedin, N.Z. 400 pp.

Molloy, B.P.J. 1964: Sweet briar - a vigorous woody weed in the South Island tussock grassland. *New Zealand Journal of Agriculture* 109: 105-118

North, H., P. Bartie and N.J. Ledgard. 2007: Mapping wilding conifers in the South Island high country. Landcare Research Contract Report LC0708/004; prepared for Land Information New Zealand, Christchurch, August 2007. www.wildingconifers.org.nz.

Norton, D. 2004. Echoes of Timberlands in high country debate - are more decisions being made on the basis of political ideology rather than principles of ecological sustainability? *New Zealand Journal of Forestry* 49(3): 39-41.

O'Connor, K.F. 1980: The use of mountains: A review of New Zealand experience. In A.G Anderson (Ed), "The Land Our Future". Paul Longman, New Zealand. 193-222

O'Connor, K.F. 2003. Conflicting innovations: A problem for sustainable development of New Zealand high-country grasslands. Mountain Research and Development 23: 104-109.

Rogers, G.M. 1996. Aspects of the ecology and conservation of the threatened tree Olearia hectorii in New Zealand. New Zealand Journal of Botany 34: 227-240.

Smith, W. W. 1903: Plants naturalised in the county of Ashburton. Transactions and Proceedings of the New Zealand Institute 36: 203-225

Wardrop, T.N. 1964. Reconnaissance survey of the occurrence of *Pinus contorta* on the Waiouru Military Reserve. Forest Management Report No 1, Forest Research Institute, P.O. Box 3020, Rotorua, New Zealand: 31 pp

Widyatmoko, D. and D.A. Norton. 1997. Conservation of the threatened shrub *Hebe cupressoides* (Scrophulariaceae), eastern South Island, New Zealand. Biological Conservation 82: 193-201.