CONSERVATION OF THE CROMWELL CHAFER *PRODONTRIA LEWISI* (COLEOPTERA: SCARABAEIDAE)

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SUMMARY: The Cromwell chafer, *Prodontria lewisi,* is a flightless chafer beetle whose natural range appears not to have been more than 500 hectares and which now, because of habitat destruction and modification, is reduced to about 100 hectares. This inhabited area is situated on the terrace on which the town of Cromwell, Central Otago, is built. The continued existence of the Cromwell chafer is threatened by the expansion of Cromwell township and increasing human activities in the vicinity.

P. lewisi is thought to have evolved from a small founder population which became isolated in the Cromwell basin some time during the Pleistocene. It lives in stabilised dunes of wind-blown sand. Adults come out at night to feed mainly on scabweeds (*Raoulia* spp.). Larvae feed on the roots of tussocks, especially *Poa laevis*. Apart from habitat modification, an important limiting factor on *P. lewisi* may be predation by the little owl, *Athene noctua.*

The Cromwell Borough Council has fenced an area of 95 hectares of predominantly native vegetation on wind-blown sand, inhabited by *P. lewisi,* south-west of Cromwell township. It is hoped that this area will soon be declared a reserve. The natural vegetation is threatened by exotic trees and shrubs, especially *Pinus radiata*. Proposals for control of exotic plants, and other management proposals, are outlined. Vegetation of the proposed reserve is mapped, and described in an appendix by Dr J. C. E. Hubbard and Mr T. Partridge.

INTRODUCTION

Only very recently has much serious attention been given to conservation of endemic insects in New Zealand, although many have been conserved incidentally in national parks, scenic reserves, forest sanctuaries and forest parks. These were initially established to preserve scenic values, trees and birds, but more recently the aims have expanded to preserve entire ecosystems, or at least representative samples of them.

Recently, Watt (1974) recommended the establishment of a reserve at Capleston, near Reefton, which was the type locality for 61 species of beetles described by Broun. This proposed reserve is intended to conserve taxonomically "typical" populations, and incidentally a very significant remnant of mature beech-podocarp forest. The area (between Flowers ana Redmans Creeks) is shown on Forest Service maps as a biological reserve, but it has not yet been formally gazetted as such, and hence lacks legal protection.

Watt (1977) drew attention to the most important type localities for New Zealand Coleoptera. Cromwell (45° 04'S, 169° WE) is a special case because within a small area it embraces the entire range of an endangered ,species.

Prodontria Broun is a genus of flightless chafer beetles (family Scarabaeidae, subfamily Melolonthinae) with nine described and several undescribed species from inland Otago, Southland, Stewart Island and the Snares Islands. It is related to, and probably derived from, the endemic genus *Odontria* White, which comprises a large number of fully-winged species.

As one would expect in a group of large, flightless beetles inhabiting various discontinuous habitats, most of the species have rather small ranges (Watt, 1975a), but *Prodontria lewisi* Broun (Figs. 1, 2) is

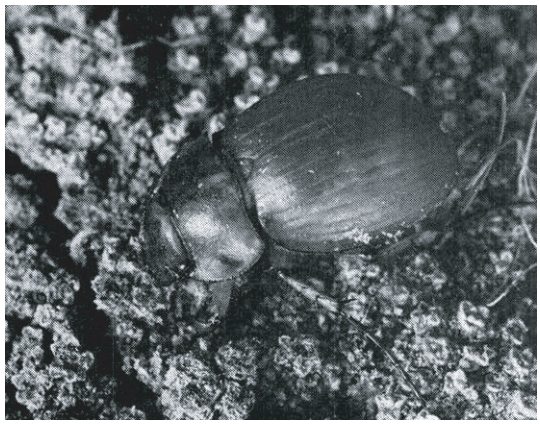

FIGURE 1. Prodontria lewisi *adult (length* 15 *mm) on* Raoulia australis.

FIGURE 2. Prodontria lewisi *larva (length ca.* 32 *mm) on Cromwell Sand.*

unique in formerly having a very limited range of about 500 hectares in and near Cromwell. Because of destruction or modification of substantial parts of its habitat, its range is now discontinuous (Fig. 3) and has been reduced to about 100 hectares.

P. *lewisi,* P. *bicolorata* Given, and P. *modesta* (Broun) comprise a group of closely related allopatric species; in fact the two latter may eventually prove to be geographical variants of a single species. P. *lewisi,* however, is as distinct from the other two as are some other species of the genus with overlapping ranges from each other.

Recent field work in Central Otago in the South Island confirmed the unique occurrence of P. *lewisi* in and near Cromwell. The continued existence of the species was threatened, first by a proposed high dam in the Dunstan Gorge which would have flooded all of the beetle's habitat, and later (when the proposed dam was lowered), by the planned expansion of Cromwell to become a dormitory town for construction workers (Ministry of Works and Development, 1975, 1977).

HISTORY

Broun (1904) described P. *lewisi* on three mutilated individuals collected at Cromwell "by Mr *J.* H. Lewis on the sandhills of the Molyneaux River". This was all that had been published on the ecology of P. *lewisi* (redescribed by Given, 1952) when I first visited Cromwell in 1968, although Hoy and Given (1952) had given a taxonomic description of the larva. In the meantime, a few adults and three larvae had been collected.

Since 1968, much searching and pitfall trapping in Central Otago has failed to reveal the Cromwell chafer anywhere except in and near Cromwell (Fig. 3). Study of the ecology of the species has helped to define its requirements, to explain its very restricted range and to suggest appropriate measures to attempt to ensure its conservation.

Some information was made available in 1970 to an interdepartmental committee considering possible development of the Upper Clutha Valley. The occur.rence of P. *lewisi* near Cromwell, and the possible threat to it from expansion of the town or related activities, was mentioned in the first Environmental Impact Report (Ministry of Works and Development, 1975, p. 114).

Later, Watt (1975b) gave a comprehensive report, based on all known information up to that time, and embodying several recommendations, to the Cromwell Joint Planning Committee and the Cromwell Borough Council. This was referred to briefly in the Clyde Power Project Environmental

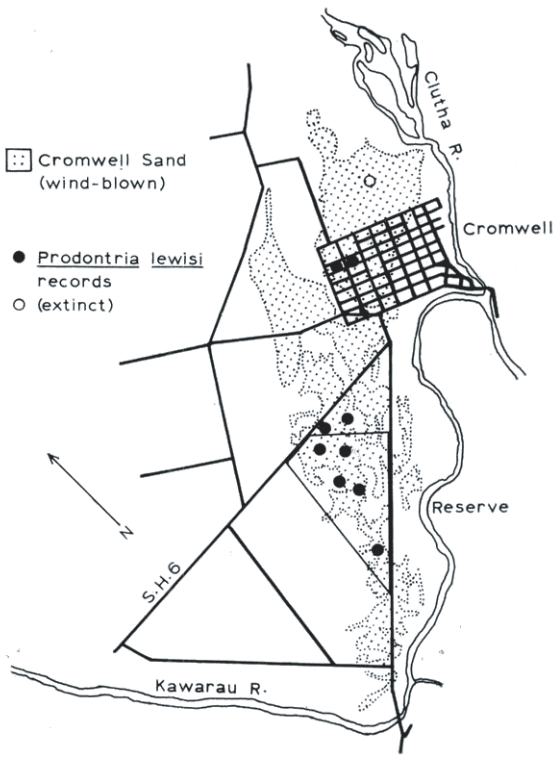

FIGURE 3. *Cromwell and vicinity, showing distribution of wind-blown Cromwell Sand, and all known records of* Prodontria lewisi.

Impact Report (Ministry of Works and Development, 1977, p. 122).

A press 'release gave newspaper, and eventually television, coverage to the Cromwell chafer, and in later television reports the beetle itself featured. This publicity was desirable, perhaps necessary, in creating awareness of, and interest in, *P. lewisi,* especially in Central Otago.

On the local scene, in November 1977 several Councillors and the Town Clerk of Cromwell inspected the area of the proposed reserve one evening to obtain an appreciation of the beetles' requirements. They were able to observe some adult beetles feeding. A framed photograph of an adult and a larva, with accompanying text, were presented to the Borough and displayed in the Public Library.

SUBSTRATE AND FOOD PLANTS

P. lewisi is found only in areas of wind-blown sand, classified by Leamy and Saunders (1967) as "Cromwell sand" and "Cromwell shallow sand" (Fig. 3). The terrain is hummocky and consists of small sand dunes, separated by depressions where the sand may be thin or absent. In these depressions, a basement of "Molyneaux very shallow loamy sand" is exposed.

The dunes support a variety of vegetation, in some places being stabilised by marram grass *(Ammophila arenaria* (L.) Link), tree lupins *(Lupinus arboreus* Sims) and/or Monterey pines *(Pinus radiata* D. Don). Of the natives grasses, silver tussock *(Poa laevis* Hook. f.) is frequent, and often dominant. The scabweeds *Raoulia australis* Hook. f. and *R. hookeri* Allan frequently grow in the depressions.

Larvae (Fig. 2) of *P. lewisi* are usually associated with *Poa laevis,* on the roots of which they feed. They may be found in moist sand amongst the roots of tussocks, but are never found in loose, dry sand. Adults (Fig. 1) apparently spend the day deep in moist sand. At night, especially during warm, humid weather, they come out shortly after dusk, and feed, mainly, but not exclusively, on *Raoulia australis*. They have also been observed feeding on a lichen, on field speedwell *(Veronica arvensis* L.) and on sheep's sorrell *(Rumex acetosella* L.).

The favoured food plants occur together in many places in Central Otago, but the only other substantial area of wind-blown sand of the Cromwell type is near Alexandra, near the confluence of the Clutha and Manuherikia Rivers (McCraw, 1964). Repeated searches and pitfall trapping in this area have failed to catch the Cromwell chafer or any other *Prodontria*. However, there is little native vegetation remaining on the Alexandra sands. *P. bicolorata* occurs on the outer margin of a terrace just north of the Alexandra "Cromwell sand", where it has been found at night feeding on scabweed growing on "Lowburn stony sand" and "Lowburn sandy loam" (McCraw, 1964). These are reasonably compact soils, and not loose, wind-blown sand. The larva of *P. bicolorata* and its habits are at present unknown.

EVOLUTION

Apparently the evolution of *P. lewisi* has involved mainly an adaptive shift from life in relatively compact, although sandy, soil, to specialisation for life in vegetated dunes of wind-blown sand. It was suggested by Park (1908) that Cromwell sand dated from the close of the last glaciation, but others have suggested that it originated as recently as a major flood in 1878.

No full species could have evolved in the 100 years since 1878, and no authenticated instance is known of a full species having evolved in the period of 11 000 years since the last glaciation. However, populations of land snails which became disjunct as a result of the formation of Cook Strait shortly after the last glaciation, have diverged sufficiently to be recognised as subspecies by some taxonomists (Te Punga, 1953: see also Climo, 1978).

Dr Royden Thomson states (1978, *pers. eomm.*) that the terrace on which *P. lewisi* now exists appears to have been constructed during the early stages of degradation following the last (Hawea) advance of the last glaciation, i.e., less than 14000 years B.P., which gives a maximum age for the present habitat. Contrary to Park's (1908) interpretation, no glacier ever extended as far as Cromwell in either the Clutha or Kawarau Valleys, and during the last glaciation glaciers did not extend much further than the existing Lakes Wakatipu, Wanaka and Hawea. However, the Cromwell basin was subjected to cyclic aggradation and degradation in response to the various glacial advances and retreats. If the Crom~ well chafer existed in this area during the Pleistocene it would have had a changing habitat and climate to contend with. Large amounts of wind-blown sand would have been transported down-valley by strong NW winds during glaciations. No doubt this sand would have tended to accumulate along the fringe of braided ,river channels (during periods of aggradation), and on the upper surfaces of flanking, higher, older, outwash terraces.

The temperature was no doubt substantially lower than at present during the glaciations. In other respects the climate was probably similar to, and probably no wetter than, that prevailing now, as the area would still have been in the rain shadow zone of the main divide. The vegetation may have been

quite like that on Cromwell sands in pre-European times, before the advent of rabbits.

From the above, it seems likely that the ancestral population of P. *lewisi* became isolated in the vicinity of Cromwell some time during the Pleistocene, where it became adapted to life in wind-blown sand. Theoretically, however, small isolated populations can diverge rapidly from their relatives through a limited fraction of the ancestral gene pool being carried by the founders of the population, and by random fixation and genetic drift (Ross, 1974). Thus, it is possible in theory, but highly unlikely, for P. *lewisi* to have speciated in isolation in its present habitat since the last glaciation.

LIFE HISTORY

The most dense population of P. *lewisi* occurs in a block in Cromwell township (Fig. 3) bounded by Antrim, Horace, Ortive and Barry Streets, where the original soil and vegetation have not been changed much by man's activities. It soon became apparent that P. *lewisi* would not be able to survive in this block if it was levelled off for housing. In 1975, Miss S. Connelly, and in 1976, Mrs R. Olds, operated dry pitfall traps in this block, and transferred the beetles which they caught to the proposed reserve (Fig. 4), selecting for release sites apparently suitable areas where P. *lewisi* was not known to occur.

The following records give the number of adult beetles caught per month from this pitfall trapping: July, 0; August, 17; September, 23; October, 53; November, 81; December, 34; and January (incomplete), 5. Regrettably, records are not available for later months. Only three live adults were collected by me in March 1975, in pitfall traps in the town block, and none were found elsewhere, despite extensive trapping and searching at night.

From these records, it appears probable that adults emerge to activity in spring. It is likely that most die off in late summer and autumn, but it is possible that some survive the winter. The specimens trapped in August may have ecloded then, or they could have ecloded from pupae in autumn and remained in pupal cells until spring. No pupae have yet been found. First instar larvae are unknown, but second and third instars have been collected in both November and March. This suggests that the life cycle requires more than one year for completion. It is clear that much more information is required before the life history of P. *lewisi* is adequately known.

LIMITING FACTORS

The present range of P. *lewisi* is considerably smaller than the area covered by Cromwell sand (Fig. 3). The beetle does not now occur in several apparently suitable areas where both *Poa laevis* and *Raoulia australis* are common. These areas all show signs of past disturbance, especially cultivation and / or fire. Apparently beetles do not travel far and are not able to recolonise isolated areas. A population which was found north of the 9-hole golf course in 1968 seems to have become extinct as

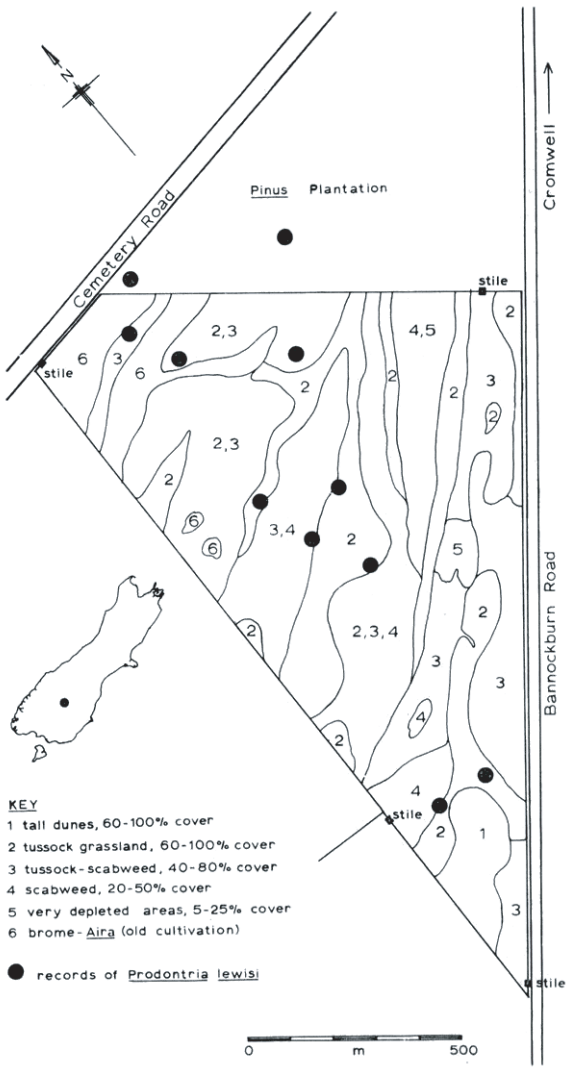

FIGURE 4. *Proposed reserve for* Prodontria lewisi, *showing vegetation communities.*

a result of bulldozing and re-sowing of the area when the golf course was extended to 18 holes. It is unfortunate that "development" was not confined to the greens and fairways, leaving the "rough" in its natural condition.

Castings of little owls, *Athene noctua* (Scopoli), found in areas where Cromwell chafers occur, contained numerous fragments of *P. lewisi* (Fig. 5). The little owl is the only known predator of Cromwell chafers. Other possible nocturnal predators which occur in the area are hedgehogs *(Erinaceus europaeus* Linnaeus), possibly rodents, about which there is no information, and within the town, domestic cats, *Felis catus* Linnaeus. No native predators are known. The lizard *Leiolopisma nigriplantare maccani* Hardy occurs in the area, but is diurnal. Marples (1942) reported that the stomach contents of 242 little owls contained 796 "Lamellicorns", which were mostly the striped chafer *Odontria striata* (White), although another similar, but smaller, species also occurred. He stated that the little owl is a ground-feeder, so flightless chafers would be particularly vulnerable to this predator.

There is no information on parasitism of *P. lewisi,* but most Melolonthinae in New Zealand are parasitised by tachinid flies. *Proscissio valida* (Hutton), known to be a parasite of several Melolonthinae, was collected commonly on the proposed reserve in November (J. S. Dugdale, *pers. comm.).* No larvae of *P. lewisi* with pathological symptoms have been observed, but they are presumably susceptible to some of the diseases which have been recorded from other Melolonthinae, mainly *Costelytra zealandica* (White), in New Zealand. These are iridescent viruses, Rickettsia, milky diseases *(Bacillus* spp.), fungi *(Metarrhizium* spp.) and Protozoa (Eugregarines, Neogregarines and Microsporidia): P. J. Wigley *(pers. comm.),* He1son (1965), Latch (1965), Allison (1969), Kalmakoff *et al.* (1972), Fowler (1974), Hall *et al.* (1977).

It is difficult to evaluate the importance of the various limiting factors. Destruction of all the native habitat occupied by the beetle would cause its extinction. Further habitat modification would pose a serious threat to the species. Predation by little owls occurs, but its overall effect on the population of *P. lewisi* is unknown. It is not known whether either parasitism or disease has much effect on total numbers of *P. lewisi.*

THE PROPOSED RESERVE

The proposed reserve is an area of about 95 hectares, situated south-west of Cromwell, north-west of Bannockbum Road and south of Cemetery Road (Figs. 3, 4). It is the only substantial area of relatively unmodified, natural valley-floor habitat remaining in the Upper Clutha Valley. The western boundary comprises an existing post and wire fence, beyond which is a paddock which has been cultivated in the past. The north-eastern boundary coincides with the new Cromwell Borough boundary, so that the entire area lies within Vincent County. It is owned, however, by the Borough of Cromwell. On the Cromwell side of the north-eastern boundary is a plantation of *Pinus radiata.*

The proposed reserve is gently undulating (Fig. 6), the undulations being largely due to low dunes of "Cromwell sand" and "Cromwell shallow sand" of

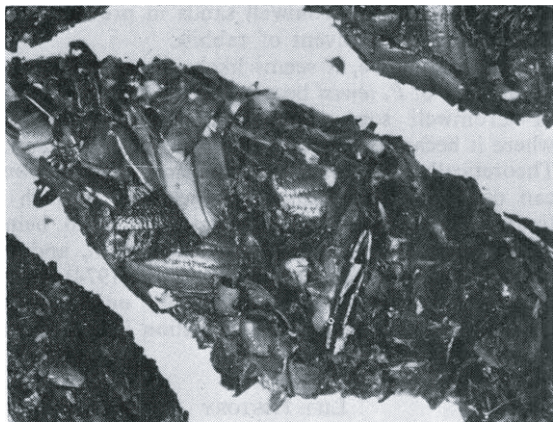

FIGURE 5. *Castings of* Athene noctua *containing fragments of* Prodontria lewisi.

FIGURE 6. *Proposed reserve, looking south-eastwards towards Bannockburn Road, showing low dunes dominated by* Poa laevis. *Woody "weeds" are self-sown* Pinus radiata *and* Cytisus scoparius.

Leamy and Saunders (1967). In some depressions a basement of "Molyneaux very shallow loamy sand" is exposed. This latter soil is very shallow, gravelly, and too compact for either adults or larvae of *P. lewisi* to inhabit, but it supports many of the scabweed plants on which the adults feed. *Poa laevis,* on the roots of which the larvae feed, grows almost exclusively on sand (Fig. 6).

The known distribution of *P. lewisi* within the proposed reserve is shown in Figure 4. Records comprise adults found feeding at night in November, and larvae dug out from under tussocks, mostly *Poa. laevis*. A record does not necessarily indicate a flourishing population.

Vegetation of the proposed reserve comprises a mixture of exotic and native plants. Six vegetation communities were recognised by Dr J. C. E. Hubbard and Mr T. Partidge (Fig. 4 and Appendix 1).

There are no native woody plants on the proposed reserve, so woody species which do occur there are a threat to the native, herbaceous vegetation. Most serious are self-sown *Pinus radiata,* which completely choke out all other vegetation in the vicinity. Near the northern end of the proposed reserve there are some small, but expanding, areas of broom *(Cytisus scoparius* L.), which also are choking out native vegetation in the vicinity. A few scattered plants of sweet briar *(Rosa rubriginosa* L.) occur.

Compared with most of the Upper Clutha Valley, the proposed reserve has been relatively little modified by man's activities. There are two defined vehicle tracks, associated with the erection and maintenance of electricity pylons. Additional wheel tracks elsewhere reveal where vegetation has been damaged by vehicles. An old, disused vehicle track runs near, and approximately parallel to, the Bannockburn Road. A small area in the north-west corner beside a dry irrigation channel appears to have been cultivated at some time. The native vegetation appears to be easily damaged by vehicles, and slow to recover.

Rabbits, *Oryctolagus cuniculus* Linnaeus, occur on the proposed reserve, as indicated by scrapes, occasional burrows, numerous faecal pellets, and infrequent sightings of the animals themselves, especially at night. More study is required to ascertain the numbers involved and how much damage they are doing to the vegetation. Perhaps exclosures will be necessary to demonstrate this.

ESTABLISHMENT AND MANAGEMENT OF THE RESERVE

Watt (1975b) recommended that the area described above should be designated a reserve, and that it should be securely fenced to prevent unauthorized access by vehicles. The provision of stiles over the fence (Fig. 4) was suggested to facilitate access for pedestrians. There is no apparent conflict between the status of the area as a reserve and its moderate use by pedestrians. Attempts a,t exclusion would not only be unsuccessful, but would cause resentment which could lead to vandalism. Extermination of woody plants was also recommended. Control of rabbits, and possibly of little owls, was advocated.

Recently, the Cromwell Borough Council resolved to fence off the area and to clear woody plants, with the aid of a subsidy from the Ministry of Works and Development. Fencing has been completed at the time of writing. No decision has yet been made by the Council to declare the area a reserve. To do so would involve a change in the Vincent County Council's district scheme, and the land being gazetted as a reserve. It is hoped that these steps will be taken in the near future, to help ensure survival of this endangered species.

APPENDIX 1

J. C. E. HUBBARD and T. PARTRIDGE

Botany Division, DSIR, Dunedin

VEGETATION OF THE PROPOSED RESERVE

Park (1908) mapped the areas of wind-blown sand which extended over most of the area surveyed. McIndoe (1932) described the relationships between the tussocks of *Poa laevis (caespitosa)* and sand: "The sand which is derived from the terrace face is not evenly distributed over the flat. . . . Wherever the thickness of sand is sufficient to allow the retention of surface moisture, then *Poa caespitosa* becomes dominant. Where sand is lacking on this flat *Raoulia australis* is dominant. Gradations can be found where the two species are evenly mixed."

In 1950 drifting sand often covered the Bannockburn-Cromwell Road and had to be removed. Since that time the stabilising effects of the pine trees and the elimination of most of the rabbits has all but halted the drift of sand. Thus, in recent times the dynamic nature of the flats has ceased. Exactly what effect this may have on the future of the area is not known, but the absence of further sand movements may mean a stabilisation of the present dunes and sandless areas, provided that other factors remain constant.

Vegetation types described below al'e mapped in Figure 4.

1. *Tall dunes;* 60-100% cover

This is a small area of dunes of sand up to 1.5 m tall. There are many species, the dominant being sheep's sorrell *(Rumex acetosella).* Moss and lichen

species are common as are cats' ear *(Hypochaeris radicata* L), Californian poppy *(Escholtzia californica* Cham.), haresfoot trefoil *(Trifolium arvense* L), vipers' bugloss *(Echium vulgare* L), red fescue *(Festuca rubra* L), cocksfoot *(Dactylis glomerata* L), dandelion *(Taraxacum ofJicinale* Webber ex Wiggers), Yorkshire fog *(Holcus lanatus* L), Australian sheep's burr *(Acaena ovina* A. Cunn.), sweet briar *(Rosa rubriginosa),* hawkweed *(Hieracium* sp.) and oxalis *(Oxalis corniculata* L). Tree lupin *(Lupinus arboreus)* occurs on the tops of many of these dunes and although at the time of the visit many were dead, there were numerous small seedlings scattered around the base. Drooping brome *(Bromus tectorum* L) is also often plentiful, indicating over-sowing at some time. The native silver tussock *(Poa laevis)* and the scabweeds *(Raoulia* spp.) are almost absent from the area.

2. *Tussock grassland,* 60-100% cover

This community is characterised by an almost complete cover and dominant sheep's sorrell and silver tussock. It mostly occurs on the slopes of the long dunes with areas of gentle slope; the dune crests and hollows being more depleted. Drooping brome which is found near the road, cocksfoot which is on the edge of the dune ridges, sweet vernal *(Anthoxanthum odoratum* L) and browntop *(Agrostis tenuis* Sibth.) point to some over-sowing. There are scattered plants of haresfoot trefoil, hawkweed, oxalis, *Carex breviculmis* R.Br., St. John's wort *(Hypericum perforatum* L), vipers' bugloss, cats' ear and a native *Epilobium* sp. Red fescue is important in places. Scabweeds play an insignificant part in this community.

3. *Tussock-scabweed,* 40-80% cover

This community is characterised by a reduction in cover, an increase in scabweed *(Raoulia australis* and *R. hookeri),* vipers' bugloss and St. John's wort, and a reduction in silver tussock. Still plentiful are sweet vernal, red fescue, *Carex breviculmis,* hawkweed, haresfoot trefoil, cats' ear, and two species of *Epilobium.* Near Cemetery Road the distinctive yellow lichen *Chondriopsis* covers a large area between the fescues.

4. *Scab weed,* 20-50% cover

The most common scabweed is *Raoulia australis,* except for an area near the south where *R. hookeri* is equally abundant. The vegetation shows considerable depletion, with many surface pebbles. Moss and lichen are the dominant cover along with the scabweeds, but silver tussock is virtually absent. Sheep's sorrell and haresfoot trefoil are plentiful but stunted. There are occasional patches of vipers' bugloss, St. John's wort, cats' ear, pincushion grass *(Agrostis mucosa* T. Kirk), wild mignonette *(Reseda luteola* L), *Scleranthus uniflorus* Williamson, *Poa* sp. and red fescue.

5. *Very depleted areas,* 5-25 % cover

This is an area of extremely sparse vegetation. Red fescue exists as small clumps, on small raised mounds of soil around which erosion has occurred. Scabweeds are frequent, but often dead. There are also scattered plants of wild mignonette, sheep's sorrell and haresfoot trefoil.

6. *Brome-Aira cultivated areas*

Occurring near Cemetery Road, this community is characterised by a complete cover and dominant drooping brome and silvery hair grass *(Aira caryophyllea* L). Most other species mentioned above are present, but only sheep's sorrell and haresfoot trefoil are abundant. Silver tussock and scabweeds are rare. The area was probably once over-sown and cultivated.

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