Inland *Lepidium* recovery plan

2000 - 2010

THREATENED SPECIES RECOVERY PLAN 32

Department of Conservation
Te Papa Atawhai

Recovery plans

This is one of a series of recovery plans published by the Department of Conservation. Recovery plans are statements of the Department's intentions for the conservation of particular plants and animals for a defined period. In focusing on goals and objectives for management, recovery plans serve to guide the Department in its allocation of resources and to promote discussion amongst a wider section of the interested public.

After preparing a technical report which was refined by scientists and managers both within and outside the Department, a draft of this plan was sent to the New Zealand Conservation Authority and relevant Conservation Boards for comment. After further refinement, this plan was formally approved by the Southern Regional General Manager in May 2000. A review of this plan is due after ten years (2010), or sooner if new information leads to proposals for a significant change in direction. This plan will remain operative until a reviewed plan is in place.

The Department acknowledges the need to take account of the views of the tangata whenua and the application of their values in the conservation of natural resources. While the expression of these values may vary, the recovery planning process provides opportunities for consultation between the Department and the tangata whenua. Departmental Conservancy Kaupapa Atawhai Managers are available to facilitate this dialogue.

A recovery group consisting of people with knowledge of inland *Lepidium*, and with an interest in their conservation has been established. The purpose of the Inland *Lepidium* Recovery Group is to review progress in the implementation of this plan and to recommend to the Department any changes which may be required as management proceeds. Comments and suggestions relating to the conservation of inland *Lepidium* are welcome and should be directed to the recovery group via any office of the Department or to the Biodiversity Recovery Unit.

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Cover photo: *Lepidium sisymbrioides* subsp. *matau*.
Photo by John Barkla.

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Abstract

Lepidium sisymbrioides, with three subspecies, and *L. kirkii* are small, cryptic, perennial herbs restricted to small, scattered populations in the depleted semi-arid grasslands of central Canterbury and Otago. Little is known of their former distribution and abundance, their present extent, their ecology, or the factors that threaten their continued existence.

This recovery plan is intended to provide the basis for remedying the deficiencies in our understanding of these threatened plants, and to ensure that viable, self-sustaining populations of the four inland *Lepidium* taxa are established or restored in the wild throughout their known natural range.

1. Introduction

Only two native species of *Lepidium*, both endemic, are restricted to inland habitats in New Zealand, whereas five endemic and one native species occur on the coast (Webb et al. 1988, Garnock-Jones & Norton 1995). The inland species are found only in Canterbury and Otago.

One of the two inland *Lepidium* species, *L. sisymbrioides* Hook. f., has three subspecies. *L. sisymbrioides* subsp. *matau* (Petrie) Thell. is known only from the Galloway district in the Manuherikia Valley, growing on gravel veneer over schist or Tertiary mudstone, and at nearby Springvale, on severely eroded Tertiary silts and clays. *L. sisymbrioides* subsp. *sisymbrioides* is relatively widespread, but nowhere common, in Central and north Otago and parts of inland Canterbury. It also occupies habitats comprising a veneer of gravel over schist bedrock, as well as occurring on deep alluvial gravels, limestone debris, and greywacke outcrops (Allen 1998). *L. sisymbrioides* subsp. *kawarau* (Petrie) Thell. occurs as scattered populations in the Kawarau Gorge area, where it grows almost exclusively in fissures on schist outcrops, and near Falls Dam in the upper Manuherikia Valley, where a few populations are found on greywacke outcrops and lakeside gravels.

Recent research has failed to ascertain the reasons for the apparent rarity of all three subspecies (Allen 1998). Cultivation and irrigation have undoubtedly reduced the area of habitat for *L. sisymbrioides* subsp. *matau* and *L. sisymbrioides* subsp. *sisymbrioides*, but there appears to be an abundance of suitable habitat that they do not occupy.

The second species, *Lepidium kirkii* Petrie, is restricted to saline/sodic soils of the intermontane basins of Central Otago. Habitat destruction resulting from cultivation and irrigation is probably the main reason for its rarity and the greatest threat to its survival.

Lepidium sisymbrioides is unusual for its dimorphic sexual systems, and all the inland endemic *Lepidium* taxa for their ecology.They are representative of a native flora that is now vastly reduced in diversity and abundance because of the severe post-European agricultural modification of its habitat. All inland native *Lepidium* taxa are listed as threatened plants (de Lange et al. 1999).

Without management, it is likely that some of the Falls Dam populations of *Lepidium sisymbrioides* subsp. *kawarau* will become extinct within a decade, along with the small outlying populations of *L. sisymbrioides* subsp. *matau* around Galloway and at Springvale.This also applies to most or all populations of *L. kirkii*. *L. sisymbrioides* subsp. *sisymbrioides* is sufficiently widespread and common to be under no immediate threat of extinction, but there will be continual loss of populations of this and *L. sisymbrioides* subsp. *kawarau* as habitat modification and other threats continue unchecked.

This recovery plan seeks to secure the continued existence of the endemic inland *Lepidium* species in a relatively natural habitat.

1.1 PAST DISTRIBUTION

There is no information on the abundance or distribution of either inland *Lepidium* species before the mid-19th century. It can be assumed that both were relatively

more widespread in the semi-arid interior of South Island when their habitat had not been modified by European farming practices. *L. kirkii* was presumably always limited by the distribution of the saline/sodic soils to which it seems restricted. Differences of opinion about the taxonomy of *Lepidium sisymbrioides* and its entities confuse the issue of its distribution. Table 1 summarises taxonomic history and distribution records.

TABLE 1: TAXONOMIC HISTORY AND DISTRIBUTION OF INLAND LEPIDIUMS

EARLIER NAME	AUTHORITY (DISTRIBUTION)	YEAR	CURRENT NAME
L. incisum	Banks and Solander (subalpine region of the Waimakariri)	1853	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides	Hooker (Lake Ohau; Waitaki Valley)	1864	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides	Armstrong (lowland and alpine Canterbury)	1880	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides	Kirk (Lake Ohau; Mackenzie country)	1882	*L. sisymbrioides* subsp. *sisymbrioides*
L. solandri	Kirk (Broken River basin, and now included *L. incisum* Banks and Solander)	1882	*L. sisymbrioides* subsp. *sisymbrioides*
L. incisum	Kirk (but considered its continued existence doubtful)	1882	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides subsp. *sisymbrioides*	Thellung	1906	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides var. *ovatum*	Thellung (Kurow)	1906	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides	Cheeseman (Broken River; McKenzie plains; Lakes Tekapo, Ohau, Pukaki; Waitaki Valley; Lake Wanaka)	1925	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides	Allan (lowland and montane tussock grassland east of divide lat 43°–45°; now included *L. solandri* Kirk and *L. sisymbrioides* var. *ovatum* Thellung)	1961	*L. sisymbrioides* subsp. *sisymbrioides*
L. sisymbrioides subsp. *sisymbrioides*	Webb, Sykes and Garnock-Jones (dry stony terraces and limestone debris throughout Canterbury and Central Otago)	1988	*L. sisymbrioides* subsp. *sisymbrioides*
L. australe	Kirk (near Cromwell)	1882	*L. sisymbrioides* subsp. *kawarau*

TABLE 1 cont.: TAXONOMIC HISTORY AND DISTRIBUTION OF INLAND LEPIDIUMS

EARLIER NAME	AUTHORITY (DISTRIBUTION)	YEAR	CURRENT NAME
L. kawarau	Petrie (Kawarau River)	1885	L. sisymbrioides subsp. *kawarau*
L. kawarau var. *dubium*	Petrie (Duntroon)	1885	L. sisymbrioides subsp. *kawarau*
L. sisymbrioides subsp. *kawarau*	Thellung	1906	*L. sisymbrioides* subsp. *kawarau*
L. kawarau	Cheeseman	1925	*L. sisymbrioides* subsp. *kawarau*
L. kawarau var. *dubium*	Cheeseman (Duntroon)	1925	*L. sisymbrioides* subsp. *kawarau*
L. kawarau	Allan (Kawarau River near Gibbston)	1961	*L. sisymbrioides* subsp. *kawarau*
L. sisymbrioides subsp. *kawarau*	Webb, Sykes and Garnock-Jones (rock outcrops in Kawarau Gorge and Manuherikia Gorge)	1988	*L. sisymbrioides* subsp. *kawarau*

Petrie (1890) first described *Lepidium kirkii* from collections from "saline situations in the Maniototo Plains", in the Gimmerburn district. He later added Bannockburn to its distribution, and reiterated that it was confined to salty situations (Petrie 1895). Cheeseman (1925) cited no additional localities. Allan (1961) provided Petrie's type locality of Gimmerburn district, and a distribution of salt patches in tussock grassland, Central Otago. Webb et al. (1988) repeated this.

1.2 PRESENT DISTRIBUTION

The following records are based on recent herbarium (CHR) records, unpublished and published reports, personal communications and observations, and Landcare Research Rare Plants Site Reports held at Landcare Research, Dunedin. Map references are to the 1:50000 NZMS 260 series.

TABLE 2: *LEPIDIUM SISYMBRIOIDES* SUBSP. *MATAU*

LOCATION	GRID REFERENCE
Chapman Road, transplants from cultivation ex Crawford Hills Road	G42 232428
Springvale Road	G42 295503
Galloway Station "water race"	G42 324482
Wardle property, Galloway Road	G42 324491
Galloway Station "Nassella block"	G42 330476

TABLE 3: *LEPIDIUM SISYMBRIOIDES* SUBSP. *KAWARAU*

LOCATION	GRID REFERENCE
Bluffs above farm track, Long Gully	F41 025619
Swift Burn, Kawarau Gorge	F41 853701
Chards Road, Kawarau Gorge	F41 865691, 867695
SH6, Kawarau Gorge	F41 867698
Adjacent SH6, Nevis Bluff, Kawarau Gorge	F41 946668
Fault scarps, north side Slapjack Creek	F41 987626, 991623
Beside access road, Slapjack Creek	F41 993614
Fiddlers Flat Road, Falls Dam	H41 650873
Manuherikia River gorge below Falls Dam	H41 651877
Western end of Falls Dam	H41 654873
Lake shore and adjacent hillside, NE extremity of Falls Dam	H41 666897

TABLE 4: *LEPIDIUM SISYMBRIOIDES* SUBSP. *SISYMBRIOIDES*

LOCATION	GRID REFERENCE
Pisa Flats, upper Clutha Valley	G41 160792, 163788
SE of Chatto Creek Hotel, Manuherikia Valley	G42 352542-356563
Chatto Creek	G42 360578
Otematata	H40 859177
Blackstone, Manuherikia Valley	H41 595770
Styx-Patearoa Road	H42 715394
Tekapo Accommodation Reserve	I37 091834
Beside Waitaki River, Kurow	I40 102023
Beside SH83 SE of Kurow	I40 115024
Hakataramea - Waimate Road, SE of Fettercairn	I40 135035
Lance McCaskill Scientific Reserve	K34 058752
Cave Stream Scenic Reserve	K34 077782
Broken River, Flock Hill scarp	K34 084795

TABLE 5: *LEPIDIUM KIRKII*

LOCATION	GRID REFERENCE
Chapman Road Scientific Reserve	G42 232428
Galloway district	G42 315467, 321465, 321469, 324482, 332506, 337497, 340515, 349499, 353509
Chatto Creek, Manuherikia Valley	G42 358575
Rockdale, Manuherikia Valley	G42 366589
Dovedale, Ida Valley	H42 521526
Gold sluicings, Styx-Patearoa Road	H42 717384
Wilson Road, near Ranfurly	H42 735486

1.3 SPECIES ECOLOGY AND BIOLOGY

Lepidium sisymbrioides

Lepidium sisymbrioides is currently recognised as three subspecies (Webb et al. 1988). Two subspecies (*L. sisymbrioides* subsp. *sisymbrioides* and *L. sisymbrioides* subsp. *matau*) have considerably overlapping morphological and ecological characteristics, and some herbarium specimens have been re-identified from one to the other (e.g. *matau* to *sisymbrioides*: CHR 329254, collected by Petrie from Eweburn in the Maniototo). Populations of the two taxa occur within 7.5 km of each other in very similar, if not identical, habitats - Galloway and Chatto Creek, Manuherikia Valley. Allen (1998) recommended exploration of the possibility that they are geographic variants of a single entity. However, because they are presently not known to be sympatric, their taxonomic status does not result in any confusion with identification or degree of threat.

Lepidium sisymbrioides is the only dioecious (plants have either male or female flowers) member of the approximately 3200 species of the cosmopolitan plant family Brassicaceae (Webb et al. 1988). All three subspecies are long-lived (>10 years) rosette-forming perennial herbs with substantial taproots that can extend for 2 m into the substrate. In cultivation, *L. sisymbrioides* subsp. *matau* and *L. sisymbrioides* subsp. *sisymbrioides* are morphologically very similar (Allen 1998). In the wild they form compact clumps of numerous small (<5 cm diameter) rosettes of grey-green to purplish, lobed or pinnate leaves, with racemes of multitudes of small flowers borne on a stem up to about 10 cm tall. Wild *L. sisymbrioides* subsp. *kawarau* typically forms more lax clumps of larger (up to 20 cm diameter) rosettes with more finely pinnate leaves than the other subspecies, and its leaves are commonly green. Its flowering stems are up to 30 cm tall.

Lepidium sisymbrioides subsp. *matau* is classified as critically endangered by de Lange et al. (1999). It is restricted to Central Otago, where it was recorded from sites in the Maniototo basin and near Alexandra in Central Otago last century (CHR herbarium records). It has been formally recorded recently as a main population of fewer than 200 plants in the Galloway district (45∞ 15' S), near Alexandra (Allen 1996, 1998), and small groups of plants at other sites within a few kilometres of this (Landcare Research Rare Plants Site Reports; CHR herbarium records).

Lepidium sisymbrioides subsp. *kawarau* bears the classification of endangered (de Lange et al. 1999). It is known from 10 small populations in and adjacent to the Kawarau Gorge (45∞ S), and a few populations in the upper Manuherikia River valley (44∞ 53' S) in Central Otago (Allen 1998). At the former location its habitat is schist outcrops, and at the latter it occurs on greywacke outcrops and adjacent talus and hillslope, and on a lakeside gravel terrace.

L. sisymbrioides subsp. *sisymbrioides* is regarded as declining (de Lange et al. 1999). It has been recorded at more than 20 localities ranging from the Waipara River gorge and Broken River in north Canterbury (43∞ 10' S) to Patearoa in eastern Central Otago (45∞ 20' S). Its habitat includes limestone debris and greywacke and schist gravel river terraces and floodplains. It is still widespread, but local and nowhere common.

All three subspecies are restricted to seasonally dry to semi-arid habitats with substantial summer soil water deficits (e.g. Hubbard &Wilson 1988) and cold winters. Typically, topsoils are thin, gravelly, and overlie either weathered bedrock, talus, or deep gravels. In the case of *Lepidium sisymbrioides* subsp. *kawarau*, topsoil may be completely absent, and most plants grow in deep crevices in rock outcrops.

Where the soil chemistry of *Lepidium sisymbrioides* subsp. *sisymbrioides* habitat has been recorded, topsoil pH is acid: e.g. 4.7-5.6 (Patearoa; Allen and McIntosh 1993) and 5.1-5.8 (Pisa Flats; Allen and McIntosh 1994). Soil pH of the limestone debris reported as *L. sisymbrioides* subsp. *sisymbrioides* habitat in Canterbury would presumably be less acid. Soil pH of *L. sisymbrioides* subsp. *matau* habitat at Galloway is similar to that for the Central Otago populations of *L. sisymbrioides* subsp. *sisymbrioides*: 4.7-6.1 (Allen & McIntosh 1993). Soils of the schist outcrop and talus of *L. sisymbrioides* subsp. *kawarau* habitat are more neutral (e.g. pH 6.6-7.3 in the Kawarau Gorge; Partridge et al. 1991), but the soil pH of greywacke habitat at Falls Dam is not known. Although none of the subspecies appears to have particular soil requirements, *Lolium* soil bioassay has shown that plants of all three tend to grow on topsoils (0-10 cm) that are more fertile than the soils of adjacent areas unoccupied by *L. sisymbrioides* (Allen 1998). There remains a possibility that *L. sisymbrioides* subsp. *matau* and *L. sisymbrioides* subsp. *sisymbrioides* are tolerant of relatively saline or sodic topsoils and subsoils.

Lepidium sisymbrioides has xeromorphic adaptations such as compact habit, small leaf surface area: volume ratio, long tap roots, and seeds that remain viable for several years (Allen 1998). The cryptic foliage has an unpleasant mustard flavour, and is seldom eaten by mammalian herbivores, although invertebrate predation is sometimes apparent. The small (c. 1.5 mm long) seeds are abundant, easily shed from the mature silicles, and sufficiently light to be dispersed at least several metres by wind.

Plants of all three subspecies can flower in their first year in cultivation, but it is not known how long they take to reach reproductive maturity in the wild. Most wild plants flower every year. The racemes are conspicuous and the flowers scented.

Insect pollination results in production of large numbers of seeds, e.g. c. 800 per female plant for *Lepidium sisymbrioides* subsp. *matau* (Allen 1996). Seed viability varies from year to year, but all three subspecies can produce seeds with >30% viability (Allen 1998).The seeds germinate readily in cultivation, but no germination was observed of viable seeds sown in experimental plots at Galloway and Patearoa in 1997/98, despite weeding, watering, and invertebrate control (R. B.Allen, unpub. data).

Lepidium sisymbrioides subsp. *matau* plants were mapped on permanent plots at Galloway in December between 1993 and 1998. Seven seedlings established during this period in plots with no sheep grazing, which had an initial population of 26, but there was a net loss of 20 plants, most through burial by erosion or rabbit burrowing. Four seedlings established between 1994 and 1998 in sheep-grazed plots, which had an initial population of 29, but there was a net loss of one plant (R. B. Allen, unpub. data).

Lepidium sisymbrioides subsp. *sisymbrioides* plants were recorded on permanent plots at Pisa Flats in December from 1994 to 1996. Five seedlings established, and there was a net gain of three plants from the original 81 in this period (R. B. Allen, unpub. data).

Seedling establishment in the wild was not clearly linked to climate, but nevertheless climate (especially rainfall) is likely to be a crucial factor in this harsh environment. Given the longevity of the species and its ability to delay seed germination, low annual seedling establishment rates are not necessarily a threat to its success.

Plants under cultivation increased their number of rosettes annually, and rosette numbers appear to be related to age in the wild (Allen 1998). Population structures in the wild vary from approximately negative exponential frequency distributions with increasing rosette numbers in *Lepidium sisymbrioides* subsp. *kawarau* plants at Slapjack Creek, *L. sisymbrioides* subsp. *sisymbrioides* plants at Pisa Flats, and *L. sisymbrioides* subsp. *matau* plants at Galloway, but frequency distributions approaching normal in *L. sisymbrioides* subsp. *kawarau* at Falls Dam and *L. sisymbrioides* subsp. *sisymbrioides* at Patearoa (Allen 1998). Slapjack Creek, Pisa Flats, and Patearoa populations contained many plants with >10 rosettes, but such plants were almost absent from the Falls Dam and Galloway populations. Plants with <3 rosettes were under-represented in the Falls Dam, Pisa Flats, and Patearoa populations, suggesting recently poor recruitment.

Despite the presence of substantially more male than female plants at Falls Dam and Galloway, sex ratios in all populations can be regarded as falling within the normal range for dioecious plants, and do not represent a constraint on reproductive success (Lloyd & Webb 1977). However, low numbers of plants of one sex can increase the vulnerability of a population to extinction if there is differential mortality between sexes.

Although the coastal native *Lepidium* species are considered to be palatable and threatened by herbivores, there is little evidence that mammalian herbivory is a major threat to *L. sisymbrioides*. Plants of all three subspecies that are accessible to all mammalian herbivores present in Central Otago show little sign of browsing apart from occasional nibbles on inflorescences. Perhaps some 30% of plants show signs of invertebrate herbivory on their foliage during and after flowering, and sometimes entire leaves are missing from rosettes, especially close to the ground (R. B. Allen, pers. obs.). The only formal record of the fauna responsible is the endemic Central Otago moth *Eurythecta zelaea* (Patrick 1994), but other butterfly and moth larvae, aphids, slugs, and snails are also contenders.

The fungal pathogen white rust (*Albugo candida*), which attacks ornamental and crop taxa of Brassicaceae, has been recorded on *Lepidium sisymbrioides* (CHR voucher PDD64224), but fungal infections do not appear to be common or serious. Invertebrate seed predation is common in arid and semi-arid plant communities, and may be a major constraint on recruitment success (Reichmann 1979, Louda 1982, Abramsky 1983, Risch & Carroll 1986). No *Lepidium sisymbrioides* seed predation has been recorded before the seeds are released from the plants (Allen 1998), but post-dispersal seed and seedling predation may be significant (Willson 1992, Crawley 1992).

Lepidium kirkii

Lepidium kirkii is a summer-green perennial herb with slender prostrate branching stems up to 10 cm long arising from a stout rootstock. Its leaves are entire with wavy or bluntly toothed edges, and 0.5-3 cm long. On individual plants, all flowers are hermaphrodite. Flowers and fruit are borne in racemes 1-3 cm long (Webb et al. 1988).

Lepidium kirkii is classified as endangered (de Lange et al. 1999). Recent records indicate that it is present as several hundred plants at fewer than 10 localities (Johnson 1976, 1988; Partridge 1981; Given & Farrell 1986; Balks & Hewitt 1987; Bruce 1988a, b, c; Bruce & Loh 1988; Loh et al. 1988; McIntosh et al. 1990, 1992).

Lepidium kirkii is only known to occur on patches of saline/sodic soils known as salt pans in the semi-arid region of Central Otago. This habitat varies from highly weathered bedrock schist (e.g., Galloway) to the gravels and silts of old gold mining sluice pits (e.g. Patearoa), and usually supports few, if any, other plant species. Allen and McIntosh (1995) described the soil chemistry of most known sites of *L. kirkii*. Topsoil (0-10 cm) pH varied from 6.0 to 9.4, but subsoil pH was usually >7.5. Soil conductivity, a measure of salinity, was between 680 µS/cm (slightly salty) and 9300 µS/cm (extremely salty), but would vary considerably at any particular site according to the time and duration of recent rainfall.

No published information is available on these aspects of *Lepidium kirkii* ecology. Seeds collected from the wild germinate readily in cultivation, and *L. kirkii* plants have been established from seeds sown in appropriate habitats in the wild (B. H. Patrick, pers. comm.).

There are no published descriptions of pathogens of *Lepidium kirkii*.

1.4 CAUSES OF DECLINE

Lepidium sisymbrioides

Williams and Given (1981) suggested that browsing and habitat modification were reasons for the decline of *Lepidium sisymbrioides* subsp. *matau* and *L. sisymbrioides* subsp. *kawarau*, citing road and hydro-dam construction as particular factors for the latter. They reported that the most immediate threat to *L. sisymbrioides* subsp. *kawarau* might be the small size of the then single known population, especially through elimination of one of the sexes, but did not postulate any reasons for the small size of the population.

Little vertebrate herbivory has been recorded on the subspecies of *Lepidium sisymbrioides*, although some invertebrate herbivory is evident. Herbivory is almost

certainly not a critical threat to *L. sisymbrioides*. Apart from the record of white rust, the effect of pathogens is unknown. Lack of evidence of diseases in the populations studied by Allen (1996, 1998) suggests that fungal and other pathogens are not critical threats, at least to adult plants. Seed and seedling predation have not been adequately examined, and may be a major factor limiting recruitment of *L. sisymbrioides*.

Every known population of *Lepidium sisymbrioides* is associated with a suite of native and introduced herbaceous plants, and some populations of *L. sisymbrioides* subsp. *kawarau* also with native shrubs, e.g. matagouri (*Discaria toumatou*) and *Carmichaelia* spp., and introduced shrubs, e.g., briar (*Rosa rubiginosa*) and thyme. Apart from thyme with *L. sisymbrioides* subsp. *kawarau* in the Kawarau Gorge, and *Festuca rubra* with *L. sisymbrioides* subsp. *sisymbrioides* at Castle Hill, there is little evidence that competition from either native or introduced plants is a significant factor limiting *L. sisymbrioides* success, although the possibility should not be discounted, especially in the absence of grazing. Herbarium (CHR) collections of *Lepidium sisymbrioides* subsp. *sisymbrioides* and *L. sisymbrioides* subsp. *kawarau* (39 and 18, respectively) have probably not made significant inroads into wild populations. Sixteen of the 19 specimens of *L. sisymbrioides* subsp. *matau* at CHR come from the Galloway location, and four of these from the "Nassella block" population, which has precariously few living plants. However, compared with natural attrition recorded at Galloway, collections have probably made a minor contribution to population decline in this subspecies.

Every site of each subspecies has been modified by fire, introduced plants, and the effects of mammalian herbivores. Irrigation, fertiliser application, and cultivation have also altered soil properties at many sites. There is no doubt that such habitat changes are the most significant factor in the decline of all three subspecies, but the processes involved have not been described. The effects of competition from introduced plants have not been quantified. Neither habitat modification nor competition appears to have resulted in a reduction of pollination success by changing the invertebrate fauna or invertebrate behaviour.

The scattered and small populations of *Lepidium sisymbrioides* are vulnerable to occasional severe climatic events, particularly droughts that characterise their semi-arid environment. *L. sisymbrioides* is known to produce abundant viable seed every year, but even in years of apparently adequate rainfall, the timing and frequency of rain may not be suitable for establishment of *L. sisymbrioides* seedlings, instead favouring the competing agricultural plants and weeds. *L. sisymbrioides* establishment may also be affected by seasonal changes in herbivorous invertebrate populations. Although individual plants of *L. sisymbrioides* can live for at least a decade, the very small size of many populations increases the risk of all plants of one or both sexes dying of natural causes before seedlings are established to replace them.

Lepidium kirkii

Williams & Given (1981) do not list *Lepidium kirkii*, and there appears to be little published information on the reasons for its decline. Dopson et al 1999 mention habitat destruction, mining, sheep grazing, and collectors. Recent descriptions of *Lepidium kirkii* sites do not mention pathogens, and there is no published information on this or herbivory.

Lepidium kirkii is usually the sole occupant of the very sodic soils it appears to be confined to. Occasionally it is accompanied by scattered stunted plants of other

species, notably halophytes including *Atriplex buchananii*, *Puccinellia* spp., *Hordeum* spp., and *Plantago coronopus*. At one site (Wilson Road; Partridge 1976, 1981), it has been reported to be associated with *Poa cita*. Competition is thus unlikely to have been a major factor contributing to the decline of *L. kirkii*, but Rogers et al. (1999) expressed concern that *Plantago coronopus* is likely to become a threat at the Wilson Road site.

Eighteen collections are deposited at CHR. Ten of these are dated 1975 or later, but are geographically reasonably widespread and probably do not represent a significant diminution of local populations.

The area of saline/sodic soils that might have supported *Lepidium kirkii* has been reduced from approximately 40 000 ha to fewer than 100 ha by activities associated with farming or mining since European settlement. Irrigation and cultivation are undoubtedly the most significant causes of the decline of *L. kirkii*, along with changes in soil structure and drainage associated with trampling by domestic stock. The role of stochastic processes is not clear, mainly because nothing is known about the reproductive ecology of *Lepidium kirkii*. The effects of irregular and generally low rainfall on isolated small populations of *L. kirkii* are likely to be similar to those described for *L. sisymbrioides*.

1.5 THREATS

Loss of small, isolated populations - and most fall into this category - is the greatest threat to long-term survival of both *Lepidium sisymbrioides* and *L. kirkii*, not least because of the implications for genetic diversity and the ability to adapt to rapidly changing conditions that may result from global climate warming.

Continued degradation of habitat must come a close second. Not only is there evidence that present habitats are already sub-optimal in terms of soil chemistry because of depletion of both nutrients (*L. sisymbrioides*) and sodicity (*L. kirkii*), but also soil structure has been changed by agricultural practices and consequent erosion. Habitat changes caused by the naturalisation of exotic plants could also be significant.

All the inland *Lepidium* taxa are small, cryptic, and horticulturally uninteresting plants. The resulting general public unawareness of the plants and their conservation plight, coupled with management constraints posed by limited resource availability in conservation agencies, adds another level of threat to their survival.

Finally, there has been little research on either the basic ecology of these four taxa, or the reasons for their present distribution and abundance. Unless this deficiency is redressed, there remains the possibility that whole populations, if not whole taxa, will become extinct before enough is known to enable their conservation management.

1.6 PAST CONSERVATION EFFORT

Populations of *Lepidium sisymbrioides* in Central Otago have been formally monitored at several localities since 1992 (Allen 1998), and a recovery plan was produced for *L. sisymbrioides* subsp. *matau* and *L. kirkii* in 1992 (Allen 1992). Legal protection has been achieved for some *Lepidium* habitat in Otago by the

establishment of the Chapman Road Scientific Reserve, and the Slapjack Creek and Long Gully Conservation Areas. The habitat of at least three populations of *L. sisymbrioides* subsp. *sisymbrioides* in Canterbury is protected by formal reserve status. However, conservation effort has been fragmented and spasmodic, and has not resulted in any population recovery of the inland *Lepidium* species.

1.7 RECOVERY POTENTIAL

The ease of growing all the taxa under cultivation suggests that there is considerable potential for recovery, at least by transplanting cultivated plants into the wild. However, unless sufficient areas of suitable habitat are provided with formal protection, and unless research and management are carried out to determine and control the critical threats to the taxa in the wild, there is little potential for the natural maintenance of wild populations.

2. Options for recovery

2.1 DO NOTHING

Most populations of the four taxa would be unlikely to survive another century; particularly *Lepidium sisymbrioides* subsp. *matau* at Galloway, *L. sisymbrioides* subsp. *kawarau* at Falls Dam, and most or all populations of *L. kirkii.*

2.2 MANAGE ONLY IN CULTIVATION

There is no doubt that this could be a viable option for ensuring the continued existence of the taxa for the foreseeable future. However, it is unlikely to be able to preserve even the present level of genetic variation, and may lead to problems with hybridisation. With all the plants in cultivation concentrated at a few sites, there would be increased risk of catastrophic loss from pests, diseases, or accident. Finally, success would rely on continuity of funding and management, neither of which could be guaranteed.

2.3 MANAGE IN THE WILD

The greatest obstacle to management in the wild is the lack of knowledge about the basic ecology of the taxa and the threats they face. Nevertheless, management in the wild, which inevitably would require some management in cultivation, is the only feasible option for the long-term survival of the taxa.

3. Recovery strategy

3.1 GOAL

To ensure that viable, self-sustaining populations of the four inland Lepidium *taxa are established or restored in the wild at key sites throughout their known natural range.*
[Key sites are all existing sites, and sites yet to be determined that conform with habitat criteria established from observation and research.]

3.2 OBJECTIVES FOR THE TERM OF THIS PLAN

Objective 1

Promote public, iwi, and particularly landowner, interest in the conservation of inland *Lepidium* populations.

Objective 2

Determine more precisely the distribution, abundance, and agents of threat of inland *Lepidium* populations.

Objective 3

Promote adaptive management and research that addresses the information deficiencies in species ecology and threats.

Objective 4

Mitigate threats to the continued existence of inland *Lepidium* populations.

4. Workplan

To meet each objective, the following actions are required:

Objective 1

Promote public, iwi, and particularly landowner, interest in the conservation of inland *Lepidium* populations.

Explanation

Plants of the inland *Lepidium* taxa are visually unexciting and very difficult to find. Until people (including Department of Conservation (DOC) staff) are aware of the plants' existence and precarious conservation status, and their importance as unusual – even unique – representatives of the Brassicaceae and of a nearly-vanished flora, then apathy is likely to be a major constraint to their conservation.The present relatively low threat classification of *Lepidium sisymbrioides* subsp. *sisymbrioides* as declining (de Lange et al. 1999) may not be an accurate reflection of its conservation status.

Actions required to meet this objective:

High priority

1 Produce a brochure outlining the plight of the inland *Lepidium* species for both the public and DOC staff by the end of 2001.
2 Conduct one field excursion for DOC staff and the public to one *Lepidium sisymbrioides* site in Otago (e.g. Patearoa or Galloway) and Canterbury (e.g. Tekapo Accommodation Reserve or Castle Hill Scenic Reserve) by the end of 2001.
3 Hold a meeting with each affected landowner by the end of 2001.

Medium priority

4 Publish at least one article in local/regional newspapers and one popular national magazine such as *Forest & Bird* or *New Zealand Geographic* by the end of 2001.
5 Provide DOC managers with a written summary of the status of populations and of departmental efforts towards species recovery by the end of 2001.
6 Review the threat classification of *Lepidium sisymbrioides* subsp. *sisymbrioides* by the end of 2002, and submit any changes to a review of the list of threatened and uncommon plants of New Zealand.

Key personnel

Conservation Officers – Programme (Biodiversity) at Central Otago, Wakatipu, Twizel, and Waimakiriri Area Offices; Technical Support Officer – (Botanist) Otago Conservancy; Landcare Research Scientist (Dunedin).

Objective 2

Determine more precisely the distribution, abundance, and agents of threat of inland *Lepidium* populations.

Explanation

The rarity of the inland *Lepidium* taxa may be apparent, rather than real, because they are so cryptic and scattered over wide areas. Habitat surveys have been neither systematic nor thorough. Only the most basic elements of the distribution and

demography of *L. sisymbrioides*, and the distribution of *L. kirkii*, are presently understood. Monitoring is essential as a means of assessing both trends in natural populations in response to stochastic processes, and the success of conservation management. Conservation of the four *Lepidium* taxa in the wild will be impossible unless knowledge is increased about the nature of the threats they face.

Actions required to meet this objective

High priority

1 Search herbaria other than CHR for inland *Lepidium* specimens by the end of 2001.
2 Visit sites of old herbarium collections to check for the continued presence of plants by the end of 2002.
3 Where access is granted by landowners, all non-cultivated rural land below 300 m a.s.l. in the lower Manuherikia Valley between Omakau and Alexandra will be surveyed for populations of *L. kirkii*, *L. sisymbrioides* subsp. *matau*, and *L. sisymbrioides* subsp. *sisymbrioides* by the end of 2006.
4 Where access is granted by landowners, all non-cultivated rural land below 600 m a.s.l. in the upper Manuherikia Valley in the immediate catchment of Falls Dam and on both sides of Fiddlers Flat Road will be surveyed for populations of *L. sisymbrioides* subsp. *kawarau* by the end of 2006.
5 Establish an appropriate archive for storage of demographic data, and store existing data in it, by the end of 2001.
6 Undertake one survey of new monitoring plots, and of existing plots at Galloway (*L. sisymbrioides* subsp. *matau*) and Pisa Flats (*L. sisymbrioides* subsp. *sisymbrioides*) by the end of 2001, and a subsequent survey by the end of each second year thereafter.

Medium priority

7 Where access is granted by landowners, all non-cultivated rural land below 300 m a.s.l. in the lower Waitaki Valley between Otematata and Duntroon will be surveyed for populations of *L. sisymbrioides* subsp. *sisymbrioides* by the end of 2006.
8 Set up permanent plots and map the distribution of all *Lepidium* plants within these in the populations of *L. sisymbrioides* subsp. *kawarau* on greywacke outcrops and lakeside gravels at Falls Dam, in at least one Waitaki Valley population and one Canterbury limestone population of *L. sisymbrioides*, and in three populations of *L. kirkii* by the end of 2001.

Key personnel

Conservation Officers – Programme (Biodiversity) at Central Otago, Twizel, and Waimakiriri Area Offices;Technical Support Officer – (Botanist) Otago Conservancy.

Objective 3

Promote adaptive management and research that addresses the information deficiencies in species ecology and threats.

Explanation

Too little is known about the habitat requirements of the four *Lepidium* taxa, which appear to have quite specialised ecology, to enable their conservation in the wild. *Lepidium sisymbrioides* taxonomy is doubtfully accurate. While it is not clear exactly what taxonomic entities and what range of genetic diversity are represented, it is not possible to target priorities for management. While nothing is known about the reproductive ecology of *L. kirkii*, it is not possible to design a programme to

manage the species in the wild. The Galloway, Slapjack Creek, and Falls Dam populations of *Lepidium sisymbrioides* are vulnerable to extinction. The last comprise the only known populations of *L. sisymbrioides* subsp. *kawarau* outside the Kawarau Gorge area, on lakeside gravels, and on greywacke rather than schist. The Galloway population of *L. kirkii*, adjacent to that of *L. sisymbrioides* subsp. *matau*, is accessible and convenient for management. Intensive management of *L. sisymbrioides* subsp. *kawarau* at Slapjack Creek is justified because of the protected status of the site, previous research there (Allen 1996), the vulnerability of the *Lepidium* population to competition from shrub weeds, and the reasonably good road access. Management of the other sites and populations of inland *Lepidium* taxa is required to maintain populations at a viable density until sufficient information is available to assess more accurately their requirements for recovery.

Actions required to meet this objective

High priority

1 The recovery group leader will maintain a list of research topics and promote and support research:

- on soils, particularly subsoil chemistry and structure, of *Lepidium* habitat for the four taxa, and the effects of soil changes resulting from agriculture, so that soil structure and chemistry at all known sites of all four taxa will be known by the end of 2006.
- on climatic requirements for recruitment in *Lepidium sisymbrioides* so that a preliminary understanding of the effects of climate on recruitment will be gained by the end of 2006.
- on seed and seedling predation in *Lepidium sisymbrioides* so that the fate of seeds after they leave the plant in all three taxa will be known by the end of 2004.
- on the reproductive ecology of *Lepidium kirkii* so that factors affecting pollination, seed production, seed viability, seed dispersal, and seedling establishment of *Lepidium kirkii* will be understood by the end of 2003.
- on the competitive effects of the associated flora so that the effects of at least the dominant native and exotic plants that accompany the four *Lepidium* taxa in the wild will be known by the end of 2006.
- to establish a phylogeny based on molecular (genetic) as well as morphological and ecological relationships within and between taxa so that an accurate record of the phylogenetic relationships between populations of each subspecies and between the subspecies of *Lepidium sisymbrioides*, and of the genetic diversity of populations of *L. kirkii*, will be available to conservation managers by the end of 2006.

Medium priority

2 Establish management programmes to increase existing wild populations with plants grown in cultivation, so that populations of *Lepidium sisymbrioides* subsp. *kawarau* at Falls Dam and Slapjack Creek, and of *L. sisymbrioides* subsp. *matau* and *L. kirkii* at Galloway, will number at least 100 plants, respectively, by the end of 2006.

3 At the other known sites, undertake holding management by monitoring population trends and supplementing with cultivated plants if significant declines occur so that populations of both species at these sites will have remained stable or increased by the end of 2006.

Key personnel

Conservation Officers – Programme (Biodiversity) at Central Otago, Twizel, and Waimakiriri Area Offices;Technical Support Officer – (Botanist) Otago Conservancy; Otago Conservancy Advisory Scientist; Science and Research Rare Plant Botanist; Landcare Research Scientist (Dunedin); Principal Regional Scientist Southern Region; research providers (CRIs, universities etc).

Objective 4

Mitigate threats to the continued existence of inland *Lepidium* populations.

Explanation

Stored seeds and cultivated plants of the inland *Lepidium* taxa are essential as an insurance against the probable demise of many wild populations, as well as a resource for future re-establishment in the wild and supplementation of existing wild populations, for experimental work, and as an educational resource. Seed and cultivated plant collections should be maintained at several localities to reduce the risk of accidental loss. All populations of the four taxa are small and at risk of local extinction; many in the near future. Loss of geographically and probably genetically isolated populations will have grave consequences for the continued existence of the taxa. Establishment of new populations in the wild will lessen the risk of catastrophic loss. Formal protection of sites is required to guarantee future access and freedom of management.

Actions required to meet this objective

High priority

1 Maintain dialogue with landowners to minimise accidental loss of plants and populations through agricultural management, and to encourage formal protection of habitat, so that the existing main population of *Lepidium sisymbrioides* subsp. *matau* and at least one existing outlier, and those of *L. sisymbrioides* subsp. *kawarau* at Slapjack Creek and Falls Dam, *L. sisymbrioides* subsp. *sisymbrioides* at Pisa Flats, Patearoa, Tekapo, and Castle Hill, and *L. kirkii* at Galloway and one other site, will be formally protected by land tenure or appropriate agreements with landowners by the end of 2006.

2 Collect seed from all known populations of *Lepidium sisymbrioides* subsp. *matau*, at least the two main locations of *L. sisymbrioides* subsp. *kawarau*, at least two geographically distinct populations of *L. sisymbrioides* subsp. *sisymbrioides* from each of Otago and Canterbury, and at least two geographically distinct populations of *L. kirkii*, including that at Galloway, and store appropriately at three or more geographically distinct locations by the end of 2002.

3 Collect seed from all known populations of all four taxa and store appropriately at three or more locations by the end of 2006.

Medium priority

4 Grow cultivated plants from at least two geographically distinct populations of *Lepidium sisymbrioides* subsp. *sisymbrioides* each in Otago and Canterbury, from Kawarau Gorge and Falls Dam populations of *L. sisymbrioides* subsp. *kawarau*, from all known populations of *L. sisymbrioides* subsp. *matau*, and from at least two geographically distinct populations of *L. kirkii,* at three or more geographically distinct locations by the end of 2003.

5 Maintain the number of stock plants in each cultivated population at a minimum of 50 from each provenance, and produce at least 50 surplus seedlings of each annually.

Low priority

6 Establish new populations of at least 100 plants by planting cultivated stock of appropriate provenance on sites that conform with habitat criteria established from observation and research so that at least five new populations of 100 or more plants of *L. sisymbrioides* subsp. *matau*, three of *L. sisymbrioides* subsp. *kawarau*, and three of *L. kirkii*, will be established on either DOC land or private land protected by land tenure or an appropriate agreement by the end of 2006.

Key personnel

Conservation Officers – Programme (Biodiversity) at Central Otago, Twizel, and Waimakiriri Area Offices;Technical Support Officer – (Botanist) Otago Conservancy; nursery staff; botanic gardens staff; staff of seed storage facilities.

5. Review Date

This plan will be formally reviewed in 2010 or sooner if new information leads to proposals for a significant change in direction.

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Numerous people contributed to what we know about the ecology of *Lepidium sisymbrioides*, and they are acknowledged in a paper on the subject published in the *New Zealand Journal of Botany* (Allen 1998). P. D. McIntosh, P. N. Johnson, P. J. Garnock-Jones, B. H. Patrick, G. Loh, G. M. Rogers, M. Tubbs, N. Head, and J. Barkla provided invaluable assistance with access to reports, lists of references, and personal observations about the inland *Lepidium* taxa. Helpful comments on a draft were received from G. M. Rogers, P. J. Garnock-Jones, B. H. Patrick, P. de Lange, R. Wardle, B. P. J. Molloy, P. Heenan, M. Tubbs, N. Head, K. Smith, and the Otago Conservation Board. J. Barkla collated comments on the draft and advised on changes in format requirements between the draft and final documents.

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Appendix 1: Published recovery plans

RECOVERY PLAN	#	COST	YEAR APPROVED
Muehlenbeckia astonii	31	($15)	Approved 2000
North Island kokako	30	($15)	Approved 1999
Weka	29	($15)	Approved 1999
Pittosporum patulum	28	($15)	Approved 1999
Cyclodina skinks	27	($15)	Approved 1999
Coastal cress	26	($15)	Approved 1999
Threatened weta	25	($15)	Approved 1998
Striped skink	24	($15)	Approved 1998
Fairy tern	23	($15)	Approved 1997
Blue duck	22	($15)	Approved 1997
Kakapo	21	($15)	Approved 1996
Stitchbird	20	($15)	Approved 1996
Brown teal	19	($15)	Approved 1996
Native frogs	18	($15)	Approved 1996
New Zealand (Hooker's) Sea Lion	17	($15)	Approved 1995
Dactylanthus taylorii	16	($15)	Approved 1995
Bat (Peka peka)	15	($15)	Approved 1995
Otago and grand skinks	14	($15)	Approved 1995
Giant land snail	13	($15)	Approved 1995
Takahe	12	($15)	Approved 1994
South Island saddleback	11	($15)	Approved 1994
New Zealand Dotterel	10	($15)	Approved 1993
Tuatara	9	($15)	Approved 1993
Kowhai ngutukaka	8	($15)	Approved 1993

Subantarctic teal	7	($15)	Approved 1993
Mohua (yellowhead)	6	($15)	Approved 1993
Chevron skink	5	($15)	Approved 1993
Black stilt	4	($15)	Approved 1993
Whitaker's and robust skinks	3	($15)	Approved 1992
Kiwi	2	($15)	Approved 1991
North Island kokako	1	($15)	Approved 1991
Yellow-eyed penguin*	–	*–	Approved 1991
Kakapo		Out of print	Approved 1989

* *Available: from Otago Conservancy, Department of Conservation, Dunedin*

Copies may be ordered from:

DOC Science Publications
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