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ABSTRACT*

This report reviews the weedy potential of eighteen legume species being tested for the replacement of *Lupinus arboreus* in sand dune reclamation. The species are: *Acacia saligna* (syn. *A. cyanophylla*), *Acacia longifolia* var. *sophorae* (syn. *A. sophorae*), *Astragalus cicer, Chamaecytisus palmensis, Dorycnium hirsutum, Dorycnium pentaphyllum, Dorycnium rectum, Hedysarum coronarium, Lathyrus latifolius, Lespedeza cuneata, Lotus corniculatus, Lotus pedunculatus, Lotus tenuis, Lupinus nootkatensis, Medicago arborea, Sutherlandia frutescens, Teline stenopetala,* and *Trifolium ambiguum.*

Any species aggressive and persistent enough to be successful as a replacement for tree lupin in sand dune reclamation is likely to have at least some potential as a weed in the adjacent environment. Factors considered most relevant to weedy potential are mode of spread, factors affecting seed germination, site and climatic adapability, competitive ability, nuisance factors, and feasibility of control.

Of the species reviewed, two, *Acacia saligna* and *A. longifolia* var. *sophorae*, have become major weeds in South Africa. This has occurred over a long time period, and has largely been attributed to their wide site adaptability and to the absence of seed predators. Some 150 years after their introduction for sand stabilisation the South African Directorate of Forestry has been actively involved in their removal.

Other species which have caused some problems as weeds overseas and which may have potential to do the same here are *Lespedeza cuneata* and to a lesser extent *Lathyrus latifolius*. *Teline stenopetala, Lupinus nootkatensis,* and the *Dorycnium* species have not been widely cultivated and should be carefully monitored as they appear to have potential for spread. *Chamaecytisus palmensis*, *Lotus pedunculatus* and *L. tenuis* are quite widespread in cultivation in New Zealand and are sometimes weeds. *Lotus corniculatus* can be a troublesome weed elsewhere but has shown little tendency to spread in New Zealand. The remaining species have not become weeds elsewhere and appear to have limited weedy potential in New Zealand. Weedy potential can however be difficult to predict and close monitoring of all species for unwanted spread would be advisable.

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* **Note: This material is unpublished and must not be cited as a literature reference.**

REVIEW OF THE WEEDY POTENTIAL OF SPECIES BEING TESTED FOR THE REPLACEMENT OF *LUPINUS ARBOREUS* IN SAND DUNE RECLAMATION

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This report reviews the weedy potential of eighteen legume species being tested for the replacement of *Lupinus arboreus* in sand dune reclamation. The species are: *Acacia saligna* (syn. *A. cyanophylla*), *Acacia longifolia* var. *sophorae* (syn. *A. sophorae*), *Astragalus cicer*, *Chamaecytisus palmensis*, *Dorycnium hirsutum*, *Dorycnium pentaphyllum*, *Dorycnium rectum*, *Hedysarum coronarium*, *Lathyrus latifolius*, *Lespedeza cuneata*, *Lotus corniculatus*, *Lotus pedunculatus*, *Lotus tenuis*, *Lupinus nootkatensis*, *Medicago arborea*, *Sutherlandia frutescens*, *Teline stenopetala*, and *Trifolium ambiguum*.

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Of the species reviewed, two, *Acacia saligna* and *A. longifolia* var. *sophorae*, have become major weeds in South Africa. This has occurred over a long time period, and has largely been attributed to their wide site adaptability and to the absence of seed predators. Some 150 years after their introduction for sand stabilisation the South African Directorate of Forestry has been actively involved in their removal.

Other species which have caused some problems as weeds overseas and which may have potential to do the same here are *Lespedeza cuneata* and to a lesser extent *Lathyrus latifolius*. *Teline stenopetala*, *Lupinus nootkatensis*, and the *Dorycnium* species have not been widely cultivated and should be carefully monitored as they appear to have potential for spread. *Chamaecytisus palmensis*, *Lotus pedunculatus* and *L. tenuis* are quite widespread in cultivation in New Zealand and are sometimes weeds. *Lotus corniculatus* can be a troublesome weed elsewhere but has shown little tendency to spread in New Zealand. The remaining species have not become weeds elsewhere and appear to have limited weedy potential in New Zealand. Weedy potential can however be difficult to predict and close monitoring of all species for unwanted spread would be advisable.

INTRODUCTION

A fungus disease, *Colletotrichum gloeosporioides*, has caused the virtual elimination of tree lupin, *Lupinus arboreus* from its role in the artificial succession of vegetation used to control coastal sand dune erosion and has forced an evaluation of alternative species. The literature relevant to factors affecting the weedy potential of 18 species being tested as substitutes for tree lupin in sand dune reclamation has been searched and reviewed. The species are:

1. *Acacia saligna* (syn. *A. cyanophylla*)
2. *A. longifolia* var. *sophorae* (syn. *A. sophorae*)
3. *Astragalus cicer*
4. *Chamaecytisus palmensis*
5. *Dorycnium hirsutum*
6. *Dorycnium pentaphyllum*
7. *Dorycnium rectum*
8. *Hedysarum coronarium*
9. *Lathyrus latifolius*
10. *Lespedeza cuneata*
11. *Lotus corniculatus*
12. *Lotus pedunculatus*
13. *Lotus tenuis*
14. *Lupinus nootkatensis*
15. *Medicago arborea*
16. *Sutherlandia frutescens*
17. *Teline stenopetala*
18. *Trifolium ambiguum*

Plants are considered weeds in situations where they become a nuisance. A plant may spread as a weed over a wide variety of sites or it may be confined to a very restricted area or habitat type suiting its particular requirements.

Weeds are a nuisance for a variety of reasons. These include:

- Interference with agricultural and horticultural production - competing with pasture and crop plants for space, nutrients and water.
- Possession of barbs, stiff hairs, sharply pointed seeds etc which may cause mechanical injury to eyes, mouthparts, skins or hide of livestock and/or lower the value of wood or mohair.
- Lowering of the quality of farm produce due to impurities or the weeds may be host to organisms which cause crop diseases.
- Possession of poisonous properties which endanger livestock, (particularly on grazing land and roadsides where livestock may graze while being moved), and in some cases humans, particularly children, especially in recreation areas.
- Invasion of protected natural areas and other natural communities, competing with and suppressing the natural vegetation. In such environments they can be seen as ecological pollutants, detracting from the aesthetic appeal of the natural plant community.
- Causing a nuisance in recreational areas, roadways, paths, embankments, waste spaces and private gardens.
- Impeding access.

- Providing increased fire hazards.

Factors considered most relevant to the weedy potential of the species reviewed are covered under the following headings.

A. Occurrence and spread of the species in New Zealand and overseas.
B. Reproduction, seed dissemination and mode of spread.
C. Factors affecting seed germination, including dormancy where the seed may remain in the soil for many years and then germinate when conditions are favourable. Many legume seeds are 'hard' i.e. they have a hard seed coat causing dormancy.
D. Site and climatic adaptability.
E. Seedling vigour, rate of growth and competitive ability.
F. Palatability to grazing stock. (If palatable, plants are much less likely to cause problems in pasture).
G. Special potential nuisance factors (such as poisonous properties).
H. Feasibility of control.

REVIEW OF THE SPECIES

1. *Acacia saligna* (Labill.) H. Wendl.

(syn. *Acacia cyanophylla* Lindl.)

Common names: golden wreath, orange wattle

Habit: Dense, evergreen leguminous shrub or small tree 2 - 10 m tall, (rarely prostrate), with a spreading crown.

Natural distribution: Western Australia where it is widespread.

2. *Acacia longifolia* var. *sophorae* (Labill.) F. Muell.

(syn *A. sophorae* (Labill.) C Martius).

Common names: Sydney golden wattle, coastal wattle

Habit: Bushy spreading shrub or small tree 2.5 m tall, often a prostrate shrub on exposed coastal sand dunes where it sends out long flexible branches which root at the nodes. It differs from *A. longifolia* var. *longifolia* mainly in its low prostrate habit, its thicker, shorter, rounded or blunt - tipped leaves (phyllodes) and extremely contorted seed pods.

Natural distribution: South eastern coastal Australia where it is chiefly restricted to sand dunes.

Factors relevant to the weedy potential of *A. saligna* and *A. longifolia* var. *sophorae*

1,2. A. Occurrence and spread in New Zealand and overseas

1. *Acacia saligna*

New Zealand: No records of *A. saligna* naturalised in New Zealand were found. It is occasionally cultivated as an ornamental and has been evaluated for soil conservation.

Overseas: *Acacia saligna* is widely cultivated in Australia and naturalised in some areas. It is used for sand stabilisation, mining site rehabilitation and stock fodder (Simmons 1981) and has been introduced into Mexico, the Middle East and North and South Africa (Tiedeman and Johnson 1992). It was introduced into South Africa in the early to mid 19th century for sand stabilisation and it has naturalised widely to become a pest species.

2. *Acacia longifolia* var. *sophorae*

New Zealand: It has been cultivated for sand stabilisation in various coastal localities, as far south as Christchurch and particularly on the Manawatu coast (Sheppard and Bulloch 1986a). Some spread from

seed is occurring on at least two sites (Whiritoa and Whangamata on the Coromandel Peninsula, ref. Herbarium specimens, NZFRI 21555 and 21558) and Webb *et al.*(1988) note that it may be found occasionally as a garden escape. The closely related *Acacia longifolia* var. *longifolia* is naturalised in Northland where it is well established as a weed especially in kanuka scrub where seedlings are abundant. *Acacia longifolia* var. *longifolia* has also spread in Auckland city, Hamilton, the Bay of Plenty, Wellington city and Nelson on wasteland and scrubland especially near the coast (Webb *et al.* 1988) and on roadsides.

Overseas: *Acacia longifolia* var. *sophorae* was introduced into South Africa from 1827 to 1835 and has since spread inland along rivers (Boucher and Stirton 1978) to become a serious weed in natural plant communities.

Acacia saligna and *A. longifolia* var. *sophorae* were introduced into South Africa in the early to mid 19th century to stabilise shifting sand dunes. They have since become serious pests, spreading from the dunes to invade natural ecosystems, particularly in the south western Cape Province area. Reasons for this spread and the impact of these two *Acacia* species on the natural environment in South Africa are described and discussed by a number of authors including Milton and Hall (1981), Weiss (1981), Macdonald and Jarman (1984), Taylor and Macdonald (1985a, 1985b), van Wilgen and Richardson (1985), Holmes (1988, 1989, 1990), Piertese and Cairns (1988), Avis (1989), Macdonald *et al.* (1989), Richardson *et al.* (1989), Witowski (1991), Moll and Trinder- Smith (1992), Musil (1993) and Witowski (1994).

Van Wilgen and Richardson, in an assessment of 33 species of invasive plants threatening natural ecosystems in South Africa according to the extent of current infestation and invasive threat, listed *A. saligna* as posing the greatest threat. Between surveys conducted in 1960 and 1980 spread had occurred from relatively favourable to unfavourable sites further removed from the seed source causing Taylor *et al.* to describe *A. saligna* as a dangerously invasive species. Of the species recorded in a survey of invasive woody plants in the Cape of Good Hope Nature Reserve *Acacia longifolia* was the most rapid spreader with an 80% increase between 1966 and 1980. According to Taylor *et al. Acacia longifolia*, with its high rate of increase, long distance dispersal, and spread to a wide range of habitats, was "an invader of formidable potential".

1/2, B. Reproduction, seed dissemination and mode of spread

Flowering in both *Acacia* species is usually prolific and takes place over an extended period from late winter to spring - approximately from August to November. Seeds are dark brown to black, in the range of 4-6 x 2-3.5 mm and are produced in pods. They ripen in early summer and are shed soon after by splitting of the pod. The reproductive biology of *Acacia saligna* and *A. longifolia* in South Africa is reviewed and investigated by Milton and Hall (1981). Seed production of *A. saligna*, based on pod masses of individual harvested trees, was estimated to be approximately 48,563 seeds per tree. Mature plants of *A. saligna* and *A. longifolia* were estimated to drop 1,000 to 7,000 seeds m^2 per year and to have a seed

bank in the soil of two to five times this magnitude, about 95% of which was dormant. Most seed falls directly to the ground from where it tends to move down slope giving greater densities at the base of dunes and along drainage lines. In South Africa there is considerable evidence of spread along streams and rivers and viable seeds of *A. saligna* and *A. longifolia* were found at densities of 60 seeds m^2 in estuary bottom sediments. According to Holmes (1990), in South Africa ants tend to rapidly remove seed below ground to their nests, out of reach of rodents which might otherwise consume them. This may have played a critical role in accumulating seed banks. In Australia, seed predation by insects (including gall wasps, Lepidopteran larvae, and ants) and birds, results in large, though variable losses to the annual seed production. According to Weiss (1981), in South Africa *A. longifolia* var. *sophorae* is approximately 100 times more successful than in Australia with soil seed levels in South Africa 500 times greater.

1/2, C. Factors affecting seed germination

In South Africa viability of the seed is high (exceeding 90% in *A. saligna*). However the seed has a hard, water impermeable coat enabling it to remain dormant in the soil for extended periods - in some cases up to 50 years (Cavanah 1980). According to Holmes (1990) longevity depends to some extent on climatic conditions during later stages of maturation and may vary in different years. Whibley (1980) states that *A. saligna* is one of the few *Acacia* species able to germinate without assistance from fire. However Holmes (1988) found the percentage of dormancy high with only about 1% of the viable seed bank emerging annually as seedlings while after fire 70% of the viable seed bank germinated.
Acacia seed dormancy is enforced by the water impermeable seed coat -the permeability of which appears to vary with species, age of seed and intensity of factors damaging the seed coat. Milton and Hall (1981) found seed of *A. longifolia* responded rapidly to immersion in hot water, 92% of seeds having germinated two weeks after treatment. A batch of seeds collected from the soil surface, where they had been directly exposed to the sun, germinated readily on damp filter paper.

1/2, D. Site and climatic adaptability

In South Africa *A. saligna* and *A. longifolia* var. *sophorae* have proved adaptable to a wide range of sites. They are both particularly suited to sandy soils but have moved off these on to a range of substrates in South Africa. Simmons (1981) reported that *A. saligna* tolerates heavy soils, lime and frost and that both species tolerate salt laden winds.

1/2, E. Seedling vigour, rate of growth and competitive ability

Both species are very fast growing (Simmons 1981), are aggressive colonisers (Taylor *et al.* 1985b) and are able to establish rapidly and dominate other vegetation. In New Zealand *A. longifolia* var. *sophorae* seedlings at 1.5 m spacing achieved complete canopy cover in 2-4 years (Sheppard and Bulloch 1986). At Mount Maunganui, *A. longifolia* var. *sophorae* was spreading vegetatively by layering at a rate of approximately 2-3 metres per plant per season, competing with and ousting native plants on the foredune (Peter Watson, Tauranga District Council, pers. comm.)

1/2, F. Palatability to grazing stock

Acacia saligna is palatable to grazing stock and can be used for stock fodder (Simmons 1981). No information was found on the palatability of *A. longifolia* var. *sophorae*.

1/2, G. Special nuisance factors

Acacia longifolia contains the potentially toxic substance HCN (Prussic acid) and was suspected on one occasion of killing a goat but its toxicity is not proven (Everist 1974). No other evidence of toxicity relating to these species or of other special nuisance factors was found.

1/2, H. Feasibility of control

In South Africa a number of investigations into various methods of control of the invasive *Acacia* species have been undertaken including those by Neser (1985), Dennill (1985, 1987, 1988), Macdonald *et al.* (1989),Macdonald and Wissel (1989), Dennill and Donnelly (1991), Morris (1991) and Selincourt (1992). According to Macdonald *et al.* (1989) virtually all early efforts at control were wasted because of the lack of appreciation of the persistence of seed banks. New seedlings are able to repeatedly take advantage of gaps created by the removal of older plants, whether by cutting, ring barking, spraying or controlled burning. Milton and Hall (1981) concluded that biological control using host specific pathogens and insects was the only economically feasible solution for the long term management of invasive Australian acacias in South Africa. Morris (1991] reviewed the use of pathogens for the biological control of *A. saligna*. An Australian gall forming rust fungus *Uromycladium tepperianum* has been introduced into South Africa and since 1987 has been inoculated onto *A. saligna* at over 50 localities throughout its natural range. It is now dispersing naturally but it was considered too early to evaluate its effect on the weed population. The bud galling wasp *Trichilogaster acaciae-longifoliae*, also introduced to South Africa from Australia, is reported to have had a major impact on the reproduction of *A. longifolia* and reduced vegetative growth. Chemical control for Acacia species generally, is covered in Davenhill *et al.*(1994). Existing plants can be controlled using Escort , Grazon or Velpar. Versatill does not control *A. longifolia*.

3. *Astragalus cicer* L.

Common names: cicer milkvetch

Habit: A robust perennial legume with prostrate or sub-erect, hollow stems to 130 cm in length.

Natural distribution: Europe, from Belgium and Northern Russia southwards to Northern Spain and Bulgaria.

Factors relevant to the weedy potential of *Astragalus cicer*

3, A. Occurrence and spread in New Zealand and overseas

New Zealand: Not recorded as naturalised (Webb *et al.* 1988). Occasionally cultivated in Hawkes Bay as an alternative forage legume (Rys *et al.* 1988), and in mountain land revegetation trials in the Craigieburn Ranges in Canterbury (Ledgard and Baker 1988).

Overseas: Occasionally naturalised north of its natural range in Europe (Tutin *et al.* 1964). Cultivated for forage in North America (Townsend 1979).

3, B. Reproduction, seed dissemination and mode of spread (Leffel 1978, Webb *et al.* 1988)

Flowers are white to pale yellow in racemes each consisting of 20-60 flowers. Pollination is primarily by bumble bees. Seed pods are black, roundish, inflated, membranous and bladder-like. Each pod contains 3-11 seeds. *Astragalus cicer* spreads vegetatively by rhizomes.

3, C. Factors affecting seed germination

The seeds have an extremely hard shiny coat. In tests 37% of seed was hard and dormancy other than that related to hard seed was negligible (Allen and Davis 1986). Germination can be slow and as a result cultivars with improved germination rates and seedling vigour have been selected (Townsend 1979).

3, D. Site and climatic adaptability

Cicer milkvetch is adapted to a range of growing conditions including a variety of soil types but prefers cool moist sites and moderately coarse soils and tolerates light acidity to moderate alkalinity. It is resistant to drought and frost and has no major insect or fungal pests (Leffel 1978).

3, E. Seedling vigour, rate of growth and competitive ability (Townsend 1970, 1979, Rys *et al.* 1988, Forde *et al.* 1989)

Initially growth of seedlings can be very slow but once it is established spread by rhizomes can be vigorous and cicer milkvetch plants can spread 60-100 cm in a year. It is reported to be very persistent and long lived both in North America and in New Zealand (on a very fertile site in Hawkes Bay).

3, F. Palatability to grazing stock

Cicer milkvetch is very palatable to grazing animals and is similar in forage quality to lucerne (Townsend and Schweizer 1984).

3, G. Special potential nuisance factors

Astragalus cicer does not contain toxic compounds although these have been widely reported in other *Astragalus* species. No cases of bloat in animals grazing the forage have been reported (Townsend *et al.* 1978).

3, H. Feasibility of control

No information on control of cicer milkvetch was found.

4. *Chamaecytisus palmensis* Bisby et K. Nicholls

(syn. *Cytisus proliferus* (L.) Link.)

Common names: tree lucerne, tagasaste.

Habit: Evergreen shrub or small tree to 5-6 m tall, with a rather open habit.

Natural distribution: La Palma, Canary Islands.

Factors relevant to the weedy potential of *Chamaecytisus palmensis*

4, A. Occurrence and spread in New Zealand and overseas

New Zealand: Originally introduced as a hedge plant and for livestock fodder, it is also cultivated for soil stabilisation and reclamation, as an aid to the regeneration of natural vegetation and as a nurse species to assist the establishment of slower growing ornamental species (Davies 1981). Tree lucerne is also grown as a stock fodder supplement and as fodder for bees providing an invaluable source of nectar for commercial apiaries during winter and early spring when nectar sources are scarce. In winter it can be important in aiding the survival of foraging bumble bees (Webb and Shand 1985). By 1919 tree lucerne had naturalised and is now quite widespread from sea level to 750 m in the North Island and 600 m in the South Island. Sheppard and Bulloch (1986) note that tree lucerne has a mild tendency to spread but this is largely confined to roadsides and waste places and it does not spread onto land with dense ground cover. It is included in a list of problem weeds in forest and scrub reserves in New Zealand protected natural areas (Timmins and Williams 1991).

Overseas: In Australia tree lucerne is a weed in high rainfall areas of South Australia, Victoria and Tasmania (Lamp and Collett 1976) and has been reported to regenerate prolifically from soil stored seed after fire (Tasmanian weed brochure).

4, B. Reproduction, seed dissemination and mode of spread (Described by Webb and Shand 1985 and Webb *et al.* 1988).

Flowering commences at a very early age, usually in the second year from seed (Hampton 1990). Flowers are white, pea-like and produced profusely from April to October with peak flowering in August and September. Bumble bees are the main pollinators. In a study by Webb and Shand (1985) of two populations in Canterbury, seed was formed in only 5% of flowers in a natural population and 16% of flowers in a cultivated population. The remainder aborted. Webb and Shand note that such reduction in seed production is common in mass flowering legumes, most of which have a seed production of less

than 10%, and despite this reduction the number of seeds produced is high. Seeds are black, shiny, about 5 mm long and are contained in pods with about 10 to each pod. Seed is disseminated mainly by the explosive dehiscence of the pod down two sutures and can be further spread by ants or water. Pod or seed predation has not been observed.

4, C. Factors affecting seed germination

No specific information was found on factors affecting seed germination but tree lucerne establishes freely from seed on adjacent disturbed ground (Sheppard and Bulloch 1986). It is reported to establish prolifically after fire in Tasmania (indicating dormancy).

4, D. Site and climatic adaptability (Davies 1982, Sheppard and Bulloch 1986).

Tree lucerne is able to grow well on dry and poor soils provided these are free draining. A wide pH range from 5.5 to 7.5 is tolerated and it can withstand salt laden winds. Spread from seed in New Zealand occurs principally on free draining substrates in areas of reasonably high rainfall, although it is also common on dry coastal cliffs. Frost and drought restrict natural regeneration on more severe sites (and it is less common or absent in inland areas subject to very heavy frosts). Tree lucerne is subject to root rots in poorly drained soils. The stem boring insects *Oemona hirta* (lemon tree borer) and *Aenetus virescens* (puriri moth) contribute to reducing the average life span of tree lucerne to 10-12 years in the North Island. Longevity in the South Island is reported as more like 20 years.

4, E. Rate of growth

Vegetative growth can be very rapid - up to 2 m per year (Sheppard and Bulloch 1986).

4, F. Palatability to grazing stock

Tree lucerne is very palatable to all grazing livestock (Davies 1981, Sheppard and Bulloch 1986).

4, G. Special potential nuisance factors

Alkaloids are present in low concentrations in the foliage of tree lucerne and in somewhat higher concentrations in the seeds but no toxicity problems have been reported in New Zealand, Australia or the Canary Islands (Sheppard and Bulloch 1986). No references to any other nuisance factors associated with tree lucerne were found.

4, H. Feasibility of control

No information was found on the control of tree lucerne. In trials undertaken (in Canterbury) to assess the response of tree lucerne seedlings to 10 soil applied pre-emergent herbicides shown to be useful in controlling weeds in woody perennial crops, diuron (Karmex 80% WP) applied at 2-4 kg ai/ha was the only herbicide to reduce establishment (Hurrell and Bourdot 1984).

5. *Dorycnium hirsutum* (L.) Ser.

Common name: hairy canary clover

Habit: Erect, very hairy, laxly branched perennial sub-shrub to about 0.5 m tall and 1 m in diameter, with a very deep tap root.

Natural distribution: Mediterranean, southern Portugal, on dry rocky hillsides.

6. *Dorycnium pentaphyllum* Scop.

Common name: prostrate canary clover

Habit: More or less prostrate, spreading, perennial sub-shrub to 30 cm tall and 1 m in diameter. Habit very like that of some *Lotus* species. Has a deep tap root.

Natural distribution: Central and south-east Europe

7. *Dorycnium rectum* (L.) Ser.

Common name: None found.

Habit: Hairy perennial herb or small shrub 30-150 cm high.

Natural distribution: Mediterranean region, central and southern Portugal.

Factors relevant to the weedy potential of *Dorycnium* species

5/6/7, A. Occurrence and spread in New Zealand and overseas (Wills and Douglas 1984, Sheppard and Douglas 1986, Wills *et al.* 1989).

New Zealand: *Dorycnium hirsutum* and *Dorycnium pentaphyllum* have been cultivated since the mid 1970s on a trial basis for dry land pasture rejuvenation and resource conservation at several sites in Hawkes Bay, the lower North Island and in Central Otago. Wills and Douglas reported young plants growing some distance from the parent plants but no other records of naturalisation in New Zealand were found. *Dorycnium rectum* has also been under evaluation in New Zealand.

Overseas: Wills and Douglas noted that canary clovers have not been used much overseas and little is known about them. They have been cultivated in the past in California and Australia for forage and soil conservation, however Wills *et al.* found no record of current use in either country. No other references were found to the cultivation of the *Dorycnium* species overseas and no references were found to them as weeds.

5/6/7, B. Reproduction, seed dissemination and mode of spread (Tutin *et al.* 1964, Wills and Douglas 1984, Wills *et al.* 1989, Huxley *et al.* 1992).

Flowering occurs in late spring to early summer. The flowers are white or pink, in heads of 5-10 in *D. hirsutum*, 15-30 in *D. pentaphyllum* and 20-40 in *D. rectum*. Pollination of *D. hirsutum* is mainly by bumble bees while *D. pentaphyllum* is visited mainly by honey bees. Seeds are contained in small pods; in *D.hirsutum* 6-12 mm long each containing 2-6 seeds, in *D. pentaphyllum* 2.5 mm long containing one seed and in *D. rectum* 10-20 mm long. Seeds of *D. hirsutum* ripen from December to February and of *D. pentaphyllum* from February to March. Dissemination is by bursting open of the pod which propels the seed up to 1-2 m from the parent plant.

5/6/7, C. Factors affecting seed germination

Wills and Douglas (1984) reported that on most trial sites *D. hirsutum* and *D. pentaphyllum* regenerated freely from seed and seedlings established readily although initial growth was slow. Sheppard and Douglas (1986) reported that seed required inoculation with rhizobia however Wills *et al.* (1989) describe seedlings growing some distance from the parent plants as being well nodulated and healthy suggesting that they were utilising rhizobia associated with the common annual legume *Trifolium arvense*.
Wills *et al.* (1989) found that while large quantities of seed are released in the field, regeneration rates were low because of stock and insect browsing and competition from other plants.

5/6/7, D. Site and climatic adaptability

In their natural ranges *Dorycnium* species are usually found on light, infertile sandy soils (Wills *et al.* 1989). In New Zealand they have been found to be best adapted to dry, free draining soils and are able to establish and grow in low fertility soils. A pH range of 5.2 to 8.5 is tolerated (Rys *et al.* 1988) and they are able to withstand exposure, drought, heavy frosts and very low winter temperatures. Growth is poor on wet soils and on soils with a high clay content (Wills and Douglas 1984) or with a high level of soluble salts (Sheppard and Douglas 1986). Sheppard and Douglas note that on wet heavy soils plants are frequently killed by root rots. Rys *et al.* (1988) report that *D. pentaphyllum* is more sensitive to site conditions and competition than *D. hirsutum*.

5/6/7, E. Rate of growth

Although seedlings often establish readily initial growth of seedlings in New Zealand has generally been slow. Sheppard and Douglas (1986) found that in Otago plants took 18 months to reach 8 cm high.

5/6/7, F. Palatability to grazing stock

Young shoots particularly, can be very palatable to grazing stock but Sheppard and Douglas (1986) observed well established plants surviving heavy browsing. According to Rys *et al.* (1988) *D. pentaphyllum* is more palatable than *D. hirsutum*. Little is known about the nutritional value of the *Dorycnium* species.

5/6/7, G. Special potential nuisance factors

There appear to be no special nuisance factors associated with these three *Dorycnium* species.

5/6/7, H. Feasibility of control

No information was found on the control of *Dorycnium* species.

8. *Hedysarum coronarium* L.

Common names: sulla, sweetvetch

Habit: An erect to prostrate perennial herbaceous legume. Stems are robust, 80-150 cm tall and up to 200 cm in diameter. It has a strong, deep, branched tap root and numerous secondary roots.

Natural distribution: Central and western Mediterranean.

Factors relevant to the weedy potential of *Hedysarum coronarium*

8, A. Occurrence and spread in New Zealand and overseas

New Zealand: First recorded in New Zealand in 1912, *H. coronarium* was reintroduced in 1949 for evaluation as a forage legume. Since then it has been cultivated in a number of localities throughout for the revegetation of eroded hill country, industrially disturbed sites and road batters and as forage. It has occasionally been recorded wild, as an escape from cultivation and as a seed impurity, in waste places and on cultivated land. However it is not truly established in New Zealand as a naturalised plant (Webb *et al.* 1988).

Overseas: *Hedysarum coronarium* is widely used for hay, silage, forage and soil conservation in Mediterranean countries such as southern Italy, Spain, Tunisia, Turkey and some parts of Australia (Krishna *et al.* 1990). It is the main forage legume in Southern Italy and Sicily. *Hedysarum coronarium* is naturalised in the central and western Mediterranean, Egypt and North Africa (Watson 1982).

8, B. Reproduction, seed dissemination and mode of spread (Tutin *et al.* 1964, Duke 1982, Watson 1982, National Soil and Water Conservation Authority 1986, Webb *et al.* 1988).

Flowering takes place from November to February with peak flowering in late spring. The flowers are usually reddish purple, occasionally white, large (12-15 mm long) and densely grouped.They are cross pollinated, with honey bees thought to be the main pollinators. Seeds are borne in flattened, slightly spiny pods which break into 2-5 rounded segments, each with a creamy white to brown seed 2.5 -3.5 mm in diameter. Warm dry summers are essential for optimal seed production. Dissemination is by splitting of the pod. Vegetative spread takes place by layering.

8, C. Factors affecting seed germination

Plants produce large quantities of seed. When grown for seed production at Palmerston North it yielded an average of 465 kg seed/ha and persisted by reseeding. The dried off herbage mat provides a favourable environment for seed germination (Douglas 1984). Hard seed usually amounts to 15-20% of the seed yield (Watson 1982). When seed is sown on a new site, a specific strain of rhizobium bacteria is required for inoculation to ensure satisfactory nitrogen fixation (National Soil and Water Conservation Authority 1986).

8, D. Site and climatic adaptability (Hampton *et al.* 1980, Duke 1982, Douglas 1984).

The environmental requirements of sulla are such that it is well adapted to many areas of New Zealand but it responds best to warm winters and mild summers. It has proved satisfactory under a range of soil pH of 4.8 - 8.5, but prefers those that are neutral to alkaline, deep and well drained. Best growth occurs on clay, calcareous soils. It tolerates drought and coastal conditions throughout New Zealand. Sulla is reported to tolerate annual precipitation of 460 - 2360 mm and an annual temperature range of 5.7 – 29.9°C. On poorly drained soils it is prone to root rot and other fungal diseases. It withstands at least moderate frosts surviving up to -11.5°C of frost in Central Otago (National Soil and Water Conservation Authority, 1986).

8, E. Seedling vigour, rate of growth and competitive ability (Watson 1982, Douglas 1984).

Seedlings are robust and grow rapidly. No specific details on growth rates or competitive ability were found. Sulla is short lived, usually lasting for 2-3 years (National Water and Soil Conservation Authority 1982) but under hot summer conditions it sometimes acts more as an annual (Douglas and Foote 1985, Rys *et al.* 1988).

8, F. Palatability to grazing stock

Sulla is highly palatable to grazing stock providing high quality non-bloating forage (Watson 1982). It is preferentially grazed and continuous grazing results in plant death (National Water and Soil Conservation Authority 1986). Cultivars (eg. 'Nectron' and 'Aokau') have been selected for forage quality (Krishna *et al.* 1990).

8, G. Special potential nuisance factors

No published references were found to nuisance factors but the spiny seed pods may possibly have nuisance value.

8, H. Feasibility of control

No references were found to *H. coronarium* as a weed and hence there was no information on its control.

9. *Lathyrus latifolius* L.

Common name: everlasting pea.

Habit: A scrambling perennial legume with climbing or prostrate stems 60-300 cm long, forming extensive patches. It has large, thick and fleshy roots.6

Natural distribution: Central and southern Europe.

Factors relevant to the weedy potential of *Lathyrus latifolius*

9, A. Occurrence and spread in New Zealand and overseas

New Zealand: First recorded naturalised in 1872, *L. latifolius* is now locally common to abundant throughout (except in Westland and Fiordland) on waste places roadsides, banks and coastal sands and gravels. Flowering patches form a conspicuous component of the roadside flora in many areas (Webb *et al.* 1988). Hilgendorf (1960) refers to *L. latifolius* as being a serious weed round Blenheim and Matthews (1975) notes that it is very persistent in waste areas in both islands. It has been used in roadside revegetation trials and is widely cultivated as a garden ornamental, especially in selected forms.

Overseas: In North America everlasting pea is used for soil conservation and for the revegetation of roadsides and waste places because of its drought tolerance, nitrogen fixation and attractive flowers. It is widely naturalised in the United States where it has spread to form spectacularly dense populations covering over a hectare. It is also widely cultivated as a garden ornamental (Godt and Hamrick 1991).

9, B. Reproduction, seed dissemination and mode of spread (from Webb *et al.* 1988, Godt and Hamrick 1991).

Flowering begins from a very early age and takes place over a long period, from September to May. Flowers are large and conspicuous, usually magenta or purple-pink but can be white or pale pink, especially in cultivated forms. A diverse group of insects visit to collect nectar but pollination is only by bumble bees. The seed pods each contain 10-25 large round reddish brown seeds. The pods burst explosively to disperse the seed which have a moderate capacity for further dispersal. Being relatively heavy and round they have an ability to roll or be carried by rainwater, especially on banks or roadsides. Lambrechtsen and Douglas (1986) note that seeds are eaten by game birds (which also shelter in the herbage provided).

9, C. Factors affecting seed germination

Lambrechtsen and Douglas (1986) consider that the percentage of hard seed may be high.

9, D. Site and climatic adaptability

Everlasting pea prefers neutral to alkaline soils (pH 6.0-7.8) but will tolerate a pH down to approximately 5.5. Once it has established a large root system (which may take 4-5 years) it is very tolerant of drought and low soil fertility and is very persistent (Lambrechtsen and Douglas 1986).

9, E. Seedling vigour, rate of growth and competitive ability

Everlasting pea seeds from an early age, has reasonable seedling vigour, and the capacity for rapid population growth (Lambrechtsen and Douglas 1986). No references were found to its competitive ability.

9, F. Palatability to grazing stock

Deer and other domestic stock will graze everlasting pea but only reluctantly, probably because of the toxic amino acids it contains. However it does not persist under grazing and has not been seen to spread onto adjoining pastures (Lambrechtsen and Douglas 1986).

9, G. Special potential nuisance factors

Although seeds of everlasting pea have been shown in experiments to be highly toxic to laboratory animals, producing characteristic nervous symptoms of hyper-excitability, convulsions and death (Kingsbury 1964) no poisonings of man or animals attributed to *Lathyrus* have apparently been recorded in New Zealand (Lambrechtsen and Douglas 1986, Connor 1977).

9, H. Feasibility of control

According to Matthews (1975) very good control of everlasting pea is obtained with dicamba, picloram and 2,3,6,-TBA,when applied to the plant in full vegetative growth and where good soil moisture is present. However it is not well controlled by 2,4 -D and 2,4,5-T because of its strong rhizomatous rootstock. Nor was it well controlled by simazine and diuron, even with additives of 2,4 -D and amitrole.

10. *Lespedeza cuneata* (Dumont) G. Don

Common name: sericea lespedeza

Habit: A long lived, erect to semi-erect, leafy herbaceous legume with coarse stems growing 60-100 cm high. It develops an extensively branched, deep taproot system.

Natural distribution: East Asia along the Himalayas from Hazara and Kashmir to Bengal - up to 2400 m a.s.l.

Factors relevant to the weedy potential of *Lespedeza cuneata*

10, A. Occurrence and spread in New Zealand and overseas

New Zealand: *Lespedeza cuneata* is not recorded as naturalised in New Zealand (Webb *et al.* 1988) and no references were found to its cultivation here.

Overseas: Cultivated in various areas of Asia and United States (Duke 1981). In the south-east United States it is grown for forage and soil conservation and improvement. After introduction into cultivation it escaped quickly in a number of states (Gleason 1974) and is referred to by Yonce and Skroch (1989) as a weed requiring control.

10, B. Reproduction, seed dissemination and mode of spread

Flowers are solitary, 7-9 mm long and mostly white with pink or purple. Seed can be produced in the first season (Jorgensen and Davis 1983). It is contained in an oval pod about 3 mm long (Gleason 1974) and seed is dispersed by shattering of the pod. Seeds are eaten by birds (Duke 1981).

10, C. Factors affecting seed germination

There is normally a high percentage of hard seed and under cultivation germination will not usually exceed 25% without scarification (Offutt and Baldridge 1978).

10, D. Site and climatic adaptability

Lespedeza cuneata is adapted to tropical, subtropical and warm temperate areas (Duke 1981) and is tolerant of drought and low fertility. Jorgensen and Craig (1983) found it to be one of the relatively few nitrogen-fixing plants capable of establishing and maintaining itself on acid, nutrient-poor forests soils and of 14 legumes tested it was one of the best adapted to a range of sites in south-east North Carolina. *Lespedeza cuneata* is reported to tolerate annual precipitation of 610mm - 2620mm, mean annual temperatures of 9.9 - 26.2 °C, and a pH of 4.9 - 7.1 (Duke 1981). In temperate climates top growth is killed by frost but the plant is renewed by dormant crown buds in spring (Forde *et al.* 1989). While *Lespedeza cuneata* is free of serious insect damage in the United States, it is prone to fungal diseases such as bacterial wilt (Offutt and Baldridge 1978).

10, E. Seedling vigour, rate of growth and competitive ability

According to Hoveland *et al.* (1971) seedlings are weak and compete poorly with spring and summer weeds in the United States and Hill and Luck (1991), in a comparison of seedling growth of 10 temperate pasture legumes in Australia, found that *Lespedeza cuneata* always produced the least vigorous seedlings. Seed requires inoculation with appropriate rhizobia (Duke 1981). Under cultivation in the United States it is very competitive and eliminates most annual and perennial weeds (Jorgensen and Craig 1983). It is reported to be long lived (Offutt and Baldridge, 1978)

10, F. Palatability to grazing stock

Sericea lespedeza is used for animal forage as pasture and hay in the United States (Offutt and Baldridge 1978). According to Duke (1981) palatability to grazing stock is not high however cultivars with improved palatability and forage value have been developed in the United States (Offutt and Baldridge 1978).

10, G. Special potential nuisance factors

No references were found to any special potential nuisance factors.

10, H. Feasibility of control:

In trials in North Carolina in which the effectiveness of glyphosate in controlling *Lespedeza cuneata* was evaluated, consistent commercially acceptable control was obtained when glyphosate was applied at 1.1 or 2.2 kg/ha at the time of flowering (which occurred from early August to mid September in North Carolina). Rate and time of application significantly affected injury and control of the weedy *Lespedeza* (Yonce and Skroch 1989).

11. *Lotus corniculatus* L.

Common names: birdsfoot trefoil

Habit: (from Jones and Turkington 1986, Webb *et al.* 1988). *Lotus corniculatus* is a herbaceous perennial with numerous erect, decumbent or prostrate stems up to 90 cm long, woody at the base and with a deep woody taproot up to 1 m long, with numerous laterals. It is sometimes very difficult to distinguish from *Lotus tenuis* and a chromosome count may be necessary for complete surety. It is also very similar to *L. pedunculatus* but it distinguishable by its more or less solid stems (hollow in *L. pedunculatus*), larger flowers, conspicuous lateral veins on the leaflets and by its lack of rhizomes.

Natural distribution: Europe, Asia and North Africa. According to Everist (1974) it is regarded by some to be native in Australia but is more likely naturalised.

Factors relevant to the weedy potential of *Lotus corniculatus*

11, A. Occurrence and spread in New Zealand and overseas

New Zealand: *Lotus corniculatus* was introduced to New Zealand during the early 1900s, however it was not widely used and it has naturalised at only one site (in Otago) where it was first recorded in 1969. It has frequently been recorded in error as naturalised in New Zealand, and almost all these records refer to *L. pedunculatus* (Webb *et al.* 1988). In recent years it has been under evaluation as a pasture legume in both the North and South Islands (Scott and Charlton 1983).

Overseas: Cultivated for forage in Britain, throughout much of Europe, in South Africa, India and North and South America. It occurs throughout Australia although not abundantly (Lamp and Collet 1976) and is a troublesome weed in the United States and Europe (Crockett 1977).

11, B. Reproduction, seed dissemination and mode of spread (from Seaney 1978, Duke 1981, Jones and Turkington 1986, Webb *et al.* 1988)

Flowers are yellow and 10-15 cm long. Webb *et al.* gave the flowering time as February in New Zealand, although according to Duke and to Seaney it flowers and sets seed over an extended period of time with both ripe pods and new flowers present on the plant at the same time. Fertilisation and seed set depend on pollination by insects, primarily species of *Hymenoptera*. Seeds ripen 25-71 days after pollination. They are about 1.5 mm in diameter, almost black at maturity and contained in narrow pods 15-35 mm long with 10-15 seeds in each pod. The pods split along both sides when mature and twist spirally ejecting the seed violently within 2 metres of the plant. Seed will germinate after passing through the digestive tract of grazing animals and birds which may be responsible for further spread.

11, C. Factors affecting seed germination

At least 50% of the seed may be hard (Jones and Turkington 1986) with a reported range of 19-90% in various seedlots (Quingfeng and Hill 1989). Hard seeds over-winter in the soil and can build up appreciable seed banks. Higher germination has been reported for seed kept for 20 years than for the original samples (Jones and Turkington 1986).

11, D. Site and climatic adaptability

Lotus corniculatus is found on a very wide range of soils from clays to sandy loams and will grow on poorly drained, infertile, acid or mildly alkaline soils, but does best on fertile, at least moderately well drained soils with a pH of 6.2 - 6.5 or higher (Seaney 1978). Duke (1981) gives the tolerated pH range as 4.5-8.2. According to Jones and Turkington (1986) *L. corniculatus* is intolerant of severe drought and generally confined to areas which do not have a long dry season. However Langer (1973) notes that the deep, much branched taproot makes it the most drought resistant of the perennial *Lotus* species. According to Duke (1981) it thrives with a rainfall of 550-900 mm per year but is reported to tolerate an annual precipitation range of 210-1910 mm and an annual mean temperature of 5.7 - 23.7°C. In Scotland it was found to succeed better than any other native legume on 'infertile' upland soils and was very cold hardy (Jones and Turkington 1986). According to Duke (1981) it tolerates water-logging when actively growing and is moderately salt tolerant. Seaney (1978) reports that in most parts of the south-east United States *L. corniculatus* does not persist well due to crown and root diseases.

11, E. Seedling vigour, rate of growth and competitive ability (Scott and Charlton 1983, Jones and Turkington 1986, Patrick and Lowther 1992).

Rhizobia infective on *L. corniculatus* are absent from New Zealand soils except for those few areas where *L. tenuis* or *L. corniculatus* have become naturalised and inoculation with rhizobia is essential for

nodulation. Low rates of nodulation can limit establishment from seed and nodulation failure may even occur when seed has relatively high populations of rhizobia at sowing. Seedling growth is slow and non-competitive compared with most New Zealand pasture species. Seedlings grow chiefly below ground in their first year and because they are slow growing above ground they are easily shaded out. However, once established *Lotus corniculatus* can have a competitive advantage because of the deep taproot, dense, fibrous, lateral roots, spreading habit, perennial nature, winter hardiness and ability to grow up, to some extent, with inherently taller species. Once established it can also be highly persistent.

11, F. Palatability to grazing stock

Lotus corniculatus is palatable to grazing animals and has a chemical composition and nutritive value equal to lucerne and other legumes (Seaney 1978). The forage contains tannins and is non-bloating (Duke 1981).

11, G. Special potential nuisance factors

Lotus corniculatus contains a potentially toxic cyanogenetic glycoside, however, despite extensive use for forage there have been very few authenticated reports of poisoning attributed to it. Poisoning by *Lotus corniculatus* in which the presence of hydrocyanic acid was confirmed, occurred in the USSR in goats at pasture and in sheep given hay containing the plant. When juice obtained from the plant was introduced experimentally into the stomachs of sheep they died a few hours later. The amount of toxic glycoside in the plant varies with climatic conditions, stage of growth and part of the plant. The leaves contain the most and the amount increases with the age of the leaves. Natural populations contain both cyanogenic and non-cyanogenic plants, the difference being genetically determined (Cooper and Johnson 1984).

11, H. Feasibility of control

No information on control specific to *Lotus corniculatus* was found, however the very similar *Lotus pedunculatus* is effectively killed by several herbicides including picloram, dicamba and amitrole (Matthews 1975).

12. *Lotus pedunculatus* Cav.

(previously known as *L. uliginosus* and *L. major)*

Common name: lotus

Habit: Perennial, woody at the base, with ascending or sprawling stems up to 180 cm and vigorous underground rhizomes.

Natural distribution: Europe, Asia and North Africa.

Factors relevant to the weedy potential of *Lotus pedunculatus*

12, A. Occurrence and spread in New Zealand and overseas

New Zealand: *Lotus pedunculatus* was first recorded naturalised in 1867 and is now widely spread throughout most of the country especially in wetter places but is less common in lowland eastern areas. It is common on roadsides, in pasture, waste places, drains and swamps and is the most widely distributed *Lotus* species in New Zealand. A tetraploid cultivar, ' Grasslands Maku ' (which is an intraspecific hybrid developed by crossing New Zealand tetraploid plants with Portuguese tetraploid plants chosen for superior winter growth), is widely cultivated in pastures, for soil conservation and under some forest plantations as a supplier of nitrogen to the trees and as forage for forest grazing.

Overseas: *Lotus pendunculatus* is a prominent forage legume in the Pacific north-west coastal regions and the south eastern areas of the United States, throughout Central Europe, western Asia and South America.

12, B. Reproduction, seed dissemination and mode of spread (from Armstrong 1974, Duke 1981, Webb *et al.* 1988).

Lotus pedunculatus flowers from November to January in New Zealand. The flowers are yellow, 9-12 mm long and in groups of about 10. Cross pollination is necessary and honey bees are adequate pollinators. Seeds are about 1 mm in diameter (but about twice the size in the cultivar 'Maku'). They are borne in a narrow straight pod, 1.5-3.5 cm long and are released by shattering of the pod. Seed is set over an extended period of time with both ripe pods and new flowers on the plant at the same time but the optimum time for seed production is mid- to late February.

12, C. Factors affecting seed germination

Lotus pedunculatus has been found to have an average of 24% hard seed. It requires a specific strain for inoculation which differs from that for clovers, medicks and other *Lotus* species, and if this is not present in the soil, seedlings may not survive (Langer 1973).

12, D. Site and climatic adaptability (Langer 1973, Armstrong 1974, Duke 1981).

Lotus pedunculatus will establish, grow well and persist on most soil types and sites in New Zealand, including infertile, acid soils. It does particularly well where conditions are damp and it is not drought-resistant. It tolerates a precipitation range of 350-1360 mm, mean annual temperatures of 5.9 - 21.3°C and a pH range of 5.5 to 8.2, although, according to Langer it is probably adapted to the greatest degree of soil acidity of any *Lotus* species and has been reported to grow well between pH 4.5-5.5. It is moderately salt tolerant but is not adapted to saline conditions to the same degree as *L. tenuis* and will tolerate only brackish water.

12, E. Seedling vigour, rate of growth and competitive ability

As with other *Lotus* species, seedlings are slow to establish and do not compete well with other vegetation (Armstrong 1974, Duke 1981). The cultivar 'Maku' has improved seedling vigour (Charlton 1982).

12, F. Palatability to grazing stock

Lotus pedunculatus is very palatable to grazing stock and provides forage of good value which does not cause bloat - the potentially fatal disorder of livestock grazing clover-rich pastures. It tends to be smothered out and does not persist in high yielding fertile lowland clover and ryegrass pastures (Charlton 1982).

12, G. Special potential nuisance factors

No records of toxicity or any other special nuisance factors were found for *Lotus pedunculatus*.

12, H. Feasibility of control

Lotus pedunculatus can be controlled using the chemicals picloram , dicamba and 2,3,6-TBA and amitrole with amitrole being particularily effective (Matthews 1975).

13. *Lotus tenuis* Willd.

[Sometimes treated as *L. corniculatus* var. *tenuifolius* although *L. tenuis* and *L. corniculatus* are quite distinct in almost all the regions where they occur together (Webb *et al.* 1988)].

Common names: narrow leaved birdsfoot trefoil, narrow leaf trefoil.

Habit: *Lotus tenuis* is a slender perennial, woody at the base, with many procumbent to ascending stems usually 20-40 cm long (occasionally up to 90 cm), more slender than *L. corniculatus* and *L. pedunculatus*. It has a long woody taproot.

Natural distribution: Europe, Asia and North Africa.

Factors relevant to the weedy potential of *Lotus tenuis*

13, A. Occurrence and spread in New Zealand and overseas

New Zealand: First recorded naturalised in 1957, now in a number of areas in both islands in waste places, swamp land and damp pastures including those on saline soils. It has also been under evaluation as a pasture legume.

Overseas: *Lotus tenuis* has been used for the revegetation of poorly drained soils in the northern part of the United States, in southern Oregon and on saline/alkaline soils in California (Lambrechtsen *et al.* 1986).

It is an important pasture and hay crop in the Pacific North-west of the United States and in upper New York State (Duke 1981).

13, B. Reproduction, seed dissemination and mode of spread (Lambrechtsen *et al.* 1986, Webb *et al.* 1988).

Flowers are yellow tinged with orange,in heads of 4-6 and appear in New Zealand from December to March. As with other *Lotus* species, pollination is by insects. The straw coloured to dark brown,seeds 1-5 mm in diameter are contained in olive-brown pods each with 5-15 seeds, which ripen over an extended period of time.

13, C. Factors affecting seed germination

Up to 50% of the seed is 'hard'. A specific rhizobium is required for inoculation (Lambrechtsen *et al.* 1986).

13, D. Site and climatic adaptability (Langer 1973, Duke 1981, Lambrechtsen *et al.* 1986).

Lotus tenuis prefers summer-moist, salty to clay soils, does well on saline, alkaline and inundated soils and is tolerant of greater salinity than any other legume with the exception of strawberry clover. It is not as winter hardy nor as drought tolerant as *L. corniculatus* because of its shallow root system, but once established it has survived severe summer drought in central Otago. In pasture near Lake Ellesmere and near Blenheim it tolerates intermittent inundation and subsequent desiccation. *Lotus tenuis* is reported to tolerate an annual precipitation range of 440 - 1160 mm, mean annual temperatures of 7.0 - 16.9°C and a pH range of 4.5 - 7.9 with best nodulation at pH 6.0 - 6.5.

13, E. Seedling vigour, rate of growth and competitive ability

As with other *Lotus* species, *Lotus tenuis* seedlings tend to lack vigour and do not compete well with other vegetation. In trials undertaken by the Grasslands Division of DSIR at Palmerston North it was found that once established, after a vigorous first years growth, plants weakened and few survived into the second winter (Lambrechtsen *et al.* 1986) and it is described by Taylor (1981) as being shortlived.

13, F. Palatability to grazing stock

Lotus tenuis is palatable to grazing stock and does not establish readily or persist well in pasture. Continuous grazing leads to its disappearance. It does not contain tannins and unlike *L. pedunculatus* and most strains of *L. corniculatus* evaluated in New Zealand, it does not prevent bloat (Lambrechtsen *et al.* 1986).

13, G. Special potential nuisance factors

No records of any toxins associated with *Lotus tenuis* or references to any other potential nuisance factors were found.

13, H. Feasibility of control

As with *L. pedunculatus*, *L. tenuis* is effectively killed by chemicals such as picloram, dicamba, 2,3,6 -TBA and amitrole (Matthews 1975).

14. *Lupinus nootkatensis* Donn ex Sims

(closely related to L. *perennis* of which it is possibly only a subspecies (Tutin *et al.* 1964)).

Common name: Nootka lupin

Habit: (Hutchinson 1955, Dunn 1965, Welsh 1974). Stout perennial herb 20 cm to 1m tall, with erect or ascending stems dying back annually to a subterranean woody caudex.

Natural distribution: North-west North America, from Vancouver Island north to Alaska and north-east Asia. It has the most westerly natural distribution of any lupin species (Dunn 1965).

Factors relevant to the weedy the potential of *Lupinus nootkatensis*

14, A. Occurrence and spread in New Zealand and overseas

New Zealand: No records of *Lupinus nootkatensis* growing wild in New Zealand were found.

Overseas: *Lupinus nootkatensis* is naturalised in Norway and the United Kingdom where it occurs in great abundance on the banks of some rivers in Scotland, especially the Dee and Tay and on bare hillsides in the Orkney Islands (Hutchinson 1955, Tutin *et al.* 1964). The closely related *L. perennis* is cultivated for ornament and for fodder, mostly in central Europe and is sometimes naturalised (Tutin *et al.* 1964). *Lupinus nootkatensis* has successfully been introduced into Iceland on eroded soil and gravelly flats and has been under evaluation for the restoration of degenerated forest soil in northern Sweden (Huss-Danell and Lundmark 1988).

14, B. Reproduction, seed dissemination and mode of spread

Flowers are blue or white and 16-21 mm long (Welsh 1974). Pollination is by bees (Hutchinson 1955). The seeds are borne in pods 3-6 cm long with 7-11 seeds in each pod (Welsh 1974). In Sweden flowering and seed production began in the second year and from the fourth year onwards all full sized plants produced seed. Average seed production after six and seven years was estimated for two plants to be 5871 and 9145 respectively, indicating a very high potential for generative reproduction (Huss-Danell and Lundmark 1988). No specific information was found on seed dissemination and spread.

14, C. Factors affecting seed germination

Self sown plants were first observed three years after *Lupinus nootkatensis* was planted in Sweden. Huss-Danell and Lundmark observed that *Lupinus nootkatensis* seemed able to produce a large seed bank in the

soil and that some of these seeds could be expected to germinate after many years when conditions for germination became favourable.

14, D. Site and climatic adaptability

Little specific information was found. In its natural range *Lupinus nootkatensis* is found in meadows, open woods, thickets and roadsides, from sea level to a few hundred feet (Welsh 1974). In Sweden self-sown seedlings established on bare mineral soil Establishment of sown *Lupinus nootkatensis* was facilitated by liming (Huss-Danell and Lundmark 1988) indicating a probable preference for alkaline soils.

14, E. Seedling vigour, rate of growth and competitive ability

In Sweden plants reached their final height (about 0.8m tall) after four years. After five years each plant covered an average area of nearly 1m in diameter. Eight years after planting and with self seeding the lupin cover was very dense (Huss-Danell and Lundmark 1988). No information was found specifically on seedling vigour or competitive ability.

14, F. Palatability to grazing stock

No specific information was found on palatability but *Lupinus nootkatensis* is claimed to have a rather high alkaloid content and sheep kept on a diet of it in Iceland were reported to have lost weight and become ill (Huss-Danell and Lundmark 1988). Cooper and Johnston (1984) note that animals are to some extent protected from lupin species high in alkaloids by their bitter taste.

14, G. Special potential nuisance factors

Apart from the reported decline among sheep kept on a diet of *Lupinus nootkatensis* in Iceland, no specific reports of toxicity involving this species were found. However many lupin species can be poisonous to grazing animals, either directly because of their alkaloid content or indirectly because of fungal infection of the plants. Major losses of domestic animals have resulted from ingestion of lupin foliage in the United States. Toxicity is variable seasonally and geographically as well as according to species. Animals vary greatly in susceptibility with sheep generally being the most susceptible (Allen and Allen 1981).

14, H. Feasibility of control

No information was found specifically on the control of *Lupinus nootkatensis*. However it is likely that, as with *L. arboreus*, the soft leaves will readily adsorb herbicides making the plant very susceptible to low rates of spray e.g. with Tordon Brushkiller or Grazon.

15. *Medicago arborea* L.

Common name: tree medick

Habit: *Medicago arborea* is an erect, woody, little branched, densely leafed, perennial shrub to 3 m tall but more typically 1-2 m depending on the site.

Natural distribution: Countries bordering the northern shore of the Mediterranean Sea, Canary Islands, southern Europe and Asia where it occurs in regions with above c. 400 mm rainfall per year (Sheppard 1980). Its distribution as a wild plant is not precisely known (Bean 1970).

Factors relevant to the weedy potential of *Medicago arborea*

15, A. Occurrence and spread in New Zealand and overseas

New Zealand: *Medicago arborea* was first discovered naturalised in New Zealand in 1958 and has established as an escape from cultivation round Wellington and Christchurch in coastal areas, on sand dunes, coastal cliffs and hillsides (Webb *et al.* 1988). It has been cultivated in trials for forage and soil conservation in some areas including Woodville, Palmerston North, Canterbury and coastal Otago (Bulloch 1986, Lambert *et al.* 1989).

Overseas: Cultivated as a forage plant and naturalised in parts of Europe.

15, B. Reproduction, seed dissemination and mode of spread (Bulloch 1986, Webb *et al.* 1988).

Flowers are yellow to orange, 10-15 mm long and appear from September to April in New Zealand. Pollination is by bees. The seeds ripen successively over the summer, are brown, c. 4-5 mm long and contained in ram's horn shaped pods 10-15 mm in diameter. Each pod contains 1-2 seeds. Pods are indehiscent, ie. do not open to free the seed.

15, C. Factors affecting seed germination

Bulloch (1986) states that seed germinates readily if given hot water treatment or mechanical scarification, indicating hard seed. No other information on factors relevant to germination were found.

15, D. Site and climatic adaptability

According to Lambert *et al.* (1989), in trials in New Zealand tree medick has been found to be slow to establish on most sites, not very vigorous and with an unthrifty appearance. Forde *et al.* (1989) note that it is best suited to warm, dry areas and is intolerant of compacted or waterlogged soils. Three years after planting on ungrazed, semi-arid trial sites in Central Otago and the Waitaki Basin it was persisting well and had adopted a low compact growth form 0.3 to 0.7 m high (Bulloch 1986). Bulloch found that it required good weed control and preferably cultivation for satisfactory establishment. In humid areas of

New Zealand tree medick is subject to leaf spot disease, *Pseudopeziza* which may affect the vigour of the plant (Sheppard 1980).

15, E. Seedling vigour, rate of growth and competitive ability

No specific information was found but tree medick has apparently been slow to establish in New Zealand with low survival levels (Lambert *et al.*1989) and competes poorly with other weeds at the establishment stage. A specific rhizobium is required and where this is absent from the soil inoculation is necessary for good growth (Bulloch 1986].

15, F. Palatability to grazing stock

Tree medick was found to have high palatability to grazing animals in trials at the National Plant Materials Centre in Palmerston North (Sheppard 1980) and is used for forage although digestibility and nutrient content in New Zealand have not been determined (Bulloch 1986).

15, G. Special potential nuisance factors

No references to toxicity in *Medicago arborea* were found.however. However *Medicago* species have been implicated in outbreaks of dermatitis and photosensitisation among grazing animals in several overseas countries and *Medicago sativa* (lucerne) can be responsible for bloat in cattle (Everist 1974, Cooper and Johnson 1984). No cases have been reported in New Zealand although in trials at Lincoln College in Canterbury, reproductive activity was depressed in animals fed *Medicago sativa* before and after mating (Connor 1977). No reference was found to any other potential nuisance factors.

15, H. Feasibility of control

No specific information was found on the control of *Medicago arborea* in New Zealand but other *Medicago* species were found to be very susceptible to amitrole and quite susceptible to MCPA/2,3,6-TBA mixture, dicamba and diuron (Matthews 1975).

16. *Sutherlandia frutescens* (L.) R.Br.

(previously known as *S. tomentosa*)

Common names: balloon pea, duck plant, cancer bush

Habit: (from Harrison 1974, Phillips and Rix 1989). A soft-wooded shrub growing up to 2 m in cultivation but more in its natural habitat, varying in habit from bushy to compact to semi-scandent.

Natural distribution: Namibia and South Africa. Dry hillsides, sand flats and dunes.

Factors relevant to the weedy potential of *Sutherlandia frutescens*

16, A. Occurrence and spread in New Zealand and overseas

New Zealand: No records were found of it as a naturalised plant. It is cultivated as an ornamental.

Overseas: *Sutherlandia frutescens* is cultivated to some extent as an ornamental for its showy flowers and decorative seed pods and has been grown as a glasshouse ornamental in Europe since about 1860 (Huxley *et al.* 1992). It is cultivated outside in the Mediterranean and in coastal and desert California (Phillips and Rix 1989). In its natural range leaf infusions have been used for the treatment of intestinal and uterine ailments including cancer (Allen and Allen 1981).

16, B. Reproduction, seed dissemination and mode of spread (from Harrison 1974, Allen and Allen 1981, Phillips and Rix 1989).

Flowers are bright scarlet to deep purple, c. 3 cm long and occur in clusters of 6-10. The seed develops in kidney-shaped, inflated, membranous, papery, bladder-like pods to c. 5 x 3 cm. They are semi-translucent, rather indehiscent and able to float, aiding dispersal. Seed is produced abundantly.

16, C. Factors affecting seed germination

According to Harrison (1974) seed germinated freely but no specific information was found on factors affecting pollination.

16, D. Site and climatic adaptability

Sutherlandia frutescens requires very well drained soil and is frost tender. In its native habitat it tolerates several degrees of frost and according to Huxley *et al.* (1992), if given impeccable drainage and sufficient summer warmth to ripen the wood, it may tolerate temperatures of -5°C in north temperate regions. It is tolerant of drought and of poor soils but is rather short-lived (Harrison 1974).

16, E. Rate of growth

No information found.

16, F. Palatability to grazing stock

No information found.

16, G. Special potential nuisance factors

No information found and no nuisance factors are apparent.

16, H. Feasibility of control

No information found.

17. *Teline stenopetala* Webb et Berth.

(also known as *Genista stenopetala* Webb et Berth.; previously known in New Zealand as *Cytisus stenopetalus*).

Common name: None found.

Habit: (Bramwell 1974, Webb *et al.* 1988) Evergreen shrub to small tree up to 6 m high, densely branched from the base.

Natural distribution: Canary Islands, in laurel Forest and *Erica* heaths between 600 and 1500 metres above sea level.

Factors relevant to the weedy potential of *Teline stenopetala*

17, A. Occurrence and spread in New Zealand and overseas

New Zealand: *Teline stenopetala* was first recorded naturalised in New Zealand in 1940. It is locally naturalised only, as a garden escape in Auckland, Gisborne, New Plymouth, Palmerston North, Wellington, Canterbury and on Otago Peninsula in dry waste places and on coastal cliffs (Webb *et al* 1988).

Overseas: Forde *et al.* (1989) mention the use of *Teline stenopetala* overseas for forage but no specific information was found.

17, B. Reproduction, seed dissemination and mode of spread

Flowers are yellow and about 1.5 cm long. Flowering occurs over a long period in New Zealand from July to April. Seeds are black, about 3 mm in diameter, in densely hairy pods 2-4 cm long with each pod containing 3-10 seeds. The pods are 2 valved and explosively dehiscent (Webb *et al.* 1988).

17, C. Factors affecting seed germination

No information was found.

17, D. Site and climatic adaptability

No specific information was found on the adaptability of *Teline stenopatala* but it naturalises on dry waste places and coastal cliffs in New Zealand.

17, E. Rate of growth

Forde *et al.* (1989) report that it is fast growing and regrowth occurs rapidly after grazing but it is not as long lived as tree lucerne.

17, F. Palatability to grazing stock

Teline stenopatala is palatable enough to be used for forage (Forde *et al.* 1989).

17, G. Special potential nuisance factors

No information was found suggesting any special potential nuisance factors associated with *Teline stenopetala.*

17, H. Feasibility of control

No information was found.

18. *Trifolium ambiguum* Bieb.

Common names: Caucasian clover, kura clover.

Habit: (from Bryant 1974, Stewart and Daly 1980, Speer and Allinson 1985, Forde *et al.* 1989). A robust perennial with procumbent to erect stems 10-60 cm long. Individual plants vary considerably from erect to prostrate. Deep rhizomatous growth is extensive with rhizomes branching and giving rise to new plants both terminally and from the nodes, resulting in a multi-tufted plant. The plant has a deep, semi-woody, multi-branched taproot.

Natural distribution: Crimea, Caucasian Russia, eastern Turkey and northern Iran.

Factors relevant to the weedy potential of *Trifolium ambiguum*

18, A. Occurrence and spread in New Zealand and overseas

New Zealand: Caucasian clover has been cultivated in trials for soil conservation and for forage (Stewart and Daly 1980, Daly and Mason 1987) however no records of naturalisation in New Zealand were found.

Overseas: Caucasian clover has been introduced and evaluated for agricultural purposes in Czechoslovakia, North America and Australia (Speer and Allinson 1985).

18, B. Reproduction, seed dissemination and mode of spread

Flowers are white, becoming reddish and are 1 - 1.5 cm long. They are highly self- incompatible but are freely pollinated by honey bees which are strongly attracted to the nectar. Seed yield is determined largely by the availability of bees for cross fertilisation. The seeds vary in colour from yellow to brown and are contained in ovoid to oblong pods with 1-2 seeds in each pod. In South Australia peak flowering was in November and seed ripened in the first week of January (Dear and Zorrin 1985). Caucasian clover also spreads vegetatively with branching rhizomes giving rise to new plants covering an area of 1 - 1.5 m (Speer and Allinson 1985).

18, C. Factors affecting seed germination

Trifolium ambiguum may have a protracted germination period due to the prevalence of hard seed. Bryant (1974) reports that 40-60% of seed is hard and Speer and Allinson (1985) estimate it could be as high as 75%.

18, D. Site and climatic adaptability

Caucasian clover can grow under a wide range of soil and climatic conditions and is found naturally on sites ranging from valley bottoms to sub-alpine areas up to 3000 m asl. It is reported to tolerate an annual precipitation range of 409 - 1160 mm, an annual mean temperature range of 8.4 - 12.5°C and a pH range of 4.5 to 7.3. Soils on which it grows include those which are acid, low in fertility and poorly drained (Stewart and Daly 1980.). With its deep strong taproot and branching system of rhizomes it is very persistent during drought though it may become dormant (Forde *et al.* 1989). Dear and Zorrin (1985) found the tap roots penetrated to a depth of 30-40 cm and Speer and Allinson (1985) reported that they consistently exceeded 60 cm in the second year of growth. Caucasian clover has a well developed winter dormancy and considerable winter hardiness (Stewart and Daly 1980).

18, E. Seedling vigour, rate of growth and competitive ability

Caucasian clover has a strong requirement for a specific inoculum and this is further complicated by marked bacterial strain specificity between ecotypes (Bryant 1974). It is reportedly very slow to establish and relatively slow growing but, because of the protected underground rhizomes, once established it is very persistent (Forde *et al.* 1989). When tested round Canberra, Caucasian clover was found to have poor competitive ability in pasture (Bryant 1974). Cultivars with improved vigour (eg. 'Treeline') have been developed for forage (Stewart and Daly 1980).

18, F. Palatability to grazing stock

Speer and Allinson (1985) report that Caucasian clover is apparently palatable to all forms of grazing livestock, and provides highly digestible forage of good quality.

18, G. Special potential nuisance factors

No evidence was found of any special potential nuisance factors associated with Caucasian clover.

18, H. Feasibility of control

No specific information was found on the control of Caucasian clover. In general perennial clovers are controlled by chemicals such as picloram, dicamba and amitrole (Matthews 1975).

DISCUSSION

Any species aggressive and persistent enough to be successful as a replacement for tree lupin in sand dune reclamation is likely to have at least some potential as a weed in the adjacent environment. Particularily significant to the weedy potential of legumes is the production of hard seed, ie. seed with a hard seed coat causing dormancy. The hard seeds are incapable of immediate germination and can remain in the soil for many years until the seed coat is damaged sufficiently (usually by weather, fire or mechanical means) to become water permeable. Hard seeds present a particular hazard in that large seed banks can build up in the soil and may be ongoing for years without being obvious. The situation may be further aggravated by the removal of soil containing hard seed either deliberating or on machinery.

Another characteristic of many legumes affecting their ability to spread is the symbiotic association with rhizobia - root nodule bacteria of the genus *Rhizobium*. Culmination of this symbiotic association is the fixation of atmospheric nitrogen. Without the association neither the plant nor the rhizobia can fix nitrogen. Recognition of the basic need for rhizobia in the successful growth of many leguminous plants has resulted in the practice of inoculation whereby effective rhizobia are added to legume seed before sowing. Some legume species are highly specific in their rhizobia requirements and if suitable strains of rhizobia are not present in the soil they may not thrive. The spread of these species from seed is thus unlikely to occur or may be constrained any distance from established plants of the same species.

The two *Acacia* species under consideration, *A. saligna* and *A. longifolia* var. *sophorae*, were introduced to South Africa for sand dune stabilisation over 150 years ago. They have since spread inland from the dunes to form dense, sometimes impenetrable stands, dominating and replacing the natural vegetation to transform natural habitats and landscapes and oust native vegetation reducing the aesthetic, recreational and scientific value of plant communities. Soil water is reduced, accessibility decreased and the fire risk increased through greater fuel loads.

While in the South African literature it is often not clear which variety of *A. longifolia* is referred to, it is clearly specified (Weiss 1981) that var. *sophorae* was introduced in the early 19th century for sand stabilisation and has become a serious weed. The two varieties are botanically very closely related with no distinct morphological discontinuity between them and are unlikely to differ to any extent in their weedy potential. In South Africa var. *longifolia* and *var. sophorae* are connected by an almost continuous range of intermediates and are often difficult to place in one variety or other with certainty (Ross 1975).

The extent of the impact on the environment in South Africa of these and another *Acacia* species (*A. cyclops*), introduced for the same purposes, has been such that the present policy is to stabilise sand dune areas only when absolutely necessary and then using indigenous species. The Directorate of Forestry in South Africa has been actively involved in removing these species from areas of natural vegetation and older stabilisation sites along the coast.

The success of these two *Acacia* species as weeds has been attributed to prolific seed production from a young age, potential of dormant seed to remain viable in the soil for a number of years forming large seed banks, adaptability to a wide range of habitats and soils, fast growth rates and the ability to establish rapidly and compete with and dominate other vegetation. The absence of seed predators which consume a large percentage of the seed produced in their native Australia is also considered a very significant factor. In South Africa, in the absence of these seed predators, large banks of dormant seed accumulate in the soil. This seed can remain viable for up to 50 years or more and is able to germinate when the seed coat is damaged, e.g. by fire, exposure to the sun, decay through weathering or by mechanical means. It has been concluded in South Africa that the only economically feasible control, given the longevity of seed banks, is likely to be by biological means.

In New Zealand *A. longifolia* var. *longifolia* is a troublesome weed in parts of Northland. No published reports have been found of problems with *A. longifolia* var. *sophorae* or *A. saligna*. *Acacia longifolia* var. *sophorae* was planted extensively on the open dunes at Santoft Beach near Bulls more than 30 years ago and more recently on the dunes at several sites on the lower Coromandel Peninsula (Whiritoa and Whangamata) and at Mount Maunganui. Recent attempts have been made by Regional and District Council staff and local residents to eradicate the plantings at Whiritoa, Whangamata and Mount Maunganui. They have been concerned by their vegetative spread, which has resulted in single plants quite quickly covering an area of several metres, competing with and ousting native plants on the foredune and impeding access. At Whiritoa Beach extensive coppicing has taken place after cutting and some spread from seed is evident with seedlings appearing some distance from the site of the original plants and at Whangamata occasional seedlings have appeared. At Mount Maunganui, mature plants of *Acacia longifolia* var. *sophorae* were removed and put through a chipper. When the resulting material was used as a mulch the seed germinated with seedlings appearing in profusion (Peter Watson, Tauranga District Council, pers. comm.). The action of the chipper had apparently effectively scarified the seed providing evidence of its potential for germination following damage to the seed coat. In a review of potential environmental weeds of the Bay of Plenty region, Beadel (1995) concluded that both *A. longifolia* and *A. longifolia* var. *sophorae* have the potential to become major weeds of sand dunes and coastal scrub in the region and recommended total control of existing populations in the Bay of Plenty and a total ban from sale and distribution.

As a result of the ability of the seed of these two *Acacia* species to remain viable in the soil for such very long periods of time it may take 50 years or more for significant spread to become evident and much longer for the problem to realise its serious potential - as has been the case in South Africa.

Although ***Astragalus cicer*** (cicer milkvetch) is naturalised in Europe and cultivated quite widely in North America no references were found to it as a weed of any significance. Although adaptable it is usually slow to germinate without scarification and the growth of seedlings is often poor - perhaps due to the

absence of natural rhizobial associates. Once established cicer milkvetch can be very persistent. Its palatability should prevent it ever being a nuisance on grazing land and it appears to have no special nuisance features. Spread is by rhizomes and by seed, some of which is hard.

Chamaecytisus palmensis (tree lucerne) was introduced to New Zealand last century. It had naturalised by 1919 and since then it has spread widely and is particularly common in coastal areas. Tree lucerne has a number of useful features and its palatability to grazing livestock will prevent it becoming a nuisance on grazed land. Dense ground cover prevents it from spreading and it is likely to be a nuisance only on disturbed sites such as some protected natural areas where drainage is good and frosts not too severe. In some situations its nuisance factors are likely to be outweighed by its value as a soil enricher and in providing shelter for regenerating native plants. While it may have the ability to germinate and establish prolifically after fire this could be an advantage in assisting regeneration as tree lucerne is very attractive to and provides valuable winter and spring food for both native and introduced birds and is particularly favoured by native pigeons. Tree lucerne is not long lived and prefers a disturbed environment therefore it is unlikely to be more than a short term invader of some regenerating areas. Palatability to possums is likely to result in control where possum populations are high.

Dorycnium species (canary clovers) have been cultivated on a trial basis for conservation, for dry land forage and for sand stabilisation at a number of sites in New Zealand. However they appear to have been little used overseas and the information available is largely based on New Zealand experience. No references were found to any *Dorycnium* species as weeds either in New Zealand or overseas. Some self seeding was occurring at New Zealand trial sites but seedlings were slow growing and prone to insect predation, animal browsing and competition from other plants. Seed is disseminated by explosive splitting of the pod and spread is limited to a short distance from the parent plant. The *Dorycniums* are palatable to grazing stock, thus are unlikely to cause a nuisance on grazing land. They have no apparent special nuisance factors. No information was found or is likely to be available on control.

Although *Hedysarum coronarium* (sulla) has been cultivated in a number of localities for conservation, beautification and forage there has been little spread beyond the original stands. This may be due to lack of seed dispersal or lack of suitable rhizobia away from the parent plants. *Hedysarum coronarium* is attractive and is used as a component in hydro-seeding mixtures for roadside and waste places - thus spread to such sites could be an asset rather than a nuisance. It is very unlikely to become a problem in pasture, being very palatable and it does not persist under continuous or heavy grazing. No references were found to any special nuisance factors.

Lathyrus latifolius, (everlasting pea) is well established in New Zealand as a weed on roadsides and waste places where soils are neutral to alkaline. It has been used in trials for roadside revegetation and selected forms are widely cultivated as garden ornamentals. Seeds are produced from an early age and the plant is relatively fast growing. Once established it is very persistent. It has not been seen to spread

onto pasture and although not very palatable to livestock it apparently does not persist under grazing. Toxicity, particularly of the seeds, could be a concern if it was accessible to grazing animals. Seeds may be spread some distance by gravity, water or possibly large birds. Some of the seed is hard allowing for possible germination in subsequent years. Everlasting pea is most likely to be considered a nuisance if it were to become established in protected natural areas where its persistence, scrambling habit of growth with the ability to cover large areas, and hard seed providing the potential for germination over subsequent years, could cause problems and where control without damage to surrounding vegetation could be difficult. Everlasting pea is apparently relatively easily controlled by chemicals such as dicamba and picloram.

No records were found of *Lespedeza cuneata* (sericea lespedeza) in New Zealand. In the United States it escaped quickly from cultivation to become a weed. While seedlings were apparently often not very vigorous, once established it was very competitive on a variety of sites. It is long lived, develops an extensive branched tap root system and if top growth is frosted back in autumn, new growth is able to develop from crown buds in the spring. There is a high percentage of hard seed allowing for possible germination in subsequent years. As the seed is eaten by birds there is the potential for dispersal some distance from the parent plant. *Lespedeza cuneata* has no apparent special nuisance factors. In North America weedy *Lespedeza* was controlled by glyphosate applied at the time of flowering.

Despite the fact that *Lotus corniculatus* has been in New Zealand since early this century it has naturalised at only one site. This is apparently due to a lack of specific rhizobia for effective nodulation in New Zealand soil and this could be a constraint on spread any distance from the parent plants. Seedling growth is slow and it is not very competitive at the establishment stage. However it is adapted to a range of sites and climatic conditions and once established is very persistent. It can be a troublesome weed in the United States and in Europe. There is a high percentage of hard seed which can build up appreciable seed banks in the soil and remain viable for a number of years. It is palatable to livestock but potential toxicity, which is variable genetically, climatically and according to the age of the plant, may be a concern.

Lotus pedunculatus is well established throughout New Zealand and widely used as a forage plant and as a roadside stabiliser. It is slow to establish from seed, particularly at a distance from the parent plant where *Lotus* is not or has not previously been growing and the specific rhizobia necessary for successful establishment are not present in the soil. It is very palatable, produces valuable forage and has no special nuisance factors. The stoloniferous habit and its vigorous growth and persistence, once established on favourable sites, could cause problems with eradication where chemical control is not feasible.

Lotus tenuis is slow to establish and once established, after initially growing well on sites to which it is well suited, it is not very persistent. Being palatable it would not be a problem in grazed pasture and it has no apparent special nuisance factors. Seed is likely to be distributed by grazing animals and by birds. Being particularly adapted to saline, alkaline and inundated habitats there may be specific swampy,

coastal natural areas where it has the potential to be a nuisance, competing with native vegetation. It can be controlled by chemicals where this is feasible. The high percentage of 'hard' seed could result in seed banks necessitating ongoing follow up control.

Lupinus nootkatensis (nootka lupin) is not recorded as naturalised in New Zealand, nor were records found of it in cultivation other than recently in sand dune reclamation trials. It is abundantly naturalised in Scotland. In Sweden where it was being evaluated for the restoration of depleted soils it was considered that the high reproductive potential might make it difficult to keep within a designated area. Large seed banks with the potential for germination many years later are a strong possibility. Although it is likely to be eaten by grazing stock only when more palatable fodder is unavailable, potential toxicity is a cause for concern. Little information was found on adaptability but in trials in Sweden on impoverished forest soils it generally established readily, was persistent and,with self seeding, had the ability to form a dense cover after several years. Where feasible, chemical control should not be difficult but, with the potential for ongoing germination from seed banks, follow-up over a number of years could be necessary for effective control.

Little indication was found in the literature of *Medicago arborea* (tree medick) being a problem weed in New Zealand or overseas. Spread in New Zealand, since it was first recorded naturalised in 1958, seems to have been minor and limited to a few coastal sites. In New Zealand it has generally been slow to establish in trials and not particularly vigorous. It seems best suited to warm dry coastal areas but has done well in central Otago. Requirement for scarification indicates a percentage of hard seed. It is palatable to grazing animals and provides an acceptable quality of forage. Lack of specific rhizobia necessary for establishment may have limited the spread by seed. Tree medick has no apparent nuisance factors associated with it.

There was a paucity of published information on *Sutherlandia frutescens* which seems to have been little grown other than as a garden ornamental. No evidence was found of it spreading from cultivation in New Zealand or overseas. It is apparently fussy as to site, being frost tender and requiring perfect drainage and it is short-lived. Bladder-like pods which float easily on water have the potential to disseminate seed (which germinates easily) some distance from the parent plant. No information was found on growth rates, palatability to grazing animals or control.

Little information was found in the literature on *Teline stenopatala*. It was first recorded naturalised in New Zealand in 1940 and there has been little spread since. However it is closely related to the weedy broom species, *Cytisus scoparius* and *Teline monspessulanus* and careful monitoring for potential spread in coastal areas would seem particularly advisable. Where chemical control is feasible the herbicides used for gorse and broom e.g. Grazon, Tordon, Brushkiller and Escort, applied during active growth are likely to provide effective control.

No records were found of *Trifolium ambiguum* (Caucasian clover) as a weed in New Zealand or overseas. It is well adapted to a wide range of sites and climatic conditions. However specific rhizobia are required for satisfactory nodulation and growth and, where these are absent from the soil, spread by seed is unlikely. Establishment tends to be poor, however once established Caucasian clover is very persistent due to the deep taproot and protected underground rhizomes. There is a well developed ability to spread by means of rhizomes with 'daughter' plants developing some distance from the 'mother' plant. No information was found on seed dissemination. The high percentage of hard seed provides the potential for germination from seed banks over a number of years. Caucasian clover is palatable to grazing animals. No references were found to any potential special nuisance factors. Control by chemical means (where feasible) is likely to be as for other *Trifolium* species with consideration being given to the very deep taproot and well developed underground rhizome system and to the high percentage of hard seed potentially requiring ongoing follow up measures.

CONCLUSIONS

The weedy potential of any one species can be very hard to predict as it is influenced by such a range of variable factors including seasonal and climatic variables, presence or absence of seed predators and of other pests and diseases, presence or absence of suitable rizobia in the soil and genetic variation in a natural population. It is particularly difficult to predict for conservation areas where the range of colonizable niches is so great (Lonsdale, 1994) A species may appear quite benign for a number of years before it becomes an obvious nuisance, by which time significant seedbanks may have built up in the soil. Control can then be very difficult and costly as on-going follow up treatment is required.

Of the species reviewed, two, *Acacia saligna and Acacia longifolia* var. *sophorae*, have demonstrated the potential to become serious environmental weeds over a period of time and in the absence of seed predators. In South Africa, 150 years after their introduction for sand stabilisation, the Directorate of Forestry has been actively involved in their removal. It would be seem injudicious to risk the possibility of a similar situation developing in this country. Other species covered which have caused lesser problems as weeds overseas and for which close monitoring for spread would be advisable are *Lathyrus latifolius* and *Lespedeza cuneata. Teline stenopetala, Lupinus nootkatensis,* and the *Dorycnium* species have not been widely cultivated and should also be closely monitored as they appear to have potential for spread. *Chamaecytisus palmensis, Lotus pedunculatus* and *Lotus tenuis* are already quite widespread in cultivation in New Zealand and are sometimes weeds. *Astragalus cicer, Hedysarum coronarium, Lotus corniculatus Medicago arborea* and *Trifolium ambiguum* seem slow to spread from seed and may be constrained by lack of suitable rhizobia in the soil away from the parent plant. *Sutherlandia frutescens* is short lived, rather exacting as to site, frost tender and would seem to have very limited weedy potential.

The only species appearing to have any potential for toxicity are *Lathyrus latifolius, Lotus corniculatus* and possibly *Lupinus nootkatensis.* No evidence was found of other special potential nuisance factors in any of the species although spiny seed pods in *Hedysarum coronarium* could possibly cause problems in animal fibres.

While in some situations (e.g. roadsides and waste areas) chemical control is relatively straightforward, although expensive if required on a large scale, it can be considerably more complicated in crops and pastures. In protected natural areas it can be difficult to undertake without damage to the surrounding vegetation.

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REFERENCES

Allen, O.N.; Allen E.K., 1981: The Lequminosae. A source book of characteristics, uses and nodulation. University of Wisconsin Press. Madison, U.S. 812p.

Allen, P.S.; Davis. T.D., 1986: Determining seed quality of cicermilk vetch (*Astragalus cicer* L.) Newsletter of the Association of Official Seed Analysts 60 (1) 86-92.

Armstrong, C.S., 1974: 'Grasslands Maku' tetraploid lotus. (*Lotus pedunculatus* Cav.) New Zealand Journal of Experimental Agriculture 2: 333-336.

Avis, A.M. 1989: A review of coastal dune stabilization in the Cape Province of South Africa. Landscapes and Urban Planning 18(1) 55-68.

Beadel, S.M. 1995: Potential environmental weeds of the Bay of Plenty Region. Report prepared for Environment Bay of Plenty, Whakatane.

Bean, W.J. 1970: Trees and shrubs hardy in the British Isles. Vol. 2 John Murray, London 784p.

Boucher, C.; Stirton, C.H. (1978): *In* Plant Invaders, Beautiful but Dangerous. Department of Nature and Environmental Conservation. Cape Town. pp. 40-43.

Bramwell, D.; Bramwell, Z. 1974: Wild flowers of the Canary islands. Stanley Thornes (Publishers) Ltd. London. 261p.

Bryant, W.G. 1974: Caucasion clover (*Trifolium ambiguum*) - a review. Journal of the Australian Institute of Agricultural Science 40: 11-18.

Bulloch, B.T. 1986: Management and uses of shrubs - an introduction. *In* Van Kraayenoord, C.W.S. and Hathaway R.L. (Eds). Plant Materials Handbook for Soil Conservation Vol. 2. Introduced plants. Soil Conservation Centre, Aokautere. Ministry of Works and Development, Wellington.

Cavanagh, A.K. 1980: A review of some aspects of the germination of acacias. Proceedings of the Royal Society of Victoria 91: 161-180

Charlton, D. 1982: Maku lotus - a new legume for New Zealand's grasslands. Alpha 21 D.S.I.R.Extension Information, Wellington, N.Z.

Connor, H.E. 1977: The poisonous plants of New Zealand. Government Printer, Wellington. 247p.

Cooper, M.R.; Johnson, A.W. 1984: Poisonous plants in Britain and their effects on animals and man. Ministry of Agriculture, Fisheries and Food. Reference Book 161. London 305p.

Crockett, L.J. 1977: Wildly Successful Plants. A Handbook of North American Weeds. Macmillan Publishing Co., Inc. New York. 268p.

Daly, G.T.; Mason, C.R. 1987: Performance of Caucasian and zigzag clovers. Proceedings of the New Zealand Grassland Association 48: 151-156.

Davenhill, N.A.; Ray, J.W.; Vanner, A L. 1994: Forest Weed Control Manual - a guide to herbicide use in forests. FRI Bulletin No. 180. New Zealand Forest Research Institute.

Davies, D.J. 1981: Tree lucerne - for shelter and grazing. MAF Aglink FPP 589.

Davies, D.J. 1982: Tree lucerne: an historial perspective and discussion of potential uses in New Zealand. *In* Logan, L.A. (Ed) Tree lucerne in New Zealand. Proceedings of a workshop held by Crop Research Division, DSIR Christchurch.

Dear, B.S.; Zorin, M. 1985: Persistence and productivity of *Trifolium ambiguum* M. Bieb. (Caucasian clover) in a high altitude region of south-eastern Australia. Australian Journal of Experimental Agriculture 25: 124-132

Dennill, G.P. 1985: The effect of the gall wasp *Trichilogaster acaciaelongifoliae* (Hymenoptera: Pteromalidae) on reproductive potential and vegetative growth of the weed *Acacia longifolia*. Agriculture, Ecosystems and Environment 14: 53-61.

Dennill, G.B. 1987: The importance of understanding host plant phenology in the biological control of *Acacia longifolia*. Annals of Applied Biology 111: 661-666

Dennill, G.B. 1988: Why a gall former can be a good biocontrol agent: the gall wasp. *Trichilogaster acaciaelongifoliae* and the weed *Acacia longifolia*. Ecological Entomology 13(1) 1-9.

Dennill, G.B.; Donnelly, D. 1991: Biological control of *Acacia longifolia* and related weed species (Fabaceae) in South Africa. Agriculture, Ecosystems and Environment 37: 1-3 115-135.

Douglas, G.B. 1984: Seed production of Sulla - a plant for soil conservation. Proceedings of the New Zealand Grassland Association 45: 234-242.

Duke, J.A. 1981: Handbook of Legumes of World Economic Importance. Plenum Press. London 345 p.

Dunn, D.D. 1965: The inter-relationships of the Alaskan lupines. Madrono 18(1) 1-32

Esler, A.E. 1988: The naturalisation of plants in urban Auckland. 6. Alien plants as weeds. New Zealand Journal of Botany 26: 585-618.

Everist, S.L. 1974: Poisonous Plants of Australia. Angus and Robertson, Sydney 684 p.

Forde, M.B.; Hay, M.J.M.; Brock, J.L. 1989: Development and growth characteristics of temperate perennial legumes *in* Persistence of forage legumes. Proceedings of a trilateral workshop at Honolulu, Hawaii. pp. 91-109.

Gleason, H.A. 1974: The New Britton and Brown Illustrated Flora of the Northeastern United States and adjacent Canada. Volume 2. Hafner Press, New York 655p.

Godt, M.J.W.; Hamrick, J.L. 1991: Genetic variation in *Lathyrus latifolius*. American Journal of Botany 78(9) 1163-71.

Hampton, J.G.; Hill, M.J.; Rolston, M.P. 1990: Potential for seed production of non-traditional herbage species in New Zealand. Proceedings of the New Zealand Grassland Association 52: 65-70.

Harrison, R.E. 1974: Handbook of Trees and Shrubs. A.H.and A.W. Reed, Wellington. 409p.

Heath, M.E.; Metcalfe D.S.; Barnes, R.F.(Eds) 1978: Forages: the science of grassland agriculture. The Iowa State University Press. Iowa USA. 755p.

Hilgendorf, F.W. 1960: Weeds of New Zealand and how to eradicate them. Whitcomb and Tombs 260p.

Hill, M.J.; Luçk R. 1991: The effect of temperature on germination and seedling growth of temperate perennial pasture legumes. Australian Journal of Agricultural Research. 42 (1) 175-189.

Holmes, P.M. 1988: Implications of alien Acacia seed bank viability and germination for clearing. South African Journal of Botany 54 (3) 281-284.

Holmes, P.M. 1989: Decay rates in buried alien *Acacia* seed populations of different density. South African Journal of Botany 553: 299-303.

Holmes, P.M. 1990: Dispersal and predation of alien *Acacia* seeds: effects of season and invading stand density. South African Journal of Botany. 56(4) 428-434.

Hoveland, C.S.; Buchanan G.A.;.Donnelly E.D. 1971: Establishment of sericea lespedeza. Weed Science 19: 21-24.

Hurrell, G.A.; Bourdot, G.W. 1984: The tolerance of tree lucerne to some soil-applied herbicides. Proceedings of the 37th New Zealand Weed and Pest Control Conference 1984. pp 210-212.

Huss-Danell, K.; Lundmark J. 1988: Growth of nitrogen - fixing *Alnus incana* and *Lupinus* spp. for restoration of degenerated forest soil in northern Sweden. Studia Forestalia Suecica 181.

Hutchinson, J. 1955: British Wild Flowers. Volume I. Penguin Books, Middlesex. 491 p.

Huxley, A.J.; Griffiths, M.; Levy M. (Eds) 1992: The New Royal Horticultural Society Dictionary of Gardening. The Macmillan Press Ltd. London and Basingstroke.

Jones, D.A.; Turkington, R. 1986: Biological Flora of the British Isles. *Lotus corniculatus* L. Journal of Ecology 74: 1185-1212.

Jorgensen, J.R.; Craig J.R. 1983: Legumes in forestry: results of adaptability trials in the south east. Research paper, Southeastern Forest Experiment Station. U.S.D.A. Forest Service No. SE 237 11p.

Jorgensen, J.R.; Davis, C.E. 1983: Methods of sericea lespedeza establishment for forest soil improvement. General Technical Report - South-East Forest Experiment Station U.S.D.A. Forest Service. SE 24: 48-53.

Kingsbury, J.M. 1964: Poisonous plants of the United States and Canada. Prentice-Hall Inc. New Jersey 626p.

Krishna, Hari; Kemp P.D.; Newton S.D. 1990: 'Necton' sulla - A preliminary agronomic evaluation. Proceedings of the New Zealand Grassland Association 52: 157-159.

Lambert, M.G.; Jung, G.A.; Costall, D.A. 1989: Forage shrubs in North Island hill country. 1. Forage Production. New Zealand Journal of Agricultural Research 32: 477-483.

Lambrechtsen, N.C.; Douglas, G.B. 1986: Management and use of *Lathyrus spp.* *In* Van Kraayenoord, C.W.S. and Hathaway, R.L. (Eds) Plant Materials Handbook for Soil Conservation. Volume 2. Introduced Plants. Soil Conservation Centre, Aokautere, Ministry of Works and Development, Wellington.

Lambrechsten, N.C.; Wills, B.J.; Douglas, G.B. 1986: Management and uses of *Lotus tenuis* (narrow-leaved birdsfoot trefoil. *In* Van Kraayenoord, C.W.S. and Hathaway R.L. Plant Materials Handbook for Soil Conservation. Volume 2 Introduced Plants. Soil Conservation Centre, Aokautere, Ministry of Works and Development, Wellington.

Lamp, C.; Collet, F. 1976: Weeds in Australia. Inkata Press Melbourne. 367 p.

Langer, R.H.M. 1973: Pastures and Pasture Plants. A.H. & A.W. Reed, Wellington.

Ledgard, N.J.; Baker G.C. 1988: Mountainland forestry: 30 years research in the Craigieburn Range, New Zealand. Ministry of Forestry, FRI Bulletin No. 145.

Leffel, R.C. 1978: Other legumes. *In* Heath, M.E.; Barnes, R.F.; Metcalf, D.S. (Eds). Forages: the science of grassland agriculture. Iowa State University Press. pp 208-220.

Lonsdale, W.M. 1994: Inviting trouble: Introduced pasture species in northern Australia. Australian Journal of Ecology. 19: 345-354

Macdonald, I.A.W.; Clark, D.L.; Taylor, H.C. 1989: The history and effects of alien plant control in the Cape of Good Hope Nature Reserve. 1941-1987. South African Journal of Botany 55(1) 56-75.

Macdonald, I.A.W.; Jarman, M.L. (Eds), 1984: Invasive alien organisms in the terrestrial ecosystems of the Fynbos biome, South Africa. South African National Scientific Programmes Report No. 85. CSIR, Pretoria.

Matthews, L.J. 1975: Weed control by chemical methods. Government Printer, Wellington 710 p.

Milton, S.J.; Hall, A.V. 1981: Reproductive biology of Australian acacias in the southwestern Cape Province, South Africa. Transactions of the Royal Society of South Africa. 44(3) 465-487.

Moll, E.J.; Trinder-Smith, T. 1992: Invasion and control of alien woody plants on the Cape Peninsula Mountains, South Africa - 30 years on. Biological Conservation. 60(2) 135-143

Morris, M.J. 1991: The use of plant pathogens for biological weed control in South Africa. Agriculture, Ecosystems and Environment 3 (1-3): 239-255.

Musil, C.F. 1993: Effect of invasive Australian acacias on the regeneration, growth and nutrient chemistry of South African lowland fynbos. Journal of Applied Ecology. 30: 361-372

National Water and Soil Conservation Authority, 1982: Sulla. Streamland 1. Soil and Water Division, Ministry of Works, Wellington.

National Water and Soil Conservation Authority, 1986: 'Aokau' sulla. Streamland 46. Soil and Water Division, Ministry of Works, Wellington.

Neser, S. 1985: A most promising bud-galling wasp, *Trichilogaster acaciaelongifoliae* (Pteromalidae) established against *Acacia longifolia* in South Africa. Proceedings of the VI International Symposium on Biological Control of Weeds, Ottawa, Canada. pp. 797-803.

Offutt, M.S.; Baldridge, J.D. 1978: The Lespedezas. *In* Heath, M.E.; Barnes, R.F.; Metcalf, D.S. (Eds). Forages: the science of grassland agriculture. Iowa State University Press. pp 189-198.

Patrick, H.N.; Lowther, W.L. 1992: Response of *Lotus corniculatus* to inoculation and pelleting on a range of Otago tussock grassland environments. Proceedings of the New Zealand Grassland Association 54: 105-109.

Phillips, R.; Rix, M. 1989: Shrubs. Pan Books, London 288p

Phillips, R.; Rix, M. 1991: Early perennials. Volume 1. Pan Books, London 240p

Pieterse, P.J.; Cairns, A.L.P. 1988: Factors affecting the reproductive success of *Acacia longifolia* (Andr.) Willd: in the Banhoek Valley, south-western Cape, Republic of South Africa. South African Journal of Botany 54(5) 461-464.

Quingfeng L.I.; Hill, M.J. 1989: Seed development and dormancy characteristics in *Lotus corniculatus* L. New Zealand Journal of Agricultural Research. 32: 333-336.

Rhys, G.J.; Smith, N.; Slay, M.W. 1988: Alternative forage species for Hawkes Bay. Proceedings of the Agronomy Society of New.Zealand. 18: 75-80.

Richardson, D. M.; Macdonald, I.A.W.; Forsyth, G. C. 1989: Reductions in plant species richness under stands of alien trees and shrubs in the Fynbos biome. South African Forestry Journal. 149: 1-8.

Ross, J.H. (Ed.)1975: Flora of Southern Africa. 16 (1). Department of Agricultural Technical Services, Pretoria 159 p.

Scott, D.; Charlton, J.F.L. 1983: Birdsfoot trefoil (*Lotus corniculatus*) as a potential dryland herbage legume in New Zealand. Proceedings of the New Zealand Grassland Association. 44: 98-105.

Seaney, R.R. 1978: Birdsfoot trefoil. *In* Metcalfe, D.S., Barnes, R.F., (Eds). Forages. The Science of Grassland Agriculture. Iowa State University Press. 177-88.

Selincourt, K. de 1992: South Africa's other bush war. New Scientist 133 (1808) 46-49.

Sheppard, J.S. 1980: The potential value of forage shrubs in New Zealand. Journal of the New Zealand Tree Crops Association Inc. 5(1) 32-39.

Sheppard, J.S.; Bulloch, B.T. 1986a: Management and uses of *Acacia* spp. (Wattles) and Albizia spp. (Brush wattles) *In* Van Kraayenoord, C.W.S. and Hathaway, R.L. (Eds). Plant Materials Handbook for Soil Conservation Volume: 2 Introduced Plants. Soil Conservation Authority. Soil Conservation Centre, Aokautere Ministry of Works and Development,Wellington.

Sheppard, J.S; Bulloch, B.T. 1986b: Management and uses of *Chamaecytisus palmensis*, tree lucerne, tagasaste. *In* Van Kraayenoord, C.W.S. and Hathaway, R.L. (Eds). Plant Materials Handbook for Soil Conservation. Volume 2. Introduced Plants. Soil Conservation Centre, Aokautere, Ministry of Works and Development, Wellington.

Sheppard, J.S.; Douglas, G.B. 1986: Management and uses of *Dorycnium* spp. *In* Van Kraayenoord, C.W.S. and Hathaway, R.L. (Eds). Plant Materials Handbook for Soil Conservation. Volume 2 Introduced Plants. Soil Conservation Centre, Aokautere, Ministry of Works and Development, Wellington.

Simmons, M. 1981: Acacias of Australia. Volume 1. Thomas Nelson, Australia. 325 p.

Speer, C.S.; Allinson D.W. 1985: Kura clover *(Trifolium ambiguum):* legume for forage and soil conservation. Economic Botany 39(2) 165-176.

Stewart, A.V.; Daly G.T. 1980: Growth of an established stand of *Trifolium ambiguum* in a fertile lowland environment. New Zealand Journal of Experimental Agriculture 8:255-257.

Taylor, R.L. 1981: Weeds of roadsides and waste ground in New Zealand. R.L. Taylor, Nelson. 176p.

Taylor, H.C.; MacDonald, A. 1985a: Invasive alien woody plants in the Cape of Good Hope Nature Reserve. I. Results of a first survey in 1966. South African Journal of Botany 51(1)19-20

Taylor. H.C.; MacDonald, A. 1985b: Invasive alien woody plants in the Cape of Good Hope Nature Reserve. I. Results of a second survey from 1976-1980. South African Journal of Botany 51(1)21-29.

Tiedeman, J.A.; Johnson, D.E. 1992: *Acacia cyanophylla* for forage and fuelwood in North Africa. Agroforestry Systems 17(2) 169-180.

Timmins, S.M.; Williams, P.A. 1991: Weed numbers in New Zealand's forest and scrub reserves. New Zealand Journal of Ecology 15(2) 153-162.

Townsend, C.E. 1970: Phenotypic diversity for agronomic characters in *Astragalus cicer* L. Crop Science 10: 691-693.

Townsend, C.E. 1971: Association among characters related to seed production in *Astragalus cicer* L. Crop Science 11: 307-308.

Townsend, C.E. 1977: Recurrent selection for high seed weight in cicer milkvetch. Crop Science 17: 473-476.

Townsend, C.E. 1979: Breeding cicer milkvetch for improved seedling emergence. Crop Science 19: 613-616.

Townsend, C.E. 1980: Registration of Monarch cicer milkvetch. Crop Science 20: 670-671.

Townsend, C.E.; Christensen, D.K.; Dozenko A.D. 1978: Yield and quality of cicer milkvetch forage as influenced by cutting freqency. Agronomy Journal 70: 109-113.

Townsend, C.E.; Schweizer, E.E. 1984: Tolerance of cicer milkvetch (*Astragalus cicer)* seedlings to herbicides. Weed Science 32(1) 37-42.

Tutin, T.G.; Heywood, V.H.; Burgess, NA.; Valentine, D.H.; Walters, S.M.; Webb, D.A. (Eds) 1964: Flora Europaea, Vol. 1. Cambridge University Press, Cambridge. 464p.

Van Wilgen, B.W.; Richardson, D.M. 1985: The effects of alien shrub invasions on vegetation structure and fire behaviour in South Africa Fynbos shrublands: A simulation study. Journal of Applied Ecology 22: 955-966.

Watson, M.J. 1982: *Hedysarum coronarium* - a legume with potential for soil conservation and forage. New Zealand Agricultural Science 16(4) 189-193.

Webb, C.J., Shand, J.E., 1985: Reproductive biology of tree lucerne (*Chamaecytisus palmensis,* Leguminosae). New Zealand Journal of Botany. 23: 597-606.

Webb, C.J.; Sykes, W.R.; Garnock-Jones, P.J. 1988: Flora of New Zealand. Volume IV. Naturalised Pteridophytes, Gymnosperms, Dicotyledons. D.S.I.R. Botany Division, Christchurch. 1365p.

Weiss, P.W. 1981: Seed dynamics of Boneseed and Coastal Wattle in relation to their potential invasiveness. *In* Proceedings of the Sixth Australian Weeds Conference, Wilson, B.J. and Swarbrick, J.T.(Eds) pp. 25-28, Queensland Weed Society for the Council of Australian Weed Science Societies, Brisbane.

Welsh, S.L. 1974: Anderson's Flora of Alaska and adjacent parts of Canada. Brigham Young University Press, Provo, Utah. 724p.

Whibley, D.J.E. 1980: Acacias of South Australia. Government Printer, South Australia. 240 p.

Wills, B.J.; Begg J.S.C.; Foote, A.G. 1989: *Dorycnium* species; two new legumes with potential for dryland pasture rejuvination and resource conservation in New Zealand. Proceedings of the New Zealand Grassland Association 50:169 - 174.

Wills, B.J.; Douglas, G.B. 1984: Canary clovers. Streamland 32, National Water and Soil Conservation Authority Publication. 4pp.

Witkowski, E.T.F. 1991: Effects of invasive alien acacias on nutrient cycling on the coastal lowlands of the Cape Fynbos. Journal of Applied Ecology 28: 1-15.

Witkowski, E.T.F. 1994: Growth of seedlings of the invasives, *Acacia saligna* and *Acacia cyclops*, in relation to soil phosphorus. Australian Journal of Ecology 19: 290-296.

Yonce, M.H.; Skroch, W.A. 1989: Control of selected perennial weeds with glyphosate. Weed Science 17: 360-364.