

Chilean needle grass (*Nassella neesiana*) – a review of the scientific and technical literature

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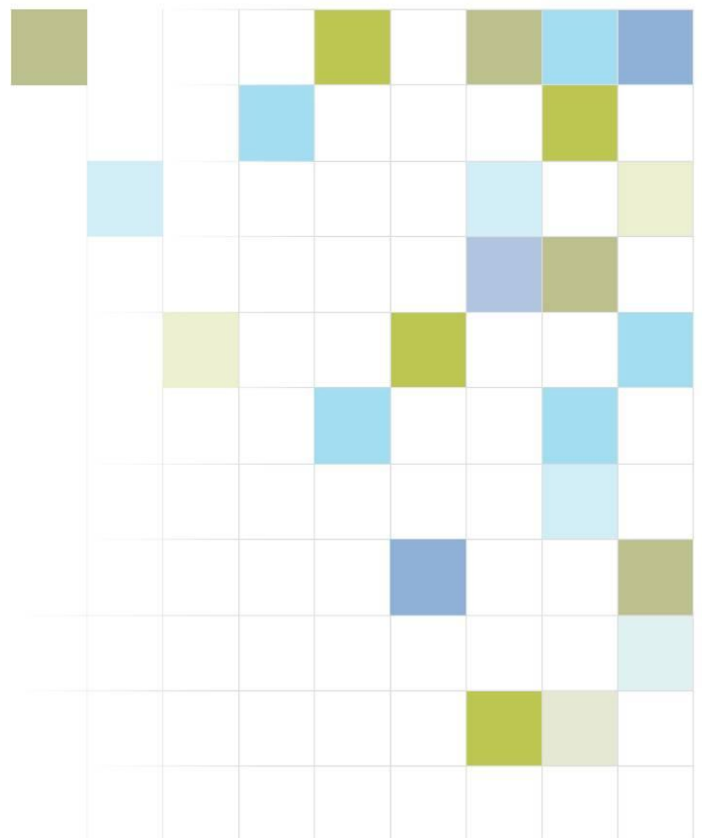
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1. EXECUTIVE SUMMARY

- AgResearch has been contracted by Environment Canterbury to review scientific and technical information on Chilean needle grass and to summarise this information in a written report to the Chilean Needle Grass Action Group.
- A literature search was conducted to find published papers on both the ecology and the management of Chilean needle grass. The key findings of these papers are discussed in this review as a basis for developing an experimental programme to evaluate alternative control options in North Canterbury.
- The key findings from the review are:
 - Chilean needle grass occurs sporadically in New Zealand and more than 70% of the known occurrences are in “high producing pasture”.
 - The weed’s potential distribution in NZ is large (15 million ha is climatically-suitable) but less than 1% of this is currently invaded. In Canterbury, 1.2 million ha of pasture land is climatically suitable, including over 1.0 million ha of high-producing pasture.
 - The seeds of the Chilean needle grass are poorly adapted for dispersal by wind but well adapted for dispersal in hair and wool of farm animals. Nevertheless, spread rates in New Zealand have been slow to date with estimates ranging between 130 metres year⁻¹ and 15-30 m every two years, the latter being associated with one new infested site year⁻¹ for every 565 ha infested.
 - The seeds require light to germinate, a pasture-gap detecting mechanism ensuring that they germinate only when conditions favour seedling establishment.
 - Soil seed banks may be large (18,000 seeds m⁻²) and seed decay rates vary from 38 to 77% year⁻¹ depending management method to prevent seed input.
 - The re-infestation potential of infested soils declines exponentially with time under no-seeding management regimes; for example, 7-10 years of annual treatment with glyphosate is required to reduce a typical seedbank to a re-infestation potential near zero. Annual mowing required 15 years.
 - The weed is detrimental to pastoral farming because its sharp seeds burrow into animal pelts resulting in hide and carcass damage. The seeds also create animal health and handling problems through eye penetration that causes blindness.
 - Under realistic assumptions about rates of local population growth and geographic spread, the benefits of controlling this weed in Canterbury outweigh the costs of control and the benefits of regional management under the RPMS are greater than the benefits from relying upon individual landholder control.
 - Chilean needle grass is a “Total Control Plant” in Hawke’s Bay and a “Containment Plant” in Marlborough.
 - Control options investigated in published experiments include grazing management, biological control, pasture species and selective herbicides, glyphosate, herbicides in lucerne, non-selective herbicides and soil fumigants. Forestry has also been suggested as have also various methods of interrupting the spread of the seeds.
- This report should form the basis for discussions on how to most effectively manage Chilean needle grass at Spotswood, its only known infestation in Canterbury.

2. BACKGROUND

The Chilean Needle Grass Action Group, based in North Canterbury, was successful in securing a Sustainable Farming Fund grant in 2010 to conduct a scoping study to identify options for managing Chilean needle grass in Canterbury. The study would be as a foundation for a larger project evaluating these options and developing a best management practice for this weed in Canterbury.

The Outcomes will be the identification of options for control, containment and education.

The beneficiaries are pastoral, viticulture and arable farmers throughout Canterbury.

The project contributes to the sustainability of agriculture in Canterbury by minimising the risk of this damaging and invasive grass from spreading throughout Canterbury from its only known infestation (at Spotswood, North Canterbury).

The first Milestone for this project is “Scientific and technical literature reviewed and summarised in written report to the Project Team (AgResearch)”. The current report fulfils the requirements of this Milestone.

3. METHODS

A literature search was conducted using the search terms Chilean needle grass, *Stipa neesiana* and *Nassella neesiana*. The findings of the published papers identified by the search are reviewed and summarised in the remainder of this report.

4. RESULTS AND DISCUSSION

The literature search found 29 publications concerning various aspects of the ecology and management of Chilean needle grass in its native range in Argentina, and in its invaded range in both Australia and New Zealand. Twenty four of these publications were scientific papers published in either peer-review science journals or scientific conferences. An additional five publications were technical brochures many of which based their recommendations on information contained in the journal papers and/or the results on unpublished experiments and trials.

4.1 Identification

Chilean needle grass (*Nassella neesiana*) is an erect, tufted, perennial grass, harsh to the touch (Bourdôt & Ryde 1986; Edgar & Connor 2000). The leaves are 1 – 5 mm wide, flat (rolled when the plant is moisture stressed), strongly ribbed on their upper surfaces, with rough margins caused by short marginal hairs. There are tufts of erect hairs on both sides of the base of the leaf in the “collar” region, and these are easily seen when the leaf blade is pulled away from the stem. A short membranous ligule can be seen (with a hand lens) as a small flap of opaque tissue extending across the insides (top) of the leaf base at its junction with the sheath.



Figure 1. Leaf-base characteristics of Chilean needle grass. The hairs on either side of the membranous ligule at the leaf based are evident.

Chilean needle grass produces very distinctive aerial spikelets (each with one seed) in aerial inflorescences (panicles) (Figure 2), and hidden (clandestine) spikelets. The latter occur in multi-floreted inflorescences at each of the nodes inside the leaf sheath (they show as bulges in the flower stem (culm) above the nodes) and as single florets at basal nodes of the culm (Connor et al. 1993). These clandestine florets are termed cleistogenes since they never open and cleistogamy (self pollination) prevails. By contrast, chasmogamy (cross pollination) prevails in the open florets of the aerial panicles (Figure 2).



Figure 2. Chilean needle grass aerial spikelets at anthesis (exerted anthers visible). Cross pollination occurs in these aerial spikelets whereas it does not in the clandestine cleistogamous spikelets hidden inside the flowering stems (culms) (not shown here).

The aerial spikelets are each composed of two purple-coloured glumes (Figure 2) that loosely enclose a caryopsis (fruit) that is itself tightly enclosed by a hardened lemma (8-10 mm long). At the top of the lemma there is a short, toothed corona through which the lemma extends into a long, twisted, two-kneed (bigeniculate), hygroscopic awn, 60-80 mm long. This whole apparatus is commonly referred to as the seed although technically the caryopsis, enclosed in the lemma, is the seed.

The lemma is attached to the spikelet axis by a hard hairy callus giving the “seed” a dart-like appearance (the Argentinian name of the plant is Flechilla = little dart) (Figure 3). When the ripe “seed” is shed from the enclosing glumes the callus remains attached to the lemma providing it with an extremely sharp penetrating based.

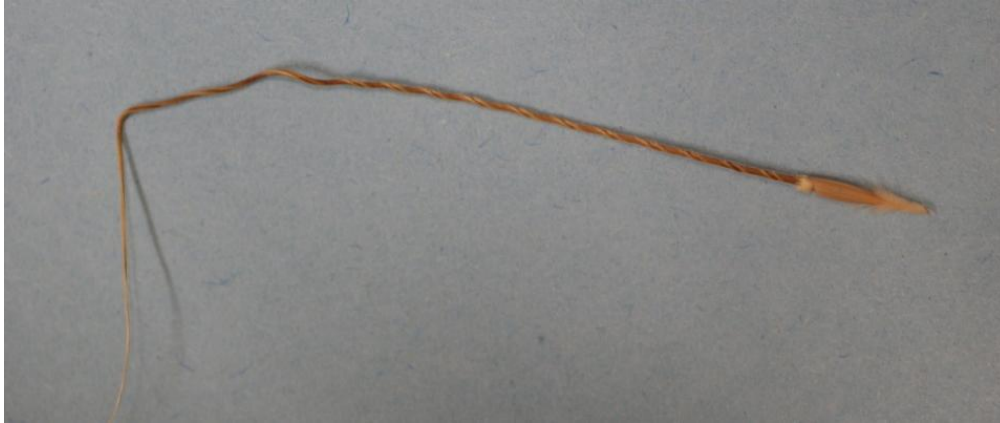


Figure 3. Chilean needle grass “seed” from an aerial panicle showing twisted awn and sharply pointed callus. The entire “seed” (including the awn) is about 7 cm long.



Figure 4. Chilean needle grass “seed” from an aerial panicle close-up showing twisted hairy awn, toothed corona and sharply pointed callus at the base of the lemma.

4.2 Distribution in New Zealand

Current distribution

Chilean needle grass is known to occur sporadically in New Zealand. It is known from Western Spring stadium (Auckland), Hawkes Bay, Manawatu (there is some doubt about the validity of this single record), Marlborough and more recently (Since 2008), North Canterbury (Figure 5).

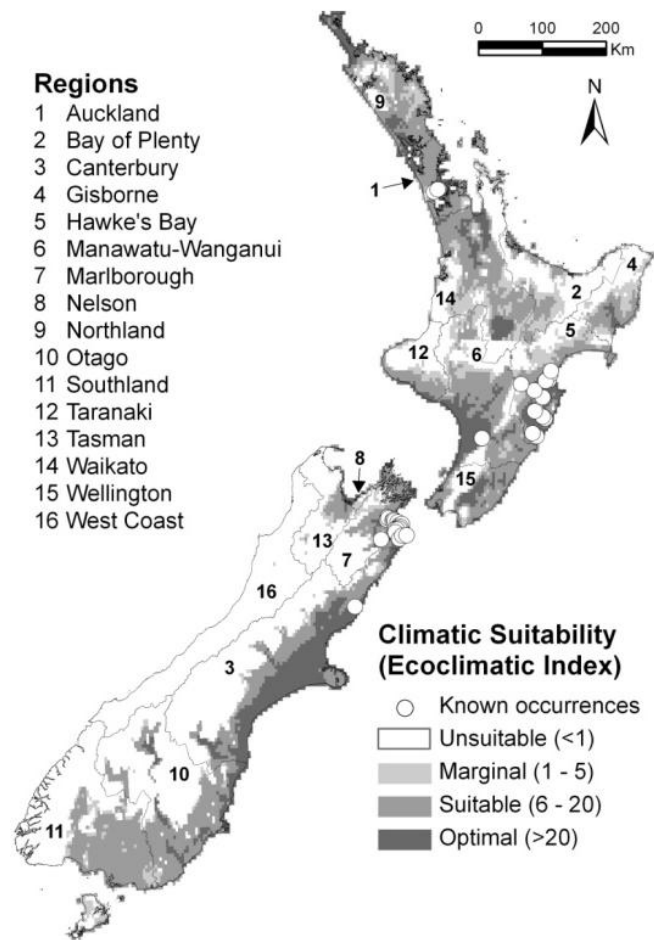


Figure 5. Known occurrences of Chilean needle grass and its climate suitability in New Zealand (Bourdôt et al. 2010 - In Press).

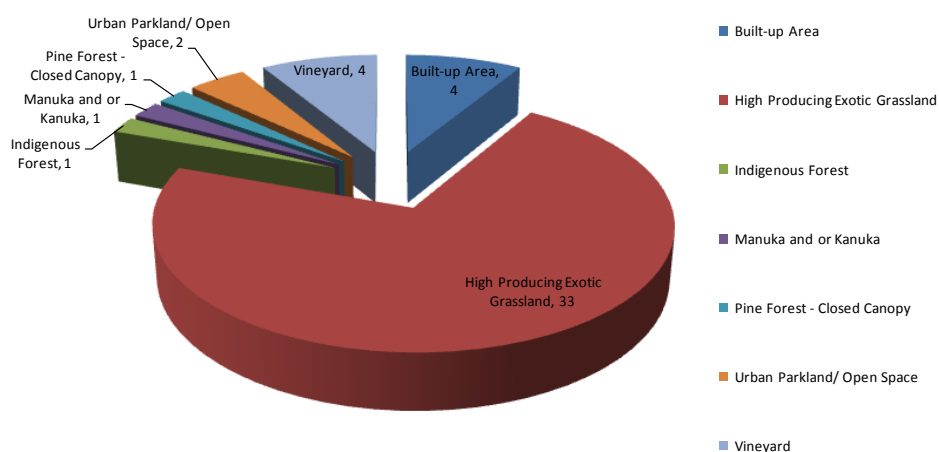


Figure 6. Distribution of the 46 occurrence records of Chilean needle grass among LCDB2 land cover categories in New Zealand.

Of the 46 geo-coded occurrence records of Chilean needle grass shown in Figure 6, 33 (72%) are from land supporting high-producing exotic grassland (Figure 6). The four vineyard occurrences are also essentially in high-producing grassland. This distribution of occurrences clearly demonstrates that Chilean needle grass is a threat predominantly to high producing pastures.

Potential distribution

The potential distribution of Chilean needle grass in New Zealand, as judged by its climate suitability is shown in Figure 5 (Bourdôt et al. 2010 - In Press). This CLIMEX model shows that 15 million ha is climatically suitable in NZ and that only 0.52% of this has been invaded to date. This implies that Chilean needle grass could potentially become a much greater problem in the future and therefore that management to limit its spread is justified.

4.3 Flowering time

The main flowering period for Chilean needle grass on the Northern Tablelands of NSW is from November to February although here some plant may also flower as late as April and May (Gardener et al. 2003a). This pattern of flowering mimics that in its native range in South America. No data exist on its flowering behaviour in New Zealand but observations suggest that it is similar to that in Australia and South America.

4.4 Seed production

Measurements in NSW, Australia indicate that Chilean needle grass produces between 20 and 30 aerial seeds per flowering shoot (culm) during a flowering season (Gardener et al. 2003a) and from 5 to 7 additional “clandestine” seeds at the nodes hidden inside the leaf sheaths (Table 1). Whilst these components of seed yield seem reasonably constant (23-34 seeds culm⁻¹), the density of flowering shoots was highly variable in Gardener’s experiments ranging from 88 to 835 culms m⁻². This variability in culm density probably reflects plant density and/or growing conditions and led to a range in seed yield from 1,993 to 28,097 seeds produced m⁻² (Table 1). By comparison, measurements made in a pasture at Blind River in Marlborough suggest that Chilean needle grass here produces fewer seeds per unit area of infested pasture (Bourdôt 1995) (Table 1). This seems to be due in part to fewer culms per unit area and fewer aerial and clandestine seeds per culm (Table 1).

Table 1. Seed yield components in Chilean needle grass (Bourdôt 1995; Gardener et al. 2003a). The figures for NZ are the averages over 4 plots at each of 3 sites in pasture on a farm at Blind River.

	NSW, Australia			Blind River, Marlborough, NZ			
	1995	1996	1997	1991	1992	1993	1994
Culms m ⁻²	88	835	233	39	155	63	129
Aerial seeds culm ⁻¹	18	27	27	6	11	6	9
Clandestine seeds culm ⁻¹	5	7	7	6	11	6	9
Total seeds culm ⁻¹	23	34	35	11	22	12	18
Total seeds m ⁻²	1,993	28,097	8,076	428	3,390	748	2,297

4.5 Seed dispersal

The seeds of Chilean needle grass readily adhere to wool by virtue of the hairy callus and the hairs on the twisted hygroscopic awn. In a study in Australia, 25 % of seeds attached to wool after grazing remained attached 5 months later (Gardener et al. 2003a) potentially enabling them to be transported long distances by the movement and/or

transportation of sheep. Gardener found that shearing sheep just before the seeds of Chilean needle grass are set in the field reduced the number in the wool.

The seeds of Chilean needle grass may be of little risk of being transported long distances in animal faeces however. For example, in Gardener's study, only 1.7% of panicle seeds and 5.3% of cleistogenes fed to cattle were voided intact (within 4 days) and less than 50% of these were viable (Gardener et al. 2003a).

The seeds are poorly adapted for dispersal by wind and may disperse only short distances (1 to 2.8 metres from parent) by this mechanism (Gardener et al. 2003a). The spirally twisting column of the awn of the aerial seeds, useful for driving them into the soil and into wool and animal pelts by its hygroscopic action, often acts against dispersal of single seeds by twisting round neighbouring awn columns producing an aggregation of seeds which are very likely to fall very close to the mother plant. This is quite unlike the behaviour of nassella tussock (*Nassella trichotoma*) where the whole panicle becomes windborne.

The clandestine seeds, hidden at the nodes inside the leaf sheath, are readily spread by cultivation during pasture renovation and in straw from infested paddocks (Bourdôt personal observation).

4.6 Seed bank, germination and seedling recruitment

In the Northern Tablelands of Australia Chilean needle grass forms a large seed bank. For example, densities of 2,500 to 5,000 seeds m⁻² have been measured (Gardener et al. 2003b). By contrast, in pastures in the Blind River area, Marlborough, New Zealand, seed banks of 4,000 and 18,000 viable seeds m⁻² were measured in 1982 and 1986 respectively (Bourdôt & Hurrell 1992). In the latter study, >99% of these soil-borne seeds were buried less than 25 mm deep.

While the seed banks formed by Chilean needle grass may be quite large, the seeds do disappear from these banks as a result of processes such as predation, germination and ageing. In Australia they were found to disappear at a constant annual rate of 41% per year in pasture from which seed input was prevented by removing the seed heads annually before seeding (Gardener et al. 2003b). In New Zealand, a similar rate of loss of the seeds from the soil seed bank was measured in an experiment at Blind River. Here the annual depletion rate was 38% in an infested pasture in the absence of seed input (achieved by annual mowing over three years) (Bourdôt & Hurrell 1992). In the same experiment, faster rates of loss were measured under other treatments; 61, 66, 68 and 77% annual loss under conditions of repeated glyphosate application, and 1, 2 and 6 cultivations (with a rotary hoe) per year respectively (Bourdôt & Hurrell 1992).

Seedlings recruit annually from the soil seed bank of Chilean needle grass by the process of germination. Estimates of the rate of this "successful" germination vary substantially. In the Australian studies of Gardener the numbers of seedlings expressed as a percentage of the seed bank varied from 0.4% to 5.6%. From similar studies in New Zealand, a crude estimate of the recruitment rate was 32% (Bourdôt & Hurrell 1992).

The process of germination (as distinct from seedling establishment, i.e. recruitment), is promoted by light (Bourdôt & Hurrell 1992). Alternating temperature partly overcomes the need for light, but the germination rate was much higher under all temperatures in the Bourdôt & Hurrell (1992) experiment when the seeds were exposed to light. This implies a pasture-gap/cultivation sensing mechanism that ensures that the seeds germinate only when conditions are favourable for the seedling to establish (i.e. when the vegetation cover has been disturbed).

The estimates of the initial size of a Chilean needle grass seed bank reviewed above, and the rates at which seeds are lost due to predation, ageing and germination, have been used to develop a model that predicts the “re-infestation potential” of an infested site (Bourdôt & Hurrell 1992). In this model the decay rate of the seeds is the most influential parameter and its effect is illustrated in Figure 7. This analysis reveals that given an initial seed bank of 15,000 viable seeds m^{-2} and a seedling recruitment rate of 6.4%, re-infestation potentials approaching zero would require an annual glyphosate treatment programme to continue preventing seed input to the soil for 7 -10 years while an annual mowing programme would need to continue for at least 15 years (Figure 7).

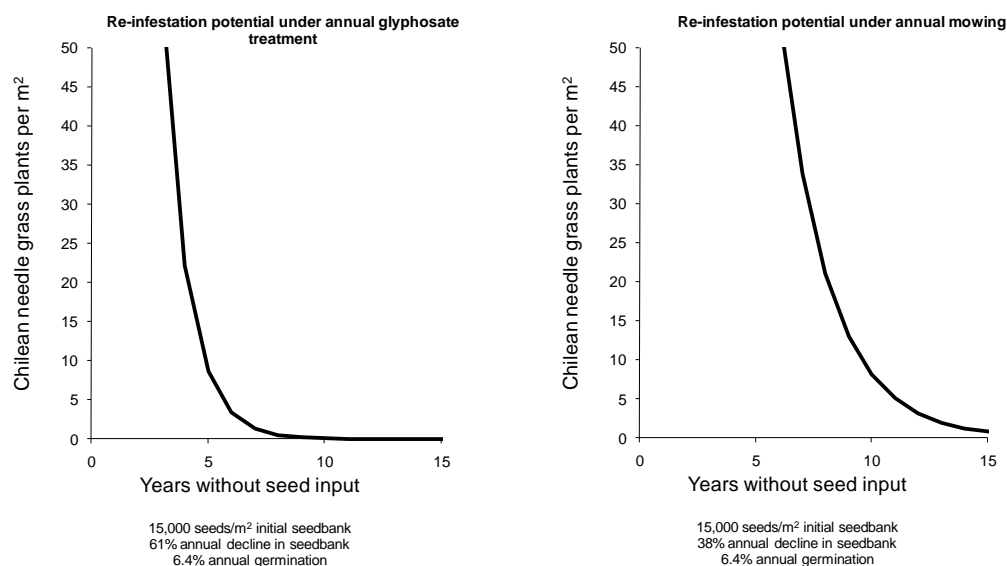


Figure 7. The predicted re-infestation potential for Chilean needle grass in infested pastures in New Zealand under annual treatment with glyphosate (left) or annual mowing (right) preventing seed input (Bourdôt & Hurrell 1992).

4.7 Population growth and spread rates

The rate of local population growth (increase in numbers of plants at an infested site) and the rate of wider geographic spread of the species are two essential parameters for a risk analysis of a weed that is currently limited in its distribution. Data on these rates is typically scarce for weeds and this is certainly the case for Chilean needle grass.

Population growth rate

In the only study of its kind regarding Chilean needle grass, the rate at which a population of this weed increases in size was measured in a sheep pasture in the Blind River area of Marlborough from 1990 until 1994 (Bourdôt 1995). An analysis of the plant density data obtained over these five years revealed that population growth is quite slow. A population of 1 plant m^{-2} was predicted to increase to a stable equilibrium density of 110 plants m^{-2} (1.1 million plants ha^{-1}) in approximately 14 years in the absence of control measures.

Taking a very different approach, using the differences in ground covered by the weed in Marlborough pastures between 1987 (Bourdôt & Hurrell 1989a) and 2005 (Bell 2006), Harris estimated that it would take approximately 30 years for a new population of Chilean needle grass in a pasture (starting at 2% cover) to reach its saturation density (assumed to be 70% cover) (Harris 2010) (Figure 8).

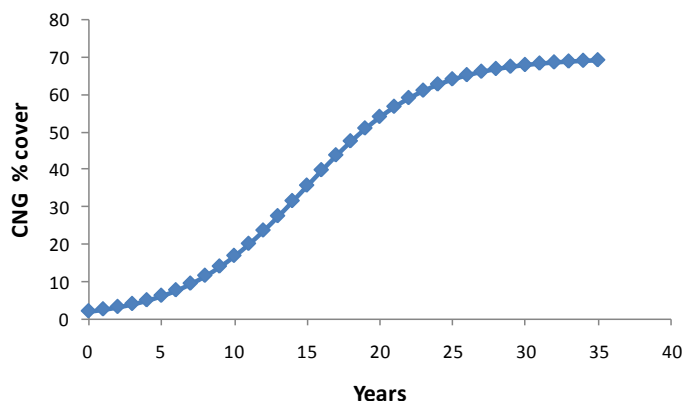


Figure 8. Probable population growth in Chilean needle grass (CNG) in pasture from the logistic model constructed by Harris based on cover estimates in 1987 and 2005 in Marlborough (Harris 2010). The model assumes a carrying capacity of 70% ground cover of the weed.

Spread rate

The rate of spread of Chilean needle grass is apparently rather slow and this may be explained by the species being poorly adapted for dispersal by wind. Crude spread rates can be calculated from historical information. The original plants that established at Blind River in Marlborough in about 1930, had spread only 8 km to the north and south by 1989, a period of 60 years (Bourdôt & Hurrell 1989a). At Waipawa in Hawke's Bay, a similarly slow rate of spread is apparent. After arriving there in about 1962 (on Mr Hornblow's farm apparently in grass seed from Marlborough), it spread about 3.5 km to the west and 1.5 km to the east across adjacent pastoral land during the 30 years until 1992 (Connor et al. 1993). Stock moving between paddocks and farms are the likely dispersal vectors since almost without exception, in both Marlborough and Hawke's Bay, the weed occurs in contiguous paddocks, and often along paddock boundaries (Bourdôt & Hurrell 1989a). Hay being fed out on farms is also a likely vector since on the most heavily infested farm in the Blind River area of Marlborough in the late 1980s, the author (of this report) noticed that many of the occurrences of the weed were associated with feed-out lines. The farmer's father had frequently made the hay in paddocks containing the weed and fed this out across other paddocks on the farm.

Calculating from the Marlborough case, a crude mean rate of spread (between adjacent paddocks and farms) is $0.14 \text{ km year}^{-1}$. This same calculation using the Waipawa data yields the remarkably similar rate of spread of $0.12 \text{ km year}^{-1}$ (Connor et al. 1993).

Harris argued, based on the number of farms newly infested in Marlborough over the period 1987 – 2005 (Bourdôt & Hurrell 1989a; Bell 2006), and the amount of land infested by the weed, that one new infestation per year arises for every 565 ha of existing infestation (Harris 2010). The number of farms infested by Chilean needle grass in Marlborough appears to be increasing exponentially. In 1987, 18 infested farms were known, but by 2000 this had increased to 53, and by 2005, 96 farms were known to be infested (Bell 2006).

4.8 Impacts and economics

Detrimental impacts

In Argentina Chilean needle grass is known as *flechilla* (little dart) because the sharp hard callus at the base of the seed enables the seeds to bore into the skins and eyes of grazing animals resulting in painful wounds. In New Zealand the seeds are known to

damage pelts and blind livestock (Bourdôt & Ryde 1986). Sheepskins from animals grazed in infested pastures during the seeding period may have hundreds of imbedded Chilean needle grass seeds making them worthless (Figure 9). The seeds may also move through the skin and into the underlying muscles causing abscesses that result in the downgrading of the carcass (Figure 9). However, in an Australia study very few of the seeds were found to move into the flesh of sheep (Gardener et al. 2003a).



Figure 9. Chilean needle grass seed damage to sheep skin (left) and carcass (right)

Lambs seem to be particularly vulnerable to the seeds penetrating their eyes resulting in blindness, stock-handling problems and a loss of thrift.

Beneficial characteristics

By contrast to New Zealand, in Argentina, on the highly productive Pampas Plains, Chilean needle grass is considered to be one of the most important winter-growing native species supporting livestock production (Gardener et al. 2005). Here it is readily grazed, produces good quality feed and its perennial nature and persistence during heavy grazing and drought are considered to be desirable attributes (Gardener et al. 2005).

Benefits of control in Canterbury

According to the potential distribution model for Chilean needle grass (Bourdôt et al. 2010 - In Press), almost all of the land east of the foothills in Canterbury is either suitable or optimally suitable climatically for this weed (Figure 10), an area totalling 1.2 million ha (Table 2).

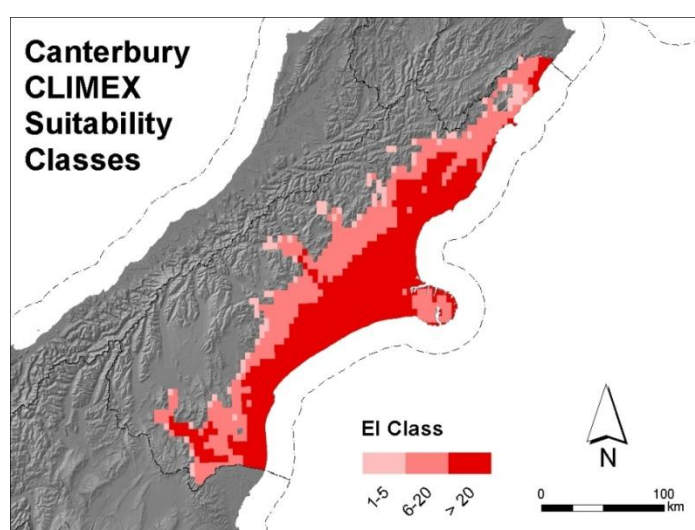


Figure 10. Climatic suitability of Canterbury for Chilean needle grass based on its distribution in South America (Bourdôt et al. 2010 - In Press). Eco-climatic Index 1-5, 6-20 and >20 mean marginally suitable, suitable and optimally suitable respectively.

The breakdown of this climatically suitable/optimal area into Land Use Capability classes and into the two LCDB2 pasture types (High and Low-producing) reveals that 43% of the climatically suitable/optimal land is in the “highly versatile” LUC classes 1-3 and that an additional 54% resides in the “less versatile” LUC classes 4-6. Only 3% of the suitable area is in LUC classes 7-8. Across these LUC classes, 84% of the climatically suitable/optimal land is occupied by “high-producing” pasture and the remainder (16%) by “low-producing” pasture. This analysis shows that Chilean needle grass in Canterbury poses the greatest threat to the high-producing pastures that occur on the highly to moderately versatile land east of the foothills and that its threat to high country pastures is relatively small. Interestingly, the McKenzie basin is climatically unsuitable.

In a recent economic analysis conducted for ECan by Harris Consulting using the above data on susceptible land areas and reasonable assumptions about the probable rates of local increase and geographic spread of Chilean needle grass in Canterbury, it was concluded that inclusion of this weed as a “Containment Plant” in the ECan RPMS is economically justified (Harris 2010). The requirements of Section 72 of the Biosecurity Act 1993 (Anonymous 1993) were met in that the benefits of control outweighed the costs of control (Section 72a) and the net benefits of having the species in the RPMS were greater than the benefits from not having the species in the strategy (i.e. relying on individual landholding intervention) (Section 72b).

Table 2. Land areas in Canterbury with EI>6 for Chilean needle grass (suitable to optimally suitable climatically) by Land Use Capability class and LCDB2 pasture cover type (Harris 2010).

	High-producing pasture	Low-producing pasture	Total
LUC 1-3	514,720	2,588	517,308
LUC 4-6	489,987	161,382	651,368
LUC 7,8	14,646	23,819	38,466
Total	1,019,353	187,789	1,207,142

4.9 Legal status

In Australia, where Chilean needle grass is considered a serious invader, it has been declared a Weed of National Significance. It is also a prohibited species under the Quarantine Act 1908, preventing its sale and distribution in Australia (Snell et al. 2007). In ACT and parts of NSW, it is a “Declared Pest Plant” requiring its control by landholders (Anonymous 2003).

In New Zealand Chilean needle grass is a “Total Control Plant” in Hawke’s Bay requiring land holders to eradicate the species (HBRC 2009) and it is a “Containment Plant” in Marlborough requiring affected landholders to control the weed to prevent it spreading from their properties (MDC 2009).

4.10 Control measures

Grazing

Field experiments conducted on the Northern Tablelands of NSW, Australia during the 1995-96 year in Chilean needle grass-infested pasture simulated the effect of rotational grazing (with 11.5 sheep equivalents ha⁻¹) with and without fertiliser application (Gardener et al. 2005). The crude protein and digestible dry matter of the weed managed in this way was 13-17% and 58-66% respectively. These levels are high enough to support good levels of animal production as has been found also in South America (Fernandez et al. 1986). Nitrogen application enhanced crude protein levels in the Australian study. In a related on-farm study in Australia, high densities of cattle and sheep grazed for short periods followed by long spelling periods reduced the dry weight

contribution of Chilean needle grass in the pasture (Gardener et al. 2005). These studies led Gardener et al. (2005) to postulate that “its [Chilean needle grass] relative abundance in a grassland can be reduced and that of other more desirable species increased, by appropriate grazing management.

Biological control

Studies have been conducted to assess the biocontrol potential of three rust fungi naturally occurring in the native range of Chilean needle grass in Argentina; *Uromyces penganus*, *Puccinia graminella* and *P. nassellea* (Anderson et al. 2010). *U. penganus* is the most promising agent because it causes significant damage to the weed in Argentina and has been found to attack the form of Chilean needle grass occurring in Australia (Anderson et al. 2010) and that in Marlborough in New Zealand (Lynley Hays, Landcare Research, *pers.comm* 2010). Unfortunately the Hawke’s Bay form of Chilean needle grass is apparently not attacked by *U. penganus*. This rust is currently the subject of an application (by Landcare Research) to ERMNZ for importation and release in New Zealand.

Pasture species, fertiliser and pasture-selective herbicide

The results of a pasture renovation experiment on a farm at Blind River, Marlborough, over the three years 1985 – 1988, suggest that the invasion of perennial ryegrass pastures near Lake Grassmere by Chilean needle grass can be attributed to the divergent adaptive strategies of these two species (Bourdôt & Hurrell 1989b); the latter being exceedingly drought tolerant and less palatable to stock. Improvement of soil fertility or selective removal of invading Chilean needle grass seedlings with low doses of the herbicide 2,2-DPA were considered to be possible solutions in a newly established perennial ryegrass pasture. Unfortunately, 2,2-DPA is no longer available in New Zealand. However, the herbicide flupropanate, may be a useful alternative to 2,2-DPA for selective removal of Chilean needle grass from a pasture (Bennett et al. 2010?). As a result of a positive market survey (Minehan et al. 2009 - planned), the data needed for the registration of this chemical in New Zealand are currently being obtained in field trials in Marlborough (Ben Minehan, Marlborough District Council, *pers. comm.*)

Other herbicides in pasture

In field experiments in Australia, glyphosate has proven effective at preventing the production of the aerial panicle seeds in Chilean needle (Gaur et al. 2005). The probability of these seeds forming reduced steadily with increasing dose rate until at 400 g glyphosate ha⁻¹ (1.1 litres Roundup ha⁻¹), less than 10% of treated plants produced viable seed in the aerial panicles. However, the viability of the basal cleistogenes was not affected (Gaur et al. 2005), presumably because they were mainly produced in previous seasons and thus no longer connected to the parent plant and unable to take up the herbicide. Rates as low as 135 g glyphosate ha⁻¹ (0.375 litres Roundup ha⁻¹), applied mid-late October prevented the production of aerial seeds. By comparison, 2,2-DPA proved ineffective at stopping seed production. These authors concluded that low, sub-lethal dose rates of glyphosate, could be used to “spray top” a pasture in spring to reduce the seed production of Chilean needle grass.

Glyphosate has also been tested on Chilean needle grass in New Zealand (Bourdôt & Hurrell 1987a). When applied in spring with a “hockey stick” wick applicator on one or both sides of the plant, it killed 44% of the plants. The remaining (56%) of plants had several surviving tillers. Glyphosate applied in May or August with a spray boom at rates from 720 to 2,160 g ha⁻¹ (2 – 6 litres Roundup ha⁻¹) killed 100% of the plants in an infested pasture. By comparison, no control was achieved when glyphosate was applied during drought conditions. 2,2-DPA suppressed the weed but ethofumesate, propyzamide, TCA and maleic hydrazide were ineffective.

Herbicides in lucerne

Lucerne provides an excellent opportunity to reduce Chilean needle grass since several grass-killing herbicides are available for use with this crop. During 1984/85 and 85/86 an experiment was conducted in a Chilean needle grass dominant pasture at Blind River, Marlborough to compare pre-plant, early post-emergence and winter applied grass killers in a spring-sown lucerne crop (Bourdôt & Hurrell 1987b). Pre-plant treatment with EPTC or trifluralin gave 99% and 97% reduction respectively in the dry matter yield of the reinvading Chilean needle grass. By contrast, early post-emergence treatments of fluazifop-butyl, alloxym-sodium or carbetamide gave poor control. Winter treatments of atrazine, simazine or metribuzin in mixture with paraquat gave more 99% reduction in the Chilean needle grass on the EPTC, trifluralin, fluazifop-butyl and alloxym-sodium plots. The recommendation from this experiment was to use either EPTC or fluazifop-butyl at the time of establishing a lucerne crop in the spring (after killing the existing Chilean needle grass with glyphosate), followed by metribuzin + paraquat in the winter (Bourdôt & Hurrell 1987b).

Non-selective herbicides

Granule formulation of hexazinone, chlorthiamid and dichlobenil were compared against Chilean needle grass in Marlborough in 1987/88 (Hurrell & Bourdôt 1988). Hexazinone applied at 16 kg ha⁻¹ in August to well-established tussocks killed all treated plants and prevented seeding and seedling establishment for at least 7 months. Lower rates gave less than 100% kill but 8 kg ha⁻¹ prevented seeding and seedling development. By comparison, chlorthiamid (up to 60 kg ha⁻¹) and dichlobenil (up to 54 kg ha⁻¹) gave only partial control of the treated tussocks and did not prevent survivors from seeding 3 months after treatment.

Soil fumigants

The fumigants, dazomet, metam-fluid and methyl bromide were compared for their ability to kill buried seeds of Chilean needle grass at Blind River, Marlborough in 1984/85 and 1985/86 (Hurrell et al. 1994). Dazomet and methyl bromide were both almost 100% effective within 7 days of application. Metam-fluid was less effective.

Technical manuals, brochures and fact sheets

In addition to the scientific papers that have tested herbicides and other control methods (reviewed above), there are several technical publications (of New Zealand and Australian origin) that incorporate the results of the above papers and, in some cases unpublished trials, into management recommendations (Bourdôt & Ryde 1986; Bourdôt 1988; Slay 2002; Anonymous 2003; Snell et al. 2007). Key among these is the booklet by Slay (2002), which is essentially a "weed management resource kit" for Chilean needle grass in Hawke's Bay. It contains information on: seed types, botanical identification, field identification, history in NZ, distribution in Hawke's Bay, pest status, lifecycle, seed production and dispersal, management options, beneficial attributes, legislation in Hawkes' Bay, glossary and references. The management options discussed are:

1. use of herbicides via "chemical topping" and "carpet wiping" in spring in hill country to prevent seeding or to kill plants using glyphosate or haloxyfop;
2. fumigation with dazomet prior to pasture establishment;
3. mowing to prevent seeding;
4. cultivation to deplete the seed bank;
5. pasture establishment to outcompete the weed;
6. grazing management to keep the weed short with few flowering tillers;
7. hand removal of individuals by digging and burying, and by spot spraying with glyphosate followed by burning and then a second glyphosate treatment to kill seedlings;

8. biological control possibilities;
9. forestry to create a canopy that inhibits the growth of Chilean needle grass.

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