Chilean rhubarb (*Gunnera tinctoria*): biology, ecology and conservation impacts in New Zealand

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Chilean rhubarb (*Gunnera tinctoria*): biology, ecology and conservation impacts in New Zealand

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ABSTRACT

The history of introduction, spread, biology, ecology, and impacts of Chilean rhubarb (*Gunnera tinctoria*) are summarised from the literature and field observations. In New Zealand, Chilean rhubarb occupies mainly damp coastal bluffs, riparian zones and disturbed ground, with its greatest abundance in Egmont Ecological District, western North Island. It produces abundant fruit, which are dispersed by birds, and forms dense patches that exclude virtually all other plants. It threatens the integrity of indigenous communities such as coastal herbfields, including those containing threatened plant species. Chilean rhubarb is at an early stage of invasion over much of New Zealand. However, it has been such a popular and widespread garden plant that control programmes have included campaigns to inform people of its impacts. It is now illegal to propagate or plant Chilean rhubarb in New Zealand, and it is listed in several Regional Pest Management strategies. Information on its control is given.

Keywords: Chilean rhubarb, *Gunnera tinctoria*, coastal herbfields, weeds, control, New Zealand.

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1. Introduction

Chilean rhubarb (*Gunnera tinctoria* [Molina] Mirbel) has been recognised as a weed of conservation land in New Zealand only within the last decade; it was not listed as a weed of protected natural areas by Williams & Timmins (1990). By 2005 it was naturalised in all thirteen Department of Conservation (DOC) conservancies and appears, generally, to be just starting to spread (Owen 1997; DOC Bioweb National Weeds Database). The potential ecological impacts of Chilean rhubarb in New Zealand may have been underestimated, as it has seldom been reported as a weed overseas. The same is true for other new weeds of conservation concern in New Zealand, including holly-leaved senecio (*Senecio glastifolius*), white bryony (*Bryonia dioica*) and climbing asparagus (*Asparagus scandens*). Some DOC staff are concerned that Chilean rhubarb is a potentially serious invasive weed in New Zealand. We undertook a literature review and investigated the species' behaviour in New Zealand generally, including fieldwork, to clarify its potential weediness. Our aim was to guide future management—a realistic aim given that, on a national scale, Chilean rhubarb is at an early stage of invasion.

1.1 OBJECTIVES

The objectives of the current study were:

- To review the biology and ecology of Chilean rhubarb; both within its native range and in the rest of the world.
- To make predictions about its possible ecological impacts and future spread in New Zealand.
- To recommend control measures.
- To provide options to increase public awareness of Chilean rhubarb.

1.2 METHODS

We searched for information on Chilean rhubarb from the international literature and solicited information from relevant DOC Conservancy and Area Offices, and other sources within DOC. This information was complemented by field observations from 2000 to 2004 by the authors, individually and together. On four days in March 2000, we visited some North Island areas where Chilean rhubarb was naturalised. At each site we filled in a plot sheet noting the nature and extent of the Chilean rhubarb infestation, the reproductive stages present and the composition of the vegetation being invaded (Appendix 1). We also drew on field work in the Taranaki area by one of us (CCO) prior to commencing this survey, and on the field trials to control Chilean rhubarb conducted by DOC staff (JC and others) in the area, and sundry observations at Nelson by one of us (PAW). The information from the various sources is presented below using a format similar to that used in other autecological

studies of weeds in DOC science publications (e.g. Williams & Timmins 1999, 2003; Williams et al. 1999) and that adopted for published biological floras. For the most part, the very scant information available in the literature and our original observations and minor experiments are interwoven; in a few sections they are presented separately.

2. Taxonomy and description

Gunnera tinctoria (Molina) Mirbel is in a distinctly southern hemisphere genus of the Family Gunneraceae. It is one of about 14 large-leaved *Gunnera* species in South America (Wanntorp 2003). The genus is represented in the New Zealand native flora by a few endemic species of small-leaved creeping herbs. There are 10 New Zealand *Gunnera* species (Allan 1961) or five (Webb et al. 1988), depending upon the taxonomic weight given to differences in characters such as fruit colour and leaf indumentum.

The common name in New Zealand for *G. tinctoria* is Chilean rhubarb (Webb et al. 1988). Some gardeners also use 'giant rhubarb', a name more often used for *G. manicata*. Chilean rhubarb is a summer-green herb, with short, stout, horizontal rhizomes which give rise to stout petioles up to 1000 (1500)[1] mm × 45 mm that are studded with short reddish prickles. The leaf lamina measures up to about 0.8 m × 1.0 m with 5–7 lobes. It is very coriaceous, and hairy beneath, especially on the veins. Massive over-wintering buds—up to 250 mm long—accumulate on the rhizomes and they are covered in pinkish, pinnatisect scales that extend to the broad leaf midribs.

The flowers are borne on panicles ≤ 1 m long; usually three or four per plant. Individual flowers are densely packed, sessile, apetalous, with minute sepals, and only c. 1 mm long. Style length is slightly less than the ovary. The drupes are reddish, oblong, and 1.5 mm–2 mm long. Each contains a single ovoid and flanged seed of 1.2 mm × 1–1.5 mm diameter, weighing 4 mg. The hundreds of fruit are regularly arranged and densely packed on the infructescence.

3. History and distribution

3.1 NATIVE RANGE

Chilean rhubarb is native to both sides of the Andes from Colombia to Chile. In Southern Chile (at latitudes of 36°–42°S) it is a delicacy associated with Mapuche Indian customs. The young petioles are commonly sold by street vendors and eaten raw, along with salt and chilli to enhance the flavour (E. Villouta pers. comm. 2004).

[1] Numerals in parentheses here and elsewhere indicate extreme dimensions e.g. 1000 (1500) mm indicates the usual petioles are around 1000 mm long, but can be up to 1500 mm.

3.2 NEW ZEALAND

Chilean rhubarb is a popular horticultural plant in much of New Zealand. It was listed by Gaddum (1999) as available at 13 wholesale nurseries in New Zealand. It has been widely grown as a waterside plant in parks, botanic gardens, and in large public and private gardens throughout New Zealand. Chilean rhubarb was first collected in the wild in New Zealand in 1968. By 1988 it had been found naturalised in Hawke's Bay, Taranaki, Wanganui, Banks Peninsula, Dunedin and Stewart Island (Webb et al. 1988). A decade later it was much more widespread, being recorded from all Conservancies and half of DOC Areas (Fig. 1).

In many situations it occurs only as a 'semi-wild' garden escape, e.g. on Stewart Island (Wilson 1982). In many other places where it might be expected, it is not (yet) present. For example, during a recent survey of the Rangitikei River from sea level to the central volcanic plateau it was not seen on bluffs or in the river bed, despite extensive wet cliffs (Williams & Wiser 2004).

At some sites in Egmont Ecological district it has been present for a long time; e.g. in 1972 Tony Druce collected specimens CHR 222632 and 222633 from 'ESE of Oeo, Taranaki coast, between Opuhi and Waikaretu Streams—wet coastal cliffs'. CCO made regular visits to the seacliffs at Normanby Road in the Egmont Ecological District during 1990–95 but first found Chilean rhubarb there in November 1995 (CHR 510231). Only three plants, all seedlings, were found and these were removed. By 1999, flowering plants and seedlings of Chilean rhubarb were common at the Normanby Road end. It may have been present much longer because it was collected in 1972 from wet coastal cliffs between Opuhi and Waikaretu Streams—in the same general area. At other sites in this ecological district it appears to be spreading quite quickly, e.g. along Timaru Stream during the course of this study. In 2000, the most northern infestation known was at Puketapu Road and the most southern at Normanby Road, Manaia. While we did not do a systematic search, the whole coast has numerous popular road-ends and there were no reports of Chilean rhubarb beyond the range we had observed ourselves in 2000. However, by May 2004, following aerial and ground surveys, the known range was much extended. Chilean rhubarb had been found as far north as the Waiongana Stream and Mimi River mouths (35 km east of New Plymouth, Joe Carson, DOC, pers. comm. 2004). In the south of the region there was a large infestation 5 km inland from Waiinu Beach, 3 km east of Waitotara.

In the Manawatu Region, Chilean rhubarb also occurs on cliffs, including inland cliffs in the Pohangina Valley.

Chilean rhubarb was not listed as a weed of conservation land in the late 1980s (Williams & Timmins 1990; Timmins & McKenzie 1995). However, a decade later (based on information supplied by CCO), it was listed as a potential weed (Owen 1997); it has since been classified as a DOC weed (C. Howell, DOC, unpubl. data). However, the weed threat posed by Chilean rhubarb is still insufficiently recognised, as the following example highlights. In November 2004, CCO found several young plants of Chilean rhubarb, one in flower, on a wet clay bank beside SH4 on the northern edge of Raetihi township in the Tongariro volcanic ring plain. One was taken as a voucher specimen: CHR 572224. The remaining plants were still present in early April 2005. Makotuku Stream, which joins the Mangawhero River about 6 km to the south, is just

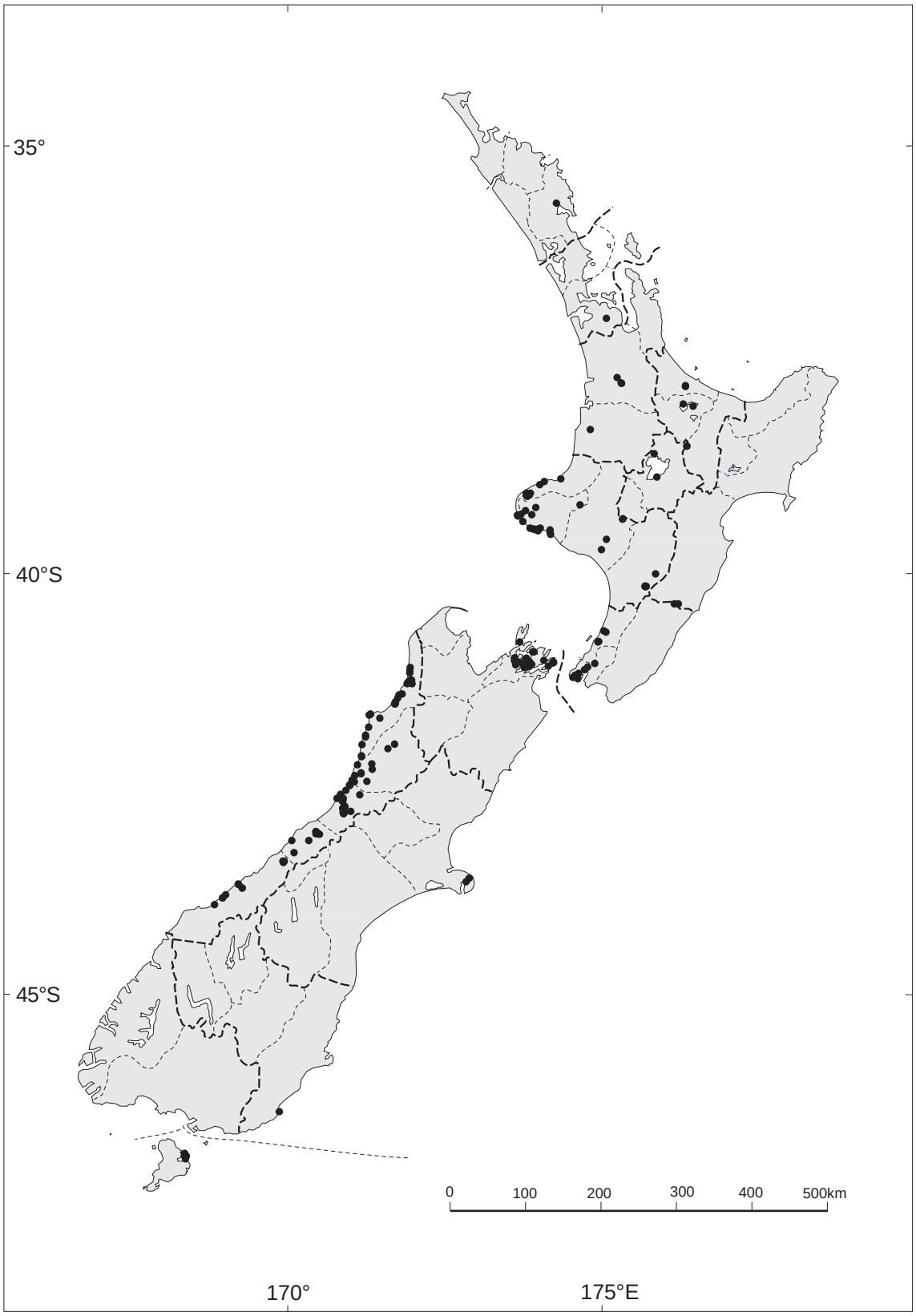

Figure 1. The naturalised distribution of Chilean rhubarb (*Gunnera tinctoria*) in New Zealand, based on observations of Department of Conservation staff and of the authors. Distribution records lodged on the DOC National Weeds Database (DOC 2004).
Note: dark lines = Conservancy boundaries; light lines = Conservancy Area boundaries.

across SH4 from the infested bank. It is very similar to infested streams on the Egmont ring plain, being cut down through lahar debris and tephra layers with steep, wet, shady banks, in a cool climate. Lessons from Taranaki about the rapid spread of Chilean rhubarb need to be applied nationally

3.3 REST OF THE WORLD

Chilean rhubarb has become naturalised in the British Isles and is particularly common in western Ireland (Hickey & Osborne 1998). It also occurs in northwestern France and the Azores (Philips & Rix 1993), and coastal California (Hickman 1993). Of these countries, only in Ireland is it considered a weed (Campbell & Osborne 1990). Both Chilean rhubarb and its larger relative *G. manicata* are available in nurseries and grown in Australia, but neither have naturalised there.

4. Habitat

4.1 CLIMATIC REQUIREMENTS

On the western side of the southern Andes, at latitude 41°S (the same latitude as the major infestations in New Zealand), Chilean rhubarb grows to c. 800 m a.s.l. (Schick 1980). In Ireland, Chilean rhubarb is confined to the western areas where freezing temperatures are uncommon because of the Gulf Stream current; its eastern expansion appears to be related to intolerance of low temperatures (Hickey & Osborne 1998).

In New Zealand, Chilean rhubarb grows from sea level to 380 m a.s.l. on Mt Taranaki in the North Island and is widely scattered elsewhere (Fig. 1; Appendix 1). The areas where it is present cover a range of summer temperatures but lack extremes, and they have abundant and relatively even, year-round precipitation. Chilean rhubarb grows in land environments (Leathwick et al. 2003) with low to high solar radiation, mild to warm temperatures, and nil to moderate annual water deficit.

4.2 SUBSTRATE

Chilean rhubarb grows on leached soils in high rainfall areas (Campbell 1994; Jarzen 1980; Osborne 1989). In Chile and Argentina these soils are mostly alluvial or colluvial, derived mainly from volcanic ash and with high water tables (PAW pers. obs.). In Ireland, it grows in thin (< 1 m) gley soils of marine origin (Hickey & Osborne 1998).

In New Zealand, Chilean rhubarb grows on substrates derived from a wide range of sedimentary rocks but, because its greatest concentrations at present are in the western North Island, most soils also have a large component of

volcanic material. The coastal cliffs in Egmont Ecological District from Manaia westwards are mudstone, overlain by volcanic (andesitic) material. The two are often intermixed on talus slopes. The most vigorous stands of Chilean rhubarb are found on colluvium or alluvium.

Chilean rhubarb appears to tolerate wet soils that are seasonally waterlogged. Along the sea-cliffs of Egmont Ecological District, we observed that it often occurs where water seeps out on top of impervious horizontal strata. Some leaves showed salt damage, but in the main the plants appear to be very tolerant of salt spray and on coastal sites can grow right to the high tide mark. Chilean rhubarb establishes less commonly on excessively drained and drought-prone sandy or stony soil. In Ireland, measurements of soil pH in summer ranged from pH 4.7–5.5 under Chilean rhubarb compared with pH 4.5–5.1 in non-colonised areas (pH water-determined; Hickey & Osborne 1998).

4.3 PLANT COMMUNITIES

In parts of its native range in Chile and Argentina, Chilean rhubarb grows on forest margins adjacent to wetland areas, stream sides and, particularly, on bluffs and talus slopes. In southern Chile, the main species in the adjacent forests are the trees *Laurelia philippiana*, *Nothofagus dombeyi* and *Saxegothaea conspicua,* and the shrubs *Fuchsia magellanica*, *Buddleja globosa* and *Aristotelia chilensis* (Schick 1980).

Outside its native range, in Ireland, Chilean rhubarb grows in unfertilised wet meadows where, pre-invasion, the main species are grasses *Agrostis* spp. and *Anthoxanthum odoratum*; sedges (*Juncus* spp.); heather (*Calluna vulgaris*); and forbs such as *Epilobium palustre* and *Ranunculus* spp. After invasion, the grasses and rushes lose dominance and are replaced by forbs including *Apium nodiflorum*, *Cardamine* spp. and *Cirsium arvense* (Hickey & Osborne 1998).

In the North Island of New Zealand, the species associated with Chilean rhubarb vary with the habitat. In coastal areas of Egmont Ecological District the main conspicuous species are *Carex* aff. *geminata*, taupata (*Coprosma repens*), toetoe (*Cortaderia fulvida*), *Cyperus ustulatus*, and flax (*Phormium tenax*). The frequent smaller species include the coastal herbs *Samolus repens*, *Selliera radicans*, *Lobelia anceps* and Yorkshire fog (*Holcus lanatus*) with sow thistle (*Sonchus oleraceus*) locally common. In more modified habitats there are wet pasture species, such as hawksbeard (*Crepis capillaris*), creeping buttercup (*Ranunculus repens*), narrow-leaved plantain (*Plantago lanceolata*) and clover (*Trifolium* spp.) on the land adjacent to the cliffs.

On streamsides close to native vegetation the associated species include tree ferns (e.g. *Cyathea medullaris*, *Dicksonia squarrosa*), *Cortaderia fulvida*, kiekie (*Freycinetia banksii*), and shrubs such as *Coprosma* spp. and hangehange (*Geniostoma rupestre* ssp. *ligustrifolium*). Away from native vegetation there are more naturalised exotic species. Vines and scrambling plants feature strongly among these, especially blackberry (*Rubus fruticosus* agg.), periwinkle (*Vinca major*) and Japanese honeysuckle (*Lonicera japonica*). In the Pohangina valley near Palmerston North, Chilean rhubarb is associated with a raupo (*Typha orientalis*) reedland. The Chilean rhubarb site

at the head of Wairau Stream in the Kaitake Range of Egmont National Park has species typical of debris slopes. These include the fern kiokio (*Blechnum novae-zelandiae*), silver tussock (*Poa cita*) and *Cortaderia fulvida*, as well as species common to all open habits, e.g. rangiora (*Brachyglottis repanda*), pate (*Schefflera digitata*) and kiekie.

In Taranaki, the habitats occupied by Chilean rhubarb are unstable and it competes directly with native species for occupancy of new sites. This competition starts from the time the bare ground is first colonised (Fig. 2). We observed few other plants growing beneath dense patches of Chilean rhubarb. At one site there were a few grasses and etiolated seedlings of karamu (*Coprosma robusta*), and at two others there were straggling vines of pink bindweed (*Calystegia sepium*) plus clumps of black nightshade (*Solanum nigrum*) seedlings. It seems likely that Chilean rhubarb will persist at these sites, to the exclusion of native species.

Figure 2. Seedlings of Chilean rhubarb (large leaves, middle ground) and threatened native plants *Euphorbia glauca* (small, narrow-leaved plant next to pen and elsewhere in photo) and *Sonchus kirkii* (lower left) colonising bare ground on a south Taranaki sea cliff. The Chilean rhubarb plant will quickly shade out the natives. *(Photo: Colin Ogle)*

5. Growth, reproduction and dispersal

Chilean rhubarb shoots are dormant under winter conditions. In the western North Island the leaves collapse by about April (autumn) and start to reappear in September (spring), reaching full expansion in November. On the coast in Egmont Ecological District, some plants retain some leaves through the winter. In Nelson in the South Island, leaves are lost by late July, but the period of dormancy lasts only a couple of months; new shoots are produced by late August, and full leaves are developed by October.

Hickey & Osborne (1998) found that in Ireland, biomass (including much leaf material) peaked in late summer and was maintained until early winter. The above-ground standing biomass of Chilean rhubarb was c. 1.3 kg/m^2 with rhizomes contributing 60–70% of the total biomass. This biomass production was similar to other measurements from Ireland and four times higher than other species from comparable grassland areas (Hickey & Osoborne 1998).

Chilean rhubarb is associated with a nitrogen-fixing cyanobacterium, *Nostoc punctiforme* (Osborne 1988; Osborne et al. 1991) which we observed even in tiny seedlings. Nitrogen concentrations in Chilean rhubarb tissue were, on average, 22 mg/g in the leaf and 8.7 mg/g in the rhizomes, which was 50% higher than plant tissue of herbs collected from plots without Chilean rhubarb (Hickey & Osborne 1998). Hickey & Osborne suggested that this did not translate to higher nitrogen concentrations in the soil of the colonised plots because of the complex relationship between water content and nitrogen mineralisation. Nitrogen mineralisation in Chilean rhubarb stands was highest in spring, providing the plants with an additional source of nitrogen when there is increased demand during the early period of canopy regrowth (Hickey & Osborne 1998).

Chilean rhubarb produces small, greenish flowers that are either female or hermaphrodite on the same plant and are, therefore, gynomonoecious (Webb et al. 1988). Hymenopterous insects, particularly bees, are probably the main pollinators (PAW pers. obs.). Flowers are produced in spring—in late October in Egmont Ecological District and by early November in Nelson. In both areas, flowers are present for at least a month. Plants in the cool, moist climate of Pukeiti Rhododendron Trust gardens (4000 mm of rainfall per annum and 360 m a.s.l.) took three years to reach tall stature and appeared to flower only after four or five years (G. Smith, Pukeiti Rhododendron Trust, pers. comm. 2003).

We observed that fruit are produced around December in Egmont Ecological District and remain on the plants through to March, becoming more conspicuous as the leaves die back. In Nelson, fruiting is from March to June. Fruits are 3 mm × 2 mm, weigh 4 mg, and have a flesh dry weight of 0.6 mg and a seed dry weight of 0.7 mg (48% flesh, dry weight). The flesh is 74% water, which is typical of fleshy-fruited adventive species in New Zealand (Williams & Karl 1996). On the coast west of Mt Taranaki, the number of fruit ranges from 12 000 to 83 000 borne on 1-m infructesences; up to a quarter of a million fruit per plant.

Germination tests were conducted on seeds collected at Oeo in Egmont Ecological District in early March 2000. Seeds were picked individually off the heads of several plants. We also obtained some from dry bird faeces at the same site. The faeces were deposited at the junction of the lamina and the petiole, probably by blackbirds (*Turdus merula*), judging from their size.

Both sets of seeds were washed under running tap water to remove the pulp or to extract them from the other faecal material. Two replicates of 25 seeds of the two seed lots were placed on filter paper within covered petri dishes and kept moist with tap water at room temperature. Germination commenced after seven days for the 'faeces seed' and 14 days for fresh seed. Fifty percent germination was achieved within 14 days for the former, and within 15 days for the latter. Both groups achieved 100% germination within 30 days.

This suggests a very high germination percentage from fresh seed, which probably have no dormancy mechanism after the flesh is removed (and, thus, less ability to form seed banks). Further evidence for a minimal seed bank comes from Pukeiti Rhododendron Trust gardens on the lower slopes of Mt Taranaki. They used to remove the flower heads from Chilean rhubarb before seed was set. Once this practice was started, it took just two years before no new seedlings came up (G. Smith, pers. comm. 2003).

Our tests suggest that seeds are not damaged by passage through at least one species of bird—rather, that germination is more rapid. Blackbird and white-eye (*Zosterops lateralis*) have been observed eating the fruit. Both are common in the Egmont Ecological District and are probably the main agents of dispersal (Cotton & Molloy 1986; Miller 1996).

Chilean rhubarb also grows readily from stem fragments, and such fragments are common where bits of established plants break off and tumble down steep slopes or where floods carry fragments down streams. The stream-side distribution of Chilean rhubarb suggests seeds are probably dispersed by water as well.

Our observations suggest that germination and seedling emergence occurs from spring right through summer. In late summer in Egmont Ecological District, we found a wide variation in plant size, from small seedlings with only two green leaves, to large adults. At a small erosion scar on Mt Taranaki, all seedlings found were pulled out in January 2000 (H. Priest, DOC, pers. comm. 2000). By March 2000 there was a new batch of seedlings. Our germination trials suggest these seedlings could well be from seed produced in the same year, but this may vary between sites.

The literature we reviewed revealed no information about predators or influence of grazing. In New Zealand, Chilean rhubarb's relative lack of insect pests and diseases made the species attractive to horticulturalists. In both the Egmont Ecological District and the Pohangina Valley we found Chilean rhubarb leaves browsed by cattle. We also observed a lack of seedlings in pasture—despite the many large plants adjacent and the consequent seed rain—suggesting that grazing limits Chilean rhubarb's encroachment into pasture.

6. Ecological Impacts

Where Chilean rhubarb invades native grasslands in Ireland, the once dense, species-rich native grassland is replaced by a sparse cover of dicotyledonous species not found in uninfested grasslands (Hickey & Osborne 1998). Chilean rhubarb also replaces grey willow (*Salix cinerea*) and thus alters the process of natural vegetation succession (Hickey & Osborne 1998). These authors also noted changes in nitrogen mineralisation, but did not consider that these were directly associated with the changes in species composition, because a high proportion of the nitrogen is actually immobilised above ground in the rhizomes of the plant.

In 2001 we asked DOC weed staff to rate the ecological impact of Chilean rhubarb in their Area or Conservancy against five impact categories—the same as those used for climbing spindleberry (*Celastrus orbiculatus*, Williams & Timmins 2003), modified from categories used by Owen (1997). The perception of these staff was that Chilean rhubarb was having an ecological impact in some parts of the country but not in others (Table 1).

The ecological impacts of Chilean rhubarb in New Zealand are particularly severe where it has formed dense stands in Egmont Ecological District, displacing native plants. Of most concern are the coastal cliffs that have become increasingly important for plant conservation as native biota in the surrounding landscape are depleted—a world-wide phenomenon (Larson et al. 1999). Further, several special native plant species which are nationally threatened or uncommon (de Lange et al. 2004) or regionally uncommon (DOC Wanganui Conservancy Threatened Plant Database) occur on the coastal cliffs that Chilean rhubarb is invading (Fig. 3). The species most at risk of being eliminated by Chilean rhubarb within the next few years are those on the steep slopes and talus of the sea cliffs (Table 2). Herbfields and turf communities on the cliff tops also contain numerous native plants of national or regional significance (Sinclair et al. 1998; Rogers 1999). In places, these turfs occur on sloping ground over the cliff edge and threatened species like *Ranunculus recens* are known only in such sites. Because cliff and cliff-top communities are not sharply delineated, the nationally threatened or uncommon species of the latter are also listed in Table 2. While Chilean rhubarb is not yet common on the cliff tops, it has been recorded at several sites and may, in the longer term, threaten these plants as well as those on the cliffs.

In 2000–2004, Chilean rhubarb was locally abundant but spreading in Egmont Ecological District. During this period, Chilean rhubarb 'exploded' along Wiremu Road, the highest-altitude road that circles the western side of

TABLE 1. ECOLOGICAL IMPACT OF CHILEAN RHUBARB BY GEOGRAPHICAL AREA IN NEW ZEALAND, RANKED BY IMPACT. THE AREAS ARE A MIXTURE OF TOWNS OR CITIES, AREA OFFICES AND CONSERVANCIES, DEPENDING ON THE CATEGORY USED BY THE DOC RESPONDENT.

RANK*	ECOLOGICAL IMPACT	GEOGRAPHICAL AREA IN NEW ZEALAND
4	Known to be damaging at some conservation sites	Taranaki, Manawatu
3	Naturalised, not yet affecting conservation sites, but impact likely in the future	Auckland, Bay of Plenty, Te Puke, Hamilton
2	Naturalised, but effects not identified	Rangitoto Island, Waikato, parts of Wairarapa, Wellington, D'Urville Island, Nelson / Marlborough, West Coast, Canterbury, Banks Peninsula, Stewart Island
1	Not naturalised yet but considered to have potential for impact if it arrives	Warkworth, Great Barrier Island, Tongariro / Taupo, East Coast, Hawkes Bay
0	Not considered to have potential for impacts	Northland, parts of Wairarapa, Waimakariri, Otago

* Greatest impact is ranked as 4 and the least impact as 0.

Mt Taranaki—in 1999 it occured in just three sites, but the following year over 20 sites were observed (JC pers. obs.). Elsewhere in the region, Chilean rhubarb occurred as scattered infestations only until the late 1990s. In 1997 it was found on the Kaitake Range and on the fringes of Egmont National Park (Appendix 1). These sites, remote from human settlement or cultivated stands of Chilean

Figure 3. Chilean rhubarb on a cliff face amongst the threatened species *Euphorbia glauca*. *(Photo: J. Clarkson).*

TABLE 2. THREATENED NATIVE PLANT SPECIES ON THE COAST OF EGMONT ECOLOGICAL DISTRICT THAT OCCUR IN HABITATS INVADED BY CHILEAN RHUBARB, OR WHICH ARE LIKELY TO BE INVADED IN THE NEAR FUTURE.

THREATENED OR UNCOMMON SPECIES	NATIONAL STATUS*	NATIVE SPECIES LIKELY TO BE SMOTHERED BY CHILEAN RHUBARB	NATIVE SPECIES POTENTIALLY AT RISK FROM CHILEAN RHUBARB
Limosella (b) 'Manutahi'	Nationally critical		Yes
Crassula peduncularis	Nationally endangered		Yes
Myosotis pygmaea var. *minutiflora*	Nationally vulnerable		Yes
Myosotis pygmaea var. *pygmaea*	Serious decline		Yes
Euphorbia glauca	Serious decline	Yes	
Sonchus kirkii	Gradual decline	Yes	
Trisetum antarcticum	Gradual decline	Yes	
Crassula manaia	Gradual decline		Yes
Ranunculus recens	Gradual decline		Yes
Oreomyrrhis "minute flower"	Sparse		Yes
Scandia rosifolia	Sparse		Yes
Leptinella dispersa ssp. *rupestris*	Range restricted	Yes	
Craspedia (d) 'Otakeho'	Range restricted	Yes	
Coprosma aff. *acerosa* 'Taranaki'	Range restricted		Yes
Crassula mataikona	Data deficient		Yes
Mentha cunninghamii	Regionally significant†		Yes
Hebe elliptica	Regionally significant†		Yes

* National status in de Lange et al. (2004)

† Species of regional significance, as listed in DOC database, Wanganui Conservancy.

rhubarb, indicate its potential for much wider distribution, certainly beyond obvious sources of distribution, such as stream channels.

Wet bluffs and mobile colluvium with a significant volcanic component are especially vulnerable to Chilean rhubarb invasion. Such sites are extensive in New Zealand—along the Whanganui River catchment, for example. On the west coast of the central North Island, mudstone seacliffs and steep hillslopes extend southeast from Taranaki to Castlecliff at Wanganui, well beyond the 2004 limit of Chilean rhubarb near Hawera. These cliffs have the same aspect and elevation as the Taranaki seacliffs, with wet seepages and colluvium from slumps that would readily be colonised by Chilean rhubarb if the species were to arrive there. Some of the threatened native plants of Taranaki cliffs also occur on these cliffs, as well as the Critically Endangered but unnamed *Pimelea*, *P.* '*Turakina*' (de Lange et al. 2004).

We conclude that Chilean rhubarb presently occupies only a fraction of the areas suitable for it in New Zealand. It will continue to spread over wide areas of central New Zealand. Initially, this spread is likely to be relatively slow because many of the suitable sites are widely separated. The exception to this will be where Chilean rhubarb is growing along rivers, where it may spread downstream quite rapidly.

7. Management and control

7.1 NATIONAL AND REGIONAL MANAGEMENT

Chilean rhubarb is classed as an unwanted organism under the Biosecurity Act 1997 and is included on the National Pest Plant Accord List (MAF Biosecurity Authority 2001), making selling, propagating or distributing it illegal throughout New Zealand.

For much of New Zealand, Chilean rhubarb has, at present, a very limited wild distribution, making weed-led control, i.e. eradication or containment across a wide area, a viable option. As soon as a new population of Chilean rhubarb appears in a catchment or conservancy, it should be eliminated. Where it is more abundant, i.e. in Egmont Ecological District, a site-led approach must be adopted—control of infestations in or near important natural areas, plus no further planting of Chilean rhubarb in the wider Taranaki Ecological Region. A useful interim measure is to remove flower heads from Chilean rhubarb plants in gardens, especially those near streams or sites of high conservation value.

Reflecting the differences in abundance of the plant, regional councils have taken different stances in their regional pest management strategies (RPMS). The Taranaki RPMS lists Chilean rhubarb as a 'containment pest plant' (Taranaki Regional Council 2001). This recognises that it is already locally abundant but aims to prevent its spread to new areas in the region and, where practicable, to reduce existing infestations. From July 2003, land occupiers have been required destroy all adult and juvenile Chilean rhubarb plants on their land. The Council is also running a programme to raise the public's awareness of the impacts of

Chilean rhubarb, and the need to manage it. Two other regional councils (Environment Waikato and Greater Wellington) specify its control at sites of ecological value, and two more (Horizons Regional Council and Bay of Plenty) have opted for regional surveillance status. None of the other eleven regional pest management strategies presently include Chilean rhubarb.

7.2 CONTROL METHODS

Chilean rhubarb can be controlled by mechanical means, but it is imperative to remove the entire rhizome because small pieces of live rhizome can re-sprout. Young Chilean rhubarb can readily be killed with chemicals. Mature plants can be harder to kill because it is difficult to apply sufficient chemical to kill the stout rhizome. Results from trials in the Taranaki Region (2000–2004) are given in Appendix 2, and summarised below.

Several forms and concentrations of glyphosate (as 'Roundup G2' or 'Roundup Renew Xtra'), alone or with 'Escort' (metsulfuron), plus the surfactant 'Pulse', have given a wide range of kill rates when applied as a spray. Higher application rates give better results than lower rates, especially for plants with large rhizomes.

Where it has been possible to reach Chilean rhubarb on foot, cutting the leaves and flower stalks against the rhizomes, and then applying 25% glyphosate by hand, has been the most effective method (Fig. 4). A trial of helicopter spraying has also been carried out (Fig. 5).

Highest kill rates for spraying are achieved when spraying is done early in the growing season, i.e. before December, and certainly before seeds mature in February to March.

It is essential to check all treated plants within a year; any surviving plants must be re-treated and all seedlings removed or sprayed.

Figure 4. Abseiler spraying cut-back stalks and rhizomes of Chilean rhubarb. *(Photo: J. Clarkson).*

Figure 5. Helicopter spraying of Chilean rhubarb on a coastal cliff in Taranaki. *(Photo: J. Clarkson).*

Control of Chilean rhubarb by whatever means is often complicated by the environment in which it grows—steep slopes are particularly challenging because it is difficult to find all the small plants. No information was found in the literature on the potential for biological control of Chilean rhubarb.

7.3 MANAGEMENT OF OTHER *Gunnera* SPECIES

The other large-leaved *Gunnera* commonly cultivated in New Zealand—*G. manicata*—may have naturalised recently. Webb et al. (1988) did not record it as naturalised in New Zealand. But in January 2003, seedlings were found in a large garden near Wanganui and thought to be from three large discrete clumps, one at least tentatively identified as *G. manicata*. The three clumps were from different horticultural sources in New Zealand. Similarly, a few *G. manicata* seedlings have been found near planted specimens by Pigeon Bay domain, Banks Peninsula (Wilson 1999). The few records of these putative *G. manicata* naturalisation events may represent a lag phase of establishment, similar to that observed for Chilean rhubarb in the 1960s. This strongly suggests that all large-leaved *Gunnera* species should be banned from propagation and sale in New Zealand.

Before any alternative species can be advocated as an alternative 'giant' garden plant, it must first be assessed for its weed potential. An alternative, if more idealistic, approach could be to invite gardeners to forego giant plants and look for a different style altogether.

8. Public awareness

> *The plant was quite well developed before any of us bothered to notice it, for it had taken root along with a number of other casuals behind the bit of hedge that screened the rubbish heap. … There must have been thousands of them about, growing up quietly and inoffensively in neglected spots, with nobody taking any particular notice of them. … It was some little time later that the first one picked up its roots, and walked.*
>
> (J. Wyndham 1951, 'The day of the triffids', pp. 40–42).

Chilean rhubarb is a popular landscaping plant. It is grown for its architectural appeal and its ease of cultivation around water features—virtues espoused in gardening books. Kingsbury (2000) describes how Chilean rhubarb impresses by its sheer size: '…[as if] from some Alice in Wonderland world where familiar plants have all become gigantic'. This book advocates *G. manicata*, the 'giant rhubarb', as the classic plant for waterside planting and describes its relative Chilean rhubarb as a 'smaller, more manageable version'. Muller (2000) lists Chilean rhubarb as a plant of preference around water features or for damp, shady spots in the Wellington region. Gardening magazines regularly sing the landscaping praises of Chilean rhubarb, e.g. the *New Zealand Gardener* (March 2001) featured Chilean rhubarb on its front cover.

Because of Chilean rhubarb's popularity, any control strategy must include a public awareness campaign—informing people of its ecological impacts. The campaign should aim to stop further propagation and planting of Chilean rhubarb, thus complementing any active control (Timmins & Blood 2003). To this end, Taranaki Regional Council produced a four-page colour brochure on Chilean rhubarb (DOC & TRC 2001). A series of magazine articles have been produced. These sought to bring Chilean rhubarb to the notice of gardeners, life-style farmers and other outdoors people (Anon. 2002; Apthorp 2002; Nolly 2002, 2003; Law 2003). Weed awareness in general and public participation in weed activities has been boosted by the national Weedbusters initiative (Bill et al. 2004).

9. Conclusions

Chilean rhubarb has been recognised as a weed of conservation concern only in the last decade, but already it is found in all DOC Conservancies and half of all DOC Areas. Its ecological impact is most noteworthy in Egmont Ecological District where it seriously compromises the conservation values of the coastal cliffs that are the habitat of a number of threatened and uncommon native plant species (Fig. 6). Chilean rhubarb has several characteristics that make it a successful weed: rapid growth, reproduction from pieces of rhizome, tall stature with giant leaves that shade the ground, early sexual maturity, flowers and fruits over an extended period and abundant, bird-dispersed fruit. These features suggest that, over time, it is likely to have an ecological impact over much of the country. It prefers damp sites where it persists, to the exclusion of

native species. Such sites are often very steep or inaccessible, making control of the weed near-impossible and costly. Chilean rhubarb has been widely planted throughout New Zealand because of its dramatic foliage. The success of any control programme will hinge, in part, on our success in reducing its public popularity and thus reducing the flow of Chilean rhubarb plants into the natural landscape.

A range of herbicide trials on Chilean rhubarb since 2002 has produced variable results. Where it has been possible to get to Chilean rhubarb on foot, cutting the leaves and flower stalks against the rhizomes and applying 25% glyphosate by hand has been the most effective control method. Treated plants must be checked within a year to re-treat any surviving plants and to spray or remove seedlings. Seed appears to survive in the soil for no more than two years. Because of difficulties in reaching and working with Chilean rhubarb on very steep sites, control on such sites has proved difficult to achieve and expensive, exacerbated by problems in monitoring and undertaking the essential follow-up work on seedlings. To date, aerial spraying has had disappointing results and at the cost of non-target plants.

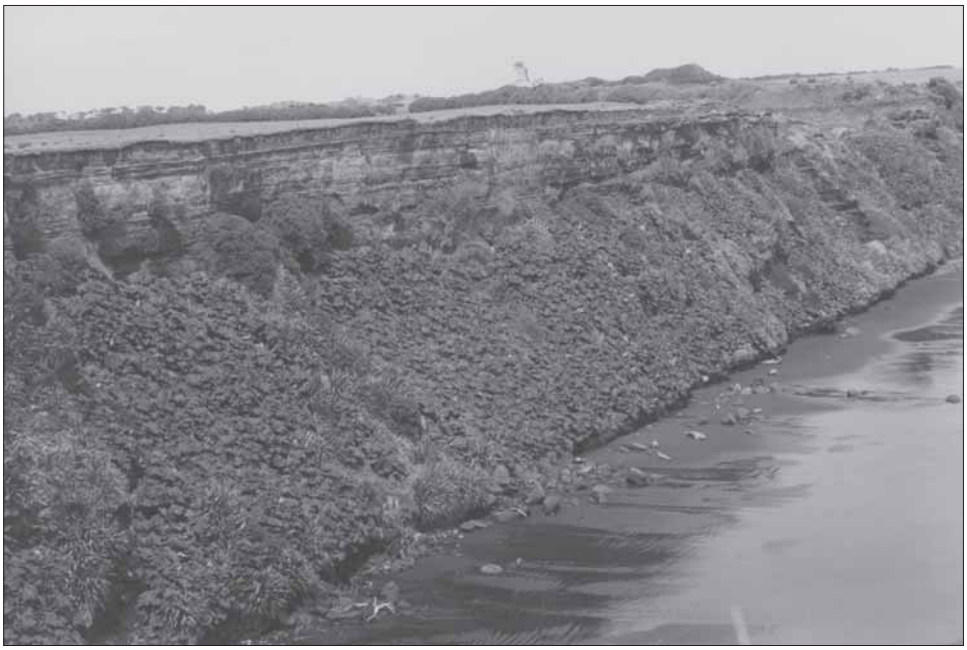

Figure 6. Chilean rhubarb dominating a sea cliff near Oeo, Taranaki Coast November 2001. *(Photo: J. Clarkson).*

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Appendix 1

SITE FACTORS AND VEGETATION ASSOCIATED WITH CHILEAN RHUBARB (*Gunnera tinctoria*) AT SITES VISITED BY THE AUTHORS IN MARCH 2000

PLOT	LOCALITY	MAP No. & GRID REF ALTITUDE (m a.s.l.)	SUBSTRATE VEGETATION	MAIN PLANT SPECIES	*Gunnera tinctoria*				PROGNOSIS
					Cover: Percentage (Area [ha])	Height: Mean (Max [m])	Phenology Date	Stand Dynamics	
1	Kaitake Range, Wairau Stream, left branch	P19 929 276 380 m	Slump face on volcanic deposits Open land with ferns, within broadleaved forest	*Blechnum novae-zelandiae, Brachyglottis repanda, Poa cita, Schefflera digitata, Freycinetia banksii, Cortaderia fulvida*	< 0.5 (0.5)	0.8 (1.2)	Dead old flower stalk 8 Mar 2000	Large plant sprayed but recovering, abundant seedlings	Will occupy site unless control continues
2	Kaitake Range, Timaru Stream	P19 906 252 140 m	Volcanic alluvium Shrubland on forest margin in streambed	*Cortaderia fulvida*, *Dicksonia squarrosa*, *Geniostoma ligustrifolium, Freycinetia banksii*	< 0.5 (1.5)	0.75 (1.0)	Full fruit 8 Mar 2000	Mixed age population in dynamic environment	Stable at this site, but spreading along valley floor
3	Oaonui Stream, Opunake	P20 803 008 40 m	Volcanic alluvium Shrub/vine land on margin in streambed	*Phormium tenax, Cyathea dealbata, Lonicera japonica, Vinca major*	5 (2.0)	1.7 (2.5)	Full fruit 7 Mar 2000	Mostly mature plant, few seedlings	Restrained by other weeds, limited expansion
4	Otakeho	P21 959 833 0–50 m	Coastal bluffs, debris, of volcanic material Chilean rhubarb herbfield	*Carex geminata, Phormium tenax, Cortaderia fulvida, Coprosma repens, Holcus lanatus*	30 (0.6)	0.5 (1.0)	Full fruit 7 Mar 2000	Abundant plants in all size classes	Continue to compete with threatened plants and dominate site
5	Manaia	P21 997 823 0–50 m	Wet coastal bluffs, debris, of volcanic material Flax land, Chilean rhubarb herbfield	*Phormium tenax, Coprosma repens, Cyperus ustulatus, Samolus repens, Lobelia anceps*	10 (2.5)	0.6 (1.0)	Fruiting 7 Mar 2000	Abundant plants in all size classes	Continue to compete with threatened plants and spread at the site

Appendix 1 continued

PLOT	LOCALITY	MAP No. & GRID REF ALTITUDE (m a.s.l.)	SUBSTRATE VEGETATION	MAIN PLANT SPECIES	*Gunnera tinctoria*				PROGNOSIS
					Cover: Percentage (Area [ha])	Height: Mean (Max [m])	Phenology Date	Stand Dynamics	
6	Manaia, Normanby Road	P21 046 803 0–50 m	Dry, coastal bluffs, debris, of volcanic material Flax land, herbfield, grassland	*Phormium tenax, Coprosma repens, Cyperus ustulatus, Samolus repens, Selliera radicans*	< 1 (2.5)	0.3 (1.2)	Fruiting 6 Mar 2000	Scattered plants in all size classes	Spreading on the site, likely to continue
7	Pohangina Valley	T23 463 073 100 m	Scarp and toe slope of gravels, alluvium Rushland, scrub	*Typha orientalis*, *Kunzea ericoides*, *Coprosma robusta, Laurelia novae-zelandiae, Melicytus ramiflorus, Rubus fruticosus* agg.	< 1 (10)	2.5 (2.6)	Fruiting 9 Mar 2000	Patches of mature plants but no small seedlings	Expansion controlled by grazing

Appendix 2

CONTROL TRIALS OF CHILEAN RHUBARB, ALL CONDUCTED ON COASTAL CLIFFS IN TARANAKI REGION

Trials of techniques for controlling Chilean rhubarb using abseilers on steep coastal cliffs were carried out in December 2002 and February 2003. The abseilers sprayed a 25% glyphosate solution onto patches of seedlings < 10 cm tall and onto cut rhizomes (15–25 cm diameter) and cut flower head stems. Results are reported in New Zealand Industrial Abseilers [NZIA] Ltd (2002, 2003).

A helicopter spray trial, applying glyphosate using a straight-jet nozzle on a boom, was conducted in March 2002 along 1.2 km of coast on slopes ranging from steep to near-vertical. The trial site was divided into 10 plots of variable length—six treated, four untreated. The former were randomly treated with a glyphosate solution (0.5%, 1%, or 1.5%), all with 'Pulse' additive. The results ranged from 55% kill of Chilean rhubarb with 1% glyphosate to an 8.5% kill with 1.5% glyphosate.

During February 2003, a cut and paint technique was trialed—leaf and flower stalks were cut and the rhizomes sprayed with 25% glyphosate in three plots. The growing tips were counted after treatment, and again the following season. Of the 376 growing tips counted only 17 had resprouts, equivalent to a 95% kill rate. However, in one of the plots, a dense carpet of seedlings appeared.

Since 2000, the Chilean rhubarb along a 2-km stretch of Timaru Stream has been controlled with 1% glyphosate with 'Pulse' additive and the number of plants recorded (Table A2.1).

TABLE A2.1. NUMBERS OF CHILEAN RHUBARB PLANTS BESIDE TIMARU STREAM, EGMONT NATIONAL PARK, BEFORE ANNUAL TREATMENT WITH 1% GLYPHOSATE PLUS 'PULSE' ADDITIVE.

YEAR	NUMBER OF PLANTS FOUND AND TREATED
2000	185
2001	No records kept
2002	424 (of which 320 were seedlings)
2003	52
2004	6