Conservation of *Olearia gardneri*

Report for the Rare, Small-leaved Tree Daisy Recovery Group, June 2003

DOC SCIENCE INTERNAL SERIES 156

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Published by
Department of Conservation
PO Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.

Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are also listed in the DOC Science Publishing catalogue on the website, refer http://www.doc.govt.nz under Publications, then Science and Research.

ISSN 1175–6519

ISBN 0–478–22539–3

In the interest of forest conservation, DOC Science Publishing supports paperless electronic publishing. When printing, recycled paper is used wherever possible.

This is a client report commissioned by Wanganui Conservancy and funded from the Science Advice Fund. It was prepared for publication by DOC Science Publishing, Science & Research Unit; editing by Helen O'Leary and layout by Lynette Clelland. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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A B S T R A C T

Gardner's tree daisy (*Olearia gardneri*) is endemic to the southern half of New Zealand's North Island. It has a conservation status of 'nationally critical'. This reflects its small and fragmented populations, poor regeneration, the patchy and mostly grazed nature of the habitat, weed infestations and the fact that most known plants are growing on unprotected land. As part of a national survey of threatened divaricating *Olearia* species, a survey was undertaken of all extant populations of *O. gardneri* in the Rangitikei region in June 2001, extending to the Wairarapa and Hawkes Bay regions in 2002–03. Sites where *O. gardneri* had occurred in the past were also searched. The total number of plants known to be growing naturally in the wild as at June 2003 was 159, comprising 111 adults and 48 seedlings and juveniles < 1 m tall. *Olearia gardneri* was often found growing with other threatened species or species with disjunct national distributions. It was found most frequently on sites with past natural disturbance and probably high fertility. These were generally river flats subject to past (but not recent) floods and eroding mudstone hill slopes. Most were on forest margins or in light gaps in forest. Seedlings were found only rarely and then nearly all in sites that had been trampled recently by stock. However, although large shrubs are able to survive grazing and browsing animals, seedlings almost always succumb to browsing before they reach a height of 1 m. Recommended conservation measures include securing natural sites and boosting small natural populations with propagated plants. Previously undocumented morphological differences were found between *O. gardneri* and Hector's tree daisy (*O. hectorii*), including the presence of yellow, glandular leaf hairs and fimbriate margins of flower-head phyllaries in the former species but not the latter.

Keywords: *Olearia gardneri*; threatened species; weed impacts; seedling establishment; *Olearia hectorii*; habitat disturbance; divaricating shrub; species conservation.

Ogle, C. 2004: Conservation of *Olearia gardneri*: report for the Rare, Small-leaved Tree Daisy Recovery Group, June 2003. *DOC Science Internal Series 156*. Department of Conservation, Wellington. 48 p.

1. Introduction

As part of a national survey of threatened *Olearia* species, a survey was undertaken of Gardner's tree daisy (*O. gardneri*), in the Rangitikei region in June 2001, extending to the Wairarapa and Hawkes Bay regions in 2002–03 and to botanic gardens containing the species in Lower Hutt and Wellington cities in March 2003. Earlier reports on *O. gardneri* surveys had been made for the Rare, Small-leaved Tree Daisy Recovery Group for the Rangitikei (Ogle 2001) and Wairarapa (Rebergen 2001; Rebergen et al. 2002) regions. This report draws much of the information in those reports together, along with new information and a discussion of the past and future status of *O. gardneri* in the Hawkes Bay region.

Until 1998, *Olearia gardneri* (Hook.f.) Heads was not distinguished formally from Hector's tree daisy, *O. hectorii* Hook.f., although some authors had pointed to differences between plants from North Island and South Island sources (Druce in Eagle 1982; Druce 1992). Plants in the wild were examined by Rogers (1996a, b) throughout the range of *O. hectorii* s.l. He detected no significant differences between North and South Island plants. However, Heads (1998) found a number of characters that distinguished North Island plants from those in the South Island. He described and named the North Island plants *O. gardneri*, while *O. hectorii* became a South Island endemic.

Olearia gardneri was known in the Hawkes Bay region until 1958, four extant shrubs were recorded from the Wairarapa region and 70 plants, including juveniles, in the Rangitikei region (Rogers 1996a, b; Heads 1998). The conservation of *O. gardneri* was discussed separately from that of *O. hectorii* by Dopson et al. (1999). When *O. gardneri* was recognised as a distinct species, it became the third rarest tree in the New Zealand flora[1]. Heads (1998) stated that there were 'fewer than 80' individuals remaining in the wild, an assessment that included Wairarapa plants.

The threatened plant list for New Zealand (Hitchmough 2002) recognised the uncertain future for *O. gardneri* by listing it as 'nationally critical'. Small and fragmented populations, poor regeneration, the patchy and mostly grazed nature of the habitat, weed infestations and the fact that most known plants grew in unprotected land were factors in this designation.

2. Existing regional knowledge of *Olearia gardneri*

There was already a considerable interest in and knowledge of *O. gardneri* before surveys were funded by the Rare, Small-leaved Tree Daisy Recovery Group in 2001. This information is summarised below, under the three regions in which the species is known or has been in the past.

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[1] The rarest is *Pennantia baylisiana*, with one female tree on Great King Island, followed by *Metrosideros bartlettii* with 28 trees in the Spirits Bay area of Northland (P. de Lange, pers. comm.).

2.1 RANGITIKEI REGION

Much of the following information on *O. gardneri* in the Rangitikei region is derived from the unpublished report by Ogle (2001).

Using the name *O. hectorii*, Rogers's survey (1996a) of the populations in the upper Turakina and Hautapu catchments gave a total of 58 adult plants, six saplings and six seedlings[2]. These data appear in Table 1 of Rogers (1996b), although his Table 3 shows 61 adults. Several populations known in the past had become extinct, including one in the Hautapu catchment at Taihape (Rogers 1996a, b; Ogle et al. 2000). Heads (1998) stated that there were 'fewer than 80' individuals remaining in the wild, an assessment that included the Wairarapa plants. The basis for Heads' (1998) figure of 80 plants is unknown, as there had not been a new comprehensive field survey since Rogers (1996b).

The only plants of *O. gardneri* listed by Rogers (1996a, b) as being on protected land were two adults and a sapling at Paengaroa Scenic Reserve, Mataroa, northwest of Taihape; and eight adults and a sapling at Ngaurukehu Scientific Reserve, 6 km in a straight line up the Hautapu River from Mataroa. Casual observations at Paengaroa Scenic Reserve by several Department of Conservation (DOC) staff in the period 1996–2000 increased the total there to between four and six plants. Plants were not marked individually at Paengaroa, resulting in doubts about the precise total.

The Department also negotiated a lease from Tranz Rail of a grazed area of forest immediately across the North Island main trunk (NIMT) railway from Paengaroa. Twenty-two adult *O. gardneri* trees and 6 seedlings were recorded for the Tranz Rail block by Rogers (1996a, b). In 1999, cattle were removed permanently and summer workers measured all the *O. gardneri* they could find, marking them individually with numbered metal tags (Briggs & Large 2000). Systematic survey and labelling of *O. gardneri* in the Tranz Rail block were consolidated in the summer of 2000–01 (Briggs & Trass 2001). In the same area, Dean Stronge and Vivienne Nicholls, of DOC's Wanganui Conservancy and Palmerston North Area offices respectively, grid-mapped the distribution of all known *O. gardneri*. These data were used in a recent study of *O. gardneri* (D. Stronge, pers. comm.). A result of these surveys was that 30 adults and 26 saplings and seedlings were marked in the Tranz Rail land. This was by far the largest known population of *O. gardneri*, and remained so after the June 2001 survey.

Paengaroa's status as one of DOC's six Mainland Island Reserves allowed the Wanganui Conservancy to employ two casual workers for each of the summers from 1996 to 2003. Three plants were listed for Paengaroa mainland island reserve by Briggs & Trass (2001), although these authors omitted a tree labelled earlier and failed to find two other unlabelled plants found several years ago in the reserve (CCO, pers. obs.). At the time of the Rangitikei survey for *O. gardneri* in June 2001, as many as six trees of the species had been seen in Paengaroa Scenic Reserve, none of them juveniles.

Incidental to the work on natural populations, cutting material of *O. gardneri* had been taken from trees in the Tranz Rail land, grown off-site and 16 individuals were planted in two parts of Paengaroa Scenic Reserve in 1996–97. In December 2000, 11 of the 16 plants were found alive, one with flowers for the first time (Briggs & Trass 2001). Three numbered plants were found dead.

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[2] Rogers (1996a) defined seedlings as being < 1 cm diameter; saplings as having a dbh of 1–3 cm; and adults as having a dbh of > 3 cm.

In January 2001, two shrubs of *O. gardneri* were found in Ngawaka Stream, a tributary of the Hautapu River, and a previously unrecorded location for the species (Ogle et al. 2001).

Invertebrates from *O. gardneri* were collected at Mataroa each summer between 1997 and 1999 for a study of Lepidoptera on divaricating *Olearia* species (Patrick 2000). He found that *O. gardneri* is a feeding host to the larvae of nine moth species, five of them specialists on small-leaved *Olearia* species, though none endemic to *O. gardneri*.

2.2 HAWKES BAY REGION

Despite numerous searches for *O. gardneri* in the Hawkes Bay region in recent years, no botanists have been able to find it in the wild. The species was known in at least one site until at least 1958.

There is some confusion concerning the location(s) and date(s) of sightings of *O. gardneri* in the region. It was stated by Heads (1998), without citing voucher numbers, that there are voucher specimens at Landcare Research NZ, Lincoln (CHR specimens) collected by N. Elder from 'Hutchinson Domain, Puketitiri (January 1958)' and from 'Ball's Clearing' (date not specified). Probably the same specimen as the first cited by Heads is a voucher specimen (CHR 141734) in Rogers (1996a, b); he also stated that this was collected by N.L. Elder at Hutchinson Bush in 1958. (While the clearing is described as 'Ball's Clearing' in Druce [1968] and some earlier references, the actual name of the Scenic Reserve is 'Balls Clearing'.) The label of CHR 141734 states that it was collected 'Hutchinson Domain January 1958'. CHR 536823 is also from Hutchinson Bush and, in full, is labelled "*Olearia* 'Rob's Whare'", and collected on 10 Dec 1957. Elder (1950) indicated that Rob's Whare was in the compact block of forest that escaped a major fire in 1946.

The specimen cited by Heads (1998) as having come from Balls Clearing is probably CHR 141726. It is labelled as '*Olearia* of Ball's Clearing of N.L. Elder' and the collector is stated to be A.P. Druce. Additional notes on the label read 'Trunk 6 inches diameter, deciduous and most leaves fallen'. There is no collection date and the hand-written label is not in Druce's hand. The specimen may be of garden origin from a person who believed that it originated at Balls Clearing. Heads' (1998) record from Balls Clearing is almost certainly a misinterpretation of the label of this specimen.

Elder's own accounts of Balls Clearing (Elder 1950, 1954) made no mention of an *Olearia* that could be matched to plants now known as *O. gardneri*. No reference was made to such an *Olearia* in Druce's (1968) description and plant list for Balls Clearing Reserve. These two reliable sources make records of *O. gardneri* from Balls Clearing very doubtful.

Hutchinson and Balls Clearing reserves are just over 2 km apart at their closest points and about 7 km by road. An unnamed *Olearia* is mentioned in an undated report entitled 'Balls Clearing and Hutchinson Bush' by Elder that was held in New Zealand Forest Service files. That file report is almost identical to his published paper (Elder 1950). Although the report has no typed date, under the

title there is a handwritten date of 'ca 1954' and another, in different handwriting, of 'about 1954'. The date of 1954 is considered to be incorrect, for the following reasons:

- Spelling corrections in the published version indicate that the typed report is a precursor to the published version.
- The report makes no reference to the bulldozing and giant-discing of the actual 'Ball's Clearing', an area of bog, tussock and shrubland; this event occurred in 1954 (Elder 1954), so the report that discusses Hutchinson Bush was written earlier.
- On p.1, Elder writes 'recently I had the opportunity of paying two visits to Puketitiri, 12 years since my last visit and 25 years since I first saw Ball's Clearing'. Elder's (1954) report refers to an inspection of Balls Clearing by the author in 1924. The addition of 25 years gives a date of 1949 for this report.
- On p.1 and p. 4, Elder reports on a 1946 fire in Hutchinson Reserve and the impacts of subsequent milling, the charred logs and long grass. It seems, therefore, that the report 'Balls Clearing and Hutchinson Bush' was written soon after the 1946 fire and logging.

The file report 'Balls Clearing and Hutchinson Bush' is cited here, therefore, as Elder (1949?). This report and the subsequent paper (Elder 1950) are significant in reassessing the past locations of *O. gardneri* in Hawkes Bay. The first half of the report deals with Balls Clearing and makes no mention of any shrub that could be interpreted now as *O. gardneri*. The second half of the report deals with Hutchinson Bush (also called Hutchinson Domain and now Hutchinson Scenic Reserve). After discussing the impacts of a fire in 1946, Elder (1950) went on to say:

> 'The compact block of forest that has been missed by fire comprises perhaps 40 acres, and if this is kept effectively fenced should maintain itself. It appears to be in better state than in 1928 and is of particular importance as it contains a vigorous colony of an undescribed species of *Olearia*, which was at first reported to have been wiped out by the fire. (Seed and some cuttings have been sent to Mr. Brockie to establish it at Otari.)'

In a tribute to Norman Lascelles Elder, 1896–1974, Davidson (1976) stated that Elder's diaries are held at Landcare Research in Lincoln. A search of the diaries might assist in verifying the above points.

A remaining unsolved linking of Balls Clearing to *O. gardneri* is that there are two large planted shrubs of *O. gardneri* at Otari Reserve in Wellington. One is labelled 'Ball's Clearing'. Records of plantings at Otari indicate that these shrubs were planted in their present site in 1990, but do not specify their origin (A. Benbrook & E. Burton, pers. comm. 2003). A past curator of Otari Reserve, Anita Benbrook, believes they are the first or second generation of plants propagated from an original plant that was in the garden's old *Olearia* border and states that the species grows rapidly in cultivation at Otari. As discussed earlier in more detail, Elder (1950) collected material from Hutchinson Bush and sent it to Otari for propagation; it is reasonable to assume that the two trees now in Otari originate from Elder's collections, probably in 1949.

If the species is to be restored to the region, it is important to decide where it grew in the past and which source(s) of plant material would be most appropriate.

2.3 WAIRARAPA REGION

The locations of four Wairarapa shrubs of *O. gardneri* were specified by Rogers (1996a, b) as two in each of the Kourarau and Wainuioru Stream catchments, in the Maungaraki Range. Thirteen past collections were detailed by Heads (1998) who cited the herbaria and dates but not accession numbers. The earliest of these were two 1947 collections, by Zotov and Druce from the Kourarau Valley, possibly when they were there together. These appear to be the first known collections of the taxon now called *O. gardneri*.

Because later collectors used different place names for what were almost certainly the same sites, the 13 collections represent as few as four sites and perhaps no more than five shrubs in total (T. Silbery, pers. comm. 2003) (Table 1). One source of confusion in the past is that the southern (dead-end) section of Admiral Road on older maps is now called Admiral Station Road. Koromiko Station on Admiral Road (and on the Kourarau Stream) was the site of the earliest collections of *O. gardneri*. However, a site discovered with one shrub of *O. gardneri* in 1994 at Te Kowhai Station on the Wainuioru River has also been said to be on Admiral (sometimes spelt erroneously as Admirals) Road, but on the portion that is now Admiral Station Road.

TABLE 1. PROBABLE LOCATIONS OF WAIRARAPA HERBARIUM COLLECTIONS OF *Olearia gardneri*, BASED ON HEADS (1998).

COLLECTION SITES IN HEADS (1998), GROUPED BY PROBABLE LOCATIONS	COLLECTOR(S)	REFERENCE[1]
Koromiko Station in the headwaters of Kourarau Stream		
Kourarau Valley	V. Zotov	CHR; 26 Feb 1947
Kouraurau[2] Valley	A.P. Druce	CHR; Feb 1947
Koromiko Station, Kourarau Valley	L. Moore	CHR; 29 Nov. 1958
Kourarau Valley	A.P. Druce	CHR; Jan. 1966
Kourarau Valley	A.P. Druce	CHR; 3 Nov. 1966
Kourarau Valley	W.D. Burke	WELTU; 3 Nov. 1966
Kourarau Valley, Maungaraki Range	A.P. Druce	CHR; July 1976
Admiral's Road	P. de Lange	CHR; 6 May 1993
Maungaraki Range	P. de Lange	WELT; 6 May 1993
Near Tupurupuru–Te Wharau Road bridge over Wainuioru River (Tyneside Station)		
Gladstone	A.P. Druce	CHR; 26 May 1958
Wainuioru Valley, Gladstone	A.P. Druce	CHR; June 1966
Opposite the end of Admiral Station Road, Te Kowhai Station, Wainuioru River		
Admiral Road, Wainuioro (sic!) Valley	P. de Lange	AK; 2 Aug. 1994
Springhill Station, Tinui		
Tinui, Springhill Station	P.J. de Lange and A. Townsend	AK; 18 Oct. 1996

[1] Voucher specimens are lodged in herbaria as follows: AK = Auckland Museum, CHR = Landcare Research NZ, WELT = Te Papa, Museum of New Zealand, Wellington.

[2] Spelling as per Druce's 1947 record.

At the start of the 2002 survey, just five shrubs or trees of *O. gardneri* were known in the wild in the Wairarapa Region: Koromiko (2), Tyneside, Te Kowhai and Springhill Stations (Rebergen et al. 2002).

The two trees at Koromiko Station are in pasture on a gentle slope, a site that has changed little in the past 30 years (A.P. Druce, pers. comm. to T. Silbery). The two trees were enclosed in separate fences by DOC staff in about 1992. One of the trees has shown a significant increase in health since it was fenced, while the trunk of other is in an advanced state of decay. This tree was supported by means of cables attached to the fence posts in 2001.

Near the Wainuioru River Bridge east of Gladstone (Tyneside Station), two trees known to earlier botanists have died, perhaps of drought, one of them in 1996 after an exclosure was built around it in 1994. An age estimate was obtained from the trunk of the first tree that died (Rogers 1996a, b). A previously unknown shrub was discovered near the dead trees (Rebergen 2001), growing with its base in a narrow entrenched watercourse. It was fenced in 2002. The single tree of *O. gardneri* at Te Kowhai Station (Admiral Station Road) was discovered during a Protected Natural Areas Programme survey in 1994 and is in a fenced area of forest. Two shrubs found at Springhill Station, Tinui in 1996 were about 40 km northeast of the next-nearest known Wairarapa shrubs of *O. gardneri* (Rebergen 2001). However, as discussed in Section 3.3, the discovery of *O. gardneri* near Tauweru in 2002 reduced this gap to about 17 km (A. Rebergen, pers. comm. 2002). One of the Springhill shrubs died in a drought in 1999 (Rebergen 2001). In September 2001, 10 plants, seed-grown from Koromiko Station, were planted at Springhill and these survived their first summer (Rebergen 2002). No naturally occurring seedlings have been found at any of the Wairarapa sites.

3. Regional surveys for *Olearia gardneri* since 2001

A standard recording form was developed by the Rare, Small-leaved Tree Daisy Recovery Group to record characters of *O. gardneri* shrubs and their habitat at each site where the species was already known or newly discovered. Characters included the shrubs' abundance, dimensions, vigour, reproductive state and site factors including landform and vegetation.

3.1 RANGITIKEI REGION

3.1.1 Survey methods and limitations

The survey was undertaken by CCO in mostly fine, frosty weather in mid-June 2001, covering parts of the upper Turakina Valley and Hautapu River catchments. As it was mid-winter, the daylight time available for survey was quite limited. All landowners approached gave permission for access and / or survey of their

properties. A new, standard site-recording form was used for each site deemed to be a separate population of *O. gardneri.* Part of the survey was undertaken by CCO alone, other parts with one of three different assistants. In the upper Turakina Valley, CCO and G. La Cock surveyed an unnamed tributary where 17 trees had been seen in April 1993 on a trip that included CCO, Tony Druce and John Barkla. Rogers (1996a, b) had called this site Owhakura Stream[3] and he recorded 17 *O. gardneri* trees and three saplings there. In the Hautapu Valley, CCO covered from the north end of Ngaurukehu Scientific Reserve, downstream to a point about midway between Taihape and the SH1 road bridge over the Hautapu River by the Taihape golf course. In addition, portions of Ngawaka Stream immediately east of SH1 were surveyed.

On land managed by DOC, labels were attached to all unlabelled (i.e. presumably 'new') plants of *O. gardneri* found. Instead of labelling plants of *O. gardneri* on private land, simple sketches were made of the location and marked with the position of each *O. gardneri* shrub or cluster of shrubs, and / or measured distances of plants from other features. Herbarium specimens for CHR (Landcare Research NZ, Lincoln) were collected of *O. gardneri* in any new location, as were unusual or new locations in this district for other plants with disjunct distributions nationally (Ogle et al. 2000). Specimens were also collected of several weeds not recorded before in the district.

Additional records were entered into a database of indigenous plants in each of a number of forest remnants of the Hautapu Valley (Appendix 1). The database included both reserves and private land and was begun in 1992, with the help of Tony Druce and several DOC staff. New sites were added in subsequent years. By January 2001, the database held plant lists for 12 sites in order down the valley from north to south. Portions of this database were published as tables in Ogle et al. (2000), to demonstrate that the distribution of plant species down the valley was influenced by climatic and altitudinal gradients. During the June 2001 survey, additional plant records were made and several new patches of forest were added to the database. A separate list was made for the *O. gardneri* site in the upper Turakina Valley. Limits imposed by the time available for the primary purpose of the field survey meant that none of the new lists was comprehensive.

In August 2001, Viv Nicholls and Don Ravine of DOC's Palmerston North Area Office discovered three further *O. gardneri* shrubs in Paengaroa Reserve, well up-slope in the northwest corner of the bush. The details of these two shrubs are: one just down from 'B track', on the edge of a small clearing and about 2.5 m tall; the shrub was not labelled. The other two shrubs were further downslope on the edges of a flat area of ground, a 'wetland' with sedges and narrow-leaved lacebark and fairly open. The two shrubs were labelled P0110 (at the top of wetland), and P0014 (bottom of wetland). They were 2.5 m and 3 m tall, respectively, and both had a basal diameter of approximately 50 mm (V. Nicholls, pers. comm. June 2002).

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[3] For future reference, Rogers (1996a, b) called this site 'Owhakura Stream' but the NZMS260 topographical map sheet T21 makes it clear that Owhakura Stream is actually a different sub-catchment of the Turakina River, west of the site with *O. gardneri*. The stream with *O. gardneri* is unnamed on the map and has no local name (D. Alabaster, pers. comm.). It joins Waiaruhe Stream and from the confluence is called Turakina River; Owhakura Stream joins the Turakina River further downstream.

3.1.2 Finding and identifying *Olearia gardneri* in the Rangitikei region

Seedlings

Field botanists, at least in the Rangitikei region, had not seen juvenile *O. gardneri* until 1999, when seedlings were found in a small stream course of the leased Tranz Rail land at Mataroa. Because some 30 shrub and tree species of the Mataroa area have small-leaved divaricating growth forms (Ogle & Barkla 1995), knowing the physical appearance of *O. gardneri* seedlings greatly improved the prospects for finding juvenile plants in the wild in the 2001 survey. Seedling features are described in Section 5.1.3.

Adult plants

The main sites where *O. gardneri* was known prior to this survey were silty river flats and mudstone hill slopes. The June 2001 survey concentrated on such sites as well, which made for very wet, slippery conditions. Except for sealed or gravel tracks, access had to be on foot. However, there were advantages in a winter survey, in that grazed land was generally closely cropped and, in ungrazed areas, pasture grasses and large weedy herbs like burdock (*Arctium minus*) had collapsed. Under these conditions, seedlings of *O. gardneri* were easier to find than in summer. Initial doubts about how to find plants of the deciduous *O. gardneri* in mid-winter were dispelled when it was found that many shrubs still retained some leaves, and these were generally pale yellow. Yellow leaves and the generally erect terminal twigs, with thick nodes where short thick shoots arise, made some shrubs of *O. gardneri* visible at distances of 50 m or more. Shrubs or trees of *O. gardneri* fully in the open were the only leafless ones. Of the other shrubs in the habitat of *O. gardneri*, only the locally common, exotic, deciduous shrub Khasia berry (*Cotoneaster simonsii*) had yellowish leaves of a similar size that confused recognition at a distance.

3.2 HAWKES BAY REGION

Because only one site with *O. gardneri* has been known in the Hawkes Bay region, namely Hutchinson Scenic Reserve, it has been the focus for a number of casual surveys in the past. The reserve has three main parts: a front block close to Puketitiri Field Centre, with many exotic plantings and native regeneration, a grazed centre block that was burnt in 1946 (Elder 1950) and a fenced back block which is in tall forest with some fringing exotic shelterbelts and patches of dense grass and vines. Verbal reports of attempts to rediscover *O. gardneri* here over the past several decades suggest that some people have searched the front and / or centre blocks for the species. However, as discussed above, Elder (1950) made it clear that he saw the species in the 'back block'. When he saw the back block in 1928, Elder noted 'a great deal of damage' by cattle to the undergrowth of this forest but fencing had improved the situation by 1949. The *Olearia* was still present then and nearly a decade later, judging by CHR specimens collected by Elder in 1957 and 1958 (see Section 2.2).

Immediately following 2 days of *O. gardneri* survey in the Wairarapa region, CCO, Graeme La Cock (DOC Wanganui) and Mike Thorsen (DOC Gisborne) visited the Puketitiri Field Station of DOC's East Coast / Hawkes Bay

Conservancy on 21 February 2003. A full day was spent traversing almost all the 'back block' of forest at Hutchinson Scenic Reserve, with special emphasis on natural gaps in the forest. The entire fenced perimeter was also walked and non-forested areas between the fence and the native forest were explored, especially the forest edges, within the limitations imposed by dense blackberry (*Rubus fruticosus* agg.), Japanese wineberry (*R. phoenicolasius*), pohuehue (*Muehlenbeckia australis*) and rank pasture grasses that dominated much of the area. The survey included grazed areas outside the fenced forest (the reserve's 'centre block'), especially where thickets of scrub and secondary forest occur on steeper ground in limestone gullies. The 'front block' was seen superficially on the way to and from the back block. An hour was also spent in Balls Clearing Scenic Reserve, partly to see the forest edge where it had once adjoined the clearing from which the reserve takes its name (Elder 1950, 1954; Druce 1968). This wetland is now grazed pasture.

3.3 WAIRARAPA REGION

The 2002 survey concentrated on an area of the Wainuioru River between the two known *O. gardneri* plants at Tyneside and Te Kowhai Stations. The survey took 18 person-days in March and late April, with dates dictated by staff availability. Botanists with practical knowledge of *O. gardneri* made up the survey team, working as combinations of the four report authors (Rebergen et al. 2002). Their survey also included two areas of podocarp forest in the Tauweru–Carswell area (Protected Natural Areas Programme sites 1809 and 1810, Eastern Wairarapa Ecological Region; Beadel et al. 1998). These were selected as being potential habitat for *O. gardneri* because of forest type, landform, geology and the presence of rivers and streams along or through the forest.

All sites were surveyed by walking. The survey team concentrated on streams and forest / pasture boundaries, especially along riverbanks and terraces cut into soft papa rock. The Tauweru–Carswell survey was more intensive than the Wainuioru River survey because the latter area was very large and the soil and vegetation types appeared to be unsuitable for *O. gardneri* (rocky and dry soil, totara, kanuka and / or beech forest). The areas targeted were riparian podocarp forest with a significant component of matai and divaricating shrubs, especially weeping mapou (*Myrsine divaricata*). Where *O. gardneri* was found, nearby forest was searched more thoroughly.

In February 2003, CCO, G. La Cock and M. Thorsen visited all but one of the Wairarapa sites with *O. gardneri*, guided by T. Silbery and G. Foster of DOC's Wairarapa Area Office, Masterton. With 2 days available, most sites were explored superficially. However, the standard survey sheets were filled out for each *O. gardneri* population visited, as for the Rangitikei survey in 2001. Earlier survey sheets are held by DOC offices in Masterton and Wellington for some of the Wairarapa sites, but these are in the Wellington Conservancy's own format for any notable species records.

3.4 BOTANIC GARDENS: PERCY SCENIC RESERVE, LOWER HUTT AND OTARI / WILTONS BUSH, WELLINGTON

On 3 March 2003, CCO visited Percy Scenic Reserve, Lower Hutt and Otari / Wiltons Bush, Wellington, in order to compare living specimens of *O. gardneri* and *O. hectorii*.

3.4.1 Percy Scenic Reserve

Comparisons of foliage and stems were made between potted *O. gardneri* from Admiral Station, Wairarapa, and a tall shrub of *O. hectorii* planted near the curator's house and later found to have been grown from one of the the Otari / Wiltons Bush trees from West Otago (T. Silbery, pers. comm.). See section 3.4.2.

3.4.2 Otari / Wiltons Bush

The main *Olearia* garden contained two tall shrubs of *O. gardneri* (one unlabelled and one labelled 'Balls Clearing') and two of *O. hectorii* (one unlabelled and one labelled 'West Otago'). It is almost certain that the 'Balls Clearing' label is an error, as the stock was probably sent by N. Elder in 1949 from Hutchinson Scenic Reserve, as discussed in Section 2.2.

4. Survey Results

Copies of the standard inventory sheets for *O. gardneri* for all sites are held by the relevant DOC offices. Rangitikei survey sheets are in the offices of Wanganui Conservancy and Palmerston North Area. Wairarapa survey sheets are held by offices of Wellington Conservancy and Masterton Area, including the standard *Olearia* survey sheets filled out in 2003 (see above) and sent electronically by CCO in June 2003. Data on the location, habitat and dimensions of each *O. gardneri* are also included with these sheets. Additional specimens were vouchered to herbaria from the 2001–03 surveys, where they represented previously unrecorded sites for the species.

4.1 RANGITIKEI REGION

4.1.1 Seedlings

Forty-eight *O. gardneri* seedlings and juvenile plants < 1 m tall were found in the 2001 survey, including those found by other DOC staff in the Tranz Rail land at Mataroa—see Section 2.1. These were in five different sites of which three sites had single plants (Table 2). Most seedlings were in the smaller size classes (Table 3). All seedlings of *O. gardneri*, to at least a height of 0.5 m, were still clad in green leaves in June 2001. It seems that young plants are not deciduous.

TABLE 2. THE HABITATS OF *Olearia gardneri* SEEDLINGS IN THE TURAKINA AND HAUTAPU CATCHMENTS.

SITE NUMBER	NAME OF SITE	NOTES ON SEEDLINGS
1	Upper Turakina Valley	4 seedlings: 3 actually in streambed in water (the stream has a very short catchment and was in flood and perhaps 30–50 cm deeper than normal), 1 on bank just above water. All in moderate shade of canopy trees (kowhai dominant) and dense shrub margin on western side of stream; no competing ground cover; silty clay loam; possibly trampled by stock, but not often.
2	Ngaurukehu Scientific Reserve	1 seedling, on limestone talus at base of cliff, under light shade of canopy trees. No stock present.
3	Coogan's hillslope	1 seedling in bed of steep small stream (probably summer dry and not flooding in winter) under broken canopy of forest edge; heavily trampled by stock; pugged clay loam, wet; no competing ground cover.
5	Tranz Rail lease, Mataroa	Many seedlings in the bed of a small stream (not subject to flooding) and on adjoining banks, under edge of forest canopy; stream bed of lahar (andesite) stones and boulders, banks of sticky clay. Heavily trampled by cattle until 1999. At the time the first seedlings were found, the ground cover was sparse with seedlings of other divaricating shrubs and some exotic grasses hanging from banks on the pasture edge (true left bank, on forest margin). Several seedlings actually found on top of mossy boulders in the stream. Many seedlings on clay banks of old cattle tracks leading into the stream bed.
10	Ngawaka Stream	Seedlings in 2 main kinds of site: six found in three sites on steep hill-slopes under open forest grazed throughout by cattle and sheep; growing on heavy clay loam at the bases of trees or the edge of low shrub thickets; little ground cover; and nine found in two sites on the edges of steep clay banks cut by cattle tracks up or down the river terraces, under open forest, pugged and seasonally wet.

TABLE 3. HEIGHT CLASSES OF *Olearia gardneri* SEEDLINGS IN THE TURAKINA AND HAUTAPU VALLEYS.

SITE NUMBER	NAME OF SITE	SEEDLING HEIGHT CLASSES (cm)				TOTALS
		0 < 25	25 < 50	50 < 75	75 < 100	
1	Upper Turakina Valley		4			4
2	Ngaurukehu Scientific Reserve			1		1
3	Coogan's hillslope	1				1
5	Tranz Rail lease, Mataroa	13	7	4	3	27
10	Ngawaka Stream	5	6	3	1	15
Totals		19	17	8	4	48

The data gathered on the habitat of each *O. gardneri* seedling during the June 2001 survey are qualitative (Table 2). However, they show some general trends characterising the habitat of *O. gardneri* seedlings including: the lack of competing ground cover plants; moist to very wet sites, at least seasonally; physical

disturbance (almost all by cattle and sometimes sheep); and light-to-moderately-heavy shading by native vegetation. Not shown in Table 2, but apparent from detailed maps on the field survey sheets, is that all the seedlings are very close to adult trees of *O. gardneri* and often immediately underneath the canopy of an *O. gardneri* tree.

4.1.2 Numbers of adult plants

Summaries of the survey's findings are shown in Table 4. The total number of plants now known in the Rangitikei region is 91 (58) adults and 48 (12) saplings and juveniles. (The totals of Rogers [1996a, b] are shown in parentheses.)

Not all *O. gardneri* shrubs or trees identified by Rogers (1996a, b) could be re-found in 2001. As an example, on 21 June 2001 Henry Dorrian and CCO spent c. 1.5 h searching for, measuring and labelling *O. gardneri* at the north end of Ngaurukehu Scientific Reserve. This is where CCO had found *O. gardneri* in January 1992 (CHR 477070, 477071) and where Rogers had measured the plants in 1994 (Rogers 1996b). Table 5 compares the findings of the two surveys of the site. Because the 2001 survey was the first to label the trees as they were measured, it is not possible to say whether that survey found seven of Rogers' nine plants or whether some found in 2001 had been missed by Rogers. As well as finding two more specimens than were found in 2001, Rogers also recorded

TABLE 4. NUMBERS OF NATURALLY OCCURRING *Olearia gardneri* IN THE RANGITIKEI REGION.

LOCATION	SITE NUMBER	TENURE	NUMBER OF ADULTS	NUMBER OF JUVENILES	TOTALS
Upper Turakina Valley	1	Private	16	4	20
Hautapu Valley[1]					
Ngaurukehu Scientific Reserve	2	DOC Scientific Reserve	6	1	7
Coogan's hillslope	3	Private	11	1	12
Coogan's river flat	4	Private	3	0	3
Tranz Rail lease	5	DOC lease	30[2]	27[4]	57
Paengaroa Mainland Island	6–9	DOC Scenic Reserve and ConservationArea	9[3]	0	9
Ngawaka Stream	10	Private	16	15	31
Totals			91	48	139

[1] In order from north [= upstream] to south.

[2] Data from Briggs & Large (2000); Briggs & Trass (2001); D. Stronge, pers. comm., 1.7.01.

[3] Includes 3 plants found August 2001 by V. Nicholls and D. Ravine (see Section 3.1.1) and 2 other plants listed by Briggs & Trass (2001) but not seen in June 2001 survey

[4] Includes one addition seen during June 2001 survey, growing just outside fence of exclosure plot

TABLE 5. TRUNK DIAMETER SIZE CLASS DISTRIBUTION OF *Olearia gardneri* AT NGAURUKEHU SCIENTIFIC RESERVE.

	TRUNK DIAMETER (dbh) SIZE CLASSES (cm)					
DATE	0–3	4–5	6–10	11–15	16–20	TOTAL
Rogers (1996b)	1	2	2	3	1	9
2001 (this survey)	1		5	1		7

one much larger tree. Differences in size distributions suggest that at least one smaller plant was found in 2001 than by Rogers, meaning that there are probably more shrubs present than were found by either survey alone.

Another test of the repeatability of *O. gardneri* surveys for unmarked trees comes from the upper Turakina Valley site. Rogers (1996b) measured 17 adults and 3 saplings here in 1994; Graeme La Cock and CCO found 16 adults and 4 juveniles in June 2001. The juveniles we found were all ≤ 40 cm tall or less and clearly not seen by Rogers. This appears to mean a net loss of four adults and saplings between 1994 and 2001. Between those two surveys, part of the forest strip had been cleared for a new fence and farm track. *Muehlenbeckia australis* is also far more rampant now than when CCO first saw this site in April 1993 with Tony and Helen Druce and John Barkla. Seventeen plants of *O. gardneri* were also counted in 1993 (CCO pers. obs.).

In 2001, the Ngaurukehu site was found to have serious infestations of European broom, *Cytisus scoparius*, and *Cotoneaster simonsii*, the broom growing in thickets to 2 m or more tall and *C. simonsii* as wide-branched small trees to over 3 m tall. These weeds have increased markedly in size and abundance over the past several years (H. Dorrian, pers. comm.). While it is possible that the weeds have smothered some *O. gardneri*, it is more likely that they obscured from view some shrubs seen by Rogers in 1994. As noted previously, *C. simonsii* is also semi-deciduous and had yellowish leaves at the time of this survey, which may have made *O. gardneri* harder to spot.

4.1.3 Height of *Olearia gardneri*

In the Rangitikei region, the tallest *O. gardneri* was calculated to be 8 m, a tree in the upper Turakina Valley (Site 1). A number of other trees were 5 m or more in height, including two others of the 16 trees in Site 1, two of 11 trees in Site 3, and six of 16 trees in Site 10. In many places, the *O. gardneri* trees had their crowns partly or wholly covered in vines, especially *Muehlenbeckia australis*, but often also by bush lawyer (*Rubus schmidelioides*) and native jasmine (*Parsonsia capsularis*). Native clematis species (*Clematis forsteri* and / or *C. foetida*) and another native jasmine (*P. heterophylla*), were occasionally recorded sprawling over *O. gardneri* trees and shrubs. Trees covered in vines had bent branches, reducing their potential stature. Several trees had branches that arched horizontally with coppicing erect shoots and others had branches that had split at the trunk, fallen but remaining attached to the parent and continuing to grow. No plant was seen that had layered and rooted (cf. Rogers 1996a, b; Heads 1998).

4.1.4 Trunk diameter

O. gardneri is commonly multi-stemmed from near the tree base. Although the dbh of at least the largest stem was usually measured in such cases, at times the diameter was measured at a lower point, below the point at which the stem forked. The largest diameter (dbh) measured was 16.5 cm, at the upper Turakina Valley site (Site 1). The largest diameter measured of a forked trunk was 23.8 cm at 1 m above ground level, also at upper Turakina; the dbh of the largest branch of this 5.5 m tall tree was 15.2 cm. Histograms of diameter size classes of three populations of *O. gardneri* are given in Rogers (1996a), and also a regression coefficient of tree height on stem diameter for 66 stems of *O. gardneri*. These 66 trees are stated (Rogers 1996a) to be from 'Hautapu

Valley', but as his total number of *O. gardneri* from the Hautapu Valley is only 44 trees and saplings and 6 seedlings, the total of 66 must include the plants from Turakina Valley.

A sample of nine trees was also cored for age determination by Rogers (1996a, b) and a growth curve was derived from these. Compared with data from *O. hectorii* s.s. on the same graph, there was a marked tendency for *O. gardneri* to have smaller old-age stems, i.e. the *O. gardneri* sample grew more slowly than *O. hectorii* s.s. in the South Island. Rogers (1996a, b) related the difference to the comparatively poorly drained sites occupied by the *O. gardneri* trees that he sampled.

4.2 HAWKES BAY REGION

The 1-day survey on 21 February 2003 found no *O. gardneri.* The intact forest was dominated by kahikatea (*Dacrycarpus dacrydioides*), matai (*Prumnopitys taxifolia*), and rimu (*Dacrydium cupressinum*), with local patches of red beech (*Nothofagus fusca*). Hutchinson Scenic Reserve is underlain by limestone, which outcrops in gullies that are now in scrub and pasture. The intact forest is on a broad, gently sloping ridge, with soils based on tephra.

While the 2003 survey cannot rule out the possibility that a shrub of *O. gardneri* might still survive somewhere in the reserve, dense blackberry and other vines occupy almost all the likely habitat for it, i.e. the forest edge (Druce 1972). The most common regenerating native shrub is kohuhu (*Pittosporum tenuifolium*). Gaps within the forest had fewer rampant vines than the forest margins, although two gaps had climbing fuchsia (*Fuchsia perscandens*) which grows with *O. gardneri* in a number of sites in the Rangitikei region (see Section 5.3) and might be regarded as an indicator of *O. gardneri* habitat. Divaricating shrubs in the forest at Hutchinson Scenic Reserve included small-leaved mahoe (*Melicytus micranthus*), *Raukaua anomalus*, round-leaved coprosma (*Coprosma rotundifolia*) and *C. propinqua*, all of which grow with *O. gardneri* in Rangitikei and Wairarapa sites but are too widespread elsewhere to be called 'indicator species'. Mountain wineberry (*Aristotelia fruticose*) is also in Hutchinson Scenic Reserve and commonly grows with *O. gardneri* in the Rangitikei region. *Coprosma rubra*, listed by Druce (1972)[4] and in an undated file list for Hutchinson Scenic Reserve by Geoff Walls, is a rather better indicator for *O. gardneri* but could not be found in the 2003 survey of Hutchinson Scenic Reserve. In the Rangitikei and Wairarapa regions, kahikatea and matai are commonly found in forest with *O. gardneri*, but rimu is rarely present and native beeches are unknown.

In some aspects of its vegetation, topography and underlying geology, Hutchinson Scenic Reserve is different from other sites containing *O. gardneri*. It has few 'indicator species' that, in the absence of past records, suggest this would be a likely place to find *O. gardneri*. Nevertheless, the species was present in the past and there appears to be suitable habitat for restoring it, on both the forest edge and in several of the larger canopy gaps. Sites on the forest

[4] Druce's plant list covers Hutchinson Scenic Reserve and Balls Clearing, without a separation of species into their respective reserves)

margin offer scope for many dozens of plants, with smaller numbers in canopy gaps. Forest margin site(s) would need considerable clearing of rank grasses and vines, and would need ongoing maintenance. Less initial management would be needed in canopy gaps; although some have blackberry and rank pasture grasses. The rate of natural closure of these gaps is unknown.

4.3 WAIRARAPA REGION

4.3.1 Wainuioru River

Eight person-days were spent searching riverbanks and gullies in the area between Tyneside and Te Kowhai Stations, without finding any additional *O. gardneri*. It is now believed that this part of the Wainuioru River (situated on Bankview, Hikorangi and Admiral Stations) is largely unsuitable for *O. gardneri*, because of the geology, substrate and vegetation (rock, stable soil, totara and beech forest). In areas that appeared suitable (gullies at Bankview Station), no *O. gardneri* specimens were found.

4.3.2 Rorokoko Stream

An area of grazed podocarp forest (with a significant component of three species of *Nestegis*) at Rorokoko Stream, approximately 4 km above the confluence with the Tauweru River, was searched on 19 and 20 April by Aalbert Rebergen. Three *O. gardneri* were found here, along a small stream, over an area of 700 m. A fourth *O. gardneri* had recently died. All three shrubs were found within 10 m of the stream, in light gaps and on soil that had slipped at some stage. More details are shown in Table 6.

4.3.3 Kaumingi Stream

Kaumingi Stream (Te Kanuka Station and adjoining farms) bush is an area of grazed podocarp forest, 2 km south of the Rorokoko Stream site. The vegetation is varied, ranging from flat river terrace forest with a dense divaricating understorey to regenerating and disturbed forest on moderately steep slopes. Other significant plant species were found here also (see section 5.3).

Twelve shrubs of *Olearia gardneri* were found in roughly three parts of the fragmented forest:

- On the narrow river flat next to Kaumingi Stream, in predominantly pasture (2 plants).
- Next to the lower reach of Stony Creek (200 m upstream from the Kaumingi Stream confluence) (4 plants).
- On the terrace riser on the western side of Kaumingi Stream, in disturbed vegetation, either on old slips or beside small watercourses (6 plants).

All *O. gardneri* shrubs were found in light gaps and on slips and disturbed soil. Against a trend of finding *O. gardneri* close to streams, were the six plants on the terrace riser well away from and above the river's direct influence, though some of these were beside small tributary watercourses. During floods, the river continues to undercut the toe of the slope, causing the naturally unstable and water-logged mudstone on the terrace riser to slump. At two or three places near *O. gardneri* were land-slips that probably occurred within the last 5 years.

4.4 BOTANIC GARDENS: PERCY SCENIC RESERVE, LOWER HUTT AND OTARI / WILTONS BUSH RESERVE, WELLINGTON

Features of cultivated plants of *O. gardneri* and *O. hectorii* which appear to differ between species are listed in Table 7. Characters not visible in the field or on the cultivated plants examined have been added from the literature, and indicated as such. They include the characters that Heads (1998) used to distinguish the two taxa and some of the author's own observations in 2003 of herbarium material at WELT and CHR and of live material of *O. gardneri* cultivated in Wanganui from Mataroa.

TABLE 6. LOCATIONS, SITE DATA AND DIMENSIONS OF 15 *Olearia gardneri* FOUND AT ROROKOKO AND KAUMINGI STREAMS (DATA FROM REBERGEN et al. 2002).

SITE NAME	DIST.[1]	HT[2]	PLANT HT[3]	ALT.[4]	COMMENTS
1 Rorokoko Stream	10	5	4.5	100	Dead individual 5 m from live one, cattle rubbing evident.
2 Rorokoko Stream trib.	5	3	1.4	110	Young plant, 1 m from cattle track, in the open.
3 Rorokoko Stream trib.	4	2	3.5	125	Multi-stemmed plant, growing from under a log.
4 Kaumingi Stream trib.	2	2	3.5	105	Plant has lots of bush lawyer growing on it, 40 m from main stream. Bush lawyer removed August 2002.
5 Kaumingi Stream	5	5	3.5	110	Plant below flood line, out in the open, some dead branches.
6 Kaumingi Stream	100	20	2.5	130	Multi-stemmed, young plant, not a wet site, 5 m from 2002–07.
7 Kaumingi Stream	100	20	3	130	Two-stemmed, densely vegetated area, 5 m from 2202–06.
8 Kaumingi Stream	100	20	2.5	130	Skinny shrub, shaded, crowded, 3 cm diameter stem.
9 Kaumingi Stream	120	30	3	140	On top of terrace riser, shaded, 10 m from 2002–10.
10 Kaumingi Stream	120	30	2.5	140	On top of terrace riser, lush growth, 10 m from 2002–9
11 Kaumingi Stream	100	20	3.5	130	Three-stemmed, large shrub, 10 cm stem diameter.
12 Stony Creek/Kaumingi	10	5	4	115	50 m from forestry boundary, dead individual 10 m away.
13 Stony Creek/Kaumingi	10	4	1.5	110	Small tree, lying flat on ground, close to 2002–14.
14 Stony Creek/Kaumingi	10	3	4.5	110	Small individual, base of trunk 1 m below flood level.
15 Stony Creek/Kaumingi	15	5	4	115	Skinny shrub, small crown, shaded, 20 m from 2002–12.

[1] Distance from river / stream (m)
[2] Height above river / streambed (m)
[3] Plant height (m)
[4] Altitude above sea level (m)

5. Discussion

The June 2001 survey of the Rangitikei region increased the numbers *of O. gardneri* known in the region by about 25% and almost doubled the number of known seedlings. Wairarapa surveys in 2001–02 increased the number of known shrubs from 5 to 20 (Rebergen et al. 2002). Even with these new finds, which give a national total of 159 naturally occurring plants in the wild (111 adults and 48 seedlings and juveniles < 1 m tall), *O. gardneri* is still the third-rarest native tree in New Zealand.

TABLE 7. DIFFERENCES BETWEEN CULTIVATED PLANTS OF *Olearia gardneri* AND *Olearia hectorii*, WITH ADDITIONAL DIFFERENCES FROM WILD PLANTS, HERBARIA AND LITERATURE.

MORPHOLOGICAL FEATURES	*Olearia gardneri*	*Olearia hectorii*
Leaf		
Leaf shape	Orbicular to orbicular-ovate; tip mucronate.	Ovate (leaves twice as long as wide), mucronate.
Petiole	Sparse cottony hairs.	Short retrorse hairs.
Upper leaf surface	Fine hairs when young but soon becoming glabrous except for cottony, appressed hairs on margins; stalked yellow (gold) glandular hairs; margins plane.	Fine hairs, becoming glabrous except for appresssed hairs on slightly down-rolled margins.
Lower leaf surface	Hairs retained on midrib and close to petiole; remainder becoming glabrate with just a few, scattered hairs, the hairs flattened, like narrow scales.	Hairs all over, dense (tomentose), the appressed, mostly anthrors hairs linear; a few obscure yellow (cream) stalked glandular hairs among the tomentum.
Tree*		
Height	3.5 m */maximum 8.0 m (Ogle 2001)].*	5.0 m */maximum 9.5 m (Heads 1998)].*
Young shoots	Bark coppery, glabrous.	Bark dark purplish-brown with white hairs when young.
Branching	4 main branches separating < 1 m above soil level; largest = 40 mm d.b.h. Branchlets ± 90° to axis (wide-divaricating).	5–7 main branches separating < 1 m above soil level; largest 70 mm and 85 mm d.b.h., on the 2 trees, respectively. Branchlets ± 30° – 45° to axis (fastigiate).
Flowers		
Phyllaries	*Approximately 16, glabrous, membranous, purple-tinged, obovate, acute (Heads 1998); upper third of each with fimbriate margins, surfaces with abundant stalked yellow glands (CCO, pers. obs., 2003).*	*Approximately 17, outer lightly tomentose all over, inner tomentose at tip and on midrib, spheroidal glands* 2 µm *also present (Heads 1998); cream (not purple), not fimbriate; yellow-stalked glands among bases of hairs (CCO, pers. obs., 2003).*
Florets	*Ray florets 9, white; disc florets 10 (Heads 1998).*	*Ray florets 2–17, dirty yellow; disc florets 8 (Heads 1998).*

Data in italics from sources other than Percy and Otari Reserve plants.

* Based upon 2 trees of each species at Otari, growing beside each other and planted 22 May 1990.

5.1 SEEDLINGS

5.1.1 'Natural' habitats of seedlings

Seedlings of *O. gardneri* have been found in the wild at five sites only, all in the Rangitikei region. In the only two sites with formal protection, there is just one seedling of *O. gardneri* (Ngaurukehu Scientific Reserve) or none (Paengaroa Scenic Reserve).

At Paengaroa mainland island reserve, the lack of regeneration of *O. gardneri* mirrors that found in the same reserve by Briggs & Trass (2001) for *Coprosma wallii*. Both species have significantly more regeneration in the adjacent Tranz Rail block where cattle were present until two years ago. There has been no significant grazing animal presence in Paengaroa since 1987 (other than a few sheep which have been found since and removed). However, there has been considerable habitat disturbance in Paengaroa over the past 10 years from weed control operations, especially of ivy (Ogle 1991). Many divaricating shrubs have regenerated in sites cleared of weeds, including threatened or regionally rare species like heart-leaved kohukohu (*Pittosporum obcordatum),* leafless mahoe (*Melicytus flexuosus), Coprosma obconica* and *C. virescens*. It might be significant that, although *O. gardneri, C. wallii* and numerous other shrub species have seedlings in the Tranz Rail forest, *P. obcordatum* seedlings have not been found there despite intensive searches (Briggs & Trass 2001). A lack of *P. obcordatum* seed sources should not be a reason, for 16 trees were found, of which 6 were confirmed as being female by the presence of fruit, and seeds from the Tranz Rail block have proved viable when planted. The gender of the remaining 10 trees could not be determined because flowering had finished before the survey; some trees may not be of flowering size. Although most of the threatened species of divaricating plant in the region's valley floor forests regenerate in disturbed sites, not all species regenerate in the same kind of site or in response to the same kind of disturbance.

5.1.2 Site management for new seedlings

From 1999, the increase in known numbers of *O. gardneri* was particularly notable for juvenile plants. While is tempting to conclude that there has been a recent flush of seedlings, caution is required. Firstly, there is better knowledge now of what juvenile plants look like; secondly, it has become easier to predict likely places to find juveniles.

The finding that most seedlings were in forests where stock are trampling and pugging the ground, or where this occurred until very recently, mitigates against the need to protect adult trees from stock damage. Under natural conditions, it appears that there is only a very short time in which viable seed are available and able to reach a suitable spot to germinate. That all natural seedlings were found under or very close to adult plants of *O. gardneri* implies poor seed dispersal. The lack of suitable places for seed germination near many of the adult plants in Paengaroa and elsewhere may be the main limiting factor for natural regeneration. This was stated by Rogers (1996a, b), who argued that introduced grasses and other herbaceous plants around adult trees were preventing seedling establishment, although he also doubted seed viability. The 2001 survey showed that low seed viability was probably not a significant

factor in the wild in the Rangitikei region, since seedlings were found in five different forest patches (Table 2) and, in at least four places within these, clusters of seedlings were found.

Different batches of seed from the same trees at Mataroa gave variable germination at Percy Scenic Reserve, that was attributed to factors such as differences in seed freshness, methods of seed storage, temperature and seed moisture (R. Smith, pers. comm.). Seed taken from the isolated trees in the Wairarapa region has had very poor germination, compared with seed gathered in the same year from the Tranz Rail block at Mataroa (R. Smith, pers. comm.). However, the six trees of *O. gardneri* in the Paengaroa Scenic Reserve are isolated from one another, making cross-pollination very unlikely. *O. gardneri* is unlikely to be self-incompatible, because seed gathered on 15 January 2001 from the single isolated tree (No. 2806) at Site 6 in Paengaroa gave 'excellent germination' at Percy Scenic Reserve. More important may be the time of seed collection. Seed gathered only 1–2 weeks later from the same tree and others on the Tranz Rail land germinated poorly. The packaging of the seed, the time between harvest and sowing, and the sowing conditions are other factors that might have produced different germination success rates in cultivation. The possibility that self-incompatibility is an issue also for *O. hectorii* has been raised (J. Barkla, pers. comm. July 2003), with the report of an instance of seed failing to germinate from an isolated *O. hectorii* tree in Dunedin.

It is clear that substrate disturbance is necessary for seeds of *O. gardneri* to germinate and develop. Just how the site disturbance needs of *O. gardneri* were met before the presence of farm animals, pasture plants, exotic pests and weeds is still uncertain. Scarification of the forest floor, as occurred as a result of pulling ivy, *Hedera helix*, at Paengaroa, produced no *O. gardneri* recruitment. A different experimental approach should be tried that emulates the sites where seedlings now occur, if there is to be successful 'natural' establishment of *O. gardneri* from seed within its natural range. The Tranz Rail block shows that removal of stock following the establishment of seedlings allowed the seedlings to grow into saplings. Three sites on private land had clusters of seedlings in cattle-trampled places in 2001. If those had been fenced, a new cohort of *O. gardneri* trees might have resulted. Restoring *O. gardneri* to the landscape requires restoration of its habitat, to allow the natural processes of forest growth, disturbance, renewal and replacement that were always part of a dynamic living system.

John Barkla (DOC Otago Conservancy) reported some success in encouraging seedling establishment of *O. hectorii* in the Catlins, South Otago by use of herbicide to kill ungrazed pasture grasses (J. Barkla, pers. comm.). Greater success followed in the Matukituki Valley near Wanaka, where Stu Thorne (DOC's Wanaka Area Office) used the same procedure in a recently fenced, fragmented population of *O. hectorii.* In October 2001, Thorne sprayed rank grass beneath and downwind of mature *O. hectorii* trees with the herbicide 'Touchdown', applied at a rate of 60 mL/L using a 10 L knapsack sprayer. By early February 2002 there was not only a good knockdown of the grasses but also 'fantastic regeneration' of *O. hectorii* seedlings in virtually all sprayed areas. Many thousands of seedlings were present with many already 10 cm tall. The seedling density was 4675 seedlings/m^2 in the most dense seedling carpets. Some seedlings were removed and grown in a nursery for other restoration

projects in the valley. It seemed that the combination of a good knockdown of grasses, coinciding with *Olearia* seed fall, followed by a wet spring and early summer produced this spectacular result. The apparent success of this experiment has raised many questions about seedling survivorship and growth rates because dry summer conditions were causing large losses by March 2002 (J. Barkla, pers. comm.).

This kind of habitat manipulation had been attempted earlier for *O. gardneri* and was reported by Rogers (1996b) for an exclosure constructed on the forest edge in the Tranz Rail block at Mataroa. A tall shrub of *O. gardneri* grew just outside the exclosure. Cattle grazed the surrounding area periodically at that time. Half the enclosed plot was dug manually to remove weeds and pasture grasses and the other half sprayed by unspecified herbicide. No *O. gardneri* seedlings were found within 12 months (Rogers 1996b). In 2001, a 20-cm seedling was found right on the fenceline of this exclosure (CCO, pers. obs.). There are several reasons why the exclosure on the Tranz Rail land did not produce the anticipated result. The exposed ground was covered with exotic herbs within a year of disturbance. Neither digging nor the herbicide killed the weeds with rhizomes or underground storage organs, like creeping buttercup and docks. The timing of the weed knockdown is also likely to be critical, as are the weather conditions when the seeds drop and for the next few months during germination and seedling growth. As success one year might not be repeatable the next, the experiment with *O. gardneri* should not have been abandoned after one failure. Although it is possible that the success of this experiment with *O. hectorii* might not apply to other species, like *O. gardneri*, it should be repeated in several sites in the Rangitikei and Wairarapa regions. The Tranz Rail exclosure at Mataroa might be used again, but weed control needs to be more effective first.

Site-specific factors such as soil type and wetness, light and absence of other plants are probably the most important determinants of whether seed that falls actually germinates and grows into larger seedlings. Casual observations of plantings of *O. gardneri* show that under similar climatic regimes, plants in gardens grow much faster than those planted into 'the wild'. Cutting-grown and seed-grown plants in Paengaroa Scenic Reserve have grown more slowly than same-age (or even younger) plants at the nearby Mataroa School (H. Dorrian, pers. comm. 2003). Cutting-grown shrubs in the Koromiko Station cottage garden, Wairarapa, have grown much faster than those planted in fenced pasture only about 200 m distant. Root competition for young plants of *O. gardneri* will be much lower in gardens than in pasture or forest edge sites, and is probably an important factor in determining the rate of growth of young plants.

While stock trampling appears to have created good conditions for seed germination in several places, on-going grazing by stock destroys the young plants. The recent 'bumper crop' of young plants in the Tranz Rail block is likely to be the result of cattle pugging of the ground to produce a seed bed, followed by removal of cattle which allowed the seedlings to continue their growth. In the wild, the right combination of conditions will be rare, but has probably led to the pulses of past regeneration inferred by Rogers (1996a) from size-class distributions in *O. hectorii* s.l. A major concern now is that suitable conditions may occur more rarely than in the past, because of introduced plants, stock grazing and reduced numbers of parent plants to produce seed.

5.1.3 Seedling form

Seedlings of *O. gardneri* have rather pale, almost bluish-green, finely hairy leaves with a short terminal mucron, and sometimes one or two obscure lobes on leaf margins. Even tiny seedlings can be distinguished from seedlings of other species by a distinct, raised ridge on opposite sides of the stem. Each ridge runs from the leaf axil to the mid-point of the node between the next pair of leaves above.

Until an 8-cm-tall seedling was found with alternate leaves in the Tranz Rail land at Mataroa in January 2000, it was believed (Heads 1998) that both seedlings and adult plants have an invariably opposite and decussate leaf arrangement. The seedling with alternate leaves was removed and grown on by Robyn Smith at the nursery of Percy Scenic Reserve, Lower Hutt. Once it started branching, the shoots produced opposite leaves only. In 2001, Robyn Smith (pers. comm.) had considerable success in growing *O. gardneri* plants from seed gathered from the Tranz Rail land. Seeds gathered from different trees on 15 January 2001 were germinated separately. In each batch of seedlings, Smith noted that many seedlings had alternate leaves, at least for approximately the first six leaves. Data from four separate trees are shown in Table 8.

Seedlings with opposite leaves were in the minority in this sample from four trees in one location. After about six leaves, the terminal shoot tends to cease growth and lateral shoots develop from the bottom nodes. Most, but not all, lateral shoots bear opposite leaves (R. Smith, pers. comm.). In February 2000, a single shoot with alternate leaves was found on one branch of an adult tree in the Tranz Rail land. This was collected and vouchered (CHR 536434) with a covering note about the phenomenon.

Alternate-leaved seedlings of *O. hectorii* have been found in the wild in the Catlins area of Otago and in cultivation, but these all produced opposite leaves once they grew beyond seedling stage (J. Barkla, pers. comm. 2001). The phenomenon has not been quantified for *O. hectorii*.

5.2 MATURE *Olearia gardneri*

5.2.1 Habitats: landforms, soils and vegetation

The habitat of *O. gardneri* was discussed under that of *O. hectorii* by Rogers (1996a, b). Although he believed he was dealing with a single taxon, Rogers (1996a, b) drew attention to differences between North Island and South Island

TABLE 8. ALTERNATE LEAVES IN *Olearia gardneri* SEEDLINGS IN CULTIVATION.

TREE NUMBER*	NUMBER OF SEEDLINGS WITH ALTERNATE LEAVES (n = 25 EACH SAMPLE)	% OF SEEDLINGS WITH ALTERNATE LEAVES
Tree 1	18	72
Tree 2	19	76
Tree 3	21	84
Tree 4	17	68
Totals	75	75

* Tree souce was separate trees on Tranz Rail land, Mataroa.
Information from R. Smith, Percy Scenic Reserve, pers. comm. July 2001.

sites. He specified the winter wetness of sites in the Hautapu Valley, coupled with hot, dry summers, and the moderate fertility of the soil parent materials (andesite, limestone and mudstone in alluvium or colluvium). In the North Island, *O. gardneri* was shown to be associated with podocarp-broadleaved forest rather than beech, the latter being stated as a common feature of *O. hectorii* sites in the South Island. There have been many additional findings of *O. hectorii* since Rogers (1996a, b). John Barkla and Dr Geoff Rogers (pers. comms. July 2003) have stated that their knowledge of the species' ecology has increased considerably since then. Almost all of the newly discovered sites were on lowland alluvial floodplains dominated either currently or previously by podocarp-broadleaved forest. *O. hectorii* grows in the vicinity of beech forest in the Matukituki and Pomahaka valleys, but these are thought to be relict populations. In the past, *O. hectorii* may have been very close to beech at, for instance, the margins of slips and other highly disturbed sites within a wider beech matrix. A further complication in assessing the previous place of *O. hectorii* in the landscape is that following forest clearance or other major disturbances, sites previously dominated by beech were often replaced by broadleaved forest. The habitats of *O. gardneri* and *O. hectorii* still appear to be very similar (G. Rogers, pers. comm. July 2003).

There is red beech at Hutchinson Scenic Reserve, Hawkes Bay, although it is not known whether *O. gardneri* grew near these trees. Kamahi and tawa are absent from sites with *O. gardneri* (Rogers 1996a, b). A feature of *O. hectorii* s.l. habitat identified by Rogers (1996a, b) was that it now occurs in 'moderately to grossly modified sites surrounded by naturalised herbaceous communities'. Only in the Wairarapa region is *O. gardneri* known in such totally modified sites.

Most adult *O. gardneri* were found on forest margins or in gaps, growing on the forest margin, or a metre or so beyond the margin in pasture, or just inside the forest edge with part, or all, of its crown in a light gap. The present-day forest margin is almost always the result of forest clearing for farming and it is hard to envisage where *O. gardneri* fitted into the pre-farming landscape. Ages of specimens from the Hautapu Valley (Rogers 1996a, b) showed them all to be under 100 years of age. This shows they established after the forest had been reduced to patches.

The discovery of several plants of *O. gardneri* in light wells in forest (e.g. in the Rangitikei, one tree at Site 7, 4 trees in Site 1, and 8 trees at Site 10) indicates that canopy gaps were a possible habitat before there was so much forest edge. Forest gaps can be the result of tree falls but, as pointed out by Ogle & Barkla (1995) and Rogers (1996a), the forest in places like the Hautapu Valley can have light wells where it is dominated by small-leaved, sometimes deciduous, trees such as ribbonwood, kowhai, *Sophora godleyi* and / or *S. microphylla*, and lacebarks, *Hoheria angustifolia* and / or *H. populnea*. Such forest has a sparse canopy, especially in winter, in comparison with many other indigenous forest types. Kowhai was recorded as part, or all, of the canopy in 8 of the 10 Rangitikei sites. In the Turakina Valley site, 10 of the 16 adult *O. gardneri* were under kowhai, as were 8 of the 16 trees in Ngawaka Stream and the single scattered trees of *O. gardneri* in Paengaroa Scenic Reserve. Site 7 at Paengaroa had ribbonwood and *H. angustifolia*. The site with 30 adults of *O. gardneri* on the Mataroa Tranz Rail land had kowhai, *H. angustifolia*, and ribbonwood as the main canopy trees, and that part of Ngaurukehu Scientific Reserve with seven adult *O. gardneri* had a sparse canopy of kowhai and ribbonwood.

Across the whole range of *O. gardneri*, more than half the adult trees and forest patches containing the species are grazed by domestic livestock. Post-and-rail fences have been put around individual shrubs of *O. gardneri* in pasture in the Wairarapa region. This protects the genetic resource in the short to medium term, e.g. for artificial propagation, but it does not allow natural expansion of the population, nor the re-establishment of the native plant community around these remnant trees. At least two Wairarapa shrubs died in the 1990s after being enclosed with 2- or 3-m-square fences. This may indicate that site factors such as changed soil moisture, soil compaction, exposure of the shrub to full sun and wind and, perhaps, past damage by stock were already leading to the inevitable loss of isolated shrubs.

Another potential habitat with sufficient light for *O. gardneri* is the edge of landslips. Ngawaka Stream had two live trees of *O. gardneri* on the edges of a recent landslip and a 22-cm-tall seedling. Another tree had been uprooted by the same slip. Riverbanks and wetland edges are other possible sites where sufficiently open areas might occur naturally. Although some adult *O. gardneri* were found beside small streams not prone to major flood events, e.g. at Sites 1, 3, 5, 6 and 7, only at Site 10 (Ngawaka Stream) were two plants found on the bank of a large stream where they might be within the flood zone. Even these were ≤ 5 m from the stream and on banks ≤ 3 m above the river's normal flow. In the Wairarapa region, the Kaumingi Stream catchment had two or three shrubs on stream banks within the flood zone. Although river banks seem to offer some suitable habitat for seedlings to establish, and some other native shrub and tree species grow within the flood zones of the rivers and large streams of the area surveyed, the rarity of *O. gardneri* in such sites suggests that it does not cope well with flood events. Mudstone hillslopes with *O. gardneri* are seasonally wet with running water, but the species was not found in places where standing water occurs for any length of time. As discussed further in Section 5.3, the range of *O. gardneri* overlaps with that of *Pittosporum obcordatum* and *Coprosma pedicellata*, but the *Olearia* does not grow in the seasonally waterlogged sites occupied by these other species. The only wetland where *O. gardneri* was seen was just upstream of Paengaroa Scenic Reserve where three shrubs were recorded growing on slightly elevated ground close to the edge of a small wetland on a river terrace. *O. hectorii* is typical of well-drained colluvium and alluvium, but John Barkla (pers. comm. July 2003) reports seeing several 1–2 m juvenile plants in a swamp among *Carex secta*.

5.2.2 Habitats: vines and *Olearia gardneri*

The effects of vines on the long-term future of *O. gardneri* are uncertain, but heavy vine growth seems likely to damage the trees physically, to limit light and to prevent much of the trees' potential to flower and fruit. Perhaps the worst smothering seen was in the upper Turakina Valley (Site 1). At the Ngawaka Stream site, the landowner stated that he already controls *Rubus schmidelioides*, wherever it occurs, and the *O. gardneri* trees recorded here were noticeably free of that vine. The extinction of *O. gardneri* and many other species in Taihape Reserve was attributed to old man's beard, *Clematis vitalba*, either by smothering or its control (Ogle et al. 2000). Apart from three patches that were found and poisoned in the Tranz Rail block in the summer of 2000–01 (Briggs & Trass 2001), *C. vitalba* has not established in any of the forest patches

covered by the *O. gardneri* survey in the Rangitikei region. It grows in the same forest patch as *O. gardneri* in Kaumingi Stream in the Wairarapa region, though the two species were not seen close together. In general, other woody weeds were absent or sparse in sites with *O. gardneri*. An exception was Ngaurukehu (Site 2) where Khasia berry and broom are common. Even here it did not appear that any of the *O. gardneri* were under immediate threat. Elderberry (*Sambucus nigra*) was recorded at Site 1 in the Turakina Valley. It is known to grow into moderate-sized trees that could shade out species like *O. gardneri*. A risk is posed by the use of herbicides to control weeds where *O. gardneri* or other threatened species occur.

The relative scarcity of *O. gardneri* in the Paengaroa mainland island (Paengaroa Scenic Reserve and adjoining DOC-managed land, see Table 4) is rather unexpected, for there seems to be ample habitat and the wide spacing of the nine known plants suggests they are remnants of a larger population in the past. The only woody exotic vine recorded at Paengaroa is garden ivy. Before 1991, extensive growths of ivy smothered the ground and climbed to the forest canopy in an estimated 14 ha of the reserve (Ogle 1991) and ivy was later found to be even more widespread. By about 1998 almost all the climbing material had been killed, mostly by hand-pulling or cutting of larger vines and applying herbicide to the stumps. It is possible that some *O. gardneri* was smothered by ivy during the period of dense infestation. Native vines occured over all the trees recorded during June 2001.

5.3 ASSOCIATES OF *Olearia gardneri*

It has been noted that the distribution of *O. gardneri* overlaps with that of other threatened or disjunct species (Rogers 1996a, b). The species he cited included *Coprosma wallii, C. virescens, C. obconica, Melicytus flexuosus* and *Teucridium parvifolium*. Such species were sometimes found growing within several metres of *O. gardneri* plants and appear to have similar habitat needs, so it is tempting to regard these associates as 'indicator species' in searches for *O. gardneri*, especially in new areas. This makes the discovery of one indicator species a reason to watch closely for others. For the forest patches containing *O. gardneri*, Table 9 gives a summary of the nationally threatened and uncommon taxa also present, and also those judged to have disjunct distributions (sensu Table 3, Ogle et al. 2000).

The usefulness of an indicator species approach may be masked by differences in past distribution patterns and more recent local extinctions. As examples, *M. flexuosus* is not known in the Wairarapa region and *Coprosma pedicillata* is not known in the Rangitikei region. *Teucridium parvifolium* is known in only one forest patch in the Hautapu catchment. This probably reflects a loss of *T. parvifolium* through grazing, for it is a rather soft-stemmed shrub compared with the other species listed by Rogers (1996a, b). As can be inferred from Table 9 and, in more detail, from Appendix 1, there are other typical (but now rare) species of the Rangitikei and Wairarapa regions' valley forests for which even the adult plants have been eliminated by stock. They include *F. perscandens* and New Zealand windgrass, *Anemanthele lessoniana*. *Teucridium parvifolium*, along with *O. gardneri* and *M. flexuosus*, became extinct in Taihape Reserve as a result of smothering by *Clematis vitalba* or its subsequent control (Ogle et al. 2000).

Differences in habitat requirements may result in species whose ranges overlap growing in different sites, even where they grow in the same remnants of native vegetation. *Pittosporum obcordatum* was identified by Rogers (1996a, b) as a species whose distribution overlaps with *O. gardneri*, but at Kaumingi Stream in the Wairarapa where the two species occur in the same forest remnant they do not grow close together. *O. gardneri* grows in better-drained sites than *P. obcordatum*, the latter usually occurring in the sites with seasonally standing water. In the Mataroa Tranz Rail block, *O. gardneri* and *P. obcordatum* do grow within perhaps 100 m of each other, but the former is concentrated along the banks of a minor stream and the latter is beside a swamp and on flat ground subject to seasonal ponding. *C. pedicellata* has a disjunct distribution that overlaps with that of *O. gardneri* in the Wairarapa. It grows with *P. obcordatum* in several places, including Kaumingi Stream, but it is not known to occur with *O. gardneri* even where it exists in the same forest remnant.

For the Hautapu catchment, the distribution of species was discussed in relation to habitat factors by Ogle et al. (2000). The full set of plant distribution data, as known currently in the Hautapu catchment, comprises Appendix 1. That data set does not separate the data in the Tranz Rail block from those in Paengaroa (they are merged in Column H1), and nor does it contain data from the Turakina

TABLE 9. NATIONALLY THREATENED, UNCOMMON AND DISJUNCT SPECIES OCCURRING IN SAME BLOCKS OF FOREST AS *Olearia gardneri* IN THE UPPER RANGITIKEI AND WAIRARAPA REGIONS.

	RANGITIKEI SITES R1–R11[1]								WAIRARAPA SITES W1–W7[2]						
Species	1	2	3	4	5	6–9[3]	10	11	1	2	3	4	5	6	7
(Equivalent Appendix 1 heading)		*(B1)*	*(G1)*	*(G2)*	*(part H1)*	*(part H1)*	*(H2)*	*(I)*							
Acaena juvenca	x		x	x	x	x	x	x							
Anemanthele lessoniana						x		e					x		
Coprosma linariifolia					x	x	x	x							
Coprosma obconica			x	x	x	x	x							x	
Coprosma pedicellata														x[4]	
Coprosma rubra	x			x	x	x	x	x	x						
Coprosma virescens			x	x	x	x	x	x	x						x
Coprosma wallii		x	x	x	x	x	x		x						
Dactylanthus taylorii			x					x							
Fuchsia perscandens	x		x			x	x	e			x				
Hoheria angustifolia			x	x	x	x	x	x							
Korthalsella clavata				x		x									
Lagenifera petiolata			x		x										
Melicytus flexuosus		x	x		x	x	x	e							
Olearia gardneri	x	x	x	x	x	x	x	e	x	x	x	x	x	x	x
Pittosporum obcordatum					x	x								x[4]	
Poa matthewsii			x		x	x	x								
Teucridium parvifolium						x		e					x		x

(x = present, e = present until at least 1970s but now extinct [Ogle et al. 2000]. Abundance is not indicated).

[1] R1 Upper Turakina Valley; R2–R10 Hautapu Valley (R2 Ngaurukehu Scientific Reserve; R3 Coogan's hillslope; R4 Coogan's river flat; R5 Tranz Rail lease; R6–R9 Paengaroa mainland island[3]; R10 Ngawaka Stream; R11 Taihape Reserves). See also Table 4.

[2] W1 Koromiko; W2 Tinui; W3 Admiral Station Road; W4 Tyneside; W5–W7 Kaumingi (W5 Kaumingi Stream; W6 Kaumingi Stream; W7 Stony Creek).

[3] Species found only in Paengaroa mainland island are not included in Table 9.

[4] Species in same forest patch as *O. gardneri*, but not growing with it (i.e. growing on elevated wet terrace on ridge above).

Valley. The data set shows some coincidences of *O. gardneri* with the distribution of other threatened or disjunct plants and, conversely, that *O. gardneri* is absent where other threatened or disjunct plants are rare or absent. An example is the Hautapu River between Paengaroa and Taihape (Columns H3–H5, Appendix 1). Along this stretch of river, the patches of kowhai-dominated forest are very impressive, but some indicator species were rare or absent: *Coprosma rubra* was uncommon, only one shrub of *C. virescens* was found, and there were no *C. wallii, C. obconica, Melicytus flexuosus,* or *Hoheria angustifolia.*

However, the absence of most 'indicator species' cannot be used to dismiss a site. If the presence of indicator species were applied rigorously as site criteria, then the upper Turakina River forest probably would not have been searched, nor Hutchinson Reserve in Hawkes Bay, nor several Wairarapa sites including Tinui and Tyneside (Table 9).

5.4 FINDING *Olearia gardneri*

There remain many unsurveyed sites with potential for finding *O. gardneri* in the Rangitikei, Wairarapa and even Hawkes Bay regions. Because some specimens survive in very modified patches of forest or shrubland, no patch can be dismissed as not having this tree daisy without a close inspection. However, there are some trends among sites known to have the species.

Olearia gardneri is more likely to be found on valley floors or lower side slopes (as opposed to ridges); on the edges of forest rather than the interior (but is occasionally found in canopy gaps); close to small streams, especially where there is a 1–3 m bank; on seasonally dripping mudstone slopes; and in places where other threatened or disjunct tree or shrub species have been found.

Mid-winter proved to be a very suitable time to survey for *O. gardneri* in the Rangitikei region, because of its yellow autumn leaves and the reduction in ground cover of grasses and herbaceous weeds.

Landowners were generally very interested in knowing about *O. gardneri* and other unusual plants and sometimes assisted enthusiastically in the surveys. In 2002, DOC staff gave nursery-grown specimens of *O. gardneri* to Rangitikei landowners who had the species on their properties or nearby. It was hoped that this might lead to more discoveries of plants by landowners themselves, as well as being a gesture of thanks to those who assisted with the survey.

5.5 DISTINGUISHING *Olearia gardneri* FROM *Olearia hectorii*

This project did not aim to consider the conservation of species other than *O. gardneri*. However, since Heads (1998) separated *O. gardneri* from *O. hectorii* there has been debate among New Zealand botanists about the validity of that decision. Questions about how to distinguish the two taxa were raised a number of times during the current project, including distinguishing shrubs already in cultivation. The criteria used in Heads' (1998, p. 257) key to

separate the two species were leaf tomentum, leaf size and the visibility of leaf veins, and the shape and hair covering of the flower head bracts (phyllaries) (Heads 1998, pp. 265–267). Additional differences were noted by CCO between cultivated plants of the two taxa at Percy Scenic Reserve and Otari / Wiltons Bush Reserve (Table 7).

Heads (1998) described *O. gardneri* as, 'a deciduous shrub or small tree to 3 m tall, trunk 15 cm diameter'. This statement was not supported by the data of Rogers (1996a, b) or by the 2001–03 surveys. As discussed in Section 4.1.3, the largest tree found in the Rangitikei region was 8 m tall and 10 or more trees exceeded 5 m. Although Heads did not specify that his trunk diameter was a dbh measurement, several specimens were found by both Rogers (1996a, b) and in the June 2001 survey that exceeded 15 cm dbh; some were much larger if measured below the fork in the trunk that is quite a common feature of *O. gardneri*.

Large branches often diverge at wide angles above a forked trunk and lead to a tree with a wide-spreading crown. However, the smaller shoots and twigs are characteristically vertical (orthotropic) from these wide-angled branches. Some trees can have a portion of the trunk that is almost horizontal; near-vertical coppicing is common from horizontal branches. Vines often suppress the vertical growth tendencies of the species. Horizontal branches or main trunks are almost always found on trees along the forest margin, as a growth response to light from one direction. It is quite common to find trees with one or more dead major branches on forked trees or branches that have split off at the trunk. An apparent, single, horizontal trunk could be the result of other forks dying. Such trees might be those that Rogers (1996b) refers to as having semi-lianoid branches.

One plant was mentioned by Rogers (1996b) in Ngaurukehu Scientific Reserve that had taken root at the point of ground contact of a collapsing stem. This plant was not found in 2001 and nor were adventitious roots found on several other collapsed trees during the Rangitikei survey. Only one such example has been recorded in the past decade, namely a shrub at Springhill Station, Tinui in the Whareama River catchment (Wellington Conservancy threatened plant database; site inspection 10 Oct 1996). Elsewhere in the Wairarapa region, no roots have been found at the point of contact of *O. gardneri* branches that touch the ground, despite close searching that included excavation under one example (G. Foster, pers. comm.). The recent field evidence, therefore, does not support Heads' (1998) statement that older branches are 'often arching and rooting'. If this does occur, it is a very rare phenomenon, and certainly is not a characteristic of the species.

As discussed in Section 5.3, a feature of *O. gardneri* is that it almost always occurs with other threatened or disjunct species, especially divaricating shrubs. None of the other taxa are confined to the North Island, but form a suite of species that occur together, typically in the eastern North and South Islands on alluvium or colluvium, in places often subject to seasonal drought and cold winters with water-logged soils. That *O. gardneri* and *O. hectorii* seem to replace each other ecologically has no obvious equivalent among other species of these habitats. For this reason Ogle (2001) followed Eagle (1982) and Druce (1992) and suggested that the two taxa might be regarded as representing two subspecies of *O. hectorii.* However, as they now appear to be discrete species, it is conceivable that *O. gardneri* occurs in the South Island—or did so in the past.

In summary, some of the features used by Heads (1998) to separate *O. gardneri* from *O. hectorii* are not as clear as suggested, particularly the larger size of the trees of *O. gardneri* and their non-layering habit. However, there are additional differences between the two taxa that were not mentioned by Heads (1998). These include fimbriate phyllaries and yellow glands on the upper leaf surfaces of *O. gardneri* but not in *O. hectorii*. Numerous morphological differences between *O. gardneri* and *O. hectorii* support Heads' (1998) view that they are separate species and might not be even closely related. It is possible that the closest relative of *O. gardneri* is some other taxon. *Olearia. polita* was proposed as one candidate by Heads (1998), but this possibility has not been examined further.

6. Summary and conclusions

Olearia gardneri is a daisy, growing as a deciduous tall shrub or small tree with a divaricating branching pattern. It is endemic to the North Island of New Zealand, where it grows mainly in river valleys on alluvium or colluvium, usually with mudstone (sometimes limestone) as the parent material. It is usually found on forest margins, with a range of other divaricating shrub species under podocarps and a small range of broad-leaved tree species. *O. gardneri* is known from only two formally protected reserves and from one other site leased by DOC. All other sites are on private land.

O. gardneri is still a critically threatened species in the wild, despite the finding of more adults and juveniles than were known prior to the 2001–03 surveys. Throughout their range, many adult shrubs and trees are in poor condition because of browsing and trunk rubbing by livestock, smothering by vines (mostly native, but this is a consequence of forest disturbance), erosion and / or compaction of soil around tree roots, and general habitat degradation. Farmers have assisted or allowed DOC staff to erect exclosures around several *O. gardneri* shrubs in farmland and, in at least two places, to enclose larger areas of farmland to exclude stock and allow revegetation projects to proceed. Like a number of other divaricating shrubs in farmland, larger individuals of *O. gardneri* have proved to be quite resilient. This gives a 'window of time' in which to gather propagating material and plan for the reintroduction of plants to protected sites. With adequate handling and storage, seed has proved easy to germinate and the shrubs have grown readily under garden conditions.

Where *O. gardneri* struggles, in comparison with most of the species around it, is in the lack of recruitment of young plants through poor seed germination or subsequent death of the juveniles. At the five sites where *O. gardneri* seedlings were found in the wild, livestock had heavily trampled the ground. The growth of pasture grasses and exotic weeds right to the bases of many mature plants prevents seedling establishment. Disturbance of the substrate surface (e.g. by cattle) seems essential to seed germination and seedling establishment in *O. gardneri*.

7. Recommendations

7.1 UNPROTECTED SITES WITH *Olearia gardneri*

Various criteria can be applied to setting priorities when considering options for managing the risks to *O. gardneri* on privately-owned sites:

- How large is the population of *O. gardneri* and what range of plant sizes is represented, particularly of juvenile plants? Larger populations can be expected to have more genetic diversity and to be more likely to survive accidental events (either large-scale like landslides, or small-scale like tree falls). In the Rangitikei region, Site 1 (upper Turakina Valley) and Site 10 (Ngawaka Stream) have the two largest populations, outside the Tranz Rail land; Site 10 has many more juveniles than Site 1. The fragmented forest around Kaumingi Stream is the Wairarapa's largest population.
- How stable is the site in terms of land and soil, flooding, forest canopy, weeds? The Turakina and Kaumingi Stream sites have been fragmented and have some landslips and woody weeds that, in the Turakina Valley, include rampant native vines that need control; Site 3 (a hillslope forest on private land just north of Paengaroa Scenic Reserve) has no woody weeds apart from some native vines and is relatively stable; Ngawaka Stream has some landslips, but few woody weeds.
- Is the site with *O. gardneri* close to another site with it? More remote sites might be more genetically different and reflect adaptation of the species to different climates and habitats. The upper Turakina Valley and Springhill Station (Tinui) rank highly on this criterion. Hautapu Site 3 is very close to Paengaroa and the Tranz Rail block, but might also be linked to the reserve by a fenced and planted or otherwise managed corridor. Ngawaka Stream is in a separate sub-catchment of the Hautapu River and several kilometres from other known sites with *O. gardneri.*
- Which other species and forest types would be protected by protecting the *O. gardneri*? Use of the presence of other threatened species as a criterion for assessing a site's importance would make the Turakina Valley *O. gardneri* site of lower importance than almost any of the Hautapu Valley sites (Table 9). Fencing the small swamp and riparian forest of Hautapu Site 4 would protect several threatened species, including the only plant known of *Coprosma obconica* bearing the rare (in the North Island) dwarf mistletoe, *Korthalsella clavata*, and also a patch of swamp, which is rare in this district. Rangitikei sites 3 and 10 have similar suites of threatened species.
- What would be the impacts on farming (e.g. on stock and vehicle movement around the farm) of erecting a fence? How much grazing land would be retired? How much fencing would be needed and over what terrain? The riparian forest in the Turakina catchment could be fenced with little impact on farming, at least downstream from the farm track crossing of the stream, but it would be a long fence for a small area of forest. The Hautapu Valley Site 3 could be difficult to fence without impacts on the farm; the same landowner's Site 4 would be easier (but the fence would enclose only three *O. gardneri* specimens).

Each site has advantages and disadvantages in terms of the above criteria. Although there have been undoubted benefits for *O. gardneri* seedling establishment in having stock, especially cattle, in forest patches, the presence of

stock will not allow the seedlings to become adult plants; and, in the long term, stock inhibit other natural regeneration and lead to forest degeneration. Hence, fencing is regarded by the author as the priority management action for each site.

In the Hautapu Valley, none of the five unprotected sites with *O. gardneri* was identified as a Recommended Area for Protection (RAP) in the Protected Natural Areas Programme (PNAP) survey of Rangitikei Ecological Region (Lake & Whaley 1995). It should be stressed, however, that the PNAP is not about protecting threatened native species *per se*, but about identifying unprotected natural areas that are not represented in the current protected natural area network. As discussed by Lake & Whaley (1995), it was felt that Paengaroa Scenic Reserve was the best representative area of the Hautapu Valley forest remnants. The Ngawaka site (Site 10) could not be surveyed at that time and, presumably, the small narrow forest patch in the upper Turakina Valley (Site 1) was considered too small or fragmented to be representative of a forest type.

For plant species protection, it is highly desirable to protect all privately owned sites where *O. gardneri* is present. Obvious priorities lie in the Wairarapa region and the Turakina Valley. Options for legal protection include covenant or purchase. Which, if any, sites are protected legally and physically depends upon future negotiations with the respective landowners.

7.2 PROTECTED SITES WITH *Olearia gardneri*

Legal and physical protection is needed for sites across the geographic range of *O. gardneri*. Only in the Hautapu Valley of the Rangitikei region does *O. gardneri* occur naturally on land that is formally protected at present. For *O. gardneri*, even the protected sites have additional management needs, some of which are listed below.

7.2.1 Paengaroa mainland island

The present mainland island programme (Paengaroa Scenic Reserve, Te Kapua CA, Section 50 block) provides adequate protection in terms of fencing, animal pest control and weed control. However, for *O. gardneri* the following might be added to future management actions:

- Continue to watch for, label and measure new specimens, on an opportunistic basis.
- Cut native vines from the existing *O. gardneri* trees.
- Consider a different experimental approach to natural seedling establishment of *O. gardneri* (based upon observations of seedlings that have appeared in other sites), with more substantial disturbance than has been attempted e.g. in the exclosure at Tranz Rail block.
- Plant nursery-grown seedlings in previously grazed areas, such as Te Kapua and the Section 50 block, but not in natural gaps on the hill-slope of Paengaroa reserve itself (such gaps are too important for a future study of forest dynamics to be deliberately planted with any species).
- Consider planting one or two *O. gardneri* close to existing natural trees; this may improve seed viability on the original trees, through cross-pollination.

7.2.2 Tranz Rail block

The largest natural population of *O. gardneri* is at Mataroa, on land leased by DOC from Tranz Rail on a year-by-year basis. Although the 2001–03 surveys have revealed many more plants throughout New Zealand, especially juveniles, than were previously known, the present data and those of Rogers (1996a, b) are heavily weighted by the Tranz Rail site. Partial protection of this site has certainly reduced the immediate threat of extinction of *O. gardneri* in the wild, but large numbers of the plants are still ≤ 0.5 m tall and they are concentrated in just a few square metres. Accidental grazing by cattle, should they break through the exclosure fence, could eliminate the young plants in a few days.

This forest is included in the present mainland island programme, where it receives protection in the form of fencing, animal pest control and weed control. The experimental approach towards improving natural regeneration of the tree daisy suggested in Section 7.2.1 could be tried here as well, or instead of Paengaroa.

- The terrain inside the existing exclosure is quite unlike that of any site with natural regeneration of *O. gardneri*. Even if it were to be stripped again of surface vegetation it seems unlikely to be suitable for *O. gardneri*. A deeper excavation might be tried, with sloping clay banks and a drain out of the exclosure so it does not fill with water.

7.2.3 Ngaurukehu Scientific Reserve

For *O. gardneri*, the following might be added to future management actions for the northern end of the reserve:

- Secure the boundary fence against sheep.
- Give high priority to weed control, including *Cotoneaster simonsii*, European broom, ivy, *Pinus contorta* and crack willow (the latter along the river banks but, more importantly, on the slope in forest gaps).
- Negotiate with owners of the house above the reserve to limit garden plant incursions, including ivy.
- With seven plants of *O. gardneri* already located and labelled, Ngaurukehu Reserve should be resurveyed and any additional specimens labelled and measured.

7.3 FUTURE SURVEYS FOR *Olearia gardneri*

7.3.1 Rangitikei region

Olearia gardneri has been found in the Hautapu catchment in an area of c. 13 km × 7 km. This area includes the now extinct population at Taihape Scenic Reserve. In addition, there is an outlying population in the upper Turakina River, north of Rangiwaea, which is 12.5 km from the nearest known Hautapu population. Because there are many forest remnants within and between these occurrences, there is a high probability that more populations exist. There are some common factors among known sites with *O. gardneri* that can be employed in further surveys. The sites are forest remnants:

- On valley floors or lower side slopes.
- On the edges of forest or canopy gaps.
- Close to small streams, especially where there is a 1–3 m bank.
- On mudstone substrates.
- In places where other threatened or disjunct tree or shrub species occur.

Several potential sites were identified during the June 2001 survey. They included:

- The western edge of Raketapauma Conservation Area, especially along the upper Turakina River and possibly into Main Gorge Stream; this area is just east of the upper Turakina (Site 1) where 16 adults and 4 seedlings of *O. gardneri* are known. Part of this site, due east of the known plants, was explored on 27 May 2002 by CCO with G. La Cock, V. Nicholls and N. Singers of DOC. No more *O. gardneri* were found. The Turakina River was deeply entrenched in a gorge at this point (approximately T21/330824–327820) and the team was unable to reach the river. An approach further downstream remains an option, via a point close to Turakina Valley Road (T21/325815).
- Some 1–1.5 km south of Rangiwaea School (Rangiwaea Scenic Reserve has been searched already, without success), forest remnants on the Turakina River beside Turakina Valley Road.
- Ngawaka Stream from State Highway 1 (SH1) to the Hautapu River confluence; this is mostly farmland but there are some small, very modified forest remnants; Site 10 with 16 adults of *O. gardneri* and 15 seedlings is just across SH1 from here.
- Puketi Creek, which joins the Hautapu River between Paengaroa Scenic Reserve and the Ngawaka Stream.
- The upper reaches of Mangoiwa Stream—the lower reaches beside Ruanui Road appear to have little native vegetation, but north from grid square 39/75 looks promising.

7.3.2 Hawkes Bay region

Before extensive burning and clearing of forest in Hawkes Bay, *O. gardneri* could have existed in many places. However, there are still many remnants of forest in the region, especially in the hill country, and it seems curious that the species has only ever been known in one location—Hutchinson Scenic Reserve. Given that new populations continue to be found in the Rangitikei and Wairarapa regions, there is still a chance that *O. gardneri* survives somewhere in Hawkes Bay. Persons who know Hawkes Bay's soils, geology and locations of forest remnants and who also have experience of *O. gardneri* in other regions should be able to draw up a priority list of areas for survey.

The suitability of Hutchinson Scenic Reserve for plantings of *O. gardneri* has been discussed in Section 4.2. In the absence of known wild plants of *O. gardneri* in the Hawkes Bay region, logical sources of plants might be from places with a climate most like Hutchinson Scenic Reserve, probably the Rangitikei region or Koromiko Station, Wairarapa. However, the recognition that Otari / Wilton's Bush contains two shrubs that are almost certainly of Hawkes Bay genetic stock makes that the obvious source. At Otari, the *O. gardneri* shrubs are intermixed with *O. hectorii* and other *Olearia* species and it would be most unwise to take seed from Otari's *O. gardneri*. Cuttings should be taken, grown away from other divaricating *Olearia* taxa (e.g. in Gisborne or even at Hutchinson Scenic Reserve) and seed eventually sourced from these for supplementary plantings at Hutchinson Scenic Reserve and perhaps other sites in the Hawkes Bay region. Only if there seemed to be a self-incompatibility problem (i.e. no seed set, despite flowering) should *O. gardneri* be brought to Hawkes Bay from another region.

7.3.3 Wairarapa region

In his report of the 2002 survey, Rebergen (2002) made the following suggestions for survey sites and identified some likely sites for as yet unknown populations of *O. gardneri* in the Wairarapa region:

- Identify the geology and soil types around existing plants and use this information to select future survey sites.
- Discuss habitat and soil types with soil conservators, Wellington Regional Council to identify future survey sites.
- Survey stream sides at Tinakori station, including Queen Elizabeth II National Trust Covenants.
- Survey Stony Creek area at Te Kanuka.
- Survey podocarp forest on Brammerton, along Tauweru River.
- Survey riparian forest on Kenmore Station.
- Survey two areas on one farm at Wainuioru, downstream from Te Kowhai.

7.4 OTHER RESEARCH NEEDS

7.4.1 *Olearia gardneri* as part of a functioning ecosystem

In the 'Recovery strategy' section of his report on the ecology of *O. gardneri*, Rogers (1996b) identified a need for a broad-scale approach to restoring and managing the ecosystems in which the species occurs. While some aspects of the plant's ecology are better known now than in 1996, there has been little progress in understanding the functioning of the forest ecosystems that support (or which should support) *O. gardneri.* Much of the habitat of *O. gardneri* comprises isolated, fragmented, mostly small and highly altered forest remnants. If *O. gardneri* is to be a self-sustaining part of natural and restored ecosystems, there is need for greater knowledge of the functioning of these ecosystems. The dynamics of even the largest and most intact remnants, such as Paengaroa and Ngaurukehu reserves, require basic research. Such studies would benefit a wide range of nationally threatened, uncommon and disjunct species.

7.4.2 Genetic differences within and between different *Olearia gardneri* populations

Some past plantings of *O. gardneri* in the wild have been of plants grown from cuttings. In passing, it might be noted that here was a much higher rooting success from soft-wood cuttings taken in spring than hard-wood cuttings in Autumn. Those in Paengaroa Scenic Reserve came from several different parent plants in the adjoining Tranz Rail block. It is not known how many cuttings were struck from each parent nor which of these are surviving as planted shrubs. The amount of genetic variation in the parent population was also not known but, in order to increase genetic variation for planting into the wild, propagation in the Rangitikei and Wairarapa regions has been from seed since about 2001. Current plantings in all sites with *O. gardneri* are with plants from that site only.

Genetic investigations might help resolve any doubts about provenance of the Otari / Wilton's Bush shrubs labelled as having come from the Hawkes Bay region; it could also assist any decision to expand the genetic base of a planted Hawkes Bay population with *O. gardneri* from other regions.

8. Acknowledgements

My special thanks to the late Tony Druce who introduced me to the incredible Paengaroa Scenic Reserve and to *O. gardneri* in Taihape Scenic Reserve in 1973, before it became extinct there. Many people have contributed to improving the knowledge of the ecology of *Olearia gardneri* since then. Thanks also to Dr Geoff Rogers (Science & Research Unit, DOC, Dunedin) for his ground-breaking studies in the Hautapu and Turakina valleys, and to other DOC staff who have helped with surveys and had many helpful discussions with me about the plant around Mataroa and beyond, including John Barkla, Don Ravine, Henry Dorrian, Peter de Lange, Graeme La Cock, Vivienne Nicholls, Dean Stronge, and summer workers at Paengaroa mainland island, especially the intensive work on *O. gardneri* in the Tranz Rail block over the summers of 1999–2001 by Caragh Briggs, Kath Large and Amy Trass. I thank other DOC helpers, previous and current. My special thanks to a dedicated team of botanists in the Wairarapa: Aalbert Rebergen, Tony Silbery, Gary Foster (all of DOC, Masterton) and Pat Enright of Ngaio in Wellington, assisted at times by Peter de Lange, whose searches since c. 2000 have added hugely to knowledge of *O. gardneri* in that region—their file reports formed the basis for much of the Wairarapa information in my report. Thanks also to Eddie Te Kahika, DOC Field Centre Supervisor at Puketitiri, Hawkes Bay for accommodation. I am grateful to Brian Patrick (Otago Museum) who keeps reminding us that *O. gardneri* is the base for a whole ecosystem of invertebrates; and to Michael Heads whose taxonomic decision on *O. gardneri* spawned not only many heated discussions but also led to resources being allocated to study and conserve the species.

My special thanks to the many landowners in the Rangitikei and Wairarapa regions who willingly allowed this and earlier surveys for *O. gardneri* on their land. These included Stephen Williams and Phyllis Leigh who helped find *O. gardneri* plants in 2001 around Ngawaka near Taihape, and Hihitahi resident Laurie Abernethy who negotiated access for survey of some key sites north of Taihape.

I would also like to thank Douglas Gordon and Owen Batley who pioneered the propagation of *O. gardneri* and others of the Taihape district's special plants; and to Robyn Smith (formerly of Percy Scenic Reserve, Petone), whose propagating skills and keen interest have ensured that DOC and others have not only had many prospective plants of *O. gardneri* to replant, but that they now know how to recognise its seedlings. Thanks to Eleanor Burton and Jane Wright of Otari Native Plant Reserve and Anita Benbrook (past curator), who assisted with information about their cultivated plants of *O. gardneri* and *O. hectorii* and to Jill Broome, acting curator of Percy Scenic Reserve.

I am grateful to John Barkla, Dr Geoff Rogers and Tony Silbery who have made constructive comments on a draft of this report and supplied additional information that I have incorporated where possible.

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Appendix 1

Indigenous plant distribution in forest remnants of the Hautapu River catchment, from North (A) to south (J) (See also Table 9 of this report, Tables 3 & 4 in Ogle et al. 2000)

x = present (abundant, common or occasional); u = present but uncommon; j = only juveniles present

	SITE															
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Species																	
Gymnosperms																	
Dacrycarpus dacrydioides	u	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dacrydium cupressinum	x	x	x	u	u		u				u						u
Libocedrus bidwillii				uj							u						
Podocarpus hallii	x	x	x	x	u						u						
Podocarpus totara	x		x	u	x	x	x		x	x	x	x	x	x	x	x	x
Podocarpus × nivalis?					u												
Prumnopitys ferruginea	uj	x	uj	uj							u					u	
Prumnopitys taxifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Monocotyledonous trees and shrubs																	
Cordyline australis	x		x	x	u	x		x	x	x	x	x	x	x	x	x	x
Cordyline banksii		u	u														
Cordyline indivisa		u															
Cordyline australis × C.banksii				u													
Dicotyledonous trees and shrubs																	
Alectryon excelsus																	x
Alseuosmia pusilla	u	x	x	x							x						
Aristotelia fruticosa		x		u			u		x	u	x	x				x	
Aristotelia serrata	x	x	x				u				x	u	x	u		x	u
Aristotelia fruticosa × A. serrata											u						
Beilschmiedia tawa											uj					u	
Brachyglottis repanda	x	x	x		x		x	x			x	x	x	x	x	x	x
Carmichaelia australis	x	u	x	x			x	x	u		x	x	x	u		x	x
Carpodetus serratus	x		x	x	x	u	x	u	x	x	x	x	x	x	x	x	u
Coprosma areolata												u			u	u	x
Coprosma crassifolia											u	x	x	x	x	x	x
Coprosma grandifolia	x	x	x		u						x			u		x	
Coprosma linariifolia	u		u	u	u		u				x	u	u		u	u	
Coprosma lucida		u	x								x	x				x	
Coprosma obconica								u	x	u	x	x					
Coprosma propinqua		u	u	x		x	x	x	x	x	x	x	x	x	x	x	x
Coprosma rhamnoides	x		x	x	x			x	x	x	x	x	x	x	x	x	x
Coprosma rigida		u	x	x		x	x	x	x	x	x	x	x	x	x	x	u
Coprosma robusta	u	u	x	u	x				x	x	x	x	x	x	x	x	x
Coprosma rotundifolia			x	x	u	x	x	x	x	x	x	x	x	x	x	x	x
Coprosma rubra			x	x		x	x			x	x	x		u	u	u	
Coprosma "t"				x			u				x			u			
Coprosma tenuifolia	x	x	x	x	u		u				x			u		x	u
Coprosma virescens						x	u	x	x	x	x	x	u			uj	
Coprosma wallii		u					u		x	x	x	x					

	SITE																
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Coprosma propinqua × C.robusta			u	u		?	?		?		u	x				u	x
Coprosma propinqua × C.tenuifolia	u		u								u						
Coriaria arborea	x	x	x	x	u		u				x			x	x	x	
Corokia cotoneaster	u	u	u				x	x	x	x	x	x		x		x	
Elaeocarpus hookerianus	u		x	x		u		u	u	u	x	u	u	u	u	u	u
Fuchsia excorticata	u		u	u	u		u				u	u				x	
Fuchsia excorticata × F. perscandens			u	u			u				u						
Gaultheria antipoda				u			u				u						
Griselinea littoralis	x	u	x	u	x	u	x		x		x	x	u		u	u	
Hebe stenophylla																x	x
Hebe stricta	x	x	x	x	u		x		x		x	x	x	x	x	x	
Helichrysum aggregatum									u	x	u	x	x		x	x	
Hoheria angustifolia								x	x	x	x	x				u	
Hoheria populnea	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Hoheria angustifolia × H.populnea				u					u	u	u	u					
Korthalsella clavata										u	u						
Korthalsella lindsayi							u	u			x	x		x	x	u	u
Kunzea ericoides							u				u	x		u	u	u	x
Leptospermum scoparium	x	u	x	u	x	u	x	u	x	x	x	x	x	x	x	x	x
Leucopogon fasciculatus	x		x	x	x						u	x				u	
Lophomyrtus obcordata		u		u		u	x	u	u	x	x	x	x	x	x	x	x
Melicope simplex	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Melicytus flexuosus		u							u		x	u				e	
Melicytus lanceolatus	x	x	x	x		u					x	u		x	x	u	u
Melicytus micranthus		x	x	u	x	x	u	x	x		x	x	x	x	x	x	x
Melicytus ramiflorus	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x
Melicytus flexuosus × M. lanceolatus											u						
Melicytus micranthus × M. ramiflorus											u					u	
Myrsine australis											u	u			u	x	x
Myrsine divaricata	x	u	u	x	u	x	x	x	x	x	x	x	x	x	x	x	u
Myrsine salicina			uj														
Neomyrtus pedunculata	x	x	x	x	x		x	x	x	x	x	x		x	x	x	
Nestegis cunninghamii	x	x	x	x	x	x	x	x	x	u	x	x	u	x		x	
Nestegis lanceolata	u	u	x	x	x	x					x	x	u	x		x	
Olearia gardneri		u							u	u	u	u				e	
Olearia rani											u						
Olearia solandri											u						
Olearia virgata ssp. *centralis*				x					x	u	u						
Pennantia corymbosa	u	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Pimelea prostrata																u	
Pittosporum eugenioides	x	x	x	x	x	x	u		u		x					x	x
Pittosporum obcordatum											u						
Pittosporum tenuifolium	x	x	x	x	u	u	x			x	x	x	x	x	x	x	x
Plagianthus regius		u				u	x	x	x	u	x	x	x			x	
Pseudopanax anomalus		u	x	u		x	x	x	x	x	x	x				x	
Pseudopanax arboreus	x	u	x	x	u		u				x	x	u		u	x	u
Pseudopanax crassifolius	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pseudowintera colorata	x	x	x	x		u	x				x	u	x	x	x	u	u
Schefflera digitata	x	x	x	x		u					x					x	u
Sophora godleyi	x?	x	x?	x?	x?	x?	x?	x?	x	x	x	x	x			x	x?
Sophora microphylla										u	u	x	u	u	u	u?	
Streblus heterophyllus			x	x					u		x		x	x	x	x	x
Teucridium parvifolium											u					e	

Appendix 1 contd.

	SITE																
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Tupeia antarctica			u				u				x						
Urtica ferox											x	u					
Dicot lianes																	
Brachyglottis sciadophila											u						
Calystegia tuguriorum								u	u		x	x	u			x	u
Clematis foetida			x	x	u	x	x	x	x		x	x	x	x	x	x	x
Clematis forsteri	x	x	x		u		x		u		x	x	x		u	x	u
Clematis paniculata			x					u	u		x					x	
Clematis quadribracteolata				u													
Fuchsia perscandens				u	u				u		x	x	u			e	
Metrosideros colensoi	?x	x	u		x				x		u					u	x
Metrosideros diffusa		x	x	x	x						u						x
Muehlenbeckia australis	x	u	x	x	u	x	x	x	x	x	x	x	x	x	x	x	x
Muehlenbeckia complexa									u	u	u				u	u	
Muehlenbeckia australis × *M. complexa*			u				u				u						
Parsonsia capsularis	u	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Parsonsia heterophylla		?	x	x	u	x	x	x	x		u	u	u		u	x	x
Parsonsia capsularis × *P. heterophylla*															u		
Passiflora tetrandra																u	x
Rubus cissoides ssp.	x		x	x	x	x	x		x	u	x	u	x	u		x	x
Rubus schmidelioides ssp.	u	u	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rubus squarrosus											u	u	u				x
Rubus schmidelioides × *R. squarrosus*													u	u			
Lycopods																	
Huperzia varia			u	u							u						
Lycopodium fastigiatum	u																
Lycopodium volubile			u														
Ferns																	
Adiantum cunninghamii		u	u								u		x			u	u
Asplenium bulbiferum	x	x	x	x	x						u						
Asplenium flabellifolium							u	u	x		u	u				x	
Asplenium flaccidum	x	x	x	x	u			x			x	x		u		x	x
Asplenium gracillimum	x	x	x	x			x	x		x	x	x	x	x	x	x	x
Asplenium hookerianum	u	u			u		u	u	x		u	x	x		u	u	
Asplenium oblongifolium		u									u				u	u	u
Asplenium polyodon	u		x	x	x	u					x					x	
Asplenium bulbiferum × *A. flaccidum*			u													u	
Asplenium bulbiferum × *A. hookerianum*																u	
Asplenium flaccidum × *A. gracillimum*											u						
Azolla filiculoides											u						
Blechnum chambersii		x	x		x				x		x		x	x		x	x
Blechnum colensoi	x	x	x	x							u						
Blechnum discolor	x	x	x	x													u
Blechnum fluviatile	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x
Blechnum membranaceum			u								u	u					
Blechnum minus (auct NZ)			x	x					u		u						
Blechnum novae-zelandiae	x	x	x	x	x		x		x		x	x				x	
Blechnum penna-marina	u		u	u			x	u	x		x	u		u		u	
Blechnum procerum	x		u														

	SITE																
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Blechnum triangularifolium		u									x		x	?	x	x	x
Blechnum vulcanicum					u						u						
Blechnum chambersii																	
×*B. membranaceum*											x						
Botrychium biforme											u					u	
Ctenopteris heterophyllus	u	u									u						
Cyathea dealbata	u		u								u		uj				
Cyathea medullaris											uj						
Cyathea smithii			u								uj						
Dicksonia fibrosa	x	x	x	x	x	u	x		u	x	x	x	u	x		x	x
Dicksonia lanata	u	u															
Dicksonia squarrosa											u	u					
Diplazium australe											u						
Grammitis billardierei	u			u							u						
Grammitis ciliata											u						
Histiopteris incisa	u		x	x							u	x				x	
Hymenophyllum demissum	x	u	u		u												
Hymenophyllum flabellatum											u					u	
Hymenophyllum multifidum			u	u							u						
Hymenophyllum rarum			u								u					u	
Hymenophyllum sanguinolentum	x?		x?					u?			x?						
Hymenophyllum villosum											u						
Hypolepis ambigua			u								x	x					
Hypolepis millefolium							x				x						
Hypolepis rufobarbata		u	u	u							u						
Lastreopsis glabella											u						
Leptolepia novae-zelandiae			u														
Leptopteris hymenophylloides	x	x	x	x							x			u		x	
Leptopteris superba		u		u							u						
Microsorum pustulatum	x	x	x	x	x	u	x	x	x	x	x	x	x	x		x	x
Paesia scaberula	u	x	u	u	x		x		u		u	u				x	x
Pellaea rotundifolia				u			x		u		x	x	x	x	x	x	x
Pneumatopteris pennigera	x	x	x		x						x	x	x	x		u	x
Polystichum richardii agg.		u	x	x	x		x		x	x	x	x	x	x	x	x	x
Polystichum silvaticum	x	x	x	x			x		x		x	x	x	x		x	
Polystichum vestitum	x	x		u			u				x	u		u		x	u
Pteridium esculentum	x	x	x	x	x				u	x	x	x	x			x	x
Pyrrosia eleagnifolia		x	x	x	x		x		u		x	x				x	x
Trichomanes venosum			u								u						
Orchids (Orchidaceae)																	
Corybas iridescens?											u						
Corybas macranthus											u	u					
Corybas trilobus agg.			x	x	u		x	x			u	u				u	
Corybas sp. (unidentified)				u			u		u								
Earina autumnalis			u						u		u						
Earina mucronata			x	x	x		x		u		x	u				x	
Gastrodia cunninghamii											x	?u					
Microtis unifolia											x	u					
Pterostylis banksii			x	x							u	?u					
Pterostylis montana agg.			x	x							u						
Thelymitra longifolia					u						u						
Grasses (Poaceae)																	
Anemanthele lessoniana											u					u	

Appendix 1 contd.

	SITE															
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Cortaderia fulvida	x	x	x	x	x			x	x		x	x	x	u		x	x
Dichelachne crinita											u						
Echinopogon ovata											x	x				x	
Hierochloe redolens	x		x	x													
Microlaena avenacea	x	x	x	x							x					x	u
Microlaena polynoda																x	
Microlaena stipoides				x					x		x						
Poa anceps	x	x	x	x	x		x		x		x	x	x		x	x	
Poa imbecilla											x	u	u			x	
Poa matthewsii			u	u				x	x		x	x	x		x		
Rytidosperma clavatum			u								x						
Rytidosperma gracile				x													
Rytidosperma unarede											x						
Stenostachys gracilis											u						
Trisetum drucei		u															
Trisetum lepidum											x						
Sedges (Cyperaceae)																	
Carex breviculmis									u		u						
Carex dissita			x	x						x	x						
Carex flagellifera					u				x		x						x
Carex forsteri								u			x	u		u		x	
Carex geminata s.s.			x	x	x		x	x	x		x	x				x	
Carex inversa				u			x		x		u						
Carex lambertiana											x					x	
Carex maorica											u						
Carex secta	u		x	x	x		x				u	u					x
Carex solandri										?	x	x	?	?		x	
Carex testacea																x	
Carex virgata				u			u		u	x	x			u		x	x
Eleocharis acuta					x		x				u						
Isolepis habra									u		u						
Isolepis pottsii											u						
Isolepis reticularis				u							x						
Machaerina sinclairii																x	
Schoenus pauciflorus					u												
Uncinia affinis?											x					?u	
Uncinia banksii	x																
Uncinia distans											x					u	
Uncinia ferruginea											x						
Uncinia laxiflora											x	x	?			x	
Uncinia rupestris				x							u						
Uncinia scabra	x		x	x							x	x				x	
Uncinia uncinata	x	x	x	x			x				x		u			x	x
Uncinia zotovii			u														
Rushes (Juncaceae)																	
Juncus australis					u		u		u		x						
Juncus distegus									u		x				x		
Juncus gregiflorus				u	u			u	u	x	x	x			x	x	x
Juncus palllidus					u						u						
Juncus planifolius											u						
Juncus sarophorus									u	u	u			u			x
Luzula picta s.s.			u	u	x		x		u		x					u	

	SITE																
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Luzula subclavata											u						
Monocots other than orchids, grasses, sedges, rushes																	
Arthropodium candidum		x					x	x	x		x	x				x	
Astelia fragrans	x	x	x	u			u	x			x	x		u		x	u
Astelia grandis				u													
Collospermum microspermum	x	x	x	x	u			x	u		x					x	
Dianella nigra											u					u	
Lemna minor (auct NZ)				x			u				u	u				u	u
Libertia ixioides	u										u					x?	
Phormium cookianum	x	x	x	x	x		x	x	u	x	x	x	x	x	x	x	x
Phormium tenax											u						
Potamogeton suboblongus				u													
Typha orientalis				u													
Wolffia australiana											u						
Daisy herbs (Asteraceae)																	
Anaphalioides subrigida											u						
Anaphalioides trinervis			u								u						
Celmisia gracilenta agg.							u										
Euchiton audax																x	
Euchiton gymnocephala									u		u	x				u	
Euchiton limosa				u							u						
Lagenifera petiolata (excl. *L.montana*)									x		x						
Lagenifera pumila											u					x	
Lagenifera strangulata											u						
Pseudognaphalium sp. (*P. luteoalbum* agg.)									u		x	x				x	u
Senecio glomeratus																x	
Senecio hispidulus														u			
Senecio minimus		u	u								u					x	
Senecio quadridentatus																x	
Senecio rufiglandulosus		u	u	u	x		x				x	x	x			x	u
Non-daisy dicot herbs																	
Acaena anserinifolia	x		u	x			x		u		x	x		u		x	u
Acaena juvenca				x	u		x	x	x	x	x	x	x	x	x	x	
Aciphylla sp. (aff. *A. squarrosa*)											u						
Australina pusilla											x					x	
Callitriche petriei											x					x	
Cardamine sp. unnamed "Glossy Leaf"				u													
Cardamine sp. unnamed "Long Style"			x	x	u	u	x	x	u		x	x				x	
Cardamine sp. unnamed "Narrow Petal"	?	?	x	x	x	x	x	x	x		x	u				x	?
Cardamine corymbosa agg.				x				x			x						
Dactylanthus taylorii			u													u	
Dichondra sp. (*D. brevifolia* agg.)												u			u		
Epilobium alsinoides									u		u						
Epilobium insulare							u				u						
Epilobium linnaeoides				u													
Epilobium nerteroides											u					x	
Epilobium nummulariifolium					x				x		u	u			u		u
Epilobium pedunculare											u						

Appendix 1 contd.

	SITE																
	A	B1	B2	B3	C	D	E	F	G1	G2	H1	H2	H3	H4	H5	I	J
Epilobium pubens		u															
Epilobium rotundifolium			u	u	x		x		x		x	x		x	x	x	
Galium propinquum							u		x								
Geranium microphyllum						u		u	u		u	u					
Haloragis erecta		u	u						u		u					x	
Hydrocotyle elongata	x	x	x	x					x	x	x	x	x	x	x	x	x
Hydrocotyle heteromeria		x	u	x							x	u				x	
Hydrocotyle moschata											u				u	x	
Hydrocotyle novae-zeelandiae s.s.			u	x							u						
Hypericum japonicum							u										
Montia fontana							u										
Myosotis forsteri											u						
Nertera depressa											u						
Nertera villosa																	u
Oxalis exilis											x	x			u	x	
Oxalis magellanica											u						
Parietaria debilis											u					x	x
Pelargonium inodorum											u						
Plantago raoulii agg.			u	u					u		x						
Pratia angulata agg.	u		u	u							x	u				x	
Ranunculus amphitrichus				x							?						
Ranunculus reflexus			x	x							u					x	
Rumex flexuosus											u	u					
Schizeilema trifoliolatum											u				u		
Stellaria decipiens		u	x	x	x				u		x					x	
Urtica incisa		u	x	x		u	x		x		x	x	x		u	x	u
Viola filicaule				x							x						
Viola lyallii											u						
Wahlenbergia rupestris									u		u					u	
Wahlenbergia violacea												u					