Regeneration ecology, conservation status and recovery planning for the endangered tree *Olearia hectorii*

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1. Introduction

Olearia hectorii has been identified by the Department of Conservation and the New Zealand Botanical Society as an endangered tree requiring comprehensive field inventory, analysis of population age structure and regeneration behaviour, and in need of habitat and ecosystem restoration initiatives. This project was undertaken in 1992–1995 by Landcare Research New Zealand Ltd, Rotorua, to inventory and study the species' distribution, population structure, reproductive biology, factors inhibiting regeneration, and methods of site manipulation that may foster natural regeneration and aid recovery planning.

2. Objectives

- Inventory the national distribution, associated rare plant species, and general habitat conditions of *Olearia hectorii* using existing information and field survey (June 1994).
- Investigate population sizes, dynamics, and habitat requirements of representative populations (June 1994).
- Investigate phenology, fruit production, dispersion, and recruitment of the species in relation to varying degrees of habitat manipulation (June 1995).
- Identify factors associated with lack of recruitment and habitat degradation (June 1994).
- Assess the levels of grazing and weed control that may be compatible with population recruitment and restoration of the habitat (June 1995).
- Investigate success of deliberate planting-out of nursery-raised seedlings in different habitats and treatments (June 1995).
- Foster university collaboration in examination of genetic variation in widely disjunct populations (June 1995).
- Examine and formally describe the basis for North Island and South Island subspecies taxonomy in relation to reproductive biology and habitat requirements (June 1994).
- Provide guidelines and site priorities for species rehabilitation initiatives. Further, co-ordinate or convene preparation of a species and habitat recovery plan with commitment from the Department of Conservation (June 1995).

3. Methods

- Inventory both North Island and South Island populations.
- Measure seed viability by germination under nursery conditions.
- Assess soil seed banks with laboratory germination trials.
- Erect exclosures to exclude farm stock and hares at one North Island and one South Island site.
- Partition exclosures for various treatments (herbicides, simulated grazing) for control of adventive grasses, with aerial broadcasting of *Olearia hectorii* seed and seedling planting-out trials.
- Monitor exclosures for grass control, and seeding and planting-out trials.

4. Results

4.1 SPECIES DESCRIPTION

Olearia hectorii is a low tree up to 9 m tall with wide-spreading branches (see Figure 1 on page 31) and often an untidy appearance. The tree may be single-stemmed or multi-leadered from the base, and single trunks are often composed of loosely coalesced stems. Multi-leadered architecture with a low, sprawling, mushroom-shaped crown develops in a high-illuminance environment, attesting to establishment with little community competition for light. Single-stemmed trees are taller and occur in forest light-gaps. Trunks and branches of mature trees have thick, grey, cork-like bark with deep longitudinal furrows. Branchlets are grooved and bronze-red.

The species is deciduous with leaves (<6) in opposite fascicles on short shoots on long slender branchlets. The short shoots have persistent bracts. Leaves have slender petioles up to 18 mm long, are oblong-ovate to broad-ovate, glabrous and moss-green above, and covered in silvery tomentum below. The composite flower is perfumed, is in the form of a capitulum (see Figure 2 on page 31), 3–5 mm in diameter, in fascicles of 2–6 suspended, and suspended on silky pedicels up to 15 mm long. There are 20–25 disc florets and up to 15 ray florets with cream petals. The achenes or seeds are elongated, 1–2 mm long, with longitudinal furrows and covered in soft shaggy hairs. The seeds have a pappus of feathery hairs to aid dispersal, but the seed can be shed prematurely in the entire capitulum.

4.2 CYTOLOGY

No chromosome counts for the species are known. However, other native *Olearia* species counted mostly have 2n=108, while *O. paniculata* has 2n=c. 288, *O. nummularifolia* has 2n=216, *O. albida* has 2n=324, and *O. angulata* has 2n=c. 432.

4.3 TAXONOMY AND RELATIONSHIPS

Olearia is a diverse genus spread throughout the southwestern Pacific in Australia, New Zealand, Lord Howe Island, and Papua New Guinea. All the New Zealand species are endemic. Allan (1961) recognises 32 species and Druce (1992) 35 in New Zealand. *O. hectorii* was first described by Hooker (1864), with the type from the 'Lakes District', probably the Matukituki valley, Lake Wanaka. Two distinct North Island and South Island subspecies have been recognised (Eagle 1982, Druce 1992), with their genetic, morphological, and ecological differences requiring elaboration. Specifically, A. P. Druce in Eagle (1982) based subspecific rank on leaf size and shape. From the present study I see no substantial basis for subspecific treatment on criteria of leaf size and shape, phenology, tree stature, and the ecological requirements of various populations. Leaf size and shape vary widely throughout both main islands in response to tree age, shading, and health. There is a tendency for leaves on North Island plants to be broadly ovate to suborbicular and for South Island leaves to be ovate to obovate, but there is no clear discontinuity in this condition. In addition, branchlets of North Island trees tend to have more pronounced ribs than South Island trees.

Despite similar overall appearance *Olearia hectorii* and *O. fragrantissima* are not taxonomically closely related: the former has fasicled leaves on opposite short shoots, the latter single and alternate. *O. fragrantissima* also loses its leaves with approaching winter later than *O. hectorii*. *O. fragrantissima* occupies more stable sites than *O. hectorii* in lowland riparian forest, and differs architecturally in developing a single stem and taller stature in its tall forest community. *O. hectorii*, on the other hand, exploits more disturbed sites, is shorter statured, and may be multi-leadered and conspicuously lianoid in its search for light in often a more shaded forest.

Coprosma rotundifolia when viewed from a distance resembles *O. hectorii* in general architecture, leaf colour and shape, and bark texture. However, *C. rotundifolia* is not deciduous, lacks opposite fascicles of adult leaves on shoots, and the leaves lack silvery tomentum below.

Olearia hectorii and *O. odorata* also are similar in appearance, and are probably closely related. Both are deciduous and low-growing, occupy open vegetation, and readily hybridise in the wild (see CHR herbarium). However, *O. odorata* has obovate-oblong leaves lacking petioles, whereas *O. hectorii* has more ovate leaves on short petioles. *O. odorata* also occupies drier sites in "grey scrub" (Wardle 1991:207), whereas *O. hectorii* is an open forest species.

There is a distinct and diverse insect fauna associated with the group of deciduous and/or 'grey' *Olearia* species (B. Patrick, pers. comm. 1994). Some 13 moth species feed solely on *Olearia odorata*, and *O. hectorii* has its own diagnostic moth species. Regional extinction of *O. hectorii* would also lead to loss of moth biodiversity, as has happened around Invercargill (B. Patrick pers. comm. 1994).

4.4 DISTRIBUTION

Olearia hectorii is currently known from 13 catchments in 5 districts: 2 catchments in Rangitikei; 2 in Wairarapa; 1 in Nelson–Marlborough; 2 in Otago; and 6 in Southland (Table 1). The total number of individuals is estimated at between 450 and 500, with approximately 300 around the confluence of the West and East Matukituki Rivers,

TABLE 1 DISTRIBUTION AND CURRENT STATUS OF ALL RECORDS OF *Olearia hectorii* IN NEW ZEALAND.

DOC CONSERVANCY	ECOLOGICAL DISTRICT	LOCALITY	POPULATION	GRID REF (NZMS 260)	NO. OF TREES	SEEDLINGS & SAPLINGS
EXTANT POPULATIONS						
Wanganui	Rangitikei	Turakina Valley	Owhahura Stream	T20 323822	17	3 saplings
		Hautapu River	Paengaroa Scenic Res.	T20 435695	2	1 sapling
				T20 423699		
			Railcorp Land	T20 426704	22	6 seedlings
			Coogans and environs	T20 429710	9	1 sapling
			Ngaurukehu Scientific Res.	T20 442764	8	1 sapling
Wellington	Eastern Wairarapa	Maungaraki Range	Kourarau Stream	T27 358051	2	
			Wainuiora Stream	T27 416063	2	
Nelson-Marlborough	George	Nidd Stream, Chalk Ra.	The Zoo	P29 869204	5	12 seedlings 8 saplings
			Nidd Stream	P30 840188	14	
Otago	Lakes	Matukituki River	West Wanaka Rd	F40 921116	5	1 seedling 2 saplings
			Matukituki mid valley	F39 855216	30	
	Arawata	Matukituki River West	opposite Cameron Flat	F39 757283	c. 250	
		Matukituki River East	opposite swingbridge	F39 751261	c. 55	
	Shotover	Lake Dispute		E41 598649	2	
Southland	Umbrella	Pomahaka Stream		G43 123043	12	
	Eyre	Eyre Creek		E43 516257	8	
	Nokomai	Waikaia Valley		F43 984082	1	
	Hokonui	Hokonui Hills	Williams Rd, duck pond	E45 668428	32	
		Hokonui Hills	Williams Rd, farmland	E45 667429	3	1 sapling
		Hokonui Hills	Sutton Rd, forest edge	F46 714387	3	
	Southland Plains	Swales Bush		E45 492495	5	
		Brown's town	Hedgehope village	E46 661344	3	
		Hedgehope		E46 714387	1	
		Ivy Russell Mem. Res.		E45 483424	4	

TABLE 1 *(CONTINUED)* DISTRIBUTION OF *Olearia hectorii*.

DOC CONSERVANCY	ECOLOGICAL DISTRICT	LOCALITY	POPULATION	HERBARIUM NUMBER	DEPOSITED BY	YEAR
POPULATIONS PROBABLY EXTINCT						
Wanganui	Rangitikei	Taihape Scenic Res.			A P Druce	c. 1960s-1970s
Hawkes Bay	Maungaharuru	Hutchinson Scenic Res.		CHR 141734	N L Elder	1958
Nelson-Marlborough	Pelorus	Pelorus River, Marlborough Sounds			T Cheeseman	
Southland	Tahakopa	Ratanui, Clutha County		CHR 17334	H H Allan	1936
	Nokomai	Waikaia Valley	Piano Flat	CHR 395503	A P Druce	1985
	Southland Plains	Myross Bush, near Invercargill		CHR 96745	Halder	1863
RECORDS NOT LOCATED DESPITE SEARCHING						
Nelson-Marlborough	Hundalee	Conway River	not relocated	OTA 022446	R J Coker	1967
	Pisa	Roaring Meg Stream	not relocated	CHR 420045	P N Johnson	1985
Nelson-Marlborough	Rotoroa	Mangles River, Nelson	not visited	CHR 331207	G O K Sainsbury	1922
POPULATIONS MENTIONED IN LITERATURE BUT NOT VISITED						APPROX. DATE OF RECORD
Southland	Hokonui	Croydon Bush, eastern Hokonui Hills			Poppellwell	1920

Otago (see Figures 3 and 4 on page 33). The main localities where additional finds are possible are in the Chalk Range and on the Hokonui Hills in gully sites and along forest margins in poorly botanised and extensively forested low rolling hillcountry. The widespread clearance of lowland to lower montane forest in all five districts must have dramatically reduced the range and frequency of the species. For instance, in Southland the species was probably common along stream and river margins of lowland alluvial floodplains, particularly along the Oreti River south to Invercargill, and in gullies on surrounding rolling hill country. Canopy gaps in the ubiquitous podocarp-broadleaved forest were concentrated in these sites. Ostensibly suitable habitat also occurs in western Waikato, Bay of Plenty, Poverty Bay, Hawke's Bay, Manawatu–Horowhenua, Wellington, Canterbury, and Banks Peninsula, but only in Hawke's Bay and eastern Otago can we be sure from herbarium records of its earlier existence (Table 1). Certainly in the North Island, the distribution of the species (Figure 5) appears explicable more in terms of the distribution of suitable habitat and climate than any landscape history factor producing a disjunct distribution. The distribution in the South Island is less easily explained by available habitat, because many of the foothill valleys of western Canterbury seem suitable. There are few if any other lowland plants in the eastern South Island with a disjunct distribution confined to Nelson–Marlborough and Otago–Southland, so the species has an unusual South Island biogeography.

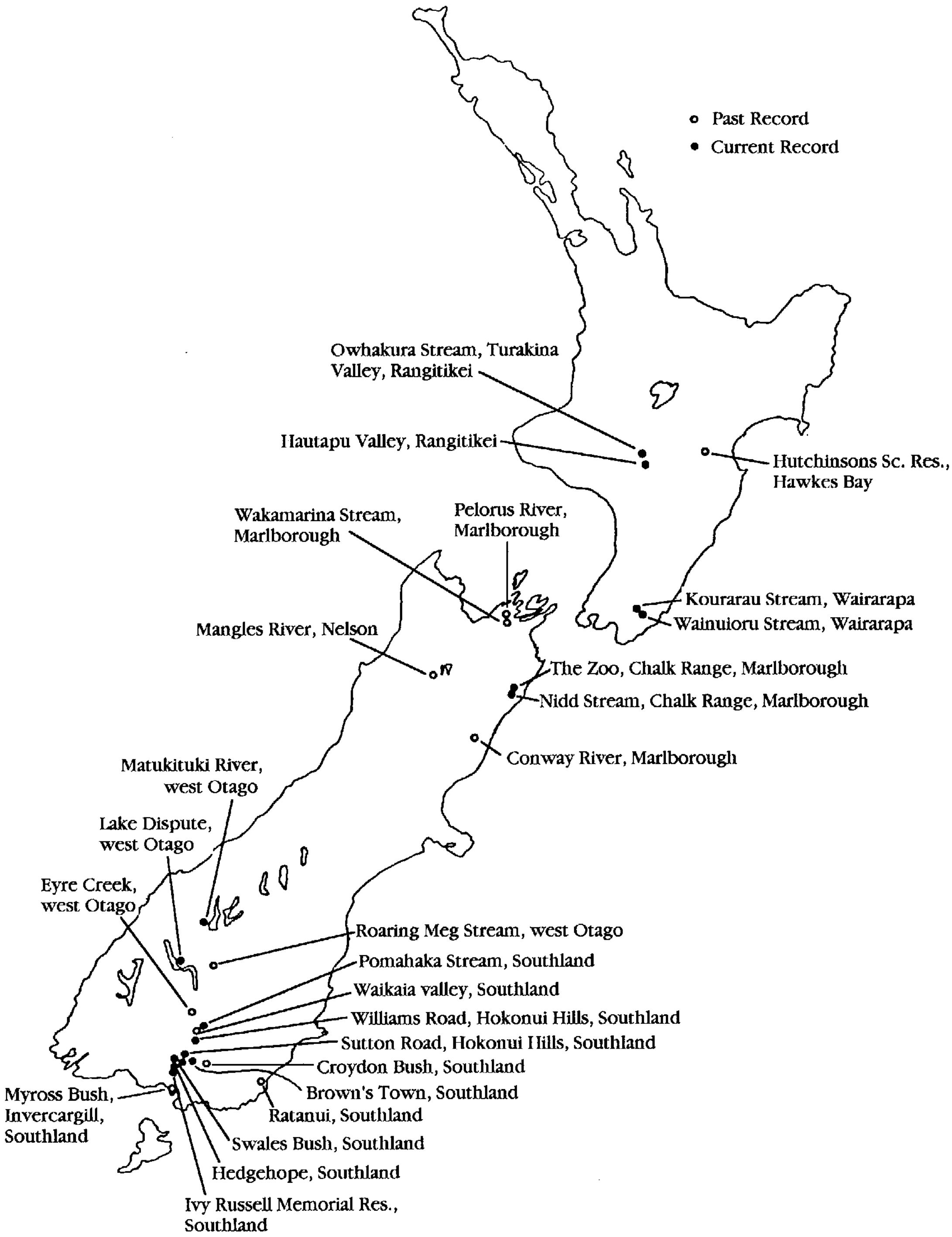
4.5 HABITAT

The species occupies three quite distinct landforms: mid and lower valley hillslopes on rolling hillcountry; colluvial and outwash fans and glacial till on valley toeslopes; and riparian oxbows and cut-off meanders, levees, and alluvial terraces on valley floors. A unifying factor on all these sites is frequent geomorphic disturbance by debris flow (see Figure 4 on page 33) and flooding and deposition of raw mineral soil, leading to frequent vegetation turnover. Regeneration opportunities were restricted to canopy gaps in tall forest in prehuman times. Other site factors favouring the species are high insolation in summer and soil parent materials with comparatively base-rich status.

Altitudinally, the species ranges from lowland to lower montane, or 100–600 m a.s.l. Climates are correspondingly varied over this wide altitudinal and latitudinal range. Climates are characterised by seasonally alternating wet and dry spells and seasonal and diurnal temperature extremes, conditions often found in deep wide valleys in the east of both main islands. For example, the Hautapu valley northwest of Taihape experiences cold, wet winters and hot, dry summers. In Southland, however, more equable rainfall and temperature predominate on the Southland plains and hillcountry.

Soils are derived from a wide range of parent materials including calcareous siltstones, mudstones, and limestones, non-calcareous sandstones, greywacke, andesitic tephra, and schist. These parent materials have moderate fertility associated with fresh, fine- and coarse-grained colluvium or alluvium. Seasonal rainfall and climatic extremes can produce edaphic fluctuations, with soils ranging from cold and waterlogged in winter to drought-prone in summer. Fluctuating watertables produce reduction reactions and gleyed soils result, with characteristic light-grey colours and mottling. Suboptimal gleyed soils for *O. hectorii* occur at the margins of oxbows and on alluvial fans and seepages where hillslopes meet river terraces. Elsewhere, however, the species

FIGURE 5 DISTRIBUTION OF *Oleria hectorii* IN NEW ZEALAND.



occupies well drained soils on all landforms. Many of the soil alluvial and colluvial profiles show multiple layers of coarse to medium-grained sediment with little soil development therein, indicating short intervals between rejuvenation events.

The species is associated with both podocarp-broadleaved and *Nothofagus* forests. The podocarps *Prumnopitys spicatus*-*Dacrycarpus dacrydioides* and mixes of *Nothofagus fusca, N. menziesii,* and *N. solandri* dominate forests in the vicinity of *Olearia hectorii* (Table 2). The former are compositionally diverse forests, the latter much less so. *Nothofagus* forests of the South Island are associated with the altitudinally and latitudinally colder-range extremes of the species, for instance in the Chalk Range, Marlborough, Lake Dispute and Matukituki valley in Otago, and the Pomahaka, Waikaia valley, and Eyre Creek, northern Southland. Cold-tolerant associates of the species in podocarp-broadleaved forest are *Fuchsia excorticata*, *Pseudowintera colorata,* and *Coprosma tenuifolia.* Although *Weinmannia*

TABLE 2 PHYSIOGNOMICALLY IMPORTANT INDIGENEOUS WOODY AND LIANE SPECIES OCCURRING IN INTACT FOREST AND INDUCED SCRUB HABITATS OF *Olearia hectorii.*

SPECIES	HAU-TAPU	WAIRA-RAPA	NIDD STREAM	MATUKI-TUKI	HOKO-NUI	POMA-HAKA	SWALES BUSH
EMERGENT AND CANOPY							
Dacrycarpus dacrydioides	x	x		x	x		x
Dacrydium cupressinum	x	x			x		
Nothofagus fusca			x	x			
Nothofagus menziesii				x		x	
Nothofagus solandri			x				
Podocarpus hallii	x		x				
Podocarpus totara	x	x					
Prumnopitys taxifolia	x	x		x	x		x
LOWER CANOPY							
Aristotelia serrata	x			x	x		x
Carpodetus serratus	x		x	x	x	x	x
Elaeocarpus dentatus		x					
Elaeocarpus hookerianus	x				x		x
Fuchsia excorticata	x			x	x		x
Griselinia littoralis	x		x	x	x	x	x
Hoheria angustifolia	x	x					
Hoheria glabrata			x	x		x	
Hoheria populnea	x	x		x			
Kunzea ericoides	x		x			x	
Melicope simplex	x				x	x	x
Metrosideros umbellata					x		
Muehlenbeckia australis	x	x		x	x		x
Nestegis cunninghamii	x	x					
Olearia fragrantissima				x	x		x
Pennantia corymbosa	x	x			x		x
Pittosporum eugenioides	x	x			x		x
Pittosporum tenuifolium	x			x	x	x	x
Plagianthus regius	x	x		x	x		x
Pseudopanax colensoi					x	x	x
Pseudopanax crassifolius	x	x			x	x	
Sophora microphylla	x			x		x	x

racemosa and *Beilscbmiedia tawa* often dominate the broadleaved component of podocarp-broadleaved forests in much of New Zealand, these two species are seldom associated with *O. hectorii*. Only on the Hokonui Hills where kamahi is common are the species sympatric. Summer-dry climates act against *W racemosa* and *B. tawa.* Overall, landscape physiography is a more reliable indicator of suitable habitat than are indications from species assemblages.

Several other localised shrubs and small trees overlap with *O. hectorii* in eastern New Zealand. *Coprosma virescens* and *C. wallii* occur at Hautapu and Wairarapa, *Coprosma obconica* and *Pittosporum obcordatum* occur at Hautapu, *Melicytus flexuosus* occurs at Hautapu, Swales Bush, and Hokonui Hills, and *Olearia fragrantissima* occurs at Hedgehope and west Wanaka. Overall, the Hautapu valley is renowned for its high diversity of divaricating shrubs and several biogeographically unusual shrubs and trees. *Coprosma wallii, C. obconica, Melicytus flexuosus, Olearia bectorii, Pittosporum obcordatum,* and *Teucridium parvifolium* are all rare in the North Island, probably reflecting rare habitat conditions, namely seasonal extremes in edaphic and climatic factors.

TABLE 2 *(CONTINUED)* SPECIES OCCURRING IN HABITATS OF *Olearia hectorii.*

SPECIES	HAU-TAPU	WAIRA-RAPA	NIDD STREAM	MATUKI-TUKI	HOKO-NUI	POMA-HAKA	SWALES BUSH
UNDERSTOREY							
Aristotelia fruticosa				x		x	
Coprosma areolata					x		
Coprosma grandifolia	x	x					
Coprosma linariifolia	x			x	x		
Coprosma propinqua	x	x		x	x	x	x
Coprosma rbamnoides	x		x				
Coprosma rigida	x				x	x	
Coprosma rotundifolia	x	x			x		x
Coprosma rubra	x	x					x
Coprosma 'Tayloriae'	x		x	x		x	x
Coprosma virescens	x	x	x				
Coprosma wallii	x	x					
Corokia cotoneaster	x			x		x	
Dracopbyllum longifolium						x	
Leptospermum scoparium	x		x	x	x	x	x
Lopbomyrtus obcordata	x	x			x		
Melicytus 'Blondin'				x		x	
Melicytus flexuosus	x	x					x
Melicytus lanceolatus	x		x	x	x		
Melicytus ramiflorus	x	x	x	x			
Myrsine divaricata	x	x	x			x	
Neomyrtus pedunculatus	x			x	x		x
Olearia lineata				x		x	
Olearia odorata				x		x	
Pseudopanax anomalus	x	x		x			
Pseudowintera colorata	x	x			x		x
Rubus cissoides	x				x		x
Rubus scbmidelioides	x	x	x		x		x
Scbefflera digitata	x				x		
Streblus beteropbyllus	x	x			x		

Most remaining populations of *Olearia hectorii* occur in moderately to grossly modified sites surrounded by naturalised herbaceous communities, with at best, only treeland vegetation pointing to the pre-human forest composition. Solitary *O. hectorii* trees in pasture (Figure 1, page 31) exist as the endpoint of conversion to farmland of the original forest. The only exceptions are a sapling in Paengaroa Scenic Reserve, in relatively intact *Prumnopitys spicatus — Dacrycarpus dacrydioides* forest on an alluvial terrace above the Hautapu River, and a stand of 14 trees on a hillslope of the Nidd Valley, Chalk Range, Marlborough.

4.6 POPULATION STRUCTURE

Life span

Trees at The Zoo were the largest (Table 3) and oldest (Figure 6) encountered, although almost universal stem rot precludes accurate age determination from large trees. Overall, the increment cores and discs suggest a life expectancy of at least 150 years. The large-diameter trees in the mid Matukituki valley (Table 3) which were not cored probably also approach 150 years of age. Life span appears to vary with site factors. For instance, trees on gleyed soils at Wainuioru and Hautapu have slower radial growth rates, a greater tendency to stem rot, and an apparently shorter life expectancy of less than 100 years than the healthy and large-diameter trees of up to 150 years on well drained and well lit sites at The Zoo, the Matukituki valley, and the Hokonui Hills. The total life span of trees that vegetatively reproduce by adventitous roots and resprouting (see Regeneration, below) are virtually impossible to calculate because the evidence for previous generations may be lost through decomposition of parent stems and branches.

Size distribution of populations

The diameter of the largest stem and the height of all individuals at each site were measured, except in the two large populations in the West and East Matukituki Rivers (Figure 6) where representative samples were taken. Seedlings were classed as <1 cm diameter and <30 cm high, saplings as 1–3 cm diameter, and adults as >3 cm diameter. Almost all the populations have cohort size-class distributions, and most span a range of <25 cm (Table 3). Restricted stem diameter distributions clearly indicate cohort establishment, perhaps a single event or pulses of recruitment over short intervals. Populations with larger size ranges mostly represent a combination of local cohorts or widely separated regeneration events scattered throughout a catchment. The Owhakura stand in the Turakina valley arose from just such a series of disparate regeneration events along a forest edge bordering farmland.

Four 10 x 10 m plots in a large stand at the confluence of the Matukituki West and East Rivers show three distinct size-class and density cohorts dating to three recruitment events. Plot 1 samples the youngest unimodal cohort peaking in the 6–10 cm class, perhaps 40 years old (Figure 6); plots 2 and 3 represent lower-density and probably older stands originating from a regeneration event some 50–60 years ago. Plot 4 has the lowest-density and the largest-diameter trees perhaps 100 years old or more. Although contiguous on a colluvial toeslope, these stands originate from separate disturbance events linked to rainstorm-induced debris flows from the schist bluffs above. The stand in plot 4 probably functioned as the seed source for the adjacent, younger stands of plots 1–3.

TABLE 3 SIZE-CLASS DISTRIBUTION OF THE LARGEST-DIAMETER STEMS OF TREES, SAPLINGS, AND SEEDLINGS IN STANDS OF *Olearia hectorii* IN NEW ZEALAND. THE SAMPLES CONSIST OF ALL INDIVIDUALS IN EACH POPULATION EXCEPT FOR THE MATUKITUKI RIVER HEADWATERS POPULATION WHERE FOUR 10 X 10 M SAMPLES OF STEMS WERE RECORDED.

DOC CONSERVANCY	LOCATION	SIZE CLASS DISTRIBUTION (cm)											
		0-3	4-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	>50
Wanganui	Owhakura Stream	3	2	5	5	3	1	1					
	Paengaroa Scenic Res.	1					1						
	Coogans Farm	1	4	4	2	3							
	Ngaurukehu Scientific Res.	1	2	2	3	1							
	Railcorp land	6	2	4	7	7	2						
Wellington	Kourarau Stream				1	1							
	Wainuioru Stream				2								
Nelson-Marlborough	The Zoo									1		1	3
	Nidd Stream, valley slopes			2	9	1	1	1					
	Nidd Stream, valley floor	20											
Otago	Matukituki R., headwaters (1)		5	35	12	1							
	Matukituki R., headwaters (2)			2	8	2							
	Matukituki R., headwaters (3)			5	4								
	Matukituki R., headwaters (4)										1		2
	Matukituki R., central valley							12	4	2	3	2	5
	Matukituki R., west Wanaka	4	1			3		1					
	Lake Dispute									1	1		
Southland	Pomahaka River			2	6		1						
	Eyre Creek			6	2								
	Waikaia River								1				
	Hokonui Hills (1)					4	9	14	3	2			
	Hokonui Hills (2)						2		1	1			
	Sutton Road						3						
	Swales Bush Scenic Res.						1		2	2			
	Brown's town						3						
	Hedgehope								1				
	Ivy Russell Memorial Res.					1	1	2					

Only around Nidd Stream at the foot of the Chalk Range are seedlings and saplings common (Table 3). However, few juveniles in the stream bed will reach reproductive maturity because flood events frequently scour the low islands, levees, and banks that they occupy. The small number of juveniles on Railcorp land at Hautapu, at Owhakura Stream, on cliff ledges on the West Wanaka Road of the Matukituki Valley, and in Nidd Stream all result from several small pulses of recruitment. Nevertheless, whereas most adult populations are characterised by cohort size-classes, large pulses of recent recruitment are absent.

Populations with large-diameter trees have few individuals for instance at The Zoo, the mid Matukituki valley, and Lake Dispute. Low-density, large diameter populations are as much a reflection of habitat fragmentation by human modification as of natural stand thinning of a single cohort over time.

The relationship between maximum tree height and stem diameter of four district populations is a broadly exponential fit, with a variable asymptote depending on competition for light in the surrounding forest or scrub (Table 4). The Hautapu population is low-growing in open scrub or on forest margins and has smaller diameters. Trees on the Hokonui Hills, Southland attain 9.5 m within broadleaved forest, but are of shorter stature in paddocks and scrub in the Matukituki valley.

Regeneration

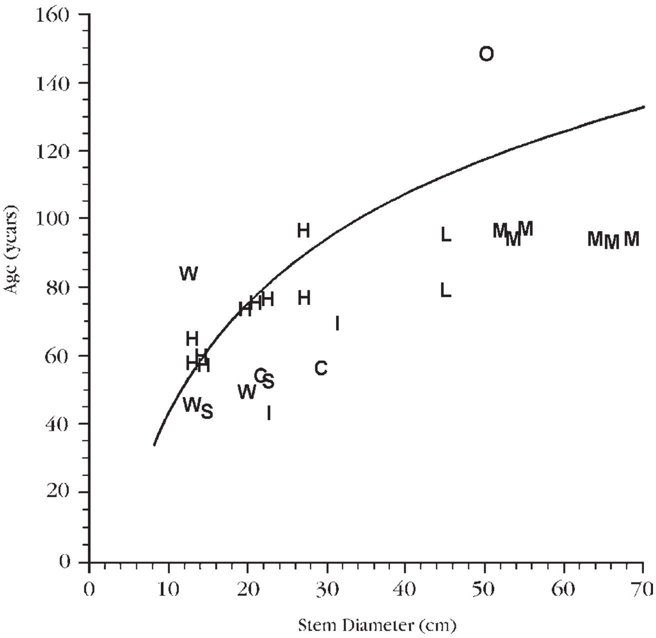
Size-class distributions suggest distinct pulses of past regeneration in most populations (Table 3). The age:diameter regression (Figure 6) indicates that most stands originated in the last 120 years. In this period of forest clearance and farm conversion the stimulus for regeneration was probably bare soil, conducive to germination before the smothering effects of naturalised grasses became widespread. Given the general absence of seedlings and saplings, regeneration opportunities in the last 30–40 years have been few. The limited number of wild seedlings and saplings suggests that the species will germinate and establish in light to moderate shade, but not within tall intact forest.

The species cannot regenerate when surrounded by dense herbaceous vegetation, particularly naturalised grasses. Both a germination failure and a seedling growth failure may contribute to this. Small areas of new mineral pavement exposed by sedimentation, mass movement, and trampling of farm stock are rapidly colonised by naturalised herbs and grasses both vegetatively and by wind-dispersed propagules. In all wild sites with seedlings and saplings, the competitive pressure from naturalised herbaceous plants is low.

Recruitment is possible under light sheep grazing on large areas of new coarse-grained or rubbly colluvium. Parts of one large stand opposite Cameron Flat in the Matukituki West River on an extensive debris fan originated within the last 40 years under light seasonal

Figure 6 Exponential age : stem diameter regression for *Olearia hectorii* sampled from 27 increment cores and discs at 8 sites.

Sampling sites: *C* = The Zoo, Chalk Range, Marlborough;
H = Hautapu Valley, Rangitikei;
I = Ivy Russell Memorial Reserve, Southland;
L = Lake Dispute, west Otago;
M = Matukituki Valley, west Otago;
O = Hokonui Hills, Southland;
S = Swales Bush Scenic Reserve, Southland;
W = Wairarapa.



sheep grazing (J. Aspinall, pers. comm. 1994) (Table 3). Naturalised herbs and grasses are slow to invade extensive new pavement, reducing potential establishment pressure on *Olearia hectorii*. Seedlings have also established in cliff crevices and ledges in the Ngaurukehu Scientific Reserve and on the West Wanaka Road. Although sheep appear not to browse this species, a distinct browse line at approximately 1.8 m on mature trees in pasture indicates that cattle crop accessible foliage.

Health

The physiological health of trees varies in terms of soil conditions, light exposure, and stock damage. Trees on gleyed soils are less thrifty than those on recent and well drained soils. On gleyed soils life expectancy is shorter and stem growth rates are slower than on well drained soils. In addition, shaded trees reproduce less vigorously than well lit trees or not at all. Farm stock, particularly cattle, severely affect tree health and recruitment by cropping seedlings, foliage, and epicormic shoots, rubbing bark, trampling roots, fracturing trunks, and creating dry, draughty forest understoreys. The Paengaroa, Wainuioru, Kourarau, Matukituki River central valley, Lake Dispute, Waikaia valley, and Hedgehope populations are all partly and mostly thoroughly debilitated.

4.7 STEM GROWTH PATTERNS

Radial increment cores from several populations revealed a wide range of stem growth rates (Table 5). Although South Island plants apparently grow faster than North Island plants, edaphic factors appear to primarily control growth rates, rather than any latitudinal temperature effect. The plants grow faster on well drained rubbly colluvium and coarse alluvium and slower on gleyed and seasonally-waterlogged alluvium. Growth rates at Hautapu and Wainuioru on fine-grained and periodically wet alluvium are half those of trees on coarse colluvium in the Matukituki valley.

TABLE 4 EXPONENTIAL REGRESSION, STANDARD ERRORS, AND ASYMPTOTES FOR TREE HEIGHT ON STEM DIAMETER FOR SAMPLED POPULATIONS OF *Olearia hectorii*.

LOCATION	NUMBER OF STEMS (N)	EXPONENTIAL REGRESSION	STANDARD ERROR	ASYMPTOTE
Hautapu valley	66	$y = 5.23(1-e^{-0.151x})$	0.35	5.25
Nidd Stream	29	$y = 5.74(1-e^{-0.114x})$	0.29	6.5
Matukituki valley	111	$y = 4.72(1-e^{-0.29x})$	0.11	4.85
Hokonui Hills	39	$y = 6.08(1-e^{-0.15x})$	0.37	6.21

Despite a moderately reliable exponential age : diameter regression ($R^2 = 0.79$) there may be a wide range of ages in any stem size-class (Figure 6). For instance, trees of approximately 50 cm diameter at Matukituki are 95 years old, while one at The Zoo is 149. Further, trees in the 21–30 cm diameter classes ranged from 42 to 96 years of age.

With age, many multi-leadered trees develop single trunks as stems coalesce, increasing their structural rigidity and potential stature. Internal stem rot is common in stems over approximately 8 cm dbh, particularly on poorly drained sites. Although stems may not be weakened where an intact annulus of living wood remains, eventually trunks develop longitudinal fractures, progressively fragment, and finally collapse.

4.8 PHENOLOGY

The species is deciduous, an uncommon life history strategy among New Zealand trees, but shared with *Sophora microphylla*, *Plagianthus regius*, and *Fuchsia excorticata*, which often occur with *O. hectorii*. However, it is not uncommon for saplings and trees of *O. hectorii* to retain a small proportion of leaves through winter, concentrated in the interior of the plant. Deciduousness could be an adaptive response to the seasonal climatic extremes of the eastern valley habitats often occupied by these species.

The general timing of vegetative and reproductive events is:

- Leaf bud expansion — early August
- Bud burst and leaf expansion — late August to mid October
- Flower maturation — late November to early December (ray florets mature 1week earlier than disc florets)
- Seed release — mid to late December, over a 3 week period
- Leaf fall — May and June.

TABLE 5 MEAN RADIAL INCREMENTS OF LARGEST DIAMETER STEMS SAMPLED FROM POPULATIONS OF *Olearia hectorii*. DRAINAGE CATEGORIES WERE ASSIGNED ON EVIDENCE OF SEASONAL WATERLOGGING AS INDICATED BY SYMPTOMS OF GLEYING AND SOIL PARTICLE SIZE AND STRUCTURE.

LOCATION	CORE/DISC	NUMBER OF STEMS (n)	MEAN (mm)	STANDARD DEVIATION	DRAINAGE CLASS
Hautapu valley	Core	9	1.42	0.69	poor
Wairarapa	Disc	2	1.52	0.9	poor
Matukituki valley	Core	2	3.21	1.16	good
Lake Dispute	Disc	5	1.86	0.91	moderate
Hokonui Hills	Core	2	2.36	0.74	good
Swales Bush Scenic Reserve	Core	3	2.42	1.09	moderate
Ivy Russell Memorial Reserve	Core	2	1.61	1.09	moderate

The period of flower maturation and seed liberation occupies just 1 month from mid November to mid-late December in the North Island. Year-to-year variations of up to 3 weeks in the timing of vegetative and reproductive events were noted for the summers spanning 1992–1994. Variations in the timing of these events have been reported; for instance, flowers were noted on the Pomahaka population in August–September 1992 (B. Patrick, pers. comm. 1994).

4.9 REPRODUCTIVE BIOLOGY

The flowers of *Olearia hectorii* are mostly perfect, i.e., have functional male and female elements, and are probably insect-pollinated. Light partly controls reproductive vigour, because shaded limbs and trees produce few flowers, whereas full light initiates abundant flowering. Well lit trees produce thousands of wind-dispersed seeds.

Olearia hectorii is capable of vegetative reproduction. Adventitious roots and shoots may develop when collapsing stems and branches contact the ground, extending the life of senescent trees. By this means a population may be maintained when opportunities for sexual reproduction are temporarily unavailable in stable landscapes.

Another curious reproductive trait of the species allows adventitious aerial roots on erect trees to develop into new stems. This is much the same phenomenon as trunk development in epiphytic northern rata, except that *O. hectorii* develops aerial roots within the moist cavities of decaying trunks. These roots finally gain ground access through internal or external trunk fractures.

Numerous life history attributes equip this opportunistic species to exploit patterns of shifting resources:

- sub-lianoid growth form of saplings and adults to exploit shifting light-gaps
- vegetative resprout from fallen stems and lianoid branches in ground contact
- rapid reproductive cycle
- mass seed production
- long-distance seed dispersal
- seed germination restricted to fresh mineral soil.

It is critical for a tree with narrow establishment tolerances to regularly produce large quantities of well dispersed seed.

4.10 SEED VIABILITY AND GERMINATION

Fresh seed from the Marlborough and Hautapu populations were sown at 4-week intervals from December 1992 to April 1993 by broadcasting onto potting mix and raw sand substrates. Seed was stored at 6°C in a refrigerator. Very small amounts of seed germinated in the first 2 months after sowing in January and February, and none thereafter, suggesting that seed viability is brief. Germination occurred only on the raw sand. Tony Silbery of Percy Reserve, Lower Hutt reports only a small proportion of fresh seed from the Wairarapa populations germinated on sand in 1995.

4.11 PROPAGATION

Cuttings may root after treatment with standard rooting hormones. Cuttings established best in late summer to autumn and these carried the new leaves through winter. However, cuttings are susceptible to damping-off fungal rot if over-watered in winter.

4.12 HABITAT MANIPULATION

Exclosure plots on Railcorp land in the Hautapu valley and at The Zoo below the Chalk Range were used to assess ways to stimulate regeneration from natural seed dispersal in the absence of grazing and browsing animals. Both exclosure plots adjoined O. hectorii stands. The resident grass sward was suppressed by (1) physically removing the top 8–10 cm of turf, and (2) by application of herbicides. The first treatment was intended to remove most of the resident propagules from the site; herbicides are unlikely to affect a litter- and topsoil-bound seed bank. Both exclosures were treated immediately before seed liberation, and abundant seed of *O. hectorii* settled in them. No recruitment of *O. hectorii* occurred in either the exclosure or the control plots up to 12 months after treatment. Rather, weeds rapidly recolonised the newly exposed mineral soil. Some recolonisation was by peripheral vegetative spread, some by germination of a deeply buried residual seed bank, and some by dispersed propagules. Even on 20 x 5 m treatment blocks, adventive grasses, herbs, and *Juncus* spp. colonised the entire surface within 12 months. Regeneration of adventive species was also rapid in the herbicide treatment blocks.

5. Recovery Planning

The sections which follow are the basis for the development of a full recovery plan.

5.1 FACTORS LEADING TO DECLINE

Habitat loss and change

Olearia hectorii has an altitudinal, landform, and soil fertility niche coinciding with valuable pastoral farm land. Four phases of habitat loss and change have consequently affected the species as follows:

- Some habitat and population reduction must have accompanied the piecemeal removal of lowland forest by prehistoric Maori, commencing c. 850 yr BP, particularly in Hawke's Bay, Wairarapa, Marlborough, Otago, and Southland.
- Rapid decline in its geographical range and abundance must have accompanied the 19th and early 20th century phase of conversion of lowland forest to farms by European colonists.
- A loss of populations now known only from herbarium records dating from the 1920s points to a third wave of local extinction during the phase of intensified pastoral use of lowlands from the 1950s.
- Present-day incremental change of habitat and population decline from farming practices.

Ten populations have probably become extinct this century (Table 1): Taihape Scenic Reserve, Rangitikei; Hutchinson Scenic Reserve, Hawkes Bay; Mangles River, Nelson; Pelorus River, Marlborough Sounds; Wakamarina Stream, Marlborough Sounds; Conway River, Marlborough; Ratanui, Clutha County, Southland; Piano Flat, Wakaia valley, Southland; Myross Bush, Southland; and the Roaring Meg, Kawarau Valley, Otago. Doubt exists over the status of the Conway River and Roaring Meg sites, where recent searching by the author and by DoC personnel has failed to relocate the solitary trees originally recorded for each site. The Roaring Meg site now supports an exotic pine plantation in the vicinity of the original record.

Many of the remaining habitats are suboptimal because of:

- A reduction in geomorphic disturbance through catchment and pavement stabilisation work. Flood control and poplar and willow planting to control debris avalanching are the principal agents.
- Fertility boost by fertiliser application and nutrient transfers by stock camping on valley floors and in sheltered gully heads.
- Deliberate clearance of forest and stock damage to native vegetation, drying forest understoreys and increasing light levels.
- More or less constant stock grazing.

Recruitment failure

The above influences all benefit the spread of naturalised herbs and grasses, which is the primary factor inhibiting *O. hectorii* recruitment. Dense herb and grass swards outcompete *O. hectorii* for regeneration sites by smothering stable ground and by more rapidly colonising small patches of disturbed ground. Excluding farm stock only leads to rank grass swards, further inhibiting regeneration opportunities. Light grazing, preferably by sheep, may offer better prospects for recruitment by suppressing grasses and exposing a small-scale mosaic of the mineral soil apparently necessary for seedling establishment.

Smothering by lianes

Smothering by *Muehlenbeckia australis* is a major threat to *O. hectorii* on the margins of forest remnants. This liane prospers from disturbances that fragment forest canopies and that lead to elevated light and fertility levels. The populations most at risk are in the Turakina valley, parts of the Hautapu valley, Wainuioru Stream, and Williams Road in the Hokonui Hills, all of which have recently lost trees to smothering by *M. australis*. The Taihape Scenic Reserve population was lost to smothering by the introduced liane, *Clematis vitalba* (C. C. Ogle pers. comm. 1995).

5.2 FURTHER RESEARCH NEEDS

Two aspects of the species' regeneration ecology may need additional research through management. Methods of habitat manipulation additional to those unsuccessfully trialed in this study may warrant investigation as means of stimulating seed-sourced regeneration. Fresh alluvium from the banks of the Hautapu Stream will be spread to a depth of 10–15 cm in the Railcorp land exclosure plot before the 1995 breeding season as a means of stimulating seed germination. Seasonally controlled sheep grazing, although difficult to implement, may also stimulate natural recruitment in a closely cropped turf of adventive grasses. Methods of stimulating vegetative reproduction from collapsed stems or artificially cropped limbs in ground contact need further work and trials will be conducted in the Hautapu valley in 1994–95. The latter approach offers potential for regeneration in competition with rank pasture.

6. Options for Species Recovery

6.1 *EX-SITU* CONSERVATION

Olearia hectorii can be propagated from cuttings with care, and grows readily in garden situations, where sandy loams provide an ideal substrate for cultivation. Despite its attractive, deeply furrowed, grey bark, bronze branchlets, and moss-green foliage it is seldom if ever distributed by specialist native plant nurseries and never by general plant nurseries. Plants grown by Department of Conservation botanists in Otago/Southland and by the author at Rotorua were invariably multi-leadered, but were compact and upright at 4 years of age. Pruning would eventually be necessary to maintain the compact form desirable for gardens.

Tony Silbery at Percy's Reserve, Petone has a tree in cultivation reputed to be a clone of the extinct Hutchinson Scenic Reserve population from Hawke's Bay, which could be used for site restoration work. Cutting material from the Wairarapa populations is also established at Percy's Reserve nursery.

6.2 *IN-SITU* CONSERVATION EVALUATION

The ecosystem health of each site and prospects for natural regeneration have been assessed in terms of: *naturalness* of vegetation, soils, and geomorphic processes; ecological *viability*; *buffering*; and *fragility*. Ecosytem naturalness is inversely related to the degree of human modification. Viability reflects an ecosystem's self-regulating capacity and an ability to resist human impacts. Buffering reduces deleterious external influences. Fragility is an expression of sensitivity to environmental change. Populations have been classified into three categories — high, moderate to low, and nil viability — in terms of the above criteria.

Sites with high-quality ecosystems are:

- Valley slopes of Nidd Stream, Chalk Range, Marlborough
- Matukituki West and East Rivers, west Otago
- Hokonui Hills (Williams Road), Southland.

These sites have comparatively healthy ecosystems with inherently high resilience, and good propects for natural regeneration. External influences on soil and vegetation turnover still exist as critical ecosystem processes. These processes are essential for disturbance-induced regeneration. Past human modification of the sites is confined to limited selective logging, patch burning, an associated mosaic of secondary vegetation, and only small patches of adventive grass. All three sites have light or intermittent stock grazing, but at levels not likely to inhibit recruitment of *Olearia hectorii* after a major disturbance event, nor at levels advantageous to adventive grasses.

Sites with ecosystems of low to moderate quality:

- Owhakura Stream, Turakina valley
- Ngaurukehu Scientific Reserve, Hautapu valley
- Railcorp land, Hautapu valley

- Coogin's property, Hautapu valley
- Paengaroa Scenic Reserve, Hautapu valley
- The Zoo, Chalk Range
- West Wanaka Road, Matukituki valley, west Otago
- Pomahaka Stream, Southland
- Eyre Creek, Southland
- Sutton Road, Hokonui Hills, Southland
- Ivy Russell, Memorial Reserve, Southland.

These sites are characterised by moderate to severe forest fragmentation and extensive, impenetrable grass swards surrounding severely modified forest remnants. Recruitment prospects are limited, mostly in suboptimal microhabitats within forest understoreys or on the margins of forest remnants exposed to grass competition. Recruitment probably depends on changes to present land use practices. Several sites in this second group should be prioritised for interventionist management because they also have significant conservation values (see section 8). Sites with virtually no long-term viability in the absence of interventionist management:

- Kourarau Stream, Wairarapa
- Wainuioru Stream, Wairarapa
- Matukituki mid valley, west Otago
- Lake Dispute, west Otago
- Waikaia valley, Southland
- farmland population, Hokonui Hills, Southland
- Swales Bush, Southland
- Hedgehope, Southland
- Browns Town, Southland.

Nine of the 24 populations (38%) therefore have no medium to long-term propects for perpetuation of *Olearia hectorii*. At all sites, farming practices have virtually eliminated the indigenous forest ecosystem in the vicinity of the *O. hectorii* stands, and more or less solitary trees remain in open pasture. Where forest remnants exist they are degraded, failing to regenerate, and disintegrating towards extinction because farm stock graze and browse the understorey. Symptoms of illthrift of *O. hectorii* at all these sites are collapsing and dead branches, fragmented and decaying trunks, poor foliar biomass to total biomass ratios, exposed root plates, stripped bark, and dense swards of adventive grasses beneath the stands. Despite this prognosis the Kourarau Stream, Wainuioru Stream, and Lake Dispute populations are biogeographically very important.

6.3 SUPPLEMENTARY PLANTINGS

Eleven seedlings were planted out by Brian Rance of DoC Invercargill in 1991 at a new site for *Olearia hectorii* on the eastern foothills of the Taringatua Range, Southland, sourced from the Swales Bush population. This Southland Plains site was chosen for supplementary planting because nearby populations were either extinct, as at Myross Bush, or surrounded by pasture, as at Hedgehope and Swales Bush. Seedlings were each surrounded by a wool-sack punctured through the centre to smother and reduce competition from adventive grasses. Only 8 saplings survived 1 year later, the remainder having succumbed to smothering by grass. Cuttings planted in the wild had average vertical growth rates of 15–20 cm per annum, even on multi-leadered plants.

Ten saplings raised at the Forest Research Institute nursery at Rotorua from local cutting material have been delivered to Neil Simpson, DoC Queenstown for supplementary planting at Lake Dispute, Otago, where only two large trees remain.

7. Recovery strategy: Goals and objectives

Whereas it is important to recognise regional or habitat provenances or ecotypes when conservation is undertaken, in the absence of genetic investigations this study offers no reason to set protection priorities on intraspecific or provenance variation alone. Rather, the criteria to be used in recovery planning will be the properties, patterns, and processes of ecosystems containing *Olearia hectorii*, with the aim of perpetuating the best remaining natural systems in biogeographically representative localities.

7.1 LONG-TERM GOAL

- To plan for and encourage land use patterns that contribute to improvements in forest ecosyatems health at important *Olearia hectorii* sites.
- To design reserves and land use patterns that permit natural, disturbance-induced regeneration of the species.
- To stimulate formal protection of the most representative sites.

Long-term objectives:

- At least five viable, comparatively intact forest communities and ecosystems have formal protection and management plans and practices conducive to natural regeneration (one each in Rangitikei, Wairarapa, Marlborough, west Otago, and Southland).
- The present fragmented and semi-natural secondary forest communities at key sites show improved cover, naturalness, and general ecosystem health.
- That recruitment opportunities exist as part of the natural disturbance regime of each site.

7.2 SHORT-TERM GOAL

- To improve the population status of the most critically endangered and biogeographically important populations using nursery-sourced seedlings.
- To improve knowledge of vegetative reproduction techniques in grossly modified communities.

Short-term objectives:

- Establish 5–10 healthy saplings, protected from stock, and sourced from local material at Wainuioru Stream, Kourarau Stream, The Zoo, Lake Dispute, and Swales Bush.
- Achieve landowner support and co-operation in moves to supplementary plant, protect from stock, and release from weeds these five critical populations.
- Establish vegetative reproduction experiments with and without seasonal grazing by sheep and/or cattle.

7.3 WORKPLAN

Supplementary planting of critically endangered populations

Basis. The five critically endangered populations in Category 2 (see 8.4 Priorities) require immediate rejuvenation to improve the species' local survival chances. Population depletion is progressing apace, with two individuals remaining at each of the two Wairarapa sites and at Lake Dispute, and one in the Waikaia valley. Swales Bush has one illthrift tree within the Scenic Reserve and 5 scattered in adjacent paddocks.

Plan and implementation. Trials have indicated that the species can be readily propagated. Given that stock graze each site, seedlings and saplings will require interim protection pending more comprehensive site restoration initiatives. A supplementary planting strategy requires integration with site restoration planning. Planting sites require careful selection in terms of:

- Drainage
- Fresh pavement and/or elevated fertility
- High-illuminance conditions for future reproductive vigour
- Maximising future natural regeneration prospects, particularly on frequently disturbed sites
- Future reserve design.

Projected outputs. Artificial recruitment must be viewed as a first step in a long-term commitment to habitat restoration. Successful establishment of cuttings will ensure biogeographic representativeness, at least in the short term, for the species at critically endangered sites.

Prepare management plans and seek protection measures for nationally and regionally significant sites

Basis. The long-term viability of *Olearia hectorii* depends on the maintenance of healthy ecosystems, including their disturbance regimes. Artificial regeneration of the species either by planting out or induced vegetative propagation are crisis recovery actions for critical district populations. Arresting habitat decline and enhancing prospects for natural regeneration must be the medium to long-term focus in nationally and regionally significant sites.

Plan. Nationally and regionally significant sites require recognition and inclusion in the Conservation Management Strategy of the local Conservancy. Regionally significant or Category 2 sites should be prioritised ahead of Category 1 sites (see 8.4 Priorities) for recovery planning and protection, because of their degraded condition and lack of regeneration. Substantial resources will be required to implement restoration plans for Category 2 sites. However, apart from the Railcorp land site in the Hautapuvalley, infrequent monitoring of natural regeneration and in some instances long-term formal protection are the only requirements for Category 1 sites.

Implementation. A Conservancy commitment to management planning for site restoration at Category 2 sites and the Hautapu valley Category 1 site is required. Management plans should target improvements in ecosystem and population health for the species, outlined in the short-term and long-term goals. For most Category 2 sites management plans should include control of smothering *Muehlenbeckia australis*, a relaxation of destructive stock-grazing, landowner co-operation in light seasonal sheep grazing, boundary fencing, removal of adventive trees and lianes, and removal of nutrient supplements as priority remedial actions. At many sites, private landowner support and co-operation will be an integral part of the recovery strategy. Management plans and site protection measures will vary in their commitment of resources according to present habitat condition, but in most instances commitments will be large.

Projected outputs. A long-term Conservancy commitment to the enhancment and protection of key sites, including improved chances for regeneration and healthier populations, will substantially correct the deteriorating national conservation status of the species. This objective can be met only by commitment at a regional level.

Trials of artificially induced vegetative reproduction

Basis. Early results from an exclosure plot suggest that the species will adventitiously root and epicormically resprout from stems and branches in ground contact. This behaviour could overcome the reproductive bottleneck imposed by adventive grasses at most sites.

Plan. Experimental design can be undertaken in conjunction with Landcare Research to examine the vegetative reproductive capacity of stems and branches. Variables to be examined should include the health and age class of stems and branches, stem length, edaphic variations, competition from adventive grasses, and stock grazing.

Implementation. Sites where the experimental variables are at least partly met and where reasonably secure populations are available for donor material are Ngaurukehu Scientific Reserve and Railcorp land, Hautapu valley; The Zoo and Nidd Stream, Chalk Range, Matukituki West and East Rivers, Otago; and Williams Road, Hokonui Hills. Experiments should be co-ordinated between Conservancies. Each site experiment would require 1–2 person days to implement and 1 day per annum for monitoring.

Projected outputs. Successful vegetative propagation in the wild would greatly improve the species' viability at grossly modified and critically endangered sites. However, the strategy contributes little to the immediate propects for ecosystem restoration.

Restoration of extinct district populations

Basis. The species has apparently become extinct in Hawke's Bay, Nelson, and eastern Otago insofar as early to mid 20th century herbarium records are indicative (Table 1). Loss of regional plant diversity can be overcome. The issue of genetic integrity can be addressed by sourcing cuttings from nearby district populations or from reliably sourced nursery stock.

Plan. Regional restoration of extinct populations can be a medium to long-term priority in an overall recovery strategy. Three districts should be targeted.

Implementation. Hutchinson Scenic Reserve is a tall podocarp forest with edges of manuka and low broadleaved forest. Tony Silbery of Percy's Reserve, Petone can provide cutting material from a clone of the original Hawke's Bay tree for a new population at Hutchinson Scenic Reserve.

Early herbarium records suggest that the Pelorus River catchment was a population centre for the species in Nelson province, and it seems appropriate for restoration of a district population. Shannel Courtney, DoC, Nelson can advise on appropriate replanting sites with Marlborough-sourced cutting material.

Replanting of a Catlins site or one in eastern Otago near Ratanui is also desirable. Brian Rance, DoC, Invercargill can obtain cutting material for propagation from Southland populations, and Neil Simpson, DoC, Queenstown can obtain western Otago cutting material. Climatically the Hokonui Hills populations equate closely to the Catlins District. Dr Peter Johnson, Landcare Research, Dunedin can advise on appropriate localities for replanting around Ratanui.

For each site, this exercise involves 5–10 person days to implement, including obtaining cutting material, arranging propagation, liaising with landowners, planting out and protecting seedlings, and releasing saplings.

Projected outputs. Artificially established *Olearia hectorii* stands associated with existing forest on suitable landforms will strengthen the national status of this critically endangered species and restore a biogeographically important asset to three DoC conservancies.

7.4 PRIORITIES

Fifteen of the present 23 populations have been prioritised for recognition as nationally and regionally significant. Recovery planning and action must target Category 2 sites ahead of Category 1 sites.

Category 1 sites (nationally significant) with the most supportive tenure, degree of ecosystem naturalness, healthiest *Olearia hectorii* populations, and highest plant diversity are:

- Railcorp land, Hautapu valley, Rangitikei;
- Nidd Stream, Nelson/Marlborough;
- the two populations at the confluence of the Matukituki West and East Rivers, western Otago;
- the duck pond, Williams Road, Hokonui Hills, Southland;
- Pomahaka Stream, Umbrella Mountains, Southland.

Category 2 sites (regionally significant) based on ecosystem health, species viability, and/or biogeographic significance are:

- Rangitikei: Owhakura Stream and Ngaurakahu Scientific Reserve;
- Wairarapa: Kourarau Stream and Wainuioru Stream;
- Nelson/Marlborough: The Zoo;
- West Otago: West Wanaka Road and Lake Dispute;
- Southland: Swales Bush Scenic Reserve and the Waikaia valley.

8. Conclusions

The low-growing tree *Olearia hectorii* is known from 13 catchments in 5 districts; some 450–500 individuals are known in the wild. At a regional level the species is extinct in Hawke's Bay, eastern Otago, and possibly Nelson, and critically endangered at Wainuioru Stream, Kourarau Stream, mid Matukituki valley, Lake Dispute, Waikaia valley, and Swales Bush. Better populations exist in the upper Turakina valley, Hautapu valley, Chalk Range, upper Matukituki valley, Pomahaka catchment, and Hokonui Hills. The species has narrow regeneration requirements. It typically establishes as cohorts on fresh alluvium and colluvium after large- and small-scale disturbance associated with mass movement, flooding and sedimentation, and tree windthrow. A lifespan of at least 150 years, a capacity to resprout vegetatively, tolerance of moderate shade, and annual production of abundant wind-dispersed seed has perpetuated the species on lowland plains and in valley heads in eastern districts within the competition of taller forest communities.

Olearia hectorii occurs mostly around the edge of forest remnants on agriculturally valuable land. Stock grazing of most remnants fosters dense grass swards that prevent natural recruitment of the species, yet totally excluding stock only increases grass stature. On the other hand, low-impact grazing may enhance regeneration prospects in moderately modified habitats by suppressing competitive weeds and fostering exposure of mineral soil. Despite quite narrow regeneration requirements, *O. hectorii* shows considerable resilience to habitat fragmentation by frequently surviving as the last indigenous plant in a pastoral ecosystem. Many stands owe their origin to the last phase of forest clearance or fragmentation in the process of farm development late last century, and now exist as moribund trees with no regeneration prospects.

In terms of the IUCN criteria, this study confirms that *Olearia hectorii* is a critically endangered species. The' critical' ranking reflects:

- the increasing modification of its remnant forest habitat by pastoral practices;
- recent extinction of some populations, and the prospect of imminent loss of others;
- opportunities for natural regeneration no longer exist in many habitats.

9. Recommendations

Recovery planning targets four strategies within a framework of short-term and long-term goals for ecosystem and species conservation:

- supplementary planting of critically endangered populations;
- preparation of management plans and formal protection measures for nationally and regionally significant sites;
- trialing of artificially induced vegetative reproduction;
- restoration of extinct district populations.

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