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ECOLOGY OF THE ENDANGERED HERB *SCUTELLARIA NOVAE-ZELANDIAE*

Summary: *Scutellaria novae-zelandiae* is a small herb restricted to the Nelson! Marlborough region. Aspects of its ecology were studied to assist in the management of wild populations. An absolute estimate of abundance is not possible as individual *Scutellaria* plants are indistinguishable and it grows in small patches up to 20 m2. There are probably between 50 and 100 such patches in podocarp-beech forest below 200 m a.s.1. on freely drained alluvium and colluvium. The vigour of *Scutellaria* patches as estimated from changes in shoot frequency and seed production varies widely depending on site conditions. It cannot tolerate competition from ferns, herbs, weeds, and shrub growth which occurs once the ground surface stabilises.

Patches of *Scutellaria* have a marked seasonal variation in mean height, reaching a peak of approximately 12-15 cm during flowering (November-December), and then declining. Fresh *Scutellaria* seeds take several weeks to germinate and many enter the soil seed bank. Seedlings rarely appeared in bare ground plots at the field sites, but many emerged rapidly from topsoil samples placed in a glasshouse, along with abundant seedlings of vigorous adventive weeds. *Scutellaria* patches expand mainly by vegetative means. *Scutellaria* has been reduced in abundance by grazing at some sites, yet at others it has probably benefitted from grazing through the removal of competition from other plants, including adventive weeds. The implications of the results for the conservation of *Scutellaria* are mentioned.

Keywords: *Scutellaria novae-zelandiae;* endangered plants; phenology; shoot growth; seed banks.

Introduction

Scutellaria (Lamiaceae) is a cosmopolitan genus of over 3000 species that is represented in New Zealand by S. *novae-zelandiae* (hereafter referred to as *Scutellaria)* of the '*S. humilis* species group' (Paton, 1990). It is a soft woody herb up to 30 cm tall with creeping stems that root at the nodes in the surface topsoil. It was listed among the rare and endangered plants of New Zealand by Given (1981) because of the very few collections and absence of information on its ecology and has received a rating of 'Endangered' according to the IUCN classification (Wilson and Given, 1989).

Scutellaria was first recorded from Nelson in 1840 and has been found only at scattered lowland sites since then, from Golden Bay to the Awatere Valley in Marlborough. Most of these sites occur in the Golden Bay and Arthur Ecological Districts (McEwen, 1987) of the North-West Nelson Ecological Region, the Moutere and Bryant Districts of the Nelson Region, and the Pelorus District of the Richmond Region. Many of these populations had not been relocated since the 1950s, and until recently *Scutellaria* was known from only one location near Takaka and several sites in the Maitai and Roding valleys near Nelson (Wilson and Given, 1989). There have been no studies of *Scutellaria,* although it has been grown in nurseries for a number of years.

The purpose of this study was to investigate aspects of *Scutellaria* ecology and biology sufficiently to determine what action, if any, needs to be taken to conserve the species in the wild. Here are described: (1) the present distribution and site characteristics of *Scutellaria;* (2) growth and phenology; (3) seed germination and soil seed banks.

Methods

Distribution and site characteristics

To clarify the present distribution of *Scutellaria,* intensive searches were made in the Tinline, Roding, Hackett, Maitai, and Takaka catchments (Table 1). This resulted in the identification of numerous sites with patches of *Scutellaria*. To characterise the site requirements of *Scutellaria,* nine sites were selected over its geographical range and site factors, altitude, aspect, slope, physiography, and soil parent material were noted. The vegetation was sampled from non-area plots by estimating the cover of species in the two layers: layer 0.3-2.0 m and the 5-12 m canopy layer. Cover classes were: (I) 0-1 %; (2) 2-5%; (3) 6-25%; (4) 26-50%; (5) 51-75%; (6) 76-100%. Ground cover as a percentage and frequency was recorded within a variable number of I m2 plots located among the

patches of *Scutellaria;* categories were individual species of higher plants, woody seedlings, bryophytes, litter, rock, and soil. Site 9 was too steep to sample.

Growth and phenology

Shoot growth, flowering, seed production, and seasonal patterns of growth and phenology were recorded at sites 1 and 2 in the Roding catchment at various intervals between 1989 and 1992. These observations, and an experiment to determine the ability of *Scutellaria* to spread onto cleared areas, were made at two pairs of contiguous 1 m2 subplots at each site. At one pair the litter and all vegetation apart from *Scutellaria* were removed from one subplot, while at the other pair only vegetation was removed from one subplot. The subplots were maintained in this state from August 1989 until December 1990.

Each subplot was gridded into 100 squares by strings stretched across a 1 m2 frame. The strings were laid out on each sampling occasion when the frequency, height, and phenological state of *Scutellaria* were recorded within each square. The number of fruiting stems and capsules per stem were counted in the subplots in 1990. The proportion of flowers producing capsules was recorded from 20 marked stems at sites I and 2 in 1992.

The undisturbed plots were enclosed in steel grill cages to preclude the possibility of animal damage.

In addition, at sites 7 and 8 in the Takaka Valley the height of 25 randomly selected shoots was recorded in December 1990. An attempt was made to locate and count the number of capsules on all fruiting shoots at sites 7 and 8, to estimate the total seed production.

Soil seed banks

The presence and abundance of seed in the ground was determined by collecting soil from beneath patches of *Scutellaria* at sites 1-4 (Table 1) in July 1990. Two 25 cm x 25 cm samples were taken of the upper 0-5 cm layer, including litter, and the material from each site was combined. This material was spread in sand-filled trays in an unheated glasshouse, and seedlings were identified as they emerged (Partridge, 1989; Mather and Williams, 1990).

Seed germination

Seeds were collected from capsules on wild plants in March 1990, stored at room temperature, and sown in August 1990. Two plastic germination trays were partly filled with sand then filled with sterilised commercial plant germination mix. Twelve seeds were placed in each of two trays at a depth of 0.5 cm. Trays were placed in an unheated glasshouse and watered from beneath for 17 weeks.

Results

Site characteristics

The sites occupied by *Scutellaria,* of which a representative sample is shown in Table I, are all below 200 m a.s.l. They are located on steep to very steep toe slopes of easterly to southerly aspect, or on gently sloping low terraces. Most sites are within 50 m of a river bed, and many are in the actual flood channel or on bank sites prone to flooding.

All sites have skeletal soils from colluvium or recent alluvium derived from both calcareous rocks, e.g., limestone at The George Creek, and acidic parent rocks, e.g., Permian sandstones in the Maitai and Roding valleys. They are well drained to excessively drained, and patches of *Scutellaria* are sometimes found in a very thin layer of humus covering small rock outcrops on toe slopes or slightly raised areas of terrace.

Table 1. *Location and characteristics of study sites and representative sites from other catchments with* Scutellaria novae-zelandiae.

No.	Catchment	Grid reference (NZMS 260)	Latitude (s)	Longitude (e)	All. (m)	Aspect (°)	Slope (°)	Physiography	Parent material
1	Roding	N27 294815	41°23'	173°14'	160	45	38	toe slope	acidic
2	Roding	027 304828	41°22'	173°15'	180	90	5	terrace	acidic
3	Roding	027 306828	41°22'	173°15'	180	90	30	toe slope	acidic
4	Hackett	N28 295787	41°24'	173°14'	180	180	5	terrace	acidic
5	Maitai	027 408905	41°17'	173°22'	100	180	40	toe slope	acidic
6	Tinline	027 538903	41°17'	173°31'	80	120	45	toe slope	acidic
7	Waitui	N26 938178	41°03'	172°49'	110	180	2	terrace	calcareous/ acidic
8	Takaka	N26 950292	40°57'	172°49'	40	0	0	terrace	calcareous / acidic
9	The Gorge	N26 973288	40°56'	172°50'	120	160	50	toe slope	calcareous

Table 2. *Clover class of species with a cover of at least* 5% *at one site in (a) the* 5-/2 *m layer and (b) 0.3-2.0 m layer at 9 sites with* Scutellaria novae-zelandiae.
Classes: 1 = 0-1%; 2 = 2-5%; 3 = 6-25%; 4 = 26-50%; 5 = 51-75%; 6 = 76-100%

Site No.	1	2	3	4	5	6	7	8	9
(a) 5-12 m layer									
Acer pseudoplatanus								3	
Carpodetus serratus			3						
Dacrycarpus dacrydioides		4				3	3	2	
Laurelia novae-zelandiae								4	
Nothofagus fusca			4						
N. menziesii				3		2			
N. solandri var. *solandri*	3		4		3	2			
Podocarpus hallii				2		3	4		
P. totara			3					4	
Prumnopitys taxifolia	3	4	2	3	3		4		
(b) 0.3-2.0 m									
Acer pseudoplatanus								2	
Aristotelia serrata	2								
Carpodetus serratus			2						
Chionochloa conspicua				4					
Coprosma australis			1						
C. *crassifolia*			1		2				
C. *linariifolia*	2		1						
C. *rhamnoides*		2	1		1	2	2		
C. *robusta*		1		2		2			2
C. *rotundifolia*		5	1				2		
C. *robusta* x C. *propinqua*				2					
Corokia cotoneaster				2	1				
Elaeocarpus hookerianus	2		1						
Fuchsia excorticata					3				
Geniostoma ligustrifolia									4
Macropiper excelsum								2	
Melicytus ramiflorus							3	2	
Melicope simplex		2	1			2			
Myrsine australis	2			2					
Neomyrtus pedunculata						1	2		
Paratrophis microphylla								2	
Parsonia heterophylla						2		2	
Pennantia corymbosa	2	2				2		2	
Plagianthus regius								2	
Pseudopanax anomalus						2			
P. crassifolius	2		1	2		1			

These soils probably have moderate levels of bases (e.g., Ca, Mg) and inorganic phosphorus because of the fresh rock fragments in the parent material.

All *Scutellaria* sites in the Maitai, Roding, and Tinline valleys (sites 1-6) support forest remnants with canopy gaps. All have *Nothofagus* spp.[1] with the exception of site 2, in addition to *Prumnopitys taxifolia* and other podocarps (Table 2). The two terrace sites near Takaka (sites 7, 8) lack *Nothofagus* spp. and are dominated by podocarps, and *Laurelia novae-zelandiae* in the case of site 8. Site 9 is the only site in scrub rather than forest and is distinctive in having *Geniostoma rupestre*.

The stands have several shrubs or small hardwood trees in the understorey, with *Coprosma rhamnoides,* C. *robusta,* and *Pennantia corymbosa* the most frequent (Table 2). Most of the other species are small-leaved, and site 8 also had the uncommon shrub *Teucridium parvifolium*.

Many microsites occupied by *Scutellaria* have a high proportion of rock or bare soil (Table 3). They generally have less than 50% total cover of vegetation, several ferns, and a few herbs (Table 3). Sites 7 and 8 in the Takaka Valley differ in having a dense layer of ferns and *Parsonsia heterophylla* (Table 3). Woody seedlings are generally frequent at all sites, and at site 8

[1] Nomenclature follows Allan (1961). Webb. Sykes and Garnock-Jones (1988). and changes listed in Connor and Edgar (1987).

Table 3. *Mean cover and frequency of* Scutellaria novae-zelandiae *and the main ground cover categories at sites* 1-8.
n = number of m2 subplots at each site. Mean cover (c) and frequency (f) class in subplots: 1 = 0-1 %; 2 = 2-5%; 3 = 6-25%; 4 = 26-50%; 5 = 51-75%; 6 = 76-100%

Site No.	1	2	3	4	5	6	7	8
n	20	20	20	4	4	4	6	8
Class	c/f	c/f	c/f	c/f	c/f	c/f	c/f	c/f
Rock	1/5	1/1	1/4	3/6	3/6	4/6	1/3	1/1
Soil	1/5	1/1	1/4	2/6	2/6	3/6	2/4	1/5
Litter	4/6	4/6	5/6	2/6	2/6	3/6	3/6	4/6
Bryophytes	1/6	1/4	1/6	4/6	2/6	2/6	2/6	1/1
Scutellaria novae-zelandiae	3/6	3/6	2/6	3/6	2/6	3/6	3/6	2/6
Acaena anserinifolia					1/4			
Arthropodium candidum								1/4
Asplenium hookerianum					1/4			
A. bulbiferum		1/4						
Cardamine debilis	1/1	1/4				1/6	1/4	
Chionochloa conspicua				4/6				
Hydrocotyle moschata								2/5
Hypolepis ambigua							3/6	
Muehlenbeckia complexa								1/5
Mycelis muralis	1/3	1/3	1/4			3/4		
Parsonsia heterophylla							1/5	3/6
Pellaea rotundifolia							2/6	
Phymatosorus diversifolius	3/5		1/4					
Polystichum richardii	1/4	2/4				2/6	2/5	
Stellaria parviflora						1/6		
Uncinia spp.	1/3	2/6				1/3		
Woody seedlings	2/5	1/3	1/6	3/6	2/6	1/4	1/6	1/6

this included *Acer pseudoplatanus*.

The grazing history of these sites varies widely; sites 1-4 and 6 have generally had a low level of grazing in recent years; sites 5 and 9 are periodically grazed by goats; sites 7 and 8 have had a long history of grazing by cattle and sheep until the last 2-3 years *(S.* Walls, *pers. comm.)*. There was no evidence of *Scutellaria* being browsed by possums *(Trichosurus vulpecula* Kerr) at sites I and 2.

Size of *Scutellaria* populations

As *Scutellaria* grows by creeping and rooting over the ground surface, the number of individual plants cannot be estimated without uprooting the plants. However, the total extent of *Scutellaria* populations can be estimated. In the Roding, Hackett, Maitai, and Tinline catchments, and sites on the Waimea Plains not shown in Table 1, *Scutellaria* is present as scattered occurrences of mostly low cover (Table 3), each occupying only a few square metres. There are probably more than 50 but less than 100 such patches in these catchments.

Better estimates are available of the populations in the Takaka catchment, where the isolated forest stands can be thoroughly searched. In site 7, *Scutellaria* occupies a single area of approximately 20 m^2 with a few shoots in an adjacent area of 1 m^2. At site 8 it occupies one area of approximately 70 m^2. Apart from these sites there are a few others several kilometres distant, including site 9, where there are scattered patches of a few m2 and with a few *Scutellaria* shoots.

Growth patterns

At site 2 during 1989 the mean height of *Scutellaria* increased between early spring and early summer and then declined as the shoots become less erect (Fig. 1). The pattern was similar in early 1990. Over the 28 month observation period there was a nett increase of 5-10% in *Scutellaria* frequency in all site 2 subplots (Fig. 2). This increase resulted entirely from the expansion of existing plants, and the only new plant to appear was a seedling in December 1991. At site 1 during the same period there was a 15-20% decline in *Scutellaria* frequency in the two undisturbed subplots and little change in the disturbed plots (Fig. 2).

During late December 1990 the height of *Scutellaria* at sites 7 and 8 in the Takaka Valley was 27.8 j: 9.6 cm and 24.0 j: 8.0 cm respectively. Plants here are twice as tall as those in the Roding and they also have substantially larger leaves.

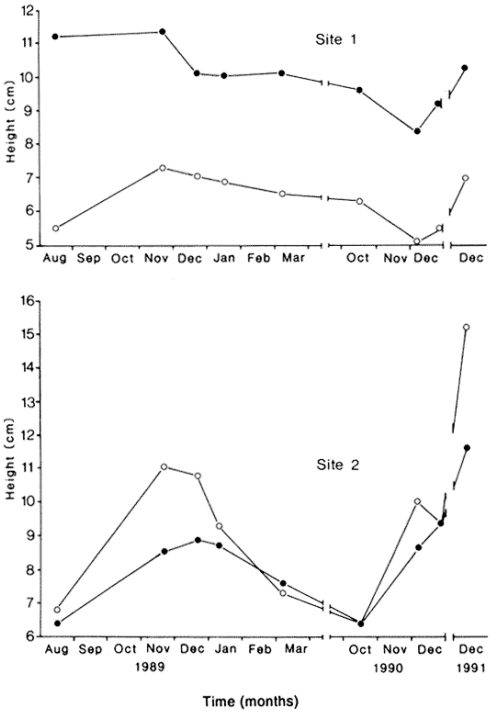

Figure 1: *Mean height of shoots of* Scutellaria novae-zelandiae *in two undisturbed subplots at sites 1 and* 2 *in the Roding catchment.*

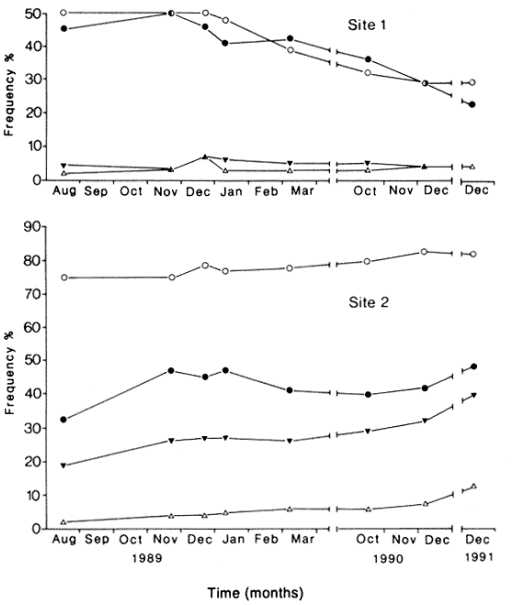

Figure 2: *Frequency of* Scutellaria novae-zelandiae *in two undisturbed (circles) and cleared (triangles) subplots at sites 1 and* 2 *in the Roding catchment.*

Phenology and seed production

In the Roding Valley (sites 1, 2) flower buds appeared in early November and flowers were present by mid December through until early January. Flowers are perfect and 95% of flowers at site 1 (n = 33) and 92% at site 2 (n = 48) produced capsules containing seeds. A few flowers appeared to have aborted, and capsules were occasionally attacked by unknown organisms. Capsules began to dehisce in late January or early February, and there were a few full capsules still present in April.

In both 1989 and 1990 fruiting stems were present in the undisturbed plots at sites 1 and 2 at frequencies of 2% and 18% of the squares respectively. In 1990 the sites had a similar number of capsules per stem, i.e., 3.6 ± 2.1 and 3.5 ± 1.4 respectively. The two undisturbed plots at sites I and 2 had an average of 5 and 57 capsules per m2 respectively.

The average number of seeds per capsule for both sites 1 and 2 was 3.6 ± 0.4 (n = 27), giving a seed production figure of 18 and 205 seeds per m^2 respectively.

At sites 7 and 8 in the Takaka Valley a total of 118 and 34 fruiting stems were recorded respectively, with 3.9 ± 1.6 capsules per stem. Total seed production per site would thus be of the order of 1700 and 500 seeds per site respectively.

Seed germination

Scutellaria seeds are 1.5 x 1.1 mm, weigh 0.5 mg, are brownish-yellow to very pale brown, and covered in a mamillated testa that is not readily broken. They float on water, but otherwise have no particular dispersal feature other than being thrown a short distance from the bursting capsules.

Three seedlings appeared in one tray 12 weeks after being sown, and two appeared in the other tray 2 weeks later. After 17 weeks a total of 11 seedlings had appeared from the 25 seeds.

Seed banks

Scutellaria seedlings appeared in soil from all sites (Table 4), but the size and composition of the seed banks varied widely between sites.

Site I had the largest seed bank, almost 3000 seeds per m^2, but there was only one *Scutellaria*. This seed

bank was dominated numerically by native species because of the large numbers of *Fuchsia excorticata* and two native herbs, *Cardamine debilis* and *Stellaria parviflora*.

Site 2 had the largest number (14) of *Scutellaria* seeds but otherwise the seed bank was dominated by adventive herbs, particularly *Agrostis capillaris, Mycelis muralis,* and *Trifolium repens*. There were also large numbers of the large native herb *Senecio minimus*. Of these four, only *M. muralis* was growing on the site and the others were 10-20 m away. Abundant C. *debilis* and *M. muralis* seedlings also appeared on the disturbed subplots at sites 1 and 2.

Site 3 also had only one *Scutellaria* seed, and was dominated by native species. *Mycelis muralis* was the most abundant adventive herb (Table 4).

Site 4 had the lowest number of seeds, but this included four *Scutellaria* seeds. Two grasses not recorded in the other sites were found here, *viz., Microlaena avenacea* and *Festuca arundinacea*. A large number of *Senecio minimus* seeds were also present. Of these three species, only *M. avenacea* was present at the site. *Scutellaria* emerged rapidly, and none appeared after 80 days (Fig. 3). Several large native and adventive herbs had a similar emergence rate to *Scutellaria,* with at least 50% emergence completed in 8 weeks or less, e.g., *Microlaena avenacea, Festuca arundinacea, Mycelis muralis,* and *Senecio minimus* (Table 4). The emergence rate of the other species was slower overall, apart from a burst of several hundred *Fuchsia excorticata* seeds at 90-100 days (Fig. 3).

Discussion

Sites occupied by *Scutellaria* are commonly on the margins of watercourses where the vegetation is periodically disturbed by flooding. Most other sites are within 50 m of running water on unstable steep toe slopes and rock outcrops. Only a few sites are on hill slopes well away from water. With the exception of the site at The Gorge Creek, *Scutellaria* grows in the shade of forest, either on the margins beneath overhanging branches or within the forest itself. Secondary vegetation such as *Kunzea ericoides* scrub appears unsuitable for *Scutellaria*.

Observations in the Roding catchment in the years following major floods of 1985 indicated that *Scutellaria* can exploit bare areas left by flooding, but it becomes suppressed when tall grasses and sedges recover from partial burial. Stable microsites with a vigorous growth of other species in the ground layer are therefore unsuitable for *Scutellaria*. This is demonstrated by the decline of *Scutellaria* at site 1, where the ground surface has stabilised after a minor slip, and its slight expansion at site 2, where the ground layer is less dense and which still receives sediment during winter freshets from the adjacent waterway. Once floodplain sites have recovered from flooding, *Scutellaria* becomes confined to microsites with thin, very freely drained soils, such as patches of coarse colluvium at the base of tall trees, perhaps because it is more drought-tolerant than many other herbs and ferns.

The increase in frequency of *Scutellaria* in the cleared plots at site 2 appeared to result entirely from the extension of existing plants. Notwithstanding the difficulty of positively identifying seedlings as opposed to rooted fragments, seedlings were rarely encountered in the wild, and only in association with bare mineral soil. This agrees with the ready germination of *Scutellaria* in a peat-sand mix and on gravel pathways adjacent to potted plants (M. Crawford, *pers. comm.),* but seedlings never having appeared near adult plants grown for years in clay soils (A. P. Druce, *pers. comm.)*.

The number of seeds per m2 and the total number of species reported here are similar to those found within a range of secondary vegetation near Christchurch (Partridge, 1989), and likewise they are predominantly ruderal or early successional species. The rarity of *Scutellaria* seedlings in the wild is not attributable to a lack of viable seed, which is produced abundantly whenever *Scutellaria* grows vigorously, e.g., sites 2, 6, 7. This seed germinated readily in the glasshouse, albeit rather slowly, and therefore some preconditioning may be necessary. As a result of an apparent element of dormancy, some seed becomes incorporated into the upper levels of the soil seed bank. The 14 seedlings from site 2 are equivalent to 112 per m2, which is about half the annual seed production of the site. Nothing is known of the length of time the

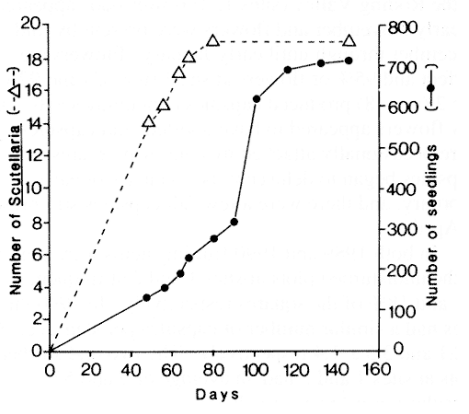

Figure 3: *Number of* Scutellaria novae-zelandiae *seedlings (triangles) and all other seedlings (circles) that emerged in the glasshouse from soil collected adjacent to* S. novae-zelandiae *plants.*

Table 4. *Number of seeds germinating from soil samples totalling 0.125m² after 132 days from 4 sites where* Scutellaria novae-zelandiae *is present.*
Weeks = No. of weeks for 50% of germinable seeds to appear.

Species	Site 1	Site 2	Site 3	Site 4	Weeks to 50%
Scutellaria novae-zelandiae	1	14	1	4	7
Agrostis capillaris		51			9
Anagallis arvensis				4	17
Aristotelia fruticosa	12	4	6	4	10
Berberis darwinii			2		15
Cardamine debilis	32	3	9	2	11
Carpodetus serratus	11	1	5	2	17
Cerastium fontanum		1		2	17
Coprosma robusta	6		2		8
C. *rotundifolia*				7	7
C. *robusta* x *propinqua*		1			-
Conyza bilbaoana	2	2	2	3	14
Corokia cotoneaster				2	-
Corybas sp.				1	-
Crepis capillaris	3	1	4	1	12
Digitalis purpurea			1	1	7
Epilobium billardiereanum				1	-
E. brunnescens				1	-
Epilobium sp.			1		-
Festuca arundinacea				2	7
Fuchsia excorticata	232	6	53		12
Gnaphalium involucratum			10		9
Hypochoeris radicata			2		8
Hydrocotyle moschata			5		11
Kunzea ericoides	1				-
Leycesteria formosa	3	3			15
Lotus pedunculatus			1	1	15
Medicago lupulina		1			-
Melicytus ramiflorus		1			-
Mentha pulegium		2	2	1	11
Microlaena avenacea				5	7
Muehlenheckia australis	4		2	1	7
Mycelius muralis	1	19	16	5	7
Parsonsia heterophylla		8	5		8
Pseudognaphalium luteoalbum	1	2	2		15
Pseudopanax arboreus	2			1	15
Ranunculus reflexus				6	11
Ribes uva-crispa	2	1	1		15
Rumex acetosella	4				7
Sagina procumbens		1			-
Senecio minimus		13	8		8
Sonchus oleraceus	4		1		11
Stellaria parviflora	41			4	7
Trifolium repens		7			10
Uncinia uncinata		4	3		7
Uncinia sp.			1		-
Total seeds per m²	2896	1168	1160	488	
No. of native species	11	11	15	14	
Native individuals (%)	94.7	41.0	77.9	63.6	
No. of adventive species	7	11	10	9	
Adventive individuals (%)	5.3	58.9	22.1	36.4	

seeds survive in the soil, but these ratios suggest a rather short life compared with some weeds, e.g., *Agrostis capillaris* and *Trifolium repens,* which may last for many years (e.g., Donelan and Thompson, 1980). Neither of these species is present in the low light environment of site 2 (Table 3), yet they are well represented in the seed bank. Furthermore, the size of the *Scutellaria* seed bank at site 2 is similar to several other species growing at the site, i.e., *Mycetis muratis* and *Cardamine debilis,* yet these latter species also produced abundant seedlings in the field.

Observations of seedling growth rates in the germination trays and in the smaller trays used to grow seedlings for identification suggest that *Scutellaria* would not survive the competition from the several adventive weeds, e.g., *Agrostis capillaris* and *Conyza bilbaoana,* that emerged with it. These observations agree with *Scutellaria* being most abundant on sites where there is insufficient light to support most weeds apart from *Mycetis muratis*. Such interactions between rare herbs and adventive weed species have seldom been documented in New Zealand (Williams and Timmins, 1990).

The dispersal modes and germination patterns of *Scutellaria* and its minimal colonisation of the bared plots helps explain its clumped distribution. Seeds are presumably dispersed for only short distances by the slightly explosive mechanism of the capsule, and then primarily by water, or by gravity on slopes. Seedlings establish only under rather precise conditions of free drainage in association with bare soil, and subsequent spread is likely to be primarily by vegetative means, particularly once a litter layer has accumulated above the mineral soil.

Many *Scutellaria* populations are grazed by sheep, goats, and cattle at varying intensities. The effect of heavy grazing is to reduce the plant to very low densities of small shoots, although whether such treatment actually kills plants was not determined. In forest sites with potentially dense ground and shrub layers, grazing of both layers may have indirectly benefited *Scutellaria* by increasing light penetration to the forest floor, e.g., sites 2, 7, 8. This applies particularly to sites invaded by *Acer pseudoplatanus* which produces abundant shade-tolerant seedlings, e.g., site 8.

The ecology and abundance of *Scutellaria* can be summarised within a framework defining the meaning of rarity in time and space outlined by Harper (1981). Overall the true abundance of *Scutellaria* must have declined severely since European settlement because of the widespread destruction of forests in the Nelson-Marlborough region, particularly those on alluvial soils (Park and Walls, 1978). In contrast, the perceived abundance has increased in the last decade through a better understanding of its distribution, although it is still known only from three main catchments. The rarity of *Scutellaria* within these catchments is not controlled by the size and number of potentially habitable forest areas, as these appear to be abundant. Dispersal and establishment at habitable sites appear to be limiting factors, and their carrying capacity appears to decline with time. Grazing by domestic and feral animals has possibly influenced the biomass of *Scutellaria,* but there is no clear evidence that it has influenced the number of sites occupied.

The conservation of *Scutellaria* needs to consider these limitations, particularly the requirement for suitably large area(s) to accommodate the spatial patterns of landscape instability that enable the establishment of new populations.

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