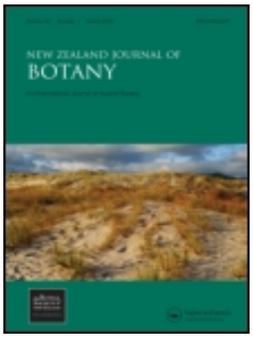

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Naturalised plants in south-west South Island, New Zealand

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Abstract Of 140 species of naturalised plants found at 58 sites between Haast and southern Fiordland 24 were deliberately planted and persist at their original sites, 51 are accidental introductions restricted to hut, settlement, and road sites, and 65 occur only at unmodified sites, especially coasts, lake edges, and valley floor grasslands. Those which most threaten native vegetation are gorse (*Ulex europaeus*), broom (*Cytisus scoparius*), crack willow (*Salix fragilis*), Canadian pondweed (*Elodea canadensis*), and marram grass (*Ammophila arenaria*). Control of naturalised plants particularly within Fiordland National Park is discussed.

Keywords naturalised plants; weeds; Fiordland National Park; conservation; ecology; weed control; distribution; south-west New Zealand

INTRODUCTION

The south-west South Island is the largest tract of land in New Zealand which has not been grossly modified. Rugged topography and high rainfall in the area have fostered the retention of the natural plant cover, mainly forest. Much of the area lies within Fiordland National Park, and one of the aims of documenting naturalised plants has been to give advice on control of weeds: the National Parks Act 1980 states that introduced flora shall as far as possible be exterminated. The study area extends beyond Fiordland National Park to include Waitutu State Forest in the south-east, and forested land as far north as Haast, thus complementing the florisic list of Wardle (1980).

These records were made between 1969 and 1979, mostly during studies on coastal and lake-shore vegetation. Voucher specimens of most species are deposited in the herbarium of Botany Division, DSIR (CHR). Some other records are also included, notably the collections of G. I. Collett from Puysegur Point in 1963.

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DISTRIBUTION AND HABITATS

Sites from which naturalised plants were recorded are shown in Fig. 1 and listed in Table 1, in order from north to south along the coast, then northwards again for inland sites. Table 2 shows the distribution of naturalised plants at the 58 sites.

In total 140 species were recorded. Of these 24 were probably deliberately planted, mostly in gardens, and have not spread far beyond their original sites. Another 51 species are accidental introductions restricted to hut sites, old settlements, roadsides, and airstrips. The remaining 65 occur at sites not directly disturbed by man.

Frequency values in Table 2 indicate the most widespread plants. Eight species occur at 30 or more sites: *Holcus lanatus* (42), *Poa annua* (37), *Cerastium fontanum* (36), *Cirsium vulgare* (35), *Anthoxanthum odoratum* (33), *Sagina procumbens* (33), *Trifolium repens* (32), and *Juncus articulatus* (30). Another 44 species occur at 10 or more sites; most of these species were recorded from several different habitats, both disturbed and undisturbed sites.

Of the 24 species which were obviously intentionally planted most occur at abandoned former settlements such as Cromarty, Te Oneroa, Martins Bay, and Big Bay, and have persisted locally but not spread. Included here are trees (*Cupressus macrocarpa*, *Ulmus* sp., *Rhododendron ponticum*, *Prunus* sp., *Crataegus monogyna*), shrubs (*Ribes uva-crispa*, *Rosa rubiginosa*, *Rubus idaeus*, *Sambucus nigra*), and garden herbs *Fragaria* × *ananassa*, *Lychnis flos-cuculi*, *Mentha spicata*, *Narcissus pseudonarcissus*, *Vinca major*, *Zantedeschia aethiopica*. A small colony of Cape pondweed (*Aponogeton distachyus*) occurs in one of the Hidden Lakes, west of Te Anau, and judging from its location at the end of a walking track, has been deliberately planted.

Five planted tree species have spread locally: *Acer pseudoplatanus* and *Eucalyptus* sp. at Martins Bay, *Pinus radiata* at Big Bay, *P. contorta* at Henry Creek, Lake Te Anau, and *Salix fragilis* around Lakes Te Anau and Manapouri. Four plants have spread from gardens at Milford: *Hypericum calycinum*, *Calystegia silvatica*, *Crocosmia* × *crocosmiflora*, and *Lupinus polyphyllus*; the latter is also well established in the Eglinton riverbed and on the eastern gravel shores of Lakes Te Anau and Manapouri.

Some naturalised species have not been deliberately planted at all of the sites where they occur,

e.g., *Digitalis purpurea, Malus domestica, Ammophila arenaria* (deliberately planted at Cascade River mouth).

Disturbed sites, such as roadsides, tracks, hut surrounds, and airstrips share many of the same species (e.g., most of those listed as occurring at 10 or more sites in Table 2). Some species are characteristic of particular habitats. Airstrips and roadsides provide a habitat where grasses and pasture herbs such as clovers are most frequently encountered. *Parentucellia viscosa* was recorded most often on airstrips, and *Achillea millefolium* and *Chrysanthemum leucanthemum* on roadsides. Compacted ground along tracks favours *Juncus bufonius, J. tenuis, Poa annua,* and *Carex ovalis.* Some common species are found primarily at hut sites where the naturalised flora is large (e.g., *Stellaria media, Rumex obtusifolius,* and *Solanum tuberosum*). Some less frequent species were recorded only at huts (e.g., *Avena fatua, Capsella bursa-pastoris*). The appearance of naturalised plants at hut sites can be rapid. Five months after construction of the hut near the Waitutu River mouth 3 species were established: *Juncus bufonius, Poa annua,* and *Sagina procumbens.* At the Deas Cove hut 11 species were evident 10 months after construction (Table 2).

Characteristic assemblages of naturalised species were found also in undisturbed habitats. On sand dunes the most common, in order of decreasing frequency are *Cerastium fontanum, Cirsium vulgare, Sagina procumbens, Ammophila arenaria, Holcus lanatus, Ulex europaeus, Stellaria media, Poa annua, Cirsium arvense, Hypochoeris radicata, Lotus pedunculatus, Rumex acetosella, Trifolium dubium,* and *Sonchus asper.* Species characteristic of lake edges include *Myosotis caespitosa, Prunella vulgaris, Juncus articulatus, J. effusus, Plantago major, Linum catharticum,* and *Centaurium erythraea.* The following are confined to wet ground near lakes and streams: *Callitriche stagnalis, Mimulus moschatus, M. guttatus, Nasturtium microphyllum, Ranunculus flammula, Alopecurus geniculatus,* and *Glyceria fluitans.* Three aquatic species were recorded in lakes: *Juncus bulbosus, Elodea canadensis,* and *Ranunculus* sp. aff. *fluitans. Plantago australis* is typically a plant of bouldery coastal sites. *Galium palustre* occurs within *Carex* swards both on the coast and on lake edges.

One rather unusual habitat — the hulk of "Stella" which lies in Northport, Chalky Inlet — has 5 species growing on her deck: *Poa annua, Cerastium fontanum, Anthoxanthum odoratum, Dactylis glomerata,* and *Epilobium ciliatum.* The last 3 were not recorded from any adjacent sites on land.

The following species were recorded from only single sites and are thus apparently distant from other populations: *Catapodium rigidum* (gravel

Fig. 1 Location map.

Table 1 Sites from which naturalised plants recorded.

Site No.	Location	Types of habitat
1	Haast area	gravel beach, edge of lakes, rivers, forest
2	Jackson Valley	roadside, valley flat grassland
3	Cascade River mouth	dune, airstrip, huts
4	Cascade Valley	valley flat grassland, riverbed
5	Barn Bay	dune
6	Big Bay	dune, gravel, beach, huts
7	Barrier River	valley flat grassland
8	Martins Bay	dune, huts, airstrip, lake edge
9	Kaipo River mouth	dune, airstrip, riverflat
10	Yates Point area	rock and gravel coast
11	Milford	road, airstrip, huts, hotel
12	Transit Beach	dune
13	Poison Bay	dune
14	Sutherland Sound	dune
15	Catseye Bay	dune
16	Looking Glass Bay	gravel beach
17	Two Thumb Bay	gravel beach
18	Neck Cove	sandy beach
19	Deas Cove	hut
20	The Gut, Secretary Id.	bay head near hut site
21	Deep Cove	roadside, huts, former construction site
22	Coal River	dune
23	Disappointment Cove	sand and gravel beach
24	Supper Cove	hut, gravel shore
25	Luncheon Cove	old house site
26	Northport	dune, deck of hulk 'Stella'
27	Chalky Island	dune
28	Southport	gravel beach, old sawmill site
29	Te Whara Beach	dune
30	Welcome Bay	sand beach
31	Tarawera Mine	old mine site
32	Cuttle Cove	rocky beach, old whaling site
33	Cording Islands	gravel beach
34	Te Oneroa	gravel beach, old settlement, hut
35	Cromarty	old settlement
36	Otagos Retreat	dune
37	Puysegur Point	lighthouse, houses, roadside, beach
38	Kiwi Burn	sand and gravel beach
39	Green Islets	sand and gravel beach
40	Big River Mouth	dune, riverbank
41	Waitutu River mouth	gravel beach, riverbank, hut
42	Wairaurahiri River mouth	gravel beach, riverbank, hut
43	Lake Hakapoua	lake shore, huts
44	Lake Poteriteri	lake shore, huts
45	Lake Hauroko	lake shore, huts
46	Lake Monowai	lake shore, huts
47	Lake Manapouri	lake shore, huts
48	Lake Te Anau	lake shore, huts
49	Lake Orbell	hut, lake shore
50	Wisely Hut	hut
51	Lake Hankinson	hut, lake shore
52	Eglinton Valley head	roadside, valley flat grassland
53	Lakes Fergus and Gunn	lake shore
54	Lake Lochie	lake shore
55	Howden Hut	hut
56	Hollyford Valley (below Marion corner)	roadside, airstrip
57	Upper Hollyford Valley	roadside
58	Cleddau Valley	roadside

Table 2 Distribution of naturalised plants at the 58 sites listed in Table 1. v = very abundant, a = abundant, f = frequent, o = occasional, r = rare, + = present (abundance not recorded). Mode of entry and spread of each species is indicated by: P = planted deliberately or garden escape, R = restricted to habitats disturbed by man, U = established on undisturbed sites.

	Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Number of species	37	20	41	24	17	43	7	71	26	28	45	1	6	6	3	5	6	7	11	2	39	6	7	5	1	13	2	18	11	6
Acer pseudoplatanus L.	sycamore	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Achillea millefolium L.	yarrow	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Agrostis stolonifera L.	creeping bent	f	–	o	–	–	o	–	r	–	o	–	–	–	r	–	–	–	–	–	–	o	–	–	–	–	o	–	–	–	r
A. tenuis Sibth.	browntop	f	+	o	r	–	f	–	f	o	–	+	–	–	–	–	–	–	o	–	–	o	–	–	–	o	–	–	–	–	–
Aira caryophyllea L.	silvery hair grass	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	r	–
A. praecox L.	early hair grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alopecurus geniculatus L.	kneed foxtail	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ammophila arenaria (L.) Link	marram grass	–	–	o	–	–	r	–	o	–	–	–	o	–	–	–	–	–	r	–	–	–	a	–	–	–	–	o	–	r	–
Anagallis arvensis L.	scarlet pimpernell	f	–	o	–	–	–	–	r	f	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Anthoxanthum odoratum L.	sweet vernal	o	+	o	r	–	v	+	v	o	–	+	–	o	–	–	–	–	–	–	r	o	–	r	–	–	o	–	–	–	–
Aponogeton distachyus Linn. f.	Cape pondweed	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Avena fatua L.	wild oat	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
Bellis perennis L.	daisy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bromus diandrus Roth	ripgut brome	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–
B. mollis L.	bromus mollis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Callitriche stagnalis Scop.	Starwort	–	–	–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Calystegia silvatica (Kit.) Griseb.	greater bindweed	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Capsella bursa-pastoris (L.) Medic.	shepherd's purse	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cardamine hirsuta L.	bitter cress	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
C. pratensis L.	cuckoo cress	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carduus pycnocephalus L.	slender winged thistle	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carex demissa Hornem.	carex demissa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. ovalis Good.	oval sedge	o	–	–	–	–	f	–	o	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Catapodium rigidum (L.) C. E. Hubbard	hard grass	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centaurium erythraea Rafn.	centaury	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cerastium fontanum Baumg. ssp. *triviale* (Link) Jalas	mouse-ear chickweed	r	+	o	o	o	f	–	f	f	o	+	–	o	o	o	f	f	–	–	–	o	–	r	–	–	f	–	–	o	o
C. glomeratum Thuill.	annual mouse-ear chickweed	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	o	–	–	–	–
Chenopodium album L.	fathen	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chrysanthemum leucanthemum L.	oxeye daisy	o	–	–	–	–	o	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cirsium arvense (L.) Scop.	Californian thistle	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	o	–	r	–	–	–	–	o	f	–
C. vulgare (Savi) Ten.	Scotch thistle	–	+	o	r	o	o	–	o	o	f	+	–	–	–	–	–	o	–	–	–	o	r	–	–	–	r	–	o	f	o
Crataegus monogyna Jacq.	hawthorn	r	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Crepis capillaris (L.) Wallr.	hawksbeard	a	–	–	–	–	f	–	f	–	–	–	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–
Crocosmia × *crocosmiflora* (Nicholson) N.E. Brown	montbretia	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cupressus macrocarpa Hartweg	macrocarpa	–	–	–	–	–	o	–	o	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cynosurus cristatus L.	crested dogstail	–	–	–	–	–	r	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyperus eragrostis Lam.	cyperus eragrostis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Cytisus scoparius (L.) Link	broom	o	–	–	–	–	–	–	a	–	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Dactylis glomerata L.	cocksfoot	–	–	o	r	–	f	–	f	o	–	+	–	–	–	–	–	–	–	r	–	r	–	–	–	–	f	–	–	–	r
Digitalis purpurea L.	foxglove	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–
Elodea canadensis Michaux.	Canadian pondweed	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 2 continued

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	site frequency	mode of entry
	1	2	2	20	28	9	47	5	9	9	15	27	24	28	34	46	55	58	9	8	11	31	7	21	23	57	33	26		
Acer pseudoplatanus L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Achillea millefolium L.	–	–	–	–	–	–	–	–	–	–	–	o	–	r	+	–	–	–	–	–	–	+	–	–	–	o	+	+	9	R
Agrostis stolonifera L.	–	–	–	–	o	–	–	–	–	–	o	–	r	–	+	–	+	+	–	–	r	–	–	+	–	–	–	+	18	U
A. tenuis Sibth.	–	–	–	a	o	r	o	–	–	o	–	o	–	r	+	+	+	+	+	+	–	+	–	–	–	a	+	+	28	U
Aira caryophyllea L.	–	–	–	r	–	–	o	–	–	–	–	r	r	–	–	+	+	+	–	–	–	–	–	–	–	o	–	–	11	U
A. praecox L.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Alopecurus geniculatus L.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	2	R
Ammophila arenaria (L.) Link	–	–	–	–	–	–	–	–	r	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	U
Anagallis arvensis L.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	U
Anthoxanthum odoratum L.	–	–	–	r	a	–	f	–	–	–	–	o	o	o	+	+	+	+	+	+	o	+	+	–	+	a	+	+	33	U
Aponogeton distachyus Linn. f.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	1	P
Avena fatua L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Bellis perennis L.	–	–	–	–	–	–	a	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	2	R
Bromus diandrus Roth	–	–	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	R
B. mollis L.	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Callitriche stagnalis Scop.	–	–	–	–	–	–	–	–	–	–	–	r	o	–	–	+	+	+	–	–	–	–	–	–	–	r	–	–	8	U
Calystegia silvatica (Kit.) Griseb.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	2	R
Capsella bursa-pastoris (L.) Medic.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	2	R
Cardamine hirsuta L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	U
C. pratensis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	1	U
Carduus pycnocephalus L.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Carex demissa Hornem.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	1	U
C. ovalis Good.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	–	+	–	o	–	+	10	R
Catapodium rigidum (L.) C. E. Hubbard	–	–	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	U
Centaurium erythraea Rafn.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	3	U
Cerastium fontanum Baumg. ssp. *triviale* (Link) Jalas	–	–	–	r	–	–	–	f	o	–	o	a	o	o	+	+	+	+	+	–	o	+	–	–	–	f	+	–	36	U
C. glomeratum Thuill.	–	–	–	–	o	r	f	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	7	U
Chenopodium album L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Chrysanthemum leucanthemum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	+	–	5	R
Cirsium arvense (L.) Scop.	–	–	–	–	–	–	–	f	o	o	o	f	o	–	+	+	+	+	–	–	–	+	–	+	+	r	+	–	20	U
C. vulgare (Savi) Ten.	–	r	f	–	o	r	o	o	o	f	o	f	o	f	+	+	+	+	–	–	–	+	–	–	–	r	+	–	35	U
Crataegus monogyna Jacq.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	P
Crepis capillaris (L.) Wallr.	–	–	–	–	–	–	–	–	–	–	–	o	–	r	–	+	+	–	–	–	–	–	–	–	–	a	–	–	9	U
Crocosmia × *crocosmiflora* (Nicholson) N.E. Brown	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	3	P
Cupressus macrocarpa Hartweg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	P
Cynosurus cristatus L.	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–	–	o	–	–	7	R
Cyperus eragrostis Lam.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Cytisus scoparius (L.) Link	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	+	–	–	r	–	+	10	U
Dactylis glomerata L.	–	–	–	–	–	–	o	–	–	–	–	o	r	o	+	+	+	+	+	+	–	+	–	–	+	o	+	–	24	U
Digitalis purpurea L.	–	–	–	a	o	r	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–	+	–	+	+	r	+	+	13	U
Elodea canadensis Michaux.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	2	U

Table 2 continued

		Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Epilobium ciliatum Raf.	tall willowherb		–	–	–	–	–	–	–	o	–	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	r	–	–	–	–
Erigeron canadensis L.	Canadian fleabane		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Eucalyptus sp.	eucalyptus		–	–	–	–	–	–	–	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Festuca arundinacea Schreb.	tall fescue		r	–	f	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–
F. rubra L. var. *commutata* Gaud.	Chewings fescue		–	+	–	–	–	o	–	o	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fragaria × *ananassa* Duchesne	strawberry		–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galium palustre L.	marsh bedstraw		o	–	f	–	–	–	–	–	–	r	–	–	–	–	–	f	r	–	–	–	–	o	o	–	–	–	–	–	–	–
Glyceria fluitans (L.) R. Br.	floating sweet grass		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gnaphalium spicatum Lam.	cudweed		–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Holcus lanatus L.	Yorkshire fog		o	+	o	f	f	v	+	v	a	r	+	–	–	o	–	–	–	a	o	r	a	r	r	v	–	o	–	o	f	–
H. mollis L.	creeping fog		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hordeum murinum L.	barley grass		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hypericum androsaemum L.	tutsan		r	+	o	–	r	o	–	o	o	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
H. calycinum L.	rose of Sharon		–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
H. pulchrum L.	slender St. John's wort		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hypochoeris radicata L.	catsear		–	+	o	f	o	v	+	v	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	–	–
Juncus articulatus L.	jointed rush		f	+	o	o	o	o	–	o	f	o	+	–	r	–	–	r	–	–	–	–	a	–	–	–	–	o	–	o	–	–
J. bufonius L.	toad rush		f	–	o	r	r	o	–	o	o	o	–	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	a	–	–
J. bulbosus L.	bulbous rush		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
J. effusus L.	soft rush		–	+	o	o	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	v	–	–	–	–	–	–	o	–	–
J. tenuis Willd.	juncus tenuis		f	+	o	r	–	o	–	o	–	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Leontodon taraxacoides (Vill.) Mérat	hawkbit		f	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	v	–	–	–	–
Lepidium desvauxii Thell.	bushy peppercress		–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Leycesteria formosa Wall.	Himalaya honeysuckle		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Linum catharticum L.	purging flax		–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lolium perenne L.	perennial ryegrass		–	–	o	–	–	r	–	r	r	–	–	–	–	–	r	–	–	–	o	–	r	–	–	–	–	–	–	–	–	–
Lotus pedunculatus Cav.	lotus		f	+	f	f	a	a	+	f	–	r	–	–	o	–	–	–	–	–	–	–	o	–	–	–	–	–	–	r	–	–
Lupinus polyphyllus Lindl. hybrids	Russel lupin		–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Luzula congesta (Thuill.) Lej.	woodrush		–	–	–	–	–	f	–	a	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Lychnis flos-cuculi L.	ragged robin		–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Malus domestica Borkh.	apple		–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Matricaria matricarioides (Less.) Port.	rayless chamomile		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mentha spicata L.	spearmint		–	–	o	–	–	r	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–
Mimulus guttatus DC.	monkey musk		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. moschatus Lindl.	musk		–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mycelis muralis (L.) Dum.	wall lettuce		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Myosotis caespitosa K.F. Schultz	water forget-me-not		o	–	r	–	–	–	–	o	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Narcissus pseudonarcissus L.	daffodil		–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nasturtium microphyllum (Boenn.) Reichenb.	water cress		–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Navarettia squarrosa (Esch.) Hook. et Arn.	Californian stinkweed		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 2 continued

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	site frequency	mode of entry
Epilobium ciliatum Raf.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	–	–	–	+	–	+	–	o	+	–	12	U
Erigeron canadensis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Eucalyptus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Festuca arundinacea Schreb.	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	+	–	–	–	–	–	–	+	–	–	–	7	U
F. rubra L. var. *commutata* Gaud.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	a	–	–	6	R
Fragaria × *ananassa* Duchesne	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	P
Galium palustre L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	10	U
Glyceria fluitans (L.) R. Br.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	2	U
Gnaphalium spicatum Lam.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	2	R
Holcus lanatus L.	r	–	–	r	o	–	a	–	–	–	–	r	–	o	+	+	+	+	+	+	o	+	+	+	+	a	+	+	42	U
H. mollis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	1	R
Hordeum murinum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Hypericum androsaemum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	9	U
H. calycinum L.	–	–	–	r	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	P
H. pulchrum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	+	–	–	–	–	+	–	4	R
Hypochoeris radicata L.	–	–	–	a	o	v	v	–	–	o	o	–	–	f	+	+	+	+	–	–	o	+	–	–	+	a	+	+	26	U
Juncus articulatus L.	–	–	–	–	f	–	f	–	–	–	o	r	o	r	+	+	+	+	–	–	–	–	+	+	+	f	–	+	30	U
J. bufonius L.	–	–	–	r	f	–	a	–	–	–	o	r	r	–	–	–	+	+	–	–	–	–	–	–	–	o	–	–	19	U
J. bulbosus L.	–	–	–	–	–	–	–	–	–	–	r	–	–	f	–	–	+	–	+	–	–	–	–	–	–	o	–	–	5	U
J. effusus L.	–	–	–	–	o	–	f	–	–	–	–	o	–	r	+	+	+	+	–	–	–	–	–	–	–	–	+	+	16	U
J. tenuis Willd.	–	–	–	–	–	–	–	–	–	–	r	–	–	–	+	+	+	+	–	–	o	–	–	+	–	f	+	+	18	U
Leontodon taraxacoides (Vill.) Mérat	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	U
Lepidium desvauxii Thell.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	U
Leycesteria formosa Wall.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	1	U
Linum catharticum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	3	U
Lolium perenne L.	–	–	–	–	r	–	o	–	–	–	–	r	–	o	+	+	–	–	–	–	–	–	–	–	–	–	–	–	13	R
Lotus pedunculatus Cav.	–	–	–	a	o	–	o	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	–	+	–	a	+	+	22	U
Lupinus polyphyllus Lindl. hybrids	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	–	–	–	–	+	–	5	R
Luzula congesta (Thuill.) Lej.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	f	–	–	5	R
Lychnis flos-cuculi L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Malus domestica Borkh.	–	–	–	r	r	–	–	–	–	–	–	–	–	r	–	+	–	+	–	–	–	+	–	–	+	r	+	+	12	R
Matricaria matricarioides (Less.) Port.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	–	–	1	R
Mentha spicata L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	r	–	–	7	P
Mimulus guttatus DC.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	2	U
M. moschatus Lindl.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	r	–	–	+	+	+	–	–	7	U
Mycelis muralis (L.) Dum.	–	–	–	–	–	–	–	–	–	–	–	–	–	r	o	–	+	–	–	–	–	–	–	–	–	–	–	–	3	R
Myosotis caespitosa K.F. Schultz	–	–	–	–	–	–	–	–	–	–	–	–	o	o	+	+	+	+	–	–	o	–	+	+	+	r	–	–	15	U
Narcissus pseudonarcissus L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Nasturtium microphyllum (Boenn.) Reichenb.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	3	U
Navarettia squarrosa (Esch.) Hook. et Arn.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	1	R

Table 2 continued

		Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Oxalis tuberosa Mol.	oca ("yam")		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Parentucellia viscosa (L.) Caruel	tarweed		–	+	r	–	r	–	+	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phleum pratense L.	timothy		–	–	–	–	–	–	–	r	–	–	+	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
Pinus contorta Dougl. var. *latifolia* Engelm.	lodgepole pine		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. radiata D. Don	radiata pine		–	–	–	–	–	o	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Plantago australis Lam.	swamp plantain		o	–	o	–	o	f	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. lanceolata L.	narrow-leaved plantain		–	+	o	–	–	f	–	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. major L.	broad-leaved plantain		o	–	o	r	–	o	–	r	–	–	+	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	a	–	–
Poa annua L.	poa annua		o	–	o	r	–	r	–	o	r	f	+	–	–	–	–	o	o	–	o	–	f	–	–	r	–	r	–	a	–	–
P. pratensis L.	poa pratensis		–	–	–	–	–	o	–	o	o	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polygonum hydropiper L.	water-pepper		o	–	r	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. persicaria L.	willow weed		–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	r	–	o	–	–	–	–	–	–	–	–	–
Prunella vulgaris L.	selfheal		f	+	r	r	o	f	–	o	f	r	+	–	–	–	–	–	–	r	–	–	o	–	–	–	–	–	–	o	–	–
Prunus sp.			–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ranunculus acris L.	giant buttercup		–	–	–	–	–	f	–	v	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. flammula L.	spearwort		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. sp. aff. *fluitans* Lam.	water buttercup		–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. parviflorus L.	small-flowered buttercup		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. repens L.	creeping buttercup		–	+	r	–	–	–	–	f	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhododendron ponticum L.	rhododendron		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ribes uva-crispa L.	gooseberry		–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rosa rubiginosa L.	sweet brier		–	–	–	–	–	–	–	r	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rubus fruticosus L. agg.	blackberry		o	–	o	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. idaeus L.	raspberry		–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex acetosella L.	sheep's sorrel		f	+	o	o	o	f	–	f	o	r	+	–	–	–	–	–	–	–	r	–	o	–	–	–	–	–	–	–	–	r
R. conglomeratus Murr.	clustered dock		–	–	o	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. crispus L.	curled dock		r	–	–	–	–	o	–	o	–	o	–	–	–	r	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–
R. obtusifolius L.	broad-leaved dock		–	–	o	r	–	–	–	r	–	o	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Sagina procumbens L.	pearlwort		f	–	o	o	f	r	–	f	r	a	+	–	–	–	–	–	–	a	–	–	a	–	–	–	–	r	–	a	r	f
Salix fragilis L.	crack willow		–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sambucus nigra L.	elderberry		–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Senecio cf. *aquaticus* Hill	marsh ragwort		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. jacobea L.	ragwort		–	–	–	–	–	a	–	v	a	–	+	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	r	–
S. sylvaticus L.	wood groundsel		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum L.	black nightshade		o	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tuberosum L.	potato		–	–	o	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	f	–	–	–	–	–	–
Sonchus asper (L.) Hill	prickly sow thistle		–	–	o	–	f	–	–	o	–	o	+	–	–	–	–	–	–	–	–	–	o	o	–	–	–	–	–	–	–	–
S. oleraceus L.	sow thistle		o	–	–	r	–	–	–	r	–	–	+	–	–	–	–	–	o	–	–	–	o	–	o	–	–	–	r	–	–	–
Sorbus aucuparia L.	rowan		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spergula arvensis L.	spurrey		o	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spergularia rubra (L.) Presl	sand spurrey		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stellaria alsine Grimm	bog stitchwort		–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. graminea L.	stitchwort		–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. media (L.) Vill.	chickweed		o	–	o	–	r	–	–	r	–	f	+	–	–	–	–	–	–	–	–	–	–	–	–	v	–	r	–	r	r	–

Table 2 continued

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	site frequency	mode of entry
Oxalis tuberosa Mol.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	1	R
Parentucellia viscosa (L.) Caruel	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	f	–	–	7	R
Phleum pratense L.	–	–	–	–	–	–	r	–	–	–	–	r	–	–	–	+	–	+	–	+	–	+	–	–	–	+	+	–	11	R
Pinus contorta Dougl. var. *latifolia* Engelm.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	1	P
P. radiata D. Don	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	P
Plantago australis Lam.	–	–	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	U
P. lanceolata L.	–	–	–	–	–	–	f	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	7	R
P. major L.	–	–	–	o	r	–	o	–	–	–	–	r	o	o	+	+	+	+	–	–	–	+	–	–	+	o	+	–	22	U
Poa annua L.	–	–	–	–	f	–	f	o	o	o	o	o	o	o	+	+	+	+	+	+	o	+	–	+	+	f	+	+	37	U
P. pratensis L.	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	+	+	o	–	–	8	U
Polygonum hydropiper L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	R
P. persicaria L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	4	U
Prunella vulgaris L.	–	–	–	r	r	–	f	–	–	–	–	r	–	–	+	+	+	+	–	–	–	+	–	+	–	o	+	–	25	U
Prunus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	2	P
Ranunculus acris L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	R
R. flammula L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	3	U
R. sp. aff. *fluitans* Lam.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	2	U
R. parviflorus L.	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
R. repens L.	–	–	–	–	r	–	r	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	o	–	+	9	R
Rhododendron ponticum L.	–	–	–	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Ribes uva-crispa L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Rosa rubiginosa L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–	4	P
Rubus fruticosus L. agg.	–	–	–	–	f	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	+	8	R
R. idaeus L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Rumex acetosella L.	–	–	–	f	o	f	a	–	–	–	o	–	–	r	+	+	+	+	–	–	r	–	–	+	–	f	+	–	27	U
R. conglomeratus Murr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	U
R. crispus L.	–	–	–	f	r	–	o	–	–	–	–	–	r	–	+	+	+	+	–	–	–	+	–	+	–	r	–	–	18	U
R. obtusifolius L.	–	–	–	–	–	–	–	–	–	–	–	–	r	–	+	+	+	+	–	–	–	+	–	+	+	f	+	+	17	R
Sagina procumbens L.	–	–	–	o	a	o	f	o	o	o	o	a	f	o	+	+	+	+	–	–	–	–	–	+	–	o	–	+	33	U
Salix fragilis L.	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	4	P
Sambucus nigra L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	2	P
Senecio cf. *aquaticus* Hill	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	1	R
S. jacobea L.	–	–	–	–	–	–	a	–	–	–	–	v	r	–	+	+	–	+	–	–	–	+	–	+	–	a	+	+	17	U
S. sylvaticus L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	–	–	2	R
Solanum nigrum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	R
S. tuberosum L.	–	–	–	–	–	–	r	–	–	–	–	r	o	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	10	R
Sonchus asper (L.) Hill	–	–	–	–	–	–	–	–	–	o	–	–	o	o	+	+	+	–	–	–	–	+	–	–	–	r	+	–	16	U
S. oleraceus L.	–	–	–	r	–	–	o	–	r	–	–	–	–	–	+	+	+	+	–	–	–	–	–	–	–	+	+	–	17	U
Sorbus aucuparia L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	1	R
Spergula arvensis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	R
Spergularia rubra (L.) Presl	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	–	–	1	R
Stellaria alsine Grimm	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	+	–	r	–	–	5	U
S. graminea L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	2	U
S. media (L.) Vill.	–	–	–	–	–	–	f	–	r	o	r	o	o	r	+	+	+	+	–	–	–	+	–	–	+	–	–	–	23	R

Table 2 continued

	Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Taraxacum officinale Weber	dandelion	–	–	–	–	–	–	–	r	–	o	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Teline monspessulana (L.) Koch	Montpellier broom	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trifolium dubium Sibth.	suckling clover	–	–	–	r	–	v	+	f	a	o	+	–	–	a	–	–	–	–	–	–	o	–	–	–	–	–	–	–	r	–
T. pratense L.	red clover	–	–	–	–	–	–	–	r	–	–	+	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–	–	–	–	–
T. repens L.	white clover	o	+	o	o	o	v	+	f	o	o	+	–	–	–	–	–	–	–	r	–	f	–	–	–	–	–	–	f	–	–
T. subterraneum L.	subterranean clover	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ulex europaeus L.	gorse	a	–	r	–	r	v	–	r	r	r	+	–	r	r	r	r	r	f	–	–	–	r	r	–	–	–	–	–	–	–
Ulmus sp.	elm	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Veronica agrestis L.	field speedwell	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–
V. arvensis L.	wall speedwell	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
V. serpyllifolia L.	turf speedwell	o	+	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–
Vicia sativa L.	vetch	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vinca major L.	periwinkle	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vulpia bromoides (L.) S.F. Gray	vulpia hair grass	–	–	–	r	–	r	–	o	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zantedeschia aethiopica (L.) Sprengel	arum lily	–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 2 continued

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	site frequency	mode of entry
Taraxacum officinale Weber	–	–	–	f	o	–	o	–	–	–	–	–	–	r	–	+	–	+	–	–	–	–	–	–	+	r	+	–	12	R
Teline monspessulana (L.) Koch	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Trifolium dubium Sibth.	–	–	–	–	o	–	f	–	–	–	r	r	–	r	–	+	+	+	–	–	–	+	–	–	–	a	+	+	22	U
T. pratense L.	–	–	–	–	–	–	–	–	–	–	–	r	–	r	–	–	–	+	–	–	–	–	–	+	+	o	+	–	10	R
T. repens L.	–	–	–	o	–	f	f	–	–	–	o	r	o	o	+	+	+	+	+	–	o	+	–	–	+	f	+	+	32	U
T. subterraneum L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	1	R
Ulex europaeus L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	r	–	–	19	U
Ulmus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Veronica agrestis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	R
V. arvensis L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	+	r	–	–	4	R
V. serpyllifolia L.	–	–	–	r	–	–	o	–	–	–	–	–	–	–	+	–	+	+	–	–	–	–	–	–	+	–	–	–	10	U
Vicia sativa L.	–	r	–	–	r	–	o	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	U
Vinca major L.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	P
Vulpia bromoides (L.) S.F. Gray	–	–	–	–	–	o	f	–	o	–	–	f	o	r	–	–	–	–	–	–	–	–	–	–	–	o	–	–	11	U
Zantedeschia aethiopica (L.) Sprengel	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	P

beach, Cording Islands), *Erigeron canadensis*, and *Cyperus eragrostis* (both at Deep Cove), and *Lepidium desvauxii* (gravel beach, Yates Point). This last is an Australian species only recently recorded in New Zealand (Garnock-Jones 1979).

Sites where I have studied vegetation but recorded no naturalised plants are Bligh Sound head (estuary and river mouth), Pandora River mouth in Thomson sound (sandy beach), Pigeon Island in Dusky Sound (R. Henry's old house site), and sites at and above treeline in Sinbad Gully (Johnson 1976), Tutoko Valley (near Milford), and near Marrington Peaks, Doubtful Sound.

Naturalised plants recorded by National Park staff, at sites additional to those in Table 2 are: *Ulex europaeus* at Arthur River and Harrisons Cove (both Milford Sound), George River mouth (George Sound), Heel Cove Creek (Nancy Sound), Cooper Island (Dusky Sound); *Rubus fruticosus* at Arthur Valley and Clinton Valley; *Cerastium fontanum* at Murcat Burn, Dore Pass (P. Dorizac, CHR 182582).

DISCUSSION

Other published records of naturalised plants within the study area are few. Poole (1951) listed 10 species from George and Caswell Sounds and Hankinson hut. Of the 5 species recorded from this hut, 2 (*Dactylis glomerata* and *Prunella vulgaris*) were not seen by me in 1974, but 4 additional species were present. Given (1973) listed *Poa annua, Cerastium fontanum, Cirsium arvense*, and *Sonchus asper* from Dusky Sound and Wet Jacket Arm, all but the *Poa* occurring away from huts, tracks or coast. Naturalised plants are absent from plant lists for Secretary Island (Wardle & Mark 1970), West Cape (Wardle et al. 1973), and Lake Shirley, near Caswell Sound (Given 1971).

As noted by Given (1973) tracks and huts must be regarded as points of entry for invading species. To these can be added roads, settlements, and construction works. It is also obvious that many invaders have arrived unaided, spreading via the sea, lakes, and rivers, to become established in unmodified but open coastal and lacustrine habitats. Few exotic species are able to invade closed native communities. Forest covers most of Fiordland and is essentially weed-free; the only species seen persisting under a forest canopy were *Hypericum androsaemum* and *Mycelis muralis*. Fresh slips within forest are sometimes colonised by *Cirsium vulgare*, dispersed by wind-blown seed. Tussock grasslands above treeline are also virtually free of naturalised plants, though most valley-floor grasslands at low altitude are modified. Valleys such as the Cascade, Jackson, Pyke, and Eglinton have flats on which grasses (*Anthoxanthum odoratum, Holcus lanatus, Dactylis glomerata*, and *Agrostis tenuis*) and herbs (*Trifolium repens, Lotus pedunculatus*, and *Hypochoeris radicata*) are now abundant. The Eglinton Valley grasslands, although within Fiordland National Park, are still leased for sheep grazing, and harvested annually for *Agrostis tenuis* seed. Gravel riverbanks also in the Eglinton Valley have large and colourful stands of *Lupinus polyphyllus*.

Lowland scrub, especially when seral, is liable to harbour scrub weeds. Thus, periodically burned fern/scrubland of bracken (*Pteridium esculentum*) and manuka (*Leptospermum scoparium*) east of Lake Te Anau contains *Cytisus scoparius, Ulex europaeus, Pinus contorta*, and *Leycesteria formosa*.

It is herbaceous plant communities of coastal beaches, dunes, and lowland lake shores which are most subject to invasion. These communities are regularly disturbed by wind, waves, or storm, resulting in bared surfaces on which new arrivals can establish in competition with native plants.

Despite the general aim of extermination of introduced flora and fauna from National Parks, this is not practicable for many species. For some aliens e.g., the *Rhododendron ponticum* which survives in what was once the hotel garden at Cromarty, historical interest outweighs nuisance value. Attempts to exterminate many of the widespread herbaceous weeds could actually result in increased modification of the native vegetation. Certain plants are problematical where they show an ability to usurp native vegetation. Among the most agressive weeds are gorse, broom, crack willow, Canadian pondweed, and marram grass.

Ulex europaeus (gorse) has been recorded widely from disturbed sites and has established itself from water-carried propagules along the sea-coast, lake margins, and river edges. It is particularly extensive at Big Bay behind the beach. Being a well-known agricultural weed, colourful and disagreeably thorny, gorse has received prompt despatch by spraying or hand pulling within Fiordland National Park. With the erection of a control dam on the Waiau River downstream of Lake Manapouri, the Mararoa River plus its load of weed seeds during floods has been diverted into Lake Manapouri. Gorse has been a major component of floating flood debris samples. New Zealand Electricity staff who collected samples had observed that gorse seed sinks when placed in water and my own tests confirm this. Thus gorse that has dispersed via lakes or sea must have had its seeds enclosed within pods, and perhaps also attached to stem fragments. To minimise introduction of weeds into the Lake Manapouri area the discoloured flood waters of the Mararoa are now spilled through the dam and down the Waiau River.

Cytisus scoparius (broom) is less widespread than gorse and has established more along roadsides than waterways. It is most abundant in dry scrublands east of Lake Te Anau.

Salix fragilis (crack willow) grows at a few sites around Lakes Te Anau and Manapouri (Johnson 1972). It is able to grow both taller and closer to the water than native woody plants, thus ousting native herbaceous communities by shading and by competition from the extensive fibrous root system. Establishment of willows at new sites around the lakes was once prevented by red deer browsing, but with marked reductions in deer numbers 10–15 years ago, willow cuttings began to survive in more places. Now, Fiordland National Park staff are working towards extermination of willows by felling, burning, and poisoning and some former stands, like that on Buncrana Island in Lake Manapouri are now eradicated.

Elodea canadensis (Canadian pondweed) is well established in Lake Manapouri from where it was first collected in 1959 (Mason 1960). It forms luxuriant growths in Lake Monowai, where it grows partly on the old forest soils that were submerged when the lake level was raised by 3.5 m for hydro-electric purposes in 1925. The ability of *Elodea* to increase rapidly yet unobserved in New Zealand lakes has been documented (e.g., Brown 1979) and it is likely that this weed will appear in other southern waterways. No control has been attempted in Fiordland.

Ammophila arenaria (marram grass) has been extensively planted in New Zealand to stabilise sand dunes. It dominates dunes in eastern South Island, having in many instances ousted the native sand binders. Marram grass has established on 10 dune systems in the south-west and displays the same propensity to displace native dune plants. Colonisation is in the initial phases only, the largest infestations being to Coal River and Martins Bay. A programme to eradicate marram has been initiated within Fiordland National Park.

Other locally troublesome weeds which are regularly controlled in Fiordland National Park tend to be either prickly (*Rosa rubiginosa* and *Cirsium* spp.) or colourful in flower (*Hypericum androsaemum, Crocosmia* × *crocosmiflora, Lupinus polyphyllus*, and *Digitalis purpurea*. These latter plants are a feature for tourists on the Milford highway, yet ironically this same colour, by contrasting with the sombre native vegetation, results in a conflict with National Park values and motivates control of these weeds by Park staff.

Compared with the 140 naturalised species found in this study area, wet and mountainous areas to the north have totals recorded as follows (shared species are in brackets): Mount Cook National Park (Wilson 1976) 137 (73); Mount Aspiring National Park (Mark 1977) 23 (22); Westland between Taramakau and Haast Rivers (Wardle 1975, 1980) 160 (89).

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