Response of broom (*Cytisus scoparius*) to control measures

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Abstract

Patches of broom (*Cytisus scoparius*) within an area of tussock land (*Chionochloa flavescens*) were killed with herbicide, and the canopy cover and broom seed bank (0–10 cm) were monitored for four years. The dead broom was replaced by grasses, mainly sweet vernal (*Anthoxanthum odoratum*) and browntop (*Agrostis capillaris*). There was an average of 3300 broom seeds per square metre in the seed bank. Highest broom seed numbers were recorded under patches of dead broom and grass swards, and lowest numbers under tall tussocks and litter. There was no measurable decline in seed density over four years despite the emergence of seedlings after spraying. Seedling growth was slowed by the browsing of hares (*Lepus europaeus*).

Keywords: broom, *Cytisus scoparius*, seed banks, weeds.

1. Introduction

Broom (*Cytisus scoparius* (L.) Link) is a globally invasive European shrub, e.g., in Australia (Waterhouse 1988), North America (Bossard 1991), India (Agrawal *et al*. 1961), and Japan (Nemoto *et al*. 1993). It is widely distributed in New Zealand (Webb *et al*. 1988), especially in montane North Island and eastern South Island areas, where it is still spreading on to conservation and pastoral land (Williams 1981; Bascand & Jowett 1982).

Broom is often sprayed with herbicide, but it has a large and persistent soil seed bank (Allen *et al*. 1995; Bossard 1991; Partridge 1989; Smith & Harlen 1991; Williams 1981) and is difficult to eradicate from a site. This study investigated the response of the seed bank and the associated vegetation to spraying, to assist in estimating the true efficacy of spraying and the long-term costs of controlling broom invasions.

In a complementary study investigating the spatial and temporal patterns of soil seed bank accumulation around pioneer broom bushes of different ages in the South Island (Allen *et al*. 1995), many bushes within the present study area (but not the plot) were sampled; these results are referred to in the discussion.

2. Methods

2.1 STUDY SITE

The study site (NZMS260; N32 958 593) is located in the Miromiro Ecological District on the Hanmer Range, 6 km north of Hanmer Springs, on a north-facing upper slope of 15° at 810 m elevation. The vegetation is mainly tussock land and scrub and the soils are high-country yellow brown earths. The mean annual temperature at Hanmer Forest (387 m a.s.l.) is 10.2°C and the mean annual precipitation 1163 mm. Conditions at the study site would be wetter and colder because of the greater altitude.

2.2 SAMPLING METHODS

An area of broad-leaved snow tussock (*Chionochloa flavescens*) tussock land with broom up to 1.5 m tall, in patches ranging from dozens of plants to scattered bushes, was marked in November 1992 into a 20 m x 20 m plot with a 1 m^2 numbered grid. Five grid lines were randomly selected on each sampling occasion. The canopy height (first sampling only) and cover were recorded by point intercept at 100 random points along the five lines and classified as broom (within the crown of a broom bush), tussock, grass (mostly *Agrostis capillaris* and *Anthoxanthum odoratum*), broom seedlings (plants <15 cm tall), manuka (*Leptospermum scoparium*), other (mostly herbs or bare ground), litter (mostly a thin layer of tussock or other litter), or dead broom. The height of 25 broom seedlings at regular intervals along the lines was measured to the nearest cm.

The seed bank was sampled at randomly located points along the five lines by taking soil cores 5 cm deep and 7 cm in diameter (75 cores for the first sampling, 25 at subsequent samplings). These were wet sieved, and all seeds were counted. At the first sampling, the distance to the nearest adult bush was measured. The bush was cut at ground level, and its age was determined from growth rings.

The plot was sprayed with Tordon® (picloram) in March 1993 by Department of Conservation (DoC) staff from Hanmer.

The plot was re-measured in February 1994, March 1995, March 1996, and March 1997.

3. Results

3.1 VEGETATION

Before spraying, broom bushes 1.0 ± 0.31 m tall were the main cover, at 28% (Table 1), followed by 18–19% of tall tussock (0.9 ± 0.18 m) and grasses (0.8 m ± 0.25), the height of the latter reflecting the tall seed heads of *Agrostis capillaris*. The remainder comprised a few manuka shrubs (0.8 ± 0.25 m), scattered native herbs and shrubs (e.g., *Dracophyllum longifolium*) represented by 'other', and 13% cover of litter.

The broom bushes ranged in age from 2 to 7 years, with an average of 3.4 ± 1.1 years. Many had flowered and set seed immediately before being sprayed. Virtually all bushes were killed by the spray, and by the end of the experiment there was only a trace of resprouting from bushes (Table 1). Dead broom stems represented 15% cover in the first sampling after the spraying, but had disappeared almost entirely after 4 years.

The broom was replaced not by the native taxa represented in 'other', nor by manuka, for which cover values remained essentially the same, but by sward grasses. These increased from 18% cover before spraying to 43% after a little over 4 years. Litter decreased from 13% to 6% over this time.

TABLE 1. VEGETATION PERCENTAGE COVER BEFORE SPRAYING AND OVER THE FOLLOWING 4 YEARS.

Cover class	24 Nov 92	08 Feb 94	14 Mar 95	24 Mar 96	12 Mar 97
Broom	28	0	0	0	1
Tall tussocks	19	26	26	36	24
Sward grasses	18	32	39	43	43
Manuka	9	4	8	6	6
Broom seedlings	5	7	6	6	18
Other	6	1	4	0	2
Litter	13	13	8	5	6
Dead broom	0	15	9	3	0

3.2 SEEDS AND SEEDLINGS

Seedlings with an average height of 10.4 cm were abundant before spraying (Table 2). On the assumption that most seedlings were killed by the spray in the same way as the adult bushes, those sampled on 8 Feb 1994 must have emerged after spraying. There was no marked increase in the number of seedlings after this initial flush (Table 2). Seedlings only doubled their height, to 18.2 cm, over four years (Table 2), although some lateral growth was indicated by the increase in cover (Table 1). Most seedlings showed signs of severe browsing by hares.

TABLE 2. NUMBER OF SEEDS (MEAN ± S.D.) AND SEEDLINGS PER 39 CM^2 CORE AND HEIGHT OF 25 SEEDLINGS.

Date	*n*	Seeds	Seedlings	Seedling height (cm)
24 Nov 92	75	13.2[a] ± 0.7	0.7 ± 1.9	10.4 ± 4.3
08 Feb 94	25	6.1 ± 9.1	1.1 ± 1.4	7.3 ± 1.4
14 Mar 95	25	21.8 ± 31.1	0.3 ± 0.3	12.9 ± 3.7
14 Mar 96	25	10.8 ± 17.1	0.5 ± 0.8	13.5 ± 7.2
12 Mar 97	25	17.3 ± 26.3	0.4 ± 0.5	18.2 ± 6.3

[a] Multiplication factor for seeds per m^2 is 256

The number of seeds per core was extremely variable, ranging from zero to 114, or almost 30 000 per m^2, with an average over all the sampling dates of 13.8 ± 6.0, or 3532 per m^2. There was no indication of any decline in the size of the soil seed bank over four years (Table 2). Highest seed densities were associated with dead broom, grass swards, and patches of seedlings (Table 3). There was no significant correlation (r = 0.027) with distance to the nearest bush, or bush age.

TABLE 3. NUMBER OF SEEDS (MEAN ± S.D.) PER 39 CM^2 CORE, FROM BENEATH DIFFERENT COVER CLASSES, BEFORE AND AFTER SPRAYING.

Cover class	*n*	Pre-spray	*n*	Post-spray
Broom	27	6.5[a] ± 14.0	0.00	-
Tall tussock	17	6.7 ± 13.2	17	7.4 ± 7.4
Sward grass	19	12.7 ± 13.8	48	20.9 ± 25.3
Manuka	10	1.1 ± 2.3	2	18.0
Broom seedlings	5	25.4 ± 20	2	9.0
Other (live)	6	0.00	2	2.2 ± 2.2
Litter	14	2.6 ± 4.7	20	6.7 ± 11.2
Dead broom		n.a.	8	32.9 ± 40.0

[a] Multiplication factor for seeds and seedlings per m^2 is 256.

4. Discussion and conclusions

The large numbers of seeds relative to numbers associated with first-generation bushes in the vicinity (Allen *et al*. 1995) indicate that the site had supported an earlier stand of broom which must have been sprayed. As the oldest bushes were 7 years old this event was probably about 8–10 years before the trial spraying; the high seed count (approx. 3500 per m^2) suggests that it would have been a fairly old stand. The distribution of this previous generation was probably represented by the existing 18% cover of sward grasses and their associated concentrations of broom seed. Many broom plants present at the time of spraying were young bushes well away from the grass swards, which partly explains why the numbers of seeds beneath broom bushes as a class were relatively low compared with the grass patches. The effect of the trial spraying - perhaps the second spraying received by the site - was to replace the broom bushes with more invasive sward grasses. The phenomenon of nutrient enrichment by experimentally killed legumes facilitating invasion by adventive grasses, with a consequential loss of species diversity (albeit not actually measured in this study), has been documented for tree lupin, *Lupinus arboreus* (Maron & Connors 1996).

There is no evidence of any change in seed bank numbers over the four years of the study because of the large pool of seeds and because the spatial variation in broom seed numbers is so variable, as Allen *et al*. (1995) also demonstrated.

The size of the broom seedling cohort changed little over four years. Subsequent seedling growth was very slow as a result of browsing by hares. These animals are probably attracted by the new grass swards associated with the decaying broom biomass, which may be higher in nitrogen (Maron & Connors 1996). Had the seedlings not been grazed, they could be expected to have reached a height of at least 0.5 m in 3 years, and to have produced their first seeds (Williams 1981).

In conclusion, when broom invading high-country soils supporting open tussock land is sprayed and killed, it is replaced by sward grasses and a new crop of broom seedlings. However, this seedling resurgence is insufficient to cause a measurable decline in the soil seed bank, which will persist for at least 16 years (Esler *et al*. 1993) and probably much longer.

The implication from these observations is that the effects of broom invasion on the vegetation, possibly the soil nutrient status, and the soil seed bank are profound and long-lasting. Control efforts should be directed towards young bushes (less than four years old) (Allen *et al*. 1995) before they perhaps irrevocably change the vegetation/soil system in their immediate vicinity.

5. Acknowledgements

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