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HAWTHORN *(CRATAEGUS MONOGYNA)* POPULATIONS IN MID-CANTERBURY

Summary: Hawthorn *(Crataegus monogyna)* is a naturalised tree that is classified as a noxious plant in several counties in the eastern South Island. It is locally abundant in lowland forest remnants, and with the indigenous spiny shrub matagouri *(Discaria toumatou),* on grazing land in Canterbury. Two scrub sites near Porters Pass, where the original hawthorn trees still existed, and a forest site near Kowai Bush were sampled by measuring stem diameters and counting growth rings, to determine the age structure and dynamics of hawthorn. Matagouri was sampled similarly at one of the sites. There is a close positive relationship between age, stem diameter and plant height for both hawthorn and the slower growing matagouri. Hawthorn growth is impeded by grazing, but it is spreading near Porters Pass in clumps of matagouri and in pastures that are only lightly grazed. If existing management continues, hawthorn is predicted to increase as more of the bushes reach fruiting age.

In the forest site, less hawthorn is establishing now than when the forest was more disturbed, whereas seedlings and saplings of native trees are abundant. Hawthorn is predicted to decrease here. The management of hawthorn should recognise these different situations.

Keywords: *Crataegus monogyna*; hawthorn; *Discaria toumatou*; matagouri; forest; scrub; noxious plants; weeds; Canterbury.

Introduction

Hawthorn *(Crataegus monogyna)** is a European shrub or low tree widely distributed in the South Island (Bascand and Jowett, 1981, 1982) where it is very conspicuous in spring and early summer when covered in white flowers. It is often present only as a hedge plant in rural districts but it may spread to adjacent waste lands, riverbeds, forest remnants and hill country farmland (Healy, 1969). A postal questionnaire to land owners recorded hawthorn as having "minor problem status" in western Otago, a few areas in coastal Southland and Otago, and over large areas in north-eastern and northern South Island (Bascand and Jowett, 1982). Hawthorn has been classified as a noxious plant in some counties of New Zealand.

Colonies are scattered through the Canterbury foothills, and concern has been expressed at its apparent spread in the Kowai Valley near Porters Pass and in forest remnants on the nearby plains. In November 1983 we studied three populations of hawthorn to assess its dynamics and persistence in different plant communities.

Study areas

Three sites representing different land management regimes were studied in November 1983. Two are near Porters Pass, adjacent to the Christchurch-West Coast highway, where the hawthorn stands originated from several large old trees planted near a roadside shed (NZMS1 S74 237835). Hawthorn has spread onto hillsides above the highway, for 1.5 km, and on low terraces of the Kowai River, for approximately 1 km north of the highway (Fig. la, 1b).

The first site (hill) is the northeast-facing hillside between 640 and 720 m a.s.l, immediately above the original trees. The second site (terrace) is along the terrace of the Kowai River at 640 m a.s.l. and 0.5 km from the original trees. The pre-Maori vegetation of the hillslopes and higher terraces was probably mountain beech *(Nothofagus solandri* var. *cliffortioides)* forest (Molloy *et al.,* 1963), a tree species with a very slow dispersal rate.

Both sites now carry shrub/grasslands of the spiny shrub matagouri *(Discaria toumatou)* and sweet vernal *(Anthoxanthum odoratum)* or browntop *(Agrostis capillaris)*. Matagouri has increased in the area over recent years, in response to phosphate fertilisers. The hill site has been partially cleared of scrub in the past, whereas the terrace has been partially retired from grazing and is less heavily stocked than the hillsides.

The soils are yellow-brown earths and related steepland soils, with recent soils on the lower river terraces (New Zealand Soil Bureau, 1968). The mean annual temperature is about 9.8°C and the mean annual rainfall is 900 mm (New Zealand Meteorological Service, 1978, 1979).

The third site (bush) is a forest remnant on the

*Latin names of introduced plants follow Clapham *et al.,* (1952) and native plants follow Allan (1961) for dicotyledons and Cheeseman (1925) for monocotyledons unless indicated.

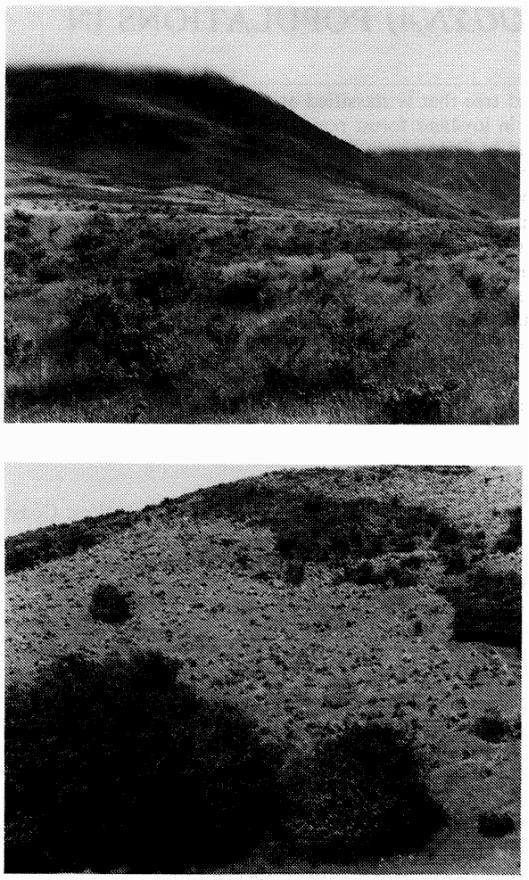

Figure 1: *Hawthorn (Crataegus monogyna) amongst matagouri (Discaria toumatou) on a terrace (a) and hill slope (b) near the Kowai River, Porters Pass.*

Canterbury Plains at Lords Bush (NZMS1 S74 385856), 16 km east of the others, at 400 m a.s.l. where soils are highly productive lowland yellow-brown earths (New Zealand Soil Bureau, 1968). Mean annual temperature is about 10.4∞C and the mean annual rainfall is 1000 mm (New Zealand Meteorological Service, 1978, 1979). Scattered kahikatea *(Dacrycarpus dacrydioides* (A. Rich) de Laubenfels) and black beech *(Nothofagus solandri)* dominate the forest canopy, over a subcanopy of mainly broadleaf *(Griselinia littoralis)* and putaputaweta *(Carpodetus serratus)*. The forest has been milled for timber and firewood and the canopy is uneven in height, density, and species composition. Sheep and cattle have grazed in the bush, but in recent years it has been partially fenced and a dense scrub of gorse *(Ulex europaeus)* and blackberry *(Rubus fruticosus)* has developed on the margins. Hawthorn has spread from hedgerows in the area and has established sporadically throughout the forest in the subcanopy and in light gaps.

Methods

On the hill site 5 plots, each 10 m x 20 m, were laid out across the slope, 20 m apart, to cover the distance between the original trees and the hawthorn highest on the slope above. On the terrace site,S plots were located 200 m apart, to cover the full extent of the hawthorn on the valley floor.

The percentage cover (0-1, 2-5,6-25, 26-50, 51-75, 76-95, 96-100%) of litter, sward, tussock grasses, and all woody plants, was estimated from the whole plot for 7 layers (0-0.05 m, 0.05-0.25 m, 0.25-0.05 m, 0.50-1.0 m, 1-2 m, 2-5 m, >5 m). Height was measured with a sliding staff (Williams, 1983). The frequency of species in the ground layer (0-0.25 m), seedlings of woody plants less than 0.23 m tall, animal droppings, and bare ground, was recorded from 10 I m2 subplots distributed through the main plots.

The height and stem diameter was measured for all hawthorn plants taller than 10 cm and with a stem diameter greater than 5 mm, and their reproductive state noted. In plots with only scattered hawthorn, the largest stem of every hawthorn bush with a diameter of 10 mm or more was cut at 8 cm above ground level, and a disk taken for counting growth rings. In plots with dense hawthorn, the first 10 or so plants were sampled from 4 subplots. A similar number of matagouri bushes were sampled from the hill sites.

Increment cores were taken from the three largest trees near the shed and several other hawthorn bushes outside the plots at all sites. Hawthorn produces adventitious shoots from underground roots in some circumstances, but these were infrequent at all the sites, where most individual stems had arisen from seed.

Lords Bush was sampled by a similar procedure, but only two plots were laid down, one on the forest margin and one in the centre of the forest. In addition, a transect 140 m x 5 m was layed out between these two plots, 5 1 m^2 subplots were recorded and all hawthorn bushes were cut and discs taken.

Results

Porters Pass

The tussock grasses shown on the hill site (Fig. 2) are silver tussock *(Poa laevis)* and hard tussock *(Festuca novae-zelandiae)*. The swards on the hill and terrace sites are different (Table 1), reflecting the greater fertility of the hill site brought about by more intensive farming. Hawthorn seedlings are infrequent at both sites. Bare ground and sheep droppings are more frequent on the hill site (Table 1).

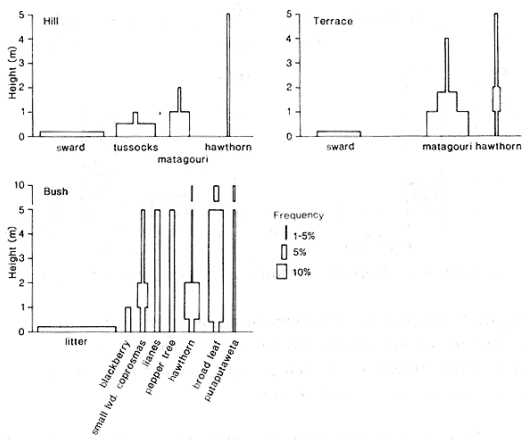

Figure 2: *Height frequency composition of the vegetation at three sites with hawthorn in Canterbury.*

The hill site has a low density of hawthorn plants (0.6 per 10 m^2) with a very high proportion in the smaller size classes of stem diameter and plant height (Fig. 3). Most of the upright, single-leadered hawthorn plants are protected by matagouri bushes; those in the open are chewed and suppressed by browsing (Fig. 4). The latter are mostly less than 0.5 m tall (Fig. 3), below the mean height ($x = 0.89, \pm 0.40$ m) of the surrounding matagouri plants. Hawthorn plants on the hill site range from 10-40 years old (Fig. 5). There are a few flowers on very young hawthorn plants but most plants flowering or fruiting are at least 20 years old (Fig. 5).

The matagouri bushes at the hill site have a similar age structure to the hawthorn, although seedlings are rare (none were recorded in the subplots, Table 1), and several plants are older than the oldest hawthorn, with some up to 60 years old (Fig. 5). Large hawthorn bushes and trees are often surrounded by dead and dying matagouri bushes, or by pasture.

The three large trees near the shed at Porters Pass are 10-12 m tall, and from the partial cores obtained, two of them are estimated to be at least 60 years old.

Table 1: *Mean frequency (%) for herbs. mosses. seedlings of woody plants, and bare ground for three areas with* Crataegus monogyna *(see text).*

	Porters Pass		Lords
	Hill	Terrace	Bush
HERBS, ETC.			
Cerastium fontanum	100	36	
Anthoxanthum odoratum	86	98	
Rytidosperma (Steudel) spp.	80		
Trifolium dubium	78		
Lolium perenne	74		
Trifolium subterraneum	60		
Aphanes arvensis	60		
Veronica verna	52		
Aira caryophyllea	36		
Cirsium arvense	32		
Crepis capillaris		66	
Agrostis tenuis		52	
Hypochaeris radicata		46	
Mosses (various)		30	
Bulbinella hookeri		24	
Acaena caesiiglauca		18	
Rubus fruticosus			50
Uncinia spp.			15
Blechnum capense			15
SEEDLINGS			
Crataegus monogyna	18	24	25
Cytisus scoparius		10	20
Dacrycarpus dacrydioides (A. Rich.) de Laubenfels			60
Griselinia littoralis			35
Pittosporum tenuifolium			35
Coprosma spp.			25
Pseudowintera colorata			20
Elaeocarpus hookerianus			20
BARE GROUND			
Bare soil	46	10	10
Surface stones	46	60	
Sheep droppings	26		
Total number of subplots	50	50	50

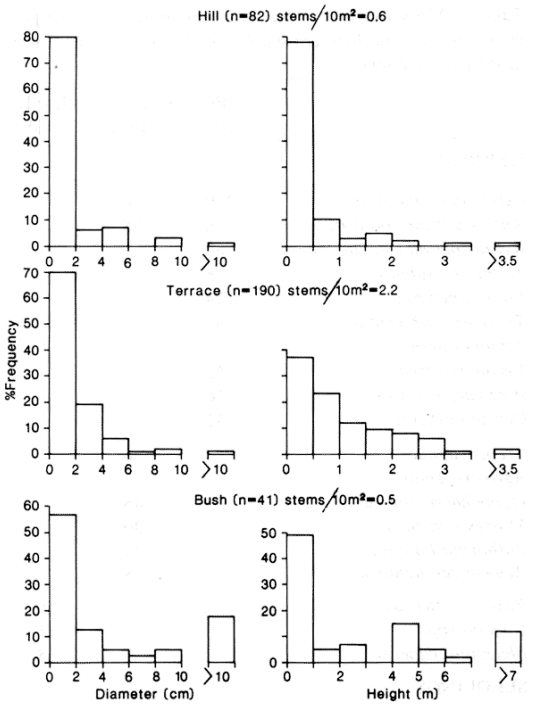

Figure 3: *Frequency of hawthorn bushes in stem diameter and shoot height classes at three sites in Canterbury.*

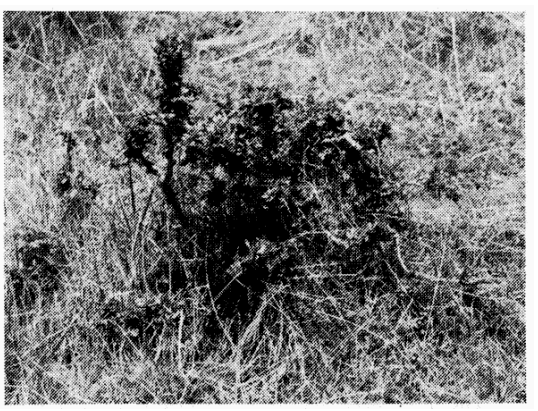

Figure 4: *Browsed hawthorn bushes on the hill site near Porters Pass.*

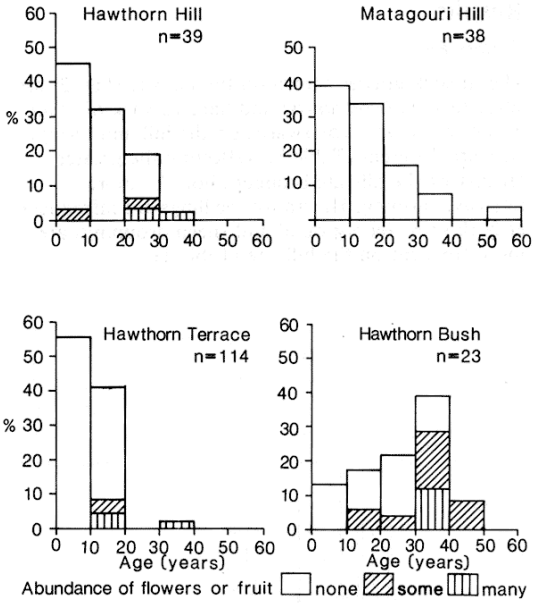

Figure 5: *Frequency of hawthorn in age classes at* 3 *sites. and of matagouri on the hill site near Porters Pass. The proportion of bushes in each age class with none. some. or many flowers or fruits is shown.*

The terrace population is the most dense, with 2.2 plants per 10 m^2. Most stems are 4 cm diameter or less (Fig. 3). Nearly all plants are younger than 20 years old, and a low proportion are flowering or fruiting. Upright young hawthorn bushes frequently grow some distance from older bushes in the grassland, beyond the protective cover of the matagouri scrub (Fig. 4). Two matagouri bushes about 2.5 m tall on the terrace had 34 and 40 growth rings.

The mean age of hawthorn plants other than seedlings was plotted against distance from the original roadside trees (Table 2). A further isolated plant 300 m beyond the distal terrace plot was 19 years old. There is clearly no gradient of decreasing age of the bushes with distance from the original trees, either up the hill or along the terrace. The density of hawthorn tends to decrease with distance on the terrace site.

Lords Bush

Fig. 2 shows the composition of the forest up to 10 m in Lords Bush. Hawthorn contributes conspicuously

Table 2: *Mean ages (± S.D.) of hawthorn plants near Porters Pass sampled from 5 plots up the hillside (20* m *apart) and along the terrace (200* m *apart). Plot* 1 *is nearest the original trees in both cases.*

Plot No.	1	2	3	4	5
Hill site	12 ±6	6± 2	13 ±3	15 ±6	15 ±6
(n)	6	12	4	*5*	10
Terrace site	12±3	11 ±3	12±4	10±3	12±*5*
(n)	40	37	11	21	4

only up to 2 m, although several hawthorn bushes were up to 9 m tall. Other species in the 5-10 m layer but contributing less than 5% are black beech, broom *(Cytisus scoparius),* gorse, kohuhu *(Pittosporum tenuifolium),* lancewood *(Pseudopanax crassifolius),* pokaka *(Elaeocarpus hookerianus),* weeping mapou *(Myrsine divaricata)* and wineberry *(Aristotelia serrata).* There are abundant seedlings on the floor, including those of the main sub-canopy tree broadleaf, and the canopy tree kahikatea (Table 1). Black beech seedlings are concentrated in the vicinity of patches.of beech trees in unsampled areas, where hawthorn is unimportant.

The density of hawthorn in Lords Bush is low, with only 0.5 bushes per 10 m^2. Seedlings and small saplings predominate, but a high proportion of trees have a stem diameter greater than 10 cm, and a height of 4 m or more (Fig. 3). The oldest tree sampled was 48 years old and 5.5 m tall. The only plants with abundant fruit or flowers are those 30-40 years old. These are all taller than 5 m, with much of their crowns exposed directly to the sky.

Linear regressions of height and diameter against age, and growth rates calculated from these regressions are shown in Table 3. Much of the variability in the height and stem diameter of hawthorn is caused by grazing stunting the bushes at the hill site, and by varying levels of light; some plants have established between the matagouri bushes or in open patches in the forest, while others have been severely shaded. Only about 42% of the variation in the growth of hawthorn can be explained by age, but between 62% and 88% of the growth of matagouri. The growth rates suggest hawthorn has grown fastest on the terrace, partly because of the relative lack of grazing when compared with the hill site. Even with grazing, though, hawthorn on the hill site has still grown twice as fast as matagouri.

Table 3: *Linear regressions and growth rates for hawthorn and matagouri, where x = age in years, y = diameter in* mm *or height in* m. ** *p <.01.*

		n	Growth rate/year
1. Hawthorn			
Kowai hill site			
Diameter			
y = - *15.06* + 32x;	r = 0.77**	39	3.3 mm
Height			
y = -0.20 + 0.10 x;	r = 0.65**	39	0.10 m
Kowai terrace site			
Diameter			
y = - 26.30 + 4.81x;	r = 0.79**	114	4.8 mm
Height			
y = 0.62 + 0.31x;	r = 0.61**	114	0.31 m
Lords Bush			
Diameter			
y = 15.04 + 3.0x;	r = 0.71**r =	23	3.0 m
Height			
y = 0.76 + 0.I5x;	0.72**	23	0.15 m
2. Matagouri			
Kowai hill site			
Diameter			
y = - 2.74 + 1.Sx;	r = 0.94**	38	1.4 mm
Height			
y = 0.35 + 0.03x;	r = 0.80**	38	0.05 m

Discussion and Conclusions

"A population age structure gives us a glimpse of a single frame in a movie film. Only inference can tell us what happened in earlier frames and only patience or extrapolation can tell us what follows" (Silvertown, 1982) - in the absence of long-term studies, inference and extrapolation from population age structures can aid decision making in the management of weeds.

Casual observations over the past 15 years at Porters Pass and elsewhere in Canterbury suggest that hawthorn produces fruit every year. The different age and size-class structures of the populations are therefore likely to indicate differences in establishment and survival of hawthorn, rather than variation from year to year in the abundance of propagules.

Hawthorn began to spread in the Porters Pass area about 30-40 years ago, when the original roadside trees would have been at least 20 years old. The age structures of matagouri and hawthorn populations are similar on the hill (Fig. 5), so they must have established at approximately the same time. This probably coincided with the control of rabbits in Canterbury during the late 1940's and early 1950's

(Bull, 1969). Hawthorn develops prickles within the first 2-3 years, but these are insufficient to deter sheep which nibble leading shoots until they grow above browse height. Establishment on the terrace was infrequent, until the earliest bushes to establish began to produce fruit about 20 years ago. The early members of this second generation also established mainly within matagouri scrub, but in recent years bushes have established in open grassland because of the reduced browsing from sheep during this time.

In open vegetation such as an old field, the density and age of invading woody plants dispersed by wind or birds often decreases evenly for more than 1 km from source (e.g. Spring *et a1.,* 1974; Read and Hill, 1983). However, in the case of bird-dispersed plants, the invading species may be clumped at "safe sites" such as old logs or near tree bases (Debussche *et a1.,* 1982; Read and Hill, 1983). No marked pattern was seen in the age of the hawthorn plants at Porters Pass, nor in flowering currant populations in South Canterbury (Williams, 1984), although the density of hawthorn decreased from the original trees at the terrace site (Table 2). The pattern of invasion at both these areas appears to be determined by the distributi.Qn of suitable habitats, such as a moist gully with a protective matagouri bush, and the likelihood of these being used by dispersal agents such as birds or perhaps even possums *(Trichosurus vulpecula).* Invasion is begun by scattered plants establishing at almost random distances from the source, followed by population expansion, perhaps consequent upon some environmental change such as browsing pressure or variation in the abundance of dispersers. This pattern of invasion of the New Zealand landscape stresses the importance of isolated individuals of potentially weedy species.

In the absence of any evidence for high age-specific mortality in the 10-30 year old classes, many hawthorn bushes in the Porters Pass area, particularly on the terrace, will become 30-40 years old within the next to years. This will result in increased seed production adjacent to extensive retired land, with many sites suitable for hawthorn. Further patches of this landscape may therefore be transformed from an essentially fire-induced indigenous one, to one dominated by adventive shrubs. As the climax forest in this area is beech forest (Molloy *et a1.,* 1963) there will be few other native trees likely to colonise the hawthorn forest that could develop. The direction of succession following the establishment of hawthorn can only be surmised, but the changes are likely to be very slow.

Forest remnants such as Lords Bush on highly productive lowland soils are important for nature conservation despite their disturbed state and the presence of weeds. The populations of hawthorn in the example studied here appear to have responded to the reduction in wood-cutting and grazing brought about by partially fencing the area. Steadily less hawthorn has been establishing in the forest since the peak of 30-40 years ago (Fig. 5). Few seedlings now establish and they have to compete with shade-tolerant native hardwoods, e.g., five finger with similar shoot elongation rates (Williams and Buxton, unpublished data). Furthermore, both broadleaf and putaputaweta, two trees commonly competing with hawthorn even at this stage of forest recovery (Fig. 2), are potentially much taller than hawthorn. These and other hardwoods will form a canopy in existing light gaps, creating conditions unsuitable for the perpetuation of hawthorn. The corollary is that hawthorn will persist in forest stands in Canterbury while these continue to be disturbed by grazing and cutting.

The role of hawthorn in vegetation succession described here is similar to its behaviour in Britain (Rackham, 1980), Europe (Sloet van Oldruitenborgh, 1976), the Mediterranean region (Byatt, 1976; Debazac, 1983), North America (Burgason, 1976) and Australia (Lane, 1979). Hawthorn has single-leadered shoot growth, seeds with large carbohydrate reserves and spines on young wood. These attributes and no doubt others not investigated here enable hawthorn to invade grassland and disturbed ground on a very wide range of soil types in the presence of light grazing. However, it will disappear where taller forest trees are competing with it. The three Canterbury situations described here can be summarised as:

1. the hill, where hawthorn is slowly invading matagouri scrub but is largely controlled by grazing on open grassy patches,
2. the terrace, where hawthorn is not being controlled by grazing and is spreading, and
3. the forest, where hawthorn will eventually be replaced by native forest species.

The management or control of hawthorn, whether for pastoral, aesthetic or nature conservation reasons, should recognise these different circumstances.

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