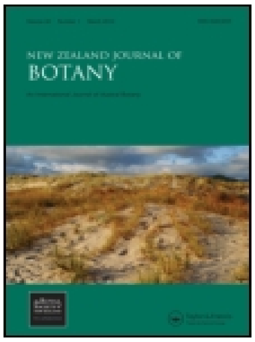

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Succession and dynamics of gorse (*Ulex europaeus* L.) communities in the Dunedin Ecological District South Island, New Zealand

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Abstract Successional patterns in gorse (*Ulex europaeus*) communities were determined from an analysis of 125 plots in the Dunedin Ecological District. Stem diameter and height growth of gorse averaged 5 mm yr^{-1} and 200 mm yr^{-1} respectively. Plants attained a maximum age of 29 years, a maximum height of 7.0 m, and a maximum diameter of 217 mm at 100 mm above the ground. Gorse matured at about 15 years after establishment with a mean stem density of 60 000 ha^{-1}, mean basal area value of 51 m^2 ha^{-1}, and a mean litter depth of 55 mm. Other naturalised woody species, particularly broom (*Cytisus scoparius*), declined in importance in older gorse stands. The establishment of native woody species was favoured by lower density, taller gorse, where litter depth was shallow, and areas of bryophyte or bare soil were available. In these stands native species reached numerical and basal area equivalence with gorse after 10–15 years on the site. However, at 60% of the sites younger than 25 years, native woody species were not establishing and it is unlikely that they will do so until after the first cycle of gorse (25–30 years) is completed. The implications of these results for the management of gorse in biological reserves are discussed.

Keywords gorse; *Ulex europaeus*; secondary succession; native species; Dunedin; Ecological District

INTRODUCTION

Although gorse (*Ulex europaeus*) is recognised as a noxious weed in New Zealand, and much published research exists on its eradication and control (see Gaynor and MacCarter 1981), some studies have noted its important successional role in the re-establishment of indigenous forest vegetation on previously cleared sites (Druce 1957, Healy 1961). It is now becoming accepted that gorse may have a useful function in biological conservation as a pioneer, transient successional species and should therefore be left undisturbed in reserve areas (Evans 1983). This may, in fact, be the only practical means of eliminating gorse because the species vigorously recolonises an area if the extant vegetation is removed. However, little quantitative information is available on the natural dynamics of gorse communities and their interaction with other woody species, and none is from the Dunedin area. The present study examines gorse communities around Dunedin to determine the rate of establishment of indigenous woody species and the likely duration of gorse dominance. Here gorse is found on sites from sea level to over 600 m in altitude, in pasture, wasteland, roadsides, fernland, scrubland, and montane snow tussock grassland.

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STUDY AREA

The study area is defined by the Dunedin Ecological District (Simpson 1982) (Fig. 1). The area is hilly, and predominantly of volcanic origin. Several peaks exceed 500 m a.s.l., with the highest, Swampy Summit, at 739 m. The moist coastal climate exhibits few extremes of temperature or rainfall.

Natural vegetation was podocarp-dicotylous forest, with *Libocedrus* important at higher altitudes. *Nothofagus* forest occurred as a few, generally small, scattered stands. Snow tussock (*Chionochloa rigida*) grassland and *Leptospermum* scrub and low forest occur generally on upland sites deforested by fire and other agencies during the past millenium (Wardle & Mark 1956).

Most sample sites were located on basalt, phonolite, or trachyte, with a few on sandstone, schist, or sand, alluvial and estuarine deposits (McKellar 1966). Soils at sample sites were predominantly brown granular loams and clays, yellow-brown earths, or intergrades between. Some higher altitude sites occurred on podzolised yellow-brown

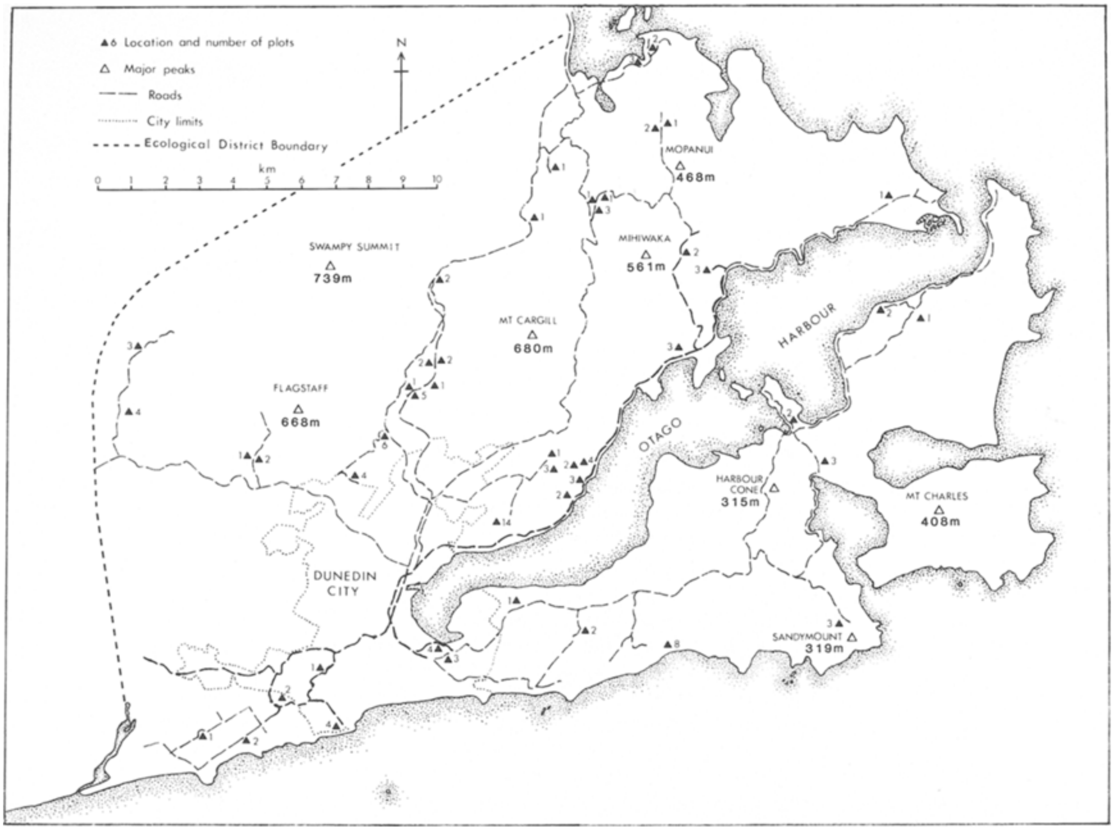


Fig. 1 Dunedin Ecological District showing sampling sites (▲) and number of plots at each.

earths. Yellow-grey earths, yellow-brown sands, saline gley recent soils, and alluvial recent soils accounted for a few sites (Tomlinson & Leslie 1978).

Rainfall increases with altitude from approximately 700 to 1500 mm yr^{-1}. Normal values (1941–1970) for Musselburgh (Fig. 1), altitude 2 m a.s.l., at the head of Otago Harbour, are given in Table 1. Temperatures are generally cool to mild, with few severe frosts. Mean total sunshine hours are 1965 per year; 41% of the possible total (New Zealand Meteorological Service 1973; 1978a,b).

METHODS

Gorse was sampled at 125 representative sites throughout the study area (Fig. 1). At each site 0.01 ha was selected as typical of the vegetation and within this a 2 m × 2 m plot was located by random coordinates. Within the plot, stem diameter, at 100 mm above ground level, and height were recorded for all stems > 5 mm diameter for all woody species. Because gorse plants are multistemmed from ground level it was not possible to record individual plants. Canopy height was measured with a graduated pole, and canopy cover estimated visually by two observers. Cover estimates were also taken of plants < 0.25 m tall, and of the ground cover of litter, bare soil, rock, and bryophytes. Seedling (stems < 5 mm diameter, < 0.3 m tall) density of all woody species was recorded. All species within a 10 m × 10 m plot centred on the sample plot were recorded. Litter depth was measured by probe at 4 points in each plot, and a mean depth calculated.

Transverse sections from a total of 305 stems were taken at 100 mm above ground level from the largest gorse plants in each plot. Growth rings were clearly distinguishable for most discs, enabling reasonably accurate age determinations, and were proved to be annual by sampling at several stands of known age. The discs provided the minimum age of the current gorse stand on the site, but there was no way of assessing whether previous generations had grown on the area.

Table 1 Climatic observations, normals 1941–1970 from Musselburgh, Dunedin.

Period	J	F	M	A	M	J	J	A	S	O	N	D	Year
Rainfall (mm)	74	61	76	74	71	66	56	46	48	58	71	71	772
Mean daily temp. (°C)	15.0	15.0	13.7	11.4	8.9	6.8	6.3	7.3	9.2	11.1	12.5	13.8	10.9
Mean daily max. temp. (°C)	18.9	19.0	17.5	15.1	12.3	10.2	9.9	11.1	13.3	15.2	16.6	17.6	14.7
Mean daily min. temp. (°C)	11.0	10.9	9.9	7.7	5.4	3.3	2.7	3.5	5.1	7.0	8.4	9.9	7.1
Ground frost days	0.3	0.3	0.8	3.2	9.1	14.8	17.2	16.4	10.5	4.8	1.8	0.3	79.5

Table 2 Simple correlation coefficients between *Ulex europaeus* stem diameter and height, age, altitude, and aspect.

	Age	Altitude	Aspect North	East
Diameter	0.72**	−0.20**	−0.09	−0.08
Height	0.65**	−0.23**	−0.23**	0.10

d.f. = 302; **significant at 1% level.

Site characteristics recorded were location, altitude, aspect, and slope, with an assessment of past management, evidence of fire, and grazing history.

The data were examined using a simple correlation matrix. However, results are generally presented using 5-year age classes as this provided a useful summary of the highly variable plot data.

RESULTS

Growth of gorse

The oldest gorse plant was at least 29 years of age, the maximum height recorded was 7.0 m, and the maximum stem diameter was 217 mm. Height and stem diameter were positively correlated with age ($P < 0.001$), and stem diameter and height declined with increasing altitude and northerly aspect (Table 2).

Stem diameter and height growth of gorse at any age were highly variable, as shown by the broad scatter of points in Fig. 2A and B. For example, gorse plants 15 years old had diameters between 20 and 220 mm and ranged from 1.2 to 6.0 m in height. Ninety-eight percent of all plants had stem diameters less than 110 mm. The slowest growing individual had an average annual stem diameter increment of 1 mm, whereas the fastest growing had a stem diameter growth rate of 14 mm yr^{-1}. Mean stem diameter growth was fastest in plants 6–10 years old, at about 4.5 mm yr^{-1} but even plants 21–25 years of age attained mean diameter increases of around 2.7 mm yr^{-1} (Fig. 3). However, this declined markedly in very old plants to about 0.4 mm yr^{-1}. Overall mean diameter growth rate for gorse was 5.0 mm yr^{-1}.

Canopy height increased with age (Fig. 2B), and most stands were between 2.5 m and 5.0 m tall after 15 years, although gorse 4.6 m tall may be only 9 years old. Juvenile plants (< 5 yrs old) extended canopy height at a mean rate of 0.28 m yr^{-1} but the rate declined steadily as the plants matured (Fig. 3B). At around 12 years plants began to topple over, accounting for the scatter of exceptionally low-canopied, large-stemmed individuals of advanced age in Fig. 2B. Overall mean height growth rate was 0.20 m yr^{-1}.

Stand structure

In stands less than 10 years old, gorse stems seldom exceeded 50 mm in diameter and most were less than 10 mm (Fig. 4). Thereafter, there was a steady increase in the proportion of stems in larger age/size classes and a rapid expansion of size range, until around 20 years when the proportion of stems in all size classes was fairly even and relatively stable. Small diameter individuals in mature and senescent stands were frequently epicormic shoots from the bases of plants whose original canopies had died, or new recruits rather than suppressed weak pioneer plants.

Canopy

Canopy height of gorse communities increased steadily up until 20–25 yrs when it reached a mean of some 4.0 m, then decreased in the oldest stands (Fig. 5A). Estimated canopy cover in the youngest stands was 60%, but fell to below 50% between 10–25 years, prior to an increase again in older stands (Fig. 5B) through the contribution of resprouting gorse stems and the growth of other woody species.

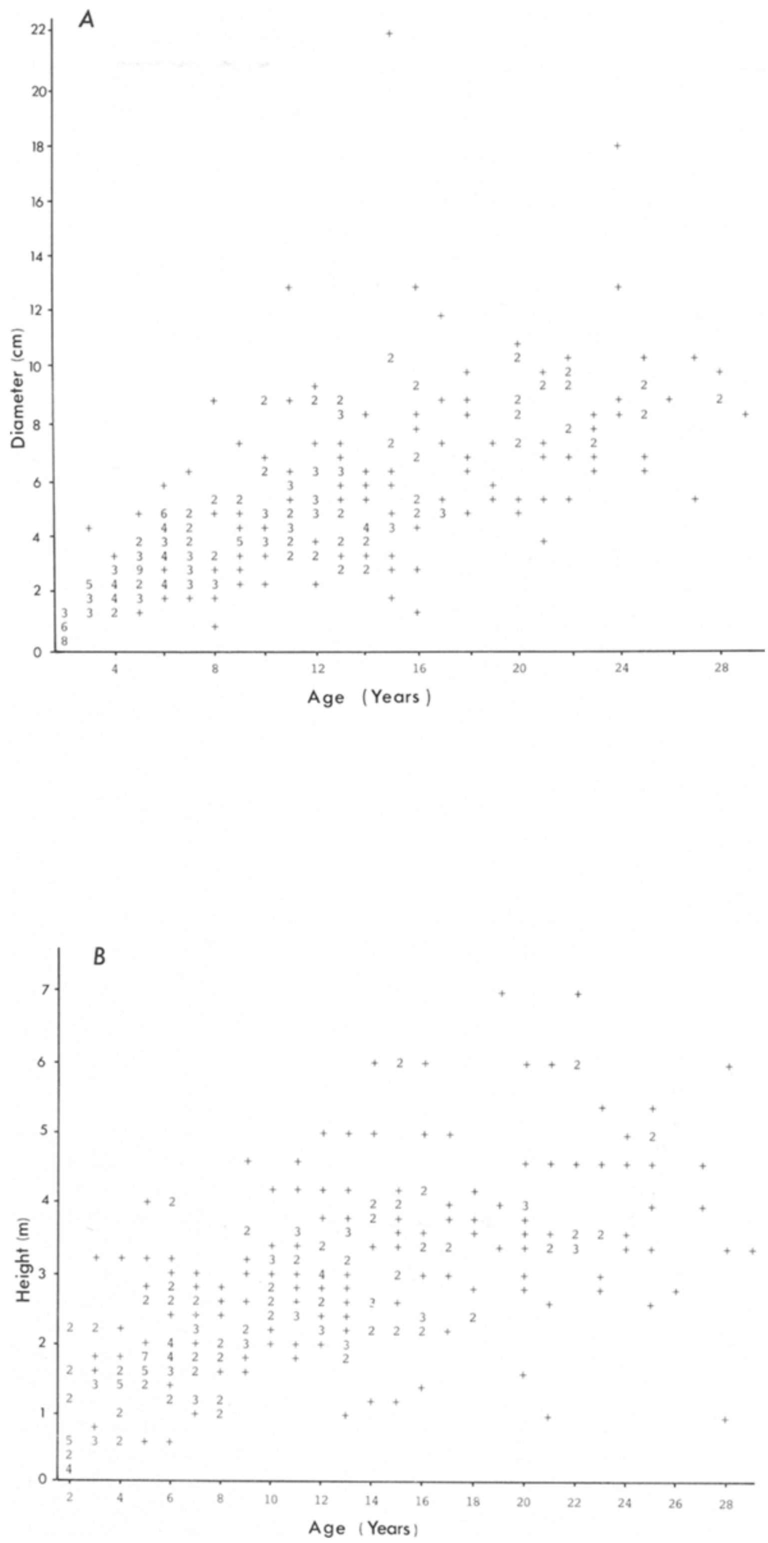
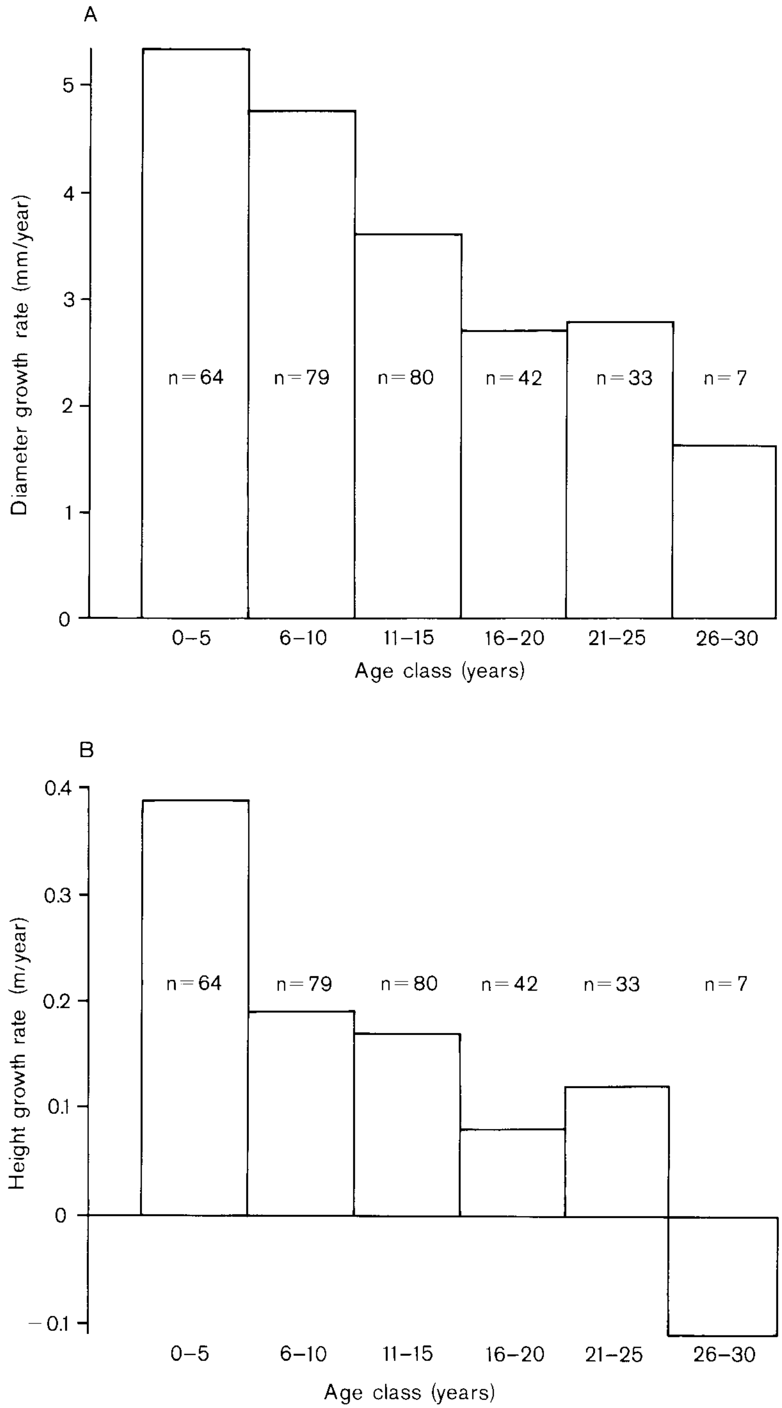


Fig. 2 Relationship between stem diameter and age **A** and height and age **B** of *Ulex europaeus* stems (n = 304). Numbers of stems at each interval are indicated as + = 1, 2 = 2, 3 = 3, etc.

Fig. 3 Mean rate of diameter growth **A**, and canopy height growth **B** of *Ulex europaeus* in 5-year age classes.



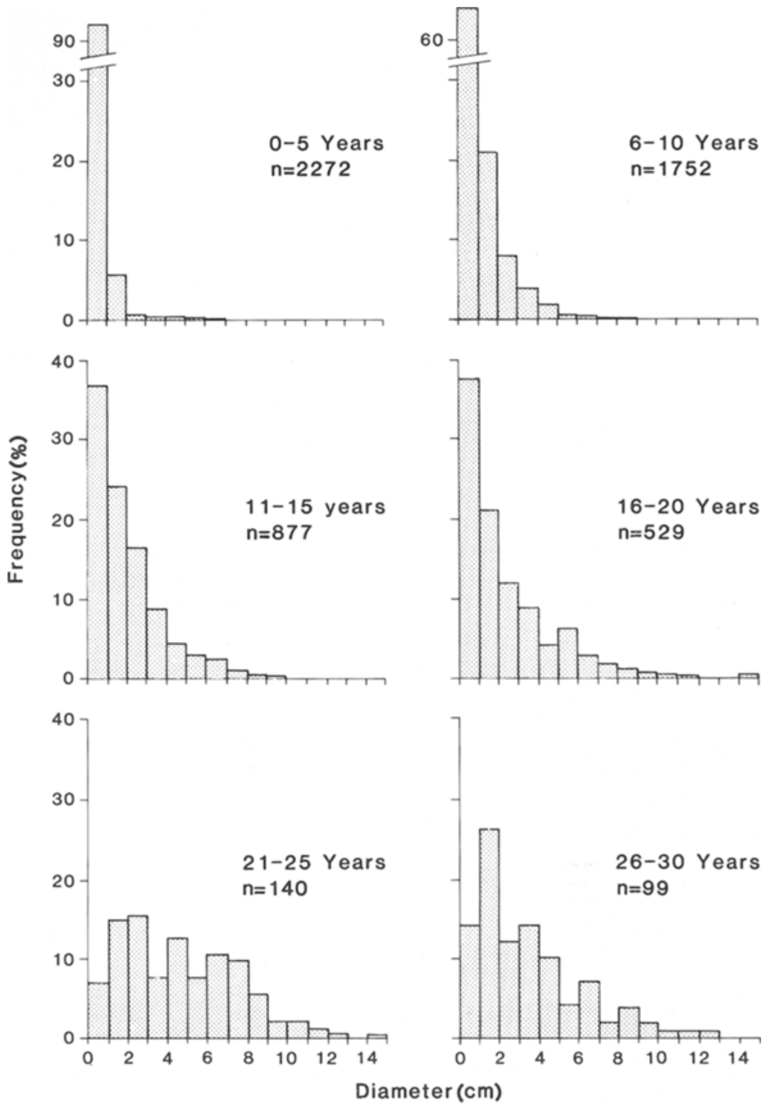


Fig. 4 Size class distribution of *Ulex europaeus* stems in 5-year age classes obtained from 125 0.01 ha plots.

Basal area and density

During the first 15 years gorse increased mean basal area at a rate of 3.5 $m^2\ ha^{-1}\ yr^{-1}$, (Fig. 5C). Mean basal area remained at 50–55 $m^2\ ha^{-1}$ in older stands, although there was considerable variation between plots.

Gorse stem density declined rapidly over the first 15 years, dropping from 32 stems m^{-2} to 6 stems m^{-2} (Fig. 5D). In stands older than 20 years, stem densities for gorse were about 2 m^{-2}. Throughout the life of the gorse stand the basal area of dead standing stems was constant at between 3 and 5 $m^2\ ha^{-1}$, and density at less than 2 m^{-2}.

Understorey

Beneath the developing gorse canopy, total cover of plants less than 0.25 m tall declined as the stand matured (Fig. 6A), mainly because of a steady decline in grass cover provided by cocksfoot (*Dactylis glomerata*), browntop (*Agrostis tenuis*), sweet vernal (*Anthoxanthum odoratum*) and Yorkshire fog (*Holcus lanatus*). Other herbs — principally

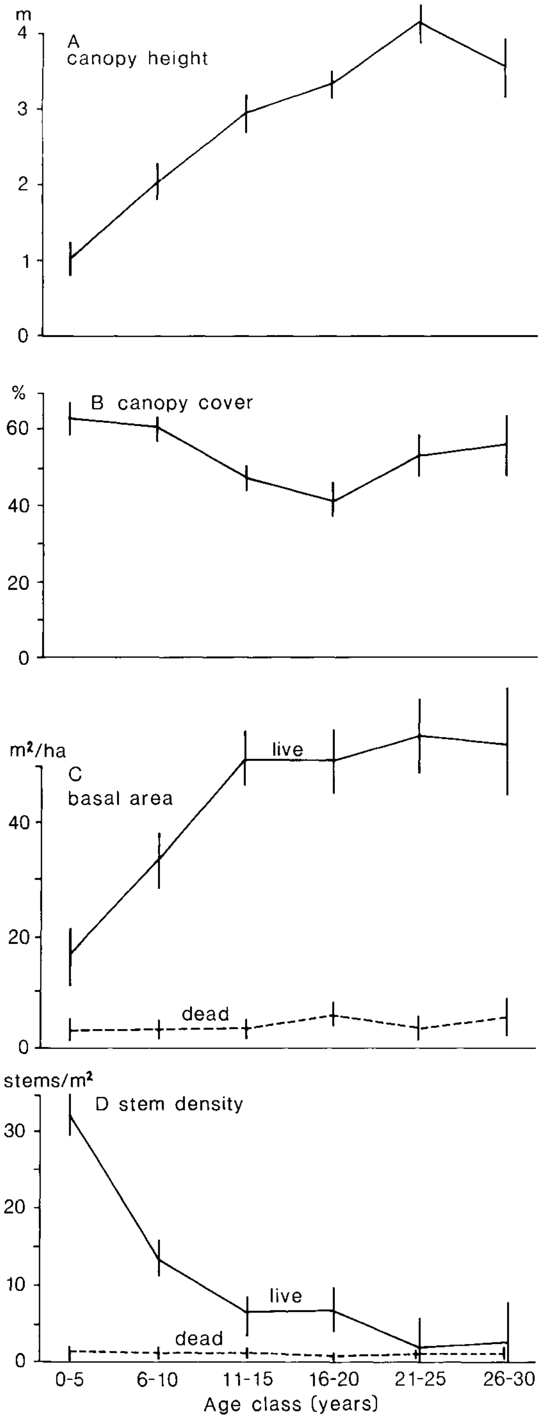


Fig. 5 Canopy height **A**, total canopy cover **B**, basal area of *Ulex europaeus* **C**, and stem density of *Ulex* **D** in stands of different age.
Mean and standard error are shown.

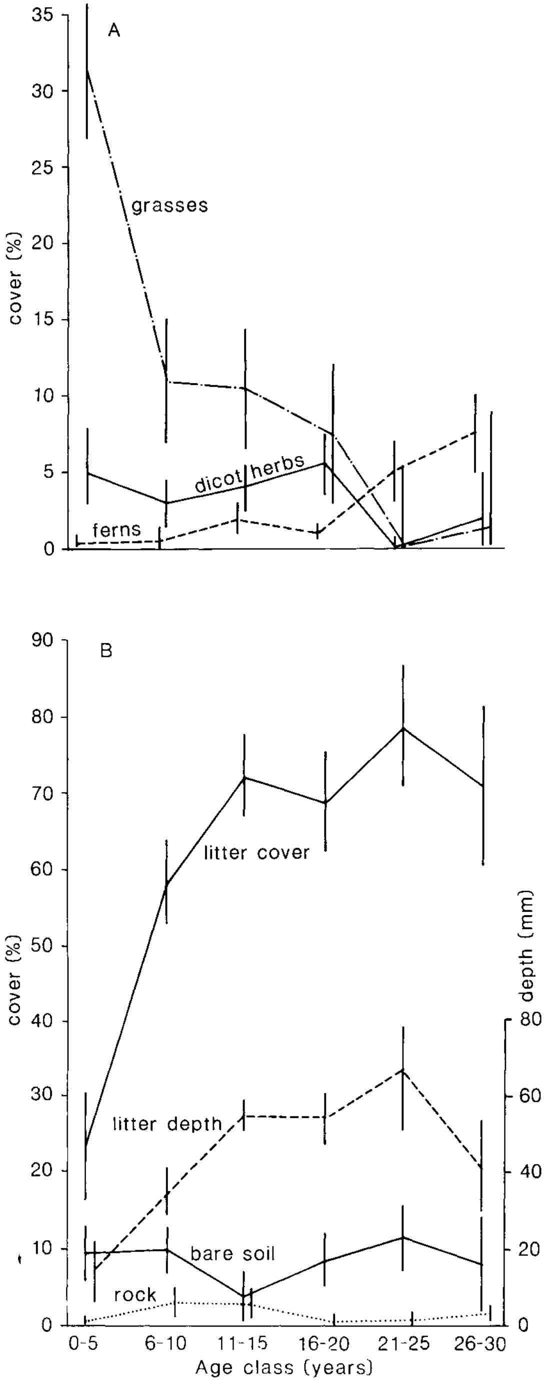


Fig. 6 Understorey features of *Ulex europaeus* stands of different age, showing % cover of plants < 0.25 m tall **A**, and % ground cover of litter (+ litter depth), bare soil, and rock **B**.
Mean and standard error are shown.

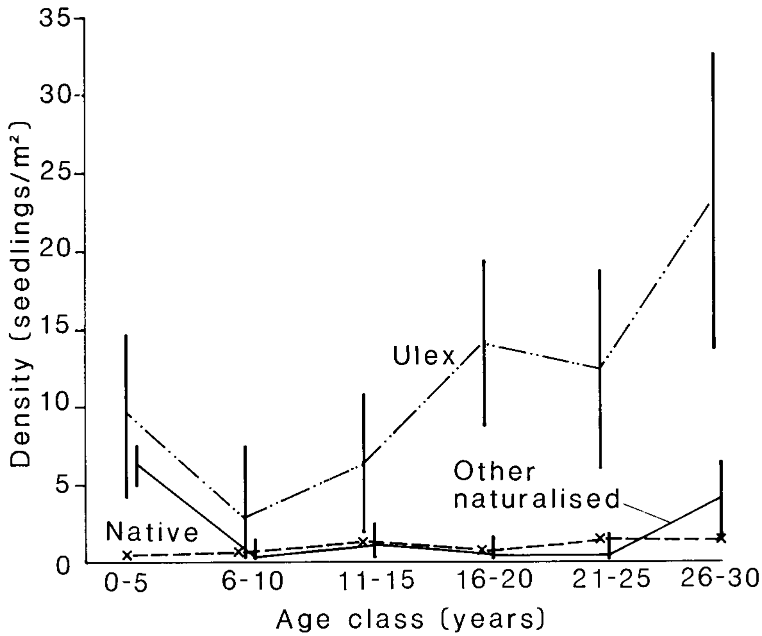


Fig. 7 Seedling densities of *Ulex europaeus*, other naturalised woody species, and native woody species in stands of different age. Mean and standard error are shown.

composites such as *Senecio minimus*, ragwort (*S. jacobaea*), and catsear (*Hypochoeris radicata*) — followed this trend less strongly. Ferns increased in importance in older stands.

Ground cover was mainly gorse litter, which over the first 15 years accumulated in depth at a mean rate of 4 mm yr^{-1}, reaching between 45 and 75 mm depth in mature stands (Fig. 6B). An apparent decline in litter depth occurred in the oldest stands. Combined soil, rock, and bryophyte cover rarely exceeded 10%, with the amount of soil and rock being significantly ($P < 0.05$) greater on steeper slopes.

Seedling density

The highest density of gorse seedlings recorded was 8600 m^{-2}, in a recently burnt 8-year-old stand. High seedling densities were recorded also in some stands less than five years old and on other sites where vegetation had been cleared recently by fire or mechanical means. Generally, where gorse was establishing in rank pasture or a sward of herbaceous plants, seedling densities were much lower (i.e., < 15 m^{-2}).

Seedling density was lowest in the 6–10 year age class (Fig. 7), but increased steadily with the age of the stand. Gorse seedling establishment was not significantly influenced by altitude, aspect, or slope.

Associated species

Of the 184 vascular plant species recorded from gorse communities 77% occurred in less than 5% of the plots (Appendix 1). The most frequent species (Table 3) were all naturalised and included 3 perennial grasses (cocksfoot, browntop, sweet vernal), the woody legume broom (*Cytisus scoparius*), and blackberry (*Rubus erythrops*). The most frequent herbs were also mostly naturalised species.

Amongst the woody species, broom and the native vine *Muehlenbeckia australis* were the most frequent, followed by native shrub and tree species, especially mapou (*Myrsine australis*), mahoe (*Melicytus ramiflorus*), broadleaf (*Griselinia littoralis*), kanuka (*Leptospermum ericoides*), and lemonwood (*Pittosporum eugenioides*), with frequencies of between 10 and 15%. Similarly abundant were the deciduous naturalised tree species elder (*Sambucus nigra*) and hawthorn (*Crataegus monogyna*), and the evergreen naturalised shrub barberry (*Berberis darwinii*).

The number of species per plot was slightly greater in older gorse communities, associated with a general increase in the number of both naturalised and native woody species and native herbs (Fig. 8). The number of naturalised herbs, in contrast, declined with increasing stand maturity.

Table 3 Percentage frequency of occurrence of major (i.e., % occurrence > 5) vascular plant species in 125 10 × 10 m quadrats in *Ulex europaeus* stands around Dunedin. *Marks naturalised species.

Species	% occurrence
Trees	
Myrsine australis	14.4
Melicytus ramiflorus	13.6
Griselinia littoralis	12.8
Leptospermum ericoides	12.8
Pittosporum tenuifolium	12.8
**Sambucus nigra*	12.0
**Crataegus monogyna*	12.0
Aristotelia serrata	7.2
Fuchsia excorticata	7.2
Leptospermum scoparium	7.2
**Acer pseudoplatanus*	5.6
Shrubs and lianes	
**Cytisus scoparius*	37.6
**Rubus erythrops*	34.4
Muehlenbeckia australis	25.6
Coprosma propinqua	16.8
**Berberis darwinii*	11.2
**Leycesteria formosa*	9.6
Parsonsia heterophylla	9.6
Rubus schmidelioides	9.6
Coprosma rotundifolia	8.8
**Cotoneaster simonsii*	6.4
Coprosma ciliata	5.6
Grasses	
**Dactylis glomerata*	47.2
**Agrostis tenuis*	32.8
**Anthoxanthum odoratum*	30.4
**Holcus lanatus*	28.0
Herbs	
Senecio minimus	28.5
**Hypochoeris radicata*	24.8
**Senecio jacobaea*	23.2
**Ranunculus repens*	19.2
**Taraxacum officinale*	17.6
**Stellaria media*	16.0
**Trifolium repens*	15.2
**Prunella vulgaris*	13.6
Acaena novae-zelandiae	13.0
**Plantago lanceolata*	12.8
**Cerastium holosteoides*	11.2
**Digitalis purpurea*	11.2
**Galium aparine*	10.4
**Rumex obtusifolius*	9.6
**Rumex acetosella*	7.2
**Sonchus asper*	5.6
Phormium tenax	5.6

Interactions with other woody species

Naturalised species

Broom was commonly recorded with gorse in stands younger than 10 years but was rare in plots where the gorse was older. Other naturalised woody species generally followed this trend, and were less important in the older communities (Fig. 9). Seedling densities suggested that establishment of naturalised woody species was mainly in very young and very old stands.

Native woody species

Seedlings of native woody species occurred in all gorse stand age classes at a low and relatively constant density of $< 2\ m^{-2}$ (Fig. 7). Stem densities declined sharply over the first 10 years (Fig. 10B) but gradually increased between 15 and 25 years. During this period basal area increased 8-fold, to around 54 $m^2\ ha^{-1}$ (Fig. 10A), and in the 21–25 year age class the dominance and abundance of the native woody species matched that of the resident gorse. However, in the oldest stands sampled both density and basal area of native species were lower than in stands in the 16–20 and 21–25 year classes.

In 64% of quadrats native woody species were absent. Less than 40% of plots in all age classes younger than 25 years contained seedlings or stems of native tree or shrub species, but these did occur in six of the seven plots which contained gorse over 25 years old.

A comparison of plots with or without native woody species identified some of the site and vegetation features that favoured the establishment and growth of native plants. In stands less than 15 years old, native species occurred in gorse stands of lower density (Fig. 11B), more open canopy (Fig 11D), and on less steep sites (Fig. 11G). The high light requirements of both manuka (*Leptospermum scoparium*) and kanuka (*L. ericoides*) restricted their establishment to this early phase, but a range of woody species could occupy the site with the pioneering gorse. In older gorse stands, where density and cover were lower the presence of mainly shade-tolerant broadleaved native species was favoured by tall vegetation (Fig. 11E), and shallow litter depths (Fig. 11F) associated with steeper slopes (Fig. 11G). There appeared to be no relation between gorse basal area and the presence of native woody species (Fig. 11A). Gorse seedling numbers followed similar trends in plots both with and without native species. (Fig. 11C), the highest densities being reached in older stands. However, densities were usually slightly less beneath a canopy including native species.

DISCUSSION

Gorse was sold locally by seed merchants and nurseries up until the 1890s for use as shelter and fodder (Jill Hamel pers. comm.) and has spread now throughout the eastern coastal areas of Otago. Here it grows from coastal sites through to at least 650 m a.s.l., on the Maungatua Range, mostly on soils

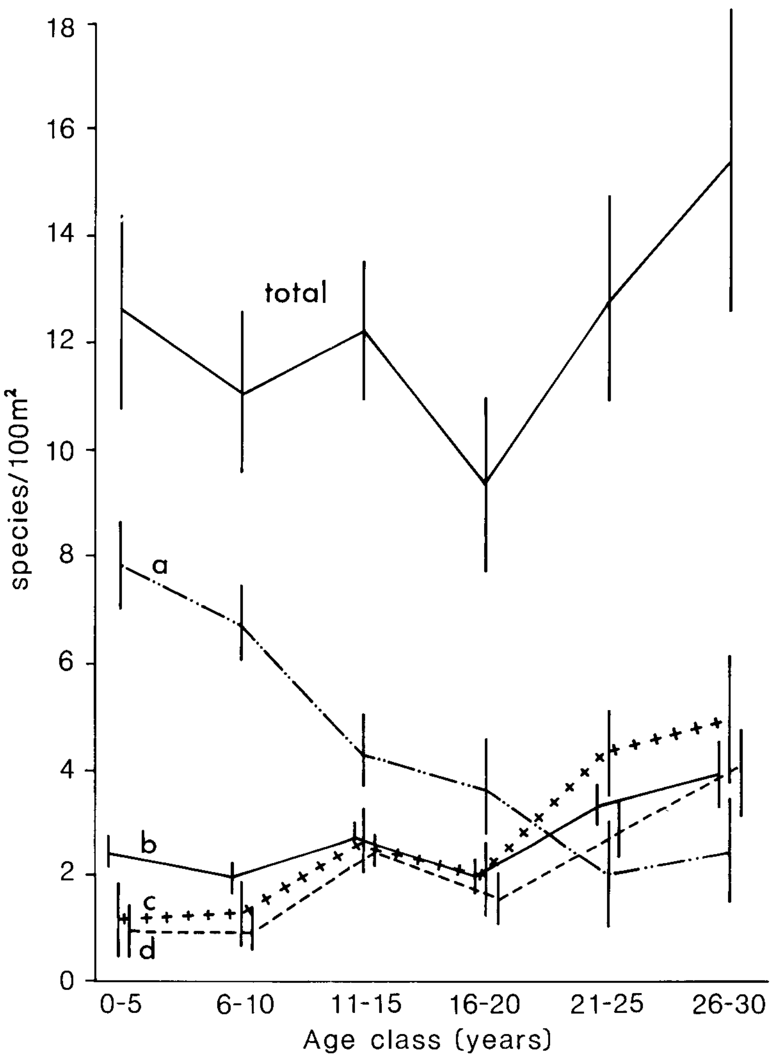


Fig. 8 Species richness (vascular plants only) in *Ulex europaeus* stands of different age: total species and **a** naturalised herbs, **b** naturalised woody plants, **c** native woody plants, and **d** native herbs. Mean and standard error are shown.

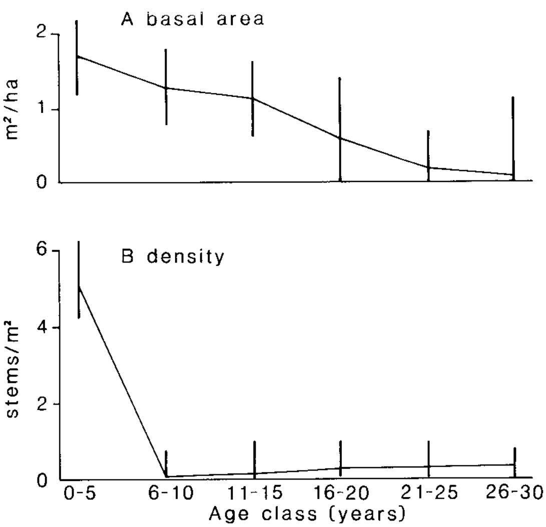
derived from loess or weathered volcanic rocks, but including sand dunes and alluvium. Gorse is able to establish following modification or removal of the native vegetation, usually forest or shrubland, in areas of low intensity pastoralism. Seed may continue to germinate after 30 years in the soil, making gorse extremely difficult to eradicate from pasture (Zabkiewicz 1976).

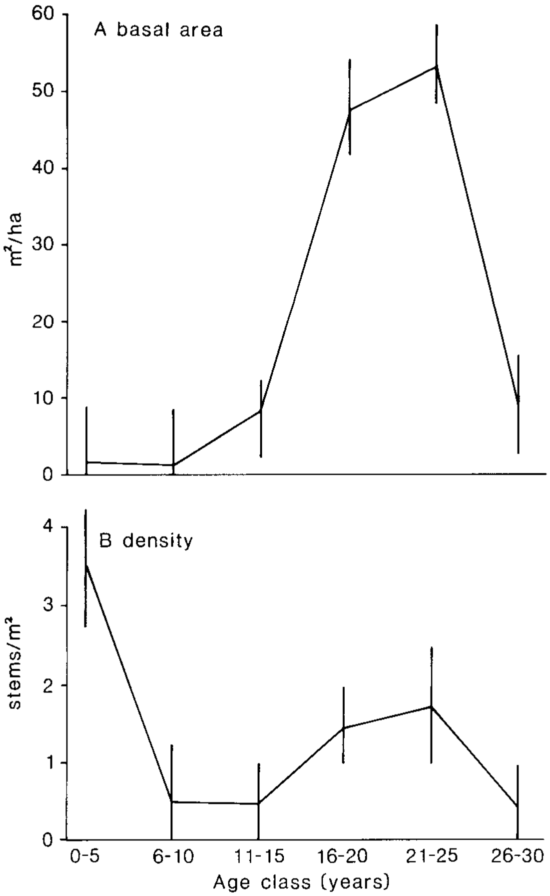
Gorse seedling densities are highest on burnt or cleared sites where gorse has formerly grown, and lowest in pasture of sweet vernal, cocksfoot, Yorkshire fog, and browntop, species characteristic of the slightly to strongly acid, moderately fertile soils that occur in the area. In the Dunedin area much gorse establishment follows burning or clearing of

Fig. 9 *(opposite above left)* Basal area **A** and density **B** of naturalised woody species in *Ulex europaeus* stands of different age.
Mean and standard error are shown.

Fig. 10 *(opposite below left)* Basal area **A** and density **B** of native woody species in *Ulex europaeus* stands of different age.
Mean and standard error are shown.

Fig. 11 *(opposite right)* Comparison of *Ulex europaeus* basal area **A**, stem density **B**, seedling density **C**, canopy cover **D**, canopy height **E**, litter depth **F**, and slope **G**, in plots with (dotted lines) or without (solid lines) native woody species in *Ulex europaeus* stands of different age. Mean and standard error are shown.


A basal area
m²/ha
B density
stems/m²
0-5
6-10
11-15
16-20
21-25
26-30
Age class (years)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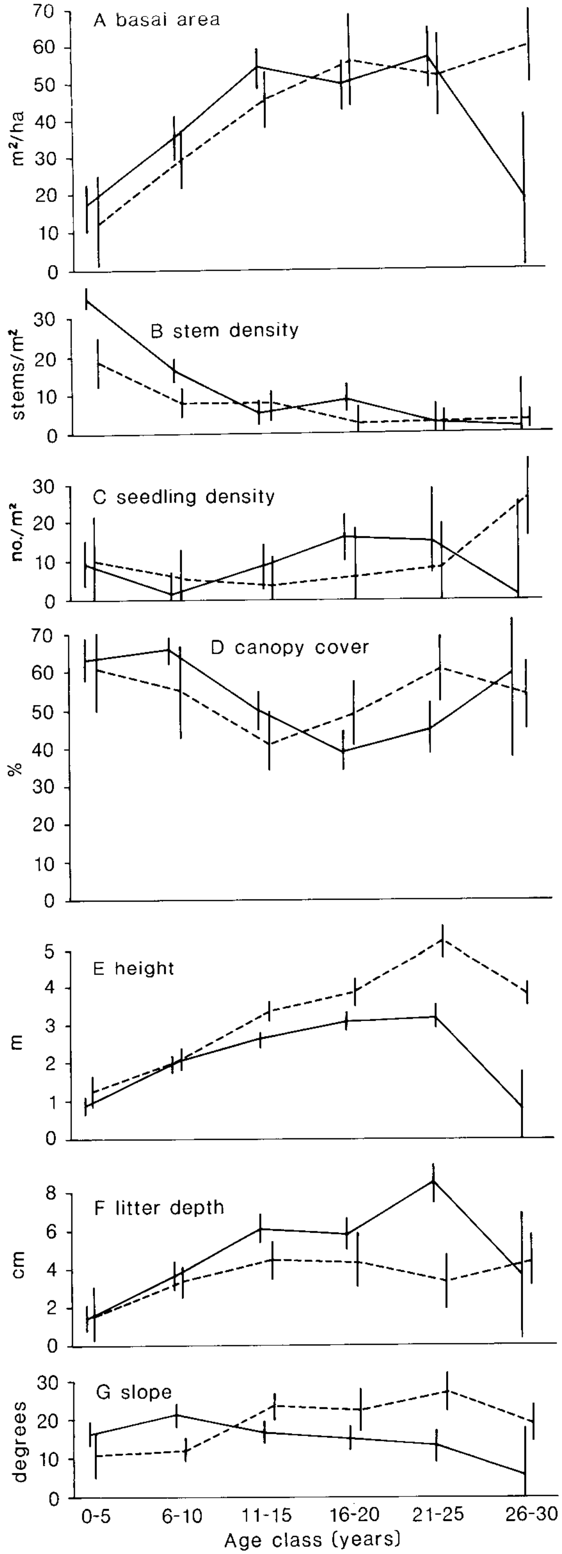
A basal area
m²/ha
B stem density
stems/m²
C seedling density
no./m²
D canopy cover
%
E height
m
F litter depth
cm
G slope
degrees
0-5
6-10
11-15
16-20
21-25
26-30
Age class (years)

existing vegetation, resulting in a preponderance of dense stands of gorse lacking any native species.

Within gorse stands, during the first 15 years after establishment, there are high rates of self-thinning, litter accumulation, height extension and diameter growth. These conditions stabilise after 15–20 years when the community reaches maturity. The final, senescent phase begins at about 20–25 years. No gorse plants were located which were older than 30 years, this being younger than has been recorded from elsewhere in New Zealand (e.g., 46 years, Druce 1957). A. P. Druce (pers. comm.) has evidence that gorse plants fail to produce discernible growth rings when they are senescent, indicating that some of our oldest plants could be 5–10 years older than calculated.

Around Dunedin other naturalised woody species are unimportant in gorse stands. Broom may establish with gorse but is generally displaced within 15 years. Williams (1981) demonstrated that where both species occur, broom is more successful on young, highly mineral alluvial soils, which are rare around Dunedin. Hawthorn occasionally grows with pioneer gorse in minor amounts. Elder is not important and does not form an intermediate stage preceding the return of native forests as appears to occur when broom is the pioneering shrub (Williams 1983).

Canopy dominants in native forest remnants around Dunedin are generally the broadleaved trees mahoe, lemonwood (*Pittosporum eugenioides*), wineberry (*Aristotelia serrata*), kohuhu (*Pittosporum tenuifolium*), marbleleaf (*Carpodetus serratus*), broadleaf, *Fuchsia excorticata*, and three-finger (*Pseudopanax colensoi*), with the two *Leptospermum* species, kanuka, and manuka. In this study all these species were generally of sporadic and sparse occurrence in gorse communities. Their failure to enter gorse was not correlated with altitude or aspect and is unlikely to be due to the unavailability of seed since all plots were within a hundred metres of areas of native scrub or forest. Native woody species were excluded initially by high densities of gorse plants and, at a later stage, by the deep litter. Gorse produces a prodigious amount of litter arising from the short-lived dwarf shoots (Egunjobi 1969). Although chemical features of gorse litter (Egunjobi 1969) would be unlikely to inhibit the germination of native seeds, it may be too coarse-textured, deep, and dry for the germination and survival of seedlings.

The restricted age range of the gorse stands sampled (30 years) limits accurate prediction of the future of gorse on these sites. Gorse evidently can remain free of native woody species for at least 25 years. Stands older than 25 years usually contain native woody seedlings or young plants, and these would be expected to grow on with the new generation of gorse which arises from resprouting stem bases and seed germination after collapse of the senescent parent gorse canopy. During gorse senescence establishment of native species would be facilitated by the reduced density of gorse, and by disturbance of gorse litter. Native species are longer-lived and grow taller than gorse. It is estimated that establishment of a native canopy and consequent demise of gorse on an undisturbed site would take no more than 50 or 60 years. Where *Leptospermum* establishes with gorse on a newly cleared site, the native species would displace gorse in 25 to 30 years.

In certain habitats which will not support forest, gorse may be a naturally stable community. For instance, some steep ledges on coastal cliffs on the seaward side of the Otago Peninsula support low gorse that is unlikely ever to be replaced completely in the longer term by either native or naturalised tree species. Such habitat cannot develop a canopy of other woody species which would overtop gorse, while the steep and permanently disturbed nature of the ground maintains sites where gorse can re-establish easily.

Druce (1957) reports gorse in Wellington as vigorous in 10-year-old scrub, but senile in 34-year-old, and dead in 40-year-old scrub where it has been replaced by native tree species. Healy (1969) recorded gorse being replaced by native forest species in Canterbury at between 15 and 25 years. Factors likely to facilitate these more rapid successions are the possible faster growth rate of native species and the more rapid decomposition of gorse litter in the warmer northern climates.

Management of gorse to facilitate the re-establishment of the native flora in biological reserves would depend primarily on the prevention of disturbances, such as burning or mechanical clearing, as these favour the establishment of dense young gorse and prolong the dominance of the species. This study has demonstrated that native woody species establish within mature gorse stands on bare soil or bryophytes; sites relatively free of gorse litter. Succession from gorse to native forest could be hastened by disturbance of litter to provide such sites for natural establishment, by planting native shrubs and trees in gorse stands, or perhaps by dense sowing of native seed on sites newly cleared of gorse.

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Appendix 1 List of minor (i.e., % frequency of occurrence < 5) vascular plant species from 125 10 × 10 m quadrats in *Ulex europaeus* stands around Dunedin.
*denotes naturalised species

Trees
Carpodetus serratus
**Cupressus macrocarpa*
**Eucalyptus delegatensis*
**E. globulus*
**Ilex aquifolium*
Myoporum laetum
Pennantia corymbosa
**Pinus radiata*
Pittosporum eugenioides
Pseudopanax colensoi
P. crassifolius
P. simplex
**Quercus robur*
Schefflera digitata
Sophora microphylla
**Sorbus aucuparia*

Shrubs and lianes
**Azara microphylla*
Cassinia vauvilliersii
Clematis paniculata
Coprosma colensoi
C. crassifolia
C. foetidissima
C. linariifolia
Coprosma aff. *parviflora*
C. rhamnoides
C. robusta
**Erica lusitanica*
Gaultheria antipoda
Hebe salicifolia
**Hedera helix*
**Lupinus arboreus*
Metrosideros diffusa
Olearia arborescens
**Passiflora mollissima*
Pernettya macrostigma
Ripogonum scandens
**Ribes sanguineum*
**Rosa rubiginosa*
Rubus cissoides
**R. laciniatus*
Urtica ferox

Herbaceous dicotyledons
**Achillea millefolium*
**Anthemis* sp.
**Aphanes arvensis*
**Calystegia silvatica*
Cardamine debilis
**Carpobrotus edulis*
**Centaurium erythraea*
**Cerastium glomeratum*
**Cirsium vulgare*
**Conium maculatum*
Cotula squalida
**Crepis capillaris*
Cyathodes fraseri
**Epilobium ciliatum*
Geranium microphyllum
**G. molle*
Gonocarpus aggregatus
Haloragis erecta
Hydrocotyle americana
H. moschata
H. novae-zelandiae
**Hypericum androsaemum*
Lagenifera strangulata
**Leontodon hispidus*
**Lotus pedunculatus*
**Mimulus guttatus*
**Mycelis muralis*
**Nemesia floribunda*
Nertera depressa
**Oxalis incarnata*
**Plantago major*
**Polygala serpyllifolia*
**Ranunculus acris*
R. foliosus

Appendix 1 cont.

**Rumex crispus*
Schizeilema trifoliolatum
**Sedum reflexum*
Senecio biserratus
S. glomeratus
**Solanum nigrum*
**S. tuberosum*
**Sonchus oleraceus*
**Stellaria alsine*
S. parviflora
Tetragonia trigyna
**Trifolium arvense*
**T. dubium*
**T. pratense*
**Veronica arvensis*
Viola filicaulis
Wahlenbergia gracilis

Monocotyledons

**Aira caryophyllea*
**Agropyron repens*
**Ammophila arenaria*
Astelia fragrans
**Bromus mollis*
Bulbinella angustifolia
Carex coriacea
C. dissita
Chionochloa rigida
Cordyline australis
**Crocosmia × crocosmiiflora*
**Cynosurus cristatus*
Dichelachne sciurea
**Juncus antarcticus*
Lepidosperma australe
**Lolium perenne*
Luzula picta
**Phleum pratense*
**Poa annua*
P. breviglumis
Uncinia angustifolia
U. rupestris
U. uncinata
**Vulpia bromoides*

Ferns

Asplenium bulbiferum
A. flabellifolium
A. lyallii
A. terrestre
Blechnum capense
B. discolor
B. fluviatile
Cyathea colensoi
C. smithii
Dicksonia squarrosa
**Dryopteris filix-mas*
Histiopteris incisa
Hypolepis ambigua
H. millefolium
Phymatosorus diversifolius
Polystichum richardii
Todea hymenophylloides