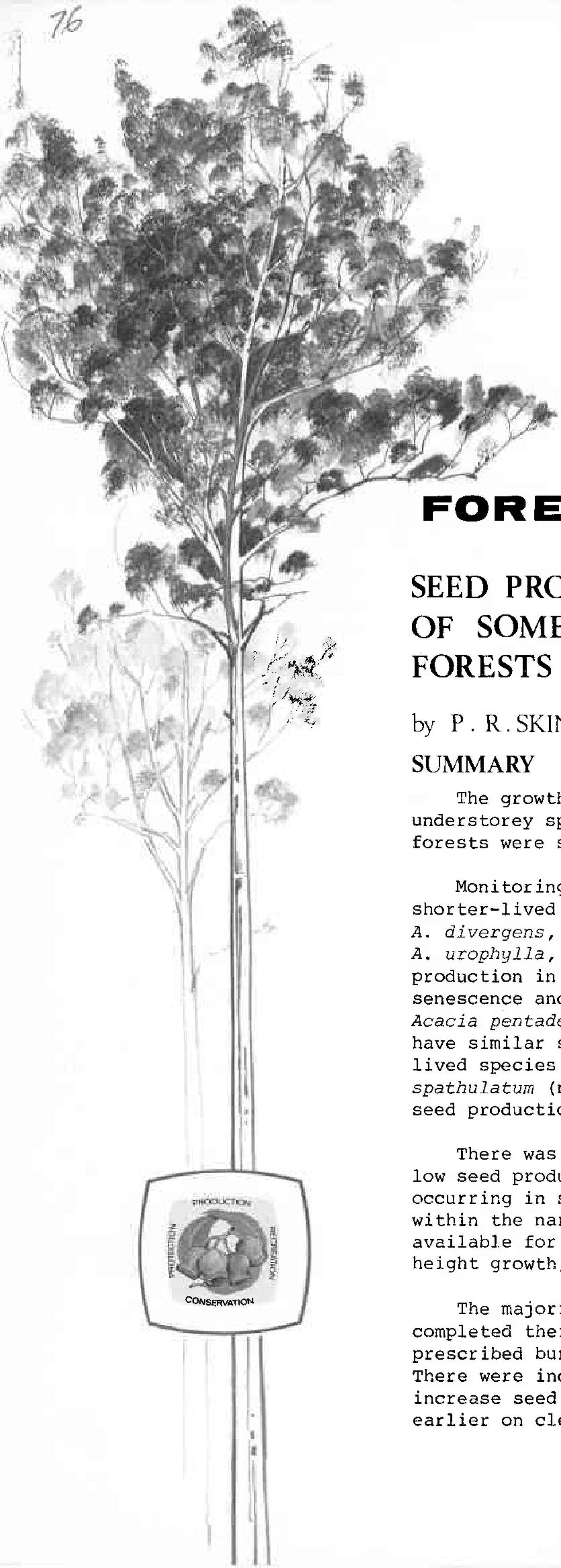

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FORESTS DEPARTMENT
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SEED PRODUCTION AND SURVIVAL OF SOME LEGUMES IN THE FORESTS OF WESTERN AUSTRALIA

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SUMMARY

The growth and seed production patterns of some major understorey species of Western Australia's south-west forests were studied.

Monitoring over an eight-year period showed that some shorter-lived species of legumes, namely *Acacia browniana*, *A. divergens*, *A. myrtifolia*, *A. pulchella* and *A. urophylla*, reached maturity and commenced seed production in three years and then quickly succumbed to senescence and death. The longer lived legume species *Acacia pentadenia* and *Bossiaea linophylla* appeared to have similar seed production patterns. Two other longer lived species studied, *B. laidlawiana* and *Trymalium spathulatum* (not a legume), did not reach their full seed production by age eight.

There was a distinct pattern of alternate high and low seed production years, with very high seed production occurring in some species. Differences in site factors, within the narrow range of soil and moisture conditions available for each species, had no apparent influence on height growth, survival or seed production.

The majority of the leguminous species studied completed their life cycle and seemed to be promoted by prescribed burning on a six to nine year pattern. There were indications that hot fires could significantly increase seed production, and that deaths occurred earlier on clear felled areas.

INTRODUCTION

A large proportion of wet sclerophyll karri (*Eucalyptus diversicolor*) and mixed karri/marri (*E. calophylla*) forest understorey is made up of fire-sensitive, hard-seeded legume species. The nitrogen fixing properties of these legumes play an important role in forest fertility, and their production of fungus-inhibiting micro-organisms reduces the susceptibility of the forest to *Phytophthora cinnamomi* (Shea, 1979).

The non-leguminous hazel (*Trymalium spathulatum*), is a major species of the karri understorey on the better loams.

Seeds of these species accumulate in the soil and litter, and can lie dormant for very long periods. For germination to occur, the seed coat needs to be made permeable to water (Beadle,1940). This is usually caused by fire, which cracks open the seed coat and allows moisture to enter. Thus the pre-dominant hard-seeded understorey species germinate prolifically after fire (Christensen & Kimber,1975).

Since 1953 the Forests Department has adopted the practice of prescribed burning every six to nine years, to reduce fuel levels in forest understorey.

A study was needed of the life cycle and seed production of preferred understorey species (legumes), to establish whether existing burning patterns favoured their promotion.

Growth measurements, survival counts and seed production were monitored for nine species within 27 plots over an eight year period, that is between two ground clearing operations.

The plots were placed to test a wide range of site factors. It was clearly established that seven of the nine species studied had completed their useful lifecycle and peak seed production had occurred within six years. Site factors had no significant effect on growth rates or seed production.

METHODS AND MATERIALS

Species chosen for the study were *Acacia browniana, A. divergens, A. myrtifolia, A. pentadenia, A. pulchella, A. urophylla, Bossiaea laidlawiana, B. linophylla* and *Trymalium spathulatum*. These species are all fire sensitive and regenerate from seed, with the exception of *B. linophylla* which regenerates mainly from subterranean rootstock. *Trymalium spathulatum (Rhamnaceae)* was the only non-leguminous species studied.

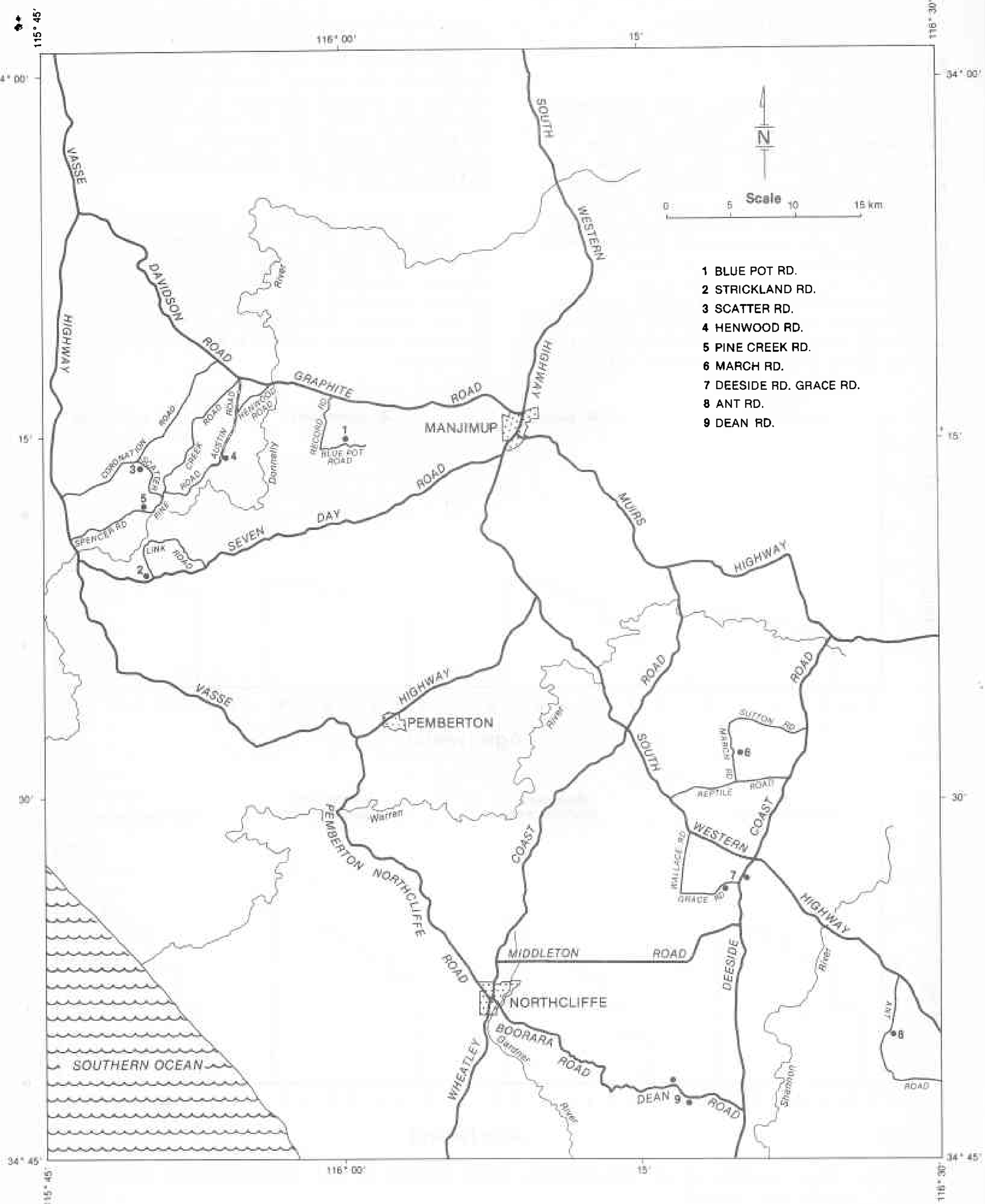
Two to four plots were selected for each of the nine species. Within each plot ten plants (marked and numbered) were chosen at random within 5 m of a central peg. Plots were located on the greatest possible range of soil and forest types, within a 50 km radius of Manjimup, at Blue Pot Road, Pine Creek Road, Scatter Road, Henwood Road, Strickland Road, March Road, Grace Road, Ant Road and Deans Road. (Map page 3).

Study areas were selected where the date of the previous burn, and hence the age of the plants, was known. All plots were established before the plants had reached seed-bearing age, except for one each of the *A. browniana* and *B. laidlawiana* plots, sited within an area of four-year-old scrub at Blue Pot Road (Appendix 1).

Annual height growth was measured with a height rod over a six-year period, by which time most species had reached their maximum height.

Survival counts were made annually and continued for a further two years, after which 13 of the original 27 plots had been disturbed (burnt or cleared) and were unsuitable for further measurements.

Seedfall was measured by placing three 0.4 m^2 (one tenth mil-acre) wire mesh trays at random points within each plot. Seedfall totals are therefore an average collection from the plots of each particular species, not just from the ten marked plants on each plot. Seed trays were placed in the plots in early December, before the seed pods ripened, and left until late February before pickup. Only the seed of the species under study was counted. It was assumed that the proportion of seed eaten by insects or birds was approximately the same within the trays as with that falling on the surrounding area. No excessive numbers of insects were seen in the trays at any stage.



115° 45'
116° 00'
15'
116° 30'
34° 00'
15'
30'
34° 45'
N
Scale
0 5 10 15 km
1 BLUE POT RD.
2 STRICKLAND RD.
3 SCATTER RD.
4 HENWOOD RD.
5 PINE CREEK RD.
6 MARCH RD.
7 DEESIDE RD. GRACE RD.
8 ANT RD.
9 DEAN RD.
VASSE HIGHWAY
DAVIDSON ROAD
GRAPHITE ROAD
SOUTH WESTERN HIGHWAY
MANJIMUP
SEVEN DAY ROAD
MUIRS HIGHWAY
PEMBERTON
PEMBERTON NORTHCLIFFE ROAD
COAST ROAD
MIDDLETON ROAD
NORTHCLIFFE
BOORARA ROAD
DEAN ROAD
WHEATLEY
DEESIDE
SOUTHERN OCEAN
Warren
Donnelly
Shannon
Gardner River

RESULTS

Height

Within each species, soil differences had little effect on height, though the narrow range of sites available made comparisons difficult (See Appendix 1). With *A. pulchella* for instance, height growth was better on the karri loam at Pine Creek than on the podsol at Scatter Road, while the reverse was the case with *B. laidlawiana*.

The smaller-to-medium sized species, *A. divergens* and *A. pulchella*, had reached well over half their final height by the end of their third year, after which annual height increment progressively decreased till maturity. *Acacia browniana* and *A. myrtifolia* had almost reached maximum height at age three. *Acacia myrtifolia* showed an overall decrease in height in its seventh year, due to severe dying back of leading shoots in that year (Fig. 1). *Acacia urophylla* was still growing in height at age seven.

The larger species, *A. pentadenia*, *B. laidlawiana* and *T. spathulatum*, grew at much the same initial rate as the smaller species, but sustained their annual growth increment over the six-year period of the trial. Individual *A. pentadenia* at Ant Road reached some 7.5 m in height at age eight.

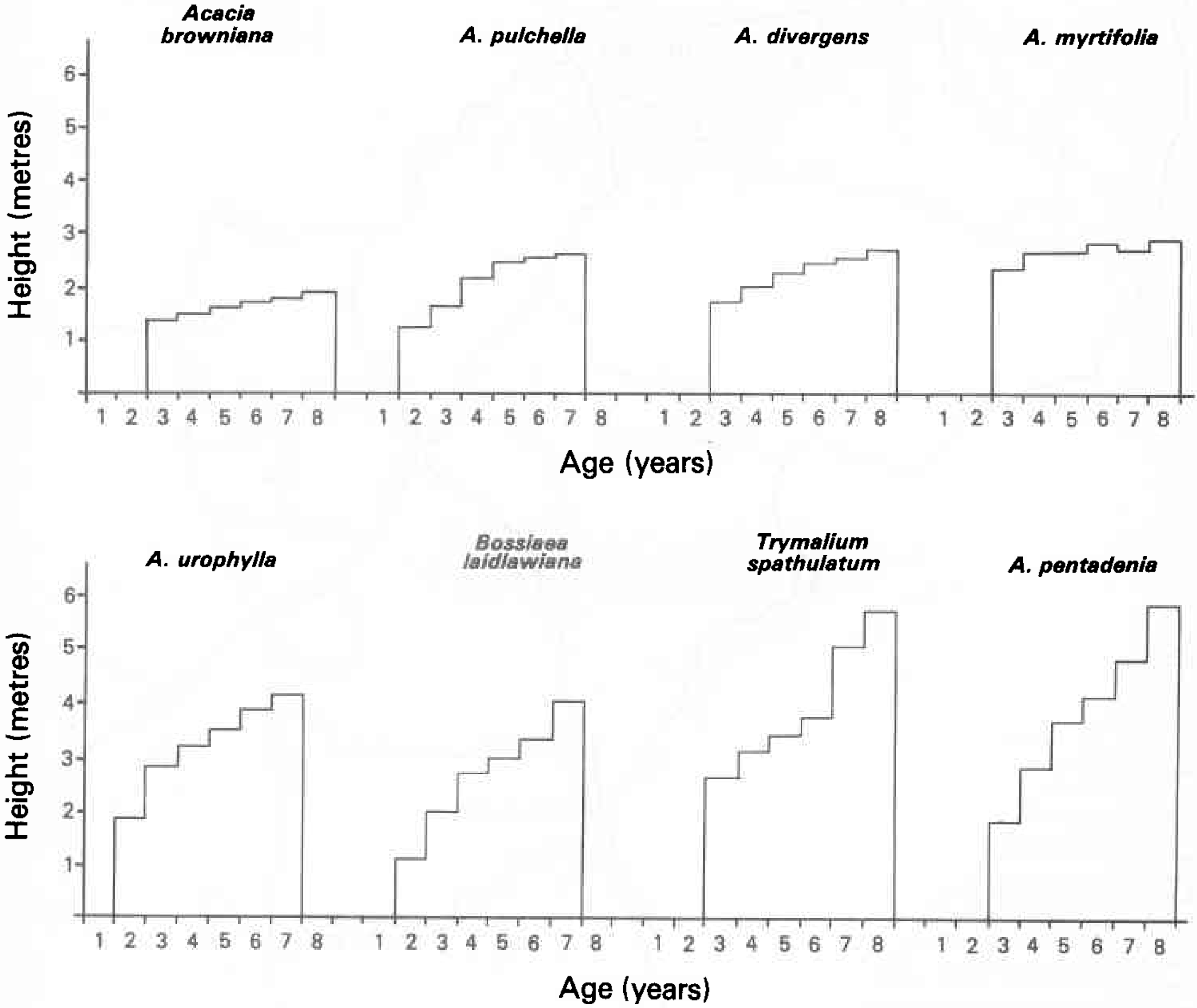


Figure 1. Mean heights of wet sclerophyll scrub species on all sites measured over a six year period .

Survival and Longevity

The smaller species, *A. browniana* and *A. pulchella*, were short-lived, the majority of them being either dead or in an advanced stage of senescence by their eighth year. *Acacia divergens* was similar to *A. pulchella* at year eight, though most of the remaining plants were senescent at that stage (Fig. 2). *Acacia browniana* generally had the shortest life span, with only one five-year-old plant surviving at March Road.

Acacia myrtifolia and *A. urophylla* were also short-lived, although their survival rate was higher in the first five years. After their sixth year degeneration accelerated, *A. myrtifolia* suffering badly from insect gall attack, defoliation and senescence. Although the *A. myrtifolia* survivals were greater at the time of measurement in year eight, the plants were severely degraded, and within three months had all died. The *A. urophylla* plots still had several survivors one year after the final measurements.

As measurements commenced when plants were two to three years old, Figure 2 does not reflect percentage casualties prior to this.

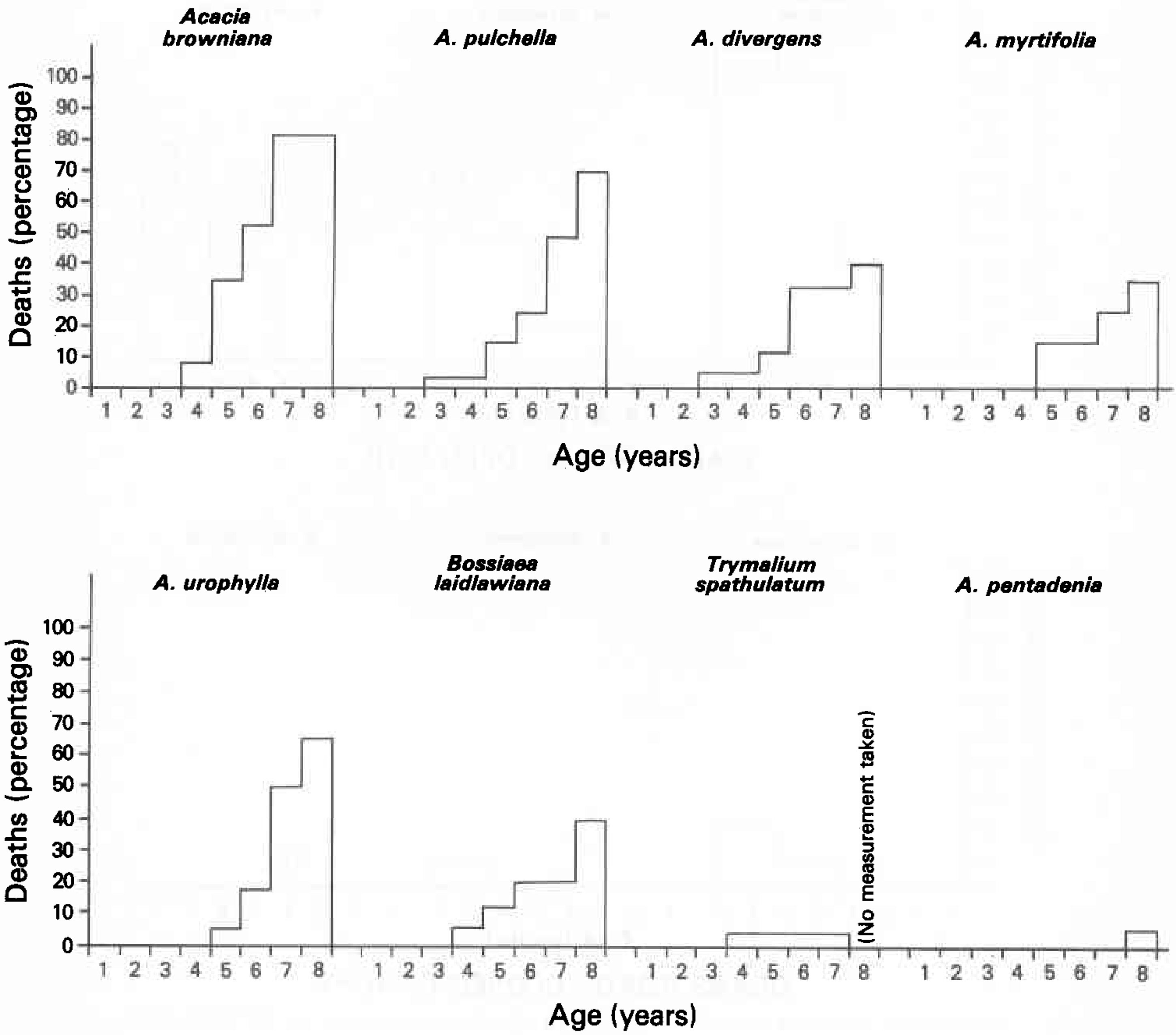


Figure 2. Casualties in wet sclerophyll scrub species over an eight year period.

There appeared to be some relationship between the presence of overhead canopy and survival rates of the short-lived species. The majority of plots had tree canopy varying from light to heavy, and there was no discernible pattern of deaths in these. At March Road, which was the only completely open area, earlier deaths were more prevalent in *A. browniana*, *A. divergens*, and *A. myrtifolia* than in comparable plots in other areas (Fig. 3).

Of the three larger species, *A. pentadenia*, *B. laidlawiana* and *T. spathulatum*, most plants were still surviving at age eight, the only casualties apparently caused by suppression or cyclone damage (plots destroyed by fire, clearing or falling trees were excluded from the assessment). The exception was the plot of *B. laidlawiana* at Pine Greek, where the first death occurred when the plants were four years old, and a steady deterioration took place in the plot until remaining plants died in their seventh year. The earlier deaths appear to have been the result of competition from *T. spathulatum*, which became the dominant species on this site.

Survival rates were better in the two *B. linophylla* plots, with all plants remaining healthy in their eighth year.

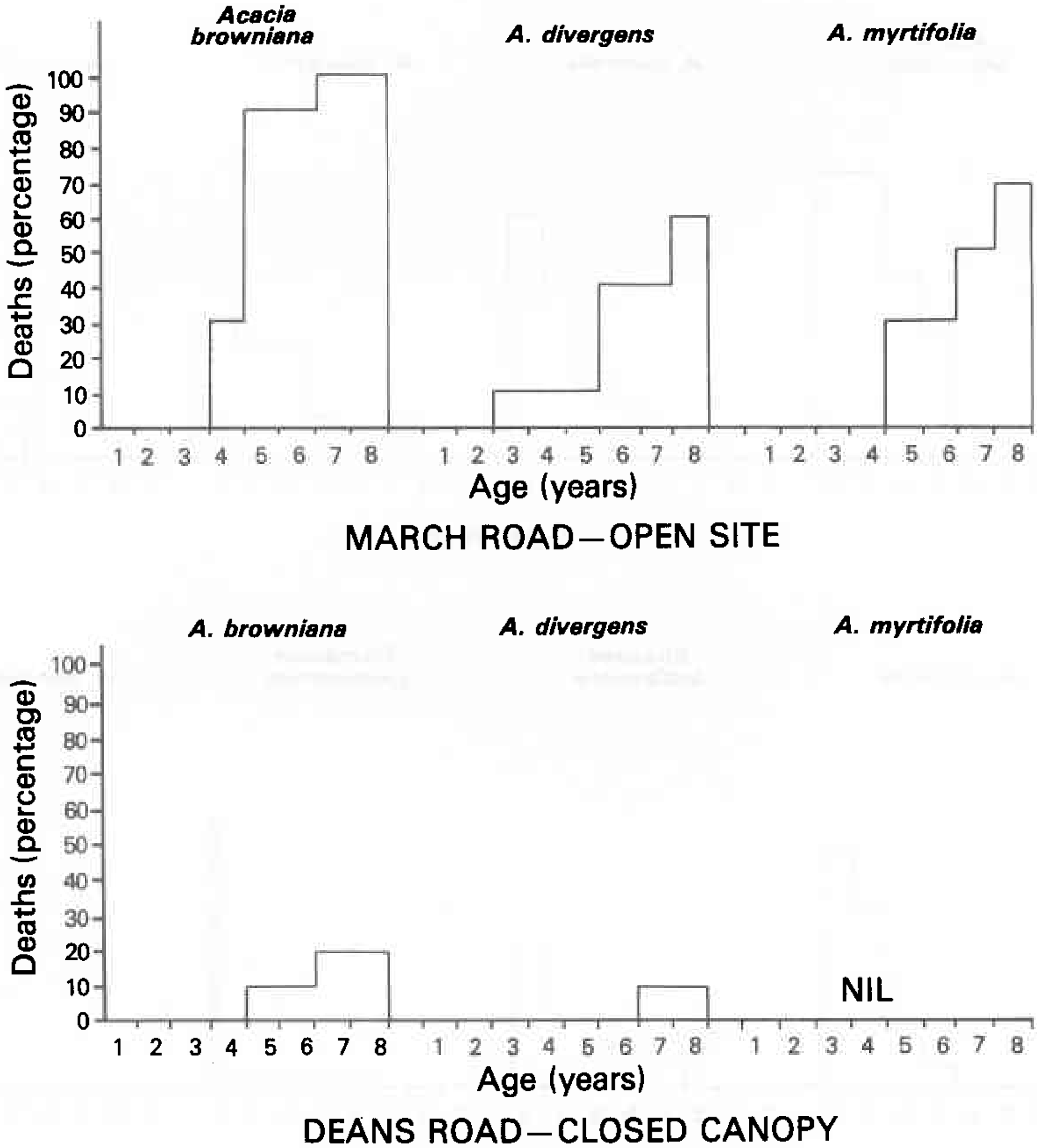


Figure 3. Percentage casualties of some acacia species compared on an open site and with closed canopy.

Seed Production

Throughout the study period an alternate high/low pattern of seed production occurred in the mature plants, irrespective of the age of the plant (Table 2). (The only species in which this pattern was absent was *T. spathulatum*). The cause of this fluctuation was not apparent.

No seed trays were put out in December 1971, but observations were made of flowering and seed pod production of the three and four-year-old trees at Blue Pot and Deeside Roads (burnt December 1968 - March 1969). The very low production observed may have been a result of the plant's immaturity, but is more likely to have coincided with a poor seed year. In December 1972, the following seeding season, plots of the four species (*A. pulchella, A. urophylla, B. laidlawiana* and *B. linophylla*) containing three-year-old plants consistently produced very high seed figures.

Most species produced some seed in their third year (Table 1), though the count was generally low. Much of the early inflorescence aborted during the flowering or budding stage. Seed production continued until age six or seven in all the short-lived Acacias, after which the deaths of many plants, and senescence of the remainder, drastically reduced production. *Acacia pentadenia* produced most seed in its fourth year, after which production progressively decreased until its eighth year, while *B. linophylla* appeared to reach its peak at six-years old, as its production at eight-years was significantly lower (.001 level in Chi-square test).

The longer-lived *B. laidlawiana* and *T. spathulatum* had apparently still to reach full production when these trials concluded. *Trymalium spathulatum*, produced no seed until its fifth year. Although inflorescence occurred in this species at ages three and four, it aborted prior to seed forming.

The distinct pattern of high and low seed years is shown in Table 2, the difference between both being significant at the 0.05 level (Student's t test). The low total seed production in 1976, which (according to the pattern) should have been a high year, was caused by the senescence and death of most of the short-lived plants and the declining seed production of *A. pentadenia*, the longest-lived of the Acacia species.

TABLE 1
Age of seed production in wet sclerophyll scrub species.

SPECIES	AGE IN YEARS					
	3	4	5	6	7	8
Acacia browniana	x	x	x	x	x	x
" *divergens*	x	x	x	x	x	l
" *myrtifolia*	x	x	x	x	o	o
" *pentadenia*	x	x	x	x	x	l
" *pulchella*	x	x	x	x	l	o
" *urophylla*	x	x	x	x	x	l
Bossiaea laidlawiana	x	x	x	x	x	x
" *linophylla*	x	x	x	x	x	x
Trymalium spathulatum	f	f	x	x	x	x

f - flowers, no seed produced
x - seed produced
l - production low

TABLE 2
Seed production in wet sclerophyll understorey scrub species (seeds/m^2)

SPECIES	YEAR				
	1972	1973	1974	1975	1976
Acacia browniana	1457	7	465	5	75
" *divergens*	1325	10	3822	50	52
" *myrtifolia*	985	10	1107	-	-
" *pentadenia*	2225	50	272	42	5
" *pulchella*	3905	65	3957	87	-
" *urophylla*	4490	185	3705	545	392
Bossiaea laidlawiana	57	5	25	22	445
" *linophylla*	130	27	1377	127	705
Trymalium spathulatum	-	2	185	1175	4800

Some species were consistently high seed producers, particularly *A. divergens*, *A. pulchella* and *A. urophylla*. Other species were uniformly lower seed producers.

Each species showed some variation between sites, however, it was insignificant in most cases. The exception was the March Road site, which over the five-year period produced a significantly greater quantity of seed (varying from .01 to .001 in individual years, Student's t test) for *A. divergens*, *A. myrtifolia*, *A. urophylla* and *B. linophylla*. *Acacia browniana* had significantly higher seed production at March Road in 1972 (.001 by Student's t test), but by 1974 most plants were dead or senescent and production was low.

DISCUSSION

The effect of site differences on height growth was not established, the mean height of each species on different sites being similar, despite considerable variation in individual plants. It was observed that plants tended to more bushy growth on the open sites.

Soil type had no apparent effect on survival rates as deaths were recorded at a fairly even rate within each species, over the whole range of sites. Deaths were slightly earlier at March Road. Though monitoring was not carried out for any species from germination to age two or more, it was observed that many casualties occurred in most species during this period. Studies on the ecology of *Boronia megastigma* show that seedling death rate accelerates from age one to age three, almost half the seedlings dying over this period. Mortality is greatest where seedling density is highest (Christensen and Skinner, 1978).

From the beginning of the trial (at two years old), the size of the existing plants had no apparent relationship to survival, as deaths occurred fairly evenly throughout the height range in each plot.

Seed bearing began in all the legume species during their third year. It was not established whether the low production observed in 1971 was due to the plant's immaturity, or whether seed production was generally low. Seed production reached a peak in the fourth to sixth year of growth in the shorter-lived species, then decreased over the next two years, by which time the majority of plants were dead or in an advanced state of deterioration.

The longest-lived species, *A. pentadenia*, reached peak seed production in its fourth year, but suffered a dramatic decrease in its sixth year (Table 2). Seed tray figures showed a continuing decline in seed production for the subsequent two years, and production in the ninth year, after these trails had finished, was observed to be almost nil. This poses the question: are early seeding and a relatively short seed producing life features of both short and long-lived Acacias of the karri forest?

The cycle of alternate high and low seed producing years was significant (0.05 level, Student's t test), at least throughout the term of this trial, but the reason for this was not clear. The high or low seed year effect was apparent in all species except *T. spathulatum* (the only non-legume), in which seed production built up gradually from the fifth year (Table 2).

Site and shade factors had no obvious effect on seed production, as individual plots under heavy shade achieved similar seed counts to those grown in the open. The high seed production of all species at March Road could have been due to the site being subjected to a very hot burn prior to germination and subsequent ashbed effects (Loneragan and Loneragan, 1964).

Optimum seed production for the legume species appears to fall well within the usually prescribed burning cycle of 6 - 9 years, and this pattern is suitable for the species' promotion. However, best seed germination depends not on the frequency of burn, but on the intensity and season of that burn.

Seed on or within the litter layer is most probably destroyed in the hot fire needed to stimulate germiantion of seed buried in the mineral soil. A cool fire is unlikely to induce any germination at all.

Spring-induced germinants are susceptible to summer drought and browsing by native fauna.

Therefore, although sufficient seed production is available for long term maintenance of legume scrub under current burning regimes, more research is needed into the season and techniques of prescribed burning; a combination of spring and autumn burns could be desirable.

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APPENDIX 1: Details of wet sclerophyll scrub species plots.

LOCALITY	SPECIES	AGE AT ESTABLISHMENT	DATE OF LAST BURN	SOIL TYPE	FOREST TYPE
Blue Pot Road	*Acacia browniana*	4 years old	Nov. 1967	Loam	Karri, dense understorey
	Bossiaea laidlawiana		"	"	"
Deeside Road	*Acacia pentadenia*		Dec. 1968	Karri loam	Marri/karri clear felled coupe
	Acacia urophylla		"	"	
March Road	*Acacia browniana*		Jan. 1969	Podsol	Clear felled coupe
	Acacia divergens		"	Loam	(Karri/marri)
	Acacia myrtifolia		"	Podsol	"
	Acacia urophylla		"	Loam	"
	Bossiaea linophylla		"	Podsol	"
Ant Road	*Acacia divergens*	3 years old	Jan. 1969	Silty loam	"
	Acacia pentadenia		"	Karri loam	"
Deans Road	*Acacia browniana*		March 1969	Podsol	Jarrah/marri
	Acacia divergens		"	Silty loam	Clear felled coupe
	Acacia myrtifolia		"	Podsol	Jarrah/marri
	Acacia pentadenia		"	Loam	Clear felled coupe (karri)
	Trymalium spathulatum		"	Sandy loam	"
Scatter Road	*Acacia pulchella*		Dec. 1969	Podsol	Jarrah/karri
Henwood Road	*Bossiaea linophylla*		Dec. 1969	Sandy loam	Marri/karri
Pine Creek Road	*Acacia pulchella*	2 years old	Dec. 1969	Karri loam	Marri/karri
	Acacia urophylla		"	"	Karri
	Bossiaea laidlawiana		"	"	Karri
Strickland Road	*Acacia pulchella*		April 1970	Loam	Karri
	Acacia urophylla		"	"	"
	Bossiaea laidlawiana		"	"	"