PLANT HARDINESS TRIAL

FIRST YEAR REPORT

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INTRODUCTION

A plant hardiness trial was initiated along the Mitchell Freeway in July 1976 to investigate the feasibility of growing West Australian native plants under freeway conditions without water, or with restricted water during establishment over the first summer and subsequently without water.

The trial was established following requests to the Forest Department from Mr Michael Heath, (Landscape Architect at that time, Landscape Division, Main Roads Department)who was concerned with the high costs of reticulation and the quality and doubtful availability of underground water.

Site Selection

A site along the Mitchell Freeway, between the Loftus Street bridge and Vincent Street, was selected for the study. This site satisfied the main requirements of the test, viz:

(1) It was sufficiently large to test a reasonable number of species with sufficient replications.

(2) It consisted of a flat and a sloping area, thus enabling differences in moisture availability to be tested.

(3) It represented the most common soil type to be found along the freeways, namely a yellow sand fill, obtained from sand quarries at depth. This provides a reasonably sterile medium, virtually free of weed seed and pathogens, although contamination is still possible. The sand at the experimental site contained 0.25% iron and had a pH value of 7.10.

TREATMENTS

Since space was limited for the experiment it had to be restricted to the minimum number of treatments. The treatments considered most relevant were soil improvement, mulch, water and fertilizer.

Soil improvement

A wide range of soil improvement mediums are available, but trials utilizing them all would become unwieldy, and was not considered necessary. Sawdust, humus, top humus sand etc., were eliminated because limited

availability could affect future supplies and thus the feasibility of their use. Cladium peat, the most natural soil improver, was not used because of the high cost, which would limit use on a large scale.

Loam, which is generally used for soil improvement in the Perth metropolitan area, is also expensive and may not always be so readily available, but it was considered the most practicable medium for this experiment. However, some loams are too heavily textured so a friable loam was requested. The loam used had a pH of 5.0 and contained 19% silt, 5% clay, 29% fine sand and 47% coarse sand.

Mulch

To help conserve soil moisture, several types of mulch were considered for the trial.

Stone mulching was avoided because of excessive weight and the difficulties it provides in spreading; damage to plants is likely and intensive labour is necessary.

Pine bark is a popular mulch but because of the heavy demand is sometimes difficult to obtain. As an alternative street tree prunings, passed through a chipper were used.

Vegetation mulches have the disadvantage of being susceptible to fire, which is an important consideration, especially if situated close to vehicle traffic areas.

Water

Initially watering was to be effected by means of 30 cm lengths of plastic piping, 10 cm in diameter, inserted vertically into the soil beside each plant. By filling twice each plant would receive approximately 4.5 litres of water. This procedure was designed to provide available moisture at depth to encourage deep root penetration. However, this method was not practical on a large scale.

The alternative to this was trickle irrigation which was adopted by the Main Roads Department in preference to the plastic piping since it is not as labour intensive and would be the method adopted for future plantings. The main disadvantages of trickle irrigation are inconsistency due to blocking or partial blocking of the micro tubes, and the possibility of not effectively achieving deep water penetration.

The tubes were checked frequently, but sometimes a watering was nearly completed, before blocked tubes were noticed.

To alleviate this the watering was increased from one to two applications of approximately 4.5 litres a week. Plants which died in watered plots were checked to make sure that the micro tube was working effectively.

Fertilizer

Different fertilizer treatments, although desirable, would have made the experiment too cumbersome so a slow release fertilizer, one 10 g Agriform tablet (N:P:K 20:4.3:4.1) per plant was used as a standard treatment throughout.

SELECTION OF SPECIES

The species were selected from a range available from the wildflower nurseries of Mr G. Lullfitz and favoured by local and State Government departments for landscaping. The plants were selected from a diversity of habitats so that if a general trend of a particular ecological type emerged, then it would be possible to postulate on other suitable species. Due to the unavailability of four species from the nursery at planting time, substitutes had to be made. The following list contains the complete range of species planted for the experiment.

Species	Harshest Natural Habitat	Rainfall above or below Metropolitan Area
1. Acacia lasiocarpa	Quindalup Dune System	Same and below
2. Beaufortia squarrosa	Moist sand	Above and below
3. Callistemon (Park special)	Hybrid from Kings Park	same
4. Calothamnus quadrifidus	Spearwood Dune System	same and below
5. Dampiera diversifolia	Moist shallow soils	above and below
6. Grevillea biternata	Loamy sand	below
7. Grevillea thelemanniana	Spearwood Dune System	same
8. Hemiandra pungens	Quindalup Dune System	same
9. Hypocalymma robustum	yellow sand	same
10. Brachysema latifolium	grey sand	same but higher summer rainfall
11. Kunzea baxteri	granite outcrops	below but higher summer rainfall
12. Kunzea pomifera	leached sand	below
13. Melaleuca elliptica	granite outcrops	below
14. Isopogon cuneatus	lateritic soil	same but higher summer rainfall

15.	Myoporum parvifolium purpurea	leached sands	above

EXPERIMENTAL DESIGN

The experiment was designed as a factorial experiment.

TREATMENT 1 SOIL TYPES

(a) Yellow sand

(b) 7.5 cm of loam incorporated into the top 30 cm of sand.

TREATMENT 2 MULCH

(a) No mulch

(b) Clipped street prunings to a depth of approximately 2 cm per plot.

TREATMENT 3 WATER

(a) No water

(b) Approximately 4.5 litres of water twice weekly

TREATMENT 4 SITE

(a) Slope

(b) Flat

TREATMENT 5 REPLICATES

10 plants set at random on each plot

METHOD

The plants were raised at Mr G. Lullfitz' nursery at Wanneroo. This nursery arranged by contract to grow the plants in plastic tubes (5 cm x 7.5 cm) with a balanced root system.

On the plots that received loam, loam was worked into the sand to a depth of 30 cm. On the steep slope it was difficult to mix the loam uniformly.

The mulch was placed on the surface of plots to be treated, to a depth of 5 cm.

Planting was completed before the end of July, which is considered by the Forests Department to be the latest date for planting stock which is to rely on natural rainfall for establishment.

A slow release fertilizer in the form of one 10 g Agriform tablet was placed 5 cm from the plant's root system and at half the depth.

The trickle irrigation was designed by Mr. K. Cole from the Department of Agriculture and was installed on randomized plots of each treatment

prior to the cessation of the rain.

The trickle system was checked in November by taking eight readings covering the flat and slope. The slope readings were taken at intervals down the slope and the flat at random tubes. The range was 500-680 ml over a quarter hour period. The mean provided 4.5 litres per plant if the water was left on for two hours.

At the end of the summer more readings were taken which entailed three consecutive readings at six positions on the flat and six on the slope. The range was 750-800 ml with a mean of 777 ml over a quarter hour period or 3.1 litres per hour. The range of water received by each plant during the summer months was 4.5-6.2 litres twice a week.

Measurements were taken after the rains ceased in November and according to the habit of the plant. Ground covers were measured across the widest spread and at right angles to this spread. Shrub measurements were recorded as height and spread. Follow-up measurements were taken when the winter rain commenced and watering was no longer necessary.

Insect attacks and disease were recorded under the following headings:

(1) Leaf-eating insects

(2) Sap-sucking insects

(3) Diseases

Leaf colour was recorded to denote differences caused by drought or the addition of loam. Three categories were used:

(1) Healthy green

(2) Pale green

(3) Yellow

As the assessment progressed no colour changes were evident but wilting became apparent on plants under stress. This factor was recorded according to its presence or absence.

Rainfall

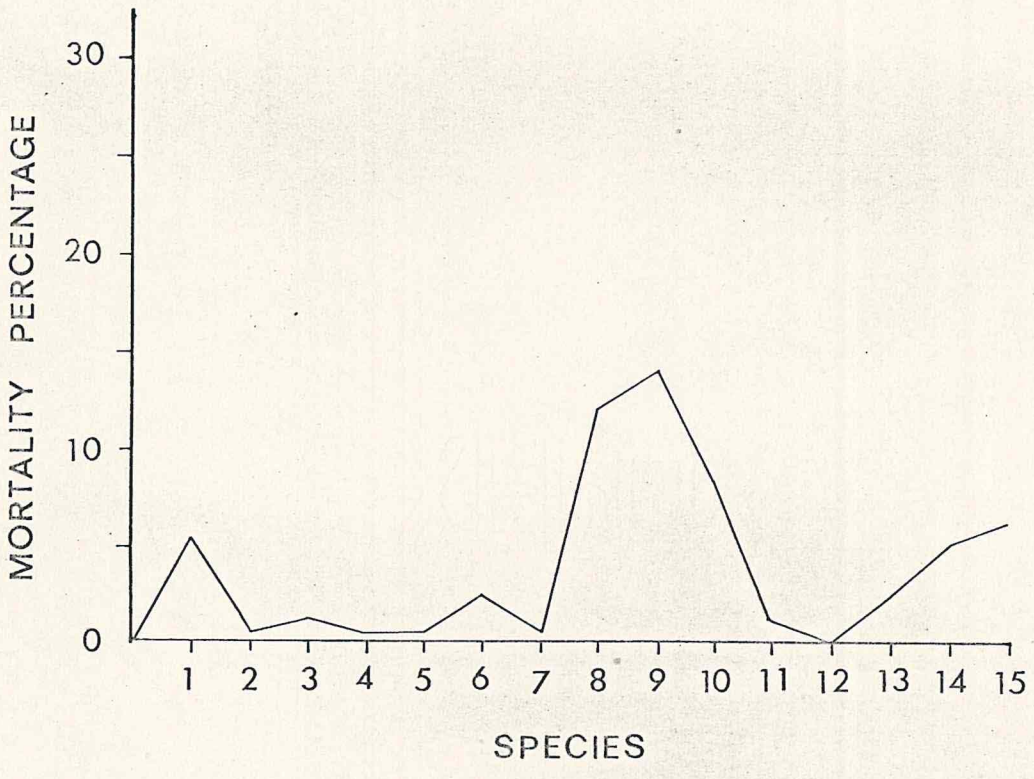
The year of establishment of the trial was a drought year with low winter rainfall and a summer of exceptionally low rainfall and above-average temperatures. From December to April inclusive, the rainfall was one third of the average normally received over this period. The conditions were ideal to establish a plant hardiness trial.

	1976										1977				
	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Rainfall (mm)	2	66	73	85	117	140	58	53	39	7	4	15	7	0	115
Average monthly rainfall (mm)	20	46	124	184	174	139	81	55	21	14	8	11	20	46	124

RESULTS: FIRST ASSESSMENT

Plants were assessed for survival rate at the end of November, when the ground was still moist from intermittent rains. Thus, it was assumed that no deaths due to drought would have occured up to this date. Figure 1 shows the percentage of mortalities of the different species.

FIG. 1



Hypocalymma robustum and Hemiandra pungens showed the highest mortality rates of 14.1 and 12.4% respectively. These were followed by Brachysema latifolium, Myoporum parvifolium, Acacia lasiocarpa and Isopogon cuneatus with mortality rates ranging from 5.2 to 8.5%. The mortality rates for the other species ranged from 0 to 2.6%. Poor handling at the initial planting of the first six species made some early replacements necessary. These were not included in the mortality percentage calculations, so that the actual percentage of deaths would have been higher than it

appears.

The reason for the high mortality in a select range of species can be attributed partially to the unskilled labour used for the planting programme. The plants affected were either ground covers which had spreading instead of upright foliage or else belonged to the slower growing group which would not have the strong stems or root systems of the more vigorous growers. Both types are prone to damage by rough handling. This became evident following a survey of the trial a few weeks after planting.

Insect attack

At the November assessment Beaufortia squarrosa, Callistemon 'Park Special', Calothamnus quadrifidus, Hypocalymma robustum, Kunzea pomifera and Melaleuca elliptica showed signs of attack by Lepidopterous larvae. The Lepidoptera order covers the range of moths and butterflies. The species which attacked these plants lay their eggs in the growing tips, the resulting larva then eats into this section of the plant, retarding growth. The infestation increased during December and control measures were considered. However, it was reasoned that if planting was extensive, spraying would not be an economical proposition, so they were left. By the end of January the pest was gone and new growth was not affected.

Wilting

Wilting was confined to unwatered areas and was recorded first in February and continued until April. Following dews and rain in May the plants revived immediately.

In Figure 2 the wilting percentage of plants is tabulated. It is evident that the yellow sand areas are superior to those with loam incorporated. Similarly the yellow sand plot showed a lower wilting percentage than the yellow sand with mulch. This is thought to be due to the retention of moisture in the surface layer by the mulch, encouraging the roots to remain close to the surface. When this surface moisture eventually dries out the plants are placed under stress and wilting occurs. In the unmulched plot the roots would tend to follow the moisture zone and would be more resistant to drought affects. This indicates that

PERCENTAGE OF PLANTS THAT WILTED - SLOPE

GENUS & SPECIES	Loam & Mulch			Loam			Sand & Mulch			Sand		
	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.
Acacia lasiocarpa	-	38	50	29	29	71	14	14	71	-	-	43
Beaufortia squarrosa	-	55	55	40	50	60	22	-	33	-	20	30
Callistemon 'Park special'	10	60	40	40	50	80	20	50	50	20	30	40
Calothamnus quadrifidus	-	18	27	10	20	60	-	10	30	10	10	10
Dampiera diversifolia	71	83	83	43	71	62	-	30	30	33	-	43
Grevillea biternata	30	20	10	80	50	50	50	-	40	20	20	20
Grevillea thelemanniana	80	60	60	75	50	75	22	22	22	30	-	-
Hemiandra pungens	-	-	20	17	17	29	-	-	57	-	-	-
Hypocalymma robustum	25	100	50	50*	50*	100	75	88	80	67	50	67
Brachysema latifolium	67	83	67	100	50*	50*	71	71	57	25	14	14
Kunzea baxteri	55	89	89	88	88	80	67	67	57	55	33	67
Kunzea pomifera	-	-	-	9	18	45	-	-	11	-	-	-
Melaleuca elliptica	-	-	20	-	-	30	-	10	-	-	10	10
Isopogon cuneatus	75	100	100	100	**	**	17	40	40	100	50*	50*
Myoporum parvifolium purpurea	66	66	100	80	50	100	60	40	60	**	**	**

* 2 plants only

** all dead

FIGURE 2

PERCENTAGE OF PLANTS THAT WILTED ON FLAT PLOTS

GENUS & SPECIES	Loam & Mulch			Loam			Sand & Mulch			*** Sand		
	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.
Acacia lasiocarpa	33	67	100	67	89	89	30	70	60	-	-	-
Beaufortia squarrosa	70	80	90	60	60	90	33	67	78	-	-	-
Callistemon 'Park special'	44	78	89	78	89	100	70	70	70	-	-	-
Calothamnus quadrifidus	43	29	86	82	54	82	40	50	60	-	-	-
Dampiera diversifolia	33	33	33	100	100	100	30	80	67	-	-	-
Grevillea biternata	67	88	88	100	100	100	73	82	73	25	-	25
" thelemanniana	20	30	80	100	40	90	100	75	63	-	-	-
Hemiandra pungens	29	71	57	100	100	100	50	75	86	-	-	-
Hypocalymma robustum	71	71	80	100	100	100	67	80	100	-	-	-
Brachysema latifolium	71	75	75	80	100	100	25	75	50	-	-	-
Kunzea baxteri	50	80	80	90	88	100	80	70	78	-	-	-
Kunzea pomifera	17	42	50	40	50	90	-	33	13	-	-	-
Melaleuca elliptica	25	78	78	22	55	89	9	55	63	-	-	-
Isopogon cuneatus	67	*	*	100	**	**	80	50	69	-	-	40
Myoporum parvifolium purpurea	50	22	33	100	100	100	71	100	33	-	-	25

* one plant only
** all dead
*** sand plot received accidental watering therefore results are invalid

mulching under conditions of natural establishment is not beneficial in the first year. Unfortunately, the sand plot on the flat received water on a few occasions when new staff from Main Roads Department turned on a nearby sprinkler to water other plants. Although the watering was minimal it was evidently sufficient to alleviate wilting and so this plot cannot be included in this year's assessment. It can however be included in next year's assessment. The sand and mulch plot on the flat showed less wilting than the loam-incorporated plots.

Survival at end of first summer

In early May, following the first winter rains, another survival count was made and the results were statistically analysed at the 0.05 probability level (Fig. 3). Six species, viz: Acacia lasiocarpa, Hemiandra pungens, Hypocalymma robustum, Brachysema latifolium, Kunzea baxteri, Isopogan cuneatus and Myoporum parvifolium purpureum showed preferences for particular treatments. The other nine species showed a uniform survival on all treatments.

DISCUSSION

Figure 3 shows the plant mortalities which can be expected in the first five months of establishment, together with preferences for particular treatments revealed by the plants.

Acacia lasiocarpa showed a preference for no water. Initially it responded well to water, but then some suddenly died. In its natural habitat Acacia lasiocarpa occupies two extremes of soil type, the dry Quindalup dune system where it develops into a short dense spreading shrub, and the heavier soils inland where it is more open in habit and of taller stature. Both areas are dry in so far as the Quindalup dune system is a porous sand and the inland areas receive low rainfall.

Hemiandra pungens showed a preference for sand with no mulching. This species also occurs on the Quindalup dune system where it forms large mats of ground cover. Its range extends into the Cottesloe system and the Darling Ranges but does not form as large or vigorous plant as the former.

Hypocalymma robustum occupies the yellow sands of the Karrakatta

FIGURE 3

RATE WHICH CAN BE EXPECTED

DEATH IN FIRST FIVE MONTHS OF ESTABLISHED PLANTS

(an asterisk indicates a preferred treatment)

Species	Flat	Slope	Sand	Loam	Mulch	No Mulch	Water	No Water	90% Confidence Interval for deaths if given prescribed treatment
1. Acacia lasiocarpa								*	5% - 17%
2. Beaufortia squarrosa									3% - 10%
3. Callistemon 'Park Special'									0% - 2%
4. Calothamnus quadrifidus									0% - 2%
5. Dampiera diversifolia									5% - 13%
6. Grevillea biternata									0% - 3%
7. Grevillea thelemanniana									3% - 9%
8. Hemiandra pungens	*		*						0% - 13%
9. Hypocalymma robustum					*				6% - 19%
10. Brachysema latifolium	*				*				0% - 12%
11. Kunzea baxteri					*				0% - 7%
12. Kunzea pomifera									1% - 5%
13. Melaleuca elliptica									0% - 4%
14. Isopogon cuneatus					*				15% - 31%
15. Myoporum parvifolium	*				*				0% - 1%

dune system and fine gravels of the Darling Ranges. Its preference for water could be attributed to its slow rate of growth and may have responded better if planted as a slightly larger specimen.

Brachysema latifolium preferred sand and water which typifies its natural habitat where it grows in sand and benefits from some summer rainfall.

Kunzea baxteri also receives some summer rainfall in its natural habitat and showed a preference for water.

Isopogon cuneatus occurs naturally in lateritic soils receiving some summer rainfall: it responded well to water.

Myoporum parvifolium grows in the leached sands of the south coast where it receives summer rain. The variety purpureum showed a preference for sand and water.

Growth rates

The growth rates over the five month period were also statistically analysed at the 0.05 probability level (Fig. 4). They were analysed separately on height and spread and their total growth combined in the histograms (Fig. 5).

The growth rates of all species was understandably influenced by watering (Fig. 4). Three species Calothamnus quadrifidus, Hypocalymma robustum and Isopogon cuneatus grew taller in the loam and water treatment, and the spread of Grevillea biternata was greater, than on the unwatered plots. Grevillea thelemanniana was influenced in height and spread by mulching and water and Acacia lasiocarpa, Grevillea biternata, Hypocalymma robustum, Kunzea baxteri and Melaleuca elliptica showed a preference for the slope. The reason for the slope preference is not clearly understood. Some compaction of the flat may have taken place during construction of the freeway. Aspect or some unknown factor could also be responsible.

CONCLUSION (1st year)

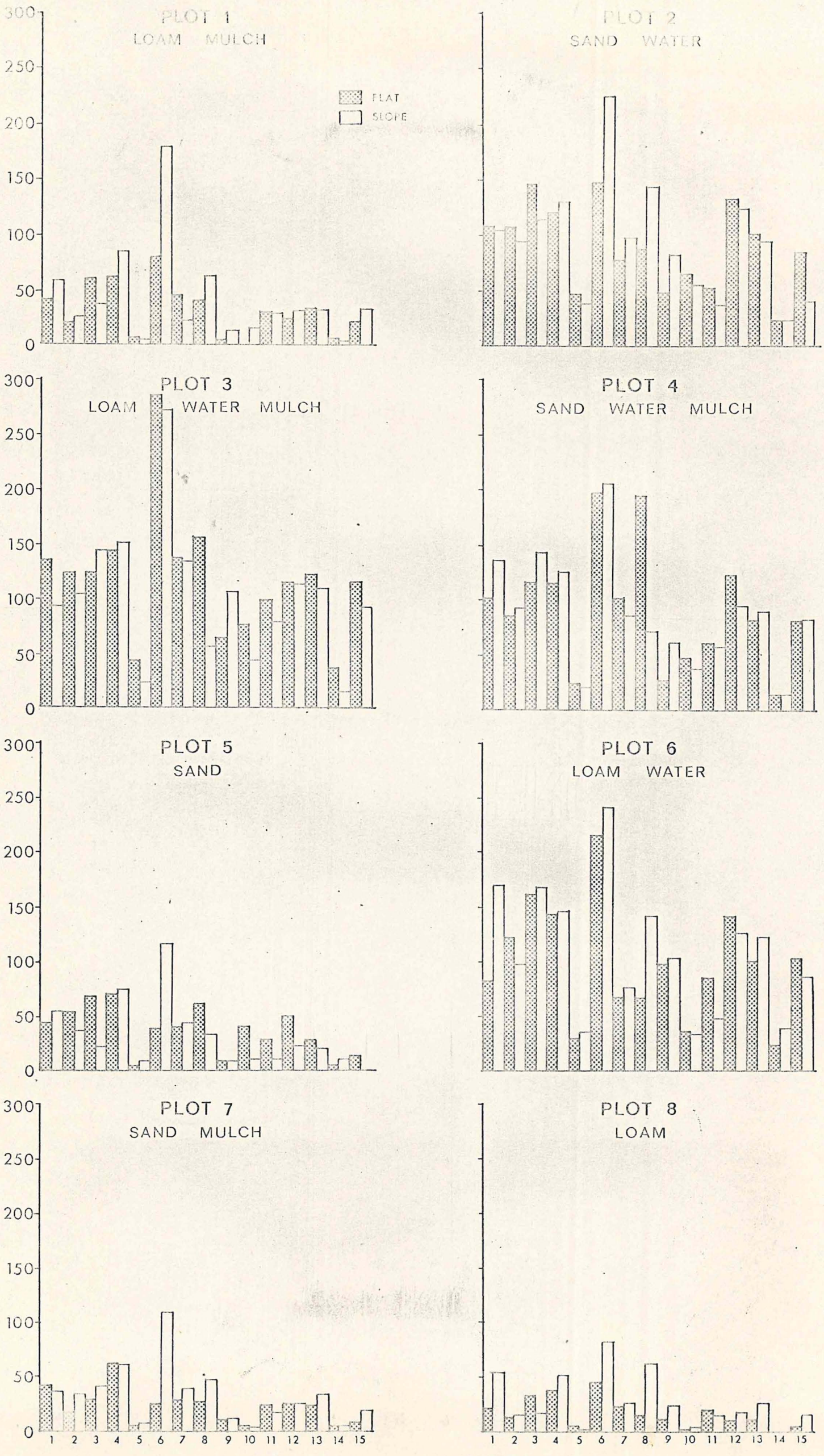
For the short period that the trial has been operative it is difficult to form any definate conclusions. The critical assessment will be after the summer of 1978 when the plants which were watered during the first summer will have experienced one summer without water. Some facts that are

FIGURE 4

		HEIGHT				SPREAD			
		Water	Loam	Mulch	Slope	Water	Loam	Mulch	Slope
1.	Acacia lasiocarpa	*			*	*			
2.	Beaufortia squarrosa	*				*			
3.	Callistemon 'Park Special'	*				*			
4.	Calothamnus quadrifidus	*	*			*			
5.	Dampiera diversifolia	Ground		Cover		*			
6.	Grevillea biternata	*			*	*	*		
7.	Grevillea thelemanniana	*		*		*		*	
8.	Hemiandra pungens	Ground		Cover		*			
9.	Hypocalymma robustum	*	*			*			*
10.	Brachysema latifolium	Ground		Cover		*			
11.	Kunzea baxteri	*			*	*			
12.	Kunzea pomifera	Ground		Cover		*			
13.	Melaleuca elliptica	*			*	*			
14.	Isopogon cuneatus	*	*			No	Spread		
15.	Myoporum parvifolium	Ground		Cover		*			

1. All species do better with water.
2. Where LOAM or MULCH is indicated, this is only effective in combination with WATER. Dry LOAM and dry MULCH are equally ineffective.
3. The effect of slope may be due to: (i) Aspect
   (ii) Looser soil in the embarkment giving better root penetration
   (iii) Something else
4. All conclusions are at the .05 probability level.

FIG. 5


PLOT 1
LOAM MULCH
FLAT
SLOPE
PLOT 2
SAND WATER
PLOT 3
LOAM WATER MULCH
PLOT 4
SAND WATER MULCH
PLOT 5
SAND
PLOT 6
LOAM WATER
PLOT 7
SAND MULCH
PLOT 8
LOAM
300
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

evident following the first assessment are:

(1) Plants can be successfully established without artificial water providing they are planted before the end of July.

(2) Plants selected for the site should be natives which, in their natural environment receive an equivalent or lower average rainfall falling over the same annual periods, and grow on the same, or inferior soil types.

(3) Water during the first summer will promote more rapid initial growth.

(4) The addition of loam provides no advantage where natural rainfall is the only source of water.

(5) For vigorous growing plants the tube stock is a suitable size for planting. However, transplanting slower growing or less vigorous species of this size is not particularly successful. Trials need to be established to determine the optimum planting size for these species and to determine whether, in fact, size is the cause of the initial high mortality rates.

(6) Mulching of plants under natural rainfall conditions for the first summer is to no advantage, except where erosion control is needed. On unwatered plots wilting was higher under mulching during March and maintained the same level as unmulched sand during April.

(7) The use of subsoil yellow sand provided a medium free of weed seed. This meant that maintenance costs were nil. Where loam was incorporated and on other areas of main road plantings (outside the trial) where top soil was mixed with the yellow sand, maintenance costs for weed control were high.

Since the assessment of the experiment in early May some other factors have become apparent. On the sand plots foliage colour has changed and is not as deep a green as those plots where loam is incorporated. A foliage analysis of these plants was taken and an iron deficiency recognised. The pH of the yellow sand is 7.1, which is sufficiently high to fix the available iron, resulting in chlorosis of the foliage. Presumably the yellow sand has come from a deep profile in a sand quarry where the lime would have accumulated. The yellow sand in most of the plant's natural habitats are slightly acid which would not interfere with the availability of iron. Over a period of time with sufficient winter rainfall, the lime

will be leached into the lower profiles and the pH lowered to make iron available. In the meantime the iron deficiency will affect the growth of plants on the sand plots and remedial measures will be taken to counteract it.

FACTORS REQUIRING CONFIRMATION IN THE SECOND YEAR

(1) The effect on plants that have been watered over the first summer.

(2) Comparison in growth at the end of the second assessment, particularly between watered and unwatered plots.

(3) The effect of no water on the loam plots that were watered the first summer.

FACTORS REQUIRING FURTHER RESEARCH

(1) The maximum density that can be achieved without watering. This can be assessed from the present trial if the planting is retained.

(2) Can direct seeding successfully replace the planting out of tube stock?

(3) What is the optimum container size for the less vigorous plants that are difficult to establish?

(4) What are the optimum fertilizer requirements. A trial could possibly be established on existing plantings.

SIZE OF PLANTING STOCK

ROOT SYSTEM IN SOIL

WASHED ROOT SYSTEM

YELLOW SAND WITH LOAM INCORPORATED (WATERED)

4 MONTHS AFTER PLANTING

YELLOW SAND WITH LOAM INCORPORATED (WATERED)

10 MONTHS AFTER PLANTING

YELLOW SAND, WATERED
4 MONTHS AFTER PLANTING

YELLOW SAND, WATERED
10 MONTHS AFTER PLANTING

MULCHING TREATMENT

EXPERIMENTAL LAYOUT FLAT AND SLOPE

YELLOW SAND NOT WATERED
4 MONTHS AFTER PLANTING

YELLOW SAND NOT WATERED
10 MONTHS AFTER PLANTING

WEED GROWTH INTODUCED IN TOPSOIL
(OUTSIDE RESEARCH PLOT)

8 YEAR OLD EUCALYPTS GROWING ON PALE YELLOW SAND,
WATERED FIRST SUMMER AND GRASS COMPETITION CONTROLLED