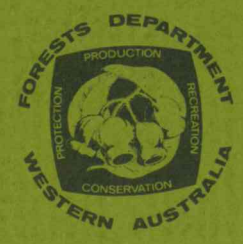
Arboreta in arid and semi-arid parts of Western Australia

A. J. Hart

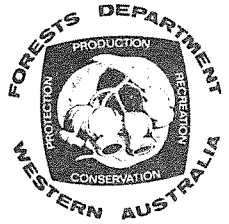
June, 1980



Arboreta in arid and semi-arid parts of Western Australia

A. J. Hart

June, 1980



Tree planting trials have been established over a wide area of the wheat growing areas of the southwest of Western Australia "to collect all the available data possible on trees and plants which can be grown in these regions, with particular attention to relating species to rainfall and soil type".[1]

Since 1949, 53 arboreta of varying sizes have been attempted in the general area of Yuna (N.E. of Geraldton) to Esperance and Gibson in the southeast of the State, with further plots at Kalgoorlie, Coolgardie and Southern Cross.

Some were abandoned after failure due to lack of attention but most plots still contain some species which have survived with minimal tending. These survivors provide a valuable demonstration of the suitability of particular species for the various localities. Lists of species that have been successful in surviving several severe drought years, have been compiled.

PLOT LOCATION

As described in Appendix 1, location of the arboreta is recorded together with rainfall and date of establishment in various climatic zones. Map 1 shows the broad distribution of plots

---

(1) Forests Department of W.A. file on Research Working Plan 10/58.

PAST RECORDS

Early reports on the arboreta were made by Brockway[1], Barrett[2] and Hopkins[3].

Since 1958, inspections and reports have been made by Perry, Thompson and Hart. These reports discussed the factors of the environment that influence tree establishment in dry areas, and set out broad guidelines for maintenance of plots and assessment of results.

Each plot has a documentary background consisting of:

* plan of arboretum at a scale of 1:782.
* duplicate field books including a plan of the arboretum, treatment of the plot, rainfall, and all plot measurements. The duplicate is an office record for security purposes.
* tracings of plot design used to print working prints.
* each plot has its own file for all correspondence associated with establishment and maintenance. Research Working Plans are maintained in separate files and record investigations of soil moisture etc.
* an album of arboreta photographs has been compiled.

PLOT ASSESSMENT

Sub-plots of four trees of each species have been adopted as the basic unit in each arboretum, although occasionally this was expanded to seven, or nine tree modules to test the effect of spacing.

Assessment was concentrated on the sub-plots and surviving trees were categorised as Excellent, Very Good, Good, Fair or Poor. Mean height and crown width was also measured and an over-view comment on plot success is summarised in Appendix 2 titled "Recommended Species Selection Chart".

---

(1) Brockway, G.E. (1953) (1954) (1957) Report on Inland Arboreta W.A.F.D.
(2) Barrett, P.H. (1953) " " " " "
(3) Hopkins, E.R. (1957) " " " " "

Routine soil surveys were made at or about the time of plot establishment, the number of holes dependent on the size of arboretum. Soil samples were analysed for physical condition and nutrient status. The soil descriptions are necessarily generalised but have been related to the Atlas of Australian Soils.[1]

CLIMATIC ZONES AND ARBORETA

Four climatic zones have been described:

Aone 1: Northern Wheatbelt: the zone is bounded generally by a line drawn northeast from Guilderton to Mogumber and Kalannie, then north and northwest toward the Murchison River. The zone has frequent cyclones early in the year, these being the good growth years. Seasons vary widely but the climate is typically mediterranean, with frosts rare except on the inland boundary. A feature of early summer is the evening fogs near coastal areas and a rainfall range of 300 to 625mm a year.

Zone 2: Eastern Wheatbelt: this joins Zone 1 to the north and extends east to the limit of the agricultural land or to the boundary of Zone 4. To the west it is bounded by the 525mm isohyet which is close to the inland border of State forests, and to the south by Zone 3. Arboreta in this zone are established on a considerable diversity of soils, while there appear to be rainfall "shadow" effects, e.g. at Kalannie. Still a typical mediterranean climate, the planting season is from mid-May to mid-July, and watering may be needed in the first summer. Frosts in winter, and summer droughts are common. Rainfall varies from 275 to 625mm a year.

---

[1] C.S.I.R.O. (1967) Atlas of Australian Soils, Sheet 5.

Zone 3: Southern Wheatbelt and Esperance Plains: the 625mm isohyet forms the western boundary, the south boundary is the Southern Ocean while the northern border is the estimated northerly limit of oceanic influences. This latter boundary is about 112 kilometres inland. The Southern Ocean creates more cloud and modifies summer temperatures, while winter conditions are colder and more salt is deposited by on-shore winds. Planting in this area can be early in the autumn due to earlier rains, or even later in the spring, but except on well drained sites, winter planting appears to increase losses due to waterlogging, wind and salt scorch. Rainfall is from 400 to 625mm a year.

Apart from the western section of diverse soils around the Porongorups and Stirling Range, most of the zone is characterised by sandy soils overlying gravelly impermeable clays. More fertile soils are found further north from Scaddan to the northern zone boundary.

Zone 4: Eastern Goldfields: the zone is bounded by Zones 2 and 3 to the west and south, and extends east and north to the limit of agricultural and pastoral activity at the 200mm isohyet. The essential feature of the zone is its unreliable rainfall during the cyclone season and also during years of heavy cyclonic rains.

Frosts are a feature of the zone although its southern edge is slightly modified by oceanic effects in the summer. Soils are frequently more fertile red-brown earths and sands of calcareous origin, but include heavy red-brown clays around Southern Cross in particular.

ASSESSING RESULTS

A series of tables have been produced which correlate successful species with soil types and vegetation types. In Appendix 2 short descriptive notes are included for species most recommended for planting, and numbering 77 in all. These 77 species are regarded as those of superior performance under particular climate and soil conditions. Species suited for zones are also listed.

In compilation of this chart, only species successful on at least 50% of trial sites were included. This has resulted in several species not being recommended due to inadequate test sites.

Species which should be tested further are listed in Appendix 3, and those which have failed are in Appendix 4.

PATTERNS OF DEVELOPMENT

Species that have succeeded to date, have survived at least two severe droughts and usually showed steady, if unspectacular, rates of growth.

Early arboreta of 1948-49 were too closely spaced and have exhibited a degree of natural thinning, in that deaths have been due to competition, not soil or rainfall.

Rabbit damage has been an important factor and future plots should use plastic (Trical) or galvanised wire mesh guards for the first 3 or 4 years.

The range of site and climate suited to Eucalyptus camaldulensis has been shown to be much less than expected. Its range is still wide, but will survive better on deeper soils with adequate moisture.

SPACING OF TREES

This assessment of arboreta has shown that a spacing like 10 metres x 10 metres is preferable in most semi-arid sites. A rule-of-thumb has been derived that the minimum spacing in metres can be found by dividing 2500 by the rainfall in millimetres. Shrubs can be spaced closer or even in open hedge-rows to form a low windbreak.

ESTABLISHMENT AND SITE PREPARATION

Plowing to a depth of about 200mm reduces grass competition, relieves moisture stress in early summer, reduces fire hazard, improves rainfall interception, discourages insect pests and assists ingress of fertilisers. On sites where plowing might initiate erosion or sand blasting, chemical grass control with diquat/paraquat mixtures will reduce fire hazard and give some long term reduction in grass growth. Spraying along planting lines only can further protect seedlings from erosion and wind damage.

FERTILISERS FOR PINUS SPECIES

Pinus species are heavily dependent on early application of appropriate types and quantities of fertiliser, and best results are obtained with application about 3 to 4 weeks after planting.

A rate of 50 to 100 grams per tree is usually adequate.

FERTILISERS FOR EUCALYPTS ETC.

Eucalyptus in general respond to nitrogen and phosphate which can be applied in several mixtures. Such formulae as sulphate of ammonia, blood and bone and urea, and "Agras" (12 parts nitrogen : 52 of phosphorus) should be applied 3 or 4 weeks after planting and at 50 to 100 grams per tree. In drier areas, nitrogenous fertilisers must be applied with great care to avoid burning of the foliage. Barnyard "green" manures may need supplements of nitrogen but are useful when composted prior to use.

EARLY MAINTENANCE (1 to 10 years)

The first two summer and spring periods are crucial in establishment of tree seedlings. During these periods, light inter-row cultivation can be practised and, depending on site, periodic watering could be needed. These activities help to destroy insect refuges, minimise moisture wastage, tide young seedlings over the summer drought and encourage the development of a tap root. The quantity and timing of watering are a matter of judgement but generally should be at a level of 12 to 15 litres per tree per month during the driest 4 or 5 months of the year.

LATER MAINTENANCE (10 years onwards)

After trees have advanced to the stage where crowns have developed and lower limbs have started to fall away so that the crown "lifts", maintenance of arboreta can be achieved by "crash" grazing by sheep, of edible grasses over the planted area. Some pruning of lower branches occurs but does little harm. Harm does occur where sheep are allowed to graze too long or to camp for long periods amongst the trees. Grazing under these conditions in late spring and if necessary, in autumn, helps plot maintenance by cleaning up the litter, reducing fire hazard, reduction of wind erosion and adding minor quantities of animal manure at a time where it will do least harm.

Cattle, and particularly horses, should not be allowed to graze among the trees unless they are securely guarded against damage by bark eating, horn sharpening etc.

Where sheep are not available, reduction of fire risk can be achieved by the use of Vorox AA or similar herbicides to create suitable firebreaks.

THE SIZE OF ARBORETA

From an examination of current survivals in the various plots, it seems that arboreta of less than 200 trees suffer considerable losses, where plots of 300 trees or more maintain a high percent survival despite drought conditions. These figures are associated with spacings of 10 metres by 10 metres, and appear to exhibit a self-protecting factor perhaps related to wind suppression and mutual shading.

EUCALYPTUS CAMALDULENSIS : SPECIAL TRIALS*

Due to the extensive range of river gum (E. camaldulensis) throughout Australia and the apparent susceptibility to insect attacks (lerps) on provenances akin to flooded gum (E. rudis), five trial plots of eleven provenances were set up in 1968 at North Eneabba, Southern Cross, Morawa (light soils) South Merredin (heavy soil) and Shackleton South.

The result of these trials has been the subject of a separate report but, in summary, it was found that 3 or 4 provenances are better than the others for establishment and resistance to insect attack. These strains appear to be characterised by marked anthocyanins in seedlings and soils of less nitrogen status. This in turn is evidently linked to palatability to insects when the plant is under stress.

SALTLAND TRIAL PLOTS

In 1967, two trial plots on salt affected land were attempted with a range of species to test salt tolerance. The results of these trials at Avondale and Wongan Hills have been reported separately but are summarised in Appendix 5.

TREE PESTS

Mistletoe (Amyema miquellii)

During inspections of arboreta, the presence of mistletoe infestation appeared to be increasing, particularly in valley situations of the Canning, Perup, Blackwood, Moore and Avon Rivers, in the wheatbelt east of Narrogin and in the Chapman Valley northeast of Geraldton.

The species most affected were wandoo (inland) (E. wandoo), marri (E. calophylla), flooded gum (E. rudis) and blackbutt (E. patens). The increased activity was attributed to a concentration of birds along the better wooded valleys, and to the prominence of these species where they persist in cleared farmland.

Stem injection of arboricides like 2-4-D and removal of affected limbs are both feasible but expensive methods of control. The long term solution is to extend tree planting schemes to replace those being killed and to reduce bird concentrations.

---

* Forests Dept. of W.A., Research Working Plan 28/68.

INSECTS

Attack on arboreta specimens by insects is common, but is usually more severe on less healthy trees.

The more important insects are grouped as follows:

*Curculionidae : Longicorn beetles, leaf eating caterpillars and wood boring larvae;

*Tenebrionidae : Leaf eating caterpillars and Christmas beetles;

*Scarabaeidae : Scarab beetles, wood boring larvae;

*Hymenoptera : Bag moths, leaf eating caterpillars of Acacia sp.

*Psyllidae : Lerps, leaf eating insects of E. rudis, E. camaldulensis.

BLACK SCALE ATTACK

Activity by black scale is not widespread and is mainly confined to brown mallet (E. astringens), blue mallet (E. gardneri), and inland wandoo (E. wandoo), particularly at East Pingelly arboretum.

Treatment with white oil/water spray and Dieldrin at 0.25% concentration, is effective, particularly if foll-up treatment can be assured.

CONCLUSIONS

* Confidence can be placed in the results of assessments made at this stage. This corresponds to a general age of about 15 years. It is considered that results up to 10 years are not entirely reliable.
* The occurrence of two drought periods in 1969-70 and 1976-77 over most arboreta, have proved the ability of some species to withstand severe drought.
* The most suitable species are those whose natural occurrence is in the same or similar environmental conditions.
* Widespread planting of river gum (E. camaldulensis) needs to be critically examined. Nevertheless, this species is still regarded as having great potential for drought prone areas on favourable moisture gaining sites.
* The use of Pinus pinaster and P. pinea on suitable soils is considered to have considerable merit due to the factors:

  (i) lower costs of plants;

(ii) better windbreak effect due to greater crown depth/ density;

(iii) establishment is easier and attack by disease and insects is minor;

(iv) longevity is as great or better than some of the other genera in arboreta;

(v) because of lower costs, greater numbers can be planted in any one year;

(vi) at suitable spacings and in design with other species they have aesthetic appeal.

However, selection of climate and soil type is of critical importance:

* Over all the arboreta assessed, approximately 50% of the initial plantings have been successful;
* Survival percentage is gradually declining and some localities should be replanted;
* There are still a number of species which warrant further testing in these or additional arboreta;
* Tree establishment can be successful on salt affected land.

RECOMMENDATIONS

1. That the arboreta with currently low stocking should be replanted with suitable species or those requiring further testing.

2. Further inspection of these arboreta be made in 1980-81 and extended to new plots in the Stirling Range area.

ACKNOWLEDGEMENTS

The assistance of various personnel in obtaining this data is acknowledged, particularly Mr S. Curry of Department of Agriculture and Messrs Eastman, van Noort, Hatch and Richmond of the Forests Department.

APPENDIX 1

LIST OF TRIAL PLOTS AND ASSOCIATED DATA BY ZONES

ZONE 1: (See plan for boundaries of zones and precise plot location).

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
7	Mingenew	(1949 (1964	400	Grey quartzy sand over gravelly clay pan		Generally flat	Heavy weeds	
14	Woongoondy via Mingenew	1948	380 (300)	Reddish brown sandy loam with gritty clay hard pan below	6.7	Level	Cropped for cereals for many years.	Small mallees to 6m. Euc. desmondensis and York gum.
15	Morawa (i) Light	1949	400	Yellow loamy sand on clay gravel	6.1	Slight slope (2°) to south.	Cleared for wheat & sheep years ago	York gum and mallees.
	(ii) Hvy soil	1953	(338)	Red loam and clay	7.5	Almost flat - on edge of creek	Cleared years ago for wheat & sheep grazing	York & salmon gums to 15-20m
16	Yuna (i) S/plain	1949	350	Deep yellow sand	6.2	Flat	Cleared for many years & subject to severe erosion	Acacias and Banksia, Grevilleas, Casuarina and Actinostrobus.
	(ii) Heavy		(313)	Yellowish grey loam with red clay gravels below.	7.0	Very slight W. slope.	Salt evident on clearing.	York gum and Hakea & Acacia.
	(iii) Salt			Yellowish grey loam.	6.5	Flat around lake	Cleared about 50 years ago.	York gum mallee
8	North Eneabba	1959-60	525	Grey sand over yellow gravelly clay	6.2	Gentle slope to the south	Cleared and pastured 1956 - oat crop 1957	Dense xerophytic scrub to 1m. Odd Euc. todtiana & E.tetragona
9	South Eneabba	1958-60	625	Coarse grey sand over cemented clay gravel	6.3	Flat	Cleared & plowed 1956. Cropped 1957 then pastured.	Dense xerophytic scrub to 1m.

(420) = Recorded average rainfall - 375 = Interpolation from isohyet plan

Zone 1 (cont'd)

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
10	Badgingarra (West Plot)	1960	600	Pale grey fine sands over mottled red concretions.	6.4	Gentle slope to valley bottom	Natural vegetation of heaths & small banksias & Xmas tree removed for planting.	Small banksias to 2m.
10A	Badgingarra (East Plot)	1960	600	Pale grey fine sand over yellowish impenetrable hard pan.	6.0	Gentle slope 2-3° to N.W. from near ridge.		
11	Miling	1960	360	Yellow sand & sandy loams	6.3	Southerly slope of 1 in 30.	First crop 1953 (wheat) last cropped 1958 Some grazing	Native pear, (Xylomelum), & Actinostrobus sp. & Banksia ashbyi.
1	Marchagee (Gunyidi)	1961 -63	375 (420)	Light brown gritty loam & yellow grey gritty		Gentle slope along creek to S.E.	Cleared about 1910.	Euc. redunca & Euc. kochii & Melaleuca spp.
6	Greenough	1962	400	A B A N D O N E D D U E	T O	F A I L U R E S		
7	Buntine	1959	350 (398)	Yellow grey loamy sand		Flat with slight depression in centre	Cleared 1962	Virgin bush of Melaleucas to 3m. Acacia pulchella, Ac. colletiodea and salt bush.
8	Dalwallinu High School	1963	350 (350)	Heavy red brown loam	?	Gentle slope to N/NE	Education reserve at north side of high school	York gums to 6m 6m and jam wattle.
51	Moora ("Warren Point")	1964	450 (450)	Light grey brown sandy clay over gravelly sandy clay	?	Marked slope to south 2-3°.	Part of cleared wheat paddock - grazed also	Jam wattle and salmon gums.

Appendix 1 (cont'd)

ZONE 2

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
11	Jennacubbine	1950	380	A B A N D O N E D				
12	Wongan Hills (Ackland)	1948-49 1956-57	380	Yellow sand	-		Cleared for wheat and grazing	York gum ? & Acacias
22	Ballidu "Wooree"	1960	330 (330)	Yellow sand of depth	6.0	Very slight slope to N & N.E.	Cleared in 1952 and cropped 3 times to 1957 with sheep grazing	Hakea, Melaleuca, E. leptopoda & Casaurina sp.
22A	Ballidu (Salt Plot)	1960	330 (330)	Heavy clay, salt affected	5.3	Slight slope to S & S.W. to salt lake 1 in 20	Cleared for same as 1960. Last crop 1957 for oats	Melaleuca, Acacia & odd E. oleosa
23	Ballidu (Thomas)	1960	330	A B A N D O N E D	6.6 & 5.7			
24	Dowerin	1960	370 (363)	Reddish brown loam over heavy gritty clay	?	Gentle slope to N & N.E.	Portion of an old farm given over for tree planting	Salmon gums
25	Koorda (T/S)	1960	290 (335)	Reddish brown heavy loam over compacted gritty clay	5.7	Flat	Cleared for some years, possibly cropped	York & salmon gums
26	Koorda (Wodjil) (Res. 16386(	1960	290 (335)	Yellow loamy sand of depth		Flat	Cleared to establish arboretum	Mainly Acacia, beauverdiana "Wodjil"
27	Koorda (Downey's)	1960	315 (315)	Yellow grey sand over very hard stony gravel	5.4	Slight slope to N.E. from road		Mallee, eucalypts, Acacia Hakea and Casuarina
28	Bencubbin	1960	290 (300)	Yellow grey gritty sand - hard pan of quartz grit	-	Slight slope to S.W.	Old cleared paddock	E. gracilis & Acacia spp.
6	Narrogin (F.D.)	1955-62	520	Dark grey brown loamy sands and silts	-	Gentle slope E along drainage channel	Wooded reserve prior to planting	York gum and wandoo, Acacia spp.

ZONE 2 (cont'd)

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
8	Dryandra	1958-61	550	Red brown loams and gritty sandy loams	-	Slight slope to the E & S.E. with flatter areas on E side	Mallet/wandoo forest prior to planting	Mallets, Wandoo marri & powder bark wandoo & Hakea spp.
10	Bruce Rock (T/S)	1951	330	Grey yellow gritty compact silt	-	Flat to slope E	(LOST DUE TO FAILURES)	Jam wattle
29	Rottnest Island	1960	700	Pale yellow calcareous sand	9.0	Gentle slope to central depression	Previous wattles to 7m, fires and wallabies reduced vegetation to that as shown	Stipa variabilis & Acacias & Acanthocarpus preissii
31	Ballidu (Sp. Gr)	1960	350 (398)	Yellow gritty silt with some gravels	6.1	Gentle slope to W & S.W. down to a flat	Trees planted in 12-18" rip. Cropped for wheat for several years prior to planting	Mallees and Casuarinas (tammar)
32	Mukinbudin	1961	275 (288)	Reddish brown gritty sandy loam over heavy gritty clay	4.8-9.4 (21")	Generally flat	Cleared and cropped for many years	Salmon and gimlet
33	Shackleton	1961	350 (350)	Grey brown silty sand with quartz particles over mottled yellow grey gritty clay	6.2 - 6.5	Gentle slope S along water-course	Cleared about 1910 & regularly cropped & grazed since then	Salmon & York gum, jam and manna wattles
34	Pingelly	1961	375 (390)	Grey yellow sandy gravel with R/Br/Y sandy gravels	5.8	Fairly steep hillside to the W with creek at W and N sides	Cropped and grazed for many years	Wandoo, salmon & York gum, Casuarinas & jam wattle
35	Beverley (Ag. Res.)	1961	480 (450)	Chocolate brown compacted gritty gravel over gritty clay and gravel	6.1 - 6.5	Hill site with 3-4° slope to W and S.W.	Cleared for 30 years at planting & grazed by sheep	York gum & jam wattle

Appendix 1 (cont'd)

ZONE 2 (cont'd)

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
36	Merredin (i) S/P	1961	330 (332)	Deep yellow sand	6.5	Generally flat	Cleared for many years and grazed with sheep	E.oldfieldii Acacia and Melaleuca spp.
37	Merredin (ii) Hvy	1961	"	Light grey brown loamy sand	5.6	Slight fall W along water-course	Cleared & cropped for many years. Grazed also.	Gimlet, Melaleuca & Acacia inophloia
38	Merredin (iii) Stony	"	"	Shallow yellow grey loamy sand over gravels	6.2	Slight slope from ridge to E & S.E.	Virgin semi-sand plain prior to rolling	E. oldfieldii Hakea, Acacia, Melaleuca and Casuarina spp.
39	Yelbeni (i) Lt.	1961	390 (375)	Yellow gritty sand over reddish yellow gravelly sand	Est. 6.0	Extends from low ridge westward with slight grade	Cleared & cropped for 30 years	Casuarina campestris, Grevilleas, "Tussocky Sandplain"
40	Yelbeni (ii) Hvy	1961	"	Yellow grey gritty cemented sand over mottled R/Br gritty clay	5.9 - 8.1	Fairly flat, slight slope to W.	Cleared & cropped since 1910 since 1910	"Yorrel", some salmon and gimlets
42	Kalannie (Lt)	1962	300 (400)	Yellow silty or clay sand over sandy gravel	?	Slight slope to S. S.E. & with hollow in centre	Cleared about 1930 - cropped every 4-5 years	E.leptophylla, Hakea, Acacia, Casuarina & Grevilleas
43	Piawaning	1962	400 (390)	Light brown gritty gravelly loam and clays	?	Slight slope to S. & S.W.	Cleared & cropped since 1920 and grazed by sheep also.	Salmon and gimlet country with tammar scrub.
44	Kellerberrin	1962	330 (393)	Yellow grey loamy gritty sand	?	Flat	Cleared for many years - used as children's play-ground	Salmon and gimlet

ZONE 2 (CONT'D)

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
45	Ardath	1962	350 (381)	Red brown gritty clay loams	?	Slight slope with E aspect	Reserve adjacent to school	York gum, yorrel, salmon and wandoo
49	Wongan Hills (T/S)	1963	380 (350)	Yellow grey loamy gritty sand	?	Fair slope to S & S.E.	Cleared about 1950s	Casuarinas, Acacias, Melaleucas & Santalum acuminatum
50	Bindi Bindi	1963	375 (294)	Gravelly gritty compacted loam over a clayey hard pan	?	Top of ridge with S aspect and slight fall to S.W. and W.	Cleared in 1928 cropped regularly and grazed. Last crop 1950.	Salmon, gimlet, York gum and Acacia spp.
52	Kalannie (Hvy)	1963	300 (400)	Heavy textured red loam	?	Flat adjacent to watercourse S-S.W. aspect	Lightly wooded area adjacent to wheat paddock	York gum, Acacias and Salmon gum
53	Cunderdin	1964	350 (350)	Light yellowish grey coarse sand over mottled cemented sandy clay	?	Flat	Not cropped but cleared	Sandplain scrub and mallees
9	Hamel	1950-51	(1075)	Light yellow grey sandy gravels.	-	Moderate slope to W and lower side of plot	P.pinaster plantn. prior to establishment	Jarrah and marri forest & Banksia sp.
(?)	Wongan Hills Salt Plot	1967	380	Grey yellow sand to gravelly sands	7.82	Flat along watercourse	Part of old cleared wheat paddock - grazed	York gum, Casuarina, Acacias
	Wongan Hills Paddock 3EB	1946 app.	380	Yellow grey loamy sand		Slight depression to north	Cleared in 1928-29	Free water at 10' depth - York gum Mallee (?)

Appendix 1 (cont'd)

ZONE 3

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
3	Esperance - Gibson Agric. Res. Station	1951	490	Greyish sand & sandy gravels over R/Br mottled gravelly clays		Flat	Cleared for settlement area	Stunted mallees, Xmas tree, hakeas, grevilleas & acacias
4 5	Newdegate Agric. Res. Station	1953	330 (400)	Grey sand and clay sand over laterite on higher parts	?	Gentle slope to S & S.E. on Plot 4 & to E N.E. in plot 5	Cleared for grazing & cropping shortly before before planting	York gum, mallees, hakea spp - some acacias
ELMS Arbm	FD Esperance	1973	520	Grey sands over mottled gravelly clay pans	?	Generally flat	Uncleared native heath type country	Heath type native flora - odd Xmas tree
54	Boxwood Hills	1964	480 (475)	Grey sand over gravelly clay loam		Flat - generally exposed	Cleared in mid 1950s for grazing and cropping	Swamp yate, mallee, hakeas & casuarinas
55	" "	"	"	Fine grey sand over gravelly sand		Flat with depression in middle	" "	Marri, jarrah, banksia association
56	" "	"	"	Deep sand & sandy gravel	?	Fairly flat overall with slope each way from low ridge	" "	Swamp yate, wandoo and casuarinas
57	" "	"	"	Clay & gravelly soils with impenetrable hard pan below	?	Gentle slope to W. towards roadway	" "	Mallee, eucalypts, hakeas & grevillea
60	Stirling Road	1977	450	Grey sand over red brown clay	?	Flat	-	-

Appendix 1 (cont'd)

ZONE 3 (cont'd)

ARBm Nc	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
61	Porongurups	1977	630	Greyish sand over clay	?	Exposed ridge orientated W-E	-	-
62	Mt Manypeaks	1977	775	Well drained grey sand over clay	?	S.E. aspect	-	-
63	Kalgan	1977	750	Good grey yellow sand over clay and gravel	?	E. aspect	-	-
64	Mt Manypeaks	1977	650	1. Grey sand 2.	?	Two plots	1. Newly cleared in 1977 2. Old established pasture	- -
65	Mt Manypeaks	1977	650	-	?	-	-	-
66	Mt Manypeaks	1977	625	Sand over clay	?	Exposure severe	-	-
67	Mt Manypeaks	1977	610	Deep grey sand over gravel	?	S. aspect - severely exposed site	-	-
68	Mt Manypeaks	1977	625	Gravel to fairly deep wet sands	?	-	-	-
69	Mt Manypeaks	1977	600	Gravels to deeper grey sands	?	Very exposed ridge top - N.E. aspect.	-	-
70	Borden (A. Campbell)	1973	420	Grey sand overlying clay at depth	?	?	Suffers severe wind erosion - cropped with cereal rye	-
71	Borden (D. King)	1974 (Replant)	420	Grey sand with broken quartz at 18-20 cm	?	?	" "	-

ZONE 4

ARBm No	LOCALITY	P.YR(S)	EST'D RAINFALL (mm)	SOIL DESCRIPTION	pH.	TOPOGRAPHY SLOPE ETC.	PAST HISTORY	ORIGINAL VEGETATION
1	Kalgoorlie	1955-70 1974 1973	220	Bright brownish red sandy silty	?	Flat, indistinct drainage W. aspect	Timber harvested for firewood, grazed by stock	Salmon and gimlet and acacias spp.
2	Southern Cross	1951-53	275	Good brown sandy loam	?	Rises about 2m from salt flat to W.	Part of a reserve	Odd salmon and yorrel, gimlet
30	Forrestiana	1960	300	Pale grey yellow sand and sandy loam	?	Very slight slope to S.W.	Portion of trial area cleared in 1959 approx.	Low scrub 1-2m tall - acacia and grevilleas and hakeas
59	Coolgardie	1973, 74, 75, 76, 77	260	Deep red brown clay loam	?	W - S.W. aspect, long gentle slope to W - S.W.	Portion of town-townsite area in boom time of gold mining	York gum, odd salmon and acacia spp.

APPENDIX 2

RECOMMENDED SPECIES SELECTION CHART FOR:
INLAND AREAS OF S.W. AUSTRALIA FOR VARIOUS SOIL/RAINFALL AREAS

	SPECIES (BY VEGETATIVE TYPE)	SOIL DESCRIPTIONS: Coastal grey sands over gravelly clays & mottled impermeable clays	Variable depths of R/Br loamy clays with and without silts and gritty gravels	Shallow Y/Br and pale Y/R/Br gritty sandy loams with impermeable clay & rock layers below	Pale grey-yellow sands to deep yellow sands of considerable depth	Stony R/Br loamy clays of variable depth to gritty R/Br sandy loamy clays, salt affected on flatter areas	R/Br loamy clays & clays of montmorillonite type	NOTES AND COMMENTS
		400-675mm	275-475mm	325-400mm	275-450mm	300-450mm	300-375mm	= RAINFALL
MALLETS AND MARLOCKS	1. Eucalyptus annulata	•				•(3)		"Open fruited mallee" - good shade for salt and wetter areas.
	2. Eucalyptus astringens	•	•			•		"Brown mallet" - success as shade tree linked to rainfall.
	3. Eucalyptus falcata	•	•			•		"White mallet" - fine, tough mallet, good shade for good soils.
	4. Eucalyptus gardneri	•	•		•	•	•	"Blue mallet" - suited to poorer soils down to 400mm rain.
	5. Eucalyptus platypus		•(3)			•		"Round leafed moort" - good wind break for better soils or rainfall.
	6. Eucalyptus platypus var. heterophylla	•			•	•	•	"Coastal moort" - wider range of soils : deeper soils inland.
	7. Eucalyptus reduncа melanophloia	•	•		•	•		"Black barked marlock" - perfect shade tree, wide application.
	8. Eucalyptus spathulata	•	•	•(3)	•	•		"Swamp mallet" - excellent shade for salt areas.
GIMLETS AND SMALL TREES	1. Eucalyptus caesia (small flowers)	•		•				"Gungurru" - ornamental low shade, wide application.
	2. Eucalyptus campaspe		•			•	•	"Silver gimlet" - very good shade on better soils inland.
	3. Eucalyptus cladocalyx nana	•		•	•	•		"Dwarf sugar gum" - excellent low shade on deep inland soils.
	4. Eucalyptus decipiens	•						"Red heart" - very good shade/shelter for 500 mm +.
	5. Eucalyptus "pterocarpa" (angulata)	•			•		•	"Rough fruited mallee" - wide soil range, 250-350 mm.
	6. Eucalytpus salubris		•		•	•	•	"Gimlet" - adaptable low shade for better soils inland.
	7. Eucalyptus torquata		•	•	•	•	•	"Coral gum" - very good shade/ornamental for dry areas.
	8. Eucalyptus torwood		•	•		•		"Torwood hybrid" - ornamental for better soils 400-450 mm.
LARGE TREES (7-15 m)	1. Eucalyptus accedens	•						"Powder bark wandoo" - restricted to wetter areas of poor soil.
	2. Eucalyptus brockwayi		•	•	•	•	•	"Dundas mahogany" - good shade/ shelter for better soils.
	3. Eucalyptus camaldulensis		•	•(5)	•	•		"River gum" - one of the best shade trees, wide application.
	4. Eucalyptus cladocalyx	•	•(2)	•(5)	•	•		"Sugar gum" - tall shade/shelter for drier areas, deep soils.
	5. Eucalyptus diptera		•					"Bastard gimlet" - low shade for better soils of dry areas.
	6. Eucalyptus dundasii		•			•	•	"Dundas blackbutt" - good shade wider soil range.
	7. Eucalyptus erythrocorys	•			•			"Illyarrie" - outstanding ornamental for poorer soils.
	8. Eucalyptus flocktoniae		•					"Merrit" - good shade/shelter for better soils inland.
	9. Eucalyptus gomphocephala	•						"Tuart" - wind firm shade on good soils to 475mm.
	10. Eucalyptus gracilis		•	•		•	•	"Yorrel" - impressive low shade in dry areas on good soils.
	11. Eucalyptus kondininensis	•	•	•		•(3)		"Stocking gum" - medium shade for good soils and salt areas.
	12. Eucalyptus loxophleba		•(4)	•	•	•		"York gum" - most reliable shade for wide application.
	13. Eucalyptus occidentalis	•		•(5)	•	•	•(2)	"Swamp yate" - very good shade on deep and alkaline soils.
	14. Eucalyptus salmonophloia		•			•	•	"Salmon gum" - slow maturing shade for good soils.
	15. Eucalyptus sargentii		•(3)	•	•	•(3)	•	"Salt river gum" - good shade/shelter for salt areas.
	16. Eucalyptus stricklandii		•	•	•		•	"Stickland's gum" - ornamental on loam clays of depth.
	17. Eucalyptus wandoo (inland)		•	•	•	•		"Inland wandoo" - reliable shade/shelter down to 200 m.

RECOMMENDED SPECIES SELECTION CHART FOR:
INLAND AREAS OF S.W. AUSTRALIA FOR VARIOUS SOIL/RAINFALL AREAS

	SPECIES (BY VEGETATIVE TYPE)	SOIL DESCRIPTIONS: Coastal grey sands over gravelly clays & mottled impermeable clays	Variable depths of R/Br loamy clays with and without silts and gritty gravels	Shallow Y/Br and pale Y/R/Br gritty sandy loams with impermeable clay & rock layers below	Pale grey-yellow sands to deep yellow sands of considerable depth	Stony R/Br loamy clays of variable depth to gritty R/Br sandy loamy clays, salt affected on flatter areas	R/Br loamy clays & clays of montmorillonite type	NOTES AND COMMENTS
		400-675mm	275-475mm	325-400mm	275-450mm	300-450mm	300-375mm	= RAINFALL
WATTLES	1. Acacia acuminata	•				•		"Jam wattle" - low shade as well as posts.
	2. Acacia aneura		•		•			"Mulga" - low wind break in driest areas, fodder.
	3. Acacia inophloia			•				Not spectacular, but useful on drier sandy loams.
	4. Acacia linophylla		•		•			"Wodjil wattle" - impressive, aggressive - good wind.
	5. Acacia microbotrya	•			•			"Manna wattle" - good shade on deep sands and better rains.
	6. Acacia pendula		•				•	"Weeping myall" - needs fertile soils : wind break lower rains.
	7. Acacia pycantha	•						"Golden wattle" - quick growing wind break in higher rains.
	8. Acacia sowdenii		•	•		•		"Western myall" - toughest of all for low wind breaks.
CYPRESS PINES	1. Callitris calcarata	•			•	NOT RECOMM-ENDED	NONE TESTED	"Black cypress" - good wind break & ornamental on deep sandplain.
	2. Callitris glauca			•	•			"White cypress" - medium wind break on dry light soils.
	3. Callitris intratropica	•	•	•				"Northern cypress" - as for white cypress but larger tree.
	4. Callitris robusta	•						"Rottnest cypress" - success in higher rainfalls only.
TAMARS AND SHEOAKS	1. Casuarina campestris	•		•	•			"Tamar" - hedge type wind break on wide range of soils.
	2. Casuarina decaisneana					•(1)	NONE	"Desert oak" - useful wind break but suitable for few soils.
	3. Casuarina dielsiana		•	•	•			"Diel's oak" - compact shade tree for poor drier soils.
	4. Casuarina glauca		•	•	•	•	TESTED	"Swamp oak" - wide range of soils, salt to dry poor soils.
	5. Casuarina huegliana	•	•	•	•			"Rock oak" - shade & shelter for wide rainfall/soil range
MALLEES	1. Eucalyptus angulosa	•	•		•			"Ridge fruited mallee" - South Australian strain - wind break.
	2. Eucalyptus dongarensis	•	•(2)					"Dongara mallee" - suitable for coastal areas of good rains.
	3. Eucalyptus eremophila	•	•	•	•	•	•	"Tall sand mallee" - sandy soils over wide rainfall range.
	4. Eucalyptus erythronema		•	•	•	•		"Red flowered mallee" - heavy textured soils.
	5. Eucalyptus ebbanoensis		•	•	•	•		"Sand plain mallee" - most reliable shade mallee.
	6. Eucalyptus foecunda	•	•		•	•		"Fremantle mallee" - useful shade mallee on drier soils.
	7. Eucalyptus kruseana		•					"Kruse's mallee" - ornamental for fertile soils and good rains.
	8. Eucalyptus lehmannii	•						"Bald Island marlock" - excellent wind break, coastal areas.
	9. Eucalyptus oleosa longicornis		•		•			"Red morrel" - impressive shade mallee of wide application.
	10. Eucalyptus oleosa var. kochii	•	•	•	•			"Watheroo mallee" - best shade mallee for better soils of dry areas.
	11. Eucalyptus oleosa (S.A. prov.)	•	•			•		"Giant mallee" - more restricted in choice of sites.
	12. Eucalyptus oleosa (Yuna prov.)	•			•			"Yuna mallee" - useful low shade, not fully tested.
	13. Eucalyptus oleosa var. plenissima	•	•					"Oil mallee" - very good shade mallee and high oil yields.
	14. Eucalyptus preissiana	•						"Bell fruited mallee" - ornamental for poor soils of good rain.
	15. Eucalyptus pyriformis elongata			•	•			"Dowerin rose" - ornamental/shade for drier poor sites.

RECOMMENDED SPECIES SELECTION CHART FOR:
INLAND AREAS OF S.W. AUSTRALIA FOR VARIOUS SOIL/RAINFALL AREAS

	SPECIES (BY VEGETATIVE TYPE)	SOIL DESCRIPTIONS: Coastal grey sands over gravelly clays & mottled impermeable clays	Variable depths of R/Br loamy clays with and without silts and gritty gravels	Shallow Y/Br and pale Y/R/Br gritty sandy loams with impermeable clay & rock layers below	Pale grey-yellow sands to deep yellow sands of considerable depth	Stony R/Br loamy clays of variable depth to gritty R/Br sandy loamy clays, salt affected on flatter areas	R/Br loamy clays & clays of montmorillonite type	NOTES AND COMMENTS
		400-675mm	275-475mm	325-400mm	275-450mm	300-450mm	300-375mm	= RAINFALL
PINES	1. Pinus canariensis			•	•		•	"Canary pine" - slow growing ornamental for good soils.
	2. Pinus halepensis	•						"Aleppa pine" - useful for shelter belts on poorer lime soils.
	3. Pinus pinea	•		•(5)	•		•	"Stone pine" - wind break for deep sands to 200mm.
	4. Pinus pinaster	•		•(5)	•			"Maritime pine" - versatile wind break of wide application.
TI-TREES, SHRUBS AND MISCELLANEOUS SPECIES	1. Hakea bucculenta					•		"Orange flowered hakea" - vigorous colorful shrub, low wind break.
	2. Hakea laurina	•			•	•	•	"Pin cushion hakea" - colorful shrub, wide soil application.
	3. Leptospermum laevigatum	•						"Victorian ti-tree" - excellent low wind break on poor soils.
	4. Melaleuca eleuthrostachya			•	•	•		"Yuna ti-tree" - low wind break in drier areas.
	5. Melaleuca hamulosa		•	•	•	•	•	"Twiggy ti-tree" - not fully tested, wide range application.
	6. Melaleuca pubescens	•	•(2)	•	•	•		"Rottnest Island ti'tree" - excellent low shade of wide application.
	7. Tamarix aphylla						•	"Athel tree" - restricted to salt areas and coastal limestone.
	8. Templetonia retusa	•						"Cockies Tongue" - colorful shrub for limestone areas.
	TOTAL NO. TEST SITES	12	13	9	8	6	4	
	CLIMATIC ZONES	1 & 3	2, 3 & 4	2 & 3	2	1 & 2	2 & 4	

NOTES AND COMMENTS

(1) Cyclonic affected areas only
(2) Higher rainfalls only
(3) Salt areas only in relevant soil type
(4) Above 375 mm rain
(5) Deep sands only

SPECIES NOT ADEQUATELY TESTED, YET IMPRESSIVE

SPECIES	COMMON NAME	POSSIBLE SITE REQUIREMENTS		DESCRIPTION
		RAINFALL	SOIL TYPE COLOUR CODE	
1. Euc. annulata	Open fruited mallee	300 - 450	Purple	Salt affected red brown loamy clays
2. Euc. intertexta	Gum bark coolabah	275 - 475	Green	Red brown loamy clay + silts gritty gravels
3. Euc. leptopoda	Tammin mallee	275 - 475	Green	" " " " "
4. Euc. nutans	Red flowered moort	400 - 675	Orange	Coastal grey sands over gravelly mottled impermeable clays
5. Euc. oleosa (Yuna Provenance)	Yuna mallee	275 - 675 +	Orange	" " " " "
			Yellow	Pale grey/yellow sands and deep yellow sands
			Black	Shallow yellow brown and pale yellow red brown gritty sandy loam with impermeable layers and rock below
6. Melaleuca elauthrostachya	Yuna ti-tree	275 - 675 +	Yellow	
			Black	
			Green	See above
			Orange	
7. P. halepensis brutia (syn. eldarica)	Calabrian pine	400 - 675 +	Orange	See above
8. Ceratonia siliqua	Carob bean	300 - 450	Purple	See above

LIST OF UNSUCCESSFUL SPECIES

APPENDIX 4

SPECIES	COMMON NAME	NO. TRIALS	LOCALITIES OF TRIALS
Acacia podalyriaefolia	Old silver wattle	1	East Pingelly
Actinostrobus areneus	Sand plain cypress	1	Mingenew
Brachy. diversifolium	Kurrajong	2	East Pingelly, South Shackleton
Tristania conferta	Brush box	1	South Eneabba
Callitris verrucosa			
Ceratonia siliqua	Carob bean	2	Avondale, Southern Cross
Cytisus proliferus	Tree Lucerne	2	North & South Eneabba
Cupressus macrocapra	Cypress	6	Badgingarra No. 1 Ballidu, East Pingelly, Miling, Dowerin, Helms Arboretum Esperance
Eucalyptus botryoides	False mahogany	5	Boxwood Hills, East Pingelly, Dryandra, Esperance
" brachycorys		2	Yuna sand plain and heavy soils
" bicostata	Eurabbie	2	Helms Arboretum Esperance
" calophylla rosea	Pink flowered marri	7	Badgemgarra No. 1 & 2, Boxwood Hills, Gardner River, Mingenew, Narrogin, Dryandra
" doratoxylon		1	Narrogin
" diversicolor	Karri	1	Helms Arboretum Esperance
" ewartiana		2	Southern Cross & Dryandra
" ficifolia	Red flowered gum	1	Dryandra
" globulus	Tasmanian blue gum	5	Helms Arboretum Esperance, East Pingelly, Narrogin, Dryandra, Gibson Research Station
" gongylocarpa		1	Southern Cross
" kesselli		1	Dryandra
" kingsmillii		1	Southern Cross
" lesouefii		4	North Eneabba, Yuna (S/P), Narrogin, Dryandra
" microtheca		1	Southern Cross
" microcorys	Tallow-wood	3	Narrogin, Esperance
" robusta	Swamp mahogany	2	East Pingelly, Narrogin, Dryandra, Esperance, Helms
" resinifera	Red mahogany	2	Esperance
" saligna	Sydney blue gum	1	Esperance
Pinus elliottii	Slash pine	1	Esperance
Myoporum insulare	Boobyalla	2	North and South Eneabba
Eucalyptus macrandra		1	Narrogin
" tetragona		1	South Eneabba
Pinus radiata	Monterey pine	1	Esperance
T. gallica	Spring flowering tamarisk	1	Badgemgarra No. 1
Eucalyptus woodwardii	Woodwardii gum	9	Dryandra, Ningenew, Dalwallinu, South Merredin, Yuna S/P, Southern Cross, Yelben (Lt) Marchagee, Woongoondy

NOTE: Paucity of trial sites detracts from reliability of results for species tried only once or twice.

NOTES ON SALT TOLERANT SPECIES

SPECIES	COMMON NAME	BEST USE	GENERAL NOTES
Euc. camaldulensis	River gum	Shade/ windbreak	Tree species 10-20m good growth rates.
Euc. diptera	Bastard gimlets	Shade	Good shade and growth rate slower - 5-10m
Euc. gracilis	Yorrel	High shade	Medium height tree 10-15m
Euc.kondininensis	Stocking	Shade/ windbreak	Tree species of 10-20m & suited to dry areas as well
Euc. occidentalis	Swamp yate	Shade	Tree of 10-20m on better soils - good growth rates and excellent shade.
Euc. platypus heterophylla	Coastal moort	Windbreak	Excellent windbreak - rapid growth and low height 3-5m.
Euc. salubris	Gimlet	Shade/ windbreak	Good windbreak and shade - fair growth rates - 5-10m.
Euc. sargentii	Salt river	Shade	Develops into a tree of 17-20m - rather slow in later years.
Euc. spathulata	Swamp	Shade/ windbreak	Low shade/windbreak tree of 8-10m - good growth rates.
Casuarina glauca	Swamp sheoak	Colonisers of heavily salted areas	Tree of 5-10m, good growth rates, but scarce foliage.
Tamarix aphylla	Athel tree	Windbreak	Useful fodder plant and best on well drained calcareous soils to 5-10m and windbreak as well.
Tamarix gallica	Spring flowering tamarix	Windbreak	Lesser height 3-5m. Useful for fodder - slower growth rates.