FORMATION, FREQUENCY & LONGEVITY OF HOLLOWS IN JARRAH

Interim Report

by Karen Faunt, January 1992

Introduction

In 1987 the company Simcoa (formerly Barrack Silicon) made a commitment to the Western Australian Environmental Protection Authority to fund a research project evaluating the effects of the company's wood gathering operations upon flora and fauna in the northern jarrah forest. This was in response to submissions to the E.P.A. stating concern over lack of knowledge of effects of the silicon project on fauna which use tree hollows and that the use of hollows by fauna needed to be monitored. The PER acknowledged that there was no information on the use of hollows by fauna in the jarrah forest and that it was therefore difficult to assess the potential impact of large scale firewood extraction.

The Department of Conservation and Land Management undertook to supervise the research effort and proposed the following rationale for a study into the effects of the Silicon project on hollow nesters.

> The provision of firewood for the charcoal production facility largely utilises dead or defective standing trees and logs already on the ground. It is possible such operations will have adverse long term effects on certain species of the jarrah hollow nesting community by reducing the availability of nest sites for hole nesting fauna and cover for fauna requiring logs on the ground. In order to measure and predict any such effects, information is needed on the formation of hollows, how long they last in standing live trees, standing dead trees, fallen trees etc, with the object of determining the impact of the project on the population of trees hollows in the forest. Data on tree hollows is essential to assess the impact of the project and to achieve management solutions to any problems that might arise. There is available already a certain amount of biological data on hole nesting species which may be used together with tree hollow data to interpret the impact of the project.

The study, intended to be of one year duration, was commenced in March 1990. Work was terminated prematurely mid-December due to failure of Simcoa to meet funding commitments. In February 1991 a further month of fieldwork was funded by Alcoa. The results are now being analysed and written up as an honours thesis undertaken part-time with the Australian National University, Canberra. The thesis will be completed in November 1992. This document is intended as an interim report on results to date.

Aims

A simple diagram was used by C.A.L.M. to illustrate the information needed.

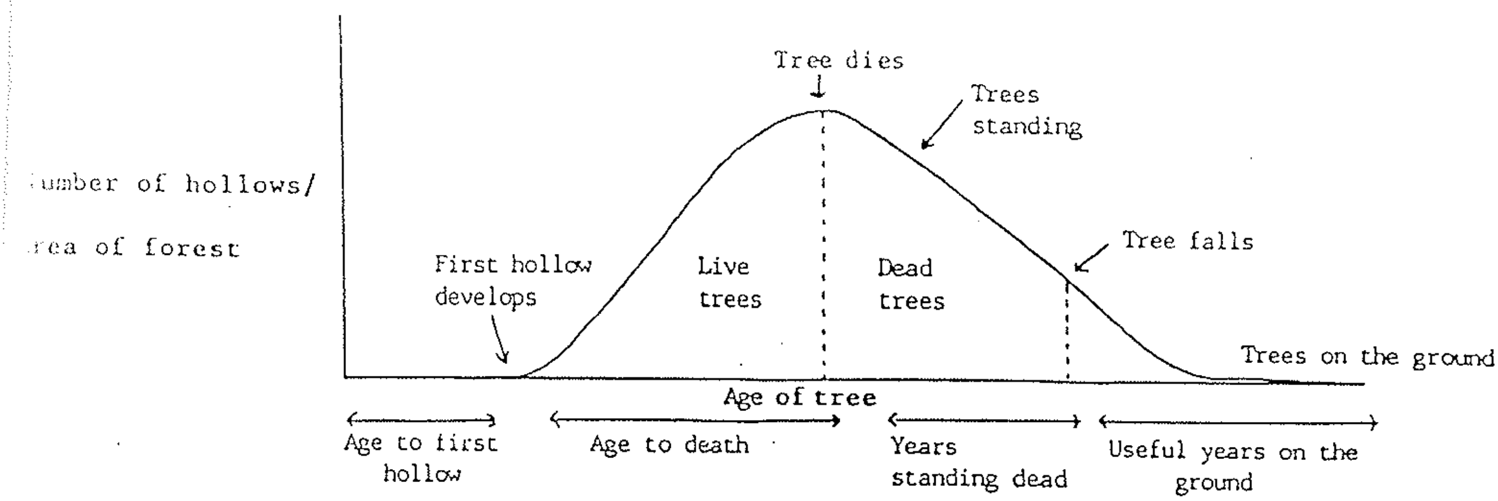


Fig 1.0: An illustration of the information hoped to be gained from the study

Specific Questions to be addressed were:

1. Age to hollow formation.
2. Age to death of tree.
3. Years Standing (dead trees).
4. Useful years on ground.
5. What percentage of live trees with hollows are affected by the project?
6. What percentage of dead trees are affected?
7. What percentage of fallen logs are affected?
8. What is the likely effect of the project on future supplies of dead standing trees and fallen logs?

This original set of questions was used to define the following aims and null hypotheses to be addressed by the study:

1. To obtain further understanding of the formation of hollows in jarrah, their abundance in standing and fallen trees,/and distribution throughout the northern jarrah forest.

2. To determine the impact of Simcoa Pty Ltd's firewood operations on the population of hollows in the forest.

Ho.1 Hollow size and frequency (per tree) is independent of tree size, tree age, and tree dominance.

Ho.2 Hollow size and frequency (per tree) is independent of crown size, crown growth stage and crown condition.

Ho.3 Hollow size and frequency (per tree) is independent of fire evidence/damage and management history.

Ho.4 'Log hollow' size and frequency is independent of the amount of log material and logging history.

H0.5 'Log hollow size and frequency is independent of log type, dimension, state of decay and fire evidence.

Ho.6 Simcoa's firewood gathering operations ha[illegible] impact on:

i) The size and frequency of hollows
ii) The distribution of hollows.

Methods

The jarrah forest was sampled by a set of ten quadrats, three sampling virgin forest and the remainder areas which had been logged to varying intensities. Location of the ten sites are marked on the map shown in Appendix 1. The names of the blocks in the sequence they were assessed are:

1 Ross Block
2 Scott Block
3 Windsor Block
4 Ross Block
5 Samson Block
6 Alcoa 1
7 Alcoa 2
8 Torrens (virgin)
9 Bombala (virgin)
10 Surface (virgin)

Quadrats were one hectare (100 x 100 metres) in size to adequately sample the patchy nature of the jarrah forest. Trees, stags, stumps and logs were assessed at each quadrat and at the first three sites jarrah trees were randomly selected, felled, and dissected to assess for hollows. The methodology employed to assess these site characteristics is summarised in Table 1.0.

Site Characteristic	Method
Trees	At each quadrat trees greater than 30 cm dbhob were assessed for specie, dominance class, dbhob and bole defects (eg termite and fire).
Stags	Stags were noted and assessed as with trees.
Dissected Trees	Trees were dissected at the first three sites only. One jarrah was randomly selected from each 10cm dbhob size class of trees occurring within the quadrat. These were photographed and characteristics of the bole and crown described. They were then felled to determine the number and dimensions of hollows. A disk was taken from the stumps of trees with minimal rot and aged by counting the growth rings on at least three radii.
Stumps	Stumps greater than 30cm dbhob were assessed similarly to logs.
Logs	All woody debris greater than Simcoa's minimum specifications for firewood was assessed for dimensions, hollows, shelter, sawn evidence, condition and suitability as firewood.
Hollows	Tree and log hollows were assessed for cavity dimensions, evidence of fire, termite and habitability.

Table 1.0: Site characteristics and methods of assessment.

Results

Statistical analysis and modelling of results is underway but incomplete. Results presented here are in the very early stages of investigation and as such only discussed in terms of broad trends.

Trees

Stand tables for the ten sites are summarised in Table 2.0 and illustrated in Appendix 2. The '%' column illustrates the major difference between the structure of logged versus virgin stands. Logged stands all exhibit non-normal, positively skewed distributions with 80 - 90% of trees represented in the smallest, 30.0 - 69.9 cm, dbhob class. In contrast the virgin stands at Torrens and Bombala have near-normal, symmetrical distributions with 40 - 50 % of trees represented in the higher, 70.0 - 109.9 cm dbhob class. The Surface virgin stand differs from this pattern but exhibits less skewness and deviation from normality than all logged sites.

Site	Diameter at Breast Height Over Bark Categories (40 cm) 30 - 69.9			70 - 109.9			110 - 149.9			150 - 189.9			Plot Total	
	Jarrah	Marri	%	Jarrah	Marri	%	Jarrah	Marri	%	Jarrah	Marri	%	Jarrah	Marri
Ross 1	84	19	82	20	1	17	1	-	1	-	-	-	105	20
Scott	29	7	82	3	1	9	1	-	2	3	-	7	36	8
Windsor	50	2	73	12	-	17	6	-	9	1	-	1	69	2
Ross 2	57	23	91	5	3	9	-	-	-	-	-	-	62	26
Samson	66	14	93	5	-	6	1	-	1	-	-	-	72	14
Alcoa 1	140	14	94	8	1	5	1	-	1	-	-	-	149	15
Alcoa 2	129	15	91	10	2	8	1	-	1	1	-	1	138	17
Torrens	42	5	44	49	3	49	6	1	7	-	-	-	97	9
Bombala	42	2	54	34	-	41	3	1	5	-	-	-	79	3
Surface	79	10	72	28	3	27	4	-	3	-	-	-	111	13

Table 2.0: Frequency of jarrah and marri in dbhob classes at sites sampled. "%" column is the proportion of total trees assessed (both specie) represented in each size class.

Stumps

Frequency of stumps in four dhhob classes and numbers of those sawn is summarised in Table 3.0 and illustrated in Appendix 3. Stumps were assessed as a measure of the level of logging activity at each site. Where it was possible to determine, they were linked with surrounding log debris. They were noted as sawn only when this was clearly evident, many more may have been man-made but were too decayed or burnt away to determine. Note that the "virgin" stand assessed at Torrens Block has seven sawn stumps. This is due to the stand being not quite one hectare in dimensions - the cut stumps were on the plot perimeter.

C.A.L.M.'s records of the logging history of each site, the number and decay status of stumps assessed, and the size of coppice from these stumps will be used to interpret as closely as possible the history of disturbance at each site. The number and size distribution of sawn stumps will be modelled against the level of log material to gauge the contribution of logging to the amount of woody debris on the forest floor

Site	Diameter Over Bark Categories (40 cm) 30 - 69.9			70 - 109.9			110 - 149.9			150 - 189.9			Plot Total	
	Total	Sawn	%	Total	Sawn	%	Total	Sawn	%	Total	Sawn	%	Total	Sawn
Ross 1	5	1	23	9	-	41	7	1	32	1	-	4	22	2
Scott	6	6	27	12	12	55	3	3	14	1	1	4	22	22
Windsor	9	2	23	15	10	39	13	7	33	2	-	5	39	19
Ross 2	43	41	61	23	22	33	3	3	4	1	1	2	70	67
Samson	21	12	54	13	4	33	5	2	13	-	-	-	39	18
Alcoa 1	26	12	48	7	3	45	3	1	6	-	-	-	53	20
Alcoa 2	29	21	57	16	10	31	6	2	12	-	-	-	51	33
Torrens	13	5	62	3	1	14	5	1	24	-	-	-	21	7
Bombala	14	-	47	14	-	47	1	-	3	1	-	3	30	-
Surface	4	-	50	2	-	25	2	-	25	-	-	-	8	-

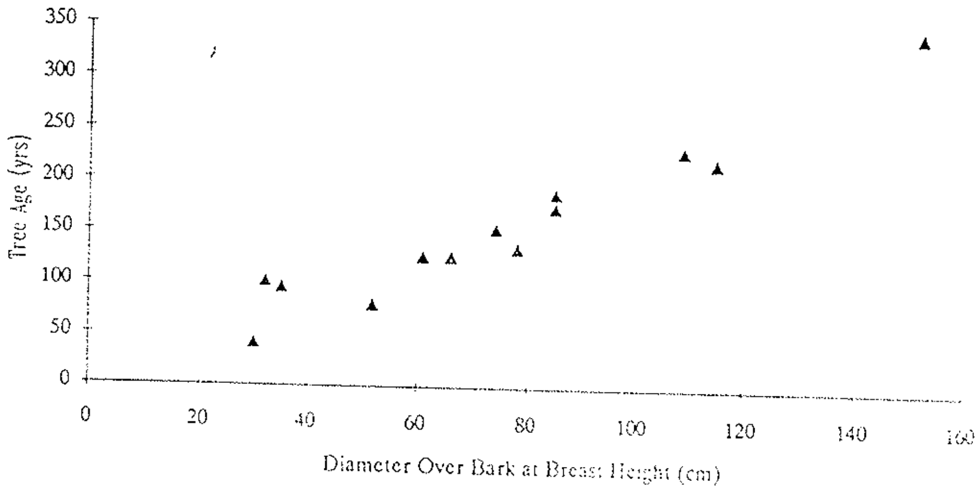
Table 3.0: Frequency of total and sawn stumps in dbhob classes at sites sampled. "%" column is the proportion of total stumps assessed represented in each size class.

Dissected Trees

A total of thirty-six trees were felled and dissected from three sites; Ross 1, Scott and Windsor. The destruction caused to the crown and hollows whentrees were felled and the difficulty inherent in thorough examination and reconstruction of the fragmented trees, introduced the potential for significant error in this method.

The age of thirteen trees was determined by counts of growth rings on disks taken from the stumps. The mean count was modelled against diameter over bark at breast height using simple linear regression. A strong relationship was found between the two with a coefficient of determination of 0.9310 increasing to 0.9866 when the intercept was forced through zero. The results are illustrated in Figure 1. The derived parameter estimate for age by dbhob was 2.096517, which was applied to the remainder of the trees.

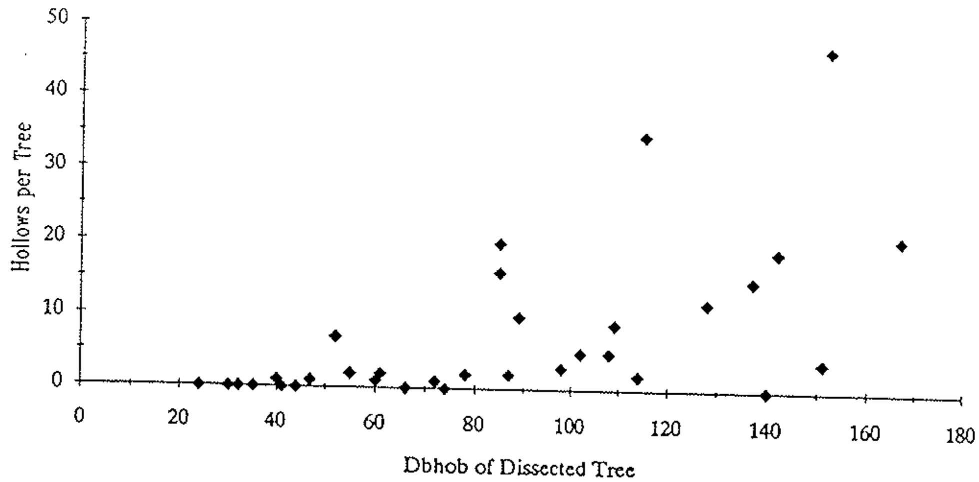
Figure 2.0: Tree Age versus Dbhob



Tree Hollows

The relationship between tree dbhob and total hollows is illustrated in Figure 3.0. Although there is a general trend of an increase in the number of hollows as tree dbhob increases, particularly for trees greater than 100cm, the results are extremely variable. This was to be expected with the low sample number and lack of stratification of the data into crown dominance and senescence categories, [illegible] senescent hollow butt would be expected to contain more hollows than a vigorous, solid tree of th[illegible] diameter class.

Figure 3.0: Number of Hollows versus Tree Dbhob



The relationship between tree size and hollow dimensions has been cursorily examined. Appendices 7 - 9 illustrate the mean, median and maximum of the three cavity dimensions, entry, depth and diameter of hollows from trees in each 10cm dbhob class. Again trends are very "noisy", but generally there is a noticeable increase in the maximum entry, depth and diameter of hollows as tree dbhob increases. The relationship between hollow dimension means/medians and increasing tree dbhob, however, is very poor.

The brief for this study was that hollows be assessed for all potential users. Minimum hollow dimensions to be considered was subsequently set at entry and internal diameter > = 2cm, and depth > = 10cm. In order to present the data on hollow dimensions it was necessary to define arbitrary hollow dimension categories to combine the measured dimensions of entry, depth and internal diameter.

To derive hollow dimension categories that reflect the potential requirements of hollow nesters. Specimens of birds and mammals that inhabit hollows in the northern jarrah forest were measured at the Western Australian Museum. The width and length of twenty birds and five mammals were measured and from these a set of five hollow dimension categories derived as follows:

Hollow Dimension Category	Dimension Components: Entry	Depth	Internal Diameter
Class 1	2 < = & < 4	> = 10	> = 2 at 10cm depth
Class 2	4 < = & < 6	> = 20	> = 4 at 20cm depth
Class 3	6 < = & < 11	> = 35	> = 6 at 35cm depth
Class 4	11 < = & < 15	> = 50	> = 11 at 50cm depth
Class 5	< = 15	> = 50	> = 15 at 50cm depth

Table 4.0: Hollow dimension categories derived from dimensions of hollow nesters.

The number of hollows assessed that matched these categories is shown in Table 5.0. It can be seen that the incidence and average number of hollows increase with tree size.

	Diameter Over Bark Categories (40 cm): 30 - 69.9		70 - 109.9		110 - 149.9		150 - 189.9		Total:
	Total	Hlws/ tree	Total	Hlws/ tree	Total	Hlws/ tree	Total	Hlws/ tree	all Trees
Dissected Trees	14	-	11	-	6	-	3	-	35
Hollows	17	1.2	73	6.6	83	13.8	72	24.0	245
Class One	2	0.1	19	1.7	16	2.6	9	3.0	46
Class Two	1	0.1	4	0.4	3	0.5	3	1.0	11
Class Three	-	-	-	-	3	0.5	6	2.0	9
Class Four	-	-	-	-	-	-	-	-	-
Class Five	-	-	-	-	-	-	-	-	-

Table 5.0: Frequency of hollows in dbhob classes of dissected trees. "Hlws/Tree" column is the average number of hollows per tree in each dbhob class.

There is available already a certain amount of biological data on the requirements of hole nesting species. Table 6.0 shows the number of tree hollows assessed that met published dimension criteria for hollow nesters.

Hollow Nester	Nest Dimensions Entry	Depth	Cavity Diameter	Tree Dbhob Classes (40cm) 30.0 - 69.9	70.0 - 109.9	110.0 - 149.9	150.0 - 189.9	Total Suitable Hollows
Regent Parrot 1 (1)	5	39	13	-	1	1	-	2
Regent Parrot 2 (1)	13	61	13	-	-	-	-	0
Port Lincoln Parrot (1)	5	36	10	-	1	3	2	6
Port Lincoln Parrot (2)	6	45	9	-	-	3	1	4
Western Rosella (1)	5	36	10	-	1	3	2	6
Red-capped Parrot (1)	5	19	10	-	3	5	2	10
Red-Tailed Black Cockatoo (2)	15	45	19	-	-	-	-	0
Corella (2)	8	45	14	-	-	1	-	1
Galah (2)	6	32	10	-	2	3	2	7
Chuditch (3)	7	70	7	-	-	-	2	2
Possum (4)	6	60	8	-	-	2	1	3
Total Hollows Assessed								

Table 6.0: Number of tree hollows assessed that met published dimension criteria for hollow nesters. References: (1) Long, J.L., No date: (2) Saunders, D.A., et al. 1982: (3) Serena, M., et al. 1990: (4) Inions, G., 1985.

Logs

The largest diameter over bark of the log is used to analyse the set of log data as it reflects the minimum size of the tree from which the log was derived. Table 7.0 summarises the total number of log pieces assessed at each site and the number of those that were bole sections. Log tables are shown in Appendix 4.

Site	Diameter Over Bark Categories (40 cm) 20 - 29.9 Total Pieces	Bole	%	[illegible] Total Pieces	Bole	%	[illegible] Total Pieces	Bole	%	110 - 149.9 Total Pieces	Bole	%	150 - 189.9 Total Pieces	Bole	%	Plot Totals Total Pieces	Bole Pieces
Ross 1	48	14	20.8	76	48	32.9	17	16	7.4	4	4	1.7	2	2	0.1	147	84
Scott	80	19	28.0	91	56	31.8	18	16	6.3	3	3	1.0	-	-	-	192	94
Windsor	45	6	25.0	76	27	42.2	11	11	6.1	2	2	1.1	-	-	-	134	46
Ross 2	86	43	23.8	125	80	34.5	13	11	3.6	1	1	0.0	1	1	0.0	226	136
Samson	38	12	18.7	73	50	36.0	13	13	6.4	2	2	0.1	-	-	-	126	77
Alcoa 1	15	8	17.2	29	21	33.3	4	4	4.6	3	3	3.4	-	-	-	51	36
Alcoa 2	24	4	12.6	74	54	38.9	15	15	7.9	2	2	1.0	-	-	-	115	75
Torrens	37	3	32.4	43	17	37.7	7	7	6.1	-	-	-	-	-	-	87	27
Bombala	55	10	33.7	57	31	35.0	4	4	2.5	1	1	0.1	-	-	-	117	46
Surface	25	7	20.2	40	28	32.2	10	10	8.1	2	2	1.6	-	-	-	77	47

Table 7.0: Frequency of total and bole log pieces in dob classes at sites sampled. "%" column is the proportion of total logs assessed represented in each size class.

The data would appear to support C.A.L.M.'s stated claim that there is an excess of woody debris on the forest floor due to logging disturbance. The notable exceptions to this being the Alcoa Site 1. The possible reason for this was the proximity of the site to a main road that was once accessible to the public. It is felt that the area had been scoured for private firewood.

Simcoa Logs

Logs arriving and stored at Simcoa's log dump in Kemerton were assessed over a period of five days. The number of and size of logs delivered are summarised in Table 8.0 and illustrated in Appendix 5. Those assessed on the dump are shown in Table 9.0 and Appendix 6.

Day	Diameter Over Bark Categories (40 cm) 10 - 29.9		30 - 69.9		70 - 109.9		110 - 149.9		150 - 189.9		Total
	Total	%	Total	%	Total	%	Total	%	Total	%	Logs
Day One	32	27	66	55	19	16	2	2	-	-	119
Day Two	35	33	58	55	12	12	0	-	-	-	105
Day Three	51	30	104	62	11	7	1	1	-	-	167
Day Four	76	26	172	60	37	13	1	-	2	1	288
Day Five	61	28	134	60	23	10	5	2	-	-	223

Table 8.0: Frequency of Simcoa logs in dob classes, delivered during one week. "%" column is the proportion of total logs assessed in each size class (by day).

Logs are sorted into size classes on the log dump. The largest log dumps were targeted for measurement, for example "Dump A" contained the largest logs that came into the silicon plant. Thus the dump data is biased and not indicative of the proportion of logs in the different size classes across the whole dump.

Day	Diameter Over Bark Categories (40 cm) 10 - 29.9		30 - 69.9		70 - 109.9		110 - 149.9		150 - 189.9		Total
	Total	%	Total	%	Total	%	Total	%	Total	%	Logs
Dump A	-	-	-	-	9	22	28	68	4	10	41
Dump B	-	-	14	40	18	51	3	9	-	-	35
Dump C	-	-	8	33	16	67	-	-	-	-	24
Dump D	-	-	8	33	16	67	-	-	-	-	150
Dump E-	-	-	53	71	22	29	-	-	-	-	75
Dump F	68	41	99	59	-	-	-	-	-	-	167
Dump G	23	30	94	80	-	-	-	-	-	-	117

Table 8.0: Frequency of dump Simcoa logs in dob classes. "%" column is the proportion of total logs assessed in each size class.

Log Hollows

The relationship between log dob and total hollows for the forest and Simcoa logs is illustrated in Appendix 10. The proportion of logs with hollows can be seen to increase with log diameter. The maximum proportion of hollow logs in the forest plateaus on 30% at 100cm dob. The proportion of hollow simcoa logs goes somewhat higher, approximately 50% at 120cm. This is to be expected since logs delivered to the plant have been trimmed with the chainsaw, exposing hollow "pipes" that may not otherwise have had an opening on the forest floor.

Similarly with tree hollows, the relationship between log size and hollow dimensions are illustrated in Appendices 7 - 9. There appears to be a significant trend of increasing hollow dimension with log size in the forest log data. The mean and median of hollow entry, depth and cavity diameter increase uniformly with log width. However the simcoa logs do not exhibit as good a relationship.

As with hollows found in the dissected trees, the number of forest log hollows assessed that met published dimension criteria for hollow nesters is shown in Table 10.0.

Hollow Nester	Entry	Depth	Cavity Diameter	Log Width Diameter Over Bark Classes 20.0 - 29.9 Hlws	%	30.0 - 69.9 Hlws	%	70.0 - 109.9 Hlws	%	110.0 - 149.9 Hlws	%	150.0 - 189.9 Hlws	%	Total Suitable Hollows
Regent Parrot 1 (1)	5	39	13	0	-	1	0.01	1	0.08	3	1.5	0	-	5
Regent Parrot 2 (1)	13	61	13	0	-	0	-	1	0.08	2	1.0	0	-	3
Port Lincoln Parrot (1)	5	36	10	0	-	4	0.06	3	0.3	3	1.5	0	-	10
Port Lincoln Parrot (2)				0	-	5	0.07	3	0.3	3	1.5	0	-	11
Western Rosella (1)	5	36	10	0	-	4	0.06	3	0.3	3	1.5	0	-	10
Red-capped Parrot (1)	5	19	10	0	-	4	0.06	4	0.4	3	1.5	0	-	11
Red-Tailed Black Cockatoo (2)				0	-	0	-	0	-	0	-	0	-	0
Corella (2)				0		1	0.01	1	0.08	2	1.0	1		4
Galah (2)				0	-	4	0.06	3	0.3	3	1.5	[illegible]		[illegible]
Chuditch (3)	[illegible]	70	7	1		[illegible]	0.1	3	0.3	2	1.0			[illegible]
Possum (4)	[illegible]	60	5	1	-	[illegible]	0.1	3	[illegible]	3	1.5			[illegible]
Total Hollows Assessed				35		123		40		5		[illegible]		N/A

Table 10.0: Number of log hollows assessed that met published dimension criteria for hollow nesters. References: (1) Long, J.L., No date: (2) Saunders, D.A., et al, 1982: (3) Serena, M., et al, 1990: (4) Inions, G., 1985.

Discussion

The discussion will address the questions first asked of the study by C.A.L.M and the set of hypotheses subsequently derived.

1. The age to hollow formation in jarrah trees appears to be approximately 80 years as shown in figure 3.0.

2. The age to the death of jarrah trees was not specifically addressed by the study, but the results of the age data for dissected trees suggest that jarrah can live to be 400 years old. Premature death may be caused by dieback, fire, or logging.

3. It is not known how long dead stags remain standing and no estimate can be made from the work done.

4. Data relating to thelength of time logs are useful to fauna has not yet examined or shown here, however, personal observations suggest that jarrah logs are very resistant to decay, particularly when compared with marri. The main element responsible for the disintegration of logs appeared to be fire. Very few logs were found in an advanced state of decay, but many solid logs were three-quarters their original size due to fire. The charred surface created by fire may render logs even less susceptible to decay agents. Without an experiment designed to specifically test the effect of fire regime on the life expectancy of logs, it is difficult to estimate their longevity, but without fire it is felt they would remain in solid, useful condition to flora for in excess of half a century.

5. Live trees large enough to contain hollows are unlikely to be affected by the project in the short term. However this question needs to be addressed in the terms of the proposed twenty year life span of the silcon project. This will be investigated further.

6. The percentage of dead trees affected by the project was not examined by the study, however it is probable that all stags devoid of termites would be taken by Simcoa.

7. In order to determine the percentage of logs affected by Simcoa's wood gathering operations all logs were assessed for suitability as charlogs. At this stage the data has not been examined in any way. However, it was observed that a relatively low proportion of logs on the ground were suitable for Simcoa due to decay or termites.

8. To date the study appears to support C.A.L.M.'s original claim that there is an excess of fallen logs on the forest floor and Simcoa's operations may not significantly reduce the population of hollows in the northern jarrah forest. However, the data has only been examined on a rudimentary level, it would be unwise to draw conclusions at this stage.

Ho.1 Hollow size and frequency (per tree) is independent of tree size, tree age, [illegible] dominance.

The results appear to refute the null hypothesis, indicating that hollow size and frequency is dependent upon tree size and age, increasing with both. There is insufficient data to test the significance of tree dominance.

Ho.2 Hollow size and frequency (per tree) is independent of crown size, crown growth stage and crown condition.

Data for this hypothesis has not been examined.

Ho.3 Hollow size and frequency (per tree) is independent of fire evidence/damage and management history.

Many hollows were found to be associated with fire scars. Observed evidence suggests that fire is an important precursor to hollow formation, particularly where large hollows were found in otherwise solid, healthy crowns. The stringy bark of a jarrah tree helps convey ground fire up the bole and into the limbs of the crown. "Dry sides" in the limbs, where the cambium is killed by the fire, were often associated with hollows. The fire scar provides an opening for elements of decay, introducing or speeding the process of cavity formation. When an opening to the cavity is created, usually by branch shed in mature crowns, the result is often a very habitable hollow. This observation is yet to be tested for statistical significance.

Ho.4 'Log hollow' and frequency is independent of the amount of log material and logging history.

The data appears to reject the null hypothesis, showing a trend of dependence upon the amount of log material which appears to increases with incidence of logging.

Ho.5 'Log hollow size and frequency is independent of log type, dimension, state of decay and fire evidence.

Hollow size and frequency apapears to be dependent on log dimension. The influence of log type, state of decay, and fire evidence is yet to be examined.

Ho.6 Simcoa's firewood gathering operations have no impact on:

i) The size and frequency of hollows.
ii) The distribution of hollows.

Data for this hypothesis has not been examined.

Conclusion

It is not possible to draw any conclusions from the study at this very early stage of examination of the data. This report presents only rudimentary results for approximately half the parameters assessed. Much work is still to be done to investigate the remainder of the data set and draw together all the elements of the study into as complete an understanding of the processes of hollow formation distribution and longevity in the jarrah forest as the data allows

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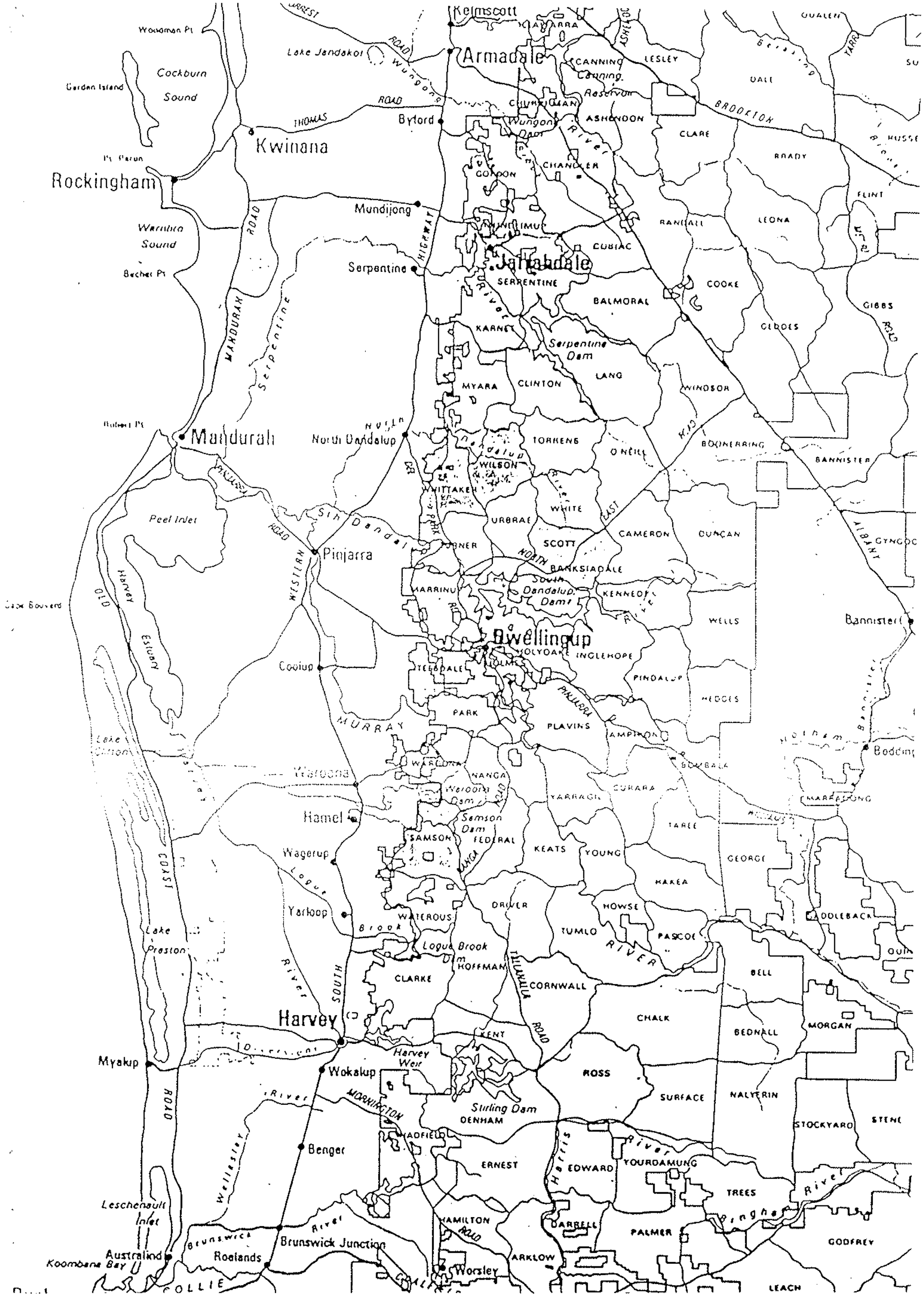
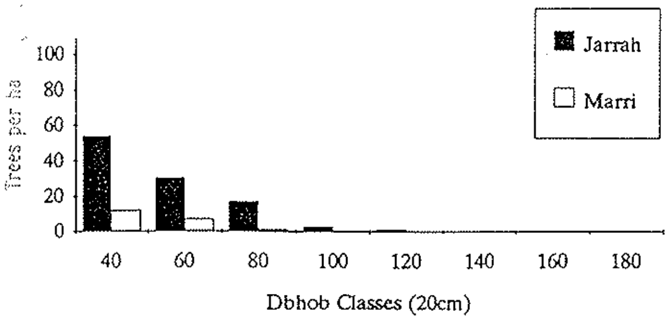
APPENDIX 1: Forest Blocks Sampled by the Jarrah Fauna Hollow Study

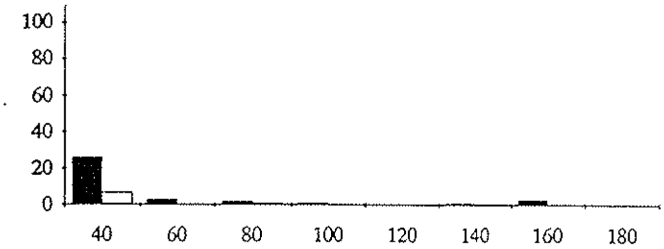


APPENDIX 2: Stand Tables of the Ten Hollow Study Sites

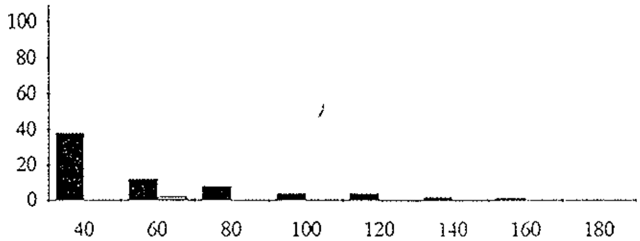
Plot 1: Ross Block



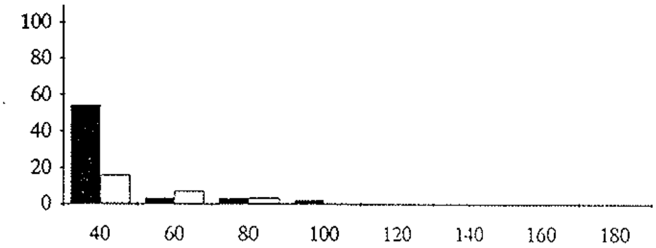
Plot 2: Scott Block



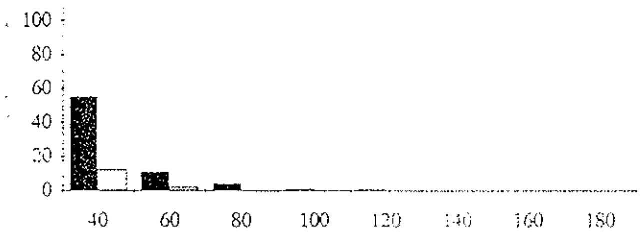
Plot 3: Windsor Block



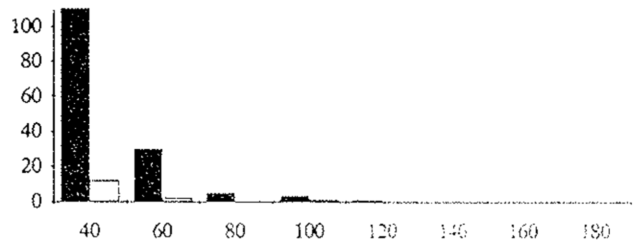
Plot 4: Ross Block



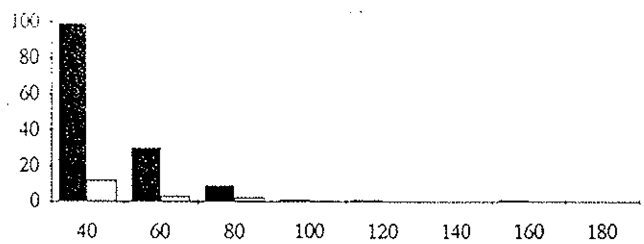
Plot 5: Samson Block



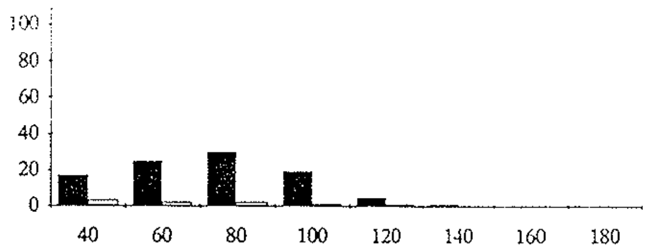
Plot 6: Alcoa Site 1



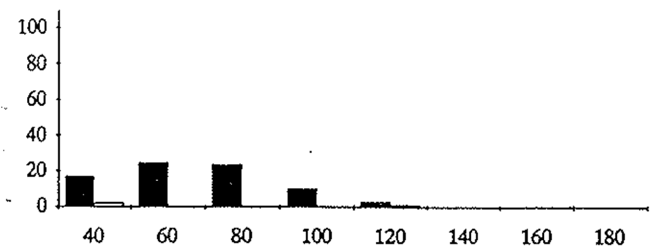
Plot 7: Alcoa Site 2



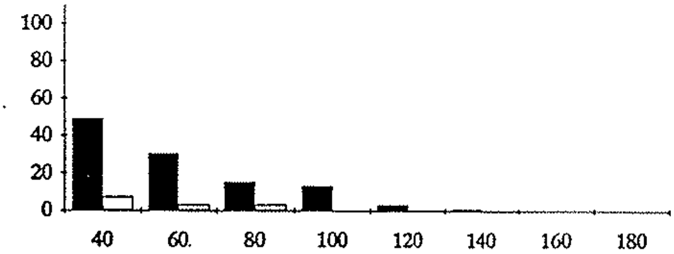
Plot 8: Torrens Block



Plot 9: Bombala Block

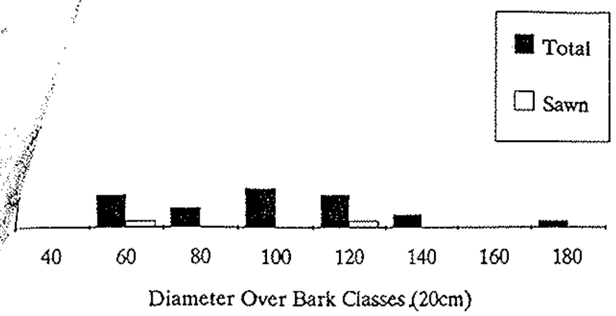


Plot 10: Surface Block

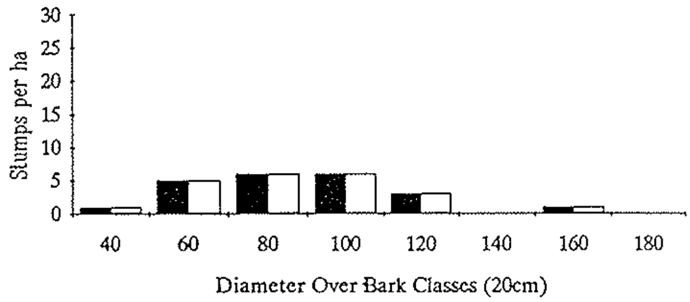


APPENDIX 3: Dob Distribution of Stumps

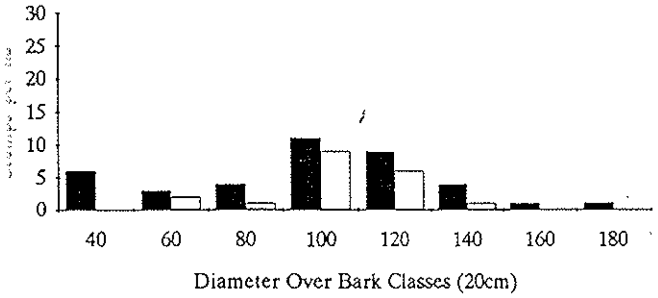
Plot 1: Ross Block



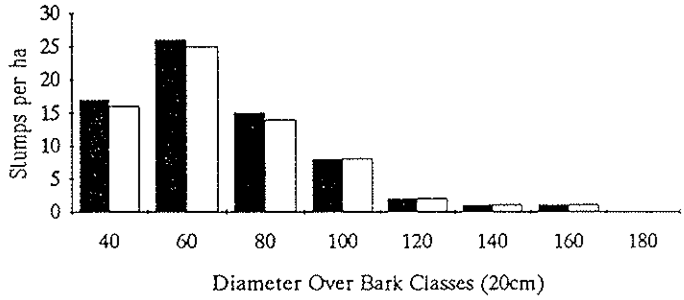
Plot 2: Scott Block



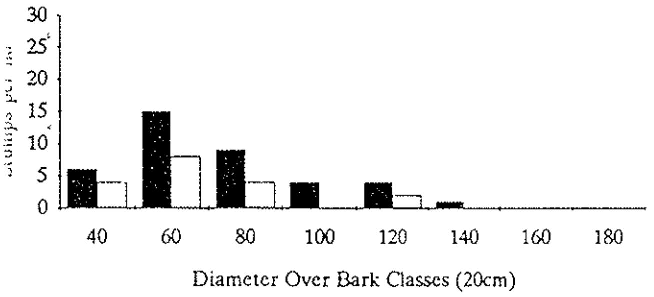
Plot 3: Windsor Block



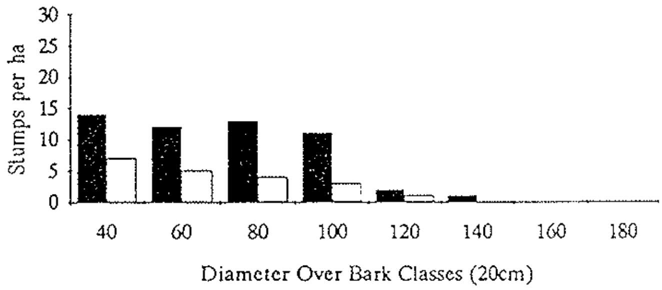
Plot 4: Ross Block



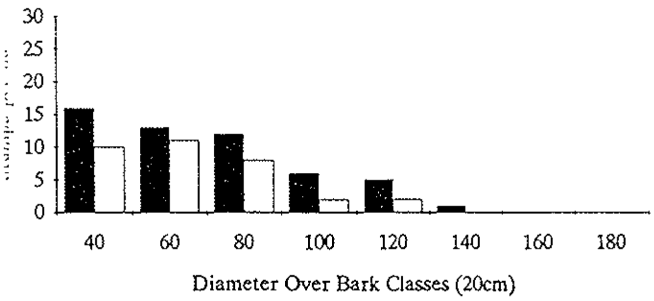
Plot 5: Samson Block



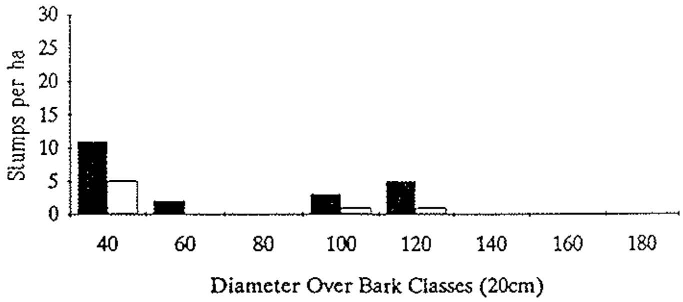
Plot 6: Alcoa Site 1



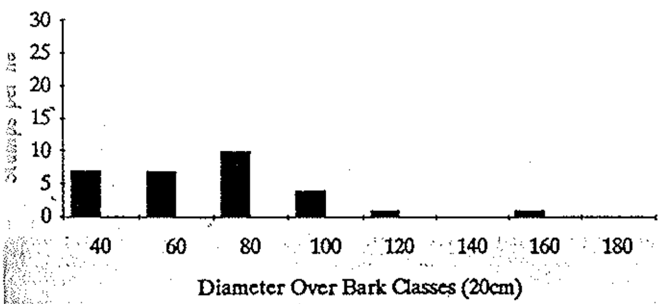
Plot 7: Alcoa Site 2



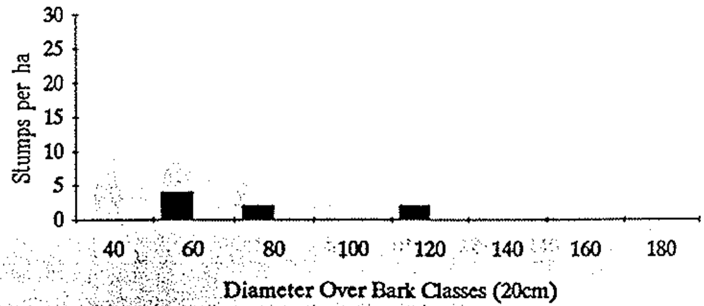
Plot 8: Torrens Block



Plot 9: Bombala Block

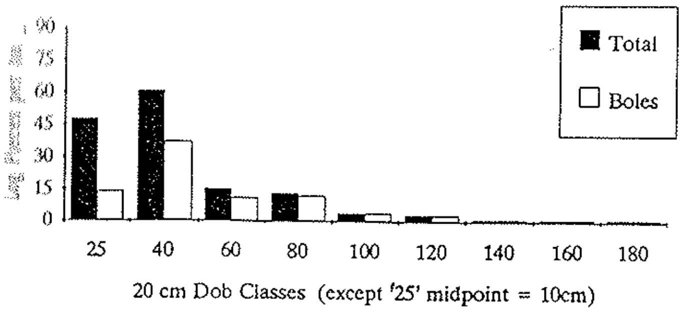


Plot 10: Surface Block

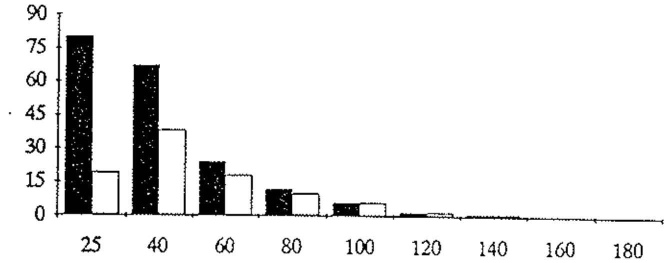


APPENDIX 4: Dob Distribution of Log Pieces

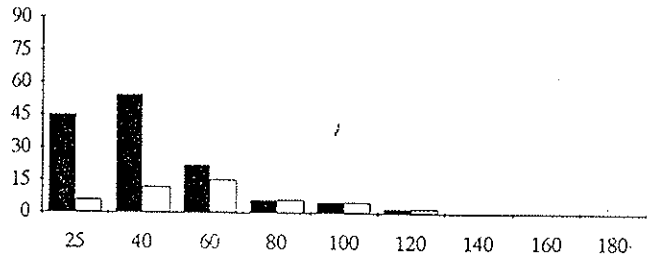
Plot 1: Ross Block



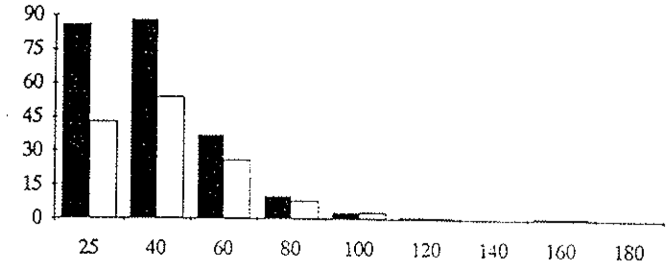
Plot 2: Scott Block



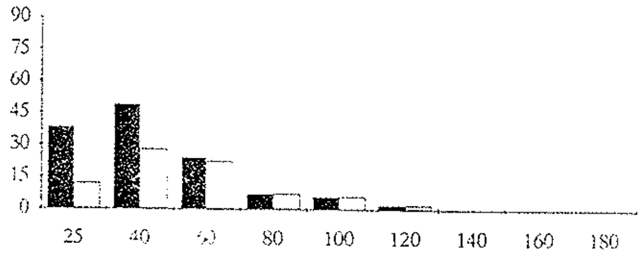
Plot 3: Windsor Block



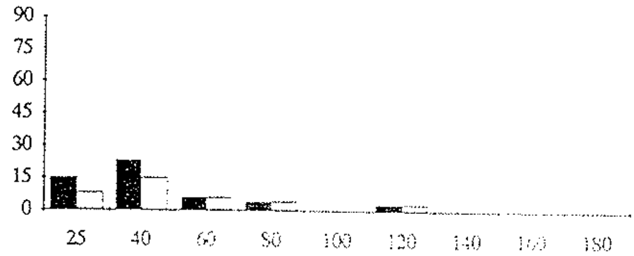
Plot 4: Ross Block



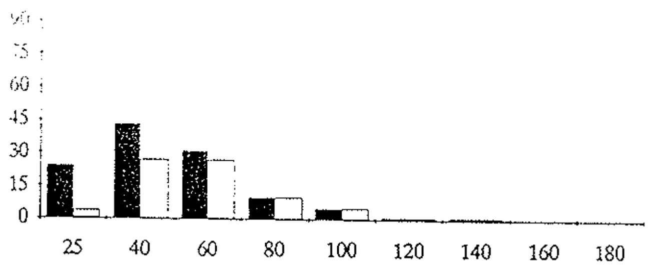
Plot 5: Samson Block



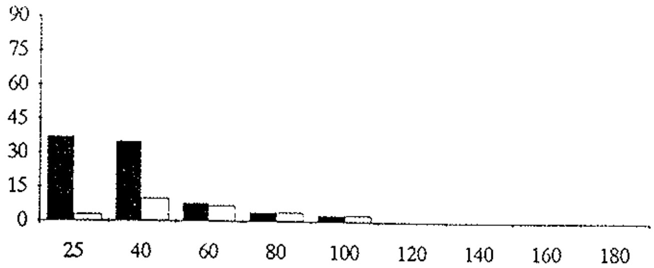
Plot 6: Alcoa Site 1



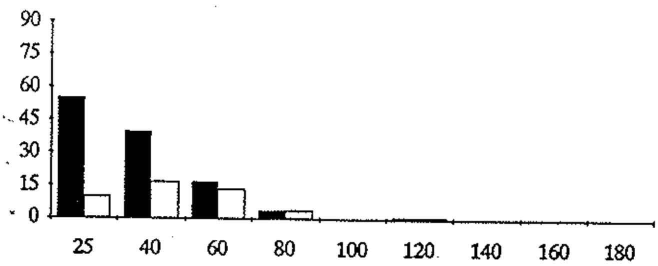
Plot 7: Alcoa Site 2



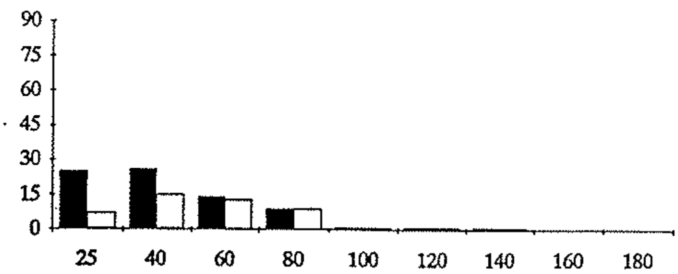
Plot 8: Torrens Block



Plot 9: Bombala Block

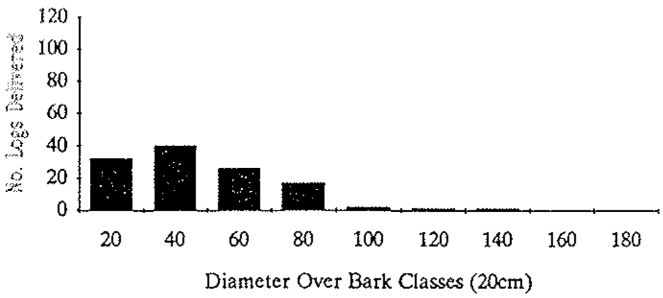


Plot 10: Surface Block

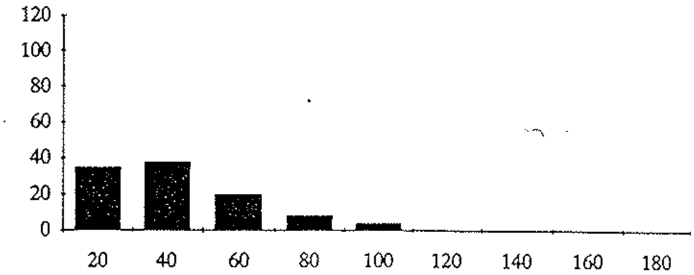


APPENDIX 5: Dob Distribution of Simcoa Truck Logs

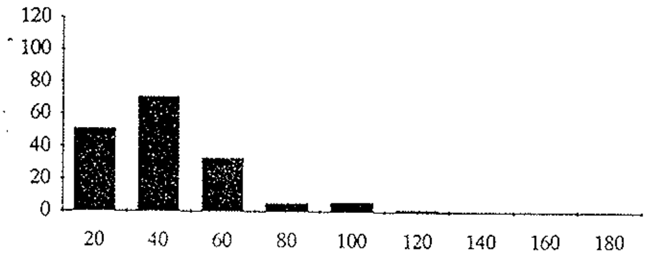
Simcoa Truck Logs, Day 1



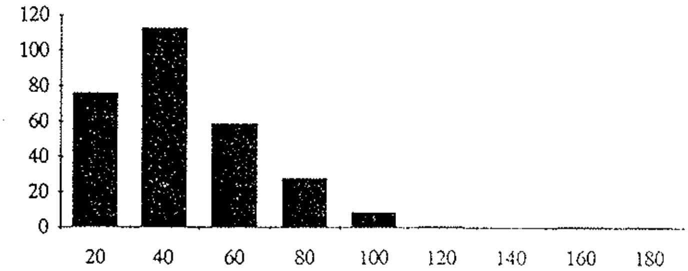
Simcoa Truck Logs, Day 2



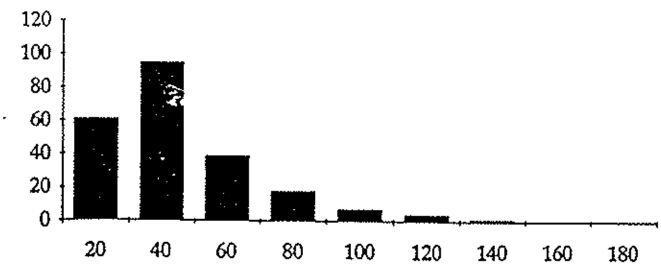
Simcoa Truck Logs, Day 3



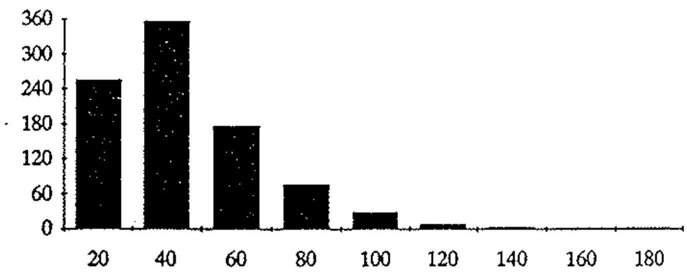
Simcoa Truck Logs, Day 4



Simcoa Truck Logs, Day 5

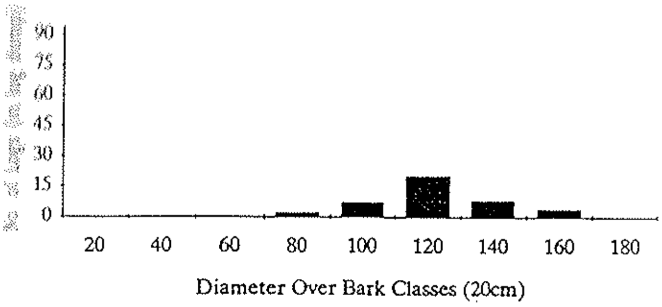


Simcoa Truck Logs, 5 Days

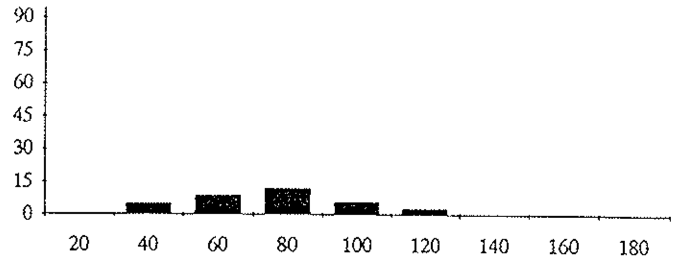


APPENDIX 6: Dob Distribution of Simcoa Dump Logs

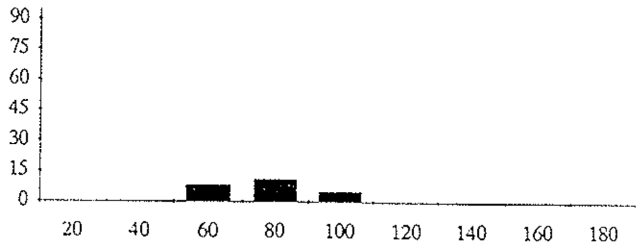
Simcoa Log Dump 1



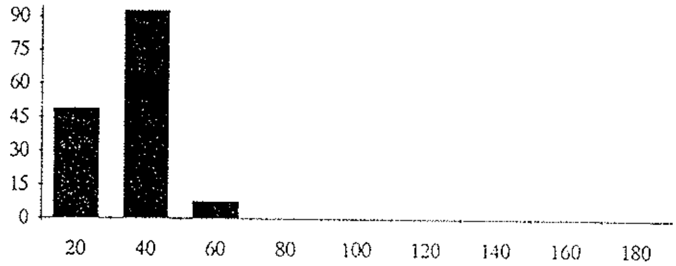
Simcoa Log Dump 2



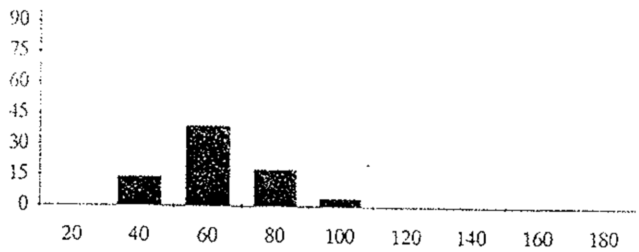
Simcoa Log Dump 3



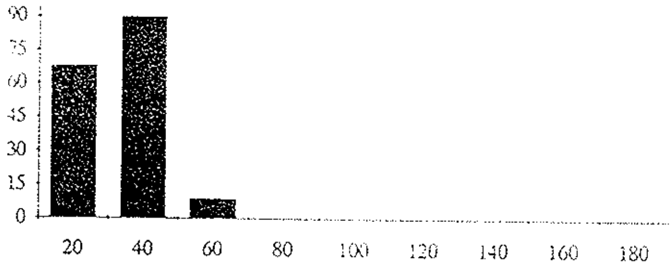
Simcoa Log Dump 4



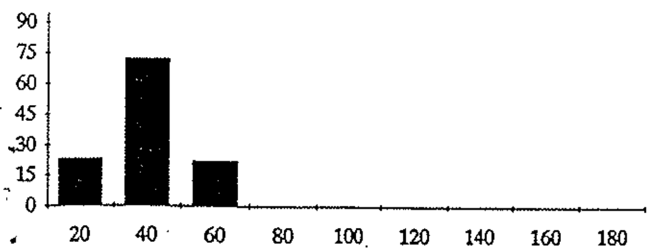
Simcoa Log Dump 5



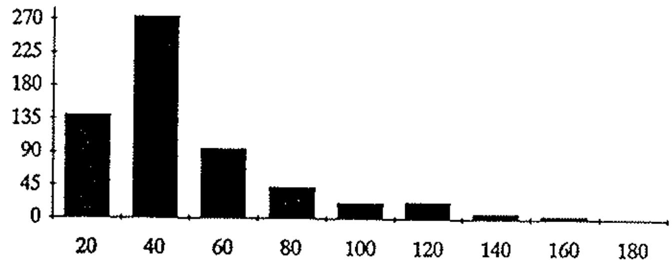
Simcoa Log Dump 6



Simcoa Log Dump 7

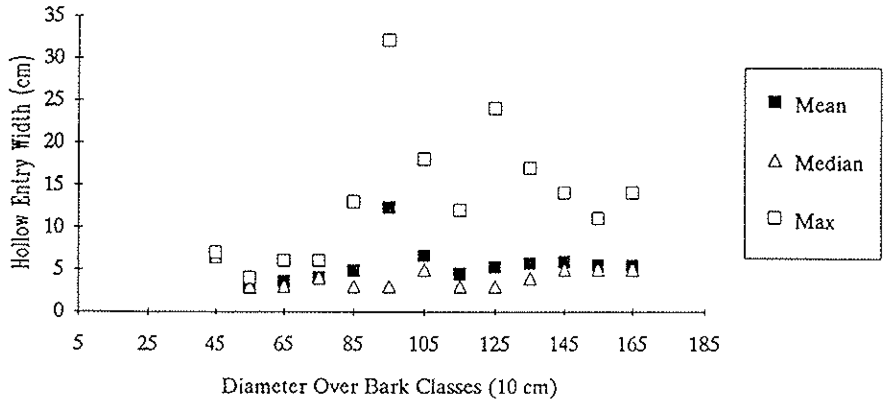


Simcoa Log Dumps

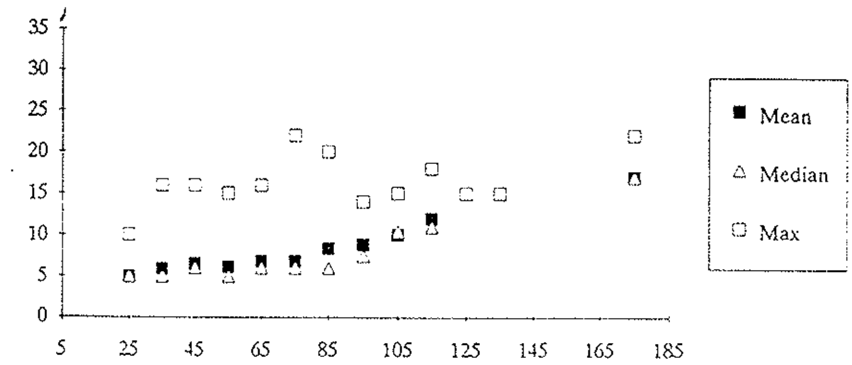


APPENDIX 7: Relationship between Hollow Entry Width and Tree/Log Dob

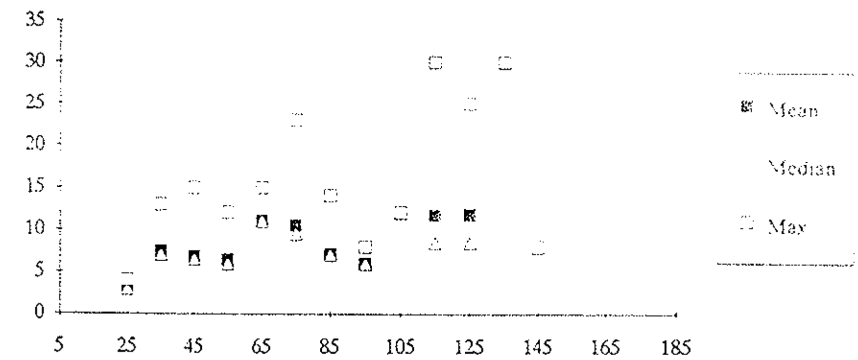
Hollow Entry Width vs Tree Dbhob



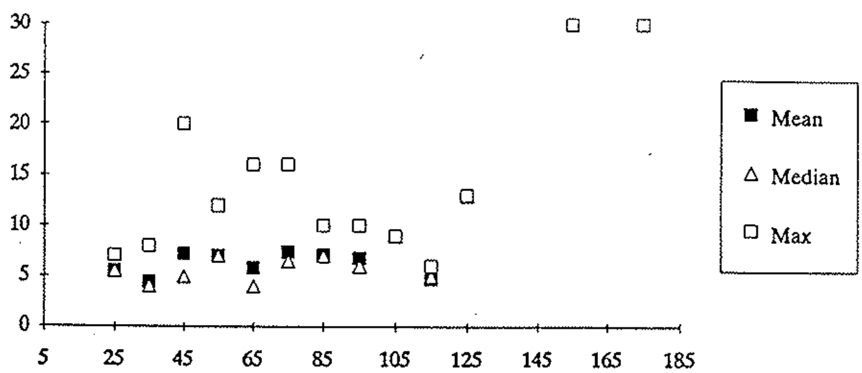
Hollow Entry Width vs Log Large Dob



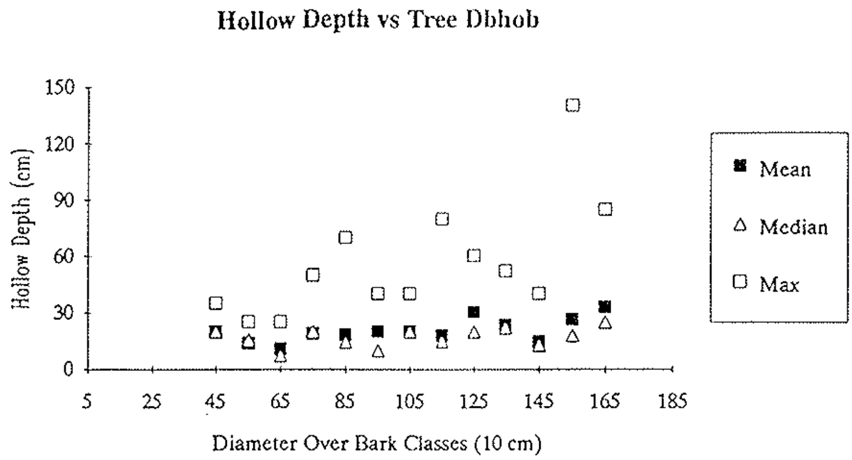
Hollow Entry Width vs Simcoa Dump Log Dob

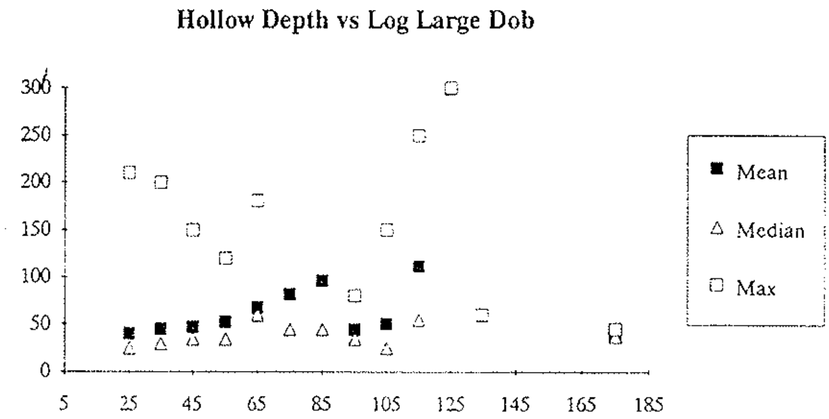


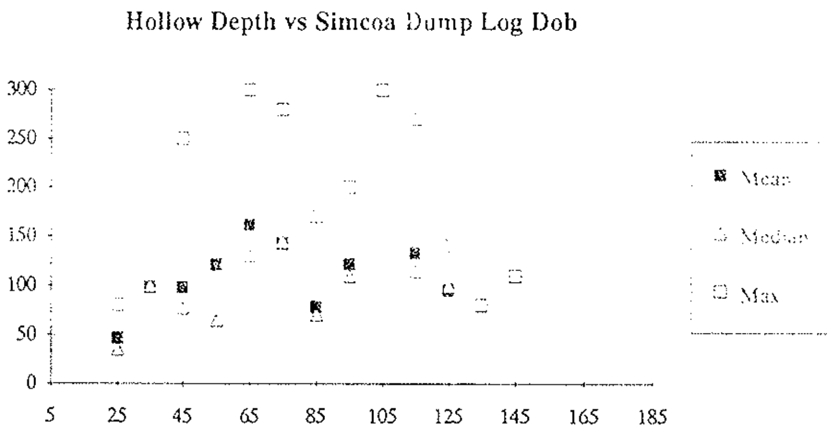
Hollow Entry Width vs Simcoa Truck Log Dob

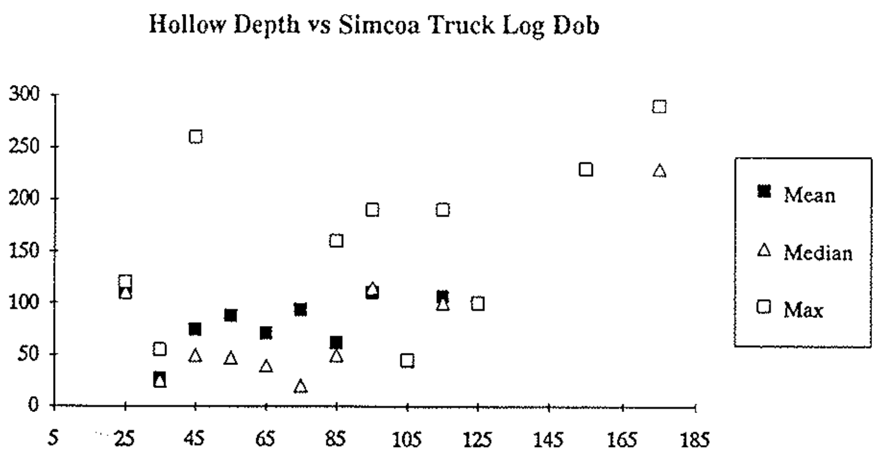


APPENDIX 8: Relationship between Hollow Depth and Tree/Log Dob



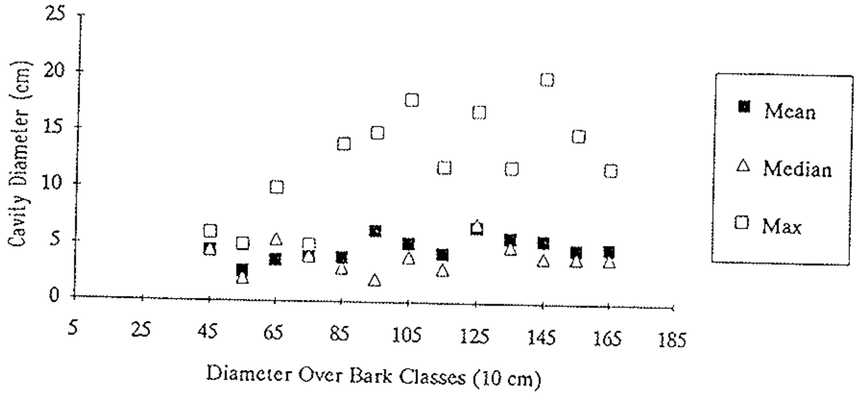




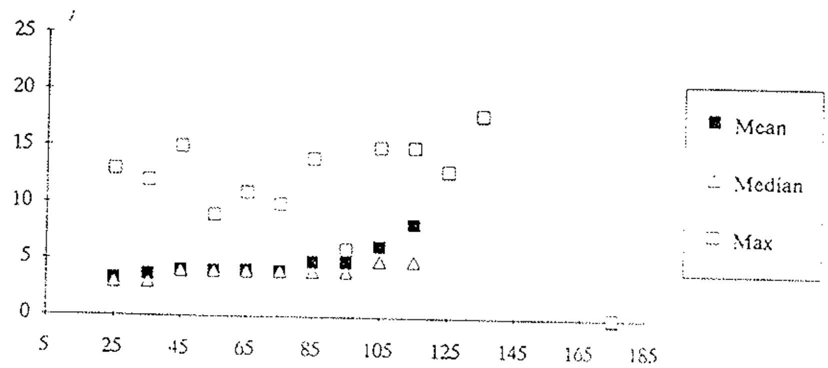


APPENDIX 9: Relationship between Internal Cavity Diameter and Tree/Log Dob

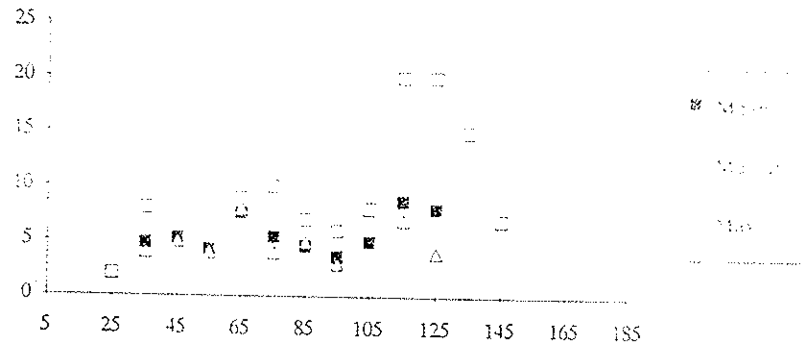
Cavity Diameter vs Tree Dbhob



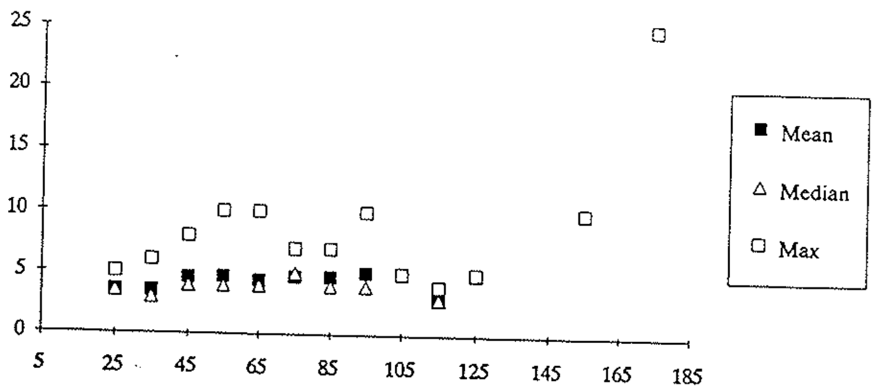
Cavity Diameter vs Log Large Dob



Cavity Diameter vs Simcoa Dump Log Dob

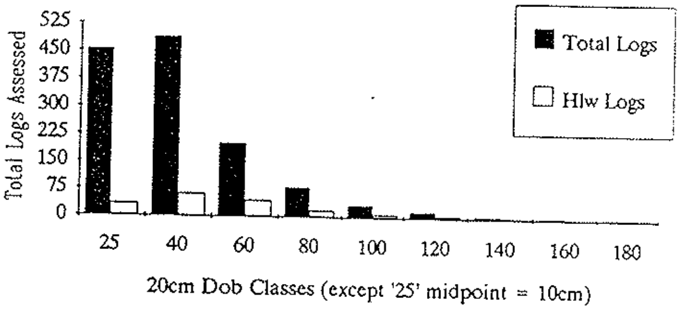


Cavity Diameter vs Simcoa Truck Log Dob

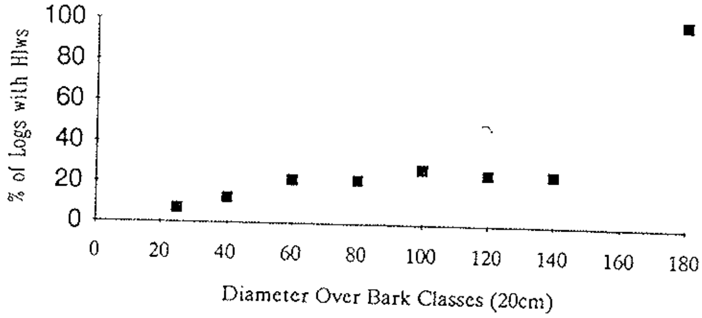


APPENDIX 10: Proportion of Lo… d to Contain Hollows

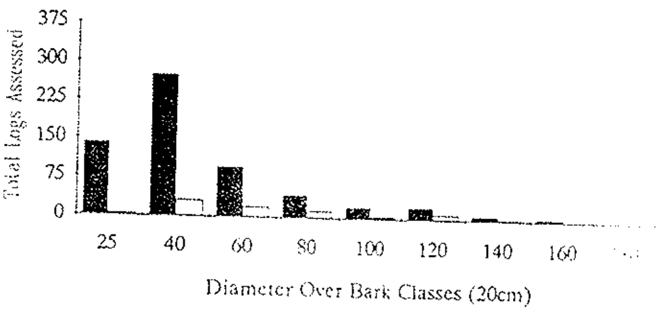
Forest Logs: Total & Hollow Logs vs Dob



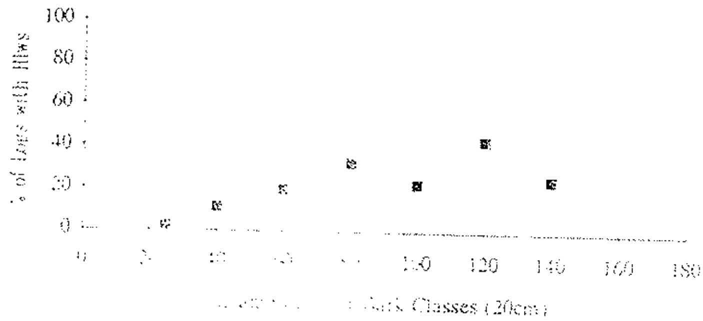
Forest Logs: Proportion of Logs with Hlws



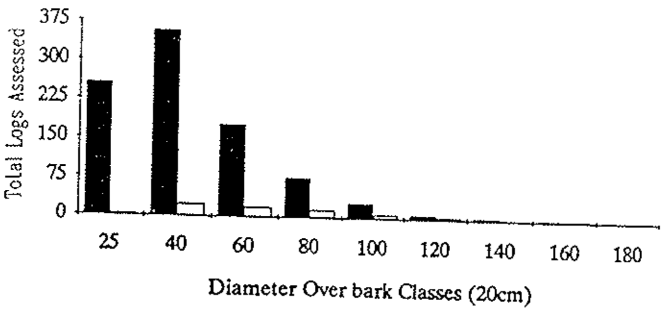
Dump Logs: Total & Hollow Logs vs Dob



Dump Logs: Proportion of Logs with Hlws



Truck Logs: Total & Hollow Logs vs Dob



Truck Logs: Proportion of Logs with Hlws