AN INVESTIGATION INTO THE DISTRIBUTION AND CAUSES OF TREE DEATHS OBSERVED ON THE EDGES OF SOUTHERN FLATS

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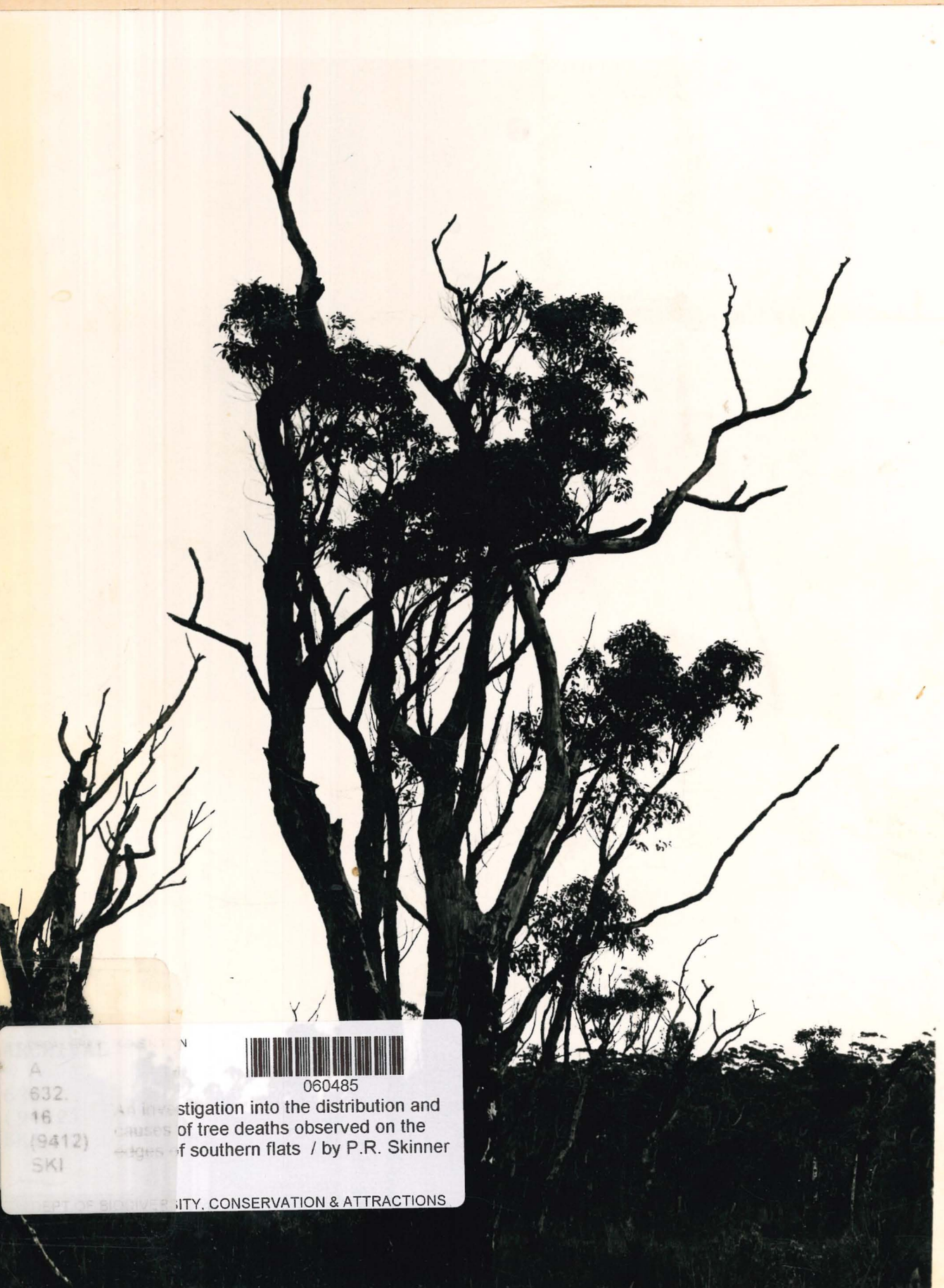
ASSIGNMENT FOR TO.1 EXAM, 1979



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INTRODUCTION

A feature of the southern acid peaty flats is the large number of dead degraded and stunted trees which occur, either around the edges of the high forest or as single trees or small groups further out into the flats. Jarrah and banksia species predominate, though marri, blackbutt or casuarina species are often present.

The tree deaths are generally attributed to the effects of fire, but - as far as can be ascertained, - no study has been carried out into the possibility of there being any other contributory cause. This investigation attempts to establish whether in fact fire is the main or only cause, and if Jarrah dieback (Phytophthora cinnamomi) or water stress are relevant factors. Some pattern of tree deaths, both in time and space, was also looked for.

Two areas were chosen for study, the first was a flat along Inlet Road, two kilometres from the south-western highway and some 16 kilometres north west of Walpole. The second was 6 kilometres further north along Brooke Inlet Road. Both flats come into the F1 Closed Herbland, Sedgeland (S) formation of the Vegetation Survey of W.A. (F.A. Smith), though interspersed with small patches of Jarrah low open woodland C4 (J). The dominant vegetation is Evandra linearis, Anarthria scabra, Agonis parviceps and Beaufortia sparsa. Agonis linearis is dominant in the wetter sections of these flats. A fuller list of vegetation is found in Appendix A.

HISTORY

There is evidence of severe fires in the karri forest over 5000 years ago (Churchill). Early travellers and settlers in the region give conflicting reports on fire frequency. Some claiming that the forest was often burnt, others stating that it contained vast areas of thick unburnt scrub. It seems probable that the highly inflammable type of vegetation present on the south coast flats would burn more frequently than that of the high closed forest, and would be more likely to be fired periodically by Aborigines. Eighteenth-century seafarers off the south-west coastline report smoke from bushfires burning along the coastal fringes. It is fair to assume that fairly frequent fires have been part of the coastal flat environment since well before European settlement.

There is also hearsay evidence that, from the 1860's, the early settlers burnt off as much as possible of the low-lying sedgeland and heath along the route while making their periodic visits to the coastal grazing lands. There is evidence also of increase in bushfires, many of which would have penetrated the southern flats, from Group Settlement days.

Introduction of dieback to the general area is believed to have occured in the late 1950's, originating from infected gravel used in building the South West Highway. The degree and rate of spread since then is uncertain, but it is quite probably present over a wide area as the use of heavy logging machinery, fire-fighting equipment, and road making activities would have ensured it's spread before the recent hygeine measures were introduced.

METHODS USED

Using chain and compass, a total of 980 metres of baseline was surveyed. This was divided into 3 sections:-

Line 1. Running northwards from Inlet Raod for 220 metres, as far as the edge of the high closed forest.

Line 2. Running southwards from Inlet Road over a low-lying area of flat and crossing 2 flowing creeks. Total distance was 370 metres, but this line did not extend as far as the treeline on the southern edge of the flat.

Line 3. Running northwards from Brooke Inlet Road for 420 metres as far as the edge of the high closed forest.

At each 20 metre mark, levels were taken along the line by Abney level and clinometer, readings being taken to the next 20 metre mark and also over longer distances where possible, e.g. at line 3 it was possible to take an overall level of the entire 420 metres, for cross-checking when mapping was done.

Also at each 20 metre mark, the soil type was noted, and a visual estimate made of the condition of the soil moisture, i.e. whether soil was dry, normal, waterlogged, or had surface water.

Between each 20 metre mark a vegetation count was done for a distance of 10 metres each side of the line. Thus each line was a succession of 20 metre square 'quadrats'.

For each quadrat, the 3 main understorey species were recorded, other species present were noted, and all trees were recorded and categorised as follows:-

Jarrah

a. Advance growth.

b. Healthy trees, divided into less than 2m height, 2-5m, 5-10m, 10-30m, over 30m. Trees were counted as 'Healthy' if there was no sign of their having lost their leading shoot, or their growth being severely interupted by fire damage. Having fire scars or some dry side did not exclude them from this category.

c. Fire damaged trees, those which had lost their leading shoot to fire at some stage, but which had re-formed a healthy crown. These also were divided into height classes as for b.

d. Severely fire damaged trees, with dead tops but some epicormic shoots.

e. Dead trees, some small branches and twigs remaining.

f. Dead trees, boles and larger branches remain. These were further sub-divided into trees with intact boles, and those with stumps only.

g. Trees with dead boles and no epicormics, but coppicing.

Banksia

a. Healthy trees.

b. Fire damaged trees, coppicing or epicormic present.

c. Dead.

d. Dead, stump only remains.

Blackboys

a. Healthy.

b. Dead.

c. Dead, stump only remains.

Examples of some categories of trees are shown in Figures 1A - 1J.

Basal area per hectare of jarrah was noted for each quadrat.

Any evidence of dieback was noted. Soil samples were taken at any point with possible symptoms, and other samples were taken at approximately 100 metre intervals along each line.

Several sections were cut from both fire damaged and healthy trees between ½m and 1m above ground level, to be used for ring-count and analysis. It was hoped that this information, combined with that from an analysis of the different categories of fire damaged jarrah as recorded above, would enable a fire frequency history to be compiled.

In an attempt to discover if comparative ground levels had any effect on tree growth, several of the better patches of jarrah, ranging from a few trees to a large group of 0.25ha., were examined. Levels were taken of each group. The groups were chosen at random over a widely distributed area, not all near the surveyed line.

RESULTS

Fire History

Ring Counts

Twelve sections of bole were taken from trees of various ages, eleven from Jarrah and one from Marri. Sections were cut at different angles, the wood was sanded and polished and several methods of staining and wetting were tried in an attempt to age the trees from annual ring counts. It was also hoped that the

frequency of fires could be picked up from the discolouration or damage of annual rings when the fires occured. The rings proved to be indistinguishable in most cases, even when examining sections under the microscope. Ring count analysis has been done successfully elsewhere with various species of trees, but in this atypical jarrah site with very degraded and slow-growing trees, the method was impractical in giving any accurate idea of either tree age or fire history.

Many trees were deeply fire-scarred, the scar often extending almost to the core of the tree. The number of fires occuring over the lifetime of each tree appeared to be easy to ascertain in these instances, by counting the ridges formed by new wood growing on the face of the fire scar (Fig. 2A). If the annual rings within each ridge could be counted, an accurate fire history could be worked out. However by this method one section, apparently 33 years old by ring count, showed eight fires of which the first 3 occured at 12 years, 16 years and 21 years. This sequence seems improbable as hot fires would be unlikely to be sustained at such short intervals as 2 years, and it was assumed my ring count was at fault. It is also possible that my interpretation of the ridge forming process was incorrect.

The easiest section to count appeared to be about 50 years old, and 8 fires were evident (Fig. 2B). These fires were estimated from the ridges on the fire scars, discolouration of annual rings did not extend very far into the sound wood.

Degree of Tree Damage

Determining the fire frequency pattern from the degree of tree damage proved more impractical than the ring count method. Most trees showed fire effects ranging from small scars to almost



Fig. 1A Advance growth (category 1). These overcome severe competition by the thick growth of monocots.



Fig. 1B Heavy epicormics on fire damaged jarrah (category 4). On the right is a smaller healthy tree which has escaped major crown damage to date (category 2).



Fig. 1C Young jarrah which has lost it's leaders, but low-growing epicormics have formed a new crown (category 2).



Fig. 1D Severely fire damaged jarrah, developing multiple stems (category 3).



Fig. 1E Severely fire damaged jarrah, showing effects of several fires. Epicormics are forming a new crown (category 3).



Fig. 1F Jarrah showing effects of several fires. Epicormics are forming new crown low down on the bole. These could also be destroyed in next fire (category 4).



Fig. 1G Fire damaged stems, producing both epicormic and coppice regrowth (category 4 and 7).



Fig. 1H Dead stump, young regrowth on right. This is possibly a coppice growth from the old stump.



Fig. 1J Old Banksia stump, the majority of dead banksia across the open flats are in this state.



Fig. 2A Typical deep fire scarring, new wood has grown after each fire forming ridges on face of scar. Earlier fires can be detected by discolouration in annual rings within the wood, but later fires are indistinguishable by this method.



Fig. 2B Fire scarring of bole. Section on right shows difficulty of counting rings accurately. This was the easiest section to count of all those cut. The tree appears to be about 50 years old, and at least 8 fires can be traced. Centre of bole was rotten.

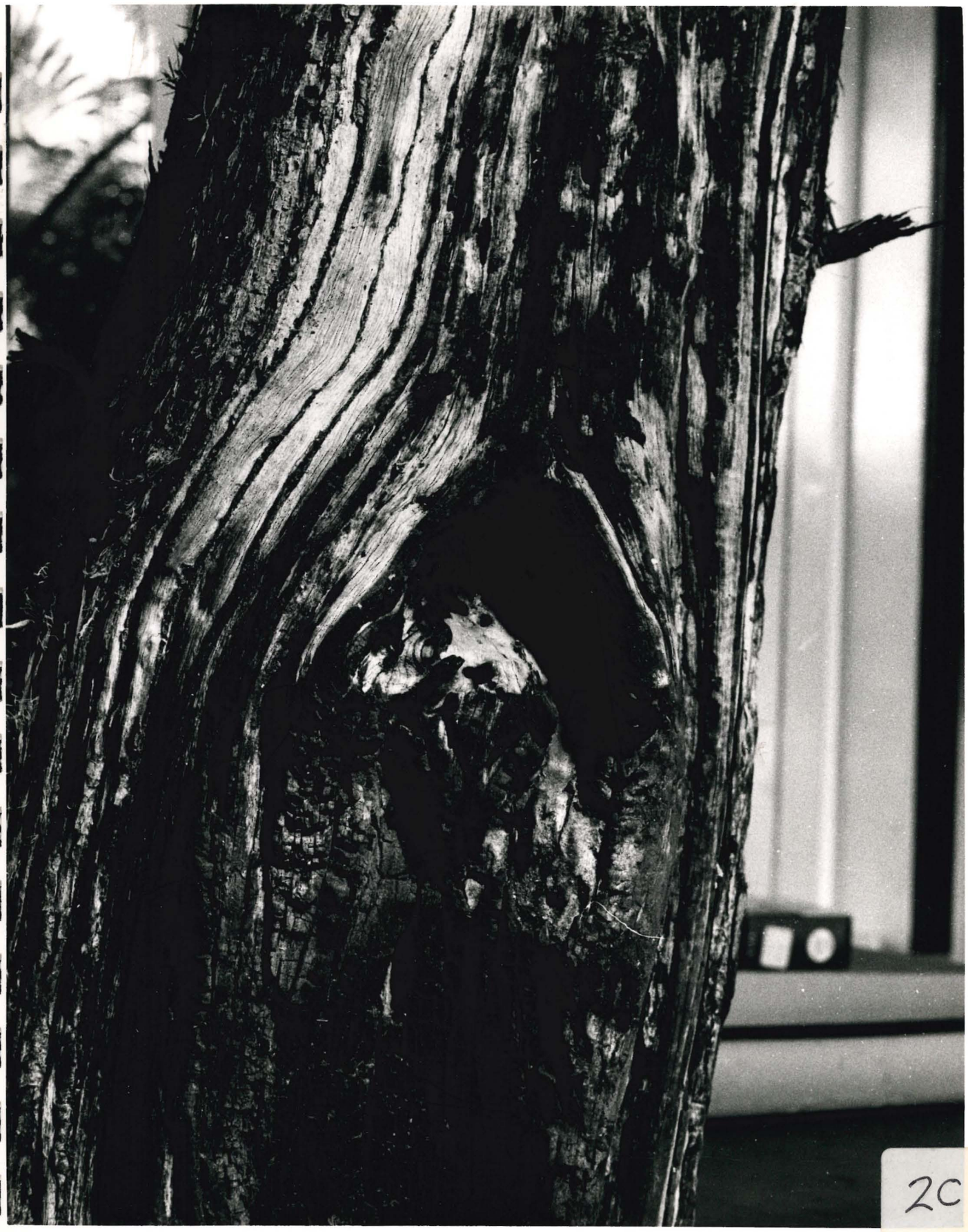

Fig. 2C Fire scarred log, last fire appears to have been severe. At least five fires are apparent.



Fig. 2D Deep fire scarring of bole. Although new wood grows on the diameter of the tree after each fire, the heartwood is gradually burnt away allowing rot and insects to enter.

complete destruction at some stage of their life. However the jarrah were remarkably resilient, reforming new crowns from epicormics after having lost most of their woody growth (Figs. 1E and 1F). Many trees, after successive exposure to heavy fires, had developed multiple stems (Fig. 1D).

Several groups and belts of trees containing a high proportion of apparently dead stems were investigated. Over two thirds of these 'dead' trees, on average, had either small live epicormics or coppice growth.

Live trees with deep fire scars in many cases had heart rot, and ants or other insects were active in the rotted out sections. This is inevitable after a time, as once a tree is fire scarred each succeeding fire is likely to burn further into the heartwood, allowing the access of harmful agencies. But no instances were seen of these agencies having caused the death of the tree.

It was evident that frequent fires had had a major effect on Jarrah growth, damaging most of the trees to some degree. The gradations of damage were not sufficiently clear to enable any time pattern or severity of past fires to be worked out.

Because of this, some of the categories of trees recorded have been amalgamated in compiling Figures 4 - 6, e.g. 'fire-damaged' and 'severely fire damaged' have been combined. 'Dead' trees include all those dead, whether the bole and branches, or just a stump remains.

Distribution of Trees

Figure 3 shows the breakdown of the numbers of jarrah trees on each line, and Table 1 gives the percentage of each category.

Line 3, the longest line, was across a more open flat with a sparser tree cover, but the percentage of trees within each category was similar to that of Line 1, the number of dead trees being very low. Line 2, along the lowest lying area and by far the wettest, had a lower proportion of healthy trees and a significantly higher percentage of dead trees (Chi-square, signif. to .01 level).

Figures 4 to 6 give comparative levels of the 3 lines, and show the distribution of trees along each line. Except for a shallow depression at the beginning of Line 3, both Lines 1 and 3 show a fluctuating rise, from the road to the tree line. Line 1 enters a gully about 20 metres wide and 1 metre deep just inside the high forest, but from the end of Line 3 the ground level rises sharply immediately inside the forest edge.

Line 2 was along undulating ground which showed an overall decline. At two points it crossed running creeks about 30cm deep, one of these being a permanent summer-flowing stream. After heavy rain a considerable amount of a surface water was evident all along this line, and drainage appeared to be poor.

It could be expected that the highest numbers of trees would occur within 50m of the high forest line, but Fig. 5 and 6 show this is not the case, though the highest proportion of advance growth and healthy trees are concentrated in this zone together with most of the healthy banksias. On the open flat nearly all trees have suffered fire damage and no particular pattern can be distinguished, it is fairly certain that the build-up of fuel on these thickly vegetated peaty flats would ensure an even and thorough burn. Within the forest line the top height of trees rises fairly abruptly to 25 metres, and no major fire damage was noticed from this point.

On Line 1 at the 140m point there is a higher proportion of undamaged jarrah. No reason for this was apparent, but it was noted that the growth of monocots was sparser in the section, which if persistent would reduce the damage from any wildfires.

There was a tendency for higher concentrations of trees on the lower slopes of any ridges or spurs and on any localised mounds, ending abruptly where the ridge or mound levelled off into the flat. The difference in level was only half a degree over 20 metres in some cases. Heavy rain had been falling in the area over the previous few days and about 40% of the surrounding flat had free-lying water, but there was very little surface water lying within the groups of trees.

Fig. 7 is a sketch map of one such patch of trees. These were jarrah with a top height of 5 metres, severely fire damaged but very vigorous. The group was growing in the middle of an otherwise treeless flat, and the difference in ground level was not apparent until measuring and Abney levelling was done.

Dieback

Of a total of 16 soil samples taken, four showed signs of dieback. Three of these were taken from the northern end of Line 1, on the edge of the high forest. The gully there (Fig. 4) is a classic dieback susceptible area, containing many dead or dying Banksia grandis, B. littoralis, and jarrah trees to 25 metre height. Two samples taken from the gully bottom and one from the highest point of the gully edge, were positive. Visible signs of dieback, mainly dead or yellowing Banksia, Blackboys and Podocarpus drouyniana extended for about 20 metres from the gully edge towards the flat, but still within the high forest line. Other B. grandis and B. littoralis nearby were unaffected.

The fourth sample that showed positive dieback was also from Line 1, only a few metres from Inlet Road. This was taken from near the root of an old Banksia stump, no other dieback indicators were present in the locality.

Apart from the areas in Line 1 where positive samples were taken, possible dieback symptoms were present on Line 3. At the 60 metre point, and some 30 metres from the line, individual small banksia and blackboy were dying off. Some of these were isolated plants, but several were within a large group of jarrah/ marri. Though the symptoms were indicative of dieback attack, two of the banksia were found to be coppicing, and other small banksia nearby showed no signs of infection.

At the end of Line 3, near and just within the high forest edge, were small patches and individual plants of dead or yellowing banksia, blackboy and Podocarpus drouyniana. There were no dead jarrah nor any showing any symptoms of dieback, and the steeper ground further in the tree line contained only healthy understorey of banksia, with indicator species such as Podocarpus sp. and Adenanthos obovata being unaffected.

Lines 1 and 2 showed more dead blackboy than live ones. In Line 3 the position is reversed, but here the live blackboys are predominantly small with stems below 30cm height. Overall, 55% of blackboy recorded were dead, and the pattern of deaths are fairly typical of dieback attack. All lines had several blackboys with yellowing or almost dead needles, but samples taken from near the roots of several of these failed to show dieback present.

In Lines 1 and 3, apart from a concentration of healthy banksias near the high forest, almost all the remainder were dead. Only the stumps remained of these dead banksia, and though they had all been affected by fire, from their condition it appeared that they had all died off at about the same time.

Line 2 however gave more live banksia than dead ones, the healthy specimens being fairly well distributed along the line.

As a positive dieback sample was taken a few metres from the road on Line 1, and the road itself is virtually a running drain during winter months, it could be expected that any dieback would have spread rapidly, particularly across the road and into the lower level of the flats. However, although Line 2 is a continuation downhill from Line 1, no dieback was found anywhere along Line 2. Samples were taken at the same time as those on Line 1.

Though Line 2 contained a significantly higher percentage of dead jarrah than either of the other lines, it also contained a higher percentage of dead boles showing coppice regrowth, which would indicate a cause of death other than dieback.

DISCUSSION

Though the investigation has proved little, it has indicated that fire is quite probably the cause of death and damage to trees on the southern peaty flats. It has shown that the actual death rate of jarrah, at least in the areas surveyed, is barely more than 5% overall if advance growth is included in the tree total. Most of the jarrah deaths are concentrated in the low-lying areas subject to waterlogging in winter. The remarkable resilience of jarrah to major fire damage in this marginal environment is evident, over 75% of trees beyond the advance growth stage having lost their leading shoots on at least one occasion. Many trees had been killed back to almost ground level but still coppiced or put out epicormic shoots very low down on the bole.

It is disappointing that no definite sequence or severity of fires could be worked out by ring counts or categorising the extent of fire damage, but it is obvious that this fire damage has been a continuing process for many years. The vegetation consists of a dense growth of fast growing monocots and woody shrubs, and could support a fire every few years. But the facts suggest that a longer interval is achieved between some fires. The open, comparatively unimpeded stretch of flat with fairly even vegetation growth would be likely to suffer a uniform burn, not the mosaic type of burn common on the high forest or drier scrub. There would have to be some longer fire-free intervals to enable dynamic shoots to develop to the fire-resistent stage. Also the height of the fire damage on some of the taller trees would suggest a bigger build-up of ground fuel than could be achieved in only 4 or 5 years.

Drainage patterns could have a very important bearing on the distribution and survival of the jarrah forest on the flats. It is well known that mounding is essential for successful planting of trees on the wetter marshy sites in Europe and elsewhere, and in mounding trials only a few kilometres from Inlet Road a dramatic increase in survival and growth of exotic eucalypts was achieved in the 1960's (B. White, pers. comm.).

The slow growth and stunting of jarrah on the flats could well be due to water stress. There is no evidence of any recent change in water table, but small changes could affect tree growth. The putting in of a road, thus creating increased drainage, could influence nearby trees. Autumn fires could aggravate water stress by defoliation of trees and decreasing transpiration, but in the sparse tree cover on these flats this is unlikely to be an important factor.

It is unlikely that dieback occured prior to the 1950's in this area. But the fact that it was isolated at all from soil samples taken during the inactive winter months, at points some 220 metres apart, proves that it can and has spread fairly rapidly, at least over a local area. The source of spread could be Inlet Road, but from there to the tree line in Line 1 the ground level rises 5½ metres in 220 metres, so it would seem impossible for the spread to be due purely to flooding as even in the wettest winter the water level would not reach a metre at Inlet Road. But it has been proved that dieback can spread uphill, in favourable conditions, 10 metres or more each year (Shea 1975). So it is quite possible it could have spread the 220 metres on this type of flat over a period of 20 years.

Another possible source of spread is from fire-fighting equipment. In the 1960's several fires occured in the vicinity of Inlet Road and there are reports, for which I could get no definite confirmation, that firelines were put in between the flats and the treeline. Dieback could have been widely distributed in such operations, and could have subsequently spread very rapidly down-hill into the flats.

The evidence of dieback from dead trees is confusing. The pattern of Banksia deaths in Lines 1 and 3, and the fact that few young banksia have grown since, indicate dieback. B. White (pers. comm.) has said that a large quantity of banksia on the Pingerup Plains, only a few kilometres from Inlet Road, died off in the early 1960's for no apparent reason, over a short period of time. The condition of the remaining banksia stumps on Lines 1 and 3 would indicate that the trees died some 10 - 15 years ago. The comparatively small number of banksia deaths in Line 2 is puzzling, it may be that the site is too wet for dieback to be active.

The extent and healthy state of the jarrah advance growth, the fact that many of the apparently dead trees are infact coppicing, and the lack of any symptoms in the live jarrah, is evidence against dieback. However it is uncertain if jarrah growing under stress in these marginal conditions would necessarily show the same reaction to dieback as the northern jarrah on drier sites.

No marri was recorded in Lines 2 and 3, and only 36 on Line 1, so these were not assessed in graph form. Of the total of 36 counted, 6 were advance growth, 8 healthy, 6 fire damaged, 13 had dead boles but were coppicing, and 3 were completely dead. These figures fit in roughly with the proportions for jarrah, but with a higher percentage dead. If dieback were the cause of jarrah deaths, the dieback resistant marri would be expected to show a lower percentage dead.

The summing-up, on evidence obtained is that drainage and water stress sets the pattern for tree distribution and growth on the flats, Fire is the main cause of the degradation and deaths of the jarrah, and dieback is a factor which has probably caused the deaths of at least some of the banksia and blackboy, and which could be a major influence on jarrah survival in the future if allowed to spread.

TABLE 1

Percentage of Jarrah Trees, in Categories, for each Line.

Tree Category	Percentages		
	Line 1	Line 2	Line 3
Advance growth	28.5	36.3	28.8
Healthy trees below 2m	1.1	0.9	4.2
" " 2m - 10m	12.5	2.6	13.6
" " above 10m	2.1	-	0.8
Fire damaged, forming new crown below 2m	3.6	4.7	13.6
Fire damaged, forming new crown 2 - 10m	23.5	9.4	12.7
Fire damaged, forming new crown above 10m	1.1	-	1.7
Fire damaged, epicormic only	5.0	9.4	9.3
Bole dead, coppicing	22.4	24.4	13.6
Dead	0.4	12.4	1.7

N.B. Taken to nearest decimal point, each line does not necessarily add up to 100%

FIG 3

NUMBERS OF JARRAH TREES IN EACH LINE, BY CATEGORIES

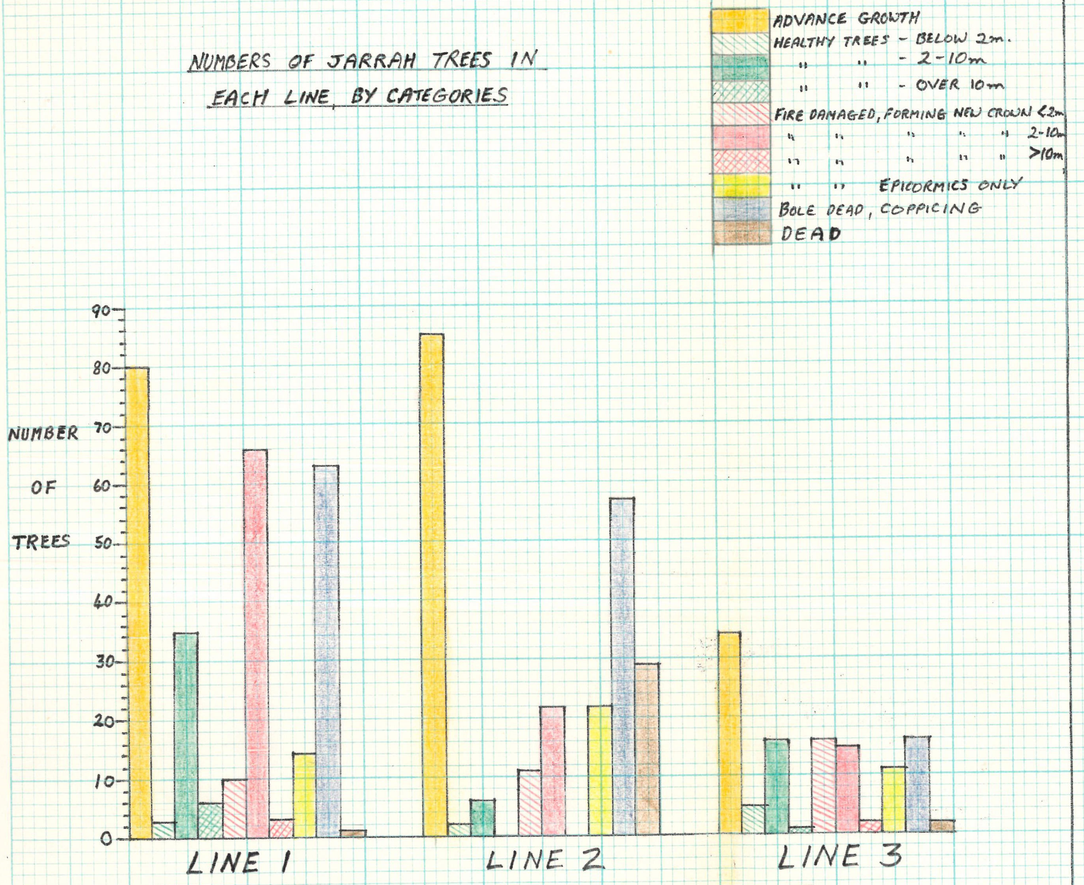

FIG 4

LINE 1 INLET ROAD

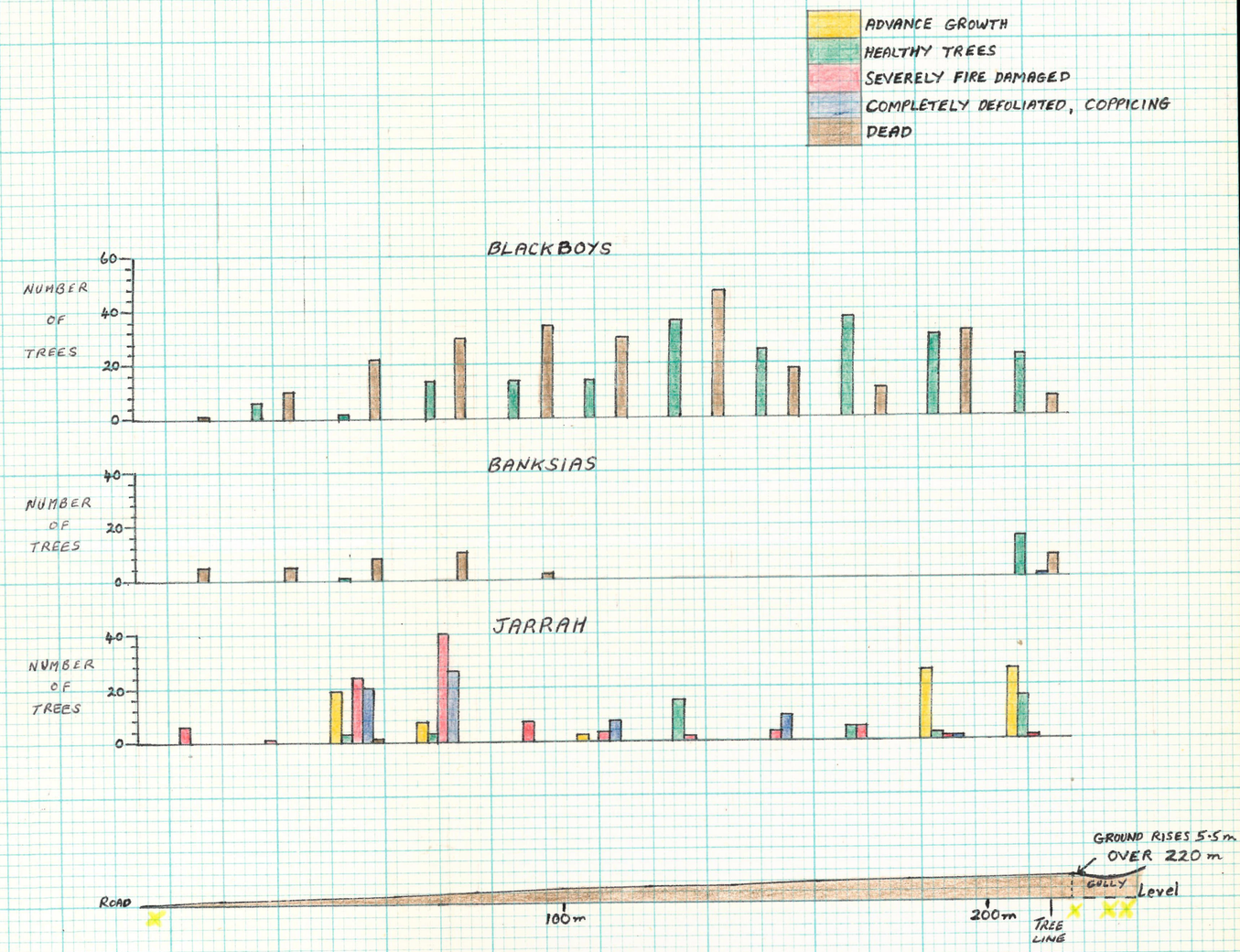

FIG. 5

LINE 2. INLET ROAD

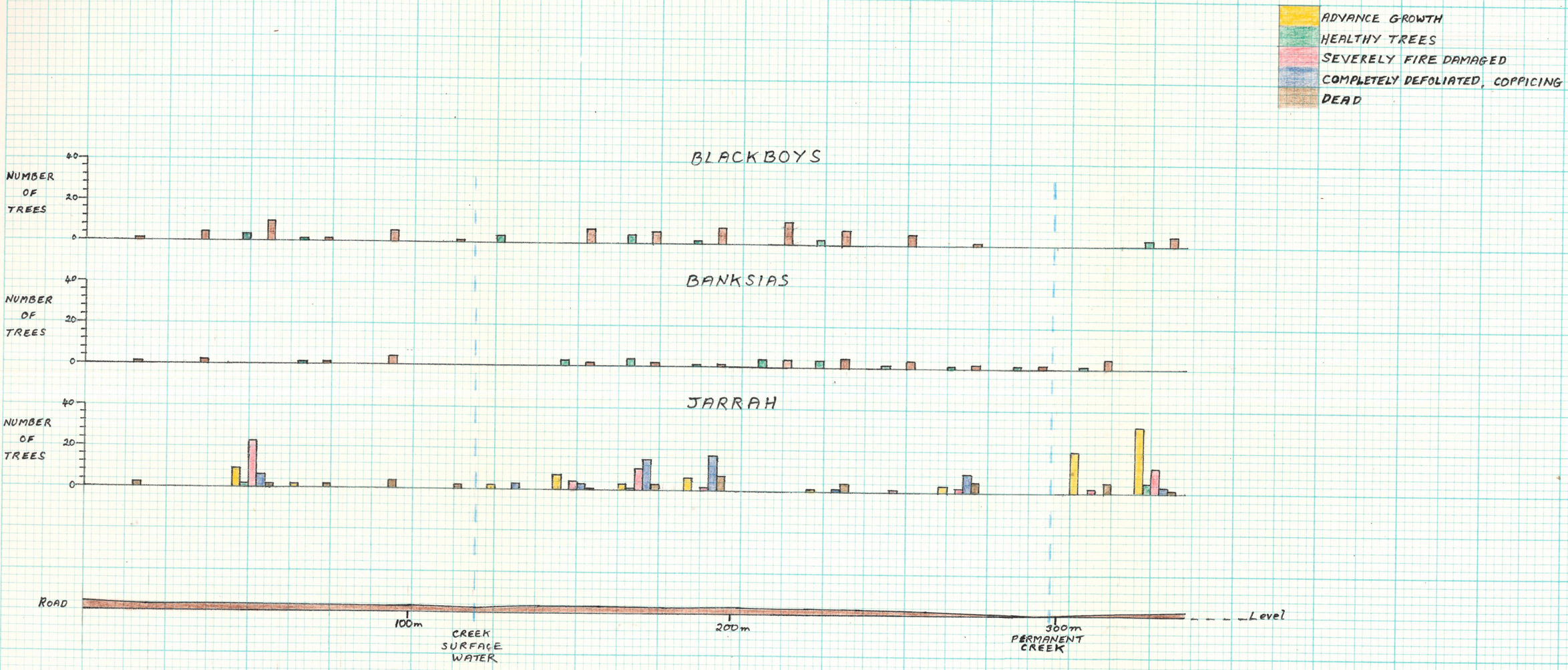

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FIG. 6

LINE 3. BROOKE INLET ROAD

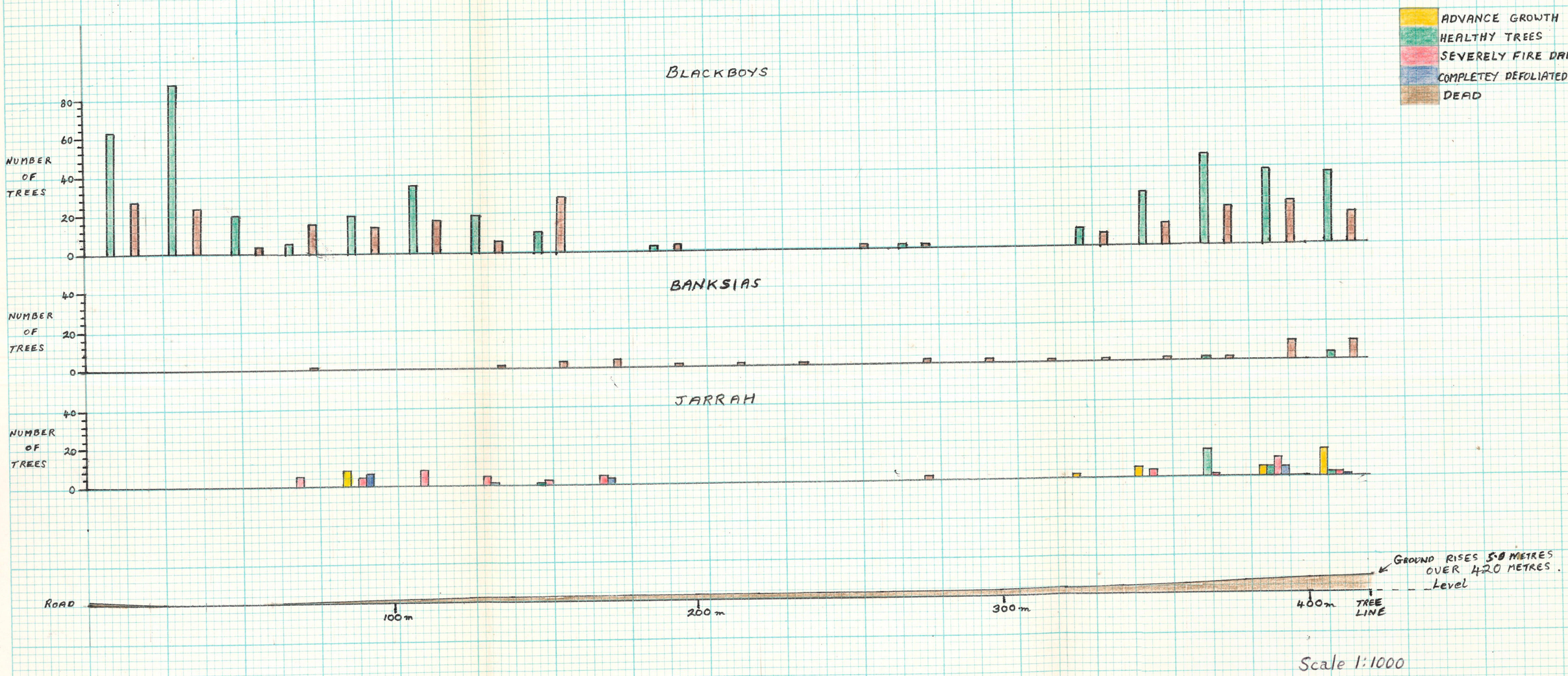

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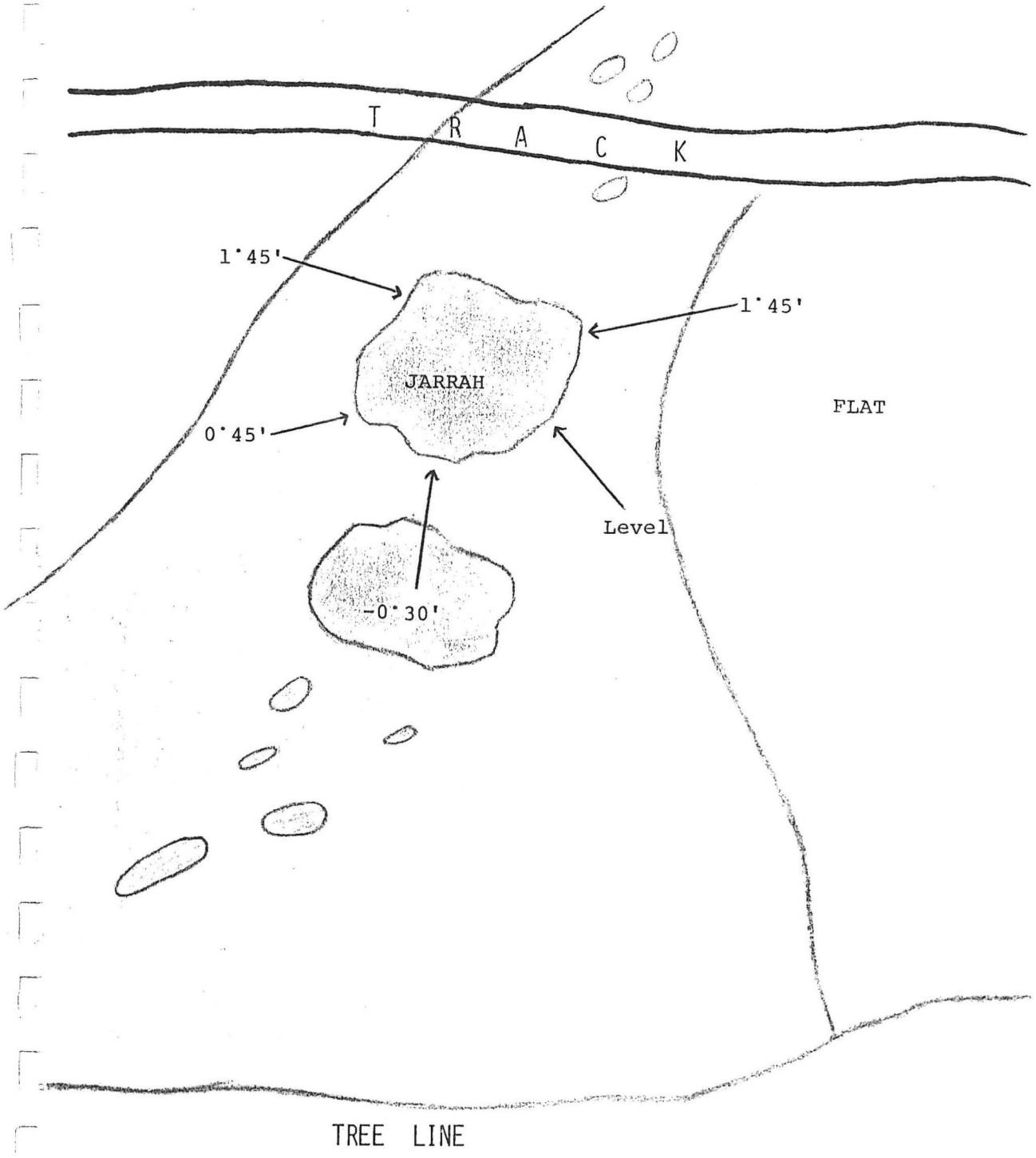
FIGURE 7

Jarrah Growing on a Ridge, in an Otherwise Treeless Flat.



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APPENDIX 1

Understorey Species Occuring in Quadrats on each Line.

SPECIES	Line 2 No. of quadrats		Line 1 No. of quadrats		Line 3 No. of quadrats	
	One of 3 main sp.	Present	One of 3 main sp.	Present	One of 3 main sp.	Present
Agonis linearifolia	11	2	-	-	-	-
Agonis parviceps	8	3	8	3	5	15
Evandra aristata	8	1	2	2	16	4
Anarthria scabra	3	5	4	3	11	8
Beaufortia sparsa	1	4	3	8	16	5
Leptospermum firmum	3	1	-	-	3	1
Mesomelaena tetragona	1	3	6	4	1	9
Loxycaria flexuosa	3	2	1	3	1	12
Adenanthos obovata	-	8	-	3	-	14
Dasypogon hookeri	-	3	-	-	-	14
Hakea linearis	-	2	-	8	-	-
Gahnia trifida	-	1	-	3	-	-
Acacia brownaina	-	3	-	1	-	-

N.B. This is not an exhaustive list of all species present. Some species, such as Podocarpus drouyniana, Leucopogon verticillata, etc. occured in limited numbers near the forest edge and were not included. Others, such as Astartea fascicularis, Aotus ericoides and Cyathochaeta avenacea were scattered throughout in very low numbers. There were also at least 8 different species of monocots occuring in various mixtures on all 3 Lines.