DWELLINGUP RESEARCH

ANNUAL REPORT 1975 — 76

10m—O

Form F.D. 80B

FORESTS DEPARTMENT

Research Station
DWELLINGUP Office,

To CONSERVATOR OF FORESTS
FORESTS DEPARTMENT
PERTH.

SEPTEMBER 20th, 1976
Western Australia

Reference—H.O.

Local R3/01

SUBJECT:

FOR ATTENTION: SUPT. J.J. HAVEL, COMO RESEARCH.

I attach a copy of the 1975-76 annual report for the Dwellingup Research Station.

The report is an attempt to present a general outline of research carried out at the station, therefore most of the research projects discussed have only been outlined briefly.

The report is strictly for internal distribution and material contained in the report should not be quoted without prior consultation with the appropriate officers at Dwellingup.

It is expected that within the next six months detailed research papers will be prepared on the majority of the projects outlined in this report.

Really?

S.R. SHEA
S.D.F.O.

SRS:LRH.

Introduction

The principal areas of research during 1975/76 have been Jarrah Dieback, Hydrology and Bauxite Mining. Priority has been given to the development of practical management techniques in each of these areas. The silvicultural and fauna research programmes have been maintained but no new experiments have been initiated. With the assistance of Senior Silviculturist Kimber research carried out into rehabilitation of dieback affected areas over the previous 10 years is being summarised. There has been a marked increase in the use of the forest for recreation in the period since the recreational surveys were carried out in 1972-73. It has not been possible to reactivate the recreational research programme but some spot surveys have been carried out.

A considerable proportion of the research carried out is in the form of co-operative studies with Australian and other State Government Departments, ALCOA, the University of W.A. and the W.A.I.T. Co-operative studies have been encouraged and wherever possible assistance has been provided. This policy has had mixed results. Some organisations are prepared to collaborate, others display a marked tendency to isolate themselves after the study has been initiated.

Staff and Buildings

Two technical assistants and two research officers have been recruited to the staff. The current staffing situation is as follows:

	Principal Duties
S.D.F.O. S.R. Shea	O.I.C.
R.O. J.R. Bartle	Bauxite Mining Rehabilitation Research
R.O. E.J. Herbert	Hydrology Research
A.D.F.O. R.G. Towers	Dieback, Rehabilitation and Hydrology Research
T.O. J. McCormick	Rehabilitation, Fire Ecology
T.O. W.B. Edgecombe	Administration and General Ecological Research
T.A. M.L. Mason	Detailed Laboratory Studies, Drafting, Fauna Research
T.A. M.J. Dillon	Administration and General Ecological Research

T.A. R.J. Kitt	Jarrah Dieback Research
T.A. L.M. Harman	Photography, General Ecological Research
T.A. R.M. Buehrig	Rehabilitation, General Ecological Research
T.A. W.D.P. Armstrong	Administration, Hydrology
T.A. P.J. Jenkins	General Ecological Research
T.A. T.C. Birmingham	General Ecological Research
T.A. C.C. Portlock	Jarrah Dieback Research, Fire Ecology
Clerical Asst. L.R. Hayes	Secretarial Duties, Data Compilation
Junior Lab.Asst. H.J. Warren	Jarrah Dieback Research

An air conditioned glasshouse has been built at the station. This has markedly improved our capacity to carry out research into Jarrah Dieback. Previously all pot studies were carried out at the C.S.I.R.O. and at Como, with generally disastrous results. Available office space is being used to the maximum.

Extension

During the year officers gave lectures to 35 external organisations (which involved contact with an estimated 800 individuals) on various aspects of the research carried out at the station. In addition, on average, the station was visited once a week by research officers from external organisations.

Photographic services were provided to a number of sections within the Department for the purpose of recording experimental results and for publications or lectures.

Papers were presented to the Australian Microbiology Conference, Australian Plant Pathology Conference, the Australian Hydrology Conference, the Australian Geography Teacher's Conference, a C.S.I.R.O. workshop on Jarrah Forest Ecology and a Bauxite Mine Research workshop. Three research papers have been submitted for publication and three formal reports have been compiled. Three research papers are currently being prepared for publication.

Jarrah Dieback Research

Jarrah Dieback research has been primarily directed at evaluating the effect of native legume species on soil physical and microbiological conditions in relation to P. cinnamomi activity.

(a) The Effect of Soil Temperature on P. cinnamomi Pathogenicity

It has been generally assumed that P. cinnamomi requires high (>15°C) soil temperatures before significant infection can take place. Studies reported in the literature, however, have not examined the temperature/infection relationship in detail. This is an essential prerequisite to understanding the activity of the fungus in the jarrah forest environment. Previous studies have indicated that the soil physical environment in freely drained soils is only marginally suitable for P. cinnamomi. However, this was based on the assumption that soil temperatures greater than 15°C were required before significant infection took place. A 2-3°C under-estimate of the temperature conditions required for infection would markedly affect the susceptibility of the forest.

Two detailed studies of the effect of temperature on P. cinnamomi were carried out.

(i) Mycelial mats were suspended in water held at 12, 14, 16, 18 and 25°C for varying periods and the number of sporangia produced was counted. The temperature regime of the 12, 14, 16 and 18°C treatments was fluctuated (12 hours at target temperature, 12 hours at 8°C) to simulate field conditions. The results are shown in Fig. 1.

Although sporangia are produced at 12°C they are insignificant compared to the number produced when the temperature regime is at 18°C or above.

(ii) The trial was repeated except that the B. grandis seedlings were placed in infected soil which was maintained at optimum moisture levels.

The results are shown in Fig. 2. These support the results of the sporulation trial and suggest that infection below 18°C is minimal.

(b) The Effect of Soil Moisture on P. cinnamomi Pathogenicity.

It has been generally assumed that P. cinnamomi requires high soil moisture levels to stimulate sporulation and hence, infections. However, there have been no reports in the literature on the critical moisture level required for sporulation, and the number of hours soil moisture levels need to be at that level before sporulation takes place. Following extensive preliminary trials techniques were developed to determine these levels. Two trials were carried out -

FIG 1 Relationship between temperature and sporulation

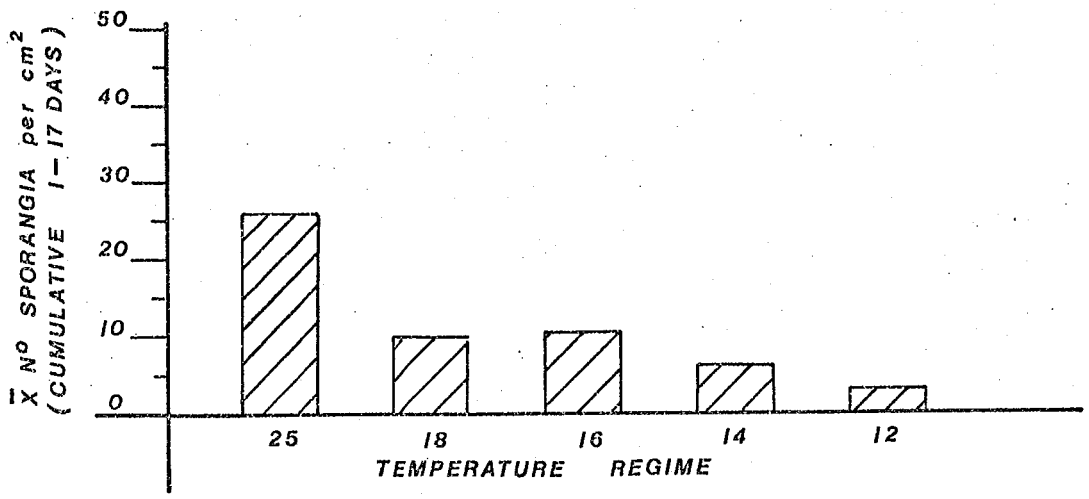


FIG 2 Relationship between temperature and infection

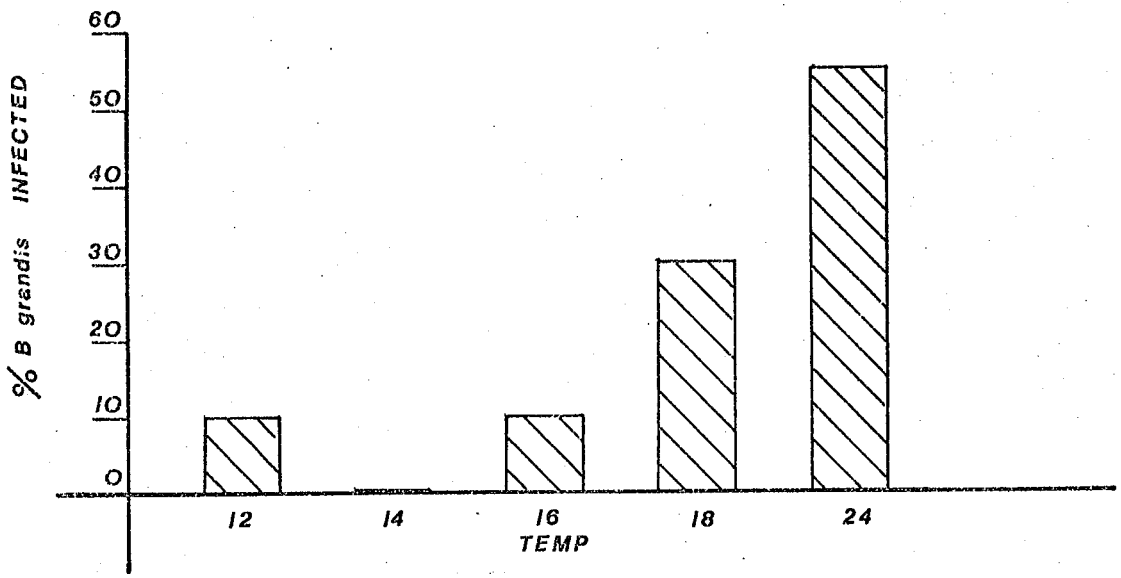


FIG 3 Hours suitable for infection in an open forest and forest with dense legume understory

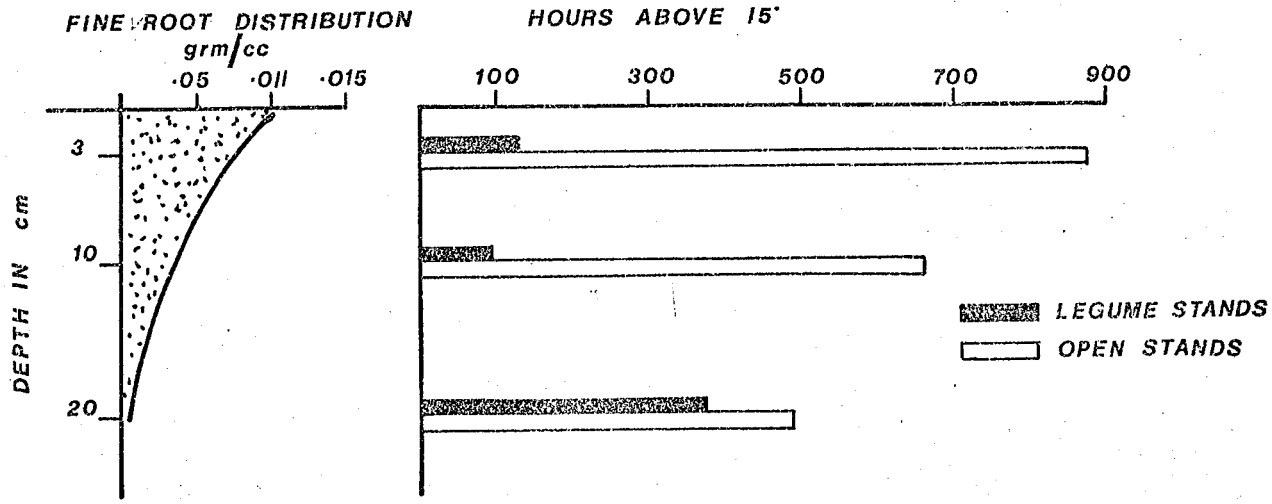


FIG 4 % Mortality of Jarrah seedlings when planted with native species

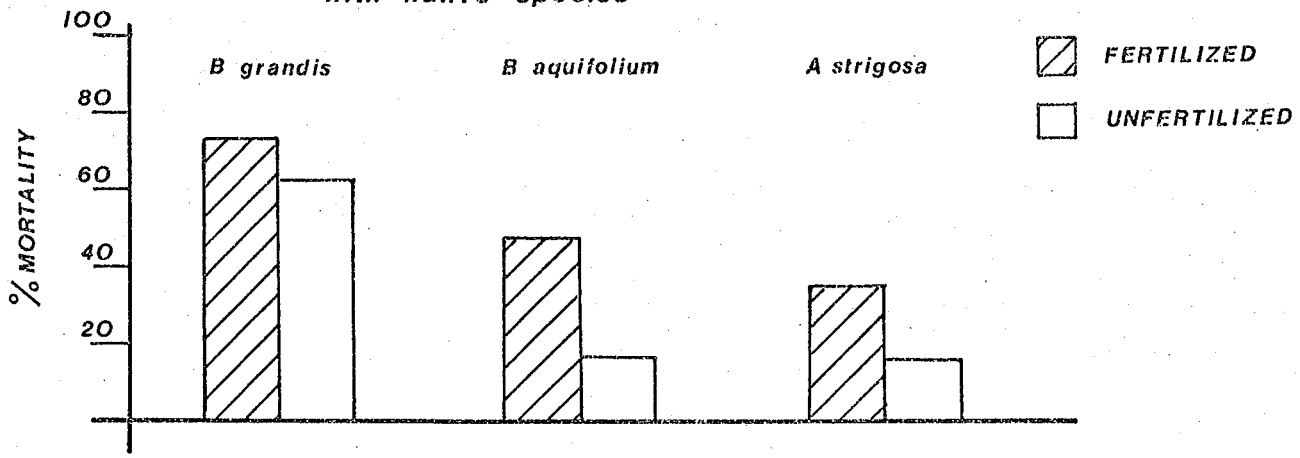


FIG 5

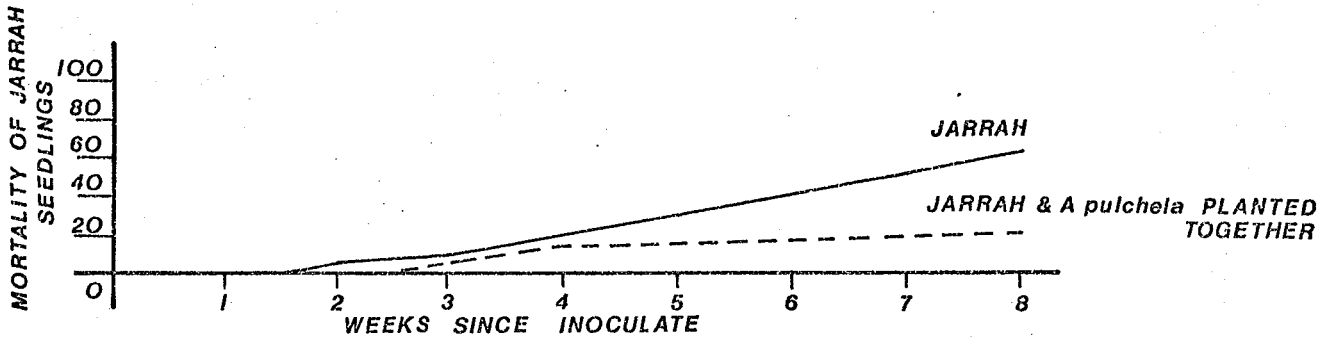
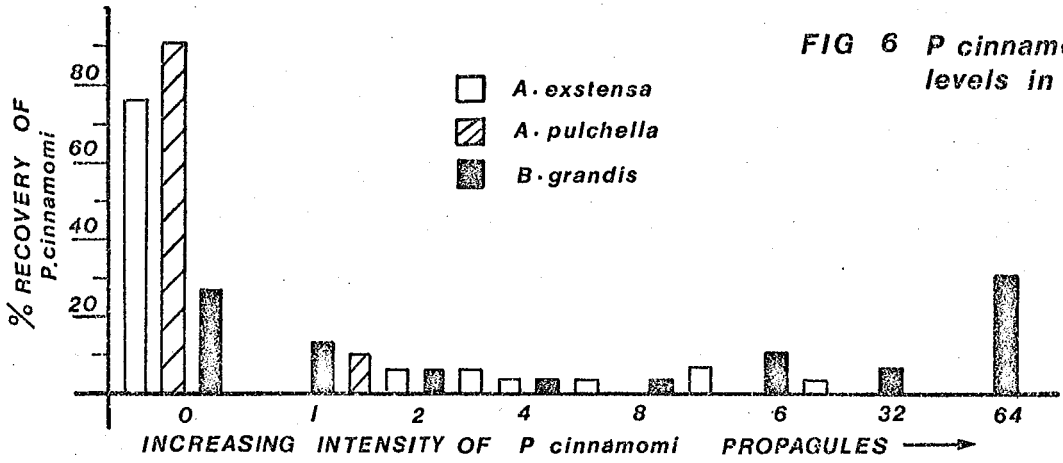


FIG 6 P cinnamomi population levels in pots



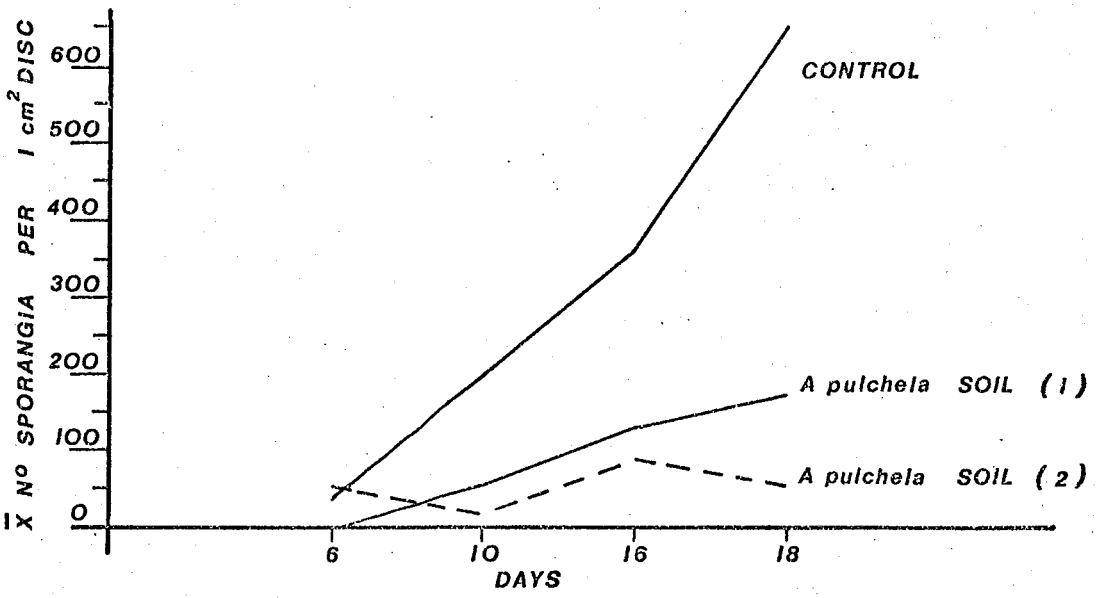


FIG 7 Sporulation of P cinnamomi in soil from legume stands and adjacent non-legume areas

(i) Small containers of soil were brought to various soil potential levels using the pressure membrane apparatus. Mycelial mats were then placed in the centre of each core of soil, the sample was resealed and placed in an incubator at 25°C. The samples were removed at 7 day intervals over a period of 3 weeks, and the mycelial mat was examined for evidence of sporulation. The effect of soil moisture levels equivalent to 25, 50, 75, 100, 150, 300 and 1,000 centibars were tested in this way.

Sporulation did not occur at any of the levels tested. To check that the mycelial was viable and that the bacteria necessary to stimulate sporulation were present in the soil a replication of the samples was removed and suspended over water. Sporulation occurred within three days. The results of this trial indicate that saturation is necessary to create environmental conditions necessary for sporulation on freely drained upland jarrah forest sites.

A further trial which is aimed at determining the length of time necessary to stimulate sporulation is currently in progress.

(ii) Polyethanol glycol solutions were used to maintain static soil moisture levels in containers in which B. grandis seedlings were planted. The preliminary results of this trial indicate that even when soil moisture levels are near saturation, infection does take place. Further trials, using this technique, which are aimed at determining the length of time soil moisture levels must be saturated for infection to take place are currently being carried out.

(c) Measurement of Field Environmental Conditions

A detailed study of the soil moisture and temperature regime on a freely drained jarrah forest site under a dense B. aquifolia stand and in an adjacent area with no canopy has been completed. Detailed measurements were made over a three year period. During spring when soil moisture levels are optimum, soil temperatures are depressed by the presence of a canopy and litter layer. In the open situation soil temperatures are above 15°C and on some days approach the optimum. Late spring, summer and early autumn rainfall showers are intercepted by the legume canopy and litter layer thus preventing rewetting during a period when soil temperature is optimum. In autumn heavy rain depressed soil temperature below the critical level for infection where it remains until the following spring.

A preliminary summary of the relative suitability of the soil physical environment for P. cinnamomi infection (measured in terms of the total hours during which significant sporulation

can take place) in the open and dense legume situations is shown in Fig. 3. This data indicates that the presence of a dense canopy and litter layer will markedly reduce the potential for P. cinnamomi to infect jarrah roots.

(d) Susceptibility of Native Legume Species to P. cinnamomi.

The use of native legume species to reduce the susceptibility of the forest to P. cinnamomi is to a degree dependent on their susceptibility to the fungus. If these species are as susceptible as B. grandis then their impact on the disease will be negligible.

In pot trials conducted under optimum conditions for P. cinnamomi infection it was found that P. cinnamomi was able to invade the root system of B. aquifolium, M. dilatata, A. strigosa and A. myrtifolia. However, mortality was restricted to B. aquifolium and then only during the initial weeks after inoculation. Extensive plating of the root system of A. extensa and A. pulchella failed to recover the fungus. This is significant as even resistant species normally are attacked by the fungus.

(e) Survival of P. cinnamomi in the Presence of Native Legumes.

Detailed sampling of the soil from the above pots trial was carried out. The fungus was readily recovered from pots containing B. grandis, A myrtifolia, A. strigosa, M. dilatata and B. aquifolium. However, population levels in A. extensa and A. pulchella pots were markedly reduced relative to those pots containing B. grandis. The fungus could not be detected in 74% and 84% of the A. pulchella and A. extensa pots respectively. Fig. 4. Fungal population levels (as indicated by serial end point dilution tests) were high in the B. grandis pots. To determine if the absence of the fungus from the legume pots was real B. grandis seedlings were replanted in these pots and in pots in which it was known the fungus was present. Preliminary results indicate that test seedlings in the legume pots remain healthy while deaths have occurred in the infested soil. This suggests that the fungus has been eliminated by a factor associated with A. extensa and A. pulchella root systems.

(f) Transfer of Factor Responsible for Resistant and Population Decline to Susceptible Species.

Jarrah seedlings were grown in association with various legume species to determine if the factors responsible for resistance could be transferred to jarrah. Preliminary results suggest that there is a marked reduction in mortality of jarrah when it is planted with legume species. The effect is reduced if fertilizer is applied. Figs. 5, 6.

These trials are being conducted in co-operation with Dr. N. Malajczuk of the C.S.I.R.O.

(g) The Effect of Legume on Sporulation and Lysis of P. cinnamomi Mycelium.

Mycelial mats of P. cinnamomi were suspended in water over soil from pot trials and field situations where legumes were growing. The mycelial mats were fixed and stained at intervals over an 18 day period. Preliminary results indicate that the legume soil causes excessive and lysis of mycelium and depresses sporulation. Fig. 7. More extensive trials are currently being undertaken.

Persistence of P. cinnamomi in Rehabilitation

Dieback Sites

In 1967 a trial to determine if it was possible to eradicate P. cinnamomi or at least reduce spread of the fungus by replanting dieback infected gullies with resistant species was initiated by S.D.F.O. Kimber.

The active "green line" in the experimental area was demarcated and a "clean" bulldozer was to push all vegetation from a strip 30 metres wide outside the green line toward the infection. The area was windrowed (the windrows were constructed over the green line), ploughed and planted with alternate rows of P. taeda and P. pinaster. Three lines of B. grandis seedlings were then planted adjacent to the healthy forest, along the green line and 30 metres inside the infection area.

Results

Progressive mortality of the B. grandis seedlings is shown below -

DATES OF ASSESSMENTS	10/67	4/68	1/69	10/69	1/74	7/75
Banksia planted on active dieback line.	0%	18%	34%	42%	75%	84%
Banksias planted 30 metres uphill from active dieback line	0%	0%	0%	4%	6%	8%
Banksias planted 30 metres behind active dieback line	0%	15%	52%	66%	88%	90%

P. taeda mortality eight years after planting was approximately 60% while the P. pinaster are healthy and vigorous.

The trial demonstrates the capacity of the fungus to persist in dieback areas even when the highly susceptible host species have been removed. It also illustrates the difficulty of evaluating dieback control treatments. It was eight years before the fungus was able to kill the B. grandis seedlings located in the old dieback zone. Apparently, the fungus can persist at extremely low population levels for long periods without host tissue but following the introduction of susceptible host species fungal population levels build up and cause mortality.

The trial demonstrated that with careful management it is possible to restrict uphill spread of the fungus during hygiene clearing operations. Extensions of the disease across the cleared break has been minimal. However, since uphill spread is usually minimal it is difficult to conclude that the operation has significantly restricted the spread of the disease uphill at this point in time.

Summary of Dieback Research

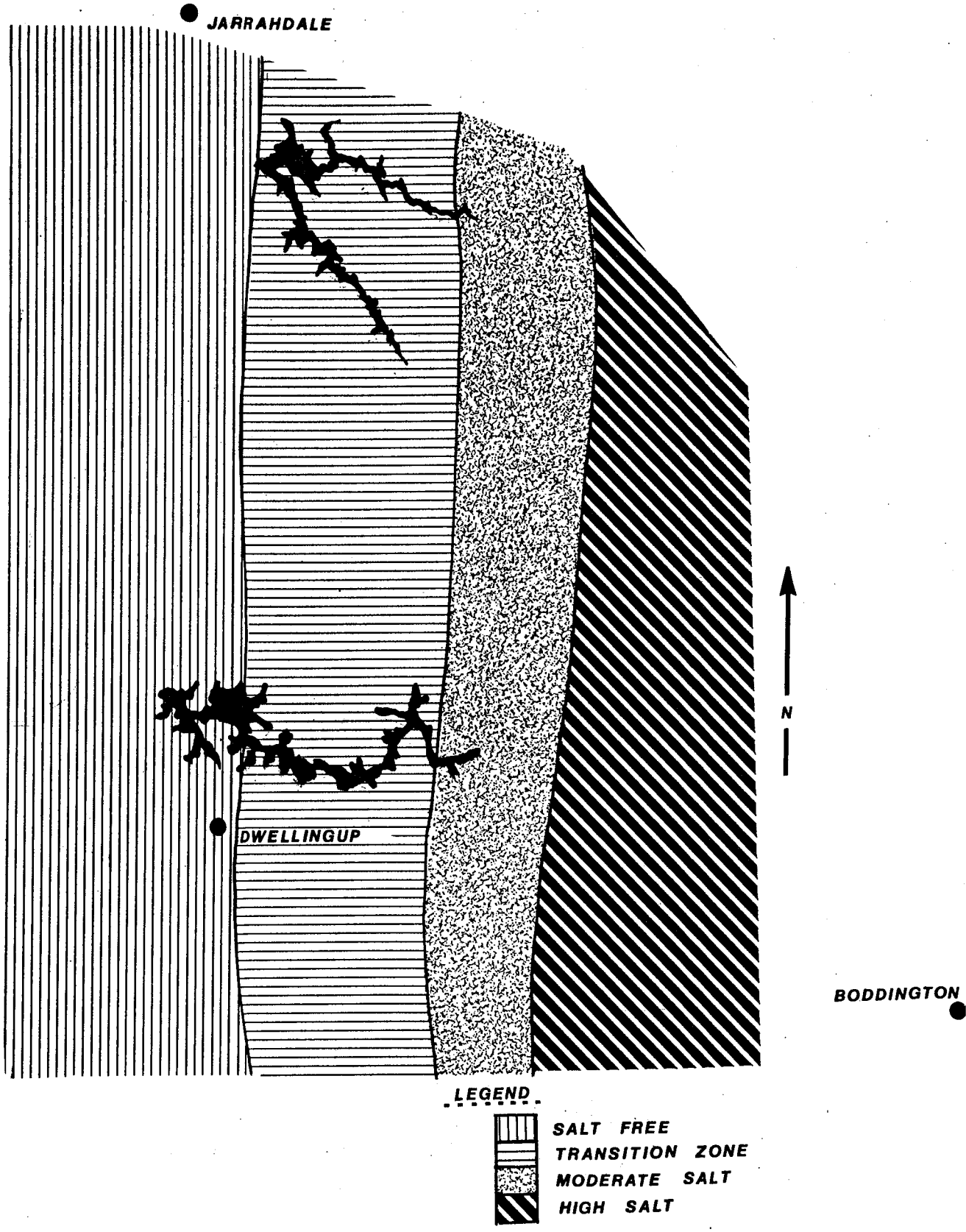
Considerable progress has been made during the previous 12 months. It can be confidently stated that replacement of the proteaceous-dominated understorey and shrub layer with a dense legume (fire weed) understorey will reduce the susceptibility of the forest to P. cinnamomi. However, it is impossible to, at this stage of the research programme, determine if the change to a legume-dominated understorey will have a significant effect on the disease. For example, it is possible that this treatment will delay jarrah mortality by 20 years. In an agricultural crop this would constitute control of a disease, but in a forest situation it does not significantly change the current dismal prognosis.

In the light of the positive results that have been achieved, Jarrah Dieback research is being intensified. The principal impedance to progress in this area is the lack of adequate laboratory facilities.

Forest Hydrology

Detailed research into fundamental aspects of the Jarrah Forest Hydrological cycle is being carried out by a number of State and Commonwealth Departments and universities. The hydrology research programme at Dwellingup is aimed at developing practical catchment management techniques which can be used to increase water yield and decrease salt yield in northern jarrah forest catchments.

FIG 9 Broad salinity zones



(1) Broadscale Salinity Surveys

During the past three years extensive stream salinity sampling has been carried out in the catchment of the Serpentine, North Dandalup, Little Dandalup, South Dandalup and Murray. The object of these surveys was to provide a broad classification of the existing salinity status of streams in the area and from their salinity during periods of base flow, an approximation of groundwater salinity. In general catchments throughout the area currently yield water of acceptable quality during periods of peak flow. However, there are some marked variations in the base flow salinities.

Comparison of base flow salinities and the salinity of groundwater (determined by coring) has been carried out in a number of catchments. In general, it has been found that base flow salinities under-estimate groundwater salinity. Thus base flow salinity levels may under-estimate the potential of a catchment to yield saline water. Nonetheless, the survey has provided a broad classification of potentially saline areas in the area sampled. Fig. 9.

(2) Yarragil Catchment Studies

The Yarragil catchment has been selected for intensive hydrological research. The catchment is being intensively monitored. Fig. 10. Following definition of the hydrological characteristics of the total catchment selected catchments will be treated to determine the effect of various forest treatments (e.g. thinning, replanting, burning etc.) on water quality and yield.

Preliminary Results

The study was commenced in 1973 but the 1975-76 water year was first for which comprehensive data on water and salt flow and groundwater characteristics were obtained. The catchments being monitored are shown in Fig. 11 and data on salt and water flows throughout the catchment are summarised in Fig. 12. Although the data is only preliminary it represents the first comprehensive characterisation of a Jarrah Forest catchment located in the high quality central jarrah forest zone.

There is marked variations in the water yield from each catchment which cannot be explained by variation in rainfall. In general, the western catchments yield up to 7 times more water per unit than eastern catchments. This can be partially attributed to differences in vegetative cover but it is also related to geomorphology (degree of dissection and valley slope) and soil characteristics (texture of the pallid zone clay). The eastern valleys are broad and drainage is sluggish relative to the more incised western catchment.

Within the western zone of the catchment, water yield also varies. Although valley type and soil type could be important, there is evidence that the degree of canopy cover has a marked effect on water yield. For example, catchment 35 yields twice the amount

FIG 10 Instumentation of Yarragil catchment

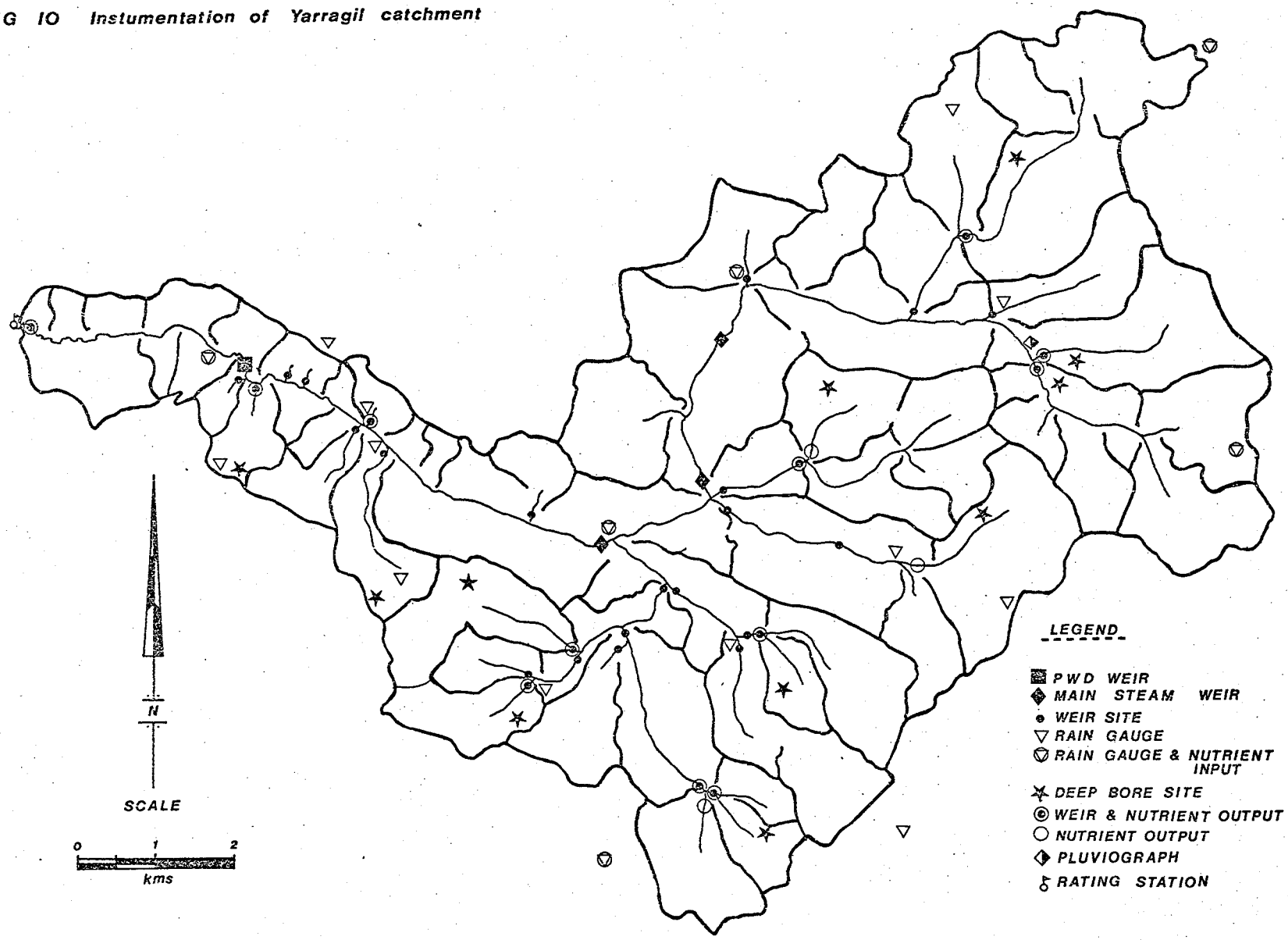


FIG II Location of catchment sample point

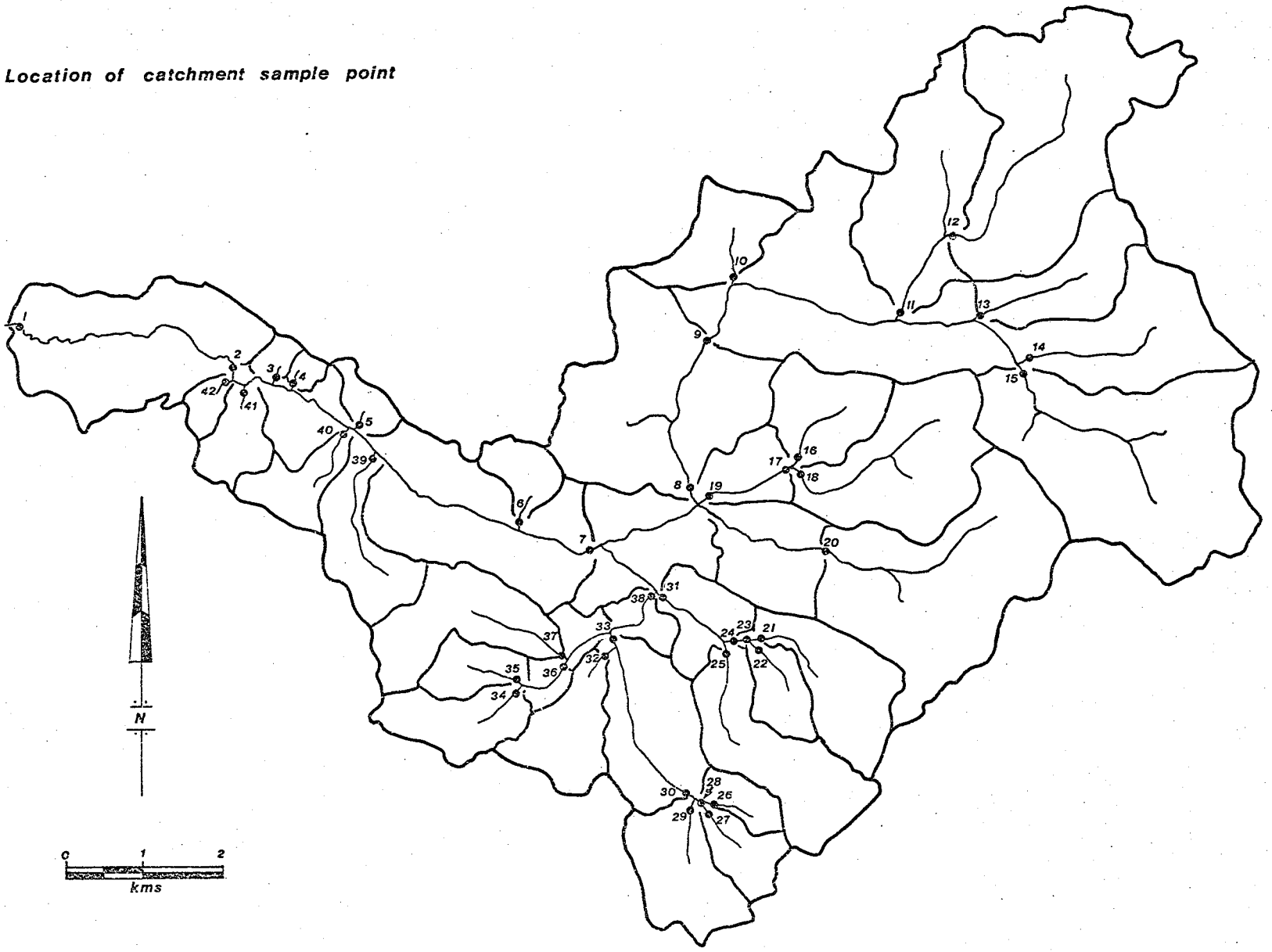


FIG 12 Variation in yield of salt and water within the Yarragil Catchment

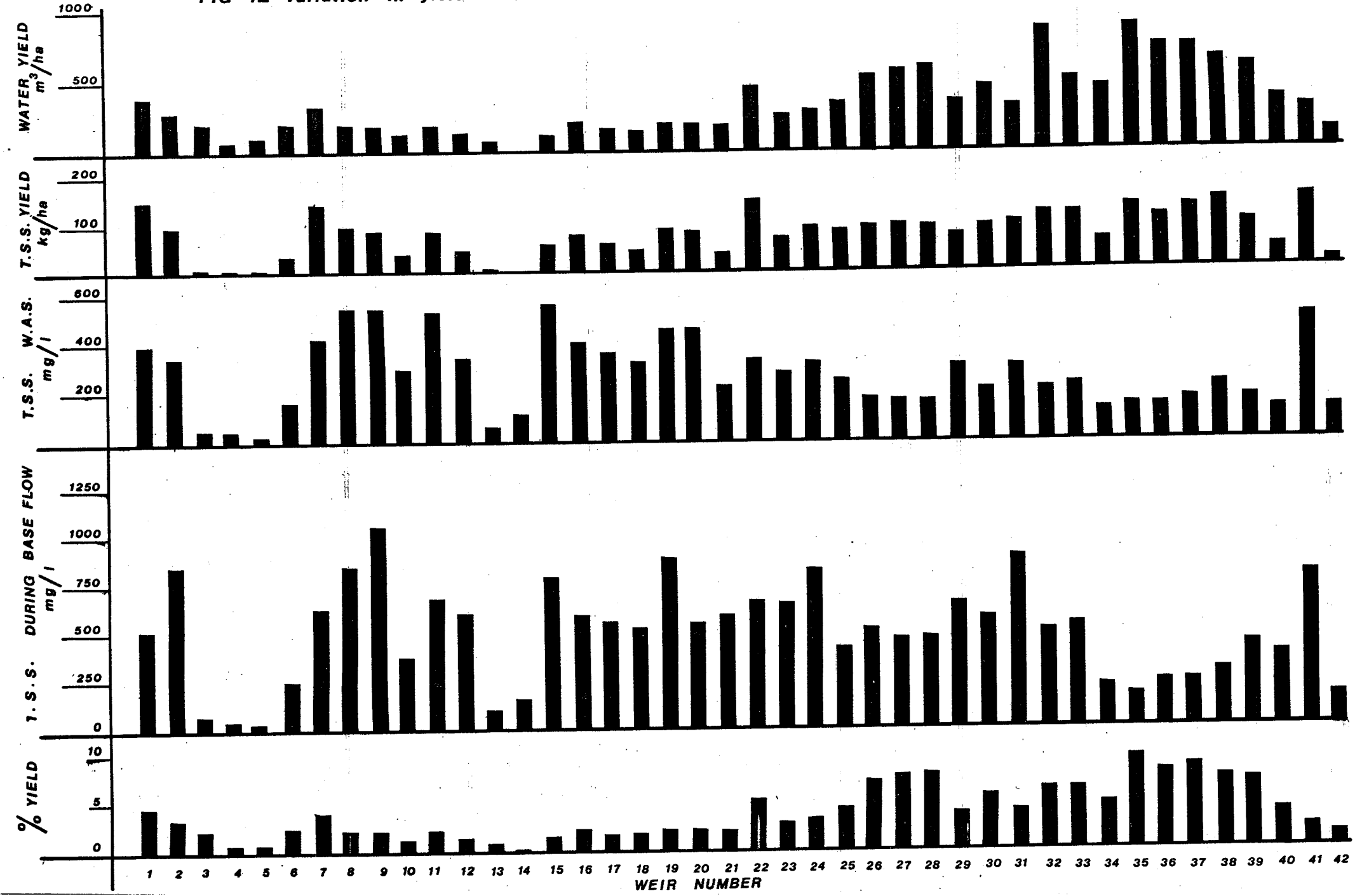


FIG 13 Seasonal variation in groundwater depth and salinity

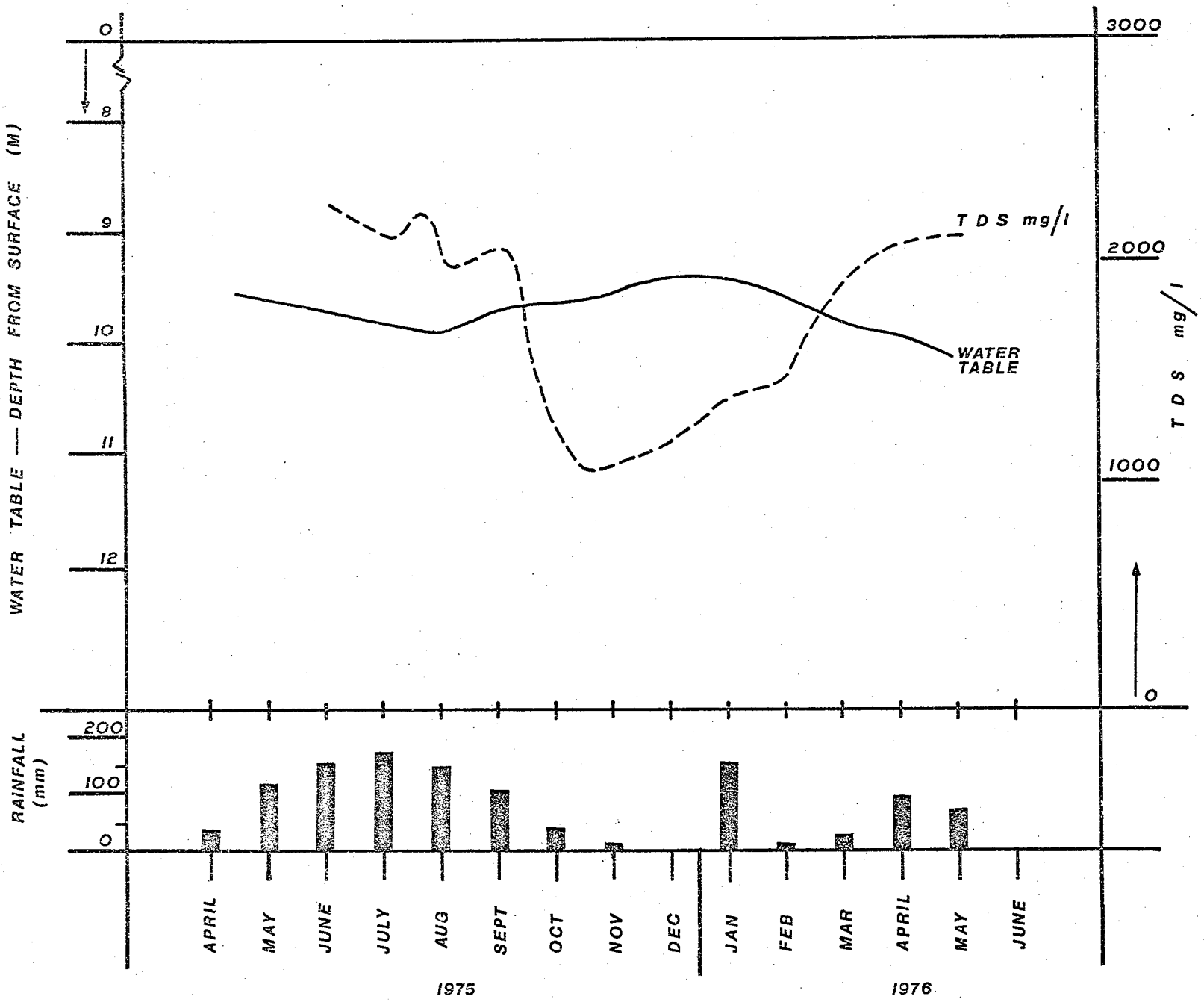
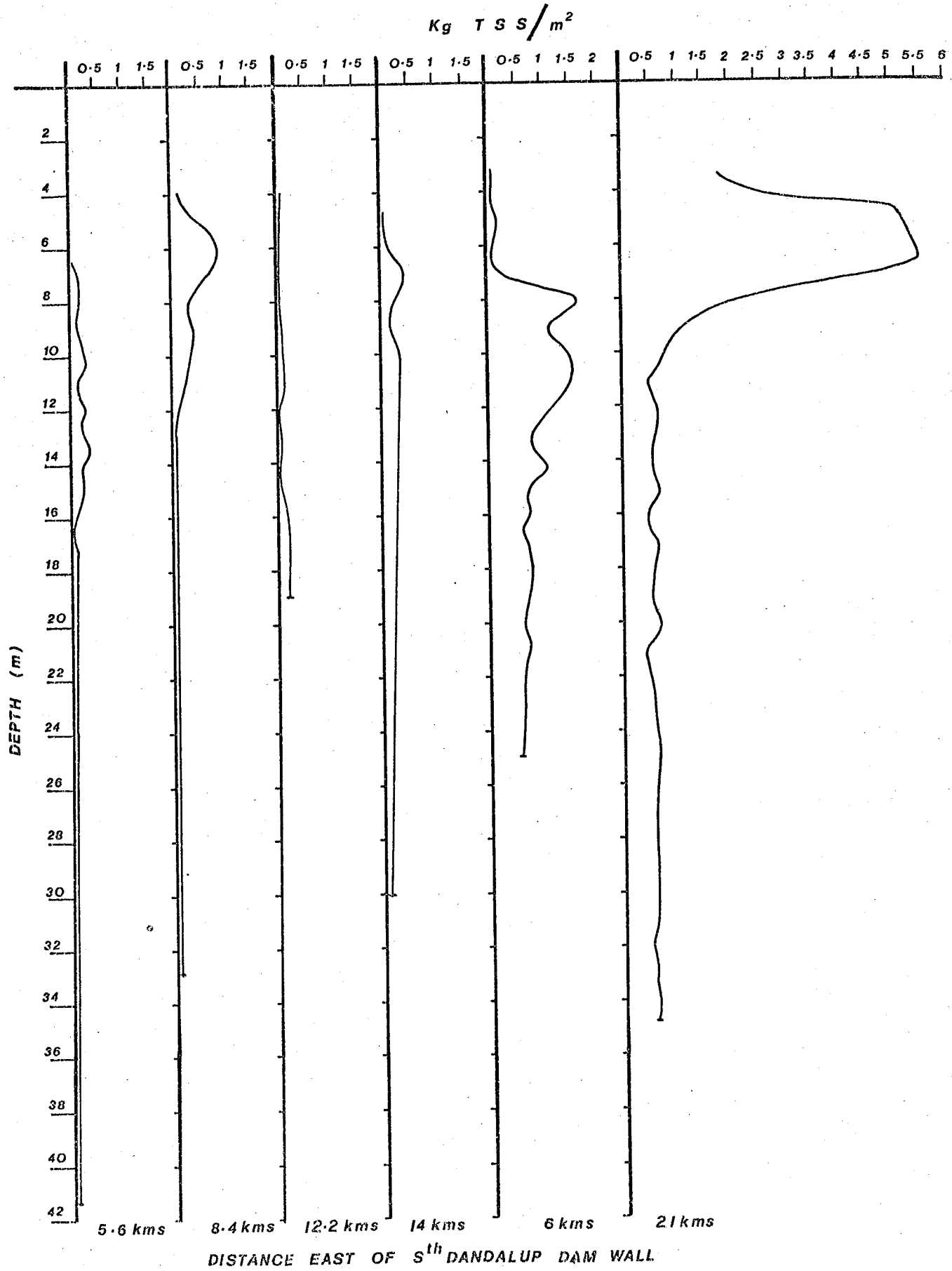


FIG 14 Variation in Total Salt Storage along an West-East transect



of water per unit hectare than the adjacent catchment 36. The two catchments are similar except that the valley vegetation of catchment 35 has been destroyed by Jarrah dieback. The area has been replanted with E. microcorys but they have not formed a complete canopy cover. Similarly, sub-catchment 38 has twice the yield of sub-catchment 31. The latter sub-catchment has some valleys which have been affected by P. cinnamomi but they are small relative to those in sub-catchment 38. These results suggest that water yield in forest areas where salt is not present in the soil profile could be significantly increased by reducing canopy cover. In the catchments 35, 34, 32 and 31 the upland vegetation forms a complete canopy cover. It is highly probable that water yield could be further increased by a heavy thinning of the jarrah stands located on the uplands of these catchments.

A proportion of the catchment is currently yielding salt at unacceptable levels. Where weighted average salinity (the total water yielded divided by the total salt yield) exceeds 500 ppm the catchment is yielding water of unacceptable quality. However, weighted average salinity levels (W.A.S.) in excess of 300 ppm are of concern since water at this level of salinity has less value as a dilutant of the highly saline water of Murray River. There is some evidence that destruction of the valley vegetation by jarrah dieback has caused the increased weighted average salinity.

The relatively high weighted average salinities which were recorded in Yarragil during 1975 are of particular concern because the catchment is still relatively undisturbed. Although cutover, the vegetation on the upland sites forms a dense canopy cover. Stream salinity during base flow and direct measurements of salinity in the soil profile determined by deep coring indicate that there are large stores of salt in the catchment. Since a relatively minor disturbance of the catchment has caused a significant deterioration in water quality in a number of catchments it is likely that a major disturbance such as that which would result from either bauxite mining or extensive dieback would cause very large increases in stream salinity. The weighted average stream salinity for the total catchment measured at the P.W.D. site was 350 ppm during 1975.

Monitoring of Deep Cores

As reported in the 1974-75 annual report 27 deep cores were established in the Yarragil catchment. Groundwater levels and salinity have been monitored monthly in each of these bores.

In fig. 13 groundwater levels and salinity in one of the bores is shown. This general trend was repeated in each of the bores in which there was a water table.

(3) Project 4 - Coring Programme

A major inter-departmental drilling programme was initiated during the summer of 1976. A series of fully cored holes were drilled at 6 locations forming a transect from Holyoake to the

Pindalup road. The initial objective of this study was to determine the total salt content in the soil profiles in the high quality forest east of Dwellingup which is a potential bauxite mine site.

Subsequent to the establishment of the core sites a series of detailed cores were established in the Coach road area and north of HOlyoake. Each of these cores has been monitored for groundwater levels and salinity at monthly intervals since their establishment.

Results

There is a general increase in total salt storage from east to west. However, there are numerous anomolies and frequently marked variations in salinity within any one site.

In Fig. 14 total salt storage of representative core holes from each site is presented graphically.

(4) South Dandalup Catchment Study

The South Dandalup catchment was selected for study as it represents a large operational catchment which is typical of those established in the Northern Jarrah Forest. The objective of the study is to determine the total hydrological characteristics of an operational jarrah forest catchment. This will permit the effect of disturbance in forest cover brought about by disease or changed land use to be evaluated in the context of the total catchment.

Streams throughout the catchment have been monitored on a weekly basis for stream salinity since 1973. In 1974-75 weirs or rating stations were established at the mouth of all major sub-catchments, a series of rain gauges were established throughout the catchment and piezometers were established in the valleys of all major sub-catchments. Fig. 15.

Results

(1) Groundwater Salinity

Base flow salinity levels and groundwater salinity determined by establishing bores or sampling old forestry wells were used to map groundwater salinity levels throughout the catchment. Fig. 16. This map provides an estimate of the salinity of the water which would be discharged if the vegetation was significantly disturbed. Although the map is only an estimate it does indicate that a large proportion of the South Dandalup catchment has the potential to yield saline water.

(2) Yield of Salt and Water in 1975-76

The location of the catchments monitored is shown in Fig. 17.

The results of 1975-76 water and salt flow measurements are shown summarized in Fig. 18. Although the data is only

FIG 15 Instrumentation of Sth Dandalup Catchment

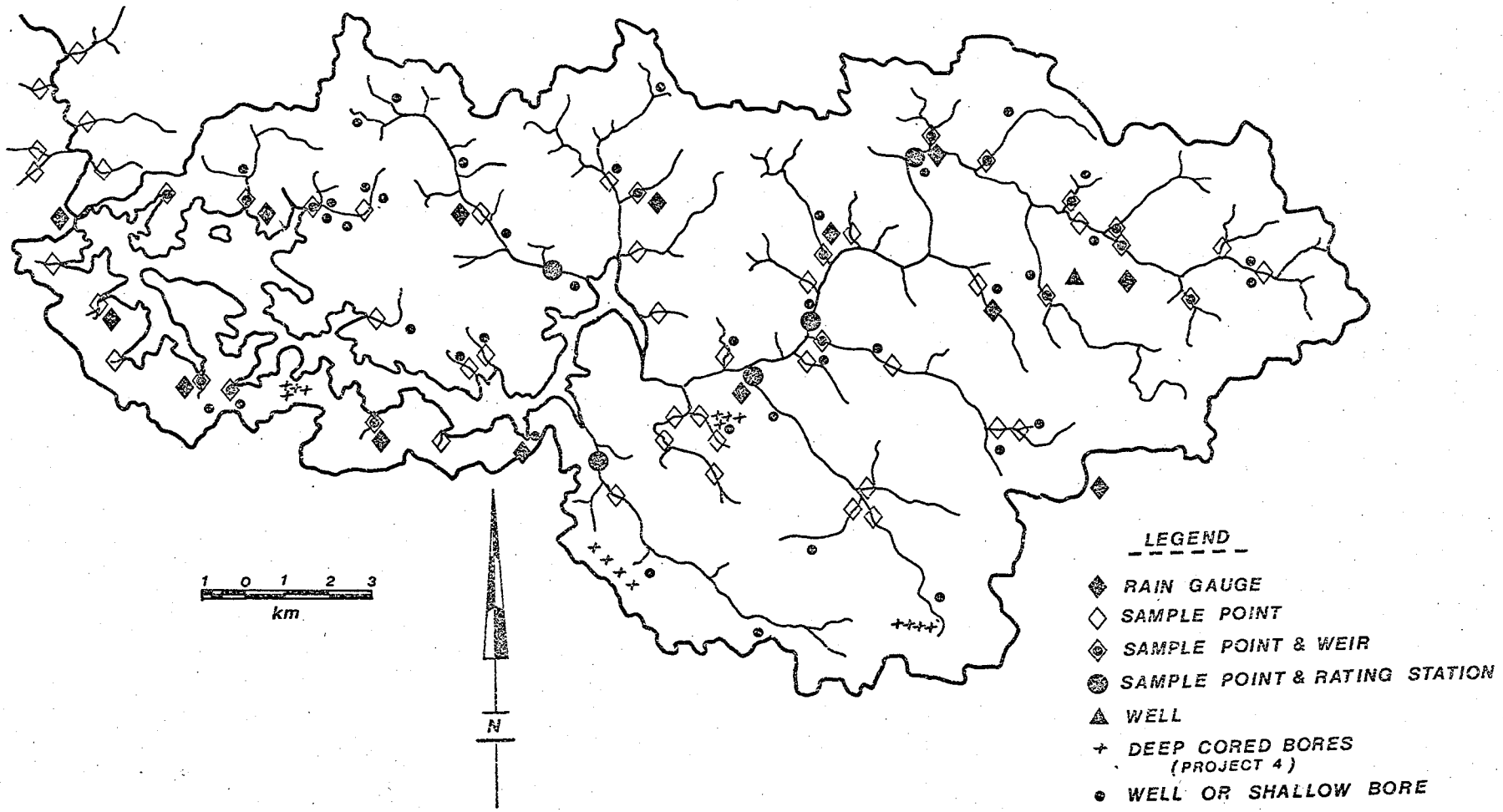


FIG 16 Estimated groundwater salinity in the Sth Dandalup Catchment

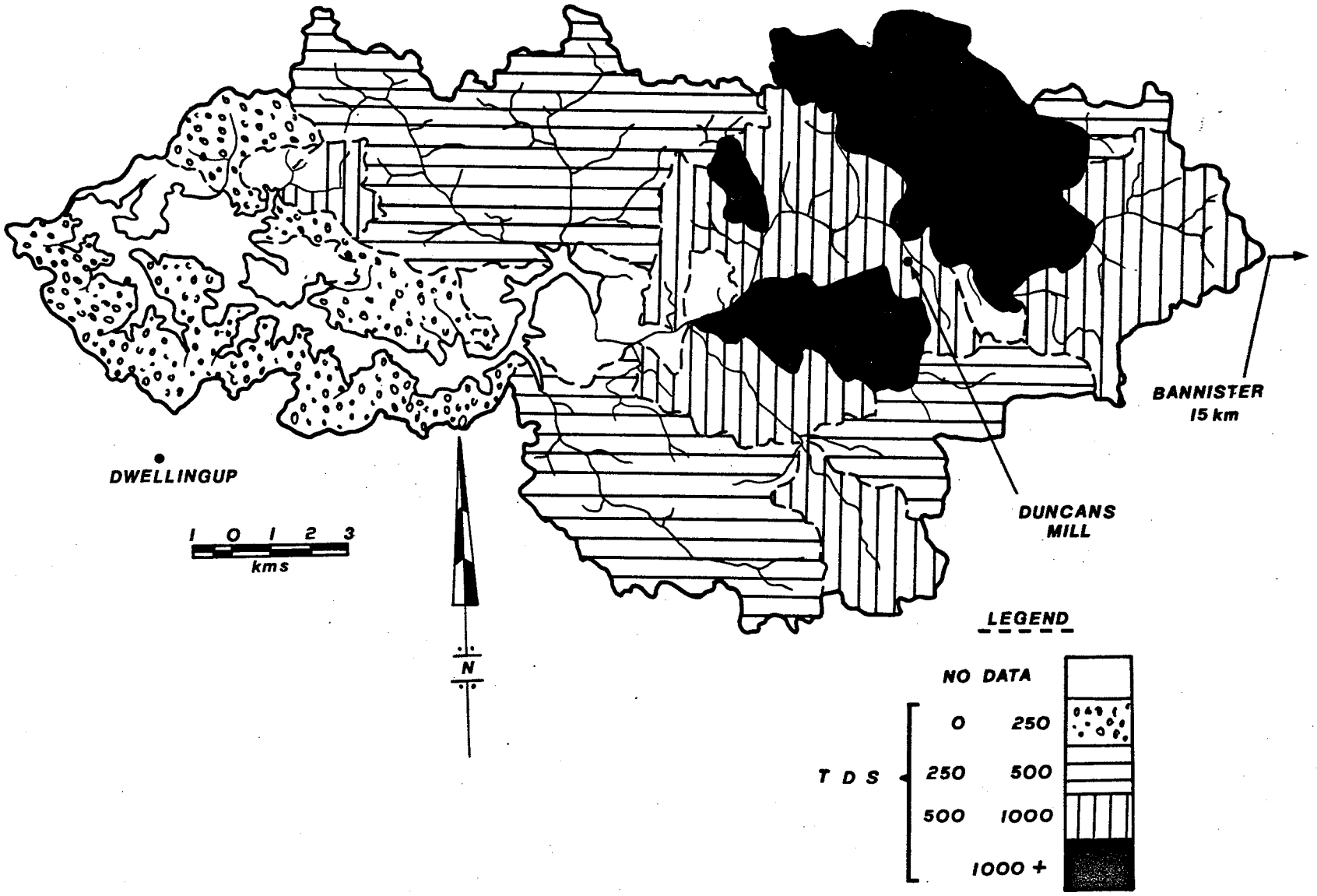


FIG 17 Sample points. Sth Dandalup Catchment

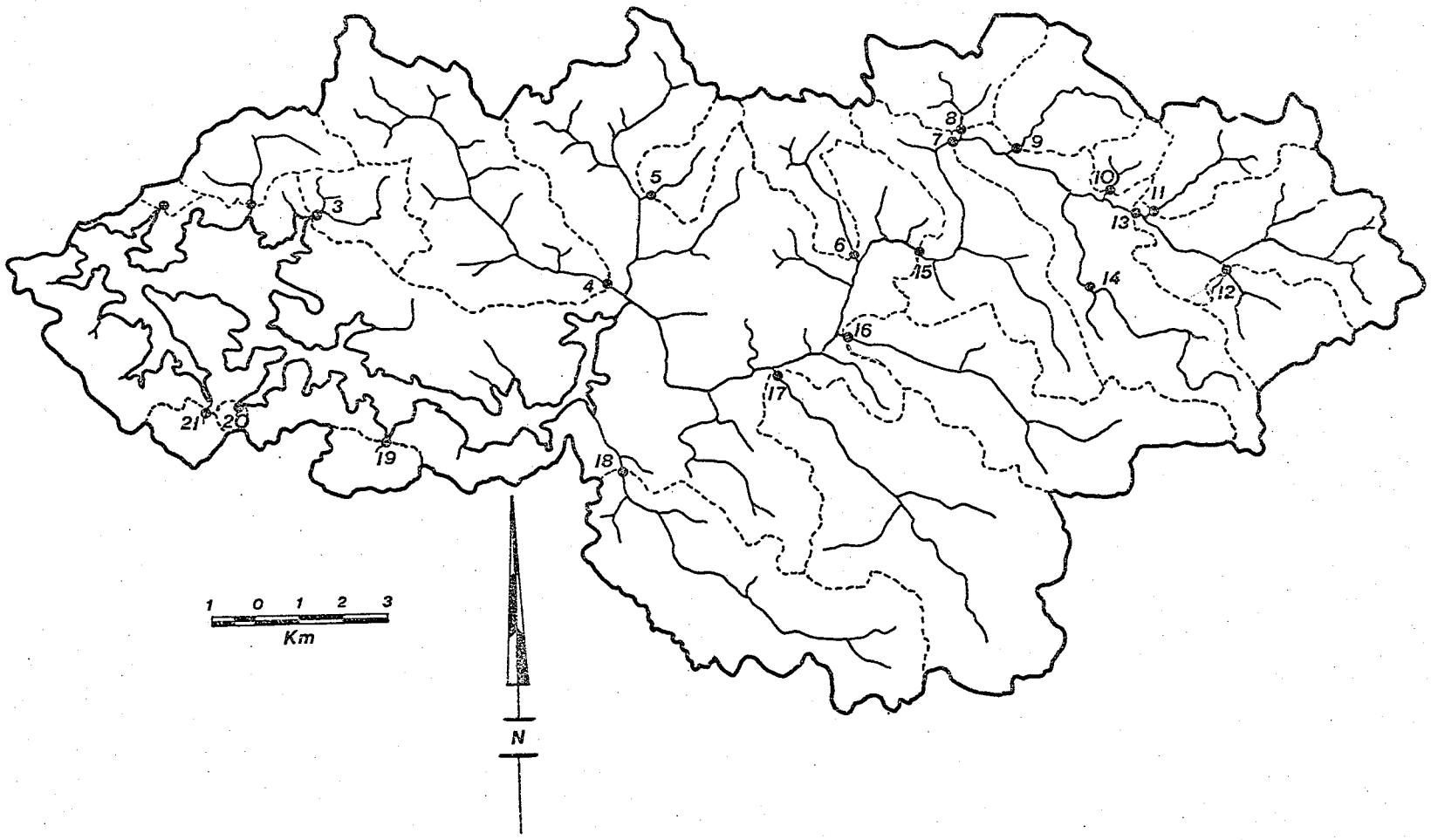
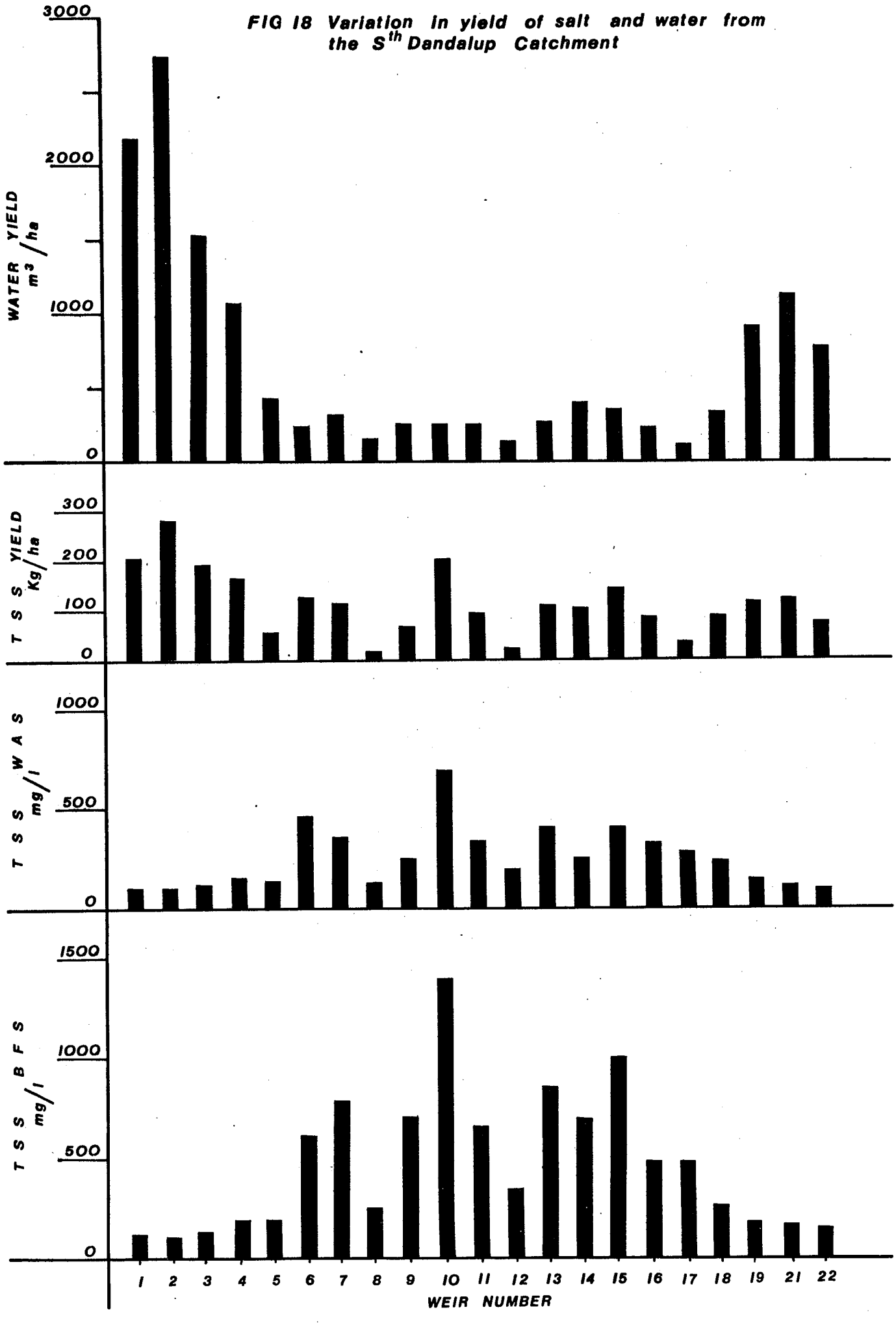


FIG 18 Variation in yield of salt and water from the Sth Dandalup Catchment



preliminary, as it is based on one year's measurements, the relative yields probably do not vary significantly from year to year.

The variation in yield per unit area is even more extreme than that exhibited by the Yarragil catchment. For example, one western catchment is yielding 20 times the amount of water than an eastern catchment. This variation cannot be explained by variation in rainfall and can only be partially attributed to difference in canopy cover. The differences in yield, as in the Yarragil catchment are correlated with valley shape. High yielding areas correspond to valleys which are incised while low yielding areas correspond with broad valleys which are sluggishly drained. Approximately 60% of the total yield of the South Dandalup catchment during 1975 originated from sub-catchments located in the narrow western neck of the catchment.

There is some evidence that reduction in canopy cover by dieback and heavy logging in the western sub-catchments of the South Dandalup catchment has caused substantial increases in water yield without a corresponding increase in salinity. Catchments 1 and 2 which have been disturbed by cutting and dieback yielded approximately twice the amount of water as catchment 17 and 18 which are relatively undisturbed.

The majority of the catchments are yielding water of acceptable quality (as indicated by weighted average salinity). However, catchment 10 has a weighted average salinity (W.A.S.) exceeding 500 ppm.

This preliminary data for South Dandalup catchment can be used to suggest a catchment management strategy which would maximize water yield. For example, heavy thinning of the western catchments which have no salt could substantially increase water yield and more importantly, increase the relative proportion of water yielded from the non-saline area. Although currently the eastern sub-catchments are yielding water of acceptable quality, their weighted average salinities are significantly higher than the western catchments. Dieback infections are already present in these catchments and it is likely that the water yielded from these catchments will progressively decrease in quality. The overall low yielding capacity of the catchment and the presence of a saline water table in over 50% of the catchment means that without careful management, reservoir water quality could deteriorate to unacceptable levels. Thus, a rehabilitation of eastern catchments could be undertaken as a prophylactic measure.

Currently, detailed mapping of the canopy density throughout the catchments, dieback infection, soil type and geomorphology is being undertaken. This information, together with the hydrological data, will be used on a simple model developed by the C.S.I.R.O. to predict the effect of changes in vegetation (either positive or negative) on water yield and quality.

Root Excavation - Native Jarrah Forest Species

It has been hypothesized that the high transpiration rate of the native forest is possible because of the extensive vertical root development of the native species. If this is correct then the species used to rehabilitate bauxite mine sites or dieback areas in salt-prone areas should have similar root characteristics if they are to prevent the discharge of saline groundwater. It is important that the root character of the native species is known to assist evaluation of species used for rehabilitation.

(1) Root Excavation

Root excavations were carried out on the Del Park mine site and in a gravel pit 1 km east of Dwellingup.

At the Del Park mine site 30 metres of the pit face was excavated to a total depth of approximately 13 metres. Twenty vertical descending jarrah roots with an average diameter of approximately 2 cm were traced to the bottom of the excavation which excavated 2 metres into the pallid zone clay. Fig. 19.

At the second excavation three B. grandis and one E. calophylla saplings were excavated to a depth of approximately 4 metres. Both species formed a tap root which extended to the bottom of the excavation approximately 2 metres into the pallid zone clay. Fig. 20.

Further excavations of the root systems of a variety of native species and P. radiata are currently being carried out.

This preliminary work confirms that native species have the capacity to penetrate the pallid zone clay. It also suggests that the root form of Jarrah, Banksia and Marri is different. The latter two species formed a distinct tap root but there was no evidence of vertical roots being formed from horizontal roots. Whereas jarrah has classical "horizontal descending" root form, that is, an extensive horizontal root system with numerous vertical roots forming from the major horizontal laterals.

(2) Analysis of Root System Exposed Following an Extensive Windthrow

On the 28/7/75 a tornado, originating at the South Dandalup Dam wall, moved in a S.E. direction for a distance of approximately 4 kilometres. The tornado caused extensive windthrow in a band of forest 4 km in length and between 100-300 metres in width. This windthrow presented the opportunity to examine the root systems of a large number of trees. It should be noted, however, that windthrows only permit examination of the superficial vertical root systems and windthrows tend to give a bias sample since those trees which have the least extensive vertical root systems are more likely to be blown over. Nonetheless, the extent and intensity of the tornado was such as to minimize this bias.

FIG 19

Jarrah vertical roots penetrating bauxite and pallid zone

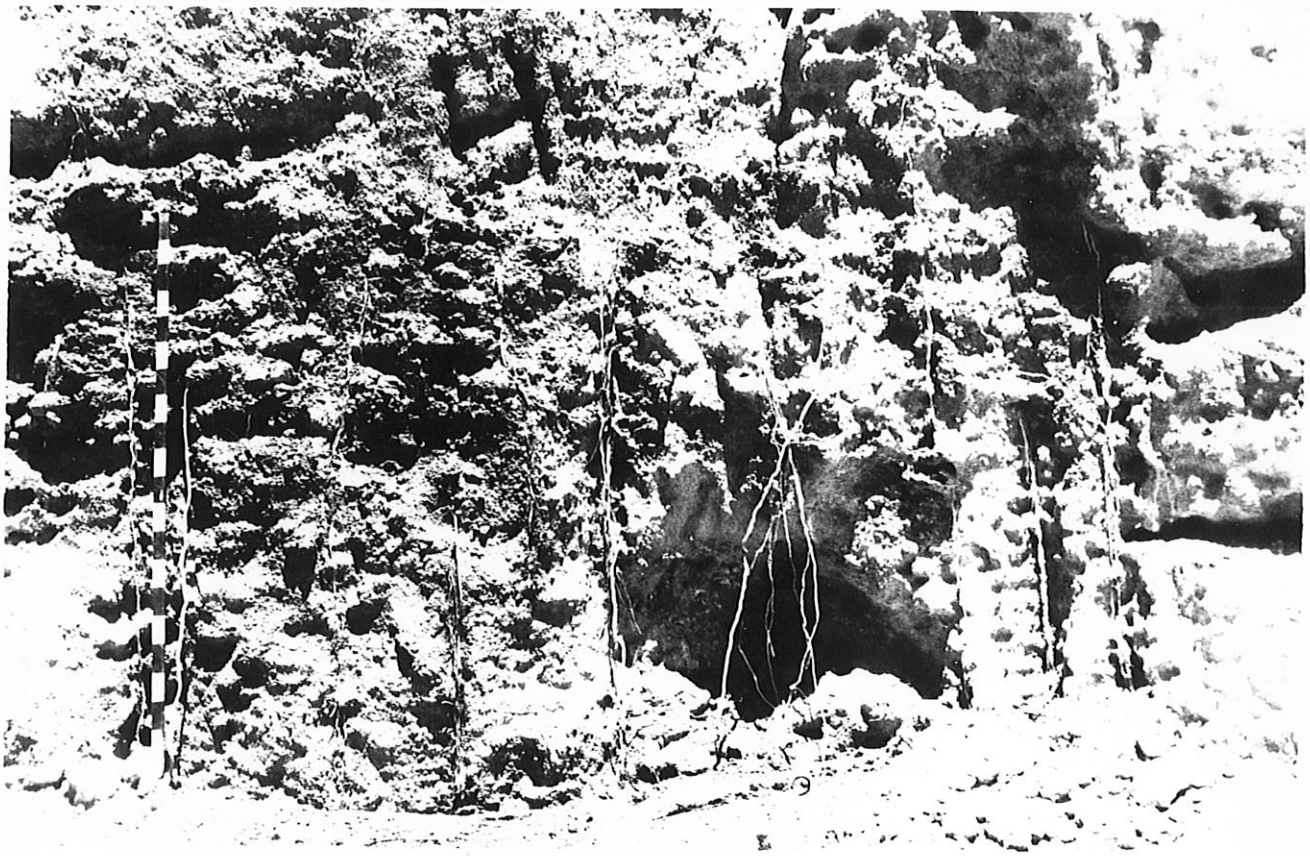
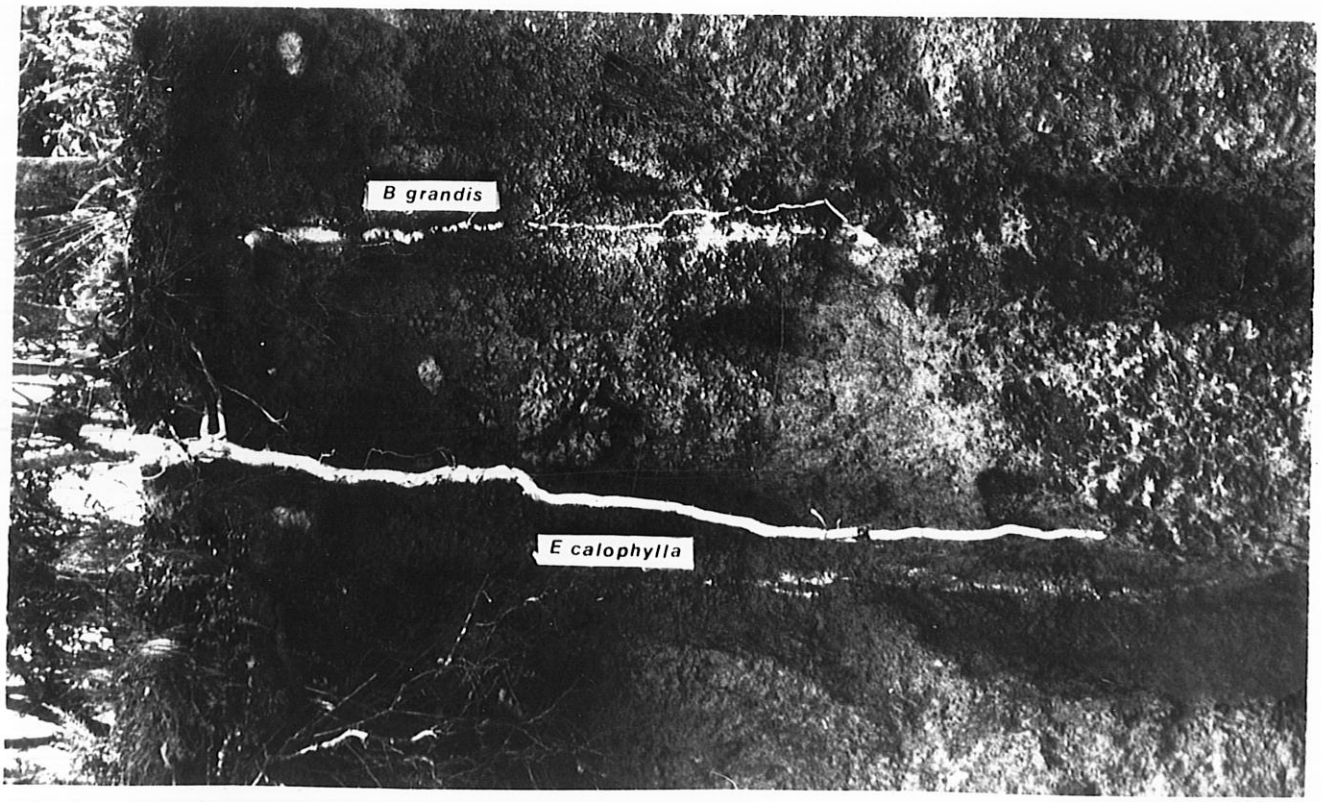


FIG 20

Banksia grandis and E calophylla roots — tap root penetrated into bauxite layer.



Species recorded in the study were Jarrah, Marri, B. grandis, Sheoak and Bullich.

Only six blackbutt and two Bullich were recorded and hence these were discarded from the analysis as they represented too small a sample.

The extent, number and form of the vertical root systems of remaining species was recorded. Three distinct forms of vertical root systems were distinguished -

1. No vertical root present.
2. Tap root- vertical root system consisted of one or at the most 2 major roots descending from the stump.
3. Horizontal descending root system - numerous small to medium (12 cm in diameter) roots descending from stump or major horizontal roots. A major vertical root may have been present but always in association with numerous smaller vertical roots.

The summarized results are tabulated below -

Species	Total No. of Trees Assessed	% Located on Cap-rock	% of Trees with no evidence of Vertical Roots	% of Trees with Tap root System	% of Trees with Numerous Vertical Roots ("hor. desc. type")
Jarrah	198	8%	8%	12%	80%
Marri	16	.06%	6%	83%	11%
Banksia	9	.1%	12%	55%	33%
Sheoak	12	0	0	0	100%

The results of this study confirm that the characteristic root form of Jarrah is "horizontally descending." In almost all cases where tap roots were present they associated with an obstruction to the root system such as cap rock or residual boulders. The sample size of marri and Banksia was smaller but these species tended to form a tap root system. Sheoak, which was absent from areas where cap rock was present but always formed a horizontally descending root system.

Eight per cent of the jarrah trees had no evidence of vertical roots. These trees were located on cap rock. To determine if any vertical roots were present at the edge of the cap rock the roots were exposed using hydaulic techniques. Vertical roots were found at distances of between 3 and 5 metres from the sump extending from horizontal roots.

The form of the vertical root system is of considerable hydrological significance. The horizontal descending root system is a more efficient extractor of water located at depth in the profile than the tap root system. The latter system probably provides sufficient water to permit survival but is unlikely to permit maximum transpiration during the summer because of the large volume of water which would have to pass through one channel. Thus, trees with a horizontally descending root system would be more likely to stabilize the groundwater table in salt-prone areas.

The study also demonstrates that care should be taken in the selecting of jarrah trees for detailed transpiration studies. It is possible that trees could be selected which do not have a fully developed vertical root system because of localized barriers. The transpiration of these trees would be atypical.

Bauxite Mining Rehabilitation

Research into bauxite mining rehabilitation is supervised by the Project 5 section of the Hunt Bauxite Mining Research Committee which is comprised of a number of officers from various Government Departments and ALCOA. Implementation of the research programme (and the preparation of research proposals) is carried out by Dwellingup research officers and ALCOA.

The principal objective of this research has been -

(1) To devise vegetative treatments which will ensure stability of the soils of the mine pit surface. Currently, water running off pits is excessively turbid and this must be contained within the mine pit. In an attempt to improve infiltration and minimize erosion large contour banks have been built and the mine pit surface has been intensively ripped: If vegetative treatments can be devised which will maintain water quality it will be possible to discharge water off the mine pits. This has three advantages -

(a) It will not be necessary to construct large embankments in the bauxite pit thus permitting easy access in the future.

(b) The large amount of money ($7000 per hectare) which is currently being expended on engineering structures on the pits could be directed to other areas (e.g. total catchment rehabilitation - see below).

(c) If techniques can be devised to direct water from the pits it may be possible to mine in areas with a saline water table. The current practice of favouring infiltration of water on the bauxite pits increased the probability that water will be discharged into the adjacent stream.

FIG 21

Direct seeded A·extensa in bauxite site· Seeded 1974

FIG 22

Results of seeding with a mixture of tree and shrub species· Seeded 1975

(2) To determine if it is possible to rehabilitate bauxite mine pits so that salination of streams can be prevented.

(1) Shrub Species Establishment on Bauxite Sites

A series of trials were carried out in 1973 and 1974 which demonstrated that native shrub species could be directed seeded onto bauxite mine sites. In 1975 an experiment which aimed to quantify the effect of different ground cover on erosion and turbidity was established. Fig. 21, 22.

The treatments were - native species applied with a straw mulch
- agricultural grasses and clover
- control (normal ripping and tree planting)

The winter of 1975 had below average rainfall and there was no significant erosion in any of the pits. Therefore, it was impossible to distinguish between treatments. However, the following observations can be made -

1. The agricultural species (Woogenellup and Seaton Park clover and Wimmera Rye grass) failed to establish adequate cover at the seeding rates applied.

2. Native legume species have successfully established cover by the end of the summer following seeding.

3. There is some evidence that clover has suppressed native species but the effect is not as striking as that which occurred during the 1974-75 trials (Fig. 23). This could be attributed to the relatively poor vigour and cover of the clover.

4. Water samples from below each plot were taken throughout the year and analysed for T.D.S., K^{+}, Mg^{++} Ca^{++}, HCo_3. T.D.S. levels were almost always below 100 ppm and none exceeded 250 ppm. Levels of K^{+} occasionally exceeded 1 meg/litre early in the season in water sampled from the collection contour bank at the base of the mine site. The water sampled at this point was a mixture of run off from all plots and normally planted sites). Nitrate and phosphate levels were not recorded. Further monitoring of water discharge from bauxite sites is planned but this data indicates that nutrient discharge from bauxite sites will be insignificant.

(2) Broadscale Shrub and Agricultural Species Trials

In an attempt to assess the practicality of establishing various vegetative shrub and understorey legumes on mine pits four individual mine pits were treated at the Del Park mine site. The treatments were direct seeding of -

(1) Agricultural species

(2) Agricultural species + native species

(3) Native species + tree species applied with a mulch.

No significant erosion occurred in any of the treated pits during the winter of 1975. However, as in experiment 1 the agriculture species did not establish complete cover. The trial did demonstrate, however, that it is possible to establish on a broad scale tree and shrub cover by direct seeding. In a previous trial it has been established that direct seeded tree species will grow as rapidly as jiffy planted stock. However, seed distribution, which was by hydroseeder, was variable.

(3) Direct Return of Topsoil (Established by W. Tacey, ALCOA)

Continued counts and recent observations indicate that there is a highly significant increase in the stocking rate of volunteer native plant species when the top 5 cm of topsoil is removed and returned separately.

	Plants/m^2	
Soil Type	Spring	Late Summer
Stockpiled	0.25	0.50
Whole Fresh	0.80	-
Top 5 cm Fresh	3.45	6.93

* following soil return in winter

This is attributed to the favourable placement of viable seed carried over from cleared forest. A stocking rate of 7 plants/m^2 is considered likely to yield an acceptable standard of ground cover two to three years after rehabilitation.

(4) Effect of Ripping on Tree Growth (Established by W. Tacey - ALCOA)

An experiment to evaluate the effect of depth of ripping on tree growth and root penetration was established at Jarrahdale in 1975. Ripping depth appears to have no effect on the growth of planted eucalypts during the first 8 months following establishment.

(5) Deep fertilizer Placement (Established by W. Tacey - ALCOA)

The experiment is aimed at determining the effects of fertilizer placement at different depths in the soil profile on root development.

No qualitative differences in growth between treatments are yet apparent. In addition, treated trees, which received one

FIG 22 Reduction in survival of native species when planted with Agricultural species

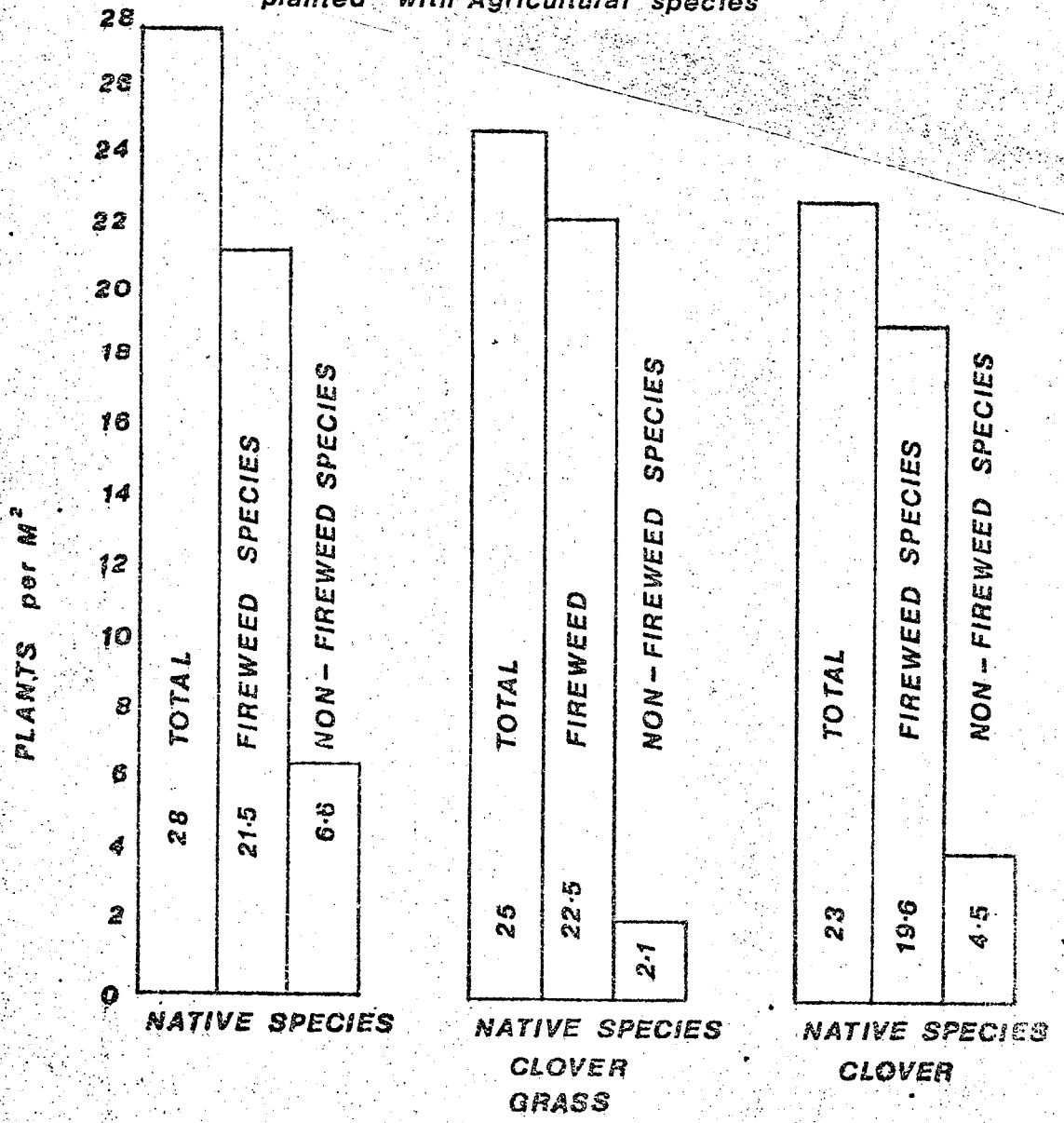
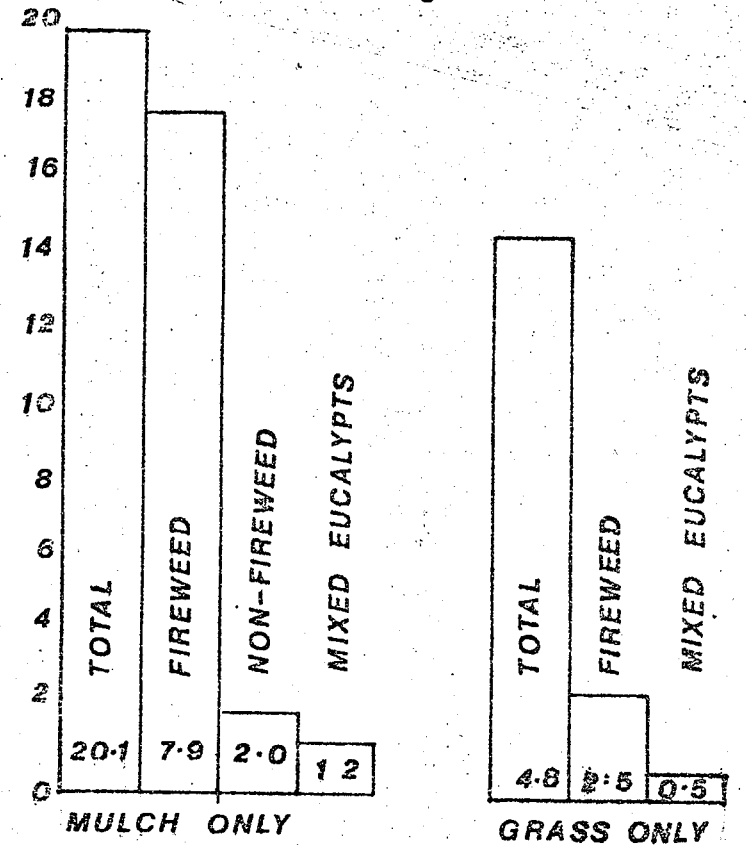


FIG 23 Result of semi operational direct seeding trial



surface application of fertilizer and one at depth, appear smaller than control trees fertilized with two surface applications. These results may indicate:

(a) that E. globulus seedlings do not derive discernible benefits from fertilizer placed at 2 ft depth within the first 8 months of growth and/or

(b) that placement at depth of fertilizer in open topped plastic bags is not an effective technique for supplying nutrient to trees.

It is anticipated that meaningful information from this experiment will become available when roots are excavated in the future.

(6) Establishment of Shrub Species Seed Orchard

A seed orchard consisting of the major native shrub legume species has been successfully established at Jarrahdale. It is expected that in the future this orchard will provide a readily accessible source of seed for broadscale shrub establishment in bauxite pits if this is required.

(7) Detailed Small Plot Run-off Trial

This trial is a refinement of the run-off work initiated in 1975 (see (1) above). The aim is to obtain statistically reliable information on both the quantity and quality of run-off water in the first 1-2 years after revegetation.

ALCOA of Australia have incurred considerable expense in the preparation of this trial site. Fig. 24, 25. The earthworks and construction have been designed for east of replacement of the actual experimental surface so that future re-runs of the trial can be made. In this way it is hoped to get results over a range of seasons.

The trial consists of four replications of three treatments:

(a) clover

(b) mixed native shrubs with straw mulch

(c) standard rows of trees

Each of the 12 plots has its own collection trough, V-notch weir and recorder. The plot size is approximately 4m x 30m, the slope is 10% and the surface is prepared in the standard way. The surface has been levelled after ripping.

The plots were operational from May 1st. Turbidity results for the 1st 6 weeks of the winter are shown below.

Plot Treatment	Sampling Data					
	17/5	20/5	1/6	18/6	27/6	2/7
Standard (trees only)	55.8	19.5	33.0	16.0	18.5	27.3
Clover	10.5	10.3	17.0	17.8	11.5	6.0
Mulch + Native Seed	9.1	5.9	8.6	18.3	11.1	4.3

These results suggest that a heavy mulch will maintain water quality. However, rainfall during the test time was below normal.

There is also some evidence that there is nutrient run-off. These results indicate that turbidity levels can be reduced to a minimum by mulching. It is expected that by the time the mulch deteriorates the native species will have established a complete ground cover.

(8) Whole Pit Run-off Trial

A whole pit rehabilitated in the standard way has been equipped with a V-notch weir and recorded to monitor total run-off. It is also planned to record total sediment reaching the stilling pond above the weir and to measure suspended sediment and turbidity.

The pit is located at Del Park and approximately 5 ha in extent. This trial was operational by May 10th.

Data from this trial will provide an estimate of the yield of water (in the form of overland flow) and sediment per unit area of mine pit surface. This information is essential for the design of the pits and for calculation of the hydrological budget.

(9) Creation of Ultimate Vegetation Types

The aim of this trial is to establish different vegetative formations on bauxite pits to provide a contrast to the standard tree plantation approach. This will provide an opportunity in the future to assess the practicality and benefits of various rehabilitation options.

Two alternative vegetation types have been established. Each occupy whole pits of approximately 9 ha in area.

(a) Parkland formation - an open woodland of trees and shrubs with clover ground cover. The clover ground cover was planted in early April. Trees and shrubs will be seeded and planted in June.

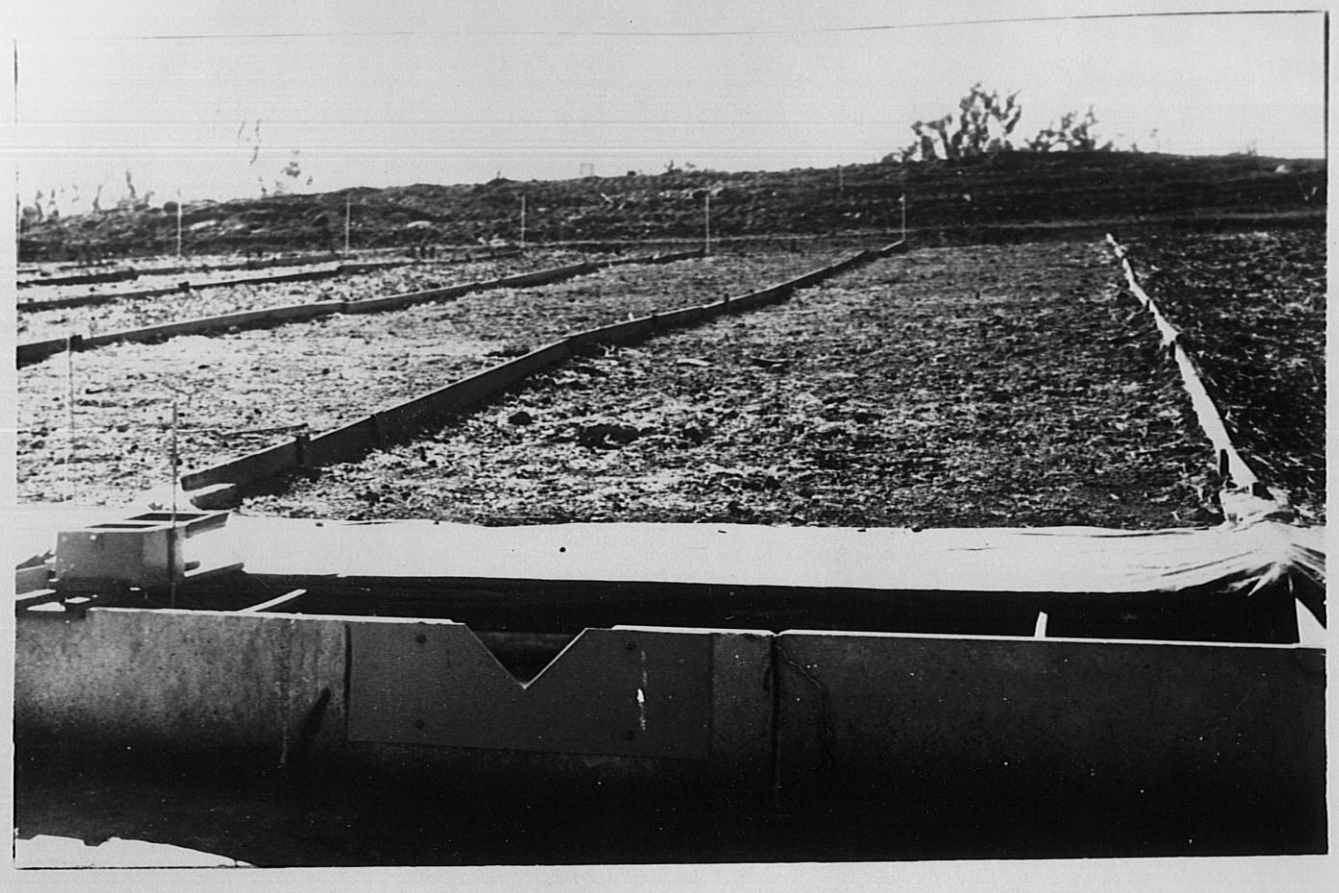


FIG 25
Instrumentation of detailed plot study

(b) Forest formation - a forest of mixed trees and shrubs randomly planted. Trees were planted as seedlings and the shrubs broadcast seeded. Broadcast seeding of tree species has also been carried out in selected areas.

(10) Assessment of Agricultural Species

The potential worth of agricultural species in revegetation has not been thoroughly investigated. It is known that agricultural species will establish more rapidly than natives giving potential for soil stabilization in the first year of revegetation. This advantage is offset by the well demonstrated depressive effect of agricultural species on the establishment and growth of natives. It is proposed to investigate the use of agricultural species as 'pioneers' in a succession leading to mixed stands of natives. Two trials have been planted to examine the persistence of agricultural species on bauxite pits.

(a) Rate of phosphate on clover - the persistence of clover on laterite soils diminishes rapidly as the availability of phosphate from the initial application declines.

(b) Species trial - six agricultural legumes are being assessed for rapidity of establishment and persistence. The species are clover, vetches (2 species), peas, lupins and serradella.

(11) Extension of Species Trial

No single large-scale planting of the wide range of eucalypts used in revegetation has previously been made. Thirty tree species have been planted in a large arboretum at Del Park. Each species will occupy approximately 1 ha which should be sufficient for valid assessment of management treatments such as thinning and fertilization.

The species that are being tested have been selected for aesthetic and potential hydrological value rather than their possible timber production capacity which previously has been the major criteria for selection.

(12) Root Excavation

Previous studies of the root development of trees planted at the No. 1 Jarrahdale site demonstrated minimal vertical root development. These excavations were carried out on trees which were planted on unripped or partially ripped sites.

Excavation of root zones of a range of species planted on ripped pits has commenced at the Jarrahdale No. 1 site. Approximately 60 trees are being excavated. Data on below ground development will assist evaluation of water consumption capacity of the species and their future long-term growth and development. Preliminary results indicate that with the exception of Jarrah and Wandoo none of the trees excavated have significantly penetrated below the over burden soils.

(13) Total Catchment Rehabilitation

The concept of total catchment rehabilitation has been outlined in a number of reports to the Hunt Bauxite Mining Research Committee. Currently, large expenditures are being made to ensure that bauxite pits are replanted with tree species. This practice ignores the fact that as a consequence of activity in the area prior to bauxite mining and currently as a result of bauxite mining the areas surrounding the pits are frequently heavily infected with P. cinnamomi. Thus, if the current policy is continued (and if revegetation of the pits is successful in the long term) bauxite mined areas will consist of vegetated pits surrounded by dead trees. In addition to overcoming this deficiency rehabilitation on a total catchment basis would permit a rational rehabilitation policy to be developed. For example, up to 1975 rehabilitation practice on bauxite pits was to replant at a dense spacing with tree species. This may be the correct policy in saline areas but current research suggests that in non-saline areas replanting with trees at a dense spacing will have a negative effect because it could significantly reduce water yield.

A study of the catchment of the Seldom Seen (located in the Jarrahdale bauxite mined area) was undertaken to determine the current and future vegetation distribution in a typical bauxite mined catchment in the Western Scarp. The predicted future vegetation status of the catchment is shown below -

Vegetation Type	Area hectares	% of total
Uninfected Protectable Native Forests	84	12
Bauxite Pits and Roads	189	27
Healthy but Potentially Dieback Infected	177	26
Advanced Dieback	244	35
	694	

This study clearly demonstrated the necessity to evolve a total catchment rehabilitation plan. It is planned to draw up a prescription for the treatment of the total Seldom Seen in co-operation with Divisional officers and ALCOA staff.

Soil Moisture Prediction Model

It is extremely difficult to obtain data on the effect of vegetation type and cover on stream flow by empirical methods (e.g. paired catchment studies) because of the large number of permutations and combinations of possible vegetation types. Modelling can be used to narrow down the number of treatments which need to be tested in the field: two soil moisture prediction models are being developed to test the effect of different tree species and spacing used to rehabilitate bauxite pits on soil moisture consumption.

(a) A soil moisture prediction model developed to predict soil moisture regimes in the Boreal forest of Northern Canada has been adapted to predict soil moisture consumption by tree species on bauxite pits. The model has been designed to predict daily moisture consumption using inputs of soil physical characteristics, root distribution, daily rainfall and evaporation. The model is currently being test run.

(b) A complex model has been devised in Oak Ridge, Tennessee, which models total catchment hydrology. The model has been brought to W.A. by Dr. R. Luxmore and is currently being set up at the C.S.I.R.O. Data for inputs into this model is being provided by the station. This includes:-

- root distribution
- infiltration rate
- soil moisture storage capacity
- interception by tree canopy
- stem flow

Rehabilitation of Open Cut Coal Mines

Initial research into the rehabilitation of forest areas which have been strip mined for coal were initiated in co-operation with the Agricultural Department and Collie Divisional Staff during 1975. Currently, almost no attempts have been made to systematically rehabilitate following open cut mining and the majority of mined over areas are barren and spoil heaps form steep slopes. Fig. 27.

(1) Preliminary Direct Seeding Trials

A small preliminary direct seeding trial was carried out on one spoil heap in August 1975. A mixture of native shrub seed was applied. There was extensive wastage of the seed but where it was retained germination and subsequent growth has been rapid. Fig. 26. The pH of the soils in which these seedlings have established averaged five.

FIG 26
Mixed native legume species 1 year after direct seeding on spoil heap

FIG 27
Landscape following open cut mining at Collie

(2) Surveys of Soil Acidity

A preliminary survey of the soil acidity was carried out. The results are shown below -

pH range	No. Samples	%
2.2 - 2.9	17	12.7
3.0 - 3.9	60	44.7
4.0 - 4.9	45	33.6
5.0 - 5.7	12	9.0
	134	100

The survey indicates that many of the mine spoil heaps are very acid. It is unlikely that agricultural species would survive without massive applications of lime at these pH levels.

A more detailed survey of soil acidity has been initiated in co-operation with S.D.F.O. Hatch. The object of the survey is to identify the soil horizons which are responsible for the low pH levels. Once identified it may be possible to prevent these layers forming the surface of the spoil heaps during the mining process. This approach has been used with some success in the Appalachian strip mining area of the U.S.A.

(3) Direct Seeding Trial

A comprehenaive trial which is aimed at determining the ability of native and agricultural species to form a cover on the spoil heap was initiated during the autumn of 1976 in co-operation with the Department of Agriculture. Fifteen agricultural species and a variety of native shrub and tree seed have been sown on two separate locations. The following treatments are being applied: topsoil and lime.

If it is possible to direct seed species with the same success as the direct seeding trials on bauxite pits, it should be relatively easy to re-establish a variable forest on the mine spoil heaps which is aesthetically pleasing.

Rehabilitation of Dieback Sites

Over the past eight years numerous rehabilitation trials in dieback sites have been carried out. A detailed report on

these trials is currently being prepared. Research into rehabilitation, apart from species tested, has primarily been concerned with the development of low cost techniques. The results from these trials can be summarized -

(1) It is possible to establish eucalypts by direct seeding on dieback sites provided there is some site pre-treatment. Without some site preparation establishment is nil.

(2) Sowing of the seed directly on ashbeds is the best method of establishment, (survival approximately 5% of seeds sown), and growth is enhanced.

(3) Ripping improves establishment but is not as successful as the ashbed treatment and is probably uneconomical.

(3) Ripping improves establishment but is not as successful as the ashbed treatment and is probably uneconomical.

(4) Fertilization with a balanced fertiliser significantly improves survival and growth. Direct seeded plants will grow as rapidly as jiffy planted stock provided they are fertilized correctly.

(5) It is possible to successfully establish P. pinaster on dieback sites by direct seeding provided ground preparation is adequate. Pre-treatment with either ploughing, ripping or herbicides to control scrub is necessary. Time of sowing is important. July-August sowings produced unsatisfactory results. Sowing should be carried out immediately after the first significant rain in Autumn.

(6) It is possible to establish a wide variety of tree and shrub species by direct seeding providing that the site has been treated by the formation of ashbeds or disturbance of the soil distribution. This technique has been used to establish attractive roadside verges at a relatively low cost.

Although further semi-operational trials are required these experiments indicate that it is technically feasible to re-establish vegetation on dieback sites at a relatively low cost. However, before a broadscale rehabilitation programme is undertaken the following should be considered -

(1) Long term survival of trees planted on upland sites should not be assumed. It will probably be necessary to maintain the forest established on these sites in the form of a savannah woodland if survival of trees is to be achieved.

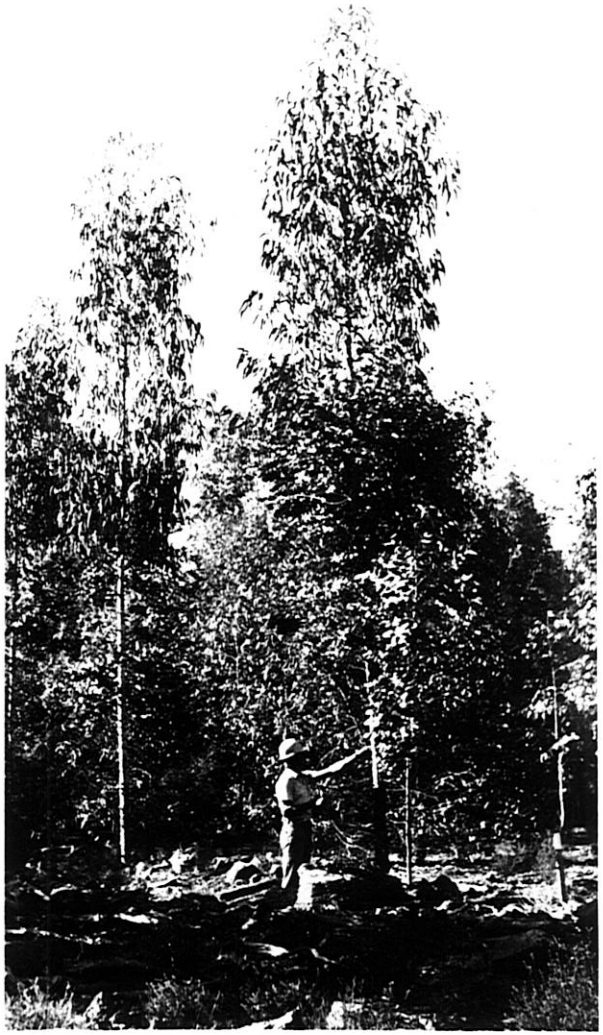
FIG 28

2 year old direct seeded E·globulus fertilized with 50 gms of Agras. Left middle foreground - unfertilized treatment

FIG 29

6 year old E.globulus, E·maculata, E·resinifera direct seeded on an ashbed· Foreground - control treatment

FIG 30



6 year old E· globulus direct seeded on ripped lines

FIG 31

3 year old direct seeded E·leucoxylon and E·robusta. Seeded on ashbed· Right forground jiffy pot planted E·resinifera

FIG 32

3 year old direct seeded E·laeliae

FIGS 33 *3 year old direct seeded Calothamnus and Callistomen*

(2) It may not be desirable to establish trees in those areas of the forest where salinity is not a problem. Current research indicate that the yield of water from dieback affected sites is significantly higher than from those which are unaffected.

(3) In salt-prone areas rehabilitation of the unplanted sites with some dieback resistant species may not significantly improve water quality because of the inability of the trees to transpire at the same rate as jarrah.

(4) Further research is required to determine what constitutes an aesthetically pleasing forest: preliminary studies suggest that a foresters concept of aesthetics is markedly different from that of the average citizen.

Currently it is recommended that rehabilitation be confined to roadside areas which are subject to high pressure from recreationists.

Urban Forestry

Following a request for assistance from the Main Roads Department a direct seeding trial was established on median strip and embankments of the Mitchell Freeway interchange in West Perth. Vegetation of the freeway embankments is required to minimize erosion, reduce headlight glare and improve the aesthetic character of the freeway. The trial is aimed at determining if native shrub species can be direct seeded onto freeway embankments. Two types of mulching treatments are also being tested.

Fire Ecology

(1) Detailed Factorial Trial - Plavins

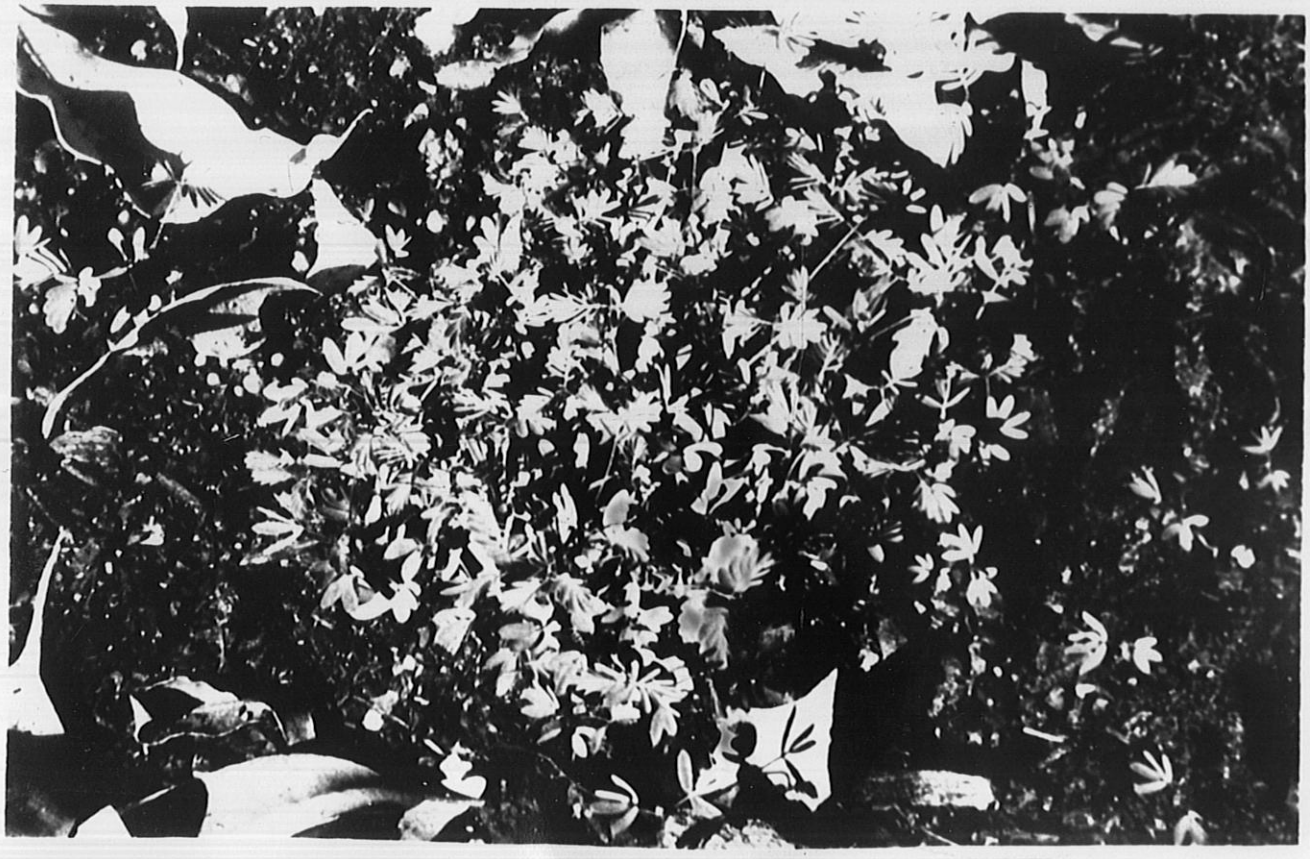
In 1971 a comprehensive study of the effect of fire intensity, frequency and season of burning on flora was initiated in Plavins Block. The trial is now approaching the second burning cycle. It has been impossible to carry out the summer high intensity burns because of protection problems. However, the trial does cover a range of treatments in the low to medium intensity range. Preliminary results suggest that the burning treatments have had no marked effect on composition and density of the flora. While providing valuable data on the effects of fire on flora this trial represents a very large commitment of staff.

(2) Pindalup High Intensity Prescription Burn

A high intensity prescription burn was carried out in March 1975 to determine if it was possible to germinate native legume seed. Details of the fire behaviour were summarized in a previous report.

FIG 34
A pulchella in fenced plot one year after intense fire

FIG 35
Clumped regeneration of A pulchella



The fire caused broadscale and dense regeneration of native legume species. Frequently germination occurred in clumps, Fig. 29, suggesting that the seed had been transported following seedfall. Subsequent to the regeneration there has been extensive browsing by native animals: fenced plots were established by the C.S.I.R.O. to protect experimental areas. Currently there are almost no surviving legume species outside the fenced plots. Fig. 28.

The intensive animal browsing observed is possibly an indication of heavy preference for legume foliage by native animals in an environment where legume species are at minimal levels because of the effect of low intensity prescription burning. It is likely that the effect of animals on legume survival will decrease if the areas regenerated to legumes are large. The generally low occurrence of legumes in the forest is probably caused by heavy selection against legumes resulting from low intensity prescription burning and animal browsing.

(3) Extension of High Intensity Burning Trials

Following the success of the Pindalup trial a more comprehensive trial was established in the same forest block. It is planned to carry out a series of burns on plots 10 hectares in area during autumn, spring and summer. The objective of this trial is to determine the relationship between intensity of burning, season of burning and legume germination.

Early autumn rain prevented the initiation of the trial. However, a small experimental burn was carried out in late autumn in Curara Block in an area which had banksia and non commercial jarrah and marri had been pushed down with a D7 bulldozer.

Although the intensity of the fire was moderate, legumes have germinated in lines parallel with the ashbeds formed by the pushed over trees: this trial suggests that legume germination may occur at moderate fire intensity provided heavy fuels are present.

Fauna Research

The Effect of Intense Fire on Mardo (Antechinus flavipes).

A swamp containing a population of 23 mardos was burnt in October 1972 following a pre-burn study of mardo numbers and mammals using a rotational grid trapping system. Three male mardos and two female mardos were trapped in February 1975. Current results indicate that only 1 male and 1 female mardo are residing in the area. The vegetation density has recovered to 93% of that which was present prior to the burn.

General Ecology.

(1) Ants and Legume Seed Dispersal.

Following the observation that legumes frequently regenerated

in clumps following the high intensity Pindalup burn it was hypothesized that ants could be responsible for transporting the seed. Accordingly, a series of observations on the behaviour of ants in relation to legume seed were made by introducing seed into an area and recording ant activity at hourly intervals. Approximately 1 hour after the introduction of the seed ants from the genus Iridomyrmex were observed to be actively redistributing the seed and placing the seed in their nest. Seed was recovered from a depth of 4 cm within the nest. The seed apendage has been removed.

This simple study has considerable significance. For example, redistribution of the seed below the surface of the soil explains why fire does not destroy the seed and why high intensity fire is required to germinate legume seed in the jarrah forest. A more detailed report on this study is currently being prepared by T/A C. Portlock.

(2) The Ecology of Ants in Jarrah Forests - Research by Dr. J.D. Majer (W.A.I.T.).

The background to this project has been described in the 1975 annual report. The Plavins ant sampling programme was designed to investigate the effects of fire and season on ant populations in order to provide a background against which predation of the Jarrah leaf miner could be considered.

Analysis of macro-invertebrate numbers taken in the 14 months trapping period shows that the ants are numerically the most abundant group (total of 10,091 individuals). Both abundance and species richness are positively correlated with temperature and negatively associated with rainfall (Fig. 30). Their abundance may also be correlated with high invertebrate food abundance in spring and autumn (Fig. 30). It is noteworthy that ant abundance is submaximal in spring when leaf miners drop to the ground.

The 30 kW/m and 175 kW/m burns had little effect on the total abundance or diversity of ants although there was a temporary increase in certain species at the expense of reduced dominant ant numbers. Principal components analysis of the weekly samples suggests that fire had no influence on the composition of the following summer's ant fauna. Additional sample areas have not been established to investigate effects of more intense spring and autumn burns. The effects on other invertebrate groups will also be investigated.

Sampling has also commenced at Manjimup and Perth in order to elucidate the phenology of ants within the leaf miner's distribution range. The effectiveness of miner predation by various ant species will be investigated in spring by means of complimentary field samples and laboratory experiments.

The role of ants in 'fireweed' distribution seeding success is also being investigated. This is being undertaken by means

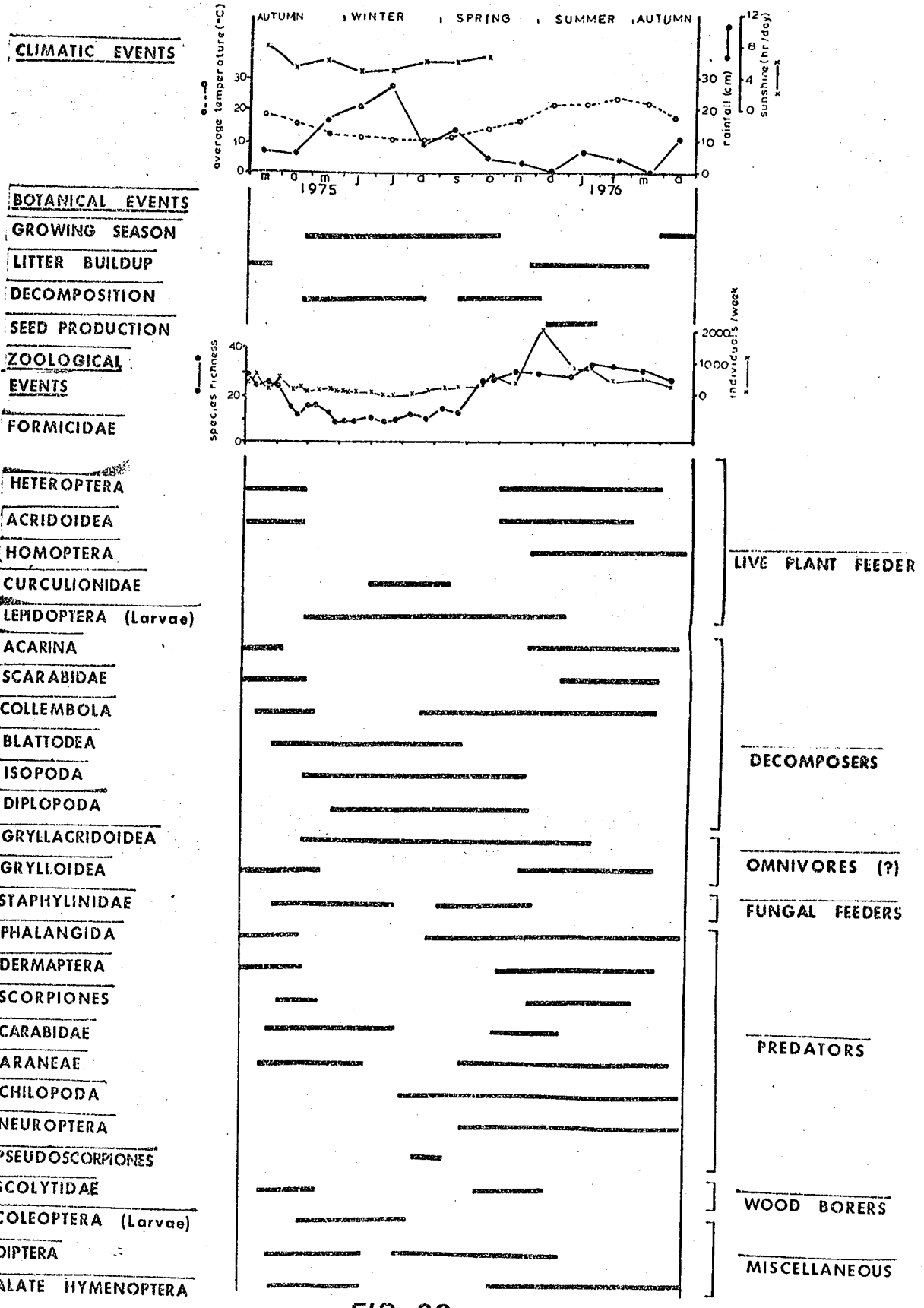

CLIMATIC EVENTS
BOTANICAL EVENTS
GROWING SEASON
LITTER BUILDUP
DECOMPOSITION
SEED PRODUCTION
ZOOLOGICAL EVENTS
FORMICIDAE
HETEROPTERA
ACRIDOIDEA
HOMOPTERA
CURCULIONIDAE
LEPIDOPTERA (Larvae)
ACARINA
SCARABIDAE
COLLEMBOLA
BLATTODEA
ISOPODA
DIPLOPODA
GRYLLACRIDOIDEA
GRYLLOIDEA
STAPHYLINIDAE
PHALANGIDA
DERMAPTERA
SCORPIONES
CARABIDAE
ARANEAE
CHILOPODA
NEUROPTERA
PSEUDOSCORPIONES
SCOLYTIDAE
COLEOPTERA (Larvae)
DIPTERA
ALATE HYMENOPTERA
AUTUMN
WINTER
SPRING
SUMMER
AUTUMN
average temperature (°C)
rainfall (cm)
sunshine (hr/day)
1975
1976
species richness
individuals/week
LIVE PLANT FEEDER
DECOMPOSERS
OMNIVORES (?)
FUNGAL FEEDERS
PREDATORS
WOOD BORERS
MISCELLANEOUS

FIG 36

of routine observations on seed associated ants and by distribution surveys of ant nests and germinating 'fireweed' seeds. It is noteworthy that the time of 'fireweed' seed production (Fig. 30) coincides with the period of maximum ant activity suggesting that these plants may exhibit temporal as well as morphological adaptations for ant carrying.

This study is associated with the third section of the project. The success of seeding bauxite mined areas appears to be reduced because ants remove seeds. The succession and ecology of seed associated ants in these areas are being investigated. It may eventually be possible to modify this succession so that seed predating species do not predominate at the time of seeding.

Recreation

(1) Preference of Forest Users for Different Vegetation Types

Increasing rehabilitation in forest areas is being carried out for aesthetic purposes. In addition, certain sections of the community have been highly critical of some forestry practices particularly those involving pine planting. A small preliminary study was carried out in an attempt to obtain an objective assessment of what the average citizen considers aesthetically pleasing in the forest.

Method

Thirty different types of forest vegetation were exhibited on slides to a group of 50 people attending a series of ecology lectures held at Mandurah. The slides were randomly assorted and following a complete run through of the slides each participant was asked to rate his preference for the particular vegetation type after viewing the slide for 10 seconds. Rating was on a scale from 1 to 10 (Unsightly - Scenic).

Results

This method of assessing preference has many disadvantages but it does provide a practical method of sampling a range of public opinion.

The results may be summarized as follows -

(1) With the exception of Dieback-affected and forest with logging debris there were no strong marked preferences. (It should be noted that this study was carried out immediately after a lecture on Jarrah Dieback so the results are somewhat biased). A typical marri stand of the type which forms in dieback areas was rated at about the same level as a high quality pole stand.

(2) The Karri forest rated higher than most other vegetation types but the difference was not striking.

(3) Natural Jarrah forest of whatever type generally had a high average rating. Of the various types of Jarrah forest, however, the parkland type had the highest scenic rating and the irregular cut-over forest had the highest unsightly rating. Surprisingly, the virgin Jarrah forest stand had a high average rating but was not rated as being very scenic.

(4) There was a mixed reaction to pine forest. There was a higher percentage of people who found pine trees more unsightly than Jarrah forest but a number of people found the virgin Jarrah forest less scenic than pine forest. It was surprising that there was a tendency for managed (pruned, thinned and regularly spaced) pine forest to have a higher scenic rating than unmanaged (unpruned, irregularly spaced and varying sized trees) pine forest.

(5) Exotic eucalypts grown in plots (regularly spaced) rated higher than pine trees and native forest.

(6) Rolling farmland, swamp and a mixed forest of Poplar and Jarrah had surprisingly average ratings.

CONCLUSIONS

All that can be concluded from this preliminary study is that foresters and zealous conservationists have markedly different preferences for forest vegetation than the average citizen.

2. Recreation Use in the Dwellingup Division

General subjective observations and spot surveys indicate that there has been a marked increase in recreational use in the Dwellingup Division since the original comprehensive surveys were carried out in 1972-73. In particular there has been a marked increase in the use of the Murray River for canoeing.

As a consequence of this increased use there is evidence of site deterioration particularly in the Murray Valley. There are frequently large accumulations of garbage at some recreation sites. In the spot surveys the highest priority was given by recreationists to the provision of garbage disposal facilities.

It is intended to carry out detailed surveys of recreational use in the Division and to provide a detailed management plan for the Murray Valley during 1976-77.

Jarrah Silviculture

During the year studies relating to Jarrah regrowth stand manipulation and fertilization were maintained. Most trials are now measured at five year intervals to overcome growth variations due to seeding cycles and prescribed burning effects.

The major trial measured was local experiment 13 established in 1964 by S.D.F.O. Kimber. This consists of 26 plots thinned to a wide range of basal areas in Inglehope Block. Data from this trial is being converted from imperial to metric. It is anticipated that summaries will be available in the near future and will serve as a useful guide to managing protectable Jarrah Forest regrowth stands.

The large store of information on jarrah silviculture will be applied both for management of the forest for water production and timber production.

ACKNOWLEDGEMENTS

The assistance of S.D.F.O. Hatch and the Como Research staff, the staff of the Dwellingup, Harvey, Kelmscott and Mundaring Divisions and Head Office Drafting Branch is gratefully recorded.