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Box 200

Bauxite Mining Rehabilitation

Research Proposals

1974

Research Station,
DWELLINGUP 6213

Supt. J.J. Havel,
Forests Department,
COMO 6152

30th April, 74.

I enclose a series of working plans concerned with bauxite mining rehabilitation research projects for your comment and approval.

The introduction of agricultural grasses at the mine sites and the proposal to artificially introduce P.cinnamomi onto the mine site represents a departure from previous Departmental policy and are specifically drawn to your attention.

I have received an unofficial quote of $200 per tank for the hydro seeding operation. Two tanks are required for the proposed project. Could you negotiate with Superintendent Grace to obtain the necessary finance as funds are not available at Dwellingup? (Supt. Grace has indicated that this probably can be arranged).

S.R. SHEA
D.F.O.

Copy to: Supt. Grace, Como.

Bauxite Mining Rehabilitation Proposals 1974

Previous research projects on bauxite mine sites have been primarily restricted to species trials, site amelioration (ripping) and fertilization trials. The expansion of bauxite mining operations, the recognition that water catchment protection will be the first priority on catchments and that other forest values in addition to timber production require greater emphasis has led to the expansion of the rehabilitation research programme.

The following preliminary research proposals are aimed in resolving rehabilitation difficulties in 4 major problem areas.

(1). Mine Floor Stabilization

During the period 1969-1972 rainfall has been abnormally low, but even under these conditions there has been considerable movement of the overburden soil on the mine sites. Fig. 1 represents an atypically severely eroded area, but it illustrates the capacity for erosion on the mine sites particularly when the underlying pallid zone is exposed. An essential prerequisite to establishing vegetation on the mine sites and maintaining water purity is the stabilization of the overburden soils. Mechanical techniques such as ripping, and the construction of contour drains and silt traps are only short-term solutions and require careful implementation if they are not to intensify the problem.

Overland flow in the natural forest is absent even during excessively high rainfall intensities and erosion does not occur. This can be primarily attributed to the presence of a litter and duff layer and the large number of roots per unit volume of soil: The establishment of native shrub species on the mine sites should stabilize the soils, reproduce the favourable infiltration capacity of laterite soils and provide a cover which will reproduce naturally.

Preliminary experiments established in the late spring of 1973 with limited quantity of seed suggest that native legumes will establish readily on the mine site provided the seed is pretreated. Fig. 2.

The establishment of grasses and clovers has been successfully used to stabilize highly erosion-prone sites but they may -

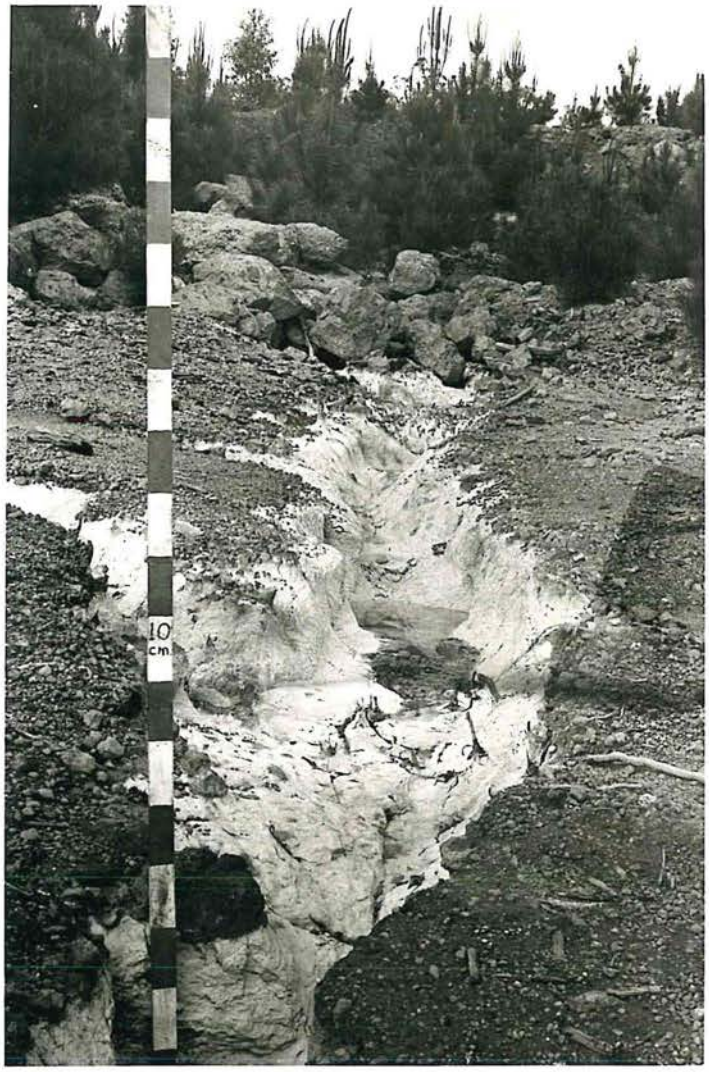

Fig. 1 Severely eroded bauxite mined area Jarrahdale

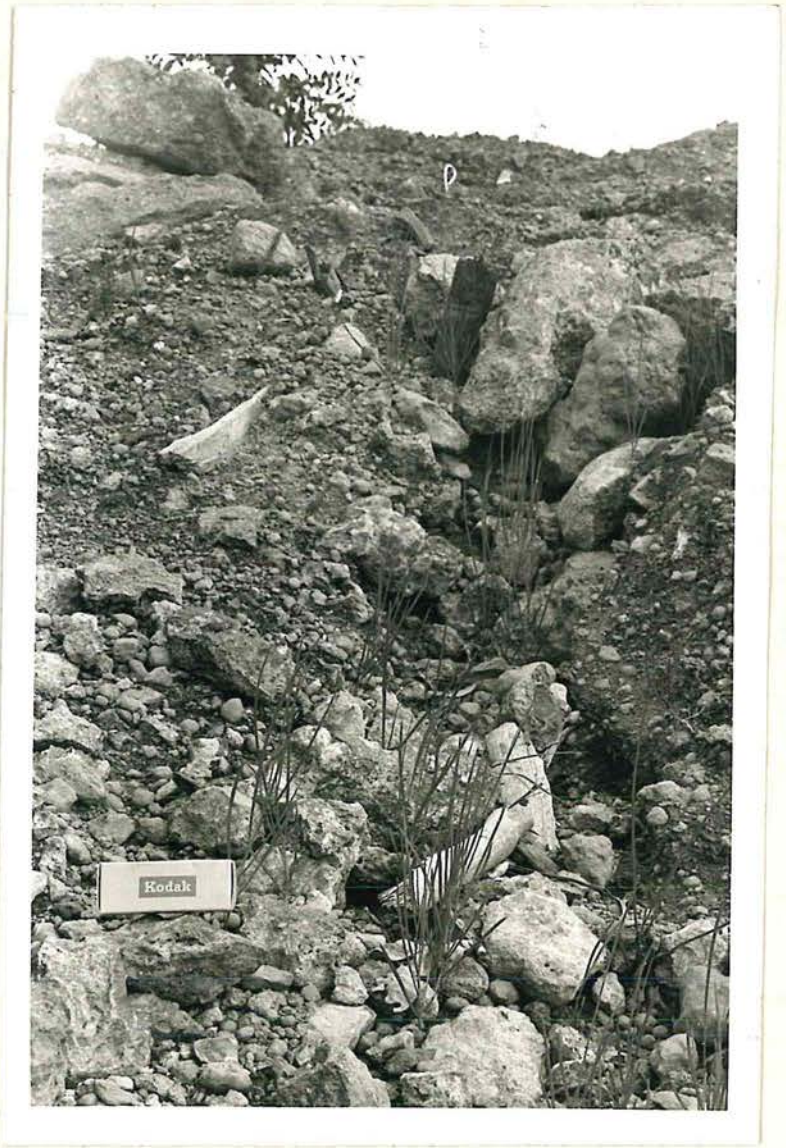

Fig. 2 A.extensa seedling sown late Spring 1973

(1). Impede the establishment of trees and native shrubs.

(2). They will eventually present a severe fire hazard.

(3). They will require frequent fertilization on a perpetual basis which in itself could contaminate water supplies and will result in a high recurring cost.

In the 1974 experiments a variety of native legumes are being tested to determine their capacity to survive and grow and stabilize soil movement. (Expt. 181). Native legumes have been selected primarily because the seed can be readily collected, they exhibit rapid growth rates and will act as soil improvers by adding nitrogen and organic matter to the soil.

The rate at which native species can establish and stabilize the soil is unknown but it is certain that grasses and clovers will provide a more rapid cover. Trials aimed at comparing the relative capacity of introduced grasses and clovers and native species are proposed. (Expt. 181). In addition, the effect of introduced species on native shrub and tree establishment will be examined. (Expt. 182). It is possible that a combination of introduced grasses and clovers and native species will provide the optimum soil stabilization treatment. The former species providing protection to the soil in the first autumn and early winter and the latter eventually dominating the introduced species and providing long-term protection.

If native shrub species are successful, mechanical methods of applying the seed will be required. Hydro-seeding techniques have been successfully used in highly erosion-prone sites in strip-mined areas in the S.E. U.S.A. and could have application on bauxite pits. (Expt. 189).

In other smaller trials it is proposed to test the effect of burning on seed germination in overburden soils (Expt. 184), the practicability of using soil collected from known wildflower and legume areas to "seed" bauxite pits (Expt. 185), and the ability of variety of jarrah forest shrub species to establish and survive on bauxite pits (Expt. 186).

(2). <u>Long-Term Survival and Salt Stabilization of Tree Species</u>

Fig. 3 E.microcorys root system Jarrahdale No. 1 site

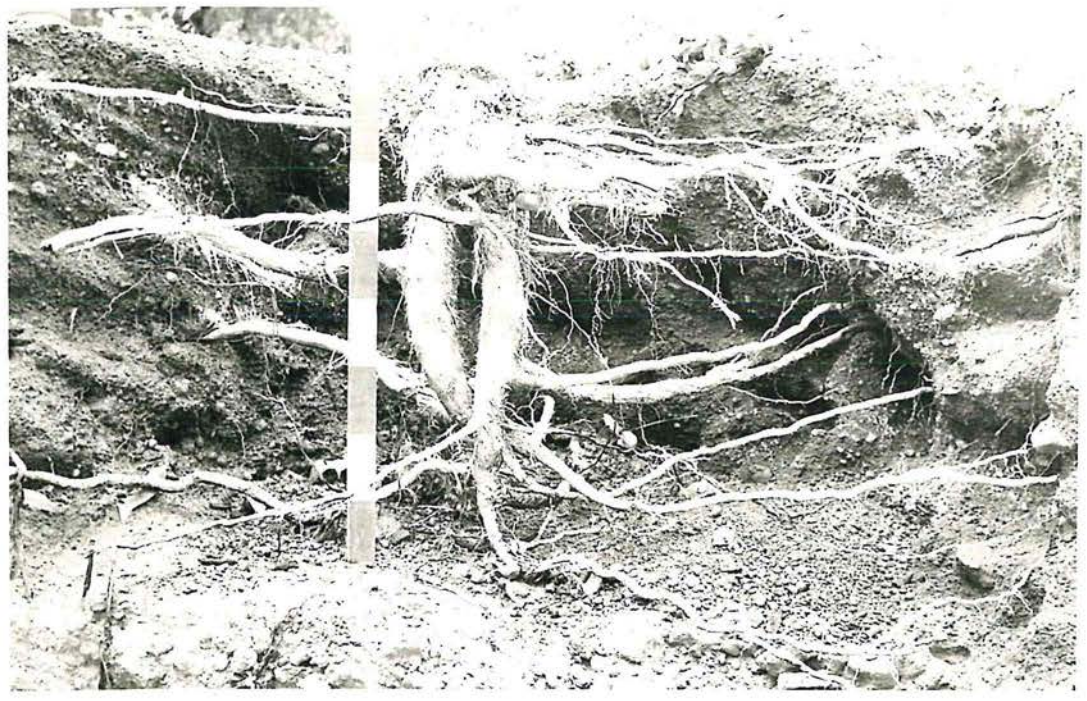

Fig. 4 E.resinifera root system Jarrahdale No. 1 site

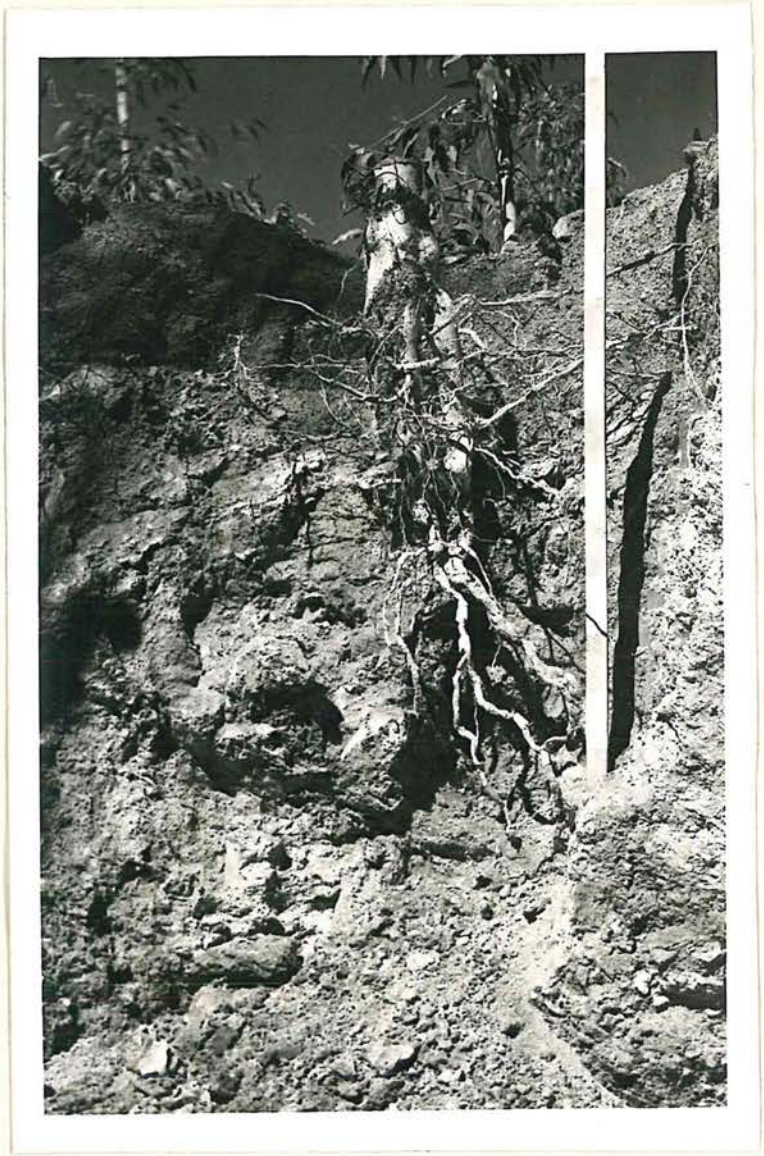

Fig. 5 E.maculata root system Jarrahdale No. 1 site

Species trials on bauxite pits have previously been biassed towards selection of species which are best suited to timber production. Consequently, the majority of the mined-over area has been planted to species which have exhibited rapid early growth such as E.microcorys, E.resinifera, E.globulus and E.saligna. This practice ignores the distinction between tree growth and tree development. Frequently trees which exhibit rapid early growth rates have their development abruptly fore-shortened. For example, in 1969 large numbers of previously vigorously growing E.microcorys trees planted on dieback sites died.

The environment which the Jarrah forest grows is peculiarly unsuited for forest growth and there is considerable evidence that Jarrah is only able to grow and survive because of unique adaptions. It follows that an alternative species which will successfully replace Jarrah will be difficult to obtain. In addition to being able to grow in a hostile environment the replacement species must be resistant to P.cinnamomi.

In areas where there is a salt store in the soil profile, a tree capable of reproducing the hydrological function of jarrah is required. Jarrah has the capacity to transpire under conditions of high evapotranspiration stress thus preventing the movement of salt through the profile into the river system.

Preliminary investigations (Expt. 155) of the root systems of species planted at the Jarrahdale No. 1 site suggest that the faster growing species, for example, E.microcorys, Fog. 3 and E.resinifera, Fig. 4, have failed to establish a vertical root system. E.maculata (Fig. 5) which is slower growing, has succeeded in producing vertical roots which penetrate the compact underlying bauxite/clay horizon. The area in which these excavations were carried out was ripped but the ripping was not as successful as that currently being carried out on the Jarrahdale No. 2 site. It is too early to evaluate the success of the more efficient ripping but preliminary studies indicate that it does permit more vigorous vertical root development. These preliminary trials, however, indicate that the vigorous above-ground growth of the major species now being planted on the bauxite pits is not balanced by an equivalent development of their root systems. It seems likely, therefore, that as the cambial area of those species increases in size and as the demand for water increases with increased crown development they will be prone to drought deaths or at least severe water stress. The current vertical root development of these species is very poor in comparison to jarrah and thus they are unlikely to be able to stabilize ground water flow and hence salt movement.

Expt. 186 represents the first of a series of species trials in which slower growing but more ecologically suitable tree species are tested. These plots will provide areas for future root excavation and hydrological studies.

(3). Aesthetic Values

There is an increasing use of the Darling Range area for recreation and bauxite-mined areas are being used for this purpose. Timber production is not necessarily incompatible with aesthetics and aesthetic values probably will only be important on a relatively small proportion of the bauxite-mined area. In those areas where aesthetics are important, however, the planting of single species in rigid lines may produce an unfavourable public reaction.

It is proposed to plant an area of 1 hectare in a manner which maximizes aesthetic values as a demonstration plot.

(4). P.cinnamomi Control

It is inevitable that P.cinnamomi will be introduced and spread throughout any area which is mined for bauxite. Thus, species which are selected for rehabilitation must be resistant to the fungus. This excludes the use of jarrah. Jarrah, however, may be the only species which will satisfactorily prevent salt movement in areas where there is a salt store in the profile.

Current research suggests that a combination of dense cover and phosphate and calcium fertilization may make jarrah resistant to P.cinnamomi. These treatments are being tested in undisturbed forest and it is proposed to repeat the treatments on the bauxite pits.

The research proposal described in detail in the following working plans, along with previously submitted plans, constitute the major bauxite rehabilitation research proposals for 1974.

Local Expt. 181 RWP /

Aim

(1). To determine if native shrub species can be used to stabilize overburden soils on bauxite-mined sites.

(2). To compare the stabilizing capacity of native shrub species and introduced grasses.

(3). To determine the effect of mixtures of native shrubs and grasses on stabilization.

Preamble

It is unlikely that tree planting at the spacing currently being used on the bauxite-mined sites will stabilize the overburden soils in erosion-prone sites until crown closure occurs. Preliminary trials have indicated that native shrub species will establish and survive on the mine sites.

Introduced grasses and clover have been used to successfully stabilize soils in agricultural situations. Their capacity to persist on these sites and their effect on the establishment of native species and trees is unknown.

This trial aims to test the soil stabilizing capacity of a variety of native shrubs sown singularly and in combination with introduced grasses and clovers relative to the stabilizing capacity of pure grass and clover.

C.I.C. D.F.C. SHEA

Associated Officers: T.O. McCormick and Dwellingup Research Staff.

Location: Del Park mine site (see attached map).

Date of Commencement: Autumn 1974

Method

(A). Design - Randomised Block - 2 blocks

(B). TREATMENT UNIT - 10 metre x 12 metre plot

(C). TREATMENTS

1. A.extensa
2. B.aquifolium
3. A.myrtifolia
4. M.dilitata
5. A.strigosa
6. Combination of Acacia species (1, 2, 3, 4, 5)
7. Combination of Acacia and other native shrub and creeper species
8. Wimmera rye grass + Woogenellup clover
9. Rye grass + clover + Acacia species (Treatments 6 and 9)
10. Rye grass + clover + Acacia + other native shrub and creeper species (Treatments 7 + 8)
11. Woogenellup clover
12. CONTROL

(D). Application - Native seed will be applied at the rate of 200 seed per square metre. Seed will be raked into the top 3 cm of the soil. Agricultural grasses will be applied at the rate of 5 lbs per acre - Wimmera rye grass; 20 lbs per acre - Woogenellup clover.

(E). Fertilization - All plots will be fertilized at the rate of 8 cwt superphosphate and 1 cwt of potassium sulphate per acre.

(F). Assessments - (1). 2 metres of the soil microprofile will be measured in 5 randomly located positions in each plot at monthly intervals. The axis of the microprofile gauge will be oriented obliquely across ripped lines. The centre of the gauge will be located on top of a ripped line.

(2). Photographic. Each plot will be photographed from a standard position at monthly intervals.

Local Expt. 182 RWP /

Aim To determine the relative persistance of native shrub species and introduced grasses and clover sown singularly and in combination on bauxite-mined sites.

Preamble Application of a combination of exotic grass, clover and native shrub seed could provide the most suitable vegetation cover for soil stabilization provided that the introduced species do not persist and spread or prevent the establishment of native shrubs.

O.I.C. D.F.O. SHEA

Associated Officers J. McCormick and Dwellingup Research Staff.

Date of Commencement Autumn 1974

Location Del Park mine site (see attached map).

Method

(A). Five 20 x 20 metre plots of the following species will be sown.

1. Wimmera rye grass + Woogenellup clover.
2. Combination of native shrub species.
3. Woogenellup clover.
4. Native shrub species + Wimmera rye grass + Woogenellup clover.
5. Native shrub species + Woogenellup clover.

(B). Application Rate -
Native shrub species - .25 seed of each species per square metre.
Wimmera rye grass - 5 lbs per acre.
Woogenellup clover - 20 lbs per acre.

(C). Fertilization - 8 cwt superphosphate per acre
1 cwt of potassium sulphate

(D). Assessments - % cover (and number of native shrub species) will be recorded in 10 randomly located permanent 1 square metre plots.

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S.R. SHEA
D.F.O.
22/4/1974

Local Expt. 183 RWP /

Aim To determine the ability of a variety of direct sown jarrah forest shrub species to establish and survive on bauxite sites.

Preamble Preliminary trials have established that native legume species can be established on bauxite sites. These trials led to the establishment of four trials being established this year. Limited quantities of seed from a variety of species are available to obtain preliminary information on their establishment and survival.

O.I.C. S.R. SHEA

Associated Officers J. McCormick and Dwellingup Research Staff.

Date of Commencement Autumn 1974

Location Del Park mine site (see attached map).

Method

(A). Design - RANDOMIZED BLOCK - 4 replications of each species.

(B). 3 x 3 metre plots will be sown to selected jarrah forest species.

(C). Assessment - (a). Percentage survival and cover will be recorded at yearly intervals.

(b). Photographic - each plot will be photographed from a standard position at monthly intervals.

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S.R. SHEA
D.F.O.
22/4/1974

Local Expt. 184 RWP /

Aim

To determine the effect of prescribed burning on germination of native shrub seed in overburden soils on bauxite-mined sites.

Preamble

The general failure of native seed to germinate following replacement of overburden soils is puzzling. It is possible that the seeds are destroyed during the overburden storage period. This may account for the disappearance of the more sensitive seeds, but it is difficult to explain the distribution of the more resistant seeds. Fire is a natural factor in the undisturbed forest and its absence from the bauxite pits may be a factor contributing to the failure of shrub species to re-establish.

O.I.C.

S.R. SHEA

Associated Officers

T.O. McCormick and Dwellingup Research Staff.

Location

Del Park mine site (see attached map).

Date of Commencement

Autumn 1974

Method

(A). Design - Randomized block with 4 replications.

(B). Treatments - 3 x 3 metre plots
- 1. Control
- 2. Burnt (approximately 3 tons per acre of jarrah litter).

(C). Assessments - Number and percentage cover of each species will be recorded at 12 months.

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S.R. SHEA
D.F.O.
23/4/1974

Local Expt. 185 RWP /

Aim To determine if soil collected from selected Jarrah Forest areas can be used to "seed" bauxite-mined sites.

Preamble The practical difficulties of collecting native species seed may prevent their use on bauxite-mined sites. This problem may be overcome if soil can be used to seed mine sites.

O.I.C. D.F.O. S.R. SHEA

Associated Officers J. McCormick and Dwellingup Research Staff.

Date Autumn 1974

Location Del Park mine site (see attached map).

Method

(A). Design - Randomized block.

(B). Treatment unit - 3 metre x 3 metre plots.

(C). Treatments - Soils

(1). Krasnozem from bauxite A.extensa stand.
(2). Gravel from bauxite M.dilitata stand.
(3). Gravel from bauxite A.strigosa stand.
(4). Sieved soil from A.myrtifolia stand.
(5). Gravel soil from wild-flower area.
(6). CONTROL

Replications - 4

(D). Soil Pretreatment - Soil will be boiled in drums.

(E). Assessment - Number and species will be recorded on each plot.

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S.R. SHEA
D.F.O.
22/4/1974

Local Expt. 186 RWP /

Aim To establish a range of tree species on bauxite-mined sites for future hydrological studies.

Preamble In areas where salt has accumulated in the soil profile the establishment of trees with maximum timber production capacity may not be compatible with the stabilization of salt flows. It seems likely that trees with rooting characteristics similar to Jarrah will be most suitable in salt-prone areas. The absence of these species in the initial trial plantings at Jarrahdale has handicapped research into the hydrological effects of bauxite mining.

O.I.C. D.F.O. S.R. SHEA

Location Del Park mine site (see attached map).

Date of Commencement Autumn 1974

Method 50 x 75 metre plots of the following species will be established at 2 metre x 2 metre spacing -

(1). E.marginata
(2). E.laelii
(3). E.calophylla
(4). E.wandoo
(5). E.accedens

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S.R. SHEA
D.F.O.
22/4/1974

Local Expt. 155 RWP /

Above and Below Ground Growth and Development of E.microcorys on Bauxite-Mined Sites

Aim

(1). To determine the form and distribution of E.microcorys root systems in relation to soil profile characteristics on

(a). Unmined sites

(b). Mined unripped sites

(c). Mined ripped sites

(2). To determine the above-ground growth characteristics of E.microcorys on the above sites using detailed stem analysis techniques.

Preamble

Predictions of future growth of trees based on gross growth characteristics during the establishment phase of tree development are not reliable particularly when the volume of exploitable soil is restricted: A more reliable assessment of future growth may be obtained by determining root and soil properties and thus the characteristics of the tree's raw material supply system. Detailed measurements of "specific" growth characteristics also provide some measure of the tree-site relationship even during the establishment phase.

In addition to assisting the prediction of tree growth data on the root form and distribution of E.microcorys on bauxite sites will assist the assessment of the effect of rehabilitation techniques on hydrology of mined over areas.

O.I.C. D.F.O. Shea

Consultants D.F.O. Bradshaw, Mr. G. White (ALCOA)

Associated Officers Dwellingup Research Staff

Date July 1973

Location — Jarrahdale Bauxite Pit

Method

(A). Unmined areas

(a). Detailed stem analysis techniques will be used to determine the above-ground growth and development characteristics of 2 dead and 2 "healthy" E.microcorys on the unmined area within the Jarrahdale mine site.

(b). An attempt will be made to excavate the root systems of one of the trees in each category.

(B). Mined - Unripped sites

(a). Detailed stem analysis techniques will be used to determine the above-ground growth characteristics of 4 of the oldest E.microcorys growing in the mined-over area - 4 adjacent trees will be analysed.

(b). Root measurements.

(i). Surface Root (30 cm.) quantity and distribution will be determined on a grid using a modified King Tube.

Root quantities at depth in the profile will be determined by sampling horizontally from a trench.

(ii). Gross root form will be determined by hydraulic excavation.

(c). Soil samples will be taken at 10 cm. depths for determination of standard soil physical and chemical properties.

(C). Mined - Ripped sites

4 trees in the oldest ripped area will be analysed and excavated as for (A).

Equipment Required

(i). 1 Fire Tanker - To be provided by F.D. Kelmscott.

(ii). 1 Back hoe - To be provided by ALCOA.

Note: The excavated sites will be returned as far as possible to their original condition.

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S.R. SHEA
D.F.O.

Local Expt. 187 RWP /

Aim	To establish a range of ornamental shrubs and grasses on a mined-over bauxite site to maximize aesthetic values.
Preamble	Previous and current bauxite mine rehabilitations have been aimed at maximizing timber values. Hence, trees have been planted in rigid lines and in single species blocks. Timber production is not necessarily incompatible with aesthetics but in some areas it may be desirable to maximize aesthetic values.
O.I.C.	S.R. SHEA
Associated Officers	J. McCormick and Dwellingup Research Staff.
Location	Del Park mine site (see attached map).
Date of Commencement	Autumn 1974
Method	An area of approximately 1 hectare will be landscape planted with a variety of trees and shrubs.

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S.R. SHEA
D.F.O.
22/4/1974

Local Expt. 188 RWP /

Aim To determine the effect of a leguminous understorey and soil amendment by fertilization on survival of B.grandis and E.marginata seedlings in the presence of P.cinnamomi on bauxite-mined sites.

Preamble Currently, it is assumed that P.cinnamomi resistant species should be used to rehabilitate bauxite-mined sites since the mining process ensures that the fungus will be present on the mine site. In areas where there is a significant salt store in the soil, E.marginata may be the only species which will retain a favourable hydrological balance. There is some evidence that the techniques used in this trial will ameriolate the disease in unmined forest. It is therefore essential to test the same techniques on mined-over sites.

O.I.C. D.F.O. SHEA

Associated Officers J. McCormick and Dwellingup Research Staff.

Location Del Park mine site (see attached map).

Date of Commencement Autumn 1974

Method

(A). Experimental Design - Factorial
(B). Factors - Understorey

1. A.strigosa, A.myrtifolia, B.aquifolium, M.dilitata.
2. CONTROL

Inoculation

1. Inoculated - vermiculite inoculum
2. CONTROL

Fertilization

1. CONTROL
2. Superphosphate + Calcium carbonate + Potassium sulphate (levels to be determined)

Replication - 3

(C). Treatment Unit - 10 x 10 metre plot

10 B.grandis and 10 E.marginata seedlings will be planted in a systematic grid within each plot.

(D). Assessments - survival will be assessed at 3 monthly intervals.

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S.R. SHEA
D.F.O.
23/4/1974

Local Expt. 189 RWP /

Aim To determine if "hydroseeding" can be used to establish native vegetation on erosion-prone sites.

Preamble "Hydroseeding" could provide a method of sowing native seeds on the steep mine banks which cannot be treated with mechanical equipment.

The technique could also be used on erosion-prone sites on the mine floor if it allows the retention of the seeds on the top of the furrows prior to germination.

OIC D.F.O. SHEA

Associated Officers T.O. McCormick and Dwellingup Research Staff.

Date Autumn 1974

Location Del Park mine site (see attached map).

Method

(A). DESIGN - Factorial.

(B). FACTORS - Mix - (1). Mulch + seed + fertilizer + water.

(2). Seed + fertilizer + water.

Location

(1). Mine floor.

(2). Mine bank.

Replications - 2

(C). TREATMENT UNIT

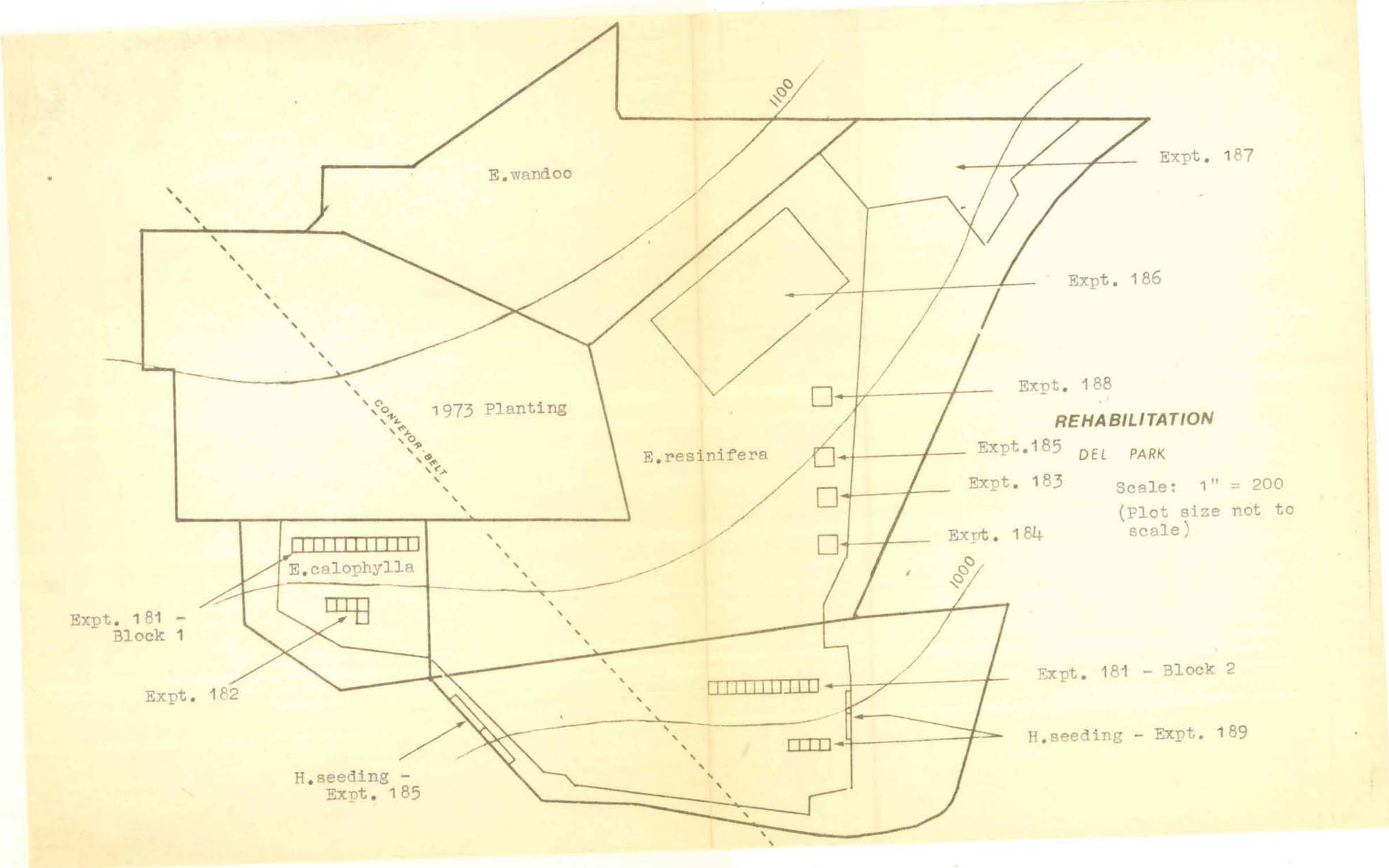
(1). Bank - 50 x 20 metre plot.

(2). Mine floor - 45 x 45 metre plot.

(D). ASSESSMENT - (1). % cover and number of each native species will be recorded in 10 randomly located 1 metre square sub plots in each plot.

(2). The number and percent cover of species established on the furrow top and bottom will be recorded in the mine floor plots.

SRS


1100
E.wandoo
Expt. 187
Expt. 186
1973 Planting
CONVEYOR BELT
E.resinifera
Expt. 188
REHABILITATION
Expt.185
DEL PARK
Expt. 183
Scale: 1" = 200
(Plot size not to scale)
Expt. 184
E.calophylla
1000
Expt. 181 - Block 1
Expt. 182
Expt. 181 - Block 2
H.seeding - Expt. 189
H.seeding - Expt. 185