ALCOA OF AUSTRALIA LIMITED

ENVIRONMENTAL RESEARCH BULLETIN

NUMBER 3

STUDIES ON INVERTEBRATES IN RELATION TO BAUXITE MINING ACTIVITIES IN THE DARLING RANGE - A REVIEW OF THE FIRST EIGHTEEN MONTHS RESEARCH

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September, 1978

SUMMARY

This report is a review of the initial work performed by the author on minesite invertebrates. It is divided into the investigation of seed theft in rehabilitated areas and the invertebrate succession in unplanted, planted and seeded areas.

Seed theft by ants and birds is considered not to be signficant in seeded mine pits although two ant species and one bird may have an extremely limited effect on seed survival along forest edges.

The succession of invertebrates, particularly of ants, is followed in an area planted with marri (Eucalyptus calophylla), an area seeded with mixed forest species and one where no revegetation attempts have been made. Lack of primary production in the latter plot resulted in the inability of new ant colonies to be sustained while a few species established small colonies in the planted area. The seeded area was colonized by considerably more ant species which reached moderately high numbers. The results suggest that seeding leads to the formation of an ecologically more satisfactory ant community. The implications of this for soil vitality and ecosystem stability are discussed.

A one-year replanted mine pit is compared with other land use types at Dwellingup for similarity of its ant fauna. The minesite fauna was found to be more closely allied with that of other artificial ecosystems, such as pine plantations, farmland and townsite vegetation than with that of the jarrah forest. It was characterised by a low species richness and equitability. The possibility of using ant faunas as indicators of the invertebrate communities present is discussed.

INTRODUCTION

Bauxite mining by Alcoa of Australia Limited is carried out in the Jarrah forest region of Western Australia. This involves the clearing of native forest, removal of topsoil and excavation of the underlying bauxite ore. Following extraction of ore the pit walls are battered down, topsoil is returned and the pit floor is deep ripped to loosen the compacted clay. At present various revegetation treatments are being carried out by the Forests Department and Alcoa. One aim of this work is to establish forest or woodland vegetation formations in the mined areas.

The invertebrate fauna is undoubtedly of crucial importance in the ecology of the pre- and post-mining ecosystems. Though Springett's (1976a, b) work has provided a considerable amount of information on forest invertebrates, similar information in the bauxite mined areas has been restricted to the Honours project of Scott (1974).

An understanding of the ecology of invertebrates in relation to bauxite mining is of importance in relation to the following points:

1. The possibility of seed theft by ants and other animals in seeded bauxite pits;

2. The role of invertebrates in nutrient recycling and pedogenesis in rehabilitated bauxite pits;

3. The ecological desirability of different approaches to rehabilitation from such points of view as stability and the likelihood of pest outbreaks; and

4. The possibility of using invertebrate community parameters as an index of the 'success' of different rehabilitation attempts.

The following account is a review of the principal findings obtained from work by the author in the mining areas over an eighteen month period. The initial aim of the work was to investigate the possibility of seed theft by ants in reseeded pits. This has been found not to be a problem, and the project has been extended to investigate the succession of invertebrates in areas subjected to different rehabilitation approaches and the influence of forest edges on minesite invertebrates.

RESULTS AND DISCUSSION

SEED THEFT STUDIES

a) Ants

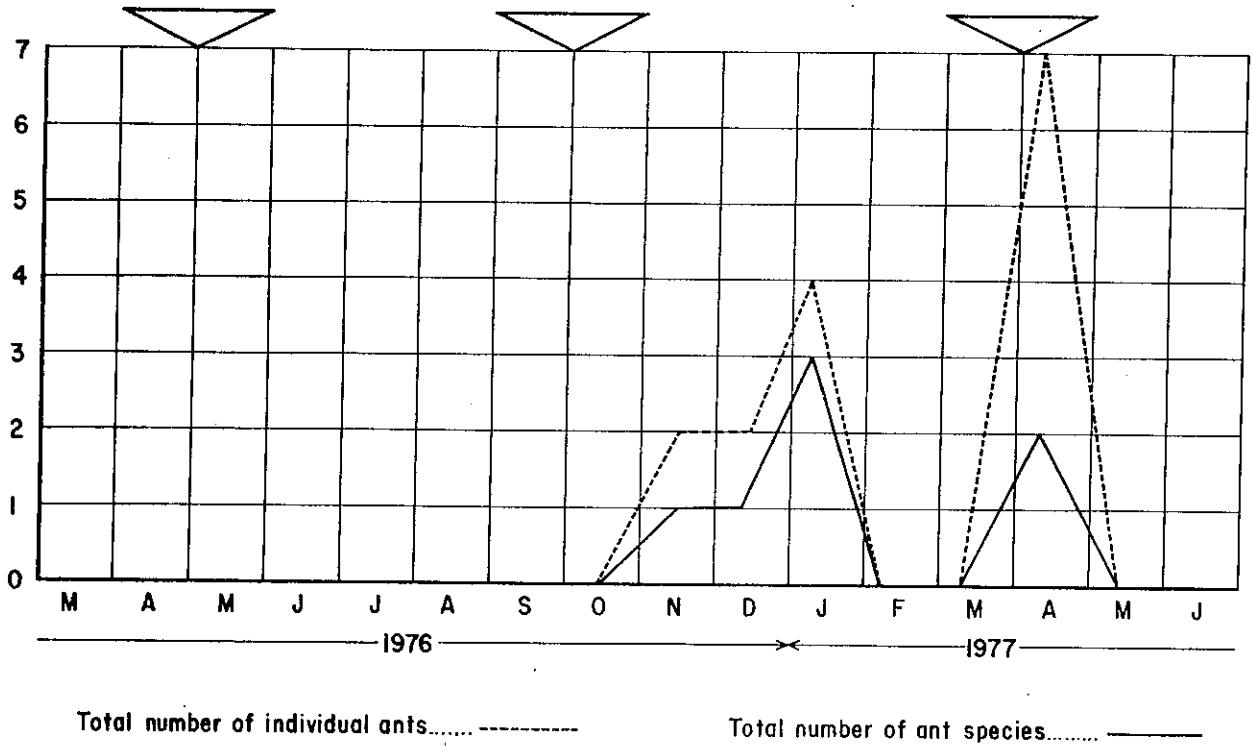
One revegetation approach which is being undertaken is to broadcast mixed seed of West Australian trees, shrubs and herbs on to prepared ground. Fertilizer is then applied and in some situations a straw/bitumen mulch may be added. It was thought that seed germination could be enhanced by reducing seed theft by animals which was thought to occur. Ants were the obvious suspect group since Scott (1974) found they were the most abundant epigaeic group occurring in the early stages of reforestation. They have also been recorded as seed gatherers or predators elsewhere in Australia (Campbell, 1966; Briese, 1974; Berg, 1975; Johns & Greenup, 1976).

To investigate this, ant nests of the common species in the Dwellingup region were excavated and inspected for presence of seeds. The species associated with seed gathering are listed in Table 1. A 100 x 100 metre plot was set aside at the Del Park minesite in February 1976 to see whether these species of ants were present in the unplanted area. The area had been cleared in 1972 and topsoil replacement and ripping were performed in October 1975. The ant fauna was monitored at monthly intervals since March 1976 using a grid of 36 pitfall traps in order to assess the initial situation and the likelihood of seed gatherers colonizing the area if seeding were delayed for some reason. The total numbers of ant species and individuals collected per month are shown in Figure 1. Only five species of ants have been found in the unplanted area compared with up to 50 species in an adjacent undisturbed forest. Furthermore the small populations which built up were evidently unable to survive in the area as numbers of most species had diminished by the autumn of 1977. I. purpureus, the only species present which gathers seeds, occurred in small numbers and was hence unlikely to have any impact as a seed gatherer. These data, and observations made on other unplanted areas, suggest that ants do not colonize the pits before seeding and hence would be unlikely to be involved in seed gathering following seeding of pits.

TABLE I

List of species of ants which have been found to gather seeds in the Dwellingup region. Species are listed in decreasing order of importance as seed gatherers.

Species	Comments
Melophorus sp. 1 (ANIC)	Stores large numbers of legume seeds in nest. Chews off elaiosome.
Pheidole latigena	Large quantities of grass and other plant seeds found within and around nests.
Rhytidoponera inornata	Variety of seeds found within nest and 'dumps' near opening. Seed often partly eaten.
Rhytidoponera violacea	Moderate numbers of Acacia and Pinus seeds found within and around nest.
Iridomyrmex purpureus	Two large unidentified seeds found 5 cm deep in one nest of this species.



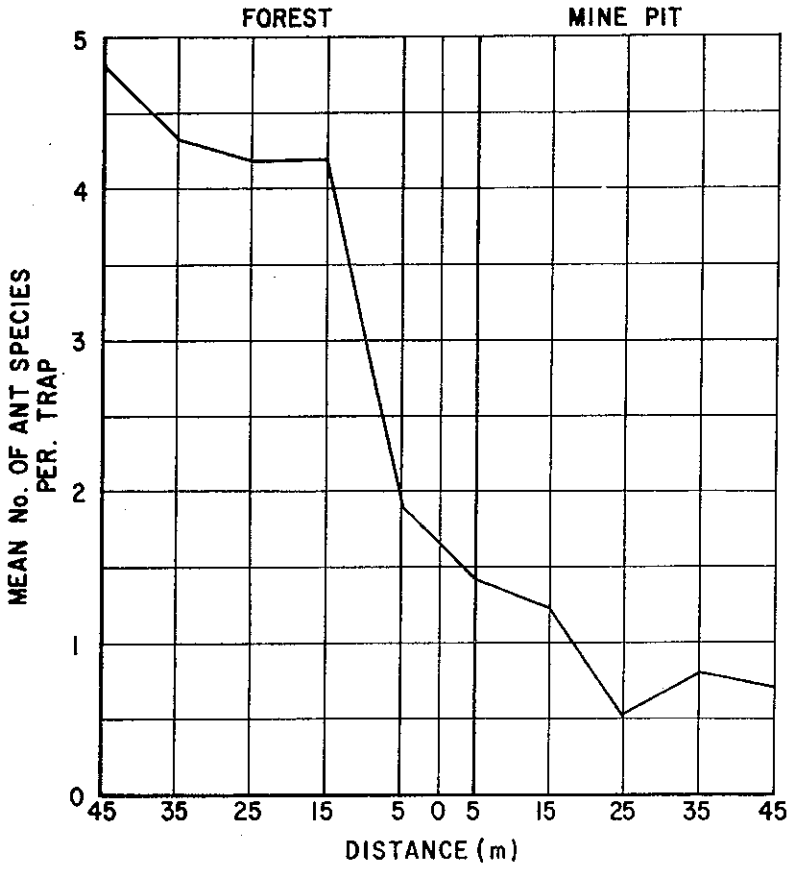
Colonization of ants in unplanted pit since February 1976. The triangles represent main periods of winged ant dispersal. The species present are – Iridomyrmex sp.21 (ANIC), Iridomyrmex sp.18 (ANIC), Iridomyrmex purpureus, Monomorium sp.1 (ANIC) and Camponotus sp.14 (ANIC).

Figure 1.

An additional possibility is that seed-gathering ant species occurring in the adjacent forest may forage in the adjoining bauxite pits. In order to investigate this, ten transects, each of ten pitfall traps, were set up at right angles to the forest edge. The traps were placed at 10 metre intervals so that half of the traps were in the forest and half in the minesite. It was not possible to select pits where revegetation had not commenced although, in all sites chosen, the regeneration was at an extremely early stage. The mean numbers of species per pitfall trap, run between 30 November - 7 December 1976, are shown in Figure 2.

A total of 38 species of ants was collected in the traps. The graph shows that ant species diversity is considerably less in the pit than in the forest. Sphinctomyrmex imbecilis was only found in the minesite suggesting that it is a pioneer species. This may also be the case for Iridomyrmex sp. 18 (ANIC) although it was also found in the forest. Rhytidoponera violacea and Iridomyrmex sp. 21 (ANIC) were forest species which were also found in lower numbers up to 45 metres into the mined area. A further five species including Rhytidoponera inornata spread 20 metres into the pit. With the exception of the two Rhytidoponera species, none of the ants present in the pit edges were seed gatherers. Of these two species, R. violacea spread furthest into the minesite although its foraging density, as measured by numbers sampled in the traps, was one seventh as great as in the forest. R. inornata occurred in very low numbers along the edge of the mine pit.

The data obtained to date suggest that the unexpectedly low germination of seeds observed after seeding was not due to seed theft by ants.



Mean number of ant species collected in ten transects of pitfall traps traversing the forest-mine pit boundary.

Figure 2

b) Birds

A seeding exercise in plot JW 411 was followed over a one week period in March, 1977. This area was on a hillside which was capped with about 2 hectares of remnant forest. Seeds of mixed trees and shrubs were broadcast at a rate of 5 kilograms per hectare during the week beginning 21 March 1977. Superphosphate was also applied with the seeds and a straw/bitumen mulch was spread later. The area was patrolled on 22-23 March and no birds were seen in the pit.

On 22 March 1977 the broadcast seed density was estimated by placing a transect of 50 20 x 20 centimetre quadrats spaced 1 metre apart across the seeded areas. The results indicated a seed density of 29.5 per square metre. The survey was repeated one week later in the same place and seed density was found to be 29.0 per square metre. These densities are not significantly different. The straw/bitumen mulch was added shortly after this. Later seed theft by birds is considered to be unlikely in view of the mulch thickness and presence of bitumen.

In order to assess the potential for seed theft by birds, species present in the adjacent forest were recorded over a three day period in March 1977. A total of twenty-one species was observed although of these only the Western Rosella, Twenty-eight Parrot and Bronzewing Pigeon are likely to feed on small seeds. These species were not observed in the seeded pits during the week of observations although workmen report occasional Bronzewing pigeons in the pits close to forest edges.

The results of this series of observations suggest that seed theft by ants or birds is not a significant limiting factor in mine-pit rehabilitation although a small amount of seed theft could occur along forest margins. These results are shortly to be reported on in greater detail (Majer, 1978).

INVERTEBRATE SUCCESSION

A number of other mine rehabilitation approaches are currently being investigated. These may be broadly grouped into plantation type tree plantings, direct seeding with tree and shrub species, or a combination of the two approaches. The latter two methods potentially have aesthetic, hydrological or economic advantages over the conventional planting method (J. Bartle, personal communication).

The following observations are designed to investigate the succession of ants and other pit trappable invertebrates in three former minesite plots: a minesite planted with marri (Eucalyptus calophylla); another seeded with species which is planned to produce a forest formation; and a third unplanted. The study aims to assess:

1) which rehabilitation technique results in an invertebrate fauna most similar to that of the adjacent forest and,

2) which approach encourages invertebrate species which have the most beneficial effect on soil structure and composition.

The three plots are described in Table II. The 'unplanted' plot is the same one as has been described under the seed theft section of this report. A forest control plot is also being studied at Del Park.

In a representative area of each plot, one grid of 36 pitfall traps was established (in March 1976 in the unplanted plot, June 1976 in the remaining plots). Sampling was performed by running the pitfall traps for seven days each month until July 1977 and bimonthly thereafter. To date only the ants have been sorted although the remaining invertebrates will eventually also be scored.

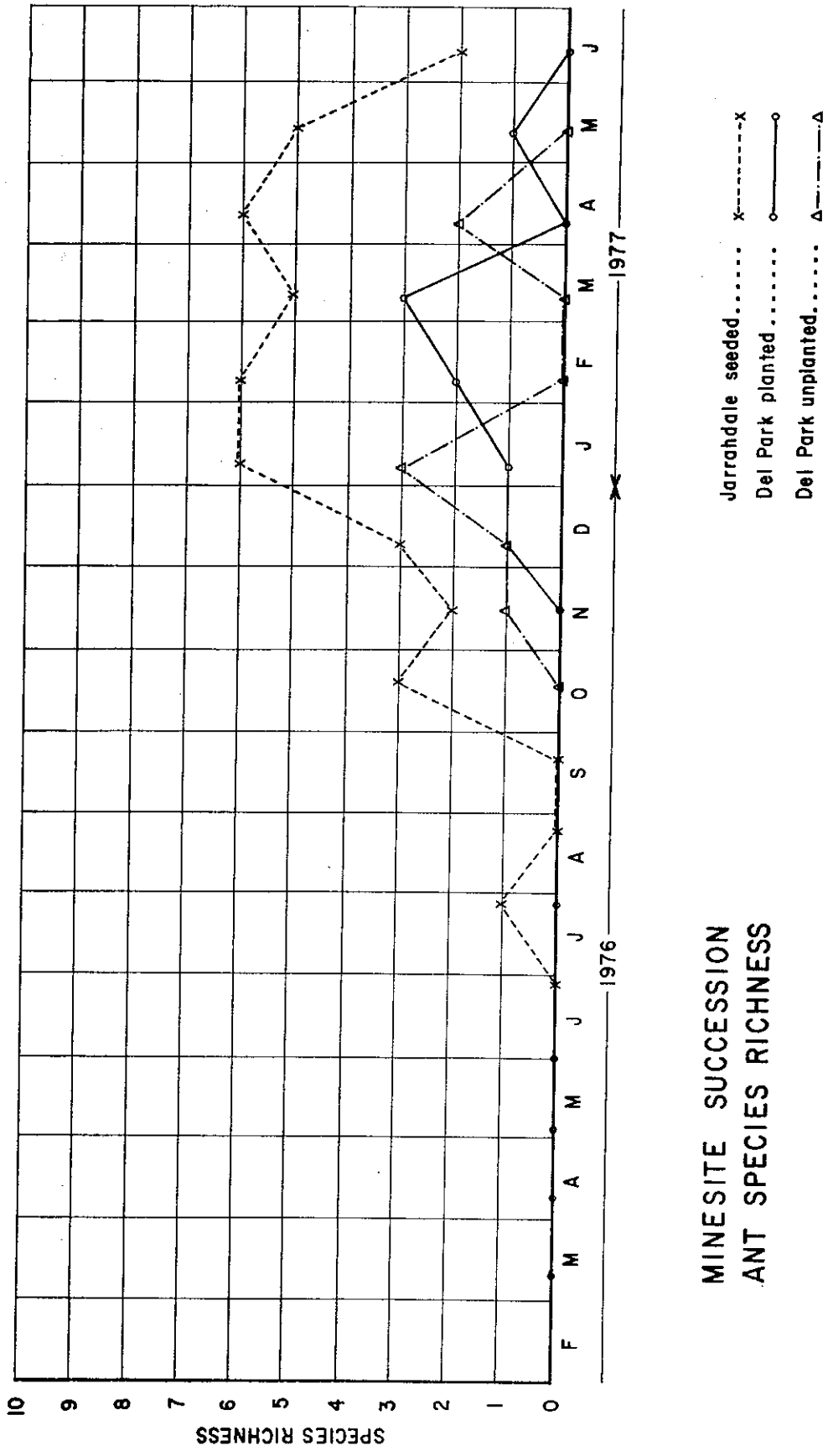
The monthly totals for ant species (species richness or diversity) and ant numbers (≡ biomass) in the three plots are shown in Figures 3 and 4. The reduction in ant diversity and abundance in the autumn of 1977 is a seasonal effect.

There was an establishment of colonies of ants from September 1976 onwards in all three plots. However, colonies only reached large sizes in the seeded plot. A total of fourteen species has been trapped in this plot compared with four in the planted plot and five in the unplanted area. As mentioned earlier, the colonies in the latter plot had mostly died out by the early autumn. The numbers of ants in the planted plot were not appreciably higher than in the unplanted area although they were sustained until the end of autumn when foraging by most species was reduced for the winter period.

TABLE II

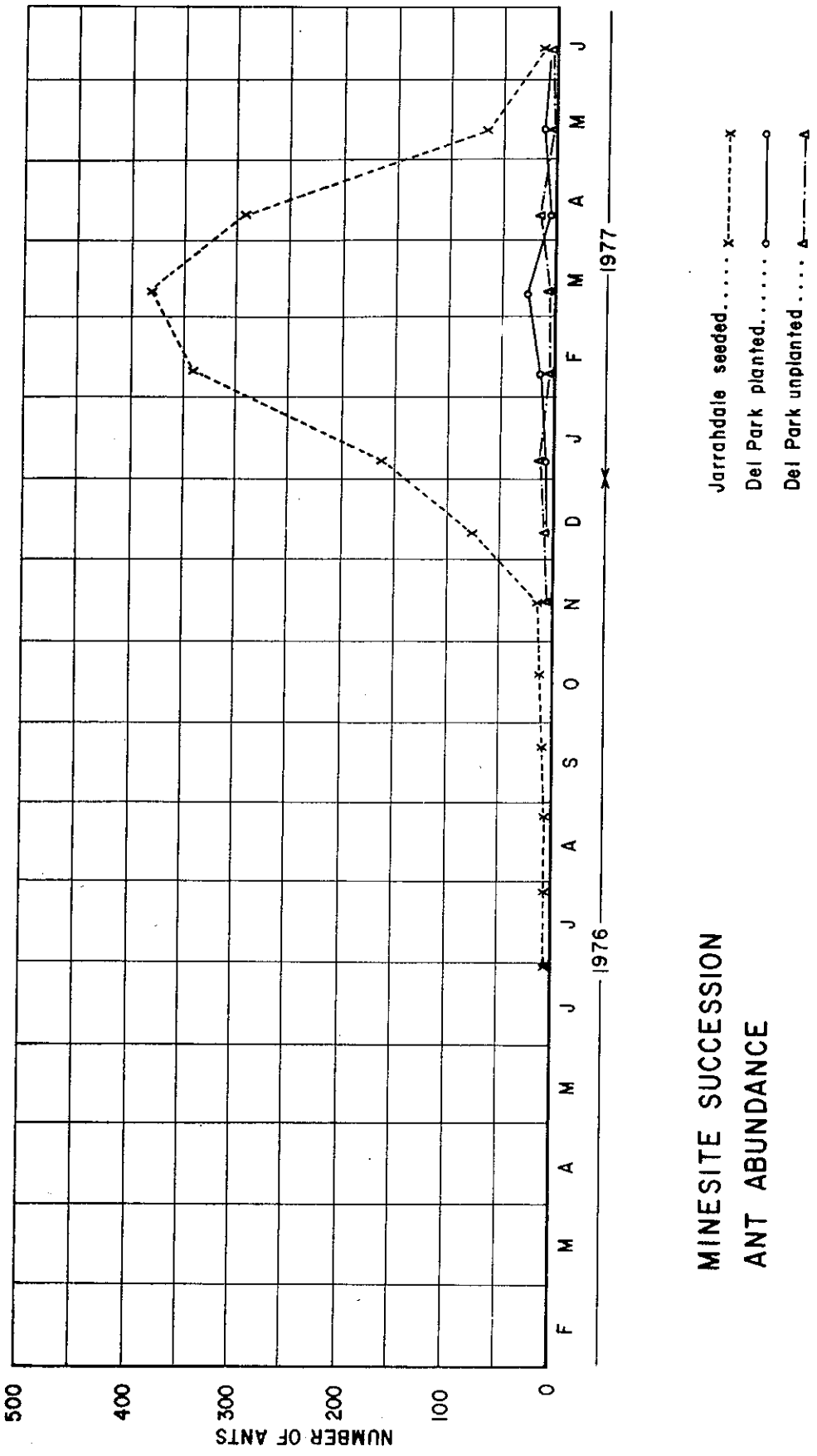
Description of three plots selected for invertebrate succession study.

PLOT DESCRIPTION	LOCATION	DATE AREA CLEARED	DATE TOPSOIL REPLACED	TOPSOIL STOCKPILED	DATE PLANTED OR SEEDED
UNPLANTED	DEL PARK DP 9	early 1972	October, 1975	YES	-
PLANTED WITH MARRI ONLY	DEL PARK DP 9	early 1972	October, 1975	YES	JUNE 1976
SEEDED WITH MIXED FOREST SPECIES	JARRAHDALE JW 402/406	early 1974	April, 1978	NO	JULY 1976



Total ant species (species richness) trapped over seven day periods in seeded, planted and unplanted mine pits.

Figure 3



Total number of ants (≡ biomass) trapped over seven day periods in seeded, planted and unplanted mine pits.

Figure 4

The observations will be continued for several years in order to obtain data on later stages in the succession. It is too early to assess with certainty the implications of the data, although it appears that the seeding approach has so far resulted in a more diverse ant fauna, which is more similar to that of the jarrah forest than is that associated with the other two plots. The advantage of seed gathering ants in the fauna is that these species will store seed in the soil at a suitable depth for germination when the area is eventually subjected to a prescribed burn.

The low diversity and simple structure of vegetation in the planted plot has provided little opportunity for colony establishment by most ant species. In the unplanted plot there is evidently insufficient primary production after seventeen months to permanently sustain any ant species. As a point of interest it should be noted that the species of ant most consistently associated with the revegetated areas is Cardiocondyla nuda. This is a tramp species, probably of African origin, and has been spread throughout the warmer parts of the world.

Data on the other invertebrates and soil nutrient composition will shortly be obtained for the three plots.

RELATIONSHIP BETWEEN MINESITE AND FOREST ANT FAUNAS

The ant fauna may probably be used as an indicator of the invertebrate fauna in general since ants are one of the most important invertebrate groups in the Australian environment (Brown and Taylor 1970). Also, many have specialized feeding habits and, at least elsewhere in the world, they have a major influence on the other invertebrates present (Leston, 1973). One possible factor which may confuse the relative abundance of ants is that, unlike many invertebrates, ants may be fire tolerant.

In November 1975, a sampling programme was performed in order to compare the ant faunas in seven areas subjected to different land use at Dwellingup. The results of this survey have been reported on in greater detail by Majer (1977). The minesite area was planted with Eucalyptus saligna which, at the time of sampling, was about 1 metre high. A brief summary of the ant fauna parameters is given in Table III. As can be seen, ant abundance in the mined area was about two thirds that in the unburnt jarrah while species richness was less than one third of the unburnt forest value. The low equitability index in the mined areas compared with the forest values, resulted from the dominance of Iridomyrmex sp. 21 (ANIC). This observation, when compared with the ant parameter values in the other land use types, suggests that the diversity and equitability of the ant communities reflects that of the vegetation present.

TABLE III

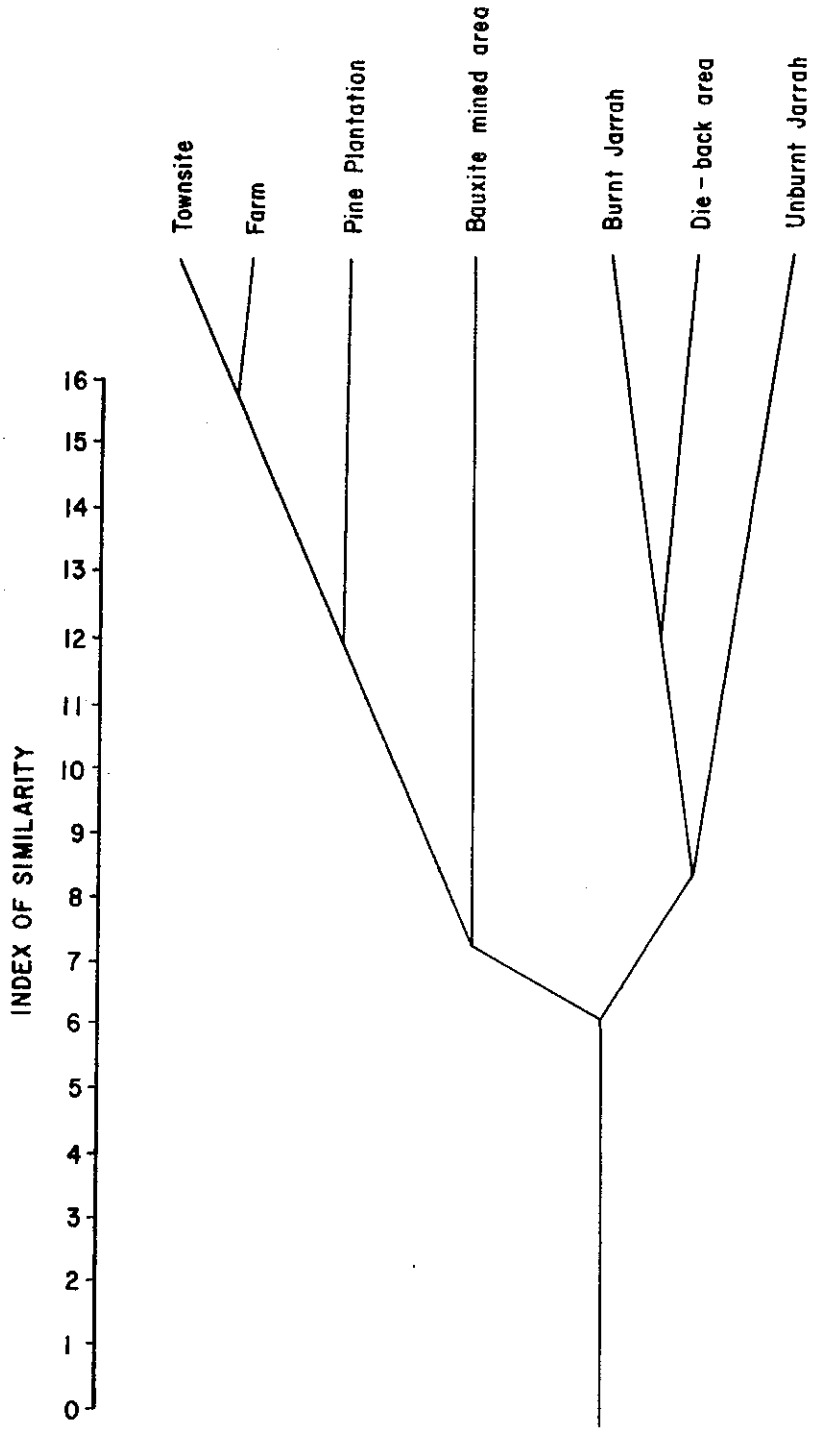
Comparison of ant parameters taken in 40 pitfall traps per site situated in different land use types at Dwellingup between 24 - 25 November, 1975.

	Total abundance	Biomass estimates	Species richness	Mean No. of species per pitfall trap set	Shannon index of diversity (decits)	Equitability index	Percentage foraging area
Bauxite mined area	141	283	6	1.7	0.23	0.31	93
Amphion unburnt jarrah	215	390	19	3.9	0.83	0.65	83
Plavins burnt jarrah	162	296	20	3.8	0.94	0.72	85
Jarrah die back area	230	424	22	5.2	1.12	0.83	90
Hollyoake Townsite	108	234	15	3.1	0.80	0.68	73
Pine Plantation	1111	2185	10	2.8	0.11	0.12	98
Farm land	30	53	4	1.1	0.48	0.80	38

Mountford's (1962) index of similarity was used to investigate the relationship between ant faunas at each site. A dendrogram is shown in Figure 5 which classifies the areas in terms of their species similarity. Two broad groupings are apparent: areas planted with exotic species and areas where the native forest remains. The fauna of the bauxite mined area is classified in the former group.

Since Scott (1974) found between 11 and 19 species of ants in mine-sites planted eight years previously it would be interesting to repeat this survey using more mature bauxite pit plantings.

The succession studies suggest that a more ecologically satisfactory ant fauna is developing in the seeded plot than in the planted and unplanted areas. It will be interesting to see in the long term what effect this has on pedogenesis and on the likelihood of invertebrate herbivore outbreaks. It should be emphasised that this survey has only concentrated on the invertebrate fauna which is active on the soil surface. Further parallel studies are required which investigate the effect of rehabilitation treatments on all soil fauna and on species occurring on the resulting regrowth.



Classification of the seven land use types at Dwellingup in terms of the species of ants present using Mountford's index of similarity x 100.

Figure 5

ACKNOWLEDGEMENTS

The author would like to thank Dr. S. Shea, Mr. J. Bartle, of the Forests Department and Alcoa of Australia Limited for assistance in performing these observations. Mr. D. Ward of the Forests Department assisted with data analysis and Messrs. J. Wallace and J. Penniket helped collect field data. Ants named to species level or with Australian National Insect Collection (ANIC) codes have been identified by Dr. R.W. Taylor, the remainder have JDM codes corresponding to the author's collection. This study was performed with financial assistance from the Reserve Bank Rural Credits Development Fund.

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