SITE ASSESSMENT

for

PINUS PINASTER (AIT.) PLANTATIONS

in

WESTERN AUSTRALIA

by

J. J. HAVEL

A paper prepared for the
Ninth Commonwealth Forestry Conference, 1968

A. C. HARRIS
Conservator of Forests

PERTH
1967

ABSTRACT:

Recent developments in quantitative ecology were employed in investigating the potential of part of the Swan Coastal Plain in Western Australia for plantation establishment of *Pinus pinaster*. The potential for pine growth was assessed by a five-year height intercept, corresponding to the maximum rate of height growth, from usually 3 to 8 years of age. This was related to the vegetation surrounding pilot plots by factor analysis. The analysis indicated that the degree of leaching undergone by the soil and the moistness of the site were the main determinants of vegetative patterns and pine planting potential within the region. Sets of indicator species were determined for each combination of factors.

Three types of limitations to plantation establishment were found:

(a) dry, strongly leached sites providing poor growth rates.

(b) dry, weakly leached sites on which pines grow satisfactorily but are subject to summer drought deaths.

(c) sites with excessively high ground water level, on which pines grow satisfactorily but are subject to malformation and death due to winter flooding.

The practicability of the assessment method was demonstrated by mapping 8,100 acres at the rate of 300 acres per day for a two-man team.

INTRODUCTION.

The Forests Department of Western Australia has an active programme of conifer establishment aimed at correcting the present unbalance between hardwood and softwood timber production. Two species of proven suitability are used. On the heavier soils, in higher rainfall areas, *Pinus radiata* is planted. On the drier and sandier soils *Pinus pinaster* is used exclusively. Areas suitable for planting *Pinus radiata* are limited, the bulk of this planting type being held in private ownership and used by agriculture. The largest area readily available for planting *Pinus pinaster* is the State Forest No. 65 of some 150,000 acres.

State Forest No. 65 is in the Wanneroo Division immediately north of the capital city Perth. It extends northwards in a discontinuous narrow belt roughly parallel to the coast. The southern boundary is only 12 miles north of Perth and its northern boundary is approximately 72 miles northwest. However, three quarters of this forest area are less than 50 miles from the key market. Apart from vegetable farms and vineyards in the south, the surrounding private land has been utilized only for extensive grazing due to infertility of the soils.

Departmental planting was initially concentrated in the south of the forest area where establishment was made possible by fertilization with phosphate and zinc. The northward expansion of pine planting involves an advance into an area of unproven plantation potential. The older plantings in the south-eastern portion were established chiefly on highly leached grey sands of the Bassendean Dune System. Success was variable. Optimum results were obtained on moist flats underlain by an organic deposition horizon. Planting on dune slopes and crests proved largely a failure as regards initial growth. Planting in swamps and on the swamp margins often suffered from winter flooding. As the planting progressed to the northwest into the less strongly leached sands of the Spearwood Dunes System, topography appeared to be less limiting. However, older plantations established on these soils south of Perth have been found to suffer from summer drought deaths in years of below average rainfall.

The aim of the investigations here described was to delineate the portion of the State Forest No. 65 which are suited for establishment of *Pinus pinaster* plantation. Two criteria needed to be considered:

(a) the rate of growth and

(b) the susceptibility to death due either to summer drought or winter flooding.

METHODS OF INVESTIGATION.

In the areas north of the existing plantations 77 small pilot plots and one large plot of 63 acres of *P. pinaster* (The Hundred Acre Plot) were established between 1948 and 1957. Some have since been lost through the release of former crown lands. At the commencement of the current investigations most plots were less than 10 years old. These plots constitute the sole source of direct information concerning the performance of *P. pinaster* north of existing plantations.

Variation in year of establishment, establishment procedure and thinning and pruning treatment prohibit plot comparison by means other than those related to height growth. The standard measure adopted was a modification of the five year height intercept developed by Wakely. In practice the five year height intercept corresponding to the maximum rate of height growth, usually from 3 to 8 years of age, was measured. The method was tested and found satisfactory in predicting height growth rates in stands up to 33 years of age and in predicting basal area and volume growth in extensive 15 year old stands in the south (Table 1).

The performance of the pines on the widely spaced pilot plots needed to be extrapolated to the intervening unsampled areas. Two alternatives were considered:

(a) directly through environmental factors.

(b) indirectly through vegetation.

Because the marked infertility of the local soil has prevented close settlement of the district, there is a dearth of recording stations and hence of climatic data. Long term rainfall data are available from only four stations on the perimeter of the State Forest. The only evaporation data available are those for Perth. The soils have been very broadly mapped into four Soil Associations but the map makes no provision for the very marked local variations in soil moisture and soil leaching. There is no topographic map of the area in question. The first alternative, the interpretation of the growth rates on the various pilot plots on basis of environmental conditions, and their application to site quality assessment of surrounding areas, would thus be difficult and unreliable.

For this reason the second alternative, the indirect approach through vegetation was adopted. Its applicability was first tested along the boundaries of older plantations, where native vegetation patterns could be compared directly with pine growth rates. The tests indicated that vegetation did in fact reflect the inter-action of environmental site factors and the potential for pine growth.

The local flora is rich, containing 16 tree species and over 180 perennial shrub species, necessitating the use of electronic computers for data analysis. Two methods were tried. The first of these, Principal Component Analysis (factor analysis) pioneered by Goodall (1954) and Dagnelie (1960), considers the quantity of each species. The second, the association analysis developed by Goodall (1953) and Williams and Lambert (1959, 1960, 1961a, 1961b), considers only the presence or absence of each species. The first method results in a co-ordinate system in which the plots are distributed on the basis of the overall similarity of vegetation. The axis of the co-ordinate system may, or may not, be identifiable with environmental factors. The second approach results in the grouping of plots on the basis of presence or absence of a set of key species. A modified form of this method, the inverse association analysis, results in the grouping of species on the basis of their presence or absence in a set of key plots. These groups of species can be used as indicators. It is apparent that the first method is likely to be most applicable where the vegetation varies gradually and continuously; the second where the changes are abrupt and definite.

In the investigations, several of the plots recently influenced by land clearing were omitted. This reduced the workable number to 67 plots. Four one-tenth acre vegetation plots were located in the surround of each pine plot. Each vegetation plot was located 33 ft. into the undisturbed native vegetation, opposite one of the four sides of the planted plot. Within each vegetation plot the basal area contributed by all the tree species present, individually and collectively, was determined, and the height of the tallest tree, irrespective of species, was measured.

The shrubs were sampled by two 13 ft. x 13 ft. sub-plots, located systematically within the vegetation plots. For the association analysis the presence and absence of the species was used as the basic data and each sub-plot was considered individually. For the factor analysis the eight sub-plots surrounding each pilot plot were pooled to obtain the frequency of occurrence. Soil samples for the 0-3 ft. and 3-6 ft. profile depths were obtained from the centre of each vegetation plot, and were used to determine the soil reaction, percentage of iron and the loss on ignition. These criteria were selected as being indicative of the degree of leaching and organic matter accumulation, which are the chief soil forming processes in this area of uniform parent material (wind deposited beach sand).

LIMITATIONS DUE TO UNSATISFACTORY GROWTH RATES.

The two main factors brought up by the factor analysis were identified as the degree of leaching undergone by the soil, and the degree of moistness of the site. There was a high degree of correlation between scores on the first factor and the percentage of iron in the soil. There was a similar, though less clearcut trend in soil reaction. The degree of moistness of the site was related to the presence of known moisture loving and drought resistant species respectively, and to extremes in topographical positions. In the intermediate positions, such as the flats and lower slopes, the moistness of the site could obviously not be assessed on topographical configuration alone.

The evaluation of the plot growth data in relation to the co-ordinate framework and to the distribution of individual shrub species within that framework indicated the following:

(i) Dry, strongly leached sites, characterised by high frequencies of *Eremea pauciflora, Leucopogon conostephioides, Scholtzia involucrata, Boronia purdieana* and *Astroloma xerophyllum,* had a five-year height intercept, of 7 to 13 ft.

(ii) Dry, but less strongly leached sites on which *Boronia purdieana* was replaced by *Calectasia cyanea, Conospermum stoechadis, Acacia sphaecelata* and *Daviesia quadrilatera,* had a five-year intercept of 11 to 14.

(iii) Moist, strongly leached sites characterised by high frequencies of *Xanthorrhoea preissii, Dasypogon bromeliaefolius* and *Phlebocarya ciliata,* had a site index from 13 to 17.

(iv) Moist moderately leached sites characterised by high frequencies of *Xanthorrhoea preissii, Dasypogon bromeliaefolius, Eremea fimbriata* and *Daviesia quadrilatera,* had a five-year intercept from 14 to 18.

(v) The degree of moistness appeared to have little effect on the site index of weakly leached sites characterised by high frequencies of *Mesomelaena stygia, Hakea costata, H. ruscifolia, Daviesia divaricata, D. nudiflora, D. pectinata, Conospermum triplinervium var. linearis, Conostylis candicans* and *Hibbertia racemosa.* Their height intercept ranged from 14 to 19.

In as much as the merchantable volume at the age of 15 years is less than 400 cu.ft./acre for height intercepts of under 15, as compared with volumes of 800 to 1500 cu.ft/acre for intercepts 15 to 20 and over 20 respectively, the suitability of sites with this index for plantation establishment is questionable at this stage.

The association analysis proved disappointing. It delineated satisfactorily groups of plots differing in degree of leaching, but appeared unable to subdivide these groups on the basis of moisture availability. As a result the grouping lacked precision. The inverse analysis pointed out several groups of plant indicators with moderate frequencies, but could not cope with the very common or rare species.

LIMITATIONS DUE TO DEATHS OF SEEDLINGS OR YOUNG TREES.

The pilot plots so far dealt with were located so as to avoid extremes in environmental conditions and stands too heavy for the light clearing equipment available at the time. Additional work was therefore carried out to investigate in greater depth the conditions under which survival, rather than growth rates become limiting. The cases are quite separate in their occurrence. Plotting of the incidence of summer drought deaths within the factor framework revealed that this condition was restricted to sites with weakly leached soil; that is those belonging to the Spearwood Dune System.

The deaths due to winter flooding are virtually restricted to strongly leached soils, belonging chiefly to the Bassendean Dune System.

SUMMER DROUGHT DEATHS.

Additional information on the vegetation of the Spearwood Dune System was available from a vegetation survey of three large pilot plots prior to clearing. These plots, of 12 acres each, yielded data on the basal area and height of the tree stratum, and percentage cover within the shrub stratum. Factor analysis of this data relegated leaching of soil and moistness of site to second and third place respectively. A new complex factor, combining north-south climatic variation and proximity to limestone outcrops, emerged as the strongest factor. This is not surprising as the three plots vary greatly in their north-south location, but are restricted to the moderately to weakly leached soils of the Spearwood Dune System. Comparison of the three plots which are similar in exposure, distance from sea, soils and topographical range, revealed a progressive disappearance of several tree species from south to north and a corresponding drop in mean basal area per acre (Table 2).

The absence of *Eucalyptus todtiana* in the two northern plots is fortuitous, as the species is quite common nearby. Otherwise the changes between the plots reflect the changes between the portions of the State Forest in which they are located. The drop in mean basal area in the northern areas is accentuated by the replacement of *Eucalyptus marginata* by *Banksia attenuata* and *Banksia ilicifolia* on lower slopes and depressions, where these species suffer severely from frost. However, there is a less marked but still quite definite drop in basal area from 45.9 to 27.6 to 17.3 sq.ft./acre even on mid slopes, where there is no frost effect, and where environmental conditions, other than climate, are best matched. It is therefore reasonable to assume that, all other factors being held constant, the north-south variation in climate is responsible for the marked decrease in capacity of the site to support tree growth.

All of the pilot plots within which summer drought deaths occurred recently are located in the Karakin sector. However, summer drought deaths also occurred in unthinned portions of the Hundred Acre Plot at Yanchep and in unthinned stands adjacent to limestone outcrops at Pinjar. On the whole the susceptibility to drought thus becomes more widespread from south to north, suggesting that the same climatic restriction on tree growth is operating in both native woodland and pine plantations. It is accentuated by proximity to limestone outcrops and elevated position of the site. Under these conditions there is usually a decrease in basal area of native woodland, and a change in species dominance. This was studied in a set of five topographical transects, located between the Pinjar and Karakin pilot plots. The approach towards a limestone outcrop is normally associated with decrease in depth of soil, ranging from the occurrence of isolated limestone pinnacles at depth to bare limestone outcrops with pockest of soil. There is also a corresponding decrease in the leaching of the surface soil. This is illustrated in Table 3. It suggests that the exposure of the limestone outcrops, originally formed at depth as a deposition horizon, was accomplished by stripping of the leached overburden by wind action.

The northward deterioration of climate and the decrease in soil depth on limestone outcrops thus combine to reduce the potential for the development of a heavy stocking in terms of basal area of native woodland. Their combined effect on the soil is to reduce the leaching of the surface layer. The ultimate effect is for an increase in pine growth potential on dry sites; at least in the early stages. The apparent anomaly may be readily understood by considering the seasonal differences between growth and survival.

The bulk of *Pinus pinaster* growth occurs in late winter and spring and is dependent on the capacity of the surface soil to retain moisture and nutrients. The survival depends on the magnitude of water reserves for the long summer drought, and is affected by the depth of the soil profile. On weakly leached shallow soils near limestone outcrops the relatively good growth rates result in an increasing unbalance between tree requirements and the site potential to supply moisture in summer. This is demonstrated in data obtained in a neutron probe study of moisture regimes under native woodland and pine plantation, carried out in co-operation with the CSIRO Division of Plant Industry. The study was carried out within and adjacent to a 15 year old pine stand at Yanchep, on two sites. One of the sites, with uniformly weakly leached soils over limestone at 7 to 23 ft. depth carried a far better pine stand than the other, on which the moderately leached surface soil was underlain by weakly leached soil more than 23 feet deep. The native vegetation was likewise better developed on the first site. The quantitative differences are presented in Table 4.

Site A was downslope from site B, and at least part of the difference between them may be attributable to this fact. A very moist layer resembling an underground stream was found below 20 feet on Site A under native vegetation. It was completely exhausted under pine plantation.

The soil moisture regimes for the period from November 1965 to November 1966 are shown in Figure 4.

It will be seen that the exhaustion of moisture reserves corresponds roughly to the basal area of the stand, though the pine stands have a relatively greater effect. The depletion of water reserves appears to be due not only to increased transpiration, but also to increased rainfall interception by the heavier cover.

The complete elimination of all sites susceptible to summer drought deaths is out of the question, as it would lead to virtual cessation of planting in the Wanneroo division. Rather it is necessary to determine at what stocking, in terms of basal area, there is a balance between water intake and water uptake. The basal area of native woodland is obviously too conservative, inasmuch it results not only in replenishment of water reserves, but also complete passage of portion of the annual rainfall through the profile. This is obvious both from the fact that the wetting front passes the depth of 23 feet each winter (Figure 4) and from the podzolic nature of the soils. On the other hand the basal area of the pine stands is obviously too heavy, as heavy needle cast and some deaths of subdominants and suppressed trees have occurred on both sites in 1967. The final answer will be available from a large basal area thinning experiment established in the same 15 year old stand. Stocking rates ranging from 31 to 107 sq. ft./acre basal area are being tried. This range covers adequately the difference between the low stocking of the native woodland and the current excessive stocking of the pine plantations. It is proposed to combine the thinning trial with a detailed hydrological study. The three large pilot plots referred to earlier were established for the same purpose.

DEATHS DUE TO WINTER FLOODING.

The study of excessively high ground water tables proved much simpler in nature within State Forest No. 65. The relationship of vegetation to the environmental factors, in particular the soil moisture, was studied in three transects spanning the full topographical range found in the areas concerned. As it was found that the depth to an organic deposition horizon (coffee rock) exercised an important effect on the vegetational pattern, the results of the study were summarised in form of a simple two-way co-ordinate system incorporating this factor and the maximum height of the water table. Although topography affects both of these factors, its effect is not sufficiently consistent, and for this reason it has not been utilised.

The very marked variations in soil moisture patterns are associated with, and are presumably the cause of, the equally marked variation in vegetation. Vegetation can thus be used to assess not merely the maximum or minimum water availability, but the entire soil water regime. Furthermore, it requires no tedious, repeated soil sampling to achieve this result.

The correlation between native vegetation and pine growth was studied in a 15 year old stand situated largely within the Bassendean Dune System. Residual native vegetation was used to stratify an area of 120 acres, containing 150 temporary sample plots. The stand characteristics are set out in Table 5.

The study complements the factor analysis of the pilot plots in that it samples a relatively high proportion of wet sites which were poorly represented in the latter. It will be seen that optimum conditions for pine growth are indicated by high frequencies of *Dasypogon bromeliaefolius* and *Xanthorrhoea preissii,* characteristic of moist sites not subject to flooding. There is fall off towards both the dry and wet sites in height, basal area and volume. The proportion of malformed trees increases with increase in moisture, and is highest in the execessivly wet *Hypocalymma angustifolium* type. Past experience indicates that sites characterised by *Regelia ciliata, Calothamnus lateralis* and *Leptospermum ellipticum* become inaccessible to machinery during the mid winter planting season. Clearing of large areas aggravates the high ground water problem. However, such areas become normal or drier than normal following canopy closure in surrounding plantations. It is foreseeable that at this later stage the formerly excessively wet sites will become usable. Under present conditions deaths due to flooding are light in the *Hypocalymma* type and moderate to heavy in the *Regelia* type.

CONCLUSION.

The findings of this investigation have already been applied in the large scale delineation of future planting areas. Detailed mapping on a grid system averaged 300 acres/per day for a two man team when applied to 8100 acres mapped prior to clearing in 1966. Delineation of new planting areas by combination of ground reconnaissance and aerial photo interpretation is possible at the rate of 500 acres per day.

The applicability of ecological methods to site quality investigations is thus considered to be proven, particularly for regions lacking detailed environmental data but carrying relatively undisturbed native vegetation.

LITERATURE CITED.

Dagnelie, P. (1960), Contribution a l'etude des communautes vegetales par l'analyse factorielle. Bull. Serv. carte phytogeogr. Ser. B; 7-71 and 93-195.

Goodall, D. W. (1953). Objective methods for the classification of vegetation. I. The use of positive interspecific correlation. Aust. J. Botany. 1; 434-456.

Goodall, D. W. (1954). Objective methods for the classification of vegetation. III. An essay in the use of factor analysis. Aust. J. Botany. 2: 304-324.

Williams, W. T., and Lambert, J. M. (1950). Multivariate methods in plant ecology. I. Association analysis in plant communities. J. Ecol. 47: 83-101.

Williams, W. T., and Lambert, J. M. (1960). Multivariate methods in plant ecology. II. The use of electronic digital computers for association analysis. J. Ecol. 48: 689-710.

Williams, W. T., and Lambert J. M. (1961). Multivariate methods in plant ecology. III. Inverse association analysis. J. Ecol. 49: 717-729.

TABLE 1.

RELATIONSHIP BETWEEN THE FIVE YEAR HEIGHT INTERCEPT AND OTHER PARAMETERS IN A 15 YEAR OLD *Pinus pinaster* STAND

Parameter	Five Year Height Intercept Class (Ft.)		
	Less than 15	15 - 20	20+
Top height (ft.) (30 tallest trees/acre)	33.2	38.4	45.7
Mean dominant height (ft.) (100 tallest trees /acre)	31.4	36.7	43.9
Merchantable volume to 4in. top diam. (cu.ft./acre over bark)	348.7	892.8	1521.7
Basal area (Sq.ft./acre all trees)	59.0	94.1	108.9

TABLE 2.

VARIATION IN THE TREE STRATUM BETWEEN PILOT PLOTS, SAMPLING THE NORTH TO SOUTH CLIMATIC GRADIENT

Location	Latitude	Components of the tree Stratum	Mean Basal Area /Acre (Sq.ft.)
Pinjar	31' 33"S	*Eucalyptus marginata*, *Eucalyptus todtiana* *Casuarina fraseriana* *Banksia attenuata*, *B. menziesii* *B. grandis* *Nuytsia floribunda*	61.6
North Yanchep	31' 24"S	*Banksia attenuata*, *B. grandis* *B. menziesii*, *B. ilicifolia* *Casuarina fraseriana* *Nuytsia floribunda*	29.6
Karakin	31' 10"S	*Banksia attenuata*, *B. menziesii*, *B. ilicifolia* *Nuytsia floribunda*	16.9

TABLE 3.

VARIATION IN NATIVE VEGETATION ON APPROACH TO A LIMESTONE OUTCROP.

BOONGARRA TRANSECT, YANCHEP, CONSISTING OF SEVEN 2 x 2 CHAIN PLOTS.

Plot Number	1	2	3	4	5	6	7	Out-crop
Non-specific features of tree stratum:								
Basal Area (Sq.ft. per Acre)	89.9	66.9	17.5	25.1	17.8	4.6	2.8	
Maximum height (Ft.)	55	52	30	19	21	17	17	
Specific features of tree stratum: Relative basal area of—								
Eucalyptus marginata ..	94.2	93.0	59.4	10.5	0.0	0.0	0.0	
Casuarina fraseriana	1.5	1.3	15.4	29.6	0.7	0.0	0.0	
Banksia attenuata	0.4	3.7	14.9	49.4	67.0	100.0	31.5	
Nuytsia floribunda	0.3	0.0	1.4	0.0	28.1	0.0	68.5	
Other species	3.6	2.0	8.9	10.5	4.2	0.0	0.0	
Percentage iron in top 3 ft. of soil	.124	.131	.173	.176	.217	.228	.244	

TABLE 4.

VARIATION BETWEEN SITES EMPLOYED IN DEEP PROBE SAMPLING AT YANCHEP.

Site	Percet. Iron in surface 3 ft. of soil	Basal Area of Native Woodland	Pine Plantation	
			Five Year Height Intercept	Basal Area at Age 15
A—Weakly Leached	0.296	60 Sq. ft.	18	100 sq. ft.
B—Moderately Leached	0.100	25 Sq. ft.	15	70 sq. ft.

TABLE 5.

RELATIONSHIP BETWEEN GROUND VEGETATION TYPES AND GROWTH OF *Pinus pinaster* IN ESTABLISHED 15 YEAR OLD PLANTATIONS.

PARAMETER	VEGETATION TYPE			
	Hypocalymma-angustifolia	Hypocalymna-Xanthorrhoea	Xanthorrhoea-Dasypogon	Leucopogon-Scholtzia
Five year height intercept	18.1	20.4	22.0	13.9
Top height in ft. (30 tallest trees/acre) ..	35.2	43.0	46.2	33.4
Mean dominant height in ft. (100 tallest trees/acre)	33.3	40.9	44.6	31.5
Basal area sq. ft./acre (All trees)	70.0	102.5	112.5	68.3
Merch. volume to 4 in. diam. (cu. ft./acre)	424.3	1312.4	1582.5	437.0
Proportion of malformed stems	23.8	19.6	11.7	3.3
	Increasing dryness of site. ——————→			

PERCENTAGE IRON IN SOIL AS INDEX OF LEACHING AND SOIL SERIES

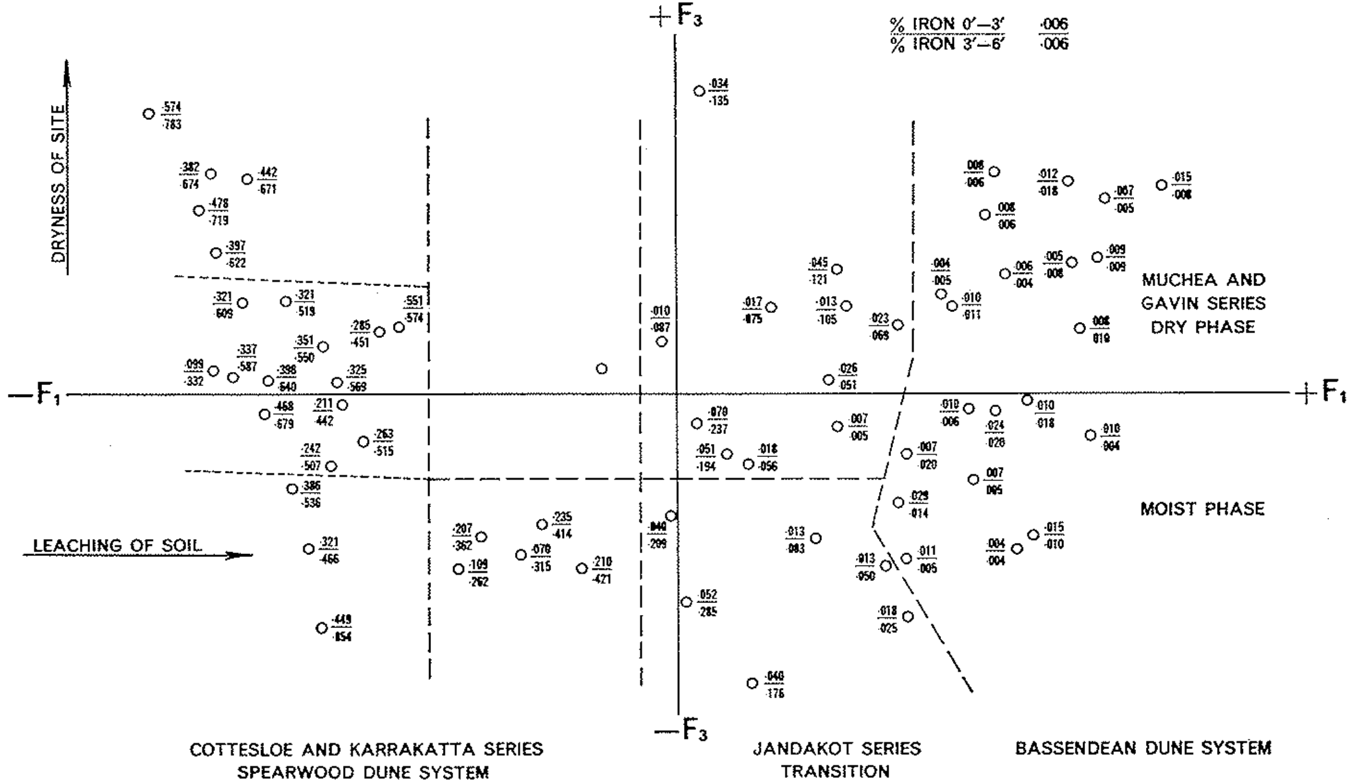

FIGURE 1

Soil characteristics of pilot plots, plotted within the co-ordinate framework established by factor analysis.

F.1. corresponds to degree of leaching undergone by the soil.

F.3. to moistness of the site. The numbers represent percentage of iron in the soil, the top figure of the fraction referring to depth of 0 - 3 ft., the bottom figure to 3 - 6 ft.

FIVE YEAR HEIGHT INTERCEPT AND DROUGHT DEATH INCIDENCE

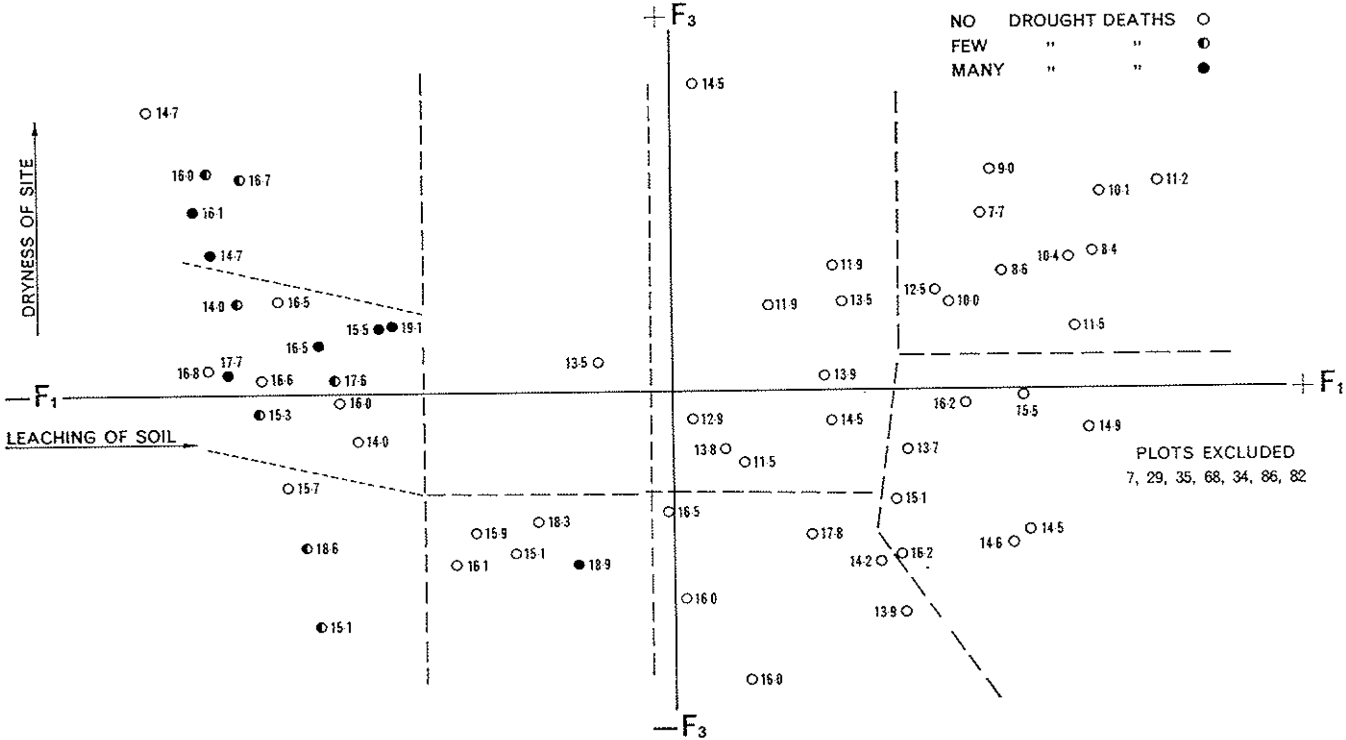

FIGURE 2

Five year height intercept and drought death incidence in pilot p lots, plotted within co-ordinate framework established by factor analysis.

F.1. corresponds to degree of leaching undergone by the soil.

F.3. to moistness of the site. The numbers represent five year height intercept, the colouring of the circles represents the severity of summer drought deaths in 1967.

DISTRIBUTION OF MAIN INDICATOR SPECIES

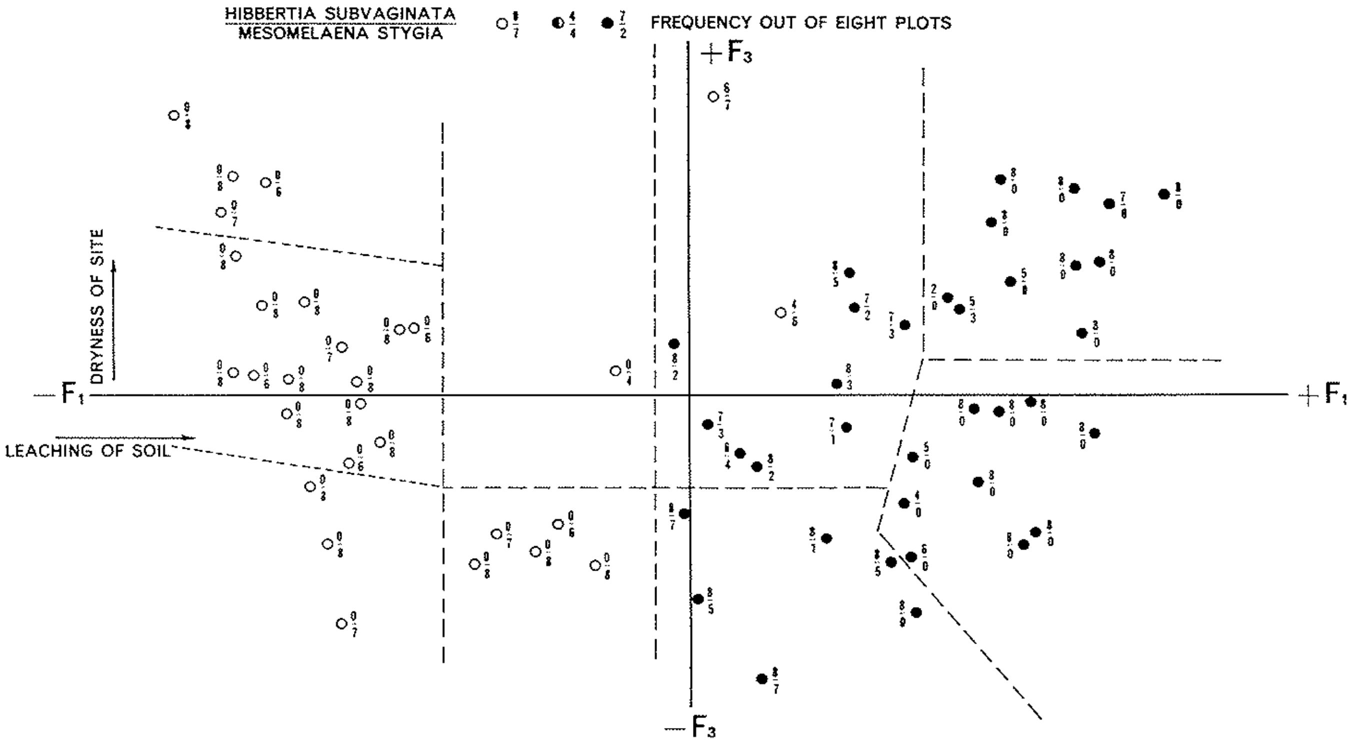

FIGURE 3

Occurrence of two indicator species, sensitive to moistness of the site, in surrounds of pilot plots plotted within the co-ordinate framework established by factor analysis.

F.1. corresponds to degree of leaching undergone by the soil.

F.3. to moistness of the site. The numbers refer to relative frequency of the two species in the eight quadrats in native woodland surrounding the pilot plots.

DISTRIBUTION OF MAIN INDICATOR SPECIES

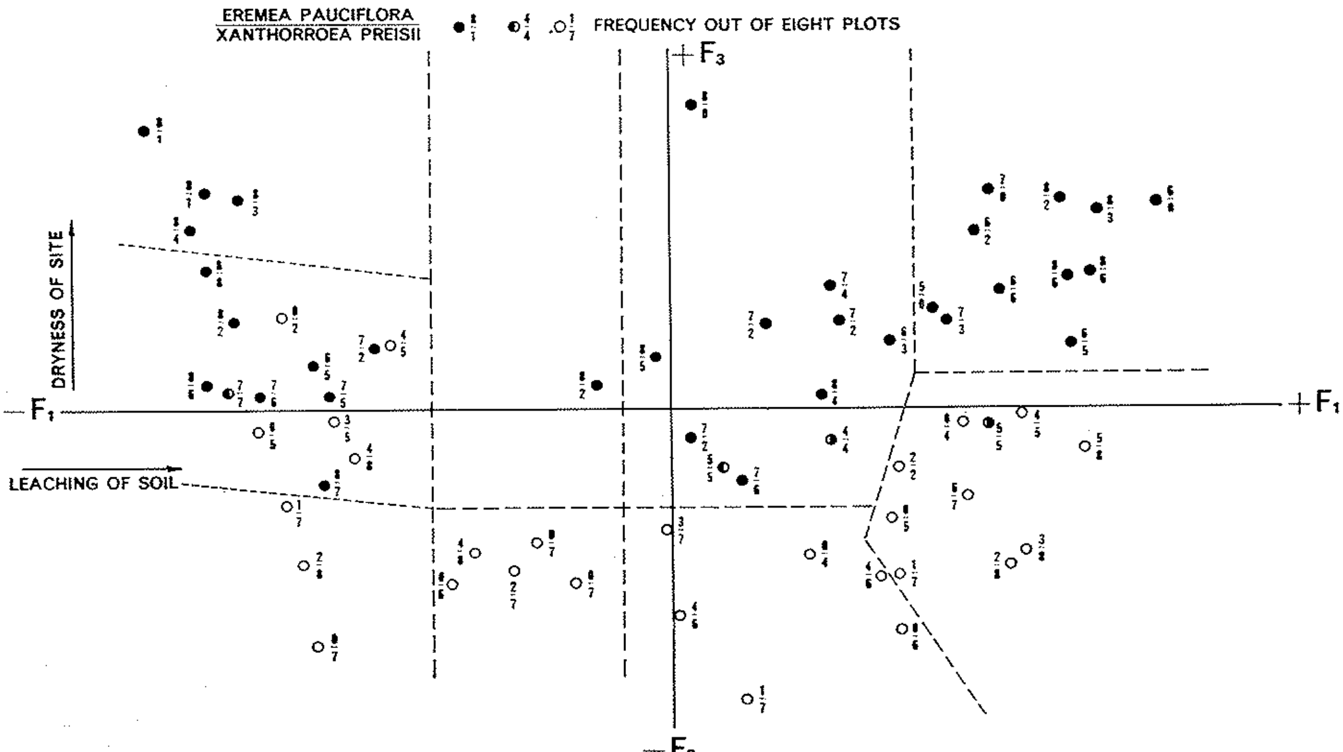

FIGURE 4

Occurrence of two indicator species sensitive to soil leaching, in surrounds of pilot plots, plotted within the co-ordinate framework established by factor analysis.

F.1. corresponds to degree of leaching undergone by the soil.

F.3. to moistness of the site. The numbers refer to relative frequency of the two species in the eight quadrats in the native woodland surrounding the pilot plots.

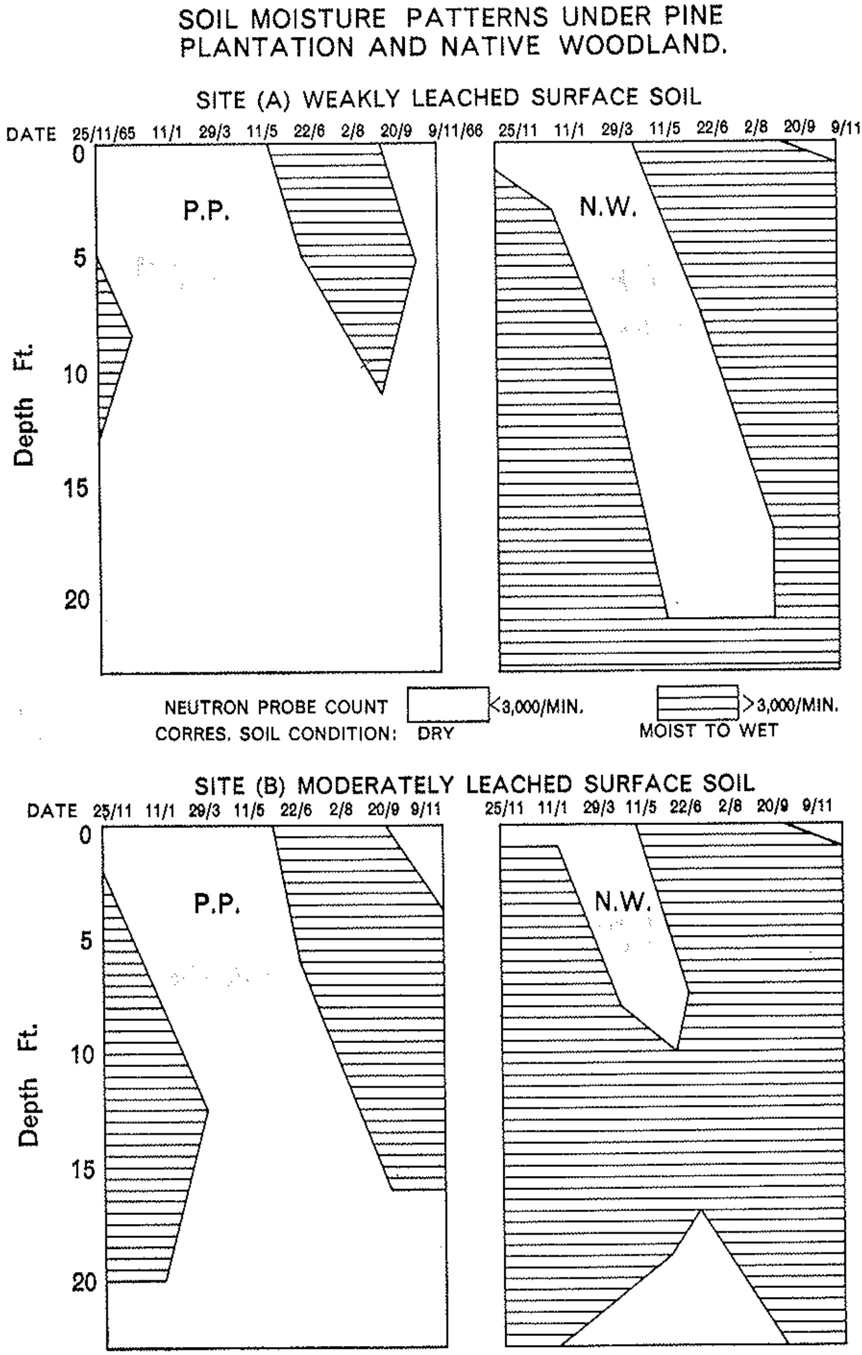

FIGURE 5

Differences in moisture exhaustion and replenishment under pine plantataion (P.P.) and native woodland (N.W.) on two sites.