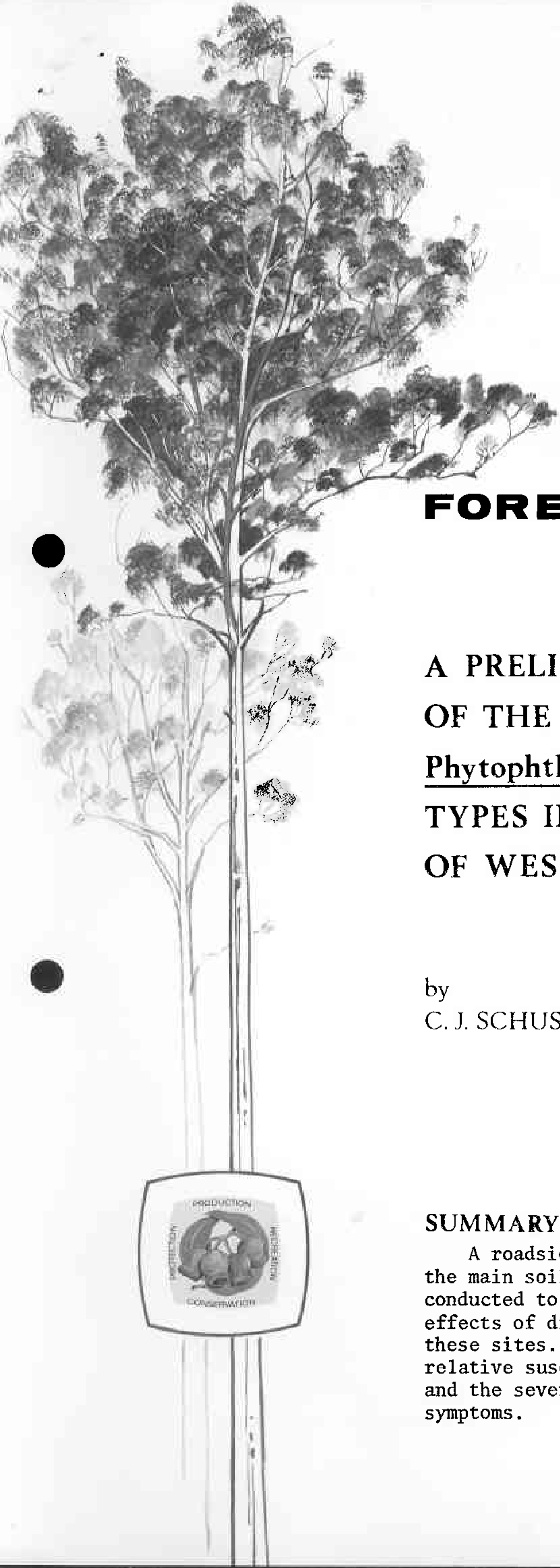

ODC 443.3

Research Paper 40
1978

**FORESTS DEPARTMENT**
*OF WESTERN AUSTRALIA*

# A PRELIMINARY INVESTIGATION OF THE RELATIONSHIP BETWEEN Phytophthora cinnamomi AND SOIL TYPES IN THE SOUTHERN FORESTS OF WESTERN AUSTRALIA

by
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## SUMMARY

A roadside survey of 227 sites, covering four of the main soil types in the southern forests, was conducted to provide information concerning the effects of dieback, Phytophthora cinnamomi Rands, on these sites. The information sought included the relative susceptibility of the sites to the disease, and the severity of the disease as evidenced by plant symptoms.

## INTRODUCTION

The forested areas of Western Australia are not uniformly susceptible to the fungal disease, *Phytophthora cinnamomi* Rands. This has been documented by Shea (1975), who noted that in the northern jarrah forests at least, the lowland sites were much more susceptible to the disease than the upland sites. The knowledge of differences in susceptibility is important if forest management is to limit the spread and severity of the disease.

A preliminary study was undertaken to define site susceptibility and disease severity in the southern forests of Western Australia. An attempt was made to relate the severity of disease to site classification based on soil type. The four main soil types of the area, in combination with the three main overstorey vegetation types, were taken into consideration.

## METHOD

The survey was conducted along approximately 140 km of road- and track-sides to the south and west of Manjimup. The survey route included the full range of soil and forest associations found in the Manjimup and Pemberton Forest Divisions.

In the survey, 227 sites were selected and assessed on the following basis. At the beginning of the road or track the soil type found was taken as the first site to be investigated. The second and subsequent sites were selected when there was a change in soil type, or the pattern of disease expression on the same soil type changed.

At each site the variables recorded included the soil type, the presence or absence of dieback symptoms in the vegetation, and the dominant plant species in both the overstorey and shrub layers. When symptoms of dieback were present the affected species were recorded.

Sites were differentiated on the basis of soil characteristics, and four categories described by McArthur and Clifton (1975) were recognized.

(1) Shallow Podsols (McArthur and Clifton, Dy3.4, Dy3.6 and Dy5.6), which are duplex soils with a shallow (< 40 cm) A horizon, which was generally sandy and grey to yellow in colour. These soils generally support a poor jarrah-marri forest.
(2) Deep Podsols (McArthur and Clifton, Dr3.21, Dr2.21) which are duplex soils with a red gravelly A horizon exceeding 40 cm in depth. These soils support mixtures of marri and karri.
(3) Red Earth soils (McArthur and Clifton, Gn2.14, Gn2.15) which are generally deep, well drained loamy soils supporting either pure karri stands, or karri-dominated mixtures.
(4) Laterites (McArthur and Clifton, KS-Uc4.2) and Sands (McArthur and Clifton, Dy5.42, Dy5.81). The well-drained lateritic soils consist of a gravelly-sandy, or loamy shallow surface layer, overlying a deep profile of weathered rock. They support only poor quality jarrah and jarrah-marri stands. The sands studied were in the main poorly drained sites on gully floors with banksia woodland and shrub communities.

TABLE 1

Dieback infection on four southern forest types

| Soil type | No. of sites examined | No. of sites infected | Percentage of sites infected |
|---|---|---|---|
| Laterite and sand | 35 | 29 | 82.9 |
| Shallow podsol | 71 | 62 | 87.3 |
| Deep podsol | 101 | 61 | 60.4 |
| Red earth | 20 | 3 | 15.0 |

## RESULTS

### Susceptibility of sites to dieback infection

The proportion of sites surveyed which showed symptoms of dieback infection are shown in Table 1.

These data were subjected to a contingency test to differentiate between real site differences and those attributable to chance.

The chi-square values for the contingency test are shown in Table 2.

TABLE 2

Chi-squared values for susceptibility comparisons between sites

| | Laterite and sand | Deep podsol | Red earth |
|---|---|---|---|
| Shallow podsol | 0.35 | 13.78** | 40.14** |
| Red earth | 23.88** | 13.88* | |
| Deep podsol | 5.78* | | |

* Significant (p = 0.05)
** Highly significant (p = 0.01)

Table 2 indicates that there are significant differences in susceptibility between three of the four soil types. The only non-significant difference was between the shallow podsols and the laterites and sands. However, both of these sites showed a higher rate of infection than the deep podsols. Very few sites on the red earth soils showed any symptoms of infection.

### Severity of disease expression

Recording the plant species which showed symptoms of dieback infection was of little value in estimating the severity of disease expression because of the widely differing assemblage of plant species on the four site types. However, marked differences were apparent in the degree of disease severity in the structural components of the vegetation. In this context two strata were recognized:

(1) the understorey trees and shrubs;

(2) the overstorey, comprising the large tree species.

Dieback symptoms on each site were recorded as either confined solely to the lower strata, or extending into the overstorey.

A summary of the severity of disease expression based on these criteria is given in Table 3.

TABLE 3

Severity of disease expression on southern forest sites

| Soil type | Percentage of infections with symptoms extending to: | |
|---|---|---|
| | Understorey only | Overstorey |
| Laterite and sand | 48.3 | 51.7 |
| Shallow podsol | 70.9 | 29.1 |
| Deep podsol | 88.5 | 11.5 |
| Red earth | 100.0 | 0.0 |

Again these data were subjected to a contingency test and the resulting chi-squared values and significance levels are shown in Table 4.

TABLE 4

Chi-squared values for disease severity comparisons between sites

| Site | Shallow podsols | Deep podsols |
|---|---|---|
| Laterite and sand | 4.43* | 17.18** |
| Shallow podsol | | 5.85** |

* Significant (p = 0.05)
** Highly significant (p = 0.01)

Considerable differences in the severity of disease expression were apparent between the four soil types studied. No dieback infections on the red earth sites, and very few on the deep podsol sites, were found to extend into the overstorey. On shallow podsol sites, although apparently as liable to dieback infection as laterites and sands (Table 1), the severity of disease expression was significantly less (29% of infections extending to the overstorey) than on the laterites and sands (52%).

TABLE 5

Relation between topography and soil type expressed as number of sites infected or not infected with dieback

| | Soil type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Red earth | | Deep podsol | | Shallow podsol | | Laterite and sand | |
| Location | I | NI | I | NI | I | NI | I | NI |
| Ridge | 1 | 2 | 46 | 25 | 39 | 6 | 16 | 3 |
| Gully | 2 | 15 | 15 | 15 | 23 | 3 | 13 | 3 |
| Total | 3 | 17 | 61 | 40 | 62 | 9 | 29 | 6 |

I = Infected
NI = Not infected

One confounding aspect of the study was the relationship between topography and soil type in the southern forests which has been summarised in Table 5. This shows a dependence for soil type upon topography with the majority of red loams in steep valleys, the majority of laterites on the ridges, and the majority of sands in broad, shallow gullies. This suggests that the observed differences in infection patterns between soil types could be due to other factors such as soil drainage.

## DISCUSSION

This study was designed on a purely comparative basis between the four soil types. The data are not suitable for extrapolation into absolute values and it should not be assumed that the percentages of the various soil types reported here to be infected with the disease represent the percentages of the areas of the soil types which are infected in the southern forests. A similar constraint applies to any extrapolation of the data on disease severity.

The proportions of the four soil types found to have symptoms of dieback infection (Table 1) have been used in this paper as an index of their comparative liability to infection. This premise assumes that all have had an equal chance of becoming infected and that there has been sufficient time for the disease to establish itself. For this reason the study was confined to the borders of roads and tracks that have been subject to regular grading operations: earth-moving operations such as grading and logging have been reported by Batini (1973) to be very successful vectors of the dieback disease. It also means that the level of infection observed in the study is much higher than for the forest as a whole.

Tables 1-4 exhibit clearly that the red earth sites are less liable to initial infection, and subsequent extension of an infection, than the other three soil types. While the red earths lack susceptible overstorey species, they support susceptible understorey species and infection levels for these species are much lower on the red earths than on the laterites and sands, and shallow podsols. This indicates that these sites are suppressive of the disease.

Much has been reported on the optimal conditions required by the dieback fungus for sporulation, vegetative mycelial growth, and hence infection capacity. Shea (1975) noted that fungal infection required soil temperatures above 15°C, and soil moisture above field capacity. For the soil types described in this study Christensen (1975) indicated that there were differences in relative susceptibility to infection between the red loams and the laterites. He showed that the red loam soils were susceptible to infection for only a limited period during the year whereas the lateritic soils have an extended period of susceptibility, which include short periods during the winter months.

However, it is likely that topography, and hence soil drainage, rather than soil type, is a major determinant of dieback susceptibility. In the study areas the four soil types mentioned belong generally to distinct topographical locations, with the red loams confined to the valleys and the laterites to the ridge tops. This indicates that the information provided in this study concerning the relative susceptibility of soil types cannot be attributed wholly to soil characteristics. To elucidate this hypothesis, a further, more detailed study would be required, particularly on the shallow and deep podsols which occur throughout the wide topographical range of the southern forests and support a comparatively wide range of vegetation types. The need for further study is accentuated by the high proportion of forestry activities currently being carried out on these soil types.

In addition to the possible effect of soil drainage on conditions suitable for fungal infection, vegetation cover markedly affects soil temperature and moisture conditions (Shea, 1975). On the red loams which, in the southern forests support karri-marri forest with a dense canopy cover, soil temperatures are relatively low for most of the year and only increase to over 15°C in the dry summer months when the soil moisture has fallen to below field capacity. Therefore, the red loams are conducive to infection for only a short period (Christensen, 1975).

In contrast, the shallow podsols and laterites have low canopy density jarrah-marri stands, due to selective logging, and temperatures increase more rapidly (Christensen, 1975) during periods when soil moisture conditions are still above field capacity (Shea, 1975). This in turn increases the duration of infection susceptibility.

Hence the differences in susceptibility between the soil types that were noted in Tables 1 and 3 may be due to the combined effects of drainage, topographical position and canopy density rather than a direct result of soil characteristics alone.

Other factors may influence the infection pattern of a site. The nutritional status of the soil, particularly a high calcium level, may provide the vegetation of the site with some resistance towards dieback disease. The deep podsols and red loams are superior to the shallow podsols and laterites and sands in calcium nutrition (McArthur and Clifton, 1975).

Secondly, the proportion of susceptible species on a site that can act as host to the fungus during the hot, dry summer conditions is important. The lateritic soils of the jarrah forests support large susceptible vegetation components of Proteaceae and Epacridaceae whereas the loams and deep podsols support only a small susceptible component.

Shea (1975) reported that the existence of a highly susceptible component in the vegetation facilitates the spread of infection. This suggests that survival of the pathogen over summer, and hence potential infection capacity during the autumn and spring, is greater on the shallow podsols and the laterites.

Furthermore, the dense growth of leguminous shrub species found on the loams and deep podsols of the karri-marri forests are considered by Shea (1975) to have an inhibiting effect on the disease in the northern jarrah forest. The dense shrub canopy slows the warming process of the surface soil and increases the rate of moisture withdrawal, thus reducing the period suitable for infection.

## CONCLUSION

This preliminary study was completed to provide an insight into the relationships between site and disease. Significant differences in infection susceptibility and expression were found between all soil types studied, with the laterites and sands exhibiting the largest proportion of infections. Infections occurred with decreasing frequency on shallow podsols, deep podsols and red loams: infections on the red loams were confined solely to the shrub and understorey species.

However, it is unlikely that the differences in relative susceptibility can be related solely to inherent soil characteristics as several confounding factors such as topography (the effect of drainage and aspect) and vegetation cover, which are also related to soil, could not be eliminated.

A further study is needed to clarify the situation.

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