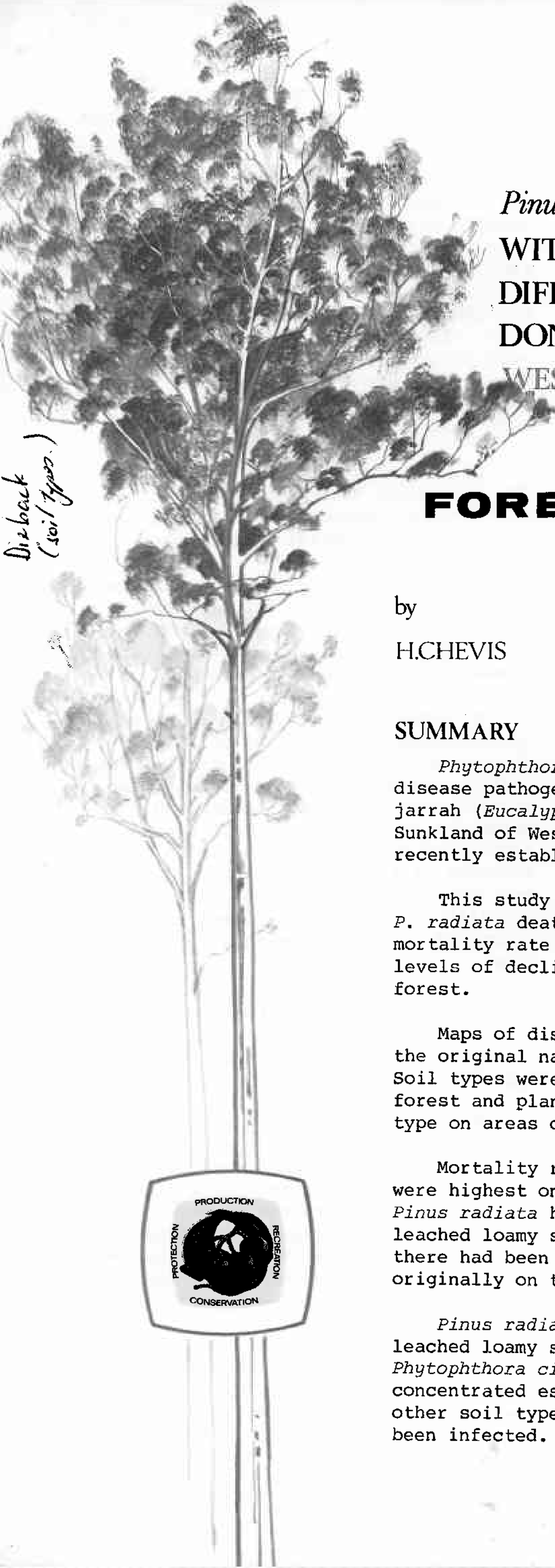
ODC 114.4:174.75:443.3

Research Paper 79
May 1984

Pinus radiata DEATH RATES ASSOCIATED WITH *Phytophthora* SPECIES ON DIFFERENT SOIL TYPES IN THE DONNYBROOK SUNKLAND OF WESTERN AUSTRALIA



FORESTS DEPARTMENT
OF WESTERN AUSTRALIA

by

H.CHEVIS

SUMMARY

Phytophthora cinnamomi Rands (the jarrah dieback disease pathogen), present in the soils of the native jarrah (*Eucalyptus marginata* Sm) forest in the Donnybrook Sunkland of Western Australia, is causing deaths amongst recently established *Pinus radiata* D. Don plantations.

This study examines the variation in the number of *P. radiata* deaths between soil types, and whether this mortality rate is related to the previously observed levels of decline and mortality in the original native forest.

Maps of disease distribution were prepared for both the original native forest, and the *P. radiata* plantations. Soil types were also mapped. Mortality rates for both forest and plantation were then calculated for each soil type on areas of infestation.

Mortality rates amongst both jarrah and *P. radiata* were highest on the silty-clay loams of the valley floors. *Pinus radiata* had a similarly high death rate on the leached loamy sands of the mid to lower slopes, although there had been a low mortality rate in the jarrah forest originally on these leached loamy sands.

Pinus radiata is being planted primarily on the leached loamy sands. Measures to reduce the impact of *Phytophthora cinnamomi* on *Pinus radiata* should be concentrated especially on this soil type, but also on other soil types where the native forest is known to have been infected.

INTRODUCTION

Part of the native jarrah (*Eucalyptus marginata* Sm) forest in the Donnybrook Sunkland of Western Australia is being converted to pine plantation, of which the principal species is *Pinus radiata* D. Don.

Some portions of the jarrah forest in this area are infected by *Phytophthora cinnamomi* Rands (the jarrah dieback disease pathogen) (Podger, 1972). This fungus and three other species of the genus (*P. cryptogea* Pethybridge & Lafferty, *P. megasperma* Drechsler var. *sojae* Hildebrand, and *P. citricola* Sawada) have been consistently associated with the deaths of established *Pinus radiata* in the plantations (Chevis and Stukely, 1982). There has been a higher mortality rate amongst *P. radiata* planted on sites identified as formerly affected by jarrah dieback disease, than on sites that have shown no signs of infection.

The soils of the region were described by Smith (1951) as the Chapman combination. For the purposes of afforestation seven soil types are recognized (McCutcheon, 1978, 1980; Appendix 1). Laterites are generally confined to the ridges. Sandy soils, either leached and grey, or yellow from iron oxide staining, cover the slopes surrounding the ridges. Loamy soils occur on the lower slopes, and a small zone of silty soils lies along the valley floors.

Pinus radiata is being planted mainly on the sands and loams of the mid-to-lower slopes.

This study was initiated to discover whether the number of *P. radiata* deaths varied between soil types, and whether this mortality rate was related to the previously observed level of decline in the native forest originally occupying these sites.

METHOD

In 1972 a soil survey was carried out over 1992 ha of native forest that was to be converted, in part, to pine plantation (McCutcheon, personal communication*). Descriptions of the soil profile were made to a depth of 1.2 m at sites on a 400 m by 100 m grid. The soil type was largely determined from the texture and colour at a depth of 0.6 m. Further soil descriptions were made at sites between the grid points to accurately locate the boundaries of the soil types. Soil maps were then prepared.

The level of mortality and degree of decline amongst both overstorey and understorey species were observed at each grid point, and the proportion of sites showing jarrah overstorey mortality, slight thinning of the overstorey, and understorey mortality, was determined for each soil type. Sites where no disease symptoms were evident were ignored. This was then used as a guide to the impact of *Phytophthora cinnamomi* on native forest for each soil type.

In 1973 maps of dieback disease (*P. cinnamomi*) distribution in native forest were prepared from 1:40 000 scale black and white aerial photographs.

In 1974, 30 ha of the area was cleared and planted with *Pinus radiata*, and a further 130 ha was cleared and planted in 1976. Dieback disease was known to be present in 70 ha of this area.

In autumn 1980 and 1981, 70 mm colour aerial photographs were taken of the plantations, and from these the *P. radiata* deaths were mapped. This map was then superimposed on the soil plan, and mortality rates for each soil type were determined within the 70 ha known to be infested with dieback disease. Correlations were made between the level of decline and mortality in the native forest, and the number of *P. radiata* deaths, for each soil type.

RESULTS

Soil types 1 - 7 are described in Appendix 1.

The highest mortality rate in the jarrah overstorey was on the silty-clay loams (Type 7), and the lowest mortality rate on the leached loamy sands (Type 4). Understorey mortality was observed least often on the silty-clay loams (Type 7), and it was only here that the percentage of sites with overstorey mortality was higher than those with understorey mortality (Table 1).

Mortality rates of *P. radiata* were higher on the silty-clay loams (Type 7) of the valley floors and the leached loamy sands (Type 4) than on other soil types

* G. McCutcheon, Officer of the Forests Department of Western Australia, Bunbury.

(Table 1). There were few deaths on the lateritic types (Types 1 and 2).

The mortality rate amongst *P. radiata* coincided with the mortality rate of the jarrah overstorey on all soil types except the leached loamy sands (Table 1). The *P. radiata* mortality rate here was high, although the jarrah mortality rate had been low.

There was a negative trend between observed understorey mortality and the mortality rate of *P. radiata*. There were, however, no significant linear correlations between decline and mortality in the native forest, and *P. radiata* deaths, on each soil type (Table 1).

TABLE 1:

The effect of jarrah dieback disease on the native forest, and *P. radiata* plantations on different soil types in the Donnybrook Sunkland.

Soil Type[1]	1 Laterite	2 Shallow Sands	3 Yellow Sands	4 Grey Sands	5 Loams	7 Silty-clay Loams
Area (ha)	4.0	10.5	10.2	25.5	15.9	4.3
Deaths per ha of *P. radiata**[2]	0.2	0.9	1.1	2.3	2.0	2.3
Percentage of sites in the native forest with:						
– understorey mortality	66	54	41	46	50	23
– understorey mortality and decline of overstorey	15	24	29	36	17	10
– overstorey mortality†[3]	19	22	30	18	33	67

* Difference between rates: $x^2 = 11.07$, $p < 0.05$

† Linear correlation between *P. radiata* deaths and amount of decline and mortality in the native forest on different soil types:

- understorey mortality and *P. radiata* deaths, $r = 0.73$ N.S.
- understorey mortality and decline of jarrah overstorey and *P. radiata* deaths, $r = 0.12$ N.S.
- jarrah overstorey mortality and *P. radiata* deaths, $r = 0.51$ N.S.

[1] See Appendix 1 for a fuller description of the soil types.

[2] *P. radiata* was planted in 1974 and 1976, and deaths were recorded in 1980 and 1981.

[3] Only sites where decline and mortality were evident were included.

DISCUSSION AND CONCLUSIONS

Mortalities of both *P. radiata* and *E. marginata* were greatest on the silty loams along the valley floors. This suggests the impact of disease caused by *Phytophthora cinnamomi* is greater on this soil type than on others. The silty loams, being low in the valley profile, are moist for long periods of the year, offering ample opportunity for activity by the fungus (Shea, 1975).

The decline of *Pinus radiata* associated with infection by *Phytophthora cinnamomi* has been found to be more pronounced on sites with poor internal drainage, and subject to waterlogging (Jehne, 1970, 1971; Davison and Bumbieris, 1973; Bumbieris, 1976). The low incidence of understorey mortality observed in the Sunklands on the silty-clay loams may be attributed to the death of many susceptible species, infected with *P. cinnamomi* , some time before this study was initiated.

The relatively high mortality rate amongst *Pinus radiata* on the leached loamy sands was not matched by a high incidence of either overstorey or understorey deaths in the native forest. On these sands rapid changes in moisture status occur between seasons. This may lead to the young pine being placed under greater stress here than on some other soil types, and therefore, to it succumbing more readily following infection. In contrast to the results of this survey, the impact of *Phytophthora cinnamomi* on native forest is considered to be high on the leached sands of the northern jarrah forest (J. Havel, personal communication*).

Only a small area planted with *Pinus radiata* in the Sunkland is on silty-clay loams. The leached loamy sands, however, are one of the major soil types being planted. This study indicates that measures to reduce the impact of *Phytophthora cinnamomi* on *Pinus radiata* should be especially concentrated on the leached loamy sands where jarrah dieback disease is known to have occurred in the native forest. Areas affected by dieback disease, on other soil types, should also receive attention.

Some measures currently under trial might be applied to these areas.

Pine genotypes which tolerate infection with *Phytophthora cinnamomi* (Butcher *et. al.*, in press) are now being established in the plantations.

A dense canopy in the pine forest may also inhibit sporulation and movement of *P. cinnamomi* by creating unfavourable soil temperature and moisture conditions (Shea, 1975), particularly in areas of marginal susceptibility. However, very conservative thinning regimes would be necessary to maintain such an environment.

ACKNOWLEDGEMENTS

I would like to thank G. McCutcheon who provided data from his surveys; the Aerial Photography Interpretation Section of the Forests Department of Western Australia, who carried out the aerial photography; J. Kruger, who helped to process the data; and A. Cribb, who edited the paper.

REFERENCES

Bumbieris, M. (1976). The role of *Phytophthora cryptogea* and waterlogging in a Decline of *Pinus radiata*. *Australian Journal of Botany*, 24, 703-9.

Butcher, T.B., Stukely, M.J.C. and Chester, G.W. (1983). Genetic variation in resistance of *Pinus radiata* to *Phytophthora cinnamomi*. *Forest Ecology and Management*, (in press).

Chevis, H.W. and Stukely, M.J.C. (1982). Mortalities of young established radiata pine associated with *Phytophthora* spp. in the Donnybrook Sunkland plantations in Western Australia. *Australian Forestry*, 45, 3, 193-200.

Davison, E.M. and Bumbieris, M. (1973). *Phytophthora* and *Pythium* spp. from pine plantations in South Australia. *Australian Journal of Biological Sciences*, 26, 1, 163-9.

Jehne, W. (1970). The occurrence of *Phytophthora cinnamomi* and tree dieback in the A.C.T. *Australian Forest Research*, 5, 1, 47-52.

Jehne, W. (1971). Soil conditions and the occurrence of *Phytophthora cinnamomi* in relation to deaths in young plantations of radiata pine near Jervis Bay. *Australian Forest Research*, 5, 3, 39-46.

---

* J. Havel, Officer of the Forests Department of Western Australia, Como.

McCutcheon, G.S. (1978). Broadscale forest site survey techniques used in the Donnybrook Sunkland. *Research Paper 48*, Forests Department of Western Australia.

McCutcheon, G.S. (1980). Field classification of vegetation types as an aid to soil survey. *Research Paper 57*, Forests Department of Western Australia.

Podger, F.D. (1972). *Phytophthora cinnamomi*, a cause of lethal disease in indigenous plant communities in Western Australia. *Phytopathology*, 62, 9, 972-81.

Shea, S. R. (1975). Environmental factors of the northern jarrah forest in relation to pathogenicity and survival of *Phytophthora cinnamomi*. *Bulletin 85*, Forests Department of Western Australia.

Smith, R. (1951). Soils of the Margaret and Lower Blackwood Rivers, W.A. *Bulletin 262*, C.S.I.R.O., Australia.

APPENDIX 1

Description of the soil types*of the Donnybrook Sunkland

Type 1 - Laterite

Any soil containing more than 20% by volume of hard lateritic gravel within 20 cm of the surface. This category includes boulder laterites.

Type 2 - Shallow Sands

Loamy sands between 20 and 50 cm deep, above soil containing considerably more than 20% gravel by volume or massive laterite. The colour of the sand may be yellowish brown or greyish.

Type 3 - Yellowish Brown Sands Deeper Than 50 cm

The texture is loamy sand, or sand, above a depth of 50 cm, but may be heavier at greater depth. There may be up to 20% by volume of gravel, usually fine or medium, in the upper 50 cm. The underlying material is usually heavy gravel or massive laterite, rarely clay. There is occasionally a thin layer, continuous or fragmentary, of accumulated organic matter (A_3 horizon).

Type 4 - Greyish Brown Sands Deeper Than 50 cm

The texture may be loamy sand, or sand, and the colour may range from light grey to dark grey or dark greyish brown. There is commonly an A_3 horizon with an upper limit between 60 cm and 100 cm below the surface. In most cases this forms a continuous layer of 'coffee rock', but sometimes it is fragmentary or only a dark brown colour horizon. Its average thickness is about 15 cm. Depth is often limited by an iron-cemented pan, otherwise it is limited by heavy gravel or massive laterite.

Type 5 - Loamy Soils

The texture in the upper A_2 horizon is usually at least sandy loam, but some profiles with loamy sand at this level are admitted because the texture becomes sandy loam or heavier within 60 cm of the surface. The colour is most commonly light yellowish brown or yellowish brown, but in some cases is light greyish brown.

In these soils the gravel content is generally less than 10%, above a limiting horizon containing approximately 50% gravel. A soil containing gravel may be classified as Type 5 provided that the proportion of gravel within 20 cm of the surface is less than 20% by volume. In most cases, however, there is no gravel and the limiting horizon is clay. The depth may vary greatly.

Type 7 - 'Alluvial' Soils

These soils are usually associated with watercourses. Colours are brownish yellow, strong brown or yellowish red.

The texture in the upper A_2 horizon is usually silty loam, silty-clay loam or sandy loam. It may become heavier with increasing depth. Up to 20% by volume of gravel may be present in some profiles; it is usually fine gravel.

Depth is usually 75 to 120 cm with laterite as the limiting horizon. Where clay texture is considered the limiting horizon, depth may be as little as 35 cm.

* Colours: Munsell Colour Company (1954). Munsell Soil Colour Charts: Baltimore, Maryland, U.S.A.