PHYTOPHTHORA SPP. IN INDIGENOUS FORESTS IN AUSTRALIA

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ABSTRACT

Indigenous forests in Australia are managed primarily for timber production, water production, and conservation. Soil infestation by *Phytophthora* spp. has the potential to affect all of these. Infestation is widespread but is perceived to affect timber production only in the mixed species eucalypt forests in Victoria and the *Eucalyptus marginata* Donn ex Sm. (jarrah) forest in Western Australia. It is known to affect water production in Western Australia. As *Phytophthora* spp. have a very wide host range, site infestation leads to vegetation changes which reduce the conservation value of indigenous forests and similar plant communities in southern Australia.

Keywords: rainforest; timber production; water production; conservation; *Phytophthora cinnamomi.*

INTRODUCTION

Native forest in Australia is defined as "land dominated by trees with an existing or potential mature height of twenty metres or more, including native stands of cypress pine in commercial use regardless of height" (Australian Bureau of Statistics 1988). The area of native forest was estimated as 41.3×10^6 ha in June 1986. Of this area, 27% is privately owned, 30% is State forest managed for multiple use including wood production, 12% is national parks, while the remaining 31% is vacant Crown land or occupied under lease. The main forest types are rainforest, eucalypt forest of different productivity classes, tropical eucalypt and paperbark, and cypress pine (Fig. 1) (Australian Bureau of Statistics 1988). This paper deals only with rainforest and eucalypt forest types.

Podger *et al.* (1965) showed that jarrah dieback in Western Australia was associated with forest sites infested with the soil-borne, pathogenic fungus *Phytophthora cinnamomi* Rands. Since that time, particularly during the 1970s, *P. cinnamomi* and other *Phytophthora* spp. have dominated forest pathology in Australia. Conferences devoted almost entirely to *Phytophthora*-related eucalypt diebacks were held in 1973 and 1978 (Marks & Idczak 1975; Old 1979). There have been numerous verbal presentations at meetings of the Australasian Plant Pathology Society and A.N.Z.A.A.S., many published papers in scientific journals, and two major reviews (Newhook & Podger 1972; Weste & Marks 1987). There is, however, very little published information on the economic effects of site infestation.

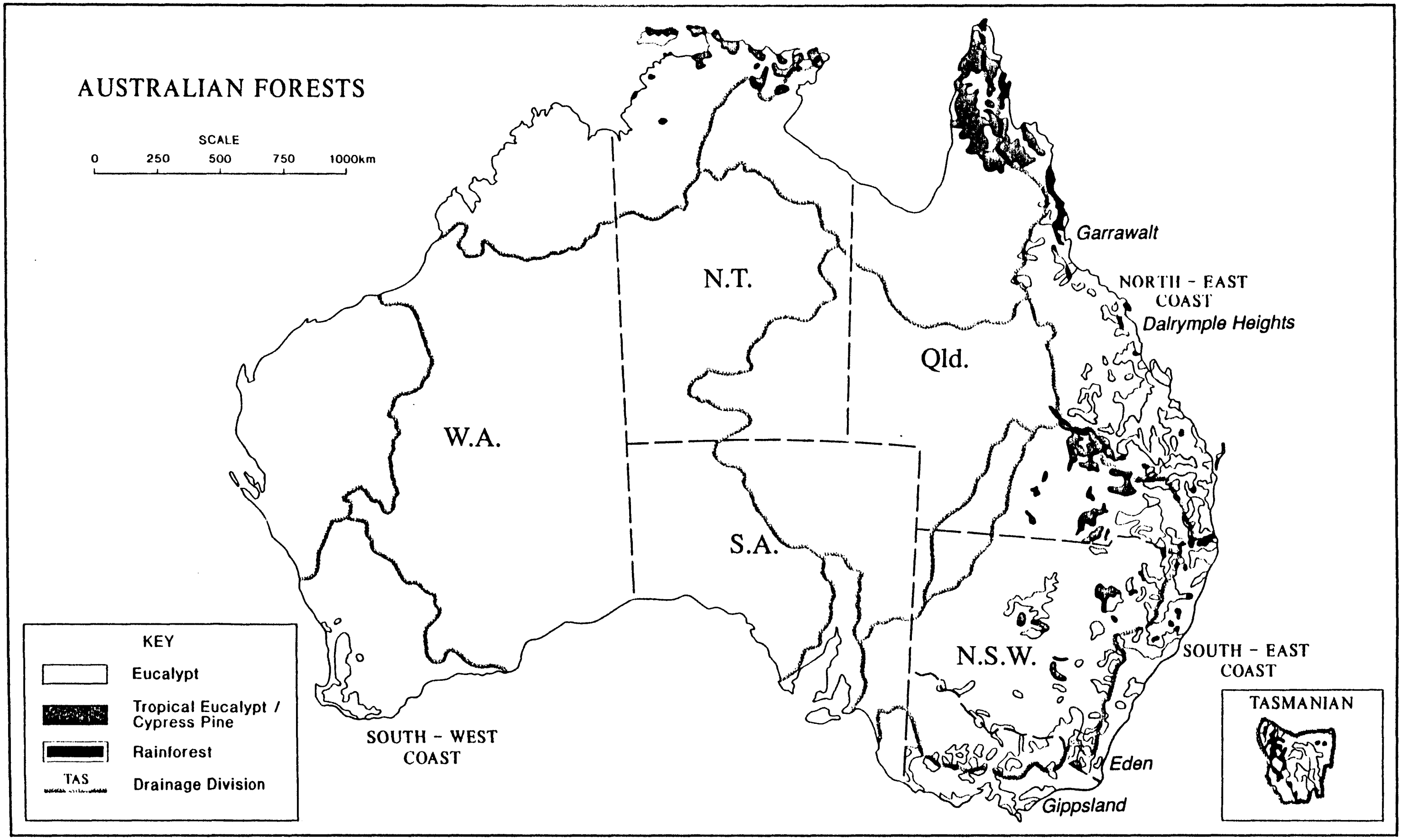

FIG. 1 — Distribution of indigenous forests and drainage divisions in Australia (modified from Forwood map 1974 and Australian Bureau of Statistics 1988).

Indigenous forests in Australia are managed for timber production, water production, and conservation; infestation by *Phytophthora* spp. has the potential to affect each of these. Effects on the production of timber and water can be quantified in monetary terms but this cannot be done for conservation values. We have not attempted an economic analysis, but have solicited published and unpublished data from State Government departments in order to review the effect of *Phytophthora* spp. on both commercial production and conservation values.

TIMBER PRODUCTION

There are many ways in which *Phytophthora* spp. could affect timber production in native forest. As the species which infest these forests are soil borne, they can be spread widely in dirt adhering to heavy machinery, in roading gravel, and in water (Batini 1973; Weste 1974; Weste & Taylor 1971). We would expect regeneration to be reduced on infested sites because these fungi are important nursery pathogens (Baker 1957). They also cause phloem cankers in the roots (Tippett *et al.* 1983; Marks *et al.* 1981) so that if infection is sufficiently extensive tree growth will be reduced. There is increased tree mortality on infested sites, especially on poorly drained areas after exceptionally heavy rainfall (Tregonning & Fagg 1984; Podger *et al.* 1965). *Phytophthora cinnamomi* can break down lignin (Casares *et al.* 1986), so that if the stem is invaded from a colonised root system timber quality could be reduced. Thus *Phytophthora* spp. are often widely distributed; where they occur we would expect regeneration and tree growth to be less than in uninfested forest, while we would expect tree mortality to be greater and there might be some reduction in wood quality.

In Queensland 11 *Phytophthora* spp. have been recorded from tropical rainforest. Only *P. cinnamomi* and *P. heveae* Thompson are widespread. In only two areas, however, in tropical rainforest at Garrawalt and Dalrymple Heights, is site infestation associated with significant tree mortality. In the worst area 20% of 640 ha is severely affected (Brown 1976; B.N. Brown, Department of Forestry, Queensland, pers. comm.). Although tree mortality in the rich, rainforest flora may be extensive, sample sizes of individual species are usually too low to make comparisons. Where comparisons have been made, the only commercial species which show very high losses are *Cinnamomum oliveri* F.M. Bail. (camphorwood), *Carnarvonia araliifolia* F. Muell. (red oak), and *Cryptocarya cinnamomifolia* Benth. Although tree growth has been measured, it is too slow to assess whether it is affected by *Phytophthora* spp. No data have been collected on the effect of *Phytophthora* spp. on regeneration or wood quality (B.N. Brown, pers. comm.).

In New South Wales, *P. cinnamomi* and other *Phytophthora* spp. are widespread in the eastern part of the State, including the forested areas (Pratt & Heather 1973a; Gerrettson-Cornell & Dowden 1978). Symptoms of decline and dieback, however, are rare (L. Gerrettson-Cornell, Forestry Commission of N.S.W., pers. comm.). When stands are logged, the increased soil moisture and higher soil temperatures which would be expected to result from a more open canopy may favour both the sporulation and spread of *Phytophthora* spp. (Christensen 1975). Yet during and after an integrated logging operation at Eden of the susceptible species *Eucalyptus sieberi* L. Johnson (silvertop ash), *E. agglomerata* Maiden, and *E. muelleriana* Howitt, there was no increase in seedling mortality due to *P. cinnamomi* compared with a matched stand which remained unlogged (Bridges *et al.* 1980). In New South Wales *Phytophthora* spp. are regarded as common soil inhabitants which have had no effect on timber production (L. Gerrettson-Cornell, pers. comm.).

In Victoria the mixed species eucalypt forests of the foothills and coasts occupy 3.7 $\times$ 10^6 ha, about 80% of both the public hardwood forests and the area designated for timber production (Department of Conservation, Forests and Lands 1986). *Phytophthora cinnamomi* is widespread throughout these forests (G.C. Marks, Department of Conservation, Forests and Lands, Victoria, pers. comm.). Crown decline and death of several species of eucalypts occurs on poorly drained, infested sites when exceptionally heavy rainfall is followed by a dry period, e.g., in 1952–53 and 1970–71 (Marks *et al.* 1972). In the Gippsland forests the commercial eucalypts which show most severe symptoms are *E. sieberi* and the stringybarks *E. obliqua* L'Herit, *E. baxteri* (Benth.) Maiden et Blakely, *E. globoidea* Blakely, *E. macrorhyncha* F. Muell. ex Benth., and *E. muelleriana* (Featherstone 1985). *Eucalyptus sieberi* is a heavy seeding, shade-intolerant, fast-growing species which has extended its range in the wake of logging and wildfires. The stringybarks too have increased their range, so that the present composition of the forest is different from that which occurred before commercial exploitation (Featherstone 1985).

Ward & McKimm (1982) carried out an aerial and ground survey of approximately 253 000 ha of coastal forests in East Gippsland and located about 300 patches of crown dieback which totalled 6000 ha (2.4% of the total area). These patches were generally associated with flat sites and poorly drained soils where *E. sieberi* and *E. globoidea* were the dominant species. These dieback sites were usually infested with *P. cinnamomi.*

In the East Gippsland forest, establishment and early growth of eucalypt species including *E. sieberi*, is satisfactory on infested sites, including those areas where mature trees had exhibited severe symptoms (Fagg 1987). On well-drained sites in these forests the gross basal area increment of *E. sieberi* stands is not affected by the presence of *P. cinnamomi* (Incoll & Fagg 1975). Effects on growth have not been measured on poorly drained soils because of the difficulty of finding uninfested areas (G.C. Marks, pers. comm.). Past management practice has made it difficult to assess production losses associated with infestation by *P. cinnamomi* in the coastal forests of East Gippsland, but it has been estimated that mortality over a 5-year period has reduced sawlog and pulpwood volumes by 6.6% and 10.3% respectively (Marks & Smith in prep.). There is no effect on timber quality (G.C. Marks, pers. comm.).

Knowledge of *Phytophthora* spp. in other eucalypt forests in Victoria is more limited. The most productive forests are the high-altitude ash forests where *Phytophthora* spp. are present only in very disturbed areas (G.C. Marks, pers. comm.). Where sites have been deliberately infested, colonisation is slow and seedling damage negligible (Kassaby et al. 1975). The infestation status of the red gum (*E. camaldulensis* Dehnh.) and box-ironbark forests is not known (G.C. Marks, pers. comm.).

In Tasmania *P. cinnamomi* is widespread but is not regarded as a problem in production forestry. Tree mortality and crown decline are restricted to *E. sieberi* and *E. obliqua* growing in poorly drained, infested areas on the east coast. Significant damage has occurred on only 13.5 ha of this forest type (T. Wardlaw, Forestry Commission of Tasmania, pers. comm.). Wardlaw & Palzer (1988) followed the regeneration of an infested area seeded and planted with a mixture of the susceptible *E. sieberi* and *E. obliqua* together with field-resistant *E. globulus* Labill. (southern blue gum) and *E. viminalis* Labill. (manna gum) over 10 years. They found that *E. sieberi* and *E. obliqua* regenerated on both well-drained and poorly drained infested sites. After 10 years both species were taller than the field-resistant *E. globulus* and *E. viminalis.* There is no information on either the effect of *P. cinnamomi* on the growth of mature forests or on wood quality (T. Wardlaw, pers. comm.).

In the Australian Capital Territory *P. cinnamomi* is the main species of concern, but there are no productive indigenous forests in this Territory (F. Ingwersen, Department of Territories, A.C.T., pers. comm.). Similarly, in South Australia *P. cinnamomi* and *P. cryptogea* Pethybridge & Lafferty are present in pine plantations (Davison & Bumbieris 1973) but there are no commercial indigenous forests in this State. In the Northern Territory *P. cinnamomi* is associated with the decline and death of *E. tetradonta* F. Muell. (Darwin stringybark) but this is not in commercially productive forest (Weste 1983).

In Western Australia the commercially exploited indigenous forests cover an area of about 1.6×10^6 ha. Where the forest is infested by *Phytophthora* spp. many midstorey and understorey species are killed and the economically important *E. marginata* (jarrah) may die. It was in these forests in the 1960s that Podger showed that jarrah dieback was associated with site infestation by *P. cinnamomi* (Podger *et al.* 1965). Podger's data showed high mortality and very slow growth of jarrah in infested areas; as jarrah is slow growing anyway, productivity of infested sites was believed to be virtually nil (Podger 1972). Contemporary observations in the late 1940s and mid 1960s indicated almost complete jarrah mortality in some infested areas. In the following years investigations therefore concentrated on minimising the spread of *P. cinnamomi*, mapping its distribution, and studying its biology (e.g., Batini 1973; Christensen 1975; Shea 1975; Shea & Dillon 1980; Shea *et al.* 1978; Shea *et al.* 1980).

The commonest species of *Phytophthora* is *P. cinnamomi*, but *P. citricola* Sawada, *P. cryptogea, P. megasperma* Drechs. var. *sojae* Hildebrand, and *P. nicotianae* Breda de Haan also occur (Shearer *et al.* 1987). In many sites infested areas are clearly demarcated by recent deaths of common susceptible species such as *Banksia grandis* Willd., as well as changes in the composition of the midstorey and understory. These changes can be recognised on shadow-less aerial photographs and, together with "ground truthing", have been used since 1978 to map the distribution of *Phytophthora* spp. in the jarrah forest (Brandis 1983). Of the 225 000 ha which have been surveyed so far, 14.2% is infested (H. Campbell, Department of Conservation and Land Management, Western Australia, pers. comm.). Within infested areas jarrah mortality is both patchy and sporadic, occurring on water-gaining sites or on soils with impeded drainage (Podger *et al.* 1965) after exceptionally heavy winter or summer rainfall, e.g., late 1940s, late 1950s, 1964, 1973, and 1982 (Davison 1988). Podger (1972) stated that jarrah mortality was 1.7% and 5% per year in two localities, but Davison (unpubl. data) using shadow-less aerial photography has found much lower mortality rates. In a survey of over 130 000 ha, photographed between 1978 and 1983, the mortality rate in infested forest (14% of the total area) was 23.4 trees/1000 ha in the 6 months prior to photography, or less than 0.05 trees/ha/year. This is about three times the mortality rate in uninfested forest. Measurements of the crown diameter of recently dead trees showed that about half of these deaths on both infested and uninfested sites were of saplings and small poles.

There have been no studies which have looked specifically at jarrah regeneration on infested sites, but as part of a wider survey G.J. Strelein (Department of Conservation and Land Management, Western Australia, pers. comm.) did not find that regeneration was consistently less than on comparable uninfested sites in three southern forest blocks. The situation in the northern jarrah forest may be different. Where jarrah has been replanted on rehabilitated mine sites which are assumed to be infested, survival has been greater than 85% in well-drained soils but lower on water-gaining sites (I.J. Colquhoun, Alcoa of Australia Ltd, pers. comm.). Jarrah seedlings are very sensitive to waterlogging (Davison & Tay 1985) and this species does not usually occur in such areas (Havel 1975).

There are no long-term, increment plot data on jarrah growth on infested sites (H. Campbell, pers. comm.), but measurements with dendrometers have been made by Podger (1972) and Davison & Tay (1988, and unpubl. data). Podger (1972) recorded a mean girth increment of 0.8 mm/year in an infested site compared with 6.3 mm/year in nearby uninfested forest. Davison & Tay (1988, and unpubl. data), however, found no reduction in girth increment and on one site found the trees in the infested area were growing faster than trees of similar girth in the adjacent uninfested forest. This was interpreted as a response to reduced competition due to midstorey and understorey death and salvage logging. Plot data would probably resolve these differences.

Wood from dead jarrah trees on infested sites checks more than timber from live trees, but there are no consistent differences in moisture content and cleavage strength between wood from infested and uninfested sites (Mackay & Campbell 1976).

CONSERVATION VALUES

Since European settlement much of the indigenous vegetation has been cleared for agriculture in the higher rainfall areas of Australia. The native forests which remain are a major reservoir for the indigenous flora and fauna; 12% of this forest area is national park (Australian Bureau of Statistics 1988).

Many soil-borne *Phytophthora* spp., and in particular *P. cinnamomi,* have a very wide host range (Zentmyer 1980). Members of the plant families Dilleniaceae, Epacridaceae, Lauraceae, Myrtaceae, Papilionaceae, Proteaceae, and Xanthorrhoeaceae are particularly susceptible so that site infestation can lead to reduced vigour and death of many plant species. Infestation may therefore lead to vegetation changes which will in turn affect both the dependent fauna and the physical conditions of the site. Thus infestation will irreparably reduce the conservation value of an area.

In Queensland there are two areas (Dalrymple Heights and Garrawalt) where site infestation by *P. cinnamomi* is associated with patches of dead and dying rainforest. These areas are in both State forest and national parks. Field studies have shown that the most susceptible rainforest species are from the family Lauraceae (B.N. Brown, pers. comm.).

In New South Wales *P. cinnamomi* was first associated with occasional deaths of native plants near Sydney in 1948 (Newhook & Podger 1972). In a survey Pratt & Heather (1973b) showed that *P. cinnamomi* was associated with disease symptoms in the understorey in eight out of 13 sites sampled in forested areas of New South Wales, although it was also present in sites where symptoms were absent.

The most comprehensive studies on vegetation changes after site infestation have been made in Victoria by Weste and her co-workers. These changes have been documented in forests and woodlands of the Brisbane and Otway Ranges, Grampians, Wilson's Promontory, and the northern foothills of the Great Dividing Range (e.g., Dawson *et al.* 1985; Kennedy & Weste 1986; Weste 1980, 1981, 1986). Many of these areas are national parks. In the Brisbane Ranges and Grampians, infestation resulted in a reduced overstorey of trees with thin crowns. Susceptible understorey species died and were replaced by Poaceae, Cyperaceae, and Restionaceae (Kennedy & Weste 1986; Weste 1986). The impact of *P. cinnamomi* in dry sclerophyll forest on krasnozem of the northern foothills of the Great Dividing Range was not as severe as in forest in the Brisbane Ranges and Grampians (Weste 1980).

Vegetation complexes from which *P. cinnamomi* is likely to eliminate susceptible plant species occupy 72% of the Grampians forests (Kennedy & Weste 1986). Of the 108 plant species assessed on seven sites, 50 were susceptible, including plant species endemic to the region. Susceptible plant species of the Proteaceae, Epacridaceae, Dilleniaceae, and Papilionaceae provide pollen, nectar, and seed for many birds and mammals and their replacement by grasses and sedges affects fauna communities. The geographically restricted mammal *Pseudomys shortridgei* (Thomas) (blunt-faced native mouse) needs floristically rich plant communities for survival (Kennedy & Weste 1986).

In Tasmania infestation by *P. cinnamomi* affects the conservation value of the implicate type of rainforest in the west, and dry sclerophyll forest in the east of the State. In both types the main effect is on the understorey species. In the implicate rainforest, mortality of susceptible species occurs only on sites which have been disturbed, e.g., by mining exploration, logging, and wildfire. On nutritionally poor sites, regeneration after disturbance can be slow, so that if *P. cinnamomi* is also present susceptible species may be unable to re-establish. There is no information on the long-term impact of *Phytophthora* spp. infestation (T. Wardlaw, pers. comm.).

In the dry sclerophyll forests in eastern Tasmania, *P. cinnamomi* infestation of site with a shrubby understorey results in mortality of many species. As in Victoria, members of the Epacridaceae, Papilionaceae, Proteaceae, and Xanthorrhoeaceae are particularly susceptible. These susceptible understorey communities occur on doleritic and granitic soils as well as on sands and sediments (T. Wardlaw, pers. comm.).

In Western Australia vegetation changes in the midstorey and understorey are used to map the distribution of *Phytophthora* spp. in the jarrah forest (Brandis 1983). Podger (1968) found that the greatest mortality was in members of the Proteaceae, Papilionaceae, and Dilleniaceae, but no further assessments have been undertaken. Host lists for *P. cinnamomi* have been compiled by Titze & Palzer (1969) from their own isolation records, from pathogenicity tests, and from the literature, and by Gardner & Rokich (1987) from isolation records. Little is known of the host range of other *Phytophthora* spp.

In some areas, infestation has resulted in a more open forest with sedge-dominated understorey. These vegetation changes affect the endemic fauna. Species characteristic of open areas such as *Meropus ornatus* Latham (rainbow bee eater), *Lalage sueurii* (Vieillot) (white winged triller), and reptiles become more common, while those species such as the skink *Lerista distinguenda* Werner, which require deep litter, or those such as *Malurus splendens* (Quoy & Gaimard) (splendid fairy-wren), *Melithreptus lunatus* (Vieillot) (white-naped honeyeater), and *Climacteris rufa* Gould (rufous tree-creeper) which require dense cover, will be disadvantaged (Nichols & Muir 1989). Abbott & Van Heurck (1985), however, found that silvicultural treatments which simulated some of the effects of infestation by *Phytophthora* spp. had no effect on bird communities.

Phytophthora cinnamomi infestation is a major factor affecting the size and location of flora reserves in the jarrah forest (Havel 1989). Flora reserves need to be upslope of existing infestations since the most rapid spread of the pathogen is downslope and most lowland areas are already infested. Thus vegetation complexes in upper landscape positions are much easier to protect than those low in the landscape.

WATER PRODUCTION

Rain is the most important factor determining land use in Australia. Its effectiveness is greatly reduced by its marked seasonality and irregularity. Urban and industrial development as well as irrigation for agriculture depend on reliable sources of water from surface storage.

Australia is divided into a number of drainage divisions (Fig. 1). Rainforest and eucalypt forest occupy a significant portion of four of these—namely, the North-east Coast, South-east Coast, Tasmania, and South-west Coast Divisions (Australian Bureau of Statistics 1988). Some data on the water use within these divisions are given in Table 1.

TABLE 1—Water use in the drainage divisions containing a substantial area of indigenous forest (from Australian Bureau of Statistics 1988)

Drainage division	Total water use 1983–84 (gigalitres)	Proportion of water use (%)		
		Irrigation	Urban/Industrial	Rural
North-east coast	1657	58.3	32.7	9.0
South-east coast	2528	40.5	53.8	5.7
Tasmania	174	55.7	37.9	6.3
South-west coast	678	39.2	56.3	4.4

A reduction in the vegetation density of major catchments will increase the volume of run-off water because of reduced interception and evapotranspiration. Increased run-off, however, may result in increased erosion and lower water quality due to turbidity. If there is salt in the soil profile, a rising water table may also lead to increased salinity in the surface water system. As infestation of native forest by *Phytophthora* spp. may lead to reduced vegetation density, effects on water production need to be considered.

As has already been discussed, vegetation changes associated with forest infestation by *Phytophthora* spp. in Queensland, New South Wales, and Tasmania are either of a limited extent, considered to be unimportant, or do not occur in major catchments. Infestation is therefore unlikely to affect either the quantity or the quality of water. In Victoria the major water supply catchments are not located in the Gippsland forests where the concern about *Phytophthora* spp. infestation is greatest. Many catchments are located in the high altitude, wet sclerophyll forests where colonisation by *P. cinnamomi* is slow and damage to eucalypt seedlings negligible (Kassaby *et al.* 1975).

Most of the population of Western Australia live in the South-west Coast Drainage Division. Land use in this area consists of uncleared forest, woodland, and sandplain as well as cleared agricultural land. About 40% of the surface water in this division is brackish or saline as a result of agricultural clearing (Schofield *et al.* 1988; Australian Bureau of Statistics 1988). As most of the readily accessible water resources of the area have already been developed, further population growth depends on providing additional supplies of good quality water. Within this drainage division annual rainfall decreases from west to east but salt stored in the profile increases with decreasing rainfall. Decreased vegetation cover will reduce interception and evapotranspiration and result in increased surface run-off and ground water recharge. Increased surface run-off results in a larger volume of water, but rising ground water will mobilise salt in the profile so that salt discharge into streams may increase. If this salt discharge is not balanced by surface run-off, the surface water will become more saline (Borg *et al.* 1988).

The jarrah forest is the largest area of uncleared vegetation in this drainage division. The western part of the forest has a high rainfall (up to 1300 mm/year) and a low salt store. Reducing vegetation here will increase run-off without increasing salinity. However, the eastern part of the forest has a lower rainfall (less than 800 mm/year) and higher salt store. Increased surface run-off resulting from reduced vegetation in this area will be insufficient to balance increased salt discharge, so that streamflow will become more saline (Stokes & Loh 1982; Water Authority of Western Australia 1987).

Jarrah mortality on infested sites is both patchy and sporadic. The mortality rate between 1978 and 1983 has been estimated as less than 0.05 trees/ha/year. During this time, jarrah mortality will therefore have had a negligible effect on both quantity and quality of water within a major catchment. The small tree *Banksia grandis*, which is common in the wetter western parts of the forest (Havel 1975), may be completely eliminated on infested sites. Greenwood *et al.* (1985) estimated that evapotranspiration from *B. grandis* was 16% of the annual rainfall; thus infestation could result in a larger quantity of high-quality surface water. Batini *et al.* (1980) calculated that water yield in a 146-km^2 catchment in the western part of the forest, would increase by 11–25% for each additional 1000-ha increase in infested forest.

In the eastern forest *Banksia* spp. are much less common, but there are other susceptible species in the midstorey and understorey. It is not known what vegetation changes will occur after site infestation and if, and by how much, these will increase the salinity of water produced by catchments in these low rainfall areas.

CONCLUSION

When jarrah dieback was shown to be associated with site infestation by *P. cinnamomi* there was immediate concern that, if this fungus was introduced into other areas of indigenous forests in Australia, timber production would be significantly reduced. Extensive surveys carried out in the late 1960s and 1970s showed that *Phytophthora cinnamomi* was widespread in the forests of eastern Australia. In most places its presence was not associated with production losses. It is only in the mixed species forests of Victoria and the jarrah forest of Western Australia that *Phytophthora* spp. infestation is still seen as an important problem. In the Gippsland forests the tree species causing greatest concern are those which have replaced the original forest since commercial exploitation. Quantification of losses in these forests is difficult because of changing species composition and past logging practice. In Western Australia limited measurements made in the 1960s indicated that serious production losses would follow site infestation; however, detailed measurements for estimating the effect of *P. cinnamomi* on commercial timber production have not been made.

Effects of *Phytophthora* spp. on water production are of concern only in Western Australia. Infestation of the wetter western part of the forest has increased the yield of potable water. We do not know whether infestation of the eastern forest with its high salt store will increase the salinity of surface water.

It is on conservation values that *Phytophthora* spp. have had the greatest impact. In southern Australia site infestation reduces the diversity of the midstorey and understorey. Some susceptible species which are common today, e.g., *Banksia grandis* and *Persoonia longifolia* R.Br. in the south-west, and *Xanthorrhoea australis* R.Br. in the south-east, may become rare and endangered in the future. As infestation does not stop at forest boundaries, areas of indigenous woodland, heath, and sandplain are equally threatened.

During the past 25 years the public has shown an increased awareness of and interest in the management of indigenous forests. Their role in conserving the unique flora and fauna of the higher rainfall areas of Australia is well recognised. It is this conservation role which is primarily threatened by *Phytophthora* spp. infestation.

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