Chapter 8

DIEBACK DISEASE AND OTHER PHYTOPHTHORA SPECIES IN THE NORTHERN KWONGAN

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Abstract

Phytophthora cinnamomi and other Phytophthora species are having a major detrimental effect on the vegetation and associated fauna of many national parks and other conservation reserves in southern Australia. In the northern kwongan studies on the extent of these plant diseases commenced only recently, but it is known that five types of Phytophthora occur there, with P. cinnamomi having recently been found near Eneabba. One infection of Phytophthora citricola has been found within the Lesueur Area, beside Cockleshell Gully Road.

Dieback disease caused by Phytophthora species would have a major impact if introduced because of the suitable climate, the abundance of susceptible plant species and vegetation types and the type of soils present. The probability of introduction of Phytophthora is high when extensive use of earth-moving equipment and vehicles takes place in a highly susceptible area, even if high standards of hygiene are maintained. If introduced, the impact of Phytophthora could be extensive, because of the high proportion of susceptible vegetation types and plant species.

8.1 BACKGROUND

Over the past 25 years, a devastating epidemic has swept through the indigenous vegetation of many national parks and reserves in southern Australia (Newhook and Podger 1972). The epidemic is caused by *Phytophthora cinnamomi*, an introduced, soil-borne fungus. In Western Australia, *P. cinnamomi* (known locally as jarrah dieback disease) kills more than 150 native species (J.T. Tippett unpublished); world-wide it has been recovered from over 900 plant species (Zentmyer 1980). Recently, in this State, several other taxa of *Phytophthora*, namely *P. citricola*, *P. megasperma* var. *megasperma*, *P. megasperma* var. *sojae*, *P. drechsleri*, *P. cryptogea* (A2) and *P. nicotianae* var. *parasitica*, have been recovered from dying plants in diseased patches of native vegetation (M.S. Stukely and T.C.J. Hill unpublished).

Detailed studies have shown the impact of *P. cinnamomi* to have been particularly severe in four national parks, two in Victoria and two in Western Australia. In Victoria, dry sclerophyll forest and shrubs in the Brisbane Ranges and dry sclerophyll woodlands, heaths and swamps at Wilsons Promontory have been badly affected (Dawson *et al.* 1985; Weste and Law 1972). In Western Australia, the disease is widespread in the Stirling Range and Cape Le Grand National Parks, where it is dramatically changing the composition of jarrah and banksia woodlands, banksia shrublands, thickets and mallee and scrub heaths (R. Wills unpublished; G.J. Keighery unpublished).

In these four parks, the development of the disease, from incipient infection to infestation, has taken only two decades. Introduction and intensification of the disease has been, in each case, directly attributable to the disturbance of the area caused by the construction of roads, tracks and firebreaks and their subsequent use. In the Brisbane Ranges, the disease appeared in 1961, after the gravelling of the major road system (Dawson *et al.* 1985). Its distribution increased dramatically in the following decade, rising from 1% of the area of the park in 1971 to 31% in 1980-81 (Dawson and Weste 1985). Roadworks and subsequent infection of drainage lines were identified as the main vectors of the disease. At Wilsons Promontory, the fungus was probably brought in to the park on fire control equipment in 1962, infecting vegetation at the junction of two firebreaks (Weste and Law 1972). In 1968, gravel from the infected area was used to repair the main access road; by 1972 the disease was well entrenched in several areas of the park. In Western Australia, the construction and gravelling of major roads and fire breaks in the Stirling Range and at Cape Le Grand in the '60s and '70s similarly established the disease in each park. Both are now severely affected.

Table 8.1

Plants, which occur on the Swan Coastal Plain or in the Lesueur area, that are susceptible to infection by Phytophthora species.

Plant Species	Pathogen[2]				
	Pc	Pmm	Pcit	Pd	Pms
Acacia huegelii[1]	**[3]				
Adenanthos cygnorum	*	**	*		
Adenanthos obovata[1]	**				
Allocasuarina fraseriana	*				
Allocasuarina humilis	*				
Andersonia heterophylla	**				
Andersonia lehmanniana	*				
Aotus ericoides[1]	*				
Astroloma sp.	*				
Astroloma xerophyllum	**				
Banksia attenuata	**	**	**	**	
Banksia grandis	*	**			
Banksia ilicifolia	**	**		**	
Banksia laricina	**				
Banksia littoralis[1]	*				
Banksia menziesii	**	*	**	*	
Banksia prionotes		**	**		**
Banksia sphaerocarpa?	*				
Banksia telmatiaea	**				
Beaufortia elegans	**				
Bossiaea eriocarpa[1]	**				
Burtonia conferta[1]	**				
Calothamnus villosus	*		**		
Calytrix flavescens[1]	**				
Calytrix sp.	*				
Conospermum stoechadis	*	*	**		
Conospermum triplinervium	**				
Conostephium pendulum	**				
Dampiera alata[1]	*				
Dampiera linearis[1]	**				
Dasypogon bromeliifolius[1]	*				
Daviesia incrassata[1]	*				
Dryandra nivea[1]	*				
Dryandra sp.		*			
Eremaea pauciflora	**				
Eremaea sp. (large star fruit)		**			
Eucalyptus marginata[1]	*				
Eucalyptus todtiana	*				
Hibbertia acerosa[1]	**				
Hibbertia hypericoides	*				
Hibbertia subvaginata	**	*			

Cont'd...

Plant Species	Pathogen[2]				
	Pc	Pmm	Pcit	Pd	Pms
Hypocalymma robustum[1]	**				
Isopogon buxifolius		**			
Jacksonia eremodendron			**		
Jacksonia floribunda	**				
Lasiopetalum floribundum[1]	**				
Leptospermum ellipticum[1]	*				
Leucopogon australis[1]	**				
Leucopogon conostephioides	**	**		**	
Leucopogon lasiostachyus[1]	**				
Leucopogon polymorphus	*				
Leucopogon propinquus	*				
Lomandra sp.[1]	**				
Lysinema ciliatum	*				
Macrozamia riedlei	*				
Melaleuca scabra	**				
Patersonia occidentalis	*	*			
Petophile drummondii	**				
Petrophile linearis	*	*			
Petrophile striata[1]	*				
Phlebocarya ciliata		**			
Scholtzia involucrata	**	**			
Stirlingia latifolia	*		**		
Thomasia grandiflora[1]	**				
Thryptomene saxicola	*				
Verticordia densiflora[1]	**				
Verticordia huegelii[1]	**				
Verticordia nitens	**				
Xanthorrhoea gracilis[1]	*				
Xanthorrhoea preissii	*	*			
Xylomelum occidentale[1]	*				

[1]Data from Podger (1968). Unless confirmed by direct root plating, only those species that were rated as severely affected by the disease were included in the table.

2Pc = Phytophthora cinnamomi, Pmm = Phytophthora megasperma var. megasperma, Pcit = Phytophthora citricola, Pd = Phytophthora drechsleri, Pms = Phytophthora megasperma var. sojae.

3* = susceptibility determined from visual symptoms, ** = susceptibility confirmed by recovery of the fungus from infected plants (direct root plating).

8.2 *PHYTOPHTHORA* SPECIES NORTH OF PERTH

In May 1989, *Phytophthora cinnamomi* was recovered from dying vegetation near Eneabba. This is the only known outbreak of *P. cinnamomi* north of the Moore River, a distance of over 150 km. The Lesueur Area is situated 20 km to the south of the diseased site. Four other *Phytophthora* taxa are also known to occur in the northern kwongan. Current knowledge of the distribution and impact of each species is outlined below.

8.21 *Phytophthora cinnamomi*

Phytophthora cinnamomi is widely distributed in, and is a major threat to the banksia woodlands that surround Perth (Shearer and Hill 1989). It destroys the structure and diversity of the woodland, killing most of the overstorey and shrub layer in affected areas. Species that have been recorded as susceptible to *P. cinnamomi* on the Swan Coastal Plain and the Lesueur area are listed in Table 8.1. *Phytophthora cinnamomi* causes greatest impact among species that belong to the families Proteaceae, Epacridaceae, Myrtaceae, Dilleniaceae, Papilionaceae and Xanthorrhoeaceae. The other *Phytophthora* species attack the same suite of plant families.

The incidence of *P. cinnamomi* infections decreases north of Wanneroo. Only one infection has so far been discovered in the Moore River National Park. At this site, the geographically restricted *Banksia laricina* is being killed.

On the Woodada access road, 5 km west of Eneabba, *P. cinnamomi* has been recovered from a site situated on the wide flood plain of the Eneabba Creek. *Phytophthora cinnamomi* A2 has been isolated from the roots of *Banksia menziesii*, *Banksia telmatiaea* (culture identified by R. Hart), *Conospermum triplinervium* and *Petrophile drummondii*. Another *Phytophthora* species (possibly *P. drechsleri*) has been recovered at the same site, from a dying *Calothamnus hirsutus*. Other affected species include *Stirlingia latifolia*, *Astroloma* sp., *Allocasuarina humilis*, *Verticordia densiflora* and *Thryptomene saxicola*. The mortality rate among susceptible species is moderate to low at present. However, the pattern in similar sites in the region indicated the likeleyhood of an increase in impact following inundation and re-infection of the banks and flood plain each winter. The downstream course of Eneabba Creek, which flows for another 6 km through Lake Logue Reserve before emptying into Lake Logue, must already be infected.

8.22 Other *Phytophthora* species

Current knowledge of the distribution and impact of other *Phytophthora* species in the northern sandplains is summarised in Table 8.2, (species killed are listed in Table 8.1; see Figure 8.1 for location of infections):

Seasonally wet conditions clearly assisted the establishment and impact of all *Phytophthora* species (including *Phytophthora cinnamomi*) at every infection north of Moore River. Sites were low lying and prone to flooding, bordering drainage lines or receiving off-road drainage. At two roadside sites, disease symptoms only appeared after modification of the road verge and resultant ponding of water.

The consistent association of disease with sites prone to seasonally wet conditions cannot be assumed to indicate that the disease will, in future, be confined only to these areas. These sites carry a high risk of infection and so would be expected to be the first to be contaminated. Without knowledge of the age of the infections, the fate of surrounding vegetation can not be predicted. *Phytophthora cinnamomi* in the Moore River National Park also appeared initially in a high risk location (along a creek line), and is now encroaching upon, and destroying, the surrounding banksia woodland. A similar sequence of establishment and expansion was evident in a series of aerial photographs of a large diseased site at Gnangara (Shearer and Hill 1989). *Phytophthora cinnamomi*, associated initially with a strawberry farm before 1942, had, by 1953, contaminated a nearby complex of ephemeral swamps. Subsequent photographs, taken at decade intervals, show the disease fronts slowly (1.1 m/yr), but steadily, advancing upslope into freely drained woodland, killing all banksias and most shrub species in the process.

Little information is available on the comparative virulence of each species against indigenous hosts. Hill (unpublished data) compared lesion lengths produced by three *Phytophthora* species, *P. cinnamomi* (IMI 264384), *P. citricola* (IMI 329667, isolated from *Banksia prionotes* at Badgingarra) and *P. megasperma* var. *megasperma* (IMI 329668, isolated from *Banksia attenuata* at Regans Ford), inoculated into stems of *B. attenuata*. Fifteen stems were wound-inoculated in early September, each with all three isolates at separate points along the stem, and harvested forty two days later. Mean total lesion lengths, for *P. cinnamomi*, *P. citricola* and *P. megasperma* var. *megasperma* were 30.2_a, 25.8_a and 19.1_b cm respectively (dissimilar letters indicate a significant difference between results, $P < 0.05$). *Phytophthora cinnamomi* also grew significantly faster than several other *Phytophthora* species, including *P. citricola*, and *P. megasperma* var.

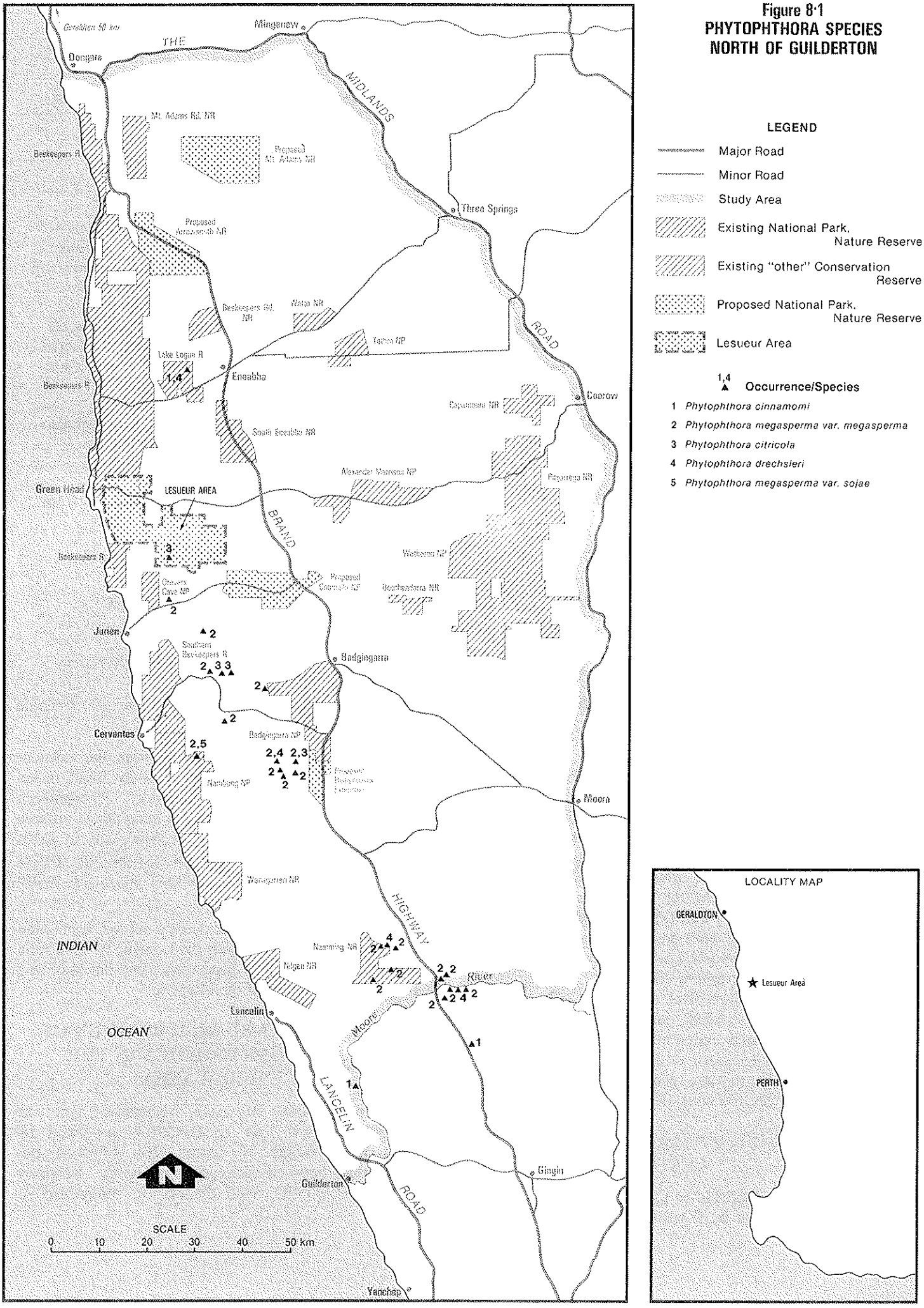

Figure 8·1
PHYTOPHTHORA SPECIES NORTH OF GUILDERTON

LEGEND

- Major Road
- Minor Road
- Study Area
- Existing National Park, Nature Reserve
- Existing "other" Conservation Reserve
- Proposed National Park, Nature Reserve
- Lesueur Area

1,4 ▲ **Occurrence/Species**

1 *Phytophthora cinnamomi*
2 *Phytophthora megasperma var. megasperma*
3 *Phytophthora citricola*
4 *Phytophthora drechsleri*
5 *Phytophthora megasperma var. sojae*

Table 8.2

Distribution and impact of *Phytophthora* species (except *P. cinnamomi*) north of Moore River National Park.

Pathogen	No.[1]	Physiographic regions[2]	Topography[3]	Vegetation Types Affected[4]	Impact
Phytophthora megasperma var. *megasperma*	15	BD, DP(s)	RV(sw), D (sw), DL, F	BLW, BLW(os), SH, LH	Initially only scattered deaths. With succesive winters, impact increases, esp. in overstorey (up to 100%).Single deaths also.
P. citricola	5	BD, DP(s)	RV(sw), D(sw) BLW,	BLW(oh), XH	Single roadside deaths. Small foci with most species affected. Scattered deaths in winter wet depressions.
P. drechsleri	3-4	BD, DP(s), EP?	RV(sw), D (sw), DL	BLW, BLW (os)	Only recovered from sites also infected by other species. Recovered from 3 spp.
P. megasperma var. *sojae*	1	BD	F	LH	Not known. Isolated only from *Banksia prionotes.*

[1]Number of occurrences.

[2]After Playford et al. 1976. BD = Bassendean Dunes, DP(s) = scarp region of the Dandaragan Plateau, EP = Eneabba Plain

[3]RV(sw) = seasonally wet road verges, D(sw) = seasonally wet depressions, DL = drainage lines, F = flood plains·

[4]BLW = banksia low woodland, BLW(os) = open banksia low woodland over sedges, BLW(oh) = open banksia low woodland over heath, SH = scrub heath, LH = low heath, XH = Xanthorrhoea heath (structural classification following Muir 1977).

sojae, in inoculated stems of *Banksia grandis*, though no such disparity occurred in stems of *Eucalyptus marginata* (Shearer *et al.* 1988).

Further variation exists between *Phytophthora* species regarding the types of survival spores they produce and in their tolerance of temperature extremes. *Phytophthora citricola*, *P. megasperma* var. *megasperma* and *P. megasperma* var. *sojae* readily produce thick-walled, desiccation-resistant oospores (sexual spores). On the other hand, *Phytophthora cinnamomi* and *P. drechsleri* only produce oospores when both mating types are present. Only one mating type of *P. cinnamomi* (A2) is prevalent in Western Australia. *Phytophthora cinnamomi* does, however, form an asexual survival spore: the chlamydospore. *Phytophthora drechsleri* possesses an unusually high tolerance to high temperature. A *P. drechsleri* isolate from the Badgingarra area grew well at 35°C, 4°C higher than the maxima recorded for *P. cinnamomi* and *P. citricola* (Shearer *et al.* 1987).

8.3 *PHYTOPHTHORA* SPECIES AT LESUEUR

Few data are available on plant diseases in the Lesueur Area. Research by CALM in the northern kwongan commenced only in 1987, and few data are available from other sources.

There is one known infection within the Lesueur Area. This is beside Cockleshell Gully Road, 1 km north of the Area's southern boundary. *Phytophthora citricola* was isolated from *Banksia prionotes* in an area of otherwise apparently healthy vegetation in 1988. South of Jurien Bay Road several *Phytophthora* species have been isolated from diseased areas of native vegetation.

A visual reconnaissance survey of the vegetation along roads and tracks within the Lesueur Area in June 1989 did not reveal any dying vegetation that indicated the possible presence of the diseases.

8.4 HAZARD AND RISK RATINGS OF PLANT COMMUMITIES IN THE LESUEUR AREA

The susceptibility of each vegetation type to *Phytophthora* spp. can be tentatively predicted by assessing a variety of factors that influence the relationship between pathogens and hosts. Keighery and Tippett (1986) rated the disease risk/hazard of

south coast vegetation types by giving each a disease risk/hazard score, based on the following queries:

1. Climate. Warm, moist conditions for part of the year?
2. High concentration of susceptible species present?
3. Are susceptible species the dominants in the community?
4. Is the risk of infection high? (amount of human use, and position in the landscape)
5. Do conditions favour the spread of the fungi?
6. Do soil characteristics suggest that conditions are favourable for the fungi?

The risk rating of a vegetation type predicts the ease with which it could become infected, and is determined mainly by its position in the landscape, its soil type and its proximity to roads and drainage lines. Risk rating is covered in point four of the above list. The other five questions address the hazard rating of the community, which reflects the likely impact of disease on the vegetation.

In a high priority nature conservation area, such as the Lesueur Area, the risk rating of a plant community becomes somewhat meaningless, as the only acceptable risk, for long term management of the Area, is no risk at all. For this reason, the risk and hazard ratings have been separated. Hazard ratings will be scored out of five; the higher the score, the more acute the likely impact. Risk will be given a subjective rating of low, medium or high.

Some comments on the hazard rating categories are given below:

Climate. The Lesueur Area receives virtually the same amount of annual rainfall, around 600 mm, as the severely diseased Stirling Range National Park, though it has drier summers (Figure 8.2). Most rain falls between May and September, a time when temperatures are comparable with late spring and early autumn at Stirling Range. In the jarrah forest, Shearer and Shea (1987) recorded the highest recoveries of *P. cinnamomi* from surface soil in mid- and late-winter, from both upland and lowland sites.

Another strong indicator of suitable climatic conditions for the fungi in the Lesueur Area is the presence of "outlying populations of species from mesic environments to the south" which "may reflect an amelioration of the general climate" (Hopkins and Griffin 1984). Overall, the relatively warm conditions in the area during winter provide a five month window for establishment and activity of *Phytophthora* spp.

The harsh summer conditions in the area will, however, not preclude survival of the fungi in the soil. At Gnangara, *P. cinnamomi* survived in 63% and 14% of colonised pine plugs buried for one and two years respectively. Plugs were buried at a depth of 0.3 m in banksia woodland growing on Bassendean sand. Survival rate of the fungus was even greater in plugs buried at 1.3 m, easing from 100% to 88% over the same period. Soil moisture in summer dropped to 0.6% of dry soil weight at 0.3 m (T.C.J. Hill, unpublished data).

The region also occasionally receives heavy rain in summer. In February of 1986, for example, Jurien received 164 mm; in 1976, 93 mm; and in 1970, 90 mm. If Greenhouse Effect predictions are correct, cyclonic influences and summer rainfall will increase in both frequency and intensity, thereby increasing the potential dieback hazard.

Abundance of susceptible species. The abundance of susceptible species in a plant community is, possibly, the most important factor in determining its hazard rating. Jarrah forest, banksia woodlands, banksia shrublands, proteaceous thickets, scrub heath and heath, all of which contain an abundance of susceptible species, are the most severely affected communities in south-western Australia. When the community is dominated by susceptible species, conditions for the fungus can become so favourable that it can virtually uncouple itself from the edaphic environment, and spread by growing within roots of susceptible plants; infecting new hosts at points of root to root contact. The Bell Track infection in the Fitzgerald River National Park appears to be operating in this manner, devastating *Banksia baxteri/Lambertia inermis* shrubland growing in deep sand, at a site that receives only 390 mm of annual rainfall.

Soil and Topography. Soil profile and topography are closely related. In the uplands of the Lesueur Area, soils on steep slopes are usually skeletal and impeding, the impeded drainage assisting the rapid, lateral spread of zoospores, but this characteristic would, however, also hinder the establishment of the fungus because the soil would dry quickly. Colluvial accumulation on lower slopes builds either poorly-drained loams and clay soils or deep, well-drained, siliceous sands. The latter, because of their low fertility, are often dominated by highly susceptible proteaceous species. Soils on uplands tend to be moderately impeding due to the presence of duricrust near the surface, but their small gradients do not promote lateral sub-surface flow.

Susceptible Vegetation Types. Table 8.3 gives the hazard and risk ratings of major plant communities in the Lesueur Area. The eastern sector of the Area

contains many vegetation types with high hazard ratings. By contrast, the western (coastal plain) sector contains only one potentially threatened community: banksia low woodland on Bassendean Dunes. This vegetation type occurs only as a small intrusion between the Peron Slopes and Spearwood Dunes landforms.

The hazard ratings of five eastern sector vegetation types (of Martinick and Associates 1988) were scored as very high (4-5 to 5). They are:

C - *Hakea neurophylla/Banksia tricuspis* heath
D - *Petrophile chrysantha* heath
H - *Petrophile seminuda* heath
M1 - *Verticordia densiflora* heath
X - *Allocasuarina campestris* Thicket

These communities are characteristically dominated (often with 50-100% foliage cover) by susceptible species, as well as containing a high concentration of associated susceptible elements. *P. cinnamomi* would probably completely destroy the present structure and significantly reduce the diversity of these communities. Complete or localised extinction of some plant species is also likely. Importantly, these vegetation types occur on a wide range of positions in the landscape, including uplands, slopes, low rises, middle to lower slopes, lower slopes, drainage lines and depressions. As in the Stirling Range, position in the landscape does not confer immunity to the disease. If *P. cinnamomi*, or any other *Phytophthora* species, is introduced, its impact would not simply be confined to low-lying, water-gaining sites.

Six other heath associations (types A,B,E,F,G and J) were rated between 3 and 4. Types A and B, the sand and lateritic heaths, contain a wide variety of sub-types; some significantly more vulnerable than others by virtue of the presence of one or more susceptible dominants. The likely impact of disease in these moderate to high hazard types is not possible to predict, though the low-lying, medium to high risk E,F,G and J associations would inevitably harbour the disease and consequently incur some level of damage.

Experience in other parts of south-western Australia, as well as in parts of south-eastern Australia, suggests that there is a high probability of introduction of *Phytophthora* spp. when extensive use of earth-moving equipment or vehicles takes place in a highly susceptible area.

The recent construction of numerous exploratory roads and drilling tracks by the mining companies was carried out under strict dieback hygiene controls. However, the opening up of large, previously inaccessible areas to both two-wheel drive and four-wheel drive vehicles presents an unacceptable hygiene risk to the Lesueur Area, and is, of course, disturbingly reminiscent of other case histories. There are no hygiene controls on the use of the area by private vehicles.

8.5 POSSIBLE IMPACT OF *PHYTOPHTHORA* IF INTRODUCED

The Bitter Pool Rises unit contains the greatest abundance of high hazard vegetation types in the Lesueur Area, with significant expanses of types D, H and M1, as well as DEH and FGH mosaics. The Gairdner Dissected Uplands unit also contains large areas of highly susceptible heaths, particularly types D, H, DFH, DFG, FGH and AE. Banovich Uplands contain fewer of the highly susceptible vegetation units. However, amongst the widespread lateritic and sand heaths are sub-types of moderate to high susceptibility. The highly susceptible types D and M1 occur in places.

Of the seven Declared Rare flora species in the Lesueur Area, at least one, *Banksia tricuspis*, would be seriously threatened if dieback was introduced. It occurs in C1 and B1.1 vegetation sub-types, both of which were scored as high to very high hazard. Localised extinction is possible. *Hakea megalosperma*, though probably susceptible to *P. cinnamomi*, occurs in less susceptible, lateritic heath communities.

Based on current Herbarium information and field studies, nine plants are entirely restricted to the Lesueur Area. Of these, five belong to susceptible genera (or in the case of *Eucalyptus*, informal sub-genera). A further 24 species have between 50% and 100% of known populations confined to the Lesueur Area. Fourteen of these belong to susceptible genera (Table 5.6).

Of the 111 geographically restricted and/or rare species listed in Appendix 2 that occur in the Lesueur Area, 60 belong to susceptible genera.

Outlying occurrences of several species, particularly *E. marginata*, may also be at risk.

Overall, dieback diseases have the potential to cause major degradation of the nature conservation values of the Lesueur Area if the area is not protected, properly quarantined and managed. Stirling Range National Park provides a warning of the problems that could occur (R. Wills pers. comm.).

Table 8.3

Hazard and risk ratings of major plant communities in the proposed LesueurArea. A hazard rating of 4 to 5 indicates high to very high disease hazard.

Vegetation Type	Hazard (0-5)	Risk (Low-High)	Comments
Eastern Sector[1]			
A (Sand heath)	3-4	Low	types A1,A2.1,A2.2 probably higher hazard than others
B (Lateritic heath)	3-4	Low-Medium	types B1.1,B1.3,B3.1 probably higher hazard than others
C (*H. neurophylla* heath)	4-5	Low-Medium	
D (*P. chrysantha* heath)	4-5	Low-Medium	
E (*Ecdeiocolea* heath)	4	Medium-High	
F (*H. erinacea* heath)	4	Medium	
G (*M. platycalyx* heath)	3-4	Medium	
H (*P. seminuda* heath)	4-5	Medium-High	
I (*G. spinosum* scrub)	3	Low-Medium	
J (*C. quadrifidus* heath)	4	High	
K (*E. wandoo* woodland)	2	Low	
L (heath)	3	High	
M1 (*V. densiflora* heath)	5	High	type M2: low hazard
SUB-TYPE X (*A. campestris* thicket)	4-5	High	
Western Sector[2] **(west of Peron Slopes)**			
$b_{1/2}L_i$ (Banksia low woodland)	4	Low-Medium	
x_9SZc (heterogeneous scrub-heath)	3	Low	
$x_6SZc/e_{44}Lp$ (Illyarrie scrub-heath)	2-3	Low	
$a_{26}m_4Zc/a_{23}m_3Sc$ (coastal thicket)	1	Low	

1 = Vegetation classification of Martinick and Associates(1989d)

2 = Vegetation classification of Beard (1976)