

History of *Phytophthora cinnamomi* management in Western Australia

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ABSTRACT: *Phytophthora cinnamomi* has recently been recognized as a key threatening process to biodiversity in Australia. The impact of this introduced microscopic water mould on destruction of forests and heathland communities has been observed since 1921 in southwestern Australia. It took over 40 years for the causal agent to be identified in 1964. Over the next 40 years, State Government Departments formulated policy and implemented management measures to deal with the problem. These measures have changed greatly over time as new knowledge about the host range and extent of the epidemic have become available. Unfortunately, the pathogen had spread over large areas of estate prior to the identification of the causal agent and the development of a management response. The spread of *P. cinnamomi* into significant areas of the conservation estate, including biodiversity hotspots, highlights the urgency of ensuring that Phytophthora dieback and its management is adequately resourced and is underpinned by appropriate research and communication programs.

This review describes the main historical events leading up to the formulation of the 2004 State Phytophthora Dieback Response Framework. These include: quarantining half a million hectares of State Forest in 1976/7 in order to map the extent of the disease and implement hygiene measures; developing policy and management practices for the conservation estate; the acceptance by the Hon. Minister for the Environment in 1996 of the 33 recommendations in the WA Dieback Review Panel Report; the establishment of community based Dieback Working Groups; the preparation of the National Threat Abatement Plan in 2001, and in 2004 the development of National Best Practices Management Guidelines and a risk assessment methodology suitable for national adoption.

In spite of these actions, much remains to be done. Flora and fauna remain threatened by the continued expansion and impact of Phytophthora dieback. We have few tools available to reduce the extension, spread and impact of the pathogen and the diseases it causes. The community needs to be better informed of the direct and indirect impacts this disease has had on individual species and ecosystem function and health, and encouraged to take greater ownership of an environmental problem that encompasses all types of land tenure. Recent developments in policy development are encouraging but need to be underpinned by much further research and collaboration.

1 INTRODUCTION

In 1921 jarrah (*Eucalyptus marginata*) trees were observed by forester L. N. Weston to be dying along with understorey species near Karragullen, an orchard district, 35 km south-east of Perth

(Podger 1968). Seven years later, W. R. Wallace noticed tree deaths near Myara Hill, some 80 km south of Karragullen (Waring 1950, Hopkins 1973). Similar stands of dying trees can be seen on 1929 aerial photos covering State forest east of the Albany Highway, 50-75 km south-east of Perth near the Travellers Arms, a roadside inn (Podger 1968). The incidence of plant deaths in the jarrah forest increased in the 1930s as the timber industry changed from rail to road transport and there was increased mechanization alongside a massive increase in postwar road building. The disorder became known as 'jarrah dieback' due to losses of the economically important jarrah tree. The establishment of a joint State and Commonwealth field Research Station at Dwellingup in 1948 stimulated interest in the problem and soon unpublished documents were reporting on the increasing incidence of the disorder. Wallace & Hatch (1954) wrote

'The poor condition of the individual crowns and the unsatisfactory general canopy in the Jarrah forest has, for the past decade caused increasing concern ... An associated problem which may or may not be connected with this general crown deterioration is the occurrence, on poorer site qualities, of dying Jarrah patches'.

More information regarding early attempts to diagnose the cause of the problem is contained in Podger (1968, 1972) and Dell & Malajczuk (1989).

In 1964, years of hard work by F. D. Podger of the Forestry and Timber Bureau, with collaboration from R. F. Doepel (W.A. Department of Agriculture) and G.A. Zentmyer (visiting Professor from Riverside, California) led to the discovery of an association between jarrah deaths and infection with the soil and water-borne plant pathogen *Phytophthora cinnamomi* (Podger et al. 1965). In a letter written to Podger and Doepel, dated 21 October 1964, Zentmyer gives the first account of the isolation and identification in the USA: 'Phytophthora cinnamomi is growing out of the Jarrah (Eucalyptus marginata) roots that I cultured on Friday, October 16 ... This confirms your thought, and my strong suspicion after seeing the problem in the field, that this must be a Phytophthora problem'. This discovery took place four decades after R. D. Rands isolated and described *P. cinnamomi* from cinnamom trees in Sumatra (Rands 1922), and about 35 years after the pathogen was identified on horticultural and tree crops in eastern Australia (Newhook & Podger 1972, Pratt & Heather 1973). The pathogen was later shown to cause disease in native eucalypt forests in Victoria (Podger & Ashton 1970). In the mid 1960s, some scientists found it difficult to accept that a pathogen of likely tropical origin was the primary agent of dieback in the jarrah forest. For example, this view was expressed by Professor E. Bjorkman of the Royal College of Forestry, Stockholm, who was invited by the Director-General of the Forestry and Timber Bureau to report on Podger's findings. The pioneering work of F. D. Podger, however, has stood the test of time and led to the implementation of vast changes in forest management including the adoption of forest hygiene practices. Prior to the discovery of the causal agent, dying patches of forest were exposed to timber salvage and, in some areas, gravel was removed for road building – practices that undoubtedly led to further spread of the pathogen. The only other recorded activity is that small dieback areas were experimentally planted with *Pinus pinaster* in 1948/49, followed by exotic eucalypts and other pines in the early 1950s. It is worth noting that the Working Plan No. 79 published in 1956 (Forests Department 1956) does not mention dieback.

Since 1965 there has been considerable work on the biology, ecology, pathology and management of *P. cinnamomi* in southwestern Australia (Shea 1975, Shearer & Tippet, 1989, Colquhoun & Hardy, 2000). It is now recognized that approximately 2284 and 800 of the 5710 described plant species in Western Australia's South-West Botanical Province are susceptible or highly susceptible to the pathogen, respectively (Shearer et al. 2004). This equates to approximately 54% of the plant species in this region having the potential to be adversely influenced by the pathogen. Its impact on ecosystem health and function in heathlands and banksia woodlands is now recognized as being considerably more devastating than its impact in the jarrah forest. It is for this reason that the term 'dieback' is used in this paper to describe the overall impact of the pathogen rather than the misleading term 'jarrah dieback', which places the emphasis on jarrah which is reasonably tolerant in comparison to the many other highly susceptible plant species in Western Australia. This paper

addresses dieback management in that part of Australia that has, in terms of land area and impact on biodiversity, been most severely impacted by *P. cinnamomi*. Dieback issues in other parts of Australia have been discussed elsewhere (Weste & Marks 1987, Davison & Shearer 1989, Marks & Smith 1991, Shearer & Smith 2000).

2 FROM DISCOVERY TO QUARANTINE (1966 – 1984)

2.1 *Early measures*

Once *P. cinnamomi* was determined to be the causal agent of the jarrah deaths, it was concluded ‘that the battle was virtually lost once the pathogen was introduced’. This view served its purpose as a shock treatment underlining the need to prevent artificial spread and motivating the adoption of hygiene measures (Forests Department 1974). Nevertheless, possible influences of environmental factors on disease development and spread were initially ignored. Vehicle wash-down facilities and associated hygiene measures were implemented alongside forestry practices and road building in an attempt to reduce the rate of spread and impact in the jarrah forest. Severe dieback-impacted areas were salvage logged. In other areas, logging operations were streamlined to minimize the number of entries by heavy machinery. Some attempts at educating forest users to adopt hygiene and quarantine measures were also put in place. In spite of this, there was still a lack of understanding about the biology of the pathogen.

To facilitate hygiene and quarantine measures, aerial surveillance was attempted to map the spread of the disease. However, this early aerial surveillance could not detect understorey death. Bradshaw (1974) and Bradshaw & Chandler (1978) recognized these limitations and commenced a small scale (1:4,500) shadowless aerial photography program for identifying disease symptoms in the forest, especially the under storey component that required the development of revolutionary low level flying (maximum of 500 feet above the tree canopy) aircraft navigation and aerial camera control systems. The technique relied on full cover cloud to enable shadow-less photographs of the forest floor to be taken with cloud at a height which allowed the aircraft to operate. The technique was expensive and total area covered in a year was limited to strategic mapping of the forest ahead of major ground disturbing activities. It formed the basis of a system of ground truthing and mapping, including targeted soil and tissue sampling, and allowed more targeted hygiene and quarantine measures to be developed. In subsequent years, ground survey techniques using GPS equipment were developed that now largely supersede the use of aerial photographs.

Due to the pessimistic view with regard to the future of the jarrah forest and the ‘mass collapse’ of forest areas in 1978- early 1980s, attempts were made to revegetate areas of ‘mass collapse’ or ‘jarrah graveyard’ sites with pines and eastern state’s species of eucalypts (Bartle & Shea 1978). Initially, eucalypt selection was based on a trial planted in 1937 on a dieback site between Harvey and Tallanalla. Tallowwood (*E. microcorys*) and Sydney bluegum (*E. saligna*) survived well and were observed to invade outside the trial. According to Havel (1989), the planting of pines was phased out when it became apparent that the replanted areas would be too costly to protect from wild fires. Rehabilitation using exotic species was later phased out when it was recognized that some indigenous tree species were recolonising dieback-affected areas and that dieback resulted in increased runoff for the reservoirs that supply the Perth metropolitan area with drinking water (Havel 1975c). Also, Western Aluminium N.L. (later, Alcoa World Alumina Ltd) rehabilitated bauxite mines known to be infested with *P. cinnamomi* with resistant eucalypt species from outside the region. This practice continued into the mid 1980s until it was observed that jarrah was not dying on infested sites. From this time, only plant species endemic to the jarrah forest were then used.

2.2 *Events leading to proclamation of Disease Risk Areas in State Forests*

By 1973, Forests Department Research Officers were reporting on the failure of hygiene procedures. This failure, together with heightened public concern on the potential for logging and dieback to exacerbate stream salinity, led to a Task Force (F.J. Campbell, D.E. Grace, J.J. Havel, F.

Batini) being appointed by the Conservator of Forests, in November 1973, to review existing hygiene procedures. The report (Forests Department 1974) stated: 'This review was prompted by the fact that the pathogen was detected over extensive areas of prime forest hitherto considered to be uninfected and by doubts about the success of the hygiene measures being practised.' Estimates of diseased forest, based on susceptible overstorey species, were reported as

'... the area affected by *Phytophthora cinnamomi* has grown from first introduction prior to 1900 to 50,000 acres in 1940 and to over 300,000 acres in 1971. It can therefore be broadly concluded that without control measures the area of dieback doubles every fifteen years and the jarrah forest on this basis could have a life expectancy of 50 to 60 years.'

The Task Group had a considerable amount of recent scientific data to consider including results from hygiene trials (e.g. Batini 1973) and information on the importance of site and environmental factors in disease expression and site vulnerability arising out of the research undertaken by J.J. Havel (Havel 1975a,b) and S.R. Shea (Shea 1975). The Task Group report supported the concept of forest quarantine which was defined further and a Working Plan was prepared in April 1974. The Forests Department Information Sheet 35 (undated) reflects the mood of the time: 'If allowed to proceed unchecked, most forest values will be adversely affected. The loss of jarrah trees will reduce the volume of timber suitable for milling, and will threaten the long-term existence of saw-mills. Extensive areas of dying forest could increase the salinity of the streams which feed the water supply reservoirs. Forest eco-systems are in peril, and some species (such as *Banksia littoralis*) are in danger of extinction. Birds and animals will suffer through the loss of vegetation. The recreational and aesthetic appeal of forests will diminish.'

Following approval in principle given by Cabinet in August 1974, detailed working plans were prepared, and there was extensive consultation with relevant authorities and individuals. A quarantine period of three years was suggested as a safe interval on which to base future planning. This would allow time for symptoms of disease to be expressed in vegetation recovering from fire and other stresses, to control spread of disease whilst symptoms were developing, to develop techniques for detecting and mapping the disease and to allow time for research developments to occur. In the end, time constraints were not incorporated in the Forest Act Amendment Act (No. 77 of 1974), which was passed in late 1974 and proclaimed on 22 January 1975. The Amendment allowed for the proclamation of forest disease areas or forest Disease Risk Areas (DRAs) to 'control and eradicate such forest diseases as are detected in such areas'. The colloquial term 'quarantine' was used in the field but not in official communications.

2.3 Implementation of forest quarantine

Substantial areas of State forest were proclaimed as DRAs (areas that were diseased and/or areas that needed to be protected from becoming infested) on 16 January 1976 (507,600 ha) and placed under restricted access. A Control Group within the Forests Department was established which oversaw the implementation of road closures, access permits, surveillance, liaison, training and enforcement. In December 1977, following the preparation of working plans for the southern jarrah forest and consultation, a further 211,961 ha were proclaimed, bringing the total area under some form of quarantine to ca. 36% of the total forest area. The implementation of DRAs coincided with a flurry of activity in setting broader forest management practices. Following Government approval of a Multiple Use Management Policy in 1976 (Forests Department 1977b), the Forests Department produced General Working 86 (Forests Department 1977a). 'For the first time the whole range of forest land use objectives, together with policies and management strategies designed to achieve them, were stated in a single document and made public' (Forests Department 1982a). At the Policy Review Group meeting of 22 December 1977, it was resolved to set up a Post Quarantine Working Group to anticipate problems which could arise following the initial period of quarantine on gazetted areas (DRAs). Its terms of reference were: to review and update the hygiene circular; to consider legislation in respect to proposals for control of access and hygiene; to consider training

requirements; to report on ground identification of symptoms for operational use; and to consider the place of dieback and quarantine with respect to the multiple use plan (Forests Department 1977b). Recommendations in the resulting Progress Report included: 'a comprehensive manual be produced to cover post 1979 dieback operations' and 'disease risk area proclamation should be extended to protectable and certain non protectable forest areas in the non quarantined areas; as soon as is practicable'. The latter was adopted as policy in the 1982 General Working Plan (see below) but was never enacted.

Intensive pre-operation (all activities involving earth moving or those with the potential to move soil such as mining, timber harvesting, road construction and maintenance, and vehicles traveling along gravel roads) efforts were maintained on mapping the extent of dieback-free forests. This was boosted when the use of 70 mm colour aerial photographs became fully operational for the detection and interpretation of dieback in the period 1977-79. A key to the success of mapping operations was the expertise of trained personnel who could accurately interpret the cause of death of understorey jarrah forest species. Typically, those conducting the pre-operation surveys were required to undertake three months intensive training to learn the skills of photo-interpretation and disease diagnosis followed by up to a years work under close supervision before becoming fully qualified. Dieback interpreters were expected to be proficient in detecting and analysing mortality in a range of ground cover plant species, varying in abundance and distribution according to landscape and environmental factors, and eliminating plant death not caused by *P. cinnamomi*. The techniques developed included a program of systematic sampling of plant tissue and soil from suspected infested areas for laboratory extraction and morphological identification of the causal agent. This system proved invaluable, as with increasing awareness of the scope and extent of the disease epidemic outside the jarrah forest ecosystems were realized, the techniques already developed were readily transferred into the northern and southern heathlands

In 1981, the protection objectives for dieback in the northern jarrah forest (Forests Department 1981) were: 'to minimise the effect of dieback on the forest, through

- (i) good hygiene practice;
- (ii) maintenance of a productive and vigorous forest; and
- (iii) rehabilitation of dieback areas.'

In the 1982 General Working Plan (Forests Department 1982a), dieback policy was far more expansive than in the previous Plan – 'Jarrah dieback disease poses a serious threat to the existence of much of the jarrah and associated vegetation types.' The management objective was: 'To limit the spread of infections of jarrah dieback disease and to improve the resistance of the forest to the disease.' The policies were:

- (1) 'Classify State forests according to disease presence, susceptibility of sites and resistance of vegetation to disease.
- (2) Where warranted extend the proclamation of disease risk areas to allow detection and mapping of existing infections.
- (3) Improve and apply hygiene measures.
- (4) Rehabilitate infected areas with dieback disease resistant species to suit the designated land use.
- (5) Research methods of disease control and rehabilitation.
- (6) Consider the introduction of measures to control vehicle access to healthy forest in unproclaimed areas.
- (7) Continue with logging trials over a range of sites in proclaimed disease risk areas.'

2.4 *Dieback review (1982)*

In 1982, following nearly a decade of research, operational trials and forest management planning, a review of dieback policy was initiated by the Conservator of Forests. The objectives were: 'to propose forest management policies and practices so that:

- (a) Forest operations are carried out hygienically, so that the disease is not spread into areas as yet unaffected.
- (b) In areas free of the disease or those where the impact of the disease is minor the natural resistance can be increased.
- (c) Where needed, areas affected by the disease can be rehabilitated.
- (d) The forest ecosystem can be productively managed in the long term.'

The review process was carried out at depth (Task Force, Expert Working Groups, Policy Review Group) and culminated in a revised Dieback Policy being accepted by the Government in 1982 (Forests Department 1982b). A major change was to allow access to DRAs subject to strict conditions. 'In the proclaimed Disease Risk Areas, access to natural resources has been severely constrained. There is mounting pressure for access into these areas for poles, sawlogs and mineral exploration'. Lands under the control of the Forests Dept were to be categorised according to the following classes: Proclaimed Disease Risk Areas and Non Proclaimed areas of forest. Within the Disease Risk Areas, four classes were to be delineated: long term isolation, short term isolation, limited access and other areas of forest. These were to facilitate a major change in policy allowing access to DRA's subject to conditions. In order to refine the systems being used and implement the Dieback Policy, a manual for training field staff in the recognition of dieback symptoms was drafted (Brandis 1983a, b) and the Protection Branch produced the 7-way Test (Forests Department 1982b, 1983). Before forest operations were permitted, the following factors were to be evaluated: type of operation, degree of hygiene, risk of introducing *P. cinnamomi*, forest type, likely impact, land use, and consequences of impact on land use.

2.5 Dieback management outside the forests

For the decade after it was linked with *P. cinnamomi*, dieback was seen as a management problem in the jarrah forest and scant attention was applied to vegetation dying in National Parks and Reserves. Lack of resources prevented the occurrence of dieback outside State forest being documented by other State authorities, even though it was widely known inside the Forests Department that dieback occurred on the south coast from Walpole as far east as Mount Manypeaks. In the winter of 1976, dieback was identified as a serious problem in Cape le Grand National Park, prompting questions in the Legislative Council. The Minister for Health, Mr Baxter, representing the Minister for Forests, Mr Ridge, stated 'that the Government would start a programme of vehicle control, hygiene and education to try to limit the spread of the disease in the park' (The West Australian 7 October 1976). The National Parks Authority (NPA) acted quickly to close some gravel pits and adopt a hygiene programme for large vehicles entering the park in co-operation with the Esperance Shire Council. The extent to which hygiene operations were implemented is not clear.

Four years later, the NPA confirmed dieback was present in another eight National Parks (Avon Valley, D'Entrecasteaux, Fitzgerald River, Leeuwin-Naturaliste, Moore River, Scott River, Stirling Range and Yanchep). A proposal to establish quarantine areas (Muir 1981) was prepared and a dieback policy was accepted and implemented by the NPA in March 1981. The policy had 6 actions including undertaking stringent hygiene procedures, developing specific hygiene and disease control actions and developing specific dieback control plans relevant to each park. Using the provision for closure under the National Parks Authority Act 1976 (Section 24.1), the NPA considered the best strategy was to close areas which had low visitation rates and were relatively free of disease. However, resources were inadequate to enable the full implementation of the policy until after management plans were prepared following the CALM Act some years later (see below). By that stage, considerable areas of susceptible vegetation in the Stirling Range National Park had been destroyed by dieback. A similar fate befell many of the Reserves set aside for conservation purposes in the south-west.

Even though Forests Department publications, like Forest Focus, had been reporting dieback outside the State forests, many still saw dieback as a jarrah-related problem. Hence, hygiene and

other control measures were not implemented in any consistent way across other arms of Government. For example, it was not until 1980 that the Western Australian Department of Agriculture published recommendations to nurserymen and orchardists on disease prevention and control (WADA 1980).

2.6 *Dieback and mining*

In 1963, Western Aluminium N.L. (later, Alcoa of Australia Ltd) began mining bauxite in jarrah forest south of Perth. Over the next decade, as mining proceeded in dieback-affected forest, hygiene procedures developed by the Forests Department for the timber harvesting industry were implemented for ore development (exploration, drilling, timber salvage and clearing operations) to minimize spread of the pathogen to unmined forest. Later, dieback control measures were adopted in active mining and ore transport areas, and in the rehabilitation of mine pits. This was underpinned by a strategic research effort by Alcoa in quantifying the impact of mining on the spread of *P. cinnamomi* (Colquhoun 1992, Gardner & Rokich 1987). Alcoa was also one of the principal supporters of the Foundation for Dieback Research that funded research projects from 1979-1987. After mining was allowed by the Government, in 1986, to proceed into dieback-free forest, detailed dieback management prescriptions were produced for all phases of the mining operation to meet Alcoa's objective of 'minimising the spread and intensification of dieback disease attributable to mining'. Similar stringent hygiene and engineering measures have been put into practice by other mining companies in the region, including companies mining mineral sands.

On land, the Petroleum Act 1967, the Petroleum Pipelines Act 1969 and the Mining Act 1978 prevail over the Forest Act (later the CALM Act, see below). Among the Agreement Acts which impinge directly on the management of *P. cinnamomi* are the Alumina Refinery Agreement Act 1961, Alumina Refinery (Worsley) Agreement Act 1973, Collie Coal (Griffin) Agreement Act 1979, Collie Coal (Western Collieries) Agreement Act 1979, the Wood Chipping Agreement Act 1969 and the Mineral Sands (Eneabba) Agreement Act 1975, under the umbrella of the Mining Act 1978, which embraces both mineral exploration and mining.

3 THE CALM ACT AND ITS IMPLEMENTATION

Implementation of the Conservation and Land Management Act (1984) led to the refining of policy and management practices and the extension of dieback management from State Forests to other conservation lands

3.1 *CALM Act*

Under the Act a single agency was created to manage all of the Crown's conservation lands and to administer the *Wildlife Conservation Act 1950* throughout the State of Western Australia. The concept included a unified and integrated approach to the protection, conservation and management of the State's biological diversity [Section 33(1)(d) 'to be responsible for the conservation and protection of flora and fauna throughout the State, and in particular to be the instrument by which the administration of the *Wildlife Conservation Act 1950* is carried out by the Executive Director pursuant to section 7 of that Act']. The relevant Part VII (and sections) of the repealed Forest Act and the Forest Management regulations were 'saved' and incorporated into the new legislation ['Part VII — Control and eradication of forest diseases Section 79. The purposes of this Part are to identify the areas of public land in which trees may be, may become, or are infected with any forest disease and to control and eradicate such forest diseases as are detected in such areas.'].

The new management agency was required to manage the land according to approved management plans (prepared by then National Parks and Nature Conservation Authority for conservation lands and the Lands and Forest Commission for State forests and approved by the Minister for the Environment – these bodies were replaced by the Conservation Commission of Western Australia in 2000) or in the absence of an approved management plan undertake only necessary operations in

nature reserves and compatible operations in national parks and conservation parks. The requirement for necessary and compatible operations to be approved in the latter case by the Minister or in accordance with approved management plans (which often recorded the occurrence of the pathogen within the area being dealt with by the plan and spelt out the need for an adequate management response) meant that fewer activities were proposed on those conservation lands (except mining – Mining Act had precedence), reducing the potential for human vectoring of the pathogen. When seeking approval of activities, managers were required to consider the disease status of the land in question and incorporate high quality disease management strategies into their proposals. The work prescriptions for approved operations were documented and limited monitoring and audit programs were instituted. Overall better planning for, and compliance with, current best practice disease management strategies across all of the conservation estate were in place.

3.2 *Extension of dieback management to the South Coast and other regions*

With the implementation of the CALM Act, there was an emergence of increased awareness of South Coast dieback issues. The responsibility for responding to the disease epidemic in the South Coast Region of the State fell to CALM. Expertise (research, detection, diagnosis, mapping and management strategies and tactics) developed in the South West forest ecosystems (CALM 1986a) were progressively transferred to the south coast. Field workers were deployed to survey and map disease occurrence in bio-diversity hot spots such as the Stirling Range National Park (SRNP). A dieback protection plan (CALM 1986b) was prepared which described the dieback situation in the South Coast administrative region of CALM, and the strategies for dieback protection. The plan was a public document and in the Preface it states that it would be 'made freely available to other government departments, Shire Councils, community groups, tertiary institutions and the general public upon request'. The plan is silent on the question as to how the public were to be made aware of the plan's existence. The plan was reviewed in 1988 (CALM 1989) and 1993 (CALM 1994b). Under the first plan, rapid progress was made in targeting priority areas, tracks and some walk trails were closed, wash-down facilities were installed and quite quickly interim management guidelines (e.g. Stirling Range NP 1987, Cape le Grand NP 1987, Cape Arid NP 1988) and draft hazard (predictions of severity of damage if pathogen was introduced and established) maps were prepared for some areas. Policies regarding dieback protection for nature reserves, timber reserves and national parks in the South Coast Region, as for the jarrah forest, aimed to 'prevent the introduction of dieback into disease-free areas' and 'minimise extension in the areas where the disease already occurs'. Strategies to achieve these aims included: identification of priority areas, preparation of dieback protection plans, dieback mapping, and increasing community awareness (CALM 1994b). Notably the current plan (1994–1998) has lapsed and has not been updated.

The Fitzgerald River National Park (FRNP) on the South Coast is one of the most important conservation reserves in Australia due to the floral endemism and diversity of flora and fauna, including 17 Threatened flora and 6 Threatened fauna species. Unlike the Stirling Range National Park, only a very small percentage of the FRNP is currently infested by *P. cinnamomi*. If the pathogen spreads further in the FRNP, the potential impact on ecosystem function and health is enormous. To date, in spite of a management plan (CALM 1991b), progress to minimize or eliminate the infestation has been slow. So far, the following have been implemented:

- (i) all vehicle access into the infested area designated Wilderness Zone requires approval from the Conservation Commission of Western Australia and approved access is then supervised by the Ranger in Charge of the National Park and is restricted to dry soil conditions;
- (ii) in December 1997 surface water diversion arresters and soil erosion measures were built;
- (iii) in an attempt to contain the spread of the pathogen a 225 ha 'envelope' encompassing the entire infestation and a buffer were aerially sprayed with phosphite in March and April 1997.

Currently (2004), options for control of surface and subsurface water-flow and hence zoospore dispersal, the prevention of root to root transmission of the pathogen, and control of animal vectoring are being investigated.

The strategies and policies outlined in the South Coast region plan were gradually adopted by some other districts to guide operations in their area. For example, wash-down facilities were installed in Nambung National Park and Moora between 1986-88 and a Dieback Protection Plan was prepared for the Moora District in 1990 (CALM 1990). Notably this plan has lapsed also and has not been updated. Dieback management was progressively incorporated into management plans for reserves. The first Plan (CALM 1985) stated: 'Officers carrying out management or research duties on the reserve will follow the operational procedures laid down in the departmental guidelines relating to *Phytophthora cinnamomi* (Forests Department 1982b)'. With time, dieback management sections of plans have fully embraced modifications in dieback Policy and Manuals as significant new research findings and monitoring results have become available. For example, the 1992 hygiene manual (CALM 1992) included sections on recognition and mapping disease symptoms, a soil and tissue sampling procedure, a simple risk assessment methodology and expanded disease management tactical information. A users guide was produced the next year (CALM 1993).

Of the eleven management regions delineated in the CALM Act, parts of six are infested with dieback (South Coast, Southern Forest, Central Forest, Northern Forest, Metropolitan and Greenough). Regional management plans spanning ten years were produced for the forest regions in 1987 (CALM 1987a,b,c). In these it was recognized that disease caused by *P. cinnamomi* cannot be eradicated and that control measures should concentrate on limiting the disease establishing in uninfested areas or spreading, once established. Broad management strategies included: directing operations into areas where mapping and demarcation has occurred; using the 7-way Test to assess all operations; undertaking ground surveys; improving self-policing of hygiene by industry; continuing research into site-vegetation and disease impacts and revising management prescriptions accordingly; continuing to develop practical hygiene monitoring systems for all operations; seeking to improve public understanding of the problem through education and involvement; and improving media awareness of disease spread problems.

4 ADOPTION OF DIEBACK POLICY BY LOCAL GOVERNMENT

During the first two decades of dieback management, it had been left largely up to the Forests Department, and later the Department of CALM, to develop dieback policy and to communicate information on dieback and measures that could be taken to limit disease spread. The first Dieback Hygiene Manual (Forests Department 1975/76) was adopted by other agencies including the National Parks Authority in 1987. However, the extent of acceptance and implementation of 'rules which must be followed to minimize the spread of dieback' within agencies that were involved in clearing or operating on Crown lands (e.g. Main Roads, State Electricity Commission, Post Master General, Shire Councils) varied greatly and was highly dependent on a small number of dedicated individuals. In 2004, there still remains the need for a whole of state approach to the problem of dieback management and there is great reliance on CALM's working manuals (CALM 1999a,b,c; CALM 2001, CALM 2003). State Government agencies are required to fulfill specific statutory functions and are not empowered nor funded to engage with neighbors and contractors operating outside the lands for which they hold responsibility. The tenuous link to ensure activities outside vested lands do not impact upon them is only acted upon by a minority of committed workers. Typically in the period 1970 to 1990, Shire councils continued to be predominantly road management and development planning and approval bodies with rate payers directing them heavily in these matters. Only in the latter part of the century, with an emerging environmental movement, has awareness developed of the need for action on Shire vested and freehold lands.

4.1 *The Dieback Working Group*

The Dieback Working Group (DWG) was formed in 1996 by Perth metropolitan area local government authorities, community groups and State government land management agencies concerned with the management of *Phytophthora* dieback. In 1998, the group obtained funding from the Natural Heritage Trust to appoint a project coordinator and to compile a set of guidelines for

local government on the management of *Phytophthora* dieback. The role of this coordinator was to facilitate the adoption of this policy document within local government, and to raise awareness of dieback within local government and the wider community. Since its formation, the DWG has sought to: increase awareness and understanding about *Phytophthora* dieback; encourage the adoption of *Phytophthora* dieback prevention and management policies; and encourage the implementation of management procedures to minimise the spread and impact of the fungus. Two documents produced so far (Kilgour 1999, Colquhoun et al. 2000) offer practical 'hands-on' guidelines and procedures that can be rapidly adopted and adapted by the general community and other users of land. The Dieback Working Group has made many important links with Community Conservation Groups, local land owners, and local governments throughout the south-west of WA that are now aware of the problem and putting procedures into place to combat the problem. Components of these documents have been adopted or adapted by agencies and conservation groups throughout southern Australia.

4.2 *Adoption of dieback policy by the Denmark Shire Council*

In November 1996, Denmark Shire Counselor Chappelle tabled a discussion paper 'An Approach to Controlling the Spread of Dieback Disease in the Denmark Shire'. Recommendations in this paper were combined with 'Dieback Disease Management Policy for Local Government Authorities' produced in January 1997, by a working party of the Canning Catchment Coordination Group, to form Town Planning Scheme Policy No. 1 for Dieback Disease Management. Denmark was the first Shire to have a dieback policy. The policy (Shire of Denmark 1997) recognises that the responsibilities of the Shire include the protection and management of vegetation on road reserves and other reserves vested in the Shire.

'The policy contains a series of seven actions, together with a range of management strategies and management tactics to provide guidance on identifying the problem and controlling it ... To reduce the risk of spreading dieback disease the Shire of Denmark and its community must ensure that all operations likely to spread the disease are closely scrutinised, and appropriate hygiene practices planned and implemented. Personnel involved in implementing these practices must be appropriately trained'.

At present there is no restriction to the movement of earthmoving equipment throughout the Shire, and no requirement for hygiene measures, such as washing of machinery and vehicles. A number of other Shires have now implemented dieback procedures into their daily operations.

5 REVIEW OF DIEBACK POLICY AND MANAGEMENT

5.1 *Western Australian Dieback Review Panel (WADRP)*

The Panel was commissioned in 1993 to undertake an independent reappraisal of the dieback problem and the strategies needed for its effective address. The Panel was asked to report on: the nature of the disease and its importance for conservation of nature and maintenance of natural productivity; the scientific basis and efficacy of management practices for control of the disease; research programs and future directions; and organisation and funding of research, maintenance of standards and translation of research findings to management practice. It was also to report on recommendations of the Stretch Committee and provide advice on the implementation of that Committee's recommendations. The Stretch Committee had been appointed by the Legislative Council on 7 May 1991 on the initiative of the Hon P.G. Pental MLC who moved in the Legislative Council on May 7, 1991, the following motion: 'That Hon W N Stretch, Hon Murray Montgomery and Hon Bob Thomas be appointed to serve on the committee and that the chairman be Hon WN Stretch'. The Terms of Reference were:

‘That a Select Committee of the Legislative Council be appointed to enquire into and report on the extent to which the disease phytophthora dieback has infected the State’s system of national parks and conservation reserves administered under the Conservation and Land Management Act and the measures being taken to combat the further spread of the disease, and that the Committee to have powers to send for persons and papers, and report back to the House by no later than 1 December 1991’.

The report contained 23 recommendations (Parliament of WA 1992). In 1996, the WADRP (Podger et al. 1996) produced a list of 33 recommendations to be incorporated into future policy. Recommendation No. 1 states:

‘That Government adopts a dieback management strategy which identifies significant protectable areas (those for which the values at risk are significant and the benefits of hygiene likely to be sustained for more than a few decades), prioritises them and concentrates available resources on rigorous application of hygiene for their protection’.

The report was endorsed in 1997 by the Minister of the Environment.

5.2 Implementation of Stretch Committee recommendations and initial outcomes

In 1997, as a result of recommendation 24 of the WADRP, the Minister for the Environment established the Dieback Consultative Council (DCC), to report directly through an independent chairman. The DCC membership encompasses a broad range of dieback management and research expertise as well as key industry and other interest groups concerned with the management of disease caused by *Phytophthora cinnamomi*. The primary function of the DCC is to provide high quality advice to the Minister for the Environment in relation to *Phytophthora* root-rot disease in Western Australia, particularly in relation to: establishing close liaison between planners, managers and research scientists; ensuring that a high degree of priority is given to research generated by management needs; publishing reviews of research findings and their implications for both management and further research; recommending on acquisition and allocation of research funding according to its perceived priorities; and, advising on appropriate institutions to carry out the work.

6 RECENT DEVELOPMENTS

6.1 Protect the Protectables Protocol

As a result of the 1996 Review of Dieback in Western Australia (Podger et al. 1996) recommendation 1 regarding the ‘identification of significant protectable areas and their prioritisation’ the Government in 1997-1998 adopted a ‘Protectable’ area policy. The DCC prepared a report titled ‘*Phytophthora cinnamomi* and disease caused by it – a protocol for identifying ‘protectable areas’ and their priority for management’, (subsequently referred to as ‘the protocol’). In 2000, the EPA after allowing opportunity for public comment provided advice to the Minister for the Environment under Section 16(e) of the Environmental Protection Act on ‘the protocol’ (EPA Bulletin 1010, 2001). The EPA recommended a trial be conducted comparing the new and former systems and stated that it should be rigorously demonstrated that the ‘new’ system was resulting in ‘an improvement in the management of *Phytophthora cinnamomi* in State Forest areas’. The EPA’s advice to the Minister for the Environment on the protocol for identifying ‘protectable areas’ and their priority for management was that it be endorsed but with a caveat that it be on a trial basis with rigorous documentation of the trial and an independent review of the outcomes of the trial within 3 years. The introduction of the protocol on a trial basis required the development of a strategy during 2001 which sets out: the responsibilities for managing the trial; the documentation required; the key elements of a scientific monitoring program; and the process of review, including a comparison between the protocol being trialed and the past system of management. Once the trial was reviewed, it would be

necessary to integrate the findings into the Forest Management Plan for 2004 and beyond. The EPA further advised that the application of the protocol to other areas of land tenure within Western Australia be held over until the scientific trial is reviewed. The Conservation Commission convened an expert working group (EWG) to design a trial to compare the current and past systems of *Phytophthora cinnamomi* (dieback) management in accord with the EPA recommendation and to report on its findings.

In 2003 the EWG reported its findings to the Conservation Commission and indicated that it was not feasible to design an all-encompassing trial to test the Protocol against the past system of management within the specifications provided in the terms of reference. Nor was it justified to establish such a trial over a longer term than the three years specified in the terms of reference due to the complexities, cost and possibility of unclear results. However, the EWG determined that it would be possible to undertake work within that timeframe that would contribute to determining the effectiveness of some key components of the Protocol and its application and would contribute to improving the management of dieback throughout the State. The Minister endorsed these recommendations and this work will be progressed from 2004 onwards.

In 2002 the Minister for the Environment called for a whole of government approach and for further development of the scoping requirements for an Environmental Protection Policy (EPP) for the 'Threat abatement for *Phytophthora cinnamomi* and disease caused by it in native vegetation in Western Australia' by the Dieback Consultative Council (DCC) and the EPA in consultation with the Conservation Commission of Western Australia (CC of WA) and CALM.

6.2 *The Murdoch University Centre for Phytophthora Science and Management (CPSM)*

The Murdoch University Centre for *Phytophthora* Science and Management (CPSM), with the support of industry and government agencies, was established in 2003. The Centre has Vision [No WA biota is threatened by *Phytophthora cinnamomi*] and Mission [Through a coordinated program of management and research, and in partnership with the industry, government and the community, the centre will provide science, management and training to underpin the amelioration of the threats posed by *Phytophthora cinnamomi*] objectives. The Goals are to: develop a cost-effective, efficient method for control of spread and impact of *Phytophthora cinnamomi*; develop technologies for biodiversity conservation, and ecosystem restoration for threatened species recovery; develop technologies for cost-effective detection and mapping; and provide excellence in research leadership, training, consulting and extension. The CPSM with support from industry and agencies aims to establish a National Centre of Excellence that can utilize expertise and research effort from around Australia to develop strategies that will reduce the impact of *P. cinnamomi* across Australia.

6.3 *New Dieback Policy Framework*

In 2004, the Minister for the Environment announced a new policy framework that includes: the formation of a Dieback Response Group (DRG) to include representatives from the Dieback Consultative Council, the Dieback Working Group, the Conservation Commission of Western Australia, the Murdoch University Centre for *Phytophthora* Science and Management, the Department of the Environment and CALM; the development of a dieback atlas for WA; the preparation of guidelines for other land tenures such as private and local government land; the preparation of a generic dieback risk assessment methodology for broad community use; an action plan specifically to tackle the dieback threat to Fitzgerald River National Park, one of our most significant conservation reserves; and a whole-of-government policy on dieback management. The DRG has already raised sufficient dollar support for an economist to develop a cost-benefit analysis of the costs associated with *Phytophthora* and its impact on ecosystem function and health and associated management. This will allow the DCC, CPSM and others to seek funding based on informed cost-benefits and not just on a public good basis. The latter has been a barrier on previous funding bids in the past.

6.4 Best Practice Guidelines for the Management of *Phytophthora cinnamomi*

In 2004, a Public Consultation Draft for 'Best Practice Guidelines for the Management of *Phytophthora cinnamomi*' was released (CALM 2004b). The guidelines are to provide Departmental (CALM) staff with concise, clear and explicit statements of the best practice methods and standards for managing the threat to biodiversity posed by the introduced plant pathogen *Phytophthora cinnamomi* and the disease caused by it. The guidelines have a direct relevance to management of native vegetation on conservation lands and other lands managed by the Department within the vulnerable areas of the south western parts of Western Australia that receive more than 400 mm of rainfall per annum. The guidelines have also been written to form the basis of guidelines for adaptation and use by other land managers, proponents of activities and others. Once public comment has been obtained, the DCC will produce standard guidelines suitable for all lands.

6.5 Threat Abatement for *Phytophthora cinnamomi*

In March 2004, a Public Consultation on the Draft replacement of Conservation and Land Management Policy Statement Number 3, 'Threat abatement for *Phytophthora cinnamomi* and disease caused by it in native vegetation', was issued. The draft policy is designed to give guidance to CALM staff in order to limit the detrimental impacts of *P. cinnamomi* on the biodiversity of Western Australia in relation to Departmental responsibilities. Finalization of the draft Policy Statement Number 3 (CALM 2004a) should result in significant changes to the 1991 Policy (CALM 1991a).

6.6 National Review of Current Best Practice Approaches to the Management of Sites in Australia that are or Could be Threatened by *Phytophthora cinnamomi*.

In 2004 the CPSM was awarded a consultancy by the Australian Government Department of Environment and Heritage to 'Review the current best practice approaches to the management of sites in Australia that are or could be threatened by *Phytophthora cinnamomi*'. A scientific advisory committee consisting of researchers and policy makers from around Australia are developing, with in principle approval from 'key stakeholders', national best practice standards for the management of *P. cinnamomi* suitable for national adoption; generic risk assessment methodology that can be adopted nationally; and process used to determine the level of threat that *P. cinnamomi* poses to a place and to identify the most cost effective management response.

6.7 Forest Management Plan 2004-2013

The Plan considers *Phytophthora cinnamomi* as the most significant threat to the health and vitality of many ecosystems (Section 18). A high priority is to minimize the risk of new infestations in areas that are uninfested. Actions proposed include: the Conservation Commission will develop a whole of Government policy framework for the management of dieback; and the Department (CALM) and the Forest Products Commission will conduct their operations having regard to the 'Management of *Phytophthora* and Diseases Caused By It' Policy and Guidelines. These will be reviewed by the Department with public consultation by 31 December 2008, and revised or new Policy or Guidelines will be submitted to the Conservation Commission for advice and approval by the Minister for the Environment before they take effect. The Plan specifies that CALM will: prepare an inventory of sites where the impact of *P. cinnamomi* on the vegetation is known to be high, with a view to setting priorities for the regeneration or rehabilitation of those areas, and further develop dieback spread and impact models, including models relating to the effects of new infections. The Conservation Commission will undertake independent audits to assess the extent to which management is undertaken in accordance with the Plan and a priority has been given to dieback hygiene.

7 CONCLUSION

Phytophthora cinnamomi as an introduced soil-borne plant pathogen has had a major ecological impact across a large range of natural ecosystems. In Western Australia, these include the jarrah forest, heathlands and banksia woodlands with an estimated 2284 and 800 of the 5710 described species being susceptible or highly susceptible to the pathogen, respectively (Shearer et al. 2004). *P. cinnamomi* is recognized in Australia's Environmental Protection and Biodiversity Conservation Act (1999) as 'A Key Threatening Process to Australia's Biodiversity'. Plant deaths caused by *P. cinnamomi* were first observed in Western Australia in 1921-22, but it was not until 1964 that the pathogen was conclusively linked to these plant deaths. Prior to its identification, *P. cinnamomi* probably spread rapidly throughout the lower south-west via infested gravel used in road building and through forestry activities. Since 1964 there has been considerable research into the biology, ecology and control of the pathogen. This has led to informed management protocols such as quarantine and hygiene measures being implemented across the vegetation zones at risk. There has been considerable agency, industry and university collaboration to develop research and management tools to limit the spread and impact of the pathogen. Despite this, the pathogen has continued to spread into new areas of previously disease-free plant communities. Recent concerted efforts between government agencies, industry, land users and universities to develop priority goals to combat the pathogen do provide hope for the future. These include the formation of the Dieback Consultative Council, the Dieback Response Group, the Centre for Phytophthora Science and Management, and culminating in 2004 with the Draft 'Best Practice guidelines for the Management of *Phytophthora cinnamomi*'.

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