CONTROL OF *PHYTOPHTHORA* AND *DIPLODINA* CANKER IN WESTERN AUSTRALIA

PROGRESS REPORT TO THE

ENDANGERED SPECIES UNIT,

AUSTRALIAN NATURE CONSERVATION AGENCY

OCTOBER 1996

Department of Conservation and Land Management
Locked Bag 104, Bentley Delivery Centre, WA 6983

PROJECT 1

THE CONTROL OF *PHYTOPHTHORA* IN NATIVE PLANT COMMUNITIES

PART A

Application technologies and phosphonate behaviour in the host

B. Komorek, B. Shearer, M. Blumberg, C. Crane and R. Fairman

SUMMARY

Phytophthora cinnamomi is a vigorous pathogen that kills a wide range of plants by attacking their root system. The fungus is very widespread in the south-west of Western Australia causing great destruction to a large proportion of understorey vegetation and the jarrah in state forests, national parks and reserves. Apart from having a big impact on the structure and genetic diversity of heath and shrublands it also affects animal communities by reducing their habitat.

It is estimated that 1500 to 2000 species of the estimated 8000 species of vascular plants in the south-west may be susceptible to infection. Many of them are highly endemic and have been brought to the brink of extinction. Therefore, dieback disease currently poses the greatest conservation threat facing Western Australia.

Potassium phosphonate is an enormously useful chemical in the control of *Phytophthora* infections. It is currently the only available option in the prevention of further losses of rare and endangered plant species from dieback in the short to medium term.

The chemical has been successfully applied, on a range of plant species, in various areas in the south-west of Western Australia. Aerial application of the chemical has proven to be a promising method, permitting treatment of remote areas cost-effectively.

The results show that the fungicide residues are retained in the plant tissue and the concentration of phosphite is increased significantly by the follow-up spraying. Initially 10 % phosphonate was applied, but this rate proved to be generally too low to achieve long term protection. Higher concentration rates of 20 and 40 %, applied in ultra-low volume of 30 to 60 l/ha, are currently being field tested and appear to be able to ensure longer protection.

In some areas 40 % concentration resulted in some leaf burning, but in all cases it occurred only in some non-target plant species. Further experiments/screening is required in order to describe plant species that are likely to be more sensitive to phytotoxicity.

40 % phosphonate applied in our trials is currently the highest concentration commercially available and has not been used to treat plants before.

A new experimental system involving miniplots and the use of an ultra-low volume sprayer commenced. It will allow economical testing of a range of options for foliar application of phosphonate to protect host regenerating in disease centres from infection by *P. cinnamomi.*

PRESENT WORK AND EXPERIMENTS

- Currently, we are monitoring trials following aerial application of phosphonate for broad-scale protection from *P. cinnamomi* and ground application, using hand held sprayers, for small target areas. Samples for chemical analysis are taken periodically to monitor changes in the concentration of the chemical in shoots and roots. This information will allow determination of the duration of protection given to plants by a particular phosphonate concentration and application rate. This will ensure the selection of the most efficacious rate of application as well as the timing of any subsequent treatments. Fungicide residues are retained in the plants and experiments are continuing to determine how the concentration changes in different plant species at low and high concentration rates

- In May this year we re-sprayed three aerial application trials with 40 % phosphonate. The trials were initially sprayed with 10 % phosphonate over two years ago. We established that the low concentration protected plants in those experimental plots for only twelve to eighteen months. Re-spraying with a higher concentration resulted in some leaf margin burning in a few non-target species. All the experimental trials sprayed recently and some operational trials, sprayed by Albany District this year, were surveyed for phytotoxicity. All plant species showing signs of phytotoxicity were recorded, including the applied concentration, rate per hectare and severity of burning. This data provides important information on the phytotoxicity of different phosphonate concentrations and sets the safe upper limits for future prescriptions.

- We also completed a comprehensive germination experiment and determined that 40 % phosphonate had no effect on seed number and viability in three *Banksia* species in the North Dandalup trial.

- An experimental system has been established that will allow economical testing of a range of options for foliar application of phosphonate to protect host, regenerating in disease centres, from infection by *P. cinnamomi*. The system uses a combination of miniplots, a hand held micro-drop applicator to simulate aircraft application and controlled introduction of inoculum. To test the system, plots have been established in naturally regenerating *Banksia coccinea* in a disease centre in Gull Rock National Park, and naturally regenerating *B. telmatiaea* in a disease centre near Eneabba. After pre-treatment monitoring in October 1994-August 1995, the regenerating Banksias were sprayed once or twice with 20 and

40 % phosphonate or not sprayed at all. Mortality has continued to increase in the unsprayed plots, but not in the sprayed plots.

- Currently we are also analysing plant material collected from the North Dandalup trial to determine whether 40 % phosphonate has any effect on plant nutrition. We are measuring the leaf concentration of major cations.

- An experimental system is currently being established where tritium labelled phosphonate will be used to determine the distribution of phosphonate in plants. The study includes determination of the source-sink relationship as well as factors influencing phosphonate absorption, movement and possible exudation through the roots. There have been no studies on the distribution of phosphonate in native plants. Results of this experiment will allow the development of prescriptions for phosphonate application tailored for different plants or communities.

ACKNOWLEDGMENTS

We wish to thank the staff of Western Australian Chemistry Centre, Agricultural Chemistry Laboratory: Dr Neil Rothnie for his aid and advice in this project and to Wayne Best for his assistance in the quantitative determinations of phosphonate in plant samples.

PROJECT 3

DEVELOPMENT OF GIS-BASED DECISION SUPPORT TOOLS AND THE DATABASING OF *PHYTOPHTHORA*-SENSITIVE TAXA

P. Gioia and A.R. Chapman

OBJECTIVE

To provide a reliable, graphical decision-support system for monitoring and controlling the spread of dieback disease.

INTRODUCTION

At the inception of this project the objectives were to:

1. database and automate access to Herbarium specimen records for *Phytophthora*-susceptible taxa;

2. maintain, update and interrogate data sets to answer basic management questions;

3. develop a model with predictive capabilities and test validity of predictions.

While significant progress was made in objective 1, efforts to achieve objective 3 had limited success. In the previous progress report on this project an independent evaluation stated that "Although there appeared to be considerable merit in pursuing a process-based modelling approach, to develop a decision-support tool for predicting *Phytophthora* spread, it has not proved successful. This is due in part to a number of unanticipated features in the study area."

A number of reasons were outlined, many of which related to the difficulty in modelling the extremely complex processes by which *Phytophthora* spreads and the unrealistic requirements for data input to the model.

In the light of this a number of options were canvassed for a *Phytophthora* Decision Support System which might have increased relevance at an operational level. For example, prioritising areas for phosphonate spraying.

This could be achieved by overlaying occurrences of *Phytophthora* with the distribution of threatened and priority flora. The *Phytophthora* occurrences would be buffered by a given amount (for example, 500 m), noting those flora populations within that buffer. To implement this goal, knowledge about locations of *Phytophthora* and threatened and priority flora is required.

Additionally, the use of expert knowledge of *Phytophthora* distribution and behaviour was considered to be more likely to provide useful management information than a reductionist process model. Expert knowledge can be used to determine a range of indices including a suitability index (that is, areas that can support *Phytophthora*), a threat index (level of damage if *Phytophthora* were to infect an area) or a risk index (the likelihood that an area might become infected by *Phytophthora*). This expert knowledge would require a range of physiogeographic coverages which are generally available within CALM. It could also be supplemented by tools such as BIOCLIM which has climatic data not otherwise available at a broad scale.

These indices, in turn, can provide an additional mechanism for determining resource priorities in the control of *Phytophthora.*

The project's objectives have been modified to reflect the above changes in emphasis. They can now be summarised as providing a set of tools for CALM managers to:

1. Obtain timely & accurate information on the distribution and potential impact of *Phytophthora* in WA
2. Aid the prioritisation of departmental resources in relation to the control of *Phytophthora*
3. Use expert knowledge to analyse the present and future distribution of *Phytophthora* in relation to environmental factors and the implications for management.

These new objectives encompass and elaborate on the original objectives.

PROPOSED OUTCOMES

Proposed outcomes are divided into two stages, the first to be implemented within the current financial year and the second subject to completion of stage 1 and further approval/availability of funds.

Stage 1

1. A comprehensive statement of known locations of *Phytophthora*, within the South West Land Division. This will include verified distribution information from all relevant CALM regions.
2. A statement of *Phytophthora* distribution in relation to susceptible plant taxa, particularly rare and threatened taxa, and CALM estate
3. Development of methods to aid the prioritisation of control measures, particularly phosphonate application
4. A protocol for ongoing coordinated maintenance of *Phytophthora* distribution data within CALM

Stage 2

1. Use expert knowledge to develop suitability, threat and/or risk indices for *Phytophthora.*

PROGRESS TO DATE

Significant progress has already been made for stage 1. Most of the available dieback distribution within CALM and other groups has been obtained. (Once acquisition of base data has been completed, the production of various map products and the development of prioritisation algorithm for phosphonate spraying will commence.)

- **herbarium voucher specimens**
  Over 55,000 susceptible flora herbarium voucher specimens have been databased. Identifications and curation for these specimens are being maintained by the WA Herbarium.

- **conservation flora populations**
  Since the inception of this project, more detailed population-based data on conservation flora have become available. Sixty populations have been databased to date.

- **Dieback distribution - forest regions**
  Acquisition of dieback distribution data for forest regions and the Swan Coastal Plain has been completed.

- **Dieback distribution - South Coast region**
  Commenced digitising of dieback distribution maps for South Coast Region

- **Vegetation Health Service (VHS)**
  CALM's VHS contains a database of samples provided by CALM operations. Pathogens in the samples are identified and provide point locations of Phytophthora that have been positively identified. The entire VHS database has been obtained and will be useful in validating dieback interpretations.

- **GIS background coverages**
  GIS background coverages have been obtained (eg CALM estate, roads, hydrology).

- **BIOCLIM**
  BIOCLIM has been evaluated as a *potential* tool for use as part of expert criteria used to determine the above-mentioned indices.

PROJECT 4

THE CONTROL AND MANAGEMENT OF *PHYTOPHTHORA MEGASPERMA* IN THE NATIVE PLANT COMMUNITIES OF WESTERN AUSTRALIA

S.A. Carstairs and L. Newcombe

A primary scope item of the *Phytophthora megasperma* research program was to:

- **Investigate control measures for *P. megasperma*.**

This scope item may be subdivided into at least three discrete research areas:

1. To investigate strategies for reducing the rate of spread of dieback at sites infected by *P. megasperma* pathogens.

2. To investigate strategies for reducing dispersal of *P. megasperma* into uninfected plant communities.

3. To compare the relative pathogenicities of taxa within the *P. megasperma* complex, and other field occurring Phytophthoras.

1. REDUCING SPREAD OF DIEBACK AT SITES INFECTED BY *P. MEGASPERMA* PATHOGENS

Bellgard *et. al.* have initiated a research program which aims to determine the effectiveness of Phosphonate applied to vegetation at a *P. megasperma* infested site in the Fitzgerald River National Park as a barrier to contain or slow the spread of the pathogen. To date there has been little spread in either treated or control areas. **This area of research is ongoing.**

2. REDUCING DISPERSAL OF *P. MEGASPERMA* INTO UNINFECTED PLANT COMMUNITIES

Much of what *Phytophthora* researchers believe they know about the mechanism(s) of dispersion of *P. megasperma* inoculum throughout the conservation estate of Western Australia is based on existing knowledge of dispersion of *P. cinnamomi* inoculum, the basis for which has been provided by Podger (1968, 1972). Podger observed that there was a marked tendency for dieback disease caused by *P. cinnamomi* to be most extensive in areas with a history of frequent or recent utilisation, and aerial photographs showed a strong association between the occurrence of dieback caused by *P. cinnamomi* and road ways. Further, although few patches of dieback caused by

P. cinnamomi were located in areas remote from roading or logging, in these cases there was evidence of the passage of vehicles or heavy equipment in the course of fire suppression, mining exploration, or firewood cutting (Podger 1972). Consequently, Podger (1972) concluded that inoculum of *P. cinnamomi* was being dispersed with soil moved during road building and logging operations.

We have initiated a program to investigate the role of heavy vehicles, road pavements and gravel/shale pits (used to provide surface materials for pavement construction) in the dispersal of *P. megasperma* inoculum throughout the conservation estate of Western Australia.

Historically *P. megasperma* has not been frequently isolated from soil samples collected from areas of the south-west of Western Australia forested with karri and jarrah. We assessed 8 heavy vehicle samples, 154 pavement samples and 193 gravel/shale pit samples from the southern karri forest region for the presence of *P. megasperma*, and other species of *Phytophthora*. The results of this survey are presented in Table 1.

Table 1 Percent recovery of *P. cinnamomi*, *P. megasperma,* and other species of *Phytophthora,* from gravel samples collected off heavy vehicles and from pavement surfaces and gravel/shale pits in an area of karri forest in the south-west of Western Australia.

Sample Source	No. Samples Tested	% Samples +ve for		
		P. cinnamomi	*P.megasperma*	*Phytophthora* sp.
Heavy Vehicles	8	0	0	25
Pavement Surfaces	154	5.2	0	44.8
Gravel/Shale Pits	193	7.2	0	10.4
Totals	**355**	**6.2**	**0**	**25.6**

P. megasperma was not retrieved from any of the 355 samples tested. In contrast with this, *P. cinnamomi* was recovered from 6.2% of the samples. Species of *Phytophthora* other than *P. cinnamomi* and *P. megasperma* were recovered from 25.6% of samples. While these results support Podger's assertion that *P. cinnamomi* inoculum is being dispersed with soil moved during road construction, as well as the inoculum of other *Phytophthora* species, we have not provided evidence to support the notion that inoculum of *P. megasperma* is being dispersed in the same manner. This may reflect a low incidence of *P. megasperma* in the study area. **This area of research is ongoing.** In the next quarter we intend to collect samples from pavement surfaces in the northern and south-eastern sand plains in order to determine their *P. megasperma* status.

It is generally accepted that high soil moisture levels are important in the development of disease caused by *P. cinnamomi* as dieback frequently occurred near and spread rapidly from culverts and drains along roadways. Further, Podger (1968, 1972) observed that while disease caused by *P. cinnamomi* was formed in almost the entire range of topographic situations in the south-west of Western Australia, it was more frequent along drainage lines and in broad valleys than on upper surfaces and ridges. Shearer and Tippett (1989) confirmed Podger's observation reporting that the dendritic pattern of areas affected by *P. cinnamomi* illustrate the interaction of the fungus with the streams in shallow valleys draining upland areas.

We have initiated a program to investigate the role of streams and "water points" (water bodies accessed during pavement construction and fire fighting) in the dispersal of *P. megasperma*. The results of a survey of 5 water points in the southern karri forest and 7 in the northern jarrah forest are presented in Table 2.

Table 2 Percent of water points in the northern jarrah and southern karri forests from which *P. cinnamomi*, *P. megasperma*, and other species of *Phytophthora*, was recovered.

Sample Source	**No. Water Points Tested**	**% Samples +ve for**		
		P. cinnamomi	***P. megasperma***	***Phytophthora* sp.**
Karri Forest	5	0	TBD[1]	100
Northern Jarrah Forest	7	14.3	TBD	57.1

1 TBD = To be determined.

Circa 200 isolates of *Phytophthora,* other than *P. cinnamomi*, have been recovered from the 10 water points found to be infested with *Phytophthora*. The identities of these isolates will be determined in the next quarter. **This area of research is ongoing**. In the next quarter we intend to survey for *P. megasperma* in streams/water points in the northern and south-eastern sand plain regions.

3. TO COMPARE THE RELATIVE PATHOGENICITIES OF TAXA WITHIN THE *P. MEGASPERMA* COMPLEX, AND OTHER FIELD OCCURRING PHYTOPHTHORAS

We have established a field experiment which aims to compare the relative pathogenicities of five molecular species of *Phytophthora* recovered from the southern karri forest with that of *P. cinnamomi*. While *P. megasperma* is not being assessed in this study, it is planned to include this species in several repeat experiments elsewhere. **This area of research is ongoing**. In samples retrieved from the northern sand plain, five molecular species of *P. megasperma* have been identified by isoenzyme analysis. The materials required to test the relative pathogenicities of these Phytophthoras with that of *P. cinnamomi* under field conditions in the northern sand plain have been prepared. The experiment will be established when weather is suitable.

ACKNOWLEDGMENTS

We wish to thank Frank Podger for his advice on research matters which is seen as vital to the ongoing success of this project.

REFERENCES

Podger, F.D. (1968). Aetiology of jarrah dieback, a disease of dry sclerophyll *Eucalyptus marginata* Sm. forests in Western Australia. M.Sc. Thesis. Univ. Melbourne. 292 p.

Podger, F.D. (1972). *Phytophthora cinnamomi,* a cause of lethal disease in indigenous plant communities in Western Australia. *Phytopathology.* **62**:972-981.

Shearer, B.L. and J.T. Tippett. (1989). Jarrah dieback: The dynamics and management of *Phytophthora cinnamomi* in the jarrah (*Eucalyptus marginata*) forest of south-western Australia. Department of Conservation and Land Management *Res. Bull.* No. 3.

PROJECT 5

IDENTIFYING, GERMPLASM STORAGE AND *IN VITRO* PROPAGATION OF *PHYTOPHTHORA* AND CANKER THREATENED TAXA

A. Cochrane and D. Coates

1. IDENTIFICATION OF RARE AND THREATENED FLORA AT RISK FROM DIEBACK DISEASE

The Department of Conservation and Land Management Declared Rare (Threatened) and Priority Flora List for Western Australia (Ken Atkins 14/09/95) is currently being used as the basis for all collections. A new updated list is pending. Recently collections have focussed on WA's critically endangered taxa as well as continued collections of *Phytophthora* and canker dieback susceptible species in the south-west of the State. Consultation with Kings Park and Botanic Gardens has highlighted the gaps in the *ex-situ* conservation of the critically endangered taxa and additional effort will be made to secure germplasm of these species in the face of declining populations and possible extinction. The plant groups targeted for collection continue to be predominantly from the families Proteaceae, Epacridaceae, Fabaceae, and Myrtaceae.

2. IN VITRO PROPAGATION

Discontinued (see Year 1 report)

3. CRYOSTORAGE

Discontinued (see Year 1 report)

4. SEED COLLECTION

Three hundred and forty-one accessions of rare or priority taxa have been incorporated into the Threatened Flora Seed Centre as of 12 September, 1996. This represents 149 taxa in 14 families. Good genetically representative seed collections of many of the 38 critically endangered taxa have been made. Several visits to the northern sandplains have resulted in the collection of a number of accessions of rare and geographically restricted taxa. Other collection trips have been in the species-rich south coast and southern sandplains.

New populations of threatened taxa and extensions of previously known populations continue to be discovered on routine collection trips. Communication between

CALM districts and the TFSC remains excellent with assistance being given for collections and the provision of field advice. Whilst in the field, staff of the TFSC continue to collect additional germplasm material from critically endangered and other taxa for cultivation at Kings Park and Botanic Garden.

This past field season has served to consolidate our knowledge and understanding of some of the variables that affect phenology, pollination, seed set, and seed ripeness as well as the identification of seed of a wide variety of species.

5. SEED STORAGE, VIABILITY TESTING AND INVENTORY SYSTEM

One hundred and thirty-six accessions have been retested for viability after 1 year in storage at -18°C or at 4°C. This comprises fifty-six taxa. The majority of accessions responded positively to storage conditions with little to no loss in germinability and in some instances improved germinability. Encouraging germination results continue to be gained through the use of new techniques such as those developed by Kings Park and Botanic Gardens (e.g. the use of smoke to break dormancy and enhance germination of *Verticordia* spp.).

New accessions will continue to be monitored on a yearly, then 5 yearly basis until adequate knowledge of the flora's response to sub-zero storage is attained.

The WASeed database is nearing completion. Germination results for all accessions have been databased and graphed, to enable ease of monitoring response of seed to storage conditions. The phenology database continues to be updated as new information and new species are added to the list of flora being targeted by the TFSC.

New articles on seed germination and dormancy, and storage techniques continue to be added to the TFSC reprint collection, which is fully databased.

A new walk-in coolroom and freezer room and humidity and temperature controlled drying room have recently been constructed. These facilities will enable greater control over the drying and storage of seed, and will permit more advanced research into the response of Western Australian species to moisture content reduction and freezing.

6. FUTURE COLLECTIONS AND PROPOSED DEVELOPMENTS

The coming year will see continued collections of threatened flora from the south-west and resampling of previously collected taxa. Additional populations of targeted flora will be added to the accessions where necessary to consolidate the gene pool of that taxon.

A Churchill Fellowship was awarded to the manager of the Threatened Flora Seed Centre for 1997. Plans are now underway to visit genebanks in the USA and the Seed Conservation Section of Wakehurst Place, Kew, UK for approximately 3 months.

Visits to the International Plant Genetic Resource Institute in Rome have been tentatively arranged and contacts are being made with researchers in South Africa. The increase in knowledge that will be gained from this opportunity to visit other scientists in genebank management overseas will be invaluable to the operations of the TFSC and assist in our efforts to conserve the native flora.

The results of the past three years' work on the response of native seed to low moisture and low temperature storage is being prepared for publication.

A technical officer has been seconded from Kings Park and Botanic Gardens for one year to assist with collections and laboratory testing of seed. It is hoped that continued research into seed storage and seed germination and dormancy breaking mechanisms for the south western flora will assist our knowledge of seed biology and enhance the overall effectiveness of the operation of the TFSC.

In the laboratory, research into a variety of techniques to promote germination continue to result in a better understanding of the biology of some of the threatened taxa. The use of growth hormones, smoke, heat treatment and scarification have provided useful information for assessing viability and determining the optimum methods for germination of seed collected.

PROJECT 6

MANAGEMENT OF *BANKSIA COCCINEA* STANDS AFFECTED BY CANKER FUNGI

L. McCaw

SUMMARY

Field work between April and September 1996 has concentrated on the identification and assessment of plant health and condition in stands of *B. coccinea* unburnt for more than 15 years. Results to date have shown that canker-induced decline is not inevitable in older stands, with a small number of inividuals more than 45 years old being still in healthy condition. Unfortunately this stand was burnt by a wildfire in April. Seedling regeneration as a result of the fire will be assessed in spring 1996. The node count method does not appear to be a reliable method for determining the age of plants more than 15 years old, probably because thickening of the stem conceals the pattern of nodes.

INTRODUCTION

Banksia coccinea R. Br. is a distinctive species characteristic of shrubland plant communities on the southern sandplain of Western Australia, occuring within the region bounded approximately by Albany, the Stirling Range and the Young River in the east. Serious decline of *B. coccinea* stands was first reported in 1989 (Shearer and Fairman 1991), and subsequent work has implicated the ascomycete *Cryptodiaporthe melanocraspeda* as the causal agent for a destructive canker disease affecting the species (Bathgate and Shearer 1995). Previous work has investigated various aspects of the disease and its impact on *B. coccinea* populations including seed bank dynamics of *B. coccinea,* sources of inoculum and conditions favouring spore release, the infection process, factors influencing disease intensity, and possible management strategies to minimise disease impact (Bathgate and Shearer 1995). The shrubland plant communities in which *B. coccinea* occurs are prone to periodic fire and the potential role of fire in the management of canker-affected stands has been recognised. Bathgate and Shearer (1995) demonstrated a pattern of increasing disease severity with increasing stand age, and recorded canker present in all surveyed stands over 14 years of age. The importance of unburnt remnants of old stands as foci for infection of adjacent, younger regeneration was also confirmed, suggesting that fire regimes which create mosaics of small patches of unburnt vegetation could exacerbate disease development.

The project described in this report is intended to build on this prior work by investigating the feasibility and wider implications of using fire to manage canker-affected stands of *B. coccinea.* Goals of the project are (1) to determine the role of fire in the management and rehabilitation of *B. coccinea* stands affected by canker, and (2) to recommend measures that may assist in maintaining viable stands of *B. coccinea* throughout its current geographic range.

WORK UNDERTAKEN MARCH-SEPTEMBER 1996

1. Assessment of health and condition of *B. coccinea* in long unburnt stands

Previous work by Bathgate and Shearer (1995) indicated a pattern of increasing disease severity with increasing stand age, and recorded canker present in all surveyed stands of *B. coccinea* over 14 years of age. This is a key issue for fire management, as the extent of decline in older stands could be used as one criteria, amongst others, for the most appropriate timing of intervention with prescribed fire to stimulate regeneration of the stand. It was therefore considered important to expand the data base for stands unburnt for longer than about 15 years across the geographic range of the species. Potential stands were identified using a variety of information including fire history maps maintained by the Department of CALM, examination of aerial photographs, local knowledge and field survey.

To date, suitable stands of *B. coccinea* unburnt for longer than 15 years have been identified and assessed at the following locations:

Location	Year last burnt
Stirling Range National Park - Two Mile Lake (A)	1969
Stirling Range National Park - Two Mile Lake (B)	1969
Stirling Range National Park - Two Mile Lake (C)	1969
Stirling Range National Park - Talyuberlup Track	pre-1950
Hopetoun - Table Hill	pre-1970
Hopetoun - Springdale Rd	pre-1970
South Stirlings	pre-1970
Chillinup Road	pre-1970

Unfortunately, the stand at Talyuberlup Track in the Stirling Range National Park was burnt by an arson-caused fire in April 1996 before the condition of the *B. coccinea* had been assessed. This stand contained a few large, widely-spaced individuals which were observed to be in good condition prior to the fire, with little or no evidence of limb dieback despite their considerable age.

At each site, the height and stem diameter of all *B. coccinea* has been recorded within transects. All *B. coccinea* plants have been permanently marked to permit re-location so that changes in health and condition can be monitored over time. Site locations have been fixed with a Global Positioning System to permit re-location, even if other forms of marking are damaged or destroyed. The extent of limb dieback was assessed using the same classification scheme employed by Bathgate and Shearer (1995). The plant species composition of the stand has been described at each site. Plant age has also been estimated using the node counting technique.

Stands display a typical even-aged structure, with evidence of suppression of some smaller and less vigorous individuals. Mortality levels are higher amongst the smaller plants, suggesting the competition may be responsible for at least a proportion of plant deaths. The highest level of mortality recorded was 18 per cent at the Stirling Range National Park Two Mile Lake (B) site. More than half the *B. coccinea* at each of the sites examined were considered to have no or only minor limb dieback.

It is intended to re-assess these sites in summer 1996/97 to determine whether there has been any significant change in condition over the winter months. These sites will also provide a valuable network for monitoring the health of the species over the longer term. At the burnt site in the Stirling Range National Park seedling regeneration will be examined to determine whether old plants are still capable of successful regeneration.

The node count method consistently under-estimated the age of *B. coccinea* and does not appear to be a reliable method for determining the age of plants more than 15 years old, probably because thickening of the stem conceals the pattern of nodes.

2. Regeneration of *B. coccinea* in stands degraded by canker

Transects to monitor the health and condition of established plants and to examine the success, or otherwise, of seedling regeneration have been established in a severely canker degraded stand at Waychinicup and in an immature stand at Wellstead where there is currently an active canker infection. Some seedling regeneration has occurred at both sites. Continued monitioring will be necessary to determine whether seedlings can persist and grow in the presence of high inoculum levels.

3. Flowering and seed production of *B. coccinea*

Populations of *B. coccinea* seedlings at the Stirling Range National Park which regenerated following fires in autumn 1989 and spring 1990 were re-assessed in September 1996 to determine flowering and seed production status in relation to plant age. Of the seedlings established in 1989, 40 per cent had flowered during the current spring. This was a smaller proportion than had flowered two years previously (60 per cent), and none had flowered in spring 1995. Only one of the 20 plants which regenerated in 1990 flowered in spring 1996, this being the first flowering recorded amongst this cohort since the fire despite the fact that the seedlings are now six years old. This result indicates that juvenile periods for plants may vary considerably even at the same site, and should not be regarded as a constant.

REFERENCES

Bathgate, J. and Shearer, B. (1995). Control and management of *Cryptodiaporthe melanocraspeda* canker threatening *Banksia coccinea*. Report to Endangered Species Unit, Australian Nature Conservation Agency, March 1995.

Shearer, B. and Fairman, R. (1991). Aerial canker fungi threaten *Banksia coccinea*. Abstract 85/C16. Proceedings of the Conservation Biology in Australia and Oceania Conference, University of Queensland.