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A Report on the P. cinnamomi problem in the Cleland Conservation Reserve.

by S.R. Shea

3/12/80.

Summary

1. *P.cinnamomi has the potential to cause extensive and irreversible loss of the overstorey and components of the understorey at Cleland.*

2. *The probability of this occurring will be significantly increased if management of the reserve is based on the premise that P.cinnamomi is not a potential problem.*

3. *The potential for the disease to spread and intensify can be markedly reduced by the development of a management program designed to minimize spread of the pathogen and avoid site disturbance which would pre-dispose the vegetation.*

4. *70 mm aerial colour photographs should be used to map the disease.*

5. *An education program should be initiated.*

6. *The park managers should have rapid access to research on the pathogen and research by Universities on the problem in the reserve should be encouraged.*

Introduction

P.cinnamomi is a powerful plant pathogen with a wide host list and a demonstrated capacity to kill a large number of Australian native species. There is a considerable weight of evidence to suggest that it is an introduced pathogen in Western Australia, South Australia, Victoria and Tasmania. Although, this fungus is of tropical origin and is very dependent on high soil moisture levels for survival, transmission and reproduction it has the capacity to destroy many Australian native species growing in a Meditterranean type climate on free drained soils.

Details of the biology of the fungus are contained in the articles enclosed. In this report I have briefly summarized the biological information on the fungus and attempted to interpret the disease situation at Cleland and provide suggestions for management on the basis of what is known of the fungus and my own experience in the Jarrah (E.marginata Sm) forest of Western Australia.

It is important to emphasize that although our knowledge of P.cinnamomi and the diseases it causes is considerable there are still may unknowns and my recommendations are made simply on the basis of the best knowledge available at this point in time. I am also conscious of the fact that there are severe practical constraints in managing native vegetation and that there may be local factors of which I am not aware that make some of my recommendations impractical.

Even though the information available is incomplete I favour the adoption of conservative management practices with respect to P.cinnamomi on the basis that it is more desirable to take every practical precaution possible, even though some measures may subsequently prove to be of limited value, because of the unquestionable capacity of this fungus to cause extensive and irreversible damage.

Current Disease Situation

Distribution of the Pathogen.

P.cinnamomi is present in a number of locations in the reserve. However, the limited surveys that have been conducted suggest that it is by no means ubiquitous that its presence is associated with previous human activity which could easily account for its introduction. Several other pathogens have also been detected (it is likely that these have been introduced on exotic plants) and it is possible that these species may contribute to the decline of native vegetation. However, P.cinnamomi is the major threat because of the number of hosts it can attack and its demonstrated capacity to kill Australian native species.

Distribution of the Disease

The occurrence of dying vegetation is much more restricted than the pathogen. The two main areas where there is significant mortality are associated with excessive surface and subsurface water flow which has resulted from man-made structures. (Water and septic tanks). In these two areas there is marked overstorey mortality. Understorey and shrub symptoms are difficult to seperate from natural dieback and decline and it is possible that in a number of other locations in the reserve that there is incipient disease. However, only in one area (downslope of the main kiosk) was there a distinctive pattern of understorey death. In this area Xanthorrea sp. exhibited a pattern of decline which was not unlike that which can be observed in Xanthorrea and the B.grandis in the Jarrah forest. (see enclosed publications and 70 mm aerial colour photographs).

The general absence of identifyable death and decline in the understorey species suggests that there are no widely spread species in the understorey and shrub layer in the reserve which are highly susceptible to the disease. If this is correct then the prognosis for Cleland vegetation is more optimistic than the jarrah forest where the B.grandis understorey provides a large reservoir of inoculum.

Potential For Spread and Intensification of the Disease.

It is impossible to predict with any certainty the future spread and intensification of the disease in the conservation area. It is possible that the disease, as distinct from the fungus, will not extend significantly beyond the current areas which are affected. Current research in Western Australia, however, suggests that following extreme climatic conditions (excess spring and/or autumn rainfall) or serious site disturbance rapid and extensive overstorey mortality may occur. For example, during the 1950's and early 1960's extensive jarrah mortality was observed in Western Australia but in the last 15 years jarrah mortality has been limited. This decrease in disease intensity is tentatively correlated with the below average rainfall which has been recorded over the last 15 years. However, extensive mortality has been recorded even during this period in areas subject to extensive disturbance such as those surrounding bauxite mine sites. Similar patterns of disease expression over long time periods have been recorded in other parts of the world where P.cinnamomi is attacking Forest. (For example, shelterbelt mortality of P.radiata in New Zealand.) Uncontrolled activities resulting in soil disturbance can lead to a dramatic increase in disease. This has occurred in Stirling Range National Park in Western Australia. Thus, it must be assumed that there is a very real potential for rapid spread and intensification of the areas affected by P.cinnamomi in the Cleland Conservation Reserve. One policy option is to ignore the disease and assume that it will remain restricted in distribution. This has obvious cost saving advantages but the adoption of this policy may lead to the loss of a large proportion of the overstorey and understorey component of the reserve in the longer term.

Accordingly I recommend that future policy and management decisions on Cleland be based on the assumption that P.cinnamomi could cause extensive and irreversible damage to the vegetation.

Biology of Phytophthora Cinnamomi (see attached publication for details).

1. P.cinnamomi has a wide host range including many Australian species. E.baxteri and E.obliqua are rated as susceptible.

2. Host susceptibility varies. The root and lower stem of some species (eg. B.grandis) are totally invaded by the fungus. Other species are subject only to fine feeder root attack. Recent research in Western Australia has shown that under certain conditions relative susceptiblity may change. For example, we have recently found that the fungus can invade the collar region of large jarrah trees. I suspect that the overstorey trees at Cleland may also be subject to large root and collar invasion.

3. The fungus is a water mould and is dependent on high soil moisture levels for reproduction, survival and transmission of spores.

4. Survival in dry soil is possible but limited.

5. Relatively high soil temperatures are required for the formation of sporangia which is the principle spore form which permits the fungus to rapidly increase its density in the soil.

6. Transmission of spores over significant distances (> 5 cm) can only occur in free water running over the soil or just below the soil surface or in soil adhering to vectors. (Usually on equipment).

7. Recent research in Western Australia suggests that the fungus is an empheral soil organism. It is reduced to a low level in the soil during the summer months on free drained sites. Reproduction in the soil appears to be restricted to autumn and spring. The fungus can be present in the soil at a low level in winter but our current research suggests that spring is the most important period for reproduction.

8. In an Meditterranean type climate on free drained soils environmental conditions are likely only to be favourable for P.cinnamomi for relatively brief periods in years of normal rainfall. It is probable that damage follows years when spring and autumn rainfall are abnormally high.

Potential Control Measures

Despite extensive research throughout the world over the past 40 years there is as yet no practical method of controlling P.cinnamomi in forest situations. The fungus is easily killed by fungicides and recent developments in chemical control suggest that a new chemical Ridomyl can be used very effectively to control P.cinnamomi in intensive cropping situations. However, this chemical is expensive and control can only be achieved by repeated applications. For example, in Avocado crops the chemical has caused a dramatic reduction in disease but it has to be applied 3 to 4 times a year. It is unlikely therefore that chemical control could be used where native vegetation is effected except in special situations where a small infection may threaten large areas of forest.

Although, absolute control cannot be achieved I believe there is the potential to significantly reduce disease intensity over long periods of time by the adoption of procedures which minimize artificial spread and create *site conditions which disfavour survival and reproduction by the pathogen. These procedures are summarized below.*

Reduction of Spread

P.cinnamomi is an introduced pathogen. Therefore, the most important means of achieving control is to restrict spread. The fungus has a limited capacity to spread by itself. In the absence of vectors it can only move a few centimeters in soil. Mycelial extension through soil is very limited and in the absence of species which are highly susceptible and have extensive horizontal root systems (these species dont appear to be present at Cleland) spread via roots is also restricted. Passive spread over significant distances can only take place in free water moving over the surface of the soil (or just below the surface) and thus, by definition this type of spread can only take place downslope from existing infections.

Significant extension of the disease can only occur if the fungus is transmitted in soil carried by vectors. Although, the surveys that have been carried out indicate that fungus is present in a number of areas in the reserve it is by no means ubiquitous. Therefore, the most important management procedure to reduce disease is to reduce the potential for spread of the pathogen by the movement of soil. The following will assist in the development of hygiene procedures in the reserve.

1. The fungus can be transmitted in minute amounts of soil. Even if a single spore is transmitted a new infection can be established. Thus, any soil movement can result in the spread of the disease. However, it is most important to stress that the probability of spreading the pathogen is markedly effected by the quantities of soil transmitted. The fact that P.cinnamomi can be transmitted in small quantities of soil can be used to rationalize a "no hygiene" policy. Our field and research evidence suggests that the probability of spreading the disease can be reduced to practical levels by stringent hygiene.

2. It is important to focus on important vectors. Thus, while it is possible that the fungus could be carried by animals or on boots these vectors are insignificant in comparison too loaders, bulldozers and trucks.

3. For spread to occur the vectors must come in contact with the pathogen. Hence seperation of activities which occur in diseased and healthy areas is essential. Identification of sources of inoculum within the park will permit seperation of activities. Where there is a need to operate machines in disease free and diseased areas vehicles should be cleaned between operations.

4. The probability of a vector picking up inoculum is effected by site and season.

> *a) Lowlying moisture gaining sites have a high probability of being a source of inoculum particularly if disease occurs nearby.*
>
> *b) The density of the fungus in the soil varies with season. It is unlikely that any vector will pick up the fungus when the soil is dry. It is possible that spring and autumn are particularly high risk periods but it must be assumed that at any period of the year when the soil is wet it is possible to pick up the fungus in soil.*

5. Even though a vector may transmit the fungus the probability of the transmitted soil causing a new infection is dependent on the environmental conditions at the reception site. It is highly improbable that a new infection will be initiated if the soil is dry and no rain falls within 2 - 3 weeks of the infected soil being transmitted.

6. The impact of a new infection on disease spread and intensification will depend on the location of the new infection. A new infection established high in the landscape has the potential to effect all the vegetation downslope. Infections established low in the landscape will have a limited capacity to expand. Therefore all operations involving movement of soil (eg. road construction) should be kept as low in the landscape as possible wherever this is practical.

7. Washdown facilities. These should be made so that the washdown operation is as simple and comfortable as possible for the operator. Care should be taken to ensure that the washdown station:-

> *a) does not become a source of inoculum. For example if conditions adjacent to the station are muddy a vehicle may leave the washdown station more contaminated than when it arrives.*
>
> *b) does not discharge into healthy forest. Water from the washdown station should be caught in a trap which can be treated with fungicide overflow water should be drained into a stream as directly as possible. Sodium hypochloride is currently used in W.A. but there is some concern as to its effectiveness. We are currently evaluating a new chemical and I will advise if this can be used when we have evaluated it. I enclose some recent publications which describe the use of chemicals in a nursery situation (Chlorine seems a likely candidate.)*

8. Movement of earth or gravel into the park could constitute a source of inoculum. It is pointless to sample such materials as they enter the park since hundreds of samples would have to be assayed before it could be confirmed that the material was uncontaminated. The source of the material should be investigated to ensure that P.cinnamomi is not present. This can be determined by examining the site for symptoms and having check assays carried out at the site.

9. All vehicles entering the park which will be moving off established roads should be washed down before they procede.

Site Disturbance

It is likely that site disturbance resulting in the site being predisposed to the fungus is as important as the effects of disturbance on transmission of the pathogen.

1. Any site disturbance which causes drainage to be impeded will intensify the disease. Ponding of water and discharge of water so that if flows overland creates ideal conditions for disease spread and intensification (The two areas at Cleland where there is significant overstorey mortality are both associated with water accumulation and flow).

2. Where drainage has to be disrupted the water should be contained in a narrow channel and directed immediately to the nearest stream.

3. Walk track construction should be such that the tracks are exactly on the contour to ensure that there is not excessive accumulation of water at any point. The tracks should be constructed so that they are hard surfaced but free draining and should be kept as narrow as is practical so that they dont form a large catchment for water.

4. It is likely that baring of the soil will increase soil temperatures and therefore sporangial production. Maintenance of a dense shrub, understorey and overstorey canopy will decrease soil temperatures during the critical period for sporangial production in spring.

5. Hazard reduction burning may increase disease by baring the soil. It is also possible that burning may alter species composition. The effect could be positive or negative. Until further data is available hazard reduction burning should be approached with caution.

The development of an effective disease control management program is dependent on the park managers acquiring a knowledge of the biology of the pathogen and then developing practical measures which will reduce the probability of spread and intensification of the disease. Before any operation is carried out in the park its potential to spread and intensify the disease should be assessed and then all practical measures should be applied to lower the probability that operation will contribute to spread and intensification of the disease. No single or combination of procedures will guarantee that no extension on intensification of the disease will occur but rigorous application of the disease principles will reduce the risk to minimal levels.

These principles are continually being applied in W.A. I enclose a example of a management aid which has been developed to assist district officers implement the disease management program. (Appendix A).

<u>Monitoring disease spread and Intensification</u>

70 mm colour photography has been used with outstanding success in W.A. It provides a means of locating potential sources of inoculum (for hygiene management) but also over the longer term it provides a method of assessing the success of the disease management program. Apart from its use in disease management it is a tool which would be an invaluable aid for general reserve management. I was advised that some preliminary trials at Cleland were not encouraging. I enclose a stereo pair of a 70 mm colour photograph of the type used to identify disease at the understorey and shrub symptoms stage of development in the Jarrah Forest. (Appendix B). Note that in this stereo pair it is possible to identify dying Xanthorrea sp. Currently it is planned to use this technique to photography in excess of 500,000 hectares of Jarrah Forest. It therefore can be readily used in an area the size of the Cleland reserve.

Mr. Bryan Myers (CSIRO Division of Forests Research, Banks Street, Yarralumla, A.C.T.) has applied this technique in various situations in eastern Australia. It is possible that his expertize could be made available to the Board.

<u>Education</u>

The key to any disease control management program adopted at Cleland will be the communication to all people associated with the reserve (from policy makers to reserve users) the disease problem, its biology and the measures that are being taken to achieve control. It is my experience that it is *pointless to prescribe a series of measures to control the disease without explaining the rational behind these measures. If those associated with the reserve are informed as to the basic biology of the problem they will be able to contribute towards devising measures to reduce the risk of the disease. It is particularly important to ensure that those associated with the park are sympathetic since many of the measures that need to be taken are dependent on goodwill. For example, it is impossible to supervise washing down of equipment and this is usually not a comfortable operation. If the personal involved are conscious of the fact that failure to do the job properly could result in destruction of the vegetation they are usually, in my experience, very conscientous. Education of people who have access to the reserve but who are not under the control of the park managers (eg. Electricity line maintenance workers) is particularly important. Similarly controls or movement or access to the park by general public will be much more sympathetically received if the reason for such measures are made known.*

Of course it is essential that the framework for the disease control management program is established before the education program is initiated.

Research

There are a number of factors associated with the specific disease problem at Cleland could be profitably researched. However, research on Phytophthora is very expensive and it would be difficult to justify the expenditure which would be required to set up a research program at Cleland. However, considerable information can be obtained at a relatively low cost by -

a) Ensuring that research fundings on this pathogen are readily available to the personal at the park. Since the W.A. situation has many parallels with Cleland much of the benefits from the large research program being carried out in W.A. can be transferred to Cleland.

b) The WAIT Agricultural Institute has some of the best plant pathologists in the world working on Phytophthora sp. and their expertize should be tapped whenever possible. The Botanical Gardens in Adelaide has an excellent plant pathologist attached to it who has experience with Phytophthora sp.

c) We have found that considerable information can be obtained at a relatively low cost by encouraging honours or post graduate students to carry research in the Jarrah Forest as part of their studies. This may involve a small expenditure in the form *of support funds but often the research will be initiated by simply advising the University supervisors of the problem and providing access and simple facilities.*

The following are some possible research projects which would be suitable for post graduate students and which would assist in developing disease control procedures -

1. Determine the susceptibility of stands and understorey species to P.cinnamomi in disease areas. This could be achieved by systematic plating of the roots of shrub species in known areas where P.cinnamomi is present.

2. Determine the relative susceptibility of Xanthorrea sp. This could be achieved by excavating dead and dying Xanthorrea and assaying there roots and stems for P.cinnamomi.

3. Determine the degree of invasion by P.cinnamomi into E.obliqua and E.baxteri. Is the collar region of these species invaded by P.cinnamomi ?

4. a) Analyse seasonal and annual rainfall and temperature variation at Cleland in relation to disease development and P.cinnamomi survival and asexual reproduction.

b) Seasonal variation in P.cinnamomi population levels in the soil. What is the capacity of P.cinnamomi to survive during the summer months ?

I would be pleased to assist in development of this type of research by communication with prospective students and supervisors ?