Direction of Dieback Research for Management Purposes

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1. INTRODUCTION

For purposes of forest management it is convenient to classify the possible causal agents of the various forms of dieback disease broadly into 'biotic' and 'abiotic' factors.

The *abiotic* factors will include fire, drought, frost, possible nutritional disorders and the complex sequence of events that sometime follows interference with a delicately-poised forest ecosystem.

Among the *biotic* factors should be included fungi, insects, nematodes, and the other living agents in the forests.

2. RESEARCH DIRECTION FOR MANAGEMENT OF DIEBACK CAUSED BY ABIOTIC AGENTS

Abiotic factors include fire, frost and unbalanced water relations. The remedies for these will not be dealt with at length because possible solutions are primarily a matter of manipulation of method. Research activity will lie more in the area of applied investigations and field observations rather than at more basic levels.

2.1 Fire

Possible remedies for the control of fire are the implementation of an adequate suppression system and the establishment of an adequate system of strategic hazard reduction, according to well-established principles.

2.2 Frost

Possible remedies for frost damage are largely a matter of designing and implementing silvicultural systems aimed at reducing radiation and inhibiting movement or ponding of cold air. Selection or shelter-wood type silvicultural systems in and adjacent to the cold air catchments can be used. Alternatively where introduction of species alien to a particular site is being considered, proper attention must be given to species selection.

2.3 Unbalanced water relations

Drought, both actual and indirect,* and water logging may commonly be regarded as arising from some alteration to the site due to felling or clearing indigenous stands. In eucalypt plantations these problems will occur if unsuitable species or unsuitable densities are employed. Manipulation of stand density seems to provide the remedy to some extent in either case. Selection of species is particularly relevant to drought (Carne, 1967), and where eucalypt plantations are being established there is wisdom in avoiding extensive monoculture (Carne, 1973).

3. RESEARCH DIRECTION FOR MANAGEMENT OF DIEBACK CAUSED BY BIOTIC AGENTS

3.1 Pathogenic micro-organisms

Dieback diseases associated with either insect or soil-borne organisms can only be managed after a careful study of the aetiology of the disease. This attempts to identify weaknesses in the disease cycle which could be exploited to control the disease. The financial aspects of the costs of researching and implementing practicable control measures in relation to the benefits of control are particularly relevant.

3.2 Cost benefit of disease control

The cost items are a relatively simple matter of accounting and budgeting, but the benefits vary substantially according to the particular management objectives and will include many intangibles such as recreation and amenity values as well as, in the case of national parks, the value of protecting indigenous ecosystems (Weste, 1973). This is a particularly sensitive area as no options are available and disease control must be absolute.

4. POLICY FORMULATION

Forest managers require economic appraisals and technical guidance to determine management priorities at policy and operational levels. These factors are essential for adequate budgeting. The requirements may be met roughly in the following sequence:

(a) determination of the existing extent, location and rate of development of the disease;

(b) prediction of the maximum damage potential of the disease if allowed to develop unchecked;

(c) estimates of the value of the resource being protected in relation to the financial loss and costs of research and control;

(d) appraisal of the effectiveness and feasibility of control measures on an operational scale.

These items are often neglected by research workers, even though research priorities and the applicability of control or rehabilitation measures cannot be judged adequately without them. For the purposes of implementing initial action successive approximations based upon the best information available at any time, are superior to no action at all, in view of the lengthy time scales involved. As an interim measure, hygiene and quarantine are regarded as prudent partial holding action and as a relatively cheap way of ensuring that the disease situation is not needlessly exaggerated (Veitch, 1973).

5. EXTENT, LOCATION AND RATE OF DEVELOPMENT OF DISEASE

5.1 Management requirements

Considerable progress has been made in this regard using ground inspection and a combination of ground inspection and various photo mapping techniques as reported in other papers. Scale and type of photography are particularly important, but considering that in such areas as Western Australia photo mapping has been in progress since 1956 and substantial areas of the more difficult vegetation types (where ground mapping is difficult) still remain unmapped, progress in this basic requirement cannot be regarded as satisfactory. Further work is required in the application of multi-spectral

* Indirect moisture stress induced by root rot, hot winds, etc.

imagery and perhaps in the development of photo sampling techniques using very large-scale photography (Western Australian Forests Department, 1972).

5.2 Terminology

Attempts to determine the rate of development of diseases or even to establish a uniform and meaningful terminology have to date been inadequate. Expression of the rate of spread in linear terms may be a useful index for research purposes but is meaningless in management, whereas expression in terms of percentage of infected area suffers the disability of a constantly changing base. Rate of development is crucial in planning timber salvage from infected areas and in organising possible control or rehabilitation measures. In Western Australia photo-monitoring (Western Australia Forests Department, 1972) key strips initially using photography dating back to 1941 have indicated overall increases in infected area of the order of 4 per cent per annum, but varying widely according to time and locality. These approximations have provided a valuable basis for some sort of management planning which unfortunately falls short of what is ultimately desirable. Firmer estimates of rate of development are essential for immediate purposes as well as to relate diseases to the overall context of land management.

6. DETERMINATION OF MAXIMUM DISEASE POTENTIAL

Forest managers require accurate and unbiased estimates of the maximum damage potential of any forest tree disease. This is often difficult to obtain. Papers from Victoria, Tasmania and Western Australia indicate that the distribution pattern of diseases is fairly well known where visible symptoms have developed, but the fact that new infections occur clearly indicates that additional susceptible areas are exposed to infection and it is necessary to know their number and area. A growth loss in regrowth stands before disease symptoms become visible has been indicated (Felton and Bird, 1972) and site conditions leading to the deterioration of old growth may carry over to induce similar symptoms of disease or disorder in regrowth on the same area (Felton, 1972).

The propensity of particular sites to diseases is vitally significant to future resource management and particularly to flora conservation. The inter-relationships between the occurrence of disease and such physical factors as roads, streams and rainfall have been examined (Batini, 1973) and a more comprehensive ecological site classification of disease susceptibility is being developed in Western Australia (Havel, personal communication). Undoubtedly similar techniques are being developed elsewhere.

This type of approach is vital and must be extended in order to inject the cardinal virtue of damage prediction into our rationale for disease management. Coupled with more accurate estimates of rate of spread it will permit a truer perspective of diseases and in the meantime allow for adjustment of treatments and programs to ensure their greater effectiveness.

Likewise, there is considerable information about the seasonal conditions of temperature and moisture controlling population fluctuations of *P. cinnamomi* (Podger, 1968) and of the eucalypt-defoliating saw-fly (Carne, 1969), yet this data has not really been applied in any predictive capacity. Despite the time scale involved in forestry this could help in scheduling essential works.

7. ECONOMIC EVALUATION

Initial work in Western Australia has indicated a relatively small but cumulative loss in long-term yield due to dieback in the jarrah forest and the longer salvage is delayed the greater the loss of standing volume. In Tasmania a marked reduction has been noted, in increment in infected regrowth stands before visible symptoms appear (Felton and Bird, 1972) but no such loss has been detected in Victoria (Incoll and Fagg, 1973*). This apparent inconsistency is due to wide differences in site conditions and age-class of the trees. No studies have as yet been carried out in New South Wales. Loss of height growth in eucalypt regrowth in Tasmania due to insect defoliation has been noted (Greaves, 1966) and it is likely that many similar piecemeal studies have been carried out elsewhere. However it is not yet possible to produce comprehensive estimates of loss of standing timber and production potential due to lack of basic information relating to the extent and rate of disease development and a meagre knowledge of the disease aetiology.

The fact that dieback symptoms have recurred in regrowth growing on sites where the old growth had been affected is cause for concern and the marked similarity between dieback in the Brisbane Ranges and in Western Australia (Podger and Ashton, 1970) together with the casually observed similarity between gully dieback in Tasmania and the early stages of dieback in Western Australia indicate serious concern for the future of existing and regrowth eucalypt stands.

Other possible economic implications have been listed (Weste, 1973) and this list could be extended.

The various philosophies of cost-benefit studies are beyond the scope of this discussion and will not be considered. However because of observed progress of dieback in Western Australia no occurrence elsewhere should be treated lightly and until there is a more comprehensive and factual estimate of the ultimate potential of dieback diseases to impair forest production and diminish other resource values, the amount of finance required for research and control, and the alternative timber production strategies cannot be assessed.

8. APPRAISAL OF ECONOMIC CONTROL MEASURES

8.1 Detection of pathogenic agents

Detection is the basis for control. Improved detection methods have been developed for *P. cinnamomi* and

* *Ed. note:* This study was carried out in dense young stands growing on a fertile, well drained site.

some are extremely sensitive (Malajczuk and Bowen, personal communication) although these do not entirely solve the problem of broadscale detection, and baiting techniques cannot always be regarded as consistent or positive. Detection of visual symptoms in the ground flora related to site susceptibility may prove equally reliable and certainly cheaper. For this reason greater attention should be given to the ecological aspects of both site and possible indicator species.

8.2 Quarantine and land hygiene

Quarantine measures are costly and difficult to apply other than in extremely limited localities. The hygiene measures as implemented in Western Australia and Victoria are regarded as purely delaying tactics. In Western Australia they are somewhat difficult to implement and by design they are not intended to be absolute. Log salvage is a matter of minimising loss rather than a control measure, and the intensive management activities proposed in Western Australia (Hopkins, 1972) are an attempt to make the best of a difficult situation.

8.3 Cultural control

Cultural methods* such as thinning and fertilising may only offer partial control while measures such as soil fumigation, soil drenching and reduction in quantities of host material are costly and likely to be applicable only in restricted areas of special value. Broadscale commercial application of insecticides is likely to have environmental repercussions and silvicultural measures could be preferable. Most of these techniques are likely to be irrelevant where conservation of native flora is the prime objective for they are likely to damage the existing vegetation. To date no satisfactory practical operational measures have been developed and the alternative possibilities of biological control are well worth investigation (Malajczuk and Bowen, 1973).

8.4 Disease tolerance

Screening alternative species for disease tolerance is primarily a matter of rehabilitation although it might lead to a measure of long-term control. Laboratory results and field trials, at least in the younger age classes, have reached a relatively satisfactory level and there are very few anomalies between the two. In view of the forestry time scale, early establishment of field trials is vital if results are to be available for future management. Large-scale field experiments with a wide range of susceptible and tolerant species is regarded as a relatively cheap and valuable *ad hoc* approach, especially in localities where a single pathogen may not be the sole cause of the disease.

9. POSSIBLE DIRECTIONS FOR RESEARCH

So far we have been dealing primarily with applied work in the fields of protection, rate of disease development, site susceptibility, economic evaluation, and physical and mechanical control, together with the need to collate presently available information into a comprehensive story for management purposes. Obviously on the assumption that dieback is of substantial importance whatever its cause, much of the applied work can only be significant if it is soundly established on more basic investigations.

From the management viewpoint the following are seen as the most profitable lines of research investigations at this stage:

(i) development of improved techniques for microscale detection of pathogens as a basis for routine sampling;

(ii) classification of site susceptibility to disease and determination of rate of disease development relevant to each major site;

(iii) development of possible biological controls through rhizosphere manipulation or antagonistic organisms;

(iv) determination of survival and dispersal mechanisms on residual affected sites where both level of pathogen and food supplies are low.

10. CONCLUSIONS

It is hoped that the above comments will stimulate profitable discussion and help to integrate the many aspects of the dieback problem into a consolidated basis for determination of future action in the fields of management and research.

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* A number of possibilities exist in this field and none have been evaluated. No doubt further work will be carried out.

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12. SUMMARY OF DISCUSSION

Discussions centred largely around *Phytophthora cinnamomi* but the need to consider other causes of dieback was stressed. Determination of the circumstances surrounding attack by pests and diseases may indicate possibilities for control without being fully aware of the ultimate cause of the dieback.

A regular national survey of pests and diseases is regarded as an initial step in exploring both their incidence and significance and was recommended for future action.

Classification of site susceptibility should be based upon the aetiology of the disease and greater attention should be given to the basic physiology and ecology of the host, as situations could arise where the host having survived attack by one pathogen could be predisposed to attack by another.

Further studies of the environment in which the pathogen operates and its vectors is also required and experts from other disciplines may be needed to assist these studies.

Quarantine, or preferably hygiene measures, are regarded as important and should be adopted while basic research is still underway. Development of resistant phenotypes and methods for their commercial scale propagation is needed.

Cultural and biological control measures should be favoured in view of the likely environmental restraints on the widespread use of chemicals. Development of biological controls based upon antagonistic soil systems and organisms should be followed up as a long-term project. Bacteria, especially in the rhizosphere, are regarded as having promise for biological control at this stage and existing work with viruses could be well worth following up especially as a method of controlling injurious insects.

Prediction of the behaviour and ultimate potential of diseases and determination of likely economic losses are essential for management in order to help in setting priorities of expenditure, and in determining suitable management techniques.

Economic evaluation should be followed up to clarify several aspects of future overall timber production strategies and a competent group of economists could be required to assist in this work.

Microscale detection techniques are considered adequate but greater attention to sampling systems is required. The capability for bulk testing of samples should be improved. This may not require the setting up of a central testing laboratory, but nonetheless greater attention should be given to uniformity in sampling procedures and to standardisation in expressing results.

Macroscale detection, especially using a wide range of air photos, should be improved to cover a wider range of disease situations, including regrowth dieback. The multiple-mapping technique is seen as a useful development in predicting site susceptibility.

Ecological site classification and the use of plant indicators should be developed as practical and useful additional tools for disease detection. Proper attention should also be given to improving our ability to predict the rate of development of pests and diseases and particularly to our methods of determining threshold conditions before insects are likely to reach plague proportions.

For future study, reference areas in a wide range of vegetation types and covering a wide range of localities should be established, in forests subjected to disease of varying intensity. Ample provision should be made for retaining these areas in an undisturbed condition. At the same time substantial species and fertilizer trials should be established on the basis of present information, however inadequate, on areas likely to be affected by diseases. These trials will help to overcome problems of timescale and to provide the basis for future study.

Although priority of investigation should be given to problems affecting production forests, programs should also be designed to resolve problems in national parks and nurseries, the latter being seen as a matter of particular urgency. Investigations of disease in relation to values other than timber production on State-owned forests was also seen as a matter of importance.

Consideration should be given to co-ordinating current and proposed research work in the overall areas of forest pests and diseases. Consolidation of existing available research data into a composite body of knowledge to assist in developing and applying management practices was seen as important, and this work should also be aimed at improving our ability to predict likely development and the final extent of diseases.

Recommendations

The Dieback Seminar at Lakes Entrance recommended to the Pests and Diseases Sub-Committee of the Standing Committee of the Australian Forestry Council:

(i) the formation of a national fund for the research and survey of diseases and pests affecting the eucalypt forests and pine plantations of Australia (with the suggestion that the fund should either be jointly financed by the Australian Government, State Governments and other interested owners of forested lands or by a levy on forest industries);

(ii) the fund should be administered and research activities co-ordinated by a committee formed under the auspices of the Australian Forestry Council;

The objectives of this committee shall include:

(a) development of specifications for an execution of regular surveys to detect and determine the incidence, severity, extent and immediate potential of diseases and pests affecting the eucalypt forests and pine plantations,

(b) annual appraisal of priorities for research into pests and diseases affecting these forests.

(The objectives of the committee may also include such matters as the standardisation and referencing of sampling and testing procedures and investigation of the feasibility of the establishment of a central pathological laboratory.)

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