THE EFFECT ON JARRAH OF PHYSICAL AND BIOLOGICAL AGENTS IN COMBINATION WITH *PHYTOPHTHORA CINNAMOMI*.

Before the effects of physical and biological agents in combination with P. cinnamomi can be assessed, the effects of the physical and biological agents by themselves must be considered. Unfortunately data is extremely limited, however some information of association between an effect and a response is available, and this is summarised below. An association, however, does not necessarily indicate a causal relationship.

Physical effects

1. Temperature. The effect of temperature on growth of jarrah seedling roots may be available from Grant (Univ. Melb.). Cold nights result in a temporary cessation of girth increment in small poles (Davison dendrometer band data).

2. Water. Podger did several pot experiments to investigate the effect of droughting and waterlogging on jarrah. Some of these experiments are summarised in unpublished reports. The droughting experiments showed that in the seedling stage, jarrah is not the most sensitive forest eucalypt to drought.

   The waterlogging experiments showed jarrah is more sensitive to continuous waterlogging than other forest eucalypts, is less able to survive after temporary waterlogging, and ability to produce new roots after temporary waterlogging is greatly impaired. Dendrometer band measurements of approximately 100 trees on 10 different sites in 1964 showed a cessation of growth from August until November

in almost all trees, following three times the normal rainfall in June and July. This effect occurred equally in trees in both healthy and dieback sites (Podger's dendrometer band data). On a well drained site, jarrah can respond very rapidly to heavy summer rain, producing new fine roots, xylem and/or phloem, and suppressing leaf production within two weeks (Fig. 1).

Fig. 1.

Heavy summer rainfall on a well-drained site results in

1. Real increase in girth (xylem and/or phloem) within 2 weeks
2. Reduction in leaf production within 2 weeks
3. No effect on flowering within 2 weeks
4. Increased root production within 1 week

[1, 2, 3, Davison, 1982; 4, Dell, 1980]

One therefore concludes that jarrah responds very quickly to water, but excessive water is extremely damaging.

How much is too much?

3. Litter and nutrient cycling. consult CSIRO, Dell, Bell, etc.

4. Wind. Is there any F.D. data on incidence of windthrow on coppice or sapling regeneration in exposed sites? How well does jarrah survive in exposed sites?

5. Fire.

6. Salinity.

7. Soil compaction.

Biological Effects.

1. Pests. Apart from leaf miner and borers what is known of insect pests, on jarrah and their effect on increment? Nematodes occur in association with cankers, are they primary or secondary? How do they get to the tops of trees? What are their effects on growth?

2. Diseases. Is there any current data on volume losses from wood rotting fungi?

The mortality rate in healthy forest is about 5 - 10 trees/1000 hect./6 months. How does this rate vary from year to year, season to season, site to site? Scattered tree deaths (approx 1/250 hect.) are probably due to basal cankers; why do groups of trees (>3/10 hect.) die?

How widespread is Armillaria? What is the mortality rate from Armillaria? How does it vary from year to year, season to season, site to site?

Cankers in the crowns of jarrah are extremely widespread, every tree has probably been infected repeatedly during its life, and the fungi associated with cankers occur on many forest and replant eucalypts. The fungi will get in through cracks and wounds in the

periderm, so that any effect on jarrah that increases wounding and cracking (eg. wind, insect damage, frost, logging damage, fire damage) will increase the incidence of cankers, even if extensive cankers do not develop. What determines whether cankers develop? How do cankers affect growth? What other diseases of jarrah are there? Leaf spots are abundant, how many different ones are there? Do they cause premature defoliation and thin crowns? What is their effect on growth?

Is it possible to draw any conclusions about the effect of pests other than leaf miner, and disease in jarrah when so little is known about them, and many of the causal organisms have not even been determined?

The suggested effects of the reduction of tree canopy on jarrah.

Fig. 2 is an attempt to summarise the effects on jarrah resulting from canopy removal. Specific effects relating to logging (soil compaction, burning etc.) have not been included.

Interaction of P. cinnamomi with physical and biological effects.

The introduction of P. cinnamomi into the forest and subsequent death of the understory results in considerable changes to the physical conditions of the site. At the margin of a dieback site, where P. cinnamomi levels are highest, one would expect a reduction in tree growth due to root infection. Podger's dendrometer band data indicates no such effect occurs.

Fig. 2.

EFFECTS OF THE REDUCTION OF TREE CANOPY ON JARRAH

(HEALTHY SITE)

Physical effect	Effect on jarrah
1. Increase in soil temperatures (F.D. data)	Not known
2. Increase in dryness of surface soil in summer (F.D. data)	Probably unimportant because of deep root system
3. Increase in surface soil wetness during winter (F.D. data)	a) In water-gaining sites, sites with impeded drainage or very wet years, growth will be reduced (Podger's data) b) In well drained sites in normal years growth will increase (thinning data)
4. Rising water tables (CSIRO, Wellington catchment data)	Not known
5. Decrease in litter and changes in nutrient cycling	Not known
6. Increased wind, frost etc. damage to the crown (Wallace & Hatch)	More entry points for canker fungi, ? crowns decline and growth decreases (Davison).
7. _____ ?	Increased incidence of leaf miner, Crowns decline and growth decreases (Mazanec).

How does P. cinnamomi fit in?

Once the understory has died the stand has been effectively thinned and an increase in growth may result. However, extensive root infection, if it occurs, would result in a decrease in growth. Our dendrometer band data indicates an increase in tree growth on a well-drained dieback site.

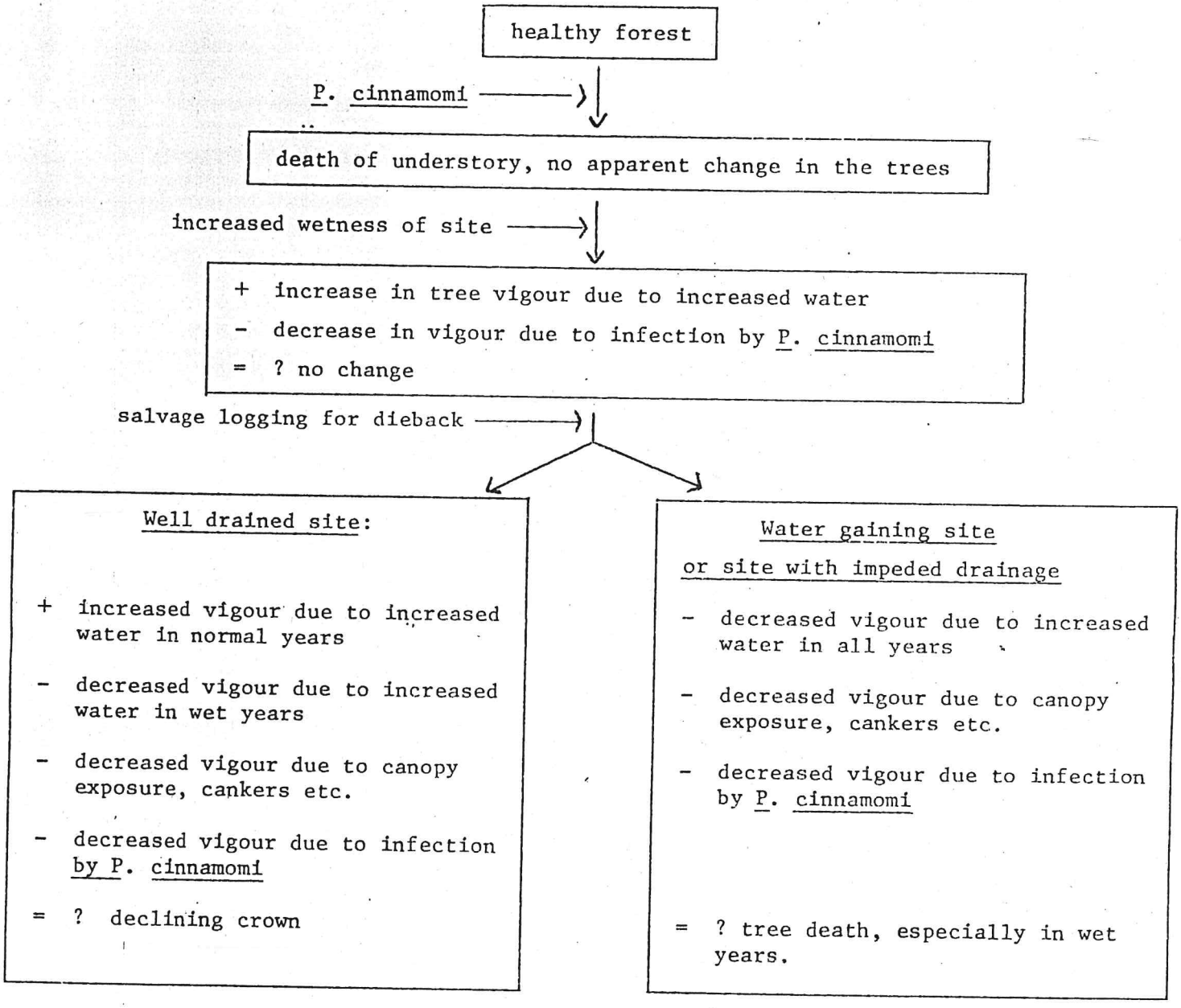
On a poorly drained site (water gaining, duplex soil type etc.) particularly in wet years, the increased site wetness, due to removal of the understory, may result in reduced growth due to temporary waterlogging.

If salvage logging occurs, the trees' crowns will become more exposed, and the subsequent wind and frost damage provide more entry points for canker fungi. Increased site wetness may result in increased growth, however, in wet years may cause a reduction in both tree growth and the ability of the tree to respond rapidly to infection in twigs, branches, trunks and roots, due to temporary waterlogging. In wet sites the effect of water on jarrah may be more important than the effect of P. cinnamomi. Podger showed that there was no difference in the height increment of jarrah grown in diseased or healthy forest soil 14 weeks after the cessation of two weeks waterlogging. Fig. 3 provides a summary.

Jarrah's response to prolonged summer rain on a well drained dieback site is no different from that of jarrah on a healthy site (effect on girth, leaf production, flowering; Davison, dendrometer band data). What is the effect on jarrah of prolonged summer rain on a watergaining site or a site where perched watertables develop? Is root death caused by waterlogging, waterlogging + P. cinnamomi or P. cinnamomi alone? What is the mortality rate of jarrah on similar sites in uninfected forest after heavy summer rain?

Fig. 3.

An interpretation of the possible sequence of events on a dieback site



E. M. DAVISON

July, 1982.

How does the mortality rate of jarrah on a dieback site compare with jarrah mortality in healthy forest? Preliminary data indicates that it is higher, but not much higher. Investigation of scattered tree deaths on dieback sites has revealed large basal cankers. Although P. cinnamomi may be present, it is not always there, and is only present in small amounts, therefore it may only be able to invade rapidly when the trunk has been partly girdled by the canker.

Suggestions for future work.

1. All the raw data on jarrah growth on healthy and dieback sites should be brought together and reexamined. Data for 1963 and 1964 (two very wet years when there were many tree deaths) are particularly important.

2. Establishment of permanent growth plots in dieback and healthy areas in a range of sites. Girth measurements to be made in early December.

3. Examination of aerial photography to determine the mortality rate of jarrah in healthy and dieback sites.

4. Investigation of grouped deaths which occur in healthy sites.

Murdoch University
Murdoch, Western Australia, 6150. Telephone: 332 2211, Telex: AA 92711

School of Environmental and Life Sciences

Mr. F. E. Batini,
Forests Dept.,
50 Hayman Road,
Como, W.A. 6152.

28th July, 1982

Dear Frank,

I enclose a summary of the effects of some physical and biological agents in combination with Phytophthora cinnamomi. I have indicated the sources of the data used, and have drawn conclusions where appropriate. From the growth data I have examined it is impossible to identify a definite effect of P. cinnamomi on jarrah, even when one would expect to find an effect due to synchronous infection by zoospores. If dendrometer bands are sufficiently sensitive to pick up the effects of low temperatures, they should be sufficiently sensitive to pick up a temporary or permanent cessation of growth due to P. cinnamomi infection. Therefore if such infection occurs, jarrah must be able to respond rapidly to wall off the damaged roots. Where there are unusual effects on the growth of jarrah they also occur on trees in healthy sites, and can be related to prolonged heavy rain. I therefore draw the conclusion that on many sites jarrah is a tolerant host of P. cinnamomi, and on sites where groups of trees die, waterlogging is strongly implicated as the cause of death. On such sites jarrah should not be considered as predisposed to infection because this implies that there has been no site alteration following the introduction of P. cinnamomi into the area. I would suggest that it is the alteration of the site, resulting from understory death and salvage logging that ultimately results in tree death.

Yours sincerely,

Elaine Davison

ELAINE DAVISON

ENC.

EMD/ch

3.8.82
1/ Mr McKinnell rep96
2/ Mr Batini
3/ Mr Havel + P96
4/ Mr Batchelor rep96

Please send. make a P copy for Bruce then put mine on Elaine Davison file.