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INTRODUCTION

The jarrah (Eucalyptus marginata Sm.) forests of Western Australia are located in the south western corner of the state and extend over 1.5 million hectares. The dominant species, jarrah, (SLIDE - MAP OF SOUTHWEST) is a high quality, durable hardwood and the forest has been exploited for timber over the 151 years since european settlement of the state. (SLIDE VIRGIN FOREST) Logging of the forest in the first 100 years following European settlement was uncontrolled but in 1918 forest management was placed under the control of a professionally directed forest service. In the following 40 years (SLIDE - JARRAH LOGS) tranditional hardwood forest management practices; for example, inventory, fire protection thinning and regeneration etc; were progressively introduced. Management and research intensified in the 20 years following the second world war but was almot entirely concerned with regulation of timber exploitation, improving timber production and protection from fire

The 1960's saw the beginning of a series of major events which has resulted in radical changes in Jarrah Forest management and research. In 1965 the casual organisms of a serious forest disease (SLIDE - JARRAH DIEBACK) "Jarrah Dieback", was identified as an introduced soil borne fungus Phytopthora cinnamomi Rands Podger (1972). By the late 1960's increased recreational use of the forest together with greater public awareness of environmental issues caused intensive public questioning of standard management practices such as prescribed burning. During this period the whole forest was placed under a lease for bauxite mining and strip mining for (SLIDE OF BAUXITE MINE) for bauxite commenced. A series of severe droughts an incrased eemand for water and serious salination of irrigation and

domestic water supplies resulting from clearing of forest and woodland areas for agriculture focussed attention on the catchment protection values of the forest.

(SLIDE - SALT SCALD - STREAM)

FOREST MANAGEMENT OBJECTIVES

In the four decades following the passing of the forest act which introduced management to the forest although forest values other than timber production were recognized it was assumed that these values would be maintained by forest management practices which ensurred timber production. During this period there was considerable silvicultural activity - for example thinning and protection of crop trees from fire. The tradiontal problems of regneration were less pressing because Jarrah readily forms a new vrop from lignotuberous growing stock and the formation of coppice from stumps.

However, although these basic silvicultural practices resulted in the maintenance of a forest crop over large areas of the forest by 1960's it became apparent that the assumption that other forest values, particularly catchment protection, were not necessary being adequately being catered for by tranditonal silvicultural treatment of the forest.

This led to a redefinition of the objectives of jarrah foreat management.

The importance of the catchment prottion function of the forest to the south west of Western Australia has placed maintenance of water quality as the first

(SLIDE - SOUTH DANDALUP RESERVOIR)

priority of forest management where other land use practices do not conflict with water quality maintenance the objectives of forest management is to maximize timber, conservation and recreational values in perpetuity.

It readily became apparent that these objectives could not be achieved in the pressure of a severe disease and with a number od competing land uses. Without an understanding of ecology of the forest.

Jarrah dieback

Jarrah Dieback has had a profound effect on forest management obviously multiple use forest management is an academic exercise if the long term the forest is destroyed.

Small areas of dying forest were first recroded shortly after the turn of the century. The effected area incrased slowly up until the end of the second world war. In the decade following the end of the war the tram line system of logn removal was replaced with one based on log trucks which required the development of an extensive roading system. The rate of disease development incrase dramatically during this period and by 1972 10% of the forest was severely diseased . As the severity of the disorder increased research was intensified but it was not until 1966 that the casual organism, Phytophthora cinnamomi (Rands), an introduced soil borne fungal pathogen was identified. Podger (1972). The pathogen causes

(SLIDE OF PHYTOPHTHORA)

death of susceptible species by destruction of the root system and/or invasion of the lower stem.

The rate of disease development varies with site and climatic conditions varies. Shea (1975) However, in many forest sites the end consequence of introduction of the pathogen is death of jarrah trees of all ages and sizes, and the majority of the species which comprize the shrub and understorey layer of the forest. It is unlikely that absolute control of Jarrah Dieback will ever be achieved but intensive research on relationships between the fungus and the jarrah forest environment has resulted in the development of management procedures which have reduced its spread and intensification.

In summary this research has shown:-

1) The upland freely drained sites which occupy between 70 -80% of the forest are only marginally favourable for fungal survival and reproduction.

(SLIDE - PERIODS OF THE YEAR WHEN P.CINNAMOMI IS ACTIVE)

The fungus can only reproduce in spring and autumn when the soil is warm and wet and it is unable to survive on these sites during the summer months.

2) The extension of disease onto these sites is very slow provided it is not carried in infected soil

(SLIDE - RATE OF SPREAD OF P.CINNAMOMI (less than 1metre per year)

This highlights the importance of hygiene in forest operations.

3) An understanding of the relationship between the fungus and the environment has permitted the development of efficient hygiene prescription. For example, since the fungus does not survive in dry soil one of the principal methods of avoiding spread by man is to restrict activities in the forest which involve movement of soil to the dry periods of the year.

4) The presence of a dense understorey of Banksia grandis which is highly susceptible to P.cinnamomi is a major contribution to the spread and intensification of the disease.

(SLIDE - SHOWING P.CINNAMOMI INVADING BANKSIA)

Banksia provides a large food base for the fungus and its capacity to invade the large roots and stumps of this species permits it to survive during the summer months.

Reduction of the B.grandis understorey density is being applied as a management treatment to reduce disease spread and intensification.

(SLIDE - SHOWING FLOW DIAGRAM)

The development of an understnaidng of the relationship between the fungus and the forest environment has led to the development of prescriptions for each forest type and disease situation and is one example of how ecological principles are being used to development management practices.

FIRE

the history of the development of prescribed fire management procedures provides another understanding of how ecological research is changing forest management practices. The first approach to fire in the jarrah forest was exclusion. Early forest managers were strongly influenced by European forest practices and for the first 35 years following the introduction of management a policy of complete protection from fire was adopted. By the early 1950's it became apparent that a fire exclusion policy was not practicable and that the vegetation was adopted to fire. Although exploitation of the forest for timber increased the intensity of wildfires and the frequency of these conflagrations was probably increased by accidental and deliberate ignition by European man there is evidence that aboriginal man used fire as management tool for thousands of years prior to European settlement. Even in the absence of man it is unlikely that the forest would remain unburnt for long periods in a Meditteranean environment when ignition from lightning strikes is common.

Following the failure of the fire exclusion stategy the second phase of fire management was introduced. A programme of periodic low intensity prescribed burning was introduced with the single objective of hazard reduction. Over a period of 25 years

(SLIDE OF MILD FIRE)

a sophisticated low cost prescribed burning programm involving rotational burning of the whole forest on a fire to seven year cycle has been developed.

(SLIDE OF AERIAL BURN)

The hazard reduction burning programme has resulted in a marked reduction in the area burnt by uncontrolled wildfire. Broadscale low intensity hazard reduction burning currently remains the only practical method of fire management in the forest. But

it has now been recognized that burning for the principal purpose of hazard reduction may not satisfy other forest management objectives and the fire management programme is now entering a third phase of development .

It is highly improbable that periodic low intensity burning in spring duplicates the "natural" fire regime and research is being directed to determining if there are long term adverse effects of this burning regime on the forest ecosystem and if fire can be used as a management tool for purposes in addition to hazard reduction. For example, low intensity burning disfavours the regeneration of a leguminous understorey because heat penetration from normal hazard reduction burns is not sufficient to stimulate germination of legume seed buried in the soil.

The effect of burning regime on legume regneration is a classic example of how an understanding of forest ecological process can effect management strategies:-

1) In the jarrah forest legume seed is rapidly collected after it falls by ants and deposited beneath the surface of the soil.

(SLIDE OF SEED CLUMPING CAUSED BY ANTS)

2) Low itnensity spring burning - which is desirable from an operational view point because the fires can be controlled - fails to regnerate this seed.

3) Higher intensity burning under dry soil conditions causes moss regeneration of legume seed because of greater heat penetration.

(SLIDE OF LEGUME UNDERSTOREY)

4) The absence of legumes resulting from low intensity burning could be deleterious to the forest in the long term because.

a) Legumes are a source of nitrogen for the ecosystem.

b) Studies on some marsupials have shown that legume thickets are essential for habitat and indirectly provide a source of nitrogen

(SLIDE OF WOYLIE)

c) Current research suggests that a legume understorey may reduce the activity of Phytophthora cinnamomi by creating a less favourable soil physical and microbiological environment.

(SLIDE OF SPORANGIAL SUPPRESSION)

Current research also suggests that low intensity burning favours the maintenance of a Banksia grandis understorey which increases forest susceptibility to the disease.

(SLIDE - FIRE INTENSITY/BANKSIA KILL)

Banksia does not reproduce seed until it is approximately 10 years old. Thus maintenance of a burning regime which prevents trees growing to a size where they reproduce will reduce Banksia density.

Catchment Management

Over 50% of the surface fresh water resources of S.W. Western Australia have been severely salinized principally as a consequence of forest clearing for agriculture. 80% of the current consumption of water originates from Jarrah Forest Catchments. Consequently the effect of any forest management practices on forest hydrology must be ccarefully evaluated. This means that forest management must be based on a knowledge of the hydrological processes which occur in the forest.

The two outstanding features of jarrah forest hydrology are the low water yields and the presence of large salt accumulations in the soil profile in some forest areas. The average percent water yield from fully forested catchments varies from 10-20% in the western high rainfall zone of the forest to less than 1% in the eastern low rainfall zone. total salt content of the soil profile

(SLIDE - SALT ACCUMULATION)

may exceed 500,000 kgms per hectare. Salt concentration is generally low in the western zone of the forest increasing with distance from the Darling Escarpment but there are significant departures from this gradient.

The low yield and salt accumulations in jarrah forest catchments are a consequence of the Meditteranean climate, the presence of deep soil profiles with a high moisture storage capacity and the method by which the forest vegetation has adopted to the environment.

(SLIDE - JARRAH ROOT SYSTEM)

Jarrah consumes because of its deep root system consumes most of the incoming rainfall. Consequently removal of this species by disease or changes in land use practice could result in mobilization of the salt stored in the soil profile and salination.

The presence or absence of salt in the soil profile has a major influence on forest management.

In high salinity areas the management aims to maintain the native vegetation or where it has been removed by disease or prior land use practices establishment of species which would restore the hydrological equilibrium.

The problems posed by rehabilitation provides a further example of need to base forest managment practices on sound ecological principles. Early attempts at rehabilitation failed to recognize the importance of rehabilitating with species which were suitable for the jarrah forest environment and which fulfilled the principal objective of restoring hydrological equilibrium.

(SLIDE - DYING EUCALYPTUS MICROCORYS)

For example E. microcorys was widely planted on dieback sites because it was resistant to P.cinnamomi. However, it was obviously not adapted to the jarrah forest environment because after wildly rapid growth it failed over extensive areas.

Species which are resistant to P.cinnamomi must be used to rehabilitate salt prone forest. However, in addition to disease resistance the selected species must have the capacity to growt a Mediterranean climate on soils with unfavourable physical and nutrient conditions, in an environment which is subject to periodic fire of varying intensities while maintaining high evapotranspiration rates. Currently no species have been identified which meet these criteria.

(SLIDE - EVAPOTRANSPIRATION TOWERS)

Intensive research is being carried out to firstly determine the capacity of selected species to indicate the transpiration rate of jarrah and secondly to growth in the jarrah forest environment.

CONCLUSIONS

The interactions between fire regime, hydrology and diease and different land use practices are the major factor contributing to the complexity of multiple use management in the Jarrah Forest. For example, any land use practice that results

the movement of soil can cause spread of jarrah dieback and destruction of the forest. Loss of forest cover in salt prone areas can cause salination. The species used to rehabilitate distrubed forest areas must be resistant to *P. cinnamomi*. It is possible that fire could be used to reduce disease susceptibility but the presence of fire as a factor in the environment also means that species used to rehabilitate disturbed areas must be fire tolerant.

Given the complexity of the Jarrah forest ecosystem and the severe conflicts between some land use practices it is not surprising that management strategies which will satisfy the multiple use objectives which have been set are still being developed.

Nonetheless we believe that considerable progress has been made and that this is because of our developing understanding of the ecology of the forest and the application of management strategies that are based on sound ecological principles.