IMPACTS OF FOREST MANAGEMENT ON NATIVE FAUNA

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The Impact of Fire on Fauna

Pre-European Fire History

It is generally accepted that fire has been an integral part of the ecology of the eucalypt forests of Australia for tens of thousands of years. Many of the eucalypt forests owe their existence in part to climatic drying and their ability to recover from fire frequently caused by lightning strikes. Evidence suggests the that fire frequency within the south west of Western Australia increased roughly 40 000 years ago, which is thought to coincide with the arrival of aboriginals. "Fire Stick Farming" by the aboriginals was used as a deliberate management technique to create hunting grounds, regenerate desired plants, and clear thick country. As a result a mosaic existed whereby different patches of forest, woodlands and heath had different fire histories (Christensen and Abbott 1989; CALM 1994). Direct evidence no longer exists for the frequency, intensity, season and size of the fires, and the subsequent mosaic pattern which existed prior to European settlement. It is therefore not possible to fully reconstruct the pre-European fire history of the south west. However, indirect evidence has been provided through ecological and dendrochronological research (Abbott and Loneragan 1983, 1986).

Most of the plant and animal communities of the south-west have evolved to live with and survive fire.

Current Fire Management

CALM is responsible for approximately 2 450 000 hectares of south west forest (jarrah, karri, tingle, wandoo, tuart and associated heathlands), on which about 300 unintended bushfires are started each year; of which 93% is directly due to human activity. Each fire has the potential to become an uncontrolled wildfire which can threaten and damage human life, property, environmental and ecological values, and economic resources. CALM consequently has a legal, moral and ecological responsibility to manage the public land in a way which does not destroy human life, property, or the sustainability of the ecosystems.

Prescribed burning is used as a general management tool by CALM to prevent fire fuel loads from reaching levels above which, (i) headfires cannot be successfully attacked under average summer conditions and, (ii) will cause unacceptable damage to young trees and will generate crown fires and spotting. Fire behaviour research has shown these fuel load limits to be around eight tonnes per hectare in jarrah forest and around 17 tonnes per hectare in karri forests. The aim of prescribed burning rotations are therefore to keep fuel loadings below these threshold limits. From the time since last burn, these fuel load thresholds are normally reached in five to seven years in more productive jarrah forests and eight to ten years in less productive and eastern jarrah forests, and six to eight years in karri forest. However, the current reality is that the time between burns is on average much greater than the time taken to reach these fuel load thresholds (Bradshaw, pers comm.).

Ecological Impacts of Fire

Any and every fire has an ecological impact. The timing (season), characteristics (intensity, and size), and history (including past fire characteristics, frequency and time since last fire) of the fire will largely determine the extent of that impact. Within jarrah and karri forests, as with many other ecosystems, fire is a natural form of disturbance and in moderation and over the long term, is a fundamental process by which bio-diversity is sustained. Generally higher diversity increases an ecosystems buffering against severe disturbance and increases its capacity to recover from such perturbations.

A substantial amount of research has been conducted on the impacts of fire in Western Australian ecosystems. Christensen and Abbott (1989) has reviewed this research and postulated that although there are variations on the theme, there is a general pattern describing the response to fire by living organisms in an ecosystem:

- There is a reduction in the numbers and sometimes species of organisms immediately after fire.
- There is a recovery in the numbers and species of organisms after fire. This recovery is often characterised by the appearance of species which were rare before the fire or were present in the ecosystem only as stored seed in the soil.
- Changes may occur in the species dominance and relative density after fire. These changes are often spectacular (e.g. fire weeds) but are almost always transient.
- Recovery from fire is achieved almost totally by propagation from within the burnt area, although recovery of vertebrates is often assisted and sometimes is achieved entirely from unburnt areas.
- The rate of post-fire recovery of animal species depends largely on vascular plant recovery patterns which in turn are influenced by the intensity and season of the fire, and by the length of intervals between fires.
- Each species of organism has a well defined response to fire. This response is flexible, allowing organisms to react across a wide range of possible fire regimes. Nevertheless, there are limits to responses, associated with individual life history strategies.

Soils and Nutrient Cycling

Significant but reversible changes in soil properties are associated with high intensity fires. Repeated low intensity fires have not been found to significantly alter the soil. Nutrients released by the fire are quickly taken up by plants, and physical and biological processes add nutrients back into the ecosystem which were lost by the fire. Due to the enormous complexity of these processes it has been difficult to ascertain whether the levels of nutrient inputs back into the system equal the losses due to fire (Christensen and Abbott 1989).

Vegetation

A wide range of responses to fire exist between plant species and within populations of the same species. These responses reflect the variability inherent in possible fire regimes. About 70% of jarrah forest understorey species re-sprout after fire. The other main strategy employed by plants is germination from soil or above ground seed. Plant biomass and species diversity is greatest in the early post-fire successional stages of jarrah and karri forests. There is no evidence of any decline of any plant species richness after several cycles of spring or autumn burning on very short cycles in WA forests (Christensen and Abbott 1989).

Micro-organisms

There have been few studies on the impact of different fires on micro-organisms despite their importance in microbial decomposition and nutrient cycling. Studies elsewhere suggest that it is unlikely that species are ever eliminated from an area by fire though the incidence of different organisms may be greatly changed by fire (Christensen and Abbott 1989).

Invertebrates

Invertebrate studies have been hampered by serious sampling and taxonomic problems, and the research which has been conducted has shown no consistent pattern of the impact of fire on insect species and numbers. Nevertheless, there is a general immediate reduction after fire, although some species and groups (e.g. earthworms) may not follow this pattern. The rate of recovery varies between species and different groups, but there is little agreement about which groups recover first or how long the recovery takes (Christensen and Abbott 1989). An investigation into whether the outbreaks of leaf miner in the jarrah forest were related to prescription spring burns could find no direct causal relationship (Abbott 1993). However, the severity of the outbreak may be reduced by high intensity autumn fires which scorch the jarrah crowns and lead to complete crown replacement the following summer.

Amphibians

Very few studies have investigated the abundance of any frog species in relation to fire (Wilson 1996). In a fire impact study in banksia woodland near Perth, most frogs seemed more influenced by their proximity to water than the time since last fire. Non-burrowing species such as *Littoria adelaidensis* were recorded in long unburnt but not recently burnt sites, as was the terrestrial breeding frog *Myobatractus gouldii* (Bamford 1985, 1986).

The *Geocrinea rosea* complex comprises four, closely related species found within south west forests of Western Australia. The distributions of *Geocrinea rosea* and Geocrinea *lutea* are larger than the endangered species *Geocrinea alba* (101 square kilometres) and *Geocrinea vitellina* (6 square kilometres). One population of *Geocrinea rosea* is reported to have survived logging and burning (Wardell-Johnson and Roberts 1991). However, a recent study on *Geocrinea lutea* found that there was a significant immediate decline (up to 29%) of calling males associated with a prescribed spring burn. These populations had still not recovered two years after fire. However, egg and larval survival did not appear to be significantly affected (Driscol and Roberts 1997). The length of time required for the populations to recover is not known, nor are the long-term effects of fire on this or other *Geocrinea* species.

Reptiles

Low intensity fire studies in banksia woodland near Perth (Bamford 1985, 1986) showed that different species responded differently to fire. Overall there were slightly fewer species of reptiles in more recently burnt areas, however, there was little difference in the numbers of animals caught. As with other animal groups, the effects of fire vary between species and recovery after fire depends on the habitat requirement of the species.

The Batalling study is the first major general study into the effect of prescribed burning on reptiles and frogs in WA jarrah forests. This research is continuing.

Birds

Several studies in jarrah and karri forests have shown similar fire (both spring and autumn) impact trends whereby immediate and temporary decreases in bird populations after fires are followed by increases within one to three years later [Christensen *et al.* (1986), Kimber (1974), Tingay and Tingay (1984) and Wooller and Brooker (1980)]. The level of disturbance to bird populations is proportional to the level of vegetation scorched or damaged by fire and the rate of vegetation recovery. Consequently, the effect of fire on birds is largely dependent on fire intensity.

Although around 70% of breeding is completed by the time spring burns are conducted, there are some nestling mortalities following spring burns, particularly of species which nest close to the ground. The impact to breeding is generally thought to be minimised by the mobility of most adult birds and their lengthy breeding season in the south west, allowing for disturbed birds to breed else where. More than 80% of the forest remains unburnt in any year, and over half the forest is always more than three years unburnt (CALM 1994).

Mammals

Any fire which burns a substantial forest area results in reduced numbers of small and medium sized terrestrial mammals either from the fire directly or by subsequent predation (Christensen and Abbott 1989). The level to which mammal species populations are affected depends on the impact to their food and shelter. Large macropods (e.g. western grey kangaroo and western brush wallaby) are less adversely affected by fires, although large intense fires are detrimental as with arboreal species such as possums. Responses to fire varies with the mammal species and with the characteristics and history of fire (and other disturbance) in the area. The recolonisation of species to a burnt area depends on the time taken for suitable habitat to regenerate and is generally largely achieved by surplus young animals from adjacent unburnt areas (Christensen and Abbott 1989).

Some examples of how mammals found within the south west forests are thought to be impacted by fire are listed below:

- Quokkas (*Setonix brachyurus*) are thought to require dense thickets unburnt for10 years or more (Christensen et al. 1986).
- Mainland Tammar Wallabies (*Macropus eugenii*) are fire dependent requiring periodic intense fires under dry conditions to regenerate the scrub thickets in which they live (Christensen 1980). Fire frequency of 25-30 years is thought necessary to maintain populations of Tammars in the presence of foxes (Christensen and Maisey 1987).
- Woylie (*Bettongia pencillata*) populations may experience immediate severe, reductions by fire followed by a rapid increase, finally reaching stable pre-fire levels 4-5 years after fire. The population increase is due largely to emigration from adjacent unburnt areas, predominantly by males and as the vegetation in the burnt area recovers (Christensen 1980).
- Brush-tail Possums (*Trichosurus vulpecula*) and Western Ring-tail Possums (*Pseudocheirus occidentalis* are temporarily reduced as result of intense fires in summer or autumn, but recovery is relatively fast (Inions 1985). Low intensity fires have minimum effect on possum populations.
- Numbats (*Myrmecobius fasciatus*) and the availability of termites (their food) are not significantly impacted by fire directly. However, the loss of habitat cover in the form of logs and thickets appears to increase mortality through predation (Friend 1994). Numbats seem to prefer areas burned relatively infrequently but can tolerate more frequent burning (Christensen and Abbott 1989). Autumn fires every 20 to 30 years at Dryandra would allow *Gastrolobium microcarpum* thickets maximum regeneration (Burrows *et al.* 1987) and shelter opportunities for Numbats.
- Southern Bush Rats (*Rattus fuscipes*) are slow to re-invade, building to maximum population levels 4-6 years after fire in karri forest, thereafter declining to lower numbers in long unburnt forest (Christensen and Kimber, 1975).
- Mardo (*Antechinus flavipes*) prefer forest with a deep litter layer (unburnt 10 years or more) (Christensen and Kimber, 1975; Sawle, 1979). Leaf litter insects (major parts of their diet) are also numerous in deep litter in unburnt areas.
- The House Mouse *(Mus musculus*) invades burnt areas after fire, rapidly breed, then disappear within a few years (Christensen and Abbott, 1989)
- The Red Fox may have a significant effect on the recovery of native fauna following fire (Christensen 1980).

The Impact of Timber Harvesting on Fauna

Brief Logging History in WA

Logging in the jarrah forest began soon after European settlement in Western Australia. For the first 90 years after the settlement of the Swan River colony, there was uncontrolled exploitation of the forest. By 1918, 500 000 hectares of jarrah forest had been cut-over and about 17 million tonnes of logs had been removed (Wallace 1965 cited in McCaw *et al.* 1989). Since the passing of the Forests Act in 1919, there has been a process of review and evolution of logging methods, forest management

procedures and silvicultural systems (Stoneman *et al.* 1989). During this time there has been an increasing recognition of the importance of managing State Forests for their ecological values.

Current Silvicultural Practices

Because the jarrah forest is a complex mosaic of stand structure, age and quality, a fixed prescription for all of the jarrah forest is not appropriate. Consequently, the silvicultural objectives are different for different forest structures: 'Thinning' is used to promote the growth of retained trees. 'Release regeneration' (gap release) allows ground coppice to develop unimpeded into saplings, poles, and trees by removing the competing overstorey. 'Regeneration establishment' (shelterwood) encourages seedling development into ground coppice by reducing the competition of the overstorey. This is done by partial removal of the overstorey to retain a forest cover while regeneration develops (CALM Silvicultural Guidelines 1/95).

The current silvicultural prescriptions for jarrah forests specify that gap-release timber harvesting treatments should be no larger than 10 hectares and that strips of undisturbed forest (TEAS) about 100m wide should separate gaps. These TEAS 'buffers' are however, available for logging in a later cutting cycle (Bradshaw 1991, EPA 1992, CALM 1992). Thinned or shelterwood patches also constitute acceptable gap separation types, provided special requirements apply for the <1100mm rainfall zone.

Shelterwood treatments in previously cut-over jarrah stands must retain 10-15 square metres per hectare of tree basal are. In areas of low site quality in the <800mm rainfall zone, basal area may be reduced to as low as six square metres per hectare. Shelterwood treatments in virgin stands retain 50% of the overstorey (however this currently under review).

Within all harvested areas in jarrah forest, at least four primary habitat trees (>70 cm dbhob) are retained per hectare. Where gaps are separated by TEAS strips, six to eight potential habitat trees (30-70cm dbhob), if present, may be retained per hectare in addition to the retained primary habitat trees. At least one habitat log or stump per hectare also remains (CALM Silvicultural Guidelines 1/95).

Karri forest is thinned or regenerated depending on the condition and structure of the forest. Regeneration involves clear-felling with a maximum coupe size of 80 hectares and a 400 metre maximum distance between patches of mature forest. For both jarrah and karri forest, riparian zones and travel route zones are not logged. Declared rare flora is also taken into consideration and managed accordingly within logging coupes (CALM Forest Management Plan 1994-2003).

Ecological Impacts of Logging

The extent of research conducted on aspects of the ecological impacts of timber-harvesting on the native fauna of Western Australia has, up until recently, been small.

Invertebrates

In a logging impact study on birds in the Jarrah forest near Dwellingup (Norwood *et al.*, 1995) invertebrate abundances were found to be greater in the understorey of the older forest than in the understorey of gaps treated two years previously. Little other information is currently published

Amphibians and Reptiles

Published studies on the impact of timber-harvesting on reptiles in Australian forests are severely lacking and non-existent for amphibians (Moro 1990). Any studies which are conducted, need to investigate the immediate and long-term effects of logging and need to be related to the habitat requirements of each species. As little is known on the requirements of most amphibians and reptiles, the effects of logging can only be speculated.

Birds

Only two studies have been published on the impact of logging in jarrah forest on birds. As expected with other groups of animals, different species respond differently to the logging disturbances, and in accord with their survival requirements. At a study conducted at Yarragil (25km south-east of Dwellingup), no bird species were found to be significantly less in number, and two species significantly increased in number immediately after 50% of the jarrah forest canopy was removed from the treatment area (Abbott and Van Heurk 1985). Of 34 bird species detected in the study areas at Kennedy State Forest Block, Dwellingup, five species were found in greater numbers in two year old gap regeneration vegetation, than in adjacent older forest areas; two species were more frequently detected in the older forest; and many species did not appear to differ significantly between areas. Overall, however, slightly more species and almost twice as many birds were detected in the regenerating gaps and edges compared with the older adjacent forest areas (Norwood *et al.* 1995). John Serventy also found an increase in the numbers of birds in the understorey two years after logging and burning in the southern jarrah forest, but found an overall decrease in the total bird numbers (pers comm - cited in Norwood *et al.* 1995). These trends are contrary to the results of the initial work in karri forest (where more birds were observed in mature forest than in gaps: Wardell-Johnson *et al.* in review; Atkinson 1994 - cited in Norwood *et al.* 1995) and to the vast majority of similar studies in other parts of Australia (Moro 1990).

Most of the bird species recorded in the two published studies in jarrah forest are widespread generalists which are common throughout the south west. In addition it is likely that compared to the eastern states, the jarrah forest canopy (which is the forest level most affected by logging) supports relatively few bird species (Norwood *et al.* 1995). As a result of these factors it is possible that most bird species in the jarrah forest may be adaptable to some forms of logging disturbance (Abbott and Van Heurk 1985). However, most other studies to date tend to suggest that species diversity and abundances increase with the structural complexity of the vegetation (Moro 1990). In addition, the level of impact of timber harvesting on the avifauna in general is likely to depend upon many factors including; proximity of disturbed areas to mature forest; the size and shape of the impacted areas; the extent of change to the overall structure of the forest (ie. level of disturbance) within those areas; the number, species and maturity of the trees retained in the logged areas; and the impact on food, roosting and nesting resources within the disturbed areas.

It is possible that less common and/or more specialised species are affected to a greater extent by logging in the jarrah and karri forests. For example John Serventy is reported to have found that Golden Whistlers declined following intensive logging in jarrah forest near Manjimup despite the retention of some trees (pers comm - cited in Norwood *et al.* 1995). Clearly further research is required to more fully understand the impact of logging on bird communities both within jarrah and karri forests.

Mammals

Susan Rhind studied the characteristics of nesting trees, their spatial organisation, and frequency of use by brush-tailed phascogales (*Phascogale tapoatafa tapoatafa*) over three years in Jarrah forest. 95% of the nesting trees were either jarrah or marri trees; the average dbhob of these trees were 76cm and 87cm respectively. Of these trees, those with a dbhob greater than or equal to 95cm were found to represent higher quality habitat trees which were visited more frequently than smaller trees. Timber-harvesting resulted in the majority of these trees being removed within the treatment areas and the cessation of phascogales nesting in these affected areas. The phascogales continued to forage through the cut coupes but confined their nesting to trees within the unlogged corridors between cut areas (Rhind 1996). Rhind estimated that the brush-tailed phascogale, required four *actual* habitat trees per hectare on the basis that the estimated mature population density on the study sites was 0.2 phascogales/ha, and that each phascogale required 20 trees each.

Current Research

"The Kingston Project" commenced in earnest in 1994 to vastly increase our knowledge of the impact of timber-harvesting and associated activities on many of the aspects of jarrah forest ecosystems. Currently underway are five to 10 year scientific studies within the Kingston State Forest Block

investigating the impact of logging on, the vegetation and flora, abundance of hollow bearing trees, invertebrates, small terrestrial vertebrates (including amphibians and reptiles), medium sized mammals and birds. In co-operation with the Region and District Branches this research is being conducted by Science and Information Staff and post graduate students (Morris *et al.* 1996).

Other studies currently underway include, the impacts of timber harvesting on birds of the karri forest and an investigation into the survival of the trees retained within logged areas over time.

Conclusion

Modern forest management policies are formulated around the concept of "ecologically sustainable development"; which according to the ESD Working Group (1991), means, *optimising the tangible (material) and intangible (non material) social and economic benefits which forests can provide to the community with the goals of maintaining the functional basis of forested land, biodiversity, and options for future generations.*

CALM is committed to investigating the impacts of their forest management practices on ecosystems with the aim of improving upon existing management techniques as sound scientific knowledge is obtained. By doing so CALM aims to fulfil it's Forest Policy Statement (CALM 1992); *To manage the native forests of the south-west of western Australia, in consultation with the community, so that they provide the values required by society while sustaining indefinitely, their biological and social diversity.*

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1997 Fauna Conservation Course

Batalling Field Study Centre
20 - 24th October 1997
Department of Conservation and Land Management
Nature Conservation Division, Wildlife Branch