AN INTEGRATED STUDY OF THE EFFECTS OF TIMBER HARVESTING ON THE JARRAH FOREST ECOSYSTEM

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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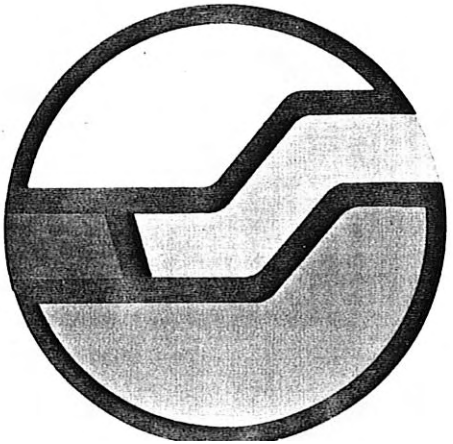

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A PROPOSED INTEGRATED STUDY OF THE EFFECTS OF TIMBER HARVESTING ON THE JARRAH FOREST ECOSYSTEM

INTRODUCTION

GENERAL BACKGROUND

The use of native forests for timber production has given rise to one of the most intense environmental debates experienced in Australia. Conservation groups argue that logging and burning the forest destroys or seriously degrades its natural integrity. On the other hand, forest managers argue that logging is compatible with conservation provided that sufficient areas are reserved and that appropriate measures are taken within production forests to mitigate the effects of logging.

Modern forest management policies are formulated around the concept of "ecologically sustainable development", a concept which has been defined variously in the literature (eg. ESD Working Group Report 1991, RAC Inquiry 1992). According to the ESD Working Group (1991), ecologically sustainable forest use implies:

- "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 the options for future generations".

The principles of ecologically sustainable forest use require the development and implementation of policies which maintain ecological processes, maintain biodiversity and optimise benefits to the community. CALM's Forest Policy Statement (CALM 1992a) embodies these principles:

> "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, the biological and social diversity".

In order to implement this policy, CALM recognises the need for basic ongoing research to gain scientific knowledge of forest ecosystem processes and how these are impacted on by forestry operations (CALM 1992a). CALM also recognises the need to monitor the implementation and impact of these operations to gauge the success of its policies in regard to achieving sustainable forest use. Meaningful monitoring procedures can only be designed and implemented with a firm understanding of natural processes and of key ecosystem elements which should be monitored. Without this information, monitoring risks being "token" and a waste of valuable management resources.

Facilitation of research within native forests

The CALM Science and Information Division (SID) has a mission which supports that of CALM's purpose to conserve and manage the lands, waters and wildlife of Western Australia for the benefit of present and future generations (Science and Information Division Strategic Plan 1993). The Division's mission is to provide up-to-date and scientifically sound information to uphold effective conservation and sustainable land management practices in Western Australia.

The new structure of Science and Information Division aims to facilitate integration and co-ordination of scientific expertise from the four primary groups which comprise the Division. This structure has also facilitated the establishment of formal links between Science Groups and the various branches within CALM.

The first such committee integrating SID with the operational areas of CALM was concerned with forest management, and was known as the Native Forest Research Committee (NFRC). It was chaired by Jack Bradshaw, Manager of the Forest Management Branch, and comprised a

core group of relevant members including the Heads of each Science Group, and the managers of operational branches. The NFRC integrated the branches through operations-based research which will address the broader CALM perspective in relation to forests. This committee should also facilitate speedy incorporation of research findings into operations and ensure that operations themselves form a part of the information gathering process.

The NFRC recognised gaps in knowledge concerned with timber harvesting operations in jarrah forest and recommended that an integrated research program be established to address this issue. NFRC also foreshadowed funding to meet the cost of this research.

A team of research scientists was established to carry out this integrated program of research. The team comprises staff from four of the six Sections within the Science and Information Division, viz. Natural Products Section (Neil Burrows (Chair) and Geoff Stoneman), Community Conservation Section (Gordon Friend), Species Conservation Section (Keith Morris) and Biometrical Services (Matthew Williams), and a PhD student with the Zoology Department of the University of Western Australia (Mike Craig). This research team and its objectives exemplify the Science and Information Division's close alignment with the Departmental goals. The Team has the capacity to integrate and co-ordinate a multidisciplinary group of scientists to provide a scientifically objective and independent source of reliable knowledge.

This document provides a brief overview of the literature relating to disturbance in the Jarrah forest ecosystem, describes the aims, methods and major research topics of such a study, and estimates the human and financial resources needed to carry out the work.

Overview of Jarrah forest disturbance studies

The jarrah (*Eucalyptus marginata*) forest of the south-west of Western Australia is a unique ecosystem occurring on the highly leached soils of the Darling Plateau. The forest originally covered about 5.3 million hectares from Gingin in the north to Albany in the south, with its eastern distribution approximating the 600 mm rainfall isohyet. Clearing for agriculture, mining, service corridors, housing and other uses have reduced the forest to about 3 million hectares (Dell *et al.* 1989).

Timber has been extracted from the forest for the past 160 years. Professional foresters have supervised the industry since the early 1920's. Non-timber values of the forest, including water catchment management, mining, recreation, and conservation, have been receiving much greater emphasis since the 1960's and today, forests are managed for all of these values.

To place the proposed work in perspective it is necessary to present an overview of the recent (last two decades) history of forest fauna and flora research and to review in more detail, the literature regarding the impact of forest management practices on the flora and fauna of jarrah forests.

Christensen *et al.* (1985) noted that "The widespread disappearance of native mammals following European settlement is an Australia-wide phenomenon, from which the forests and woodlands have suffered less than the more arid woodland areas ". Declines in numbers and distribution of some species of south-west forest fauna during the 1930s and 1940s have been largely attributed to predation by the introduced fox (*Vulpes vulpes*) (Christensen 1978 and 1980b). Few forest species have become extinct, possible exceptions being the Potoroo (*Potorous tridactylus*), the Burrowing Bettong (*Bettongia lesueur*) and the Dalgyte (*Macrotis lagotis*) (Christensen *et al.* 1985). As part of the then Forests Department's research program to investigate the effects of forest management on wildlife, Christensen *et al.* (1985) undertook the first comprehensive, systematic biological surveys in the southern forests over the period between 1972 and 1982. There has been ongoing research into the effects of logging and of fire on forest wildlife by CALM, CSIRO and tertiary institutions.

For the purposes of this document, only the two practices associated with the production of wood will be considered, viz. burning and logging. The reader is referred to Dell *et al.* (eds.) (1989), Wardell-Johnson and Nichols (1991) , CALM Occasional Paper No. 2/92 (1992b) and Christensen (1992) for a comprehensive review of Western Australian forest wildlife and habitat management issues, and to Christensen and Abbott (1989) for a review of the impact of fire on the forest ecosystems of southern Western Australia.

Fire

With respect to vegetation, early studies concentrated on the regeneration responses of Jarrah to fire (Van Noort 1960, Wallace 1966, Peet and McCormick 1971, Nicholls 1974, Kimber 1978, Abbott and Loneragan 1983) while other studies examined aspects of damage to the trunk and crown of trees (McCaw 1983, Burrows 1987) and impacts on timber values (Peet and Williamson 1968). Detailed work has also been carried out on the role of fire in the dynamics of recruitment in several understorey species such as legumes (Shea *et al.* 1979), *Boronia megastigma* (Christensen and Skinner 1978) and *Banksia grandis* (Abbott 1985a, 1985b, Burrows 1985).

Few studies, however, have examined the broader aspects of the impact of fire on plant communities. Peet (1971) recorded higher cover values and more species in areas burnt under moderate intensity, primarily because of the presence of leguminous fireweed species (eg. *Acacia pulchella*), while Christensen and Kimber (1975) found few changes in the number of species following a series of low intensity fires. Similar results were described by Abbott (1984) and Abbott *et al.* (1984), while Bell and Koch (1980) used multi-variate analyses to reveal that sites factors, rather than fire, were the main determinants of plant species richness and composition.

There is very little information available on the long term effects of frequent fire on plant species richness and composition in the jarrah forest. However these aspects are being examined in a series of plots established in 1970 near Manjimup. (Christensen and Burrows *pers. comms.*) Results to date indicate that no species have gone extinct and the majority of species show minor changes in abundance as a result of any of the treatments.

Although invertebrates have received some attention in relation to fire in the Jarrah forest, no consensus on the impact of such disturbance on these organisms has yet been achieved. Early studies by McNamara (1955) and Springett (1976, 1979) suggested that fire had a significant long-term effect on the litter fauna, with recovery taking longer than the normal prescribed fire interval of 5-7 years. By contrast Bornemissza (1969), Whelan *et al.* (1980), Majer (1980, 1984) and Abbott (1984) found significant short-term effects (both increases and decreases in selected taxa), but found (or predicted) recovery of the invertebrate communities within 2-3 years. Similarly, Abbott *et al.* (1984) found few differences in the litter and soil fauna of regularly burned and long-unburned jarrah forest, and concluded that periodic low intensity fires in these forest types have few permanent effects on such components of the fauna.

Many of these conflicting conclusions have arisen because of variations or shortcomings in experimental design, taxonomic treatment and length of study. Few studies have any prefire data or any long-term post-fire data, and in the majority of cases invertebrates have been identified only to ordinal level, thus potentially masking important changes in species and family composition following fire. In addition, most workers have contemporaneously sampled areas of different fire histories and ascribed faunal differences to the effect of these fires. Given the inherent within-site variability of invertebrate populations (Campbell and Tanton 1981) this assumption of pre-fire homogeneity between control and treatment plots is tenuous.

Studies on the effects of fire on small vertebrates in Jarrah forest show a clear dichotomy in approaches and research effort. No work has been published on reptiles, and only the work of Driscoll *et al.* (*pers. comm.*) on restricted *Geocrinia* spp. (frogs), and Wardell- Johnson in the Walpole-Nornalup National Park are current. Work on birds has focussed at the community level and examined the responses of various guilds in relation to foraging heights (Kimber

1974, Christensen and Kimber 1975, Christensen *et al.* 1985). In general, the effect of fire on individual species was inversely proportional to their foraging height, and the overall impact on the community was largely dependent on fire intensity.

Mammal studies, on the other hand, have primarily concentrated on individual species such as the Woylie *Bettongia penicillata* and Tammar *Macropus eugenii* (Christensen 1980a), and the Common Brushtail Possum *Trichosurus vulpecula* and the Western Ringtail Possum *Pseudocheirus occidentalis* (Inions 1985, Inions *et al.* 1989). Only the work of Christensen and Kimber (1975) examines response patterns of small mammals at the community level. They reported that fire reduces populations of many species to low levels, and that post fire recovery proceeds in tandem with the regeneration of the vegetation. Predation can be an important factor influencing the immediate post-fire outcome, but mammal species response patterns and longer-term successional patterns are largely determined by their life history parameters, particularly their requirements for food, shelter and breeding (Friend 1993).

The above overview indicates that carefully designed studies which incorporate pre-fire data and unburnt control sites are clearly needed to clarify the role of fire in the management of the Jarrah forest ecosystem. As indicated by Christensen and Abbott (1989), these studies need to be long term and focus primarily on key species which are likely to be sensitive to fire. Such work is currently underway near Collie, and is seen as an important adjunct to the studies on timber harvesting proposed here.

Logging

Research on the ecological impacts of logging in the jarrah forest is very sparse. No work has been reported on the effects of logging on mammals, although several potentially sensitive and/or endangered species occur in jarrah forest (eg. Chuditch *Dasyurus geoffroii*, Quenda *Isoodon obesulus*, Mardo *Antechinus flavipes leucogaster*, Western Pigmy Possum *Cercarteus concinnus*, Common Brushtail Possum *Trichosurus vulpecula*, Brush-tailed Phascogale *Phascogale tapoatafa* and several species of bat). Although some work has focussed on birds and logging in Karri forest (Wardell-Johnson unpubl.), only two studies have addressed this topic in jarrah (Abbott and Van Heurck 1985, Norwood *et al.* in review). Abbott and Van Heurck (1985) suggested that the jarrah forest bird community has high threshold levels of tolerance to disturbance, and that no species were affected significantly by logging. Norwood *et al.* (in review) studied the response of birds to edge effects created by intensively logged gaps, and compared these sites to the adjacent unlogged forest. Fourteen species were tested for differences in distribution between treatments. Eight, two and one species were more frequently observed in gaps, edges and forest respectively, while the remaining three species showed no significant differences between treatments. Although limited in duration, this work provides important direction for further work of this nature.

The only other faunal study on silvicultural practices in jarrah forest is that by Curry and Humphries (1988) who examined insect communities in *Pinus radiata* plantations and the native forest which they replaced (ie. not logging *per se*). Assessment of the degree of impact was dependent on the level of identification of taxa (as was the case in the fire studies, see above), with ordinal level analyses unable to separate treatments from the background variability attributable to season and site. At the family and generic levels of identification several groups such as the Diptera (flies) and Lepidoptera (moths and butterflies) could be highlighted as particularly sensitive to disturbance. These groups, along with spiders (from the work of Curry *et al.* (1985) regarding logging in karri forest) are likely to be useful indicator taxa on which to focus attention in future studies.

Although jarrah forests have been logged since settlement (1829) there is no evidence that any species have gone extinct as a result of this. Modern declines in forest fauna have been largely attributed to the fox (see above). However, if sound management decisions on future silvicultural practices, logging levels and sustainability are to be made, they must be made from a satisfactory knowledge base. There is an ongoing need for empirical information on the ecological effects of timber harvesting operations on the jarrah forest ecosystem.

Indeed, this is also the case at the national level. Recent forestry reports and national reviews of forestry practices (eg. RAC, ESD, NPAC, NFPS and IGAE) conclude that, Australia-wide, the research base is far from adequate. The RAC Inquiry (1992) concluded that there is insufficient information available to support claims about whether impacts resulting from forest activities are benign or deleterious to the forest environment. Further, the Inquiry stated that current levels of monitoring were inadequate and recommended that systematic, long-term research and monitoring be established as a matter of highest priority. This requirement was also a recommendation of the 1992 EPA report (EPA 1992).

CALM's (1992a) recent review of forest management strategies has been well accepted at the national level. It is clear that some proposals highlighted in the report are intuitively well considered. It is also true, however, that there are limited data upon which to demonstrate the value of the approach, or where necessary, to refine it. Empirical data will be necessary to allow sensible decisions to be made regarding optimal multiple use of the jarrah forest in a changing social framework. This research proposal represents a natural progression and continuation of past research in Western Australian forests.

THE PROPOSED STUDY

OVERALL DESIGN AND METHODS

Science Project Plans (SPPs)

A Science Project Plan (SPP) must be prepared and approved before any research can be undertaken by SID scientists. This is a detailed, formal planning process which requires the proponent to describe aims, scientific method, benefits to CALM, costs, staff involved, location of the research, outcomes, etc. When a SPP has been prepared by a scientist, it is scrutinised, evaluated and endorsed (or rejected) by a number of key people including region and district managers, biometrician, animal ethics committee and senior SID staff (Section Manager, Head of Group and the Director). Once approved, the SPP is allocated a number and incorporated in the SID SPP data base.

SPPs have been prepared and approved for the experimental phase (phase 1, the Kingston experiments) of this project. SPPs have also been prepared for retrospective studies (phase 2) but as these plans will not be implemented until 1995/96, they have not been through the formal approval process as yet. To maintain brevity, summarised and updated versions of all SPPs relevant to this project are presented in this document rather than the entire SPP.

The program of research advocated in this plan is designed to investigate the ecological effects of integrated timber harvesting operations in the jarrah forest. While empirical in nature, the research is designed to gain an understanding of disturbance and recovery processes following timber harvesting operations. The study will integrate the work of scientists with expertise in plant and animal ecology, silviculture and landscape ecology.

The study involves two approaches:

1. Experimentation over a narrow but critical geographical area and range of sites, to concentrate on short-term (1-5 years post-logging) effects (phase 1)

2. Contemporaneous sampling of sites over their geographic range (retrospective study) to enable a temporal and spatial perspective on experimental results (phase 2).

The phase 1 experiment is designed to examine short term (1-5 years past logging) phenomena in detail. The overall study design of the experiment is of the BACI (before, after, control, impact) repeated measures type, with several replicates of each of the four treatments.

Sampling associated with each of the various projects described below will be based on some 24 grids (160 m x 160 m) located in each of the treatment areas (App. 2). The four treatments are:

1. Control (forest area that will be burnt but not logged during the study period),
2. Shelterwood (in coupes with patches of 5-50ha),
3. Gap with standard 3 habitat trees per ha (in coupes with gaps no larger than 10ha),
4. Gap without retained habitat trees (in coupes with gaps no larger than 10ha).

Commencing in 1993/94, there will be 12-18 months of pre-treatment data collection to calibrate study sites. All sites will be burnt at the same time prior to the harvesting treatments. Each coupe (consisting of many gaps or patches) will include three replicate blocks. Further replication necessary for some aspects of the study will be carried out in gaps within a coupe, but in sites at least 200m apart. This design will allow the impacts of the current harvesting operations to be assessed. The four treatment areas will be contiguous, allowing delimitation of edge effects for some variables. The spatial and temporal effectiveness of habitat trees will also be examined. It is recognised that introduced predators have a major impact on native wildlife, particularly following disturbance. Thus the experimental domain comprises a large area which has been regularly baited for fox control over several years prior to the commencement of the study.

The experimental work is planned to occur in open jarrah forest of the medium rainfall zone in Warrup/Kingston Forest Blocks, 25km north east of Manjimup (App. 1). These sites are representative of a major focus of timber production in State Forest over the next decade, and include populations of several species of gazetted threatened fauna. The experiment will be carried out within planned operations in the lateritic uplands and sandy terrain of the Bevan landform unit. This landform/soils unit represents the most widespread of the sites from which jarrah timber is harvested. This unit is replaced north of the Blackwood River by the Dwellingup unit and in the Blackwood Plateau by the Kingia unit.

The experimental study will provide results not only on the short-term effects of the treatments, but, because of the multidisciplinary approach and sharing of the individual data sets that this engenders, also on processes and interactions between various components of the ecosystem. This synergism will allow much more rapid advances in knowledge and extrapolation of the results beyond the study area.

The proposed phase 2 retrospective study will commence in 1995/96 and will be carried out simultaneously to the experimental work (years 2-5 of the experiment) to ensure a broader temporal and geographic applicability of the results. This study is also being limited to two soil types (lateritic and sandy) but in three equivalent landform units (Dwellingup, Bevan and Kingia) in both the medium and high rainfall zones of the jarrah forest. Eight study sites each with a range of logging and burning history have been chosen (Dwellingup, Jarrahdale, Margaret River, Nannup, Yornup, Kirup, Lockhart and Dixon; App. 2). The layout of quadrats and data collection procedures in the two studies will allow direct comparison of the results between them. The Dwellingup area will continue to be sampled over the four year period to provide seasonal and year-to-year control for other areas.

Although further aspects of the ecology of the jarrah forest ecosystem could also be examined in this study, it is considered that the most important priorities are being examined within the constraints of a reasonable funding request. Further, the most cost-efficient means of data collection, storage and analysis have been sought through a multidisciplinary approach to the work. Effective delivery of scientifically sound experimental and monitoring results to forest managers and receipt of feedback on costs, management implications and practicality will be the primary considerations in the conduct of the study.

In addition to the Kingston Block experiment and the retrospective studies, it is anticipated that results of related research and inventory data will be used to develop a patch level silvicultural model and a between patch model (Fig. 1). These will model patch development and habitat,

and change in habitat pattern. Together, these two models will allow regional patterns of habitat and abundance of animals to be modelled, as well as estimates of animal abundance and habitat at various scales. Monitoring of selected sites would be required as an independent test of model estimates of animal abundance and habitat. While modelling of results from this and related research is believed to be the best approach to predicting the effects of various silvicultural practices, there is some contingency in this framework (Fig. 1), as the other major outcome of this project, i.e., developing ecologically sustainable silvicultural systems, will be directly determined from a) the Kingston experiment, b) the retrospective studies and c) related research.

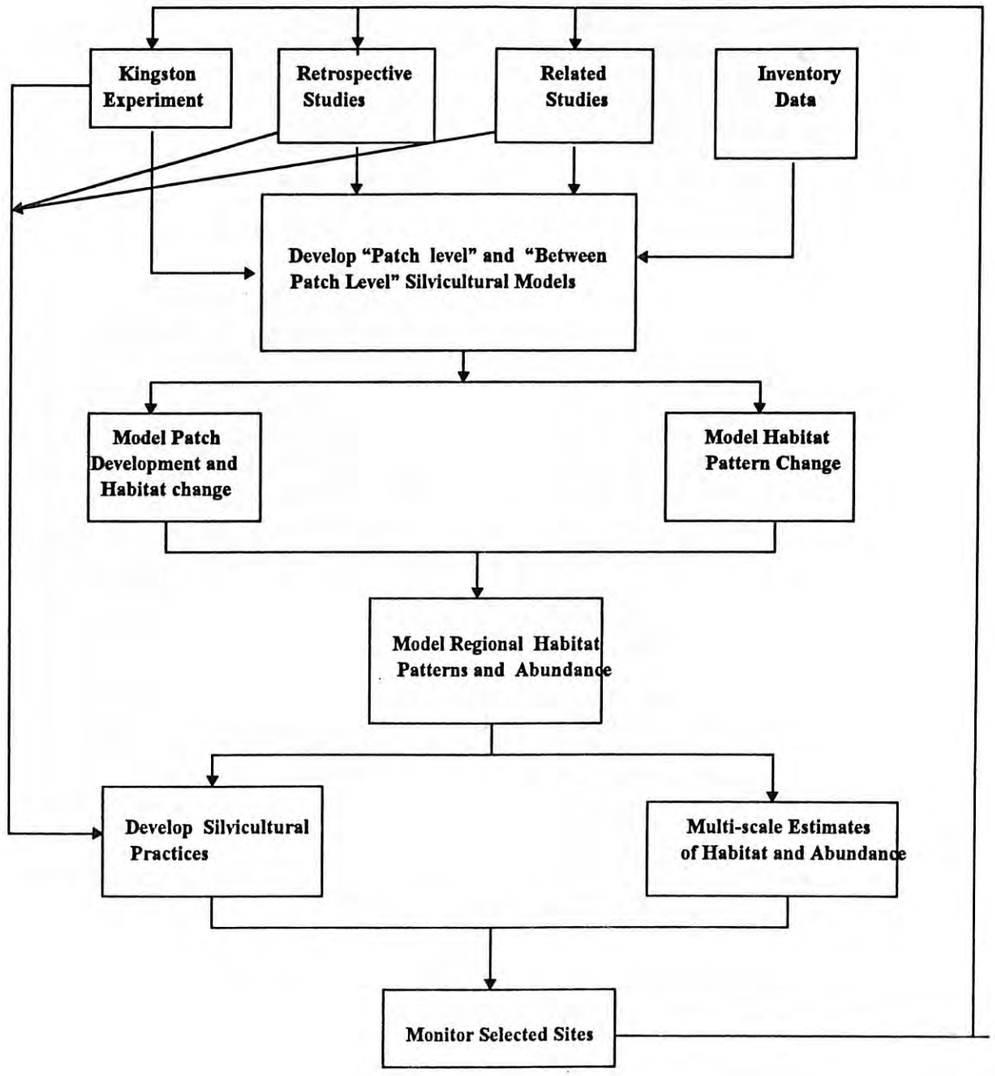

Figure 1: A framework for developing a patch and regional scale silvicultural model for jarrah forests which incorporates wildlife values.

Human Resources

Below are listed the principal CALM personnel involved in the study. The Science and Information Division team are liaising closely with the Southern Forest Region and Manjimup District staff to ensure efficient planning and implementation of the experiment in Kingston and Warrup blocks.

Principal Calm Personnel Involved

NAME	AFFILIATION	EXPERTISE
Neil Burrows	Science & Information Division	Vegetation/fire response
Gordon Friend	Science & Information Division	Vertebrate/invertebrate ecology
Keith Morris	Science & Information Division	Vertebrate ecology
Geoff Stoneman	Science & Information Division	Silviculture
Mike Craig	PhD student, U.W.A	Vegetation/bird response
Matthew Williams	Science & Information Division	Experimental design/analysis
Kevin Vear	Southern Forest Region	Regional management
Alan Lush	Southern Forest Region	Planning
John Lloyd	Manjimup District	District Manager

In addition, a large number of technical and administrative staff from within CALM will be involved in the work. Details are provided in the relevant Project Plans which follow in this document.

Costs:

Phase 1: First five years of the Kingston Experiment. No allowance is made for salary creep. Costs do not include on costs which can be assumed to be about 20% of total cost.

	1993/94	1994/95	1995/96	1996/97	1997/98
Plant	20 940	23 609	20 020	19 414	12 814
Materials	25 300	15 170	14 250	14 855	14 400
Travel	14 492	11 264	9 955	9 279	9 933
Overtime	2 400	1 700	2 000	2 000	2 100
CALM Salaries	161 994	161 994	161 994	161 994	161 994
TOTAL ($)	**225 126**	**213 737**	**208 219**	**207 542**	**201 241**

Phase 2. Retrospective studies.

	1995/96	1996/96	1997/98
Plant	14 590	15 250	16 050
Materials	18 540	11 550	7 850
Travel	6 860	6 930	7 860
Overtime	5 600	5 900	6 200
CALM salaries	182 530	182 530	182 530
TOTAL ($)	**228 120**	**222 160**	**220 490**

Detailed breakdown of estimated expenditure is provided by the individual Project Plans. These proposals and costings represent the minimum level of input to effectively research the effects of timber harvesting on the jarrah forest ecosystem.

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DETAILS OF PROPOSED STUDIES

SCIENCE PROJECT PLAN # 93/98 - SUMMARY

1. Title of Project:

Effects of timber harvesting on the floristic composition, vegetation structure and some habitat characteristics of intermediate rainfall jarrah forests.

2. Project Leader: N. Burrows

3. Aim:

To study the effects of logging treatments and fire on jarrah forest vegetation. Specifically;

a) plant mortality and regeneration/recruitment
b) floristic composition
c) vegetation structure (cover, height and density)
d) habitat characteristics
e) understorey biomass

4. Background/Justification:

While there is a long association between fire, climate and the jarrah forest, logging is a relatively recent disturbance factor. Although jarrah forests have been commercially logged virtually since European settlement there are no detailed studies of the impact of logging on the forest vegetation communities.

There is a substantial amount of literature on the effects of fire on components of the jarrah forest ecosystem, especially vegetation, (see review above), but there is a surprising lack of information on the impact of logging and on the combined, synergistic effects of logging and fire. For the most part, this situation holds for most Australian commercial forests. Past logging impact research in Australian *Eucalyptus* forests has concentrated on the silviculture and ecology of commercial timber species, of selected fauna, hydrology, soil damage, and nutrient cycling. The most extensive studies of the impact of logging on vegetation have taken place in rainforest.

Vegetation is important in its own right and forms habitat for a diverse suite of fauna. Broadly, logging impacts on vegetation by;

i) physical removal of trees and damage to understorey vegetation, altering the structure, cover and composition of the forest

ii) inducing micro-climatic changes resulting from tree removal and disturbance to the understorey, litter layer and soil.

ii) soil disturbance and physical damage caused by roading, snig tracks and log dumps which affect plant establishment and development.

iii) accumulations of logging debris

The effects of a fire on jarrah forest vegetation are reasonably well understood. In addition, there are ongoing studies to address questions of fire regime effects. However, there have been no studies of the combined effects of fire and logging on vegetation. Logging, as well as causing the impacts reported above, causes a significant re-distribution of fuel. Heavy accumulations of large fuel particles such as non commercial logs and tops, burn more intensely and with longer duration than the predominantly litter

fuels of an undisturbed forest. The type of fire resulting from the combustion of logging slash is likely to have a greater physical impact on vegetation and soils.

Logging and burning are major management-induced perturbations to the jarrah forest, impacting on all organisms and on the soil and hydrology. A firm understanding of these impacts is essential for responsible management and utilization of the jarrah forest to achieve production and conservation benefits.

5. **Keywords:**
Jarrah, logging, fire, vegetation, floristics, structure, effects

6. **Target Users:**
Forest operations, research scientists

7. **Associated Staff:**
B. Ward, L4 @ 0.15 F.T.E
G. Liddelow, L4 @ 0.15 F.T.E
A. Robinson, L3 @ 0.15 F.T.E

8. **Associated Institutions:** Nil

9. **Study Design**
The work will be carried out in Kingston, Winnejup and Warrup Forest Blocks, about 25 km north-east of Manjimup. Four treatments will be imposed: (i) burning only (control); (ii) shelterwood logging; (iii) gap creation leaving habitat trees; and (iv) gap creation leaving no habitat trees (clearfell). Logged areas will be subjected to the normal prescribed burning carried out for such an operation. It is anticipated that logging operations will commence in the summer of 1995.

A complete plant species list will be prepared for the study area by regular specimen collection visits. Voucher and museum specimens will be made.

This study will be integrated with the large (160 m x 160 m) grids used for faunal sampling, as described by the SPP's below. Nine vegetation plots, each 30 m x 30 m, will be systematically located in each large faunal grid. Plots will be permanently marked, labelled and mapped.

Vegetation sampling and habitat description will be stratified and measured as described below. The following measurements will be made prior to timber harvesting operations and then at yearly interval for at least five years.

9.1 Floristic composition

All vascular plants and their abundance will be recorded in each 30 m x 30 m plot. An abundance rating system devised by Havel (1975) will be used. Voucher specimens will be collected and housed at SID Manjimup.

9.2 Understorey structure (forest floor to 2 m)

Four x 30 m line transects will be established at 5 m intervals across each plot. Understorey cover and structure will be measured along these transects using point ntercept and Levy rod (Levy and Madden....) technique. This involves recording vegetation contacts at known height intervals on a small diameter rod inserted vertically through the scrub at 2 m intervals along the line transect. Height of vegetation will be estimated at each point using the drop plate technique (Bell and Schneider 1985). Ground cover and soil disturbance will be assessed at each Levy rod point and classified.

9.3 Understorey biomass

Understorey biomass (alive and dead) will be measured annually in each faunal grid before and after treatments by collecting all phytomatter in the understorey strata (0 - 2 m) from 30 x 1m^2 quadrats placed randomly (but outside the 30 m x 30 m plots). Material will be sorted as to live and dead and oven dried.

9.4 Mid (2 - 10 m) and Upper (10 - 25 m) canopy strata

Vertical projections of the Levy rod will be made at each 2 m point sample along the line transects using a "periscope" type densiometer. Mid and upper canopy interceptions will be recorded.

9.5 Logs

The following will be recorded for all logs (>50 mm diameter) intercepted by the line transects:

I) Species
ii) Diameter at intercept
iii) Small and large end diameters
iv) Length
v) Extent of decomposition (visual classification)
vii) Diameter of hollows
viii) Hollows used (visual assessment)

9.6 Tree species

Tree species will be classified as;

I) linotuberous advanced growth
ii) saplings (<15 cm dbhob)
iii) trees (>15 cm dbhob)

All lignotubers and saplings within each 30 m x 30 m plot will be counted by species. The following will be measured for all other trees;

I) Species
ii) dbhob
iii) Fire damage
iv) Bole condition (leaning, bent etc.)
v) Height to crown break (tape and clinometer)
vi) Top height (tape and clinometer)
vii) Number and location of hollows, possum tracks, drays, nests etc.

9.7 Seedlings

Seedlings will be counted, by species, within 10 x 1 m^2 quadrats randomly located within each 30 m x 30 m plot.

Permanent photographic points will be established in each plot. Management history will be collated.

9.8 Statistical analysis

Before and after treatment, each site will be classified on the basis of vegetation association and using ordination and cluster analysis. Species composition and richness will be compared . Vegetation structural differences, variation in habitat measures (such

as number of hollows), ground cover and soil condition (degree of disturbance) between treatments will be tested using ANOVA and Chi-squared techniques.

10. Costs

	1993/94	1994/95	1995/96	1996/97	1997/98
Materials	2 150	1 200	900	1 000	1 200
Plant	3 400	3 800	4 200	4 500	4 800
Travel	1 000	1 350	1 500	1 700	1 900
TOTAL	**6 550**	**6 350**	**6 600**	**7 200**	**7 900**

Salaries

CALM salaries/annum 0.15 F.T.E Level 7 research scientist ($7 800) 0.3 F.T.E Level 4 technical officer ($10 650), 0.15 F.T.E Level 3 technical officer ($4 950).

Total CALM salaries/annum (not adjusted for salary creep) $23 400.

SCIENCE PROJECT PLAN # 93/109 - SUMMARY

1. Title of Project:

The effects of timber harvesting and associated activities on medium sized mammals in the jarrah forest.

2. Project Leader:

Keith Morris.

3. Aim:

a) To investigate the ecological impacts of logging and associated burning operations on populations of medium-sized mammals inhabiting medium rainfall jarrah forest.

b) To determine what factors contribute to the observed impacts.

c) To use the results of this investigation to develop prescriptions for the appropriate management of timber harvesting operations in the jarrah forest.

4. Background/Justification:

CALM's operations in the jarrah forest are coming under increasing public scrutiny and there are few published accounts of the ecological impact of timber harvesting activities on the jarrah forest fauna. Several medium-sized mammals, such as the chuditch and woylie, that have declined or become extinct in other parts of Australia still occur in parts of the jarrah forest and maintenance of suitable forest habitat is critical for their conservation. In particular the maintenance of adequate tree hollows and ground logs is important, yet little information is presently available for managers to prepare prescriptions for this.

This project is designed to investigate the direct and short-medium effects of standard logging operations on medium sized mammals in the jarrah forest and is part of a larger co-ordinated project examining the impacts of timber harvesting on vegetation, invertebrates, small terrestrial vertebrates, bats and birds. The Chuditch Recovery Plan (Orell and Morris 1994) also requires that the effects of timber harvesting on Chuditch be examined and prescriptions prepared to enhance the conservation of this species in the jarrah forest..

This study will provide silvicultural management prescriptions that will ensure that the jarrah forest continues to support populations of medium-sized mammals, some of which are threatened species.

5. Keywords:

Medium sized mammal, logging disturbance, fire, chuditch, woylie, possum, tree hollows, ground logs, jarrah..

6. Target Users:

CALM managers in the Forest Resources Division and Swan, Central Forest and Southern Forest Regions. Managers of other dry sclerophyll forest ecosysytems in south east Australia.

7. Associated Staff:

Gordon Friend, Brent Johnson, Peter Orell and Mike Choo, Woodvale.
Mike Dillon, Dwellingup.
Neil Burrows, Geoff Stoneman and Matthew Williams, Como.
Leon Price and Tim Foley, Manjimup District.
John Rooney and Colin Ward, Manjimup SID.

8. Associated Institutions:

None.

9. Study Design:

The study will be in the Kingston, Winnejup and Warrup forest blocks, 25 kilometres north east of Manjimup. The experimental study design is the same as for the study into logging effects on small vertebrates (GRF). Three logging treatments will be imposed:

1) Shelterwood (thinning in coupes with patches of 5-50 ha)
2) Gap creation with three habitat trees per ha.(in coupes with gaps no larger than 10 ha.)
3) Gap creation with no retained habitat trees (in coupes with gaps no larger than 10 ha)

It is anticipated that logging operations will be undertaken in summer/autumn of 1995 and 1996.

In early 1994 trapping grids will be established in experimental and control areas. For each treatment, a grid will be established within the treatment area (shelterwood or gap) and another across the treatment / unlogged forest boundary. Another grid will be established in forest to remain unlogged either adjacent to or close to the treatment area (paired treatment/control). Each treatment will be replicated in areas to be logged in early 1995. Another replicate will be established in areas to be logged in 1996. Four grids will also be established (2 in Warrup block, 2 in Winnejup block) in forest that will remain unlogged and distant from the experimental areas. In summary the following grids will be established:

	Treatment	# grids	Established
1.	Shelterwood / edge (replicated)	2 x 2 = 4	March 1994
2.	Gap with no habitat trees / edge (replicated)	2 x 2 = 4	March 1994
3.	Gap with habitat trees / edge	2 x 2 = 4	March 1994
4.	Shelterwood / edge	2 x 2 = 4	March 1994
4.	Unlogged controls within expt. compartments		
	a) adjacent to gap creation	2	March 1994
	b) vicinity of shelterwood	2	March 1994
5.	Unlogged controls distant from expt. compartments	4	March 1994
6.	Gap / edge	1 x 2 = 2	August1994
7.	Shelterwood / edge	1 x 2 = 2	August1994

To accommodate the anticipated different movement patterns of the medium-sized mammals, sampling will occur at two levels. At the broader scale, 25 km of line trapping transects will be established through the experimental and control areas using

100 wire cage traps set at 200m intervals. At a finer scale, a 3 x 3 grid (80m cage trap spacings) will be established in each of the experimental and control replicates (total of 24 cage grids, each with 9 cage traps = 216 traps). These grids will overlay and compliment the pit and Elliott trap grids established by GRF to sample small vertebrates in this study. Trap sites will be marked for repetitive use. Sampling on grids and line transects will be undertaken simultaneously for three and four nights respectively, five times over a year before the treatments are imposed. To facilitate the number of traps and grids to be checked, "northern" and "southern" grids will need to be sampled alternatively between trips. Sampling will continue at the same frequency for four years after treatment. Animals captured will be individually marked, sexed, measured, weighed and released. Some will be fitted with radio-transmitters to determine movement patterns, den and home range requirements. Standardized spotlighting transects will be established in both the treatment and control areas.

Forest structure and habitat parameters will be assessed before and after logging in studies by Neil Burrows and Geoff Stoneman. In particular, the availability of suitable habitat trees and ground logs for possums and chuditch will be assessed.

Fox control will be necessary to reduce fox predation as a contributing factor to fauna abundance. Fox baiting will be implemented throughout Kingston and Warrup blocks prior to the study commencing, using a regime shown elsewhere in the jarrah forest to sufficiently control foxes and allow increases in medium-sized mammals (4.5mg 1080 in dried meat baits, 250m spacings along tracks, every three months).

Pre treatment data on abundance, distribution, and requirements of the medium-sized mammals and relevant habitat parameters will be collected from spring 1993 to summer 1994/5. Logging treatments are programmed to commence in January 1995, and post-treatment data will continue to be collected until January 1999. Comparison of pre- and post-treatment data with the control will provide the basis for assessing impact. Paired T-tests and ANOVA's will be used to compare species diversity and abundance. Movement patterns will be analysed using RANGES or similar. Den logs, burrows and habitat trees will be located before treatments using radiotracking and GPS techniques, and the fate of same determined after the treatment.

10. Costs:

	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99
Materials	13 400	7 520	7 750	7 980	8 220	8 460
Plant	2 840	2 500	2 575	2 650	2 730	2 810
Travel	5 170	4 600	4 740	4 880	5 030	5 180
Publication						500
TOTAL	21 410	14 620	15 065	15 510	15 980	16 950
Less ANCA	5 600	3 400	3 400	8 400	3 360	3 360
CRF required	**15 810**	**11 220**	**11 665**	**7 110**	**12 620**	**13 590**

Salaries

It is anticipated that 0.25 FTE Level 7 research scientist ($13 015) and 3 x 0.25 FTE Level 4 technical officer ($27 314) will be involved in this project. Total CALM salaries/annum $40 329. Salary estimate does not allow for salary creep.

TOTAL CALM SALARIES/ANNUM **$40 329**

SCIENCE PROJECT PLAN # 93/114 - SUMMARY

1. **Title of Project:** Effects of timber harvesting on small vertebrates in medium rainfall jarrah forest.

2. **Project Leader:** Gordon Friend

3. **Aim:**

   (a) To investigate the effects of logging and the associated burning operations on populations of selected small mammals and reptiles inhabiting medium rainfall jarrah forest.
   (b) To compile information on the life history strategies of these small vertebrate species, and examine their population dynamics and habitat preferences.
   (c) Use these data to develop predictive models of the impact of logging/burning operations on small vertebrates and formulate general principles for the management of fire and logging in jarrah forest ecosystems.

4. **Background/Justification:**

   The impact of burning and logging on Australia's native terrestrial fauna is the subject of much controversy, but there have been relatively few studies which address this issue. There is an urgent need for experimental studies (in combination with retrospective (space-for time) studies) which examine the immediate and short-term impacts of integrated burning and logging operations on small vertebrates in jarrah forest, focusing particularly on keystone species likely to be sensitive to disturbance. Relevant small vertebrate species include litter-dwelling skinks and those reptiles requiring logs and tree-trunks, and small mammals dependent on hollows in old standing trees or logs (eg. the Mardo *Antechinus flavipes* and the Brush-tailed Phascogale *Phascogale tapoatafa*).

   Although habitat trees are now retained as part of standard logging operations in the jarrah forest there are few data enabling decisions to be made regarding species selection, spatial configuration and age or size class of retained trees with respect to their influence on faunal species or community composition. Critics of CALM have focussed on these as key issues in jarrah forest management. If these criticisms are to be addressed, managers require sound data on the influence of coupe design and the retention of trees in logged areas on faunal species.

   The present study is designed to investigate the direct and short-term effects of standard logging/burning operations on the above groups of small vertebrates in medium rainfall jarrah forest. The work is part of a large, multidisciplinary project examining the impacts of such operations on medium-sized mammals, birds, bats, invertebrates, vegetation, stand structure and dynamics, and microclimate.

   The work will later be integrated with a broader-scale (retrospective) study which will examine relationships between species/community composition of the vertebrate fauna and logging and fire history in medium to high rainfall jarrah forest throughout the south-west. This combined approach will provide data on both the short and long-term impacts of logging and burning, and ensure a broader geographic applicability of the results from the experimental work. The study will also complement existing work on small vertebrates and fire near Collie, and the work being undertaken by a Ph.D. student from Murdoch University (Susan Rhind) on the ecology of *Phascogale tapoatafa*.

5. **Keywords:**

Small vertebrates, disturbance, logging, fire, reptiles, mardo, phascogale, jarrah.

6. Target Users:

Managers of state forests in the Swan, Central Forest and Southern Forest regions. The study will also provide data regarding disturbance ecology of relevance to other researchers and the general public. Much of the data will also be relevant to the dry sclerophyll forest ecosystems of south-eastern Australia.

7. Associated Staff:

Keith Morris, Brent Johnson, Peter Orell and Mike Choo (Woodvale); Neil Burrows, Geoff Stoneman and Matthew Williams (Como); Colin Ward and John Rooney (Manjimup SID); Leon Price and Tim Foley (Manjimup District).

8. Associated Institutions:

Murdoch University (Susan Rhind, Ph.D. student).

9. Study Design:

The work will be carried out in Kingston, Warrup and Winnejup Forest Blocks, 25 km north-east of Manjimup. Three logging treatments will be imposed in the Kingston Block: (i) shelterwood logging; (ii) gap creation leaving habitat trees; and (iii) gap creation leaving no habitat trees (clearfell). It is anticipated that logging operations will be carried out in the summer/autumn of 1995 and 1996.

The experimental setup will conform to a Before/After/Control/Impact (BACI) design whereby data will be collected from fixed sites before, during and after logging and compared with those from control sites which will remain unlogged for the term of the study. A total of 20 sampling sites (trapping grids) will be established in early 1994. Two sites will be set up to sample the centre and ecotone (edge) respectively of each of the three logging treatments, and replicated between coupes (ie. 2 x 3 x 2 = 12 grids). The remaining eight sampling sites will be located in control areas and comprise: (i) external controls, with two sites in each of Warrup and Winnejup Forest Blocks (ie. four grids); (ii) internal controls within the Kingston Block but outside the logging coupes (two grids); and (iii) within-coupe controls in unlogged buffers (two grids). A further four sites will be established to sample the centre and ecotone of two gaps (with habitat trees retained) in separate coupes which will be logged in 1996. These latter grids will be set up in late 1994 and sampled thereafter to provide some temporal (as well as spatial) replication. The complete design will therefore comprise a total of 24 sampling sites. Half of these grids will be run on each monthly sampling trip (ie. each is sampled every second month), except for the two internal control grids which will be sampled each trip to provide a continual baseline data-set.

Each sampling site will comprise a core area of 80 x 80 m in which a 5 x 5 grid of pitfall traps will be established with 20 m spacing. Superimposed over this grid will be a larger 5 x 5 grid of small mammal traps (Elliott Type A) with 40 m spacing. Large wire-cage traps will also be placed in a 5 x 3 grid at 80 m spacing as part of the integrated studies on medium-sized mammals (KDM; see Appendix). Traps will be run for three consecutive nights on each sampling occasion and animals captured will be individually marked, measured and released.

Although abundance and distributional data will be gathered on a wide range of small vertebrate species and their response to logging operations, the major focus of the work will be on several species of litter-dwelling skinks and two species of small mammals, the Little Long-tailed Dunnart (*Sminthopsis dolichura*) and the Brush-tailed

Phascogale (*Phascogale tapoatafa*). With respect to Phascogales, 10 - 15 individuals will be fitted with radio collars in the K1 and K3 coupes during early summer 1995 (shortly before the logging operations) and monitored during and after the treatment. This work is designed to complement the detailed work being carried out by Susan Rhind (Murdoch University) on the ecology of *P. tapoatafa* in the Perup Nature Reserve, and the species response to logging in the K5 coupe at Kingston. It will use some of the techniques already developed by Susan, and will extend her work to enable data to be gathered on further logging sites.

Forest structure and habitat parameters which may be of relevance to small vertebrates, and particularly *P. tapoatafa* and *S. dolichura* (such as the distribution , abundance and size of hollow trees and logs, and leaf litter and understorey vegetation cover), will be quantified on each site before and after logging/burning in integrated studies being carried out by Neil Burrows and Geoff Stoneman. Vegetation floristics and microhabitat parameters (eg. abundance and distribution of woody debris, temperature and humidity regimes) will also be assessed in these related studies.

Analyses will involve examining initial similarity between grids using clustering and ordination techniques. Pre and post-treatment similarity in faunal abundance and composition between areas will be assessed and provide the basis for measuring impact. Pairwise t-tests and ANOVAs will be used to compare species richness and abundance between treatments, with time periods providing additional replication.

10. Costs:

	1993/94	1994/95	1995/96	1996/97	1997/98
Materials	7 100	4 400	4 000	4 200	4 400
Plant	4 300	3 900	4 200	4 500	4 700
Travel	4 000	2 500	2 800	2 900	3 100
Overtime	2 400	1 700	2 000	2 000	2 100
TOTAL	17 800	12 500	13 000	13 600	14 300

Salaries

CALM salaries/annum 0.5 F.T.E Level 7 research scientist ($26 929), 1.0 F.T.E Level 4 technical officer ($34 500).

TOTAL CALM SALARIES/ANNUM **$61 429**

SCIENCE PROJECT PLAN # (tba) - SUMMARY

1. **Title of Project:**

   Effects of timber harvesting on terrestrial invertebrates in medium rainfall jarrah forest.

2. **Project Leader:** Gordon Friend

3. **Aim:**

(a) To investigate the effects of logging and the associated burning operations on the terrestrial invertebrate fauna (particularly spiders, beetles and flies) inhabiting medium rainfall jarrah forest.

(b) To compile information on seasonal abundance, habitat preferences and species composition of the above groups.

(c) Use these data to develop predictive models of the impact of logging/burning operations on terrestrial invertebrate communities and formulate general principles for the management of fire and logging in jarrah forest ecosystems.

4. **Background/Justification:**

The impact of burning and logging on Australia's native terrestrial fauna is the subject of much controversy, but there have been relatively few studies which address this issue. This is particularly so with respect to invertebrates, which are now recognized as central to ecosystem functioning and biological diversity, yet are usually ignored in ecological research. There is an urgent need for experimental studies (in combination with retrospective (space-for time) studies) which examine the immediate and short-term impacts of integrated burning and logging operations on invertebrate communities in jarrah forest, focusing particularly on key groups likely to be sensitive to disturbance. Earlier work carried out in forests and shrublands has pinpointed spiders (particularly Mygalomorphs), certain beetles (eg *Catasarcus* weevils), cockroaches and flies as potentially sensitive to forest management practices and excellent bio-indicators of environmental conditions.

Although habitat trees are now retained as part of standard logging operations in the jarrah forest there are few data enabling decisions to be made regarding species selection, spatial configuration and age or size class of retained trees with respect to their influence on faunal species or community composition. Critics of CALM have focussed on these as key issues in jarrah forest management. If these criticisms are to be addressed, managers require sound data on the influence of coupe design and the retention of trees in logged areas on faunal species.

The present study will be undertaken as a Ph.D. project by Karin Strehlow (Murdoch University), and is designed to investigate the direct and short-term effects of standard logging/burning operations on the above groups of invertebrates in medium rainfall jarrah forest. It is part of a large, multidisciplinary project examining the impacts of such operations on small terrestrial vertebrates, medium-sized mammals, birds, vegetation, and stand structure and dynamics.

It is anticipated thet the work will later be integrated with a broader-scale (retrospective) study which will examine relationships between species/community composition of the invertebrate fauna and logging and fire history in medium to high rainfall jarrah forest

throughout the south-west. This combined approach will provide data on both the short and long-term impacts of logging and burning, and ensure a broader geographic applicability of the results from the experimental work. The study will also complement existing work on invertebrates and fire in the Perup Nature Reserve (RPP 20/90).

5. **Keywords:** Invertebrates, disturbance, logging, fire, spiders, beetles, cockroaches, flies, jarrah.

6. **Target Users:**

Managers of state forests in the Swan, Central Forest and Southern Forest regions. The study will also provide data regarding disturbance ecology of relevance to other researchers and the general public. Much of the data will also be relevant to the dry sclerophyll forest ecosystems of south-eastern Australia.

7. **Associated Staff:**

Karin Strehlow (Ph.D. student, Murdoch University), Keith Morris and Brent Johnson (Woodvale), Neil Burrows, Geoff Stoneman and Matthew Williams (Como).

8. **Associated Institutions:**

Murdoch University (Drs Jenny Davis and Stuart Bradley, co-supervisors of Karin Strehlow), Western Australian Museum, Australian National Insect Collection (CSIRO, Canberra), University of Western Australia (Dr Barbara Main).

9. **Study Design:**

The work will be carried out in Kingston, Warrup and Winnejup Forest Blocks, 25 km north-east of Manjimup. The study will examine two logging treatments: (i) gap creation leaving habitat trees; and (ii) gap creation leaving no habitat trees (clearfell). It is anticipated that logging operations will be carried out in summer/autumn of 1995 and 1996, and all areas will be subjected to the normal prescribed burning carried out for such operations. Aspects of study design are largely the responsibility of the Ph.D. student undertaking the work, but are closely aligned to that adopted for the small vertebrate component.

Within each compartment each treatment will be matched with an adjacent unlogged control. In early 1994 five paired treatment/control sites will be established, and these will be replicated in an adjacent compartment to be logged the same year (1995). This design may be further replicated in two compartments to be logged the following year (1996), but these sites will not be established until six months after the first set. Each paired treatment/control site will comprise two trapping grids: one within the coupe, and the other within the unlogged surrounding forest. Thus 5x2x2 = 20 grids grids will be established in year 1 (1994), and further grids may be established six months later. In addition, at least four grids will be established within undisturbed forest in compartments well away from those affected by logging. Sampling will alternate between the two sets of grids.

Each sampling site will comprise a 15 x 15m grid of 16 pitfall traps (cups 90mm diameter and 110mm deep) in a 4 x 4 array at 5m spacing. When operational, traps will be 3/4 filled with Galt's solution (preservative) and left open for 10 days, Traps will then be bulked by four to give four samples per sampling session. Fifty sweeps of the understorey vegetation (<2m) on each grid will be taken on each sampling occasion using a 60cm diameter hoop net. Samples will be taken six times during each year (every second month). Forest structure and habitat parameters which may be of relevance to terrestrial invertebrates will be quantified on each site before and after logging/burning in integrated studies being carried out by Neil Burrows and Geoff

Stoneman. Vegetation floristics and microhabitat parameters (eg. abundance and distribution of woody debris, temperature and humidity regimes) will also be assessed in these related studies.

Invertebrate samples will be sorted and collated initially at the Order level, and subsequently spiders (particularly Mygalomorphs), beetles, cockroaches and flies will be identified to family or species level.

Analyses will involve examining initial similarity between grids using clustering and ordination techniques. Pre and post-treatment similarity in faunal abundance and composition between areas will be assessed and provide the basis for measuring impact. Pairwise t-tests and regression techniques will be used to compare species richness and abundance between treatments and relate these data to habitat attributes, with time periods providing additional replication.

10. Costs:

Per annum costs detailed below include only essential equipment purchases and plant costs.

	1994/95	1995/96	1996/97	1997/98
Materials	1 300	1 000	1 050	1 100
Plant	2 800	2 500	2 600	2 700
TOTAL	**4 100**	**3 500**	**3 650**	**3 800**

Salaries

No CALM salaries

SCIENCE PROJECT PLAN # 93/95 - SUMMARY

1. Project Title:

Characteristics of hollow-bearing jarrah (*Eucalyptus marginata*) and marri (*Eucalyptus calophylla*) trees and coarse woody debris (CWD), their use by selected species of fauna, and the effect of logging-and-burning jarrah forest on them.

2. Project leader: Geoff Stoneman and Kim Whitford

3. Aim:

A. To develop allometric relationships between tree and stand parameters, and the size and abundance of hollows in jarrah and marri trees and CWD.

B. To develop relationships between tree and stand parameters, the size and abundance of hollows in jarrah and marri trees and CWD, and the use of these trees by selected species of fauna.

C. To determine the effects of the logging-and-burning treatments on the abundance of hollow-bearing trees and CWD, and to relate this to the abundance of selected species of fauna.

Hypotheses to be tested are:

A.
Hollow size and frequency (per tree) is independent of tree size, tree age, and tree dominance status.

Hollow size and frequency (per tree) is independent of crown size, crown growth stage and crown condition.

Hollow size and frequency (per tree) is independent of fire evidence/damage and management history.

The size and frequency of hollows in CWD is independent of the amount of log material and logging history.

The size and frequency of hollows in CWD is independent of log type, dimensions, state of decay and evidence of fire.

B.
The use of trees by selected fauna species is independent of tree size, tree age, and tree dominance status.

The use of trees by selected fauna species is independent of crown size, crown growth stage and crown condition.

The use of trees by selected fauna species is independent of fire evidence/damage and management history.

The use of CWD by selected fauna species is independent of the amount of log material and logging history.

The use of CWD on the ground by selected fauna species is independent of log type, dimensions, state of decay and evidence of fire.

C.
The abundance of hollow-bearing trees and CWD is independent of the logging-and-burning treatments.

The abundance of selected species of fauna is independent of the changes in abundance of hollow-bearing trees and CWD caused by the logging-and-burning treatments.

4. Background/Justification

There has been concern for several decades now on the possible adverse effects of clearing for agriculture, logging and fire on fauna which nest and roost in hollows in trees (Hampton and Seebeck 1970, Cowley 1971, Sanderson 1975, Tyndale-Biscoe and Calaby 1975, McIlroy 1978). Subsequently, a considerable amount of research has been done on the use of tree hollows by selected fauna in eucalypt forest in the eastern states and wheatbelt areas of Western Australia (Calder 1979, Golding 1979, Saunders 1979, Ambrose 1982, Saunders et al. 1982, Calder et al. 1983, Lindenmayer 1992).

However, there is relatively little known about the development of hollows in trees, and the effects of silvicultural practices on the development and longevity of hollows in trees in Australian forests, and the effect this has on hollow dependent fauna. Mackowski (1984) studied the ontogeny of hollows in *Eucalyptus pilularis*. Trees smaller than 100 cm diameter provided negligible hollows and only trees greater than 120 diameter provided large hollows. From spotlighting studies he showed that the populations of gliders and possums were less in stands with less than 3 hollow trees per hectare. Lindenmayer and others have studied tree hollows in Victoria's montane ash forests and hypothesized about the effects of silvicultural treatments on present and projected populations of the endangered species, Leadbeater Possum, and some other arboreal fauna (Lindenmayer 1991, Lindenmayer 1992, Lindenmayer et al. 1990 abcd, Lindenmayer et al. 1991abcde).

In State Forest in Western Australia there have been two studies on tree hollows. The first investigated the habitat role that tree hollows provide and the effects of fire on tree hollows in jarrah/marri forest (Inions 1985, Inions et al. 1989). The second investigated the formation, frequency and longevity of hollows in jarrah trees and the effects of firewood harvesting on the population of hollows in the forest (Faunt 1992).

Inions (1985, et al. 1989) found that the Common Brushtail Possum and the Ringtail Possum used suitable hollows regardless of the tree species, tree condition, height or size of tree. Using very general tree growth data, he estimated that suitable hollows would form in jarrah at about 300 years of age, and in marri at about 200 years. The average age of trees inhabitated by possums was estimated to be as high as 500 years for jarrah and 400 years for marri. He found that possums used about 3 trees per hectare for refuge. Silvicultural prescriptions for retention of habitat trees have been based on this observation. A high intensity fire destroyed 38% of the trees previously used by possums. The fire killed the older and larger trees and reduced the average age of trees containing suitable hollows by about 100 years.

Faunt (1992) counted growth rings on trees with and without hollows and found the age to hollow formation in jarrah was only about 80 years, in contrast to Inion's estimate of 300 years. Hollow formation increased with tree size and age, and fire seemed to be an important precursor to hollow formation. Faunt only investigated hollows in 36 jarrah trees, whereas she indicates (Faunt pers comm 1993) that at least 120 trees would be required to get good estimates of hollow formation in relation to tree size and condition, logging history and fire history. Faunt's study concentrated much more on hollows in logs on the ground. Hollows in this material seemed to increase with the amount of this material on the forest floor, which in turn increased with the incidence of logging. The size and frequency of hollows in logs on the ground increased with log dimensions.

Part A of this RPP is essentially proposed to build on and extend the work done by Faunt (1992). Part B will further develop this work by relating tree, stand and hollow characteristics to use of the trees by selected species of fauna. This will allow estimates to be made of the number and characteristics of trees used by these animals. Part C will partially test the hypotheses developed in part B about the number and characteristics of hollow-bearing trees required by the fauna. These studies will probably show that abundance of hollow-bearing trees decreases following the logging-and-burning treatments, and that populations of the fauna also decrease following these treatments. However, this would not prove that the reduction in abundance of hollow-bearing trees was the causal factor as many other factors will also change due to the logging-and-burning treatments. To test the hypothesis that a critical number of suitable trees per hectare is required to maintain a particular population of animals, it would be necessary to reduce the abundance of these trees by some other artificial means, and determine the impact of this on fauna populations. For example, one-way gates near the base of the trees, which would allow the animals to get down the tree but not to return back up the tree, may be a suitable means. If this approach were to be taken another area would need to be monitored and the population of suitable trees reduced at the same time as the logging-and-burning treatments.

The project is innovative because it integrates data on trees with that on fauna which use them, and tests the effect that logging and burning has on this interaction. Previous research has only concentrated on one or other of these aspects.

This SPP is part of a larger project investigating the effects of logging and burning on the jarrah forest ecosystem. The integration in the overall project will allow the development of a process-based predictive model, and it is by this means that the results from this project will be applied to forest management in the three Forest Regions.

5. Keywords:

State Forest, Southern Forest Region, Manjimup District, Forest Resources Management Program

6. Target users: Forest managers, forest planners

7. Associated staff:

Other SPP's for the Kingston Block experiment are dealing with invertebrates (Gordon Friend), small vertebrates (Gordon Friend), medium vertebrates (Keith Morris), avifauna (Grant Wardell-Johnson) and understorey vegetation (Neil Burrows). Proposed retrospective studies on logging and burning effects on invertebrates (Gordon Friend), small vertebrates (Gordon Friend), avifauna (Grant Wardell-Johnson) and floristics (Grant Wardell-Johnson) are also relevant.

8. Associated institutions: Nil

9. Study design:

A. Relationships between tree and stand parameters and size and abundance of hollows.

This part of the project is a continuation of the work done by Faunt and will use the same methodology.

Plots:

Plots will be established and all trees > 30 cm dbhob will be assessed for species, dominance class, dbhob, bark depth and bole defects.

Hollows in standing trees:

One tree of each species will be randomly selected from each 10 cm diameter size class and assessed for hollows. Faunt has already assessed some 36 standing jarrah trees and it is anticipated that about 120 trees of each species will be required to develop reasonable relationships. These trees will be photographed and described in terms of crown dominance, crown density, crown size, crown senescence, bole epicormics, fire scarring, and evidence of rot and fire on the stump. The height to all primary branches on the bole will be measured, and diameter and internal rot and termite damage at 1.3 m from where the branch leaves the bole will be recorded. Type, position, orientation and aspect of hollow, cavity dimensions, extent of mudguts, evidence of fire, termites, borers and habitation will be assessed. The tree will be aged by couting growth rings in a section cut from the stump.

Coarse woody debris (CWD):

All coarse woody debris will be assessed for dimension, hollows, shelter, condition and suitability for wood products.

Hollows in CWD:

These will be assessed the same as hollows in standing trees. Faunt has already done a lot of work on hollows in jarrah CWD and it is anticipated that future research will concentrate on marri.

B. Relationships between tree, stand and hollow parameters and the use of these trees by selected species of fauna.

This study will be based in Kingston Block, Manjimup District and will be part of a large inter-disciplinary study. Keith Morris will be using spotlighting and radio-transmitters to identify trees and CWD used by Chudich, Woylie, Quenda, Brush-tailed Possum and to a lesser extent Numbat and Ring-tailed Possum. Gordon Friend will be identifying trees and CWD used by Phascogale, Mardo and lizards, and RPP's by Grant Wardell-Johnson will identify trees used by birds. These trees and CWD will be assessed for bole and crown characteristics as in part A above. Following treemarking of the area and just prior to logging of the area, the trees which will not be retained in the logging will be fallen and assessed for hollow characteristics as in part A above. CWD used by the fauna will be assessed as in part A above. Additional characteristics of the understorey near each tree and CWD will be recorded as this has been found to affect use of trees by some species (Lindenmayer et al., 1991b). Sample size for this work is yet to be determined. Analysis of data from part A above and that of Lindenmayer and co-workers will help to estimate variability, and thus sample size.

C. To determine the effects of the logging-and-burning treatments on the abundance of hollow-bearing trees and CWD, and to relate this to the abundance of selected species of fauna.

This study will also be based in Kingston Block, Manjimup District and will be part of a large inter-disciplinary study. Keith Morris will be using spotlighting and radio-transmitters to identify trees and CWD used by Chudich, Woylie, Quenda, Brush-tailed Possum and to a lesser extent Numbat and Ring-tailed Possum. The relationships between the abundance of hollow-bearing trees and CWD, and the abundance of selected species of fauna, determined in part B above will be tested to see if these relationships are good predictors of the abundance of fauna following the logging-and-burning treatments.

10. Costs

	1993/94	1994/95	1995/96	1996/97	1997/98
Materials:	2 000	1 050	550	575	600
Plant	3 290	6 909	2 270	614	614
Travel	5 592	3 914	2 055	1 079	1 133
Total	10 882	11 873	4 875	2 268	2 347

Salaries

CALM salaries/annum 0.2 F.T.T Level 6 research scientist ($9 236), 0.8 F.T.E Level 4 technical officer ($27 600).

TOTAL CALM SALARIES/ANNUM **$36 836**

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SCIENCE PROJECT PLAN # (93/155) : SUMMARY

1. **Title of Project:** The effects of timber harvesting on birds of the jarrah forest.

2. **Project Leader:** Mike Craig and Gordon Friend

3. **Aim:** To quantify the effect of logging and fire in medium rainfall jarrah forest on the composition of the avifauna. To determine the influence of old-growth marri and jarrah trees (habitat trees and edge effects) on the composition of the avifauna following logging and burning. To determine critical habitat components of marri and jarrah trees. To determine the most appropriate pattern of retained trees.

   To develop general models of the relationships between bird species composition and logging and fire history and formulate general principles for the management of fire and logging in jarrah forest ecosystems.

4. **Background/Justification:** The impact of timber harvesting on Australia's avifauna is the subject of much controversy, yet there have been relatively few detailed studies which address this issue. There is an urgent need for experimental studies (in combination with retrospective-space for time-studies) which examine the immediate and short-term impacts of integrated burning and logging operations on birds in jarrah forest, focusing on key species likely to be sensitive to disturbance. Relevant bird species include hollow nesting (eg. Rufous Treecreeper) and other mature forest dependent species.

   The retention of habitat trees forms a part of standard logging operations in jarrah forest, yet there are few data allowing a basis for species selection, the spatial configuration of retained trees, or the age or size class of retained trees in respect to their influence on community or species composition. Similarly edge effects on bird communities are critical considerations in the planning of logging operations.

   There have been several brief studies on the effects of logging on birds of the jarrah forest (eg. Serventy pers. comm, Abbott and Van Heurck 1985, Norwood *et al.* in press). but none have been sufficiently detailed to provide guidelines on suitable spatial/temporal configuration of retained habitat trees or to determine the influence of edge effect. Critics of CALM have focussed on these as key issues in jarrah forest management. Managers require direction concerning coupe design and the retention of trees in logging operations.

   The present study is designed to investigate the direct and short-term effects of different intensities of logging/burning operations on the birds of the medium rainfall jarrah forest. It is anticipated that a similar study will be commenced in high rainfall jarrah forest as the present work nears completion.

   The work will be carried out alongside a broader-scale (retrospective) study which is examining relationships between species/community composition of the avifauna and logging and fire history in medium to high rainfall jarrah forest throughout the south-west. This combined approach will provide data on both the short and long-term impacts of logging and burning, and ensure a broader geographic applicability of the results from the experimental work. The study will also compliment existing work on birds and fire/logging impacts in the karri forest (eg. RPP 22/82 and studies by Ph.D student Penelope Atkinson).

5. **Keywords:** Habitat trees, marri, jarrah, disturbance ecology, birds, edge effects, fire, logging Vegetation structure.

6. **Target users:** Operations (Design), Research (Disturbance Ecology), Public (Perceptions and Information). Managers of State Forests in the Swan, Central Forest and Southern Forest Regions. The study will also provide data regarding disturbance ecology of relevance to other researchers and the general public. Much of the data will also be relevant to the dry sclerophyll forest ecosystems of south-eastern Australia.

7. **Associated staff:** Mike Craig (PhD project), Gordon Friend, Keith Morris, Neil Burrows, Geoff Stoneman, Mathew Williams, Chris Vellios.

8. **Associated Institutions:** UWA (Dr J.D. Roberts, supervisor of Mike Craig).

9. **Study Design:** The work will be carried out in Kingston and Warrup Forest Blocks, 25 km north-east of Manjimup. Four treatments will be imposed: (i) burning only (control); (ii) shelterwood logging; (iii) gap creation leaving habitat trees; and (iv) gap creation leaving no habitat trees (clearfell). Shelterwood treatments would probably occupy 20% of the logging area and be in patches of 5-50 ha. The gap treatment would be limited to 10 ha for any one gap, but in this sort of forest up to 80% of the conventional logging area may be suitable for gap treatment.

   The control area would be in an area of about 400 ha and the other three treatments would all be located within a conventional logging area which in total covered an area of about 400 ha.

   There will be five replicate bird census areas in each of the four treatments each with three census grids (exterior, edge ie straddling treatment, and interior: hence 60 census sites). An area search method as adopted in the RAOU Australian bird count (ABC) will be used to census birds. The alternative point count and transect count methods are not being used because of lower bird densities in jarrah forest compared with structurally similar forests in eastern Australia and because for this study, the area count method allows comparisons with sampling procedures for other components of the biota, site measures at the same sites and the methods proposed for the retrospective study. Each quadrat will be censused for 20 minutes at least three times in each season (ie 180 counts per season). In view of the proximity of the census locations, approximately 10 censuses can be carried out each day (ie 27 days census per season). Recording sheets will be the same as used in the ABC but data will be analysed by project consultant in relation to site factors.

   Birds use of trees, habitat data on trees and site will be recorded to relate species/community composition to management regime. Analyses will involve examining initial similarity between grids using multivariate techniques. Pre and post-treatment similarity in bird composition between areas will be assessed and provide the basis for measuring impact.

   In addition it is hoped to conduct nocturnal censuses. There would be one census per replicate per season which amounts to 60 censuses per season. At a rate of three censuses per night these would take 20 nights to complete and censuses would be conducted in the 2 hours after sunset. Nocturnal censuses may also include playback of species calls though there are many biases associated with this method which would be investigated.

   Various site variables will be measured at each replicate so a picture of bird abundances relative to features of the forest can be determined in a pre-logging landscape. By determining natural variations in abundance these results can be used to assess the impact of the various logging treatments on the avifauna.

   Several species will be selected for detailed studies of their ecology. Aspects of their ecology to be investigated are nesting foraging and roosting ecology. Both censuses and the single species ecologies will run for the duration of the project (ie. one year pre-

logging and one year post-logging for consultancy/Ph.D and at least two years post Ph. D consultancy).

Single species ecologies will be determined by actively searching for species nests and recording the location of each nest found as well as its success. If required radio-tracking will be used as an aid to locating nests of diurnal species and will almost certainly be needed to locate nests of nocturnal species. Nests will be monitored on a weekly basis to determine fledging success and will be monitored more closely to determine the types of foods bought to the young.

Foraging ecology will be largely determined by observational studies. The site of a foraging bird will be recorded and if possible whether the manoeuvre was successful.

Roosting ecology will be determined through radio tracking . Again the type of roost and its location will be recorded as well as the number and sex of the birds using the roost.

The kinds of variables to be recorded for these investigations include:

i) Width of trunk/branch

ii) Angle of the trunk/branch to the ground

iii) Height of the tree

iv) Height of nest/roost/foraging observation from the ground

v) Species of tree

vi) If the substrate is dead or alive

vii) If on the ground the type of substrates (eg. litter, laterite, sand etc)

viii) Whether the animal is foraging on leaves

ix) Whether the tree is flowering or fruiting

x) Whether the animal is nesting/foraging/roosting in a group or singly and the sex ratio in any group.

Where possible the age and sex of the bird will be determined

Possible species to be included for detailed ecological study include:

i) Long-billed White-tailed black Cockatoo (*Calyptorhychus baudinii*)

ii) Red-capped Parrot (*Purpureicephalus spurius*)

iii) Western Rosella (*Platycercus icterotis*)

iv) Western Yellow Robin (*Eopsaltria griseogularis*)

v) Western Thornbill (*Acanthiza inornata*)

vi) Rufous Treecreeper (*Climacteris rufa*)

vii) Western Spinebill (*Acanthorhynchus superciliosus*)

This list is provisional and final selection will depend on the results from the first years census.

10. Costs:

	1993/94	1994/95	1995/96	1996/97	1997/98
Materials	2 700				
Plant	5 050	4 600	4 850	5 100	5 400
Travel					
TOTAL	**7750**	**4 600**	**4 850**	**5 100**	**5 400**

Salaries

This work is being carried out by a PhD student so does not involve CALM salaries.

SCIENCE PROJECT PLAN # (tba)

1. **Title of Project:** Retrospective study on the effects of timber harvesting on avifauna in lateritic and sandy terrain in three landform units in jarrah forest in the medium to high rainfall areas of the south-west

2. **Project Leader:** Grant Wardell-Johnson

3. **Aim:** To establish a series of permanently located monitoring quadrats for bird census in jarrah forest with a range of management history. To determine the relationship between bird species and community composition, and logging and fire history within sandy and lateritic terrain in three equivalent but geographically separated landform units (Bevan, Dwellingup and Kingia) in jarrah forest in the medium to high rainfall areas of the south-west. To determine the relationship between bird species and community composition, and vegetation structure.

4. **Background/Justification:** There is considerable debate as to the effects of logging and burning on the birds of the jarrah forest. There are few quadrats available in jarrah forest which can serve as long term monitoring sites for bird community and species composition in relation to logging and fire. A retrospective study being established to examine the relationship of vertebrate and vascular plant composition to logging and fire provides this opportunity. The ABC of Australian birds provides a method for comparison throughout Australia and the involvement of volunteers and volunteer co-ordination through the RAOU.

5. **Keywords:** Birds, jarrah forest, disturbance ecology (logging and burning), Vegetation structure.

6. **Target users:** Operations (how to design operations), Research (Community Conservation, Community Resources, Natural Products), Public (perceptions and information).

7. **Associated staff:** Volunteer co-ordinator (possible MSc Project), Chris Vellios

8. **Associated Institutions:** To be determined.

9. **Study Design:** Approximately 140 80m x 80m permanent quadrats will be established in groups of about 20 in eight areas(Dwellingup, Jarrahdale-year 2, Margaret River, Nannup-year 2, Yornup, Kirup-year 2, Lockhart, and Dixson-year 2) in sandy and lateritic soils in three equivalent landform units (plateau elements) with various logging and fire histories (including unlogged and long-unburnt sites) over a two year period. This will provide coverage over the major area of the jarrah forest from where timber is harvested. Sites will be relatively uniform in both logging history and topography and be within a larger area of similar history (minimum size treatment area of approx 10 ha). Each 80 m x 80 m quadrat will form the centre of a larger (up to about three hectares depending on the density of understorey vegetation) bird ABC count (see appendix 2 for detailed methods).

   An area search method as adopted in the RAOU Australian bird count (ABC) will be used to census birds. The alternative point count and transect count methods are not being used because of lower bird densities in jarrah forest compared with structurally similar forests in eastern Australia and because for this study, the area count method allows comparisons with sampling procedures for other components of the biota and site measures at the same sites.

   Each quadrat will be censused for 20 minutes at least three times in each season (depending on the number of censusers and the necessity for calibration). Co-ordinator will census birds at least once at all sites each season. Recording sheets will be the same as used in the ABC but data will be analysed by project consultant in relation to site and management history.

   A predictive model of bird community composition in relation to management history and site characteristics will be developed. The study will involve two years of quadrat establishment/recording and one year of analysis and writup.

10. **Costs:**

	1995/96	1996/97	1997/98
Plant	7 650	8 050	8 500
Materials	500	550	550
TOTAL	8 170	8 600	9 050

Salaries

CALM salaries/annum 0.2 F.T.E Level 7 research scientist, ($10 400) 1.0 F.T.E Level 4 technical officer ($34 500).

TOTAL CALM SALARIES/ANNUM **$ 44 900**

SCIENCE PROJECT PLAN # (tba)

1. **Title of Project:** Retrospective study on the effects of timber harvesting on terrestrial vertebrate fauna in lateritic and sandy terrain in three landform units in jarrah forest in the medium to high rainfall areas of the south west.

2. **Project Leader:** Gordon Friend

3. **Aim:** To determine relationship between species/community composition of terrestrial vertebrate fauna and logging and fire history within sandy and lateritic terrain in three equivalent but geographically separated landform units (Bevan, Dwellingup and Kingia) in jarrah forest in the medium to high rainfall areas of the south west. To determine relationship between species/community composition and stand structure.

4. **Background/Justification:** There is considerable debate regarding the effects of logging and burning on terrestrial vertebrate fauna of the jarrah forest. Data are sketchy on the subject. A detailed experiment is being set up to examine impacts within an area of medium rainfall in jarrah forest near Manjimup during 1993 with a similar study in the high rainfall area later (see proposed RPP by Gordon Friend).

   This study is being carried out simultaneously to ensure a broader geographic applicability of the results from those experiments. The study is being limited to two soil types in three landform units (Dwellingup, Bevan and Kingia) in the medium to high rainfall zone of the jarrah forest.

5. **Keywords:** Terrestrial vertebrates, vascular plants, disturbance (logging/burning), Vegetation structure.

6. **Target users:** Operations (how to design operations), Research (Community Resources, Community Conservation, Natural Products), Public (perception and information).

7. **Associated staff:** PhD and consultancy project on vertebrates, Geoff Stoneman, Brent Johnson, Chris Vellios, Ian Wheeler, Tony Annels, District staff and volunteers.

8. **Associated Institutions:** University of W.A. (Dr J.D. Roberts supervisor to Ph. D project).

9. **Study Design:** Approximately 140 80m x 80m permanent quadrats will be established in groups of about 20 in eight areas (Dwellingup-year 2, Jarrahdale-year 3, Margaret River-year 2, Nannup-year 3, Yornup-year 2, Kirup-year 3, Lockhart-year 2, and Dixon-year 3) in sandy and lateritic soils in three equivalent landform units (plateau elements) with various logging and fire histories (including unlogged and long unburnt sites) over a two year period. This will provide coverage over the major area of the jarrah forest from where timber is harvested and place the experimental studies in context. Sites will be relatively uniform in both logging history and topography and be within a larger area of similar history (minimum size treatment of approx 10 ha). A minimum of two quadrats within each history/site characteristic will be established. Eighty quadrats will be established in year one and sixty in year two. Twenty quadrats will be run for two years to provide controls between time periods. About ten quadrats will be run during each week session by two people.

   In each quadrat, ten pitfall traps each with seven metre drift fence, ten elliot traps and five wire cage traps will be run for three nights in each of four seasons over one year. Quadrat and trap layout design is attached as appendix one. Searching for one person hour and spotlighting in the surrounds of each plot will also be carried out seasonally during trapping periods. A record of total catchings/detections will be kept. Specimens

will be lodged of all small vertebrates at the WA Museum. Overall design and detailed trapping design will ensure compliance with existing and planned experimental studies (Batalling, Kingston) while allowing for broad relevance in the jarrah forest.

Site factors such as slope, aspect, detailed logging and fire history, diameter at breast height of all trees > 10 cm dbhob and detailed measures of course woody debris will be recorded. Species composition and abundance will be related to disturbance history and site factors such as the abundance of course woody debris enabling the experiment at Kingston to be placed in context. A predictive model of vertebrate presence in relation to site characteristics will be developed.

The study will involve one year of site selection (funding applied for in vascular plant application), two years of quadrat establishment/recording and one year of analysis and writeup.

Grant Wardell-Johnson will be responsible for vertebrate sampling at Margaret River and Nannup, Gordon Friend at Dwellingup and Jarrahdale and Mike Craig at Yornup, Dixon, Kirup and Lockhart. Mike Craig will be responsible for recording site factors at all sites.

Five stand structure/age classes will be nominally included as treatments although it is recognized that there have been considerable variation in logging treatment from decade to decade and from site to site.

10. **Costs:**

	1995/96	1996/96	1997/98	1998/99
Travel	4 160	4 150	4 900	5 200
Plant	3 140	3 200	3 350	3 550
Materials	13 240	6 100	2 000	2 100
Overtime	3 200	3 400	3 600	3 800
TOTAL	**23 740**	**16 850**	**13 850**	**14 650**

Salaries

CALM salaries/annum 0.2 F.T.E Level 6 research scientist ($8 930), 0.2 F.T.E Level 7 research scientist ($10 700), 1.0 F.T.E Level 4 technical officer ($34 500).

TOTAL CALM SALARIES/ANNUM **$54 130**

SCIENCE PROJECT PLAN # (tba)

1. **Title of Project:** Retrospective study on the effects of timber harvesting on vascular flora in lateritic and sandy terrain in three landform units in jarrah forest in the medium to high rainfall areas of the south west.

2. **Project Leader:** Grant Wardell-Johnson

3. **Aim:** To determine relationships between species/community composition of vascular plantsand logging and burning history in lateritic and sandy terrain in three landform units (Bevan, Dwellingup and Kingia) in jarrah forest in the medium to high rainfall areas of the south-west. To determine relationship between vegetation structure and floristics in these sites.

4. **Background/Justification:** There is considerable debate regarding the effects of logging and burning on vascular plants of the jarrah forest. Data are sketchy on the subject. A detailed experiment is being established to examine impacts within an area of medium rainfall in jarrah forest near Manjimup during 1993 with a similar study in the high rainfall area later (see proposed SPP submitted by Neil Burrows).

   A retrospective study is also being set up to examine impacts on vertebrate communities over a broad geographic range. The study is being limited to two soil types in three landform units (Dwellingup, Bevan and Kingia) in the medium to high rainfall zone of the jarrah forest. This study is being carried out simultaneously to ensure a broader geographic applicability of the results from those experiments. This will also limit the range of vegetation types being examined.

5. **Keywords:** Vascular plants, disturbance (logging and burning), Vegetation structure.

6. **Target users:** Operations (how to design operations), Research (Community Conservation, Community Resources, Natural Products), Public (perceptions and information).

7. **Associated staff:** Neil Burrows, Tony Annels, Chris Vellios, Ian Wheeler

8. **Associated Institutions:** None with this projectUniversity of W.A.

9. **Study Design:** Approximately 140 80 m x 80 m permanent quadrats will be established in groups of about 20 in eight areas (Dwellingup-year 2, Jarrahdale-year 3, Margaret River-year 2, Nannup-year 3, Yornup-year 2, Kirup-year 3, Lockhart-year 2, and Dixon-year 3) in sandy and lateritic soils in three equivalent landform units (plateau elements) with various logging and fire histories (including unlogged and long unburnt sites) over a two year period. This will provide coverage over the major area of the jarrah forest from where timber is harvested and place the experimental studies in context. Sites will be relatively uniform in both logging history and topography and be within a larger area of similar history (minimum size treatment of approx 10 ha). A minimum of two quadrats in each history/site combination will be established. Eighty quadrats will be established in year one and sixty in year two. These quadrats are being established for a survey of terrestrial vertebrates.

   Within each 80 m x 80 m quadrat, four 20 m x 20 m subplots will be established for measures of course woody debris and the size class distribution of overstorey plants. All vascular plants will also be recorded at these sites on a minimum of two visits on a 1-10 cover scale (as per biogeographical studies and Kingston experiment). Soil samples will also be obtained from a minimum of two quadrats within each history/site combination. A 10 m x 10 m subplot will be established in each 20 m x 20 m plot (see appendix 1 for

design) to determine if species area curves vary with logging history. Thus 560 20 m x 20 m plots and associated subplots will be assessed over a two year period.

A predictive model of vascular plant abundance and plant community patterns in relation to logging/fire history will be developed.

The study will involve one year of site selection and site history data collection two years of quadrat establishment and assessment, and one year of analysis and writeup.

10. **Costs:**

	1995/96	1996/97	1997/98	1998/99
Travel	1 100	1 100	1 200	1 200
Plant	1 800	1 900	2 000	2 000
Materials	4 800	4 900	5 300	5 500
Overtime	2 300	2 400	2 500	2 700
TOTAL	**10 000**	**10 300**	**11 000**	**11 400**

Salaries

CALM salaries/annum 0.2 F.T.E Level 7 research scientist ($10 700), 0.6 F.T.E Level 4 technical officer ($21 300). Total CALM salaries/annum $32 000.

TOTAL CALM SALARIES/ANNUM	**$32 000**

SCIENCE PROJECT PLAN # (tba)

1. **Title of Project:** Retrospective study of the effects of timber harvesting on terrestrial invertebrates in jarrah forest in the medium to high rainfall areas of the south-west.

2. **Project Leader:** Gordon Friend

3. **Aim:**

(a) To determine relationships between species/community composition of the terrestrial invertebrate fauna and logging and fire history within lateritic terrain in the Dwellingup and Bevan landform units in jarrah forest in the medium to high rainfall areas of the south-west.

(b) Use these data to develop general models of the relationships between invertebrate species/community composition and logging and fire history and formulate general principles for the management of fire and logging in jarrah forest ecosystems.

4. **Background/Justification:**

The impact of burning and logging on Australia's native terrestrial fauna is the subject of much controversy, but there have been relatively few studies which address this issue. This is particularly so with respect to invertebrates. There is an urgent need for studies which examine long-term trends in invertebrate community composition, focusing particularly on keystone groups or species and those likely to be sensitive to disturbance. Earlier work carried out in forests and shrublands has pinpointed spiders (particularly Mygalomorphs), certain beetles (eg *Catasarcus* weevils), cockroaches and flies as potentially sensitive to forest management practices and excellent bio-indicators of environmental conditions.

A detailed experiment is being set up to examine the impacts of logging on vertebrate and invertebrate fauna in one area near Manjimup. The present study is being carried out simultaneously to ensure a broader geographic applicability of the results from that experiment. The study is based on space-for-time substitution (retrospective approach) and is limited to one soil type and landform unit in the medium to high rainfall zone of the jarrah forest.

5. **Keywords:** Terrestrial invertebrates, disturbance, logging, fire, spiders, beetles, flies, jarrah.

6. **Target Users:**

Managers of state forests in the Swan, Central Forest and Southern Forest regions. The study will also provide data regarding biogeographic patterns and disturbance ecology of relevance to other researchers and the general public. Much of the data will also be relevant to the dry sclerophyll forest ecosystems of south-eastern Australia.

7. **Associated Staff:**

Invertebrate ecologist (to be appointed), Grant Wardell-Johnson and Brent Johnson (Woodvale), Matthew Williams (Como).

8. **Associated Institutions:**

Western Australian Museum, Australian National Insect Collection (CSIRO), University of Western Australia (Dr Barbara Main)

9. **Study Design:**

The field work will run over four years (spring 1994 - spring 1998) and include a total of eight areas, as in the integrated retrospective studies on small vertebrates and floristics (see other RPPs). Two areas will be sampled in each year: Dwellingup and Margaret River in1994/95, Jarrahdale and Nannup in 1995/96, Kirup and Lockhart in 1996/97, and Yornup and Dixon in 1997/98 (see map attached). Site selection will be undertaken during 1993/94 as part of the other retrospective studies on small vertebrates and floristics (see other RPP with G. Wardell-Johnson). Data analysis and writing up will take place in 1998/99.

In each area four sites of differing ages since logging will be selected and replicated, giving a total of 8 sampling sites. Ages represented will include 0-2 years, 5-10 years, 25-50 years and 60+ years/virgin (unlogged) forest. These sites will be sampled four times per year (ie. seasonally) using pitfall trap grids. Each 15 x 15m grid comprises 16 traps (cups 90mm diameter and 110mm deep) in a 4 x 4 array at 5m spacing. When operational, traps will be 3/4 filled with Galt's solution (preservative) and left open for 10 days. Traps will then be bulked by four to give four samples per trap session. Fifty sweeps of the understorey vegetation (<2m) on each grid will be taken on each sampling occasion using a 60cm diameter hoop net. Vegetation floristics and microhabitat parameters (eg. leaf litter cover and distribution, understorey vegetation cover, abundance and distribution of woody debris, temperature and humidity regimes) will also be assessed on the grids.

Invertebrate samples will be sorted and collated initially at the Order level, and subsequently spiders (particularly Mygalomorphs), beetles, cockroaches and flies will be identified to family or species level. These invertebrate groups have proven to be useful indicators of disturbance in previous studies.

Analyses will involve examining initial similarity between grids using clustering and ordination techniques. Similarity in faunal abundance and composition between areas of differing logging history will be assessed and provide the basis for developing relationships between time since disturbance and invertebrate species/community composition.

10. Costs:

	1995/96	1996/97	1997/98	1998/99
Travel	1 600	1 680	1 760	
Plant	2 000	2 100	2 200	
Materials	1 000	1 050	1 100	
Overtime	100	100	100	
TOTAL	**4 700**	**4 930**	**5 160**	

Salaries

CALM salaries/annum 1.0 F.T.E Level 6 research scientist ($44 600), 0.2 F.T.E Level 4 technical officer ($6 900). Total CALM salaries $51 500.

TOTAL CALM SALARIES/ANNUM **$51 500**