A WORKSHOP ON ENVIRONMENTAL EFFECTS OF TIMBER HARVESTING IN THE JARRAH FOREST
Perup Forest Ecology Centre
7&8 May 2001

A synthesis of recent research by the Science Division, Department of Conservation & Land Management

1. Objectives of the workshop

a) To provide forest managers and policy-makers with a comprehensive overview of research findings relevant to the environmental effects of timber harvesting in the Jarrah forest;
b) To identify mechanisms by which current research findings can be incorporated in the revision of silvicultural guidelines and the next Forest Management Plan (FMP).

2. Format for sessions

Presenters were asked to:
- Briefly overview the methodology used in their study, sufficient to make results interpretable.
- Summarise the key findings, giving priority to those that have implications for management and that can be manipulated by future silvicultural practices.
- Make recommendations for changes to management practices that could be considered in the context of the next Forest Management Plan.

3. Summary of presentations

Attached are brief summaries of most presentations made at the workshop, together with a statement from the authors regarding the key management implications of their findings:

- *Short term impacts of logging on understorey vegetation in the Jarrah forest* (Neil Burrows, Bruce Ward & Ray Cranfield).
- *Evaluation of key soil indicators of sustainability in Australian Mediterranean forests* (Kim Whitford)
- *Using electromagnetic induction to estimate soil salt storage* (Joe Kinal)
- *Hydrological response to logging in the intermediate rainfall zone of the jarrah forest* (Joe Kinal)
- *Logging and burning impacts on cockroaches, crickets and grasshoppers, and spiders in Jarrah forest* (Ian Abbott and colleagues)
- *Short-term Impacts of Logging on Birds in a Jarrah Forest at Kingston* (Graeme Liddelow)
- *Tree hollows in Jarrah and Marri* (Kim Whitford)
- *Response of terrestrial vertebrates to timber harvesting at Kingston* (Adrian Wayne and colleagues)
- *Brushtail Possum (Koomal) responses to timber harvesting at Kingston* (Adrian Wayne and colleagues)

- *Western Ringtail Possum (Ngwayir) responses to timber harvesting at Kingston* (Adrian Wayne and colleagues)

Summaries of presentations made by Keith Morris on management of the Chuditch, and by Paul de Tores on fox baiting and on the ecology and conservation status of the Western Ringtail Possum are currently being prepared.

4. Issues identified and discussed

4.1 Issues were divided into three categories according to whether they were relevant to:
- meeting compliance requirements for the current FMP,
- providing direction to or constraints on the new FMP,
- modification of silvicultural guidelines and codes of practice.

4.2 Issues relating to compliance requirements for the current FMP

All of the information presented from the Kingston study and associated projects is relevant to demonstrating compliance with conditions placed on the current plan, notably:
- Ministerial Condition 3 - Precautionary approach and,
- Ministerial Condition 11 - Jarrah silvicultural trial.

Specific projects have also provided information relevant to:
- Ministerial Conditions 12 and 16 – Phased logging and high salt risk catchments,
- Ministerial Condition 13 – Habitat trees

4.3 Issues relating to preparation of the next FMP

An appropriate and achievable scale for managing and monitoring achievement of ESFM needs to be determined. Suitable scales could include the forest block, catchment (3rd or 4th order), or some other landscape unit.

Conservation objectives for species, guilds and communities of plants and animals that are specific enough to be measured at intervals over time need to be developed. This would provide guidance to forest managers about the success in achieving ESFM. Focus groups comprised of scientists and managers may be used to develop initial objectives. Science Division staff with specific expertise on particular aspects of ESFM should liaise with staff from SFM Division and with the team responsible for preparation of the draft plan. This needs to happen over the next 2-3 months.

Management of TEAS in the second cutting cycle under the current silvicultural prescription needs to be reviewed, in particular:
- length of time between initial gap creation and TEAS removal,
- silviculture for the second cut.

There may be merit in conducting some experimental studies at Kingston where TEAS are removed at a ten-year interval following the initial harvest, in order to determine the sensitivity of different plant and animal guilds to this disturbance. To allow ongoing silvicultural experimentation, the design of the proposed Greater Kingston National Park should aim to exclude the central group of experimental grids. Aspects of provisional reserve design have been discussed with Geoff Stoneman.

Shelterwood harvesting in the intermediate and low rainfall zone during the next planning period will be a significant influence on ecological outcomes. Important issues include:
- the extent of shelterwood silviculture that will be required because of the forest types scheduled for harvesting,
- distribution of unharvested forest retained within shelterwood areas,

- related issues of the scale and intensity of post-harvest burning, and the potential impacts on other forest values.

Adaptive management and monitoring will become even more important, including the need to monitor during the period of the next plan so that new practices can be developed as required.

Linkages between research findings and inventory databases need to be strengthened so that issues can be examined in a "whole-of-forest" context. For example, availability of hollows in standing trees can now be modelled and displayed for the public forest estate, based on Kim Whitford's algorithms and the Jarrah inventory database.

There is a need for an explicit statement about the importance of minimising undesirable forms of soil disturbance that may lead to loss of soil structure, accelerated erosion, or loss of ecological integrity of soil flora and fauna.

4.4 Modification of silvicultural guidelines and codes of practice

Ecological principles and results from research studies highlight the need to minimise the extent of disturbance in areas of the forest landscape that are excluded from harvesting (eg. TEAS, stream buffers, Diverse Ecotype Zones). Prescriptions should be specific about this requirement, and there should be provision for monitoring and enforcement during field operations.

Guidelines for management of soil disturbance during harvesting operations should be revised and expanded to include measures to minimise long-term loss of plant species richness and abundance. Factors including silvicultural treatment, season of harvesting and type of equipment used need to be taken into account.

Regeneration stocking standards need to be reviewed to determine whether a single stocking standard should be applied to all Jarrah sites, regardless of site productivity and rainfall zone. In stands with a high component of Marri, retention of a substantial number of mature standing trees may make it difficult to meet the current regeneration standard. Some future wood growth potential may need to be foregone if there are good ecological reasons for retaining a high number of mature trees.

In the light of the above three points, there is a sound case for establishing studies to compare the adequacy of regeneration and stand development under different levels of JSI treatment, including a 'no-treatment' option. Because of scaling issues, these studies will need to be conducted on an operational scale, with good liaison between Science Division and FPC staff.

Guidelines for management of habitat components in Jarrah silvicultural operations are currently being reviewed, with changes likely to:

- the definition and number of habitat trees and potential habitat trees retained,
- recommend retention of mature Balga grasstrees,
- recommend increased frequency of fox baiting in harvest areas adjacent to private property.

Marking potential habitat trees may be a useful measure in improving public perceptions of silviculture.
The process for revision and approval of changes to silvicultural guidelines needs to be made explicit and be endorsed by the Department's Corporate Executive, the Conservation Commission and Forest Products Commission.

5. Providing information to the public and broader scientific community about the Department's ecologically sustainable forest management research program

During the initial planning for the workshop it was envisaged that the presentations prepared by Science Division staff could provide the framework for subsequent seminars intended to provide information to the scientific community and general public. The change of State government in February and resulting acceleration in preparations for the next Forest Management Plan have made this initial proposal inappropriate. However, there will be an excellent opportunity to present an overview of ESFM research in conjunction with the public consultation phase for the Forest Management Plan. This will require development of a package of succinct and complementary presentations on a range of ecological issues affecting forests. Expertise in design and presentation should be used to assist in the development of presentations, ideally targeted appropriately for different interest groups (eg. general community, scientific community, policy makers, media).

Lachlan McCaw
Project Leader, ESFM
Science Division
Department of Conservation & Land Management
Manjimup

10 July 2001

Short-term impacts of logging on understorey vegetation in a jarrah forest

N.D. Burrows, B. Ward and R. Cranfield
Science Division, Kensington and Manjimup

Summary

In 1985, modified silvicultural treatments were implemented in jarrah (*Eucalyptus marginata*) forests available for wood production. As part of a scientific investigation into the ecological impacts of two of these treatments, gap cutting and shelterwood cutting, a retrospective survey was conducted four years after logging to examine the effects of these treatments on understorey vegetation species richness and abundance. Sampling scale was found to be an important factor affecting the results and subsequent interpretation of impacts. At the coupe scale, native plant species richness in unlogged coupe buffers was similar to that in logged patches. However, analysed at a scale of 1 m^2, species richness in the buffers was 20-30% higher than in the logged patches. At all sampling resolutions, the abundance (number of plants) of native plants was 20-35% higher in the buffers, but the abundance of introduced (weed) species was significantly higher in the logged patches. Given the low fecundity and low dispersal capacity of many native species, it is our view that many woody shrubs and perennial herbs are unlikely to return to pre-logging abundance levels in the medium term. We attribute the reduction in the abundance of native plants to mechanical soil disturbance, which ranged from 60-80% of the area on logged coupes, and to physical/mechanical damage to the vegetation associated with the logging and post-logging activities.

Management Implications

We recommend modifying logging practices in jarrah forests to minimise soil disturbance, therefore impact on the understorey. This could be achieved by:

a) Reviewing the practice of mechanically disturbing the soil to create a receptive seedbed for commercial tree species.
b) Reviewing the practice of removing understorey competition by mechanically downing/removing non-commercial tree, lower tree and shrub species.
c) Investigating new systems for accessing, felling and extracting timber that minimises machine traffic on the coupes.
d) Investigating options for utilising machinery with lower ground bearing pressures.
e) Investigating the importance of soil moisture as a factor affecting the extent of soil damage during logging operations.
f) On-going monitoring (perhaps five-yearly) to check that the recommended modifications to logging practices are achieving the desired outcome.

Evaluation of key soil indicators of sustainability in Australian mediterranean forests (Indicators 4.1d, 4.1e)

Kim Whitford
Science Division, Dwellingup

A joint Department of Conservation & land Management, Forest and Wood Products Research and Development Corporation project

This projects examines the application of Montreal Process Indicators 4.1d and 4.1e to the forest of south west WA with the aim of developing practical, cost-effective and sensitive indicators.

Part 1. The effect of fire on soil organic matter and bulk density in jarrah and karri forests.

We used retrospective studies to examine the impact of fire frequency on soil carbon, nitrogen and bulk density at three sites in the jarrah and karri forests. Fire frequencies studied included 36 and 26 years unburnt and a regular 8 year cycle at the high rainfall Strickland site (karri), 23 years unburnt and regular 4 and 5 year cycles at the intermediate rainfall McCorkhill site (jarrah), and 18 years unburnt and 5 and 7 year cycles at the low rainfall Yackelup site (jarrah).

The greatest response of soil carbon and nitrogen to the effects of fire frequency occurred in the surface soil layer (0-75mm), and the response of soil nitrogen generally followed that of soil carbon. Across all sites, and within individual sites, there was a general increase in the percentage carbon content of the surface soil with decreasing fire frequency. Clay content was not useful as a covariate to explain natural soil variation. The strongest relationship observed in this study was a negative relationship between fine earth bulk density and surface soil carbon content, ($r = -0.80$). There was also a decrease in fine earth bulk density as the period between fires increased. The correlation between soil carbon and bulk density indicates that the changes with fire frequency are likely expressions of changes to soil biological processes that incorporate organic matter into the soil and lower the bulk density of the fine earth fraction.

Part 2. The impact of logging on soil physical properties at three sites in the northern jarrah forest.

We examined a variety of displacement and coring techniques for measuring bulk density in gravelly soils and found the smallest corer provided efficient and accurate estimates of bulk density in these soils.

Large differences in estimates of snig track area occurred between three different methods of estimating snig track area. GPS provided the most efficient and accurate estimate. Snig tracks are the major disturbance on jarrah logging coupes and planning and managing the layout of snig tracks could significantly reduce the area of disturbance within the coupe.

Soil disturbance and the draft Montreal Indicator.

Within the jarrah forest approximately 30% of the total area of logging coupes show visual signs of soil disturbance, however relatively small areas of these logging coupes (~10%) exceeded the 20% increase in bulk density proposed by Rab (1999) as a threshold for Montreal Indicator 4.1e. Fine earth bulk density provides a more meaningful basis for interpreting the indicator than total bulk density. Bulk density measurements are time consuming and costly to collect and soil strength and visual classification provide simpler and more efficient means of identifying disturbed soil.

Management Implications

- Soil carbon is difficult to measure because of the high charcoal content of Australian forest soils and therefore Indicator 4.1d (Soil Organic Matter) is unlikely to be implemented in native forests
- Visual assessments of soil disturbance have received general acceptance as a valid method for identifying changes in soil physical properties caused by logging
- National soil indicators project group recommended staged implementation and calibration of visual assessment against bulk density on case study and representative sites
- The soil disturbance classification used for WA native forests should be revised in line with the draft national protocol
- Improved design and control of snig track layout can be effective in minimizing soil disturbance

Using electromagnetic induction to estimate soil salt storage

J. Kinal
Science Division, Dwellingup

Summary

This study was conducted to determine the suitability of an EM31 electromagnetic induction meter for estimating soil salt storage in the jarrah forest and consequently to help identify which "environmentally sensitive catchments" may be regarded as "high salt risk".

The Department of Conservation & Land Management and Water and Rivers Commission nominated 56 second order catchments in the intermediate rainfall zone as being "environmentally sensitive" in a Record of Agreement that relates to Ministerial Condition 16 attached to Forest Management Plan 1994-2003. The Agreement also determined that "environmentally sensitive" catchments would be regarded as "high salt risk" if they met both the following criteria

1. depth to groundwater at the catchment outlet of less than four metres, and
2. soil solute concentration above this groundwater table greater than 2000 mg/L total soluble salts.

The results of this study confirmed that the EM31 is suitable for estimating salt storage in the upper 4m of the soil profile. However, moisture significantly increased the response of the EM31 in spring compared with autumn hence the appropriate seasonal regression equation must be used when estimating soil salinity.

EM31 surveys of the streamzone of 22 "environmentally sensitive" catchments indicated soil salt levels in the upper 4m which exceeded 2000 mg/L TSS along at least half of the length of the second order stream. The highest levels of salt storage were not necessarily near the catchment outlet. A further two catchments which could only be surveyed along part of the length of the second order streamzone had soil salt levels in the upper 4m which did not exceed 2000 mg/L TSS. The remaining 32 "environmentally sensitive" catchments could not be surveyed because access to or along the streamzone was not feasible because of dense vegetation.

Management Implications

The EM31 was demonstrated to be suitable for estimating soil salinity and an appropriate method for estimating soil salinity in valleys was developed and applied to a selected number of catchments. The results provide a basis for determining high salt risk catchments.

Hydrological response to logging in the intermediate rainfall zone of the jarrah forest

J. Kinal
Science Division, Dwellingup

Summary

Forest logging has greatest potential impact on stream salinity in the intermediate rainfall zone (IRZ) of the jarrah forest. Recognition of this impact on water resources is reflected in Forest Management Plan 1994-2003 and Ministerial Condition 12 whereby logging practices in the IRZ have been modified to a more precautionary, conservative approach. This study has been undertaken since there have been no catchment studies on the hydrologic impacts of the current silvicultural practices in IRZ jarrah forest.

The study, which is currently in progress, is a Before, After, Control and Impact based on three second order catchments in the IRZ jarrah forest. Two catchments have been logged in 2000/01, one according to standard IRZ logging and silvicultural treatments, and the second a more intensive treatment. The third catchment remains untreated as a control. Records exist of groundwater level, stream flow, stream salinity, and salt load for at least the previous ten years and monitoring is ongoing.

Pre treatment hydrological data are used to establish regressions with the control catchment. The regressions are then used to make post-logging predictions of hydrological parameters and the response to logging is calculated as the difference between observed and predicted. The catchments are expected to provide different levels of hydrological response that will enable an estimate of changes to the hydrology in relation to changes in vegetation density.

Management Implications

The results of this study will have potentially important implications for forest management in the IRZ. These will not be apparent until groundwater levels and stream salinities peak and decline and may take four to five years. Until this occurs it is vital that monitoring continues.

Logging and burning impacts on cockroaches, crickets and grasshoppers, and spiders in Jarrah forest, Western Australia

Ian Abbott[a], Tom Burbidge[a], Karin Strehlow[b], Amanda Mellican[a], Allan Wills[a]

[a] *Science Division, Department of Conservation and Land Management, Locked Bag 104 Bentley Delivery Centre, Western Australia 6983.*
[b] *School of Environmental Sciences, Murdoch University, Murdoch, Western Australia 6150*

Summary

In 1985 modified silvicultural prescriptions for managing Jarrah *(Eucalyptus marginata)* forest in south-west Western Australia came into operation. The most extreme treatment involved removal of most of the overstorey from 10 ha patches, followed by a regeneration fire. This paper, part of a broader integrated study, reports on the impact of these disturbances on more than 400 species of leaf litter arthropods captured in pitfall traps one year before logging, one year before burning, and three years after burning.

Most species of cockroaches (Blattodea), crickets and grasshoppers (Orthoptera), and spiders (Araneae) were resilient to logging and burning, and immediate decreases in species richness or total abundance were rapidly reversed. Changes in community structure caused by the imposed disturbances were also minimal or short-term. Community structure in treatment and control sites at the end of the study was different from that at the beginning of the study, perhaps indicative of the overriding importance of climatic variation.

The results of the study have broader relevance to understanding the long-term resilience of forest ecosystems in south-west Western Australia. Because of the role of the taxa studied in mediating decomposition, herbivory and predation, these ecosystem processes appear to be robust to the logging and burning prescriptions applied.

Management Implication

Invertebrate ecosystem processes appear to be robust to the logging and burning treatments applied, and therefore no modifications to current prescriptions are required to maintain invertebrate biodiversity in Jarrah forest.

Short-term Impacts of Logging on Birds in a Jarrah Forest at Kingston

G.L.Liddelow
Science Division, Manjimup

Summary

The introduction of modified silvicultural treatments in jarrah forest (*Eucalyptus marginata*) in 1985 raised some concerns on the impact of these treatments on the avian population. A combined study was set up in Kingston Block looking at aspects of these impacts on fauna and vegetation in 1994. Mike Craige (Phd student UWA) commenced the study on the birds in autumn 1994 and continued until 1996. The area was logged in summer 1994/95 and silvicultural burnt in November 1996. The Science Division, Department of Conservation & Land Management, took over the censuses in autumn 1997.
A total of 54 species of bird have been recorded on the grids with a further 8 being recorded in the vicinity.
Mike Craige found in his study (BACI) there was a significant decrease in the bird density in all the treated areas after logging, a non-significant decrease in species numbers and no change in the diversity of species in the treated areas. Since the Science Division has continued with the study (to Spring 2000) the Buffer areas have changed from a 30% decrease to a 10% decrease(BACI), the Shelterwood from 22% decrease to a 25% increase(BACI) and the Gap showing no change at around 25% decrease(BACI).
Overall the individual treatment trends show no change in abundance in the Control, Buffer and Gaps with a slightly increasing trend in the Shelterwood.
Some individual bird species are showing decreasing trends ie. Western Yellow Robin in the treated areas, but this species prefers open understorey and would be disadvantaged by the dense regeneration at this time. In contrast the Inland Thornbill and the White- browed Scrubwren are showing increasing trends at this stage of the forest regeneration.
Even though we have recorded over 12000 individuals during this study there are still too few numbers for any meaningful statistical analysis, we can only show trends within the treatments with time since treatment.

Management Implications

This study should be continued as it will be the only long term study on the impact of logging on the avian fauna in the jarrah forest, and can be compared with a similar study in karri forest at Grey block. The study should be continued on an annual basis until at least 10yrs since the silvicultural burn (2006) or until there is crown separation in the regeneration. Censuses should then continue on 5yr intervals from that time.
We should look at modifying our logging practice in the Shelterwood areas by retaining un-logged refuge areas within the coupes. The spacing of these un-logged refuges should be approximately 300 m.

Tree Hollows in jarrah and marri

Kim Whitford
Science Division, Dwellingup

This work covered three areas: the occurrence and abundance of hollows, the longevity of hollow bearing trees, and strategic risk assessment.

Key findings:

- Defined the relationship between tree age and diameter for jarrah and marri
- Determined the age of hollow bearing jarrah and marri and the ages of trees bearing hollows suited to various bird and mammal species.
- Identified 130 years as a realistic minimum age to hollow formation for forest management purposes.
- Determined that the minimum Primary Habitat tree diameter (70 cm) corresponds to a tree age of 171 years.
- Developed descriptions of the ranges of hollow sizes used by various species of birds and mammals
- Developed an improved method of defining the dimensions of hollows used by fauna
- Produced basic data on: hollow occurrence, distributions of hollow sizes, interrelationships between hollow dimensions, shapes of hollows, hollow orientations, and the order and sizes of branches bearing hollows.
- 90% of hollows in the forest are borne on trees with diameters between 20 and 100 cm.
- Approximately 100 hollows/ha in the jarrah forest. About 90% of these are small, ie. about 10 hollows/ha are potentially usable.
- Identified the relationship between hollow occurrence and the following tree attributes: tree age, DBH, crown size, crown condition, tree status (alive/dead), tree species, amounts of dead wood in the crown, termite damage, and tree lean. These are the basis of the current prescription.
- **Predictive relationships developed. These enable predictions of hollows occurrence across the forest for individual fauna species and allow investigation of different H tree retention strategies for specific fauna goals, eg. Preferential stand management for particular species modelling population viability across forest**
- Examined factors affecting habitat tree longevity and determined the relationship between probability of tree fall and tree and stand attributes.
- Identified relationship between log attributes and occurrence of hollows (CWD component by Matt Williams).
- Assessed risk to different species as a basis for determining hollow management strategies.

Management Implications and Recommendations

- Core information has already been included in Habitat tree prescriptions.
- The progression of fauna management requires the establishment of explicit fauna management goals where possible.
- Include crown senescence in future forest inventory work to enable and improve the Department of Conservation & Land Management's ability to predict hollow availability across the forest.
- Distinctively mark Potential Habitat trees to distinguish them from actual Habitat trees for the uninformed observer

- With fox baiting fauna populations are dynamic. We need to monitor fauna and adapt management to cater for the changes in habitat demand as fauna populations increase. Predictive models allow modeling of these scenarios.

Response of terrestrial vertebrates to timber harvesting at Kingston

A. Wayne, C. Ward, J. Rooney and I. Wheeler
Science Division, Manjimup

Summary

Small vertebrates

Capture rates of most small vertebrate species were too small to take analyses beyond descriptive trends and species richness tests;

• For those taxa with >40 capture records, all (except the brushtailed phascogale), were present after disturbance within each treatment that were present prior to harvesting;

• For taxa with <40 records, the sample sizes were too small to comment on the impacts of logging;

• Species Richness:

- small mammals declined over time (phascogale and dunnarts)
- frogs and reptiles recovered to pre-logging levels within 5 years
- logging is not likely to be the principle cause for these trends as external controls behaved similarly;
-

•*Brushtailed phascogale*:

- none have been caught on Kingston grids since June 1995,
- declines began before logging and occurred regionally,
- logging impacts remain unresolved.

Implications for Management

Small Vertebrates

•Extensive trap effort provided only limited data and it was only possible to draw conclusions about the impacts of harvesting on a few species

• No evidence of direct negative impacts of logging on native small vertebrates BUT the limitations of the data do not negate the possibility of impacts

• House mouse is a disturbance opportunist, which may have implications for native small vertebrates (competition & predation)

• Phascogale and Dunnart populations declined over the period of the study, but this did not appear to be related to timber harvesting

Quenda

• Populations responded positively to fox baiting

• No evidence of negative impacts from logging on population size (treatment populations equal or greater than control after logging)

• Recent declines on controls and treatments, although not directly related to logging, remain to be resolved

Woylie

• Populations responded very positively to fox baiting

• No evidence of negative impacts from logging on population size

• High densities of Woylies can affect the effectiveness of trapping other species because of trap saturation and future monitoring studies should take account of this

Brushtail Possum (Koomal) responses to timber harvesting at Kingston

A. Wayne, C. Ward, J. Rooney and I. Wheeler
Science Division, Manjimup

Implications for Management

Landscape level management

- Conservation objectives for arboreal fauna should be developed in the context of the full range of species that may potentially inhabit an area;
- Unharvested areas (including TEAS) within coupes are important in maintaining Koomal populations because of declines in gap and shelterwood cells;
- *Banksia, Gastrolobium,* and others shrubs are seasonally important food for Koomal that is impacted by logging and therefore may impose greater pressure on other resources (if available) and affect Koomal population abundances.

Habitat tree retention

- A few trees are used more extensively and are therefore more valuable to protect, in particular Marri, leaning trees, short & fat trees;
- Standing trees with a wider range of crown senescence should be considered for retention;
- Preliminary results show at least 3.5 standing trees per hectare are utilized by Koomal;
- Appropriate retention rates will be dependent on habitat type, possum density, and competition, all of which are dynamic over time.

Habitat log retention

- Koomal use of hollow logs will be dependent on possum densities, competition and habitat
- In some circumstances, Koomal may limit hollow log availability for other species such as Chuditch and possibly Numbats if hollow log densities are low;
- Hollow log recruitment in regrowth will be very low for a long period following harvesting;
- Natural hollow logs are used more extensively than logs from felled trees.
- Hollow log selective criteria could be expanded to include logs with:
  - external diameter >20 cm (currently 30-100cm)
  - internal diameter 6 to >30 cm (currently 6-15cm)
  - preference for natural hollow logs.

Monitoring and Research

- Environmental, Habitat, Observer and Survey variables affect Koomal spotlight detection and therefore need to be measured and accounted for in surveys;
- Survivorship of leaning habitat trees and hollow logs needs to be quantified;
- Continuing analysis of current data and further proposals for possum ecology research.

Western Ringtail Possum (Ngwayir) responses to timber harvesting at Kingston

A. Wayne, C. Ward, J. Rooney and I. Wheeler

Science Division, Manjimup

Logging impacts on Ngwayir Survivorship

• Two weeks after harvesting completed within the ranges of radio collared animals
- 31% treatment animals alive within coupe
- 80% control animal alive
• All 17 treatment animals were dead before the silvicultural burn (<2 years).
• Average breeding lifespan of Ngwayir was reduced by about 50%).
• Difference in survivorship difference between control and treatment animals was marginally significant (p=0.0559), but statistical power was low (e.g. 80% probability of detecting a 40% difference with 95% confidence).
• Up to 18% of treatment animals died from falling.
• Increased vulnerability to predation during harvest activities (generally acute) was the principal cause of the survivorship decline. Logging impacts on Ngwayir Survivorship

•85% decline throughout greater Kingston since 1997

Refuges used by Ngwayir

• above-ground nests
• typically dreys, more common in dense and/or riparian vegetation
• In jarrah (45%), marri (31%), *Melaleuca incana* (17%)
• forest harvesting debris
• mainly harvest debris, some road piles, rarely natural
• use of debris confined to harvested areas

Nocturnal Habitat Use

• Ngwayir sighted on the ground more than twice as often in harvested forest (ie. increased vulnerability to predation)

•Saplings (Jarrah and Marri) are used more extensively than more mature trees

Daytime Refuge Use

• Broader range of refuge types used than Koomal
• Standing trees with hollows are the most extensive form of refuge
• Balga grass-trees are important refuge
• Use of forest debris problematical during silvicultural burning
• A few refuges are used more extensively than most; these should be targeted for protection
• At least 7.7 refuges/ha (4 to 6 ST/ha)

Modification recommended to Jarrah Silvicultural Guidelines

- Additional fox baiting particularly adjacent to the interface between forest and cleared land
- Retention of balga grass trees, in clumps or large solitary plants
- Schedule advanced burns before harvesting to minimize the intensity of post-harvest burning

Habitat tree retention rates

To provide possum refuges for Koomal and Ngyawir at their current level of demand in Kingston at least 8 habitat trees (>70cm DBH) per hectare should be retained. This figure does not factor in competition by other species for these trees/hollows (e.g. cockatoos, Phascogales and bees), inefficiency of suitable habitat tree selection, future increased densities of recovering fauna populations.

Operation Foxglove:
Large scale fox control in the northern jarrah forest of southwest Western Australia

Paul de Tores, Kathy Himbeck, Beth MacArthur, Marika Maxwell, Jim Cocking, Mick Dillon, Liz White and Suzanne Rosier

(Prepared for workshop at Perup, May 7-8, 2001)

Summary

Western Australian fox research has shown baiting at an intensity of 5 baits/km^2 will result in an 80% or greater uptake of 1080 meat baits by foxes. However, the most efficient and cost effective baiting frequency is unknown. Baiting frequencies known to be effective over small areas are cost prohibitive if implemented over large areas.

The northern jarrah forest fox control and research project (***Operation Foxglove***) is designed to reduce fox density over large areas. The project's primary objectives are:

- to enable native fauna populations to increase and be sustained over large tracts of multiple use forest;
- to determine efficient and cost effective 1080 baiting regimes for fox control over large tracts of conservation estate and multiple use forest;
- to determine the level of fox density reduction required to allow native fauna populations to increase and be sustained; and
- to determine whether fox predation is a major limiting factor to native fauna abundance.

The study area covers approximately 544,000ha. and has 3 baited treatments and an unbaited control. 1080 dried meat baits are aerially delivered at 5 baits/km^2. Supplementary baiting, also at 5 baits/km^2, is carried out using conventional vehicle delivery in areas at the interface with agricultural land. Treatments and areas covered by each treatment are:

- 2 baitings per year: 221,400ha.
- 4 baitings per year: 130,400ha.
- 6 baitings per year: 88,600ha.
- Unbaited control: 103,500ha.

Fauna response to baiting is monitored in each baited treatment and the unbaited control. Native fauna monitoring falls within the following areas:

- radio-telemetry monitoring of survivorship of translocated populations of woylies, *Bettongia penicillata*;
- radio-telemetry monitoring of survivorship of, and habitat use by, resident populations of the common brushtail possum, *Trichosurus vulpecula*; and
- conventional trapping of the suite of native fauna.

Fox density is monitored in each treatment by deriving an annual index to density through the use of sandplots.

Results and management implications

The results from the intensive monitoring of woylies indicate the requirement for increased levels of fox control at the forest/agricultural land interface. Fox density was shown to be significantly and inversely correlated with distance from agricultural land. Re-invasion of forest areas was shown to occur within two weeks of baiting. Implications are that the fox population was regularly "turned over" (reduced and re-stocked).

The results from fox monitoring and the woylie survivorship study indicate an 80 per cent reduction in fox density may be necessary to maintain viable populations of predation sensitive native fauna [80% value is subject to final analysis]. The frequency of baiting needed to achieve this level of reduction will be determined by the boundary to area ratio of the area to be baited, the proximity of potential points for fox re-invasion and the predation sensitivity of the species to be protected. The implication is current large area operational baiting regimes require modification. Subject to final analysis (later this year), a revised aerial baiting prescription will be available.

Trapping data are highly skewed and implicate site specific habitat variables as co-limiting native fauna abundance. The implication is that habitat management may be as important as predator control. Final analysis will assess the relative importance of fox control and habitat management, specifically, the importance of vegetation structure and floristics. The importance of habitat management concurs with the results from the brushtail possum survivorship and habitat use study.

Habitat use by the common brushtail possum, Trichosurus vulpecula, in the northern jarrah forest

Paul de Tores, Kathy Himbeck, Beth MacArthur, Marika Maxwell, Liz White and Suzanne Rosier

(Prepared for workshop at Perup, May 7-8, 2001)

Summary

Habitat use of the brushtail possum was carried out as part of a larger research program (*Operation Foxglove*) assessing the native fauna response to different levels of fox density reduction in the northern jarrah forest.

General objectives of the brushtail possum study were to:

- monitor survivorship at different levels of fox density reduction; and
- assess the relative importance of predator control and habitat management.

Specific objectives of the brushtail possum research relevant to assessing the environmental effects of timber harvesting are:

- determining whether a specific tree form (senescence category) is preferred;
- determining whether any such preference is consistent across tree species;
- determining whether there is a preference for a specific type of hollow;
- determining other characteristics of den trees (e.g. the importance of contacts/access, lean angle etc);
- detailing how den tree use varies at different predator densities and different possum densities;
- determining whether den tree use in unlogged forest is different from logged forest; and
- providing better habitat tree prescriptions for an obligate tree hollow user with a requirement for large hollows.

The criteria for selection of habitat trees (Appendix 5 of Silviculture Guideline 1/95) are currently under review. Addressing the above objectives will enable these criteria to be more accurately defined.

The data are currently being analysed, the following information was presented at the workshop:

- Analysis of DBHOB for known den trees from a preliminary dataset;
- Analysis of a subset of 153 of the known 304 den trees from the Operation Foxglove unbaited control and a smaller subset of 37 trees within 10m of each known den tree to determine if there was a preference for den trees with an increased angle of lean;
- A review of senescence categories of the above 153 known den trees; and
- A review of the use of dead trees as den trees.

Findings, implications for management and recommendations

DBHOB

The minimum DBHOB for known den trees differed between species. The DBHOB for the smallest wandoo known to be a den tree was 21cm, for marri was 35cm and jarrah was 49cm. The current criteria for retention of habitat trees does not recognise this difference between species and recognises mature trees only (greater than 70cm DBHOB) for retention as primary habitat trees.

Recommendation: **the criteria be amended to allow for jarrah as small as 49cm DBHOB to be retained as primary habitat trees.**

Recommendation: **criteria be defined for retention of wandoo and marri to enable retention of primary habitat trees as small as 21cm DBHOB (wandoo) and 35cm DBHOB (marri).**

Angle of lean

The mean angle of lean for known den trees was shown to be significantly different from the mean angle of lean for non den trees. This should be interpreted cautiously, as although angle of lean has been shown to be a significant contributor to models predicting trees that bear hollows suited to brushtail possums (Kim Whitford, this workshop) other variables may be stronger predictors. The distinction should also be made that the model presented by Kim Whitford was a predictor for hollow occurrence, whereas the data from the Operation Foxglove study were for den trees known to be used by brushtail possums.

Recommendation: **subject to final multivariate analysis concurring with the interim findings and angle of lean being shown to be a good predictor for den trees used by brushtail possums, the criteria for retention of habitat trees be amended to allow for retention of trees with a greater angle of lean. A range of angles will be quantified to simplify the selection process.**

Senescence categories

The current criteria for retention of habitat trees recognises 8 categories of crown decline (senescence categories) and identifies categories 4 to 7 as those for retention as habitat trees. The criteria for retention as habitat trees do not differentiate between tree species. The Operation Foxglove den tree data collection process recognised an expanded range of senescence categories to include the suite of trees with crown decline categories known to be used by the brushtail possum. The expanded list of 10 categories is shown as attachment 1 (two pages).

Of the 153 known den trees, 32 were living jarrah. Category 10 was the most commonly recorded senescence category (31%) for living jarrah. This category falls outside the range of categories currently recognised for retention as habitat trees.

Of the 153 known den trees, 63 were living wandoo. Categories 2 and 3 were the most commonly recorded senescence categories (25% and 38%) for living wandoo.

Recommendation: **the criteria for retention of habitat trees be amended to expand the range of senescence categories. The attached list of categories is recommended for adoption.**

Recommendation: **subject to final data analysis concurring with the interim findings, the criteria for retention of jarrah be amended to show a preference for retention of senescence category 10.**

Recommendation: **criteria be defined for retention of wandoo and marri. Criteria should show a preference for retention of the relevant senescence categories.**

Use of dead trees

The current criteria for retention of habitat trees does not allow for retention of dead trees. Of the 153 known den trees from the subset of Operation Foxglove den trees, 31 were dead. 1 of 61 wandoo, 13 of 45 jarrah and 17 of 40 marri were dead.

Recommendation: **subject to final data analysis concurring with the interim findings, criteria for retention of jarrah be amended to allow for retention of dead trees and criteria be defined for marri to allow for retention of dead trees.**

The western ringtail possum, *Pseudocheirus occidentalis*: Distribution, conservation status, habitat use and implications for forest management

Paul de Tores

(Prepared for workshop at Perup, May 7-8, 2001)

Summary

The distribution of *Pseudocheirus occidentalis* has shown a marked contraction from its former distribution as inferred by historic, museum and sub-fossil records.

The known extant distribution shows a northern, southwestern and southeastern extension to the distribution identified by Jones et al. (1994). However, this increase appears to reflect a recent increase in knowledge of distribution rather than a recovery of the species. Although there has been an increase in knowledge of the distribution, there is very limited information on population and subpopulation size(s). Estimates of subpopulation size are known from 9 locations only. One of these is a translocation release site, another is currently being cleared for residential development.

The recently completed review of conservation status recommended the species remain listed as a threatened species in accordance with the WA Wildlife Conservation Act and also recommended the species remain listed as Vulnerable, in accordance with IUCN criteria. The western ringtail possum is also listed as vulnerable in accordance with the Commonwealth's Environmental Protection and Biodiversity Conservation Act (EPBC Act).

Issues relevant to the conservation of the western ringtail possum include:

- Destruction and/or modification of peppermint woodland for residential development is continuing in coastal areas known to support western ringtail possum sub-populations and population fragmentation appears to have increased.
- Logging of jarrah/marri forest has been implicated as increasing predation risk to part of the only known forest sub-population.
- The one re-introduction to forest habitat (Lane Poole Reserve) cannot yet be deemed a success and predation appears to be limiting success.

Results from a sub-set of data from radio-telemetry monitoring of translocated populations at Yalgorup National Park were presented as follows:

- 98% of recorded den trees had contact with a neighbouring tree(s). 50% of these had 5 or more contacts.
- 13 of 178 diurnal records showed possums used rest sites on the ground.
- Additional diurnal records of rest sites showed use of Rhagodia and Spyridium thickets at heights less than 1m.
- 17 diurnal records were in 7 grass trees. All grass trees had multiple heads, a large thatch and all had contact with neighbouring vegetation (the number of contacts ranged from 1 to 11).

Management implications and recommendations

The increase in knowledge on distribution reflects an increasing level of awareness of fauna conservation issues within operational districts. Appropriate maintenance of location and distribution information and access to this information should be seen as a high priority.

Recommendation: **Science Division continue to maintain the distribution database and ensure data are appropriately attributed and validated.**

Recommendation: **Data be made available via the CALM web through a GIS interface to provide relevant information to all departmental staff.**

There are western ringtail possum populations of conservation significance within areas currently subject to harvesting in the southern forest region.

Recommendation: **Silvicultural prescriptions need to clearly define the habitat requirements of the western ringtail possum and incorporate appropriate habitat protection measures. These measures need to acknowledge that habitat requirements will be different from those required for the common brushtail possum.**
Subject to final data analysis and recommendations from the Yalgorup translocation study, specific areas to address are the retention of appropriate Balga grass trees (i.e. those with multiple heads, a deep thatch and multiple contacts with neighbouring vegetation) and retention of den trees (habitat trees) with contacts with neighbouring vegetation.