Bat community structure and habitat use across logging regimes in jarrah eucalypt forests of south-western Australia

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Abstract

In many parts of the world, the increasing demand for timber and other forest products has led to loss, fragmentation, degradation or modification of natural forest habitats. The consequences of such habitat changes have been well studied for some animal groups, however not much is known of their effects on bats. In Australia, logging of native forests is a major threat to the continent's biodiversity and while logging practices have undergone great changes in the past three decades to selective logging (including ecologically sustainable forest management), which is more sympathetic to wildlife, there is still concern about the effects of logging on the habitat of many forest-dwelling animals. The goal of this thesis was to investigate the effects of logging on the bat species assemblages at both community and individual species levels in terms of their foraging and roosting ecology in jarrah forests of south-western Australia. This information is necessary to strengthen the scientific basis for ecologically sustainable forest management in production forests. The outcome of this research may help in the formulation of policy and management decisions to ensure the long-term maintenance and survival of viable populations of forest-dwelling bats in these altered environments. Bats were selected because they comprise more than 25% of Australia's mammal species and constitute a major component of Australia's biodiversity. In addition, bats play key roles in forest dynamics and may act as indicators of disturbance. In the jarrah forests, bats are a significant proportion of the mammal fauna (9 of around 30 native extant species).

As a basis of understanding how bats use modified habitats, nine species of bats were investigated by assessing their foraging and commuting habits (measured as bat

activity) in different forest types (logged, young regrowth and old regrowth forest). To assess patterns of habitat use across a gradient of managed forest conditions, and to help predict impacts of logging on bats, four replicates were selected from each of three distinct post-harvest management treatments, recently logged forest or gaps (<6 years since logging), young regrowth forest (12–30 years since logging) and old regrowth forest (> 30 years old). Sites were monitored for bat activity on two nights, with Anabat detectors placed on track and off-track positions. The relationships between bat species assemblages in terms of their relative use and foraging activity and various forest structural variables, and the relationship between bats and the insect biomass were examined in order to identify the effects on the bat fauna of historical logging practices. Overall, 12 sites were sampled (four sites for each forest type) with bat activity and vegetation structure conducted on-track and off-track at each site and insect abundance sampled only at off-track sites.

Secondly, because roosts are an important resource for bats, and may be a limiting factor in modified landscapes, we investigated the roosting requirements of two sympatric species of jarrah forest-dwelling vespertilionid bats, the Southern forest bat *Vespadelus regulus* and Gould's long-eared bat *Nyctophilus gouldi*. Their sensitivity to the loss of roost sites from logging and the effectiveness of current management practices at conserving appropriate roost sites were examined. As part of the research, tree (age, size, type, condition, presence of hollows, loose bark) and landscape characteristics (elevation, logging history, distance to water holes and creeklines, etc) of roosting sites were compared with random trees and their surrounding forest structure at local roost tree and broader landscape scales to determine whether bats selected roost trees and sites with particular characteristics.

The fieldwork was carried out during 2007 – 2009 and information was gathered through capture, radiotelemetry and passive monitoring using echolocation call detectors. Specifically, harp traps and radiotelemetry were used for roost-selection studies while Anabat bat detectors were used to assess bat activity (commuting, foraging) among different logging histories and in response to forest structural attributes and insect activity. Light traps were used to assess insect availability in relation to bat activity and forest structure.

The activity of different bat species related in different ways to the structural vegetation parameters, generally reflecting bat echolocation ability and manoeuvrability. Bats tended to use tracks more than off-track locations, thereby avoiding clutter at off-track locations. At the same time, tracks recorded similar activity across logging histories. However, off-track activity in old regrowth was significantly greater than either young regrowth or recently logged forest. Two taxa, *Vespadelus regulus* and *Nyctophilus* spp. were more active in old regrowth than other logging histories. Similarly, *V. regulus*, *Nyctophilus* spp., *Chalinolobus gouldii*, *C. morio* and *Falsistrellus mackenziei* activity was significantly greater on-track than off-track, but this activity was similar on-track across forest types, suggesting bats' use of forest tracks was unaffected by logging. As an indication of the association of low bat activity off-track with clutter, negative relationships of under-storey clutter were the most consistent predictors of bat habitat use. Conversely, reduced clutter and abundant roost resources seemed the most likely explanations for greater activity at old regrowth sites.

There were both inter-specific similarities and differences in the selection and location of roost trees and roost sites between *V. regulus* and *N. gouldi*. Both species were highly selective, preferring old large trees (> 80 cm diameter at breast height over bark – DBHOB) at intermediate or advanced stages of decay, crown senescence and deterioration with a lower percent bark cover compared to random trees. Both species also selected hollows for roosting, with *V. regulus* roosting exclusively in hollows but a few *N. gouldi* also used roosts under decorticating bark, cracks and under balga (*Xanthorrhoea preissii*) skirts. *V. regulus* preferred tall trees in the canopy with roost entrances high above the ground with little surrounding vegetation while *N. gouldi* preferred roosting closer to the ground and in dense clutter. In general, little evidence was found of bats roosting in either shelterwood creation or gap release silvicultural treatments, although a few *N. gouldi* bats roosted in retained habitat, or remnant, trees in these silvicultural treatments. Only riparian buffers and structurally mature forests appeared to provide multiple alternate roosts, containing a higher density of trees with hollows required by bats for roosting. In contrast, gap release and shelterwood creation sites contained substantially lower densities of hollow bearing trees. Pockets of mature forest that were previously only lightly and selectively logged before the introduction of Ecologically Sustainable Forest Management (ESFM) were important roosting sites for bats. However, although some *N. gouldi* bats selected roosts in retained or remnant trees in gap release and shelterwood creation silvicultural treatments, it remains unclear if bats can successfully breed in such regrowth forests in the absence of older forest stands and this should be a priority for future studies.

This study demonstrated that unharvested buffer strips surrounding ephemeral streams, and more open mature forests, with reduced midstoreys, were important roosting habitats for bats because they provided a large pool of older and mature trees in a variety of decay classes as roost sites. With short logging rotations in the jarrah forests and with only approximately 39 % total forest area currently reserved from logging in the study area, the roosting requirements of bats may be affected negatively as the abundance of old trees with hollows, exfoliating bark and other forms of senescence may be reduced. Thus, although this study demonstrated the importance of mature forest and buffers as mitigating measures on bat roost sites, it was unclear whether the area of retained habitat is adequate for for roosting bats given the dynamics of logging regimes in the jarrah forests, and this should be a priority to address in future research.

As the only mammals capable of true flight, bats may persist in selectively logged forests. However, as this study showed, bats are specialised in their foraging and roosting requirements. Therefore, the maintenance of forest tracks and the protection, and sustained recruitment, of hollow-bearing trees are essential for the conservation of these animals in such modified landscapes. Current management practices in the jarrah forests have created a mosaic of successional stages within logged landscapes that may satisfy the foraging requirements of many bat species. This is especially true because tracks and unlogged buffers and structurally mature forest with reduced clutter provided access to post-disturbance forests such as regrowth areas. The study also demonstrated that habitat retention, as provided by adjacent streamside buffers and mature forest in the jarrah forests were important roost sites for bats, and could mitigate against logging impacts in the long term. However, retained habitat trees in

logged coupes were avoided by roosting bats and further studies are required to demonstrate if these can be used effectively by viable bat populations, especially in the absence mature unlogged forest and unlogged riparian buffers nearby. In addition, further research is required to shed light on bat overwintering and maternity roost sites that are important for the survival of bat populations. In addition, a long-term study to clarify temporal/seasonal and intra-specific variation in bat distribution and roost site selection needs to be undertaken in the jarrah forests of south-western Australia to better determine if current ESFM practices are effective at maintaining bat populations in logged forests.

Statement of Originality

I certify that the thesis entitled

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submitted for the degree of

Doctor of Philosophy

is the result of my own work and that where reference is made to the work of others, due acknowledgment is given.

I also certify that any material in the thesis which has been accepted for a degree by any other university or institution is identified in the text and duly acknowledged.

Tuesday, March 15, 2011

Paul W. Webala

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Preface

During my PhD project, I designed the study in collaboration with my supervisors, Michael Craig, Stuart Bradley, Bradley Law (informally), Kyle Armstrong, and Adrian Wayne. With the help of volunteers, I collected all the data; undertook all statistical analyses with assistance of my supervisors; drafted and revised all chapters (including those accepted for publications and/or already published); and took all photographs included in this thesis, with the exception of a few, which have been acknowledged.

Structure of the thesis

The main chapters in this thesis have been published as journal articles and are indicated below:

Chapter 3: Webala, P. W., Craig, M.D., Law, B.S., Armstrong, K.N., Wayne, A.F. & Bradley, J.S. (*in press*) Bat habitat use in logged jarrah eucalypt forests**,** south-western Australia. *Journal of Applied Ecology*, no. doi: 10.1111/j.1365-2664.2010.01934.x

Chapter 4: Webala, P. W., Craig, M.D., Law, B.S., Wayne, A.F. & Bradley, J.S. (2010) Roost site selection by southern forest bat *Vespadelus regulus* and Gould's long-eared bat *Nyctophilus gouldi* in logged jarrah forests; south-western Australia. *Forest Ecology and Management* **260**, 1780–1790.

The articles were written with the support of some or all of my supervisors, who have therefore been included as co-authors (indicated below).

Names, addresses and roles of supervisors and/or co-authors (in alphabetical order)

- **Adrian F**. **Wayne**, Science Division, Department of Environment and Conservation, Locked Bag 2, Manjimup, WA 6258, Australia. Overall supervision of thesis, especially with regard to fieldwork and assisted with the drafting and editing of Chapter 4 and the subsequent drafting of the manuscript arising thereof for publication
- **Bradley S**. **Law**, NSW Department of Primary Industries, West Pennant Hills, PO Box 100, Beecroft, NSW, 2119, Australia. Special support in the thesis write up and guidance in the development of both manuscripts for publication. Brad also provided technical input on aspects of Australian bat ecology, especially with regard to bat foraging and roosting requirements.
- **Kyle N**. **Armstrong**, University of Adelaide, Darling Building, School of Earth and Environmental Sciences, North Terrace Campus, Adelaide, South Australia 5005, Australia. Overall supervision of thesis but special input in the bat activity study
- **J**. **Stuart Bradley**, Murdoch University, School of Biological Sciences, South St, Murdoch, WA 6150, Perth, Australia. Overall supervision of this thesis but also greatly assisted with problematic data analyses and facilitated with fieldwork.
- **Michael D**. **Craig**, Murdoch University, School of Biological Sciences, South St, Murdoch, WA 6150, Perth, Australia. Overall supervision of this thesis, but especially data analyses, fieldwork and invaluable guidance in the drafting of the manuscripts for publication.

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helping me complete the writing of this thesis as well as the challenging research underlying it. Mike has been a friend and mentor. Alongside Brad Law and Adrian Wayne, he taught me how to write academic papers. As a result, research life became smooth and rewarding for me. Mike, I am grateful in every possible way and hope to keep up our collaboration in the future.

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