Project NNP2: Final Report

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Biodiversity dynamics in relation to habitat loss and disturbance in the New South Wales wheatbelt

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Summary of methods and modifications

In originally proposing this project we had three main motivations: to bring new ideas and analytical methods to bear on native vegetation management; to emphasise the importance of landscape and biodiversity dynamics; and to reach policy audiences. Our prior experience with NSW native vegetation and natural resource management policy forums has been that scientists are generally asked for answers to guide immediate planning prescriptions. In our view, a better role for scientists is to provide concepts, methods, frameworks and partnerships in the spirit of adaptive management.

During the course of this project, the legislative and regulatory arrangements for native vegetation management in NSW were completely altered. Our original target audiences (Regional Vegetation Committees) were dissolved. Previously dominant policy ideas (vegetation targets and thresholds) were replaced by new proposals. Despite this, the research undertaken as part of this project (albeit with some modification) has remained relevant because it is based on the fundamental need to understand and predict biodiversity trends in agricultural landscapes rather than being tied to any particular policy or planning scheme.

Important modifications to the methods originally proposed are discussed below under the relevant project objectives. In brief, the balance between model development and model testing was changed after deciding that both the plant and the animal models required a higher level of detail to be useful in an applied conservation and land-use planning context. The objective to provide guidelines for fire and grazing impacts was dropped after assessing available knowledge and the worth of guidelines versus methods to explore case studies relevant to particular species, regions and management issues. A new strand, regional scenario modelling for policy and general audiences, was added to the project to complement the detailed plant and animal modelling strands.

Accompanying this document are three technical reports and five draft manuscripts, each of which present project activities and outputs in depth. The Dept. of Environment and Conservation increased its in-kind contribution to the project, in the form of salary support for one of the Project Officer positions. Thanks to this we are able to continue our research for a further six months and will provide a supplementary report to Land and Water Australia in December which will include further manuscripts.

Project results summarised against original objectives

1. **Identify relationships between clearing of native vegetation and environmental variables (e.g. climate, topography, soils) in the NSW wheatbelt.**

Compilation and analysis of historical data showed that clearing rates and intensities have been highly variable over the last 150 years. Statistical analysis of recent clearing patterns confirmed important environmental determinants but also highlighted the dominant influence of spatial contagion in the spread of clearing. See attached draft manuscript: *Patterns and determinants of woodland clearing in central western New South Wales, Australia*.

2. **Generate future landscapes by modelling different vegetation management scenarios.**

We have developed a simple framework to explore and illustrate future landscape scenarios involving a variety of vegetation clearing and offsetting schemes. Using this we have

examined consequences of such schemes for a range of native woodland fauna in the NSW wheatbelt. See attached draft manuscript: *Do offset schemes prevent biodiversity loss from native woodland clearance?*.

3. Use models to explore the change in disturbance regimes resulting from clearing and fragmentation.

We modified the generalised landscape approach to modelling fire and woodland dynamics originally proposed after recognising that this too coarse to depict scenarios of interest for conservation and land-use planning or provide outputs amenable to field testing. We have developed a new model of pine-box woodland stand dynamics to investigate scenarios for clearing (including thinning) and fragmentation, altered fire and grazing regimes, and climatic influences. A woodland stand can be depicted as part of a larger block or as an isolated remnant, with each case involving different settings for fire propagation and opportunities for tree recruitment. See attached manual: *The tm package for simulation woodland stand dynamics in R.* We have tested this model against data from forestry for white cypress pine stands. See attached manuscript: *A model of woodland tree dynamics: validating model performance for* Callitris *(cypress pine) in central western New South Wales.* We are presently applying it to a critical assessment of benchmarking approaches to managing invasive scrub including cypress pine. See attached manuscript: *Expert-elicited benchmark values for woodland tree density: a comparison with modelled stand dynamics.*

4. Conduct a review of published and unpublished information relevant to the study area to define plant and animal functional groups that reflect integrated syndromes of response to fire and grazing.

We have focussed on two plant functional groups, represented by the two major genera dominant in wheatbelt woodlands: *Callitris* and *Eucalyptus*. Species of these two genera, in inland NSW, exhibit fundamental differences in their functional recovery response to disturbance, respectively being obligate seeder and resprouter (Hawkins 1966; Lacey 1972; Iwaszkiewicz & Semple 1988; Williams & Woinarski 1997). They differ in their tolerance of competition (Lacey 1972, 1973; Baur 1982-1989; Horne & Robinson 1987; Horne 1990) and possibly drought (Clayton-Greene 1983; Attiwill & Clayton-Greene 1984; Heady *et al.* 1994; Heady 2001; Zeppel *et al.* 2004). The woodland stand modelling framework (see Objective 3) has been developed to consider these two groups separately or in mixed stands. An extensive literature survey and series of consultations have shown that data on many important attributes are sparse for both groups, although more exists for *Callitris* from silvicultural studies. Further details were provided in Milestone Reports for this project.

For fauna - 45 fauna assemblages were developed covering the 516 vertebrate species considered native to the northern wheatbelt of New South Wales via expert workshops and literature review. Thirty three of these species were considered tolerant of agricultural practices and not assigned to any assemblage, while 41 were considered to require active management beyond vegetation restoration or management and also could not be assigned to any assemblage. See attached report: *A classification of the native vertebrate species of the northern wheatbelt of New South Wales.*

Note: the fauna modelling framework developed under this project considers fire and grazing effects where they can be related to habitat resource value for a species (See Objective 6).

5. Prepare guidelines on fire and grazing impacts in booklet or other form(s) tailored towards land managers.

After an extensive literature review we judged that there was insufficient knowledge to meet this objective. Also, in the light of other project activities, we favour providing concepts, methods and exploration of relevant case studies rather than general prescriptions. The literature review has contributed to many aspects of our research modelling woodland plant and animal dynamics. Both the plant and animal models are capable of exploring a variety of fire and grazing scenarios.

6. **Use outputs from (1), (2) and (3), together with data on functional responses for selected plant and animal groups defined from step (4), to explore the consequences of projected changes in habitat quantity and quality across real and modelled landscapes.**

See comments under previous objectives as well as the following attached manuscripts:

Do offset schemes prevent biodiversity loss from native woodland clearance?

Applying a spatially-explicit individual-based model to a declining territorial species with variable group compositions in a fragmented landscape.

A further manuscript, *Modelling malleefowl responses to changing resource availability under different fire management regimes* will accompany our supplementary report in December.

7. **Carry out field studies in several areas within the NSW wheatbelt to assess the results and insights drawn from the modelling exercises and to refine models.**

As mentioned above, we devoted a much greater amount of time and effort to model development than originally proposed. Assessment of model performance is under way.

Plant modelling – Literature survey revealed inadequate quantitative data to fully parameterise the tree model for *Callitris* and *Eucalyptus*. For example, silvicultural studies of *Callitris* typically ignore seedling or senescent stages of trees and we could find no data that integrated height, canopy shape, dbh, reproductive output over the full range of tree sizes. We therefore focused field studies on collecting basic data to refine morphometric and survival parameters in the model. We have formed an on-going collaboration with Dr Ian Lunt and co-workers, Charles Sturt University. This is allowing us to examine and refine the performance of the model in relation to reference field data, asking (a) can we replicate observed changes in woodland stands over the last 130 years? (b) under what conditions of disturbance does correspondence arise between model results and reference data for pre-European simulations. Model testing with respect to *Callitris* stand dynamics is detailed in the attached manuscript: *A model of woodland tree dynamics: validating model performance for Callitris (cypress pine) in central western New South Wales.*

Fauna modelling – Collaborative studies are being developed with other research groups to apply the animal population model developed under this project to a range of species and scenarios. Studies with university researchers are concentrating on woodland species: Caroline Blackmore from the Australian National University studying babblers; Rodney van der Ree from the University of Melbourne on possum and gliders; and Rob Close from the University of Western Sydney on koalas. Collaborative work on mallee birds is forthcoming with Peter Cale from the South Australian National Parks and Wildlife Service. In addition, Peter has conducted studies on woodland birds in the South Australian agricultural belt and initial trials of the model against his study population showed a strong concordance in the predicted geographic contraction with the documented decline, even though the model

parameters were not specifically collected from his study area. We expect these collaborations to extend over three to five years.

8. Carry out new field studies to measure functional group responses in the field in relation to disturbance syndromes to further assess modelled responses and explore relevant theory.

The intensity of the drought in central New South Wales over the course of this project limited fuel loadings and virtually eliminated fires from the study area, but it provided a rare opportunity to investigate intense drought. Plot and transect measurements have been carried out across the width of the wheatbelt for both the pine and the box functional groups to investigate the impacts of the recent drought on survival in various height classes, and of competition on the pattern of seedling establishment and mortality. These results are being incorporated into the woodland modelling package and are partly explained in the attached manuscript: *A model of woodland tree dynamics: validating model performance for* Callitris *(cypress pine) in central western New South Wales*.

Basic morphometric data is lacking for both the pine and box functional types, and what exists generally only relates two measures to each other e.g. height and basal area. From our own field studies we have assembled an extensive dataset covering height, canopy parameters, trunk parameters and fruit production. Initially this has been directly incorporated into the woodland modelling but such basic data is likely to be useful for a variety of other purposes. To make it available we will include a further manuscript: *Allometric relationships for Callitris and Eucalyptus species in woodlands of central western New South Wales* with our supplementary report in December.

A number of the fauna studies mentioned above involve post-graduate students, either already studying or commencing in the 2006 calendar year. Of these, studies on mammal species are likely to consider effects of infrastructure on population dynamics in fragmented landscapes. The Ph.D. study of babblers is set to investigate the concordance of modelling with field data during the 2005/2006 financial year. Peter Cale, SA, is commencing work on fire effects on mallee birds, many of which occur in the western margins of the NSW wheatbelt. The results should be applicable to a wide band on the west of the wheatbelt plus much of southwest NSW. Habitat modelling for the fauna assemblages presented in the attached report has commenced in association with the Lower Murray Darling Catchment Management Authority. This latter work is being undertaken by Murray Ellis.

9. Contribute to current approaches to vegetation management through explicit simulation of target and offset mechanisms and general evaluation of vegetation management proposals in the light of project outputs.

Our models of regional native vegetation management schemes and their likely consequences for native fauna species have been presented to senior executives within NSW Dept. Environment and Conservation and Dept. Infrastructure, Planning and Natural Resources as well as local and international scientific meetings.

We are presently applying the woodland stand dynamics model to critically assess benchmarking approaches to managing invasive scrub including cypress pine. See attached manuscript: *Expert-elicited benchmark values for woodland tree density: a comparison with modelled stand dynamics.*

The fauna classification, presented in the attached report, is providing the basis of habitat modelling under an agreement with the NSW Central West Catchment Management

Authority and the Lower Macquarie Castlereagh CMA. This work is being undertaken by Murray Ellis, a project team member.

Results of population modelling for the brown treecreeper, a threatened woodland species, as well as general inferences and advice on fauna conservation in fragmented landscapes that stem from the modelling, are being provided to the NSW Biodiversity Strategy Working Group.

10. Effectively communicate the results of the project to key target audiences.

Three NSW Catchment Management Authorities (see above) are adopting fauna habitat modelling, based on groups defined in this project, to assess impacts of alternate landuse options within their catchments.

There is an on-going relationship between project team members and DEC Western Planning and Assessment officers, who are delegated to liase with Catchment Management Authorities as well as assess clearing and cropping applications, to provide and advise on project outputs and discuss further information and research needs.

Our flora and fauna models have been presented to the International Association of Landscape Ecologists, the Royal Zoological Society of NSW and the Ecological Society of Australia, and resulted in the four collaborative fauna projects mentioned above being developed.

Adoption of project outputs and activities to date

Four collaborative fauna projects in NSW, ACT, Victoria and SA are looking at using the fauna modelling developed in this project for detailed analysis of the behaviour and viability of a variety of woodland species in specific areas. Once the basic parameters are tested they can be applied in novel areas and scenarios for elucidating the response of fauna to landscape management. Three CMAs in western NSW are adopting fauna assemblage modelling to evaluate landuse options proposed under catchment planning. Preliminary meetings have been conducted with the NSW Biodiversity Strategy Working Group regarding the inclusion of fauna modelling case studies, for evaluating long-term impacts of landuse decisions, in the *NSW Biodiversity Strategy*. Additional meetings in June and July 2005 will determine the final content and format of the included case studies.

Commercial potential

Not applicable.

Publications

Draft manuscripts and reports provided as attachments

1. Bedward, M., Ellis, M., Ross, K. and Simpson, C. (in prep) **Woodland: A package for simulating woodland stand dynamics in R. Reference manual. Version 1.0** New South Wales Department of Environment and Conservation, Sydney.

2. Bedward M, Ross K, Ellis MV and Simpson CS (In prep.) **Expert-elicited benchmark values for woodland tree density: a comparison with modelled stand dynamics.** *To be submitted to Biological Conservation.*

3. Bedward M, Simpson CS, Ellis MV and Metcalfe LM (In prep.) **Patterns and determinants of woodland clearing in central western New South Wales, Australia.** *To be submitted to the Journal of Environmental Management.*

4. Bedward M, Simpson CC and Ellis MV (In prep.) **Do offset schemes prevent biodiversity loss from native woodland clearance?** *To be submitted to Biological Conservation.*

5. Ellis MV (2005) **A classification of the native vertebrate species of the northern wheatbelt of New South Wales.** New South Wales Department of Environment and Conservation, Sydney.

6. Ellis MV and Bedward M (In prep.) **Applying a spatially-explicit individual-based model to a declining territorial species with variable group compositions in a fragmented landscape.** *To be submitted to Biological Conservation.*

7. Ellis MV and Bedward M (2005) **CafeAnimal: technical specification and user manual version 1.0.** New South Wales Department of Environment and Conservation, Sydney

8. Ross K, Ellis MV, Bedward M and Simpson CS (In prep.) **A model of woodland tree dynamics: validating model performance for *Callitris* (cypress pine) in central western New South Wales.** *To be submitted to the Australian Journal of Botany.*

Further manuscripts to be provided in December 2005 supplement (working titles)

9. Ellis MV and Bedward M. (In prep.) **Modelling malleefowl responses to changing resource availability under different fire management regimes.** *To be submitted to Wildlife Research*

10. Ellis MV and Bedward M (In prep**.) 'Diode effects': causes of asymetrical animal dispersal across fragmented landscapes and their implications for clearing and restoration planning**. *Journal to be decided.*

11. Ross K and others. (In prep.) **Inferring the structure and dynamics of pre-European temperate woodlands in central western New South Wales through simulation modelling and empirical studies.** *Journal to be decided.*

12. Ross K (In prep.) **Allometric relationships for *Callitris* and *Eucalyptus* species in woodlands of central western New South Wales.** *Journal to be decided.*

13. Ross K and others (In prep.) **A model of woodland tree dynamics: validating model performance for *Eucalyptus* (box tree species) in central western New South Wales.** *To be submitted to the Australian Journal of Botany.*

Obtaining additional information

Contact Michael Bedward.

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