OUR RURAL LANDSCAPES SUB-PROJECT 1.1

NATIVE BIODIVERSITY FUTURES IN AGRICULTURAL LANDSCAPES

WORSHOP REPORT

Wednesday 21st July 2004, 250 Victoria Parade, Melbourne

SUMMARY

The "Our Rural Landscape" (ORL) sub projects 1.1 (Our Landscape) and 1.4 (Our Biodiversity) are establishing important linkages between DPI agricultural and spatial scientists, DSE ecological scientists, and ecologists in Victorian Universities. A one day workshop was convened to bring together the scientists involved in landscape and biodiversity research in order to share ideas in current research projects or proposals. Primary questions addressed at the workshop included 1. How do we estimate persistence of species and ecosystem services in future agricultural landscapes? 2. Can we optimise habitat, species persistence and ecosystem services and maintain or increase agricultural production? The workshop was convened by Dr Josh Dorrough from DSE's Arthur Rylah Institute in Heidelberg, Melbourne.

Presentations on ORL, three ARC linkage projects, and a LWA project proposal were given. Each project presentation was followed by discussions focussing on strengths, weaknesses, opportunities and threats. Research gaps and possible linkages were also discussed.

Details of the participants, workshop programme, SWOT analyses, and project summaries form the body of this report.

In final discussion the group agreed that some level of formalisation of this biodiversity and landscape futures interest group would be beneficial. A name for the group and a fact sheet describing membership and purpose is to be prepared.

It was agreed that the future aims of the group will be to:

1. Develop a collaborative research program that would address landscape scale ecological questions relevant to land-use planning
2. Develop approaches to predicting distribution and persistence of native biota in landscapes with differing land use, vegetation cover and pattern.
3. Facilitate adoption of sound ecological research and understanding in the undertaking of landscape planning questions.

NEXT MEETING agreed OCT/NOV 04

Attendees, from left to right: Josh Dorrough, Robin Adair, Kristy Youman Matt Gibson, Mick MacArthy, Sarah Bekessey, Ralph MacNally, Peter Vesk, Vivienne Turner, Hemayet Hussain, Richard MacEwan, Jason Alexandra, Jim Radford, Brendan Wintle, Joe Banks, Andrew Bennett, Kathryn Sheffield, Angie Donaldson, Graeme Newell. Missing: Alan Crouch, Kim Lowe, Ian Masergh

Apologies: Angela Avery, Craig Beverly

WORKSHOP PROGRAMME

9.00 am **Richard MacEwan** and **Josh Dorrough** Overview of ORL 1.1 and outline of ecological research program (10-15mins) followed by questions and discussion (20 mins)

9.35 am **Andrew Bennett** – Proposed ARC linkage “Our rural wealth: using functional responses of native fauna to assess conservation values of agricultural landscapes” (10-15min) followed by questions and discussion (40mins)

10.30 – 10.45 Short break

10.45 am **Ralph MacNally** – Proposed ARC linkage “Models for biodiversity futures for massively altered agricultural landscapes” (10-15 mins) followed by questions and discussion (40mins)

11.40 am **Sarah Bekessey** –ARC linkage “Re-imagining the Australian suburb: biodiversity planning in urban fringe landscapes” (10-15 min) followed by questions and discussion (40mins)

12.35 - 1.15pm Lunch

1.15pm **Robin Adair**- Land and Water Australia proposal “Landscape Biodiversity Index” (10-15mins) followed by questions and discussion (40mins)

2.10 pm Overall project discussion. Is there anything missing? What are the key research questions that may require more resources? 1 hr

3.10 pm Short break

3.30 pm **Andrew Bennett** Collaboration and implementation “Lessons from the Box -Iron Bark project (15 mins) followed by questions and discussion (30 min)

4.15pm Formation of working groups/technical reference panels for each project (30 min)

4.45 Close

INDIVIDUAL PROJECT DISCUSSIONS

1. OUR RURAL WEALTH: USING FUNCTIONAL RESPONSES OF NATIVE FAUNA TO ASSESSCONSERVATION VALUES OF AGRICULTURAL LANDSCAPES

Chief Investigators: Dr Andrew **Bennett** (Deakin), Associate Professor Ralph MacNally (Monash), Dr Jim Radford (Deakin)
Partner Investigators: Dr Josh Dorrough (DSE), Dr Robin Adair (DPI)

STRENGTHS

- Whole mosaic
- Existing large databases already in forerunner project
- 24 study landscapes with potential to feed into Long Term Ecological Research (LTER) sites

WEAKNESSES

- data hungry: need large datasets
- large number of variables
- bird and mammal datasets only

OPPORTUNITIES

- encourages management to focus on the selection of landscape variables
- builds on existing land use management modelling
- changed site management leading to changed response in BD
- LTER status for 24 study landscapes
- Time series data
- Expand methodology to include other taxa eg plants
- Time since clearing / intensification
- What is the value of agricultural landscapes as habitat
- Metapopulation Landscape Index (Brendan??) – total amount habitat+connectivity
- Other research : weed invasion, ecological processes (eg. seed predation, pollination)

THREATS

- no funding for LTER
- project won’t lead to generalizations leading to improved management
- not funded by ARC

ACTIONS

- Graeme Newell to speak with Andrew Bennett about a parallel project

2. MODELS FOR BIODIVERSITY FUTURES FOR MASSIVELY ALTERED AGRICULTURAL LANDSCAPES

Chief Investigators: Associate Professor Ralph **MacNally** (Monash), Dr Andrew Bennett (Deakin), Dr Peter Vesk (Monash), Dr Michael Bevers (USDA Forest Service) and Dr Danny Spring (Monash)
Partner Investigator: Dr Josh Dorrough (DSE)

STRENGTHS

- Temporal dimension
- Very long time frames
- Vegetation dynamics for habitat (ie identifies medium term shortfalls in habitat availability)
- Highlights geriatric tree population
- Design tool leading to increased funding leverage
- Critical resources eg for nectarivores over time
- End focus of cost effective restoration

WEAKNESSES

- Bias in existing vegetation pattern due to history
- Need to account for historical processes and species interactions (eg. competition, predation)
- Upscaling of atlas data (Angie Donaldson data 1 x 1km grids may help)
- Birds may not be good umbrella indicators for sedentary taxa
- Error propagation inherent in additive models
- Mismatch between decision timeframes and ecological timeframes
- CMA biodiversity co-ordinators as partners

OPPORTUNITIES

- Providing temporal perspective to land managers in context of cost effective revegetation
- Links to wider network of activities (practitioners)
- Linkage to LWA priorities and activities
- Climate change?
- Links to carbon sequestration project (ARI/DSE)

THREATS

- Discounting potential importance of error propagation
- Belief by target audience that models are the truth (can be overcome partially by using maps as communication tool)
- No ARC funding

3. RE-IMAGINING THE AUSTRALIAN SUBURB: BIODIVERSITY PLANNING IN URBAN FRINGE LANDSCAPES

Chief Investigators: Dr Sarah **Bekessey** (RMIT), Dr Brendan Wintle, Dr Mick McCarthy (University of Melbourne)
Partner Investigator: Dr Josh Dorrough

STRENGTHS

- Systematic decision making tool based on BD
- Short project timeframe leading to increased focus on critical variables
- Bringing BD into triple bottom line decisions
- Big picture view; regional perspective
- Theoretical background
- Partnerships (unis, govt., developer)
- ARC funded ie recognition that it is a national agenda issue
- Highlight need for dispersal data

WEAKNESSES

- Useful outcome with so little data leading to dangerous precedent
- Limited data especially re dispersal
- Few taxa considered
- Not integral part of planning process

OPPORTUNITIES

- Development of generalized model to asses viability of landscape
- Links with Bennett *et al.* project via functional perspective
- Map of greater metro region for BD values (esp. for CMAs)
- Highlight priority areas for protection, enhancement and restoration
- Net gain: regional scale plans
- Dynamic landscape modelling
- Assembling complex information

THREATS

- Ignored by planning process
- Increasing complexity leading to decreasing accessibility
- Limited data
- Credibility issue

ACTION

- Put methodology into statewide planning framework

4. A LANDSCAPE-SCALE SIGNATURE OF BIODIVERSITY HEALTH; MEASURING THE IMPACT OF LANDSCAPE CHANGE ON BIODIVERSITY

Angela Avery, Dr Robin **Adair**, Dr Vivienne Turner, Dr Penny Riffkin, Dr Tony Parker, Dr Andrew Bennett, Dr Kim Lowe, Dr Pauline Mele.

STRENGTHS

- Good choice of attributes
- Landscape scale

WEAKNESSES

- Potential for misuse
- Should it consider function
- Question utility of a single index (ie aggregation issue) – need to present all scores
- Who is the target audience
- Liklihood of correlations
- Ecosystem outliers eg wetlands, grasslands – how can they be dealt with
- Is it too unbounded?

OPPORTUNITIES

- Focussing on three significant variables may be more useful than a single index/score
- Builds on conceptual thinking behind the Montreal Criteria and Indicators developed for sustainable forestry (ie report card)
- Heuristic for stakeholders
- Non-woody vegetation communities vegetation condition (habitat hectares) development
- Focus for interesting debate
- Opportunity for validation through other projects in group (ie AB, RM,SB)

THREATS

- Too big and hard
- Non-transparency of “model”
- Not enough data
- Obscure critical conservation detail eg ireplaceability

LESSONS FROM THE BOX IRON BARK PROJECT

Key factors – team work hard but valuable, regular open communication, regular working group meetings (6/year), consistent approach to data collection, co-ordinator essential.

Steering committee valuable – external people to provide review and questioning. Met 1/year

Must manage expectations

Uptake of results a key factor – who is target audience, need for communication strategy

Working group included management and policy

LINKS AND COLLABORATION

CSIRO Healthy Country – Saul Cunningham and Peter Thrall
CSIRO Sustainable Ecosystems : David Freudenberger, Mike Dunlop
Lower Murray Landscape Futures
DPI Catchment Analysis Tool
LWA
Climate Modelling – Monash/CSIRO

GAPS

- Ecosystem services
- Future drivers of landscape change and assessment of alternative futures
- Aquatic biodiversity
- Agent behaviour under different scenarios and impacts on biodiversity
- Spiritual and recreational services of landscapes

REFERENCE GROUP

It was proposed that a reference group should be formed that could take on the role of advocacy and project governance.

Possible membership

- Planning : Peter Durkin
- Policy: Kim Lowe, Garry McDonald
- Management: Peter Wilcock
- Research: Denis Saunders, Mark Burgman, Sue McIntyre, Jann Williams
- Farming: Richard Weatherly
- Communication: Rob Gell, Melissa Fyfe
- Chief Scientist: John Stocker, Graeme Mitchell

FUTURE DIRECTIONS

It was agreed that the group should be formalised with an aim of:

4. Developing a collaborative research program that would address landscape scale ecological questions relevant to land-use planning
5. Developing approaches to predicting distribution and persistence of native biota in landscapes with differing land use, vegetation cover and pattern.
6. Facilitating adoption of sound ecological research and understanding in the undertaking of landscape planning questions.

Research will focus on rural and peri-urban landscapes.
Was agreed that the group should meet 4 – 6 times per year. Name tentatively “Landscape Biodiversity Futures Research Group”. Development of a reference panel/steering committee also agreed upon.

Initial communication activities: pamphlet and website

Future Tasks: establish reference group (draft letters of invitation), approach Myer Foundation for funding, investigate opportunities for additional project funding through LWA

NEXT MEETING agreed OCT/NOV 04

PROJECT SUMMARIES

BACKGROUND

Managing and conserving habitats in rural landscapes will be critical in assuring the persistence of native biota and their services to agriculture across the landscape. There is a need to develop strategic, integrated landscape designs that enhance conservation outcomes for biodiversity while providing increased ecosystem services for sustainable agriculture. Throughout Australia we are faced with the need to restore natural ecosystems to improve the long-term survival prospects of native species and to enhance ecosystem functions and services in order to maintain resilient future farming landscapes. In reality only small percentages of landscapes are likely to be revegetated in the immediate future. Prioritising where and how much native vegetation needs to be re-established is therefore a key research area. While the methodology for developing landscape designs is emerging (eg Wilson and Lowe 2003), the tools to determine the adequacy (i.e. persistence of species and ecosystem functions) of such designs are lacking. There is also a paucity of knowledge on the effects of the pattern and extent of agricultural land-uses on the persistence of native species and maintenance of ecosystem services they provide (eg. pollination and predation). Recent research indicates that thresholds in the amount of tree cover in the landscape may govern the occurrence and ultimately persistence of woodland birds. This insight provides us with some guidance for restoration activities. However, the reliability and predictability of these thresholds for a broad range of fauna remains to be tested. Another key issue that has been largely neglected is the temporal aspect of native vegetation restoration. Time-lag effects in the provision of suitable habitat for niche specialists is recognised, but is rarely taken into consideration in the planning or implementation of habitat restoration programs. Uniting spatial and temporal habitat requirements of native biota, at the species and functional group level, is required for the effective integration of biodiversity conservation in changing agricultural landscapes.

Through the Victorian government Our Rural Landscapes (ORL) 1.1 and 1.4 projects we are developing a research program focusing on improving the tools and understanding required to adequately plan for native biota and the ecosystem services they provide, and to assess the effectiveness of habitat restoration efforts within rural landscapes. The outputs of the project will be decision-support tools, which would incorporate measures such as a landscape biodiversity index, that can be used by landscape managers to make better policy, planning and management decisions. We are hoping to develop an integrated and flexible framework for application at scales ranging from sub-catchments to bioregions.

OBJECTIVES

- To undertake research that will improve our ability to predict the future persistence of native biota in the rural landscape.
- To better understand the contributions native biota make to ecosystem services in rural landscapes.
- To develop a framework for improving our understanding of native biota in the rural landscape for improved landscape assessment and planning.
- To provide methods and tools that can be used to rapidly assess the landscape value of various land-use options including the relative merit of revegetation options for native biota and their ecosystem services to agriculture.
- To develop methods and tools to enable optimisation of vegetation placement for habitat and ecosystem services.

CURRENT OR PROPOSED PROJECTS

1. Models for biodiversity futures for massively altered agricultural landscapes
2. Our rural wealth: using functional responses of native fauna to assess conservation values of agricultural landscapes
3. Re-imagining the Australian suburb: biodiversity planning in urban fringe landscapes
4. Development of a landscape biodiversity index

PROJECT 1. MODELS FOR BIODIVERSITY FUTURES FOR MASSIVELY ALTERED AGRICULTURAL LANDSCAPES

Chief Investigators: Associate Professor Ralph MacNally(Monash), Dr Andrew Bennett (Deakin), Dr Peter Vesk (Monash), Dr Michael Bevers (USDA Forest Service) and Dr Danny Spring (Monash)
Partner Investigator: Dr Josh Dorrough (DSE)

Summary

Problems with soil and water and declines in native biodiversity have been linked to clearance of native vegetation. We consider future landscapes with substantially more native vegetation than at present to deal with these natural resource problems. Plantings will be slow to mature so optimal planning for landscape revegetation must consider how long it will take for the new vegetation to provide suitable habitat, both at patch and landscape scales. We will develop an optimization framework incorporating models of vegetation maturation and biotic responses to aid designs for placement and scheduling of replantings to give the best outcomes for biodiversity management given constraints on amounts of retired area and costs of implementation.

Under many national and global pressures, Australia’s agricultural landscapes and communities face imminent change. Other parts of the world have seen major shifts including extensive abandonment of land used for production. Coupled with problems such as dryland salinity, climate change and especially biodiversity decline, Australia needs a framework for optimal planning of reconstructed agricultural landscapes for sustainable biodiversity management. Given the poverty of Australia’s soils, we must consider vegetation maturation and how resources become available for the biota through time into account. The project will provide a framework that will inform land-use managers about optimal placement and scheduling of revegetation actions.

Aims and Background

Sustainable biodiversity management in agricultural landscapes almost certainly will require replanting of large amounts of natural vegetation. Given that only fractions of landscapes (< 30%?) are likely to be made available for replanting, setting priorities for planting needs to be optimized. How much vegetation will be planted per planting (local amounts)? Where in the landscape and of what kind of vegetation (vegetation community) will be replanted? With limited areas and funding, how can the best biodiversity management result be obtained for that investment? While some thinking has already been done on this idea, most of this work has involved finding optimal solutions based on spatial considerations alone. That is, where would vegetation be placed to provide the optimal result for sustaining native biodiversity? This apparently simple idea nevertheless is a difficult one needing sophisticated optimization modelling techniques such as simulated annealing to solve. A major limitation of existing work is that these optimal solutions place vegetation essentially “ready made” in the landscape, ignoring the problem of how long it takes for the vegetation to mature. Most models also do not take into account the senescence of veteran trees, and they assume that existing vegetation will remain suitable into the future.

Therefore, time lags in vegetation maturation are a critical knowledge gap in optimal planning of vegetation placement in future landscapes, This means that time-frames of centuries into the future is the appropriate planning (and modelling) horizon. Much of the land for which we need to make revegetation plans will not produce fast growing conditions, so that many important ecological resources (tree hollows, fallen timber) will not come “on line” for many decades. Bringing in the temporal dimension makes the optimization problem much more complex than spatial models alone, so we will employ advanced decision-theory methods to address these goals.

Our goal is to build an implementable framework for making optimal decisions for replanting natural vegetation for biodiversity management that takes into account time-lags in vegetation development and the subsequent provision of ecological resources for animals. To do so, we will—

- Assemble data and build models representing maturation of habitats of a range of types though time

- Develop quantitative models for locations in landscapes animal species (specifically birds, see below) are likely to occur if *mature vegetation* were available for them, and how species may respond to intermediate stages of vegetation maturation
- Construct quantitative models describing species' dependence upon locations of suitable habitats in landscapes, and
- Build models for finding optimal or constrained optimal solutions to vegetation placement and management under specified sets of constraints (how much land will be available? how many resources [money, personnel] will be available for planting and management?)

Approach

We will focus on the biodiversity futures for the central Victorian box-ironbark system over the next 200 years. Our focal organisms are birds because birds are among (or are) the most responsive groups to landscape-scale structures. Moreover, there are several detailed, spatially explicit data sets that can and will be used to construct models (*Birds Australia 2nd Atlas*, *Birds on Farms*, *Victorian Wildlife Atlas*). We now outline the sets of models to be refined or to be built and describe the unification of models in such a way that the biodiversity implications for alternative future landscape can be evaluated quantitatively.

Groups of Model

Four groups of models are to be built in this project:

- *Birds-in-landscapes models*: bird species' responses to landscape structure (amounts, distribution and type of vegetation)
- *Vegetation dynamics models*: vegetation maturation and senescence models. These refer to growth and decay of the long-lived trees, which provide much of the vertical structure, biomass and resources and have the greatest longevities of the plants. We consider a mature state to have large individuals (or a range of size classes) of the dominant growth forms of the particular vegetation type. Reproductive maturity is encompassed by specifying large individuals, but reproductive maturity need not ensure provision of some resources associated with large size or old age, such as large boughs, woody debris and tree hollows. Models will encompass management effort (methods and intensities of revegetation and on-going management over long periods) and costs.
- *Birds' resources models*: resource provision for breeding and for foraging by individual species of birds as a function of the developmental state of vegetation
- *Landscape-reconstruction models*: the three groups of models are integrated in a fourth, unifying phase, in which biodiversity futures are evaluated under a series of possible landscape-reconstruction scenarios. We will seek the optimal biodiversity outcomes using this phase under specified constraints, such as limited total amounts of vegetation to be regrown, spatial constraints on the positioning of new vegetation, and caps on management costs.

These groups of models are linked logically:

- Group (A) models provide an indication of the potential occurrence of species across the landscape *given* that mature vegetation is in place
- Group (B) models describe the time-course of vegetation maturation and senescence[19] from planting, represented explicitly as a three-layer model (trees, shrubs, ground-layer). These models will give a schedule for the provision of utilizable resources for birds (e.g. shrub and foliage invertebrates, nectar, tree hollows and fallen timber) as a function of maturation state.
- Group (C) models are explicit formulae for individual bird species' resource requirements for foraging and for breeding. Therefore, Group (A) models provide the potential distribution of each species (if vegetation were mature), Group (B) models describe the state of the vegetation and, when linked with Group (C) models, provide an indication of the "suitability" of habitat for satisfying a bird species' foraging and breeding needs.
- Group (D) models yield two outcomes. First, they translate possible landscape-reconstruction specifications into a design for the landscape subject to constraints, such as total amount of vegetation to be regrown (an additional 30%, say), the mix of vegetation types to be regrown and the costs of planting and management. Second, these models will also allow optimization of reconstruction designs subject to those constraints but also to satisfy biodiversity objectives. The latter may be of the form: over 200 years, which design (given vegetation amounts and mix, and costs of replanting and management) provides the greatest amount of vegetation suitable for supporting birds' foraging and breeding requirements? The answer to the latter question should be an integrated one over all species of birds and one that minimizes the chances of very small amounts of suitable vegetation occurring over that 200 year period.

PROJECT 2. OUR RURAL WEALTH: USING FUNCTIONAL RESPONSES OF NATIVE FAUNA TO ASSESSCONSERVATION VALUES OF AGRICULTURAL LANDSCAPES

Chief Investigators: Dr Andrew Bennett (Deakin), Associate Professor Ralph MacNally (Monash), Dr Jim Radford (Deakin)
Partner Investigators: Dr Josh Dorrough (DSE), Dr Robin Adair (DPI)

Summary

Agricultural environments are undergoing great change due to economic, social and environmental pressures. Significant shifts in land-use may sustain agricultural productivity, but as a nation we risk the loss of our natural wealth - native flora and fauna. The aim of this project is to develop and test a new approach for assessing the conservation value of agricultural landscapes in Australia. It is based on identifying the functional responses of the fauna to the extent and pattern of native vegetation and types and intensity of agricultural land-uses in whole landscapes. Different response types will be interpreted in relation to ecological characteristics of species. We will use this knowledge to predict the status of birds and mammals in novel landscapes in three bioregions, and test the predictions by field studies. This new landscape-level approach will help land managers assess present agricultural environments as well as evaluate scenarios for future changes in land-use. This knowledge will enhance our national capacity to integrate nature conservation and agricultural productivity.

Aims

This collaborative project pioneers a new approach to assessing conservation values that moves beyond conventional measures (such as species richness or vegetation cover), to one based on the *functional responses* of fauna to agricultural landscapes. By ‘functional response’ we mean the way in which the occurrence or abundance of a species is related to the amount, composition and configuration of native vegetation, together with the types and intensity of human land-use in the landscape. This project also makes a conceptual advance from current thinking based on responses of native fauna in *individual* patches of habitat, to understanding how they respond to whole mosaics of agricultural land-uses and native vegetation *at the landscape scale*.

The project has two main aims.

1. To quantify the *functional responses* of birds and mammals to agricultural land mosaics. We will identify the types of functional responses that species show, the attributes of agricultural landscapes to which they most strongly respond, and the ecological characteristics of species associated with particular types of response.
2. To develop a predictive framework for assessing the conservation value of agricultural landscapes for native fauna. We will test the generality of the framework by developing *a priori* predictions of conservation value for novel landscapes in contrasting bioregions and testing them by field investigations.

Background

The persistence of species in agricultural environments strongly depends on the types of habitats that each species can use, and the spatial configuration of those habitats in the landscape. To date most studies of the response of wildlife to habitats in agricultural landscapes have been carried out at the ‘patch-level’ – that is, the unit of study has been individual patches of habitat and their use by the fauna. This has provided knowledge of how the richness and composition of faunal assemblages, and the occurrence of individual species, are related to attributes such as the size and shape of patches of remnant forest or woodland, their position in the landscape and the quality of habitat within those patches.

However, there is a growing call to expand the scale of investigation to a broader ‘landscape level’, and to recognize the range of land-uses in a rural environment that may influence the biota – not simply patches of remnant vegetation. If we are to assess the value of agricultural landscapes for biodiversity conservation, we must view them as mosaics and seek to understand how the pattern of the *overall mosaic* affects the occurrence of species and the functioning of ecological processes.

Recognising groups of organisms that share similar types of functional responses is an approach that has been widely used in plant ecology and conservation; for example, understanding responses of species to fire or other disturbance processes and relating them to ecological traits. However, this approach has received limited attention in animal ecology, although a notable exception is the use of functional response groups of ants as environmental indicators.

A major challenge for landscape ecologists and conservation biologists is seek generality in research outcomes: that is, to understand the extent to which the findings from a particular study location can be reliably applied beyond that context to predict likely outcomes in other locations. It is simply not feasible, however desirable, to carry out detailed studies of the native biota in all agricultural regions. Making predictions about ecological outcomes is difficult. Nevertheless, decisions about land use in agricultural landscapes will be made, with or without ecological knowledge. If a reliable predictive approach can be developed, it offers great advantage for land-use planning, and will also advance conceptual understanding in ecology.

This research project builds upon an existing project (*Landscape thresholds for conservation of biodiversity in rural environments*) to be completed in 2004. The existing project (funded by Land and Water Australia and Dept Sustainability & Environment, Victoria) has systematically collected data on the occurrence and abundance of birds and mammals in a series of rural 'landscapes', each 10 km x 10 km (i.e. 100 km^2), selected to represent a gradient in extent of native vegetation from 2% to 60% cover. Results from this work are exciting, and provide clear evidence for a 'threshold response' to vegetation cover for richness of woodland-dependent birds. This data set is unique in Australia in providing an opportunity to investigate further how a wide range of native species respond to agricultural mosaics at the landscape level.

Approach

1. Understanding functional responses of birds and mammals to agricultural landscapes

The first step is to identify the way in which different components of the fauna respond to landscapes that have different patterns of land-use. Field data for birds and mammals (excluding bats) have been systematically collected from 24 landscapes (each 100 km^2) in northern Victoria. These landscapes are in rural environments within a defined climatic range, and were selected to represent differing amounts of tree cover, ranging from 2% to 60 % of the landscape. The dispersion of tree cover ranges from highly clumped to scattered throughout the landscape. Data for each species is available as presence/absence in each landscape, or as a measure of abundance based on the number of survey sites at which it was recorded (n=10).

Potential influences on responses of species include (*data already collated):

- total extent of remnant tree cover in the landscape*
- type of native vegetation (based on mapped vegetation classes)*
- size class and spatial dispersion of patches of vegetation*
- extent and pattern of streams and wetlands*
- habitat condition*
- types and intensity of agricultural land uses
- size of paddocks and farm properties (intensity of agricultural land use)
- topographic variation, elevation*
- soil types
- climatic conditions (rainfall, temperature)*

Univariate correlations and comparisons between measures of faunal occurrence/abundance and landscape descriptors will be used initially to explore the types and strength of relationships between species and landscape properties. Multivariate approaches (e.g. MDS ordination) will then be used to identify species that have similar types of responses (functional response groups) (see Fig. 1). The landscape attributes to which each species or group of species most strongly respond, will help define the different types of functional responses. For example, some species may respond most strongly to variables relating to the extent and patch size of native vegetation in the landscape, while others may respond to the type and intensity of agricultural land uses, or relative representation of riparian vegetation.

These sets of responses will be important for land managers, by providing better understanding of the types of landscape change likely to have greatest impact and the types of species likely to respond to a particular type of change.

We need to go beyond identifying the types of responses that species display, to being able to understand why they respond in this way. That is, we seek to understand the ecological basis for the functional responses. A range of ecological and life-history characteristics will be tabulated for each species, such as body size, territory size, movement patterns, diet, reproductive output and frequency, social organisation and habitat specificity. We will then explore the use of neural network models and genetic algorithms to examine the relationships between functional response groups and ecological attributes (see Fig. 1). By relating functional responses to ecological attributes, we are able to predict responses in species not previously encountered.

Finally, predictive, quantitative models (e.g. generalized linear models) of species richness for each functional response group will be developed, based on landscape attributes (see list above). By measuring the same landscape attributes in new landscapes, we can calculate the predicted values expected for each response variable. In this way, we will generate quantitative a priori predictions that are directly amenable to testing.

2. Assessing the conservation values of new landscapes – a predictive approach

The second component is to evaluate the predictive capacity of the landscape attribute models and hence our ability to predict the conservation values of novel agricultural landscapes. Our intention is not to predict the occurrence or abundance of individual species; rather, to predict the richness of different response groups and therefore help land managers to assess the relative composition and conservation status of the fauna in landscapes where it is not possible to carry out extensive surveys. We will develop and test predictions in two phases (see Fig. 1):

a) First, predictions will be generated for six new landscapes in the same region as that from which the models were derived (north-central Victoria). This will test for internal reliability of the predictive approach, particularly the allocation of species to functional groups.

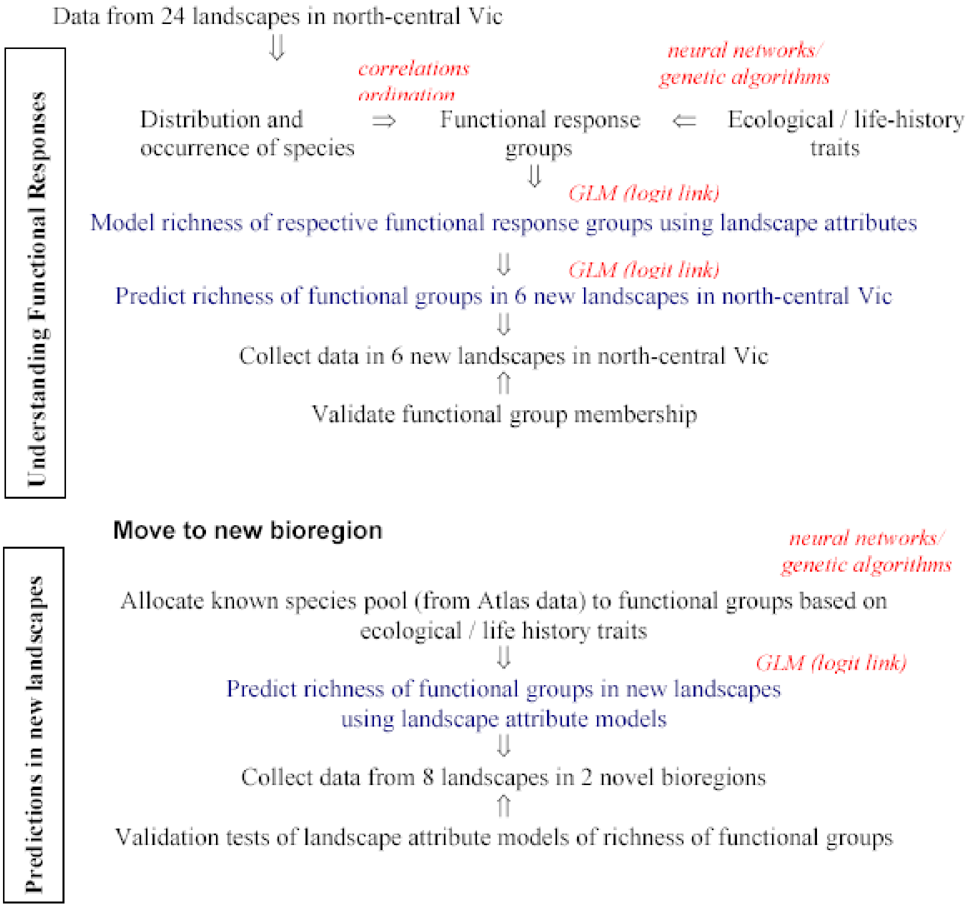
b) A second set of predictions will then be generated for eight new landscapes in each of two other bioregions, one that has a drier climate (Mallee region) and one that has a more mesic climate (south-western Victoria). These will test the general applicability of the approach in new environments. An added test for the modelling framework will be its adaptability to new species pools: a truly robust predictive tool should be applicable across a range of environments with associated variation in species composition. The process will involve several steps (Fig. 1).

- in the new bioregion, species known to occur (from Atlas data bases) will be allocated to functional groups based on their ecological attributes and life-history traits (using the neural network or genetic algorithm models).
- the predicted richness of functional groups in landscapes in the new bioregion will then be calculated by using the landscape attributes models. Note that we will model richness as the proportion of species within each functional group, because the overall species pool differs between bioregions.
- these predictions will then be tested by undertaking field surveys in the new landscapes. Because we have allocated species in the new region to functional response groups (from their ecological traits), we can then tally the proportion of observed species in each response group and compare it with that predicted for each group from the landscape models.

Testing these predictions requires systematic collection of field data on the occurrence and abundance of birds and mammals in the new landscapes. Protocols for site selection and faunal sampling have been carefully established and field-tested in north-central Victoria, and will be repeated in the new landscapes. These field surveys for birds and mammals are a major undertaking, involving a range of procedures at each of 220 sites (22 landscapes x 10 sites).

Birds: two censuses per season for each of two seasons (spring/autumn) on a 2 ha transect at each site

Mammals: one spotlight transect at each site, diurnal searches for tracks and signs, direct observations, 10 hair-sampling tubes at each site. We do not propose to undertake trapping because of the massive effort required for 220 sites. In the drier environments (such as north-central Victoria) the few species of ground mammals occur in low abundance, and hair-tubes have proved successful in detecting them.


Data from 24 landscapes in north-central Vic
Understanding Functional Responses
correlations
ordination
neural networks/
genetic algorithms
Distribution and occurrence of species
Functional response groups
Ecological / life-history traits
GLM (logit link)
Model richness of respective functional response groups using landscape attributes
GLM (logit link)
Predict richness of functional groups in 6 new landscapes in north-central Vic
Collect data in 6 new landscapes in north-central Vic
Validate functional group membership
Move to new bioregion
Predictions in new landscapes
neural networks/
genetic algorithms
Allocate known species pool (from Atlas data) to functional groups based on ecological / life history traits
GLM (logit link)
Predict richness of functional groups in new landscapes using landscape attribute models
Collect data from 8 landscapes in 2 novel bioregions
Validation tests of landscape attribute models of richness of functional groups

PROJECT 4. RE-IMAGINING THE AUSTRALIAN SUBURB: BIODIVERSITY PLANNING IN URBAN FRINGE LANDSCAPES

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Summary

Over 40% of nationally listed threatened ecological communities occur in urban areas. Accelerating urbanisation in Australia is considered one of the greatest threats to biodiversity. This threat will increase without a more strategic approach to conservation planning in urban environments. Protection of biodiversity in urban areas brings numerous societal benefits but involves complicated tradeoffs between competing land uses including housing development, agricultural production and conservation. This project builds on recent advancements in ecological modelling and mathematical optimisation to develop and test tools to facilitate transparent decisions based on optimal trade-offs between competing values. It will result in a more strategic approach to planning conservation in urban environments.

Aims and Background

Governments at all levels place considerable emphasis on urban planning, and have commitments to ensure that developments are socially and ecologically sustainable (Commonwealth of Australia 2003a; Government of Victoria 2003). However, there is currently little scientific input into the biodiversity aspects of the urban planning process and any consideration of biodiversity values is, at best, ad-hoc. Rapidly increasing urbanisation rates pose a threat to the substantial biodiversity values of the urban fringe (Williams *et al.* 2001) and create an urgent need to improve conservation planning practices in those areas. An opportunity exists to substantially improve the way biodiversity is considered in planning the future of the urban fringe. In this project, we will develop and test methods that can be used to optimise tradeoffs between land uses in urban fringe areas, including housing development, agricultural production and conservation. This project is part of *Re-Imagining the Australian Suburb*, a larger collaboration based at RMIT University that examines the key dimensions of sustainability in the suburbs.

Consistent with a worldwide trend, the size of Australian cities has increased dramatically over the last 100 years (Global Urban Observatory and Statistics Unit 1999). Increasing numbers of people are choosing to live in urban environments, with nearly 75% of Australians living in the metropolitan areas of capital or smaller cities and this is projected to increase to 90% by the year 2011 (Newman *et al.* 2001). The growth of urban areas has resulted in the loss of natural habitats and fragmentation of the landscape, and urbanisation is now considered one of the greatest current threats to Australia's biodiversity (Williams *et al.* 2001). The biodiversity value of remnant areas is considered nationally and internationally significant, with over 40% of nationally listed threatened ecological communities (Newman *et al.* 2001) and more than 50% of threatened species occurring in urban fringe areas (Yencken & Wilkinson 2000). Aside from the ecological significance, conservation of native plants, animals and ecological communities increases the quality of life in cities, and provides a number of important ecosystem services (Binning *et al.* 2001).

Conservation planning in the urban fringe poses several key challenges. Firstly, a long-term strategic view is required, as ad-hoc conservation efforts will ultimately fail to protect remnant patches of vegetation (Pressey *et al*. 1993) either from outright loss or gradual degradation due to the incremental pressures of urbanisation. Secondly, protection of habitat for biodiversity in urban fringe areas involves tradeoffs between a complex range of land uses including housing development, agricultural production and conservation, and the intensity of the pressures placed on natural areas is often much higher than other regions. Thirdly, in these modified landscapes, significant funding is available for restoration and revegetation projects, which are often required through Net-Gain policies (eg., Parkes *et al*. 2003). However, decisions regarding the location and types of plantings are relatively ad-hoc and the biodiversity value of current approaches is questionable (McCarthy *et al*. in press).

There is likely to be benefit gained from the application of systematic conservation planning tools that have been used in planning processes for protected areas (eg., Margules & Pressy 2000). Conservation planning has two key objectives: representativeness and persistence (ibid). Several approaches have been proposed that attempt to achieve one or other of these objectives within a planning framework, including the application of general principles derived from island biogeography (Simberloff 1983), numerical optimisation frameworks based on principles of irreplaceability (Ball & Possingham 1999), focal species (Lambeck 1997) and umbrella species (Noss & Cooperrider 1994) approaches and metapopulation viability models (Akçakaya *et al.* in press). However, there is little guidance for agencies planning for conservation in the urban fringe regarding which of these methods is most appropriate or practical under given circumstances. In addition, few attempts have been made to optimise landscapes for both representativeness and persistence (e.g., Haight *et al.* 2002) and developing methods that integrate the two objectives has been identified as an important research need (Opdam *et al.* 2002). .

An opportunity exists to develop clear recommendations for conservation planning in the urban fringe that optimises the trade-off between conservation objectives and other competing demands of urbanisation within legislative and policy constraints. This project will develop recommendations about suitable tools and rules of thumb that will facilitate a more strategic approach to conservation planning in urban environments. Recommendations will be made on the basis of case studies in the urban fringe landscapes of Melbourne. Case studies will be realistic and generalisable because they will involve all of the key players responsible for planning in Melbourne's urban fringe. These players, all of whom are partners in this project, include local governments, Melbourne's catchment management authority, the property developer Stockland, and Victoria's Department of Sustainability and Environment.

A fundamental outcome of the project will be to promote design and management of urban fringe landscapes based on a sound, scientific understanding of landscape patterns, species requirements and environmental pressures. Specifically, the aims of the project are:

- To identify the biodiversity values of Melbourne's urban fringe areas.
- To develop landscape planning tools to optimise the spatial arrangement of protected areas for a set of key values. Optimisation will be carried out for a set of negotiated scenarios representing alternative tradeoffs between housing development, agricultural production and biodiversity conservation.
- To assess proposed planning scenarios in terms of persistence and response of broad groups of species, utilising individual species and generalised modelling approaches.
- To provide a practical framework for applying the Net Gain policy as an example of methods to assist with prioritising areas for revegetation and restoration.

Approach

The approach to this project may be broadly divided into four parts.

1. **Collate data:** Broadly identifying biodiversity values of Melbourne's urban fringe areas and developing geographic information system (GIS) layers to use in the optimisation phase. The project will be based on a case study area in Whittlesea/Hume City Councils in a region earmarked for development over the coming decades. Both municipalities incorporate urban and rural land-uses, and face many challenges in managing potential conflicts between urban development, agricultural intensification and the protection of environmental values. GIS layers developed will include detailed habitat maps for a range of species, ecological vegetation classes (Oates & Taranto 2001) and layers representing the tradeoffs, such as land productivity and economic value. Habitat maps will be developed using similar approaches to those in the ARC Linkage project C00106936. These methods integrate expert judgement and data to predict the distribution of species as a function of important explanatory variables. Recent developments by Wintle *et al.* (in press) will allow us to account for errors in the data, particularly false absences. Field data collection will be necessary to supplement gaps in the current data and to validate habitat maps. This part of the project will rely on data and expertise provided by the industry partners, and will require extensive cross-agency collaboration.
2. **Develop scenarios:** In collaboration with industry partners, a set of planning scenarios and evaluation criteria will be developed through a series of workshops. The scenarios and evaluation criteria will then be converted into planning objective functions that will be optimised for the case-study area. This will require the development and refinement of landscape planning tools to optimise the spatial arrangement of land uses in urban fringe areas for a set of key values. Several scenarios will be developed representing different tradeoffs between competing land uses. The scenarios will be developed on the basis of criteria such as the percentage of habitat protected, the connectivity of habitat, the number and arrangement of new housing developments, the value of

agricultural production and recreational uses. This part of the project will build on existing landscape planning approaches (using the software MARXAN (Ball & Possingham 1999). MARXAN uses simulated annealing to find good solutions to conservation planning problems. Targets for the amount of habitat protection and its spatial configuration will be obtained from generalised population viability models (e.g., Burgman *et al.* 2001) and empirically based conservation planning approaches (e.g., Lambeck 2003). We will then use MARXAN to optimise the economic value of urban development subject to the biodiversity constraints. Similarly, we will also maximise the biodiversity values, subject to economic constraints. These two approaches to the problem will allow us to examine tradeoffs between development and biodiversity conservation. The industry partners will provide data that are used in this optimisation process, and will help the CIs interpret the importance of the optimisation output.

3. **Test impact of scenarios on biodiversity persistence:** investigating the impact of the various landscape scenarios on the persistence of native biodiversity. Initially, population viability models will be developed for a range key species, although an important focus will be exploring and evaluating ways to generalise population modelling. As with any modelling exercise, the development of the viability models will involve extensive and iterative consultation with relevant experts. This part of the project will evaluate scenarios with different designs and on-ground management approaches (e.g., mowing/revegetation/weed control) to consider temporal aspects of conservation planning. This component of the project will link closely with current ARC funded projects involving McCarthy and Bekessy (Coo106936, DP0346165) and a collaboration between Wintle, Bekessy and the Canadian Forest Service. This will allow us to evaluate a range of protocols that have been suggested for conservation planning (e.g., Burgman *et al.* 2001; Lambeck 2003; Parkes *et al.* 2003; McCarthy *et al.* in press). While there is considerable uncertainty associated with using population viability models to predict actual risks of extinction (Taylor 1995; McCarthy *et al.* 1996; Beissinger & Westphal 1998; Fieberg & Ellner 2000), these models appear to be useful for predicting changes in risks of extinction and for ranking different management strategies (McCarthy *et al.* 2003). The models allow the available data and information to be integrated in a manner that is comprehensive, explicit and repeatable, which then allows a transparent assessment of the consequences of different management strategies (McCarthy *et al.* in press).
4. **Develop generalisations and recommendations about suitable strategies for biodiversity planning in the urban fringe:** In collaboration with industry partners, the results of the previous three sections will be evaluated and a series of general recommendations about planning approaches, tools, and landscape design principles will be generated. In addition to the results of the current project, these generalisations will be informed by our work with the other projects with which we are involved (as mentioned below). Publication of results will be undertaken in international journals and dissemination of results will be achieved through local government workshops and the ecological society, and planning institute conferences providing an important nexus between the two disciplines.

This project builds on the results of current ARC projects and other collaborations in which research partners are currently involved. In collaboration with Professor Hugh Possingham, McCarthy is currently working on developing theory for the management of ecological systems as part of an ARC Discovery grant (DP0346165). Part of this work involves the further development of conservation planning tools, which will be available for use in this project. McCarthy and Bekessy have involvement in an on-going ARC project (C00106936) designed to link landscape ecology and management to population viability analysis. This project is concerned with exploring relationships between extinction risk and the amount and spatial configuration of habitat for a variety of rare, threatened and sensitive forest-dependent species in Northeast Tasmania. Wintle and Bekessy are currently involved in a collaboration with the Canadian Forest Service investigating the utility of landscape dynamic population modelling methods in assessing forest silvilcultural management options. The project has utilised new innovations in landscape modelling software (Akcakaya *et. al.* in press) to predict future landscapes composition under a range of management scenarios. These predictions are then used to assess the impact of different management options on indicator species through the application of population viability analysis (Burgman *et al.* 1993).

PROJECT 4 A LANDSCAPE-SCALE SIGNATURE OF BIODIVERSITY HEALTH; MEASURING THE IMPACT OF LANDSCAPE CHANGE ON BIODIVERSITY

Chief Investigators: Angela Avery, Robin Adair, Dr Vivienne Turner, Penny Riffkin, Dr Tony Parker, Dr Andrew Bennett, Dr Kim Lowe, Dr Pauline Mele.

Background

The composition of rural landscapes is influenced by a multitude of environmental, economic and social factors that shape land-use activities in a temporal and spatial context. Landscapes often change under these influences in a chaotic, ad hoc manner, but are also strongly directed by a range of governing policies, incentives schemes, and planning activities. Broad and expanding community awareness of the functionality, conservation value and aesthetics of biodiversity in rural landscapes requires that alterations to landscape pattern, whether in a planned or unplanned context, encompass impact assessment on biodiversity values. While species-based and plant or animal community-based assessments are a regular feature of impact assessment procedures within the three tiers of government, broad-scale assessment of biodiversity health and impact of change has not been possible beyond site-specific foci eg. habitat hectares (Parkes *et al*. 2003).

A **landscape-scale signature of biodiversity health** requires broad-based criteria that capture the contributions from the full spectrum of land-use types ranging from areas dedicated to nature conservation, agricultural/horticultural production zones in the surrounding matrix, urban land-use areas, water production zones and non-reserved land-use areas etc. Assessment criteria that are based on empirically-determined rules sets where the relationship with biodiversity indicators is known or at least can be substantiated with case studies, should provide the basis for a landscape-scale measure of biodiversity. Additionally, assessment criteria need to be readily measurable and the tests repeatable so that the impact of landscape changes can be quantified.

The Victorian Departments of Primary Industries and Sustainability and Environment aims to construct a Landscape Biodiversity Index (LBI) to record the impact of landscape change on biodiversity using eight broad-based environmental indicators. The preliminary thinking indicates that fundamental ecological principles form the basis of all assessment criteria. Most will require field-based validation under Australian conditions to justify their inclusion in the assessment procedure. This application seeks funding to quantitatively determine the relationships between several environmental criteria used in the LBI and biodiversity using functional group indicators.

Objectives

Three hypotheses (A, B, C) will be tested that examine the relationship between land-use in the landscape matrix and biodiversity conservation values. In the rural landscape, the matrix will consist largely of agricultural-based land-use activities. The hypotheses are:

Perennial vegetation**:** landscapes dominated by perennial agricultural vegetation support a greater range of indigenous biodiversity, as measured by target functional group representation than landscapes dominated by exotic annual species. This hypothesis assumes that agricultural enterprises, based on perennial vegetation, albeit exotic, will more closely mimic native landscapes which exhibit a high degree of natural perenniality and inherently less frequent disturbance regimes will increase.

Landscape mosaic complexity**:** complex landscape mosaics support a greater range of indigenous biodiversity, as measured by target functional group representation, than simpler landscapes. This hypothesis is based on the assumption that land-use types vary in their capacity to support biodiversity and as the range of land-uses increases in the landscape, there is a proportional increase in the range of organisms supported. The hypothesis assumes that different land-use types make approximately equivalent contributions to biodiversity enhancement.

Scattered trees**:** landscapes with higher densities of mature, scattered, native trees support a greater range of indigenous biodiversity, as measured by target functional group representation, than landscapes with fewer trees. This hypothesis assumes that individual trees in a rural landscape, contribute to biodiversity in a similar manner as total vegetation cover (Radford & Bennett 2004) and that as remnant tree density increases there will be a linear to curvilinear increase in biodiversity.

Methods

Using GIS map overlays, study landscapes (sites) will be selected from within a single bioregion in Victoria. In order to test the first hypothesis (A), sites will be chosen representing a continuum in the amount of perennial agricultural vegetation present in the landscape. The three target functional groups will be measured: birds, insects, and soil microbiota. Sampling will occur from spring – mid summer. Data will be analysed using Principle Co-ordinate Analysis (PCA) with the methods refined following biometric input prior to sampling. In order to test the second hypothesis (B), sites will be chosen representing a continuum, from less diverse to more diverse landscapes in terms of land-uses. Sites will be large (500-1000+ ha) and selected to avoid or accommodate confounding due to differences in levels of perenniality. Birds and aerial insect fauna will be sampled. . Data will be analysed using PCA. To test the third hypothesis (C), sites will be within a single land-use class (eg grazing), at least 20 km from native vegetation remnants >10ha, and will range in tree density from 0-100 trees/ha. Sites will be separated by at least 10 km. Birds, bats and aerial insects will be sampled.

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