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THE CONSERVATION OF WIDELY DISTRIBUTED SPECIES: IMPLICATIONS OF DIFFERENCES BETWEEN WESTERN AND EASTERN KOALA POPULATIONS

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INTRODUCTION

Regional variation in species-habitat relationships, where species have natural geographic ranges extending over multiple biogeographic regions, has seldom been studied (Whittingham *et al.* 2005) and simple conservation rules, uniformly applied over multiple regions, may be ineffective for these species. The koala is one such species. It is widely distributed in eastern Australia, extending over 30 bioregions from Queensland to South Australia. Studies in southern and eastern Australia have reported sensitivity to landscape change, urbanisation and amount and connectivity of high quality habitat (Rhodes *et al.* 2006; McAlpine *et al.* 2006a; 2006b). Populations are in decline due to habitat loss and fragmentation, dog attacks, vehicle collisions and disease (ANZECC 1998). However, we have little idea whether these relationships hold generally across the koala's broad geographic range and management of western koala populations based purely on data from eastern populations is a risky strategy.

Arid and semi-arid areas occupy approximately 696,000 km^2 or 43% of the koala's total distribution. The Mulga Lands (Qld) and the adjoining Darling Riverine Plains (NSW) bioregions support a significant koala population (Sullivan *et al.* 2003; Sullivan *et al.* 2004), despite approximately 40% of potential koala habitat in Queensland's Mulga Lands being cleared between 1969 and 2004. The distribution and population dynamics of koalas in these areas are not well understood and their status and trend is in dispute. Studies suggest western koalas face threats from habitat loss and fragmentation, thermal stress due to increased heat-waves and drought, and restrictions on normal koala dispersal (Sullivan *et al.* 2004; Gordon *et al.* 2006). Exploring the role of increasing temperature in driving species' distribution patterns has assumed a sense of urgency as the global climate becomes warmer. Throughout the western koala's range, the frequency of droughts and heatwaves are expected to increase and moisture availability decrease. Previous studies indicate that summer heat-waves and drought caused significant mortality (~ 63%) among koala populations (Gordon *et al.* 1988). We need to quantify how vulnerable western koalas are to predicted climate change and how this is likely to interact with landscape change.

The project aims to identify: (1) the relationships between the amount and spatial configuration of habitat and koala distribution and viability; (2) the impact of landscape history; and (3) the likely impact of climate change/variability. A comparison of these findings with previous work on eastern koala populations will enable a broader understanding of regional variation in these relationships and the implications for regional conservation planning.

METHODS

The experimental design will apply a nested hierarchical approach to address the research questions and objectives. The data collected will be coordinated and nested within four ecologically relevant spatial-levels: the bioregion (10,000s km^2), the landscape (100 km^2), sub-landscape (1,000s ha), and the site (<1 ha). Each spatial level represents a different ecological focus, each being representative of the spatial and temporal scale at which koalas interact with, and are constrained by, their environment. The study will focus on the Mulga Lands and Darling Riverine Plains biogeographic regions of southwest Queensland and northwest New South Wales. Mean annual rainfall is 600 mm in the east, declining to 250 mm in the west. Vegetation clearing for cropping (mostly cotton) and improved pasture is concentrated in the east of both regions, where koala populations are also concentrated (Sullivan *et al.* 2003).

Objective 1: Determine current koala distribution, habitat suitability and potential geographic range (bioregion) - Community surveys, targeting pastoral properties and urban communities, will be used to quantify the current range of koalas in the study region. The community survey form will consist of an A2 map sheet and an explanatory letter and a questionnaire, seeking information on where wildlife, including koalas, has been seen, perceived changes in wildlife abundance and pest status. There will also be a web-based version of the questionnaire. Habitat suitability will be classified from regional ecosystem mapping from the Queensland Herbarium and NSW DECC, following a method developed by McAlpine *et al.* (2006a; 2006b). Bioclimatic (temperature, rainfall, humidity) and environmental data (soils, vegetation) will be used to determine parameter estimates for bioclimatic models and determine the potential geographical range of koalas.

Data will be entered into a GIS database containing land tenure, pastoral property boundaries, habitat suitability, environmental and bioclimatic layers. This will give us the current distribution and potential geographic range and western limits of koalas.

Objective 2: Assess population and habitat use dynamics (landscape) - The current geographic range will be stratified into 10 x 10 km landscapes (n ≈ 50), each with different spatial configurations and area of remnant koala habitat and regrowth vegetation. Faecal pellet searches will be used to detect koala presence/absence. This method will allow us to determine koala presence/absence over 10,000s-100,000s ha within a relatively short time. A presence will be recorded for each site where one or more koala pellets are found. Habitat structure, configuration and other landscape attributes will be collected for each site, and landscape history for each 10 x 10 km landscape will be mapped from air photos. Population density will be derived using the standing crop methodology developed by Sullivan *et al.* (2002) in a range of ecosystems/habitat types used by koalas. Those ecosystems/habitats will include those where there is a previous estimate by Sullivan *et al.* (2004) for comparison, and for assessing likely changes in koala density and distribution over the past decade. Understanding the genetic structure of sub-populations or metapopulations is also important to achieve satisfactory broad scale conservation outcomes in the very long term. Genetic data will be collected from cell DNA sloughed off from the GI tract and excreted in faecal pellets. The results will be analysed to determine the degree of genetic divergence of western populations and the relationship between this divergence and environmental/landscape heterogeneity and landscape history.

Data will be integrated into a multi-scaled GIS for each landscape. We will quantify the role of landscape attributes on koala occurrence using generalised linear models similar to those applied by McAlpine *et al.* (2006a; 2006b) for eastern koala populations. The importance of landscape variables, including landscape history, their effect sizes and associated uncertainties, will be determined using information-theoretic and/or Bayesian approaches.

Objective 3: Assess the viability of koala populations in response to landscape change (sub-landscape/site) - We will capture and satellite collar a number of koalas to determine the movement of individuals in relation to habitat type, patch size, cleared ground and landscape connectivity, especially riparian corridors. Tracking will be conducted for ≈ 20 individuals for approximately 15-18 months, thereby quantifying movement patterns under a range of temperatures and rainfall. We will determine which habitats are selected by individuals within their home range, and the dispersal movement of individuals across landscapes with varying spatial configurations of habitat. Habitat selection is important for understanding population processes, and will be analysed using a similar approach to Rhodes (2005).

Identifying variations in stress and reproductive hormones is important when assessing social dominance and reproduction in most animals. This study will use faecal steroid and hair sample assays to assess stress and reproductive status in koalas. Both methods indicate circulating hormone levels over the period during which the products were being formed and stored. This enables the stress hormones to be measured without any interference from possible stress caused by trapping (Bradley 2003). We will analyse these samples and test for spatial relationships with landscape structure, landscape history and environmental gradients. Physical condition will be assessed by determining a condition index obtained from body mass and tibial length measurements. Animals will be routinely assessed in the field to estimate fecundity and mortality, information vital to parameterising the mechanistic population model.

We will initially utilise the empirical models developed in Objective 2 to assess the viability of koala populations under a range of landscape structures and climate change scenarios. We will extend these models and the viability analysis to mechanistic population models. This will allow a greater understanding of the underlying processes involved in driving changes in koala populations and provide better predictions for scenarios that extend outside of the range of data used to fit the empirical models. Further, by using these two different approaches, the robustness of the predictions can be assessed. The mechanistic population models will be parameterised using data collected in this Objective, and from other studies. We have previously developed spatially-explicit population models for eastern koala populations (Rhodes *et al.* 2005) and, as a first step, this model will be re-parameterised for western koala populations. In addition, we aim to develop novel Bayesian state-space models of the spatial dynamics of koala populations.

Objective 4: Assessing the impact of climate change and the interaction with landscape change (bioregion/landscape) - We will evaluate the performance of a range of climatic and statistical models using the bioclimatic analysis of existing koala distributions to provide a baseline for predicting and modelling the effects of climate change on habitat (Objective 1) (sensu Lawler *et al.* 2006). Using down-scaled climate change scenarios derived from CSIRO and Queensland Department of NRW, we will identify future climate including mean annual temperature, rainfall, frequency of droughts and heatwaves and use these data to predict the likely shifts in the koala's geographic range according to changes in temperature and rainfall gradients. The dispersal of koalas through fragmented landscapes altered by climate-induced landscape changes will be modelled using rule-based GIS models and cellular automata. The rules driving these dispersal models will be derived from the knowledge gained under Objective 2 on the role of landscape attributes for koala occurrence, and the bioclimatic outputs describing changing geographic ranges. Therefore we will gain an understanding of spatial and temporal dynamics of koala populations under changing climatic conditions.

Objective 5: Compare western koala population dynamics and threats with those of eastern koala studies - This objective will compare the results from Objectives 2-4 with the previous work for eastern Australia, with a focus on the importance of landscape, patch and site-level variables on koala occurrence and the presence of critical habitat retention thresholds. Previous work demonstrates that habitat loss and fragmentation are major threats to eastern koala populations, but there is considerable variation in the effect and relative importance of most variables. There is also strong support for the existence of threshold responses of koala occupancy to habitat loss for a range of habitat qualities and spatial extents. However, threshold points vary, often substantially, among regions and may be related to differences in habitat quality and demographic rates. A comparison of the western koala case study with the previous results will allow us to address the question: how similar are wildlife habitat relationships and population dynamics in different regions for species with a broad geographic range?

Objective 6: Koala management plan - The project will provide essential spatially and temporally-explicit information, derived from Objectives 1-4. This information will be integrated into a regional koala management plan and guidelines for use by regional natural resource management (NRM) bodies. Spatial prioritisation of financial incentives for on-ground actions appears to be a major challenge for regional NRM bodies. At present, management targets associated with developing or providing financial incentives to landholders do not correlate with an adequate profile of spatial priorities for biodiversity conservation.

REFERENCES

ANZECC (1998). National Koala Conservation Strategy. **Environment Australia, Canberra**.

Bradley, A.J. (2003). Stress, hormones and mortality in small dasyurid marsupials. *In* 'Predators with Pouches: The Biology of Carnivorous Marsupials'. (Eds M. Jones, C. Dickman and M. Archer). **CSIRO Press**, **Sydney**, 250-263.

Gordon, G., Brown, A.S. and Pulsford, T. (1988). A koala (Phascolarctos cinereus Goldfuss) population crash during drought and heatwave conditions in south-western Queensland. *Aust. J. of Ecol.* 13: 451-461.

Gordon, G., Hrdina, F. and Patterson, R. (2006). Decline in the distribution of the Koala *Phascolarctos cinereus* in Queensland. *Aust. Zoologist* 33: 345-358.

Lawler, J.J., White, D., Nelson, R.P. and Blaustein, A.R. (2006). Predicting climate-induced range shifts: model differences and model reliability. *Global Change Biol.* 12: 1568-1584.

McAlpine, C.A., Bowen, M.E., Callaghan, J.G., Lunney, D., Rhodes, J.R., Mitchell, D.L., Pullar, D.V. and Possingham, H.P. (2006a). Testing alternative models for the conservation of koalas in fragmented rural-urban landscapes. *Aust. Ecol.* 31(4): 529-544.

McAlpine, C.A., Rhodes, J.R., Callaghan, J.G., Bowen, M.E., Lunney, D., Mitchell, D.L., Pullar, D.V. and Possingham, H.P. (2006b). The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: a case study of koalas in Queensland, Australia. *Biol. Conserv.* 132(2): 153-165.

Rhodes, J.R. (2005). 'The ecology, management and monitoring of wildlife populations in fragmented landscapes: a koala case study. PhD dissertation.' Brisbane, The University of Queensland.

Rhodes, J.R., McAlpine, C.A., Lunney, D. and Possingham, H.P. (2005). A spatially explicit habitat selection model incorporating home range behavior. *Ecol.* 86: 1199-1205.

Rhodes, J.R., Wiegand, T., McAlpine, C.A., Callaghan, J., Lunney, D., Bowen, M. and Possingham, H.P. (2006). Modelling species distributions for improving conservation in semi-urban landscapes: a koala case study. *Conserv.n Biol..* 20(2): 449-459.

Sullivan, B.J., Baxter, G.S. and Lisle, A.T. (2002). Low-density koala (*Phascolarctos cinereus*) populations in the mulgalands of south-west Queensland. I. Faecal pellet sampling protocol. *Wildlife Res.* 29: 455-462.

Sullivan, B.J., Norris, W.M. and Baxter, G.S. (2003). Low-density koala (Phascolarctos cinereus) populations in the Mulga Lands of south-west Queensland. II. Distribution and diet. *Wildlife Res.* 30: 331-338.

Sullivan, B.J., Baxter, G.S., Lisle, A.T., Pahl, L. and Norris, W.M. (2004). Low-density Koala (Phascolarctos cinereus) populations in the Mulga Lands of south-west Queensland. IV. Abundance and conservation status. *Wildlife Res.* 31: 19-29.

Whittingham, M.J., Swetnam, R.D., Wilson, J.D., Chamberlain D.E. and Freckleton, R.P. (2005). Habitat selection by yellowhammers Emberiza citrinella on lowland farmland at two spatial scales: implications for conservation management. *J. of Appl. Ecol.* 42: 270-280.