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Assessing Climate Change Vulnerability:

Novel methods for understanding potential impacts on Australian Tropical Savanna Birds

Thesis submitted by

April Elizabeth Reside

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School of Marine and Tropical Biology

James Cook University

Townsville, Queensland 4811

Australia

Squatter pigeons (*Geophaps scripta*), a bird of the eastern tropical savannas in Australia.

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Co-authors of published manuscripts within this thesis participated in one or more of the following ways: discussions of concept and study design, advice on methods and editing of manuscripts.

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Publications associated with this thesis

Peer-reviewed publications

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Reside, A. E., VanDerWal, J.J., Watson, I.W., Kutt, A. S. and S. E. Williams (2011) Fire regime shifts affect bird species distributions. *Diversity and Distributions.* early view pp 1-13. DOI: 10.1111/j.1472-4642.2011.00818.x.

Reside, A. E., Watson, I.W., VanDerWal, J.J., and Kutt, A. S. (2011) Incorporating low-resolution historic species location data decreases performance of distribution models. *Ecological Modelling* 222(18): 3444-3448, DOI:10.1016/j.ecolmodel.2011.06.015.

Manuscripts in review

Reside, A.E., VanDerWal, J.J., and Kutt, A.S. (Accepted) Projected changes in distributions of Australian tropical savanna birds under climate change using three dispersal scenarios. *Ecology and Evolution*.

Manuscripts in preparation

Reside, A. E., VanDerWal, J.J., Kutt, A. S., S. E. Williams and S. Garnett (In Prep) Predicting the vulnerability of Australian tropical savanna birds to climate change.

Popular literature

Reside, A. (2008) Times they are a changing. *Contact Call*, Newsletter for Birds North Queensland.

Conference presentations

Reside, A.E., VanDerWal, J., (2011) Predicting the vulnerability of Australian tropical savanna birds to climate change. Ecological Society of Australia conference, Hobart.

Reside, A., VanDerWal, J., Watson, I. and Kutt, A. (2010) How will climate change impact bird species across Australian tropical savannas? Ecological Society of Australia conference, Canberra.

Reside, A. E., VanDerWal, J. J., Watson, I. and Kutt, A.S. (2010) Incorporating altered fire frequency scenarios in species distribution models improves climate change predictions for tropical savanna birds. Association for Tropical Biology and Conservation, Conference in Bali

Reside, A. E., VanDerWal, J. J., Watson, I. and Kutt, A.S. (2010) Predicting the effects of changing fire regimes on tropical savanna birds using species distribution modelling, Birds Australia Congress, Townsville.

Reside, A. E. (2010) Understanding distributions of vagile species in a dynamic landscape. Seminar to the Spatial Ecology Lab at University of Queensland.

Reside, A.E., VanDerWal, J., Kutt, A. and Williams, S. (2010) Improving species distribution modelling using weather, not climate: Temporal data provides better understanding of bird distributions. CSIRO Climate Adaptation Flagship symposium, Melbourne.

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Other peer-reviewed publications generated during my candidature

Godfree, R., Lepschi, B., **Reside, A.**, Bolger, T., Robertson, B., Marshall, D. and Carnegie, M. (2010) Habitat heterogeneity increases resilience and resistance of a keystone grassland species to extreme drought and climate change. *Global Change Biology*. 17: 943-958 DOI: 10.1111/j.1365-2486.2010.02292.x.

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Mokany, K., Richardson, A. J., Poloczanska, E. S., Ferrier, S., and the CSIRO CAF Biodiversity Working Group (Elith, J., Robinson, L., **Reside, A.**, Harwood, T.D., Dunstan, P. K., Williams, K. J., Hilbert, D. W., Austin, M. P., Smith, F., Booth, T. H., Ellis, N., Barry, S.) (2010) Uniting marine and terrestrial modelling of biodiversity under climate change. *Trends in Ecology and Evolution*. 25: 550-551

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Anderson, A. S., **Reside, A. E.**, VanDerWal, J., Shoo, L. P., Pearson, R. G. And Williams, S. E. (In review) Species distribution modelling predicts dispersal mediation of lowland biotic attrition due to climate change in Australia‟s north-eastern rainforest birds. *Global Change Biology*.

Thesis Abstract

The current global biodiversity decline is predicted to be amplified by escalating anthropogenic change. Climate change stands as one of the major threats to biodiversity, and evidence for changing climate such as rising temperatures and altered precipitation have been well-documented. These changes have led to changes in species distributions, assemblages and interactions. The abilities of species to withstand or adapt to climate change are compromised by the synergies between climate change and the other drivers of decline, particularly habitat loss through land modification. The level of threat to biodiversity, coupled with large gaps in the scientific knowledge of many aspects of global biota particularly in the southern hemisphere, necessitates large-scale vulnerability assessments. These vulnerability assessments can be used to focus finite conservation resources to maximise conservation gain.

Tropical northern Australia houses a large proportion of Australia‟s biodiversity, however many species in northern Australia are under threat from climate change, land modification and introduced species. Most of northern Australia is tropical savanna, a biome that covers nearly one-quarter of mainland Australia. Australian Tropical Savannas (ATS) have been substantially less modified than the landscapes of southern Australia, and are consequently considered to be largely intact. However, alarming population declines have been recorded for mammals and granivorous birds that occur within the ATS. Despite the extent and species richness of the ATS, and the need for further conservation attention, no assessments of the vulnerability of ATS fauna to climate change have been conducted to date.

This thesis addresses the need for further understanding of the vulnerability to climate change of birds of the ATS, in two stages. I begin by improving methods for understanding the distributions of ATS birds, firstly by testing whether training distribution models of ATS birds on short-term weather variables better explains distributions when compared with standard long-term climate models (Chapter 2; Reside *et al.*, 2010). Next, I test whether the inclusion of coarse-resolution historic species data decreases the performance of models that are otherwise composed of recent, high-resolution species data (Chapter 3; Reside *et al.*, 2011ba). The second stage of this thesis predicts the impact of major threats to ATS birds: increasing fire frequency (Chapter 4; Reside *et al.*, 2011ab) and climate change (Chapter 5; Reside *et al.*, In Review), by modelling the response of species distributions to predicted change. Finally, I use the predictions of species sensitivity to changes in fire regimes, the predictions of distribution change due to climate change, and information on their

life history and ecology to generate an overall vulnerability assessment (Chapter 6; Reside *et al.*, In prep).

Species distribution modelling (SDM) is a frequently-used tool for estimating species‟ ranges, and predicting how species will respond to future change. However, the SDM process needs to be scrutinised for relevance to the species and system being modelled and the question being addressed. This thesis examines two issues concerning SDM of ATS birds. Firstly, whether the standard method of using long-term (c. 30 year) climate data averages adequately explains the dynamic ranges of ATS birds. ATS birds are highly mobile, with many species tracking resource availability throughout the landscape. Many species have large distributions, and use either nomadic or migratory movements to respond to changes across their range. I found that SDM was improved for ATS birds by training the models on the climatic variables averaged over a short time frame (three, six and 12 months), when compared with models trained on climatic variables averaged over 30 years. The improvement was particularly apparent for modelling distributions of wide-ranging, nomadic and desert species.

The second issue concerning SDM examined in this thesis is whether to include all available species records in the distribution model, or to include species records only with fine spatial resolution. The impact of including historic, coarse-resolution data on model performance was tested using bird location data in a model experiment. I found that models run using both fine- and coarse-resolution data (spatial accuracy ranging from 100 m to 222 km), when compared with models run using only fine-resolution data (mostly with 100 – 500 m accuracy, but with some with 5 km) had significantly lower model performance.

Next, this thesis focuses on two of the major threats to birds of the ATS: increasing fire and climate change. Fire is an integral part of the ATS; however, fire regimes have changed due to shifts in land management practices. Further changes are expected globally, with fire frequency predicted to increase. The impact of increasing fire frequency, and in particular fire frequency confined to the late-dry season, on the distributions of ATS birds was investigated by projecting modelled species distributions onto scenarios of increased fire frequency. Increased annual fire frequency was predicted to result in a distribution decrease for two-thirds of species, but a slight increase in distribution for one-third of species. In contrast, increasing frequency of fire in the late-dry season was predicted to result in 98% of species decreasing in distribution area. These results support the hypothesis that frequent late-dry season fires have a detrimental impact on many species of ATS birds.

The impact of climate change on the distributions of ATS birds was investigated by projecting species distributions to 2080 using a mid-range emissions scenario (A1B) and eight global circulation models.

The impact of dispersal scenario on predictions of species ranges was investigated by comparing future distributions under full dispersal, no dispersal, and a partial dispersal scenario of 30 km per decade. To achieve realistic predictions of species future distributions we assigned each species to the most appropriate of the three dispersal scenarios depending on the mobility and habitat specificity of each species. Under the realistic dispersal scenario, 67% of species were predicted to face distribution decreases by 2080; however many migratory and tropical-endemic species were predicted to increase in distribution.

Finally, I integrated the predictions for changes in species distributions due to changes in fire and climate, and biological and ecological species traits influencing species sensitivity, into a vulnerability assessment of the ATS bird assemblage. The analysis found that overall ATS have low biological sensitivity, but a range of ecological sensitivities. Threatened species have higher ecological sensitivity than non-threatened species, and species restricted to Cape York Peninsula have the highest vulnerability.

Overall, this thesis demonstrates the importance of applying modelling techniques that are relevant to the species and the system being modelled. In particular, the data used in the models and the methods for model training need to be examined to assess their appropriateness in the given ecological context. Additionally, this thesis has made predictions on the vulnerable elements of the ATS bird fauna, specifically in relation to distribution shifts resulting from increased fire frequency and climate change. This information coupled with other extrinsic factors such as land use change through invasive species and land clearing is vital for conservation of the birds of the ATS.

Contents

List of Figures

List of Tables

List of Appendices