What makes species vulnerable to extinction following habitat fragmentation and degradation? A test using the insect fauna in native temperate grasslands in South-eastern Australia

Anett Richter

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Institute for Applied Ecology
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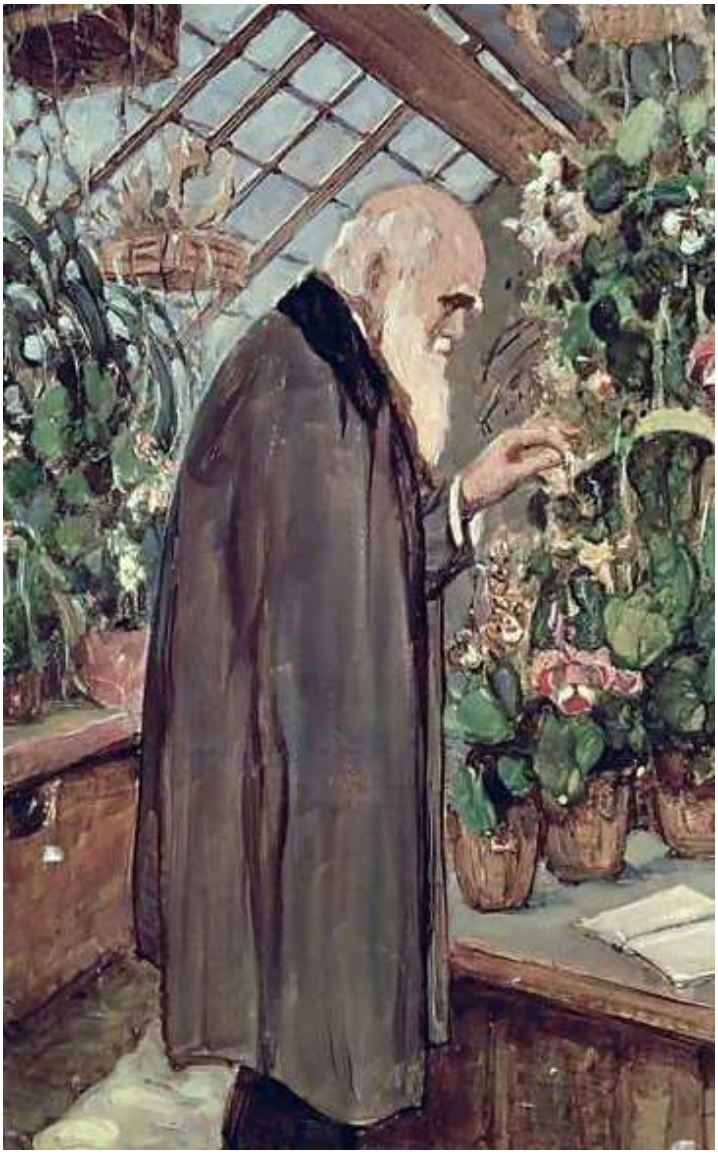

"I have an old belief that a good observer really means a good theorist"

C. Darwin to Bates in 1860 as cited by I.R. Ball (1975)

Charles Robert Darwin (1809-1882) painted by John Maler Collier (1850- 1934)

Abstract

Landscape fragmentation and modification are the main factors believed to be responsible for the current high rates of species declines and extinctions. Native temperate grassland is one of the most threatened ecosystems in Australia having undergone extensive loss and degradation, to the extent that only less than five percent of the original community remains in reasonable conditions. Effective conservation of temperate grassland is hampered by our inability to predict the responses of the biota to further loss and fragmentation, and to changes in the way the grasslands are managed.

In this thesis, I report on a three year study of the conservation ecology of terrestrial insects in highly fragmented native temperate grassland in the Australian Capital Territory (ACT). I examine the vulnerability of carabid beetles (Carabidae, Coleoptera) and scarab beetles (Scarabaeidae, Coleoptera) to modifications in landscape structure and habitat quality following native grassland fragmentation. To complement that study, I also conducted an autecological study of the golden sun moth (*Synemon plana,* Castiniidae, Lepidoptera), a flagship species in the ACT grasslands which is classified as critically endangered at both the state and national levels.

Below, I outline the contents of each chapter that together comprise my PhD thesis.

To begin**, Chapter 1** provides an introduction to the thesis and an overview of our current understanding of the consequences of fragmentation on terrestrial biological diversity. The chapter introduces the reader to insect conservation in Australia with an emphasis on previous insect research conducted in native temperate grassland in the ACT and identifies the gaps in our understanding of how the Australian insect fauna has been affected by large scale natural habitat loss and fragmentation. The general methods of site selection and the rationale for the selection of insect taxa that were investigated are described. Furthermore, I present a summary of the climatic

conditions characterised by above average monthly temperatures and significant deficiencies in precipitation that occurred at the time of investigation.

In **Chapter 2** I review the influence of land use change and predicted climate change on temperate grasslands – an overlooked ecological community at the global scale - and identify future research strategies to halt the further loss of biodiversity in these grasslands. I discuss previous research that has contributed to our understanding of grassland ecology and describe how two major threats to temperate native grasslands (land use change and climate change) might affect the ecological integrity of these grasslands. Based on a consideration of research conducted in three native temperate grassland regions - North America, South Asia and South-eastern Australia - it is concluded that increasing legal protection, a wider public appreciation and more research is required to reverse the current trend of biodiversity loss and to improve the current lack of appreciation of temperate grasslands. In particular, there is a need for more detailed inventory surveys of the temperate grasslands biota and increased autecological research on the invertebrate fauna. The establishment of long term monitoring is required to provide a measurement of the success of conservation action and to relate the effects of historical and current threats to native grassland and component biodiversity.

In **Chapter 3** I modelled the response of carabid and scarab beetles to the effects of fragmentation in highly fragmented native temperate grassland. Zero- inflated models and ordination techniques were applied to relate beetle diversity to fragments size at the level of three basic characteristics of community structure: 1) the number of species (species richness), 2) the identity of those species (species composition) and, 3) the relative abundance of those species. My analysis revealed a clear relationship between the size of native temperate grassland remnants and beetle diversity at the community level and with respect to community composition. Specifically, fragments larger than seven hectares hosted higher numbers of species and individuals of carabid and scarab beetles. Similar trends of increasing diversity with increasing fragment size were observed in the composition of the scarab beetle community. Smaller fragments contained less diverse communities than larger fragments. Overall,

these results indicate that carabid and scarab beetles are sensitive to the reduction of native grassland.

In **Chapter 4** I applied multiple hypotheses testing of single and combined ecological models using Akaike Information Criterion (AIC) analysis to test for: 1) the relationship between habitat heterogeneity and the diversity of carabid and scarab beetles, 2) the relationship between landscape structure and the richness of carabid and scarab beetles, and 3) the influence of kangaroo and livestock grazing and mowing on the richness and abundance of carabid and scarab beetles and arthropods in fragmented native temperate grassland. The analysis revealed that native grassland quality, specifically a rich diverse flora, best described the occurrence pattern of carabid and scarab beetles in the fragmented native grassland. The importance of the type of management was also evident at very high taxonomic resolution (species level). The analysis showed that while management that included mowing positively affected the richness and abundance of ground dwelling arthropods, kangaroo grazing was a factor positively associated with the diversity of carabid and scarab beetles. The intensity of management seemed not to have any significant influence on the distribution of the insect diversity.

In **Chapter 5** the hypothesis that life history traits of grassland beetles can be used as predictors for species sensitivity to fragmentation was tested using carabid beetles (Carabidae, Coleoptera). My aim in this chapter was to assess the relationship between environmental variables and life history traits in ground beetles and to test for the sensitivity of species and associated traits to the consequences of fragmentation. Ordination techniques and three table analysis (RLQ - Analysis) revealed that there was no overall significant effect of environmental variables on life history traits in ground beetles. However, I found significant relationships between the spatial patch characteristics of isolation and floristic diversity and life history traits that are shared among ground beetles found in fragmented native temperate grassland. Species of carabid beetles characterized by larger body size, lower dispersal abilities and restricted biogeographical distribution were most sensitive to the consequences of fragmentation.In **Chapter 6** I examined a range of quantitative characteristic of the biology and ecology of the critically endangered golden sun moth

(*Synemon plana),* a native grassland specialist and a flagship species for these grasslands. I tested the species vulnerability to fragmentation and grassland modification. My data provide clear evidence that *S. plana* at all its life stages (egg, larvae, pupae and adult stage) occupies habitats dominated by native grasses, particularly mixed wallaby grass (*Austrodanthonia* spp,) and spear grass (*Austrostipa bigeniculata*), but can also occur at sites comprised almost entirely of the exotic Chilean needle grass (*Nassella neessiana*). The size of grassland fragments proved to be of less importance. Based on field work conducted over two years I detected the species at 32 grasslands in the ACT with an overall characteristic of very low densities among most *S. plana* populations. The examination of empty *S. plana* pupae cases to identify the species sex ratio revealed a male biased sex ratio in the species. These findings about the species adult and larval biology and ecology fill important gaps in our understanding for one of the critically endangered insect species in Australia.

In **Chapter 7** – the final chapter I provide a synthesis of my results on the sensitivity of carabid beetles and scarab beetles to the effects of fragmentation and highlight the importance of maintaining a rich floristic diversity and the presence of kangaroo grazing (as opposed to livestock grazing and mowing) for a diverse ground dwelling beetle fauna in temperate grassland fragments. I highlight the significance of considering multiple taxa and taxonomic resolutions to predict the vulnerability of insects following fragmentation and provide suggestions for future insect conservation in native temperate grassland in Australia. Follow up research should a) address the spatial distribution of the terrestrial insect fauna in temperate grassland; focussing particularly on a range of types of grasslands, including identification of suitable and unsuitable habitat in the surrounding matrix and, b) should include the studies of the autecology of temperate grassland insects species to better link species ecology with native temperate grassland fragmentation and modification.

The research chapters in this thesis have been written as stand - alone manuscripts for later publication (except Chapter 1). As a result, there is some repetition between chapters, particularly in the Introduction and Method sections, although I have attempted to minimise this where ever possible by referring back to earlier chapters.

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Ich vermisse Euch sehr.