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GRASSLAND BIODIVERSITY AND CONSERVATION IN A CHANGING WORLD

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PREFACE

Grasslands cover around 30% of the Earth's terrestrial surface and provide important ecosystem services including food production, water purification and carbon sequestration. On the other hand, grasslands are among the most endangered ecosystems, threatened by land-use change, mainly through agricultural intensification or abandonment, and ongoing climatic changes, such as warming and drought. Worldwide, ecological research aims at understanding the effects of land-use and climatic changes on grasslands in order to protect, conserve and restore these valuable ecosystems. The principal aim of this book is to give an overview of current knowledge and future challenges for ecological studies in grasslands. The book also provides important new perspectives for management and conservation of grasslands ecosystems. Both aboveground and belowground ecosystem components, as well as the linkages between these components, are taken into consideration.

The first chapter of this book presents current threats on grasslands by reviewing the influence of land-use and climate change on the integrity of grassland ecosystems, through changes in plant species composition and biodiversity (Chapter 1). While aboveground patterns and processes in grasslands are relatively well known, the importance of belowground components in shaping grassland ecosystem is less well understood. This is despite recognition that most of grassland biomass and biodiversity is belowground, and that soil communities provide key ecosystem functions. Chapter 2 redresses the importance of soil organisms by synthetizing their effects on grassland production and diversity, illustrated by a simplified soil food web with antagonist and mutualistic pathways. Soil microbial communities are particularly important for grassland functioning and need to be taken into account in management practices. As such, Chapter 3 highlights the importance of seasonal variability of soil microbial communities and gives perspectives to better manage disturbed grasslands. In addition to temporal variation, also spatial variability should be considered in grassland management. Chapter 4 presents a conceptual toolkit that accounts for spatial and temporal variability to facilitate restoration planning and management. Grazing is one of the most common practices in grassland management, with positive or negative effects on biodiversity and ecosystem functioning, depending on intensity and frequency. Chapter 5 investigates how grazing components (i.e. defoliation, trampling, animal excretions) affect spatial heterogeneity and as such affect the functioning of grassland ecosystems and the services they provide. Grazing can also be used as a tool to restore degraded ecosystems and Chapter 6 shows how grazing, as well as other management practices, affects plant diversity and biomass production in a unique long-term restoration experiment in China. In a historic

perspective, over the past two centuries, grasslands have been transformed globally by conversion to intense agricultural use, while low-intensity grazed grasslands are disappearing. The ongoing effects of climate change are an additional threat to these endangered ecosystems as shown in Chapter 7. Climate change impacts are especially important in high elevation ecosystems, which are disproportionally affected, and Chapter 8 and 9 explore the influences of land-use and climate change on mountain and alpine grasslands. Both these chapters focus explicitly on changes in plant functional group composition, which are key drivers of ecosystem properties and functioning. In this light, Chapter 10 gives and overview of the role of the largely understudied functional group of bryophytes by showing how this group contributes to the biodiversity of grasslands and constitutes a key group in the functioning of grassland ecosystems.

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Chapter 1

TEMPERATE GRASSLANDS: OUT OF SIGHT, OUT OF MIND? CONSERVATION AND RESEARCH PRIORITIES FOR ONE OF THE WORLD'S MOST THREATENED ECOLOGICAL COMMUNITIES

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ABSTRACT

This chapter reviews the influence of land-use change and predicted climate change on temperate grasslands – an overlooked ecological community at the global scale - and identifies future research strategies to halt the further loss of biodiversity in temperate grasslands. We discuss how previous research has contributed to our understanding of grassland ecology and describe how two threats to native temperate grasslands 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.

Keywords: Native temperate grassland, conservation, ecosystem services

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INTRODUCTION

'Heaven knows, we've got plenty of grass' (former Victorian Conservation Minister Australia). Native (naturally occurring) temperate grasslands are ecological communities that have, at a global scale, undergone dramatic reduction and modification as a result of agricultural and, more recently, urban development (TGCI 2008). According to the Millennium Ecosystem Assessment (2005) nearly 80 percent of the world coverage of the temperate grassland biome has already been lost. Surviving intact remnants face an array of threats and are afforded poor conservation protection (Chape et al., 2008; TGCI 2008). At an international scale, these grasslands are afforded a very low level of protection when compared to other terrestrial biomes (Chape et al., 2008; TGCI 2008). Fortunately, in many countries, conservation efforts have commenced that provide some protection for specific grassland communities, particularly those that are endangered. Nonetheless, the level of protection applied to temperate grasslands at the global and regional level is not sufficient to stop further loss of biodiversity and ecosystem degradation. In this chapter we provide an international perspective on the conservation of native temperate grasslands. We provide an overview of their vulnerability to past and ongoing threats and identify priorities for research and conservation that will be better secure their future. In our review we draw attention to key studies from East Asia, North America and South-eastern Australia and focus on what we consider are major threats to their persistence: (1) the consequences of past habitat loss, fragmentation and degradation; (2) climate change; and (3) biotic invasion to the biodiversity in temperate grassland. We selected these geographically remote temperate regions to demonstrate the global pattern of large scale temperate grassland modification and the effects of new arising threats such as climatic change. These regions once supported extensive areas of temperate grassland and are representative of the extent of temperate grassland modification at the global scale. This brief review also allows us to consider key research topics that are currently underrepresented with respect to native grasslands and to identify future research and conservation priorities of international relevance. The review is not intended to be exhaustive; rather it reveals the knowledge gaps present in our understanding of native temperate grasslands as distinctive ecological communities, describes the threats posed to them from historic, ongoing and combined environmental changes, and considers the future research and conservation actions that are essential to maintaining the viability of these unique grasslands.

To do this we address the following questions:

1. What are the ecological characteristics of native temperate grasslands?
2. What are the historical and current distributions of temperate grasslands and what are the threats that they are exposed to?
3. How has research improved the understanding of the biodiversity and ecology within temperate grasslands?
4. What direction should future research take to improve the conservation of native temperate grasslands?

SETTING THE SCENE

'Knowing trees, I understand the meaning of patience. Knowing grass, I can appreciate persistence' (Unknown author).

In an international context, native temperate grasslands are recognised by many names. In North America they are known as short and tallgrass prairies, they are called steppes in parts of north-central Eurasia, veldt in South Africa, pampas in South America, puszta in Hungary and lowland native grassland (natural temperate grassland) in South-eastern Australia (ACT Government 2005; Gurevitch et al., 2002). The term 'temperate native grassland' is interchangeably used in the literature for 'natural temperate grassland' or 'native temperate grassland' or 'indigenous temperate grasslands' (Mark & McLennan 2005). We use the term 'native temperate grassland' throughout this overview as that is the term most broadly applied internationally. Most native temperate grasslands are located in the interior of large continents in the rain shadow of mountain ranges where continental climate brings harsh winter conditions along with hot dry summers (Chape et al., 2008). All native temperate grasslands share the characteristic of the absence of a mature tree cover and the overall dominance of a ground layer of perennial warm-season (C_4) and cold-season (C_3) grass species with a mixed forb layer (Duffey et al., 1974; Gurevitch et al., 2002). The dominance of grasses is explained by climatic conditions (mainly low rainfall and periodic droughts) and disturbance mechanisms such as fire (natural and anthropogenic origin) and grazing activities by native herbivores (Anderson 2006; Bredenkamp et al., 2002; Gurevitch et al., 2002; Walter 1968). All major groups of fauna are represented in temperate grasslands and many native grasslands have levels of diversity as high as those characteristics of tropical forests (Sala et al., 2001). The flora and fauna in temperate grasslands is often diverse, highly specialised and endemic (Groombridge 1992). For example, in North America, more than 250 native plant species are found in tallgrass prairies with the majority belonging to perennial grasses (Freeman 1998). Around 350-400 vascular plant species have been recorded in temperate grasslands in China (Peng et al., 2008). The most obvious and iconic animals in temperate grasslands are the large herbivores which have prominence in secondary production (Sala et al., 2001). Bison are the most well-known of the large ungulate grazers in North America that make a significant contribution to the functioning and production of the prairies through their impact on nutrient cycles, primary production and for the shaping of the composition of the flora (Frank et al., 1994; Frank & McNaughton 1992). Smaller-bodied vertebrates such as birds, rodents and reptiles also play an important role in shaping the biodiversity of temperate grasslands. Birds are one of the best documented groups in temperate grasslands (Brennan & Kuvlesky 2005; Chapman et al., 2004; Coppedge et al., 2001). The continental location of most temperate grasslands, such as the prairies in North America, collectively often constitute a transition zone for birds where eastern and western bird species are found (Costello 1969). Reptiles comprise another grassland group that takes advantage of the characteristics of the grassy ecosystem. Microhabitat structure (grass tussocks, rocks and soil cracks), sufficient dietary supply (micro and macroinvertebrates) and high level of solar radiation provide ideal settings for a rich reptile fauna in temperate grasslands (Collins 1993; Osborne et al., 1993b). They are however, a much less diverse group than birds and mammals (Kauffman et al., 1998). Invertebrates are one of the most diverse and abundant groups in grassland ecosystems. They are essential for the functioning of the ecosystems through their role as herbivores,