Rangeland Ecology & Management 69 (2016) 430–436

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Balancing Biodiversity and Food Production: a Better Understanding of Wildlife Response to Grazing Will Inform Off-Reserve Conservation on Rangelands☆

H. Neilly *, J. Vanderwal, L. Schwarzkopf

College Marine and Environmental Science, James Cook University, Townsville City, Queensland 4812, Australia

ARTICLE INFO

Article history:
Received 25 February 2016
Received in revised form 10 July 2016
Accepted 11 July 2016

Key Words:
community composition
land sharing
livestock grazing
response mechanism
sustainable agriculture
vertebrate fauna

ABSTRACT

Protected areas are essential, but not sufficient on their own, to conserve biodiversity into the future. Rangelands, used primarily for livestock grazing, have the potential to complement existing reserve systems and be used for "off-reserve" conservation. Success relies on our ability to manage rangelands to simultaneously achieve positive economic outcomes for graziers while maintaining the ecological processes that support biodiversity. However, we argue that research has failed to effectively inform off-reserve conservation strategies, particularly in relation to vertebrate fauna. Most research has focused on the difference in faunal diversity between ungrazed and heavily grazed areas, but faunal responses between these extremes have received less attention. In reality, moderate levels of grazing seem more likely to achieve the ecological, economic and social balance that would be required for successful off-reserve conservation on rangelands. Here we review the current knowledge on the impact of grazing by domestic livestock on terrestrial vertebrate fauna in rangelands, highlighting the relative lack of research on the impact of grazing regimes between the extremes. We argue that a more detailed understanding of vertebrate responses to different grazing intensities is required. Furthermore, if the potential for off-reserve conservation on rangelands is to be realized, graziers need management advice based on the integration of ecological, economic, and social data.

Introduction

"Off-reserve" conservation in areas with an alternative primary land use is a way to complement existing reserve systems (Fischer, 2011) as protected areas are increasingly considered inadequate, on their own, to conserve biodiversity into the future (Margules and Pressey, 2000). Rangelands used for domestic livestock grazing provide an ideal opportunity for off-reserve conservation. For rangelands to serve a dual purpose (i.e., food production and conservation), positive outcomes for the primary land user must be maintained while protecting the ecological processes that support biodiversity (Norris, 2008). Therefore, it is important to not only understand the impacts of domestic livestock grazing on biodiversity but also combine ecological knowledge with economic and social data (Eyre et al., 2011).

On rangelands, the response of vegetation to grazing has been studied in detail (Landsberg et al., 2003; Díaz et al., 2007); however, the response of vertebrate fauna is complex and less well understood. Research to date has focused on high-contrast treatments (e.g., Knox et al., 2012; Pafilis et al., 2013; Rickart et al., 2013). Under high-intensity grazing regimes, faunal diversity is generally reduced (e.g., Dorrough et al., 2012). However, there are relatively few detailed inquiries into the effects of more moderate levels of grazing. Under moderate intensity grazing, overall faunal diversity may remain relatively constant or may even increase (Martin and McIntyre, 2007; Lusk and Koper, 2013). The effect of moderate levels of grazing on faunal communities deserves further attention, as this is likely to be where a balance between food production and conservation could be achieved.

Overall measures of biodiversity, such as abundance and species richness, provide insight into faunal response to grazing but may be misleading. These measures can remain constant while the community composition shifts as different species increase or decrease in abundance. Community compositional changes and the responses of individual species to grazing are, arguably, more important than overall biodiversity measures for informing off-reserve conservation on rangelands (Derner et al., 2009). This is especially true if conservation goals include protecting certain species or encouraging particular assemblages.

So far, research has highlighted the differences between heavy grazing and low or no grazing, but we still don't know how *best* to graze rangelands. We need to further understand faunal responses to grazing, yet there are challenges involved in collecting the data that will inform off-reserve management strategies. These include 1) designing experiments at the appropriate scale that will examine faunal responses at

☆ H.N. was supported by an Australian Postgraduate Award, a grant from Meat and Livestock Australia, and the Holsworth Wildlife Research Endowment.
* Correspondence: Heather Neilly, College Marine and Environmental Science, James Cook University, Townsville City, QLD 4812.
E-mail address: heather.neilly@my.jcu.edu.au (H. Neilly).

http://dx.doi.org/10.1016/j.rama.2016.07.007
1550-7424/

moderate levels of grazing and take into account the complex abiotic and biotic processes that occur on rangelands and 2) relating this information to food production outcomes, including the economic and social implications of particular management actions. In overcoming these challenges, strategies for off-reserve conservation on rangelands could be developed.

The aim of this review is to broadly synthesize the current global knowledge on the impact of grazing by domestic livestock on terrestrial vertebrate fauna. We highlight the relative lack of research on the impact of grazing between high and low extremes, asserting that this area of moderate grazing intensity is critical for informing off-reserve conservation on rangelands. Finally, we provide direction for future research, arguing that experimental grazing trials could facilitate a multidisciplinary approach to data collection and inform conservation management strategies on rangelands.

Why are Rangelands Suitable for Off-Reserve Conservation?

Anthropogenic disturbances such as agriculture influence biodiversity, often reducing it or changing the assemblage structure (Laurance et al., 2014). Livestock grazing is the most widespread land use in the world. It occurs on 25% of the global land surface including semiarid and arid zones, as well as tropical and temperate regions (Asner et al., 2004). Most livestock grazing takes place on rangelands. Rangelands are defined here as open country that naturally produces forage plants suitable for grazing of domestic livestock or wild animals.

Although rangelands are primarily used for food production, the importance of these vast areas in terms of conservation cannot be overlooked. Indeed, there is fierce debate about the best way to achieve conservation and food production objectives on agricultural land (Norris, 2008; Phalan et al., 2011; Hodge et al., 2015). "Land sharing" is where dual land use occurs over large areas, generally with lower intensity agriculture, whereas "land sparing" refers to higher-intensity agriculture over smaller areas, with areas set aside solely for conservation purposes (Phalan et al., 2011).

There is high potential for land sharing to be successful on rangelands. In contrast to intensive agricultural practices like cropping, rangelands may be relatively "intact" (McIntyre and Hobbs, 1999). Additionally, their sheer size means that management changes could have major biodiversity implications on a large scale.

An understanding of faunal response to various levels of grazing could also help with management of protected areas. While it is implied that protected areas exclude livestock, this is not always the case. In many situations, livestock can exist at relatively high densities inside protected areas, whether managed intentionally (Porter et al., 2014; Williamson et al., 2014) or as feral animals. Removal of feral livestock may be expensive and difficult to achieve, so understanding their impact on fauna could assist with protected area management. The fact that domestic livestock grazing occurs "on reserve" and "off reserve" suggests that a flexible view of land sharing and/or sparing is required when considering the interface between conservation and agriculture (Kremen 2015).

It is also important to consider that many rangeland systems have an evolutionary history with herbivory and are disturbance dependent (Knapp 1999; Fynn et al 2016). Additionally, the presence of domestic livestock alongside native herbivores creates a cumulative grazing pressure (e.g., Ash and Smith 2003). Therefore, the capacity of a rangeland system to tolerate domestic livestock grazing will depend on the evolutionary history of herbivory at that location and the existing native herbivore grazing pressure. Because of these factors, the management strategies required to achieve off-reserve conservation are likely to be system specific.

Impact of Livestock Grazing on the Landscape

The specific set of agricultural management practices associated with grazing constitutes a grazing regime. Stocking rates are managed according to the pre-existing land condition and the system productivity (i.e., rainfall) and can be manipulated by fencing and watering point configurations. Grazing may be continuous, seasonal, or rotational with intermittent spelling, and different livestock are sometimes grazed together in mixed flocks. Fire is commonly used in conjunction with grazing to promote new growth and suppress undesirable shrub or woody encroachment in grasslands (Gregory et al., 2010; Bock et al., 2011). Additionally, woody growth may be mechanically or chemically removed. In grasslands this is generally to combat encroachment, whereas in open woodlands, existing trees may be thinned or cleared to promote grass growth and assist with livestock movement through the landscape (Asner et al., 2004). In some areas, forage plant abundance and growth are promoted with the application of fertilizer and introduction of exotic grasses (Kutt and Fisher, 2011). Management practices associated with grazing combine with the effect of grazing itself to create a cumulative impact on the landscape and determine the overall "disturbance intensity." The inherent complexity of grazing regimes is one reason it has been difficult for previous grazing studies to reach clear conclusions and translate these into management recommendations.

Grazing has an effect on the composition, structure, and functioning of ecosystems. Heavy grazing can profoundly alter the abiotic and biotic components of a system through 1) removal of vegetation via herbivory, altering vegetation structure and floristics; 2) trampling, leading to soil compaction and destruction of the soil crust; or 3) the input of nitrogen (Graetz and Tongway, 1986). Indirectly, grazing may change competition and predator/prey dynamics, leading to a change in food web structure (e.g., Knox et al., 2012; Pafilis et al., 2013; Pettigrew and Bull, 2014).

The response of vegetation to grazing has been studied in detail (Landsberg et al., 2003; Díaz et al., 2007). Changes in soil nutrients and the soil microbiotic crust due to concentrated grazing have been commonly observed and occur relatively rapidly (Eldridge et al., 2011). The destruction of the microbiotic crust through livestock trampling has implications for water infiltration and seed germination (Eldridge and Greene, 1994; Prasse and Bornkamm, 2000; Facelli and Springbett, 2009). Heavy grazing generally favors annuals over perennials and those plant species that are short and prostrate with a stoloniferous or rosette architecture (Díaz et al., 2007). The resulting vegetation structure is simplified and more open with a higher proportion of bare ground (Landsberg et al., 2003). In some grazing regimes the vegetation structure is further altered by tree clearing or the introduction of exotic grasses (Martin and McIntyre, 2007; Dorrough et al., 2012; Germano et al., 2012). This knowledge of plant diversity response to grazing has facilitated the development of generalized models.

Response curves of plant diversity to grazing were proposed a number of decades ago (Milchunas et al., 1988) and built upon in more recent times (Cingolani et al., 2005). It is generally accepted that vegetation heterogeneity is highest under low to moderate levels of grazing but lowest when grazing is very low or high and the extent of the effect depends on the evolutionary history of herbivory and its interactions with other biotic and abiotic factors (Milchunas et al., 1988). Response curves of vertebrate faunal diversity do not exist. It could be assumed they will closely follow plant diversity response, yet this has not been tested for vertebrate fauna and appears not to be the case for invertebrate fauna. In a global review, van Klink et al. (2014) found that overall, increasing grazing intensity has a negative effect on arthropod diversity. In addition, arthropod diversity responds more negatively to grazing than plant diversity (Rambo and Faeth, 1999; Van Klink et al., 2014). It is reasonable to suggest that vertebrate fauna diversity responses to grazing will also differ from plant diversity responses.

Effect of Grazing on Vertebrate Fauna

The extent to which species are influenced by grazing will depend on how much they rely on the niches affected by grazing (Milchunas et al., 1988). Grazing can directly alter important structural habitat features at ground level (Smith et al., 1996; Brown et al., 2011; Eldridge