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Review

Rediscovering traditional vegetation management in preserves: Trading experiences between cultures and continents

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ABSTRACT

Land managers are grappling with massive changes in vegetation structure, particularly in protected areas formerly subjected to fire and grazing. The objective of this review was to compare notes on the historical and current management of ecosystems around the world (especially in wet to dry grasslands in the Americas, Australia, Africa, Europe and Asia) with respect to the usage of fire, grazing and cutting to reduce dominance and support the biodiversity of rare species. This review suggests that former disturbances, which are now often lost, may have once kept tall vegetation from pushing out rarer subdominant species. In cases where prehistoric biodiversity depended on fire or large ungulate grazing, traditional agricultural and indigenous practices may have carried biodiversity forward to historical times by mimicking pre-cultural disturbances (e.g., lightning fire and bison grazing). Ironically, biodiversity related to species richness, landscape heterogeneity and function may decline in preserves, especially if traditional management once maintained this biodiversity. Managers can benefit from a cross-continental comparison of the full arsenal of management techniques used to control encroaching vegetation.
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1. Introduction

Exclusion of human activities in nature preserves is a common practice. Nevertheless, natural disturbances, traditional agricultural and indigenous land management were once important components of maintaining worldwide landscapes including certain grasslands, wetlands, and even some types of forests (Russell-Smith et al., 1997; Middleton, 1999; Kimmerer and Lake, 2001; Raisch et al., 2005; Anderson, 2006; Gellrich et al., 2007; Rey Benayas et al., 2007). Disturbance is an important component of species richness, heterogeneity and/or function in these landscapes (Fuhlendorf and Engle, 2004; Öckinger et al., 2006). These days, some preserves may not be receiving the appropriate disturbances to maintain these landscape attributes (Russell-Smith et al., 1997; Berkes et al., 2000). Certain traditional land management practices (e.g., haying, cattle grazing, wood cutting, fire) may have resembled pre-historical disturbances (large mammal grazing, lightning fire; following Svenning, 2002; Rey Benayas et al., 2007), creating an argument to use some of these traditional land management practices to mimic pre-historical disturbances.

A cross-continent exploration of techniques to recreate natural disturbances could be helpful in designing management strategies for conservation biodiversity. The objective of this paper was to examine approaches used in various parts of the world to manage vegetation before and after nature preserve designation, and to

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what extent grazing and fire was currently used to support biodiversity. The methods of this review paper were to consider a comprehensive set of research articles on this topic, particularly those published since 2005. Using this approach, comparisons were made on how successful particular methods were in reducing vegetation encroachment and in maintaining species in various ecosystems of the world.

Beyond the scope of this paper is any consideration of the role of disturbance in support of biodiversity in tropical ecosystems, because human activities in the tropics may be simultaneously acted on by intense logging, agricultural intensification, and/or cattle grazing (following Flamenco-Sandoval et al., 2007; Dent and Wright, 2009; DeClerck et al., 2010; Norris et al., 2010; Tabarelli et al., 2010). Also excluded are areas that have had extensive agricultural intensification related to planted pastures, e.g., the cerrado of Brazil (Ratter et al., 1997).

While natural landscapes change naturally with or without disturbance (Middleton, 1999), a lack of contemporary grazing, burning and cutting has resulted in the loss of biodiversity (Rey Benayas et al., 2007). Loss of endangered or Red Listed subdominant species can occur with the proliferation of taller species, which can be reduced by disturbance (see especially Scanga and Leopold, 2012; Schuch et al., 2012). Appropriate management may be more important than climate change to the long-term maintenance of rare species in some ecosystems (Bucharová et al., 2012).

A crisis emerges for land managers if tall vegetation proliferates in formerly grazed nature preserves designated to protect small rare species. Eventually, the shorter species may be extirpated under the shade of tall species (Galvánek and Lepŝ, 2008; Ruprecht et al., 2010). After some time, sites may become too wooded for restoration, if permanent thresholds have been crossed (Grant and Murphy, 2005). Before the regenerative capabilities of rare species are lost, traditional practices could stall these thresholds by opening the vegetation by grazing, fire, haying, and mechanical cutting.

Overgrowth of tall species is not purely a natural outcome of succession following the lack of fire and grazing/cutting related to pre-historical disturbances or traditional vegetation management. These days, many landscapes have little exposure to what may be necessary levels of fire and grazing acting in concert (Murphy and Bowman, 2007; Fuhlendorf et al., 2008). Native animal species are no longer present in many contemporary natural preserves, but these have been key elements for maintaining biodiversity in natural ecosystems, e.g., marsupials in Australia (Williams, 2000; Yibarbuk et al., 2001; Vigilante et al., 2009), elephants in Africa (Laws, 1970; Smart et al., 1985), and European or North American bison (Bachelet et al., 2000; Kuemmerle et al., 2010). For a list of large mammals by region and their degree of persistence since AD 1500, see Morrison et al. (2007). Along with native animals, fire was an important disturbance in certain grasslands and open woodlands, and these were ignited by both indigenous people and lightning (Yibarbuk et al., 2001; Anderson, 2006; Vigilante et al., 2009; Pivello, 2011). Fires set by traditional agriculturalists decreased greatly after WWII in midwestern North America (Middleton et al., 2006a,b). Much natural land has ceded to public agencies during the past century (Appendix 1), and managers could benefit from the knowledge of cross-cultural, continental and historical management approaches.

2. Disturbance and biodiversity maintenance: theoretical underpinnings

Disturbance plays an important role in the maintenance of species in ecosystems by reducing competitive exclusion by dominant species (Connell, 1978). Vegetation composition shifts depending on levels of disturbance (van der Valk, 1981; Hobbs and Huenneke, 1992, respectively). More recent models predict high biodiversity with intermediate disturbance as long as other parameters are constant (e.g., rainfall; Oba et al., 2001). Also, the dynamic equilibrium model explains that low to moderate levels of cattle grazing promote abundant butterfly and moth populations in semi-natural grasslands in Europe (Pöyry et al., 2004).

Biodiversity response to cattle grazing largely follows the intermediate disturbance hypothesis in many ecosystems, but the effect of grazing level depends on ecosystem type. In high levels of grazing, species richness decreases (e.g., in Ponderosa pine, sagebrush desert and mountain canyons) (Rummel, 1951; Reynolds and Trost, 1980; Cottam and Evans, 1945, respectively). A high diversity of native plant species can be maintained in grassy woodlands in Australia using low levels of cattle grazing (Dorrough et al., 2006). Similarly, moderate and low levels of grazing can support high plant species richness in tallgrass prairie (Hickman et al., 2004) but little information is available on the effects of heavy grazing in this system (Symstad and Jonas, 2011). In short grass prairie, most studies suggest either neutral or negative effects with either moderate or heavy grazing (Symstad and Jonas, 2011). Some effects of cattle grazing may take some time to manifest themselves; after cattle are removed from pastures, shrubs may increase (Winegar, 1977; Schulz and Leininger, 1990). Disturbance also can promote the invasion of non-native species in ecosystems (e.g., Hobbs and Huenneke, 1992). For example, livestock grazing may promote the invasion of Kentucky bluegrass (*Poa pratensis*) in wet meadows (Middleton, 2002a,b; Valles Caldera Trust, 2009). Even though low levels of cattle grazing could introduce disturbance to help maintain biodiversity, high intensities of cattle grazing would be unacceptable in many ecosystems.

Many studies examine the role of cattle grazing in the maintenance of habitat features for various types of species. High insect biodiversity has been linked to the role of cattle grazing in creating environmental heterogeneity (Rickert et al., 2012). Certain rare plant species benefit from selective grazing by low densities of sheep, e.g., *Gentianella* and *Gentianopsis* in nutrient-poor calcareous grasslands (Oostermeijer et al., 2002). Landscapes with a mixture of traditionally kept or recently abandoned hay meadows, mature abandoned grasslands or uncut grassland within hayfields could help maintain habitat heterogeneity (Baur et al., 2006; Humbert et al., 2012). Habitat heterogeneity may be of benefit to insects because such features support the full gamut of life stages (Schwarzwälder et al., 1997). A lack of heterogeneity in habitats from the combined suppression of natural disturbances and traditional management may be reducing biodiversity in natural areas (Pykälä, 2001; Galvánek and Lepŝ, 2008).

While the practices of traditional agriculturalists likely supported biodiversity by reducing dominant vegetation, the herding of domestic animals may have dispersed seeds in ways that resembled earlier pre-historical grazing systems. At the same time, native grazers can no longer move freely in most modern landscapes, so that the earlier avenues of long-distance seed dispersal disappeared along with herds of North American and European bison (Rosas et al., 2008; Jaroszewicz et al., 2008). Nevertheless, cattle still move the seeds across landscapes through ingestion and defecation (Middleton and Mason, 1992; Mt. Pleasant and Schlather, 1994; Bruun and Fritzbøger, 2002), but the movement of cattle is becoming much more limited with modern agricultural approaches. Traditional patterns of long-distance movement of livestock by traditional agriculturalists and transhumant herders (Ruiz and Ruiz, 1986; Manzano and Malo, 2006; Middleton, 2002a; Nyssen et al., 2009; Huband et al., 2010; Middleton et al., 2006c) may have once moved seeds of natural ecosystems long distances. At least a few studies have documented long-distance seed dispersal by transhumant sheep herding (Manzano

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