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Review

Grazing vs. mowing: A meta-analysis of biodiversity benefits for grassland management

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ABSTRACT

To maintain the high biodiversity of semi-natural grasslands, management by grazing or mowing is needed. Given the limited resources and few remaining areas, the best management method should be used. However, only a few studies comparing the effects of mowing and grazing on grassland biodiversity exists. Therefore, the goal of the present review was to extract as much data as possible from the literature and evaluate them using a meta-analysis approach. We searched scientific and grey literature for studies comparing the effects of grazing and annual mowing on outcomes relevant for biodiversity conservation. We identified 35 relevant studies on grazing and annual mowing that provided data suitable for the meta-analysis. We found that grazing generally had a more positive effect on the conservation value of semi-natural grasslands compared to mowing, but effect sizes were generally small to moderate for most contrasts. Furthermore, effects varied across some grassland characteristics e.g. for different grassland types, with grazing and mowing having a similar effect or mowing having a more positive effect in certain cases. Our results suggest, that in most cases grazing should be the preferred management method when managing for grassland conservation.

Contents

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1. Introduction

Grasslands are defined as habitats characterized by a mixture of native grasses and dicotyledonous herbs, and with a low proportion of woody species. They cover large areas and occur all over the globe. Generally, grasslands have been formed in climates not suitable for woody vegetation (e.g. steppe or prairie), or by natural disturbances such as fire or herbivory (e.g. savanna). Semi-natural grasslands are defined as grasslands modified by human activities, originating from deforestation or alteration of natural grasslands (Crofts and Jefferson, 1994; Gibson, 2009). In many cases semi-natural grasslands have been created and maintained by traditional agricultural practices since the Neolithic Age (Poschlod et al., 2009). Hence, they have not been modified by intense agricultural practices, like the regular use of inorganic fertilizers or herbicides (Crofts and Jefferson, 1994).

Apart from forage, semi-natural grasslands provide essential ecosystem services such as pollination (Öckinger and Smith, 2007), soil carbon sequestration (De Deyn et al., 2011) and erosion regulation (Bazzoffi, 2009). In addition, semi-natural grasslands often maintain a high biodiversity (WallisDeVries et al., 2002; Pärtel et al., 2005; Wilson et al., 2012) and harbour a high number of both plant (e.g. Zhou et al., 2002; Verrier and Kirkpatrick, 2005; Chytrý et al., 2015) and animal species (e.g. Swengel, 1998; D'Aniello et al., 2011; Shi et al., 2014). Some meadows even belong to the most species-rich habitats in the man-made landscape of Central Europe (Poschlod et al., 2009; Wilson et al., 2012). Many of the species present in this habitat type are confined to it and hence highly dependent on it for their survival. Therefore, semi-natural grasslands are widely recognized to be of high conservation value (Crofts and Jefferson, 1994). Substantial resources are spent on their preservation each year, e.g. in Europe by economic subsidies provided by the European Union (European Commission Directorate General for Agriculture and Rural Development, 2005). However, the funds are not sufficient to protect all grasslands of high conservation value.

Management is often required to prevent afforestation of semi-natural grasslands (Hansson and Fogelfors, 2000; Wahlman and Milberg, 2002). Furthermore, the removal of above-ground biomass by grazing and mowing promotes the biodiversity of semi-natural grasslands through the depletion of nutrients (Al-Mufti et al., 1977). Therefore, there is a clear association between high species richness, occurrence of rare species and the management of semi-natural grasslands (Pykälä, 2003; Klimek et al., 2007). During the Neolithic Period domestication of livestock resulted in the creation of grasslands as a consequence of grazing of forests or clear cuts adjacent to settlements. The application of mowing was only introduced in the Roman Period. From the Medieval Age onwards, mowing for hay and grazing became a vital part of the mixed farming system that developed in Europe (Poschlod and WallisDeVries, 2002; Poschlod et al., 2009). Hay-making was closely associated with the winter-stabling of livestock, summer grazing and availability of manure for fertilization of arable fields (Pedersen and Widgren, 2011). During the second half of the 20th century agricultural practices were modernized and intensified, with an increasing use of inorganic fertilizers to increase yields. Considerable area of grasslands have been abandoned or been converted to arable land or high-yielding grasslands in many areas; in other cases grasslands were converted to forests through tree planting or natural succession, leading to the loss of grasslands and grassland biodiversity (Milberg, 1995; Krebs et al., 1999; Hansson and Fogelfors, 2000; Firbank, 2005; Poschlod et al., 2005; Moller et al., 2008; Briske et al., 2015). As a consequence, many of the species that thrive in this habitat type have become rare and threatened (The IUCN Red List of Threatened Species, 2014).

Maintenance of traditionally managed species-rich grasslands is becoming increasingly difficult, partly due to the high costs of mowing (i.e. cutting and removal of cut plant material) (Schreiber et al., 2009). Furthermore, the number of available grazers are limited as a consequence of the decreasing number of livestock herds (Kumm, 2003) and the increase in the number of potential grazers being kept in stables and fed silage (Poschlod, 2015). Therefore, to optimize the utilization of the limited resources available for biodiversity conservation, it is crucial to improve the management choice to ensure that the "best" management option is used. In spite of this urgent need, relatively few studies have evaluated the benefits and disadvantages of the two most widely applied management methods: grazing and mowing once a year (henceforth termed "annual mowing"). Even fewer studies have compared the two methods and the conclusions have often been contradicting, with more positive effects of grazing (e.g. Cauwer and Reheul, 2009; D'Aniello et al., 2011), mowing (e.g. Wahlman and Milberg, 2002; Grandchamp et al., 2005; Tälle et al., 2015), or positive effects of both grazing and mowing (e.g. Kahmen et al., 2002; Saarinen and Jantunen, 2005). Furthermore, many of the available comparisons are of low quality, often unreplicated and do not span more than a few seasons (Milberg et al., 2014; Milberg and Bergman, 2014). As a result, the effects of the potential management options on biodiversity remain poorly understood, and there is no clear guideline for choosing the most proper conservation measure.

A meta-analysis approach enables a critical evaluation and synthesizing of available studies regarding a specific research question. It can overcome the problem with low quality studies and the lack of conclusive results to some degree, by weighting studies when pooling for effect size (Pullin and Knight, 2001; Milberg, 2014). Our goal was to determine whether grazing or annual mowing is more effective in preserving the biodiversity of semi-natural grasslands, by reviewing the literature, and evaluate as much as possible of the available data in meta-analyses. We aimed to determine the best available management method and give direct recommendations for the management of semi-natural grasslands.

2. Methods

2.1. Search strategy

In October 2014 studies, in any language, comparing grazing and mowing were searched for in the databases Scopus, Biological Sciences and Biological Abstract. The search terms used were