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Does cattle movement between forest pastures and fertilized grasslands affect the bryophyte and vascular plant communities in vulnerable forest pasture biotopes?

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ABSTRACT

The intensification of agriculture has led to a dramatic decrease in traditional forest pastures in Northern Europe. Furthermore, the remaining forest pastures have often lost their typical characteristics due to eutrophication and forestry practices. We investigated whether the common management practice of fencing forest pastures within the same enclosures as fertilized grassland pastures leads to eutrophication and the consequent decline of bryophyte and vascular plant diversity in Finnish forest pastures, given that when cattle can freely roam between the fertilized grassland pastures and unfertilized forest pastures, nutrients are transported to the forest pastures in the feces and urine of the grazing animals. We found that grazing led to higher electrical conductivity and potassium (K) levels in the forest pastures ($n = 18$) compared to the background levels in adjacent non-grazed forests ($n = 18$). Vascular plant species richness and diversity (Shannon's entropy) were higher and community structures different in the forest pastures compared to the adjacent forests. Highest species richness was observed in the forest pastures that were unconnected to fertilized grasslands ($n = 7$). Connection here refers to the situation where cattle can access both forest pasture and adjacent fertilized grassland simultaneously. Furthermore, many species indicative of valuable semi-natural pasture biotopes were found only in these traditionally managed forest pastures. In contrast, bryophyte species richness did not differ between the forests and the two types of forest pastures. Moreover, bryophyte communities largely overlapped between the forests and the forest pastures. Our results indicate that even if the forest pastures connected to the fertilized grasslands sustain plant communities that are characteristic of unfertilized semi-natural forest pastures, the conservational quality and diversity of vascular plant communities in particular may be reduced in comparison to the forest pastures without grassland connection. This decline can, at least partially, be caused by the transport of nutrients to the forest pastures and, hence, we recommend that forest pastures are not connected with fertilized grasslands.

1. Introduction

In Finland, forest pastures were classified as endangered in the first assessment of threatened habitat types in 2008 (Schulman et al., 2008). From the 1950s to the present, the total area of forest pastures has decreased by over 99%, as fertilized grassland pastures established on cultivated land were increasingly used for forage production and as pastures (Schulman et al., 2008). Furthermore, the quality of the remaining forest pastures is often low because of intensive forestry and eutrophication (Schulman et al., 2008). The decrease in area and quality has affected all Finnish semi-natural (traditional) rural biotopes and, as a consequence, numerous species dependent on these environments have become threatened (Rassi et al., 2010).

The effects of cattle grazing on biodiversity are generally positive in productive habitats of Northern Europe (Olff and Ritchie, 1998; Proulx and Mazumder, 1998). However,

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understanding the effects of different management practices is essential for a comprehensive assessment of biodiversity patterns in semi-natural biotopes (Klimek et al., 2007). The fencing of semi-natural forest pasture and fertilized grassland pasture into the same enclosure is one of the controversial practices generally thought to cause eutrophication in the forest pasture (Pykälä, 2001), although this practice is not permitted in forest pastures subsidized via European Union (EU) agri-environmental aid. If substantial harmful effects arise, the recommended management approach is to maintain separate enclosures in the forest pastures and fertilized grasslands. At the same time, however, the management of forest pastures must be practicable for the farmers and provide sufficient quality for grazing animals. Otherwise there is a risk that forest pastures will be abandoned and this will lead to a further decline in the area of semi-natural rural biotopes.

In Finland, the recommended stocking rates per hectare for a 120 day annual grazing period range from 2.5 to 7.5 (depending on cattle type) in fertilized grasslands and from 0.05 to 0.8 in forest pastures (Salminen and Kekäläinen, 2000). If the stocking rate in an enclosure that comprises both forest pastures and fertilized grassland pastures is determined by the productivity of the grassland, then there is a risk that the grazing intensity will be too high and potential eutrophication in the forest pasture is likely, as the free-roaming cattle will transfer nutrients in the urine and manure from the highly-productive fertilized grasslands to low-productive unfertilized forest pastures (Pykälä, 2001; Uytvanck et al., 2010). It is worth noting that in practice, farmers adjust grazing intensity and grazing periods in accordance with seasonal weather conditions, prevailing herd sizes on their property and on other practical considerations rather than on official guidelines. The patterns of nutrient accumulation and grazing intensity in forest pastures also depend on the proportional areas of grassland and forest pastures in an enclosure and on the daily movements of cattle (Uytvanck et al., 2010). The nutrient enrichment and subsequent eutrophication can be especially high if cattle use the forest pastures as resting sites and feed mainly on the grasslands (Pykälä, 2001; Uytvanck et al., 2010).

Eutrophication (increased production, the increase of a few competitive species, the competitive exclusion of subordinate species) is clearly the most severe problem associated with the practice of connecting forest pastures to fertilized grasslands. Generally, eutrophication is considered to be the most important mechanism behind plant species loss caused by the nutrient enrichment–acidification and direct toxic effects are also important factors (Hautier et al., 2009; Bobbink et al., 2010; Ceulemans et al., 2013). Although atmospheric nitrogen (N) deposition is considered to be one of the major threats to biodiversity in both boreal forests and unfertilized semi-natural grasslands (Sala et al., 2000; Bobbink et al., 2010), there is also an urgent need to study the management practices that may potentially lead to nutrient enrichment. The role of phosphorous (P) enrichment in the loss of biodiversity in semi-natural grasslands has also been highlighted recently (Merunkova and Chytry, 2012; Ceulemans et al., 2013). In addition to nutrient transfer and eutrophication, the connection of forest pastures to fertilized grasslands can also change the intensity and spatial patterns of other effects of grazing in forest pastures, such as trampling and food species selection.

To our knowledge, the impacts of this common management practice on the vegetation of semi-natural pastures have received little attention. In this study, we examine the effects of the potentially adverse management practice on vascular plant and bryophyte communities of semi-natural forest pastures. In contrast to vascular plants, there is little known in regard to the effects of grazing and different management practices on bryophytes. As small and poikilohydric plants, bryophytes can also be especially sensitive to both the toxic effects of nutrient enrichment and eutrophication (Aude and Ejrnæs, 2005). They can also be very slow to recover if eutrophication has taken place (Virtanen et al., 2000; Cunha et al., 2002; Edmondson et al., 2013).

The objectives of this study were (1) to determine whether connection to a fertilized grassland lead to changes in pH, electrical conductivity and nutrient levels (Ca, K, P, Mg, S) in semi-natural forest pastures compared to the background levels in adjacent non-grazed forests, (2) to determine how vascular plant and bryophyte species richness and diversity are affected by the grassland connection in forest pastures and (3) assess the effect of the grassland connection on the bryophyte and vascular plant communities of forest pastures. We emphasize the two last objectives, as the causation between soil chemistry parameters and vegetation variables always remains approximate in a non-manipulative study like this.

2. Material and methods

2.1. Study sites

We included 25 cattle farms in North Karelia, eastern Finland, in the study (Fig. 1). The area is at the border of the southern and middle boreal vegetation zone (Kalliola, 1973). In 18 farms, we examined semi-natural forest pastures with grassland connection (i.e. grazing cattle can freely roam between a fertilized grassland pasture and an unfertilized forest pasture) and, for comparison, forests at the edge of the same fertilized grasslands. At the remaining seven farms, we examined traditionally managed semi-natural forest pastures at the edge of fertilized grassland but without a grassland connection. It was not possible to find this type of forest pasture in the vicinity of majority of the 18 forest pasture/forest-pairs included in the study, so we decided to use data collected earlier in the study project within the same region for the category of the forest pastures unconnected to grasslands.

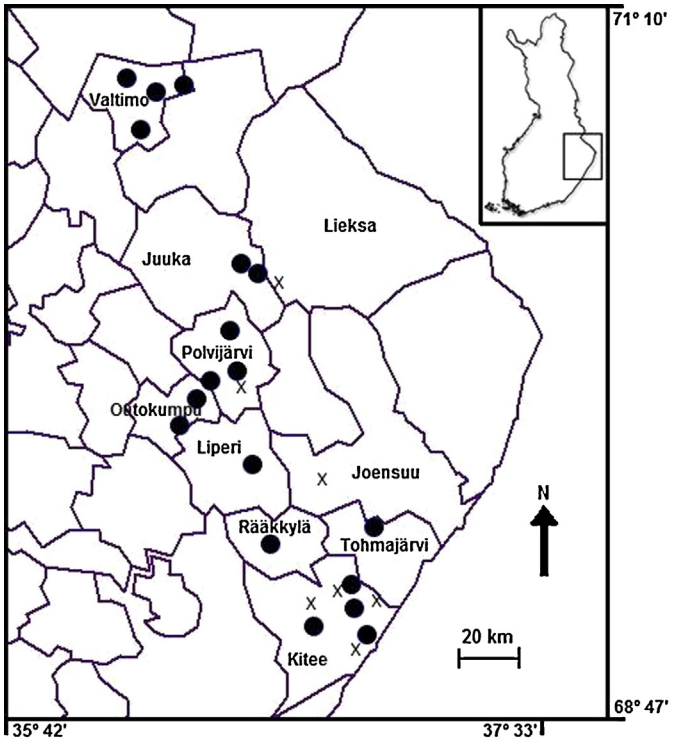

Fig. 1. Study sites. The location of the 18 pairs of connected forest pastures and forests. The seven forest pastures without grassland connection (X) are also included.