Recreation of semi-natural grasslands: assessing hay transfer and seed-sowing methods

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Abstract: Semi-natural grasslands have declined considerably both in numbers and area extent in Europe during the last 50-100 years. Therefore, restoration or recreation of semi-natural grasslands may be a way of maintaining this nature type and it's species that are at risk. However, there are few places in the modern landscape where the landscapes are managed in such a way that it is kept open except along the roads. To recreate semi-natural grasslands with the desired species composition along new roads may however be challenging. Seed-sowing of preferred species is generally costly and can therefore only be done within a limited area, but diaspore transfer with hay may be cheaper and better. In the present study we examined four different methods to recreate semi-natural grasslands at an experimental site along a new road: seed-sowing, two ways of hay transfer (hard raking and light raking) and succession on bare soil (reference treatment). The seeds and the hay were taken from nearby semi-natural grasslands, i.e., donor sites. We compared the species composition in the plots at the experimental site with their species composition at the donor sites with Bray-Curtis dissimilarity index. The species composition of the seed-sowing and the two hay transfer treatments significantly changed towards their donor species composition during three years of succession. These three treatments followed the same pattern over time, implying that diaspore transfer with hay, irrespective of way the hay is collected,

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Introduction

The plant species adapted to grow in semi-natural grasslands are at risk under the large ongoing landscape changes in Europe (Fischer & Stöcklin 1997; WallisDeVries et al. 2002), where both the numbers and area extent of semi-natural grasslands declines (Poschlod & WallisDeVries 2002). To maintain populations of grassland species recreation and restoration are required alongside the conservation of the, few remaining intact sites (Stevenson et al. 1995).

Road verges are open habitats that show similarities to meadows, usually with gras dominated vegetation that are cut at least annually. Therefore, if roads are constructed in a proper way and managed equally, they may act as substitute habitats for semi-natural grassland species (Tikka et al. 2001; Auestad et al. 2008). However, they need to be constructed in another way than by hydroseeding with commercial seed mixtures consisting of few species. Seed-sowing of preferred species or hay transfer may be topical methods (e.g., Patzelt et al. 2001; Hölzel & Otte 2003; Edwards et al. 2007).

In the present study we examined how two different methods of hay transfer (hard- and light raking; hard raking also transferring a large proportion of the ground debris), seed-sowing and succession from bare soil (natural regeneration = "reference") influence the re-vegetation patterns the three first years after creation of a new road verge. We compared the vegetation in plots at the recreation site with their respective donor plots at the donor sites.

Materials and methods

Study sites. We conducted the study in western Norway in Lærdal, Sogn og Fjordane. The three Donor sites, where the seeds for the seed-sowing treatment and hay for the hard raking and light raking treatments were collected, and the recreation site are situated within a distance of 11 km. Further information of the donor sites, consisting of pastures and road verges, can be found in Auestad et al. (2008).

Sampling design and data analysis. At the recreation site (a road verge) a top layer of local soil consisting of 80% gravel and sand made of local bedrock and 20% local meadow soil was added in autumn 2004. We placed five blocks (8 × 8 m) each with 16 randomly placed quadrats (1 × 1 m). Each qudrat had a plot of 0.5 × 0.5 m, divided into 16 equal subplots. Species abundance of vascular plants was recorded as frequency out of 16 subplots, for first time in late summer of 2005, and the two following years. In addition total cover of bottom layer and total cover of field layer was recorded in each plot every year. We used the same method for recording species abundance in the donor sites in 2004, which enabled plot by plot comparison between donor plots and recreation plots. In each block, the four treatments were randomly selected, six quadrats to hay transfer, light raking, six qudrats to hay transfer, hard raking, three quadrats to seed-sowing and one quadrat to reference (succession from bare soil). The seed-sowing treatment involved sowing of 11 species in each plot. We collected the seeds at the donor sites when they were ripe. The seeds were sown in late September 2004 at the time when the construction of the road verge was finished. Our local seed-mixture consisted of 125 seeds of the selected grass species and 25 seeds of the herbs. The hay at the donor sites was cut, collected and dried in drying cabinets, before transported to the recreation site in late September 2004. From 2006 and onwards the recreation site was annually mowed in late summer.

We calculated Bray-Curtis (BC; Legendre and Legendre 1998) compositional dissimilarity index for each donor plot between the initial year (2004) and each other year (recreation plots 2005-2007) for the hay transfer and seed-sowing treatments. For the seed sowing plots at recreation site, the species composition the initial year in 2004 was set to the species sown with a subplot frequency of 16. Since reference plots were not related to any donor plots, 2005 was taken as the initial year, but in the present paper we pay less attention to this treatment.

Differences in BC, using normalized BC as response, between treatments and years were analysed with a linear mixed-effect model (LME, Pinheiro & Bates 2000) to account for the nested structure of the plots, i.e. within the 5 blocks, and the repeated measurement of the individual plots. We used year and treatment as factors in a two-way approach, with random effects of block and plot-identification nested within block. All statistical analyses were performed using R versions 2.6.0 (Anonymous 2007).

Results and discussion

Both vascular plant cover and bryophyte and lichen cover increased significantly with time from the first year after establishment in 2005 and the two following years (Fig. 1). The different treatments did not differ significantly. The cover of both layers were slightly higher in 2007 than in their donor grasslands of 2004. The rapid reestablishment of cover is a common pattern of experiments aiming to recreate grasslands (Patzelt et al. 2001; Kiehl & Wagner 2006).

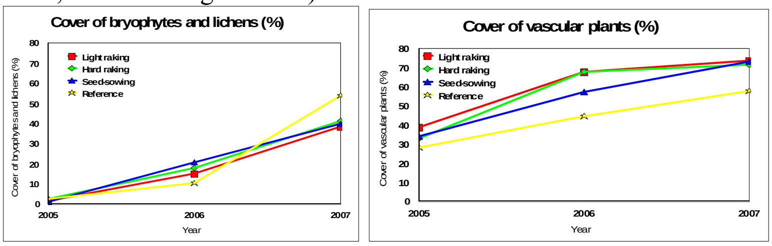

Figure 1. Mean percentage cover for three years after the establishment of the restoration site for bryophytes and lichens and vascular plants.

Transfer rates were high, > 70%, for common species (i.e. species with a occurrence in the total data set ≥ 3.5%) but around 50% when all species existing in the donor plots were included. Although transfer rates were relatively high, the BC floristic dissimilarities were still high three years after establishment(0.68 - 0.72; Fig. 2) for the three treatments with a donor reference. The species composition of the treatments significantly changed towards their donor specie composition during three years of succession, but levelled out the third year (Fig.2). Which is an unexpected result, since the few comparable studies show that vegetation at recreation sites increase their similarity with donors in subsequent years for a longer period than three years (Patzelt et al. 2001; Edwards et al. 2007). Our result the third year may be due to a decrease in frequency by some species that still haven't reached their donor frequency (e.g., *Dactylis glomerata* and *Pimpinella saxifraga*), and an increase beyond their donor frequency (and abundance) for other species (e.g., *Rumex acetosa* and *Trifolium pratense*). There were small non-significant differences between the treatments. We had expected a better development of hay transfer treatments compared to seed sowing, and also that hard raking should have shown better development than light raking because of higher number of seeds transferred as well as better seed bed conditions. There may be several explanations for this. First, we had to use dried hay since the recreation site became available at the end of September 2004. And fresh hay is regarded to perform better than dried hay (Jones et al. 1995). However, since we kept the hay in the same paper bags from the time of cutting until transfer we hardly lost any seeds, but germination ability may have been influenced. The donor plots were also used in 2003 for hard and light raking in a similar experiment but this experiment was destroyed by strong autumn winds. We therefore had to restart the experiment the following year at a new place, but we had to use the same donor plots. Implying that species with a persistent seed bank may have been transferred in a lesser degree than if these plots had not been reused.

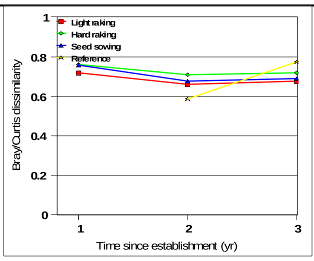

Figure 2. Mean Bray-Curtis compositional dissimilarity among treatments.

Conclusions

Road verges can be used for recreating semi-natural grasslands but with methods that enhance biodiversity. Such methods may be seed-sowing of seeds of local provenance and hay transfer. If fresh is available then hay transfer should be used since it is often cheaper than seed-sowing and usually gives better results (Jones et al. 1995).

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