Establishment of an *Arrhenatherion* meadow through on-site threshing material and green hay transfer

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Abstract

Arrhenatherion meadows are highly abundant in semi-natural grasslands of Central Europe and are regarded as an important resource for the ecological restoration of species-rich grassland. The effectiveness of different restoration methods of former intensively used arable land was tested by means of a field experiment. A donor site was harvested via i) on-site threshing (OST) and ii) fresh hay cutting - green hay (GH). The harvested material was transferred to a receptor site, which was deep ploughed before applying the seed and plant material. Three years after the establishment 20 target species with a transfer rate of 61% were observed for the OST method, resulting in a vegetation cover of target species of 72%. In the same year, the GH method achieved a number of 16 target species at the transfer rate of 52% and a share of target species at the vegetation cover of 74%. The number of target species and also the transfer rate increased over the years of observation. Both establishment methods are, in combination with an adequate site preparation, effective methods for the ecological restoration of *Arrhenatherion* meadows on former arable land. A PCoA analysis showed a trend of increasing similarity of donor site and receptor site over time, but up to now without any statistical significance.

Keywords: receptor site, target species, ecological restoration, transfer rate

Introduction

Semi-natural grasslands are the result of long and sustainable utilization of meadows and/or pastures by humans in Central Europe. *Arrhenatherion* meadows are one of the most common plant communities of these semi-natural grasslands and also an important resource for the ecological restoration of species-rich grassland. Practically relevant restoration of semi-natural grassland has been realized successfully on differing sites for many years in several European countries (Prach *et al.*, 2012; Scotton *et al.*, 2012). Restoration success can be defined as the development towards a natural, self-maintaining habitat with the physical and biological characteristics defined in the restoration project (Scotton *et al.*, 2012). The aim of this research work was to study the transfer rate of target species and the development of the vegetation cover on the receptor site established with on-site threshing material and green hay.

Materials and methods

The donor site (nutrient-poor *Arrhenatherion* meadow) is located in Upper Austria, at 48°18'N, 14°03'E; 310 m a.s.l. The receptor site was an area of plain arable land, located at 47°29'N, 14°06'E, in the Enns valley, at an altitude of 700 m a.s.l. Before establishment, site preparation was done by deep ploughing (80 cm), not only to reduce the nutrient level but also to deplete the soil seed bank of unwanted weeds (Scotton *et al.*, 2012). The soil properties of the donor site and the receptor site are presented in Table 1. The on-site threshing (OST) material was harvested with a plot combine thresher at a cutting width of 1.5 m on 1 July

2009. The harvested material was air-dried and roughly cleaned with a 6 mm sieve. After determination of purity and thousand seed weight of the OST material (described in Haslgrübler *et al*., 2011) the receptor site was sown with a seed density of 3 g m^{-2} on 25 August 2009. The green hay (GH) was harvested on 1 July 2009 with a hand-operated motor mower early in the morning, because the morning dew enables the seed to stick to the plant. The fresh material was immediately brought to the receptor site to avoid decay and seed losses, as recommended by Scotton *et al*. (2011). The green hay application was implemented immediately after cutting with 3.5 kg m^{-2} on the receptor site, representing a biomass ratio between donor: receptor site of 2:1. In the year of establishment the GH treatment received a cleaning cut after two months in order to control weeds. The experimental trials were established as a complete block design with 3 replicates of 174 m^2 each. The projective cover of the different species on the donor site was surveyed according to Schechtner (1958) in the harvesting year 2009 and on the receptor site twice a year between 2010 and 2012. The development of the different species was assessed over a period of three years under a 2-cut regime. The count of target species was done over all replicates; therefore no statistical tests were possible.

Table 1. Soil properties of the donor and restoration site.

	Gravel %	N % mass	pH $CaCl_2$	P (CAL) mg kg^{-1}	K (CAL) mg kg^{-1}
Donor site (0–20 cm)	44.14	0.52	7.2	15.8	73.9
Receptor site (0–20 cm)	47.83	0.15	6.2	56.0	91.9

A MANOVA and Principal Coordinates Analysis (PCoA) was used for data analysis, done with the statistics language R, Version 2.15.2 with the package vegan, Version 2.0-5 (Oksanen *et al*., 2012). The analysis was based on a distance matrix focusing on beta diversity calculated with the metric Jaccard index as implemented in vegan (functions 'vegdist' and 'betadisper' in vegan). The grouping variable was year, respectively age of the plot.

Results and discussion

Restoration success depends not only on the number of different species at the donor site and on the transfer rate, but also on site conditions of the receptor area. The OST method showed the highest number of species in 2010, including annual weeds like *Capsella bursa-pastoris* and *Viola arvensis*. The number of target species and also the transfer rate increased over the years. In 2012, twenty target species were observed over all replicates in the OST treatment, and the transfer rate was 60.9% of the total species count. The proportion of target species of the total projective vegetation cover increased over the years and reached 72.2% in 2012. The total number of species in the GH treatment remained stable over the years. The number of target species over all replicates increased slightly between 2010 and 2012. In 2012, the GH treatment reached a total number of 16 target species resulting in a transfer rate of 51.6% of the total species count. The mean relative cover of target species found over all replicates in the vegetation cover was 74.3%. The high amount of biomass/mulch from the GH method in the first year after establishment prevented the germination of forbs and therefore more grasses than forbs were transferred.

In 2012, three years after establishment, more target species were found in the plots of the OST treatments than in the GH plots (Table 2).

The results of the MANOVA (function 'adonis' in vegan) showed no significant differences between the two restoration methods (P = 0.883, R^2 = 0.00754) and years (P = 0.919, R^2 = 0.04828) concerning group (OST vs. GH) variance based on a dissimilarity matrix. The result of the following PCoA for donor and receptor site shows the development of the two methods OST and GH together over three years. The variance (represented by the mean distance from

the centroid) within the replicates was, independent of the method in the first two years (2010 to 2011), higher compared to the donor site, and lower in 2012, though without any statistical significance. The receptor site was still rather far from the donor site in terms of its species composition; however, the development of the vegetation seems to be heading in the anticipated direction. Part of the difference might possibly be explained by the distinction of climatic conditions and soil properties of the donor and the receptor site; e.g. the pH value on the receptor site is lower and the soil P content much higher than at the donor site (Table 1).

Table 2. Species number, vegetation cover and transfer rate of target species from on-site threshing (OST) and green hay (GH).

Treatments	Donor site	Receptor site					
Parameter		OST			GH		
Date of survey	6/2009	6/2010	6/2011	6/2012	6/2010	6/2011	6/2012
Number of species	67	38	27	28	30	30	30
Numb. of target species (over all replicates)	48	16	19	20	14	15	16
Transfer rate of target species (% species)	-	50.7	60	60.9	47.7	48.5	51.6
Total cover (%)	97.6	58.7	91.0	85.6	67.0	73.3	86.0
Proportion of target species (% total cover)	83.9	70.1	55.5	72.2	79.0	73.6	74.3

Conclusion

On-site threshing and green hay are suitable harvesting methods and an effective way for an ecological restoration of *Arrhenatherion* meadows on arable land in combination with adequate site preparation, as shown by the results of our project. Four years after establishment of the experimental site there were no significant differences found between on-site threshing and green hay, and therefore it can be stated that the choice of restoration method for establishing an *Arrhenatherion* meadow depends more on the availability of equipment and other practical conditions, such as the accessibility of the sites.

References

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