Grassland restoration: Best practice of sod transplanting by considering spontaneous colonization pattern

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introduction
Sod transplantation is well known as an efficient method for establishment species-rich grassland. Advantages over other restoration measures like seeding are the transfer of even diaspore missing individuals of vascular plants, ground mosses and lichens, soil biota, microorganisms and small animals. In addition, sod transplantation proved to achieve high transfer rates of target species, especially when carried out in early Spring or late autumn, combined with relatively low degrees of weed infection. So, translocation of species-rich grassland sods should be a standard procedure for (1) mitigation measures or, (2) enrichment of existing species poor grassland, given that respective sites are demanded by building activities when the destruction of those sites is inevitable.

Apart from the rather expensive restoration method of sod transplantation, natural colonization can be a cost-effective supplement in the course of grassland restoration, given that donor sites are directly bordering. To maximize the effect of both restoration measures, while simultaneously reducing the costs for the generation of species rich grassland, we recommend a combination of sod transplantation with self-colonization in the areas between the sod patches.

characteristics of project areas (Fig. 1)
Soils are exclusively rain fed, comprise non-calcaric alluvial soils and stagnosols (Lebensministerium 2016) and are relatively acidic (pH 4.5-5.3). Nutrient content was even on restoration sites (former arable fields) relatively low and did not exceed 39/137 mg/kg for P/K. The vegetation of the donor sites belonged to Molinio coeruleae and Arrhenatherion elatioris.

methods
In a recent study (Sengel & al. subm.) we compared hay transfer and seeding with sod transplantation and self colonization between sods. We found out that, within a three year-period, applying the latter method restoration sites with the greatest similarity to the reference sites could be generated. The efficiency of sod transplantation was proved also by other authors (Bruehnelle & Flintrop 2000, Kiehl & al. 2010, Rydgren & al. 2010).

sod cutting and transplanting: In April, the upper 30 cm of the soil layer and vegetation cover were cut out with a modified excavator shovel; individual sod pieces were approximately of 1x1 m size (Fig. 2). The sods were then transferred to two receptor sites. The distance between donor and restoration sites was in each case < 1 km. The receptor sites encompassed four patches of 15 m × 15 m, which were prepared by removing the upper 30 cm of the topsoil.

Natural colonization: Sites were prepared by ploughing and harrowing and did not receive any plant material, but were directly bordering on the sod transplantation sites.

In our study, we used the following design for sod transplantation/self colonization: sod pieces were joined at the receptor site to patches of 15 m × 15 m (Fig. 3) in a distance of 10 m to each other. After three years, the absolute species number but also the number of target species on the areas between the sods were nearly as high as on sites where hay transfer was applied. Obviously the self colonization distance of 10 m could be reached by most of the species, a fact we revealed in a previous study (Sengel & al. 2015). Consequently by optimizing this design, we could triplicate the area of new species-rich grassland in comparison to donor area (16 sod plots × 225 m² = 3600 m² for 1 ha of restoration area, donor site/restoration site ratio = approx. 1:3).

Fig. 1: Location of study areas A (47°03’N. 16°04’E, 280 m a.s.l) and B (46°43’N, 15°56’E, 230 m a.s.l.) in the South Eastern Alpine Foreland of Austria. AT = Austria; CZ = Czech Republic; SK = Slovakia; HU = Hungary; HR = Croatia; SI = Slovenia; ITA = Italy; DE = Germany.

Fig. 3: sod plots ≈ 15x15m, donor site/restoration site ratio approx. 1:3

Fig. 4: sod plots ≈ 5x5m, donor site/restoration site ratio approx. 1:11

discussion
As vascular plants in species-rich grassland in our region achieve a colonization distance of 10 m within a few years, the distance between individually applied sods could theoretically reach up to 20 m. Nevertheless, we propose a maximum distance of 10 m because individual sods do not likely contain the whole species pool of transplanted sites.

For future projects we propose sod plots ≈ 5x5m, which could lead to a donor site/restoration site ratio up to 1:11 (36 sod plots ≈ 25 m² ≈ 900 m² for 1 ha) (Fig. 4). As 25 m² should be enough for establishing a stable vegetation patch as a source for further colonization this approach could reveal a further advantage besides enlarging the possible area of restoration: We should gain a higher colonization probability for small, stress-tolerant species because their dispersal might be limited by higher growing plants in their surroundings. As the most important plant trait for an effective anemochory is the height (Lauterbach & al. 2013, Thomson & al. 2011), only prominently exposed diaspores can effectively be transported. As smaller sod plots exhibit a greater amount of edges, this could eventually promote the dispersal of small species.

Fig. 5: Example of a site restored by sod transplantation (right half)/self colonization (left half), four years after implementation (phot. P. Sengl 2015)

conclusion
Of course, sod transplanting could only be an option, if species rich grassland have to be destroyed. But if so, this very effective method should be applied for creating new grassland and for enriching species poor communities as well. In the latter case, the restoration area should be ploughed and harrowed before the sods are yielded. However, all restoration efforts depend on proper follow-up management (Fig. 5).

Fig. 5: Example of a site restored by sod transplantation (right half)/self colonization (left half), four years after implementation (phot. P. Sengl 2015)

Fig. 2: workflow of sod transplantation: a) extraction of sods with a modified excavator shovel; b) transfer to donor site; c) transplantation; d) established sod (summer in year of transplantation) (phot. P. Sengl 2013)

Fig. 6: Transplanting on semi-natural lowland meadows in Austria: a comparison of five techniques and introduction of a new index.

Literature

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