High-elevation grassland re-establishment using adapted seed mixtures

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Abstract

The re-establishment of grassland vegetation at high elevations is challenging due to harsh climate, a short vegetation period and shallow, nutrient-poor soils. Moreover, environmental conditions differ greatly between sites, so site-adapted restoration measures are required. Seed mixtures allow for a flexible addition of adapted plant species at appropriate dates during the short vegetation period, either alone or in combination with transplanted turf or seedlings. We have reviewed seed mixtures proposed for the subalpine and alpine zones of the Alps. The 24 identified seed mixtures were often built around a common set of dominant species complemented by a large diversity of additional plant species (188 species). A subset of eight mixtures was tested in a randomised experiment at a high-elevation site. Despite considerable overlap in the core composition of the mixtures, large differences in yield of the first cut and the composition of the sward were found. This highlights the need to test seed mixtures for high-elevation restoration in the field.

Keywords: high elevation, restoration, multi-species mixture, sward establishment

Introduction

Growth conditions at high elevations differ tremendously from those in lowlands (Schneider *et al.,* 2017). Frost may occur even during the short vegetation period, soils are shallow and barely retain water and nutrients. Despite these limitations, land in most mountain areas in covered by vegetation, except for very steep, rocky places or areas under snow and ice. Natural events such as landslides and avalanches may destroy this protective vegetation cover, but also construction works, excessive grazing or ski runs may impair it, causing the loss of fine soil and humus. Disturbed sites may be repopulated by pioneer species only very slowly and it may take years until a stable, site-adapted vegetation re-establishes. Additional efforts to recreate a protective vegetation are therefore often necessary.

Sowing of multispecies seed mixtures is frequently used to re-establish vegetation at high elevations. It is crucial to sow species and genotypes adapted to the specific conditions of high-elevation sites. Our aim was therefore to review the available literature on seed mixtures for high-elevation restoration in the Alps and to test them in the field.

Materials and methods

The 13 mixtures identified by the literature review were complemented by two mixtures from commercial seed companies and nine mixtures specifically designed for restoration projects. Eight mixtures (six from the literature and two commercial mixtures) were further tested in a field experiment in the Eastern Swiss Alps at 1,850 m.a.s.l. (46.793°N, 9.687°E; cambisol on serpentinite; 3.6 °C mean temperature and 1,365 mm mean precipitation). Details about the mixtures can be found in Table 1. The trial was a randomised complete block design with plots of 2.5×7 m and three replicates. Mixtures were sown on 2 July 2018. A first cut was carried out on 27 September 2018 and cover proportions of functional groups were visually

Table 1. Species mixtures with their source, the number of species (Nsp) and the species with highest seed amounts.

	Akronym	Source	Nsp	Species with highest seed amounts
A	SM 491	Suter *et al.*, 2017	20	*Fes.nigre, Agr.gigan, Lot.alpin, Tri.badiu, Poa.prate, Tri.prate*
B	SM 492	Suter *et al.*, 2017	29	*Fes.nigre, Agr.gigan, Poa.prate, Ant.vulne, Fes.viola, Lot.alpin*
C	acidic	Krautzer, 2001	12	*Fes.nigre, Poa.alpin, Fes.ovina, Fes.pseud, Fes.viola, Phl.rhaet*
D	alkaline	Krautzer, 2001	8	*Fes.nigre, Poa.alpin, Lot.corni, Agr.capil, Ant.vulne, Fes.viola*
E	N5	TBA, 2013	25	*Fes.nigre, Lol.peren, Poa.alpin, Phl.rhaet, Agr.alpin, Ant.alpin*
F	N6	TBA, 2013	22	*Fes.nigre, Lol.peren, Ave.flexu, Phl.rhaet, Poa.alpin, Agr.rupes*
G	Terra verde 57	Schutz Corp.	13	*Poa.alpin, Fes.nigre, Phl.hirsu, Phl.rhaet, Poa.viola, Ach.mille*
H	OH-Pre alpin	OH seeds Corp.	15	*Fes.nigre, Fes.rubra, Lol.peren, Poa.prate, Fes.ovina, Dac.glome*

estimated. Differences in yield and cover proportions were analysed using one-way analysis of variance and subsequent pairwise least square difference tests with Holm correction.

Results and discussion

The 24 mixtures contained on average 26 plant species and 188 in total. The ordination of species composition showed that the mixtures evaluated in the trial differed in composition from the mixtures specifically designed for restoration projects (Figure 1). The mixtures in the trial were associated with warmer conditions and soils relatively rich in nutrients and humus. Since mixtures A and B, C and D, E and F originated each from the same authors, the analysis also indicated a pairing by author, likely because every author developed mixtures for a particular application or based on a limited set of available seeds.

Despite the fact that many of the dominant species in the mixtures were relatively similar, the tested mixtures differed greatly in yield and composition of the first cut (Table 2). The commercial mixture H had the highest yield and a high proportion of grasses and legumes. It was the only mixture that contained the lowland species *Lolium multiflorum* var. *westerwoldicum* and high yields may likely be transient (Suter *et al.*, 2013). The two mixtures A and B by Suter *et al.* (2017) also had high yields but were dominated by legumes and, to a lesser extent, by grasses. In contrast, mixtures C and D by Krautzer (2001) were

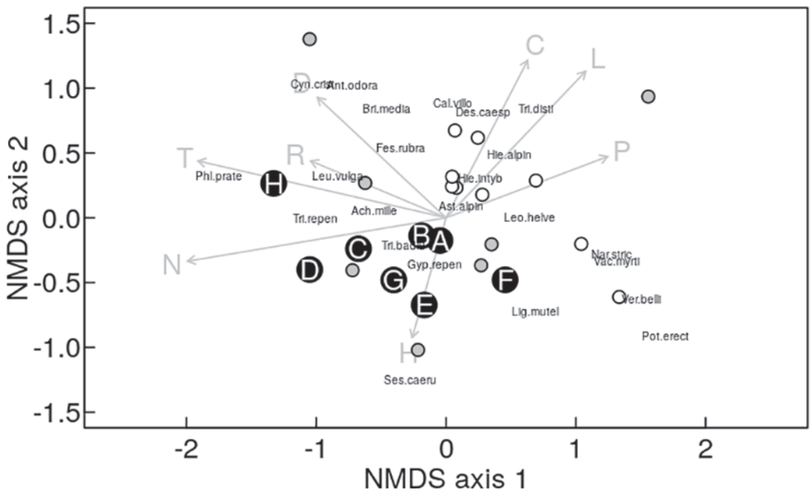

Figure 1. Non-metric multidimensional scaling of the species composition (presence-absence) of seed mixtures for high-elevation restoration. Black dots with capital letters indicate eight mixtures used in a field experiment, grey dots represent other mixtures from the literature, white dots mixtures of a restoration project. Text labels show the position of selected plant species in the ordination. Grey arrows are the fitted vectors of mean indicator values for nutrients N, temperature T, soil pH R, rooting depth D, continentalism C, light L, soil permeability P and humosity H taken from Landolt (2010).

Table 2. First assessment of yield (g DM m^{-2}), estimated total ground cover (%) and estimated cover % of sown grasses, legumes and forbs as well as unsown species in the first cut, two months after sowing.[1]

Nr	Yield	Total cover	Grasses	Legumes	Forbs	Unsown
A	329 ab	98 a	34 a	45 a	4 c	15 ab
B	272 ab	93 ab	27 ab	42 ab	5 c	20 a
C	264 ab	97 ab	6 b	48 a	36 a	7 b
D	312 ab	97 ab	6 b	50 a	33 ab	8 b
E	168 b	82 b	47 a	6 c	5 c	23 a
F	165 b	85 ab	32 a	23 bc	5 c	25 a
G	165 b	88 ab	33 a	12 c	22 b	22 a
H	386 a	100 a	40 a	47 a	7 c	6 b
LSD	215	16	25	22	13	13

[1]Different letters denote differences beyond the least significant difference (lsd) at the 5% level.

initially dominated by legumes and forbs, mainly *Achillea millefolium*. Mixtures E-G showed slower establishment, lower yields and a lower total coverage. As a consequence, they had the highest cover of unsown species.

Conclusion

The majority of recommended multispecies mixtures are representative of only a limited part of high-elevation grasslands. Mixtures by the same authors are often more similar among each other than to the mixtures of other authors. Despite a relatively similar core set of species in the eight tested mixtures, they strongly differed in yield of the first cut after establishment and the proportions of grass, legumes and forbs. This highlights the need for specific testing of mixtures for application in high-elevation restoration.

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References

Krautzer B. (2001) *Rekultivierung und Begrünung in Hochlagen*. In: Tagung für die Jägerschaft, Bundesanstalt für alpenländische Landwirtschaft Gumpenstein, Irdning, Austria, pp. 41-44.

Landolt, E. (2010). *Flora indicativa* (2^{nd} ed.). Haupt, Bern, Switzerland, 378 pp.

Schneider M., Suter D., Krüsi B. and Rixen C. (2017) *Begrünung in Hochlagen*. Arbeitsgemeinschaft zur Förderung des Futterbaues, Zurich, Switzerland, 6 pp.

Suter D., Rosenberg E., Mosimann E. and Frick R. (2017) Standardmischungen für den Futterbau, Revision 2017-2020. *Agrarforschung Schweiz* 8, 1-16.

Suter D., Rosenberg E., Hirschi H.U. and Lüscher A. (2013) Potential of Westerwold ryegrass as a nurse crop for grass-clover mixtures. *Grassland Science in Europe* 18, 174-176.

TBA (2013) *Samenmischungen für Strassenböschungen*. Tiefbauamt Graubünden, Chur, Switzerland, 25 pp.