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What are the long-term effects of livestock grazing in steppic sandy grassland with high conservation value? Results from a 12-year field study

Welches sind die Langzeit-Effekte von Beweidung mit Großherbivoren in naturschutzfachlich wertvollen Steppenrasen auf sandigem Substrat? Ergebnisse einer Studie über 12 Jahre

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Abstract

To examine the necessity of livestock grazing for managing threatened sand vegetation so as to ensure and develop its nature-conservation value, we investigated a grazing system in a model nature reserve (German upper Rhine valley) characterized by threatened steppic sandy grassland (*Allio-Stipetum* vegetation complex: Habitats Directive Annex I, priority type 6240, additionally *Koelerion glaucae*: priority type 6120). The area has been grazed by sheep and additionally by donkeys since late summer of the year 2000. We established ungrazed (Au) and grazed plots (Ag) in the *Allio-Stipetum* complex in a systematic grid-plot design before grazing impact started.

We sampled phytosociological relevés yearly in the Au/Ag plots for 12 vegetation periods. Additionally, we sampled relevés on former farmland adjacent to the *Allio-Stipetum* complex (systematic grid-plot design) over ten vegetation periods. These former fields (Fg) were integrated in the grazing system since the beginning of the study. A constancy table was produced for Au, Ag, Fg. To determine the portions of target species (*Koelerio-Corynephoretea*, *Festuco-Brometea* species) we calculated target-species ratios (proportion of target species in comparison with the total species number; qualitative or quantitative approach: $TSR_{qual/quant}$). We tested the effects of grazing, year and interactions on structural and phytodiversity characteristics of the relevés by mixed linear models.

The results of the long-term experiment confirmed significant beneficial effects of grazing on habitat-typical structure and phytodiversity: e. g. reduction of litter, support of species which are short in height (< 20 cm), reduction of taller species (> 50 cm), support of the diversity of all plant species, of non-graminoid herbs and of target plant species, reduction of *Calamagrostis epigejos,* positive effects on TSR_{qual} and TSR_{quant} values.

Similar developments, e.g. for phytodiversity and *Calamagrostis epigejos* cover, were observed on the former fields, but there are still seed limitations and high ruderal-plant dominances. In general $TSR_{qual/quant}$ show remarkable increases, but do not reach the values of the Ag plots.

Concerning aims of nature conservation, the habitat-typical vegetation structure and phytodiversity of the *Allio-Stipetum* shows an excellent development as a consequence of the used grazing management. However, occasionally small populations of target species did not increase (e.g. *Koeleria glauca*). The former fields show a development towards valuable sandy grassland.

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Erweiterte deutsche Zusammenfassung am Ende des Manuskripts

1. Introduction

Grazing is a powerful management tool for the preservation and development of various vegetation types with high phytodiversity (ROSENTHAL et al. 2012). Here we investigated a grazing approach in vegetation complexes comprising small patches of threatened *Koelerio-Corynephoretea* in Klika in Klika et Novák 1941 stands (*Koelerion glaucae* Volk 1931: priority habitat 6120 "Xeric sand calcareous grasslands") and large areas of *Allio-Stipetum* Korneck 1974 steppic sandy grassland (*Festuco-Brometea* Br.-Bl. et Tx. in Br.-Bl. 1949, *Festucetalia valesiacae* Br.-Bl. et Tx. ex Br.-Bl. 1949; priority habitat 6240 "Sub-pannonic steppic grasslands", see Fig. 1); (European Habitats Directive 92/43/EEC, EUROPEAN COMMISSION 2007). This vegetation mosaic has extraordinary importance in a regional and whole European context (ZIMMERMANN et al. 2010); it is an example of a "European High Nature Value (HNV)" farming system (OPPERMANN et al. 2012). As in many other European ecosystems, the remains of such habitats are mostly small and isolated within the densely settled northern upper Rhine valley.

Fig. 1. Part of the nature-protected area (NSG) "Griesheimer Düne und Eichwäldchen" in the inland-dune area of the northern upper Rhine valley with dominant *Allio-Stipetum* aspect and flowering *Euphorbia cyparissias.* In the background: former fields, now part of the NSG (May 2005. Photo: A. Schwabe).

Abb. 1. Teil des Naturschutzgebietes (NSG) „Griesheimer Düne und Eichwäldchen" im Binnendünen-Gebiet der nördlichen Oberrheinebene mit Dominanz des *Allio-Stipetum* und blühender *Euphorbia cyparissias.* Im Hintergrund: ehemalige Äcker, die in das NSG integriert wurden (May 2005. Foto: A. Schwabe).

Endangered plant species such as *Bassia laniflora*, *Medicago minima, Phleum arenarium, Silene otites* and *Stipa capillata* are present as well as threatened habitat types. This vegetation mosaic is also well known for its richness in endangered invertebrates (e.g. flower-visiting wild-bee species, which depend on the offered flower resources and mostly open nesting places), see BEIL (2007), BEIL et al. (2008), ZIMMERMANN et al. (2010).

In a previous study we investigated the spontaneous succession of sand vegetation in the northern upper Rhine valley by means of permanent plots (SÜSS et al. 2010). We also summarized the current knowledge about the sand vegetation on base-rich sites in the northern upper Rhine valley (SÜSS et al. 2010). An important result was that initial stands with pioneer vegetation and biological soil crusts were characterized by very slow vegetational changes over a time period of 11–12 years. In the specific case of the *Allio-Stipetum* we were able to study spontaneous succession up to 15 years and found various effects: sites with establishment of shrubs (e.g. *Prunus spinosa*), sites with a severe decrease of species numbers, sites with small changes (SÜSS et al. 2010). All in all most of the *Allio-Stipetum* plots have shown losses of phytodiversity and changes in floristic structure. However, the question of how far grazing management could counteract such developments remained unanswered.

To guarantee and – if possible – increase the conservation value of the Habitat type 6240 and its mosaic, it should be managed in a way that ensures also partly regressive developments of dense *Allio-Stipetum* stands, which means to redynamize parts of consolidated sandy grassland. Therefore dense stands of *Allio-Stipetum* should be partly opened to guarantee the existence of a fine-scale mosaic between *Koelerio-Corynephoretea* and *Festuco-Brometea* species. Our hypothesis is that grazing should be an important biotic factor to secure this dynamization in the long run. We implemented a grazing system with sheep for the basic management (SCHWABE et al. 2004a, b). The used sheep herd comprised mainly old breeds such as Skudde. Additionally donkeys were integrated in a system of successive sheep- and donkey-grazing management to secure high extraction of graminoids, which is typical for donkey diet and was examined in different studies in our sites (STROH et al. 2002, SÜSS & SCHWABE 2007). In other sandy areas grazing with sheep and partly with donkeys was found to be an adequate measure to stop ruderalization and to ensure a diverse vegetation mosaic (e.g. KOOIJMAN & VAN DER MEULEN 1996 in dune areas of the Netherlands, LAMOOT et al. 2005 in dunes of Belgium, PLASSMANN et al. 2010 in dunes of North Wales, UK).

Meanwhile data have been provided by a field study initiated in the year 2000 during the implementation of a livestock management plan, which included the assessment of grazed and non-grazed plots and lasted for 12 vegetation periods. Additionally, we studied the vegetation development in grazed former fields which were integrated in the studied nature protection area and in the grazing approach since the beginning of our studies.

Our main questions were the following: (1) Does the applied grazing regime lead to a change of important structural characteristics? (2) Does the grazing regime alter phytodiversity, and especially the proportion of target species? (3) Is there a change in the dominance structure of competitive graminoids during the grazing period? (4) Are the developments in the grazed former fields similar, especially concerning phytodiversity and competitive graminoids?

2. Study area, climatic events and grazing system

The sandy areas of southern Hesse were deposited in the late glacial period of the Wuerm glaciation by aeolian transport from the upper Rhine terraces and relocated in the postglacial period also by aeolian processes. This was favored by men mainly since the Middle Ages due to forest clearings and creation of open habitats, e.g., for military purposes (AMBOS & KANDLER 1987, ZEHM & ZIMMERMANN 2004).

The mean annual temperature during the period 2000–2011 was 11.4 °C, average annual rainfall amounts to 644 mm and 1684 annual sunshine hours were recorded (average without the year 2003). The climatic conditions are characterized by high amplitudes of temperature (19 °C yearly fluctuations). Climate data in the study period show one extraordinary year (2003) with extremely low precipitation (379 mm) and high values of sunshine hours (2138 h). Annual precipitation values (507–778 mm) and sunshine hours (1507–1944) in the other years were on average (data from Frankfurt International Airport, Deutscher Wetterdienst).

The study was carried out in the protected area (Naturschutzgebiet: NSG) and Natura 2000 site "Griesheimer Düne und Eichwäldchen" (45 ha; 100 m a.s.l., 8°34'E, 49°50'N), which is an extraordinary target area for base-rich steppic sand ecosystems and one of the oldest and most valuable protected areas in our region (core area already established in the year 1953). There are mainly consolidated dune structures with maximal height of 5 m. At the beginning of the study, the management status of the area was in deficit; large facies of *Calamagrostis epigejos* occurred even in the core area of the dune complexes. In addition to the core area, new parts were integrated on the margins of the old NSG. In the year 2000 these former *Asparagus* fields, which fell fallow in the year 1987 and were afterwards tilled, were dominated by competitive graminoids such as *C. epigejos.*

In the year 2012 the NSG was characterized by a dominant mosaic of mainly *Allio-Stipetum* with small patches of *Koelerion glaucae* and pioneer vegetation (*Corynephoretalia canescentis* Klika 1934 stages, more open microhabitats with *Koelerio-Corynephoretea* species).

Since the year 2000 the whole area has been grazed by a moving sheep flock of 300 to 500 mother animals; during lambing season up to 800 animals. In different fenced parcels of the NSG, sheep grazed mostly in July/August for a few days only (map in ZEHM & ZIMMERMANN 2004) with a stocking capacity of 0.2 to 0.4 livestock units ha^{-1}. In the former fields this capacity was higher (mainly 0.8–1.0 livestock units ha^{-1}, see ZEHM & ZIMMERMANN 2004). Since 2000/2001 donkey grazing was additionally established to complement the fodder selection by sheep, especially concerning graminoids, with similar stocking capacities (Figs. 2, 3). The sheep flock changes mostly between target sandy areas and restored parcels of land and also grazes some parts of the year in more productive areas of the "Hessian Ried" (see the concept and the results of this approach in SÜSS et al. 2011).

3. Methods

3.1 Study design, study period and nomenclature

The study started in spring/early summer 2000 to sample first the status quo before initial grazing took place in summer 2000. The plots were recorded in June (including assessments in early spring to account adequately for ephemeric annuals like *Erophila verna* and *Veronica praecox*), using the differentiated Braun-Blanquet scale according to BARKMAN et al. (1964). With the exception of four relevés

Fig. 2. Donkey grazing opens the *Stipa capillata* facies (June 2001. Photo: A. Schwabe).

Abb. 2. Durch Eselbeweidung werden die *Stipa capillata*-Fazies geöffnet (Juni 2001. Foto: A. Schwabe).

Fig. 3. *Allio*-*Stipetum* complex after donkey grazing in the year 2008. Left side: part of one of the ungrazed plots with *Calamagrostis epigejos* dominance (June 2008. Photo: A. Schwabe).

Abb. 3. *Allio*-*Stipetum*-Vegetationskomplex nach Eselbeweidung im Jahr 2008. Linke Seite: Teil einer der unbeweideten Untersuchungsflächen mit Dominanz von *Calamagrostis epigejos* (Juni 2008. Foto: A. Schwabe).

in 2000, which were recorded by M. Nobis, all relevés were sampled by A. Schwabe. For further data analysis the cover-abundance scale was transformed to cover values, as follows: r = 0.1%, + = 0.3%, 1 = 1%, 2m = 3%, 2a = 9%, 2b = 19%, 3 = 38%, 4 = 63%, 5 = 88%.

In the NSG a systematic grid system was established with circular plots of 79 m^2 (50 m distance from each other; grazed *Allio-Stipetum* complex (Ag: 14 plots); ungrazed plots (with fences) in between (Au: 10 plots, see one example in Fig. 3); grazed former fields (Fg: 16 plots). The fences excluded sheep and donkeys, but not rabbits or rodents, which were regarded as natural biotic factors inside and outside the exclosures. Especially in the year 2011 there was a considerable rabbit impact at many plots. It was not easy to convince the administration that it is important for the assessment of grazing impact to establish fenced reference plots in this extraordinary area. It was allowed to construct 10 exclosures for the *Allio-Stipetum* complex (see above), but the former field areas should be developed entirely towards the target areas (Fig. 4a, b). Hence, no ungrazed former field plots could be established. Nevertheless the combination of the three datasets also allows for Fg to show particular trends.

Due to the size of 79 m^2 the *Allio-Stipetum* plots represent the typical mosaic, including also small-sized open parts.

Nomenclature of vascular plant species follows WISSKIRCHEN & HAEUPLER (1998), of bryophytes KOPERSKI et al. (2000) and of lichens SCHOLZ (2000); the syntaxa refer to OBERDORFER (2001).

3.2 Data analysis

We generated a constancy table, showing the three columns: *Allio-Stipetum* complex ungrazed, grazed and the former fields for the whole study period. To highlight species that show monotonic trends with time, Spearman's rank correlation coefficients between presence of each species and year were calculated and tested for significance. The reported *P* values of the rank correlation coefficients are to be interpreted as exploratory. Accordingly, alpha adjustment was not performed. The software Statistica 6.0, StatSoft Inc. was used for all calculations.

The effects of grazing treatment and year as well as possible interaction effects on various dependent variables characterizing community structure and phytodiversity in the *Allio-Stipetum* complex were determined by mixed linear models (SAS 9.2, PROC GLIMMIX, SAS Institute Inc.). The status quo year (2000) was treated as baseline variable (LITTELL et al. 2006). We compared 13 covariance structures and chose the one with best fit according to the corrected Akaike criterion (FERNÁNDEZ 2007). For the calculation of degrees of freedom, we selected the Kenward-Roger approximation. JACQMIN-GADDA et al. (2007) and VALLEJO et al. (2004) were able to show that mixed linear models using this method are robust against deviation from normal distributions in terms of both error control and power. Nevertheless, the studentized residuals and conditional studentized residuals were examined for normality by means of graphical display (histograms and quantile–residuum plots); a nearly Gaussian distribution could be ascertained for all variables except the cover of *Calamagrostis epigejos*. In this case we applied square-root transformation after which the residuals were satisfactory. Non-significant interactions and main effects were removed from the final models. Tukey-adjusted post hoc tests were carried out to test for effects of treatments within each year ("slice" option of PROC GLIMMIX).

The growth heights for the calculation of three different values (1: < 20 cm height, 2: 20–50 cm, 3: > 50 cm) were determined using the data of OBERDORFER (2001) and our own data from local assessments.

To determine the portions of target species in the dataset we calculated the target-species ratios per single relevé, which express the proportion of *Koelerio-Corynephoretea* or *Festuco-Brometea* species (both target species) in comparison with the total species number. It was calculated as follows:

- qualitative target-species ratio (TSR_{qual}): number of target plant species/total number of plant species
- quantitative target-species ratio (TSR_{quant}): cover sum of target plant species/cover sum of all plant species (for further details, see EICHBERG et al. 2010).

Fig. 4a. Former fields in the year 2001. The area is characterized by large facies of *Calamagrostis epigejos* (July 2001. Photo: A. Schwabe).

Abb. 4a. Ehemalige Äcker im Jahre 2001. Die Fläche ist durch große Fazies von *Calamagrostis epigejos* charakterisiert (July 2001. Foto: A. Schwabe).

Fig. 4b. Former fields in the year 2009 with inflorescences of *Armeria maritima* subsp. *elongata*. This species was present in 6% of the plots 2000, in 19% 2009 and in between (2005, 2006) in 31% of the 16 plots (May 2009. Photo: A. Schwabe).

Abb. 4b. Ehemalige Äcker im Jahr 2009 mit Blütenständen von *Armeria maritima* subsp. *elongata*. Diese Art war im Jahr 2000 in 6 % der Probeflächen vorhanden, im Jahre 2009 in 19 % der Probeflächen und in den Zwischenjahren (2005, 2006) in 31 % der 16 Probeflächen (May 2009. Foto: A. Schwabe).

4. Results

4.1 Overall results of changes in the floristic structure

Table 1 in the supplement shows the constancy columns of the *Allio-Stipetum* complex: Au (ungrazed), Ag (grazed) as well as the former fields (Fg) for the 12 (Fg: 10) investigated vegetation periods. Au/Ag are characterized by typical elements of the *Allio-Stipetum,* intermingled with *Koelerio-Corynephoretea* species. Some *Festuco-Brometea* species increased their presence in Ag. This trend is significant for *Stipa capillata*, *Linum perenne*, *Arabis hirsuta* agg. and *Ajuga genevensis* (groups 1 and 2). However, there was no development of larger populations of *Koeleria glauca* in the study period.

Remarkably, some *Koelerio-Corynephoretea* species (group 3a) decreased in the ungrazed Au plots, e. g. *Medicago minima* or *Vicia lathyroides.* Without grazing, 20 target species show a significantly declining trend, compared to five target species in the grazed plots.

The former field is also populated by a lot of target species of groups 1–3, but mostly with lower presence degrees compared to Au and Ag. Four species of these groups increased their presence significantly in Fg: *Potentilla argentea* agg., *Alyssum alyssoides, Medicago falcata* and *Koeleria macrantha*. Group 5 clearly characterizes the Fg plots with former agricultural treatment; differential species are, e.g., *Artemisietea vulgaris* Lohmeyer et al. ex von Rochow 1951 species and *Tripleurospermum perforatum*. Some of the *Artemisietea vulgaris* species decreased in the study period (*Solidago canadensis, Urtica dioica*).

In the case of *Calamagrostis epigejos* there was a decline in presence data in all types, but the cover data were significantly reduced in the grazed type Ag (see below: results from the mixed linear model). Another competitive graminoid (group 4), *Carex hirta*, increased in presence in Ag and Au, but with grazing only from 57 to 64%, without grazing from 30 to 70%.

4.2 *Allio-Stipetum* complex: ungrazed (Au)/grazed (Ag) plots

4.2.1 Structural data

Figure 5 shows a steadily decreasing cover of litter in the grazed plots (Ag) to values below 5%. In the Au plots there was first an increase, then a slight reduction, followed by a stabilization around a mean value of 16% cover since 2006, with considerable variation between the plots. The litter-decreasing effect of grazing is significant since 2002.

Other structural data which show partly significant changes as a consequence of grazing impact are the growth height classes of plant species. The differentiated groups of growth heights 1 (< 20 cm) and 3 (> 50 cm) show significant grazing or interaction effects: Group 1 (Fig. 6a) an increase in 2003 and continuously from the year 2007, group 3 (Fig. 6c) a decrease from the year 2007. There is no effect of grazing evident in group 2 (20–50 cm; Fig. 6b). The results of the mixed linear models are shown in Table 2.

4.2.2 Phytodiversity and species-(group) data

There was a highly significant interaction between grazing and year concerning total species numbers (including cryptogams), resulting in deviating courses of the curves (Fig. 7). At the beginning, the values were very similar (about 35 species); afterwards the grazed plots had a highly significant ($P < 0.0001$) higher phytodiversity across the whole time period. In the Au plots the species numbers decreased (below 30). In general there was

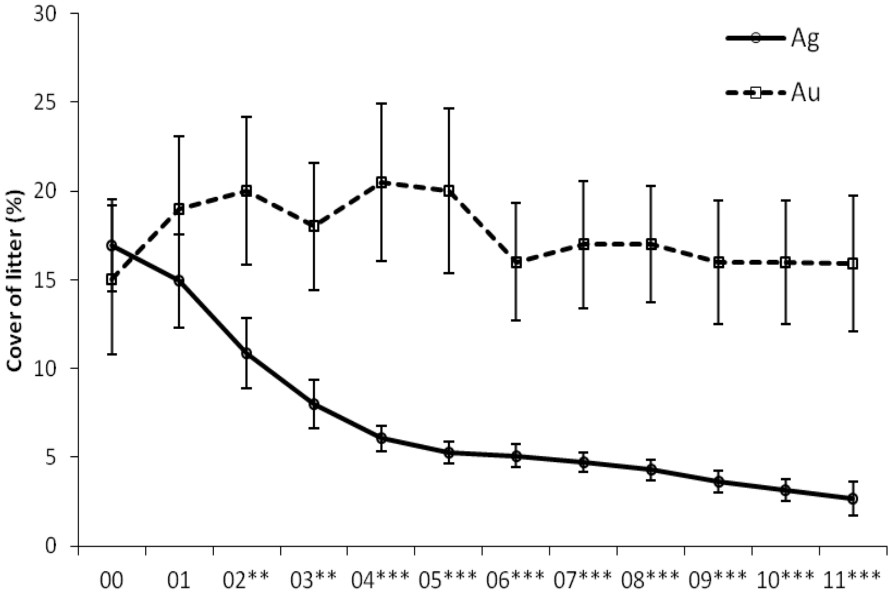

Fig. 5. Cover of litter (%) in the *Allio-Stipetum* complex from 2000 (status quo, beginning of grazing in summer 2000 after first recording) to the year 2011: grazed plots (Ag, n = 14) and ungrazed plots (Au, n = 10). Error bars: SE (Standard error). Years with significant difference between Au and Ag after accounting for the baseline (= year 2000) are marked with asterisks at the x axis. Levels of significance: *: $0.05 \geq P > 0.01$, **: $0.01 \geq P > 0.001$, ***: $0.001 \geq P$.

Abb. 5. Streudeckung (%) im *Allio-Stipetum*-Vegetationskomplex von 2000 (status quo, Beginn der Beweidung im Sommer 2000 nach der Erstaufnahme) bis zum Jahre 2011: beweidete Probeflächen (Ag, n = 14) und unbeweidete (Au, n = 10). Fehlerbalken: SE (Standardfehler). Jahre mit signifikantem Unterschied zwischen Au und Ag (Basislinie Jahr 2000) sind mit Sternchen auf der x-Achse markiert. Signifikanzniveaus: *: $0{,}05 \geq P > 0{,}01$, **: $0{,}01 \geq P > 0{,}001$, ***: $0{,}001 \geq P$.

a slight decrease of species numbers also in the Ag treatment after an extraordinary increase in the year 2002 (about 50 species). Both treatments show low values in the abiotically extreme year 2003, which were compensated in the following year.

If the non-graminoid herb species are regarded separately, there are similar results (Fig. 8). Already in the first year after treatment the differences between Au and Ag were six species per plot and later mostly ten or even more. The non-graminoid herb species are characterized by low values in the extreme year 2003 for both treatments, which were compensated in the following year.

The development of cover percentages of the main competitive graminoid species *Calamagrostis epigejos* shows a strong grazing effect (Fig. 9). Without grazing there were increasing cover percentages until 2009, whereas grazing led to an uninterrupted decrease in the first 6 years and afterwards a low level of cover.

If the target species (*Festuco-Brometea* and *Koelerio-Corynephoretea* species) are considered (Fig. 10), the Au plots are characterized by a constant decline in species numbers, while there was an increase in the Ag plots (with the exception of the last year). A highly significant grazing effect could be found in the mixed linear model, showing enhancement of target species by grazing from 2002 on.

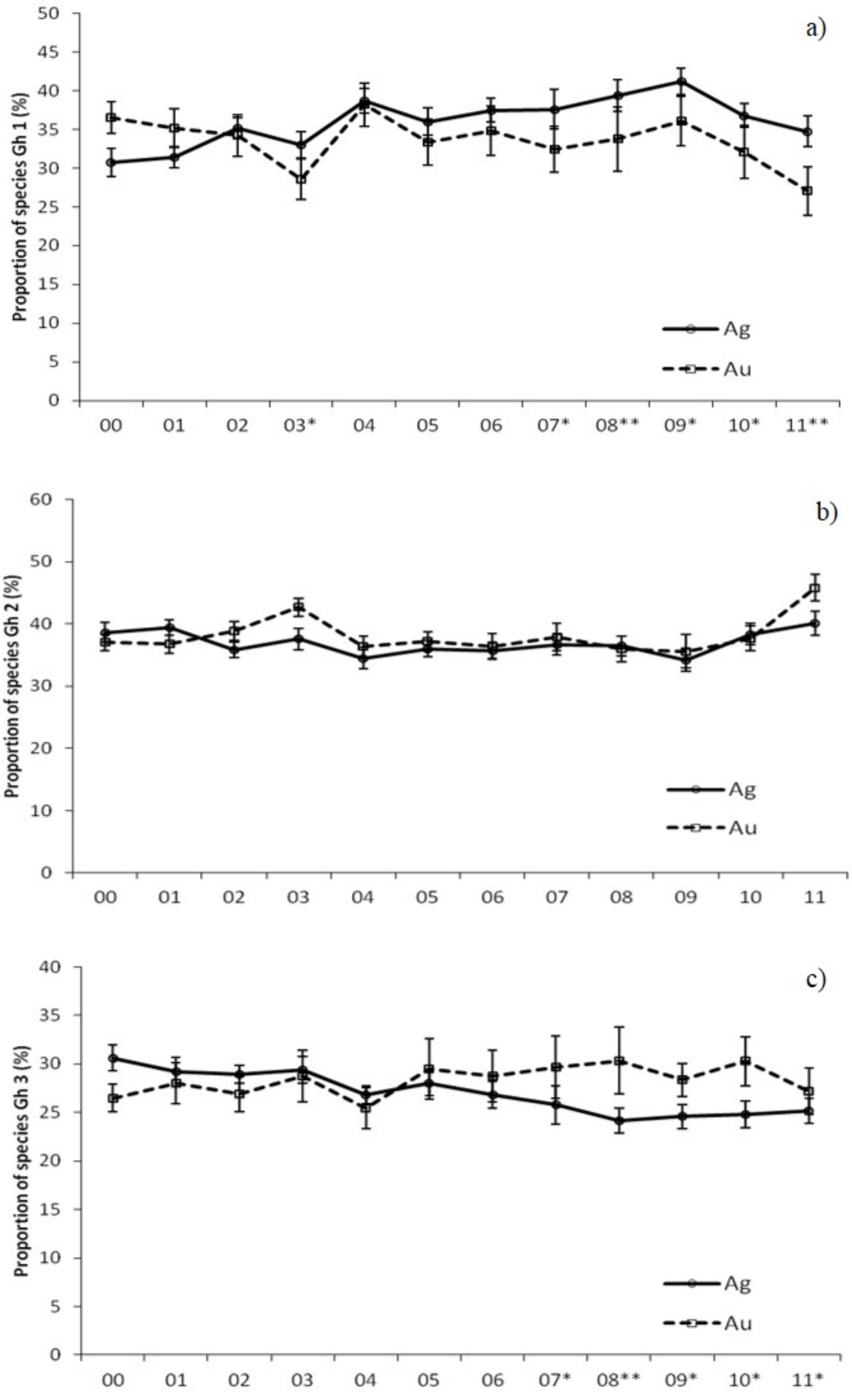

Fig. 6a, b, c. Proportion of species (%) of growth heights 1 (a), 2 (b), 3 (c) in the grazed and ungrazed plots. Error bars: SE. Further information see Fig. 5.

Abb. 6a, b, c. Anteil der Arten (%) der Wuchshöhen 1 (a), 2 (b), 3 (c) in den beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5.

Table 2. Effects of treatment (= trt), year (= yr) and interactions of both (= trt*yr) on various dependent variables, as tested by mixed linear models, num DF = degrees of freedom numerator, den DF = degrees of freedom denominator, *F* = *F* value, *P* = significance level, Growth height1/2/3 = number of species of growth height 1/2/3, TSR qual = qualitative target species ratio, TSR quant = quantitative target species ratio. The selected covariance structures are indicated after each variable: ante = ante-dependence, arma (1,1) = autoregressive moving-average, hf = Huynh-Feldt, toep = Toeplitz. Non-significant (*P* > 0.05) effects and interactions were removed from the final models.

Tabelle 2. Effekte von Behandlung (= trt), Jahr (= yr) und der Interaktion beider (= trt*yr) auf verschiedene abhängige Variablen, getestet mit gemischten linearen Modellen, num DF = Zählerfreiheitsgrade, den DF = Nennerfreiheitsgrade*,* *F* = *F*-Wert, *P* = Signifikanzniveau, Growth height1/2/3 = Zahl der Arten mit Wuchshöhe 1/2/3, TSR qual = qualitative „target species ratio", TSR quant = quantitative „target species ratio". Die ausgewählten Covarianzstrukturen sind bei jeder Variable angeführt: ante = ante-dependence, arma (1,1) = autoregressive moving-average, hf = Huynh-Feldt, toep = Toeplitz. Nicht signifikante (*P* > 0.05) Effekte und Interaktionen wurden aus den endgültigen Modellen entfernt.

	num DF	den DF	*F*	*P*
Cover of litter (toep)				
trt	1	28.0	24.87	<.0001
yr	10	83.5	2.38	0.0155
trt*yr	10	83.5	3.23	0.0015
Growth height1 (arma1,1)				
trt	1	21.5	5.49	0.0289
yr	10	189.6	6.24	<.0001
Growth height2 (arma1,1)				
yr	10	172.5	4.9	<.0001
Growth height3 (hf)				
trt*yr	21	106.3	2.24	0.0039
Total number of species (hf)				
trt	1	35.8	79.40	<.0001
yr	10	220.0	31.54	<.0001
trt*yr	10	220.0	4.23	<.0001
Number of non-graminoid species (arma1,1)				
trt	1	23.4	78.71	<.0001
yr	10	185.6	19.9	<.0001
trt*yr	10	185.6	3.61	0.0002
Cover of *C. epigejos*, square root transformed (ante1)				
trt	1	24.1	11.74	0.0022
yr	10	56.5	2.51	0.0144
Number of target species (arma1,1)				
trt	1	24.0	35.42	<.0001
yr	10	188.7	20.38	<.0001
trt*yr	10	188.7	5.27	<.0001
TSR qual(arma1,1)				
trt	1	23.8	4.95	0.0357
yr	10	187.0	4.98	<.0001
trt*yr	10	187.0	3.48	0.0003
TSR quant (ar1)				
yr	10	215.4	3.33	0.0005
trt*yr	11	203.5	2.06	0.0247

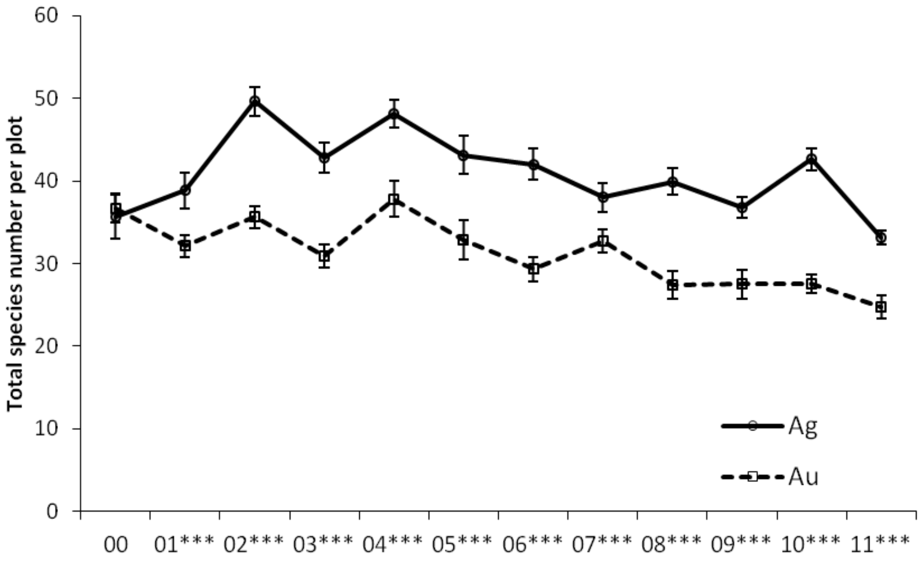

Fig. 7. Species numbers of grazed and ungrazed plots. Error bars: SE. Further information: see Fig. 5.

Abb. 7. Artenzahlen der beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5.

Accordingly, there is a decrease of the TSR_{qual} values (Fig. 11a) in the Au plots, whereas the grazed plots tend to increase in TSR_{qual} values (with the exception of the last two years, where there was a slight decrease). There is a significant interaction of treatment and year, leading to significant grazing effects since 2007. Both treatments show low values in the abiotically extreme year 2003, which were compensated in the following year.

Also concerning the TSR_{quant} (Fig. 11b) there is a significant interaction term. Beginning with the year 2007 there is a significant difference of the TSR_{quant} depending on treatment. The ungrazed plots show first constant values, later decreases of the TSR_{quant} values. On the other hand, the grazed plots show nearly a doubling of their TSR from 0.30 to 0.58.

4.3 Former fields

Litter cover and cover of *Calamagrostis epigejos* show strong decreases comparable to the Au plots (Table 3, Fig. 5, 9). The values for the decrease of litter cover are very similar to those of Figure 7. The difference in the case of *C. epigejos* is that the starting point was rather high in the area of the former fields (mean cover of 34%) and the decrease amounts to 26 percentage points in nine years. Already after three years of grazing impact the cover was reduced by around one half. Regarding the species number (Table 3) there were considerable changes until 2005/2006, afterwards the numbers are similar to the starting point. TSR_{qual} and TSR_{quant} show remarkable increases, but do not reach the values of the *Allio-Stipetum* complex. For the physiognomical aspects of the former fields, see Figure 4a, b.

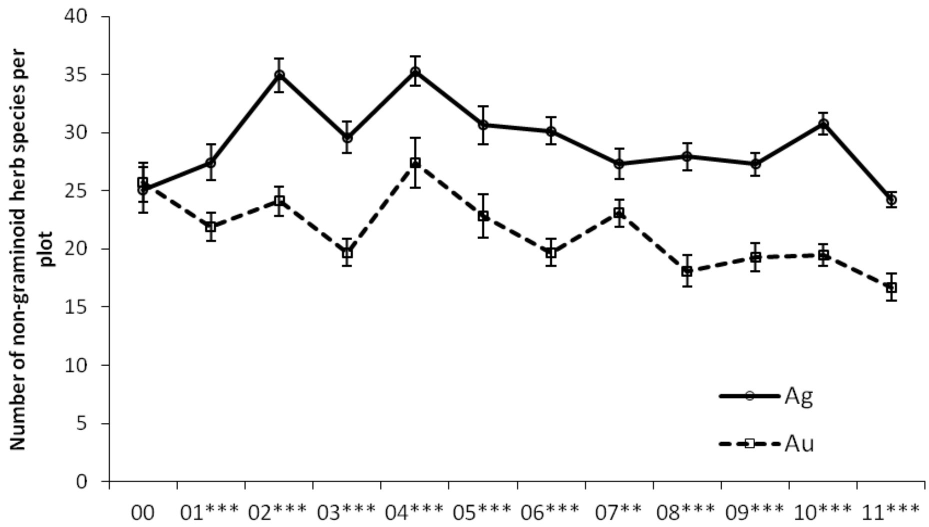

Fig. 8. Number of non-graminoid herb species in grazed and ungrazed plots. Error bars: SE. Further information: see Fig. 5.

Abb. 8. Zahl der krautigen Arten in beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5.

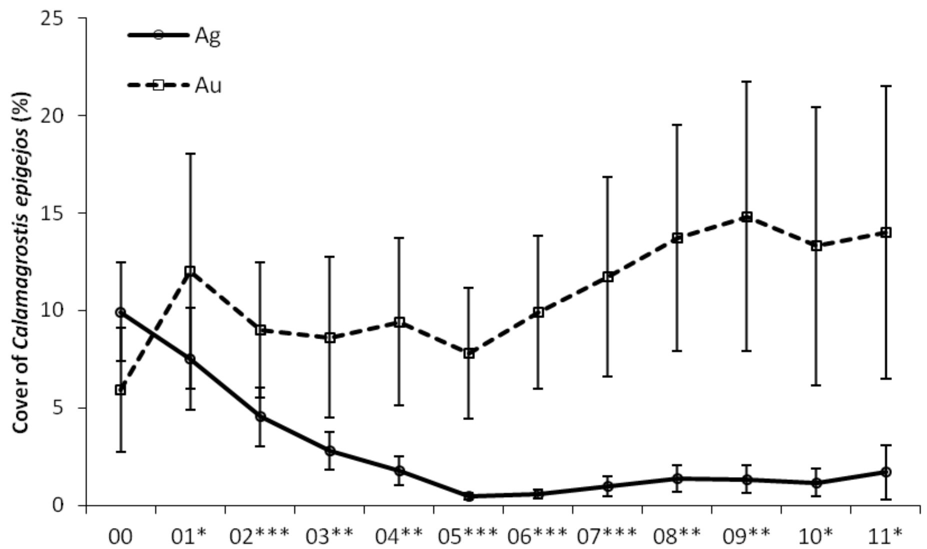

Fig. 9. Cover (%) of *Calamagrostis epigejos* in grazed and ungrazed plots. Error bars: SE. Further information: see Fig. 5.

Abb. 9. Deckung (%) von *Calamagrostis epigejos* in beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5.

5. Discussion

5.1 Does the grazing regime lead to a change of structural characteristics?

In our study system, the influence of grazing was clearly detectable by means of structural data. This is in line with other studies of grazing impact (e. g., ARMSTRONG et al. 1997, ADLER et al. 2001, HELLSTRÖM et al. 2003; see also the review of ROSENTHAL et al. 2012). According to BAKKER & OLFF (2003) and their studies in grazed floodplains, plant species richness is mainly determined by the structural type of subordinate herbs in this system; this is comparable to our study system.

Higher cover of litter in abandoned areas was found in various studies (e.g. KAHMEN et al. 2002 and RUPRECHT & SZABÓ 2012 for dry grassland, in our system by SÜSS et al. 2010 and FAUST et al. 2012). Litter effects on plant regeneration are variable depending on the system (RUPRECHT et al. 2010). The authors detected for steppe-habitats that litter removal combined with further management (in this case cutting) promoted the survival of seedlings.

There is probably a strong interrelationship between the decrease of the litter cover by grazing in our system and the detected increase of small plants (growth height 1).

The increase of open ground after grazing has been shown by various authors (e.g. SCHRAUTZER et al. 2004). Such microsites favor the regeneration of characteristic "gap species" (BULLOCK et al. 1994), which are typically small-growing annuals and are able to build up soil seed banks (EICHBERG et al. 2006, 2008). All species of group 3a in Table 1 (which decreased in ungrazed plots) and nearly all non-graminoid herbs of the *Koelerio-Corynephoretea* species of group 3b (exceptions: *Bassia laniflora, Thymus serpyllum*) were already detected in the seed banks of our area by EICHBERG et al. (2006, 2008). All species of group 3a and nearly all non-graminoid herbs of group 3b are tiny plants (growth height 1).

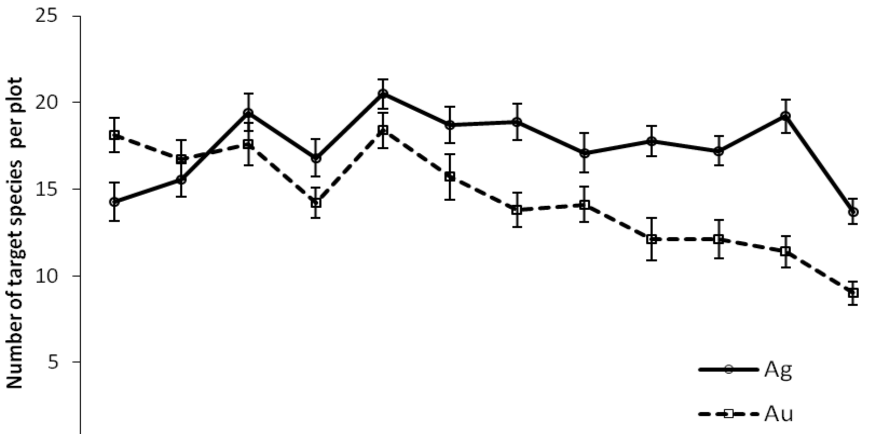

Fig. 10. Species numbers of target species (*Koelerio-Corynephoretea* and *Festuco-Brometea*) in grazed and ungrazed plots. Error bars: SE. Further information: see Fig. 5.

Abb. 10. Artenzahlen der Leitarten der *Koelerio-Corynephoretea* und *Festuco-Brometea* in beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5.

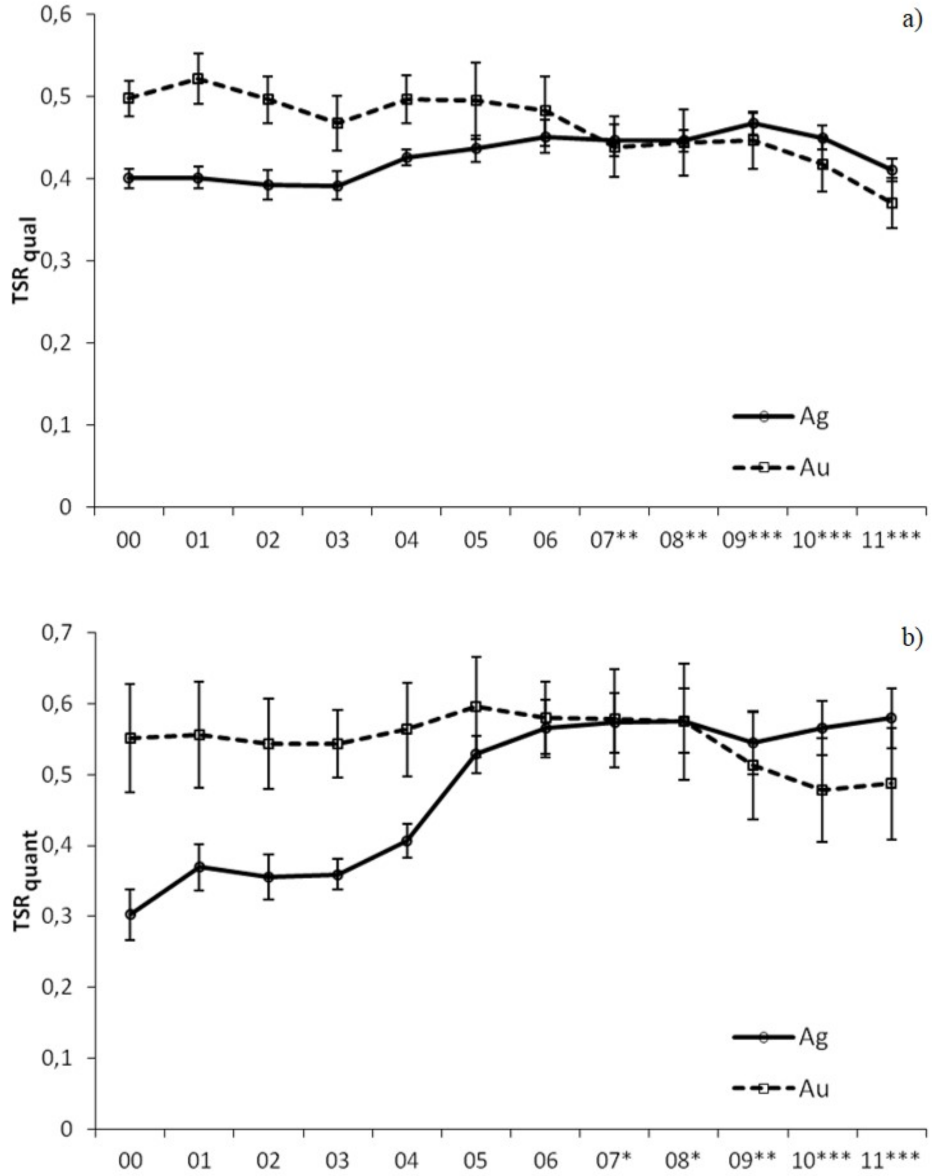

Fig. 11a, b. TSR Target-Species Ratio (qualitative) (a) and quantitative (b) in grazed and ungrazed plots. Error bars: SE. Further information see Fig. 5 and text.

Abb. 11a, b. TSR Target-Species Ratio (qualitativ) (a) und quantitativ (b) in beweideten und unbeweideten Probeflächen. Fehlerbalken: SE. Weitere Details, s. Abb. 5 und Text.

Table 3. Structural and phytodiversity variables characterizing the development of the former fields from 2000 to 2009. TSR_{qual} = qualitative target species ratio. TSR_{quant} = quantitative target species ratio. SE = standard error.

Tabelle 3. Struktur- und Phytodiversitätsvariablen, die die Entwicklung der ehemaligen Äcker von 2000 bis zum Jahr 2009 kennzeichnen. TSR_{qual} = qualitative „target species ratio". TSR_{quant} = quantitative "„target species ratio". SE = Standardfehler.

	Cover litter %		Species No.		*C. epigejos* % cover		Target species No.		TSR qual		TSR quant	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
2000	19.4	4.5	32.3	1.5	34	8	9.1	1.3	0.27	0.03	0.18	0.05
2001	15.1	3.7	35.8	1.6	25	6	11.4	1.4	0.31	0.03	0.24	0.04
2002	9.7	2.1	41.2	2.1	17	5	12.9	1.2	0.31	0.02	0.26	0.03
2003	7.8	1.2	39.1	1.6	16	5	11.6	0.9	0.30	0.02	0.20	0.03
2004	5.8	0.7	43.3	1.7	12	4	14.2	1.3	0.32	0.02	0.30	0.04
2005	5.8	0.7	44.1	1.6	11	4	15.2	1.4	0.34	0.03	0.31	0.04
2006	4.6	0.6	39.1	1.4	12	4	13.9	1.2	0.35	0.02	0.29	0.04
2007	5.3	1.1	33.2	1.7	12	5	10.6	1.1	0.32	0.03	0.23	0.04
2008	5.2	1.0	36.3	1.6	10	5	11.4	1.2	0.32	0.03	0.22	0.04
2009	5.0	0.8	33.8	1.2	8	4	12.0	1.2	0.36	0.03	0.28	0.05

The trampling effects of livestock contribute not only to open the litter layer but also may enhance seed incorporation by hoof prints and promote an increase of emerged seedlings (STAMMEL & KIEHL 2004, FAUST et al. 2011a).

5.2 Does the grazing regime alter phytodiversity, and especially the proportion of target species?

The beneficial influence of grazing on total, non-graminoid herb and target species richness was clearly detectable. In general diversity of open grassland systems depends on traditional types of land use (BAKKER & BERENDSE 1999, BECKER et al. 2012). Remarkable is that the number of target species increased in one case (Ag) but decreased in another (Au). The proportions TSR $_{qual}$ and TSR_{quant} reflect the same trends, but later in the study period. The integrated approach to determine the proportion of *Festuco-Brometea/Koelerio-Corynephoretea* species in endangered sand vegetation is a powerful tool to demonstrate the effects of the management for nature-conservation value, as was shown also by EICHBERG et al. (2010) for restoration measures. All these indicators show a significant and sustainable positive effect of grazing.

On grazed land, domestic herbivores generate and modify various processes such as selective phytomass removal, disturbance and seed dispersal (ROSENTHAL et al. 2012). By the disturbance effects of grazing the heterogeneity of the environment is increased (AARSSEN 2001, SÜSS et al. 2007). Probably these heterogeneity effects, which facilitate the activation of the seed bank (see section 5.1) and the establishment of endo- and epizoochorously dispersed seeds (EICHBERG et al. 2007, EICHBERG & WESSELS-DE WIT 2011) as well as wind-dispersed seeds, caused the extraordinarily high mean species numbers of about 50 (per plot) in the year 2002. Disturbance in general will reduce the competition for limited resources

(WILSON & TILMAN 1993). Heterogeneity effects may be reduced again after the first years of grazing impact. This may have caused the decrease of species numbers under weak grazing impact (Fig. 7).

Large domestic herbivores function as effective intra- and inter-habitat seed dispersal vectors (KUITERS & HUISKES 2010, ROSENTHAL et al. 2012). In our study, some plant species emerged newly within the study period. An example of a plant species that has been transferred to our study area with high probability by sheep is the threatened *Linum perenne*. In 2003, it established newly in the NSG on Ag plots, and since then it has persisted. Probably the seeds were dispersed in the fur of sheep, because they are not able to germinate after sheep-gut passage (WESSELS 2008).

On the other hand, *Koeleria glauca* could not establish itself on the grazed plots within the study period. Probably the small populations in the NSG-area were not able to set fruits in a sufficient quantity and additionally there was a rabbit impact; especially the infructescences of this plant species were grazed preferably by rabbits. Also *Corynephorus canescens* was not able to increase in presence in the Ag plots, and decreased significantly in the Fg plots. According to HAMMES et al. (2012) there is a strong relationship between high individual phytomass of *Corynephorus canescens* (facilitating the seed production) and successful dispersal; additionally substantial dynamization is needed.

The decrease of species in the course of cessation of management was described by different authors, e.g. by DUPRÉ & DIEKMANN (2001) in a space-for-time study in Sweden. To our knowledge there are no other long-term data concerning such species losses in the non-managed *Allio-Stipetum* complex.

The effects of the extremely hot and dry year 2003 led to severe losses of species in Ag as well as Au plots, as was shown in other sandy areas in the upper Rhine valley (FAUST et al. 2011b, 2012). The high resilience of the system is remarkable after the extremely hot and dry summer 2003, leading to a complete recovery of species richness as was also shown by FAUST et al. (2011b, 2012) in another nature protection area.

5.3 Is there a change in the dominance structure of competitive graminoids during the grazing period?

In our case we regard *Calamagrostis epigejos* as a model species for competitive graminoids. According to PRACH & PYŠEK (1999) this graminoid fulfills the "requirements" of an "ideal successional dominant": tall, wind-pollinated, growing by lateral spread, preferring high nutrient supply (see also SÜSS et al. 2004). We detected an increase in *C. epigejos* cover in the Au plots over the 12-yr study period which was described by KOOIJMAN & VAN DER MEULEN (1996) as "grass encroachment". Also in other inland dune areas successional stages are characterized by *C. epigejos*, e.g. in Croatia (HRŠAK 2004) and in large parts of Central Europe (REBELE 1996, REBELE & LEHMANN 2001). In our study grazing proved a suitable tool to reduce this species from a mean cover of 10% to < 2%.

Also in our permanent-plot study about spontaneous succession in the whole sandy area near Darmstadt we found grass encroachments as a consequence of clonal spread (SÜSS et al. 2010). It is difficult to prevent such encroachments exclusively by sheep grazing (SCHWABE et al. 2004a, b), therefore we employed the successive sheep and donkey grazing system. This approach was already applied by SÜSS & SCHWABE (2007) in sandy habitats of the upper Rhine valley with separated treatments (only sheep, only donkeys and successive treatment) and has shown the successful restorative effect especially of the successive treatment. LAMOOT et al. (2005) applied donkey grazing in coastal dunes of Belgium and detected the high quantity of graminoid foraging by donkeys in all seasons (80% graminoids). The same is true for other non-ruminants such as horses, which control dominant tall grasses, as was shown in submediterranean mountain pastures in Italy by CATORCI et al. (2012).

5.4 Are the developments in the former fields similar, especially concerning phytodiversity and competitive graminoids?

The tendencies of development were similar in the former fields compared to the *Allio-Stipetum* complex. Different studies have shown that former fields with high phosphate values in the soil are difficult to develop towards plant communities of the *Koelerio-Corynephoretea/Festuco-Brometea* complex exclusively by "restorative grazing" (e.g. STROH & SCHWABE 2007). There should be an abiotic improvement and strategies to complement the species pool by inoculation with target community material or seed addition. For these seed additions and the successful establishment there are strict requirements like suitable microsites and autochthonous seed material (KIEHL et al. 2010, FRITSCH et al. 2011, HÖLZEL et al. 2012). Nevertheless it is remarkable that so many target species occurred newly in the study area (Table 1) without the assistance of manual seed-addition approaches, probably because they were dispersed into the area or germinated as a consequence of seed bank activation. Among the seed bank species, *Potentilla argentea* agg. and *Alyssum alyssoides* increased significantly (Table 1). *Potentilla argentea* agg. was also detected in faeces of sheep in high numbers (EICHBERG & WESSELS-DE WIT 2011). *Koeleria macrantha* (which is epi-, endozoochorously dispersed according to EICHBERG & WESSELS-DE WIT 2011 and also by wind) established successfully and increased in presence significantly. In general also the seed bank may contribute to the restoration success. Species such as *Medicago minima* and *Sedum acre* are present in the seed bank of former farmland in our area (KROLUPPER & SCHWABE 1998). Also KALAMEES et al. (2012) demonstrated in abandoned calcareous alvar grassland in Estonia a high potential of the seed bank.

EICHBERG & WESSELS-DE WIT (2011) detected in several studies a total of 93 phanerogam species in fur and faeces of sheep, 34 of which were target species. They showed an extremely high dispersal potential of sheep: a herd of 800 animals will transport 0.5–2.5 Mio. seeds d^{-1} endozoochorously and > 300,000 in the fur when moving from one paddock to another. With respect to restoration aims, this is especially effective if sheep first graze a high-value nature reserve and afterwards a restoration site, as was frequently carried out in the study period.

After about seven years there was a certain stagnation and a constant portion of ruderal species in the former field area. After ten vegetation periods there were still clear floristic differences between the former fields and the *Allio-Stipetum* complex.

6. Implications for nature conservation strategies and outlook

The study has shown that the *Allio-Stipetum* vegetation complex clearly needs management. Whether the *Allio-Stipetum* stands can be classified as anthropogenic or natural requires a differentiated answer. Probably in the late-glacial/early postglacial landscape of the Upper Rhine Valley (AMBOS & KANDLER 1987) there were dynamical successional series, e.g., with drift sand areas, including the *Allio-Stipetum*. In the fragmented landscape today this dynamic landscape context is lacking.

The following points should be a major task for the preservation and development of the *Allio-Stipetum* vegetation complex:

(1) Large populations of the target species should be preserved and developed, and their long-term survival in the community types in question should be guaranteed. Grazing is an adequate method to secure the specific phytodiversity of these stands. Target species are supported by the grazing management described here, and – as other studies have shown – dispersal traits of many species are secured. Therefore the conditional status of the Annex I habitat types of the Habitats Directive can be improved by grazing management.

(2) Especially for our area there is a great responsibility to preserve and develop one of the most western occurrences of the combination of the priority habitat types 6120 and 6240.

(3) Such habitat sites should be enlarged by restoration measures (e.g. restorative grazing) as in the case of the former fields which were presented in this study.

(4) Also patches dominated by ruderal entomophilous herbs may have great importance, e.g., for the endangered fauna of wild bees. For flower-visiting wild bees especially some of the ruderal species, e.g. *Malva alcea, Berteroa incana* and *Sisymbrium altissimum*, are very important pollen resources (BEIL 2007). *Malva* has even increased its presence in the grazed Ag plots; this species provides pollen to the oligolectic bee species *Tetralonia macroglossa* (Illiger, 1806). The grazing system should be adapted so that wild bees are constantly supplied with pollen resources, e.g. by step-by-step grazing of relatively small paddocks.

Erweiterte deutsche Zusammenfassung:

Einleitung – Allgemein gilt Beweidung als ein in der Regel wirkungsvolles Instrument für die Entwicklung von verschiedenen Vegetationstypen mit hoher Phytodiversität (ROSENTHAL et al. 2012). Um die Effekte der Beweidung für das Management von gefährdeten Sandrasen-Komplexen zu prüfen, untersuchten wir ein Beweidungssystem mit Schafen und zusätzlich mit Eseln im Naturschutzgebiet „Griesheimer Düne und Eichwäldchen“ (nördliche Oberrheinebene, Hessen, 45 ha). Besonders bezeichnend sind hier großflächige Vorkommen des *Allio-Stipetum*-Vegetationskomplexes (Abb. 1, 2, 3). Das Gebiet wurde seit dem Jahre 2000 beweidet.

Die untersuchten Vegetationseinheiten gehören zu den prioritären Lebensraumtypen im Natura 2000-Netzwerk und sind im Anhang I der Fauna-Flora-Habitat-Lichtlinie aufgeführt: „Subpannonische Steppen-Trockenrasen“, Code 6240; kleinflächig „Subkontinentale Blauschillergrasrasen (*Koelerion glaucae)“* Code 6120). Die heutigen Vorkommen dieser Lebensräume in unserem Gebiet liegen isoliert und stellen nur noch Reste in einer dicht besiedelten Landschaft dar.

Es konnte zusätzlich auch noch die Entwicklung ehemaliger Äcker, die heute im NSG liegen, untersucht werden, die ebenfalls seit dem Jahre 2000 beweidet werden (Abb. 4a, b). Die Hauptfragen diese Untersuchung sind: (1) Führt das angewandte Beweidungssystem zu wichtigen strukturellen Veränderungen? (2) Kommt es durch die Beweidung zu Änderungen in der Phytodiversität? Verschieben sich die Anteile der charakteristischen Leitarten der *Koelerio-Corynephoretea* und *Festuco-Brometea*? (3) Gibt es Veränderungen bei den Dominanzstrukturen der konkurrenzkräftigen Grasartigen während des Beweidungszeitraumes? (4) Sind die Entwicklungen in den ehemaligen Äckern ähnlich?

Material und Methoden – (1) Wir installierten vor Beginn der Beweidung unbeweidete (Au: 10 Flächen, gezäunt und zwischen den beweideten Flächen liegend, Beispiel in Abb. 3) und beweidete Untersuchungsflächen (Ag: 14 Flächen) im *Allio-Stipetum*-Vegetationskomplex, die in einem systematischen Raster angeordnet sind. Die kreisförmigen Flächen, die jeweils 50 m voneinander entfernt liegen, haben je eine Größe von 79 m^2. Es erfolgten pflanzensoziologische Aufnahmen in den Au/Ag-Flächen für 12 Vegetationsperioden. Auf den ehemaligen Äckern (FG) konnten für 10 Vegetationsperioden 16 beweidete Flächen, die in einem entsprechenden systematischen Raster angeordnet sind, pflanzensoziologisch aufgenommen werden. Die Erstaufnahme fand jeweils im Jahr 2000 vor Beginn der

Beweidung statt. (2) Es wurde eine Stetigkeitstabelle erstellt für die Au-, Ag- und Fg-Flächen. (3) Um die proportionalen Anteile der Leitarten festzustellen, berechneten wir die qualitative und quantitative „Target-species ratio" (TSR: Anteil der Leitarten der *Koelerio-Corynephoretea*- und *Festuco-Brometea* im Vergleich zur Gesamtartenzahl). (4) Wir setzten als statistische Methode gemischte lineare Modelle ein (SAS 9.2, PROC GLIMMIX, SAS Institute Inc.) und prüften die Effekte der Beweidung, der jeweiligen Jahre und mögliche Interaktionen. Besondere Beachtung wurde Strukturmerkmalen der Vegetation sowie Charakteristika der Phytodiversität geschenkt.

Ergebnisse – Allgemeine Ergebnisse bezüglich der Veränderung der floristischen Struktur (Tab. 1 in der Beilage): Die Au/Ag Flächen sind charakterisiert durch typische Elemente des *Allio-Stipetum*, verzahnt mit *Koelerio-Corynephoretea*-Arten. Einige *Festuco-Brometea*-Arten vergrößerten ihre Stetigkeit in Ag (signifikant für *Stipa capillata*, *Linum perenne*, *Arabis hirsuta* agg. und *Ajuga genevensis,* Gruppe 1 und 2). Es kam jedoch nicht zu Vergrößerungen der Populationen von *Koeleria glauca.* Ohne Beweidung zeigen 20 Leitarten einen Trend der signifikanten Abnahme, in den beweideten Flächen sind es nur 5 Leitarten. Die ehemaligen Äcker weisen Leitarten der Gruppen 1–3 auf, mit in der Regel geringeren Stetigkeitsprozenten. Die Gruppe 5 charakterisiert diese Flächen u.a. mit *Artemisietea*-Arten; diese nehmen z. T. gegen Ende der Untersuchungsperiode ab.

Allio-Stipetum-Vegetationskomplex; Daten zur Struktur (Tab. 2, Abb. 5, 6): In den beweideten Flächen nimmt die Streudeckung signifikant ab; erhöht wird in diesen Flächen der Anteil von Arten mit geringen Wuchshöhen (< 20 cm) und erniedrigt der Anteil von Wuchshöhen von > 50 cm.

Allio-Stipetum-Vegetationskomplex; Daten zur Phytodiversität und zu Artengruppen (Tab. 2, Abb. 8, 9, 10, 11): Am Beginn der Untersuchungen hatten die Au- und Ag-Flächen ähnliche Artenzahlen (um 35 Arten), danach gewannen die Ag-Flächen eine hoch signifikante höhere Artenzahl über die gesamte Untersuchungszeit. In den Au Flächen fiel die Artenzahl auf unter 30. Betrachtet man die krautigen Arten gesondert, sind die Ergebnisse ähnlich. Das konkurrenzkräftige *Calamagrostis epigejos* zeigt einen starken Beweidungseffekt im Sinne einer Abnahme. Wenn man die Leitarten betrachtet, zeigen diese in den Au-Flächen eine konstante Abnahme, wohingegen sie in den Ag-Flächen zunahmen. Entsprechendes zeigt sich bei den TSR-Werten.

Daten zu den ehemaligen Äckern (Tab. 3): Diese Entwicklungen zeigen nur Trends auf, vor allem im Vergleich mit den Au-, Ag-Flächen, da es nicht möglich war, hier unbeweidete Flächen zu errichten. Die Flächen zeigen Abnahme der Streudeckung und Abnahmen von *C. epigejos.* Bereits nach drei Jahren war die Deckung von *C. epigejos* um die Hälfte reduziert. TSR_{qual} und TSR_{quant} weisen bemerkenswerte Zunahmen auf, erreichen aber nicht die Werte des *Allio-Stipetum*-Vegetationskomplexes.

Diskussion – Unsere Befunde zur höheren Streumenge in unbeweideten Flächen und zur Anreicherung von niedrigwüchsigen Pflanzenarten korrespondieren mit Befunden anderer Autoren (s. z. B. das Review von ROSENTHAL et al. 2012). Die Erhöhung des Anteils offener Stellen in beweideten Flächen kann zur Aktivierung der Diasporenbank führen; so gehören alle Arten der Gruppe 3a (Tab. 1 in der Beilage), die in unbeweideten Flächen abnahmen, zu den nachgewiesenen Arten in der Diasporenbank (EICHBERG et al. 2006, 2008).

Neben den nachgewiesenen für den Naturschutz günstigen Effekten der Beweidung auf die Artenzahlen und den Reichtum von Kräutern und Leitbildarten, zeigt besonders das integrative Maß der "Target Species Ratio" die Effekte besonders deutlich. Viele Prozesse, die durch Beweidung initiiert werden, wie z. B. Störungen und Diasporenausbreitung sowie allgemein eine Erhöhung der Heterogenität, spiegeln sich in erhöhten Anteilen der Leitbildarten der *Koelerio-Corynephoretea* und *Festuco-Brometea* und somit in der TSR wider. Ziehende Schafherden können eine Fernausbreitung von gefährdeten Pflanzenarten bewirken; so konnten wir *Linum perenne* in unseren Aufnahmen nachweisen. Die Art erreichte die Fläche während des Untersuchungszeitraumes, wahrscheinlich via Epizoochorie, da die Samen bei einer Magen-Darm-Passage ihre Keimfähigkeit verlieren (WESSELS 2008): ein Beispiel für einen Inter-Habitat-Transfer (s. auch KUITERS & HUISKES 2010, ROSENTHAL et al. 2012). Es gelang nicht, die kleinen Populationen von *Koeleria glauca* zu vergrößern; die Pflanze wurde wahrscheinlich durch Kaninchen in ihrem Fruchterfolg stark beeinträchtigt.

Dominanz von konkurrenzkräftigen Graminoiden: Wir betrachten – wie auch andere Autoren (z. B. PRACH & PYŠEK 1999) *Calamagrostis epigejos* als sehr erfolgreiche konkurrenzkräftige Art, die jedoch aus Naturschutzsicht nicht erwünscht ist. In den unbeweideten Untersuchungsflächen kam es zu einer signifikanten Anreicherung. Bei Beweidung wurde die Deckung auf im Mittel unter 2 % dezimiert. Hier bewirkt nach den Ergebnissen anderer Studien im Gebiet (SÜSS & SCHWABE 2007) und in anderen Gebieten (z. B. LAMOOT et al. 2005 in belgischen Küstendünen) vor allem die Eselbeweidung eine Reduktion.

Ehemalige Äcker: Die Tendenzen der Entwicklung waren hier ähnlich wie im *Allio-Stipetum*-Vegetationskomplex, obwohl die Fläche nicht abiotisch verbessert wurde im Sinne einer Nährstoffreduktion und auch nicht biotisch im Sinne eines Transfers von Diasporen durch den Menschen. Vor allem die Beweidungsdynamik führte zu Erhöhungen z. B. der TSR-Werte. Viele Diasporenbank-Arten sowie endo- und epizoochore Arten stellten sich ein. Ein stetiges hohes ruderales Potential auf diesen Flächen besteht immer noch.

Schlüsse für den Naturschutz, Ausblick – Die Studie zeigt deutlich, dass der *Allio-Stipetum*-Vegetationskomplex in unserem Gebiet gezielte Pflege benötigt. Die folgenden Punkte sollten als wichtige Aufgabe für den Naturschutz berücksichtigt werden: A) Große Populationen der Leitbildarten sollten erhalten und entwickelt werden, um das Langzeit-Überleben in den jeweiligen Pflanzengesellschaften zu sichern. Beweidung ist eine adäquate Methode, die spezifische Phytodiversität dieser Bestände zu sichern und zu entwickeln. B) Insbesondere für unser Gebiet gibt es eine besonders hohe Verantwortung zur optimalen Pflege der Vorkommen subkontinental geprägter Sandvegetation, da es sich mit um die westlichsten Vorkommen des Mosaiks der FFH-Lebensraumtypen 6120 und 6240 handelt. C) Ihre Fläche sollte durch Restitutionsmaßnahmen vergrößert werden, wie z. B. im Falle der hier untersuchten ehemaligen Äcker. D) Die Management-Maßnahmen sollten auch zooökologisch bewertet werden. So können auch Flecken, die durch ruderale Kräuter bestimmt werden, große Bedeutung haben, z. B. für gefährdete Wildbienen. So sind *Malva alcea, Berteroa incana* und *Sisymbrium altissimum*, wichtige Pollenlieferanten (BEIL 2007). *Malva* hat in der Stetigkeit in den beweideten Flächen zugenommen; diese Art ist die Pollenressource von der gefährdeten *Tetralonia macroglossa*. Das Beweidungssystem sollte an die Sicherung von Pollenressourcen angepasst werden, z. B. durch Staffelbeweidung kleiner Koppeln.

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Supplements and Appendices

Supplement 1. Table 1. Constancy table of the long-term data set.

Beilage 1. Tabelle 1. Stetigkeitstabelle des Langzeit-Datensatzes.

References

AARSSEN, L.W. (2001): On correlations and causations between productivity and species richness in vegetation: predictions from habitat attributes. – Basic Appl. Ecol. 2: 105–114.

ADLER, P.B., RAFF, D.A. & LAUENROTH, W.K. (2001): The effects of grazing on the spatial heterogeneity of vegetation. – Oecologia 128: 465–479.

AMBOS,R. & KANDLER, O. (1987): Einführung in die Naturlandschaft. – Mainzer Naturwiss. Archiv 25: 1–28.

ARMSTRONG, R.H., GRANT, S.A., COMMON, T.G. & BEATTIE, M.M. (1997): Controlled grazing studies on *Nardus* grassland: effects of between-tussock sward height and species of grazer on diet selection and intake. – Grass Forage Sci. 52: 219–231.

BAKKER, E.E. & OLFF, H. (2003): Impact of different-sized herbivores on recruitment opportunities for subordinate herbs in grasslands. – J. Veg. Sci. 14: 465–474.

BAKKER, J.P. & BERENDSE, F. (1999): Constraints in the restoration of ecological diversity in grassland and heathland communities. – Trends Ecol. Evol. 14: 63–68.

BARKMAN, J.J., DOING, H. & SEGAL, S. (1964): Kritische Bemerkungen und Vorschläge zur quantitativen Vegetationsanalyse. – Acta Bot. Neerl. 13: 394–419.

BECKER, T., SCHMIEGE, C., BERGMEIER, E., DENGLER, J. & NOWAK, B. (2012): Nutrient-poor grasslands on siliceous soil in the lower Aar valley (Middle Hesse, Germany) – neglected vegetation types in the intersection range of four classes. – Tuexenia 32: 281–318.

BEIL, M. (2007): Blütenbesuchende Wildbienen-Gemeinschaften (Hymenoptera, Apoidea) in Sand-Ökosystemen. –Thesis TU Darmstadt: 147 pp.

BEIL, M., HORN, H. & SCHWABE, A. (2008): Analysis of pollen loads in a wild bee community (Hymenoptera: Apidae) – a method for elucidating habitat use and foraging distances. – Apidologie 39: 456–467.

BULLOCK, J.M., CLEAR HILL, B., DALE, M.P. & SILVERTOWN, J. (1994): An experimental study of the effects of sheep grazing on vegetation change in a species-poor grassland and the role of seedling recruitment into gaps. – J. Appl. Ecol. 31: 493–507.

CATORCI, A., GATTI, R. & CESARETTI, S. (2012): Effect of sheep and horse grazing on species and functional composition of sub-Mediterranean grasslands. – Appl. Veg. Sci. 15: 459–469.

DUPRÉ, C. & DIEKMANN, M. (2001): Differences in species richness and life-history traits between grazed and abandoned grasslands in southern Sweden. – Ecography 24: 275–286.

EICHBERG, C., BOES, J. & SCHWABE, A. (2008): Which vegetation and seed-bank changes are induced by the disturbance regime of livestock trails in open sand ecosystems? – Abh. Westfäl. Mus. Naturkd.70: 63–80.

EICHBERG, C., STORM, C. & SCHWABE, A. (2006): A differentiating method for seed bank analysis: validation and application to successional stages of *Koelerio-Corynephoretea* inland sand vegetation. Phytocoenologia 36: 161–189.

EICHBERG, C., STORM, C. & SCHWABE, A. (2007): Endozoochorous dispersal, seedling emergence and fruiting success in disturbed and undisturbed successional stages of sheep-grazed inland sand ecosystems. – Flora 202: 3–26.

EICHBERG, C., STORM, C., STROH, M. & SCHWABE, A. (2010): Is the combination of topsoil replacement and inoculation with plant material an effective tool for the restoration of threatened sand vegetation? – Appl. Veg. Sci. 13: 425–438.

EICHBERG, C. & WESSELS-DE WIT, S. (2011): Schafe als Ausbreitungsvektoren von Samen und Früchten und als Faktoren für den Etablierungserfolg dieser Diasporen in offenen Sand-Ökosystemen. – Naturschutz Biol. Vielfalt 110: 137–162.

EUROPEAN COMMISSION (2007): Interpretation Manual of European Union Habitats. – EUR 27: 1–142.

FAUST, C., EICHBERG, C., STORM, C. & SCHWABE, A. (2011a): Post-dispersal impact on seed fate by livestock trampling – a gap of knowledge. – Basic Appl. Ecol. 12: 215–226.

FAUST, C, SÜSS, K., STORM, C. & SCHWABE, A. (2011b): Threatened inland sand vegetation in the temperate zone under different types of abiotic and biotic disturbances during a ten-year period. – Flora 206: 611–621.

FAUST, C, STORM, C. & SCHWABE, A. (2012): Shifts in plant community structure of a threatened sandy grassland over a 9-year period under experimentally induced nutrient regimes: is there a lag phase? – J. Veg. Sci. 23: 372–386.

FERNÁNDEZ, G. (2007): Model selection in PROC MIXED - A user-friendly SAS macro application. – Proceedings of 2007 SAS Global Forum, April 16–18 Orlando FL, paper 191-2007. – URL: http://www2.sas.com/proceedings/forum2007/191-2007.pdf [accessed December 2009].

FRITSCH, M., DROBNIK, J., STORM, C. & SCHWABE, A. (2011): Etablierung von Zielarten des *Cirsio tuberosi-Molinietum* nach Bodenabtrag im Bereich von entwässerten Altneckar-Schlingen (Hessen). – Tuexenia 31: 127–151.

HAMMES, V., REMY, D. & KRATOCHWIL, A. (2012): Untersuchungen zur längerfristigen Etablierung von Corynephorus canescens-Populationen in einem großflächigen Restitutionsgebiet einer Auenlandschaft Nordwestdeutschlands. – Tuexenia 32: 119–140.

HELLSTRÖM, K., HUHTA, A.-P., RAUTIO, P., TUOMI, J., OKSANEN, J. & LAINE, K. (2003): Use of sheep grazing in the restoration of semi-natural meadows in northern Finland. – Appl. Veg. Sci. 6: 45–52.

HÖLZEL, N., BUISSON, E. & DUTOIT, T. (2012): Species introduction – a major topic in vegetation restoration. – Appl. Veg. Sci. 13: 161–165.

HRŠAK, V. (2004): Vegetation succession and soil gradients on inland sand dunes. – Ekológia (Bratislava) 23: 24–39.

JACQMIN-GADDA, H., SIBILLOT, S., PROUST, C., MOLINA, J.M. & THIÉBAUT, R. (2007): Robustness of the linear mixed model to misspecified error distribution. – Comput. Stat. Data Anal. 51: 5142–5154.

KAHMEN, S., POSCHLOD, P. & SCHREIBER, K.-F. (2002): Conservation management of calcareous grasslands. Changes in plant species composition and response of functional traits during 25 years. – Biol. Conserv. 104: 319–328.

KALAMEES, R., PÜSSA, K., ZOBEL, K. & ZOBEL, M. (2012): Restoration potential ofthe persistent soil seed bank in successional calcareous (alvar) grasslands in Estonia. – Appl. Veg. Sci. 15: 208–218.

KIEHL, K., KIRMER, A., DONATH, T.W., RASRAN, L. & HÖLZEL, N. (2010): Species introduction in restoration projects – evaluation of methods for the establishment of semi-natural grasslands. – Basic Appl. Ecol. 11: 285–299.

KOOIJMAN, M. & VAN DER MEULEN, F. (1996): Grazing as a control against “grass-encroachment“ in dry dune grasslands in the Netherlands. – Landsc. Urban Plan. 34: 323–333.

KOPERSKI, M., SAUER, M., BRAUN, W. & GRADSTEIN, S.R. (2000): Referenzliste der Moose für Deutschland. – Schriftenr. Vegetationskd. 34: 1–519.

KROLUPPER, N. & SCHWABE, A. (1998): Ökologische Untersuchungen im Darmstadt-Dieburger Sandgebiet (Südhessen): Allgemeines und Ergebnisse zum Diasporenreservoir und Niederschlag. – Bot. Naturschutz Hess. 10: 9–39.

KUITERS, A.T. & HUISKES, H.P.J. (2010): Potential of endozoochorous seed dispersal by sheep in calcareous grasslands: correlations with seed traits. – Appl. Veg. Sci. 13: 163–172.

LAMOOT, I., CALLEBAUT, J., DEMEULENAERE, E., VANDENBERGHE, C. & HOFFMANN, M. (2005): Foraging behaviour of donkeys grazing in a coastal dune area in temperate climate conditions. – Appl. Anim. Behav. Sci. 92: 93–112.

LITTELL, R.C., MILIKEN, G.A., STROUP, W.W., WOLFINGER, R.D. & SCHABENBERGER, O. (2006): SAS for mixed models (2nd ed.). – Cary, NC, USA: SAS Institute.

OBERDORFER. E. (2001): Pflanzensoziologische Exkursionsflora für Deutschland und angrenzende Gebiete. – Ulmer, Stuttgart: 1051 pp.

OPPERMANN, R., BEAUFOY, G. & JONES, G. (2012): High Nature Value Farming in Europe. – Verlag Regionalkultur, Ubstadt-Weiher: 544 pp.

PLASSMANN, K., JONES, M.L.M. & EDWARDS-JONES, G. (2010): Effects of long-term grazing management on sand dune vegetation of high conservation interest. – Appl. Veg. Sci. 13: 100–112.

PRACH, K. & PYŠEK, P. (1999): How do species dominating in succession differ from others? – J. Veg. Sci. 10: 383–393.

REBELE, F. (1996): Konkurrenz und Koexistenz bei ausdauernden Ruderalpflanzen. – Dr. Kovac, Hamburg: 200 pp.

REBELE, F. & LEHMANN, C. (2001): Biological flora of Central Europe: *Calamagrostis epigejos* (L.) Roth. – Flora 196: 325–344.

ROSENTHAL, G., SCHRAUTZER, J. & EICHBERG, C. (2012): Low-intensity grazing with domestic herbivores: A tool for maintaining and restoring plant diversity in temperate Europe. – Tuexenia 32: 167–205.

RUPRECHT, E., ENYEDI, M.Z., ECKSTEIN, R.L. & DONATH. T.W. (2010): Restorative removal of plant litter and vegetation 40 years after abandonment enhances re-emergence of steppe grassland vegetation. – Biol. Conserv. 143: 449–465.

RUPRECHT, E. & SZABÓ, A. (2012): Grass litter is a natural seed trap in long-term undisturbed grassland. – J. Veg. Sci. 23:495–504.

SCHOLZ, P. (2000): Katalog der Flechten und flechtenbewohnenden Pilze Deutschlands. – Schriftenr. Vegetationskd. 31: 1–298.

SCHRAUTZER, J., IRMLER, U., JENSEN, K., NÖTZOLD, R. & HOLSTEN, B. (2004): Auswirkungen großflächiger Beweidung auf die Lebensgemeinschaften eines nordwestdeutschen Flusstales. – Schriftenr. Landschaftspfl. Naturschutz 78: 39–61.

SCHWABE A., ZEHM, A., EICHBERG, C., STROH, M., STORM, C. & KRATOCHWIL, A. (2004a): Extensive Beweidungssysteme als Mittel zur Erhaltung und Restitution von Sand-Ökosystemen und ihre naturschutzfachliche Bedeutung. – Schriftenr. Landschaftspfl. Naturschutz 78: 63–92.

SCHWABE A., ZEHM, A., NOBIS, M., STORM, C. & SÜSS, K. (2004b): Auswirkungen von Schaf-Erstbeweidung auf die Vegetation primär basenreicher Sand-Ökosysteme. – NNA-Ber. 17 (1): 39–53.

STAMMEL, B. & KIEHL, K. (2004): Do hoof prints actually serve as a regeneration niche for plant species in fens? – Phytocoenologia 34: 271–286.

STROH, M. & SCHWABE, A.(2007): Untersuchungen zur Restitution von Sandtrockenrasen: das Seeheim-Jugenheim Experiment in Südhessen. – Tuexenia 29: 181–197.

STROH, M., STORM, C., ZEHM, A. & SCHWABE, A. (2002): Restorative grazing as a tool for directed succession with diaspore inoculation: the model of sand ecosystems. – Phytocoenologia 32: 595–625.

SÜSS, K. & SCHWABE, A. (2007): Sheep versus donkey grazing or mixed treatment: results from a 4-year field experiment in *Armerio-Festucetum trachyphyllae* sand vegetation. – Phytocoenologia 37: 135–160.

SÜSS, K., STORM, C. & SCHWABE, A. (2010): Sukzessionslinien in basenreicher offener Sandvegetation des Binnenlandes: Ergebnisse aus Untersuchungen von Dauerbeobachtungsflächen. – Tuexenia 30: 289–318.

SÜSS, K., STORM, C. & SCHWABE, A. (Bearb.) (2011): Ried und Sand: Biotopverbund durch extensive Landbewirtschaftung. – Naturschutz Biol. Vielfalt 110.

SÜSS, K., STORM, C., ZEHM, A. & SCHWABE, A. (2004): Successional traits in inland sand ecosystems: which factors determine the occurrence of the tall grass species *Calamagrostis epigejos* (L.) Roth and *Stipa capillata* L.? – Plant Biol. 6: 465–476

VALLEJO, G., FERNÁNDEZ, P., HERRERO, F.J. & CONEJO, N.M. (2004): Alternative procedures for testing fixed effects in repeated measures designs when assumptions are violated. – Psicothema 16: 498–508.

WESSELS, S. (2008): The contribution of sheep zoochory to the conservation and restoration of target plant communities in isolated sand ecosystems. – Thesis TU Darmstadt: 158 pp.

WILSON, S.D. & TILMAN, D. (1993): Plant competition and resource availability in response to disturbance and fertilization. – Ecology 74: 599–611.

WISSKIRCHEN, R. & HAEUPLER, H. (1998): Standardliste der Farn- und Blütenpflanzen Deutschlands. – Ulmer, Stuttgart: 765 pp.

ZEHM, A. & ZIMMERMANN, K. (2004): Sandgebiete in der hessischen Oberrheinebene: Untersuchungsflächen und Untersuchungsansatz des BMBF-Projektes „Sand-Ökosysteme im Binnenland“. – NNA-Ber. 17(1): 69–77.

ZIMMERMANN, M., VISCHER-LEOPOLD, M., ELLWANGER, G., SSYMANK, A. & SCHRÖDER, E. (2010): The EU Habitats directive and the German Natura 2000 network of protected areas as tool for implementing the conservation of relict species. – In: HABEL, J.C. & ASSMANN, T. (Eds.) Relict Species: Phylogeography and Conservation Biology: 323–339. – Springer, Berlin, Heidelberg.

Table 1. Constancy table of the long-term data set. rS: Spearman's rank correlation coefficient between presence and year, p: p value of rS (exploratory tests). Shaded: species with significant decrease (p< 0.05). Bold and rS, p: underlined: significant increase (p< 0.05).
Tabelle 1. Stetigkeitstabelle des Langzeit-Datensatzes. rS: Spearmans Rangkorrelationskoeffizient zwischen Stetigkeit und Jahr, p: p Wert von rS (exploratorische Tests). Schattiert: Arten mit sign. Abnahme (p< 0.05). Fett, rS, p: unterstrichen: sign. Zunahme (p< 0.05).

Type	Community complex	Allio-Stipetum (A)													
	Groups ungrazed, grazed	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au		
	Year (2000-2011 or 2009)	0	1	2	3	4	5	6	7	8	9	10	11		
	n	10	10	10	10	10	10	10	10	10	10	10	10		
	Species number (average)	37	32	36	31	38	33	29	33	27	27	28	24		
	SE	2	1	1	1	2	2	1	1	2	2	1	1		
1	**Allio-Stipetum**													rS	p
34	Stipa capillata	100	100	100	100	100	100	100	100	100	100	100	100		
8	Allium sphaerocephalon	.	.	.	.	10	10	.	.	.	.	.	.	-0.13	0.6882
2	**Other Festuco-Brometea species**														
34	Festuca duvalii	40	40	50	50	50	40	20	30	20	10	20	10	-0.82	0.0012
34	Phleum phleoides	40	50	60	40	50	40	40	40	20	20	20	20	-0.82	0.0011
34	Centaurea stoebe s.l.	90	90	100	90	90	100	80	90	40	40	50	10	-0.76	0.0038
34	Euphorbia cyparissias	90	100	100	100	100	100	70	90	60	80	100	100	-0.21	0.5184
34	Helianthemum numm. subsp. obscurum	60	50	60	50	50	50	60	60	60	40	40	40	-0.50	0.0956
34	Medicago falcata	30	30	30	30	50	30	30	20	30	30	20	30	-0.37	0.2326
34	Ononis repens	100	100	100	100	100	100	100	100	100	100	100	90	-0.48	0.1139
33	Salvia pratensis	20	20	30	30	30	40	40	40	30	30	30	40	0.57	0.0517
32	Asperula cynanchica	30	40	30	20	30	30	30	30	20	20	20	20	-0.70	0.0112
31	Koeleria macrantha	10	10	10	20	20	30	20	10	.	10	10	20	-0.02	0.9532
28	Silene otites	50	40	30	30	30	20	10	10	.	.	.	.	-0.97	0.0000
20	Stachys recta	10	.	.	.	.	.	.	.	.	.	.	.	-0.48	0.1139
19	Artemisia campestris	10	20	20	20	20	.	.	.	.	.	.	.	-0.80	0.0019
19	Ajuga genevensis	10	.	10	10	.	.	10	10	10	20	10	20	0.58	0.0502
14	Arabis hirsuta agg.	.	.	.	.	.	.	10	.	.	10	.	.	0.26	0.4161
13	Dianthus carthusianorum	.	.	.	.	.	.	.	.	.	.	.	.		
9	Linum perenne	.	.	.	.	.	.	.	.	.	.	.	.		
5	Euphorbia seguieriana	10	10	10	.	.	10	10	.	.	.	.	.	-0.66	0.0193
3	Galium verum	.	.	.	.	.	.	.	.	.	.	.	.		
3	**Koelerio-Corynephoretea species**														
3a	**Annual species with high probability to decrease in ungrazed plots**														
32	Cerastium semidecandrum	90	90	50	.	40	60	10	10	20	30	20	.	-0.63	0.0292
32	Medicago minima	50	10	30	20	70	10	20	20	10	20	.	.	-0.62	0.0323
30	Petrorhagia prolifera	70	30	60	30	40	50	10	10	.	10	.	.	-0.87	0.0002
27	Trifolium campestre	30	10	.	10	40	10	10	.	.	.	.	.	-0.68	0.0154
25	Vicia lathyroides	10	10	.	.	10	.	.	.	.	.	.	.	-0.64	0.0247
24	Myosotis ramosissima	20	10	.	.	.	.	.	.	.	.	.	.	-0.65	0.0220
3b	**Other Koelerio-Corynephoretea species**														
34	Helichrysum arenarium	80	80	80	80	70	60	60	50	70	40	50	50	-0.88	0.0001
34	Potentilla argentea agg.	60	60	60	50	70	50	50	40	20	30	40	40	-0.82	0.0010
34	Agrostis vinealis	10	10	10	10	10	10	10	10	10	10	10	10		
34	Alyssum alyssoides	50	60	90	60	90	90	90	90	70	70	60	10	-0.08	0.7948
34	Arenaria serpyllifolia agg.	100	90	90	20	90	90	90	90	80	100	90	10	-0.31	0.3289
34	Echium vulgare	40	70	60	60	60	60	40	70	30	50	50	60	-0.21	0.5169
34	Erodium cicutarium	40	20	20	40	60	20	30	60	40	50	40	80	0.55	0.0663
34	Hieracium pilosella	30	20	20	20	10	10	10	10	20	10	30	20	-0.16	0.6223
33	Sedum acre	50	80	80	60	60	80	20	50	70	80	30	10	-0.40	0.1932
31	Rumex acetosella s.l.	30	20	10	.	20	20	20	20	20	.	10	.	-0.49	0.1027
29	Veronica verna	30	20	20	.	30	40	20	.	.	20	10	.	-0.50	0.0941
26	Corynephorus canescens	60	60	50	40	20	30	40	30	40	30	40	10	-0.66	0.0193
25	Trifolium arvense	20	.	40	.	40	.	10	10	.	.	.	.	-0.48	0.1128
24	Silene conica	.	.	20	.	50	10	20	.	.	.	.	.	-0.26	0.4093
23	Armeria maritima subsp. elongata	10	.	.	.	.	.	.	.	.	.	.	.	-0.48	0.1139
21	Poa bulbosa	.	.	10	10	10	.	.	10	10	10	.	10	0.27	0.3973
21	Vulpia myuros	.	.	.	.	10	10	10	10	10	.	10	.	0.34	0.2826
21	Saxifraga tridactylites	30	30	.	.	10	.	.	.	10	.	.	.	-0.54	0.0678
18	Erophila verna	.	.	.	.	.	.	.	10	.	.	.	.	0.13	0.6848
18	Myosotis stricta	10	10	.	.	.	10	20	10	20	10	10	.	0.17	0.6019
17	Koeleria glauca	40	40	40	40	20	30	20	20	20	20	10	.	-0.92	0.0000
13	Thymus serpyllum	30	40	40	50	40	30	50	50	40	30	40	30	-0.12	0.7208
12	Bassia laniflora	10	10	10	10	10	10	10	10	.	.	10	.	-0.64	0.0247
14	Veronica praecox	10	10	10	.	.	.	.	.	.	.	.	.	-0.75	0.0047
12	Acinos arvensis	10	.	10	.	20	.	.	.	.	.	.	.	-0.55	0.0625
10	Poa badensis	10	10	10	10	10	10	10	10	10	10	.	.	-0.65	0.0228
9	Phleum arenarium	.	.	.	.	.	.	.	.	.	.	.	.		
5	Jasione montana	10	.	.	.	.	.	.	.	.	.	.	.	-0.48	0.1139
5	Herniaria glabra	.	.	.	.	.	.	.	.	.	.	.	.		
1	Aira caryophyllea	.	.	.	.	.	.	.	.	.	.	.	.		
1	Holosteum umbellatum	.	.	.	.	.	.	.	.	.	.	.	.		
4	**Competitive graminoids**														
34	Calamagrostis epigejos	90	90	90	90	70	80	80	80	70	70	60	60	-0.90	0.0001
34	Carex hirta	**30**	**30**	**50**	**50**	**30**	**50**	**50**	**50**	**70**	**70**	**70**	**70**	**0.88**	**0.0002**
34	Poa angustifolia	80	90	90	90	80	80	80	80	90	90	90	70	-0.13	0.6909
5	**d former fields (+- exclusively = > 5 columns)**														
12	Holcus lanatus	.	.	.	.	.	.	.	.	.	.	.	.		
11	Cerastium holosteoides	.	.	.	.	.	.	.	.	.	.	.	.		
10	Solidago canadensis	.	.	.	.	.	.	.	.	.	.	.	.		
10	Festuca filiformis	.	.	.	.	.	.	.	.	.	.	.	.		
10	Tripleurospermum perforatum	.	.	.	.	.	.	.	.	.	.	.	.		
9	Trifolium repens	.	.	.	.	.	.	.	.	.	.	.	.		
9	Tanacetum vulgare	.	.	.	.	.	.	.	.	.	.	.	.		
8	Viola riviniana	.	.	.	.	.	.	.	.	.	.	.	.		
7	Ornithopus perpusillus	.	.	.	.	.	.	.	.	.	.	.	.		
5	Urtica dioica	.	.	.	.	.	.	.	.	.	.	.	.		
5	Daucus carota	.	.	.	.	.	.	.	.	.	.	.	.		
6	Valerianella carinata	.	.	.	.	.	.	.	.	.	.	.	.		
6	**Agropyretea species**														
33	Saponaria officinalis	20	20	.	10	10	20	20	10	10	20	20	10	0.00	0.9904
30	Cerastium arvense	20	.	.	10	10	10	10	10	10	10	10	10	0.15	0.6374
29	Elymus repens	20	20	30	20	30	.	10	10	10	.	.	10	-0.72	0.0078
24	Diplotaxis tenuifolia	80	50	70	70	60	60	10	30	10	.	10	10	-0.85	0.0004
23	Convolvulus arvensis	10	.	.	20	10	20	.	10	20	10	.	.	-0.10	0.7646
12	Elymus athericus	.	.	.	.	.	.	.	.	.	.	.	.		
11	Isatis tinctoria	.	.	.	.	.	.	.	10	.	.	.	.	0.13	0.6848
7	Potentilla reptans	10	10	10	10	10	10	10	.	.	.	.	.	-0.86	0.0004
5	Chondrilla juncea	.	.	.	.	.	.	.	.	.	.	.	.		
2	Chaerophyllum temulum	.	.	.	.	.	.	.	.	.	.	.	.		
7	**Artemisietea species**														
34	Berteroa incana	40	40	50	50	50	30	30	30	20	20	30	20	-0.81	0.0015
34	Cynoglossum officinale	60	60	60	60	40	30	60	70	60	60	50	90	0.20	0.5274
34	Oenothera biennis s.l.	**80**	**80**	**90**	**70**	**90**	**90**	**80**	**90**	**100**	**100**	**100**	**100**	**0.81**	**0.0014**
33	Carduus nutans	20	20	20	20	30	40	10	30	40	50	70	20	0.51	0.0906
31	Malva alcea	10	.	.	10	20	10	10	10	10	.	10	20	0.32	0.3117
28	Silene latifolia subsp. alba	.	20	10	10	10	20	.	30	.	.	.	.	-0.42	0.1715
27	Anchusa officinalis	**10**	**.**	**10**	**10**	**10**	**10**	**20**	**20**	**20**	**20**	**10**	**20**	0.70	0.0112
27	Rubus caesius	10	10	10	10	10	10	10	10	10	10	10	10		
22	Tragopogon dubius	10	10	30	20	.	10	.	.	10	.	.	.	-0.67	0.0162
8	Rubus fruticosus agg.	10	10	.	.	.	.	.	.	.	.	.	.	-0.65	0.0228
7	Reseda lutea	.	.	.	.	.	.	.	.	.	.	.	.		
4	Artemisia vulgaris	.	.	.	.	.	.	.	.	.	.	.	.		
3	Epilobium tetragonum subsp. lamyi	.	.	.	.	.	.	.	.	.	.	.	.		
3	Erigeron annuus	.	.	.	.	.	.	.	.	.	.	.	.		
2	Cirsium vulgare	.	.	.	.	.	.	.	.	.	.	.	.		
1	Cirsium arvense	.	.	.	.	.	.	.	.	.	.	.	.		
1	Galium aparine	.	.	.	.	.	.	.	.	.	.	.	.		
1	Linaria vulgaris	.	.	.	.	.	.	.	.	.	.	.	.		

Type	Community complex	Allio-Stipetum (A)														former Asparagus field											
	Groups ungrazed, grazed	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag			Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg		
	Year (2000-2011 or 2009)	0	1	2	3	4	5	6	7	8	9	10	11			0	1	2	3	4	5	6	7	8	9		
	n	14	14	14	14	14	14	14	14	14	14	14	14			16	16	16	16	16	16	16	16	16	16		
	Species number (average)	36	39	50	43	48	43	42	38	40	37	43	33			33	36	41	39	43	44	39	33	36	34		
	SE	3	2	2	2	2	2	2	2	2	1	1	1			1	2	2	2	2	2	1	2	2	1		
1	**Allio-Stipetum**													rS	p											rS	p
34	Stipa capillata	93	93	100	100	100	100	100	100	100	100	100	100	0.65	0.0228	31	31	25	25	25	19	13	13	13	13	-0.95	0.0000
8	Allium sphaerocephalon	.	14	7	.	14	.	.	.	.	.	.	.	-0.52	0.0830	.	13	6	.	13	.	.	.	.	.	-0.48	0.1609
2	**Other Festuco-Brometea species**																										
34	Festuca duvalii	14	21	29	36	21	29	29	21	21	29	29	21	0.14	0.6569	6	13	13	13	13	13	13	13	13	13	0.52	0.1215
34	Phleum phleoides	21	36	43	29	50	36	36	36	36	29	43	29	0.02	0.9460	13	25	25	31	25	31	25	25	25	31	0.44	0.2067
34	Centaurea stoebe s.l.	86	86	86	86	93	100	100	79	64	50	64	14	-0.65	0.0231	56	69	50	56	50	81	75	69	63	50	0.10	0.7860
34	Euphorbia cyparissias	93	86	86	93	100	100	100	100	100	86	100	100	0.53	0.0749	44	50	50	56	50	50	44	44	38	44	-0.55	0.0999
34	Helianthemum numm. subsp. obscurum	36	36	50	43	50	50	57	57	57	36	50	36	0.20	0.5389	6	13	13	13	6	19	13	13	13	25	0.58	0.0816
34	Medicago falcata	43	50	50	43	50	57	43	64	50	57	64	50	0.54	0.0705	**13**	**6**	**6**	**13**	**13**	**19**	**13**	**19**	**25**	**19**	**0.81**	**0.0047**
34	Ononis repens	71	71	71	71	71	71	71	71	71	71	71	71			19	19	13	31	25	19	25	13	19	19	-0.05	0.8864
33	Salvia pratensis	14	21	21	14	29	21	21	21	29	21	21	21	0.38	0.2280	.	6	6	6	6	6	6	6	6	6	0.52	0.1215
32	Asperula cynanchica	36	43	43	36	57	43	50	50	50	50	57	43	0.56	0.0580	13	13	6	13	6	6	13	6	.	.	-0.73	0.0173
31	Koeleria macrantha	29	36	36	50	36	36	29	36	43	29	21	7	-0.45	0.1392	**.**	**6**	**6**	**13**	**.**	**6**	**6**	**13**	**13**	**25**	**0.71**	**0.0226**
28	Silene otites	29	43	43	64	50	36	50	43	14	7	14	14	-0.58	0.0468	13	6	19	6	6	6	25	13	.	.	-0.42	0.2326
20	Stachys recta	7	7	7	7	7	7	7	7	7	.	7	7	-0.31	0.3339	6	6	6	.	6	6	6	6	6	.	-0.26	0.4662
19	Artemisia campestris	7	7	14	7	7	7	7	7	7	7	7	7	-0.31	0.3339	.	.	6	.	13	.	.	.	.	.	-0.24	0.5002
19	Ajuga genevensis	**.**	**.**	**.**	**7**	**7**	**.**	**7**	**7**	**21**	**14**	**7**	**7**	**0.71**	**0.0093**	.	.	6	6	.	.	.	.	.	.	-0.35	0.3242
14	Arabis hirsuta agg.	**.**	**7**	**.**	**14**	**7**	**7**	**14**	**21**	**14**	**29**	**14**	**7**	**0.60**	**0.0379**	.	.	.	.	.	.	6	.	.	6	0.52	0.1215
13	Dianthus carthusianorum	7	7	7	7	7	7	7	7	7	7	7	7			.	.	.	.	.	6	.	.	.	.	0.06	0.8735
9	Linum perenne	**.**	**.**	**.**	**7**	**7**	**7**	**14**	**7**	**7**	**7**	**21**	**7**	**0.72**	**0.0078**	.	.	.	.	.	.	.	.	.	.		
5	Euphorbia seguieriana	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
3	Galium verum	.	.	.	.	.	.	.	.	7	7	.	.	0.39	0.2118	.	.	.	.	.	.	.	6	.	.	0.29	0.4161
3	**Koelerio-Corynephoretea species**																										
3a	**Annual species with high probability to decrease in ungrazed plots**																										
32	Cerastium semidecandrum	93	86	100	36	93	93	86	57	86	86	100	100	0.15	0.6379	75	81	88	56	88	94	94	50	81	88	0.19	0.5963
32	Medicago minima	29	29	86	79	100	57	43	50	50	57	57	50	0.09	0.7837	44	50	50	44	56	63	50	44	44	50	0.01	0.9859
30	Petrorhagia prolifera	21	36	50	21	79	64	57	29	14	7	36	.	-0.40	0.1976	31	50	44	50	100	94	75	50	25	25	-0.18	0.6096
27	Trifolium campestre	29	7	71	7	29	36	36	36	21	29	36	.	-0.06	0.8592	69	81	94	69	88	81	81	69	63	69	-0.42	0.2292
25	Vicia lathyroides	7	14	36	29	21	29	21	7	14	43	21	14	0.05	0.8691	25	50	81	63	75	81	69	56	69	75	0.35	0.3235
24	Myosotis ramosissima	21	14	14	7	14	43	64	7	14	71	50	36	0.43	0.1614	38	38	63	50	56	88	50	31	56	81	0.34	0.3419
3b	**Other Koelerio-Corynephoretea species**																										
34	Helichrysum arenarium	64	71	79	86	79	79	64	86	57	64	57	36	-0.55	0.0650	25	31	38	31	25	31	25	19	31	25	-0.34	0.3324
34	Potentilla argentea agg.	79	71	71	57	57	50	57	57	71	43	64	64	-0.38	0.2268	**56**	**31**	**63**	**69**	**63**	**75**	**88**	**75**	**81**	**69**	**0.76**	**0.0100**
34	Agrostis vinealis	7	14	29	21	21	21	14	14	14	14	14	7	-0.32	0.3039	13	13	13	13	13	13	13	13	13	19	0.52	0.1215
34	Alyssum alyssoides	29	29	43	57	64	57	57	57	64	57	71	43	0.54	0.0702	**6**	**6**	**13**	**13**	**31**	**25**	**31**	**25**	**25**	**25**	**0.69**	**0.0258**
34	Arenaria serpyllifolia agg.	79	86	93	64	100	100	100	100	86	93	100	71	0.20	0.5252	56	69	88	69	88	81	75	69	69	81	0.21	0.5528
34	Echium vulgare	64	57	64	86	86	79	64	57	71	71	86	86	0.43	0.1649	19	31	44	44	38	31	31	25	19	31	-0.25	0.4943
34	Erodium cicutarium	36	57	71	71	93	43	79	86	71	100	79	86	0.65	0.0221	25	44	44	63	56	69	44	19	38	38	-0.22	0.5384
34	Hieracium pilosella	36	36	43	50	36	36	36	29	36	29	36	36	-0.45	0.1376	19	19	25	38	31	31	25	25	31	31	0.50	0.1450
33	Sedum acre	64	79	86	79	71	86	50	64	64	64	57	36	-0.67	0.0176	6	13	.	13	19	6	6	19	13	19	0.50	0.1437
31	Rumex acetosella s.l.	21	29	29	14	21	21	21	21	21	14	29	14	-0.34	0.2775	44	63	69	69	56	75	75	63	63	38	-0.06	0.8788
29	Veronica verna	21	29	57	14	29	43	29	21	43	21	50	7	-0.10	0.7668	13	.	19	19	13	19	25	13	13	13	0.07	0.8431
26	Corynephorus canescens	14	14	14	14	14	14	14	14	7	14	7	14	-0.45	0.1388	13	6	.	.	.	.	.	.	.	.	-0.70	0.0240
25	Trifolium arvense	14	29	36	.	36	14	36	29	.	14	14	7	-0.34	0.2767	75	81	88	6	88	75	81	25	31	63	-0.41	0.2395
24	Silene conica	7	7	50	50	57	50	14	14	21	36	14	.	-0.17	0.5884	6	13	6	6	19	38	19	.	6	13	0.06	0.8629
23	Armeria maritima subsp. elongata	14	14	14	7	14	14	14	14	14	7	21	21	0.38	0.2280	6	13	6	6	13	31	31	13	13	19	0.62	0.0544
21	Poa bulbosa	14	.	.	14	14	14	21	7	21	7	14	14	0.30	0.3428	.	6	.	.	6	.	.	6	6	.	0.14	0.6953
21	Vulpia myuros	.	.	7	.	.	7	14	7	29	7	79	.	0.51	0.0930	.	19	25	.	6	13	19	31	19	44	0.59	0.0721
21	Saxifraga tridactylites	29	21	36	7	36	21	36	7	14	.	7	.	-0.67	0.0173	6	13	25	6	19	31	19	.	.	.	-0.46	0.1844
18	Erophila verna	.	.	.	7	21	7	14	7	21	43	7	.	0.41	0.1851	.	6	25	31	19	19	19	6	38	6	0.21	0.5699
18	Myosotis stricta	.	.	.	.	.	7	7	.	7	21	7	.	0.53	0.0762	.	.	.	.	13	6	19	6	13	.	0.49	0.1522
17	Koeleria glauca	.	7	.	.	.	.	.	.	.	.	.	.	-0.39	0.2063	6	6	.	.	6	.	6	.	6	.	-0.24	0.4974
13	Thymus serpyllum	.	.	.	.	.	.	.	.	.	.	.	7	0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
12	Bassia laniflora	.	.	.	.	.	7	7	.	.	7	.	.	0.20	0.5434	.	.	.	.	.	.	.	.	.	.		
14	Veronica praecox	14	14	14	7	7	7	.	.	21	7	.	.	-0.60	0.0411	.	.	.	.	.	.	6	6	6	.	0.57	0.0855
12	Acinos arvensis	.	14	7	.	.	.	7	7	7	.	.	.	-0.24	0.4463	.	6	.	.	6	6	.	.	.	6	0.07	0.8453
10	Poa badensis	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
9	Phleum arenarium	.	.	14	14	7	14	14	7	14	7	14	.	0.14	0.6722	.	.	.	.	.	.	.	.	.	.		
5	Jasione montana	.	.	.	.	.	.	.	.	.	.	.	.			6	6	.	6	.	.	.	6	.	.	-0.50	0.1435
5	Herniaria glabra	.	.	7	7	7	.	.	7	.	.	7	.	-0.07	0.8205	.	.	.	.	.	.	.	.	.	.		
1	Aira caryophyllea	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	6	.	.	.	.	.	-0.06	0.8735
1	Holosteum umbellatum	.	.	.	.	.	.	.	.	7	.	.	.	0.22	0.4954	.	.	.	.	.	.	.	.	.	.		
4	**Competitive graminoids**																										
34	Calamagrostis epigejos	79	79	86	86	79	71	71	71	79	64	64	50	-0.81	0.0014	94	88	94	88	94	81	75	81	81	69	-0.83	0.0030
34	Carex hirta	**57**	**57**	**57**	**57**	**57**	**57**	**57**	**57**	**64**	**57**	**64**	**64**	**0.70**	**0.0118**	81	81	56	75	88	88	75	69	88	75	0.00	1.0000
34	Poa angustifolia	100	100	100	100	100	100	93	86	86	93	93	100	-0.57	0.0522	75	81	94	100	94	100	100	100	100	94	0.61	0.0613
5	**d former fields (+- exclusively = > 5 columns)**																										
12	Holcus lanatus	.	.	.	.	.	7	.	.	7	.	.	.	0.13	0.6882	25	38	44	31	6	19	25	44	63	38	0.29	0.4103
11	Cerastium holosteoides	.	.	7	.	.	.	.	.	.	.	.	.	-0.31	0.3339	31	38	50	38	31	44	44	25	38	38	-0.02	0.9587
10	Solidago canadensis	.	.	.	.	.	.	.	.	.	.	.	.			19	19	19	13	13	13	13	6	6	6	-0.94	0.0000
10	Festuca filiformis	.	.	.	.	.	.	.	.	.	.	.	.			6	19	25	25	19	19	13	13	13	6	-0.41	0.2438
10	Tripleurospermum perforatum	.	.	.	.	.	.	.	.	.	.	.	.			6	6	13	6	19	19	6	6	6	6	-0.15	0.6795
9	Trifolium repens	.	.	.	.	.	.	.	.	.	.	.	.			6	38	31	31	.	25	31	31	38	31	0.25	0.4923
9	Tanacetum vulgare	.	.	.	.	.	.	.	.	.	.	.	.			.	6	6	6	6	6	6	6	6	6	0.52	0.1215
8	Viola riviniana	.	.	.	.	.	.	.	.	.	.	.	.			.	6	6	6	.	6	6	6	6	6	0.44	0.2087
7	Ornithopus perpusillus	.	.	.	.	.	.	.	.	.	.	.	.			.	.	13	.	19	13	6	19	13	6	0.47	0.1715
5	Urtica dioica	.	.	.	.	.	.	.	.	.	.	.	.			13	13	13	13	.	6	.	.	.	.	-0.86	0.0013
5	Daucus carota	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	13	.	6	6	13	6	.	0.38	0.2856
6	Valerianella carinata	.	.	.	.	.	.	.	.	.	.	.	.			.	6	6	6	.	6	6	.	6	.	-0.14	0.6953
6	**Agropyretea species**																										
33	Saponaria officinalis	29	21	21	29	21	29	21	21	21	21	21	21	-0.47	0.1196	6	6	6	6	6	6	6	6	6	6		
30	Cerastium arvense	**21**	**21**	**29**	**50**	**36**	**29**	**36**	**36**	**57**	**57**	**50**	**43**	**0.75**	**0.0048**	6	6	6	6	6	6	.	.	19	13	0.21	0.5556
29	Elymus repens	57	43	43	36	43	43	36	29	21	21	14	14	-0.93	0.0000	44	44	44	13	31	25	25	13	.	.	-0.89	0.0007
24	Diplotaxis tenuifolia	43	36	43	43	43	36	29	36	36	29	29	36	-0.69	0.0132	.	.	.	.	.	.	.	.	6	.	0.41	0.2441
23	Convolvulus arvensis	7	21	36	14	14	.	.	.	7	.	.	.	-0.75	0.0054	44	25	44	13	31	19	31	13	13	19	-0.60	0.0663
12	Elymus athericus	7	7	7	7	7	.	7	.	7	.	.	.	-0.71	0.0097	6	.	6	.	6	6	6	.	.	.	-0.38	0.2747
11	Isatis tinctoria	**7**	**.**	**14**	**7**	**.**	**7**	**14**	**7**	**14**	**14**	**14**	**14**	**0.63**	**0.0270**	.	.	.	.	.	.	.	.	.	.		
7	Potentilla reptans	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
5	Chondrilla juncea	.	7	7	.	7	.	.	7	.	.	7	.	-0.17	0.5943	.	.	.	.	.	.	.	.	.	.		
2	Chaerophyllum temulum	.	.	.	.	.	.	.	.	.	.	.	.			.	6	6	.	.	.	.	.	.	.	-0.52	0.1215
7	**Artemisietea species**																										
34	Berteroa incana	43	57	57	57	71	57	43	50	57	57	50	43	-0.25	0.4427	56	44	38	56	69	63	50	44	50	50	-0.04	0.9191
34	Cynoglossum officinale	93	71	71	86	64	50	64	50	36	50	57	50	-0.80	0.0016	56	50	44	69	50	31	44	31	50	31	-0.60	0.0641
34	Oenothera biennis s.l.	93	93	100	100	79	86	86	64	86	79	86	86	-0.60	0.0385	31	69	75	69	38	81	56	56	44	38	-0.17	0.6484
33	Carduus nutans	57	71	64	64	57	57	43	43	36	57	50	43	-0.71	0.0090	13	25	13	13	13	19	13	6	6	.	-0.73	0.0173
31	Malva alcea	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**21**	**21**	**14**	**21**	**0.64**	**0.0247**	6	6	6	13	6	6	6	6	13	13	0.49	0.1469
28	Silene latifolia subsp. alba	7	7	14	14	21	29	21	14	7	14	43	21	0.49	0.1019	6	6	13	31	19	6	25	19	19	19	0.49	0.1526
27	Anchusa officinalis	14	7	7	.	.	21	7	.	.	.	7	.	-0.46	0.1316	19	13	13	13	19	19	25	25	19	13	0.31	0.3811
27	Rubus caesius	21	29	29	29	21	21	14	21	21	14	14	7	-0.80	0.0017	6	.	.	.	6	6	.	.	.	.	-0.34	0.3336
22	Tragopogon dubius	36	50	86	43	36	7	7	.	.	.	.	.	-0.90	0.0001	31	63	44	.	38	31	25	6	6	6	-0.62	0.0582
8	Rubus fruticosus agg.	.	.	.	7	7	14	14	7	.	.	.	.	-0.10	0.7606	.	.	.	.	.	.	.	.	.	6	0.52	0.1215
7	Reseda lutea	7	.	.	7	7	7	7	.	.	.	7	7	0.02	0.9398	.	.	.	.	.	.	.	.	.	.		
4	Artemisia vulgaris	.	.	.	.	.	.	.	.	.	.	.	.			13	6	6	6	.	.	.	.	.	.	-0.87	0.0009
3	Epilobium tetragonum subsp. lamyi	.	.	.	.	.	.	.	.	.	.	.	.			13	19	.	.	.	6	.	.	.	.	-0.62	0.0564
3	Erigeron annuus	.	.	.	.	.	7	.	.	.	.	.	.	-0.04	0.8928	6	.	.	.	.	.	.	.	.	6	0.00	1.0000
2	Cirsium vulgare	.	.	.	.	.	.	.	.	.	.	.	.			.	6	.	6	.	.	.	.	.	.	-0.44	0.2087
1	Cirsium arvense	.	.	.	.	.	.	.	.	.	.	.	.			19	.	.	.	.	.	.	.	.	.	-0.52	0.1215
1	Galium aparine	.	.	.	.	.	.	.	.	.	.	.	.			13	.	.	.	.	.	.	.	.	.	-0.52	0.1215
1	Linaria vulgaris	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	6	.	.	.	.	.	-0.06	0.8735

Continued on back page
Fortsetzung auf der Rückseite

Type	Community complex	Allio-Stipetum (A)														Allio-Stipetum (A)														former Asparagus field											
	Groups ungrazed, grazed	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au	Au			Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag	Ag			Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg	Fg		
	Year (2000-2011 or 2009)	0	1	2	3	4	5	6	7	8	9	10	11			0	1	2	3	4	5	6	7	8	9	10	11			0	1	2	3	4	5	6	7	8	9		
	n	10	10	10	10	10	10	10	10	10	10	10	10			14	14	14	14	14	14	14	14	14	14	14	14			16	16	16	16	16	16	16	16	16	16		
	Species number (average)	37	32	36	31	38	33	29	33	27	27	28	24			36	39	50	43	48	43	42	38	40	37	43	33			33	36	41	39	43	44	39	33	36	34		
	SE	2	1	1	1	2	2	1	1	2	2	1	1			3	2	2	2	2	2	2	2	2	1	1	1			1	2	2	2	2	2	1	2	2	1		
8	**Molinio-Arrhenatheretea species**																																								
34	Achillea millefolium agg.	40	20	40	40	40	30	30	30	10	40	30	40	-0.13	0.6796	64	71	71	79	50	50	64	57	64	64	64	43	-0.50	0.0961	50	44	56	69	44	63	50	56	63	63	0.45	0.1896
34	Crepis capillaris	50	30	50	10	20	50	30	50	70	40	30	20	-0.08	0.7985	43	50	64	7	57	71	86	64	64	57	71	43	0.30	0.3419	44	31	38	31	75	50	56	25	44	19	-0.18	0.6250
34	Galium album	30	30	50	40	50	40	20	30	10	20	40	30	-0.35	0.2714	36	43	57	57	43	43	50	50	43	21	50	36	-0.21	0.5150	25	38	50	56	50	56	44	56	56	50	0.54	0.1034
32	Helictotrichon pubescens	20	10	10	10	10	40	20	10	.	10	10	.	-0.48	0.1128	7	29	64	36	14	43	21	21	36	14	50	21	0.06	0.8614	**6**	**13**	**13**	**13**	**13**	**19**	**13**	**13**	**31**	**25**	**0.78**	**0.0080**
29	Hypochaeris radicata	20	10	10	30	10	10	.	20	10	.	.	.	-0.66	0.0188	14	21	50	36	36	21	.	29	7	7	21	14	-0.41	0.1807	25	44	81	88	81	69	75	56	56	31	-0.07	0.8408
23	Plantago lanceolata	10	10	10	10	.	.	.	.	.	.	.	.	-0.82	0.0011	7	7	7	7	7	7	7	7	7	7	14	7	0.39	0.2063	**.**	**6**	**.**	**6**	**.**	**6**	**6**	**6**	**13**	**13**	**0.76**	**0.0102**
22	Dactylis glomerata	.	.	20	.	.	.	.	.	10	.	10	.	0.13	0.6897	14	14	21	14	7	7	.	.	7	7	7	.	-0.74	0.0056	**6**	**13**	**13**	**13**	**6**	**6**	**13**	**25**	**38**	**31**	**0.68**	**0.0312**
20	Taraxacum sect. Ruderalia	.	.	.	.	.	.	.	10	.	.	.	10	0.45	0.1388	.	7	7	21	.	7	.	21	14	.	7	7	0.12	0.7052	19	31	38	63	44	38	44	19	13	25	-0.25	0.4846
21	Arrhenatherum elatius	10	10	20	20	.	.	.	10	.	.	.	.	-0.69	0.0130	7	.	14	21	7	14	7	.	.	.	.	.	-0.59	0.0426	25	19	38	19	31	31	25	25	31	25	0.17	0.6354
3	Prunella vulgaris	.	.	.	.	.	.	.	.	.	.	.	.			.	14	14	.	.	.	.	7	.	.	.	.	-0.41	0.1860	.	.	.	.	.	.	.	.	.	.		
1	Festuca pratensis s.l.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	7	.	.	.	.	.	.	.	.	.	-0.31	0.3339	.	.	.	.	.	.	.	.	.	.		
1	Stellaria graminea	.	.	.	.	.	.	.	.	.	.	.	.			.	7	.	.	.	.	.	.	.	.	.	.	-0.39	0.2063	.	.	.	.	.	.	.	.	.	.		
9	**Stellarietea species**																																								
34	Conyza canadensis	60	70	80	30	60	90	90	100	70	90	90	70	0.48	0.1131	64	86	86	57	79	86	79	71	86	71	86	71	0.05	0.8743	50	44	50	44	81	75	50	44	50	38	-0.21	0.5621
33	Bromus tectorum	70	70	60	80	90	70	40	50	30	10	10	.	-0.83	0.0009	50	64	100	86	93	93	57	50	50	36	50	14	-0.66	0.0205	38	31	56	56	50	56	56	31	31	19	-0.39	0.2700
31	Sisymbrium altissimum	20	.	10	.	80	70	40	70	30	40	60	10	0.33	0.2933	29	.	50	29	100	57	57	50	36	64	79	43	0.47	0.1254	13	6	13	6	44	31	6	6	6	13	-0.14	0.7045
29	Veronica arvensis	20	10	10	.	10	10	.	.	.	20	10	.	-0.34	0.2853	29	64	86	57	86	79	71	36	57	79	79	21	-0.10	0.7513	88	94	88	63	94	100	75	31	75	94	-0.15	0.6703
29	Bromus hordeaceus	40	20	.	20	30	10	10	20	20	.	.	.	-0.60	0.0379	43	29	79	79	86	64	57	36	36	21	36	.	-0.55	0.0617	75	81	81	81	94	88	94	94	75	75	0.06	0.8765
26	Arabidopsis thaliana	10	10	10	.	40	20	.	.	.	10	.	.	-0.51	0.0928	21	7	57	14	71	21	14	.	14	43	29	.	-0.19	0.5600	31	31	44	25	88	69	19	13	50	25	-0.22	0.5423
25	Vicia hirsuta	20	10	10	10	10	.	.	.	.	.	.	.	-0.88	0.0002	14	7	21	14	7	14	7	14	7	7	.	.	-0.67	0.0163	50	44	56	63	69	75	56	50	44	44	-0.22	0.5371
24	Setaria viridis	30	20	30	20	20	20	30	20	20	40	50	80	0.49	0.1066	14	14	7	14	14	14	21	21	14	7	14	29	0.33	0.2965	.	.	.	.	.	.	.	.	.	.		
24	Psyllium arenarium	40	30	50	40	40	40	30	40	40	40	40	40	0.04	0.8983	.	7	14	7	7	14	14	29	14	14	14	7	0.47	0.1245	.	.	.	.	.	.	.	.	.	6	0.52	0.1215
23	Salsola kali subsp. tragus	**20**	**20**	**20**	**10**	**20**	**10**	**20**	**40**	**20**	**30**	**60**	**40**	**0.66**	**0.0187**	**7**	**7**	**.**	**7**	**14**	**14**	**29**	**14**	**36**	**7**	**36**	**36**	**0.75**	**0.0052**	.	.	.	.	.	.	.	.	.	.		
21	Bromus sterilis	.	.	.	.	.	.	10	.	.	.	.	.	0.04	0.8928	7	29	43	36	43	21	14	14	14	14	.	.	-0.60	0.0377	50	44	63	63	69	44	44	56	50	31	-0.33	0.3465
21	Vicia villosa s.l.	.	.	.	10	10	.	.	.	.	.	.	.	-0.26	0.4161	7	7	29	7	7	14	7	14	7	.	.	.	-0.57	0.0515	63	63	75	63	75	75	50	63	44	56	-0.52	0.1238
20	Senecio vernalis	10	.	10	10	30	.	10	10	.	10	.	.	-0.36	0.2478	7	7	29	14	36	7	.	.	.	.	.	.	-0.77	0.0033	6	13	19	6	25	19	.	.	.	6	-0.49	0.1542
19	Fallopia convolvulus	**.**	**.**	**10**	**.**	**40**	**20**	**30**	**30**	**20**	**30**	**30**	**20**	**0.60**	**0.0393**	7	7	.	.	.	.	7	.	7	7	36	14	0.51	0.0939	6	.	.	.	.	.	.	6	.	6	0.19	0.5992
19	Papaver dubium s.l.	.	.	.	.	20	.	.	.	.	.	.	.	-0.13	0.6848	14	7	21	29	57	7	21	.	7	7	29	.	-0.33	0.2960	13	6	6	.	31	19	6	13	6	.	-0.20	0.5891
18	Crepis tectorum	20	.	.	20	20	10	30	20	.	.	.	.	-0.35	0.2697	7	.	7	7	7	14	.	.	.	7	14	7	0.12	0.7053	13	6	13	.	.	6	.	.	.	.	-0.74	0.0138
17	Apera spica-venti	10	.	.	.	.	.	.	.	.	.	.	.	-0.48	0.1139	29	14	29	.	14	21	21	7	7	.	7	.	-0.66	0.0187	50	19	6	.	19	6	13	6	.	.	-0.66	0.0376
16	Anchusa arvensis	.	.	.	.	20	10	.	.	.	.	.	.	-0.13	0.6771	7	14	7	7	21	.	.	.	7	.	.	.	-0.70	0.0118	.	6	6	6	38	.	19	6	6	19	0.42	0.2230
16	Chenopodium album agg.	**.**	**.**	**.**	**10**	**20**	**.**	**10**	**30**	**.**	**20**	**30**	**60**	**0.72**	**0.0085**	**.**	**14**	**.**	**.**	**.**	**.**	**21**	**7**	**7**	**7**	**21**	**64**	**0.66**	**0.0198**	.	.	.	.	.	13	.	.	6	.	0.32	0.3673
16	Viola arvensis	.	.	.	.	.	.	.	.	.	.	.	.			.	.	7	7	7	.	7	14	14	7	21	.	0.44	0.1555	.	.	13	6	19	25	19	13	6	6	0.34	0.3355
9	Corispermum leptopterum	10	10	.	10	10	10	10	.	10	.	10	20	0.14	0.6673	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
9	Papaver rhoeas	.	.	.	.	40	10	.	.	.	.	.	.	-0.13	0.6771	.	.	7	.	7	.	.	.	.	.	.	.	-0.32	0.3044	13	.	.	6	6	.	6	13	.	.	-0.20	0.5847
7	Amaranthus sp. seedling	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**20**	**10**	**10**	**10**	**.**	**0.58**	**0.0481**	.	.	.	.	.	.	.	14	7	.	.	7	0.50	0.0965	.	.	.	.	.	.	.	.	.	.		
7	Solanum nigrum	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**20**	**10**	**20**	**20**	**50**	**0.87**	**0.0002**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**14**	**.**	**7**	**36**	**0.70**	**0.0117**	.	.	.	.	.	.	.	.	.	.		
6	Capsella bursa-pastoris	10	.	.	.	10	.	.	.	.	.	.	.	-0.45	0.1388	.	.	.	.	14	.	.	7	7	7	.	.	0.25	0.4292	.	.	.	.	.	.	.	.	.	.		
6	Lactuca serriola	.	.	.	.	.	.	.	.	.	.	.	.			21	7	7	.	.	.	.	.	.	.	.	.	-0.76	0.0042	19	13	6	.	.	.	.	.	.	.	-0.81	0.0043
3	Polygonum aviculare agg.	.	.	10	.	.	.	10	.	.	10	.	.	0.03	0.9315	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
2	Amaranthus retroflexus	.	.	.	.	.	.	.	.	.	.	.	30	0.48	0.1139	.	.	.	.	.	.	.	.	.	.	.	14	0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
2	Cardamine hirsuta	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	6	.	.	.	6	.	0.26	0.4662
2	Lamium purpureum	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	6	.	.	.	6	.	0.26	0.4662
2	Sonchus oleraceus	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	6	.	6	.	.	.	.	.	-0.26	0.4662
1	Lamium amplexicaule	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			6	.	.	.	.	.	.	.	.	.	-0.52	0.1215
1	Papaver argemone	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			6	.	.	.	.	.	.	.	.	.	-0.52	0.1215
1	Stellaria media	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	7	.	0.39	0.2063	.	.	.	.	.	.	.	.	.	.		
10	**Other species**																																								
32	Agrostis capillaris	10	20	20	10	10	10	10	10	10	.	10	.	-0.71	0.0096	57	57	50	29	29	21	21	14	14	14	36	14	-0.77	0.0037	56	56	63	56	56	56	63	50	56	56	-0.22	0.5466
34	Verbascum phlomoides	90	100	100	70	80	70	80	90	100	100	90	80	-0.03	0.9288	86	93	86	86	93	86	86	93	86	86	86	93	0.05	0.8744	56	63	88	69	81	88	69	75	69	44	-0.04	0.9193
34	Hypericum perforatum	30	60	60	50	60	60	50	60	60	60	70	60	0.55	0.0636	50	50	36	29	36	50	50	29	36	21	50	57	0.04	0.9101	63	69	69	63	56	75	75	44	56	56	-0.42	0.2255
34	Potentilla tabernaemontani	10	20	20	30	20	30	30	30	20	30	30	20	0.43	0.1652	50	43	43	50	43	43	50	50	50	36	36	43	-0.34	0.2739	13	13	13	31	13	13	13	19	13	19	0.34	0.3408
34	Rumex thyrsiflorus	40	50	30	50	40	30	30	50	40	20	40	20	-0.44	0.1508	14	43	64	57	50	43	57	43	43	43	50	43	-0.05	0.8714	44	88	81	94	88	88	88	94	88	88	0.45	0.1893
33	Geranium molle	40	10	20	10	40	.	30	50	30	20	30	20	0.10	0.7580	**29**	**21**	**64**	**79**	**71**	**36**	**71**	**86**	**86**	**79**	**71**	**93**	**0.75**	**0.0047**	44	38	75	94	94	94	69	94	94	88	0.52	0.1203
32	Agrimonia procera	**30**	**20**	**20**	**30**	**30**	**30**	**40**	**40**	**30**	**30**	**30**	**40**	**0.58**	**0.0483**	7	7	7	21	7	.	14	7	.	7	14	21	0.23	0.4814	**6**	**13**	**25**	**31**	**25**	**19**	**31**	**25**	**38**	**31**	**0.73**	**0.0172**
31	Asparagus officinalis	90	50	70	50	20	50	20	30	30	20	10	.	-0.86	0.0003	64	71	71	50	57	43	14	21	21	.	7	.	-0.93	0.0000	44	38	38	50	44	38	44	25	31	25	-0.62	0.0574
31	Carex spicata	20	10	10	10	10	20	20	20	20	.	.	10	-0.27	0.3993	7	7	7	7	7	7	7	7	7	7	7	7			6	.	6	6	6	6	6	6	6	6	0.41	0.2441
29	Festuca ovina agg. (ohne duv.)	30	20	30	30	20	10	20	20	.	.	.	10	-0.82	0.0012	36	50	57	36	29	36	43	29	36	.	7	36	-0.56	0.0566	19	25	25	19	25	25	31	13	19	.	-0.39	0.2700
28	Senecio jacobaea	20	10	20	.	20	.	10	10	.	.	.	.	-0.68	0.0144	36	57	57	64	71	29	36	21	29	43	29	14	-0.65	0.0231	56	75	75	81	56	81	63	63	44	50	-0.46	0.1808
25	Arabis glabra	10	.	.	20	20	10	10	.	.	.	.	.	-0.45	0.1388	7	.	14	14	21	29	7	7	.	7	7	7	-0.21	0.5204	6	13	13	13	19	44	13	6	6	25	0.15	0.6879
24	Luzula campestris	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**10**	**10**	**10**	**0.75**	**0.0047**	**7**	**7**	**7**	**7**	**7**	**.**	**7**	**21**	**14**	**14**	**14**	**14**	**0.71**	**0.0099**	**6**	**31**	**31**	**31**	**31**	**31**	**38**	**50**	**56**	**50**	**0.91**	**0.0002**
23	Taraxacum sect. Erythrosperma	.	.	10	10	.	.	.	10	.	.	.	.	-0.25	0.4316	.	7	21	36	71	57	29	36	50	21	14	14	0.12	0.7114	6	6	19	44	25	19	13	.	19	6	-0.12	0.7453
22	Securigera varia	.	.	.	.	.	.	.	.	.	.	.	.			14	14	14	14	14	14	21	14	14	14	21	14	0.32	0.3044	**6**	**6**	**6**	**6**	**6**	**13**	**6**	**13**	**13**	**25**	**0.81**	**0.0044**
21	Vicia angustifolia	.	.	.	.	.	.	.	.	.	.	.	.			7	14	21	21	14	14	14	21	14	14	14	.	-0.22	0.4915	56	69	88	75	69	69	63	63	75	69	0.04	0.9175
20	Campanula rapunculus	.	.	.	.	10	.	.	.	.	.	.	.	-0.13	0.6848	21	21	21	29	29	29	29	14	.	.	7	.	-0.64	0.0263	38	25	31	25	44	50	38	13	31	25	-0.19	0.5963
16	Thymus pulegioides s.str.	.	.	.	.	.	.	.	.	.	.	.	.			21	21	21	29	21	14	14	14	14	7	7	14	-0.84	0.0007	6	6	6	6	.	.	.	.	.	.	-0.85	0.0017
16	Festuca brevipila	.	.	.	.	.	.	.	.	.	.	.	.			7	7	7	7	7	7	7	7	7	.	.	.	-0.75	0.0047	6	6	6	6	6	6	6	.	.	.	-0.80	0.0057
14	Festuca rubra	.	.	.	.	.	.	.	.	.	.	.	.			.	.	71	7	7	.	.	14	14	21	21	.	0.27	0.4030	6	6	25	13	13	.	6	13	.	.	-0.46	0.1816
10	Vincetoxicum hirundinaria	.	.	.	.	.	.	.	.	.	.	.	.			**.**	**.**	**.**	**.**	**.**	**.**	**7**	**.**	**7**	**7**	**7**	**7**	**0.81**	**0.0015**	.	.	.	6	6	.	.	6	6	6	0.59	0.0715
8	Silene vulgaris s.l.	.	.	.	.	.	.	.	.	.	.	.	.			7	.	7	7	7	7	.	.	.	7	7	7	0.00	1.0000	.	.	.	.	.	.	.	.	.	.		
4	Poa trivialis s.l.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			13	25	19	6	.	.	.	.	.	.	-0.85	0.0020
4	Rumex obtusifolius	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			13	.	6	13	.	13	.	.	.	.	-0.54	0.1064
3	Fragaria vesca cultivar	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	6	6	6	.	.	.	.	-0.11	0.7539
2	Dryopteris carthusiana	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			6	6	.	.	.	.	.	.	.	.	-0.70	0.0253
2	Peplis portula	.	.	.	.	.	.	.	.	.	.	.	10	0.48	0.1139	.	.	.	.	.	.	.	.	.	.	.	7	0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
1	Geranium sibiricum adv.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	7	0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
1	Astragalus glycyphyllos	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	6	.	.	.	.	.	.	.	.	-0.41	0.2441
11	**Lichens**																																								
30	Cladonia furcata s.l.	50	50	50	50	60	70	60	30	40	40	40	30	-0.60	0.0373	21	21	36	43	43	43	29	29	29	29	21	14	-0.29	0.3623	6	.	.	6	6	.	6	6	6	.	0.07	0.8453
23	Cladonia rangiformis	30	30	50	50	50	40	40	40	40	40	40	40	0.06	0.8552	7	7	7	.	.	.	7	7	7	7	14	14	0.53	0.0749	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**6**	**6**	**0.70**	**0.0253**
19	Peltigera rufescens	30	.	30	20	10	.	10	10	.	.	.	.	-0.65	0.0226	.	7	.	14	7	7	.	.	.	.	.	.	-0.46	0.1343	13	13	13	19	6	13	13	6	13	.	-0.52	0.1226
6	Cetraria aculeata	10	20	10	10	10	10	.	.	.	.	.	.	-0.88	0.0002	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
12	**Bryophytes**																																								
34	Brachythecium albicans	10	10	10	10	10	10	10	10	10	10	10	10			21	21	29	36	36	43	36	36	36	36	29	21	0.18	0.5817	38	44	75	81	81	69	75	69	69	69	0.14	0.6899
34	Hypnum lacunosum	90	80	90	90	90	90	90	90	90	90	90	90	0.39	0.2063	100	100	100	100	100	100	100	100	100	93	100	100	-0.31	0.3339	**31**	**38**	**56**	**50**	**56**	**56**	**56**	**56**	**56**	**56**	**0.75**	**0.0119**
34	Tortula ruraliformis	30	20	40	40	20	20	30	40	50	30	20	20	-0.11	0.7326	29	21	21	57	57	36	36	43	64	36	36	36	0.39	0.2063	13	13	6	25	44	38	19	13	13	6	-0.10	0.7826
18	Thuidium abietinum	.	.	.	10	10	.	.	.	10	.	.	.	-0.08	0.7961	.	.	.	.	14	7	14	21	.	.	14	21	0.55	0.0615	13	19	13	13	.	6	6	13	6	6	-0.59	0.0736
17	akrok. Kleinmoose	.	.	.	.	.	.	.	.	.	.	.	.			.	.	7	7	7	7	14	7	7	7	.	.	0.02	0.9608	6	6	13	19	31	25	13	13	13	.	-0.01	0.9863
12	Brachythecium rutabulum	.	.	.	.	.	.	.	.	.	.	.	.			.	7	7	.	.	.	.	.	.	.	.	.	-0.52	0.0844	13	13	13	13	13	13	13	13	13	13		
6	Tortella inclinata	.	.	.	.	10	.	.	.	.	.	.	.	-0.13	0.6848	.	.	.	.	7	.	7	.	14	.	.	.	0.11	0.7325	.	.	.	13	6	.	.	.	.	.	-0.18	0.6155
3	Mnium spec.	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	13	13	.	6	.	.	.	.	-0.30	0.4003
3	Scleropodium purum	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			13	13	6	.	.	.	.	.	.	.	-0.81	0.0046
2	Abietinella abietina	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	7	14	.	0.52	0.0821	.	.	.	.	.	.	.	.	.	.		
2	Bryum argenteum	.	.	.	.	.	.	.	.	.	.	.	10	0.48	0.1139	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	6	.	.	.	.	.	.	-0.17	0.6305
1	Bryum spec.	.	.	.	.	.	.	.	.	.	.	.	.			7	.	.	.	.	.	.	.	.	.	.	.	-0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
1	Polytrichum formosum	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	6	.	.	.	.	.	.	-0.17	0.6305
1	Rhytidium rugosum	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	7	.	0.39	0.2063	.	.	.	.	.	.	.	.	.	.		
13	**Woody species (diff. developm. stages)**																																								
33	Prunus spinosa	30	30	30	20	30	20	20	30	30	30	30	20	-0.15	0.6336	21	21	21	21	21	29	29	21	29	21	21	21	0.14	0.6657	6	6	19	13	13	13	6	13	13	.	-0.11	0.7592
33	Quercus robur	10	20	20	20	10	10	10	20	20	20	20	10	0.07	0.8205	14	21	21	21	14	14	21	14	14	14	29	7	-0.27	0.3952	25	25	31	31	19	.	6	19	25	13	-0.54	0.1094
26	Rosa canina s.l.	20	10	10	10	20	20	20	20	30	20	10	.	-0.02	0.9532	.	7	7	7	.	7	7	.	.	.	7	7	-0.02	0.9398	6	6	6	13	6	6	.	.	6	6	-0.36	0.3075
22	Crataegus monogyna	.	.	.	.	.	.	.	.	.	.	.	.			29	36	36	29	29	29	21	21	21	7	21	14	-0.89	0.0001	13	6	13	13	6	13	13	13	13	6	-0.04	0.9170
20	Euonymus europaea	.	.	.	.	.	.	.	.	.	.	.	.			14	14	21	14	14	14	21	14	14	14	21	21	0.36	0.2525	6	.	6	.	13	6	13	6	6	6	0.33	0.3513
16	Rosa spinosissima	**.**	**.**	**.**	**.**	**.**	**10**	**.**	**10**	**10**	**10**	**.**	**10**	**0.61**	**0.0344**	.	7	7	7	7	7	7	7	7	7	7	7	0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
14	Prunus serotina	.	10	.	.	.	.	10	.	.	.	.	10	0.08	0.7961	7	.	.	.	.	.	.	.	.	.	.	7	0.00	1.0000	25	.	6	6	6	13	6	6	6	6	-0.10	0.7899
12	Pinus sylvestris	10	10	10	10	10	10	10	10	10	10	10	10			7	7	7	.	.	.	.	.	.	.	.	.	-0.75	0.0047	.	.	.	.	.	.	.	.	.	.		
12	Populus canadensis	.	.	.	.	.	.	.	.	.	.	.	.			7	7	7	7	7	7	7	7	7	7	7	7			.	.	.	.	.	.	.	.	.	.		
11	Ligustrum vulgare	.	.	.	.	.	.	.	.	.	.	.	.			7	7	7	7	7	7	7	7	7	7	7	.	-0.48	0.1139	.	.	.	.	.	.	.	.	.	.		
10	Acer pseudoplatanus	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			13	13	6	13	13	13	13	6	6	6	-0.57	0.0864
10	Clematis vitalba	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			13	13	13	13	13	13	13	13	13	13		
9	Ulmus minor	.	.	.	.	.	.	.	.	.	.	.	.			**.**	**.**	**.**	**7**	**7**	**7**	**7**	**14**	**14**	**14**	**14**	**7**	**0.80**	**0.0016**	.	.	.	.	.	.	.	.	.	.		
2	Prunus avium	.	.	.	.	.	.	.	.	.	.	.	.			.	7	7	.	.	.	.	.	.	.	.	.	-0.52	0.0844	.	.	.	.	.	.	.	.	.	.		
2	Rosa spec.	.	.	.	10	.	.	.	.	.	.	.	10	0.19	0.5451	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.		
1	Rhamnus catharticus	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	7	.	.	.	.	.	.	.	.	-0.22	0.4954	.	.	.	.	.	.	.	.	.	.		
1	Cornus sanguinea	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	7	.	.	.	0.22	0.4954	.	.	.	.	.	.	.	.	.	.		
1	Robinia pseudoacacia	.	.	.	.	.	.	.	.	.	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.			6	.	.	.	.	.	.	.	.	.	-0.52	0.1215