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Regeneration of a natural dry grassland in Central Europe after abandonment of agricultural use

Verfasser

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Pict 1 View over shooting range Großmittel

Pict 2 Feather grass (*Stipa eriocaulis*) in bloom

Pict 3 Round-headed leek (*Allium sphaerocephalon*)

Pict 4 Spiked speedwell (*Veronica spicata*)

Pict 5 Sprawling needle sunrose (*Fumana procumbens*)

Pict 6 Sheep and goat grazing prevents expansion of shrubs in dry grassland

Pict 7 The litter of upright brome (*Bromus erectus*) poses a severe problem especially for chamaephytes

Preface

The present diploma thesis arose from the desire to explore the vegetation of the Steinfeld intensively. Born in Wiener Neustadt familiar with the landscape since earliest childhood, it greatly surprised me to discover that this area has a considerable and endangered flora. It serves as a refuge for animals such as the European ground squirrel (*Spermophilus citellus*), which has one of its biggest Austrian populations in the Steinfeld or the snail *Helicopsis striata austriaca*, a subspecies endemic to the southeast of Lower Austria (Bieringer 2001), threatened with extinction (Frank and Reischütz 1994) and therefore listed as priority taxon in the Annex II of the EU Habitats Directive (Council of the European Union (1992)). A botanical field trip into the Steinfeld during my studies, in which Norbert Sauberer also took part, whose doctoral thesis deals with the vegetation of the Steinfeld and whose knowledge of it is formidable, made me take the decision to write about the dry grasslands of this region.

Regrettably, only very few people are aware of the nature conservation value of the Steinfeld. Most associate worthless, bleak badlands with it, only good to be used as airfield or military training ground. Even local authorities do not have any clue or interest. Much worse, they try to sell as many dry grassland areas as possible as commercial lands or building plots to improve their financial situation. Moreover, the construction of bypasses to ease the traffic situation in the surrounding municipalities results in further loss of steppe. Those zones in possession of the Austrian Armed Forces are protected against human destruction most effectively. Even access to the restricted areas without prior permission is prohibited, thus any building activity excluded. However, in times of increasing economic pressure budget cuts hit the military as well, many barracks were closed, facilities and areas sold. This affected the district Wiener Neustadt-Land too. Luckily, the biggest part of the steppic zone in the northern Steinfeld is protected by having been declared as habitat after Annex I of the EU Habitats Directive (Council of the European Union (1992)).

Fortunately, many areas used agriculturally in the past have been abandoned and natural succession started afterwards. It is here I intend to come in with this work. It aims at shedding light on the prospects of success, thus clarifying, whether ploughed areas can be brought to the original condition again. Because, for nature conservation the question finally is, are such areas lost for centuries or maybe forever, or does succession provide a chance for native plants to establish once again?

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Manuscript

Abstract

The northern part of the Wiener Neustädter Steinfeld contains the largest natural steppe area of Central Europe. Its primary character makes it very distinctive; it developed postglacially without any human involvement. Sadly, anthropogenic interferences within the last 250 years irrecoverably destroyed huge parts of this unique landscape or changed it dramatically. On the other hand, many agricultural fields have been set aside during the last century, enabling dry grassland plants to return. This work examined to what extent those secondary parts differ from the primary, never ploughed ones. For that matter 200 vegetation plots were surveyed. First, primary, never ploughed areas were distinguished from secondary, formerly agriculturally used ones, and secondary, it was of importance, whether the plots were situated in relatively small, isolated dry grassland parts or in the vast zone of the steppe. Furthermore, for secondary areas the age class was noted, possible grazing and alteration by fire was considered and age of the latter assessed. In a first step, relevés were aggregated into 10 groups based on detrended correspondence analysis (DCA) and nonmetric multidimensional scaling (NMDS). Afterwards, those groups were investigated for statistically significant differences using comparisons of indicator values, α- and β-diversity, as well as generalized linear models (GLM) for six characteristic Steinfeld species in order to reveal differences in their probability of occurrence in those groups in relation to the reference group containing plots in the unaltered vast steppe area. The analysis of indicator values displayed considerable differences between young secondary plots on the one hand and old secondary or primary plots on the other; among the latter, no such difference existed. Likewise, GLM and β-diversity, in a limited way α-diversity too, showed the same pattern. Based on those findings a positive progress of secondary succession from former agricultural fields back to dry grassland can be inferred. The time necessary for such succession could not be defined as there were not enough areas of different age for performing such an analysis. As it turned out during the samplings, a much bigger threat to the steppe emanates from the increasing abundance of the grass species *Bromus erectus*, which benefits from enhanced anthropogenic airborne nitrogen depositions, thus suppressing light-demanding plants. Grazing appears by far the most effective management measure for suppressing this species. Fires, which episodically occur during summers, can

have rather negative impacts on endangered animals and plants such as *Fumana procumbens* or *Helianthemum canum*. In contrast, winter fires do not have such severe consequences and help in removing accumulated litter. In the military training area, in which grazing is impossible at the moment, this is the only method of preventing further spread and population growth of *Bromus erectus*.

Keywords

Austria · Bromus erectus · Central Europe · Natural dry grassland · Restoration · Secondary succession · Vienna Basin

Abbreviations:

P	Primary	S	Secondary	V	Vast	I	Isolated
yb	young burn	ob	old burn	s	sheep grazed	c	cattle grazed
r	ruderalized	58	1958	74	1974	91	1991
00	2000	04	2004	08	2008	09	2009

Introduction

The Vienna Basin, named after the Austrian capital, is located in the very west of the Pontic-Pannonic-South Siberian floral region, at the junction of the Alps and the Carpathians. The southernmost part of this basin is known under the name Steinfeld (German for "stone field"), an almost totally plane landscape whose name derived from its stony soil. These limestone and dolomite deposits were amassed by rivers, primarily Schwarza and Piesting, during the last two glacial periods, now covering the tertiary sediments in the area. The climate clearly shows continental features, annual precipitation in the central Steinfeld is below 600 mm. Despite maximum precipitation in June, summer is partly semi-arid. Although precipitation is too high for allowing development of a climatic steppe, the dry, stony soils of the area fostered the establishment of edaphic dry grasslands of Central European type. Such natural regions are very rare in Europe, particularly in Central Europe and therefore listed in Annex I of the EU Habitats Directive (Council of the European Union 1992) as priority habitat type, originally under number 6240 Sub-pannonic steppic grasslands. With the 2004 enlargement of the European Union and the accession of Bulgaria and Romania in 2007, a new habitat type was added to the list of habitat types to be protected across Europe, which is phytosociologically identical to the dry grasslands in the Steinfeld; it is habitat type 6190 Rupicolous pannonic grasslands (Stipo-Festucetalia pallentis).

Following the Interpretation Manual of European Union Habitats (European Commission, Directorate-General for the Environment 2007), the dry grasslands of the Steinfeld now – given the vegetation types and the floristic composition – have to be included in this habitat type.

Hence, the dry grasslands of the Steinfeld, developed on gravel, represent a very rare vegetation type and are of outstanding importance for conservation. Additionally, the bigger part of the dry grasslands of Central Europe is of secondary origin, whereas in the Steinfeld no human involvement was necessary for developing this vegetation type. A striking feature is the vast extent of the steppe vegetation of the Steinfeld. This largest continuous dry grassland of Austria comprises more than 50 % of the estimated total area of 40 km² of all existing sub-pannonic steppe grasslands in Austria (Ellmauer and Essl 2005). Until 250 years ago this natural landscape extended across the bigger part of the Steinfeld, when enormous interventions in the course of economic and technical turnovers took place. While the southern part of the Steinfeld had already been changed irrecoverably by large afforestations of black pine in the 15th century (Sauberer 2001), the north was luckily prevented from sharing this fate, only being used agriculturally or as pasture. It still has a huge steppe zone, which is primarily used as a military training area. Since many agricultural fields in this part were abandoned in the past and left to succession, it is suitable for comparing primary and secondary dry grasslands in order to verify whether former disturbances have led to relevant changes in structure and composition of the vegetation. In doing so, it can be analyzed, if there are nontransient losses of conservation value.

Materials and Methods

Study area

Situated in Lower Austria, the plain of the Wiener Neustädter Steinfeld comprises the southernmost part of the Vienna Basin. It is one of the westernmost areas of the Pannonian floristic province. This research is focused on the northern part of the Steinfeld, north of the city of Wiener Neustadt. The entire digitized territory has a geographical size of approximately 43 km², the survey area in the narrow sense, that is, without pine plantations and inaccessible military zones, spreads across almost 12 km² and lies within a military training area for the most part. The so-defined region spans an elevation from 220 m above Adriatic Sea in the east to 272 m in the west. From a geological point of view, the Vienna Basin is a tectonic basin between the Alps and the Carpathians filled with tertiary sediments, which in the area of the Steinfeld had been overlaid with limestone and dolomite gravel during the glacial periods of Riß and Würm, transported by rivers from the foothills of the Alps (Küpper 1962). The dominating soil type is Rendzina (Bieringer and Sauberer 2001a); its water capacity is very low, pH ranges from 7–8. The percentage of organic matter in the topsoil is high with an average of 9 % as the decomposition rate of the soil is very low; mull is the humus form (Soltani-Taba 1970).

The climate of the Steinfeld is characterized as Central European with continental influence. The mean annual temperature in Wiener Neustadt is 9.4 °C with January being the coldest month with an average temperature of −0.8 °C and July the hottest with 19.7 °C. Mean annual precipitation amounts to 599 mm with a maximum of 81.9 mm in June and a minimum of 25.3 and 25.5 mm in January and February (data for the period of 1971–2000: Zentralanstalt für Meteorologie und Geodynamik, Vienna). However, Bieringer and Sauberer (2001a) additionally refer to Hann (1904), whereupon at the end of the 19th century an annual precipitation of only 523 mm was reported in an observation period of seven years at a weather station in Theresienfeld, which is closer to the study site. Since the measuring point in Wiener Neustadt is not located in the central Steinfeld anymore, these measurements are probably more representative for the study area, despite being a little older. Bieringer and Sauberer (2001a) conclude from comparing the monthly precipitation means with the evaporation values, that the central northern Steinfeld has semi-arid conditions; from March to September water balance is negative. On top of this come frequent, gusty down-slope winds from the framing mountains in the west and dry east winds. The frequent storms result in erosion of the shallow soils and aggravate the dryness (Soltani-Taba 1970).

In combination with climate conditions the low water retention capacity of the gravelly soils and their nutrient deficiency have given rise to the formation of the largest continuous dry grassland of Austria. It is fairly certain that the northern part of the Steinfeld is a woodless zone by nature (Sauberer and Bieringer 2001). However, anthropogenic activities within the last 250 years have changed large parts of this until then almost totally preserved natural landscape. Above all, agricultural use depleted the share of untouched steppe albeit huge afforestations of black pine (*Pinus nigra*) and exploitation of gravel also contributed to its destruction (Bieringer and

Grinschgl 2001). At least in its unchanged zones, the originally much larger steppe landscape phytosociologically belongs to the association of the Fumano-Stipetum eriocaulis Wagner 1941 corr. Zólyomi 1966 (Mucina and Kolbek 1993; Buchner 1976; Sauberer and Buchner 2001). In the northeast of the military zone

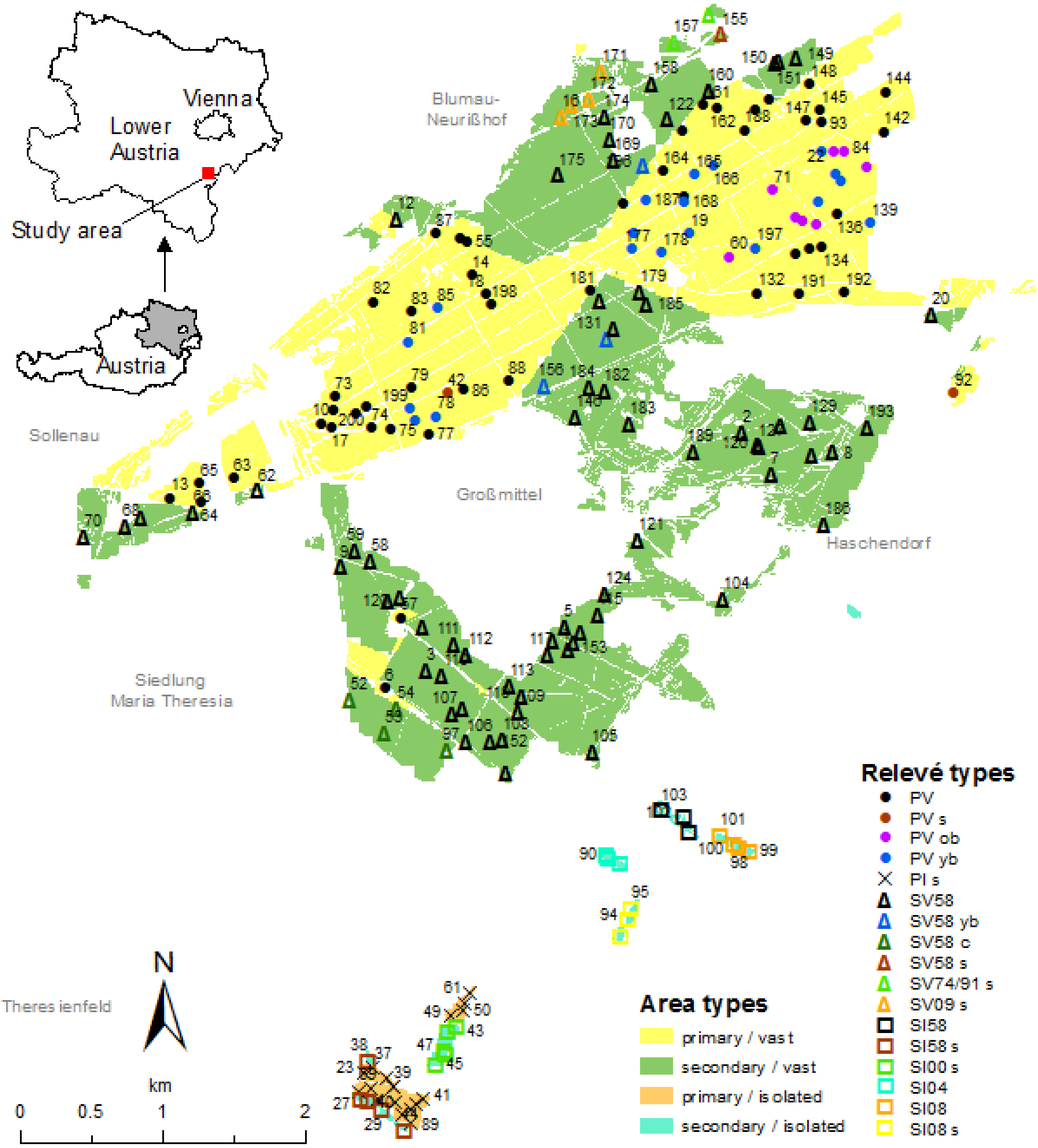


Fig. 1 Map of study area with sample plots

slightly deeper soils are found, which results in a vegetation somewhat different from the typical floristic composition. Buchner (1976) and Buchner and Sauberer (2001) respectively, refer to this variety of the Fumano-Stipetum as Inula-Jurinea-variant, because here *Jurinea mollis*, *Inula ensifolia* and especially *Inula hirta* are prominent elements of the vegetation. In order not to distort data and outcomes and for the sake of clarity, this part was excluded from the study.

Data collection

For identification of dry grasslands in the study area historical maps of the Franzisco-Josephinian land survey (Franzisco-Josephinische Landesaufnahme) from 1873, aerial photographs from 1958, 1974, 1991 and orthophotos from 2004 from the Federal Office of Metrology and Surveying (Bundesamt für Eich- und Vermessungswesen) were used, as well as Google Earth satellite pictures from 2010 and 2011 for controlling the latest developments. Those images were digitized and intersected, using ArcGIS, version 10 (ESRI 2011). Thus, it was possible to differentiate between primary, unaltered, and secondary dry grasslands and between small, isolated, and large, continuous ones respectively. Originally, it was intended to partition the secondary areas further into different age classes and to subsequently sample them separately. However, it turned out the changes between the years 1958, 1974, 1991, and 2004 were only marginal while alterations between 1873 and 1958 were considerable. Therefore, the secondary areas were pooled, regardless of their age. Age classes had not been taken into consideration until conducting statistical analysis.

In the next step, an orthogonal raster with a mesh size of 5 m was put over the digitized maps. Fragmentary cells, whose size were smaller than 25 m² and cells that were not exclusively covered with dry grassland of only one type, were eliminated. An orthogonal grid with a mesh size of 100 m was put over the remaining areas. In the case of the continuous steppe, grid cells with dry grassland covering less than one third were excluded; the same was true for the isolated dry grassland area when the cover in a cell was less then one fourth.

The subsequent random selection of sample sites was tied to the condition not to choose more than one 5 m plot per 100 m raster cell in order to prevent spatial clustering. For every 100 m raster cell of isolated dry grasslands one sample site was chosen by random selection, but the continuous steppe area was simply too large for this sampling design. Because of this, the number of sample sites to be chosen for the vast zone was divided up equally by primary and secondary areas, and under inclusion of the number of plots in the isolated parts the remaining sample sites were selected randomly, adding up to a total of 200 quadratic plots, each one sized 25 m².

The random selection was conducted using freeware Hawth's Analysis Tools, version 3.27 (Beyer 2007).

The vegetation sampling was carried out from 1 June to 28 July 2011 and from 28 May to 26 July 2012. The plots were located using a GPS device. In the field, I realized that the vegetation at some sites within the continuous zone had been completely destroyed by fire shortly before due to military training activity. Such plots were replaced with previously determined substitutes. The vegetation was recorded using a modified Braun-Blanquet scale: level 2 was divided into sublevels 2a (5–15 % cover) and 2b (15–25 % cover). Nomenclature of plant taxa follows Fischer et al. (2008). For the sake of practicability some species were aggregated to species groups – those species would have been determinable nonambiguously only in bloom, but were always or partly met in the vegetative phase. Cover values of litter and open soil were assessed in percents. The vegetation height disregarding emergent individuals was calculated by taking the mean of the measures at the four corners and the center point. The same five points were used for measuring soil depth with a weeding trowel, again taking the mean afterwards. As this tool was only 20 cm long and a few of the plots had measuring points deeper than that, for the sake of simplicity, a soil depth of 20 cm was recorded in such cases. The approximate age of burns was estimated and based on this a partition into two categories was made: fire within the last three years – young; fire more than three years ago – old. The kind of grazing was recorded for pastures: sheep (and goat) or cattle. Mowing was not taken into account, for it only concerned seven plots that additionally were grazed.

Statistical analyses and ordinations

The recorded data were administrated with the software Turboveg (Hennekens and Schaminée 2001). All statistical calculations and diagrams were carried out using statistical software R (R Development Core Team 2012). A major part of the computations was performed with R package vegan (Oksanen et al. 2012). Indicator values adapted to the Pannonian floristic region (Borhidi 1995) were added to the data. Taxa not mentioned by Borhidi were provided with values after Ellenberg et al. (1992). Taxa without any indicator values were simply omitted in the calculations. Though, strictly speaking, the approach of taking the unweighted arithmetic mean of ordinally scaled variables is improper, mean indicator values of the relevés were calculated in this way. This was done because the indicator values actually are just a rule of thumb and should only give a simple evaluation. In the end, the accuracy of those values has to be validated by measurements.

Prior to examination, the whole data set was categorized by aspects as followed: quality (primary/secondary), type (isolated/vast), age class of secondary plots (1958/1974/1991/2000/2004/2008/2009), grazing (none/sheep (and goat)/cattle), burn (none/old/young). 17 relevé types were formed from this categorization (Fig. 1; Table 3).

As starting point for all further statistical analyses and for aggregating the relevé types into groups, a DCA (detrended correspondence analysis) (Hill and Gauch 1980) was run. Tentatively, the ordination was done with abundance data first and with presence/absence data in a second step. The latter proved to be favorable, since use of the first led to an ecologically not reasonably interpretable arch effect. Hence, all subsequent calculations were done using binary data. To verify the results of the DCA, an NMDS (non-metric multidimensional scaling) (Kruskal 1964) was performed additionally, following the recommendation of Økland (2007). Computation of the NMDS was carried out using function 'metaMDS' in the vegan package. This method helps preventing usage of local optima as solutions by conducting an iterative process (Minchin 1987; Oksanen et al. 2012; Legendre and Legendre 2012). Bray-Curtis dissimilarity (Bray and Curtis 1957) was used as dissimilarity index. The result of the NMDS was verified with a stress test using function 'stressplot', which plots the ordination distances against the original dissimilarities in a Shepard diagram. This function provides two different measurements of goodness of fit: (1) "non-metric fit", which is based on stress S ($R^2 = 1 - S^2$) and (2) "linear fit", which is the squared correlation of ordination distances and fitted values (Oksanen et al. 2012).

To verify the degree of concordance between DCA and NMDS the method of Procrustes analysis (Gower 1971) was applied and its statistical significance ($\alpha < 0.05$) estimated by using a Monte Carlo permutation test (999 permutations) (Jackson 1995). Function 'protest' was used for this analysis. In addition, a Mantel test (Mantel 1967) was carried out, whose product-moment correlation also was assessed by doing a permutation test ($\alpha < 0.05$; 999 permutations).

Ecological indicator values, estimated cover values of vascular plants, litter and open soil and measures of mean vegetation height and mean soil depth were fitted onto DCA and NMDS respectively. Once again, significance ($\alpha < 0.05$) was calculated from 999 permutations. Furthermore, product-moment correlation and 95 %-confidence intervals of all aforementioned values were computed for all axes. Besides calculation of linear predictors, function ‘ordisurf’ was used for fitting surfaces based on GAMs (generalized additive models) for the respective variables. This method is a more appropriate approach for fitting values, since a strictly linear relationship does not reflect reality in most cases. The level of significance again was $\alpha < 0.05$.

A more detailed analysis was done for those predictors that had been significant in linear, as well as in non-linear post-hoc correlation in both ordination techniques, at the same time explaining at least 50 % of the variation in the data. Boxplots were used for visual pre-assessment of the respective variables. Normal distribution first was checked visually with quantile-quantile plots and afterwards numerically with Shapiro-Wilk tests (Shapiro and Wilk 1965) ($\alpha < 0.05$) adjusted to larger sample sizes (Royston 1982). In all cases data were normally distributed or deviated from normal distribution to an acceptable degree. Hence, no data transformations were necessary. To validate homogeneity of variances Levene tests (Levene 1960) were done ($\alpha < 0.05$) by using function ‘leveneTest’ of R package car (Fox and Weisberg 2013). After that, an ANOVA (analysis of variance) ($P < 0.05$) followed or in case of heteroscedasticity a Welch test (Welch 1951) ($\alpha < 0.05$) respectively. Dunnett’s modified Tukey-Kramer test (Dunnett’s C) for unequal sample sizes (Dunnett 1980) and without precondition of homogeneity of variances ($P = 0.05$) was conducted for revealing pairwise differences, using function ‘DTK.test’ of R package DTK (Lau 2013). In case of homoscedasticity a Tukey-HSD test was done additionally, using the R standard function for moderately imbalanced sample sizes ($\alpha < 0.05$), which produces a little bit narrower confidence intervals and therefore is less conservative.

To analyze differences of frequency between the relevé groups on one side and the reference group PV (primary, vast areas without human influences) on the other, GLM (generalized linear model) regressions with binomial distribution ($\alpha < 0.05$) were used for six in the Steinfeld characteristic dry grassland species (*Helianthemum canum*, *Fumana procumbens*, *Teucrium montanum*, *Globularia cordifolia*, *Seseli hippomarathrum*, *Carex liparocarpos*).

The α-diversities of all groups were calculated and compared first using all taxa and second only those, which are reported for dry and nutrient-poor habitats explicitly in Fischer et al. (2008). Exactly the same steps were applied as with the predictors.

For assessing species turnover, β-diversities of all groups were computed. Initially, several β-indices were tested for their response to the different sample sizes. As no relevant difference was found between using all taxa and using only dry habitat taxa, it was decided to employ the index β^{sim} used in Lennon et al. (2001), including all taxa. The further approach was exactly the same as mentioned for analysis of predictors and α-diversity. Although criterion of normal distribution had not been met, it was abstained from transforming the data, since the difference in results using transformed and unchanged data had been proven to be only marginal. Moreover, interpretation was much easier because of unaltered scale.

Unfortunately, the analysis of predictors, α- and β-diversity indicated a low power, as the sample sizes of some relevé groups were too small. The large confidence intervals made interpretation difficult. Mere consideration of statistical significance in this case would have been a useless undertaking, especially as effect size also would have been necessary to check. No power analysis had been done prior to the statistical calculations for assessment of required minimum sample sizes and moreover, would have been of questionable value, for the effect size would have had to be determined arbitrarily. An erroneously often-conducted post-hoc power analysis would have made absolutely no sense (Hoenig and Heisey 2001; Colegrave and Ruxton 2002; Walters 2009), and for that reason their recommendation of rather paying attention to the 95 % confidence intervals to verify significance was followed. The subjective determination of a minimum effect size was regarded as senseless; rather relations of effect sizes among the different relevé groups were inspected. Finally, this approach proved to be of limited explanatory value, as well. Therefore the relevé groups were further aggregated and the whole analysis of predictors, α- and β-diversity done again.

Results

A total of 192 taxa was identified, one being potentially endangered, 38 endangered and eight highly endangered in Austria (after Niklfeld and Schratt-Ehrendorfer 1999; Table 5 of Appendix I). With *Euphorbia caesia*, a new Central European species was found, recently described for Austria (Geltman and Till 2009) and not even listed in the Austrian excursion flora (Fischer et al. 2008) yet.

The eigenvalues (axis lengths) of the first four DCA axis were 0.382 (3.734), 0.121 (3.878), 0.119 (1.955) and 0.081 (1.962). Except for vegetation cover, all environmental variables of the linear fit were significant, of the non-linear even all without exception. Coefficient of determination and explained deviance was notably high for R, N, T and F. These parameters also were strongly correlated with the axis 1 (Table 1). Axis 1 seemingly represents an age gradient. Primary and old secondary plots were located on the left side, whereas young secondary plots, which had been abandoned ca. during the last decade, were pictured on the right (Fig. 2). Interpretation of axes 2 and 3 was much harder, and in addition, their eigenvalues were almost equal. The highest correlation coefficients on axis 2 were found for mean vegetation height and mean soil depth. There were a few more variables with similar

Table 1 Significance of predictors fitted in DCA with linear and nonlinear model (in bold: P value for significant predictors (P < 0.05)). R^2 = coefficient of determination; r = product-moment correlation coefficient; GAM = generalized additive model.

Variable	Linear					Nonlinear (GAM)	
	R^2	P	r Axis 1	r Axis 2	r Axis 3	Deviance explained	P
R	0.795	**0.001**	−0.85	0.22	−0.306	73.50 %	**0.001**
N	0.868	**0.001**	0.91	−0.2	0.254	84.80 %	**0.001**
T	0.781	**0.001**	−0.842	0.247	−0.273	78.10 %	**0.001**
F	0.864	**0.001**	0.89	−0.152	0.298	84.70 %	**0.001**
L	0.5	**0.001**	−0.476	−0.107	−0.469	38.10 %	**0.001**
K	0.246	**0.001**	−0.419	0.176	0.176	27.80 %	**0.001**
Vegetation cover	0.045	0.089	0.154	−0.141	0.047	21.20 %	**0.001**
Litter	0.253	**0.001**	−0.248	0.212	−0.366	15.00 %	**0.001**
Open soil	0.274	**0.001**	0.185	−0.148	0.443	6.83 %	**0.001**
Vegetation height	0.092	**0.001**	−0.002	0.273	−0.026	14.50 %	**0.001**
Soil depth	0.162	**0.001**	0.024	0.268	0.304	10.20 %	**0.001**

correlation values. Therefore, it remained unclear, whether axis 2 really represents an ecological gradient or just scatter. Correlation coefficients on axis 3 were highest for litter, open soil and indicator value L. This axis roughly pictures the varying light conditions of the plots, which result from differences in cover of litter and vegetation density. No sensible interpretation for axis 4 could be found.

The stress value of NMDS was S = 0.116, non-metric fit R^2 = 0.987 and linear fit R^2 = 0.958. All environmental variables of the linear, as well as the non-linear fit were statistically significant. As above with DCA, the coefficient of determination and the explained deviance was notably high for R, N, T and F; and again those parameters were strongly correlated with axis 1 (Table 2). For axes 2 and 3 the same pattern was found as with DCA, whereas axis 3 of DCA corresponds to axis 2 of NMDS and vice versa (Fig. 2). Axis 4 again was meaningless.

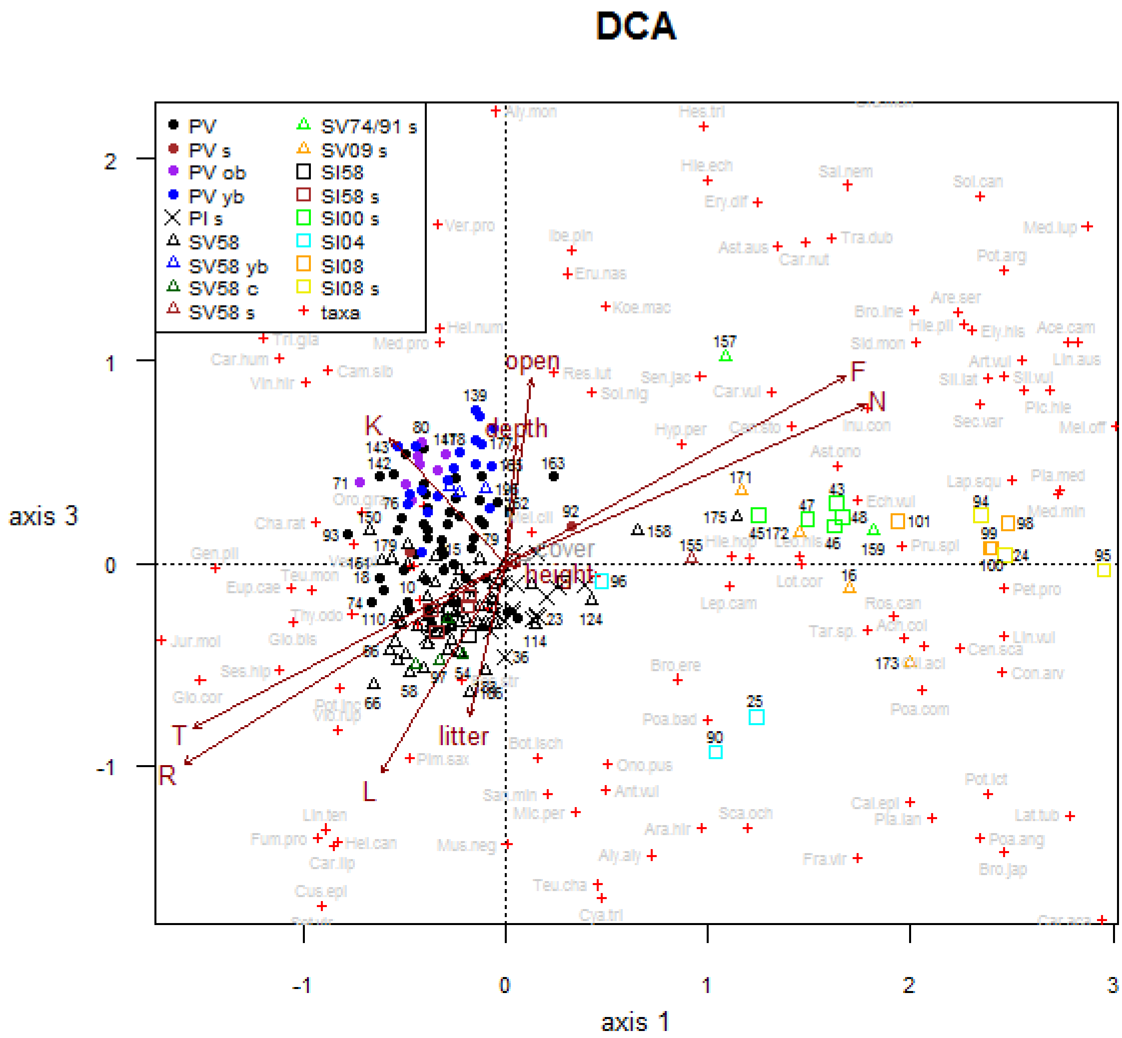
Table 2 Significance of predictors fitted in NMDS with linear and nonlinear model (in bold: P value for significant predictors (P < 0.05)). R^2 = coefficient of determination; r = product-moment correlation coefficient; GAM = generalized additive model.

Variable	Linear					Nonlinear (GAM)	
	R^2	P	r Axis 1	r Axis 2	r Axis 3	Deviance explained	P
R	0.8	**0.001**	−0.848	0.27	−0.05	81.00 %	**0.001**
N	0.858	**0.001**	0.901	−0.188	−0.099	85.60 %	**0.001**
T	0.735	**0.001**	−0.836	0.184	−0.044	79.40 %	**0.001**
F	0.827	**0.001**	0.887	−0.123	0.158	84.90 %	**0.001**
L	0.422	**0.001**	−0.467	0.298	−0.282	45.70 %	**0.001**
K	0.321	**0.001**	−0.413	−0.264	0.076	35.10 %	**0.001**
Vegetation cover	0.16	**0.001**	0.151	−0.186	0.284	14.10 %	**0.001**
Litter	0.271	**0.001**	−0.266	0.384	−0.228	23.20 %	**0.001**
Open soil	0.177	**0.001**	0.211	−0.341	−0.039	27.60 %	**0.001**
Vegetation height	0.292	**0.001**	−0.018	0.254	−0.426	6.49 %	**0.001**
Soil depth	0.231	**0.001**	0.008	−0.065	−0.286	5.99 %	**0.001**

Procrustes analysis delivered a correlation coefficient of r = 0.848 (P = 0.001), the Mantel test a correlation coefficient of r = 0.951 (P = 0.001). Hence, NMDS largely confirmed DCA. Based on these results, it was possible to aggregate the 17 relevé types into 10 groups (Table 3). I paid attention not to mix plots from secondary and primary areas, as well as from isolated and continuous parts. Group SV 09 s | r was special as it consisted of relevés of different age classes (2009, 1958, 1974, 1991). The three older relevés in this group had been in a very bad condition until grazing with sheep and goats was started in 2009. Due to their quite ruderal state, it was decided to combine them with the aforementioned relevés from 2009. This combination also had pragmatic reasons: statistical evaluation with a sample size n < 5 would have hardly been possible. In addition, the spatial proximity of those relevés in DCA and NMDS substantiated this decision. In order to increase explanatory power of the statistical analyses of predictors, α- and β-diversity, the 10 relevé groups were further merged into three aggregations (Table 3).

The predictors R, N, T and F fulfilled all conditions for further analysis. The values for the boxplots of the young secondary plots (SV09 s | r, SI00/04 - | s, SI08 - | s) clearly differed from the other plots (Fig. 3). ANOVA was significant for R (F = 49.7, P < 0.001). A Welch test was conducted for N, T and F, due to heteroscedasticity in their data, which was significant also (N: F = 18.39, P < 0.001; T: F = 26.37, P < 0.001; F: F = 41.175, P < 0.001). The Dunnett modified Tukey-Kramer tests provided a fairly consistent picture for all four indicator values. Tukey-HSD test for R matched those outcomes. The comparison of indicator values of the young secondary plots with the other ones in nearly all cases provided significant differences. Among these groups only three significances were found (Fig. 3). The Welch tests with the three aggregation groups were all highly significant (P < 0.001). The positions of the confidence intervals delivered the same picture for all indicator values. The young plots differed considerably from the primary and old secondary plots, while there was no noteworthy difference between the latter.

A multitude of results with high standard error was obtained in the GLM analysis (Table 4). In connection with a negative estimate total absence was the reason for it, constant presence in connection with a positive estimate. In spite of lacking statistical significance, a definite difference was inferred in such cases. Except



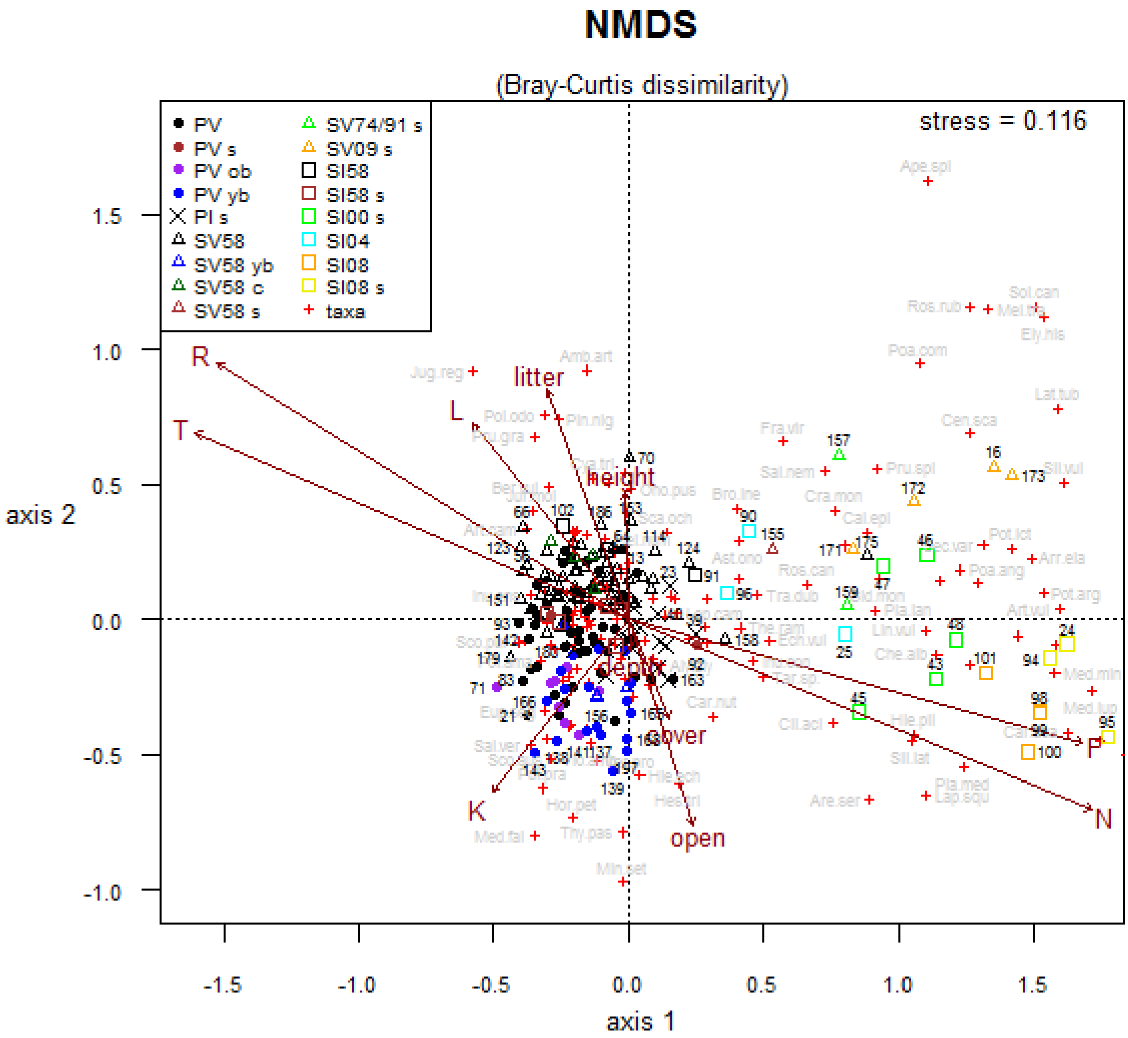


Fig. 2 DCA (axes 1 and 3) and corresponding NMDS (axes 1 and 2) of sample plots and taxa with linear predictors (arrows). For abbreviations of taxa names see Table 5 of Appendix.

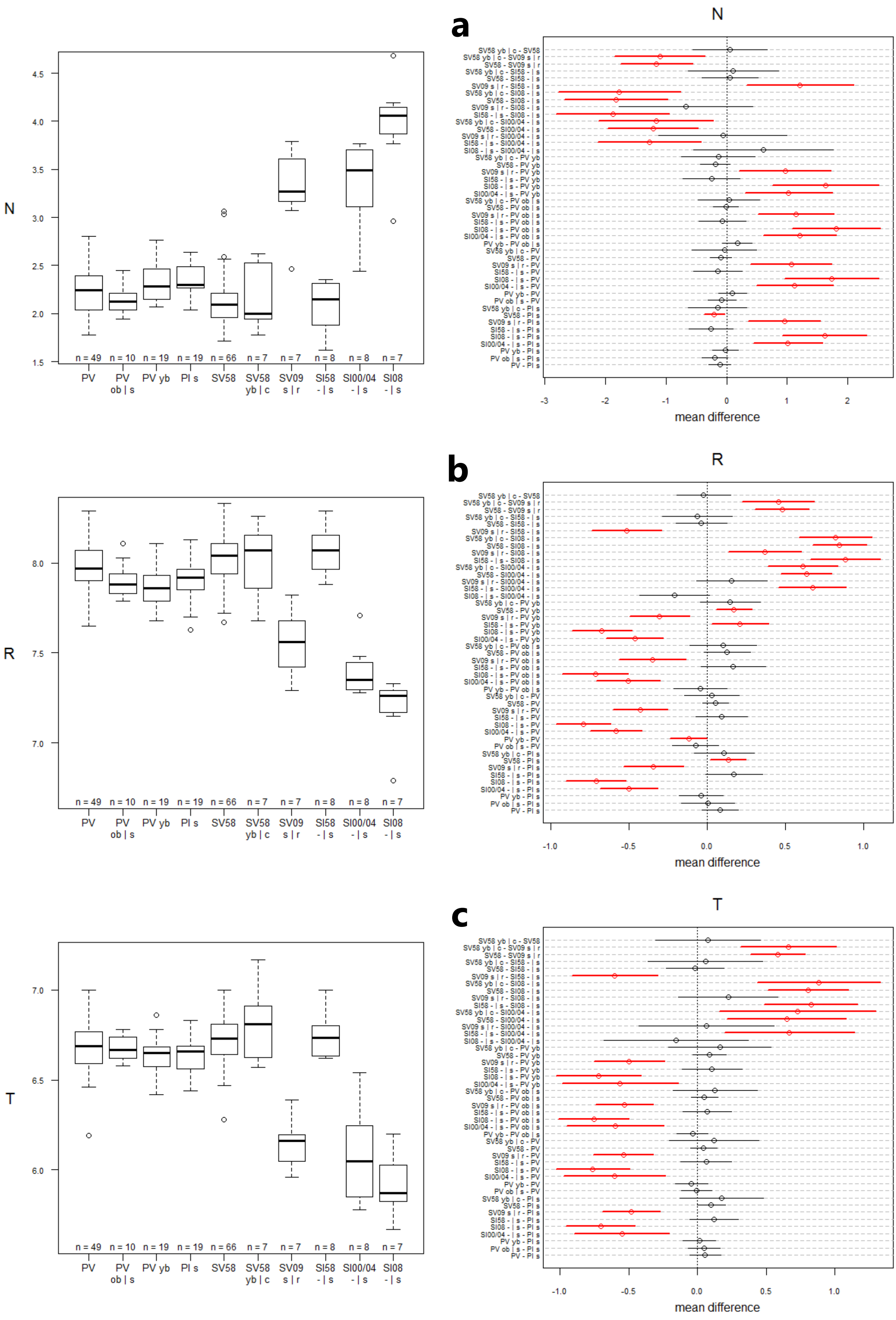
for *Carex humilis*, which was always absent in group SI08 - | s only, all species had significant lower presence or total absence in the young secondary plots. *Helianthemum canum* only slightly missed significance in group SI00/04 - | s. No further significant deviances were found for *Globularia cordifolia*. *Teucrium montanum* constantly occurred in groups PV ob | s, SV58 yb | c and SI58 - | s, *Helianthemum canum* in SV 58 yb | c and PI | s. *Carex humilis*, *Helianthemum canum* and *Fumana procumbens* had significantly higher presence in group SV58 and significantly lower presence in groups PV yb and PI s, except for *Helianthemum canum* in the last. Moreover, *Seseli hippomarathrum* and *Fumana procumbens* showed significantly lower presence in group PV ob | s.

ANOVA provided significant values for α-diversity using all species ($F = 3.951$, $P < 0.001$), as well as using only dry habitat species ($F = 6.035$, $P < 0.001$). The subsequent Dunnett modified Tukey-Kramer tests provided no conclusive picture, neither for the entire data set nor for the dry habitat species. The same was true for the Tukey-HSD test with all species. A better outcome was obtained by using Tukey-HSD test with dry habitat taxa. The high diversity in group PI s and the low diversity of the young secondary plots was remarkable. Of course, α-diversity of all the groups was higher when using the entire data set. Nevertheless, in the young secondary plots the difference was strikingly high, albeit not always significant. When analyzing the aggregated groups with the entire data set, no conclusive picture was obtained. But, a clear trend was obvious, when using only dry habitat taxa. ANOVA was highly significant ($F = 20.37$, $P < 0.001$). The subsequent Dunnett's C procedure, as well as the Tukey-HSD tests provided significant results throughout. The young plots had clearly lower α-diversity than the primary plots. The differences between young and old secondary plots were by far lower and lowest between old secondary and primary plots (Fig. 4).

Due to heterogeneity of variances a Welch test was conducted for analysis of β-diversity, which provided a significant result ($F = 33.98$, $P < 0.001$). The Dunnett's C tests showed a tendency of higher β-diversity in the young secondary plots, most comparisons between these three groups and the others were significant (Fig. 4). It

Table 3 Initial relevé types and their assignment into groups based on results of DCA and NMDS and further merging into aggregations.

Aggregation	n	Group	n	Relevé type	n
Primary	97	PV	49	PV	49
		PV yb	19	PV yb	19
		PV ob | s	10	PV ob	8
				PV s	2
		PI s	19	PI s	19
Secondary	81	SV58	66	SV58	66
		SV58 yb | c	7	SV58 yb	3
				SV58 c	4
		SI58 - | s	8	SI58	3
				SI58 s	5
Young	22	SV09 s | r	7	SV58 s	1
				SV74/91 s	2
				SV09 s	4
		SI00/04 - | s	8	SI04	3
				SI00 s	5
		SI08 - | s	7	SI08	4
				SI08 s	3


a
N
mean difference
b
R
mean difference
c
T
mean difference
n = 49 n = 10 n = 19 n = 19 n = 66 n = 7 n = 7 n = 8 n = 8 n = 7
PV
PV ob | s
PV yb
PI s
SV58
SV58 yb | c
SV09 s | r
SI58 - | s
SI00/04 - | s
SI08 - | s

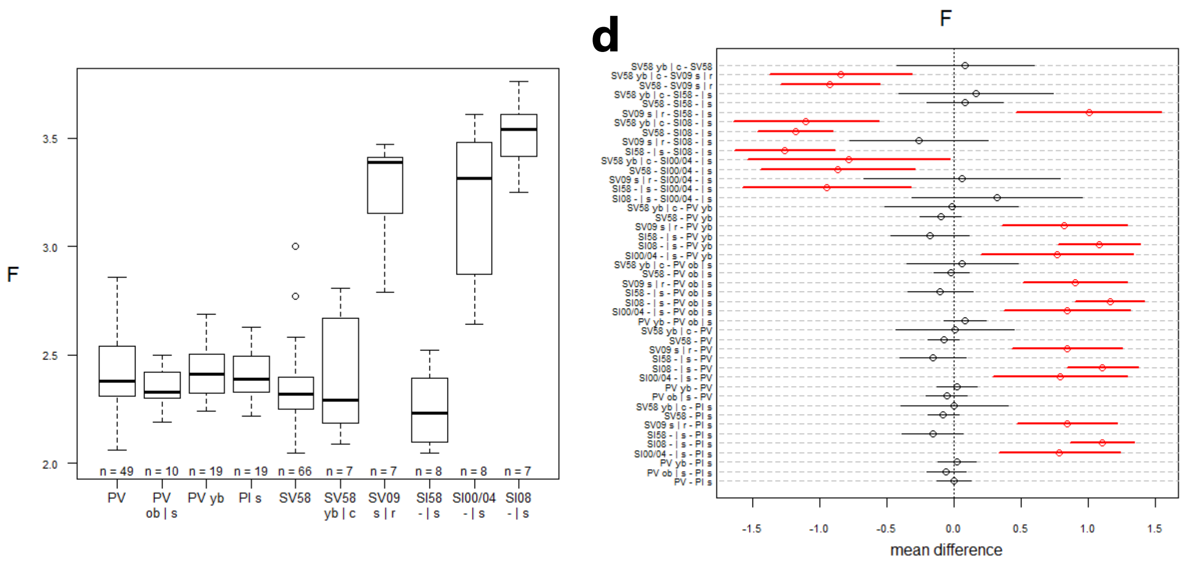


Fig. 3 Comparisons of indicator values **a** N, **b** R, **c** T and **d** F per group drawn by boxplots (left) and plots of 95 %-confidence intervals (right) calculated via pairwise Tukey-Kramer tests (Dunnett's c) for N, T and F (**a**, **c**, **d**) and via Tukey HSD test for R (**b**). Confidence intervals in red denote significant differences between compared groups.

also was true for group SV 58 yb | c, whose β-diversity values mostly were statistically higher. On the contrary, β-diversity of group PI s in most cases had significantly lower values than in the other groups. This largely was the case too when testing the aggregated data set. Welch test provided a highly significant result ($F = 59.941$, $P < 0.001$), Dunnett's C revealed clear differences between young plots and the other ones. β-diversity of young plots was clearly higher, while the difference between old secondary plots and primary plots was only marginal.

Discussion

Positive progress of regeneration

The results of the statistical analyses indicate successful regeneration of dry grasslands having been in agricultural use in the past. It had already hardly been possible to detect any difference between primary and old secondary plots in the ordination diagrams with relevés being located next to another or even admixed. In addition, the results confirm the impression, which had been received during field work. Unsurprisingly, youngest relevés differ from the other ones. A timespan of only up to 10 years simply is too short to expect completion of succession. Nevertheless, as time goes by, formerly cultivated areas increasingly resemble primary grasslands and after 50 years no significant difference is recognizable anymore. It was not possible to make an exact statement how long this process takes, as there had not been enough suitable areas abandoned between 1958 and 2000, which could have

Table 4 Analysis of frequency of occurrence in relevé groups of six species typical for dry grassland in the Steinfeld compared to frequency of occurrence in reference group PV using generalized linear models (GLM). Negative estimates indicate lower frequencies than in reference group whereas positive estimates indicate higher ones. In bold: P-values for significant estimates and estimates < −10 and > 10 (which also can be regarded as significant since the regarding species does not occur in such a group).

Species	Group	Estimate	P	Species	Group	Estimate	P
Helianthemum canum	PV ob | s	−0.862	0.224	Globularia cordifolia	PV ob | s	−0.97	0.194
	PV yb	−2.131	**0.002**		PV yb	−0.017	0.975
	PI s	−0.562	0.302		PI s	−1.152	0.053
	SV58	2.284	**0.001**		SV58	−0.617	0.107
	SV58 yb | c	−0.169	0.836		SV58 yb | c	0.165	0.84
	SV09 s | r	**−18.023**	0.99		SV09 s | r	**−17.69**	0.991
	SI58 - | s	1.489	0.179		SI58 - | s	−1.221	0.158
	SI00/04 - | s	−1.555	0.073		SI00/04 - | s	**−17.69**	0.99
	SI08 - | s	**−18.023**	0.99		SI08 - | s	**−17.69**	0.991
Fumana procumbens	PV ob | s	−2.654	**0.015**	Seseli hippo-marathrum	PV ob | s	−1.492	**0.042**
	PV yb	−2.131	**0.002**		PV yb	−0.17	0.801
	PI s	−1.779	**0.005**		PI s	**17.074**	0.991
	SV58	1.153	**0.009**		SV58	0.012	0.98
	SV58 yb | c	−1.373	0.121		SV58 yb | c	**17.074**	0.995
	SV09 s | r	−2.249	**0.045**		SV09 s | r	**−20.058**	0.994
	SI58 - | s	−0.457	0.551		SI58 - | s	0.454	0.688
	SI00/04 - | s	−2.403	**0.03**		SI00/04 - | s	**−20.058**	0.993
	SI08 - | s	**−17.023**	0.985		SI08 - | s	**−20.058**	0.994
Teucrium montanum	PV ob | s	**16.597**	0.994	Carex liparocarpos	PV ob | s	−1.91	0.081
	PV yb	−0.296	0.699		PV yb	−1.386	**0.045**
	PI s	0.171	0.844		PI s	−1.386	**0.045**
	SV58	1.075	0.143		SV58	1.346	**0.001**
	SV58 yb | c	**16.56**	0.995		SV58 yb | c	1.204	0.174
	SV09 s | r	−3.761	**0.001**		SV09 s | r	−1.504	0.179
	SI58 - | s	**16.597**	0.994		SI58 - | s	−0.223	0.776
	SI00/04 - | s	−3.915	**0.001**		SI00/04 - | s	−1.658	0.134
	SI08 - | s	**−20.536**	0.993		SI08 - | s	**−16.278**	0.986

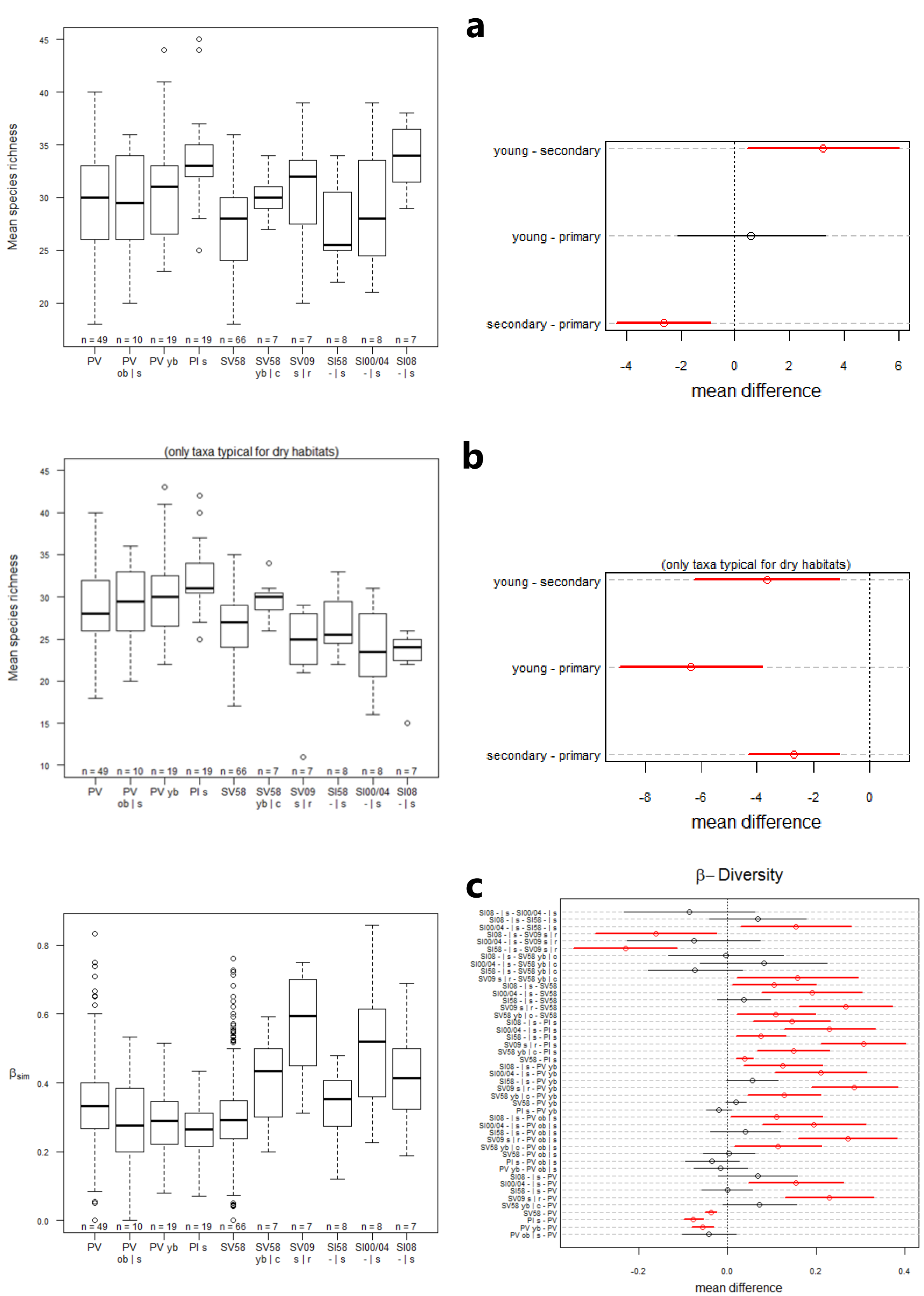


Fig. 4 Comparisons of **a** α-diversity calculated from all taxa, **b** α-diversity calculated from taxa that are typical for dry habitats and **c** β-diversity per group drawn by boxplots (left) and plots of 95 %-confidence intervals (right) calculated via pairwise Tukey-Kramer tests (Dunnett's c) using aggrega-

tions for α-diversity (**a**, **b**) and groups for β-diversity (**c**). Confidence intervals in red denote significant differences between compared groups and aggregations respectively.

served for such an analysis. Malicky (1970) makes a short statement about the Steinfeld claiming that it takes about 20 to 30 years till a stage is reached in which *Stipa pennata*, *Stipa capillata*, *Pimpinella saxifraga*, *Eryngium campestre* and *Bromus erectus* are apparent. For the Russian steppe between rivers Don and Volga, developed on Chernozems, Boonman and Mikhalev (2005) indicate a period of only 15 years, which, of course, would be too optimistic in the case of the Steinfeld steppe. Van der Sluis et al. (2000) note that in the case of some Ukrainian restoration projects even after 30 years not all original taxa had returned. Stadler et al (2007) still witness notable differences in floral composition between permanent plots and nearby dry grassland plots after 10 years in eastern Germany and deduce it will take about 20 years or more for complete restoration. A Hungarian chronosequence study on sandy soil (Csecserits and Rédei 2001) concludes that the basal processes will have finished within ca. 10 years. The different findings point to the fact that success and length of the process depend on a variety of factors and no general statement can be made. In this context, it is noteworthy to mention the uniqueness of the Steinfeld and that results and conclusions from other studies cannot be transferred easily, since it is the only remaining landscape with vast natural dry grassland steppe on carbonate gravel substrate in Central Europe. Calcareous grasslands in Central and Southeast Europe typically arose from anthropogenic activity. Their soils are somewhat more humid and richer in nutrients and therefore those grasslands most likely would turn back into forest or forest steppe after complete abandonment. The steppe rests of Eastern Europe totally deviate from the conditions in the Steinfeld by their fertile Czernosem soils. The other primary Central European dry grasslands, which are mainly located on karst slopes and karst plains, are too small in size to allow for comparison, high mountain grasslands have not even been taken into consideration. In areas of Central or Southeast Europe with a similar geological history as in the Steinfeld dry grasslands have already been mostly destroyed (Essl and Denk 2001).

In any case, the old secondary plots do not differ significantly anymore from the primary plots with respect to all four analyzed indicator values. The statistically proven higher β-diversity of the young secondary plots can be explained by the higher heterogeneity of their species composition. Variability of primary and old secondary plots simply is by far lower, Buchner (1976) and Sauberer and Buchner (2001) respectively ascertain a particular monotony and species poorness for the Steinfeld. Nonetheless, some of the pairwise tests between primary and old secondary plots showed significant results, but always in connection with a very low mean difference, which indicates that they are not of practical relevance. Group SV58 yb | c, which clearly has a notably higher β-diversity, is the exception. But most likely this fact is due to its small sample size and its heterogeneous configuration, consisting of young burns and cattle grazed plots.

Because of the different group sizes detection of significances comparing α-diversities turned out to be problematic. The confidence intervals of those pairwise tests concerning groups with $n < 10$ were quite broad, as it had been the case when comparing indicator values and β-diversities. But unlike the latter, the differences of α-diversity simply were too low and significant differences accordingly rare. Nevertheless, a tendency towards higher α-diversity in primary and old secondary plots could be observed. When only relevés of vast areas are compared the somewhat lower species counts of the totally untouched (i.e. no fire or grazing) old secondary plots are noticed. This indicates the necessity of regular disturbances to preserve species diversity in formerly ploughed areas, especially since the α-diversity of old secondary plots that are regularly disturbed equals those of primary plots. The highest species counts are found in isolated primary plots with sheep grazing. The positive influence of grazing is remarkable as there are increased occurrences of small therophytes such as *Microthlaspi perfoliatum*, *Alyssum alyssoides* or *Cerastium glutinosum*. This positive effect mainly is caused by suppression of *Bromus erectus*, which increases in areas with absolutely no disturbance. Germination of the aforementioned annuals is also hindered by the litter of this grass, which, without any perturbation, remains on the spot and covers the ground like a blanket. Compared to the isolated primary plots the isolated old secondary plots have a much lower α-diversity, although they are sheep grazed. However, it has to be added, that grazing in both groups had not started until 10 years ago and that they had been in a very bad condition before, so that species such as *Fumana procumbens* or *Veronica spicata* had almost disappeared. The primary parts of this area had had a more favorable starting position and thus been able to recover much faster, while in the secondary parts this process takes a lot longer and has not finished yet. Obviously, isolation also plays a role as the possibility of propagules entering the area increases with quantity and extent of donor areas.

Influence of nitrogen deposition and role of woody plants

Although there is hardly any question the original dry grassland vegetation recovers in areas formerly used agriculturally, a threat of completely different kind is not to be ignored. The increased amounts of atmospheric nitrogen deposition due to increasing emissions from agriculture, industry and traffic are a serious problem for the steppe. Bieringer and Sauberer (2001b) recognize proceeding degradation of the dry grasslands and point out that this is in fact the biggest threat to the Steinfeld steppe nowadays, since it cannot be tackled permanently on a local basis. According to Frey and Lösch (2010) agricultural animal husbandry was responsible for approximately 75 % of all emitted ammonia in Western Europe in the mid-90ies. In the period from 1860 till 1990 the global amount of reactive nitrogen of anthropogenic source rose from ca. 15 Tg yr^{-1} up to ca. the tenfold, till 2050 a further increase up to ca. 270 Tg yr^{-1} is predicted (Galloway et al. 2004). This is not a big issue in environments with moderate to high nutrient availability but leads to severe alterations and a loss of biodiversity in habitats where plants are adapted to low nutrient levels. Eutrophication of nutrient poor ecosystems is increasingly attracting attention of vegetation ecologists and subject of a plenty of studies, for instance Wilson et al. (1995), Bobbink (1998), Roem and Berendse (2000), Stevens et al. (2004), Peter et al. (2009) or Bonanomi et al. (2013), just to name a few. Species, which respond with an intensified growth to this additional supply and boost their competitiveness at the expense of other species, are a severe problem for dry grassland, which is also true for the Steinfeld. So to say, the “enemy” lurks inside and is an integral component of the vegetation. This especially is true for *Bromus erectus*, actually a rather typical plant of dry and oligotrophic biotopes. However, enhanced nitrogen deposition fosters its growth and linked to this, in absence of disturbances, dead plant material accumulates. As a consequence light demanding dwarf shrubs and other small plants are suppressed and finally disappear, which happens in both secondary and primary dry grassland areas. Relief can be produced by grazing, mowing with subsequent removal of clippings and fire. Although the first method is the most preferential, it cannot be taken into consideration, since grazing is (currently still) impossible in the military training area. Despite its effectivity against further population growth of *Bromus erectus* and in discharge of nitrogen, fires can have disastrous consequences for endangered animal and plant species when appearing in the wrong season. The effects of winter fires are mainly positive as there are no birds breeding and almost no invertebrates present aboveground. On the contrary, summer fires can do much harm (Bieringer and Sauberer 2001c). This is particularly true for *Fumana procumbens* and *Helianthemum canum*, which apparently need a very long time to recolonize burned areas. Mowing cannot really be considered as appropriate, because the dry grassland area simply is too large for this approach. Moreover, if executed mechanically expansion of *Bromus erectus* might even be promoted (Klimeš and Klimešova 2002): mechanical mowing cuts the vegetation at some height above the ground and since *Bromus erectus* stores reserves in its leaf bases and makes use of them for regeneration (Wagner 1972 cit. in Ellenberg 1996), this method finally achieves the very opposite effect. Exactly for the same reason this species is intolerant towards sheep grazing as those animals appreciate its leaf bases as nutritional source.

Luckily, *Robinia pseudacacia*, which is often mentioned in connection with nitrogen enrichment and its implication for nutrient poor habitats (Paar et al. 1994), does not pose a threat to the Steinfeld steppe. In contrast to dry grasslands of anthropogenic origin in which this invasive neophyte has to be managed, it does hardly encroach into the Steinfeld because of dryness and structure of the soil. First, in a depth less than half a meter there is a concretion layer made of gravel cemented by calcium carbonate (Soltani-Taba 1970), which prevents penetration of roots into deeper zones. Second, the very low water storage capacity of the soil is a difficulty *Robinia pseudacacia* cannot overcome. Grasses can deal far better with this, as their roots are adapted to these conditions. Even on formerly ploughed soils with their altered structure, which provides woody plants with competitive advantages, *Robinia pseudacacia* cannot outcompete the grasses in the long run (Sauberer and Bieringer 2001). Shrub encroachment by *Rosa canina*, *Rosa rubiginosa*, *Crataegus monogyna* and *Prunus spinosa* is a bigger problem only in the north of the survey area at the former course of river Piesting. There, soils are fairly deeper, moister and somewhat richer in nutrients. Conveniently, this part is located outside of the military area and can be managed by sheep and goat grazing. As Bieringer and Sauberer (2001a) and Sauberer and Bieringer (2001) respectively point out, woody plants can only predominate at highly altered sites such as wreckages, bomb and grenade craters and similar places where the concretion layer has been broken up. Nevertheless, attention always has to be put to fallows, which have been set aside only recently, because in formerly ploughed areas with their altered soil conditions woody plant invasion is an issue as long as grasses and chamaephytes have not re-established and built up a sod. The effects of the large plantations of *Pinus nigra* remain questionable. In the southern part of the Steinfeld they have existed for many centuries, hence it can be concluded the original vegetation there has gone lost forever. The plantations in the north of the Steinfeld are of much younger age. Moreover, they are in a much worse condition because of the shallower soils. However, given the acidification of the soils by the needles, restoration of the natural vegetation after removal of pines does not seem very likely without additional measures.

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Appendix I: Additional Material

Table 5 Identified taxa and their endangerment status for Austria (Niklfeld and Schratt-Ehrendorfer 1999). In bold: taxa that are typical for dry habitats (after Fischer et al. 2008)

Taxa	Abbreviation	Endangerment status
Acer campestre	Ace.cam	
Achillea collina (s. lat.)	Ach.col	
Allium sphaerocephalon	All.sph	endangered
Alyssum alyssoides	Aly.aly	
Alyssum montanum subsp. montanum	Aly.mon	endangered
Ambrosia artemisiifolia	Amb.art	
Anagallis arvensis	Ana.arv	
Anthemis austriaca	Ant.aus	
Anthericum ramosum	Ant.ram	endangered in Pannonian floristic province
Anthyllis vulneraria	Ant.vul	subsp. polyphylla endangered
Apera spica-venti	Ape.spi	
Arabis hirsuta agg.	Ara.hir	
Arenaria serpyllifolia (s. str.)	Are.ser	
Arrhenatherum elatius	Arr.ela	
Artemisia absinthium	Art.abs	
Artemisia campestris	Art.cam	
Artemisia vulgaris	Art.vul	
Asperula cynanchica (s. str.)	Asp.cyn	
Astragalus austriacus	Ast.aus	endangered
Astragalus cicer	Ast.cic	
Astragalus onobrychis	Ast.ono	
Berteroa incana	Ber.inc	
Berberis vulgaris	Ber.vul	
Bothriochloa ischaemum	Bot.isch	
Bromus erectus	Bro.ere	
Bromus inermis	Bro.ine	
Bromus japonicus	Bro.jap	
Calamagrostis epigejos	Cal.epi	
Campanula sibirica (subsp. sibirica)	Cam.sib	
Carduus acanthoides	Car.aca	
Carex humilis	Car.hum	
Carex liparocarpos	Car.lip	endangered
Carduus nutans	Car.nut	
Carlina vulgaris	Car.vul	
Centaurea jacea	Cen.jac	
Centaurea scabiosa	Cen.sca	
Centaurea stoebe	Cen.sto	
Cerastium glutinosum	Cer.glu	
Chamaecytisus ratisbonensis	Cha.rat	endangered

Taxa	Abbreviation	Endangerment status
Chenopodium album	Che.alb	
Chondrilla juncea	Cho.jun	
Cichorium intybus	Cic.int	
Cirsium arvense	Cir.arv	
Cirsium vulgare	Cir.vul	
Clematis vitalba	Cle.vit	
Clinopodium acinos	Cli.aci	
Convolvulus arvensis	Con.arv	
Consolida regalis	Con.reg	
Crataegus monogyna (subsp. monogyna)	Cra.mon	
Crepis biennis	Cre.bie	
Crepis foetida subsp. rhoeadifolia	Cre.foe	
Cuscuta epithymum	Cus.epi	
Cyanus triumfettii	Cya.tri	
Dactylis glomerata	Dac.glo	
Daucus carota	Dau.car	
Dorycnium germanicum	Dor.ger	
Echium vulgare	Ech.vul	
Elymus hispidus	Ely.his	
Elymus repens	Ely.rep	
Erigeron acris subsp. acris	Eri.acr	
Erigeron annuus	Eri.ann	
Erigeron canadensis	Eri.can	
Erucastrum nasturtiifolium (s. str.)	Eru.nas	
Eryngium campestre	Ery.cam	
Erysimum diffusum agg.	Ery.dif	E. andrzejowskianum (auct. austr.) highly endangered, E. diffusum endangered
Euphorbia caesia	Eup.cae	not reported, probably endangered
Euphorbia seguieriana	Eup.seg	endangered
Fallopia convolvulus	Fal.con	
Festuca pseudovina	Fes.pse	potentially endangered
Festuca rubra subsp. juncea	Fes.rub	
Festuca rupicola	Fes.rup	
Festuca stricta (subsp. stricta)	Fes.str	endangered
Filipendula vulgaris	Fil.vul	endangered
Fragaria viridis	Fra.vir	
Fumana procumbens	Fum.pro	
Galium album (s. lat.)	Gal.alb	
Galatella linosyris	Gal.lin	endangered
Galium lucidum (s. str.)	Gal.luc	
Genista pilosa	Gen.pil	
Geranium pusillum	Ger.pus	
Globularia bisnagarica	Glo.bis	endangered
Globularia cordifolia	Glo.cor	endangered in Pannonian floristic province
Helianthemum canum	Hel.can	

Taxa	Abbreviation	Endangerment status
Helianthemum nummularium subsp. obscurum	Hel.num	
Hesperis tristis	Hes.tri	endangered
Hieracium echioides	Hie.ech	endangered
Hieracium hoppeanum subsp. testimoniale (s. lat.)	Hie.hop	highly endangered
Hieracium pilosella (s. str.)	Hie.pil	
Hieracium piloselloides s. str.	Hie.pld	
Holosteum umbellatum	Hol.umb	
Hornungia petraea	Hor.pet	endangered
Hypericum perforatum	Hyp.per	
Iberis pinnata	Ibe.pin	
Inula conyzae	Inu.con	
Inula ensifolia	Inu.ens	endangered
Inula hirta	Inu.hir	endangered
Inula oculus-christi	Inu.ocu	endangered
Juglans regia	Jug.reg	
Jurinea mollis	Jur.mol	endangered
Koeleria macrantha	Koe.mac	
Lappula squarrosa (s. str.)	Lap.squ	endangered
Lathyrus tuberosus	Lat.tub	
Leontodon hispidus	Leo.his	
Lepidium campestre	Lep.cam	
Linum austriacum (subsp. austriacum)	Lin.aus	endangered
Linum tenuifolium	Lin.ten	endangered
Linaria vulgaris (s. str.)	Lin.vul	
Lotus corniculatus agg.	Lot.cor	L. borbasii endangered
Medicago falcata	Med.fal	
Medicago lupulina	Med.lup	
Medicago minima	Med.min	endangered
Medicago prostrata	Med.pro	highly endangered
Medicago x varia	Med.var	
Melica ciliata	Mel.cil	
Melilotus officinalis	Mel.off	
Melica transsilvanica (subsp. transsilvanica)	Mel.tra	
Microthlaspi perfoliatum	Mic.per	
Minuartia setacea	Min.set	endangered
Muscari neglectum	Mus.neg	
Ononis pusilla	Ono.pus	endangered
Orobanche gracilis	Oro.gra	
Petrorhagia prolifera	Pet.pro	highly endangered
Petrorhagia saxifraga	Pet.sax	
Phleum nodosum	Phl.nod	endangered
Picris hieracioides subsp. hieracioides	Pic.hie	
Pimpinella saxifraga s. lat.	Pim.sax	

Taxa	Abbreviation	Endangerment status
Pinus nigra	Pin.nig	
Plantago lanceolata	Pla.lan	
Plantago media	Pla.med	
Poa angustifolia	Poa.ang	
Poa badensis	Poa.bad	
Poa compressa	Poa.com	
Polygala amara	Pol.ama	
Polygonum aviculare s. lat.	Pol.avi	
Polygonatum odoratum	Pol.odo	
Potentilla argentea (s. lat.)	Pot.arg	
Potentilla incana	Pot.inc	
Potentilla inclinata	Pot.ict	endangered
Prunella grandiflora	Pru.gra	endangered in Pannonian floristic province
Prunus spinosa (subsp. spinosa)	Pru.spi	
Pulsatilla grandis	Pul.gra	endangered
Pulsatilla pratensis (subsp. nigricans)	Pul.pra	endangered
Reseda lutea	Res.lut	
Rosa canina s. str.	Ros.can	
Rosa rubiginosa	Ros.rub	
Rubus caesius	Rub.cae	
Rumex thyrsiflorus	Rum.thy	
Salvia aethiopis	Sal.aet	highly endangered
Salvia nemorosa	Sal.nem	
Salvia pratensis (subsp. pratensis)	Sal.pra	
Salvia verticillata	Sal.ver	
Sanguisorba minor	San.min	
Scabiosa canescens	Sca.can	endangered
Scabiosa ochroleuca	Sca.och	
Scorzonera austriaca	Sco.aus	
Scorzonera purpurea	Sco.pur	endangered
Securigera varia	Sec.var	
Senecio jacobaea	Sen.jac	
Seseli annuum	Ses.ann	endangered
Seseli hippomarathrum	Ses.hip	endangered
Setaria viridis var. viridis	Set.vir	
Sideritis montana	Sid.mon	endangered
Silene latifolia subsp. alba	Sil.lat	
Silene otites subsp. otites	Sil.oti	endangered
Silene vulgaris subsp. vulgaris	Sil.vul	
Solidago canadensis	Sol.can	
Solanum nigrum	Sol.nig	
Stachys recta s. lat.	Sta.rec	
Stipa capillata	Sti.cap	
Stipa pennata agg.	Sti.pen	
Syringa vulgaris	Syr.vul	
Taraxacum species	Tar.sp.	

Taxa	Abbreviation	Endangerment status
Teucrium chamaedrys (subsp. chamaedrys)	Teu.cha	
Teucrium montanum	Teu.mon	
Thalictrum minus s. lat.	Tha.min	
Thesium ramosum	The.ram	endangered
Thymus odoratissimus	Thy.odo	
Thymelaea passerina	Thy.pas	highly endangered
Tragopogon dubius	Tra.dub	
Tragopogon orientalis	Tra.ori	
Trinia glauca (subsp. glauca)	Tri.gla	endangered
Trifolium repens (subsp. repens)	Tri.rep	
Veronica arvensis	Ver.arv	
Veronica prostrata (s. str.)	Ver.pro	
Veronica spicata (s. str.)	Ver.spi	endangered
Vicia angustifolia	Vic.ang	
Vicia hirsuta	Vic.hir	
Vicia pannonica subsp. striata	Vic.pan	
Vincetoxicum hirundinaria (subsp. hirundinaria)	Vin.hir	
Viola ambigua	Vio.amb	highly endangered
Viola arvensis	Vio.arv	
Viola rupestris	Vio.rup	

Table 6 Environmental data and additional informations about sample plots. Indicator values are calculated from unweighted means.

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
1	SV58	SV58	50	50	0	17.00	9.56	8.13	2.00	6.79	2.25	8.33	4.83	47.88330	16.30156
2	SV58	SV58	60	25	15	13.80	2.36	8.10	2.46	6.86	2.35	8.14	4.86	47.89674	16.31819
3	SV58	SV58	50	50	0	20.00	4.60	8.33	1.90	6.89	2.05	8.11	4.26	47.88207	16.28818
4	SV58	SV58	54	45	0	22.40	7.24	8.17	1.96	6.71	2.25	8.17	4.88	47.87969	16.29152
5	SV58	SV58	40	60	0	18.60	8.46	7.91	2.10	6.62	2.38	7.95	4.76	47.88470	16.30118
6	PV	PV	70	29	1	10.40	8.06	8.00	2.32	6.60	2.32	7.84	4.84	47.88100	16.28430
7	SV58	SV58	43	50	5	14.20	3.60	7.93	2.48	6.68	2.46	8.19	4.82	47.89410	16.32085
8	SV58	SV58	49	46	4	13.40	3.44	8.04	2.37	6.85	2.44	8.11	4.82	47.89544	16.32662
9	SV58	SV58	55	35	5	19.60	6.68	8.08	2.35	6.62	2.42	8.15	4.89	47.88871	16.28032
10	PV	PV	50	50	0	14.20	4.80	8.13	2.19	6.75	2.38	8.25	4.75	47.89780	16.27856
11	PV	PV	50	50	0	13.00	4.94	8.29	1.81	7.00	2.14	8.33	4.71	47.89844	16.28181
12	SV58	SV58	65	35	0	17.00	11.02	8.19	2.18	6.76	2.41	8.05	4.73	47.91066	16.28611
13	PV	PV	48	50	0	15.20	5.70	8.10	2.07	6.72	2.37	8.21	4.83	47.89325	16.26438
14	PV	PV	50	50	0	26.00	7.40	7.92	2.75	6.46	2.63	7.88	4.38	47.90697	16.29300
15	PV	PV	55	45	0	13.00	4.86	7.90	2.38	6.59	2.55	8.00	4.48	47.90930	16.29186
16	SV09 s | r	SV09 s	54	35	10	17.40	4.80	7.66	3.55	6.10	3.40	7.83	4.55	47.91692	16.30173
17	PV	PV	55	45	0	13.20	4.84	8.21	1.89	6.74	2.16	8.17	4.89	47.89750	16.27954
18	PV	PV	65	35	0	10.60	6.54	8.17	1.96	6.96	2.21	8.25	5.04	47.90582	16.29421
19	PV yb	PV yb	50	1	44	8.60	9.90	7.91	2.35	6.70	2.52	8.13	5.17	47.90937	16.31349
20	SV58	SV58	50	50	0	16.00	9.06	8.07	1.90	6.62	2.21	7.97	4.79	47.90401	16.33615
21	PV	PV	40	60	0	21.20	8.90	7.96	2.41	6.73	2.55	7.77	4.86	47.90804	16.32339
22	PV ob | s	PV ob	43	30	25	9.00	9.32	7.79	2.13	6.71	2.33	8.00	5.46	47.91438	16.32703
23	PI s	PI s	73	25	0	11.00	7.02	7.92	2.64	6.68	2.60	8.04	4.64	47.85680	16.28167
24	SI08 - | s	SI08 s	73	2	25	11.20	8.44	7.31	3.97	6.20	3.37	8.00	4.90	47.86518	16.30602
25	SI00/04 - | s	SI04	60	34	1	18.20	7.94	7.34	3.37	6.09	2.94	7.91	4.69	47.87025	16.30470
26	PI s	PI s	75	24	1	10.60	7.80	7.63	2.59	6.50	2.63	7.97	4.48	47.85502	16.28270
27	SI58 - | s	SI58 s	60	40	0	15.20	7.70	8.11	2.00	6.72	2.22	7.94	4.83	47.85514	16.28130
28	SI58 - | s	SI58 s	53	35	7	8.80	8.82	8.09	2.33	6.64	2.41	8.19	4.43	47.85503	16.28203
29	SI58 - | s	SI58 s	55	40	0	10.80	7.40	8.04	2.29	6.79	2.24	8.04	4.68	47.85446	16.28327
30	PI s	PI s	65	34	1	12.80	6.40	8.04	2.30	6.78	2.30	7.96	4.63	47.85501	16.28317
31	PI s	PI s	60	39	1	9.00	6.60	8.00	2.23	6.67	2.33	8.04	4.73	47.85410	16.28526
32	PI s	PI s	70	30	0	12.80	8.14	7.70	2.54	6.56	2.48	8.12	4.54	47.85444	16.28601
33	PI s	PI s	65	33	2	10.40	6.58	7.84	2.47	6.47	2.54	8.05	4.76	47.85483	16.28463
34	PI s	PI s	75	23	2	15.00	5.52	7.93	2.19	6.59	2.22	8.12	4.65	47.85470	16.28643
35	PI s	PI s	75	24	1	9.20	6.68	7.93	2.26	6.74	2.36	8.11	4.59	47.85560	16.28113
36	PI s	PI s	70	30	0	14.00	9.60	7.96	2.27	6.64	2.46	7.96	4.65	47.85579	16.28228

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
37	PI s	PI s	68	30	0	12.60	7.50	7.97	2.10	6.66	2.35	7.93	4.79	47.85705	16.28255
38	SI58 - | s	SI58 s	78	20	1	9.40	6.84	8.20	1.95	6.75	2.05	8.15	4.55	47.85751	16.28204
39	PI s	PI s	75	25	0	8.00	7.60	7.72	2.32	6.56	2.51	8.03	4.68	47.85583	16.28435
40	PI s	PI s	60	35	5	11.00	6.92	7.88	2.32	6.66	2.38	8.07	4.71	47.85583	16.28449
41	PI s	PI s	75	20	0	12.20	8.90	7.83	2.27	6.44	2.39	8.00	4.68	47.85504	16.28718
42	PV ob | s	PV s	49	49	2	15.20	6.14	7.89	2.21	6.74	2.50	8.04	4.57	47.89961	16.29051
43	SI00/04 - | s	SI00 s	50	30	15	9.00	4.06	7.41	3.61	6.06	3.41	7.71	4.61	47.85964	16.29032
44	SI58 - | s	SI58 s	58	40	0	11.60	7.52	7.88	2.30	6.63	2.38	8.17	4.44	47.85315	16.28541
45	SI00/04 - | s	SI00 s	50	30	2	6.20	5.02	7.48	3.08	6.04	3.22	7.65	4.77	47.85726	16.28831
46	SI00/04 - | s	SI00 s	51	40	8	9.40	6.74	7.29	3.70	5.88	3.46	7.74	4.17	47.85787	16.28928
47	SI00/04 - | s	SI00 s	50	35	15	8.80	7.14	7.28	3.77	5.78	3.61	7.71	4.53	47.85814	16.28917
48	SI00/04 - | s	SI00 s	53	40	5	12.60	5.50	7.36	3.71	5.82	3.50	7.67	4.19	47.85930	16.28950
49	PI s	PI s	49	49	1	6.80	5.10	8.13	2.04	6.83	2.22	8.13	4.70	47.86028	16.28982
50	PI s	PI s	64	33	2	8.40	7.44	7.86	2.50	6.46	2.54	8.00	4.57	47.86061	16.29104
51	PI s	PI s	74	20	4	14.00	8.40	7.87	2.31	6.70	2.33	8.03	4.41	47.86106	16.29127
52	SV58 yb | c	SV58 c	57	40	0	14.00	9.92	8.26	1.78	7.17	2.09	8.30	4.48	47.88032	16.28092
53	SV58 yb | c	SV58 c	67	25	4	8.80	4.26	8.19	1.93	6.81	2.22	8.19	4.63	47.87821	16.28414
54	SV58 yb | c	SV58 c	53	44	1	6.80	6.46	8.07	1.96	6.82	2.29	8.18	4.86	47.87975	16.28537
55	PV	PV	65	35	0	9.80	5.24	8.03	2.07	6.72	2.33	8.03	4.70	47.90914	16.29259
56	SV58	SV58	50	50	0	22.00	5.70	8.15	1.71	6.80	2.05	8.14	4.95	47.88652	16.28468
57	PV	PV	58	40	0	19.00	6.60	8.17	1.78	6.78	2.06	8.00	4.78	47.88546	16.28583
58	SV58	SV58	45	55	0	21.20	7.70	8.26	1.90	6.79	2.21	8.37	5.05	47.88908	16.28309
59	SV58	SV58	50	50	0	21.60	6.40	7.92	2.21	6.79	2.32	8.04	4.88	47.88975	16.28165
60	PV ob | s	PV ob	60	35	5	9.00	8.76	8.03	2.03	6.63	2.30	8.00	5.10	47.90788	16.31722
61	PI s	PI s	60	34	1	10.20	5.70	7.97	2.30	6.67	2.32	8.10	4.53	47.86172	16.29178
62	SV58	SV58	65	35	0	17.02	20.00	8.04	2.22	6.70	2.39	8.00	4.96	47.89363	16.27263
63	PV	PV	50	50	0	24.40	6.54	8.20	2.04	6.84	2.31	8.16	4.44	47.89445	16.27034
64	PV	PV	50	50	0	21.40	5.88	7.68	2.42	6.52	2.62	7.89	4.62	47.89300	16.26718
65	PV	PV	50	50	0	12.20	4.82	8.09	2.09	6.77	2.22	8.22	4.96	47.89417	16.26717
66	SV58	SV58	40	60	0	31.00	5.44	7.88	2.00	6.81	2.38	8.06	4.44	47.89230	16.26653
67	SV58	SV58	40	60	0	21.00	5.64	8.10	2.05	6.80	2.33	8.19	4.86	47.89201	16.26177
68	SV58	SV58	39	59	1	13.40	3.98	8.20	1.90	6.80	2.20	8.37	4.68	47.89151	16.26020
69	PI s	PI s	70	28	2	9.20	6.80	7.92	2.56	6.72	2.40	8.04	4.71	47.85643	16.28378
70	SV58	SV58	58	40	0	23.00	5.78	8.13	1.96	6.83	2.28	8.20	4.72	47.89089	16.25622
71	PV ob | s	PV ob	57	15	25	7.00	12.14	8.11	2.06	6.78	2.33	7.78	5.22	47.91205	16.32141
72	PV	PV	48	50	2	18.00	6.80	8.00	1.93	6.78	2.21	8.18	4.79	47.89858	16.27981
73	PV	PV	49	50	1	21.40	5.74	7.78	2.03	6.75	2.38	8.03	4.69	47.89952	16.27999
74	PV	PV	59	40	0	13.20	5.84	8.27	1.96	6.82	2.22	8.13	4.74	47.89745	16.28329
75	PV	PV	50	50	0	14.20	7.16	7.81	2.18	6.50	2.55	7.85	4.70	47.89732	16.28509

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
76	PV yb	PV yb	70	20	5	6.40	5.84	7.79	2.23	6.50	2.43	7.97	4.69	47.89789	16.28733
77	PV	PV	60	40	0	18.80	5.96	7.82	2.24	6.54	2.52	7.86	4.55	47.89700	16.28875
78	PV yb	PV yb	53	25	15	10.80	5.04	8.11	2.07	6.78	2.32	8.04	4.82	47.89811	16.28942
79	PV	PV	57	40	3	15.20	9.70	7.93	2.40	6.79	2.33	8.10	4.70	47.89992	16.28718
80	PV ob | s	PV ob	50	30	20	9.40	10.16	7.83	2.17	6.58	2.42	7.74	5.30	47.91340	16.33013
81	PV yb	PV yb	40	3	57	7.60	6.28	7.88	2.28	6.64	2.36	8.00	5.12	47.90285	16.28694
82	PV	PV	45	55	0	16.80	5.60	7.92	2.42	6.64	2.50	7.92	5.00	47.90541	16.28361
83	PV	PV	40	59	1	18.60	6.16	8.04	2.40	6.56	2.52	7.88	4.68	47.90478	16.28719
84	PV ob | s	PV ob	69	15	15	5.40	20.00	7.85	2.12	6.62	2.39	7.84	5.28	47.91440	16.32804
85	PV yb	PV yb	50	5	40	13.80	5.20	7.96	2.36	6.65	2.46	8.00	4.72	47.90499	16.28974
86	PV	PV	50	50	0	11.60	6.82	8.07	2.24	6.68	2.41	7.93	4.62	47.89975	16.29206
87	PV	PV	60	40	0	18.40	5.80	8.00	2.31	6.73	2.31	8.23	4.31	47.90967	16.28967
88	PV	PV	78	15	5	8.00	4.78	7.89	2.48	6.62	2.54	7.96	4.76	47.90027	16.29630
89	PI s	PI s	65	34	1	11.40	6.62	7.96	2.29	6.56	2.48	8.04	4.58	47.85349	16.28596
90	SI00/04 - | s	SI04	50	50	0	20.80	9.00	7.30	3.15	6.40	2.80	7.85	5.00	47.87003	16.30482
91	SI58 - | s	SI58	60	35	0	11.60	7.14	7.89	2.35	6.62	2.52	8.04	4.62	47.87158	16.31247
92	PV ob | s	PV s	65	25	10	11.20	8.86	7.79	2.45	6.66	2.50	8.00	4.76	47.89901	16.33800
93	PV	PV	58	40	0	10.40	6.86	7.97	1.97	6.79	2.24	8.07	4.83	47.91625	16.32600
94	SI08 - | s	SI08 s	60	10	30	13.40	5.12	7.15	4.06	6.09	3.54	7.79	4.49	47.86624	16.30668
95	SI08 - | s	SI08 s	77	2	20	27.00	8.20	6.79	4.68	5.86	3.76	7.93	4.89	47.86687	16.30692
96	SI00/04 - | s	SI04	40	60	0	26.00	7.60	7.71	2.44	6.54	2.64	7.82	4.56	47.86973	16.30588
97	SV58 yb | c	SV58 c	50	40	5	7.80	5.12	8.12	2.00	7.00	2.15	8.15	4.77	47.87702	16.28997
98	SI08 - | s	SI08	58	30	7	9.60	5.20	7.19	4.10	5.87	3.61	7.71	4.42	47.87061	16.31717
99	SI08 - | s	SI08	61	35	3	14.80	4.90	7.27	3.77	5.67	3.61	7.57	4.53	47.87036	16.31809
100	SI08 - | s	SI08	55	30	10	10.20	6.22	7.33	4.19	5.79	3.46	7.72	4.59	47.87080	16.31671
101	SI08 - | s	SI08	50	20	10	9.60	9.52	7.26	2.96	5.96	3.25	8.08	4.38	47.87142	16.31541
102	SI58 - | s	SI58	48	50	0	13.00	5.18	8.29	1.62	7.00	2.10	8.24	4.86	47.87259	16.31200
103	SI58 - | s	SI58	67	30	0	11.60	3.60	8.05	1.81	6.81	2.10	8.19	4.76	47.87305	16.30988
104	SV58	SV58	55	30	5	17.40	4.60	8.11	2.28	6.82	2.48	8.07	4.79	47.88626	16.31612
105	SV58	SV58	55	40	5	21.00	19.70	8.11	1.93	6.93	2.14	8.11	4.82	47.87681	16.30360
106	SV58	SV58	48	48	2	16.20	4.24	8.04	2.04	6.74	2.33	8.11	5.00	47.87761	16.29187
107	SV58	SV58	44	54	1	20.00	8.42	8.04	2.04	6.71	2.25	8.00	5.17	47.87931	16.29056
108	SV58	SV58	40	40	20	21.80	6.18	7.93	2.57	6.61	2.57	8.07	4.75	47.87766	16.29522
109	SV58	SV58	30	70	0	19.40	4.72	8.05	2.14	6.86	2.24	8.05	4.76	47.87937	16.29679
110	SV58	SV58	53	45	1	21.60	4.90	7.96	1.96	6.80	2.19	8.00	4.58	47.88180	16.28963
111	SV58	SV58	40	60	0	19.60	7.50	8.14	1.95	6.62	2.29	8.10	5.10	47.88375	16.29088
112	SV58	SV58	45	50	0	18.00	3.40	8.05	1.95	6.80	2.20	8.10	4.55	47.88301	16.29198
113	SV58	SV58	42	55	2	18.60	4.24	7.91	2.24	6.81	2.29	8.24	4.24	47.88106	16.29595
114	SV58	SV58	55	45	0	25.20	5.40	7.92	2.09	6.63	2.25	8.22	4.61	47.88365	16.30212

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
115	SV58	SV58	50	50	0	18.20	9.74	8.05	2.00	6.67	2.27	8.05	4.76	47.88543	16.30436
116	SV58	SV58	60	40	0	14.60	8.84	8.14	1.91	6.77	2.13	8.17	4.87	47.88388	16.30006
117	SV58	SV58	45	55	0	17.20	20.00	8.04	2.12	6.88	2.28	8.12	4.68	47.88299	16.29961
118	SV58	SV58	58	37	3	12.84	15.60	8.11	2.07	6.82	2.25	8.18	4.93	47.87553	16.29550
119	SV58	SV58	45	54	1	16.60	4.54	7.96	2.07	6.63	2.30	8.15	4.82	47.88031	16.29704
120	SV58	SV58	40	60	0	23.40	12.82	7.90	1.95	6.58	2.40	7.90	4.65	47.88677	16.28577
121	SV58	SV58	60	40	0	27.60	5.90	7.96	2.13	6.64	2.36	7.88	4.58	47.89010	16.30831
122	SV58	SV58	50	50	0	14.80	13.10	8.04	2.19	6.68	2.39	7.96	4.67	47.91662	16.31169
123	SV58	SV58	45	55	0	18.00	4.78	8.17	1.90	6.72	2.32	8.00	4.79	47.88486	16.28793
124	SV58	SV58	59	40	0	15.80	20.00	7.80	2.43	6.50	2.58	7.93	4.57	47.88677	16.30504
125	SV58	SV58	50	50	0	22.00	5.32	7.87	2.20	6.67	2.29	8.10	4.87	47.89531	16.32460
126	SV58	SV58	35	40	25	11.60	3.08	7.80	2.57	6.73	2.45	8.13	4.60	47.89584	16.31975
127	SV58	SV58	57	40	3	17.00	3.58	8.08	1.96	6.83	2.17	8.17	4.83	47.89593	16.31969
128	SV58	SV58	45	55	0	22.80	3.28	8.04	2.14	6.86	2.24	8.07	4.86	47.89714	16.32176
129	SV58	SV58	55	37	8	12.80	2.86	7.92	2.12	6.68	2.28	8.16	4.72	47.89738	16.32459
130	SV58 yb | c	SV58 yb	40	45	15	9.60	3.96	7.68	2.62	6.64	2.81	7.85	4.77	47.90282	16.30555
131	SV58	SV58	60	40	0	22.00	4.68	8.08	2.15	6.64	2.42	7.92	4.85	47.90353	16.30626
132	PV	PV	55	45	0	15.80	9.92	8.05	2.30	6.60	2.40	7.95	4.60	47.90556	16.31977
133	PV	PV	50	50	0	27.00	8.54	7.96	2.32	6.70	2.39	7.86	5.05	47.90832	16.32468
134	PV	PV	60	40	0	18.20	13.60	7.94	2.39	6.59	2.41	7.94	5.00	47.90838	16.32582
135	PV ob | s	PV ob	63	34	1	18.60	10.00	7.93	2.35	6.67	2.33	7.89	4.81	47.90988	16.32530
136	PV	PV	75	25	0	21.20	12.50	7.80	2.41	6.53	2.57	7.83	5.28	47.91050	16.32728
137	PV yb	PV yb	56	40	2	12.00	7.70	7.71	2.39	6.58	2.33	7.96	5.04	47.91122	16.32558
138	PV yb	PV yb	50	20	30	7.80	9.50	7.79	2.17	6.58	2.37	7.78	5.39	47.91256	16.32767
139	PV yb	PV yb	64	1	35	13.00	6.88	7.68	2.76	6.55	2.68	7.91	4.86	47.90988	16.33039
140	PV ob | s	PV ob	54	38	7	12.40	8.26	7.87	2.04	6.61	2.26	7.87	4.91	47.91024	16.32345
141	PV ob | s	PV ob	59	30	10	10.40	9.86	7.94	1.94	6.75	2.19	8.13	5.03	47.91009	16.32404
142	PV	PV	60	37	3	14.40	12.30	7.90	2.35	6.58	2.55	7.95	5.30	47.91561	16.33179
143	PV yb	PV yb	70	25	10	13.60	8.14	7.86	2.10	6.86	2.24	7.95	5.29	47.91293	16.32722
144	PV	PV	49	35	15	7.00	6.94	8.08	1.96	6.65	2.31	7.96	4.84	47.91812	16.33200
145	PV	PV	65	35	0	29.00	20.00	7.76	2.32	6.19	2.86	7.55	5.05	47.91706	16.32592
146	SV58	SV58	54	45	0	13.60	3.66	8.08	2.08	6.96	2.20	8.16	4.92	47.89795	16.30260
147	PV	PV	60	40	0	19.40	20.00	7.94	2.29	6.74	2.47	7.88	4.94	47.91638	16.32454
148	PV	PV	58	38	2	14.60	8.48	7.97	2.13	6.69	2.53	7.90	5.13	47.91866	16.32494
149	SV58	SV58	65	35	0	13.80	10.66	8.17	2.00	6.88	2.40	8.00	5.32	47.92036	16.32376
150	SV58	SV58	75	25	0	10.80	13.54	8.12	2.12	6.73	2.42	8.00	5.19	47.92018	16.32214
151	SV58	SV58	74	25	1	16.20	10.28	8.04	2.00	6.65	2.50	7.92	5.00	47.92009	16.32194
152	SV58	SV58	49	50	0	22.20	9.58	8.00	2.04	6.80	2.19	8.04	4.92	47.87755	16.29408
153	SV58	SV58	40	60	0	22.00	6.44	8.06	1.94	7.00	2.29	8.13	4.75	47.88435	16.30269

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
154	PV	PV	55	45	0	14.60	6.68	8.00	2.05	6.59	2.36	7.96	4.73	47.91773	16.32120
155	SV09 s | r	SV58 s	64	35	1	18.60	5.90	7.82	2.46	6.39	2.79	7.89	4.61	47.92194	16.31682
156	SV58 yb | c	SV58 yb	50	33	17	12.40	6.50	7.86	2.48	6.57	2.63	8.00	4.93	47.89991	16.29963
157	SV09 s | r	SV74/91 s	60	40	0	41.00	20.00	7.56	3.27	6.16	3.42	7.69	4.42	47.92146	16.31237
158	SV58	SV58	45	55	0	27.40	10.70	7.67	3.03	6.47	2.77	7.97	4.35	47.91886	16.31022
159	SV09 s | r	SV74/91 s	59	35	6	18.20	20.00	7.42	3.79	6.16	3.47	7.42	4.37	47.92318	16.31582
160	SV58	SV58	45	55	0	14.60	20.00	7.94	2.18	6.64	2.42	8.03	4.73	47.91837	16.31554
161	PV	PV	40	60	0	17.40	6.68	7.94	2.24	6.65	2.59	7.88	4.59	47.91748	16.31503
162	PV	PV	50	50	2	13.60	6.86	7.79	2.39	6.66	2.52	7.82	4.89	47.91731	16.31629
163	PV	PV	70	30	0	20.80	7.66	7.65	2.80	6.54	2.73	7.80	4.24	47.91587	16.31292
164	PV	PV	58	30	10	16.20	4.94	7.94	2.34	6.58	2.33	8.03	4.84	47.91335	16.31104
165	PV yb	PV yb	60	30	7	17.40	8.24	7.86	2.14	6.55	2.46	8.05	5.19	47.91309	16.31404
166	PV yb	PV yb	48	5	45	8.00	7.80	8.00	2.14	6.68	2.41	8.05	5.19	47.91363	16.31581
167	PV	PV	60	40	0	26.00	9.68	7.79	2.70	6.58	2.50	7.96	4.70	47.91177	16.31296
168	PV yb	PV yb	54	1	45	14.80	7.34	7.86	2.53	6.57	2.49	8.15	4.82	47.91141	16.31307
169	SV58	SV58	64	35	1	24.00	9.60	7.96	1.91	6.83	2.13	8.30	4.61	47.91414	16.30660
170	SV58	SV58	60	20	0	10.00	7.44	8.10	2.09	6.52	2.32	7.96	4.86	47.91541	16.30620
171	SV09 s | r	SV09 s	45	10	45	9.80	8.06	7.70	3.07	6.23	2.93	8.00	4.03	47.91975	16.30558
172	SV09 s | r	SV09 s	50	15	35	10.40	7.38	7.42	3.66	6.00	3.39	7.78	4.47	47.91798	16.30441
173	SV09 s | r	SV09 s	50	35	15	18.00	4.16	7.29	3.26	5.96	3.38	7.57	4.35	47.91762	16.30278
174	SV58	SV58	60	40	0	22.40	8.22	7.96	2.16	6.52	2.44	7.92	4.64	47.91686	16.30575
175	SV58	SV58	50	50	0	30.00	20.00	7.72	3.06	6.28	3.00	7.82	4.65	47.91324	16.30132
176	PV yb	PV yb	60	30	10	21.00	8.54	8.03	2.13	6.66	2.28	7.94	4.84	47.90951	16.30821
177	PV yb	PV yb	57	1	40	12.40	13.22	7.95	2.16	6.76	2.32	8.08	4.92	47.90848	16.30808
178	PV yb	PV yb	50	30	20	11.00	9.36	7.85	2.58	6.42	2.69	7.96	4.69	47.90823	16.31081
179	SV58	SV58	35	65	0	20.50	9.18	8.06	2.06	6.50	2.39	8.06	4.94	47.90580	16.30887
180	SV58	SV58	57	40	2	12.80	5.90	8.10	2.14	6.62	2.33	8.14	4.57	47.90527	16.30495
181	PV	PV	45	55	0	16.00	6.68	8.00	2.17	6.72	2.38	8.03	5.10	47.90588	16.30399
182	SV58	SV58	64	30	5	10.20	5.22	8.04	2.21	6.78	2.25	8.21	4.71	47.89959	16.30530
183	SV58	SV58	50	49	1	13.20	5.52	8.04	2.25	6.67	2.38	8.13	5.08	47.89741	16.30765
184	SV58	SV58	48	47	3	15.80	3.94	8.17	2.24	6.75	2.36	8.12	4.84	47.89976	16.30397
185	SV58	SV58	65	33	2	12.60	7.80	8.04	2.04	6.67	2.25	8.04	4.83	47.90498	16.30936
186	SV58	SV58	60	38	2	12.20	5.20	8.04	2.22	6.87	2.33	8.30	4.78	47.89087	16.32575
187	PV yb	PV yb	40	10	45	12.40	9.04	7.72	2.54	6.69	2.52	8.07	4.82	47.91159	16.30940
188	PV	PV	45	55	0	30.00	7.50	7.90	2.42	6.63	2.37	7.95	4.58	47.91585	16.31875
189	SV58	SV58	65	15	20	15.20	2.66	7.91	2.59	6.73	2.55	8.09	4.84	47.89697	16.31364
190	PV yb	PV yb	62	1	30	6.60	10.66	7.76	2.21	6.66	2.38	8.00	5.25	47.91445	16.32597
191	PV	PV	45	55	0	16.60	7.76	8.09	2.04	6.83	2.26	7.96	4.52	47.90546	16.32364
192	PV	PV	55	45	0	23.60	7.22	7.96	2.65	6.74	2.70	7.74	4.52	47.90553	16.32787

Nr.	Group	Relevé type	Vegetation cover of vascular plants in %	Cover of litter in %	Open soil in %	Mean vegetation height in cm	Mean soil depth in cm	R	N	T	F	L	K	Latitude (WGS84)	Longitude (WGS84)
193	SV58	SV58	60	38	2	10.00	3.64	7.94	2.13	6.68	2.29	8.07	4.87	47.89697	16.32992
194	PV	PV	40	60	0	25.00	7.24	7.89	2.30	6.63	2.56	8.00	4.96	47.91713	16.31983
195	PV	PV	50	50	0	20.20	8.46	8.17	1.87	6.79	2.21	8.09	4.78	47.91138	16.30731
196	SV58 yb | c	SV58 yb	60	5	35	10.40	10.18	7.86	2.57	6.61	2.71	7.96	4.54	47.91371	16.30925
197	PV yb	PV yb	50	47	3	22.20	9.52	7.82	2.71	6.68	2.64	7.96	5.11	47.90840	16.31966
198	PV	PV	60	40	0	13.20	6.26	8.07	2.03	6.93	2.28	8.17	4.90	47.90513	16.29470
199	PV yb	PV yb	63	5	30	11.20	5.64	7.79	2.38	6.63	2.32	8.13	4.75	47.89862	16.28690
200	PV	PV	55	44	1	15.60	4.82	8.05	2.00	6.91	2.22	8.05	5.05	47.89877	16.28283

Table 7 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Acer campestre–Carlina vulgaris*

Nr.	Ace. cam	Ach. col	All. sph	Aly. aly	Aly. mon	Amb. art	Ana. arv	Ant. aus	Ant. ram	Ant. vul	Ape. spi	Ara. hir	Are. ser	Arr. ela	Art. abs	Art. cam	Art. vul	Asp. cyn	Ast. aus	Ast. cic	Ast. ono	Ber. inc	Ber. vul	Bot. isch	Bro. ere	Bro. ine	Bro. jap	Cal. epi	Cam. sib	Car. aca	Car. hum	Car. lip	Car. nut	Car. vul
1										+		r		+				+							3				r			+		
2												+						+						+	3							+	r	
3																		r							3						2a			
4										r								+							3						2a	+		
5										r								+							2b							r		
6									+	r															2a						2a		r	
7		r								+								+		r				+	3				r		r			
8										+								+					r	1	3				+		+	+		
9															r			+							3				+			+		
10										+															+				r			+		
11										1		r													2a				r			+		+
12										1								+			+				2b				+					
13		+								+		r						+			r			1	2b				r			+		+
14																		+							3						+		+	+
15										1								+							2b				r		1			+
16		1								+				2a											2b		r	+						
17										1															1						2a	+		
18										2b								+						+	2a				r		+	+		
19			r															+						+	2b				+		1		r	
20																		+							3						1	+		
21									r									+							1				+		2b			
22									r									+						+					r		2a			
23		r	r							r		r						+						+	1				+		2a			+
24		2b											1	r	r										3					1				
25				+								r	+	1	1										+			2b		+				
26		+		r					r	r															1				+		2a		r	
27												+						+						+	1						1			
28										+								+							2b						2b			

Nr.	Ace. cam	Ach. col	All. sph	Aly. aly	Aly. mon	Amb. art	Ana. arv	Ant. aus	Ant. ram	Ant. vul	Ape. spi	Ara. hir	Are. ser	Arr. ela	Art. abs	Art. cam	Art. vul	Asp. cyn	Ast. aus	Ast. cic	Ast. ono	Ber. inc	Ber. vul	Bot. isch	Bro. ere	Bro. ine	Bro. jap	Cal. epi	Cam. sib	Car. aca	Car. hum	Car. lip	Car. nut	Car. vul
29			+	+						+								+							1				+		2a		r	
30			r							+		r						+							1				r		2b		r	
31				+						+								+							2a				+		2a			
32			r	1						+		+	+					+							3						2a	+		
33		+	+	+						+		+	+												2b				r		2a		1	
34				+						r		+													2a						2a			
35										r		r						+						+	2a				r		1			
36				+						+		r						+							1			2a			2b			r
37												r						+						+	3				r		2a			
38			r															+							2b						2b			
39		+	r	+						+		r						+							3				+		2b			
40		+		+						+		+						+							2b				r		2a	+	r	
41				+						+			r					+							1						2b			
42										1								+							3				+		1	+		r
43		+												r			r	+						r	3			+					r	
44										+		r						+							2a						2a			
45																		r	r		+			r	3			+	r					r
46		+								+				r			r								3			+						+
47										+				+				+							3			+						+
48										+				r											3			+					r	+
49									r	r								+						+	2b						2a	+		
50				+						r		+	+					+							2b						3		r	
51			r	+						+		+						+							+						3		r	
52			r															+							2b							+		
53																		+							3				r		2a	+		
54										r								+							1				r			+		
55										2b								+							3				+			1		+
56																		r							3							+		
57																		r							3						2b			
58										r		r						+						+	2b				r			+		
59										+								+							3							+	r	
60				r														+							r				r		3		r	
61				r					+	+								+						2a	2b						2b			
62																		+							3			+	r		+	+		r
63			r									r						+							2b							1		r
64																		r						r	2a							2b		r
65										+								+							2b				r			+	+	
66										r								+							3									
67										+								+							2a				r			+		+
68										+								r						+	+							+		r
69			r						r			r						+						1	2b				+		2a			
70					+					+								+			+				3				r			+		
71																		+											+		2b			
72			+							+								r							3				+		2b	+		
73			r		r					r								+							3				r		2a	r		

Nr.	Ace. cam	Ach. col	All. sph	Aly. aly	Aly. mon	Amb. art	Ana. arv	Ant. aus	Ant. ram	Ant. vul	Ape. spi	Ara. hir	Are. ser	Arr. ela	Art. abs	Art. cam	Art. vul	Asp. cyn	Ast. aus	Ast. cic	Ast. ono	Ber. inc	Ber. vul	Bot. isch	Bro. ere	Bro. ine	Bro. jap	Cal. epi	Cam. sib	Car. aca	Car. hum	Car. lip	Car. nut	Car. vul
74										3								+							3				r		2b			
75		+							+	2a															2b				+		1	1		r
76					+				+	1			r					+							2b				+		2a			
77									+	+								r							3						1	+		
78																		+							2b				+		2a	+		
79										+								+							3				r		+	+	r	
80									r									+											+		2a			
81			r							+								r							+				+		+	+		r
82										+								+							1				+		2b		r	
83									r																2a				r		2b			
84					+													+						+							2b			
85			+							r								+							1				+		2b			
86										1								+							3				+		2a	+		r
87			+							r								+							3									
88									r	3								+							2a						2a	r		
89				+						+		r						+							1						2b			
90		r													r										3									
91										+		r		r										+	3							+		
92										1		+						+			r				1				r		2b		r	
93			r							1								+							2b						2a			
94		1								+			+	1	r						r				+								r	
95													+	1	2a							+								+				
96		r																r							3			r			+	+		r
97										+		r						+							2a						1	+		
98		+						+					+	2a											+								+	
99		+						r				r	+									r			1								r	+
100		+						+					+	1											1								+	+
101		+								+			+												3								+	
102																					r				3							+		
103		+										r						+							2a							+		
104									r	+								+						+	2b				r		r	+		
105										+								+							1				r			2a		
106										+						r		+							3				r		1	+		
107																		+						+	2b				r			+		
108		r								+								+							2b							+		
109										r								+							3							+	r	
110																		+							3						2a	1		
111										r		r						+						1	3						1	+		
112										r								+							3							+		r
113			r							r								+							3							+		r
114		+								r								+							2b							+		
115										r								+						r	3									
116									+			r						+						+	2b						2b	r		
117										+		r						+							2b							+	r	+
118																		+						1	3						2b	+		+

Nr.	Ace. cam	Ach. col	All. sph	Aly. aly	Aly. mon	Amb. art	Ana. arv	Ant. aus	Ant. ram	Ant. vul	Ape. spi	Ara. hir	Are. ser	Arr. ela	Art. abs	Art. cam	Art. vul	Asp. cyn	Ast. aus	Ast. cic	Ast. ono	Ber. inc	Ber. vul	Bot. isch	Bro. ere	Bro. ine	Bro. jap	Cal. epi	Cam. sib	Car. aca	Car. hum	Car. lip	Car. nut	Car. vul
119		+								r								+							3							+		
120																		+							3						2a			
121																		+							2b						+			r
122										+								+							3				+		r			r
123										+								+							3							+		
124																		+							3			1				1	r	+
125		r																+							2b							2a		
126										r								+							2b							+		
127																		+							3						+	+		
128																		+							3						1	1		
129		+			+					2a								+						+	2b						2a			
130									r	r								+						r	2b				1		2a		+	r
131					r					2b								+						+	3						1	r		+
132									+									+							3				r		2a			
133			r						+									+							3						2a			
134									+	r								+						r	3				r		3		r	
135			r						r									+							2a				r		2a		r	
136									1																				+		1	+	r	
137			+						+									+											r		2b		r	
138																													+		2b			
139									2a																				+		2b		1	r
140																		r											+		2a			
141			r										+					+											+		2b			
142																		+							3						1	r		
143			+																										+		2b			
144																		r							2b						1			
145		+																r							2a	1					1			
146										+								+							2b				r			r		
147									r									+						+	3						2a			
148		+								r								+	r						3						2a			+
149																		r							3						1	+		
150																		r							2b				r		1	+		
151																		+							1				+		2b			
152										r								+							2b							+		
153																		+							2b							1		
154									+									+							3				+		2a			r
155		+																+			+				2b				r					r
156										r		r						r							3				+		+	+	+	
157		r			+						+			+				+							3									r
158												+		+				+							3					r				r
159	+																								3	+		+						+
160		r								+								+							3				r		r			+
161												r													3						1			r
162									+			+						+							1				+		2b	+		
163																		r							3						+		+	r

Nr.	Ace. cam	Ach. col	All. sph	Aly. aly	Aly. mon	Amb. art	Ana. arv	Ant. aus	Ant. ram	Ant. vul	Ape. spi	Ara. hir	Are. ser	Arr. ela	Art. abs	Art. cam	Art. vul	Asp. cyn	Ast. aus	Ast. cic	Ast. ono	Ber. inc	Ber. vul	Bot. isch	Bro. ere	Bro. ine	Bro. jap	Cal. epi	Cam. sib	Car. aca	Car. hum	Car. lip	Car. nut	Car. vul
164			+						+	+								+							3				r		1		r	
165			r															+							2b				r		2a			
166																		r											+		2a			
167									r									+							3						1		+	
168			+						1				+					+							1				+		1		r	
169										+								+							3				r			+		
170										1								+							3						r			
171		+								+				1				r							2b								r	r
172		+								+				+										+	2b			1				r	r	
173		+								r		+		2b											+									
174									r	+								+							3				+		1	+		+
175		r										r		+											3								r	
176									r									+							2a				r		2a			
177			r		+							r						+							2b				+		2a		r	r
178													+					r							3				+		2a		r	
179										+								+							3						2a			
180										r		r						+							2a				r		3			
181										+								+			+				3						1	+	r	
182									+	2a								+							3				+		1	+		
183												r						+						1	2a			1				r		
184										1		+						+							3			+	+		r	+		
185									r	3															2a						2a	+		
186						r				r								+						r	3									
187			+						r									r							+				+		2a		r	
188																									3						2a		r	
189							r			r								+						+	3				+			+		r
190					+					r								+						+					+		2b			
191																		+							3						1			r
192									1									r							2b						2b		r	r
193									r	1								+						+	3				r			+		
194			r		r													+							3				r		1			r
195			+															+							2b						2b			
196										+								+						+	2b						2a			
197			r										r					+							2a				r		2b		+	
198			r							1								+						+	2b				r		+			r
199													r					+							3				+			+		
200										+									r						3				r			+		

Table 8 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Centaurea jacea–Fallopia convolvulus*

Nr.	Cen. jac	Cen. sca	Cen. sto	Cer. glu	Cha. rat	Che. alb	Cho. jun	Cic. int	Cir. arv	Cir. vul	Cle. vit	Cli. aci	Con. arv	Con. reg	Cra. mon	Cre. bie	Cre. foe	Cus. epi	Cya. tri	Dac. glo	Dau. car	Dor. ger	Ech. vul	Ely. his	Ely. rep	Eri. acr	Eri. ann	Eri. can	Eru. nas	Ery. cam	Ery. dif	Eup. cae	Eup. seg	Fal. con
1					r																+										+		
2			+																			1							r					
3					+																	1											
4					+																	+								r			
5																						1											
6					1																	r											
7			+																			+						+			r		
8																						+						r					
9					1								r					r				+						+					
10																						1											
11			r																			+										+		
12																						2a						+					
13			r																			1								r			
14																						+						1					
15																	r				+	r						r					
16		1	r					r					+										r	2a					r	r	r			
17			r																			+										r		
18					+																	+											
19																						2b								r	r	+		
20					r												r				1											
21					+																	+						1			+		
22					+																	1								r			
23					+																	+						r	r		+		
24			r				r							+			r			+	+		+				+			+				
25				+		r						r	+										r							+				r
26			+	r	1																	+											
27				r	+																	+										+		
28			r																			+						r					
29			r		+																											+		
30					1																	+										r		
31			+	+	+																	r								r		r		
32			+	+	+																		r									r		
33			1	1	+																	+								r			
34			1	+	1																	+								r			
35			r	+	+																	1	r							+		+		
36					+												r				+								r		+		
37					1												+				+										+		
38					+																	+										+		
39			1	+	+																	+	r							1		+		
40			2a	+	+							r										r								+	r	+		
41			+	+	2a																	+								r			
42																						+						r					
43		r	+														r				r						+			+				

Nr.	Cen. jac	Cen. sca	Cen. sto	Cer. glu	Cha. rat	Che. alb	Cho. jun	Cic. int	Cir. arv	Cir. vul	Cle. vit	Cli. aci	Con. arv	Con. reg	Cra. mon	Cre. bie	Cre. foe	Cus. epi	Cya. tri	Dac. glo	Dau. car	Dor. ger	Ech. vul	Ely. his	Ely. rep	Eri. acr	Eri. ann	Eri. can	Eru. nas	Ery. cam	Ery. dif	Eup. cae	Eup. seg	Fal. con
44	r		+	+	+							+										+								+	+	r		
45			r										r									+	r				r							
46			+										r				r					+	+											
47			r																	+		1	r								r			
48			+																			1	r				+							
49					+																	+										+		
50				+	1																	+										+		
51			2b	r	+																	+	+											
52					+													r				2a								+		+		
53					+																	+								r				
54					+																	+								+				
55																		r				+												
56					1														r															
57					+																	1												
58																						1										r		
59			r		1																	+	r							+		r		
60					+																	+										r		
61			+		+																	1								+		+		
62																						2a												
63			r																			+							r			r		
64													r									1	r											
65																						1												
66																						+												
67																						1										+		
68			r																			+												
69				r	1																	+										+		
70																														r	r			
71					r																	+												
72																						+								+		+		
73					+																	+												
74																						+										r		
75																		+				+								+	r	r		
76				r																		+										+	+	
77					+																	+	r									r		
78				+																		+							r		r			
79																						+	r								+	r		
80			r		r																	+										+		
81																						+												
82																						+							+			+		
83																						+							+			+		
84			r		r																	+												
85			+		+																	+							r			+		
86																						+										r		
87																						+	r											
88			r																										+		r	r		

Nr.	Cen. jac	Cen. sca	Cen. sto	Cer. glu	Cha. rat	Che. alb	Cho. jun	Cic. int	Cir. arv	Cir. vul	Cle. vit	Cli. aci	Con. arv	Con. reg	Cra. mon	Cre. bie	Cre. foe	Cus. epi	Cya. tri	Dac. glo	Dau. car	Dor. ger	Ech. vul	Ely. his	Ely. rep	Eri. acr	Eri. ann	Eri. can	Eru. nas	Ery. cam	Ery. dif	Eup. cae	Eup. seg	Fal. con
89			r	r	+																	+								+	r	r		
90																				r										+				
91			r		r																	r								r		+		
92			2a		1								+		r							1	r							+	r			
93					+																	+												
94			+				r						+	+			r			+	+		r				1			+				
95			r				+		r				+				r			2b	r		+		+		+	+		1				
96			+		+																	+								+				
97					1													r												r		r		
98							+					+	+				r			+							r			r				
99			r									+	+							+					2b		r							
100			r				r			r		+	+							2a						+								
101												+								+						r				+	+			
102					+													r				+								r		+		
103					+													r				2a								+		1		
104																		r				+							r	r				
105			r		r																	+										r		
106	+				+																	+												
107					+																	+										r		
108																						+							r	+	r			
109					+																	r								+				
110					+																	+												
111					+																	r												
112					+																	+										+		
113																						1	r											
114			r																			2a								r				
115			r																			2a										r		
116					1																	r								r				
117					+																	+								+				
118					+																	+								+				
119					1													r				r								+		r		
120					1																									r				
121			+																			+								+				
122			+																			1								+				
123					+																													
124			+		r							r	r						r			1								r				
125			r																			1	r							+				
126			+																			1	r						r	+				
127			r																			1								1				
128			+																			2a								+				
129				r	1													r				r								+		r		
130																						+							r					
131		+																				+										+		
132																						1										r		
133			r		+																	+									r	r		

Nr.	Cen. jac	Cen. sca	Cen. sto	Cer. glu	Cha. rat	Che. alb	Cho. jun	Cic. int	Cir. arv	Cir. vul	Cle. vit	Cli. aci	Con. arv	Con. reg	Cra. mon	Cre. bie	Cre. foe	Cus. epi	Cya. tri	Dac. glo	Dau. car	Dor. ger	Ech. vul	Ely. his	Ely. rep	Eri. acr	Eri. ann	Eri. can	Eru. nas	Ery. cam	Ery. dif	Eup. cae	Eup. seg	Fal. con
134			+		+																	1										+		
135			+		+																	1										+		
136			2a		1																	2a								2a	r	+		
137			r		+							r										2a												
138			r		r																	+										+		
139			1																			3							+					
140					r																	1										+		
141			r	r	+							r										1								r		r		
142																						1								+		+		
143					+																	+												
144			+		r																	+								+				
145					+																	1												
146																						1								r				
147					+																	2a							r	r	r			
148					+																	+								+				
149					+																	1								+				
150																						1								+				
151																						+										+		
152					+																									r		r		
153			r																			1								r				
154																						+												
155			+										r									2a					r			+	r			
156			+																			1										+		
157															1							2a								+	+			
158			r										r									+	+						+	+				
159							+		r		2a		r		+																			
160																		+				+								+				
161					+																	1							r					
162			+		+																	2a							+					
163			1		r																	2b	r						+	+				
164			r												r							1								r				
165			+																			1								+	r			
166			+		r																	1							r		r	r		
167			+		r																	1	r						r	r	r			
168	r		r	+																		1							r	+				
169												+										+								r				
170																						+												
171		+	r										+		r							+		+					+	+				
172			+										+							r				+					r		r			
173		+	+										+			r					+													
174																						1												
175			1										+																	+	r			
176			+		+																	+								r	r			
177					+																	1								+	+			
178				+																		1							r		r	+		

Nr.	Cen. jac	Cen. sca	Cen. sto	Cer. glu	Cha. rat	Che. alb	Cho. jun	Cic. int	Cir. arv	Cir. vul	Cle. vit	Cli. aci	Con. arv	Con. reg	Cra. mon	Cre. bie	Cre. foe	Cus. epi	Cya. tri	Dac. glo	Dau. car	Dor. ger	Ech. vul	Ely. his	Ely. rep	Eri. acr	Eri. ann	Eri. can	Eru. nas	Ery. cam	Ery. dif	Eup. cae	Eup. seg	Fal. con
179					+																	+									r	+		
180																						+												
181																		r				+										r		
182																						1	r									r		
183																						2a								r				
184																						2a												
185																						+												
186			r																			1								r				
187			r																			1	r						r	r				
188																						1	r									+		
189			+		r																	+							+					
190			+		+																	1												
191																						1								+		+		
192					+																	1							r	r				
193			+									r										+												
194					r																	1							r	r				
195			+		+																	+								r	r			
196					1																	r	r						+	+				
197					+																	+							2a	r	+	+		
198																						+								r				
199			+	+																		+	r								r			
200			r																			+												

Table 9 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Festuca pseudovina–Lathyrus tuberosus*

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
1				1			+			+			1	+	+																	+		
2				1		+	+			+			+		+				r												r	r		
3				1			+			+			1		+																			
4				2b			+			+			1	+	1																	r		
5				+			+			+			1		+									r		r								
6				2b			r			+			+		r									+										
7				+			+			+			1		+																	r		
8				1			+			r			1		+									r										
9				+			+						1	r	1				+					r								+		
10				2b			+			+			1	2a																				
11				1			+			+			+	2a	+										+									
12				2a			+						1		2a				r													2a		
13				1			+			+			+	+	+											+						r		
14				1						+			+	1	r									r		1							r	
15				1			+			+			+	2a	+			+								r						r		
16			2a			2a																										+		

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
17				2a			+			+			1	2a	1																			
18				1			+			+			+	+																				
19				r						+				+				r														+		
20				+			+			+			+	1	+									r		r						r		
21				+					+				+		r			r								r								
22				+					+	+			2a					+						+			r					+		
23				2b											+				1															
24			+																							+								
25	+			1											+			r						+		+						+		
26				3						+	+								1					r										
27				1			+			+																								
28				1						r			r	1	+				+					r										
29				2b											+				+					+										
30				3						+					+				r					+										
31				2b						+									+															
32				2b						+														+										
33				2a						+				+					1					r										
34				2b						+					+									+										
35				3			+			+				1					+					r										
36				1			+			+									+															
37				1										+	+				r					r										
38				2a			r							+	+				1															
39				+						r					+				+					+								+	r	
40				1						r					+									+										
41				2b						+														r										
42							+			+	1		+	+	+			r							+									
43										+								r	r					+		r						1		
44				2b						+					+																			
45				+														r						r								2a		
46				2b															+					+										
47				+															1					+										
48				r														r	+					+										
49				1			r			r				2a	+																			
50				1						+														+								+		
51				+						+					2a									+										
52				1			+			+			+	1	+																			
53				2a			+			+			+	+	1				+					r								+		
54				2a						+			1	1	+				+					r										
55				1			+			+			1	1	+											r								
56				1			+			1			1	+	+																			
57				+			+			+			+		+																			
58				2a			+			+			1	1	1																			
59				1						+			1		1									r								r		
60				1					2a	+			+	1	+			r						r								r		
61				+			r			+			+		+									r										

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
62				1			+			+			1		+									+		r								
63				1			+			1			+	+	+									r										
64				+						+	1		+		+											r								
65				+			+			+			+	+	1			r																
66				+			+			+	+		+		+															r				
67				+						+			+	1																				
68				r			1			+			+	1	+																			
69				2a						+									+															
70				2a			+			1			1		+																	+		
71									2a	r			r		+									r										
72				1			r			+			+	1	+			r						r										
73				2a						+	+		+	2a	1			+						r										
74				r			+			+			+	2a	+																			
75				+			+			+	r		+	2a	+			+	+						+	r								
76				r						+	1		+	3	+									r	+									
77				r			+			+	1		1	2a	+									+										
78				r			+			+			+	+	+								+	r										
79				r			+			+			2a						r					r	r									
80				r					1	+			2a					r	r					+		r		r				+		
81										+			+					+	r															
82				1			+						+					r																
83				r			+			+			+	1	r				r							+								
84				1					3	+			+		r			r	+								+	+				r		
85										+			2a	+				r	1															
86				+			+		+	+			+	+									+			r								
87				2a			+		+	+			+	+	+										+									
88				r					r	+			+	3	+									r										
89				2b						+				r										r										
90										1					+									r										
91				2a						+			+		+			+	+	+				r								+		
92				1						+								+						+								+		
93				2a			+			+	1		+	+	+												+	2a						
94		3																+								r								
95			2b									+														+								
96							+			+														+		+						+		
97				2a						+			1		+																			
98		3																			+	+		r		+							+	
99		2b						r												+		+		r		+								
100		3						+										r				+				2a							r	
101								r											r	+		+				+								
102				2a			+			+			+		1																	+		
103				2b			+			+			+		1				+					r								+		
104				2a			+			+			2b	1	+																			
105				2b			+			+			1		+				+					r								+		
106				2b			+			1			+		1																	r		

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
107				2a			+			+			1		+									r										
108				2a			+			+			+		+									+								+		
109				+			+			+			+		+									r										
110				1			+			+	+		1		+																			
111				+			+			+			+	+	+																			
112				1			+			+			1		+									r										
113				2a			+			+			1		+									r										
114				2b			+			+			+		+									r										
115				1			+						1		+									+		r						r		
116				r			+			+			+	+	+																			
117				+			+			+			1		r									r		+						r		
118				+			+			+			+		1																	r		
119				1			r			+			+	1	+									r								r		
120				+						+	+		+	1	+																	r		
121				2a		+	+			1			1		1				+					+										
122				+			+						1		+									+		r								
123				+			+			+			+	2a	+																			
124				1			+			r			+		r									+		r								
125				1			+			+			+		+	+								+								+		
126				+			+			+			+		r									r								r		
127				2a			+			+			1		+									r								r		
128				2a			+			+			1		+									+								r		
129				1			+			+			+		+																			
130										+	1							r														+		
131				1						+			1		+				2a									r						
132				+			1			+			1	1																				
133										+														r								+		
134				1						+				1	r									r								r		
135										+			1										r	+								+		
136									r	+			r					+						+		+						+		
137				+					r	+								r						+								1		
138				r					1	+								r						+								r		
139										+			r					+						r					1					
140										r			+					+					+	+		r						1		
141				r						r				1			r	r					+	1								r		
142				r					+				1											+			+	1				1		
143				+					2b	+								+														2a		
144				2a					1	+			2a	r	+				+							+		1				r		
145									r		+				+	+											2a	2b						
146				1		+	+			+			1		1																			
147							r			+			+		+									r		r	r	+						
148				r	r				1	+			+						+								1	2b						
149				+			r		1	+			1		1												+	3			r			
150				2a					+	+			+	1	1									r			1	3			+			
151				2a						+	1		+	+	+				+								1	3			+	r		

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
152				2b						+			1		1									+										
153				1			+			+			+											+										
154				+						r			+	1				r																
155				2b		+				1			r						+													+		
156									1	+			+	+				+		+				+								+		
157										1														r								2a		
158				+			+			+					+			r						+	+	+						+		
159				2b		2a				+																r						+		+
160				1			+		r	+			+		+									+		+	+					r		
161				r						+			+					r														r		
162				1						r								+	r					r		r						+		
163				+			+			+								+						r		r						+		
164				r		+	r			+			1		+	r		r														r		
165				r						+			1	+				+						r								2b		
166										r			1	+										+								+		
167										+			+											+										
168				+					r	+			1	+				r					+	r	r							1		
169				+			+			+			2a		1									+								+		
170				2a		+				+			+	2a	+																			
171		+											r																					
172		2a	+			+	r												+						+									
173			+			2a																		r		r								+
174				1						+			2b	1	+			r						+	+									
175				1		+				r			r				r		r					r		r						+		
176				2a			+			+			+	1	1									+								+		
177				+						+			+	2a				+					+	r	+	r						+		
178				+						r			+	1					+				r	+								1		
179										1			r	+																		r		
180				1			+			+			1	2b	+																	+		
181				+						+			+		r																	+		
182				1			+			+			1	2a	+																			
183				1		2a	+			+			+		+									r								+		
184				1			+			+			2a	1	+				+															
185				1			+			+			1	1	+									r								+		
186				2a		r	+			+			1	+	+																			
187				+						+			+					r						r								+		
188				+			+			+			+					r							r							+		
189				2a			+			+			2a	+	1									r			+				+			
190				+					2a	+			1				r	r	+					+								+		
191				r			r			r			+		+											r								
192				+			+			+															r	r						r		
193				1			r			+			1		+									+										
194				+						+			+	+				r						r										
195				+						+			+	1											r							+		
196										+			+											r		r						r		

Nr.	Fes. pse	Fes. rub	Fes. rup	Fes. str	Fil. vul	Fra. vir	Fum. pro	Gal. alb	Gal. lin	Gal. luc	Gen. pil	Ger. pus	Glo. bis	Glo. cor	Hel. can	Hel. num	Hes. tri	Hie. ech	Hie. hop	Hie. pil	Hie. pld	Hol. umb	Hor. pet	Hyp. per	Ibe. pin	Inu. con	Inu. ens	Inu. hir	Inu. ocu	Jug. reg	Jur. mol	Koe. mac	Lap. squ	Lat. tub
197				r					+	+							r	+										1				r		
198				+			+		+	+			+		+			r																
199				+			+			+			1											+	r									
200				1			r			+			1		1										r									

Table 10 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Leontodon hispidus–Polygonatum odoratum*

Nr.	Leo. his	Lep. cam	Lin. aus	Lin. ten	Lin. vul	Lot. cor	Med. fal	Med. lup	Med. min	Med. pro	Med. var	Mel. cil	Mel. off	Mel. tra	Mic. per	Min. set	Mus. neg	Ono. pus	Oro. gra	Pet. pro	Pet. sax	Phl. nod	Pic. hie	Pim. sax	Pin. nig	Pla. lan	Pla. med	Poa. ang	Poa. bad	Poa. com	Pol. ama	Pol. avi	Pol. odo
1						+				r		r						+												r			
2				+								r							r														
3												+					+		r					r									
4																		+															
5				r																													r
6																			r														
7				+								+														+							
8				+								r												r									
9												+							r														
10																			+														
11				r						r									+					r									
12																		r	r					r									
13						+													+					r									
14												+							r														
15												+							r														
16		+				1							r							+			+	+		+		1		+			
17						+																											
18												1							+														
19												+																					
20												r							r														
21										r		r							r														
22												r																					
23				+		+						+					+									r							
24						+		+	+		+	+	+							+		+	1										
25												+														+		2b					
26	r	r		+		+											+																
27												+																					
28				r								r					+																
29				+						r		1					+		r					r									
30				+		+				r		+			r		+		r														
31				+		+						+			+		+																
32		r		+		r						1					r			+													
33	r	+		+								+			+		+							r									
34		r		+						r		r			+					+													

Nr.	Leo. his	Lep. cam	Lin. aus	Lin. ten	Lin. vul	Lot. cor	Med. fal	Med. lup	Med. min	Med. pro	Med. var	Mel. cil	Mel. off	Mel. tra	Mic. per	Min. set	Mus. neg	Ono. pus	Oro. gra	Pet. pro	Pet. sax	Phl. nod	Pic. hie	Pim. sax	Pin. nig	Pla. lan	Pla. med	Poa. ang	Poa. bad	Poa. com	Pol. ama	Pol. avi	Pol. odo
35				r								+					+							+									
36				+		+						+					r							+									
37	r			+		r				r		+					+		r							r							
38				+								+					r																
39	+									+					r		1				+					+			r				
40				+													+				+					r							
41												+																					
42				r		+						+							+					r									
43					+	2b		+	+		+		1						r				+			+		+					
44		r										r																					
45						+		+	+											r			+			+		1					
46						+		r	+		+									+			+			+							
47					r	1		r			r		r										+										
48						1		+	+				r					+		+			+			r		r					
49				+		+						+					r																
50		+		r								1					+	r		+						r							
51				+		+						+					+		r	+													
52				r		r						r					r		r						+								
53				r								+						+	r					r									
54	r			+													r	+	r														
55												+						r	r					r									
56												+												r									
57												r																					
58																																	
59																			+					+									
60										+		r							r														
61		+		+		+						r					r			r				r									
62				r																													
63												+					r	r	+					+									
64					+	r													r					+									
65												+							+					r									
66												+																					
67												r							r					r									
68												r																					
69				+		r						+					+									+			+				
70																		+		+	+			r				+					
71																			r														
72						+						r							+		+			r									
73						+						r					r	+	r		r												
74				r						+									r					r									
75						+													+				r	+									
76				r		+						+							r					r							+		
77						r													r					+							r		
78						+						+									r			+									
79				r		+						+							r		+			+									

Nr.	Leo. his	Lep. cam	Lin. aus	Lin. ten	Lin. vul	Lot. cor	Med. fal	Med. lup	Med. min	Med. pro	Med. var	Mel. cil	Mel. off	Mel. tra	Mic. per	Min. set	Mus. neg	Ono. pus	Oro. gra	Pet. pro	Pet. sax	Phl. nod	Pic. hie	Pim. sax	Pin. nig	Pla. lan	Pla. med	Poa. ang	Poa. bad	Poa. com	Pol. ama	Pol. avi	Pol. odo
80										r																							
81												r																					
82												r							r					r									
83												r																					
84																																	
85												+							r														
86						r						+							+					r									
87		r										+							+		+												
88				+		+						+														r							
89		r		+		+													r							r							
90														+												r		1					
91										+							r		r							+							
92						+						+						r	r					r									
93				r						r		+							+														
94						+		+	+			1	2a							+		+	1			r						r	
95					+			+			1		+							+			+			2a							
96						+						+								r	r					+		+					
97				+		r						r						r	r														
98						+		1	2b				+							+			+			+							
99					+	+		2b	+				+							+			1			r	+	+					
100						+		1					1							+			1			+	+	+					
101			r			2a		+	+											+			+			+							
102																		r	r														
103												+							r														
104				r															r					r									
105										+		+					r	+	+					r									
106																		+	r														
107																																	
108								r											r														
109						r													+														
110				r								r					r		r					r									
111																																	
112												r							r														
113												r							r														
114									r			r																					
115																			r					+									
116												r												r									
117												r						r	r														
118		r			r					+		r												r									
119		r										r							r														
120												r							r					r									
121												r							r														
122										r									r														
123																								r									
124					r	r													r					r									

Nr.	Leo. his	Lep. cam	Lin. aus	Lin. ten	Lin. vul	Lot. cor	Med. fal	Med. lup	Med. min	Med. pro	Med. var	Mel. cil	Mel. off	Mel. tra	Mic. per	Min. set	Mus. neg	Ono. pus	Oro. gra	Pet. pro	Pet. sax	Phl. nod	Pic. hie	Pim. sax	Pin. nig	Pla. lan	Pla. med	Poa. ang	Poa. bad	Poa. com	Pol. ama	Pol. avi	Pol. odo
125				+																	r			+		+							
126				+		+						r									r			r									
127				+		+															r												
128				+		r													r		r			+									
129																										r							
130						r						+							r					r									
131																			r					r									
132												r							+														
133		r																	r														
134										+		r							+														
135												+							r														
136		+																										1					
137												+							r														
138																																	
139												2a																					
140												+							+														
141				r								1							+														
142																								+									
143												+					+																
144				+		r						+																					
145						r																		+									
146				r		+						+							+					r									
147																			r														
148												r												+									
149																								r			r						
150																			+														
151						+													+					r									
152												+						+	r					r									
153						r												r	r					r									
154												r							r														
155									+			r						+	+					+				+					
156												+							+		+			+									
157						r		+										r	+					+									
158												+							r				+										
159									+			r																+					
160						+						r						+	r											r			
161												r							r														
162										r		1							+														
163												+							+														
164				r		r						+																					
165										+		+											r										
166				r								+																					
167						+						+																					
168										+		2a				+																	
169												r							+		+												

Nr.	Leo. his	Lep. cam	Lin. aus	Lin. ten	Lin. vul	Lot. cor	Med. fal	Med. lup	Med. min	Med. pro	Med. var	Mel. cil	Mel. off	Mel. tra	Mic. per	Min. set	Mus. neg	Ono. pus	Oro. gra	Pet. pro	Pet. sax	Phl. nod	Pic. hie	Pim. sax	Pin. nig	Pla. lan	Pla. med	Poa. ang	Poa. bad	Poa. com	Pol. ama	Pol. avi	Pol. odo
170												r												r									
171	r					+				r		2b					r						r			+				+			
172	r	+				r						2b	r										+			+		+		+			
173														r									r			+		2b		+			
174												+							r														
175												+	r																				
176										+		+							r														
177				+		+				+		+				r			r														
178												1																					
179												r																					
180												+									+												
181						r				r		r							+		+												
182				r		+						+							r					r									
183																									+								
184						r						r							+					r									
185						+						+							r														
186				+								r												r									
187												+																					
188																			+														
189				+		r						+														r							
190				+								+																					
191												1							r														
192												+							+														
193				+		+				r									1							r							
194							r					r																					
195										+		+							r														
196										r		+							r														
197												1							r														
198						+						r							r		+			r									
199						r						+												+									
200						+												r						r									

Table 11 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Potentilla argentea* (s. lat.)–*Stipa pennata* agg.

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
1																									+									+	2a
2		+															+		r					r	r	+								+	2b
3		+															+						r		+										+
4		+															+						r		+									r	2a
5		r															+																	+	2b
6		1															+	+		r			r		+									+	2b
7		1															+		r				r		+									+	2b

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver
8		2a						r								
9		1						r								
10																
11		+														
12		+														
13		+														
14																
15		+														
16																
17		+														
18		+														
19		+														
20		1														
21																
22		+														
23																
24													+			
25		1						r						r		
26		+						r								
27																
28		1														
29		+													+	
30		1														
31		1													+	
32		1														
33		2a						r								
34		3														
35		+														
36		1														
37		2a														
38		2b														
39		1	r													
40		+														
41		1														
42		+														
43																
44		1														
45									r							
46																
47																
48																
49		2a														
50																
51		2a														
52																

Nr.	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
8	+		+						+									+	2b
9	+								+									+	3
10		r					r		r									+	2b
11									+									r	3
12	+																+	+	2b
13	+						r		+									+	2b
14		+					r		+										+
15		+					r		+									+	2b
16	1					+					r								
17		r							+									+	2b
18		1		r					+									r	3
19		+		+			r		+									+	1
20	r		r					r	+									r	1
21		r		r									r					1	2b
22		r							+									+	2b
23	+		+				+		+									2a	2b
24			r			2b					+								
25	2a		+			r	+											r	+
26	+		r				+		+										3
27	+								r									+	3
28	+						+		+									+	2a
29	+						+		+									+	2b
30	+			r			+		+										1
31	1						+		+									+	2b
32	1						+		+									r	2a
33	1	+		r		r	+		+									1	1
34	1						r		+									+	1
35							+		+									+	2b
36	+						r		+									+	3
37	1	r		r					1									1	2b
38	+						+		r									2a	2b
39	+		+			+	+		r										1
40	1		+				+		+									+	2b
41	1						r		+									1	3
42		+			r				+										2a
43		+				+	+							+				+	
44	+						+		+									+	2b
45		r				1	r											+	+
46	r					r	+												
47						2b													
48						+	+							+					
49	+								+									+	2a
50	+								+									+	2a
51	+						r		r									r	+
52			r						+										2b

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
53		+															+						r		+										1
54		1															+		r						1									+	2b
55		1															r	+					r		+									+	2b
56		+															+	+							1										2a
57		2a															+			r					+										1
58		+															r								+									1	2b
59		1															+								1									+	2b
60		+															r	+		r				r	+				r					r	3
61		1															+		+				+		+									+	2b
62		+															+								+									+	1
63		+															+								+										3
64		+															+		r				r		+									1	2b
65		+															+		r						+									r	2b
66		+																							1										+
67		+															r		r						+									r	2b
68		+															r								+									r	3
69		2b															1						r		+			r						r	2a
70		+															+		+			+							r				+		1
71		+																+		+									+					+	3
72		+															r								1				r						2a
73		1															+	+		r			r												1
74		+																r							1										+
75		1															+	+	r						+										2b
76		+															r	1		r			r		1				+				r	+	3
77		1															+	r		r			r		+										+
78		1															+	+		r					+									+	2b
79		+															r	r					+		+		+		r				+		1
80		1																r						r					+					+	2b
81		r																r		+			+		+								+	r	3
82		1															r	+			r				1								+	r	2b
83		+						r										+		r					+				r				+	+	2b
84		1					r										+	r	+	r			r						+						1
85		+																r		r			+		+								+		2b
86		1																+		+			r		+								r	r	2b
87		2a															r	r					+		+								+		1
88		1															+	r		+					+										2a
89		1															+								+									+	3
90		+											r				+	+					+											+	+
91		1															+					r	r											+	1
92		1															+						+	r											2b
93		1																+			r			r	+									r	3
94													1									2b						+							
95													+																						
96		+															+	r																	
97		1													+		r	r	+						+										2a

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
98													+									+	r												+
99																						+													+
100													r						r				r												+
101	+		r																r			r													1
102		1															+								r				r					+	1
103																	+								+										2b
104		1															+	r							+									+	2b
105		2a															+		r						+										2b
106		+															+		r						+									1	1
107		1													1		+	+							r									1	2b
108		1															+		r				r		r				r			r		+	2a
109																	r								r									r	+
110		1															+						r		1										1
111		1															+								+									r	+
112																	+								+										2a
113																	+						r		+										1
114																	+					+	+		+										2b
115		+															+								+									+	2b
116		+																							+										2b
117																									+									r	2b
118		2a															+		r						+									r	1
119																	+								r									r	+
120		+															+																		1
121		1							r								+	r																	3
122		1															+	+	r				r		+				r						+
123		1															r	+							+										2a
124									r								+						r		+									+	1
125		1															+	+	+				+		+									+	2a
126		+						r									+		r				r	r		+								1	2b
127		1						r									+								+									+	2a
128		+												+			+	r					r											+	2b
129		2a															+						r		+				r					+	2b
130		r																+							+									r	1
131		1															r	+							+									r	1
132																		r		r			r												1
133		+																+		r					1									r	
134		+																+		+			r	r	r									r	2a
135		2a															+	+					r											2b	2b
136		+						r									+	+							+									2b	3
137		1																					+		r				+					+	2b
138		1																r		+			r		+				+						3
139								r															+											1	2a
140		1																		+			r		r				+					2b	2b
141		+																+		r				r	+				+					+	3
142																r		+							+				r						2b

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
143		+																+		+			+						+					1	2b
144		+															+								+									r	2b
145				+													+							+											3
146		1															+	+	r															+	3
147		+				r											r	r			r		r		+									r	1
148		1						r									+	r	r					r	+									r	2a
149		1															+	r						r	+									r	2a
150		+															r	+						+	+									+	2a
151		+															+	+							+										2b
152		1						r									+		r						r									r	2b
153																	r																	+	2b
154																				+					+										1
155					1				+								+		r			+	r				r								
156																r		r		r			r		+				+						2a
157										1	1	+		r			+		+			r	r												
158					+			r											+				+				r							1	1
159									r																										
160		+															+		+	r			r		+										1
161		r																		+															+
162		+															+			+			r		+									r	2a
163								r															+												1
164		+															2a						r	r	+				r					r	1
165																				+														+	2b
166		r																		r					1				r					2a	2b
167																							r		+									+	1
168								+												r			+		r		+							1	3
169		+																							+										2b
170		2a																r	r						+									r	2b
171	r	r								+							1					r	r						r	r					
172					+					+							1					+	+							r	r				
173			r														+					+					r			+					
174		1															+	r							+										2a
175																	+					+													
176		+															+	+		r			+		+				+				+	+	2b
177		+																+		+			+		+		r		+					+	2a
178		+																+		r			+						+						1
179		+																+							+										1
180																		+					r		+										2a
181		+															r	+		r			r		+				r					+	2a
182		1															r		+				r		+									r	2b
183		+															+						r		+									1	3
184		r						r									+	+							+									1	2a
185		1																+		+					+									+	2a
186		1															+		r															+	2b
187		1															r	r					r		2a										2b

Nr.	Pot. arg	Pot. inc	Pot. ict	Pru. gra	Pru. spi	Pul. gra	Pul. pra	Res. lut	Ros. can	Ros. rub	Rub. cae	Rum. thy	Sal. aet	Sal. nem	Sal. pra	Sal. ver	San. min	Sca. can	Sca. och	Sco. aus	Sco. pur	Sec. var	Sen. jac	Ses. ann	Ses. hip	Set. vir	Sid. mon	Sil. lat	Sil. oti	Sil. vul	Sol. can	Sol. nig	Sta. rec	Sti. cap	Sti. pen
188																				r			+										r	+	1
189		1						r											+						r	+								+	2b
190		+					r										r	r					+		+				+					r	2b
191																		r							r									r	2a
192																	+	+																r	1
193		1															+			r				r	+									+	2b
194								r										r		+					+				r					+	+
195		+															+	r							1										1
196								r										+					r	r	r				r					+	3
197																		r					r		+									2b	2b
198		2a															+	+							1									r	3
199		1						r										+		r			+		+				+						3
200		+															r	+					+											+	2b

Table 12 Relevés with modified Braun-Blanquet covers (2a: 5–15 %; 2b: 15–25 %) for *Syringa vulgaris–Viola rupestris*

Nr.	Syr. vul	Tar. sp.	Teu. cha	Teu. mon	Tha. min	The. ram	Thy. odo	Thy. pas	Tra. dub	Tra. ori	Tri. gla	Tri. rep	Ver. arv	Ver. pro	Ver. spi	Vic. ang	Vic. hir	Vic. pan	Vin. hir	Vio. amb	Vio. arv	Vio. rup
1			r	+			+								+							
2				+			+								+				r			
3				+			+															
4				+			+								r				+			
5				+			+								+				r			+
6				+			+								+				+			r
7				+			+								r							
8				+			+								r							
9		r		1			+															+
10							+								+							
11				r			+								+							
12				+			1								r				r			
13				+			+								+							r
14				+			+								+				+			+
15		r		+			r								+				+			
16			+						r													
17				r			+								+				r			
18				+			+				r				+							
19				+															+	r		
20		+	+	+			+				r								r			r
21				r											r				+			
22				+			+								+				+			
23			+				+															

Nr.	Syr. vul	Tar. sp.	Teu. cha	Teu. mon	Tha. min	The. ram	Thy. odo	Thy. pas	Tra. dub	Tra. ori	Tri. gla	Tri. rep	Ver. arv	Ver. pro	Ver. spi	Vic. ang	Vic. hir	Vic. pan	Vin. hir	Vio. amb	Vio. arv	Vio. rup
24		r															r					
25		+	+			+									+	r						
26				1			1				r								+	r		
27			1	+			+												+			r
28				+			+															
29		+	r	+			+				r								r			
30			1	1			+												+			
31		r	+	+			+												+			r
32		+					+		r										r			
33		r		+			1		r		+								+			+
34				+			+												+			+
35		+	+	+			+												+			
36				+		+	r												r			
37			+	1			+				r								+			
38		r		+			+												r			
39		r	+	+			+		r					+					r			
40			+	+			+												+			
41			r	+			+												r			
42				+			+								+				r			
43		+																				
44				+			+		r		r											
45		+																				
46							+		r													
47							+															
48		r																				
49		r		+			1												+			
50			+	+			+												r			r
51		+		+		r	+		+										+			
52				+			+								r							
53			+	+			+															
54			2a	+			+								+							r
55				+			+				r				+				+			r
56				+			+								+				r			r
57				2a			+								r				+			
58				r			+															r
59				+			1								+				r			
60				+			+								+				+			
61		r		1			+												r			
62				2a			+								+							+
63				2a			+												r			+
64				r											r				r			r
65							+															r
66				1			+															r
67				+			+								+							
68				+			+															

Nr.	Syr. vul	Tar. sp.	Teu. cha	Teu. mon	Tha. min	The. ram	Thy. odo	Thy. pas	Tra. dub	Tra. ori	Tri. gla	Tri. rep	Ver. arv	Ver. pro	Ver. spi	Vic. ang	Vic. hir	Vic. pan	Vin. hir	Vio. amb	Vio. arv	Vio. rup
69		+		+											+				+			
70				+			1															
71				+			+												+			
72				+			+								r				+			r
73				+			+				+				+				+			
74				r			+								+				r			r
75			+	+			+								+				+			r
76				+			+				r				+				+			
77				+			+								+				+			
78				+			+								+				+			
79				+			+								r				+			r
80				r			+								1				+			
81				+			+								+				r			+
82		+					+								+				+	+		+
83		r		r					r						+				+			r
84				+			+								+				+			
85				+			+								+				+			
86		r		+			+								+				r			
87		r		+			+								+				1			
88				+			+								r				r			
89		+		+			+												+			r
90			+												+	r						
91				+			+															
92		r		+			+								r							r
93				+			+								+				r			
94		+							r				r			r						
95		+										r						r				
96			+	+					r						r							
97			+	1			+				r				+							
98										r			+			+	+					
99		r								r						+	+					
100		+								+						+	r				r	
101		r													+							
102				+			+		r													
103				+			+															+
104				+			+								+				r			
105				1			1								+				r			
106				+			+								r				r			r
107			+	+			r								+				+			+
108				+			+								r				+			+
109				+			+								r				r			
110				1			+							r	+				r			r
111							+								+				r			+
112				+			+								+							+
113				+			+								+							

Nr.	Syr. vul	Tar. sp.	Teu. cha	Teu. mon	Tha. min	The. ram	Thy. odo	Thy. pas	Tra. dub	Tra. ori	Tri. gla	Tri. rep	Ver. arv	Ver. pro	Ver. spi	Vic. ang	Vic. hir	Vic. pan	Vin. hir	Vio. amb	Vio. arv	Vio. rup
114			+	+			+								+							+
115				+			+								+							r
116				+			+								+				r			r
117				+			1								+							+
118			+	+			r								+							
119				+			+								+				r			+
120		r		+											r				+			+
121	+			1			+								+				r			r
122			+	+			+								+					r		+
123			+	+											+				+			
124		r		+					r						+							+
125				+			+								+				+			+
126				+			+								+				r			
127				+			+								+				r			
128				+			1				r				+				r			+
129		r		+			+								+							
130				+			+												+	+		
131				+			+								+				+			r
132		r		+			+								+				+			r
133				+			+								+				+			+
134		r		+			+		r						+				+			r
135				+			1							r	+				+			
136							1							r	+				+	r		r
137							+								1				+			
138				r			1								+				+			
139				+			+								+				+	1		
140				+			+								1				+			
141				+			2a				r			r					+			
142				+			+								+				+			
143				1			+				r				1				r			
144			+	+			+								r				r			
145			+	+															+	r		r
146				+			1								+							r
147				+	+		+				r				+				+	r		r
148			1	+			+													r		
149				+											+							
150				+											r				r			
151				+			+								r							r
152			+	+			+								+				r			r
153							r								+							
154			+	+			+				r				+				r			r
155															r							
156				+											+				r			r
157									r													
158				1															r			+

Nr.	Syr. vul	Tar. sp.	Teu. cha	Teu. mon	Tha. min	The. ram	Thy. odo	Thy. pas	Tra. dub	Tra. ori	Tri. gla	Tri. rep	Ver. arv	Ver. pro	Ver. spi	Vic. ang	Vic. hir	Vic. pan	Vin. hir	Vio. amb	Vio. arv	Vio. rup
159																						
160			+	+			+															r
161				r											r				+			
162		r		1			+		r						+				+			
163							+		r						r				r			r
164				2a			+								+				+			r
165							+								+				r			
166				1			+								r				r			
167			+	1			+								r				r			+
168				1			+								+				+			
169				1			+								+				+			
170			+	+			+								+				+			
171		r		r																		
172							+		r										r			
173		r							+													
174			+	+			+												r			
175																						
176				+			1		r						+				r			
177				+			+	+							+				r			r
178				+			+		r						+				+	r		
179				r											+				+			+
180				+			+								+				r			
181							+								r				r	r		r
182				+			+								+							r
183				+			+								+							r
184				+			+								1							
185				+			+								+				r			
186				+			+								+							
187				1			+				r				+				+	r		
188				+			+								+				r			
189				+			+								+							r
190				+			1								+				+			
191				+			r		r		r				+				+			r
192				+											+				+			+
193			+	+			+								+				r			r
194				+			+								+				+			
195			+	+			+								+				+			
196			+	+															+	+		
197		r							r		r				+				+			r
198				+			1								+							r
199				+			+								+				+			
200				+			+				+				+				r			

Appendix II: Zusammenfassung

Das Wiener Neustädter Steinfeld beherbergt in seinem Nordteil den größten zusammenhängenden Trockenrasen Österreichs. Er bietet Lebensraum für zahlreiche bedrohte Pflanzen- und Tierarten und ist somit von hohem naturschutzfachlichem Wert. Eine weitere Besonderheit stellt sein primärer Charakter dar, er bildete sich nacheiszeitlich ohne Zutun des Menschen. Durch anthropogene Eingriffe, hauptsächlich land- und forstwirtschaftlicher Art, innerhalb der letzten 250 Jahre wurden leider große Teile dieser einmaligen Naturlandschaft verändert oder unwiederbringlich zerstört und auch heute noch hält diese Bedrohung an. Andererseits kam es glücklicherweise auch zur Aufgabe von Ackerflächen, auf denen sich wieder Trockenrasen auszubilden begannen. Diese Arbeit hat zum Ziel, zu überprüfen, inwiefern sich diese sekundären von den primären, niemals umgebrochenen Trockenrasen unterscheiden.

Zu diesem Zweck wurden im Untersuchungsgebiet 200 Vegetationsaufnahmen durchgeführt. Dabei wurde erstens zwischen niemals umgebrochenen, primären und ehemals ackerbaulich genutzten, sekundären Flächen unterschieden, zweitens war es von Bedeutung, ob sich die Plots in relativ kleinflächigen, isolierten oder in den ausgedehnten Trockenrasen befanden. Weiters fanden Berücksichtigung: Altersklasse von Sekundärflächen, Veränderung durch Feuer sowie Alter der Brandfläche und Beweidung.

Mithilfe einer DCA bzw. einer NMDS konnten die Aufnahmen zu zehn Gruppen aggregiert werden, die dann auf statistische Unterschiede analysiert wurden. Zur Anwendung kamen Vergleiche der ökologischen Zeigerwerte, der α- und β-Diversität sowie die Berechnung von GLM-Regressionen mit sechs für das Steinfeld charakteristischen Arten. Da die Teststärke aufgrund der niedrigen Stichprobenzahl in einigen der Gruppen unbefriedigend gering war, wurden die zehn Gruppen noch weiter zusammengefasst und die Auswertung der Zeigerwerte sowie der α- und β-Diversität mit nur drei Gruppen wiederholt. Die Analyse der Zeigerwerte zeigte einen deutlichen Unterschied zwischen jungen Sekundärflächen einerseits und alten Sekundärflächen bzw. Primärflächen andererseits, innerhalb der Alt- und Primärflächen gab es diesen Unterschied hingegen nicht. Gleiches galt zum Großteil für die GLM-Analyse und auch die α- und β-Diversitätswerte zeigten ein solches Muster.

Auf Grundlage dieser Ergebnisse lässt sich eine positive Entwicklung ehemals ackerbaulich genützter Flächen zurück zu Trockenrasen feststellen. Der Zeitraum, den dieser Prozess bis zu seinem Abschluss benötigt, konnte leider nicht eruiert werden, da keine ausreichend hohe Zahl von Flächen unterschiedlichen Alters für solch eine Untersuchung zur Verfügung stand. Aufgrund anderer Studien lässt sich aber eine Dauer von etwa 30 Jahren schätzen. Wie sich während der Aufnahmen herausstellen sollte, geht eine weitaus höhere Gefahr von der Vergrasung durch *Bromus erectus* aus, das durch den anthropogen bedingt erhöhten Stickstoffeintrag über die Luft gefördert wird und lichtbedürftige Trockenrasenvertreter, vor allem Chamaephyten, verdrängt. Wie diese Arbeit gezeigt hat, kann Beweidung hier entscheidende Abhilfe schaffen, Brände hingegen haben, sofern sie im Sommer auftreten, besonders auf Arten wie *Fumana procumbens* und *Helianthemum canum* eher negativen Effekt. Zudem können sie oftmals verheerende Auswirkungen auf seltene Tierarten haben. Brände aber, die außerhalb der Vegetationsperiode auftreten, bergen solche Gefahren kaum und sind oftmals sogar von großem Nutzen, da die angehäufte tote Biomasse auf diesem Weg entfernt wird. Im militärischen Sperrgebiet, in dem sich Beweidung von selbst verbietet, stellt diese Methode zudem den einzig gangbaren Weg zur Entfernung der Streu und zur Verhinderung einer überhandnehmenden Dominanz von *Bromus erectus* dar.

Appendix III: Curriculum Vitae

Christian LAGONA

geboren:	26. 12. 1975, Wiener Neustadt
wohnhaft in:	Lichtenwörth
Familienstand:	Lebensgemeinschaft mit Barbara Toth
Kinder:	Jana und Lara (beide 2011)

SCHULAUSBILDUNG

1982 – 1986	Volksschule in der Josefstadt, Wiener Neustadt
1986 – 1990	Bundesgymnasium Babenbergerring, Wiener Neustadt
1990 – 1991	Polytechnischer Lehrgang, Wiener Neustadt
2004	Berufsreifeprüfung, Handelsakademie Baden

BERUFSAUSBILDUNG

1991 – 1994	Lehrausbildung zum Versicherungskaufmann
1998 – 1999	Lehrausbildung zum Metalltechniker

UNIVERSITÄRE AUSBILDUNG

2005 – 2006	Studium der Mechatronik und Mikrosystemtechnik, Fachhochschule Wiener Neustadt (nicht abgeschlossen)
2006 – 2013	Studium der Biologie, Studienrichtung Ökologie, Spezialisierung Naturschutz und Vegetationsökologie, Universität Wien

ZUSÄTZLICHE QUALIFIKATIONEN

Software: ArcGIS, SPSS, R, Microsoft Access u. a.
Abfallbeauftragtenprüfung (Universität für Bodenkultur Wien)
Englisch in Wort und Schrift
Führerschein B