©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Tuexenia 29: 353–368. Göttingen 2009.

Steppe-like grasslands in Transylvania (Romania): characterisation and influence of management on species diversity and composition

– Eszter Ruprecht, Anna Szabó, Márton Z. Enyedi and Jürgen Dengler –

Abstract

In this paper we aim to present data on current state of steppe-like grasslands dominated by feather grasses (*Stipa* spp.) in the Transylvanian Lowland (Romania), and to investigate whether management type affects species composition, biodiversity, or the occurrence of rare and endangered vascular plant species in these grasslands. Twelve grassland stands, originating from nine areas and belonging to two associations, *Stipetum lessingianae* and *Stipetum pulcherrimae* from the alliance *Stipion lessingianae* (*Festucetalia valesiacae*, *Festuco-Brometea*), were investigated by phytosociological sampling. Our data set contains 60 relevés originating from differently managed grasslands: grazed and abandoned stands as well as former grasslands afforested with *Pinus nigra*. Transylvanian stands of the *Stipion lessingianae* occur on steep, south-facing slopes. The species composition has an accentuated sub-continental character, including several steppe elements of Siberian and Pontic origin, many of them reaching the western edge of their distribution in this region. By comparing the species composition of the two associations, we identified 12 differential species for the *Stipetum lessingianae* and 19 for the *Stipetum pulcherrimae*, but these associations also contained many species in common, which underlines their close syntaxonomic relatedness. Grazing vs. abandonment had only a slight influence on species composition and vegetation structure, while afforestation with pines resulted in strong transformations: decreased cover of the herb layer, increased cover of litter, decreased representation of diagnostic (i.e. typical) species of the two associations but increased frequency of woody, ruderal, and mesophytic grassland species. As the *Stipion lessingianae* belongs to the priority habitats of the Habitats Directive, these alterations call for grassland restoration measures. Our study revealed a lack of high-quality data on the vegetation of steppe-like dry grasslands in southeast Europe, where they have their largest and best-developed stands on the continent. Thus, we emphasize the need for compiling such data and for developing a consistent supranational vegetation classification of *Festucetalia valesiacae* communities in this region.

Zusammenfassung: Steppenrasen in Siebenbürgen (Rumänien): Charakterisierung und Einfluss der Nutzung auf Diversität und Artenzusammensetzung

Ziel dieser Arbeit ist es, einen aktuellen Überblick über die von Federgras-Arten (*Stipa* spp.) dominierten Steppenrasen im Siebenbürgischen Becken (Rumänien) zu geben. Ferner soll analysiert werden, ob verschiedene Managementmaßnahmen die Artenzusammensetzung, die Biodiversität oder das Vorkommen seltener und gefährdeter Gefäßpflanzenarten beeinflussen. Es wurden zwölf Trockenrasenbestände der beiden Assoziationen *Stipetum lessingianae* und *Stipetum pulcherrimae* aus dem Verband *Stipion lessingianae* (*Festucetalia valesiacae*, *Festuco-Brometea*) aus neun Gebieten pflanzensoziologisch untersucht. Unsere insgesamt 60 Vegetationsaufnahmen stammen aus aktuell beweideten, vor längerem brach gefallenen sowie mit *Pinus nigra* aufgeforsteten Beständen. Die siebenbürgischen *Stipion lessingianae*-Bestände wachsen generell an steilen, südexponierten Hängen. Ihre Artenkombination hat einen ausgeprägt subkontinentalen Charakter und enthält zahlreiche Steppenelemente sibirischen oder pontischen Ursprungs, die im Gebiet ihre westliche Verbreitungsgrenze erreichen. Der Vergleich der Artenzusammensetzung ergab 12 Differenzialarten für das *Stipetum lessingianae* und 19 für das *Stipetum pulcherrimae*, wobei beide Assoziationen zugleich viele gemeinsame Arten aufweisen, was ihre syntaxonomische Nähe unterstreicht. Während die Nutzungsaufgabe ehemals beweideter Trockenrasen nur einen geringen Einfluss auf Artenzusammensetzung und Vegetationsstruktur hatte, führten Kiefernaufforstungen zu erheblichen Veränderungen (geringere Deckung der Krautschicht, erhöhte Streudeckung, Abnahme diagnostischer Arten der Assoziationen bei gleichzeitiger Zunahme von Gehölzen, Ruderal- und mesophytischen Grünlandarten). Da das *Stipion lessingianae* ein prioritärer Habitattyp der FFH-Richtlinie der Europäischen Union ist, unterstreichen diese Ergebnisse die Notwendigkeit von Renaturierungsmaßnahmen auf solchen aufgeforsteten Flächen. Unsere Arbeit zeigte ferner, dass es einen

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Mangel an qualitativ hochwertigen Daten von den Steppenrasen Südosteuropas gibt, obwohl dieser Vegetationstyp dort innerhalb Europas seine größten und bestentwickelten Bestände aufweist. Deshalb betonen wir abschließend die Notwendigkeit, solche Daten zu erheben bzw. zusammenzutragen, um auf dieser Basis eine konsistente, supranationale Klassifikation der *Festucetalia valesiacae*-Gesellschaften dieser Region zu erstellen.

Keywords: abandonment, dry grassland, *Festuco-Brometea*, grazing, pine plantation, *Stipion lessingianae*.

1. Introduction

European semi-natural grasslands carry an exceptionally high diversity of plants (e. g. KORNECK et al. 1998). Their characteristic species are adapted to human land use, and grassland diversity is strongly related to past and current management practices (POSCHLOD & WALLISDEVRIES 2002).

In Romania, a large variety of grassland types exist (SANDA et al. 1980, 2008, DONIȚĂ et al. 1992), their occurrences determined mostly by geographic position, geomorphology, soil type, and land use. Steppe-like grasslands are of a special interest because they are considered to be relic vegetation types from the Late Glacial that escaped Holocene woodland invasions (ILLYÉS & BÖLÖNI 2007, KUNEŠ et al. 2008). For this reason, they harbour many plant species of eastern and southern origin as well as several endemic taxa. Such vegetation types are typical for steep south-facing slopes in the Transylvanian Lowland. This region represents the westernmost outpost of the distribution for many species of Siberian or Pontic origin (e.g. *Nepeta ucranica, Cephalaria uralensis, Centaurea ruthenica, Peucedanum tauricum*; see SOÓ 1942).

The occurrence of such typical steppic species prompted the raising of a separate alliance, the *Stipion lessingianae* Soó 1947 within the order *Festucetalia valesiacae* Br.-Bl. & Tx. ex Br.-Bl. 1950 of the class *Festuco-Brometea* Br.-Bl. & Tx. ex Klika & Hadač 1944 (SOÓ 1947). In Romania, this alliance comprises four associations distributed in Transylvania, Moldova, Muntenia and Dobrogea, but only two of these occur in Transylvania: the *Stipetum lessingianae* Soó 1947 and the *Stipetum pulcherrimae* Soó 1942 (SCHNEIDER-BINDER 1977, DONIȚĂ et al. 1992, SANDA et al. 2008). Following their description by SOÓ (1942, 1947), the major focus of which was on species composition, several other studies investigated these grassland types (e.g. SOÓ 1949, CSŰRÖS et al. 1961, SCHNEIDER-BINDER 1975, 1977, BĂDĂRĂU et al. 2001). From these studies, it is evident that steppe-like grasslands from Romania represent an important link between eastern European grasslands dominated by feather grass species (*Stipa* spp.) and central European dry and semi-dry grasslands. The stands of the *Stipetum lessingianae* from Transylvania were considered by SOÓ (1949) as western exclaves of the Ukrainian monocot-dominated steppes (see LAVRENKO & KARAMISHEVA 1993, BOHN et al. 2003), and the *Stipetum pulcherrimae* as the westernmost representative of the Russian steppes in central Europe (SOÓ 1942).

Due to their high species richness and the occurrence of rare and endangered species grasslands dominated by *Stipa* spp. are a focus of conservation (SSYMANK et al. 1998). More specifically, the alliance *Stipion lessingianae* together with three other alliances constitutes the priority habitat type 62C0 (Ponto-Sarmatic steppes) of the Habitats Directive of the European Union (EUROPEAN COMMISSION 2007, GAFTA & MOUNTFORD 2008). This conservation interest revealed a serious lack of data regarding the actual state and dynamics of the xeric grassland types in the Transylvanian Lowland (CREMENE et al. 2005). Aspects of vegetation dynamics caused by changes in management, which may be attributable to present-day conservation problems, have scarcely been studied in recent decades, with the exception of two regional-scale surveys on the long-term consequences of abandonment of these grasslands (CREMENE et al. 2005, ENYEDI et al. 2008).

The aim of our study was to present data about the actual state of *Stipa*-dominated steppe-like grasslands in the Transylvanian Lowland. Further, we question how management type affects species composition, species diversity, and the occurrence of endangered plant species in the studied grassland types.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

2. Material and methods

2.1. Study area and studied vegetation types

The dry grassland stands we studied are situated in the Transylvanian Lowland (Câmpia Transilvaniei), in north-central Romania (Fig. 1). The climate is temperate continental, with an annual precipitation of 520–650 mm with a summer peak (June, July, August), and a mean annual temperature of 8.4–9.7 °C (KUN et al. 2004).

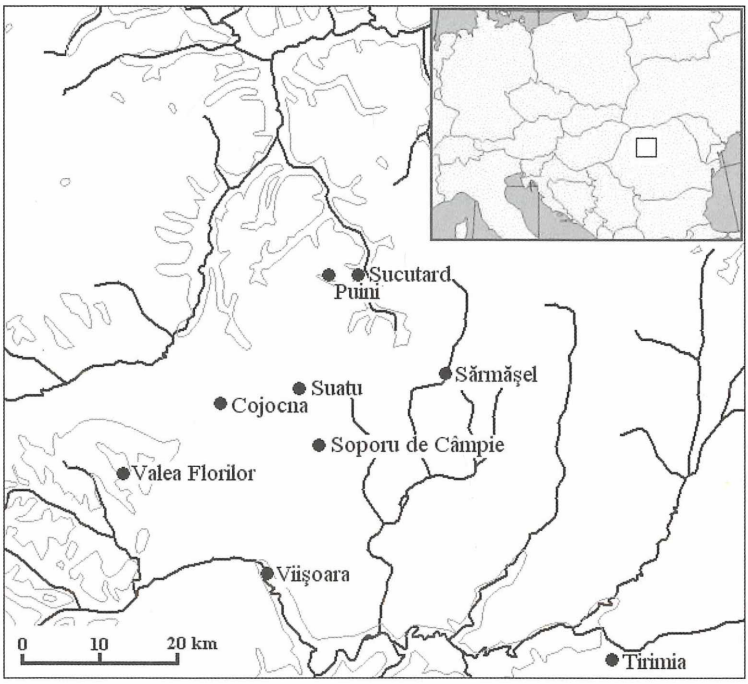

Fig. 1: Overview of the research area with location of sampled grassland sites in the Transylvanian Lowland, Romania.

Abb. 1: Überblick des Untersuchungsgebietes und der erfassten Trockenrasenflächen im Siebenbürgischen Tiefland, Rumänien.

The potential vegetation according to BOHN & NEUHÄUSL (2000) is "subcontinental thermophilous (mixed) pedunculate oak and sessile oak forests" and according to KUN et al. (2004) forest-steppe/forest. Extensive deforestation of the Transylvanian Lowland occurred more than 1,000 years ago. At present, small remnants of oak (*Quercus robur*, *Q. petraea*) and oak-hornbeam (*Q. petraea*, *Carpinus betulus*) woods grow on hilltops or on north-facing slopes, while the remaining area is occupied by large agricultural fields and grasslands.

The target dry steppe-like grasslands belong to the alliance *Stipion lessingianae*, which represents one of the most xeric grassland types of the Transylvanian Lowland, where it is found on steep, south-facing slopes with eroded carbonate chernozemic soils on clayish or marly substrate. The stands are dominated by either of two species, *Stipa lessingiana* or *S. pulcherrima*, and were assigned to two associations accordingly: the *Stipetum lessingianae* or the *Stipetum pulcherrimae*. These grasslands have an open structure owing to the dense tussock habit of the dominant species.

Traditional management of these steppe-like grasslands was grazing by sheep or cattle from spring to autumn. Through the last 50 years, land-use has changed in this region greatly, influencing several dry grassland sites. Livestock number has decreased due to the low profitability, and because these dry grasslands have the lowest productivity (600 g m^{-2} yr^{-1}

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

dry matter) among the region's grasslands, they were the first to be abandoned. Likewise, the low productivity and open structure of *Stipa* communities led to disfavour in human economic interest, and so some stands were converted to plantations of *Pinus nigra* (or less often of *Pinus sylvestris*), for both profit and erosion control. However, this anthropogenic afforestation has slowed in recent years owing to low profitability.

2.2. Field sampling

We analysed 12 dry grassland stands in nine different sites (Fig. 1, Table 1). Seven stands were assigned to the *Stipetum lessingianae* and five to the *Stipetum pulcherrimae* based on the prevalence of either of the two name-giving *Stipa* species. We distinguished three management categories: grazed pastures (G), abandoned pastures (A), and pine plantation on former grasslands (P). Abandoned grasslands were removed from grazing by sheep or cattle 30–50 years ago, while plantations of the non-indigenous *Pinus nigra* had been established on former grasslands 30–45 years ago. In case of pine plantations, relevés were made in both the planted area and in the intact part of the same grassland site (Table 1). By this sampling strategy, we intended to represent differently managed situations impacting the two dry grassland types.

In each of the 12 stands, we made five phytosociological relevés, using 4 m x 4 m or 5 m x 5 m plots. Cover of all vascular plant species was estimated visually in percent. We also estimated total cover of vascular plants (herb and shrub layer), of the tree layer (in case of pine plantations), of litter, and of bare ground. Cover of bryophytes was estimated for 50 % of the relevés, while cover of lichens was not considered because it was negligible (< 0.1 %) throughout. Aspect and slope were noted, and land use of the last decades (management type) was determined through interviews with local people.

Species nomenclature follows "Flora Europaea" (TUTIN et al. 1968–1993). The chorological assessment of taxa follows SANDA et al. (1983).

Table 1: Location, altitude, date of sampling, and management characteristics for the nine grassland stands and the three pine plantations sampled

Tab. 1: Geografische Angaben, Meereshöhe, Untersuchungsdatum und Nutzung der neun untersuchten Trockenrasenbestände und der drei Kiefernanpflanzungen

Relevé no. in Table 2	Location	Coordinates	Altitude (m a.s.l.)	Date of sampling	Management type
1–5	Cojocna	46°75'N, 23°83'E	350	05.07.2005	grazed by sheep
6–10	Sucutard	46°90'N, 24°07'E	380	07.07.2005	grazed by sheep
11–15	Valea Florilor	46°67'N, 23°67'E	464	13.08.2004	grazed by cattle
16–20	Suatu	46°77'N, 23°97'E	400	06.07.2006	grazed by sheep
21–25	Soporu de Câmpie	46°70'N, 24°00'E	395	22.07.2007	abandoned pasture
26–30	Suatu	46°77'N, 23°97'E	400	06.07.2006	pine plantation
31–35	Soporu de Câmpie	46°70'N, 24°00'E	395	22.07.2007	pine plantation
36–40	Tirimia	46°45'N, 24°50'E	425	26.06.2005	abandoned pasture
41–45	Puini	46°90'N, 24°02'E	400	08.07.2005	abandoned pasture
46–50	Sărmăşel	46°78'N, 24°22'E	440	18.08.2004	abandoned pasture
51–55	Viişoara	46°55'N, 23°91'E	335	15.07.2007	abandoned pasture
56–60	Viişoara	46°55'N, 23°91'E	335	15.07.2007	pine plantation

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

2.3. Data analysis

We determined differential species both between the two associations and within these for the different management types. For this purpose, we applied the criterion of at least two-fold constancy as suggested by DENGLER (2003; see also DENGLER et al. 2005). We disregarded all those species whose concentration was insignificant according to Fisher's exact test at $\alpha = 0.05$ (calculated with the online tool at www.langsrud.com/stat/Fishertest.htm). Putative character species of higher syntaxonomic units (alliances, order, class) were basically assigned according to SANDA et al. (2008), supplemented by SOÓ (1947), MUCINA & KOLBEK (1993), CHYTRÝ (2007) and JANIŠOVÁ (2007).

We calculated species richness, cover-based Shannon index, Shannon-based evenness, and the number of red-listed species for each vegetation relevé (BOŞCAIU et al. 1994; DIHORU & DIHORU 1994; OLTEAN et al. 1994; all species listed in at least one of these publications were regarded). To account for potential confounding effects of different plot sizes, we additionally calculated species richness standardised to 16-m² plots, using the mean *z*-value (0.21) of the power-law species-area relationship that was reported by DENGLER (2005) for a wide range of different dry grassland types. Accordingly, the expected species richness on 16 m² is 91.1 % of the value on 25 m². We compared all these diversity measures as well as the available environmental (slope) and structural data (cover of vascular plants, of litter, and of bare ground) both between the two associations (only non-afforested sites were considered) and among the management types within the two associations. As some of the response variables were not distributed normally, we applied non-parametric tests throughout. We used Mann-Whitney *U*-tests for the comparisons between the two associations and between the two management types of the *Stipetum pulcherrimae*, and Kruskal-Wallis tests for comparisons between grazed, abandoned, and afforested sites in the case of the *Stipetum lessingianae*. Analyses were done with Statistica, ver. 6.0 (StatSoft Inc.).

3. Results

3.1. Characterisation of the two associations

The stands of both associations (Fig. 2–4) occurred on southerly exposed (mostly S to SW, rarely SE or W), steep slopes with a mean inclination of nearly 40° (range: 20–55°; see Table 2 in the Supplement). Mean inclination did not differ between the two associations (Table 3). In the case of non-afforested stands, the cover of vascular plants was slightly higher in the *Stipetum pulcherrimae* than in the *Stipetum lessingianae* (90% vs. 83%, Table 3), and in the latter association there was typically more bare ground (8% vs. 14%, Table 3), while cover of litter was not different between the two associations (Table 3). The non-afforested stands of both associations were similar in vascular plant species richness (Table 3) with an average value of around 40 species per plot of 16–25 m² size and extreme values ranging from 24 to 63. Shannon diversity and evenness were not different between the two associations, but the number of red-listed species was higher in the *Stipetum pulcherrimae* (Table 3).

The two associations studied shared a large number of species many of which occurred with high constancy and are largely considered to be character species of superior syntaxonomic units (Table 2 in the Supplement). However, within our dataset according to the criteria applied, the *Stipetum pulcherrimae* (19 differential species) was also well separated from the *Stipetum lessingianae* (12 differential species, Table 2). The differential species of both associations included several rare or endangered taxa (Table 2).

The species composition of these two feather grass associations contained Siberian (e. g. *Stipa lessingiana, S. pulcherrima, Brassica elongata, Nepeta ucranica, Peucedanum tauricum, Artemisia pontica*), Pontic (e. g. *Astragalus dasyanthus, Cephalaria uralensis, Crambe tataria, Echium russicum, Inula ensifolia, Linum flavum, L. nervosum, Salvia nutans, Serratula radiata*), sub-Mediterranean and Mediterranean species (e. g. *Astragalus monspessulanus*, *Plantago argentea*). Additionally, there were some endemic species or subspecies occurring in these grasslands (e. g. *Cephalaria radiata, Salvia transsylvanica, Allium albidum* subsp. *albidum*, *Jurinea mollis* subsp. *transylvanica*) (see Table 2).

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Fig. 2: Extensively grazed stand of the *Stipetum lessingianae* with *Nepeta ucranica* near Valea Florilor (Photo: András Kun, May 2003).

Abb. 2: Extensiv beweideter Bestand des *Stipetum lessingianae* mit *Nepeta ucranica* nahe Valea Florilor (Foto: András Kun, Mai 2003).

Fig. 3: Species-rich stand of the *Stipetum pulcherrimae* with *Echium russicum, Salvia nutans, Dictamnus albus, Stachys recta, Verbascum phoeniceum*, and *Campanula sibirica* near Mociu (Photo: Eszter Ruprecht, May 2001).

Abb. 3: Artenreicher Bestand des *Stipetum pulcherrimae* mit *Echium russicum, Salvia nutans, Dictamnus albus, Stachys recta, Verbascum phoeniceum* und *Campanula sibirica* bei Mociu (Foto: Eszter Ruprecht, Mai 2001).

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Fig. 4: Long-term abandoned stand of the *Stipetum pulcherrimae* with *Salvia nutans, Leontodon crispus*, and *Adonis vernalis* near Suatu (Photo: Mónika Deák, May 2003).

Abb. 4: Vor langem brach gefallener Bestand des *Stipetum pulcherrimae* mit *Salvia nutans, Leontodon crispus* und *Adonis vernalis* bei Suatu (Foto: Mónika Deák, Mai 2003).

3.2. Effects of management on species composition

Abandonment had only moderate effects without clear trend on the species composition of the *Stipetum lessingianae* (Table 2 in the Supplement; no data for grazed sites of the *Stipetum pulcherrimae* were available). While four species were differential for grazed vs. abandoned stands, nine showed significantly increased constancy under abandonment. Interestingly, the five relevés from the single abandoned stand of the *Stipetum lessingianae* were even less similar to grasslands of the *Stipetum pulcherrimae* (all abandoned) than were the two other management types of the first association. This is evidenced by the nearly complete absence of diagnostic species for the second association in relevés no. 21–25 in Table 2.

By contrast, the effect of afforestation on species composition was much stronger. In the *Stipetum lessingianae,* seven species showed a strong and significant decrease compared to both the grazed and the abandoned stands (plus additional two compared to the grazed stands and eight compared to the abandoned stands), while 10 species fall into this category in case of the *Stipetum pulcherrimae* (Table 2). Many of the decreased species belong to the differential (i. e. typical) species of the associations (five for the *Stipetum lessingianae*, two

Table 3: Comparison of slope, vascular plant diversity parameters, and structural parameters (mean ± standard deviation) for plots of 16–25 m² size between non-afforested stands of the *Stipetum lessingianae* and of the *Stipetum pulcherrimae* (left) and among differently managed stands within both associations (right; G: grazed pasture, A: abandoned pasture, P: pine plantation). Differences in the mean values between the columns of each group have been tested with Mann-Whitney *U*-tests (two columns) and Kruskal-Wallis tests (three columns), respectively. Bold letters indicate significant differences at $p < 0.05$.

Tab. 3: Vergleich von Hangneigung, Gefäßpflanzendiversität und Strukturparametern (Mittelwert ± Standardabweichung) für 16–25 m² große Aufnahmeflächen nicht aufgeforsteter Bestände des *Stipetum lessingianae* und des *Stipetum pulcherrimae* (links) und zwischen unterschiedlich genutzten Beständen innerhalb beider Assoziationen (rechts; G: genutzte Weide, A: brach gefallene, ehemalige Weide, P: Kiefernanpflanzung). Unterschiede der Mittelwerte zwischen den Spalten einer Gruppe wurden mit Mann-Whitney *U*-Tests (zwei Gruppen) bzw. Kruskal-Wallis-Tests (drei Gruppen) geprüft. Fette Werte zeigen signifikante Unterschiede ($p < 0{,}05$) an.

	Stipetum lessingianae ($n = 25$)	*Stipetum pulcherrimae* ($n = 20$)	$z_{[25,20]}$	p	*Stipetum lessingianae*					*Stipetum pulcherrimae*			
					G ($n = 20$)	A ($n = 5$)	P ($n = 10$)	χ^2 (df = 2)	p	A ($n = 20$)	P ($n = 5$)	$z_{[20,5]}$	p
Slope (°)	39 ± 7	38 ± 7	0.24	0.811	39 ± 7	43 ± 6	43 ± 7	4.38	0.112	38 ± 7	36 ± 13	0.68	0.497
Species richness	39.2 ± 7.0	41.6 ± 9.9	–0.56	0.576	39.7 ± 7.6	37.6 ± 3.4	31.4 ± 12.2	1.31	0.519	41.6 ± 9.9	54.0 ± 2.7	–2.58	**0.010**
Species richness standardised to 16 m²	37.9 ± 7.4	40.4 ± 9.1	–0.80	0.424	38.8 ± 7.9	34.2 ± 3.1	28.6 ± 11.1	2.97	0.226	40.4 ± 9.1	49.2 ± 2.4	–2.45	**0.014**
Shannon diversity	2.63 ± 0.36	2.59 ± 0.34	0.75	0.451	2.62 ± 0.40	2.68 ± 0.17	2.25 ± 0.73	1.97	0.373	2.59 ± 0.34	2.81 ± 0.33	–1.22	0.221
Evenness	0.72 ± 0.09	0.70 ± 0.06	1.46	0.144	0.71 ± 0.10	0.74 ± 0.04	0.66 ± 0.18	0.57	0.751	0.70 ± 0.06	0.70 ± 0.09	–0.27	0.786
No. of red-listed species	2.8 ± 2.8	4.8 ± 2.8	–2.30	**0.022**	3.1 ± 3.0	1.4 ± 0.6	1.9 ± 2.0	3.96	0.138	4.8 ± 2.8	6.0 ± 2.4	–1.12	0.262
Vascular plant cover without *Pinus nigra* (%)	83 ± 11	90 ± 10	–2.14	**0.033**	83 ± 11	79 ± 9	38 ± 25	13.38	**0.001**	90 ± 10	67 ± 9	2.92	**0.004**
Litter (%)	20 ± 26	27 ± 22	–1.72	0.085	14 ± 26	42 ± 8	77 ± 17	21.59	**<0.001**	27 ± 22	77 ± 16	–3.06	**0.002**
Bare ground (%)	14 ± 11	8 ± 10	1.99	**0.047**	17 ± 11	6 ± 4	4 ± 5	12.29	**0.002**	8 ± 10	10 ± 10	–0.54	0.587

©Floristisch-soziologische Arbeitsgemeinschaft, www.tuexenia.de; download unter www.zobodat.at

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

for the *Stipetum pulcherrimae*) or are character species of superior syntaxa. Two species (*Dichanthium ischaemum* and *Asperula cynanchica*) showed a consistent decrease in both associations. Interestingly, three typical dry steppe species were highly diagnostic for afforested stands in the case of the *Stipetum pulcherrimae* (*Iris pumila*, *Oxytropis pilosa*, and *Salvia transsylvanica*). However, the large majority of species showing significant increase in afforested stands were either woody species (e.g. *Robinia pseudacacia*, *Crataegus monogyna*), ruderals (e.g. *Lactuca serriola*, *Buglossoides arvensis*), or mesophytic grassland species (e. g. *Dactylis glomerata*).

3.3. Effects of management on diversity and vegetation structure

Species richness did not differ between management types in the case of the *Stipetum lessingianae*, but it did in the *Stipetum pulcherrimae*, where the afforested grassland had significantly higher species richness per relevé as compared to abandoned stands (Table 3). This result was unaffected by accounting for plot size differences (Table 3). Shannon diversity, evenness, and the number of red-listed species were not significantly different between relevés originating from differently managed grassland stands in any of the two associations (Table 3).

Vegetation cover differed between differently managed stands of the *Stipetum lessingianae,* with afforested plots having lower vascular plant cover as compared to grasslands, and the same pattern was found for the *Stipetum pulcherrimae* (Table 3). Similarly, litter cover differed between stands under different management in case of both associations. The lowest litter cover was found for grazed stands of the *Stipetum lessingianae*, and the highest for afforested sites (Table 3). The quantity of bare ground differed between differently managed stands only in case of the *Stipetum lessingianae*, where in grazed grasslands bare soil was more prevalent than in abandoned and planted sites (Table 3).

Aspect was similar between differently managed stands of the two associations (Table 2), and slope did not differ significantly (Table 3), thus the compositional and structural differences presented above were not caused by different topography of the studied sites.

4. Discussion

4.1. Syntaxonomy

In this study, we assigned the relevés *a priori* to the two presumed associations, *Stipetum lessingianae* and *Stipetum pulcherrimae*, based on the dominating *Stipa* species only. Regardless of this simple approach, this separation resulted in two floristically well-defined phytosociological units, each of which had a remarkably long list of differential species. Admittedly, most of the diagnostic species determined by us can only serve as differential species as they are widespread in other *Festuco-Brometea* communities, too, or even have their major occurrences in other classes. Regionally, *Stipa lessingiana* and *S. pulcherrima* can certainly be considered as character species of the two associations, though at least *S. pulcherrima* is frequent in other *Festuco-Brometea* associations elsewhere, e. g. in Hungary (SENDTKO 1999) and the Czech Republic (CHYTRÝ 2007). From a supra-regional perspective, *Crambe tataria* and *Jurinea mollis* subsp. *transylvanica* could be more suitable as character species of the *Stipetum pulcherrimae*.

Both associations were described by SOÓ (1942, 1947) from the same region as our present study. The character species mentioned by him only partly correspond to those determined by us. Only three of his character species of the *Stipetum lessingianae* were also found by us to be differential (*Stipa lessingiana*, *Astragalus monspessulanus*, *Leontodon crispus*), while *Allium paniculatum* and *Chondrilla juncea* were absent from our relevés, and *Allium albidum* subsp. *albidum*, *Chamaecytisus albus*, and *Pulsatilla montana* were more frequent in the *Stipetum pulcherrimae* than in the *Stipetum lessinginae* (Table 2). In case of the *Stipetum pulcherrimae*, we only confirmed the name-giving feather grass as diagnostic, while *Astragalus asper*, *Lathyrus pallescens*, and *Thlaspi kovatsii* did not occur in our

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

relevés, and *Linum nervosum*, *Phleum montanum*, *Pulsatilla montana*, and *Chamaecytisus albus* were too rare to be considered as diagnostic (Table 2). While we used a consistent statistical fidelity approach and included more relevés than SOÓ (1949; in 1947 the author provided only a synoptic list without mentioning the number of underlying relevés), our findings are still to be considered as preliminary as long as no synoptic table or vegetation database is available that allows for a comparison with all other dry grasslands communities in Romania and beyond.

In Romania, the two associations studied, *Stipetum lessingianae* and *Stipetum pulcherrimae*, are usually placed in the alliance *Stipion lessingianae* within the order *Festucetalia valesiacae* (SOÓ 1947, SANDA et al. 1980, 2008). Romanian authors consider the *Stipion lessingianae* to be different from the *Festucion valesiacae* Klika 1931, the first comprising steppe communities of steep slopes occurring mostly in the Transylvanian Lowland, and the second continental xerophytic grasslands of wider distribution (SANDA et al. 2008). However, our table of two major associations of the *Stipion lessingianae* from Transylvania (Table 2) demonstrates that 'character species' of the *Festucion valesiacae* are even more frequent in the stands than those of the *Stipion lessingianae* (according to the assignment of SANDA et al. 2008). This finding clearly questions the justification for two separate alliances. Non-Romanian authors rarely accept the *Stipion lessingianae* as a separate alliance (but see RODWELL et al. 2002). In the only published European synthesis of *Festuco-Brometea* communities based on synoptic tables of constancy columns, ROYER (1991), for example, identified the *Stipion lessingianae* with a 'groupe d'associations de Transylvanie', which he included in the *Festucion rupicolae* Soó 1940 corr. 1964 (= *Festucion valesiacae*).

It is evident that we cannot solve these syntaxonomic problems here, either based on the existing publications or on the data of our own study. To overcome the strong inconsistencies and idiosyncrasies of existing systems, a supranational classification is needed that is based on a larger number of relevés to which statistical fidelity criteria are applied. Unfortunately, up to now the large number of accepted and newly proposed *Festucetalia valesiacae* associations and alliances in southeastern European countries such as Hungary, Romania, and Ukraine (SOLOMAKHA 1996, KRASOVA & SMETANA 1999, BORHIDI 2003, SANDA et al. 2008), strongly contrasts to the near complete lack of synoptic tables that would allow the comparison of the species composition of different syntaxonomic units and the objective determination of diagnostic species.

4.2. Succession, management and conservation

Although our selection of study sites was not completely random, the fact that most of the *Stipetum lessingianae* stands were grazed, while all stands of the *Stipetum pulcherrimae* were abandoned, may indicate a successional relationship between these two associations. In a case study from the same region, ENYEDI et al. (2008) were indeed able to demonstrate with repeated vegetation sampling and repeated vegetation mapping that cessation of grazing often leads to the transformation of stands of the *Stipetum lessingianae* into stands of the *Stipetum pulcherrimae*. Thus, the two associations may represent two dynamical/successional stages of the same grassland type, the first being characteristic of persistently and extensively grazed sites, the second representing long abandoned sites (ENYEDI et al. 2008). However, in the present study the only abandoned stand of the *Stipetum lessingianae* we analysed did not show particular floristic similarities to the *Stipetum pulcherrimae* (Table 2).

Grasslands can react differently to changes in land-use, which is a function of the history of change in management and productivity of the community (NAVEH & WHITTAKER 1979, MILCHUNAS et al. 1988). Not only land-use intensification (e. g. overgrazing), but also cessation of former pasture-type management can have significant effects on vegetation that is evolutionarily adapted to grazing (SALA et al. 1996). Following abandonment less trampling-induced erosion is expected, and litter accumulation together with decreasing bare soil surfaces can lead to dramatic changes in species composition and diversity (VIRÁGH & BARTHA 1996, KAHMEN et al. 2002, PYKÄLÄ et al. 2005, ENYEDI et al. 2008). Between grazed and

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

abandoned stands of the *Stipetum lessingianae* we found only slight differences in species composition and no difference in species diversity parameters, even though litter quantity was significantly higher and bare soil surfaces were lower in the abandoned site compared to those continuously grazed.

Contrary to grazing vs. abandonment treatment, planting with pines caused drastic compositional and structural changes in both associations. One of the most obvious long-term consequences of afforestation was the increased cover of woody species additional to the planted *Pinus nigra*. Contrary to the findings of HALBRITTER et al. (2003) relating to pine plantations on dolomite grasslands in Hungary, our results suggest that environmental conditions in planted sites might become more suitable for colonisation by shrubs and trees. This may be due to erosion abatement, increased humus content of the soil, and shading by planted trees. By these means, planting with pines can cause former grassland communities to take on characteristics of a later successional stage, one dominated by woody species. Another important structural difference between grasslands and pine plantations is the decreased quantity of hemicryptophytes in planted sites in the case of both associations. Light-demanding grassland species in particular have lower cover values in plantations, with the dominant and highly abundant grasses (i. e. *Stipa lessingiana, S. pulcherrima, S. capillata, Elymus hispidus*). This is in line with the findings of LEEGE & MURPHY (2001) in the case of sand dune communities, where *Pinus nigra* plantations on sand grasslands were also associated with reduced cover of the herb layer. Decreased cover of herbaceous species is probably brought about by the shading effect of planted trees and subsequent shrub encroachment. The canopy cover of pines and perhaps also disturbances caused during planting facilitated weed infiltration into afforested stands. This may explain the prevalence in such sites of archaeophytes (e.g. *Lactuca serriola, Marrubium peregrinum, Matricaria perforata*) and invasive species (*Robinia pseudacacia, Fraxinus pennsylvanica*) (KÜHN et al. 2004). Changes in species composition are accompanied by the accumulation of pine litter in the planted stands, and, on a longer term, depletion of seed-bank stores (CSONTOS et al. 1997, MACCHERINI & DOMINICIS 2003). These effects could threaten restoration potential of semi-natural grassland communities after timber harvest.

Surprisingly, and in contrast to the results of CREMENE et al. (2005), we found that pine plantations on steppe-like grasslands may have similar or even higher species densities than typical stands, and can preserve a large set of rare and endangered species even 45 years after planting. Notwithstanding, because planted sites lose part of their typical flora, and vegetation and landscape structure are altered, planting non-indigenous trees in grasslands is inappropriate to the interests of biodiversity conservation and landscape ecology (LEEGE & MURPHY 2001, TAMÁS 2001, CREMENE et al. 2005).

4.3. Methodological issues

Both regarding the characterisation of the two associations and the assessment of the effects of different management (grazing, abandonment, afforestation) our results are somewhat preliminary as we analysed only a moderate number of replicates. Additionally, several methodological problems may be involved. First, we had unequal and insufficient sampling of different management types, and differently managed situations were not temporal repetitions of the same grassland stand, as well as we were never able to sample proximal occurrences of the two associations.

Second, the sampling was carried out on five plots per steppe patch and management type, which could be seen as pseudoreplication (e.g. QUINN & KEOUGH 2002), leading to spatial autocorrelation and thus underestimation of p-values through potentially confounding effects of idiosyncrasies of the individual patches. Topography (i.e. slope and aspect), possibly the most important environmental factor operating on landscape scale in this region, was equivalent among associations and treatments. Additionally, all relevés originated from a relatively small geographic area. Thus, we are confident that such potentially confounding effects were subordinate in our study to other factors.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Third, as practically all biodiversity measures are scale-dependent and also species co-occurrence patterns and classification results are influenced by plot size (see DENGLER 2003, OTÝPKOVÁ & CHYTRÝ 2006, DENGLER et al. 2008, in press), the two different plot sizes could be problematic. In the case of species richness, we were able to correct for different plot sizes approximately by applying a previously established species-area relationship (see DENGLER 2009). However, for the Shannon index and number of red-listed species no such 'correction functions' are available, though evenness should be relatively unaffected by plot size because this diversity parameter is already standardised to species richness. Finally, available studies suggest that species co-occurrence patterns and thus the determination of diagnostic species is affected by plot size but that the effects will be negligible for a plot-size ratio of only 1.56 as it is in our study (DENGLER 2003, OTÝPKOVÁ & CHYTRÝ 2006, DENGLER et al. in press).

5. Conclusions and outlook

Steppe-like grasslands of Romania have characteristics similar to those of zonal steppes in central Eurasia, but are mostly represented by smaller, extra-zonal stands (SOÓ 1942, 1949, LAVRENKO & KARAMISHEVA 1993). Stands of the *Stipion lessingianae* in Transylvania are particularly species-rich (up to 63 vascular plant species on 16 m²) and contain many endangered as well as some endemic taxa (e.g. *Cephalaria radiata*, *Nepeta ucranica*, *Jurinea mollis* subsp. *transylvanica*, *Crambe tataria*, *Salvia transsylvanica*, *S. nutans*, *Peucedanum tauricum*, *Allium albidum* subsp. *albidum*). This together with the fact that high quality steppe-like grasslands are now scarce in SE Europe gives them high priority in national and international conservation efforts (DONIȚĂ et al. 2005, EUROPEAN COMMISSION 2007).

As can be seen from our study, many of the traditionally grazed steppe patches in Transylvania are now either abandoned or afforested with *Pinus nigra*. Both alterations in management cause significant changes in floristic composition and partly also in biodiversity. As grazed and abandoned patches both contain a specific set of characteristic rare steppe species, conservation strategies should aim at maintaining a mosaic of these two management types. By contrast, afforestation clearly has negative effects on the occurrence of various steppe taxa. Therefore, further plantations of pine species on steppe-like grassland patches should be avoided and existing plantations should preferably be restored to grassland vegetation.

Finally, our study revealed an astonishing lack of high-quality data on the vegetation of steppe-like dry grasslands in SE Europe, where they have their largest and best-developed stands on the continent. Despite recently published syntaxonomic overviews of SE European countries (SOLOMAKHA 1996, BORHIDI 2003, SANDA et al. 2008), speculation plays a large role in determining the major types of steppic grasslands in this region, whether differently named syntaxa are truly distinct, and whether some syntaxa require placement in synonymy. To remedy these ambiguities, we highlight the urgent need for a consistent supra-national vegetation classification. This is a task not only for purely scientific interest, but also one of great importance for conservation. Only with a methodologically sound classification will it be possible to determine the rarity or commonness and ecological integrity of certain steppe types. Additionally, statistically determined, unambiguous units of classification would allow experience gained in one restoration effort to be confidently put to use in restoration in other regions.

Acknowledgements

We thank the Transylvanian Museum Society and the Hungarian Academy of Sciences (Scholarship Program for Research Abroad) for supporting our research and Réka Balázs for field assistance. We are grateful to Péter Csontos for his advice regarding pine plantations. We are grateful to Erika Schneider and Anna Kuzemko for providing copies of hard-to-get literature on dry grasslands in SE Europe. We thank Ute Jandt, Christian Dolnik, and four anonymous reviewers for constructive comments on former versions of the manuscript, and Curtis Björk for polishing the English usage. Katrin Romahn's help and funding by the German "Arbeitsgruppe Trockenrasen" were indispensable in promoting the participation of ER in the 5th Dry Grassland Meeting on "Dry grasslands in a changing environment" in Kiel.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

References

BĂDĂRĂU, A. S., DEZSI, Ş. & MAN, T. (2001): Cercet ri biogeografice asupra speciilor stepice-silvostepice de *Astragalus* L. din Depresiunea Transilvaniei (II.) (Studies on the steppic and forest-steppe species of *Astragalus* L. in the Transylvanian Basin (II.)) [in Romanian, with English summary]. – Stud. Univ. Babeş-Bolyai, Geogr. 56: 51–67. Cluj.

BOHN, U. & NEUHÄUSL, R. (2000) [Eds.]: Karte der natürlichen Vegetation Europas – Maßstab 1 : 2 500 000 – Karten. – Bundesamt für Naturschutz, Bonn: 10 maps + 1 legend.

–, GOLLUB, G., HETTWER, C., NEUHÄUSLOVÁ, Z., SCHLÜTER, H. & WEBER, H. (2003) [Eds.]: Karte der natürlichen Vegetation Europas – Maßstab 1 : 2 500 000 – Erläuterungstext. – Bundesamt für Naturschutz, Bonn: 655 pp., 13 maps, CD-ROM.

BORHIDI, A. (2003): Magyarország növénytársulásai (Plant associations of Hungary) [in Hungarian]. – Akadémiai Kiadó, Budapest: 610 pp.

BOŞCAIU, N., COLDEA, G. & HOREANU, C. (1994): Lista roşie a plantelor vasculare dispărute, periclitate, vulnerabile şi rare din flora României (Red list of extinct, threatened, vulnerable and rare vascular plant species of Romania) [in Romanian, with French summary]. – Ocrotirea Nat. Med. Înconjurător 38: 45–56, Bucuresti.

CHYTRÝ, M. (2007) [Ed.]: Vegetace České republiky. 1. Travinná a keřičková vegetace (Vegetation of the Czech Republic. 1. Grassland and Heathland Vegetation) [in Czech, with English summary]. – Academia, Praha: 526 pp.

CREMENE, C., GROZA, G., RAKOSY, L., SCHILEYKO, A. A., BAUR, A., ERHARDT, A. & BAUR, B. (2005): Alterations of steppe-like grasslands in Eastern Europe: a threat to regional biodiversity hotspots. – Conserv. Biol. 19: 1606–1618. Malden, MA.

CSONTOS, P., TAMÁS, J. & KALAPOS, T. (1997): Soil seed banks and vegetation recovery on dolomite hills in Hungary. – Acta Bot. Hung. 40: 35–43. Budapest.

CSŰRÖS, I., RESMERIŢĂ, I., CSŰRÖS-KÁPTALAN, M. & GERGELY, I. (1961): Contribuţii la cunoaşterea pajiştilor din Câmpia Transilvaniei şi unele consideraţiuni cu privire la organizarea terenului (Grasslands from the Transylvanian Lowland and considerations about their management) [in Romanian]. – Stud. Univ. Babeş-Bolyai, Biol. 2: 15–61. Cluj.

DENGLER, J. (2003): Entwicklung und Bewertung neuer Ansätze in der Pflanzensoziologie unter besonderer Berücksichtigung der Vegetationsklassifikation. – Arch. Naturwiss. Diss. 14: 297 pp. Galunder, Nümbrecht.

– (2005): Zwischen Estland und Portugal – Gemeinsamkeiten und Unterschiede der Phytodiversitätsmuster europäischer Trockenrasen. – Tuexenia 25: 387–405. Göttingen.

– (2009): Which function describes the species-area relationship best? – A review and empirical evaluation. – J. Biogeogr. 36: 728–744. Oxford.

–, BERG, C. & JANSEN, F. (2005): New ideas for modern phytosociological monographs. – Ann. Bot. N. S. 5: 193–210. Rome.

–, CHYTRÝ, M. & EWALD, J. (2008): Phytosociology. – In: JØRGENSEN, S. E. & FATH, B. D. [Eds.]: Encyclopedia of Ecology: 2767–2779. Elsevier, Oxford.

–, LÖBEL, S. & DOLNIK, C. (in press): Species constancy depends on plot size – a problem for vegetation classification and how it can be solved. – J. Veg. Sci. Oxford.

DIHORU, G. & DIHORU, A. (1994): Plante rare, periclitate şi endemice în flora României – Lista Roşie (Red list of rare, threatened and endemic plants from flora of Romania) [in Romanian, with English summary]. – Acta Bot. Horti Bucur. 1994: 173–199. Bucureşti.

DONIŢĂ, N., IVAN, D., COLDEA, G., SANDA, V., POPESCU, A., CHIFU, T., PAUCĂ-COMEĂNESCU, M., MITITELU, D. & BOŞCAIU, N. (1992): Vegetaţia României (Vegetation types of Romania) [in Romanian]. – Editura Tehnică Agricolă, Bucureşti: 407 pp.

–, POPESCU, A., PAUCĂ-COMĂNESCU, M., MIHĂILESCU, S. & BIRIŞ, I. A. (2005): Habitatele din România (Romania's habitats) [in Romanian, with English summary]. – Editura Tehnică Silvică, Bucureşti: 496 pp.

ENYEDI, Z. M., RUPRECHT, E. & DEÁK, M. (2008): Long-term effects of the abandonment of grazing on steppe-like grasslands. – Appl. Veg. Sci. 11: 53–60. Uppsala.

EUROPEAN COMMISSION (2007) [Ed.]: Interpretation Manual of European Union Habitats – EUR27. – European Commission, DG Environment, Brussels: 144 pp.

GAFTA, D. & MOUNTFORD, J. O. (2008) [Eds.]: Manual de interpretare a habitatelor Natura 2000 din România (Manual for interpreting Natura 2000 habitats from Romania)[in Romanian]. – Risoprint, Cluj: 101 pp.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

HALBRITTER, A., CSONTOS, P., TAMÁS, J. & ANTON, A. (2003): Dolomitsziklagyepek és feketefenyvesek talajainak összehasonlító vizsgálata (Pedological comparisons of dolomite rock grasslands and Autrian pine plantations) [in Hungarian, with English summary]. – Természetvédelmi Közlem. 10: 19–35. Budapest.

ILLYÉS, E. & BÖLÖNI, J. (2007) [Eds.]: Lejtősztyepek, löszgyepek és erdőssztyeprétek Magyarországon (Slope steppes, loess steppes and forest steppe meadows in Hungary) [in Hungarian, with English summary]. – Budapest: 236 pp.

JANIŠOVÁ, M. (2007) [Ed.]: Travinnobylinná vegetácia Slovenska – elektronický expertný systém na identifikáciu syntaxónov (Grassland vegetation of Slovak Republic – electronic expert system for identification of syntaxa) [in Slovak, with English summary]. – Botanický ústav SAV, Bratislava: 263 pp. + CD ROM.

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

KORNECK, D., SCHNITTLER, M., KLINGENSTEIN, F., LUDWIG, G., TAKLA, M., BOHN, U. & MAY, R. (1998): Warum verarmt unsere Flora? – Auswertung der Roten Liste der Farn- und Blütenpflanzen Deutschlands. – In: KLINGENSTEIN, F. & LUDWIG, G. [Eds.]: Ursachen des Artenrückgangs von Wildpflanzen und Möglichkeiten zur Erhaltung der Artenvielfalt. – Schriftenr. Vegetationskd. 29: 299–444. Bundesamt für Naturschutz, Bonn.

KRASOVA, O. O. & SMETANA, M. G. (1999). The steppe vegetation of Kobylna gully [in Ukrainian, with English summary]. – Ukr. Phyotosociol. Col. Ser. A 12–13: 21–30. Kyiv.

KÜHN, I., DURKA, W. & KLOTZ, S. (2004): BiolFlor – a new plant-trait database as a tool for plant invasion ecology. – Diversity Distributions 10: 363–365. Oxford.

KUN, A., RUPRECHT, E. & SZABÓ, A. (2004): Az Erdélyi-medence bioklimatológiai jellemzése (The bioclimatological characteristics of the Transylvanian Basin (Romania)) [in Hungarian, with English summary]. – Múz. Füzetek 13: 63–81. Cluj.

KUNEŠ, P., PELÁNKOVÁ, B., CHYTRÝ, M., JANKOVSKÁ, V., POKORNÝ, P. & PETR, L. (2008): Interpretation of the last-glacial vegetation of eastern-central Europe using modern analogues from southern Siberia. – J. Biogeogr. 35: 2223–2236. Oxford.

LAVRENKO, E. M. & KARAMYSHEVA, Z. V. (1993): Steppes of the former Soviet Union and Mongolia. – In: COUPLAND, R. T. [Ed.]: Ecosystems of the World 8B. Natural Grasslands. Eastern Hemisphere and Resumé: 3–59. Elsevier, Amsterdam.

LEEGE, L. M. & MURPHY, P. G. (2001): Ecological effects of the non-native *Pinus nigra* on sand dune communities. – Can. J. Bot. 79: 429–437. Ottawa.

MACCHERINI, S. & DOMINICS, V. DE (2003): Germinable soil seed-bank of former grassland converted to coniferous plantation. – Ecol. Res. 18: 739–751. Tokyo.

MILCHUNAS, D. G., SALA, O. E. & LAURENROTH, W. K. (1988): A generalized model of grazing by large herbivores on grassland community structure. – Am. Nat. 132: 87–106. Chicago, Ill.

MUCINA, L. & KOLBEK, J. (1993): *Festuco-Brometea.* – In: MUCINA, L., GRABHERR, G. & ELLMAUER, T. [Eds.]: Die Pflanzengesellschaften Österreichs – Teil I: Anthropogene Vegetation: 420–492. Fischer, Jena.

NAVEH, Z. & WHITTAKER, R. H. (1979): Structural and floristic diversity of shrublands and woodlands in Northern Israel and other mediterranean areas. – Vegetatio 41: 171–190. Dordrecht.

OLTEAN, M., NEGREAN, G., POPESCU, A., ROMAN, N., DIHORU, G., SANDA, V. & MIHĂILESCU, S. (1994): Lista roşie a plantelor superioare din România (Red list of higher plants from Romania) [in Romanian, with English summary]. – Stud. Sinteze, Doc. Ecol. 1: 1–52. Bucureşti.

OTÝPKOVÁ, Z. & CHYTRÝ, M. (2006): Effects of plot size on the ordination of vegetation samples. – J. Veg. Sci. 17: 465–472. Uppsala.

POSCHLOD, P. & WALLISDEVRIES, M. (2002): The historical and socioeconomic perspective of calcareous grasslands – lessons from the distant and recent past. – Biol. Conserv. 104: 361–376. Oxford.

PYKÄLÄ, J., LUOTO, M., HEIKKINEN, R. K. & KONTULA, T. (2005): Plant species richness and persistence of rare plants in abandoned semi-natural grasslands in northern Europe. – Basic Appl. Ecol. 6: 25–33. Jena.

QUINN, G. P. & KEOUGH, M. J. (2002): Experimental Design and Data Analysis for Biologists. – Cambridge Univ. Pr., Cambridge: XVII + 537 pp.

RODWELL, J. S., SCHAMINÉE, J. H. J., MUCINA, L., PIGNATTI, S., DRING, J. & MOSS, D. (2002): The Diversity of European Vegetation – An overview of phytosociological alliances and their relationships to EUNIS habitats. – Rapp. EC-LNV 2002/054: 168 pp. National Reference Centre for Agriculture, Nature and Fisheries, Wageningen.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

ROYER, J.-M. (1991): Synthèse eurosibérienne, phytosociologique et phytogéographique de la classe des *Festuco-Brometea*. – Diss. Bot. 178: 296 pp., 8 tables. Cramer, Berlin.

SALA, O. E., LAUENROTH, W. K., MCNAUGHTON, S. J., RUSCH, G. & XINSHI ZHANG, A. (1996): Biodiversity and Ecosystem Functioning in Grasslands. – In: MOONEY, H. A., CUSHMAN, J. H., MEDINA, E., SALA, O. E. & SCHULZE, E. D. [Eds.]: Functional Roles of Biodiversity: A Global Perspective: 129–149. Wiley, Chichester,.

SANDA, V., POPESCU, A. & DOLTU, M. I. (1980): Cenotaxonomia şi corologia grupărilor vegetale din România (Coenotaxonomy and chorology of vegetation types from Romania) [in Romanian]. – Stud. Comun. Suppl. 24: 11–171. Sibiu.

–, –, – & DONIŢĂ, N. (1983): Caracterizarea ecologică şi fitocenologică a speciilor spontane din flora României (Ecological and phytosociological characteristics of the native flora of Romania) [in Romanian]. – Stud. Comun. Suppl. 25: 5–126. Sibiu.

–, ÖLLERER, K. & BURESCU, P. (2008): Fitocenozele din România. Sintaxonomie, structură, dinamică şi evoluţie (Associations of Romania. Syntaxonomy, structure, dynamics and evolution) [in Romanian]. – Ars Docendi, Bucureşti: 570 pp.

SCHNEIDER-BINDER, E. (1975): Pajiştile xeroterme din ord. *Festucetalia valesiacae* Br.-Bl. et Tx. 1943 în zona colinelor marginale ale Depresiunii Sibiului (Die Trockenrasen der *Festucetalia valesiacae* Br.-Bl. et Tx. 1943 im Hügelgebiet um die Zibinssenke in Südsiebenbürgen) [in Romanian, with German summary]. – Stud. Comun. 19: 95–120. Sibiu.

– (1977): Consideraţii asupra asociaţiilor din alianţa *Stipion lessingianae* Soó 1947 în România (Über die pflanzengesellschaften des *Stipion lessingianae* Soó 1947 in Rumänien) [in Romanian, with German summary]. – Stud. Comun. Suppl. 21: 91–113. Sibiu.

SENDTKO, A. (1999): Die Xerothermvegetation brachgefallener Rebflächen im Raum Tokaj (Nordost-Ungarn) – pflanzensoziologische und populationsbiologische Untersuchungen zur Sukzession. – Phytocoenologia 29: 345–448. Berlin.

SOLOMAKHA, V. A. (1996): The syntaxonomy of vegetation of the Ukraine [in Ukrainian, with English summary]. – Ukr. Phytosociol. Collection Ser. B 4: 119 pp. Phytosociocentre, Kyiv.

SOÓ, R. (1942): Az Erdélyi Medence endémikus és reliktum növényfajai (Die Endemismen und Reliktarten des Siebenbürgischen Beckens) [in Hungarian]. – Acta Geobot. Hung. 5: 139–183. Cluj.

– (1947): Révue systématique des associations végétales des environs de Kolozsvár. – Acta Geobot. Hung. 6: 3–50. Cluj.

– (1949): Les associations végétales de la Moyenne-Transylvanie II. Les associations des marais, des prairies et des steppes. – Acta Geobot. Hung. 6: 3–107. Debrecen.

SSYMANK, A., HAUKE, U., RÜCKRIEM, C., SCHRÖDER, E. & MESSER, D. (1998): Das europäische Schutzgebietssystem NATURA 2000. – Schriftr. Landschaftspflege Naturschutz 53: 560 pp. Bundesamt für Naturschutz, Bonn.

TAMÁS, J. (2001): A feketefenyvesek telepítése Magyarországon, különös tekintettel a dolomitkopárokra (Austrian pine plantations in Hungary with special attention to dolomite hills) [in Hungarian, with English summary]. – Természetvédelmi Közlem. 9: 75–85. Budapest.

TUTIN, T. G., HEYWOOD, V. H., BURGES, N. A., MOORE, D. M., VALENTINE, D. H., WALTERS, S. M. & WEBB, D. A. (1968) [Eds.]: Flora Europaea – Volume 2: *Rosaceae* to *Umbelliferae*. – Cambridge University Pr., Cambridge: XXVII + 455 pp.

–, –, –, VALENTINE, D. H., WALTERS, S. M. & WEBB, D. A. (1972) [Eds.]: Flora Europaea – Volume 3: *Diapensiaceae* to *Myoporaceae*. – Cambridge University Pr., Cambridge: XXIX + 370 pp.

–, –, –, – & – (1976) [Eds.]: Flora Europaea – Volume 4: *Plantaginaceae* to *Compositae* (and *Rubiaceae*). – Cambridge University Pr., Cambridge: XXIX + 505 pp.

–, –, –, –, – & – (1980) [Eds.]: Flora Europaea – Volume 5: *Alismataceae* to *Orchidaceae* (*Monocotyledones*). – Cambridge University Pr., Cambridge: XXXVI + 452 pp.

–, BURGES, N. A., CHATER, A. O., EDMONDSON, J. R., HEYWOOD, V. H., MOORE, D. M., VALENTINE, D. H., WALTERS, S. M. & WEBB, D. A. (1993) [Eds.]: Flora Europaea – Volume 1: *Psilotaceae* to *Platanaceae*. 2nd ed. – Cambridge Univ. Pr., Cambridge: XLVI + 581 pp.

VIRÁGH, K. & BARTHA, S. (1996): The effect of current dynamical state of a loess steppe community on its responses to disturbances. – Tiscia 30: 3–13. Szeged.

©Floristisch-soziologische Arbeitsgemeinschft; www.tuexenia.de; download unter www.zobodat.at

Eszter Ruprecht, Anna Szabó and Márton Z. Enyedi
Department of Taxonomy and Ecology
Babeş-Bolyai University
Republicii street 42
400015 Cluj Napoca
ROMANIA
ruprecht@grbot.ubbcluj.ro, annuc19@gmail.com, enyedimarton@freemail.hu

Jürgen Dengler
Plant Systematics and Vegetation Ecology
Biocentre Klein Flottbek
University of Hamburg
Ohnhorststr. 18
22609 Hamburg
GERMANY
dengler@botanik.uni-hamburg.de

Managing editor: Ute Jandt
Manuscript received 30.10.2008, accepted 09.03.2009.

©Floristisch-soziologische Arbeitsgemeinschaft; www.tuexenia.de; download unter www.zobodat.at

Table 2: Vegetation table with 60 relevés from nine steppe-like grassland stands and three pine plantations on former sites of such grasslands in the Transylvanian Lowland, Romania
For data about location, altitude, and date of sampling, see Table 1. At the right margin, we present synoptic columns with percentage constancy values for all relevés, for the relevés of the two associations (excluding the pine plantations), and for the different management types within these. The header of the table contains important topographic, structural, and biodiversity parameters, and in the constancy columns, arithmetic means of these. The figures in the columns are percentage cover values. Differential species of relevé groups within our dataset are highlighted in grey and arranged according to decreasing constancy. Character species of higher syntaxa among the diagnostic species of the associations are marked in the second column. Red-listed species are marked with an asterisk after their name.

Tab. 2: Vegetationstabelle mit 60 Aufnahmen von neun Steppenrasen und drei Kiefernanpflanzungen auf ehemaligen Steppenrasen im Siebenbürgischen Becken (Rumänien)
Informationen zur geografischen Lage und Meereshöhe der Trockenrasengebiete sowie zum Aufnahmedatum können Tab. 1 entnommen werden. Neben den Spalten der Einzelaufnahmen (mit prozentualen Deckungswerten) folgen rechts Stetigkeitsspalten (mit prozentualen Stetigkeitswerten) für alle Aufnahmen, für die beiden Assoziationen (ohne die aufgeforsteten Bestände) und für die Managementypen innerhalb der Assoziationen. Im Kopf der Tabelle sind wichtige topografische, strukturelle und Biodiversitätsparameter der Aufnahmen bzw. Mittelwerte derselben in den Stetigkeitsspalten angegeben. Differenzialarten von Aufnahmegruppen sind grau hinterlegt und nach fallender Stetigkeit angeordnet. Diejenigen Charakterarten höherer Syntaxa, die zugleich diagnostisch für eine der beiden Assoziationen waren, sind in der zweiten Spalte entsprechend gekennzeichnet. Ein Stern hinter dem Namen markiert Arten der Roten Listen.

| Association | Stipetum lessingianae | | |

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: Tuexenia - Mitteilungen der Floristisch-soziologischen Arbeitsgemeinschaft

Jahr/Year: 2009

Band/Volume: NS_29

Autor(en)/Author(s): Ruprecht Eszter, Szabo Anna, Enyedi Marton Z., Dengler Jürgen

Artikel/Article: Steppe-like grasslands in Transylvania (Romania): characterisation and influence of management on species diversity and composition 353-368