DOI: 10.2478/hacq-2014-0003

MANAGEMENT REGIMES WITHIN SYNTAXA OF SEMI-NATURAL GRASSLANDS IN WEST BULGARIA

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Abstract

This study focuses on mesic and xeric grasslands of mostly secondary origin, and that are influenced by human activity. Mesic grasslands are traditionally used for hay-making, and xeric ones for pastures. Over the last 20 years, livestock farming in Bulgaria has significantly declined so that less grass is needed. Many types of grasslands are no longer used and lots of abandoned fields can be found nowadays in Bulgaria. The analyses in this study are based on 868 relevés collected on xeric and mesic grasslands according to the methodological approach of Braun-Blanquet. As a result, five alliances within two classes are recognized: the class *Festuco-Brometea*, represented by three alliances, namely *Cirsio-Brachypodion pinnati*, *Chrysopogono-Danthonion calycinae* and *Festucion valesiacae*, and the class *Molinio-Arrhenatheretea*, represented by two alliances, namely *Arrhenatherion elatioris* and *Cynosurion cristati*. The majority of the managed grasslands are situated in close proximity to settlements. Most of the abandoned areas (30%) are found within *Cirsio-Brachypodion* alliance. These grasslands are characterized by the highest values of total cover of vegetation. They are located in the most distant and least accessible areas. If use is not resumed, all the abandoned grasslands will be under threat of extinction in the near future. At the same time, many arable lands have been abandoned and turned into grasslands by the processes of secondary succession.

Keywords: classification, grazing, mowing, ordination, species diversity, syntaxonomy, vegetation.

Izvleček

V raziskavi smo se osredotočili na mezična in kserična travišča večinoma sekundarnega nastanka, ki so pod vplivom človekovih aktivnosti. Mezična travišča se tradicionalno uporabljajo za seno, kserična pa kot pašniki. V Bolgariji je živinoreja v zadnjih 20 letih močno upadla in je potreba po krmi manjša. S številnimi tipi travišč ne gospodarijo več in danes je v Bolgariji moč najti številne opuščene površine. V analizi smo zbrali 868 vegetacijskih popisov kseričnih in mezičnih travišč, narejenih z Braun-Blanquetovo metodo. Uvrstili smo jih v pet zvez in dva razreda: razred *Festuco-Brometea*, ki ga predstavljajo tri zveze *Cirsio-Brachypodion pinnati*, *Chrysopogono-Danthonion calycinae* in *Festucion valesiacae* in razred *Molinio-Arrhenatheretea* z dvema zvezama *Arrhenatherion elatioris* in *Cynosurion cristati*. Večina vzdrževanih travišč se nahaja v bližini naselij. Večino opuščenih površin (30%) uvrščamo v zvezo *Cirsio-Brachypodion* in za te travnike je značilno, da imajo največjo skupno pokrovno vrednost in se nahajajo v najbolj oddaljenih, težko dostopnih območjih. Če jih ne bomo ponovno začeli uporabljati, bodo v bližnji prihodnosti izginili. Obenem se opuščajo tudi številne obdelovalne površine, ki se spreminjajo v travnike v procesu sekundarne sukcesije.

Ključne besede: klasifikacija, paša, košnja, ordinacija, vrstna pestrost, sintaksonomija, vegetacija.

1. INTRODUCTION

Traditionally, Bulgarian semi-natural grasslands are not improved, either by treatment with artificial fertilisers and pesticides, by or reseeding. The grasslands with mesic character are cut for hay, whereas those with xeric character are used as pastures. The significant decline in farming intensity over the past 20 years has resulted in a reduced demand for grass, by farmers for their livestock.

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Abandonment leads to scrub, forest and bracken (*Pteridium aquilinum*) encroachment within grasslands. This is known as secondary succession, i.e. the gradual replacement of one plant community by another. Such regeneration of the natural vegetation in the same place after human or natural disturbances is also described in literature as "demutation", "demutational changes", "regenerative changes", "secondary succession" and "progressive succession" (Schmithüsen 1961, Shennikov 1964, Bykov 1967, 1970, Rabotnov 1978, Barbour et al. 1980). Meshinev et al. (2000), Meshinev (2001), Apostolova & Meshinev (2001) and Yordanova (2001) reported active regeneration of the potential natural vegetation within grasslands that were no longer under a pasture or mowing regime. Less accessible pastures and those of higher altitudes are more often abandoned (Nikolov 2010, Vassilev et al. 2011), while managed grasslands are situated mainly close to settlements. Typically, the latter grasslands have low species diversity, a compacted substrate because of the intensive trampling, and considerable presence of ruderal species (Velev 2005). A diminished need for hay results in abandonment of many hay-meadows. Some of them are now used as pastures or have been abandoned completely. Shifting the management type from hay-making to grazing favours an increased presence of xeric and ruderal species, as has been recorded by Vassilev et al. (2011) in West Bulgaria. They state that abandoned pastures are dominated by mesic species, while grazed pastures are dominated by mesoxeric species. The invasion of forest and shrub vegetation into grasslands is highlighted as one of the major negative consequences of the abandonment of meadows and pastures (Meshinev et al. 2005, Schrautzer et al. 2009, Hegedüšová & Senko 2011). Bush encroachment causes a decline in the grazing capacity of grasslands (Smit 2004). Abandoned grasslands are subject changes in their floristic composition, ecology and syntaxonomy (Meshinev et al. 2000, 2009, Jantunen 2003, Stránská 2004, Velev & Apostolova 2008, Ruprecht et al. 2009, Rusina & Kiehl 2010, Házi et al. 2011, Priede 2011). When such changes occur in vegetation, some grassland types may locally disappear (Stančić 2008, Hegedüšová & Senko 2011). These changes in the vegetation are also reflected in other components of biodiversity, such as insects (Söderström et al. 2001, Wiezik et al. 2011, Šumpich & Konvička 2012), birds (Nikolov 2010), etc.

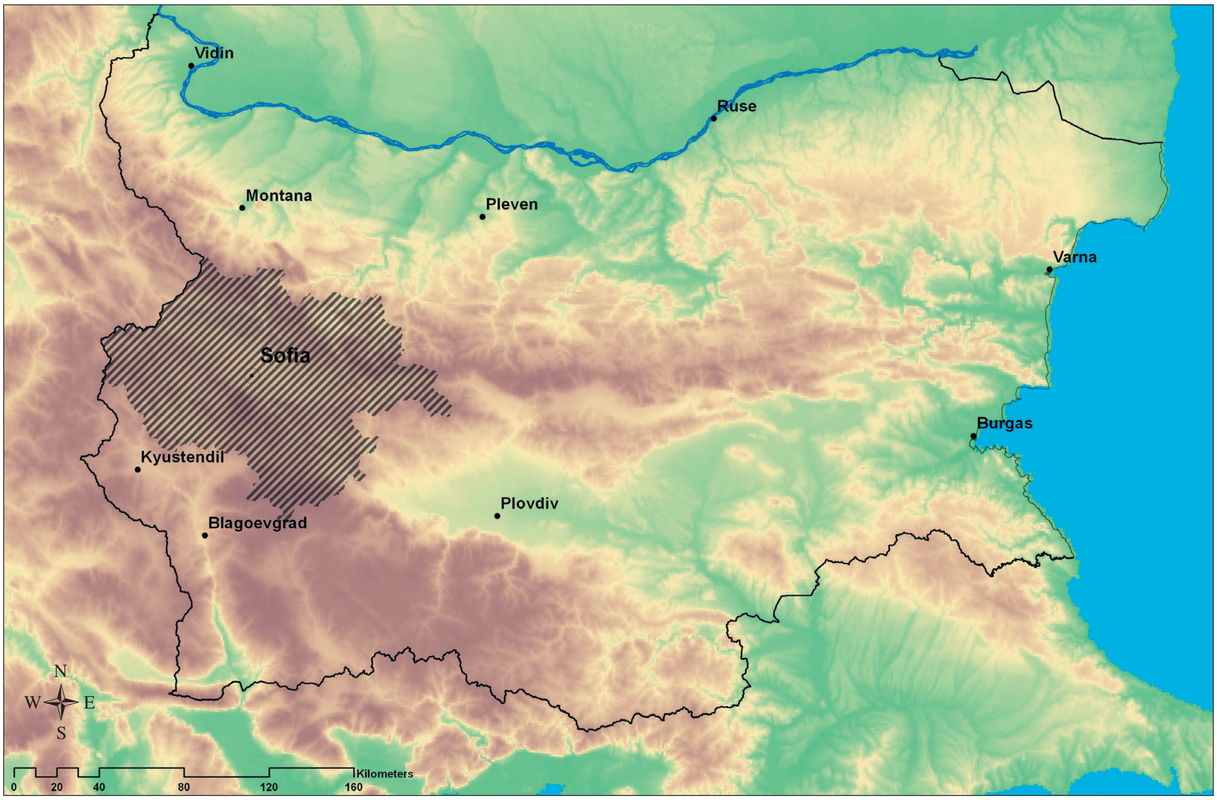


Figure 1: Map of Bulgaria. The study area is shaded.

Slika 1: Karta Bolgarije, obravnavano območje je osenčeno.

The aim of this study is to find: 1. Which syntaxa occur in West Bulgarian dry and mesic semi-natural managed grasslands? 2. What is the species diversity within these grasslands? 3. What types of management are these grasslands subjected to?

2. MATERIAL AND METHODS

2.1 Study area

The study area is situated in the central part of West Bulgaria (Figure 1). The total study area is more than 10,000 km^2. The research was focused on the mesic and xeric grasslands, which are mostly secondary and are influenced by human activity. According to the climatic zones of Bulgaria, the study area is classified as temperate-continental and transitional-continental (Velev 2002). The climate in this region is characterized by warm summers and cold winters and by high annual amplitudes of air temperature. The average annual temperature is 10.0 °C with a minimum in January and maximum in July. The average annual precipitation is 571 mm with a minimum in February and a maximum in June (Lieth et al. 1999). An ombrothermic climatic diagram from Sofia observatory is shown in Figure 2. The bedrock of mesic grasslands is mainly silicate, whereas that of the xeric grasslands is mainly limestone.

2.2 Field sampling

Dry and mesic semi-natural managed grasslands from the study area in West Bulgaria were sampled. The sampled localities were chosen randomly. We tried to set the sample plots so as to uniformly cover the entire study area. The management types of grasslands as grazing, mowing and abandonment were recorded. In the analyses, three dummy variables were used to indicate the absence or presence of these three management types. The analyses were based on 868 relevés collected according to the methodological approach of Braun-Blanquet (Braun-Blanquet 1965, Westhoff & van der Maarel 1973, Mueller-Dombois & Ellenberg 1974). All relevés were collected within four vegetation growing seasons (2007–2010). The sample plots were square with area of 16 m^2, which is recommended for grasslands (Knapp 1984, Kent & Coker 1992, Chytrý & Otýpková 2003). The expanded Braun-Blanquet combined scale (Barkman et al. 1964, van der Maarel 1979, Parolly 2003) was used for the estimation of species' cover/abundance. All 868 relevés were stored in a TURBOVEG database (Hennekens & Schaminèe 2001) and in the Bulgarian vegetation database (Apostolova et al. 2012). The taxonomy of species follows primarily Kozhuharov (1992). Taxa not included in this source were determined using Delipavlov & Cheshmedjiev (2003) and Assyov & Petrova (2012).

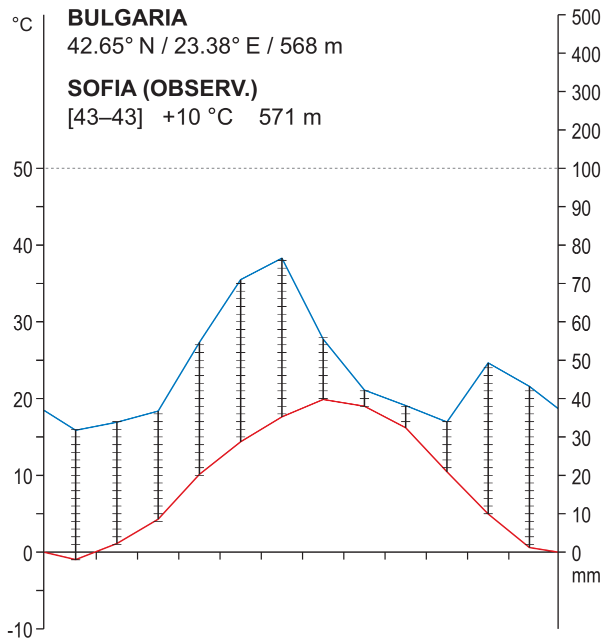


Figure 2: Ombrothermic climatic diagram for the study area, according to Lieth et al. (1999).

Slika 2: Ombrotermični klimatski diagram obravnavanega območja, po Lieth et al. (1999).

2.3 Data analysis

Numerical classification was performed by TWINSPAN (Hill 1979) incorporated in the JUICE 7.0 software package (Tichý 2002). Three pseudospecies cut levels (0, 5, 25) were used in the analyses. The same software was used for calculating some syntaxa attributes, such as the number of relevés, total species number, average species number, average Whittaker β-diversity, average positive fidelity, sharpness index and uniqueness index. The quality of the classified syntaxa was expressed by the indices of sharpness and uniqueness. Analyses of these indicators express the well-defined and poorly defined syntaxa (Chytrý & Tichý 2003). Sharpness and uniqueness indices were calculated on the basis of 100 randomly selected relevés. The species in the synoptic table (Table 1) were represented by two indicators: fidelity measure, expressed by the phi-coefficient multiplied by 100 (Chytrý et al. 2002), and constancy, expressed in percentage. For the fidelity calculation, all relevé groups were standardized to equal size (Tichý & Chytrý 2006). The phi-values were verified by Fisher's exact test ($P<0.001$), in order to eliminate the statistically insignificant phi-coefficients. The β-diversity for each syntaxon was calculated on the basis of 100 randomly selected relevés. Indirect Gradient Analysis (DCA) was applied using the CANOCO version 4.55 software (ter Braak & Šmilauer 2002) in order to interpret ecologically the vegetation differentiation. A preliminary DCA analysis established that the gradient length of first axis is higher than four standard deviation units. Large differences between vegetation units are best described by unimodal response models (ter Braak & Prentice 1988) and this is the reason why DCA was chosen. Rare species were downweighted in the analyses, because DCA ordination is sensitive to species that occur even in few samples (ter Braak 1987). The data were normalized by "square root transformation" (McDonald 2008, Osborne 2010). The variables such as management regime, total cover and Shannon index were passively projected onto the first two DCA axes in order to explore any existing patterns in the studied grassland vegetation. The Shannon index is a widely used index for characterizing the species diversity in a plant community by taking into account the species richness and evenness (Clarke & Warwick 2001, Tichý & Holt 2006). The Shannon indices of the studied vegetation units were summarized and presented as box-and-whiskers plots. The observed differences were tested for statistical significance by Mann-Whitney U-test.

3. RESULTS

3.1 Classification and ordination

As a result of the TWINSPAN classification, five vegetation groups were distinguished. These clusters are identified as five alliances within two classes: class *Festuco-Brometea* Br.-Bl. & Tüxen ex Soó 1947, represented by three alliances, namely *Cirsio-Brachypodion pinnati* Hadač & Klika ex Klika 1951, *Chrysopogono-Danthonion calycinae* Kojić 1959 and *Festucion valesiacae* Klika 1931, and class *Molinio-Arrhenatheretea* Tüxen 1947, represented by two alliances, namely *Arrhenatherion elatioris* Luquet 1926 and *Cynosurion cristati* Tüxen 1947. The recognized syntaxa are in compliance with Klika (1931, 1951), Kojić (1959), Chytrý (2007), Chytrý et al. (2007), Hájková et al. (2007) and Sanda et al. (2008).

Festuco-Brometea and *Molinio-Arrhenatheretea* grasslands are well distinguished in the DCA ordination diagram (Figure 3). The eigenvalue of the first axis (0.591) shows a good dispersion of the sample plots along it. Its gradient length is 4.539 and explains 8.10% of the total inertia. The main gradient (first axis) could be related to moisture. The variance explained by the second DCA axis (0.291) is a small portion (3.99%) of the total inertia in the data set (7.293). The gradient length of the second axis is 3.967. It is closely related to soil acidity. Soil pH increases between the alliances *Cirsio-Brachypodion* and *Festucion valesiacae* (Figure 3). The *Festuco-Brometea* class is represented by 368 relevés, and *Molinio-Arrhenatheretea* by 500 relevés. The *Arrhenatherion* alliance is best represented (by 298 relevés), followed by *Festucion valesiacae* (by 236 relevés), while the least represented is the alliance *Chrysopogono-Danthonion* (by only 10 relevés). All the alliances are shown in a synoptic table with phi-coefficients (Table 1). The best separated alliance within our database is *Cirsio-Brachypodion*. The Sharpness index (19.97) and the Uniqueness index (1.0) values prove its distinctness within the data set (Table 2).

3.2 Management practices

The vegetation within the *Festuco-Brometea* class is found only in pastures, while some of the grasslands classified in this class are abandoned. Although some of the dry grasslands are mesic enough to be mown (like *Cirsio-Brachypodion*), we did not observe any mowing activities during this study. *Molinio-Arrhenatheretea* grasslands are used both for grazing and mowing (Figure 4). Usually these grasslands are cut once per year. Mowing is the prevailing management type within mesic grasslands, even within the *Cynosurion* alliance, which is traditionally managed as pastures. The majority of dry grasslands are used

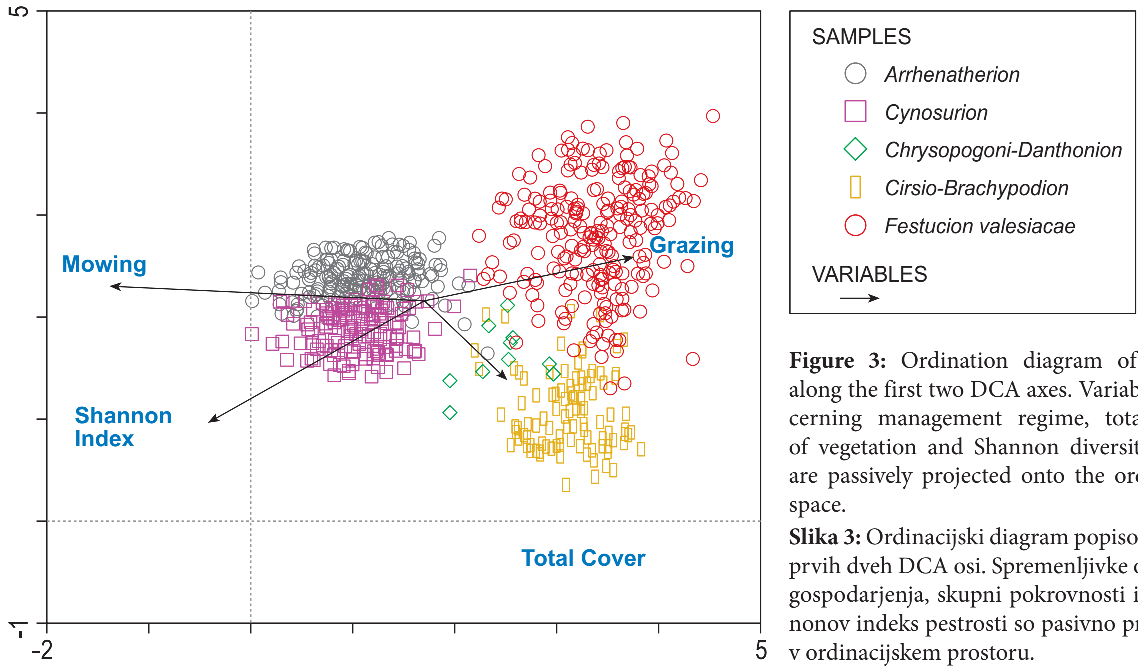


Figure 3: Ordination diagram of relevés along the first two DCA axes. Variables concerning management regime, total cover of vegetation and Shannon diversity index are passively projected onto the ordination space.

Slika 3: Ordinacijski diagram popisov vzdolž prvih dveh DCA osi. Spremenljivke o načinu gospodarjenja, skupni pokrovnosti in Shannonov indeks pestrosti so pasivno prikazane v ordinacijskem prostoru.

as pastures (89%), while 11% of them are abandoned. Mesic grasslands are mainly used for hay (43%). Grazing only and combined usage (both grazing and mowing) of grasslands occur in 22%

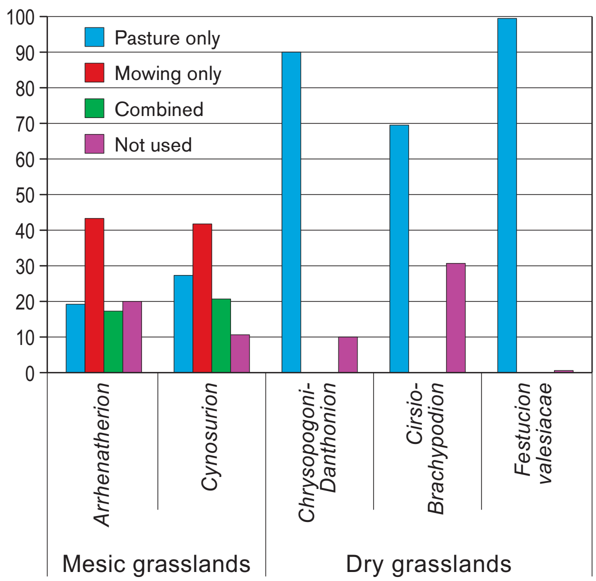


Figure 4: Management regimes within the considered alliances. Percentage values of the management regimes recorded in the relevés sampled within each alliance are given.

Slika 4: Načini gospodarjenja v posameznih zvezah. Prikazane so odstotne vrednosti različnih načinov gospodarjenja, zabeleženih v vzorčenih popisih posamezne zveze.

and 19% of the mesic grasslands, respectively. Abandoned mesic grasslands represent 16% of their total area. The highest percentage (30%) of abandoned lands and the highest values of total cover were found within the *Cirsio-Brachypodion* alliance (Figure 4), followed by the *Arrhenatherion* alliance with 20% of abandoned lands. The lowest proportion of abandoned grasslands was found within the *Festucion valesiacae* alliance – less than 0.5%.

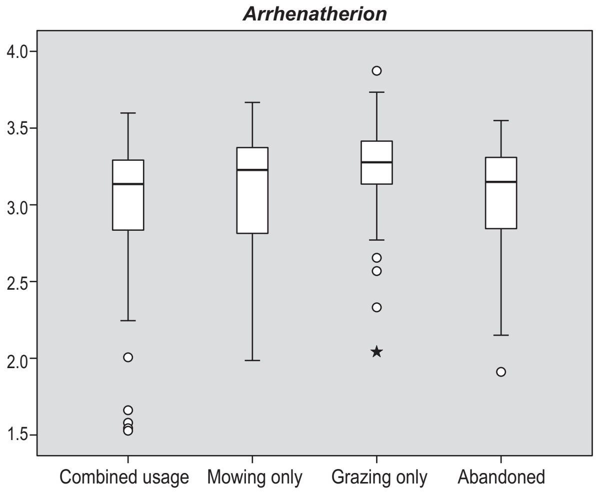
3.3 Species diversity

The dry grasslands of the *Festucion valesiacae* alliance is the syntaxon with the highest species richness within the analyzed dataset, presenting also the highest β-diversity values. The vegetation of mesic grasslands is more homogenous than that of dry grasslands, and has the lowest β-diversity values. The Shannon species diversity index is highest within the *Cynosurion* alliance indicating the highest community complexity (Figure 3). As a result, the *Cynosurion* alliance has the highest average species number and at the same time the lowest β-diversity value. The *Festucion valesiacae* alliance shows the opposite pattern, with the lowest average species number but the highest β-diversity value. Within both alliances, average species number is negatively related to β-diversity (Table 2).

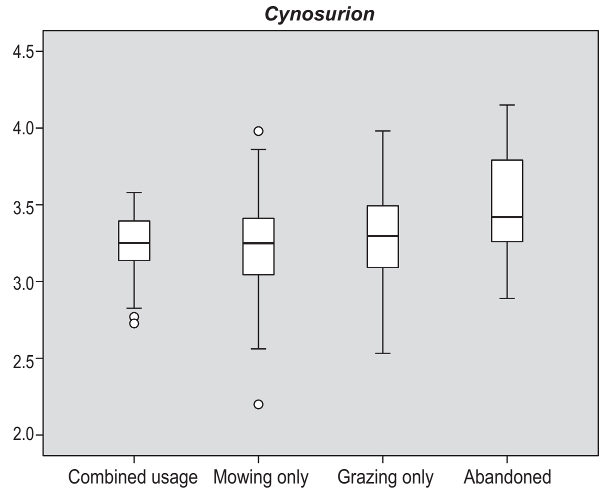
4. DISCUSSION

Changes in management type lead to changes in species composition of grasslands (Jantunen 2003, Farris et al. in press), and also the course of vegetation succession (Velev & Apostolova 2008). Grazing management of *Arrhenatherion* grasslands, for example, increases the species diversity (Figure 5), as it reduces the strong dominant role of *Arrhenatherum elatius*. The potential of grazing for biodiversity enhancement and restoration of pastures in this way is reported by Metera et al. (2010) and Wrage et al. (2011). In contrast, the *Cynosurion* alliance shows increased species diversity within its abandoned grasslands (Fig. 5). We consider this as a short-term effect after the abandonment of grasslands. The diversity loss within abandoned meadows may be driven by different mechanisms depending on the life history strategy of the dominant species (Csergő et al. 2013). Mesic grasslands are characterized by low values of β-diversity, but high Shannon index values (Table 2, Figure 5). The highest values of total cover were found within the abandoned lands, mostly within *Cirsio-Brachypodion pinnati* alliance. These are among the most distant and least accessible grasslands. Most of the managed grasslands are situated in close proximity to settlements, as is the case for the mesic grasslands of the *Arrhenatherion* and *Cynosurion* alliances. Unsurprisingly, the remoteness of grasslands from settlements is negatively related to the intensity of their management and vice versa. *Cirsio-Brachypodion* grasslands are among the most distant ones from villages and this explains the high percentage of abandoned lands within this alliance (Figure 4). If no longer managed, all the abandoned grasslands in the study area will end up in diverse shrub and forest communities. Nearly 14% of the grasslands are abandoned within the study area. Grazing and mowing of Bulgarian grasslands has gradually declined in the past 20 years, and in many places has ceased completely (see also Apostolova & Meshinev 2006). The absence of regular mowing and grazing within these grasslands has put them under threat of extinction. Shrubs and trees are known to be more competitive than herbaceous species and all abandoned lands in the study area are gradually invaded by shrub and forest vegetation. Similar processes occur in many other localities in Bulgaria (Meshinev et al. 2000, 2005, Velev 2005). The abandonment, as well as the overgrazing of pastures are considered to have a negative impact on biodiversity and should be avoided (Metera et al. 2010). There are places where the development of shrub vegetation is so advanced that the former grasslands have completely transformed into shrub communities (information obtained from local people). Nowadays, a lot of mesic pastures are converted into hay meadows or are abandoned. At the same time, much arable land has been abandoned and become grassland by the processes of demutation. Such secondary succession on abandoned croplands is also called old-field succession (Barbour et al. 1980). Usually, these are *Arrhenatherum elatius* dominated plant communities classified within *Arrhenatherion* alliance. Such lands are located close to villages and now are used for hay-making or as pastures.

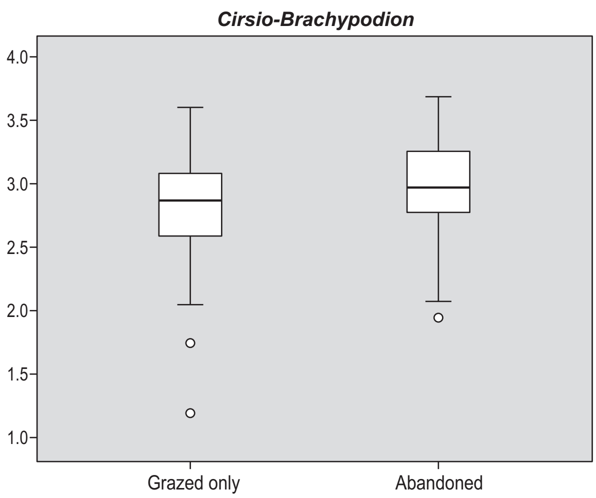
As a rule, in the study area the grazing is of low intensity and intensive grazing almost completely ceased over 20 years ago. Typically, *Cynosurion* grasslands used to be managed as pastures, but it is notable that mowing now prevails within *Cynosurion* alliance (Figure 4). This is in accordance with the decreased livestock numbers and decreased need of pasture lands, as in general, farmers now keep only one or two grazing animals. Meshinev et al. (2005) and Apostolova & Meshinev (2006) also indicate mowing as the predominant management type within the *Cynosurion* alliance in Bulgaria. According to Horvat et al. (1974), the *Cynosurion* vegetation on the Balkans is managed in a different way as compared to Central Europe, where it is managed as pastures and in many cases is improved by manuring. Bulgarian semi-natural grasslands are completely unimproved. Depending on the management practices, *Cynosurion* type grasslands may be developed from other vegetation types as *Arrhenatherion* or *Calthion* (Zuidhoff et al. 1995, Dierschke 1997, Hájková et al. 2007). Traditionally, the meadows of the *Arrhenatherion* alliance are used for hay-making. Today, due to the decreased demand for hay, many of these meadows are abandoned or used as pastures. The alliance with the most abandoned land (30%) is the *Cirsio-Brachypodion pinnati*. Abandoned grasslands in Bulgaria within this alliance have also been recorded by Pedashenko et al. (2013). These communities contain some rare species of high conservation value on national and international level, such as Balkan endemics (*Chamaecytisus calcareus*, *Sesleria latifolia*, *Silene roemeri*), species included in the national Biological Diversity Act (*Lilium jankae, L. martagon*), species included in



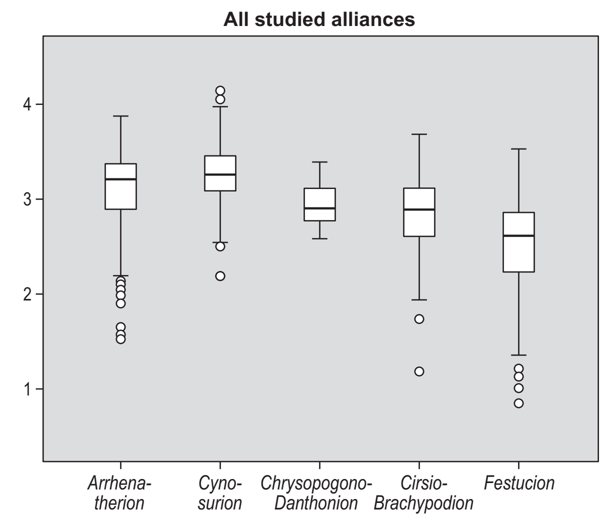
	Mowing only	Grazing only	Abandoned
Combined usage	0.128	0.002	0.825
	Mowing only	0.032	0.271
		Grazing only	0.005



	Mowing only	Grazing only	Abandoned
Combined usage	0.473	0.51	0.01
	Mowing only	0.185	0.004
		Grazing only	0.044



	Abandoned
Combined usage	0.101



	Cynosu-rion	*Chrysopogono-Danthonion*	*Cirsio-Bra-chypodion*	*Festucion*
Arrhena-therion	0.000	0.056	0.000	0.000
	Cynosu-rion	0.002	0.000	0.000
		Chrysopogono-Danthonion	0.585	0.003

Figure 5: Box-and-whiskers plots of Shannon index. Results are tested for statistical significance by Mann-Whitney U-test. The significance levels of P-values are presented below every diagram. The observed differences are statistically significant if P<0.05. Box-and-whiskers plots are not presented for the *Festucion valesiacae* and the *Chrysopogono-Danthonion*, because within them mostly or only grazing management practice has been recorded.

Slika 5: Shannonov indeks, prikazan z grafom škatla z brki. Rezultate smo statistično testirali z Mann-Whitneyevim U testom. Stopnje značilnosti so prikazane pod vsakim grafom. Razlike so statistično značilne pri *P*<0,05. Škatla z brki ni prikazana za zvezi *Festucion valesiacae* in *Chrysopogono-Danthonion*, ker se ta travišča gospodari večinoma s pašo.

the Red Data Book of the Republic of Bulgaria and in the Annex II of the Directive 92/43/EEC (*Echium russicum*) and species included in the Red List of Bulgarian vascular plants (*Thesium linophyllon*, *Tragopogon balcanicus*) (Vassilev et al. 2012). At the present time, these grasslands are under serious threat from shrub and tree invasion. The regular management of these semi-natural grasslands is considered to be an excellent tool for restoration, sustainability and protection from extinction. Grazing is suggested as an intervention to prevent the invasion of shrubs in open landscapes (Metera et al. 2010). Extensive grazing and control of shrub encroachment are good practices in the management of xerophytic and mesophytic grasslands in West Bulgaria (Vassilev et al. 2011). According to Begon et al. (2006), a moderate grazing regime will introduce the necessary heterogeneous environment, without causing pasture deterioration and strong compaction of the substrate, thus increasing grasslands species richness.

5. ACKNOWLEDGEMENT

The authors are grateful to H. Pedashenko for configuring and preparing the map. We also express our sincere thanks to the reviewers and the editor, whose suggestions improved the manuscript considerably. Special thanks to Laura Sutcliffe for linguistic editing and IAVS for supporting the editing financially through a project grant to EDGG.

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Received 2. 3. 2013
Accepted 3. 1. 2013

Co-ordinating editor: Ioannis Tsiripidis

Table 1: Fidelity (phi coefficients) and relative constancy synoptic table of the alliances of grasslands in West Bulgaria. Only statistically significant fidelity values (*P*<0.001; Fisher's exact test) are presented. Phi-values are multiplied by 100. Taxa which have phi<30 have been omitted.

Tabela 1: Navezanost (fi koeficient) in sinoptična tabela z relativno stalnostjo zvez travišč v zahodni Bolgariji. Prikazane so samo statistično značilne vrednosti navezanosti (P<0,001; Fisherjev natančni test). Fi vrednosti smo pomnožili s 100. Taksoni s fi vrednostjo, manjšo od 30, niso prikazani.

Syntaxa recognized	*Arrhenatherion elatioris*		*Cynosurion cristati*		*Chrysopogono - Danthonion*		*Cirsio-Brachypodion*		*Festucion valesiacae*	
Number of relevés	298		202		10		122		236	
Fidelity (x100) / Constancy	Phi	%	Phi	%	Phi	%	Phi	%	Phi	%
Poa pratensis	59	89	30	62	---	---	---	14	---	---
Vicia grandiflora	57	60	24	---	---	---	---	---	---	1
Vicia cracca	56	58	---	21	---	---	---	2	---	1
Geranium dissectum	49	31	---	1	---	---	---	---	---	---
Arrhenatherum elatius	45	62	23	44	---	9	---	1	---	2
Taraxacum sec. *Ruderalia*	45	63	39	58	---	---	---	---	---	---
Festuca pratensis	45	72	42	69	---	---	---	10	---	1
Dactylis glomerata	42	73	30	62	---	18	---	11	---	1
Trifolium campestre	41	55	---	25	---	18	---	2	---	6
Trisetum flavescens	40	42	---	15	---	9	---	---	---	3
Convolvulus arvensis	39	74	20	56	---	9	---	18	---	26
Myosotis arvensis	37	26	---	7	---	---	---	---	---	2
Vicia tetrasperma	36	38	13	23	---	---	---	---	---	6
Dipsacus laciniatus	35	22	1	6	---	---	---	---	---	---
Silene vulgaris	35	17	---	1	---	---	---	---	---	---
Cirsium arvense	34	29	6	12	---	---	---	2	---	2
Galium album	34	23	4	8	---	---	---	---	---	1
Crepis biennis	33	40	30	37	---	---	---	---	---	---
Tragopogon dubius	33	21	---	4	---	---	---	---	---	3
Trifolium striatum	32	24	9	12	---	---	---	---	---	---
Elymus repens	31	54	5	31	---	9	---	20	---	17
Lathyrus aphaca	31	14	---	1	---	---	---	---	---	1
Salvia nemorosa	31	31	---	2	---	9	---	11	---	3
Lathyrus nissolia	30	20	1	6	---	---	---	1	---	1
Ranunculus polyanthemos	30	28	18	21	---	---	---	---	---	1
Holcus lanatus	---	7	63	54	---	---	---	---	---	---
Cynosurus cristatus	---	20	62	82	---	27	---	2	---	1
Agrostis capillaris	---	4	57	85	---	45	---	22	---	1
Leontodon autumnalis	---	9	50	45	---	---	---	7	---	---
Deschampsia caespitosa	---	5	49	35	---	---	---	---	---	1
Rumex acetosa	---	14	48	54	---	18	---	---	---	1
Cerastium holosteoides	18	30	46	50	---	---	---	---	---	1
Stellaria graminea	18	41	45	64	---	18	---	---	---	1
Ranunculus acris	12	36	44	64	---	18	---	4	---	5
Centaurea phrygia	---	1	43	24	---	---	---	---	---	---
Trifolium repens	29	56	42	68	---	9	---	11	---	3
Alopecurus pratensis	21	38	42	54	---	9	---	---	---	1
Prunella vulgaris	---	7	40	43	---	9	---	11	---	1
Rosa canina	11	18	39	35	---	---	---	---	---	---
Phleum pratense	---	8	38	34	---	---	---	8	---	1
Trifolium pratense	28	63	38	72	1	36	---	3	---	2
Leontodon hispidus	22	43	37	55	---	18	---	1	---	1

Number of relevés	298		202		10		122		236	
Rhinanthus rumelicus	15	41	37	60	---	27	---	---	---	7
Trifolium dubium	---	4	35	21	---	---	---	---	---	1
Trifolium patens	---	4	34	20	---	---	---	1	---	---
Cirsium canum	8	12	33	25	---	---	---	---	---	---
Carum carvi	9	12	32	24	---	---	---	---	---	---
Achillea millefolium	31	84	32	85	---	36	---	22	---	35
Trifolium hybridum	18	21	32	29	---	---	---	---	---	---
Sanguisorba officinalis	---	1	31	14	---	---	---	1	---	---
Festuca rubra agg.	---	27	31	54	---	27	---	24	---	1
Carex hirta	3	8	30	21	---	---	---	2	---	1
Lolium perenne	25	29	30	32	---	---	---	---	---	---
Danthonia alpina	---	2	---	20	69	82	---	9	---	3
Linum catharticum	---	2	---	4	61	73	12	32	---	4
Briza media	---	9	---	41	59	100	13	55	---	2
Polygala vulgaris	---	4	---	11	56	55	---	3	---	1
Carex tomentosa	---	---	---	---	54	36	---	1	---	1
Chrysopogon gryllus	---	1	---	1	53	45	---	1	---	9
Thymus callieri	---	2	---	1	47	73	---	5	41	68
Anthoxanthum odoratum	---	13	30	74	46	91	---	31	---	13
Scorzonera hispanica	---	---	---	1	43	27	---	3	---	---
Orchis morio	---	---	---	1	41	27	---	2	---	2
Luzula multiflora	---	---	---	---	38	18	---	---	---	---
Dorycnium herbaceum	---	2	---	8	38	18	---	---	---	---
Trifolium montanum	---	4	---	11	38	45	5	21	---	2
Filipendula vulgaris	---	5	---	34	36	73	32	70	---	8
Koeleria nutidula	---	---	---	---	36	45	---	5	27	39
Hieracium praealtum	---	12	---	21	35	55	---	13	---	20
Campanula sparsa	---	---	---	---	35	18	---	2	---	---
Prunus spinosa	---	1	---	2	32	27	---	3	3	11
Avenula compressa	---	2	---	2	31	27	---	3	3	11
Phleum phleoides	---	---	---	1	30	18	---	2	---	5
Asperula cynanchica	---	1	---	2	---	---	74	78	---	14
Thymus longicaulis	---	---	---	---	---	9	74	71	---	2
Brachypodium pinnatum	---	3	---	3	---	---	69	65	---	5
Potentilla cinerea	---	---	---	---	---	---	66	63	---	13
Scabiosa columbaria	---	---	---	---	---	---	64	53	---	6
Veronica austriaca	---	1	---	---	---	---	61	50	---	6
Bromus riparius	---	---	---	---	---	---	60	45	---	2
Hypericum linarioides	---	---	---	---	---	---	60	43	---	1
Primula veris	---	1	---	1	---	---	53	34	---	1
Minuartia viscosa	---	---	---	---	---	---	49	30	---	1
Sesleria latifolia	---	---	---	---	---	---	48	28	---	---
Asperula purpurea	---	---	---	---	---	---	48	42	---	15
Pimpinella tragium	---	---	---	---	---	---	47	31	---	4
Trifolium alpestre	---	---	---	3	---	36	46	60	---	8
Artemisia chamaemelifolia	---	---	---	---	---	---	45	25	---	---
Seseli peucedanoides	---	---	---	---	---	---	45	28	---	3
Koeleria macrantha	---	4	---	2	---	---	44	32	---	1
Carlina acanthifolia	---	3	---	---	---	18	44	55	2	22
Cerastium banaticum	---	---	---	---	---	9	43	34	---	3
Carex humilis	---	---	---	---	---	---	39	21	---	2
Festuca dalmatica	---	8	---	5	15	45	37	66	---	32

Number of relevés	298		202		10		122		236	
Inula salicina	---	1	---	4	---	9	37	30	---	---
Hieracium pilosella	---	1	---	1	1	18	37	45	4	21
Achillea setacea	---	---	---	---	5	18	37	40	---	13
Chamaecytisus calcareus	---	---	---	---	3	9	36	26	---	1
Fragaria viridis	---	4	---	2	2	18	36	43	---	2
Chamaespartium sagittale	---	1	---	1	26	36	35	43	---	2
Polygala major	---	1	---	---	---	---	35	20	---	4
Veratrum nigrum	---	---	---	---	---	---	34	15	---	---
Globularia aphyllanthes	---	---	---	---	---	---	34	19	---	4
Cruciata glabra	---	---	---	1	4	9	33	24	---	---
Galium lovcense	---	---	---	---	15	27	33	40	---	12
Corothamnus procumbens	---	---	---	---	---	---	30	11	---	---
Centaurea triumfetti	---	---	---	---	---	---	30	11	---	---
Avenula pubescens	---	2	---	3	---	---	30	18	---	1
Astragalus onobrychis	---	1	---		---	---	---	2	75	66
Medicago minima	---	4	---		---	---	---	1	44	30
Eryngium campestre	---	26	---	16	---	36	---	33	44	81
Poa angustifolia	---	---	---	---	---	18	---	10	42	44
Centaurea sp.	---	---	---	---	---	---	---	7	42	29
Dichanthium ischaemum	---	---	---	---	---	---	---	3	39	23
Veronica verna	---	---	---	---	---	---	---	---	38	18
Teucrium polium	---	---	---	---	---	---	---	1	37	18
Medicago falcata	---	10	---	2	---	---	14	28	37	45
Trifolium dalmaticum	---	---	---	---	---	---	---	2	37	19
Trifolium aureum	---	1	---	4	---	---	---	4	34	23
Erysimum diffusum	---	1	---	---	---	---	---	---	33	15
Rosa sp.	---	---	---	---	---	9	---	7	33	28
Alyssum minus	---	---	---	---	---	---	7	10	32	22
Thesium arvense	---	---	---	---	---	---	---	2	31	14
Verbascum phlomoides	---	---	---	---	---	---	---	---	31	12
Convolvulus cantabrica	---	1	---	---	---	---	---	1	30	14
Stipa eriocaulis	---	---	---	---	---	---	---	---	30	11
Festuca rupicola	---	3	---	3	---	---	---	---	30	18

Table 2: Attributes of the studied vegetation units. The measures of β-diversity, Sharpness and Uniqueness indices were calculated on the basis of 100 randomly selected relevés per group, in order to obtain comparable values between the different groups; the same attributes are not given for *Chrysopogono-Danthonion* alliance because it was only represented by small number of relevés.

Tabela 2: Značilnosti proučevane vegetacije. Vrednost β diverzitete, indeksa Sharpness in Uniqueness smo izračunali na osnovi 100 naključno izbranih popisov na skupino, da bi zagotovili primerljive vrednosti med različnimi skupinami. Vse značilnosti niso prikazane za zvezo *Chrysopogono-Danthonion*, saj je vzorčena z majhnim številom popisov.

Alliance	Number of relevés	Total species number	Average species number	Average Whittaker beta-diversity	Average Shannon index	Sharpness index	Uniqueness index
Arrhenatherion elatioris	298	275	35.59	7.96	3.10	6.20	0.92
Cynosurion cristati	202	269	38.89	7.08	3.26	4.70	0.92
Chrysopogono-Danthonion	10	111	33.40	–	2.96	–	–
Cirsio-Brachypodion	105	210	33.95	8.28	2.87	19.97	1.00
Festucion valesiacae	231	326	27.16	12.60	2.54	2.71	0.88