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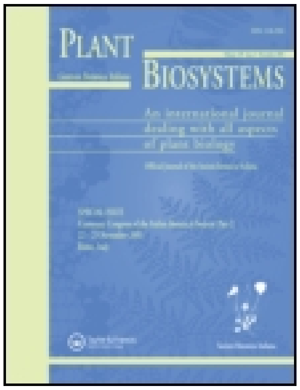

Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tplb20

The value and need for protection of kurgan flora in the anthropogenic landscape of steppe zone in Ukraine

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Available online: 14 Sep 2011

To cite this article: B. Sudnik-wóójcikowska, I. I. Moysiyenko, M. Zachwatowicz & E. Jabłłońńska (2011): The value and need for protection of kurgan flora in the anthropogenic landscape of steppe zone in Ukraine, Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology, 145:3, 638-653

To link to this article: http://dx.doi.org/10.1080/11263504.2011.601335

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Plant Biosystems, Vol. 145, No. 3, September 2011, pp. 638–653

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SUCCESSION, MANAGEMENT AND RESTORATION OF DRY GRASSLANDS

The value and need for protection of kurgan flora in the anthropogenic landscape of steppe zone in Ukraine

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Abstract
The aim of this study was to determine and compare the floristic value of kurgans distributed over an area of approximately 32,100 km^2 spreading in four climatic-vegetation zones (steppes and forest steppe) in southern Ukraine. Among the 450 kurgans visited during the growing seasons 2004–2010, 106 best preserved kurgans were investigated. Of 721 species identified, 69 were sozophytes (species of special concern), threatened with extinction. They were usually recorded on the slopes of kurgans and were mostly associated with communities from the classes *Festuco-Brometea* and *Festucetea vaginatae*. The distributional patterns of the most frequent sozophytes within kurgans coming from four different climatic-vegetation zones were analyzed. Our study confirmed that kurgans could play a role as refugia of the steppe flora. However, the spatial isolation (about 82–90% of the Ukrainian steppe was turned in agricultural land) and relatively small populations of sozophytes do not contribute to their survival. Other threats to kurgan flora include the following: a direct destruction of the kurgans by frequent fires, excessive grazing, cultivation practices, human activities, e.g. archeological excavations, or illegal activities of archeological looters. The active conservation of kurgans as archeological sites, as well as areas of high floristic value is recommended.

Keywords: *Kurgan flora, protection of kurgans, refugia of steppe flora, species of special concern, steppe zone, threats to kurgans*

Introduction

Kurgans, or ancient burial mounds, are widely found throughout the temperate zone of Eurasia, particularly in Europe (e.g. Great Britain, the Netherlands, Germany, Poland, Hungary, Romania, Bulgaria), as well as in former USRR provinces (Ukraine, Russia, Kazakhstan) and Mongolia. The earliest kurgans were built over 5500 years ago and the most recent ones are over 700 years old, dating back to the Eneolithic, Bronze, the early Iron Age, Pre-Roman and Roman Times, and the Great Migration Period and the Middle Ages. They were constructed by the nomadic populations of Kimmerians, Scythians, Sarmatians, Thracians, Bulgarians, Huns, Magyars, Polovtsians, Nogays and others (Bibikov 1971; Smirnov 1974; Ecsedy 1979; Artemenko 1985, 1986; Shilov 1991; King 2006; Morgunova & Khokhlova 2006; Khodarkovsky 2009). These conical or dome-shaped burial mounds with a wooden, stone, or wood-stone construction usually contained one or several urn or skeleton graves. Some of the kurgans have been also used as cemeteries up to the present times. Kurgans are numerous in Ukraine, where they are a characteristic element of native landscape, especially of the steppe plains. Originally there were about half a million kurgans in the current territory of Ukraine. However, today only 50,000–100,000 kurgans remain (150,000 according to Skorii & Kyslii 2008). About 5000 kurgans have been reported from the Kherson Region in a southern part of country. Such a high concentration of kurgans in one region is unique in Europe. They are usually 1–10 m tall and range from 8–100 m in

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ISSN 1126-3504 print/ISSN 1724-5575 online © 2011 Società Botanica Italiana
DOI: 10.1080/11263504.2011.601335

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diameter in size. Most of the small barrows have been ploughed up but those taller than 3–4 m still remain and are easily recognizable in the Ukrainian landscape.

The archeological value of the kurgans has been widely recognized and appreciated. However, not much is known about the floristic value of these human-made structures. It is surprising that specific flora and fauna of kurgans have been a subject of only a few studies in the central and southeast Europe. Investigations were carried, e.g. in Bulgaria (Paczoski 1933), Hungary (Ecsedy 1979; Penksza & Joó 2002; Barczi 2003; Barczi et al. 2004), Poland (Cwener & Towpasz 2003; Cwener 2004, 2005; Towpasz 2006), Russia (Dzybov 2006; Bykov & Khrustaleva 2008) and Ukraine (e.g. Melnyk 2001; Boreiko et al. 2002; Bozhko 2008; Fisun 2008; Lystopad 2009). Considering that 82–90% of steppe areas in Ukraine have been practically destroyed due to maintenance of agricultural practices and development of human settlements, in consequence its area has been reduced 50-fold during the past 2000 years. Hence kurgans could play an important role in the local restoration of the steppe vegetation. Before the "taming of the steppe" – about 200 years ago (e.g. Sunderland 2004; Khodarkovsky 2009) – the barrows in the Kherson Region were surrounded by virgin steppe vegetation, which promoted formation of the plant cover similar to the natural steppe vegetation. As a result of human activities, smaller kurgans disappeared. Fortunately, most of the bigger barrows have remained, but the state of preservation of their plant cover varies significantly. At present state, they resemble native flora islands in "the agricultural ocean". The best preserved kurgans are of high conservation value as they can play a significant role as refugia of local steppe vegetation.

The aim of this study was to evaluate the natural value of kurgans in different steppe zones of southern Ukraine and provide insight on their threats and significance of their active conservation.

Material and methods

The first comprehensive research on the flora of kurgans in distinguished steppe and forest steppe zones was started in 2004 and conducted in two phases: in the years 2004–2007 and 2008–2010. The floristic study was carried out on the kurgans in southern Ukraine distributed over an area of approximately 32,100 km^2, situated in the Black Sea Lowland and Dnieper Upland, within the Kherson, Mykolaiv, Kirovograd, Cherkasy and Poltava regions, in the three steppe zones and a forest steppe zone (Figure 1).

The classification below is based on the classification scheme used in the "*Map of the Natural Vegetation of Europe*" (Bohn et al. 2000). The classification scheme developed by Russian and Ukrainian authors (e.g. Bilyk et al. 1973; Lavrenko et al. 1991) is given in square brackets:

- west and central Pontic desert steppe (M16), usually occurs in combination with halophytic vegetation (solonchak, solonetz); [wormwood/sod-grass or desert steppe; Russian: polynnaya step];
- west Pontic grass steppe (M12); [forb-poor fescue/feather-grass steppe; tipchakovo-kovylnaya step – Russian: biednoje raznotravie];
- west and central Pontic herb-grass steppe (M5) and west and central Pontic herb-rich grass steppe (M1); [forb-rich fescue/feather-grass steppe; tipchakovo-kovylnaya step; Russian: bogatoje raznotravie];
- forest steppe: the complex of vegetation (L2, L3, L4, F41, F44, F62, D57 – see Figure 1); [Russian: lesostep].

The investigated area lies within the temperate continental climate zone. The main differences between the steppe zones are shaped by climatic characteristics: mean annual temperature (from south to north: 9–10°C, 9–11°C, 7–9°C) and total precipitation (up to 350 mm, 350–400 mm, 400–450 mm, respectively). The soil quality changes from light and dark chestnut soils occurring in combination with solonetz-solonchak soils, through southern chernozem, to typical humic chernozem.

The forest steppe zone, which is located furthest to the north, is characterized by a temperate climate, with moderately hot summers and cold winters. The mean annual temperature is 7.7°C. The mean annual precipitation is usually 550–750 mm in the west, and 450 mm in the east, which only slightly exceeds evaporation. Humidity levels are close to optimum levels. The main soils of the belt are deep black chernozems, podzolized chernozems, and grey forest soils. The forest steppe zone is a macro-mosaic of different forest types, mainly occurring on podzolized chernozems and meadow steppe on deep black soils.

During our study, we visited more than 450 kurgans in total. Floristic surveys were conducted on 106 kurgans (26, 26, 29, and 25 barrows in the four zones, respectively). We visited the kurgans at least three times during the growing season: in spring, summer, and autumn. During the whole period of our study we spent an average of 1–2 days investigating each kurgan. The following criteria were used to select the kurgans subjected to a floristic analysis:

- the height of kurgans; those less than 3 m in height were omitted;

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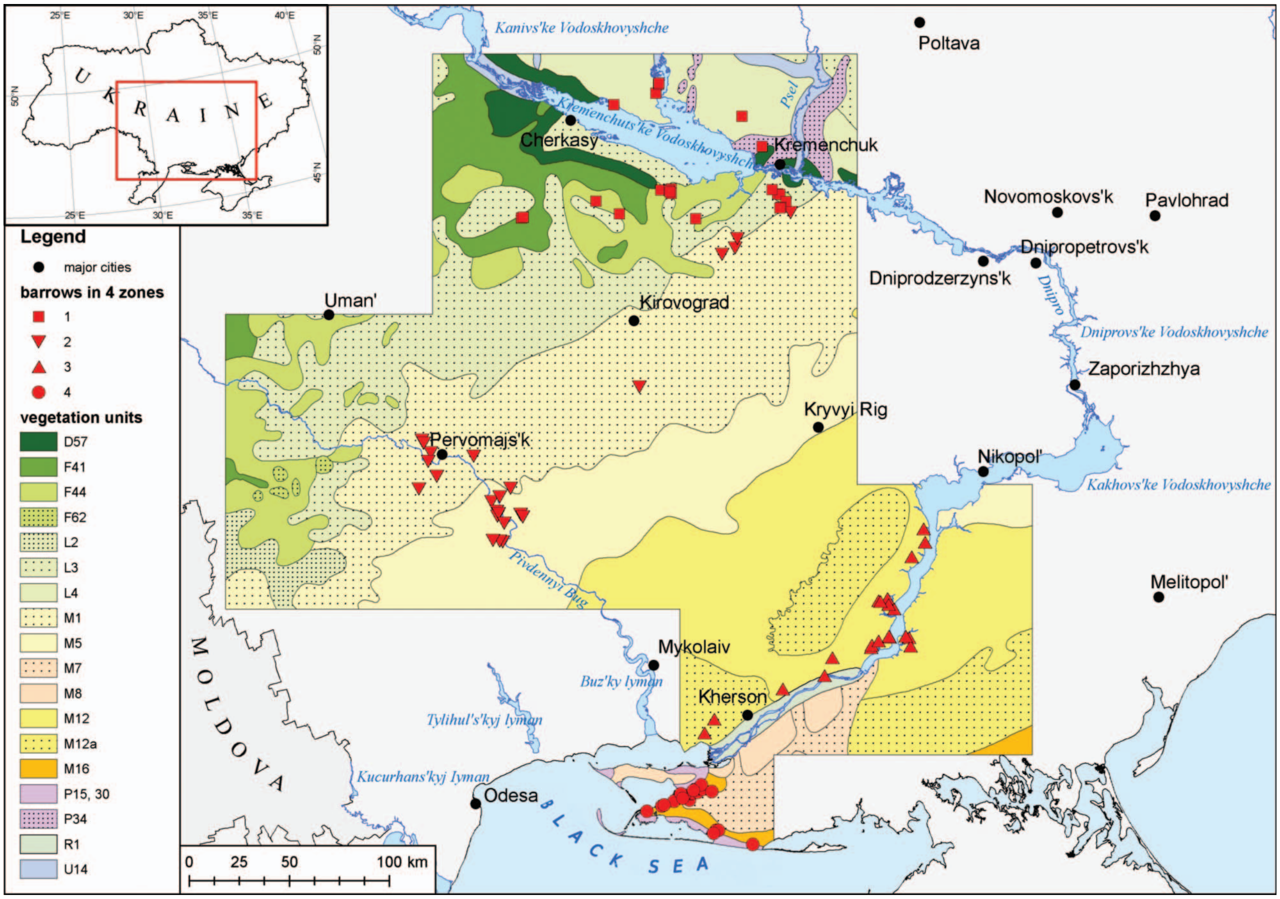

Figure 1. Distribution of the kurgans investigated in the steppe zones in southern Ukraine: (1) square – kurgans in the forest-steppe zone; (2) upside down triangle – kurgans in the west and central Pontic herb-grass steppe and west and central Pontic herb-rich grass steppe zone; (3) triangle – kurgans in the west Pontic grass steppe zone; (4) circle – kurgans in the desert steppe zone. Designations (according to Bohn et al. 2000): *The forest steppe zone*: D57 – southeast European herb- and grass-rich xerophytic pine and oak pine forests, F41 – east Polish-Ukrainian lime-pedunculate oak-hornbeam forests, F44 – Podolian-Moldavian thermophilous hornbeam-pedunculate oak forests; F62 – east pre-Carpathian-Moldavian sessile oak-hornbeam forests; L2 – Vohlyn-Podolian meadow steppes; L3 – Moldavian-Ukrainian meadow steppes; L4 – south Sarmatian meadow steppes; *the steppe zones*: M1 – west and central Pontic herb-rich grass steppes; M5 – west and central Pontic herb-grass steppes; M7 – Pontic hemi-psammophytic herb grass steppes; M8 – Pontic psammophytic herb grass steppes; M12 – west Pontic grass steppes; M12a – west Pontic grass steppes in combination with halophyte vegetation (solonchak); M16 – west and central Pontic desert steppes in combination with halophyte vegetation (solonchak, solonetz); P15 – west and central Pontic sand-dune vegetation, P30 – west Pontic halophytic vegetation; P34 – west and east Pontic salt meadows; R1 – freshwater tall reed swamps; U14 – Pontic hardwood alluvial forests.

- the state of preservation of kurgans; barrows destroyed or severely altered by human activity were not considered (e.g. due to extraction of earth, strong disturbances occurring in the upper parts of kurgan, or intensive use of barrows as cemeteries);
- the state of persistence of the plant cover; it was assumed that the presence of typical steppe species, tuft grasses such as *Festuca valesiaca, Koeleria cristata* and *Stipa capillata* (or *S. lessingiana* and *S. ucrainica*) as well as *Bothriochloa ischaemum* and *Cleistogenes bulgarica*, was an indicator of a relatively good condition of the plant cover.

Floristic lists were compiled for each of the five microhabitats identified within the kurgans: (top – T; northern and southern slope – Sn, Ss; northern and southern base – Bn, Bs). The microhabitats could be easily distinguished physiognomically, and a vertical moisture gradient was observed within studied kurgans. The northern and southern slopes differed in light, temperature, and moisture conditions. These gradients in abiotic conditions were reflected in vegetation types. The boundary between the disturbed top and slope of the kurgans was clearly marked. The vegetation changed at the boundary between a base and slope of the barrow. Agricultural field practices determined a clear boundary between a foot of kurgans and a cultivated land.

In each microhabitat, the abundance of each species was estimated according to 3-point scale:

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1 – sporadic: a few records of the species;
2 – infrequent: scattered sites;
3 – common: frequent occurrence (a species present in larger patches).

The species nomenclature was given after Mosyakin & Fedoronchuk (1999).

The outcomes of carried studies on the flora of kurgans and their location within each of the four zones have already been published (Moysiyenko & Sudnik-Wójcikowska 2006, 2009; Sudnik-Wójcikowska & Moysiyenko 2006, 2010a). In the present study, a special attention was given to species of high floristic value, known as sozophytes, which are protected by law and included in international, European, Ukrainian and local red lists: International Union for Conservation of Nature (IUCN) Red List of Threatened Plants (Mosyakin 1999), European Plant Red List (Shelyag-Sosonko 1996), Washington Convention CITES 1975, Bern Convention 1979, Appendix II (Vinichenko 2006), The Red Data Book of Ukraine (Didukh 2009a), The Red Data List of Kherson (Boiko & Podgainyi 2002), The Red Data List of Mykolaiv Region (mscr.), The Red Data List of Poltava Region (Bayrak & Stetsyuk 2005), The Red Data List of Kirovograd Region (Andrienko 1999), List of rare vascular plants protected in Cherkasy Region (Shevchyk et al. 2006).

For each species of special concern, the following information was included: detailed data about the occurrence of the species within identified kurgan microhabitats, their life form, higher syntaxa the species is associated with (according to Solomakha 1996; Mirkin & Naumowa 1998), and the justification for classifying the species as sozophytes.

In total 100 (25 randomly selected from each zone) kurgans were subjected to statistical analysis. The distributional patterns of the most frequent species of sozophytes in five microhabitats within kurgans occurring within three steppe zones and a forest steppe zone were analyzed. The most frequent species of sozophytes were considered the ones which occurred on the kurgans more than 10 times in at least one of the four distinguished climatic-vegetation zones. Two-way ANOVA was performed to find out whether there were any significant differences in the species mean occurrence within specified microhabitats and steppe zones, followed by the post hoc Tukey test. Moreover, factors threatening the existence of sozophytes, as well as means of ensuring effective conservation of the natural vegetation of kurgans were considered in the study.

Results

Sozophytes as components of the kurgan flora

A total of 721 species were recorded on 106 kurgans in the four studied zones (depending on the zone, on average 82.3–125.5 species per kurgan). The total number of species and the average number of species per kurgans in a specified steppe zone, as well as the number of sozophytes, increased going northwards (see also Table I).

Among all recorded species, 69 (about 10%) were species of special concern (sozophytes, Figure 2). A complete list of sozophytes within kurgans, their life form, their associations with particular syntaxa, a zone in

Table I. Basic floristic parameters characterizing the flora of kurgans in the three steppe zones in southern Ukraine and in the forest-steppe zone.

Characteristics of the flora of kurgans investigated in the steppe and forest steppe zones	Zone: West and central Pontic desert steppe (D)	West Pontic grass steppe (P)	West and central Pontic herb(-rich) grass steppe (R)	Forest steppe (F)
Number of kurgans in particular zones	26	26	29	25
Mean high/mean diameter of the kurgans in particular zones (m)	5.4/56.7	5.8/52.3	5.7/67.1	5.0/46.7
Total number of species in particular zones and percentage of the total flora of kurgans (721)	305 (42.3%)	355 (49.2%)	435 (60.3%)	460 (63.8%)
Mean (minimum and maximum) number of species on a kurgan in particular zones	82.3 (48–103)	110.0 (72–141)	125.5 (89–171)	107.5 (85–189)
Percentage of native species on kurgan flora in particular zones	77.2	70.4	74.2	75.4
Percentage of nonsynanthropic species in kurgan flora in particular zones	39.6	38.9	41.2	41.8
Percentage of steppe species in kurgan flora in particular zones	41.0	56.1	49.9	49.0
Number of sozophytes in kurgan flora in particular zones (total 69 species)	10	18	18	47
Number of species of international value on kurgans in particular zones (total 13 species)	5	8	8	4
Number of species from "Red Data Book of Ukraine" in particular zones (total 14 species)	4	6	5	4

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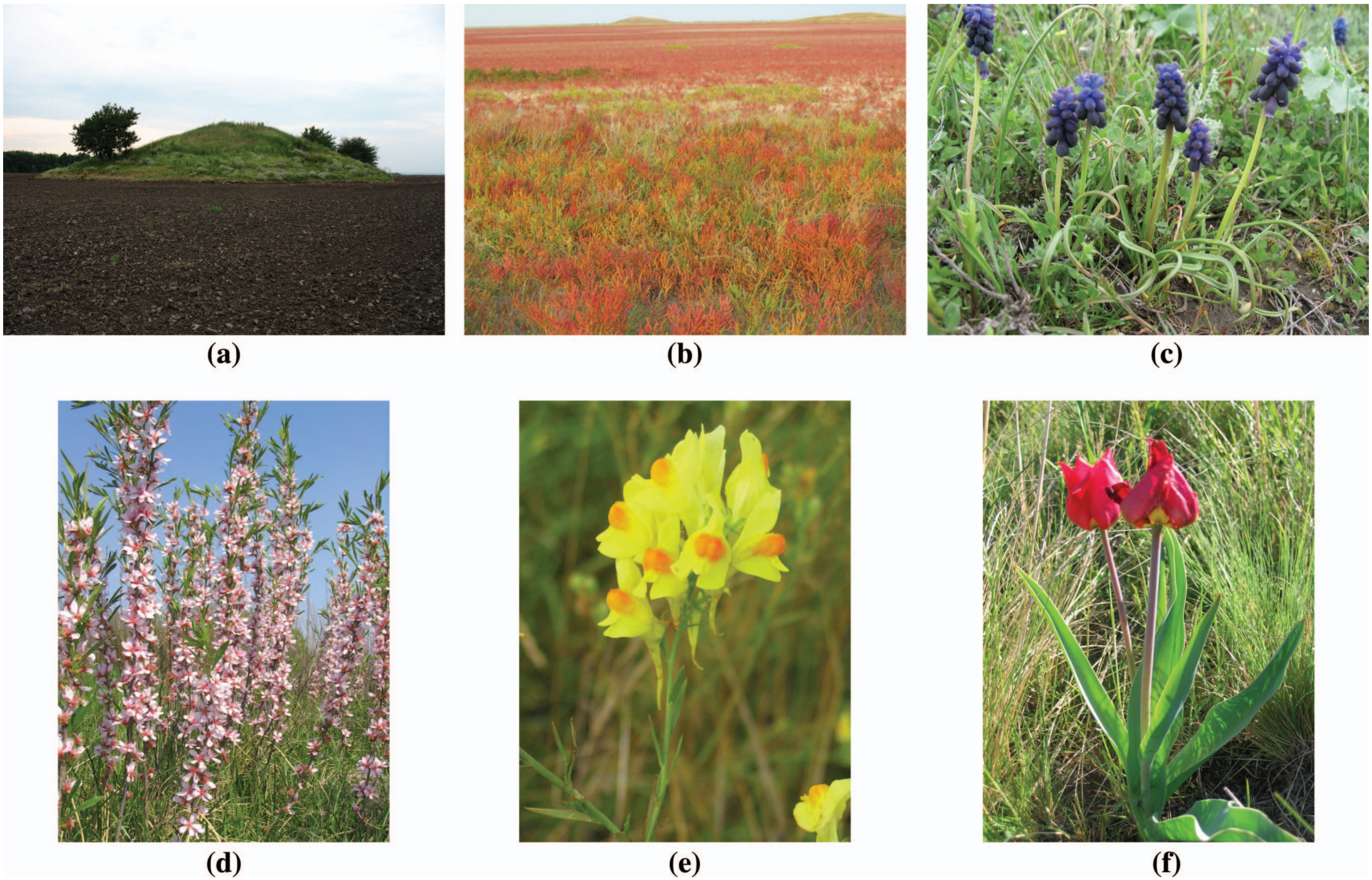

Figure 2. Kurgans as refugia of steppe flora: (a) in the forest steppe zone – kurgan surrounded by arable fields; (b) in desert steppe zone – kurgan surrounded by extensive pastures and solonchaks. Species of special concern recorded on the kurgans: (c) *Muscari neglectum*, (d) *A. nana*, (e) *L. biebersteinii*, and (f) *Tulipa schrenkii*.

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Table II. Characteristics of sozophytes recorded on 106 Ukrainian kurgans.

Number of records of sozophytes on kurgans in each zone																
D [26 kurgans]	P [26 kurgans]	R [29 kurgans]	F [25 kurgans]	Life forms	Syntaxa	Sozophytes	W	E	U	B	T	K	M	R	P	C
–	–	4	2	H	*Fest-Brom*	*Adonis vernalis* L.			+		+		+			
–	–	7	–	h	*Fest-Brom*	*Adonis wolgensis* Steven ex DC.			+							
–	–	8	6	g	*Fest-Brom*	*Allium flavescens* Besser										+
11	–	11	1	g	*Fest-Brom, Fest vagi*	*Allium guttatum* Steven										+
1	–	–	–	g	*Moli-Arrh, Fest-Brom*	*Allium regelianum* A.Becker ex Iljin	+	+	+	+						
–	1	10	3	nf	*Fest-Brom*	*Amygdalus nana* L.						+	+	+		+
2	–	–	–	g	*Moli-Arrh, Fest-Pucc*	*Anacamptis picta* (Loisel.)R.M. Bateman			+		+					
–	–	–	4	h	*Fest vagi*	*Anchusa pseudoochroleuca* Dest.-Schost										+
–	–	1	2	h	*Trif-Gera, Gali veri, Fest-Brom*	*Anemone sylvestris* L.							+	+		+
–	–	2	2	h	*Fest-Brom, Stel medi*	*Anthemis tinctoria* L.									+	
–	–	–	2	h	*Fest-Brom, Gali veri*	*Aster bessarabicus* Bernh. ex Rchb.										+
–	1	–	–	h	*Fest vagi*	*Astragalus borysthenicus* Klokov		+	+							
–	1	5	2	h	*Fest-Brom*	*Astragalus dasyanthus* Pall.	+	+	+							
–	1	–	–	h	*Fest-Brom*	*Astragalus pallescens* M.Bieb.	+									
–	6	–	2	h	*Fest vagi, Fest-Brom*	*Astragalus varius* S.G.Gmel.										+
–	–	2	3	h	*Fest-Brom*	*Asyneuma canescens* (Waldst. & Kit.) Griseb. & Schenk									+	
11	19	5	7	h	*Fest-Brom*	*Carex stenophylla* Wahlenb.								+		
1	20	7	8	hg	*Fest-Brom*	*Carex supina* Willd. ex Wahlenb.										+
–	1	3	1	h	*Fest-Brom*	*Cephalaria uralensis* (Murray) Schrad. ex Roem. & Schult.										
19	2	–	–	t	*Fest-Brom*, Poly-Arte	*Cerastium ucrainicum* Pacz. ex Klokov						+				
–	–	–	2	n	*Rham-Prun*	*Cerasus fruticosa* (Pall.) Woronow								+		+
–	1	–	4	h	*Fest-Brom*	*Cleistogenes bulgarica* (Bornm.) Keng										+
–	–	2	–	g	*Fest-Brom*	*Crocus reticulatus* Steven ex Adams			+							
3	3	–	–	h	*Fest-Brom*	*Dianthus lanceolatus* Steven	+	+								

(*continued*)

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Table II. (*Continued*).

Number of records of sozophytes on kurgans in each zone: D [26 kurgans]	P [26 kurgans]	R [29 kurgans]	F [25 kurgans]	Life forms	Syntaxa	Sozophytes	W	E	U	B	T	K	M	R	P	C
						ex Rchb.										
1	–	8	5	h	*Fest-Brom*	*Elisanthe viscosa* (L.) Rupr.										+
–	–	2	–	hg	*Fest-Brom*	*Elytrigia stipifolia* (Czern. ex Nevski) Nevski	+	+	+							
–	3	–	1	*n*	*Fest-Brom*, *Ammoph*	*Ephedra distachya* L.						+		+		
–	–	–	5	h	*Fest-Brom*	*Eremogone micradenia* (P.Smirn.) Ikonn.										+
–	8	–	2	h	*Fest-Brom*	*Eremogone rigida* (M.Bieb) Frenzl	+									
–	–	–	2	h	*Fest-Brom*, *Artemi*	*Euphorbia kaleniczenkoi* Czern.										+
–	–	–	7	h	*Fest-Brom*	*Euphorbia subtilis* Prokh.										+
2	3	4	1	h	*Fest-Brom*	*Galatella villosa* (L.) Rchb. f.										+
–	2	15	–	h	*Fest-Brom*	*Galium volhynicum* Pobed.		+								
–	7	7	1	h	*Fest-Brom*	*Goniolimon tataricum* (L.) Boiss								+		
–	–	–	1	h	*Fest-Brom*	*Helictotrichon pubescens* (Huds.) Pilg.										+
–	–	7	1	th	*Fest-Brom*	*Hesperis tristis* L.										+
–	1	4	3	h	*Fest-Brom*	*Hieracium virosum* Pall.										+
–	12	–	3	g	*Fest-Brom*	*Hyacinthella leucophaea* (K.Koch) Schur						+		+	+	
1	–	4	–	g	*Fest-Brom*, *Fest-Pucc*	*Iris halophila* Pall.							+			
–	–	–	2	g	*Fest-Brom*	*Iris hungarica* Waldst. & Kit.									+	+
8	17	14	5	g	*Fest-Brom*	*Iris pumila* L.										+
–	–	–	1	h	*Fest-Brom*	*Jurinea calcarea* Klokov										+
–	1	–	3	h	*Fest-Brom*	*Jurinea salicifolia* Grun.										+
–	–	–	1	h	*Fest-Brom*	*Lathyrus pannonicus* (Jacq.) Garcke										+
–	–	8	–	h	*Fest-Brom*	*Limonium platyphyllum* Lincz							+			
–	–	–	1	h	*Fest-Brom*, *Fest-Pucc*	*Limonium tomentellum* (Boiss.) Kuntze subsp. *alutaceum (Stev.)* Moysiyenko								+		
3	25	29	17	h	*Fest-Brom*, *Gali veri*, *Agro int-rep*, *Moli-Arrh*	*Linaria biebersteinii* Besser	+									
–	–	–	1	h	*Fest-Brom*	*Linum hirsutum* L.										+
8	–	2	3	g	*Fest-Pucc*, *Gali veri*, *Fest-*	*Muscari neglectum* Gus. ex						+		+		+

(*continued*)

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Table II. (*Continued*).

Number of records of sozophytes on kurgans in each zone																
D [26 kurgans]	P [26 kurgans]	R [29 kurgans]	F [25 kurgans]	Life forms	Syntaxa	Sozophytes	W	E	U	B	T	K	M	R	P	C
					Brom	Ten.										
15	15	6	3	g	*Fest-Brom*	*Ornithogalum kochii* Parl.								+		
–	–	2	4	h	*Fest-Brom*	*Peucedanum alsaticum* L.										+
–	2	7	–	h	*Fest-Brom*	*Phlomis hybrida* Zelen.		+								
7	7	14	3	h	*Fest-Brom*	*Phlomis pungens* Willd.										+
–	1	–	–	h	*Fest-Brom*	*Prangos odontalgica* (Pall.) Herrnst. & Heyn						+				
–	–	–	3	h	*Fest-Brom, Dicr-Pini*	*Pulsatilla pratensis* (L.) Mill.			+							
1	–	–	5	m	*Quer-Fage*	*Quercus robur* L.						+				
–	22	10	11	h	*Fest-Brom*	*Ranunculus scythicus* Klokov						+				
–	–	7	1	h	*Fest-Brom*	*Salvia austriaca* Jacq.									+	+
–	–	–	3	h	*Fest-Brom*	*Salvia betonicifolia* Etl.									+	
–	–	–	4	h	*Fest-Brom*	*Salvia nutans* L.										+
6	–	–	–	h	*Fest vagi*	*Senecio borysthenicus* (DC.) Andrz. ex Czern.		+								
2	17	23	13	h	*Fest-Brom*	*Seseli tortuosum* L.										+
25	24	24	17	h	*Fest-Brom*	*Stipa capillata* L.			+							
–	1	11	–	h	*Fest-Brom*	*Stipa lessingiana* Trin. & Rupr.			+							
–	1	–	–	h	*Fest-Brom*	*Stipa ucrainica* P.Smirn.			+							
–	5	4	2	c	*Fest-Brom, Fest vagi*	*Thymus dimorphus* Klokov & Des.-Shost.										+
–	17	–	–	g	*Fest-Brom*	*Tulipa biebersteiniana* Schult. & Schult. f.			+							
5	–	–	–	g	*Fest-Brom*	*Tulipa schrenkii* Regel			+							
–	–	7	4	g	*Fest-Brom, Trif-Gera*	*Vinca herbacea* Waldst. & Kit.										+
						Total	7	8	14	1	2	8	5	10	6	32

(a) The number of records of sozophytes on kurgans in particular zones: D – west and central Pontic desert steppe, P – west Pontic grass steppe, R – west and central Pontic herb-grass steppe (M5) and west and central Pontic herb-rich grass steppe (M1), F – forest steppe; the number of kurgans investigated in each zone is given in the brackets; (b) Life forms: g – geophyte, h – hemicryptophyte, t – therophyte, th – short-lived (2-, 3-, or 4-year-old) perennial, mf – megaphanerophyte, nf – nanophanerophyte; (c) Syntaxa which the sozophytes are associated with (according to Solomakha 1996, Mirkin, Naumowa, 1998): *Agro int-rep – Agropyretea intermedio-repentis, Ammoph – Ammophiletea, Artemi – Artemisietea vulgaris, Dicr-Pini – Dicrano-Pinion, Fest-Brom – Festuco-Brometea, Fest-Pucc – Festuco-Puccinellietea, Fest vagi – Festucetea vaginatae, Gali veri – Galietalia veri, Moli-Arrh – Molinio-Arrhenatheretea, Poly-Arte – Polygono-Artemisietea austriaceae, Rham-Prun – Rhamno-Prunetea, Quer-Fage – Querco-Fagetea, Stel medi – Stellarietea mediae, Trif-Gera – Trifolio-Geranietea;* (d) Base for considering the species to be a species of special concern: W – IUCN Red List of Threatened Plants, E – European Plant Red List, U – Red Data Book of Ukraine, B – Appendix II of the Bern Convention, T – CITES Convention; regional red lists of: K – Kherson Region, M – Mykolaiv Region, R – Kirovograd Region, P – Poltava Region, C – Cherkasy Region.

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which they are protected, and the grounds for conservation of a species (type of red data book) are presented in Table II.

The sozophytes identified on the kurgans represented 26 families and 50 genera; 68 species belonged to the class *Magnoliophyta* and only 1 (*Ephedra*) represented the class *Pinophyta*.

Within variety of life forms, hemicryptophytes (48 species) were the dominant group of species among sozophytes in all the three steppe zones. Geophytes (14) were found to be over-represented within studied kurgans. The other life forms were recorded less frequently: 2 therophytes, 1 chamaephyte, 3 nano- and 1 megaphanerophyte.

Among the 69 taxa included in international and regional red lists, 58 species occurred with frequency below 20% and only 4 species with frequency between 20 and 40%. Only two species were quite common: *Stipa capillata* (93%) and *Linaria biebersteinii* (74%).

Sozophytes in various microhabitats within the kurgans

About 90% of the sozophytes recorded within kurgans had the optimum growth on the slopes of the barrows. Only eight species (12%) of sozophytes were most frequently recorded at the base of kurgans (mostly mesophilic or woody species). None of the species of special concern was clearly associated with the top section of a barrow – anthropophytes and hemiapophytes dominated in this type of microhabitat. A relatively small number of sozophytes occurred with similar frequency in two types of microhabitats, e.g. *Cerastium ucrainicum* that was found on the slopes and top of kurgans and *Adonis vernalis, Iris halophila* and *Senecio borysthenicus* – recorded on both slopes and a base of kurgans.

Two-way ANOVA and Tukey multiple comparisons revealed that abundances of all the most frequent species of sozophytes differed significantly among steppe zones (Table III, Figure 3). Few species were linked to a single steppe zone: D – *C. ucainicum*, P – *Carex stenophylla*, *Tulipa biebersteiniana, Hyacinthella leucophaea*, R – *Galium volhynicum, Stipa lessingiana, Amygdalus nana*. Other species were noted in more than one zone. For instance, widely common *S. capillata* showed similar distribution patterns in all steppe zones.

Moreover, the abundances of analyzed species differed significantly among selected microhabitats (Table III, Figure 3). A group of species associated dominantly with the slopes of kurgans (Figure 3– M-shaped diagram for at least one steppe zone) could be clearly distinguished: *C. ucrainicum, Allium guttatum, C. stenophylla, T. biebersteiniana, H. leucophaea, Phlomis pungens, S. lessingiana, Carex supina,* and *S. capillata*. Species associated mostly with a base of kurgans (V-shaped diagram for at least one steppe zone) were *A. nana, L. biebersteinii,* and *Ranunculus scythicus*.

Discussion

The characteristics of sozophytes

The preliminary results of the comparative studies of the flora of kurgans and the surrounding areas (Moysiyenko, unpublished) indicate that more than 40% of the taxa occurring within kurgans are not commonly noted in a surrounding agricultural landscape. Among these taxa, 69 are species of special concern or sozophytes. Most of them are typical steppe species representing the class *Festuco-Brometea*. Some species are most strongly associated with

Table III. Two-way ANOVA for the most frequent species of special concern.

Species	Zones		Microhabitats		Interaction	
	F	*p*	*F*	*p*	*F*	*p*
Allium guttatum	22.77	< 0.0001	5.65	0.0002	1.77	0.0507
Amygdalus nana	24.49	< 0.0001	4.46	0.0015	2.89	0.0007
Carex stenophylla	25.89	< 0.0001	9.03	< 0.0001	3.52	< 0.0001
Carex supina	9.88	< 0.0001	12.74	< 0.0001	3.27	0.0001
Cerastium ucrainicum	126.3	< 0.0001	1.76	0.1348	1.61	0.0853
Galium volhynicum	59.24	< 0.0001	1.54	0.1901	1.45	0.1386
Hyacinthella leucophaea	22.81	< 0.0001	4.24	0.0022	3.63	< 0.0001
Iris pumila	24.76	< 0.0001	12.55	< 0.0001	1.43	0.1497
Linaria biebersteinii	80.24	< 0.0001	19.82	< 0.0001	4.12	< 0.0001
Ornithogalum kochii	6.98	0.0001	5.74	0.0002	1.82	0.0417
Phlomis pungens	18.04	< 0.0001	4.37	0.0018	0.69	0.7651
Ranunculus scythicus	49.08	< 0.0001	8.37	< 0.0001	5.14	< 0.0001
Seseli tortuosum	29.8	< 0.0001	4.47	0.0015	1.01	0.4418
Stipa capillata	6.52	0.0002	38.95	< 0.0001	1.52	0.1116
Stipa lessingiana	28.86	< 0.0001	5.55	0.0002	5.21	< 0.0001
Tulipa biebersteiniana	49.83	< 0.0001	2.99	0.0186	2.99	0.0005

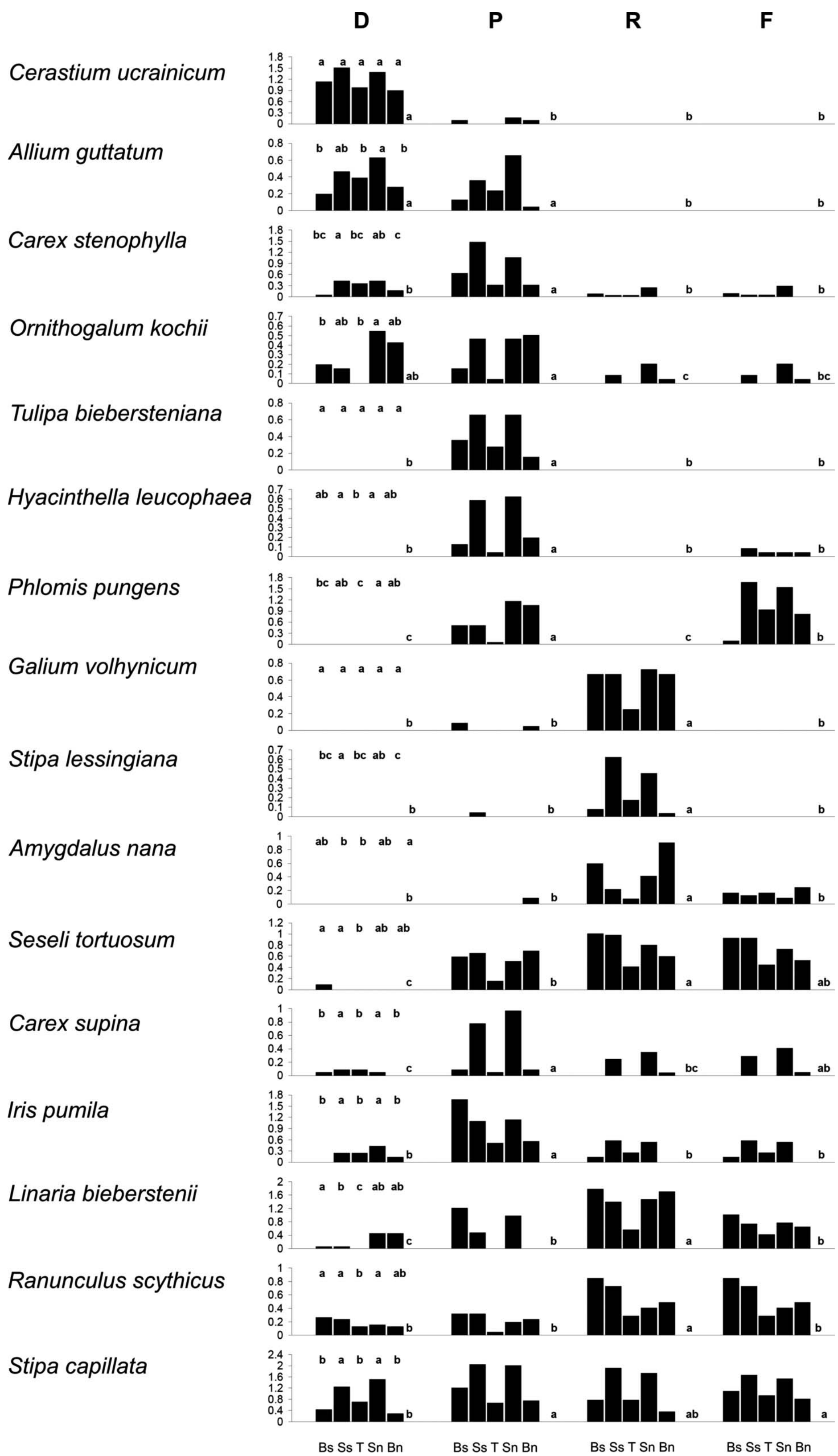

Figure 3. Average abundance (*Y*-axis) expressed on a 3-point scale (1 – sporadic, 2 – infrequent; 3 – common) of the most frequent species of sozophytes in microhabitats of studied kurgans in three steppe zones and forest steppe zone. T, top of kurgan; Sn, Ss, northern and southern slope; Bn, Bs, northern and southern foot; D, west and central Pontic desert steppe; P, west Pontic grass steppe; R, west and central Pontic herb(-rich)grass steppe; F, forest steppe zone. Results of Tukey tests for differences between microhabitats are marked with a, b, and c above the diagram for the D zone; the results for differences between zones are marked with a, b, and c on the right side of the diagrams for each zone. The species mean abundances between microhabitats/zones which are not marked with the same letter are significantly different ($p < 0.05$).

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plant communities from distinguished classes, such as: *Festucetea vaginatae, Molinio-Arrhenatheretea, Festuco-Puccinellietea, Trifolio-Geranietea*, and *Querco-Fagetea*. A considerable number of taxa appeared on several lists of species requiring active conservation (Figure 3, see also Moysiyenko & Sudnik-Wójcikowska 2008, 2010; Moysiyenko et al. 2009). In addition, the presence of plant communities from *Amygdaletea nanii, Stipetea capillatae,* and *Stipetea lessingianae* classes that had been included in the ''Green Data Book of Ukraine'' (Didukh 2009b) was observed on the kurgans.

Our results show that sozophytes find the most suitable conditions for growth and development on slopes of barrows where the anthropogenic influences are usually limited (cf. e.g. Sudnik-Wójcikowska & Moysiyenko 2008). A base of kurgans is regularly disturbed due to on-going agricultural procedures and in consequence species associated with this type of microhabitat (e.g. *A. vernalis, A. nana, Anemone sylvestris, L. biebersteinii*) might be seriously affected by these practices. None of the species of special concern was clearly associated with the top section of barrow, where a plant cover is most strongly disturbed by human activities. For example, the tops of kurgan, which are highly visible across the plains, have served as landmarks (orientation points) for a considerable period of time. They also were used to erect triangulation towers, monuments, etc. or to guard the crops from thieves. In addition, the kurgans served as observation points in places where animals were pastured.

There are a surprisingly small number of publications on the flora and vegetation of kurgans in Ukraine, and broad-scale research of this type was never conducted before. Therefore, it is difficult to make a detailed comparison of our findings to the existing data from other regions. A large number of kurgans are found in Hungary (ca 40,000). The plant cover and soil conditions of some of these barrows were investigated in detail (Barczi & Joó 2002; Barczi 2003; Barczi et al. 2004; Joó et al. 2007). In the case of the best documented Csípő-halom kurgan (Great Hungarian Plain, Hortobágy), 72 species were recorded within the barrow and its close vicinity. It was recognized that plant cover of kurgan contributed to the local flora lists, by adding new species that had been rarely reported from Hortobágy Region, i.e. *F. valesiaca*, *Festuca rupicola*, *Festuca javorkae*, *Agropyron pectiniforme*, and *Erodium ciconium*. Even small size kurgans were covered with various types of phytocoenoses, generally belonging to two vegetation groups – loess and sodic vegetation at a base of the barrows. The larger part of the barrow was characterized by a common presence of perennial grass *Poa angustifolia*. The drought-resistant loess vegetation has a pioneer character and belongs mainly to *Agropyro cristati–Kochietum prostratae* association dominating at the top of kurgan. The base of kurgan was covered with small patches of salt-affected sodic vegetation (*Artemisio santonici–Festucetum pseudovinae*), whereas the lower parts of the slope were covered with the loess steppe grasslands *Salvio nemorosae–Festucetum rupicolae* with protected herb *Phlomis tuberosa*. During the investigations conducted on other kurgans in the region, the authors observed that kurgan slopes were recurrently covered with the relatively weedless loessgrasses, contrasting with the top and base sections of kurgans.

The presence of rare and endangered species on kurgans in Russia, e.g. *Stipa pennata, S. pulcherrima, S. ucrainica, S. caspia, T. gesneriana* (syn. *T. shrenkii*), *T. biebersteiniana, Colchicum laetum*, was also reported by Dzybov (2006), who investigated few kurgans in Stavropolskii Krai. The author noticed the presence of specific micro-zones (microhabitats) within the kurgans. Despite many methodological differences between the studies, the general conclusions on the specific role of kurgan slopes usually of northern exposition are in preserving the original steppe vegetation. The weeds dominated on the top and bottom sections of barrows. It should be noted that the overall similarity between the slopes of barrows and their surrounding was only 18%.

A relatively small number of kurgans exists also in Poland and 13 of them were studied in detail (Cwener 2004). Like those in Ukraine, Russia, and Hungary, the Polish kurgans are usually surrounded by cultivated fields and pastures. The flora of kurgans was estimated at 228 species (the number of species per kurgan ranged from 44 to 81). Native species clearly dominated; anthropophytes comprised 23% of the total flora. As in the case of the Ukrainian, Russian, and Hungarian kurgans, the slopes supported some of the most valuable species: *S. capillata, A. vernalis, A. sylvestris,* and *Verbascum phoeniceum*; some of them are extremly rare in Poland and recorded in the Polish Red Data Book (Kaźmierczakowa & Zarzycki 2001), e.g. *Ranunculus illyricus* and *Rosa gallica*. Anthropophytes mainly inhabited the top and the base of kurgans.

Final remarks

Major threats to kurgans

A number of studies conducted on kurgans in different parts of Europe confirmed their value as refugia for endangered, previously common species. However, the present study showed that only about 20–25% of the kurgans in Ukraine (106 out of the 450 kurgans visited) were of considerable floristic value.

For hundreds or even thousands of years, kurgans have been subjected to natural as well as anthropogenic processes causing their destruction. The

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main natural process is erosion, which reduces the height of kurgans. There are also a number of threats related to human activities:

(1) One of the greatest threats faced by the plant cover of kurgans were the activities of archeologists (Boreiko et al. 2002; Bozhko 2008; Skorii & Kyslii 2008; Fisun 2008; Lystopad 2009; Rowińska et al. 2010) due to the methods they used to explore these sites (Figures 4a–c and 5a). The Ukrainian kurgans were surveyed intensively in 1970s and 1980s. During this period, many of the barrows were unrecoverable destroyed. Moreover, since the beginning of their existence kurgans have also been of great interest to archeological looters. Their illegal, plundering practices left behind deep hollows and shallow tunnels in the body of kurgans.
(2) Kurgans posed a serious problem for large-scale agriculture in the territory of the former USSR. The process of their devastation escalated in the middle of the twentieth century. Many of the smaller barrows have been destroyed to a large extent due to nivelation and agricultural activities (Figure 5b). Even less invasive human activities, such as litter deposition, fertile chernozem soil removal (Figure 5c), collecting plants or digging them up and transplanting to gardens may lead to a serious destruction of rare species.
(3) Factors that regularly influence the plant cover on the kurgans, such as extensive grazing and infrequent fires usually have a positive effect on plants, as they induce the steppe species to develop faster by preventing the accumulation of dead organic matter and by slowing down the process of the so-called "reserve succession" (Russian: rezervatnaia suktsesia). Periodical fires that occur every 15–20 years are a natural phenomenon in the steppe (Melnikov 2005; Gavrilenko 2007; Lysenko 2008). However, too frequent fires of anthropogenic origin (i.e. stubble burning), as well as, the over-grazing can be destructive to the plant cover of kurgans (Figure 5d and e).
(4) In some locations, kurgans still act as cemeteries (Figure 5f). In a case of neglected, old burial sites a number of steppe species have a chance to survive intact; however, the flora of intensively used cemeteries is usually dominated by anthropophytes.

The direct and indirect human impacts lasting for centuries can certainly constitute a significant threat to many specially sensitive species of the kurgan flora. Large-scale land cultivation leads to the scattered distribution of kurgans, which resemble

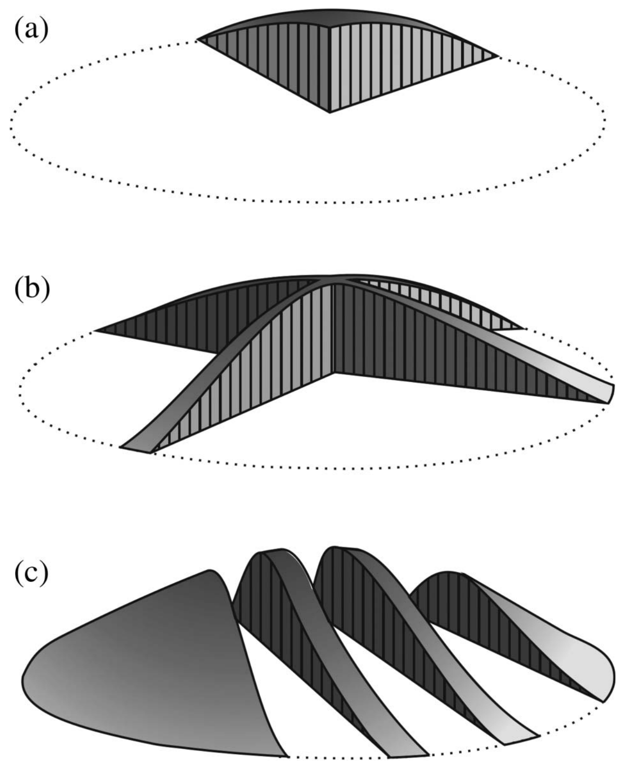

Figure 4. Methods of archeological exploration of kurgans: (a) quarter sectioning; (b) method of perpendicular balks; (c) method of parallel balks.

"islands" (enclaves of more or less well preserved natural vegetation) in a surrounding "sea" of cultivated land and human settlements. The steppe communities are not well developed due to the small sizes of kurgans; thus the species of special concern are usually represented by a dozen or so individuals. However, our investigations (Sudnik-Wójcikowska & Moysiyenko 2010b) showed that the flora of kurgans varied between the different steppe zones and retained characteristics typical for the native flora of exact climatic-vegetation zone. Dzybov (2006) presents a hypothesis about the persistence for hundreds of years a stable and self-maintaining gene bank (Russian: samopodderzhivaiushchii bank genofonda) on kurgans situated in semi-desert areas of Russia. It seems that the chance of survival of the most threatened species increases with size and density of the kurgans in the particular area (due to increased availability of suitable microhabitats). Also the occurrence of neighboring patches of natural or semi-natural vegetation is an important factor counteracting the spatial isolation of kurgans. Further research is needed to explore this in detail.

The urgent need for protection

It is necessary to introduce changes in the currently functioning recommendations for conservation of

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(a) (b) (c) (d) (e) (f)

Figure 5. Factors responsible for the impoverishment of the flora of kurgans: (a) activities of archaeologists, (b) disturbing due to agricultural practices, (c) fertile soil removal, (d) over-abundant fires, (e) over-grazing, and (f) utilization of kurgans as cemeteries.

kurgans. In Ukraine, signs are often placed on kurgans which include the following warning notice: "*archaeological site-protected by law*". Not only should the anthropological value of kurgans be protected, but also its natural value in order to maintain the local biodiversity. It is important to recognize the

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well preserved kurgans as nature monuments (in Ukrainian: "pamyatki prirody") protected by adequate environmental regulations including in its description "unique structures with exceptional natural, scientific, educational, and esthetic values that should remain intact" (Andrienko et al. 2001).

It is worth noting that a few archeologists themselves have come to realization that archeological sites should be protected as objects of nature value as well (cf. e.g. Petrashenko 1998). At present, archeological exploration of kurgans are conducted within the "rescue programs" in areas designated for various development purposes. However, botanical expertise should precede archeological field investigations. In spite of the apparent conflict of interest, collaboration between archeologists and botanists seems possible and is necessary for the better protection of the kurgans of particularly high floristic value.

Appropriate legal regulations should, therefore, be implemented to ensure more effective protection of the kurgans. Recently, several non-governmental organizations have pointed out the necessity of taking appropriate legal actions (Andrienko 1999; Melnyk 2001; Boreiko et al. 2002; Bozhko 2008; Fisun 2008; Lystopad 2009).

The decision-making process regarding the protection of kurgans should always be supported by a public information campaign. Complex strategies for protection of kurgans as historical and nature monuments are essential to assure preservation of the integrity of cultural landscape. Such activities are consistent with the European Landscape Convention (2000) recognizing that the steppe vegetation has been destroyed to a greater extent than any other type of zonal vegetation and therefore should be, at least locally, restored and protected. The kurgans with well preserved plant cover could play a significant role in this process.

Acknowledgments

The study was supported by the Ministry of Science and Higher Education in Poland in 2004–2007 – Grant 2 P04G 046 27 and in 2008–2011 – Grant NN 304 081835. We thank Ms K. Petrovic for English language correction.

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