# INDICATIVE ROLE OF THE FLORA OF KURGANS IN THE 'WILD FIELD' (SOUTHERN UKRAINE)

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**Abstract:** Kurgans (barrows) are human-made structures which constitute a characteristic element of the agricultural landscape in Ukraine. Barrows as the objects of value of material culture were recognized quite early, while almost no attention was paid to their importance as natural sites. The Polish-Ukrainian research conducted on the flora of kurgans in the south of Ukraine in the years 2004–2011 indicated that the best preserved kurgans were not only of archaeological value but were also floristically valuable. Today, when the steppes are one of the most threatened ecosystems in Europe, kurgans are important micro-centres of floristic biodiversity and provide refuge for steppe species. Our studies also confirmed the non-random distribution of species within the microhabitats on kurgans and certain regularities in the distribution of species on barrows in four climatic-vegetation zones. It turned out that present day flora of kurgans, which were built by man hundreds or thousands of years ago, quite accurately reflects the natural diversity of flora in different zones.

***Key words:*** *bioindication, kurgan flora, refuge of flora, steppe and forest steppe zone, desert steppe.*
**Słowa kluczowe:** bioindykacja, flora kurhanów, ostoje flory, strefa stepów i lasostepu, step pustynny.

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## 1. Introduction

Kurgan or barrow, mound, tumulus, tomb is defined as a mound of earth and/or pile of stones, often conical or hemispherical in shape, constructed over a burial chamber containing a single or multiple graves. Mounds are not associated with a specific climate or vegetation zone, but most of them are located in the steppes or their American equivalent, the prairie.

Mounds were built from Eneolithic through the Bronze and Iron Ages up to the early Middle Ages. Most of them were attributed to the nomadic peoples. The origins of mounds in the south-eastern and eastern Europe are particularly rich and diverse. They are a distinctive feature of the landscape and provide evidence of migrations and wars conducted by several nomadic or semi-sedentary peoples, such as: representatives of Yamna, Catacomb and Srubna cultures (Bronze Age), Cimmerians, Scythians, Sarmatians (Iron Age), and later: Huns, Magyars, Polovtsians, and others (Rowińska et al., 2010).

It is hard to imagine the history and landscape of Ukraine without barrows. Ukraine is referred to as „the land of kurgans" not without reason. The original number of kurgans in Ukraine is estimated at half a million, of which probably about 100 000 (according

to other authors: 50 000 or 150 000) have survived to this day.

During the 19th and 20th century, thousands of barrows were examined by archaeologists in detail. The methods used often led to the complete destruction of these structures. Particular threat to kurgans was posed in the 20th century, by the new investments, large farming and the exploitation of raw materials in the former Soviet Union. Tens of thousands of smaller mounds were then leveled, plowed and completely destroyed.

Mounds as the objects of value of material culture were recognized quite early, while almost no attention was paid to their importance as natural sites. A surprisingly small number of publications exists on the subject of their plant cover (Paczoski, 1914, 1933). At present, there has been a growing interest in kurgans (Rudenko, 2001, Dzybov, 2006, Zolotov and Biryukov, 2009, Kuksova, 2011). Naturalists are looking for arguments for the need to protect them.

Our long-term floristic survey conducted in 2004–2011 (Sudnik-Wójcikowska et al., 2012) showed that remnants of preserved steppe vegetation were found on the slopes of the kurgans as well as a number of valuable species ("species of special concern") which are protected and red-listed in Ukraine (Diydukh, 2009). Therefore, the urgent need for protection of the other remaining barrows is justified (Moysiyenko and Sudnik-Wójcikowska, 2008).

The aim of the present study is to determine if the flora of kurgans could play an indicative role. Therefore, the main questions are as follows:

a) Are there any regularities in the distribution of plants within the microhabitats on the kurgans?
b) Are there any trends characteristic of the kurgan flora in different climatic-vegetation zones in the south of Ukraine?

## 2. The investigated area

'Wild Field' is a historical term (16th–18th centuries) referring to the territory between the Dniester and Don rivers, situated on the lower Dnieper. The above area was within the borders of Polish-Lituanian Commonwelth after the Union of Lublin (1569).

Our floristic study was conducted on the kurgans located in southern Ukraine, on the surface of about 32,100 km$^2$. This area was part of the 'Wild Field' and located within the regions: Kherson, Mykolaiv, Kirovograd, Cherkasy and Poltava (Fig. 1a). This is an area where kurgans are most numerous in Europe, although they vary in their history, origin, degree of isolation and the intensity of anthropogenic factors. The area is diverse in terms of climate, soil (Lavrenko et al., 1991; Tab. 1) and history of use. It is located in the Black Sea Lowland and Dnieper Upland, in four climatic-vegetation zones, from south to north: D – the west and central Pontic desert steppe zone (desert steppe, Fig. 1b), P – the west Pontic grass steppe (= proper steppe), R – the west and central Pontic herb-rich grass steppe , F – the forest steppe (macromosaic of the medow steppe and forests).

Tab. 1. Variation in environmental conditions within four climatic-vegetation zones in the south of Ukraine (Lavrenko et al., 1991, Boiko,1998)
*Tab. 1. Zróżnicowanie z warunków w czterech strefach klimatyczno-roślinnych w południowej części Ukrainy (Lavrenko i wsp., 1991, Boiko, 1998)*

| Climatic-vegetation zones/differentiation Strefy klim*atyczno-roślinne/ zróżnicowanie* | Average annual temperature *Średnia roczna temperatura* (°C) | Precipitation *Opady* (mm) | Soil *Gleby* | Number of species per 100 m$^2$ *Liczba gatunków na 100 m$^2$* | Number of phenological aspects *Liczba aspektów barwnych* |
|---|---|---|---|---|---|
| The forest steppe | 5.6 | >450 | rendzinas; chernozem | 80 | 12 |
| The west and central Pontic herb-rich grass steppe | – | 400–450 | chernozem; dark brown | up to 25 | 7–8 |
| The west Pontic grass steppe | 9.8 | 300–350 (400) | chesnut; dark brown | 18–20 | 7–8 |
| The west and central Pontic desert steppe | 9.5 | < 300 | chesnut light brown; brown steppe; solonetz; solonchak | 9–12 | 7 |

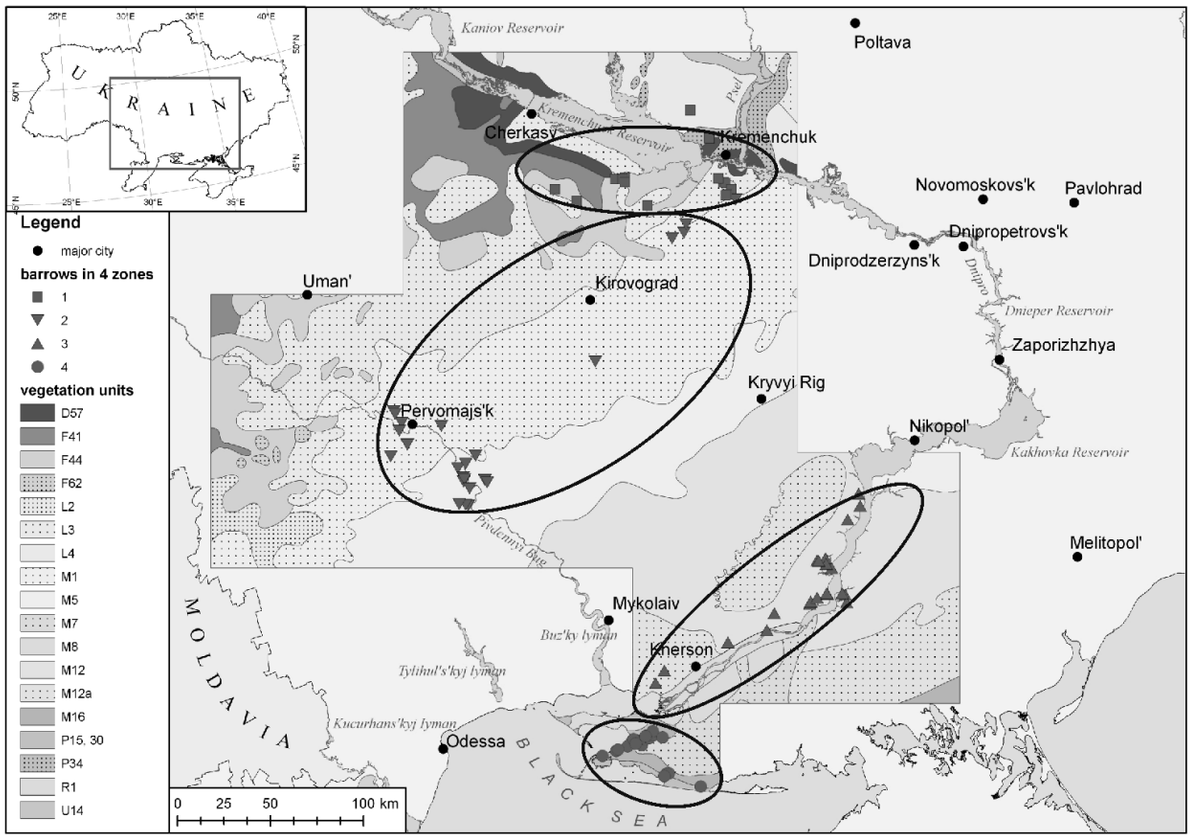



Fig. 1a. Distribution of the investigated kurgans in the climatic-vegetation zones in Ukraine: ● – kurgans in the desert steppe zone, ▲ – kurgans in the west Pontic grass steppe zone, ▼ – kurgans in the Pontic herb(-rich) grass steppe zone, ■ – kurgans in the forest--steppe zone; zones designations of vegetation units (according to Bohn et al., 2000):
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; 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.
According to Map of the natural vegetation of Europe; Bohn et al. (2000).

*Ryc. 1a. Lokalizacja badanych kurhanów w strefach klimatyczno-roślinnych Ukrainy: ● – kurhany w strefie stepu pustynnego, ▲ – kurhany w strefie stepu trawiastego (właściwego) w wariancie uboższym gatunkowo, ▼ – kurhany w strefie stepu trawiastego (właściwego) w wariancie bogatszym gatunkowo, ■ – kurhany w strefie lasostepu; jednostki roślinności wyróżnione w klasyfikacji Bohna i in., 2000:*
*D57 – południowo-wschodnioeuropejskie kserofityczne bory sosnowe i mieszane sosnowo-dębowe; F41 – wschodniopolsko-ukraińskie lasy wiązowo-dębowo-grabowe; F44 – podolsko-mołdawskie termofilne lasy grabowo-dębowe; F62 – wschodnio-karpacko-mołdawskie lasy dębowo-grabowe; L12 – wołyńsko-podolskie stepy łąkowe; L3 – mołdawsko-ukraińskie stepy łąkowe; L4 – południowo-sarmackie stepy łąkowe; M1– zachodnio- i centralnopontyjskie stepy trawiaste (w wariancie najbogatszym gatunkowo); M5 – zachodnio- i centralnopontyjskie stepy trawiaste (w wariancie bogatszym gatunkowo); M7 – pontyjskie hemi-psammofilne stepy trawiaste ; M8 – pontyjskie psammofilne stepy trawiaste; M12 – zachodniopontyjskie stepy trawiaste (w wariancie uboższym gatunkowo); M12a – zachodniopontyjskie stepy trawiaste w kombinacji z roślinnością halofilną (sołonczaki); M16 – zachodnio- i centralnopontyjskie stepy bylicowe (piołunowe, pustynne) w kombinacji z roślinnością halofilną (sołonczaki, sołońce); P15 – zachodnio- i centralnopontyjska roślinność wydm piaszczystych; P30 – zachodniopontyjska roślinność halofilna; P34 – zachodnio- i wschodniopontyjskie słone łąki; R1 – słodkowodne zbiorowiska szuwaru wysokiego; U14 – pontyjskie lasy aluwialne. Jednostki według Karte der natürlichen Vegetation Europas; Bohn i wsp. (2000).*

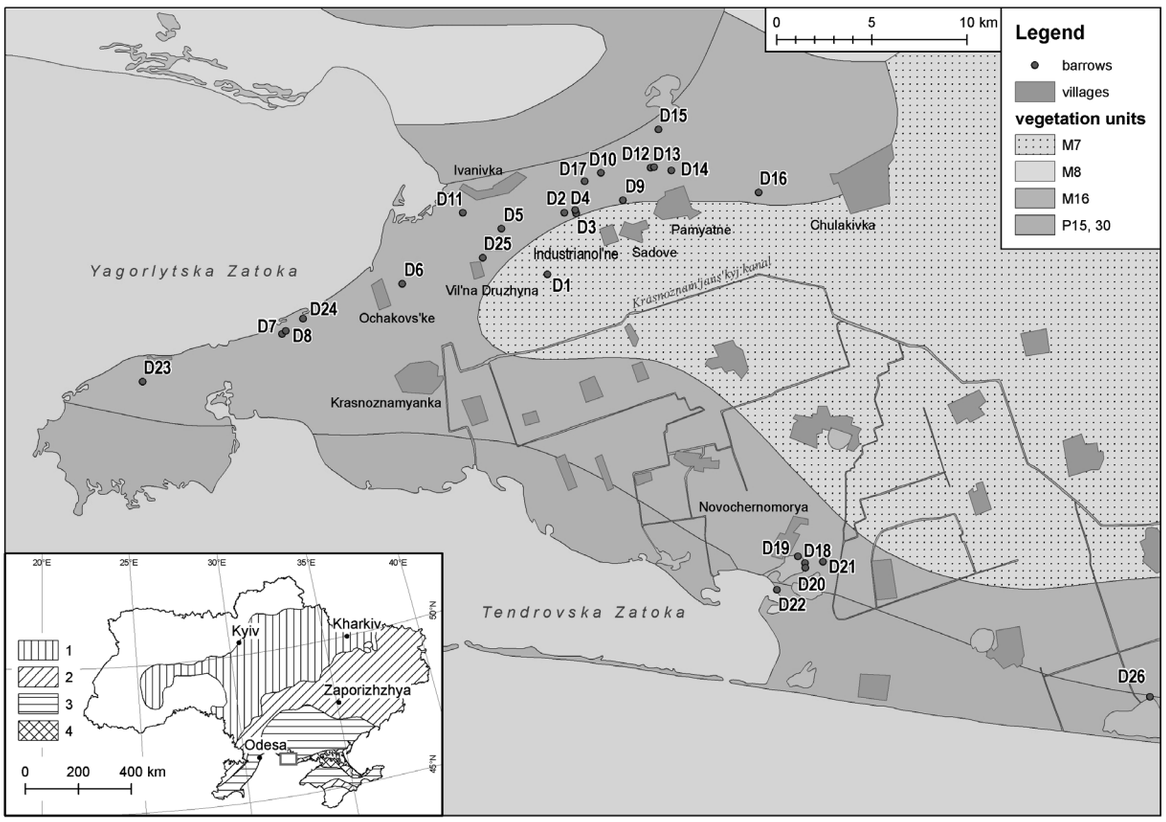



Fig. 1b. Distribution of kurgans in the desert steppe zone (D)
Ryc. *1b. Położenie kurhanów w strefie stepu pustynnego (D)*

## 3. Materials and methods

The selected mounds (26–29 per each of the four climatic-vegetation zones, 106 kurgans in total) had to meet certain criteria: size greater than 3 m in height, a relatively good state of preservation, the presence of steppe vegetation and flora, especially tufted grasses from the genera: *Stipa*, *Festuca*, and *Koeleria*, and *Bothriochloa* further north.

At first glance, the habitat conditions on the kurgans do not seem to be uniform. The northern slopes have different light and temperature conditions than the southern slopes. Different moisture levels and intensity of soil erosion process are also observed at the top and foot of the barrows. Thus we could expect differences in the floristic composition and assemblage of plant community types within the microhabitats on the kurgans.The floristic exploration was conducted in five microhabitats; floristic lists were compiled for top – T, northern and southern slope – Sn, Ss, northern and southern foot – Bn, Bs. Floristic list has been compiled in databases (Moysiyenko and Sudnik-Wójcikowska 2006a, 2009; Sudnik-Wójcikowska and Moysiyenko 2006b, 2010a; Sudnik-Wójcikowska et al. 2012).

In the present study the indicative role of the flora of kurgans was determined based on the analysis of tendencies in:

a) the variation of the flora of the microhabitats identified on the kurgans located in desert steppe zone (D), in projected regional landscape park „Valley of the kurgans";

b) the diversity of the flora of kurgans located in four climatic-vegetation zones (D, P, R, F).

Ad a)

As pointed out earlier, the differences between the microhabitats on the kurgans were mainly related to soil moisture, light and temperature conditions. The soils of the desert steppe zone contain high level of salt. In our study we attempted to determine if soil salt content could also be an important environmental gradient that differentiates the microhabitats on the kurgans and influences the plant cover of the barrows. Therefore, soil samples were collected from 5 microhabitats identified on a typical kurgan and subsequent analyses were performed.

The indicative role of the flora of microhabitats identified within the kurgans was evaluated by analyzing the changes in the proportion of socio-ecological groups

a

b

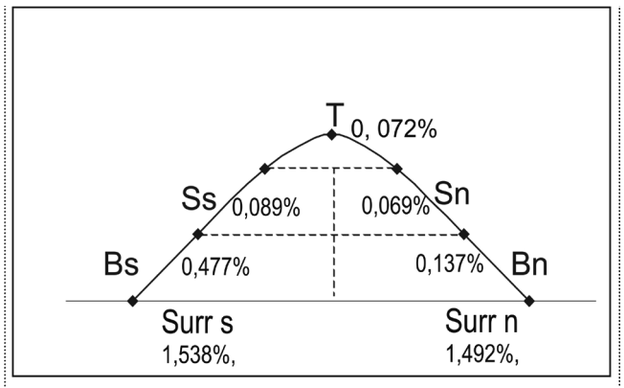



Fig. 2a. Kurgans in the desert steppe zone: barrows in solontchak; view from the top of kurgan; barrows extensively used (cemetary, pasturage); b. Salt content (%) in the particular microhabitats within kurgan D2 and its immediate vicinity (the desert steppe zone).

Abbreviations: T – top of the kurgan, Ss, Sn – southern and northern slopes, Bs, Bn – southern and northern foot, Surr s – surroundings – south part, Surr n – surroundings – north part.

*Ryc. 2a. Kurhany w strefie stepu pustynnego: kurhany wśród sołonczaków, widok z wierzchołka kurhanu; kurhany ekstensywnie użytkowane (cmentarz, wypas); b. Zawartość soli (%) w podłożu w poszczególnych mikrosiedliskach na kurhanie D2 i w jego bezpośrednim sąsiedztwie.*

*Objaśnienia skrótów: T – wierzchołek kurhanu, Ss, Sn – zbocze południowe i północne, Bs, Bn – południowe i północne podnóże, Surr s, Surr n – otoczenie kurhanu od strony południowej i północnej*

of species in particular microhabitats. The socio-ecological groups of species are associated with specific vegetation units having their "sociological optimum" within specific syntaxa (units of higher rank – classes were taken into consideration). The differences in the percentage of species representing the specific syntaxa within the microhabitats on the kurgans will be illustrated in a diagram. It should be noted that this is a necessary simplification as a specific species is not always associated with only one syntaxon of higher rank, in which it finds its optimum.

Ad b)

As stated earlier, the investigated 106 kurgans were distributed throughout a wide study area, within four climatic-vegetation zones, which are characterized by different climatic conditions (Tab. 1). Canonical analysis was used to compare the qualitative composition of the flora of kurgans in the particular climatic-vegetation zones. This allowed us to determine whether and to what degree the flora of kurgans reflected the flora of the climatic-vegetation zones. To analyse the structure in floristic data Detrended Correspondence Analysis (DCA) was used (Hill and Gauch 1980). As the gradient length exceeded 3 standard deviations we used DCA as the unconstrained ordination method suitable for describing unimodal data.

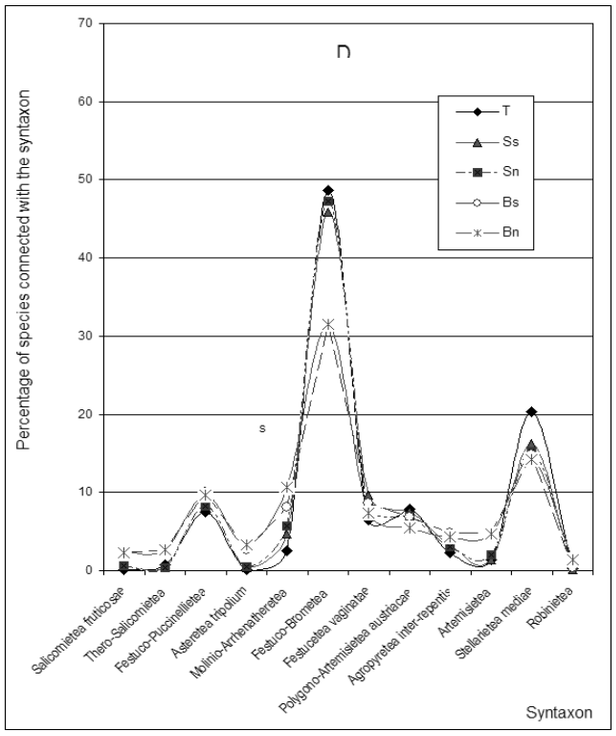



Fig. 3. Percentage of species associated with high-rank syntaxa (classes) in the flora of microhabitats within kurgans in the desert steppe zone (D). Syntaxa represented by at least 1% of the flora were taken into account. Line segments joining the points are of secondary importance and they make easier to characterize the particular microhabitats
Abbreviations – see Fig. 2.
*Ryc. 3. Udział gatunków związanych z syntaksonami w randze klasy we florze poszczególnych mikrosiedlisk na kurhanach w strefie stepu pustynnego (D). Wzięto pod uwagę syntaksony reprezentowane w danym mikrosiedlisku przez co najmniej 1% flory (linie łączące punkty mają jedynie znaczenie pomocnicze – ułatwiają scharakteryzowanie mikrosiedlisk)*
*Objaśnienia skrótów: T, Ss, Sn, Bs, Bn – zob. ryc. 2.*

## 4. Results and discussion

a) Diversity of the flora of microhabitats within kurgans in the desert steppe zone.

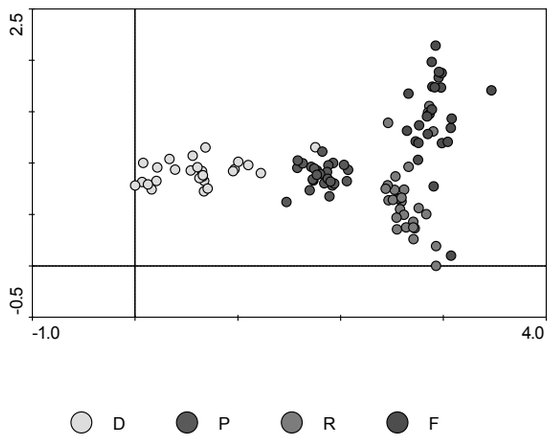
In Fig. 2a kurgans typical of the desert steppe zone are presented. Diagram (Fig. 3) shows a comparison of microhabitats on the barrows in terms of species most strongly associated with these syntaxa. It should be noted that this diagram shows only trends in the data. For each microhabitat the percentage of species representing syntaxa of higher rank (classes) is illustrated (Sudnik-Wójcikowska and Moysiyenko 2008).The specificity of the flora of barrows is its comprehensive nature – co-domination of two groups of species: steppe species (Festuco-Brometea class) and synanthropic (*Stellarietea mediae*). The class comprising xerothermic grasslands, i.e. *Festuco-Brometea*, is best represented on the slopes Ss, Sn (mostly on the north slope) and top (T) of the kurgans. At the same time the top of the barrows supports species from synanthropic communities (in the case of the desert steppe, the upper parts of some of the barrows have been disturbed as a result of erecting triangulation towers etc.). A higher number of meadow mesophyte species (from the class *Molinio-Arrhenatheretea*), which are more moisture demanding than steppe species, occur at the foot of the barrows (Bs, Bn) which has higher moisture levels. In addition, the foot supported a small number of tree species (associated with the class *Robinietea*), which had been introduced from plantations of trees or windbreaks.

The specificity of barrows in the desert steppe zone is the occurrence of halophytes. The authors (e.g. Fedorov 1982; Agbunov 1987; Konikov et al. 2007) point to the fact that the desert steppe range has changed since the ancient period as a result of fluctuations of the Black sea level (e.g. Phanagorean regression, Nimpheian transgression, Medieval regression, and modern transgression). Since the 15$^{th}$ century the sea level has increased and the coastline of the Black Sea has changed.

An increase in soil salinity in the adjacent desert steppe has also been observed. In the study area barrows are the indicators of transgression: on their slopes and tops the steppe communities are preserved while on the surrounding plains – the former desert steppe vegetation has been displaced by halophytic vegetation as a result of transgression.

Our analysis of the salt content in the soil of particular microhabitats within typical kurgan showed a marked increase in salinity from the top to the foot of the barrow (Fig. 2b). This corresponds to the percentage of species associated with halophilous communities (from the classes *Salicornietea fruticosae*, *Thero-Salicornietea*, *Asteretea tripolium*), and subhalophilous grasslands (*Festuco-Puccinellietea*). An increasing share of halophytes at the foot of the kurgans is attributed mainly to the presence of salinized soils at the foot of the barrows and their immediate vicinity.

As a consequence of concentric arrangement of the microhabitats is concentric arrangement of the vegetation cover on the mounds. Floristic diversity in the kurgans is the result of habitat diversity. This has been confirmed also for other types of relatively small, convex landforms of anthropogenic origin, and emphasized by other authors, such as Celka (1999; old settlements), Kamiński (2004; old settlements), Rostański (2006; post-mining slag heaps), Podgórska (2010; gob piles – remnants of old iron-ore extraction sites).




DCA oś I i II

| Axes: *Osie* | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalue: *Wartości własne osi* | 0.461 | 0.164 | 0.125 | 0.090 |
| Lengths of gradient: *Długości gradientu* | 3.468 | 2.143 | 2.173 | 1.924 |

Fig. 4. DCA (detrended correspondence analysis) of 106 kurgans in the 4 climatic-vegetation zones, based on floristic lists.
Abbreviations: D – west and central Pontic desert steppe, P – west Pontic grass steppe, R – west and central Pontic herb(-rich) grass steppe, F – forest steppe.
*Fig. 4. DCA 106 kurhanów z 4 stref klimatyczno-roślinnych, na podstawie spisów flory.*
*Objaśnienia skrótów: D – strefa stepu pustynnego, P – strefa stepu trawiastego (właściwego), wariant uboższy gatunkowo, R – strefa stepu trawiastego (właściwego), wariant bogatszy gatunkowo, F – strefa lasostepu.*

b) Differentiation of the kurgan flora in four climatic-vegetation zones

The above considerations deal with the structure of the flora of kurgans in only one climatic-vegetation zone. However, it would be particularly interesting to determine the differentiation of the qualitative composition of the flora in the four climatic vegetation zones, based on the analysis of the flora of "anthropogenic structures" such as kurgans.

Our study on 106 kurgans confirmed that the species richness was lower in the desert steppe zone and increased gradually towards the north: in the west Pontic grass steppe zone and herb-rich grass steppe zone, and was the highest in the forest steppe zone.

The DCA analysis allowed us to compare the qualitative composition of the flora of the kurgans in each specific zone. Figure 4 illustrates the similarities and differences between the floras of all the 106 kurgans located in the four climatic-vegetation zones. On the diagram the first axis separates primarily the flora of the desert steppe, followed by the flora of the grass steppe zone, from the kurgans in the herb-rich grass steppe zone and the forest steppe zone (however, kurgans from the last two zones are poorly separated). The second axis separates the herb-rich grass steppe zone from the forest steppe zone.

Based on the further analysis of species it can be hypothesized that along the first axis the gradient of moisture of soil and salt in soil is noticeable (Sudnik-Wójcikowska et al. 2012). Soil salinization process is most intensive in the case of the Black Sea coast, in the desert steppe, which is associated with the above-mentioned modern transgression. Along the second axis (separating the herb-rich grass steppe zone from the forest steppe zone) the gradient of light is marked. In the forest steppe zone more shade-loving species or species with higher ecological amplitude tolerating shade are groupped. An almost twofold higher number of woody species is also characteristic, which is to be expected in the forest steppe zone.

It should be particularly noted that the zonal character of the flora was confirmed in the case of kurgans – anthropogenic landforms (usually at least 700 years old). It means that composition and structure of the kurgan flora is typical of the zone where the barrows are located. The former steppe areas surrounding the kurgans have a different history of land use: the northern part of the area surveyed has been used for agriculture purposes for many hundreds of years, the southern part of the area has been extensively utilized by man (for farming – mainly pasture) for about 200 years. However, most of large barrows were not strongly damaged by man. Kurgans are usually situated within large cultivated fields and remain practically inaccessible for most of the growing season (until harvest).

Research on the kurgans should be continued in the future, as there are new questions and problems arising, such as the role of kurgans in the landscape, the problem of isolation of the kurgan flora, effectiveness of pollen and propagulae dispersion, the existence and chance of survival of metapopulations of rare species.

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## INDYKACYJNA ROLA FLORY KURHANÓW NA „DZIKICH POLACH" (POŁUDNIOWA UKRAINA)

*Streszczenie*

Kurhany to elementy antropogeniczne w rolniczym krajobrazie Ukrainy. Do naszych czasów przetrwało ich około 50–100 tysięcy (pierwotnie ich liczbę szacuje się na 0,5 mln). Polsko-ukraińskie badania florystyczne prowadzone w latach 2004–2011 na kurhanach na południu Ukrainy (ryc. 1) wykazały, że lepiej zachowane kurhany to nie tylko obiekty badań archeologicznych, lecz także cenne obiekty przyrodnicze. Stanowią one mikrocentra różnorodności florystycznej (i zapewne biologicznej), a także refugia flory stepowej. Jest to ważne w sytuacji, gdy stepy są dziś najbardziej zagrożoną formacją roślinną Europy.

Badania potwierdziły także nieprzypadkowy rozkład gatunków (związanych z określonymi syntaksonami) w mikrosiedliskach na kurhanach (ryc. 2, 3) oraz pewne prawidłowości rozmieszczenia gatunków na kurhanach położonych w 4 strefach klimatyczno-roślinnych (strefa stepu piołunowego, stepu właściwego w wariancie ubogo- i bogatogatunkowym oraz strefa lasostepu). Okazało się, że współczesna flora kurhanów, wznoszonych przez człowieka przed setkami czy tysiącami lat, dość dobrze odzwierciedla naturalne zróżnicowanie flory w poszczególnych strefach (ryc. 4). Można więc mówić o roli wskaźnikowej flory kurhanów w „mikroskali" – w odniesieniu do siedlisk oraz w „makroskali" – w strefach klimatyczno-roślinnych.