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Ukrainian kurgans as refugia of steppe flora and their role in steppe restoration

Vast agricultural fields, kurgans (ancient burial mounds) and protective forest belts are very characteristic, anthropogenic components of the Ukrainian landscape. Windbreaks were planted widely in the 1950s and 60s. Kurgans were built from the Neolithic period to the Middle Ages. Their original number in Ukraine is estimated at 500,000. Today, however only 50,000-100,000 of these barrows remain. Polish-Ukrainian research of the flora of barrows has been conducted since 2004 through the project *“The kurgans as refugia of steppe flora and micro-centers of biodiversity in the anthropogenic landscape”*. The study involved 106 selected mounds from among nearly 450 visited. They were located in the forest steppe zone and three steppe zones (southern Ukraine). The study demonstrated that about 25% of Ukraine’s barrows had a valuable flora (more than 700 species, including 69 red listed species). It was also found that the flora of these kurgans reflected the climate vegetation zones. The large number and natural value of the mounds indicate that they are important in the process of restoration of the steppe. The three examples from different steppe zones show the role that kurgans could play in the process of the return of the steppe grasslands to areas of abandoned agricultural land. The distance between the kurgans and enclaves of natural vegetation and windbreaks is significant as well. On a European scale, the steppe vegetation has been destroyed to a greater degree (80-90%) than any other type of zonal vegetation. Therefore, the analysis and determination of procedures for local steppe restoration are of particular importance. Recently, a concept has been introduced to create “steppe belts” between large cultivated fields. “Steppe belts” could be a rich source of fodder and the starting point for local regeneration of the steppe in the future. Our results indicate that the rich flora of the neighboring kurgans could play an important role as a source of steppe species. Research on the kurgans will be continued, including the problem of spatial isolation of mounds. An estimation of the chances of survival of selected meta-populations on kurgans is an interesting subject of investigation as well.

Abstract

Ukrainische Kurgane als Refugien der Steppen-Flora und ihr Potenzial für die Renaturierung der Steppe

Ausgedehnte Äcker, Kurgane (alte Grabhügel) und Gehölz-Schutzstreifen sind charakteristische anthropogene Elemente der Ukrainischen Landschaft. Wind-Schutzstreifen wurden großflächig in den 1950er und 1960er Jahren angelegt. Kurgane wurden vom Neolithikum bis ins Mittelalter errichtet. Ihre ursprüngliche Zahl wird auf 500.000 geschätzt. Heute sind nur noch 50.000-100.000 dieser Hügel erhalten. Im Polnisch-Ukrainischen Forschungsprojekt „Die Kurgane als Refugien der Steppenflora und Mikrozentren der Biodiversität in der anthropogenen Landschaft“ wird seit 2004 die Flora der Grabhügel erfasst. Die Studie umfasst 106 ausgewählte von fast 450 voruntersuchten Grabhügeln, die in der Waldsteppenzone und drei verschiedenen Steppenzonen der südlichen Ukraine liegen. Mehr als 25 % der Ukrainischen Grabhügel weisen eine wertvolle Flora auf (mehr als 700 Arten, davon 69 Arten der Roten Liste). Die Flora der Kurgans spiegelt die klimatischen Vegetationszonen wider. Die große Zahl und der natürliche Wert der Grabhügel zeigt, dass diese wichtig für den Prozess der Renaturierung der Steppe sind. Die drei Beispiele aus unterschiedlichen Steppenzonen zeigen die Rolle auf, die Kurgane beim Prozess der Umwandlung der Steppen-Grasländer in Gebiete ohne landwirtschaftliche Nutzung spielen könnten. Hierbei ist auch der Abstand der Kurgane, der Enklaven natürlicher Vegetation und der Windschutzstreifen von Bedeutung. Im Europäischen Maßstab wurde die Steppen-Vegetation in einem größeren Ausmaß zerstört (80-90 %) als jeder andere Typ der Zonalen Vegetation. Aus diesem Grund sind die Analyse und Determination von Verfahren zur lokalen Wiederherstellung von Steppe von besonderer Bedeutung. Kürzlich wurde ein Konzept zum Anlegen von „Steppen-Gürteln“ zwischen großen kultivierten Feldern vorgestellt. Solche „Steppen-Gürtel“ könnten eine reiche Nahrungsquelle sein und den Ausgangspunkt für eine zukünftige, lokale Regeneration der Steppe sein. Unsere Ergebnisse legen nahe, dass die reiche Flora der benachbarten Kurgane eine wichtige Rolle als Quelle für die Steppen-Arten spielen könnte. Die Erforschung der Kurgane wird fortgesetzt, einschließlich des Problems der räumlichen Isolierung. Ein interessantes Forschungsthema ist auch die Abschätzung der Überlebenswahrscheinlichkeit ausgewählter Meta-Populationen auf den Kurganen.

Zusammenfassung

1

What is a kurgan?

A kurgan (barrow or tumulus) is a mound of earth or pile of stones constructed over a grave or graves. The majority of these barrows are recorded in Eurasia. There are thousands of barrows throughout Europe, most of which are small and not easily distinguished in the landscape (Fig. 1a, b). In Ukraine (Fig. 1c, d), their number is estimated at 50,000-100,000. Among them are mounds reaching up to 20 m in height.

Eurasian kurgans were built from the Neolithic to Middle Ages. Many of them are complicated structures with internal chambers. They were constructed by the nomadic populations of Cimmerians, Scythians (Fig. 1e), Sarmatians, Huns, Bulgarians, Magyars, Polovtsians, Nogays and others. In other continents, mounds used as a place of burial or sacred worship were also built by North American Indians (Fig. 1f), and the Aborigines in Australia (BROCKWELL 2006).

2

Kurgans in contemporary natural studies

These mounds were recognized quite early as valuable cultural objects, while almost no attention was paid to their importance as natural sites. A surprisingly small number of publications exist on the subject of their vegetation, however, there has recently been a growing interest in the flora of kurgans. The investigations carried out so far have concerned mostly the flora of the individual mounds, e.g. ANDRIENKO (1999) in Ukraine, CWENER (2004) in Poland, DZYBOV (2006), ZOLOTOV & BIRIUKOV (2009), BYKOV et al. (2009), in Russia. Contemporary complex floristic studies of Ukrainian kurgans will be discussed in greater detail in the next section. Hungarian researchers pay special attention to the current relationship between the soil and vegetation on the kurgans (BARCZI 2003). Russian research on kurgans focuses, among others, on soil variation in different microhabitats (e.g. LISIECKII & POLOVINKO 2008).

Attempts to employ environmental indicators (ecological index numbers) in relation to the vascular flora of barrows have only been made in recent years. Studies of the stone mounds in the Altai region showed that indicators differentiate well between the flora of the kurgans and the flora of their vicinity (BYKOV et al. 2009). The indicatory role of lichens was also analyzed. It allowed, with a certain approximation, to compare the age of the mounds.

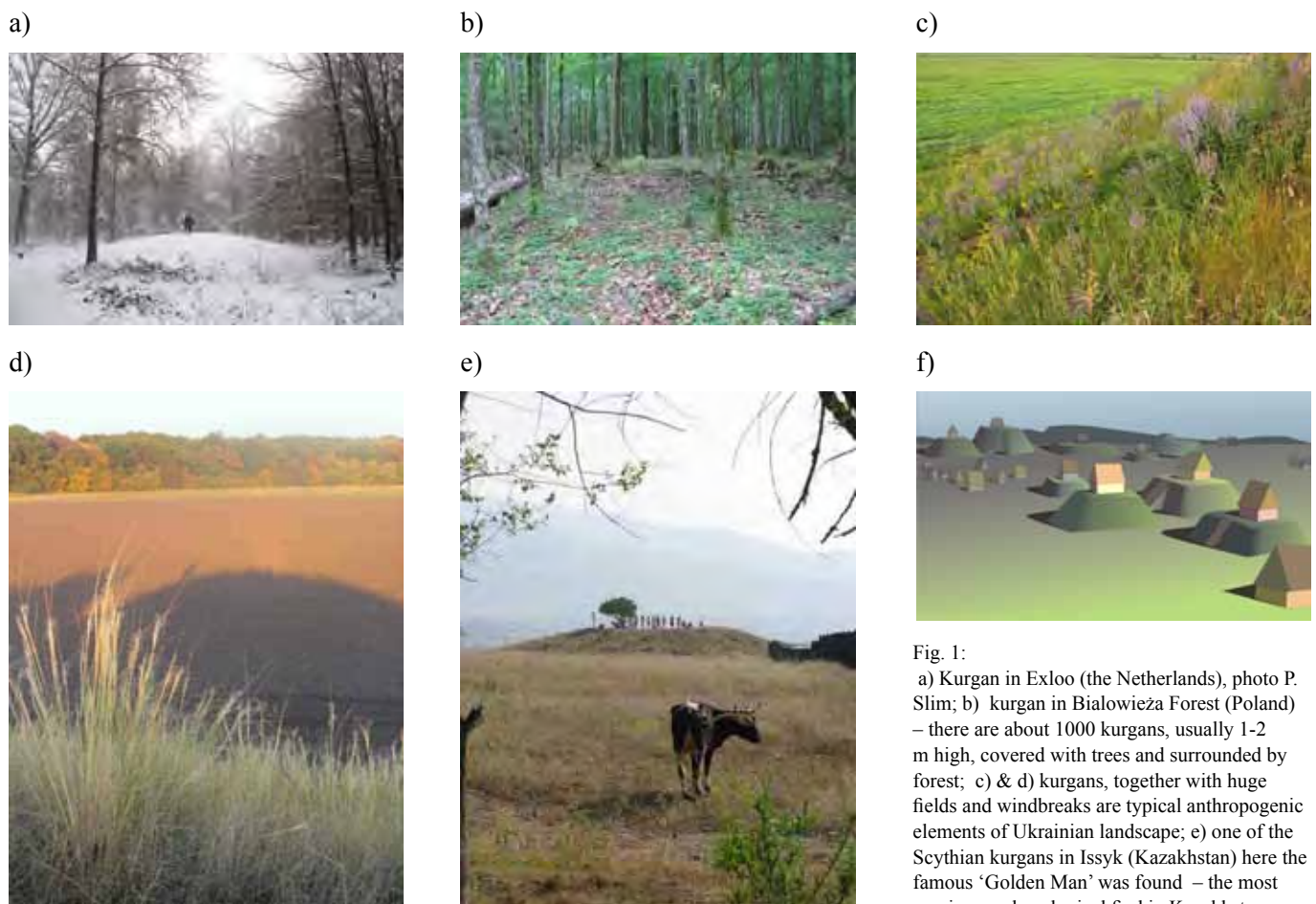


Fig. 1:

a) Kurgan in Exloo (the Netherlands), photo P. Slim; b) kurgan in Bialowieża Forest (Poland) – there are about 1000 kurgans, usually 1-2 m high, covered with trees and surrounded by forest; c) & d) kurgans, together with huge fields and windbreaks are typical anthropogenic elements of Ukrainian landscape; e) one of the Scythian kurgans in Issyk (Kazakhstan) here the famous ‘Golden Man’ was found – the most precious archaeological find in Kazakhstan; f) North American kurgans built by Mississippi Indians (800-1500 AD), fig. H. Galera.

A multidisciplinary study of fossil soils and attempts to reconstruct the palaeo-climate and habitat conditions of the time when the kurgans were built, has been conducted over the last few years in Ukraine, Russia and Hungary (e.g. GOLYEVA & KHOKHLOVA 2003, Joó et al. 2007). When the analysis of soil parameters is inadequate, microbiological soil analysis and biomorph analysis (micro- and macro-remains in the context of their origin) are applied. These are phytoliths, petrified plant fragments, pollen grains, diatoms, sponge spicules, as well as the composition of snail species in certain soil layers.

From the soil at the bottom of the kurgans, fossil, palynological and carpological materials (macro-remains, including seeds and fruits) were collected. These materials, combined with archeological data, can be dated quite precisely – hence the possibility of reconstructing the vegetation history.

Naturalists recognize the importance of kurgans and they are looking for reasons to protect them. The authors' long-term floristic survey serves this purpose as well. In 2004 we started a large-scale comprehensive field study of the flora of Ukrainian barrows (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2012, Appendices 1 and 2). The study continued until 2011 and covered a large area of southern and central Ukraine (about 32 000 km², within the Kherson, Mikolaiv, Kirovograd, Cherkasy and Poltava regions). This area contains more kurgans than anywhere else 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 and history of use. It is located in the Black Sea Lowland and Dnieper Upland, in four climatic-vegetation zones (Fig. 2), from south to north: D – the west and central Pontic desert steppe zone (desert steppe), 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 meadow steppe and forests). The selected mounds had to meet certain criteria (height over 3 m, in a relatively good state of preservation, and with the presence of steppe vegetation and flora, especially tufted grasses from the genera *Stipa*, *Festuca*, and *Koeleria*, and *Bothriochloa* further north). The floristic exploration was conducted in five microhabitats within kurgans, three times in the growing season.

3 Floristic research of kurgans (2004–2011)

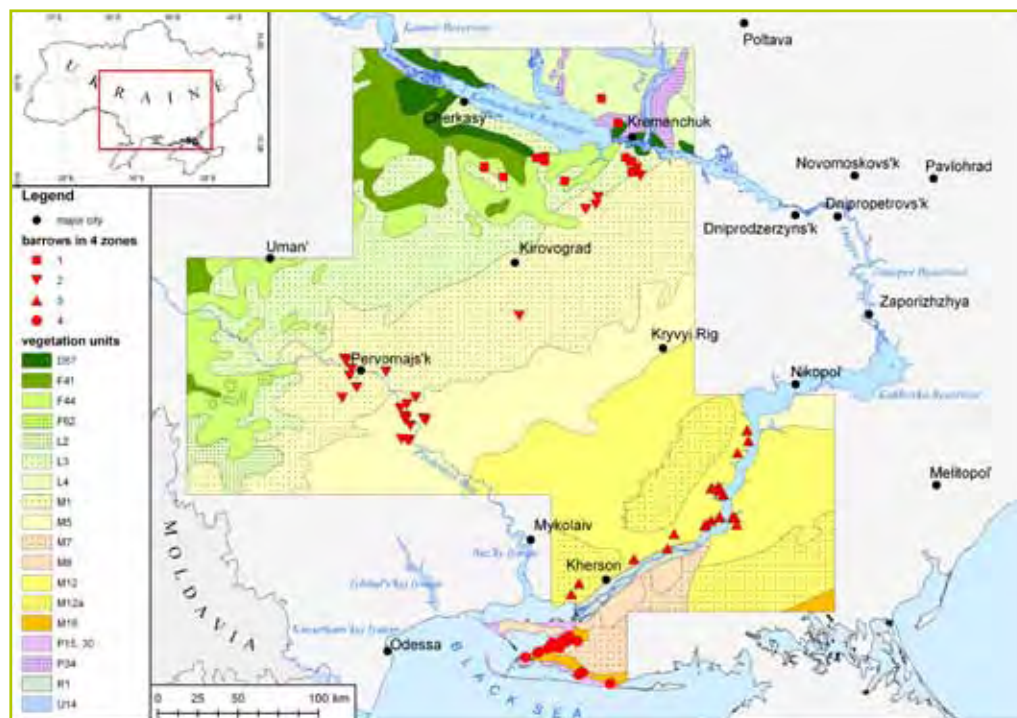


Fig. 2: Distribution of the kurgans investigated in the steppe and forest steppe zones in southern Ukraine: ○ – kurgans in the desert steppe zone; △ – kurgans in the west Pontic grass steppe zone; ▽ – kurgans in the west and central Pontic herb-rich grass steppe zones; □ – kurgans in the forest steppe zone.

Designations (according to BOHN et al. 2000): D57, F41, F44, F62 – south-east European forests (xerophytic pine and oak pine forests, lime-pedunculate oak-hornbeam forests, thermophilous hornbeam-pedunculate oak forests; sessile oak-hornbeam forests); L2, L3, L4 – meadow steppes; M1 – west and central Pontic herb-rich grass steppes; M5 – west and central Pontic herb-grass steppes; M7 – Pontic hemipsammophytic 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, fig. Ł. Banasiak, based on BOHN et al. (2000).

We visited about 450 barrows, of which 25% met the above criteria. Therefore, we conducted our floristic study on 106 barrows (25-29 from each zone). The floristic data, collected over a period of 8 years, were compiled into a database. On this basis, we characterized the total flora of the kurgans, as well as comparing the flora of microhabitats within kurgans and the flora from different climatic-vegetation zones.

The results are summarized in the points below:

1. We estimated the floristic value of the 106 investigated kurgans: among the 721 recorded species (some examples – see plate I), 69 are sozophytes (protected, rare, endangered species, included in the red data books of different ranks). The most valuable species are: *Allium regelianum*, *Astragalus borysthenticus*, *A. dasyanthus*, *A. pallescens*, *Crocus reticulatus*, *Dianthus lanceolatus*, *Stipa lessingiana*, *S. ucrainica*, *Tulipa schrenkii*. We also recorded communities from 4 classes included in the ‘Green Data Book of Ukraine’: *Amygdaletea nani*, *Stipetea capillatae*, *Stipetea lessingianae* and *Stipetea ucrainicae*. We confirmed that in the ‘sea of fields’, mounds represent refugia of the steppe flora (MOYSIYENKO & SUDNIK-WÓJCIKOWSKA 2008, 2010).
2. We determined the composition and structure of 106 kurgan flora (the families and genera with the largest share of species, the spectrum of life forms, synanthrope groups and the origin of alien species). The richness and diversity of the flora indicate that the mounds stand out from their surroundings (usually large fields, with flora of little interest) and in this monotonous anthropogenic landscape can be considered micro-centres of biodiversity.
3. We showed that the flora within the mounds varies in microhabitats. The distinctive feature of kurgans, compared with other types of natural and semi-natural habitats in the steppe zone, is the complex nature of flora due to the presence of different microhabitats (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2008a). There are floristic differences between the northern and southern sides of the mound. More extreme conditions on the slopes (compared to the base) allow for the persistence of steppe species. In contrast, meadow or pasture species and segetal weeds (including some very rare ones) are located at the base. Species of weeds are usually also found on the disturbed tops of the kurgans. It is interesting to note that the slopes of barrows are more resistant to the colonization of synanthropes than the bases and tops.
4. The structure of barrow flora in particular climatic-vegetation zones was identified by analyzing the spectra of life forms (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2010). From south to north, the known specificity of flora of the steppe and forest steppe zones is characterized by a decreasing role of therophytes and an increasing share of perennials: hemicryptophytes and phanerophytes (trees and shrubs). The socio-ecological structure of the flora of kurgans in particular zones changes from south to north as well: the proportion of halophytes shows a very clear decline, but the number and proportion of meadow and forest species gradually increase from south to north. Although the burial mounds in particular zones differ in the richness of the species, the spectrum of synanthrope groups is similar (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2008b).
5. The DCA analysis allows the qualitative comparison of the flora of each of the 106 barrows investigated in all 4 zones (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2012). On the 4 diagrams presented in this publication 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. The second axis separates the herb-rich grass steppe zone from the forest steppe zone. We can assume that the flora of the kurgans in the four climatic-vegetation zones reflects the flora of these 4 zones.

4

Future research on kurgans

The identification of the composition and structure of kurgan flora and the creation of databases for more than 100 barrows conclude an important phase of the research. Further research should also focus on other groups of organisms, besides higher plants and lichens.

In the future, as new questions and problems arise, investigations should continue regarding the role of mounds in the landscape, the problem of isolation of the kurgans, the existence and chances of survival of rare species, etc. The future survival of the plant (and animal) populations existing in these habitats largely depends on the number of species and the gene flow among different populations. Kurgans seem to be an ideal object for studies on the dispersal strategies of steppe plants. It can be assumed that local populations of steppe plant species attached to these ‘islands’ of natural vegetation surrounded by arable fields function in accordance with the metapopulation theory.

The perception of the role of the mounds and the threats they face have changed over the centuries. Some Eurasian mounds are still used as burial places, but this is not widespread. In the past, the mounds were held in esteem as places of ancestor worship, although unfortunately from the very beginning of their existence, they have also been vulnerable to robbery. Today, the robbers leave traces of their activities in the form of hollow shafts, pits or horizontal corridors. Archaeologists are also partly to blame. The most valuable kurgans have been thoroughly excavated, documented and sadly very often no longer exist.

A particular threat to kurgans was posed in the 20th century (especially in the former Soviet Union) by the new investments, large farms and exploitation of raw materials. Barrows were destroyed if they stood in the way of large construction projects such as building new roads, canals, settlements and reservoirs. At the time, mounds were often seen as an obstacle on the road to economic development. Tens of thousands of smaller mounds were then leveled, plowed and completely destroyed.

Paradoxically, the huge fields themselves, to a certain extent, make kurgans difficult to access and provide protection for plant cover against anthropogenic impacts: trampling, burning, looting soil or gathering plants. In the growing season these mounds are isolated and become accessible only after the harvest, when the seeds and fruits of the steppe species have already matured and been distributed. Some mounds are at risk from urban areas due to their proximity. On top of some kurgans, located in the immediate vicinity of highways, monuments or boards have been erected. Others, easily accessible, often visited and trampled, have been devastated. Still others have become the location for triangulation towers and measurement or observation points.

Nature on the kurgans is also threatened by frequent fires of anthropogenic origin. They cause the loss of some less well-adapted species. It is interesting that extensive grazing and infrequent fires promote many of the steppe species. Both factors cause the elimination of not only shrubs and trees, but also the excess dead organic matter, which forms a thick layer that hinders the development of many therophytes, spring geophytes and some other perennials.

The size of some mounds is reduced when the fertile soil is stolen and later used to grow horticultural crops. Wild flowers are dug up and transplanted from kurgans to gardens. There is a problem with the legal regulation of the status of kurgans. According to the law in Ukraine, kurgans cannot be privately owned. This law, however, is not fully observed. When the land was passed into private hands, the kurgans were not made into separate parcels of historical and cultural significance, and the area was counted together with the barrows. Kurgans are still seen as an obstacle to agriculture, and there are many technical opportunities to 'remove' them. An adequate inventory of mounds is required; each mound should be strictly registered, have 'a passport' and a legal guardian. There should be a 'buffer zone' in the immediate vicinity of the mound.

In the urbanized landscape, mounds have little chance of preserving the natural plant cover. However, in the agricultural landscape they may, to a greater or lesser extent, preserve natural steppe flora and vegetation. Our research has shown that the mounds, especially those in good condition, are important micro-centres of steppe biodiversity. Three anthropogenic elements dominate in the landscape of southern Ukraine: huge arable fields, windbreaks and kurgans (Fig. 1c, d). Kurgans, together with other existing enclaves of natural vegetation, can be a starting point for the expansion of steppe species into adjacent areas (SUDNIK-WÓJCIKOWSKA & MOYSIYENKO 2012, see also e.g. KUKSOVA 2011). If propagules of steppe plants reach intensively cultivated areas, they usually die. However, if the anthropogenic pressure decreases (e.g. on abandoned fields, in orchards, or in pastures where grazing has ceased) and kurgans are no longer isolated, many well-preserved burial mounds become an important source of propagules. However, sometimes the process of steppe regeneration may interfere with the expansion of tree species from the nearby windbreaks to the abandoned fields. Therefore, the question of the character of the final steppe communities remains open (Fig. 3). It is possible that the return of the steppe grassland would be faster if the windbreak had been removed before abandoning the field.

Another example (Fig. 4) also refers to the role of barrows and windbreaks in the regeneration of the steppe grassland, but in the "micro-scale". The first protective belts in southern Ukraine were planted in the early 19th century. They had often been planted since the mid-19th century, and on a massive scale – in the 1950s and 60s. Today trees from the older windbreaks are aging, and some of them fall to the ground. Maintaining forest belts in the steppe zone requires no small effort. Some steppe species are observed to occur in gaps within the neglected windbreaks. The process intensifies if sources of propagules (such as gorges, balkas or kurgans) are close to the protective belts. Steppe species can grow luxuriantly in these places with sufficient access to light and not disturbed by agricultural practices.

5 Past and present threats to kurgans and the need to protect them

6 The role of kurgans in the restoration of the steppe

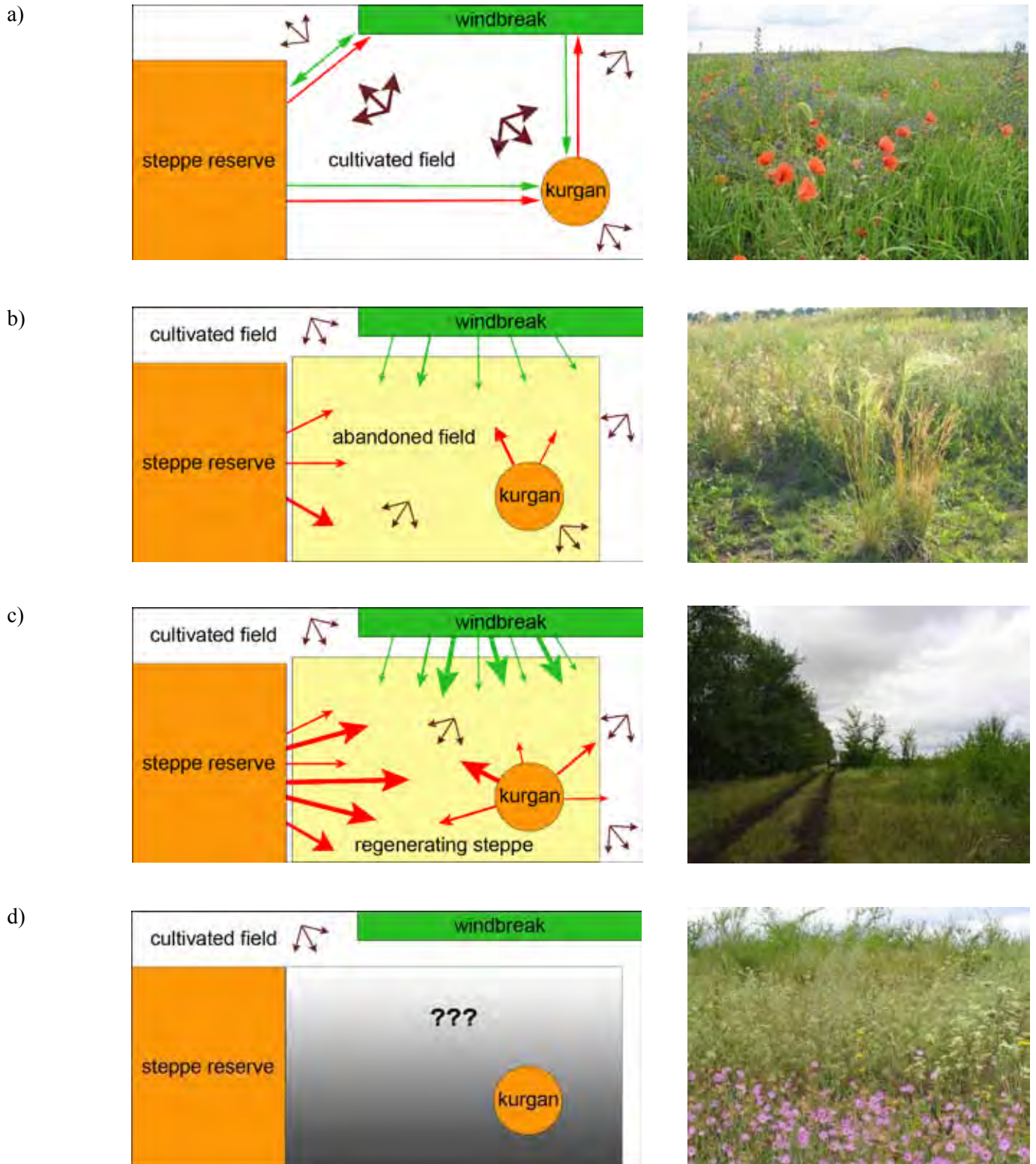


Fig. 3:
 Stages of steppe restoration in abandoned fields surrounding a steppe reserve and kurgans:
 a) starting point: intensive farming in the vicinity of the reserve;
 b) a few years after abandonment a field;
 c) more than 10 years after abandonment a field;
 d) the question of the character of the final steppe communities remains open. Explanations:
 green arrows – exchange of seeds of trees and shrubs, red arrows – exchange of seeds of steppe species,
 brown arrows – exchange of seeds of weeds, fig. A. Krzyk.

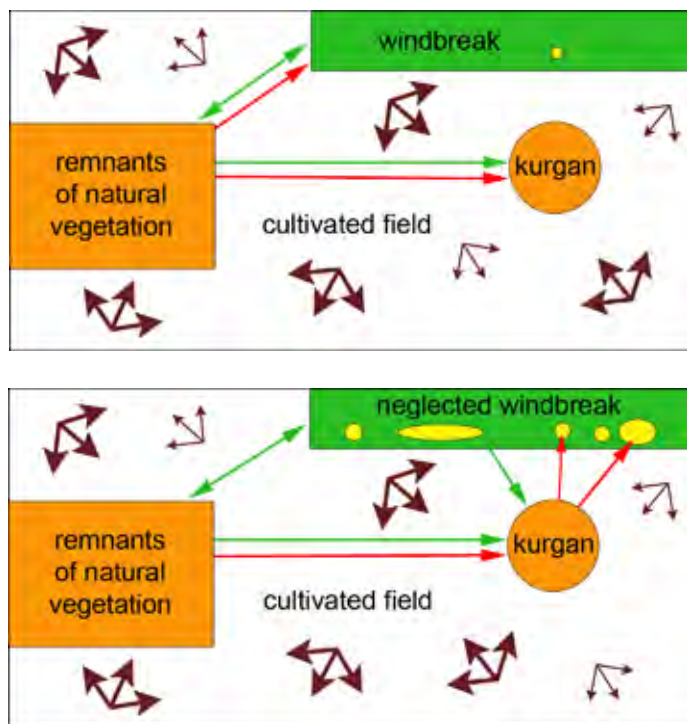


Fig. 4: Regeneration of steppe grasslands on a micro-scale: a) intensive farming and windbreak in good condition – regeneration of the steppe grassland proceeds very slowly; b) intensive farming and neglected windbreak – the regeneration process is more effective in gaps within the windbreak; kurgans and nearby natural vegetation play important role in this process; steppe species in gaps within the neglected windbreaks. Explanations: see Fig. 3; yellow – ‘points’ of grassland regeneration, fig. A. Krzyk.

A new trend in the Russian economy, which combines the interests of agriculture and nature conservation, is the concept of ‘the protective steppe belts’ (Dzybov 2001, 2006). The basis of the concept was: *the acceleration of the regeneration potential of the feed subsistence of pasture in the steppe zone*. The author of the concept suggests that between forest belts, in the large fields and pastures, belts of steppe vegetation should be created by sowing a mixture of seeds of steppe species. We would like to stress that kurgans located among the vast fields could be a valuable source of propagules of steppe species. They can play a vital role in maintaining the ‘protective steppe belts’ (Fig. 5).

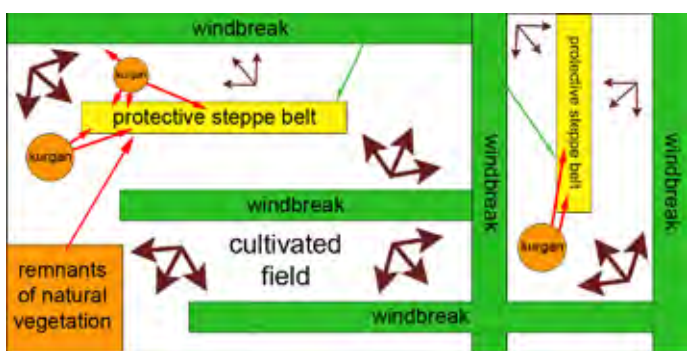


Fig. 5: The role of kurgans in maintaining the ‘protective steppe belts’ proposed by Dzybov (2007), fig. A. Krzyk.

Kurgans are some of the most characteristic features of the Ukrainian and Russian landscape. Due to their huge numbers and incidence in the fields, they can play an important role in local regeneration of steppes, and in time, along with other natural vegetation enclaves – role in the process of restitution of the steppes – the most endangered plant formation in Europe.

The archaeological value of kurgans has been known for a long time, but their ecological value is equally important – hence there is a great need for their conservation. It is absolutely necessary to urgently extend the legal protection of kurgans and to make it more effective. However, effective protection is only possible when the growing social awareness, and activity of local authorities and NGOs will be met with an understanding of the seriousness of the problem and the goodwill of decision makers.

Acknowledgments

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Plate I:
 Species found on the kurgans in the steppe and forest steppe zones:
 a) *Allium paniculatum*;
 b) *Amygdalus nana*;
 c) *Iris pumila*;
 d) *Lavatera thuringiaca*;
 e) *Stipa capillata* – species included in the “Red Data Book of Ukraine” (DIDUKH 2009);
 f) *Veronica spuria*;
 g) *Tulipa schrenkii* – species included in the “Red Data Book of Ukraine” (DIDUKH 2009);
 h) *Verbascum phoeniceum*.

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