VERSITA

10.2478/v10067-011-0021-5

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXVI, 1 SECTIO C 2011

BARBARA SUDNIK-WÓJCIKOWSKA[1], IVAN I. MOYSIYENKO[2]

[1]Department of Plant Ecology and Environmental Conservation, Faculty of Biology
University of Warsaw, Al. Ujazdowskie 4, Pl-00-478 Warsaw, Poland
e-mail: barbara.sudnik@uw.edu.pl
[2]Department of Botany, Kherson State University, Str. 40 let Oktriabrya 27,
73000 Kherson Ukraine, e-mail: Vanvan@ksu.ks.ua

Anthropogenic elements of the Ukrainian landscape and the problem of local steppe restoration

Antropogeniczne elementy ukraińskiego krajobrazu
i problem lokalnej restytucji stepów

SUMMARY

Vast agricultural fields as well as kurgans and protective forest belts are characteristic, anthropogenic components of the Ukrainian landscape. The paper discusses the role that kurgans and windbreaks could play in the local restoration process of the steppe in areas excluded from agricultural use (abandoned fields, orchards and pastures). Three examples are presented schematically. The investigated areas are located in three different climate-vegetation zones: desert steppe zone, west Pontic grass steppe zone and Pontic herb(-rich) grass steppe zone. Special attention is paid to how the local restoration process of the steppe proceeds. In addition, the effectiveness of the process and the role of alien tree species are assessed.

The present study also attempts to identify future research directions which will be useful in a wide range of applications. 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 regularities in the local restoration process of the steppe are of particular importance.

Key words: kurgans, windbreaks, recovery on abandoned fields, local steppe restoration

Słowa kluczowe: kurhany, pasy przeciwwietrzne, zarastanie porzuconych pól, lokalna restytucja stepów

STRESZCZENIE

Oprócz ogromnych pól, kurhany i pasy przeciwwietrzne są bardzo charakterystycznym, ale całkowicie antropogenicznym elementem ukraińskiego krajobrazu. W pracy omówiono rolę, jaką

kurhany i pasy przeciwwietrzne mogłyby odgrywać w procesie powrotu muraw stepowych na tereny wyłączone z użytkowania rolniczego (porzucone pola, sady i pastwiska). Schematycznie przedstawiono trzy przykłady – omawiane obiekty są zlokalizowane w trzech różnych strefach klimatyczno-roślinnych: w strefie stepu piołunowego, stepu właściwego w wariancie ubogim gatunkowo i stepu właściwego w wariancie bogatym gatunkowo. Zwrócono uwagę na etapy procesu restytucji stepów i na rolę, jaką w ich przebiegu mogą odgrywać gatunki obcego pochodzenia.

W sytuacji, gdy stepy należą do formacji europejskich przekształconych na największą skalę (80–90%) – analiza i poszukiwanie prawidłowości w procesie restytucji stepu mają szczególne znaczenie. Opracowanie ma także nieco szerszy aspekt. Jest próbą wskazania dalszych, kierunków badań o znaczeniu aplikacyjnym.

INTRODUCTION

Joint Polish-Ukrainian research in the forest steppe and steppe zones in southern Ukraine (Fig. 1) has been conducted by the authors since 2004. The investigations are concerned with the flora of kurgans and windbreaks, which constitute anthropogenic elements in the agricultural landscape of Ukraine. The works dealing with kurgans (barrows, mounds) include: (22, 25, 38, 40). Windbreaks (forest belts) were discussed in more detail in the following papers: 42, 43.

The purpose of this study is to draw attention to these man-made structures, which are of completely different origin than the enclaves of natural vegetation. In addition, their role in the local steppe restoration in areas excluded from agriculture is assessed. The significance of alien species associated with kurgans and windbreaks is also determined.

In Europe steppes are concentrated mainly in Ukraine and southern Russia. Steppes are a formation transformed (mainly into fields and pastures) to a greater extent than any other type of zonal vegetation in Europe. Thus, attempts should be made to restore the steppe vegetation in these countries. Just recently, a new threat to steppe appeared – an attempt to implement the "Kyoto Protocol", which says that afforestation in the temperate zone should reach 27%! (48).

Due to destruction of the steppes, the analysis and search for regularities in the local restoration process of the steppe are of particular importance. The present work also attempts to identify future research directions, which will be useful in a wide range of applications.

ANTHROPOGENIC ELEMENTS OF THE AGRICULTURAL LANDSCAPE OF UKRAINE AND THEIR ECOLOGICAL SIGNIFICANCE

It is estimated that about 80–90% of the steppe area in Ukraine has been destroyed due to agricultural activities and development of human settlements. As a consequence, the Ukrainian landscape is dominated by large fields (Fig. 2a). Some enclaves of the steppe have been preserved in nature reserves and national parks, on the slopes of river valleys, balkas, canyons etc. In addition to the intensively used fields, kurgans (Fig. 2b) and windbreaks (Fig. 2c) are one of the most characteristic elements of the anthropogenic monotonous landscape of the steppe zone. Mounds were constructed by the nomadic populations, mainly Kimmerians, Scythians, and Sarmatians (1, 4, 17, 18, 32, 34, 36).

Figures 3a-c show schematically the history of a Scythian kurgan in the steppe area on the northern Black Sea coast. In this area, anthropogenic influences and changes in the vegetation cover of the mounds occurred only about 200 years ago (forced colonization in the time of the Russian empress Catherine II).

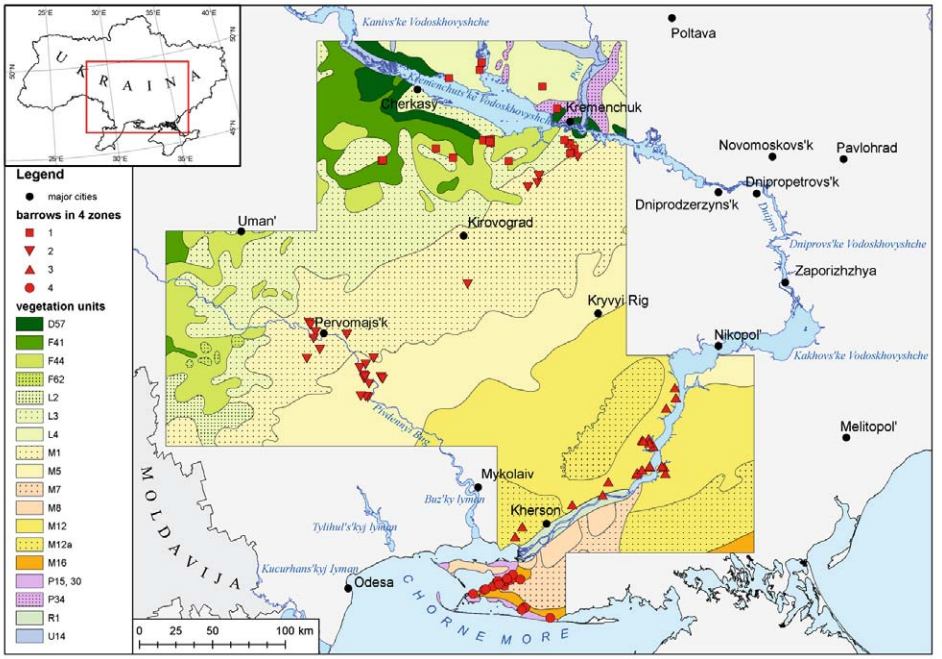

Fig. 1. Distribution of the kurgans investigated in the steppe and forest steppe zones in southern Ukraine: □ – kurgans in the desert steppe zone; □ – kurgans in the west Pontic grass steppe zone; □ – kurgans in the west and central Pontic herb-grass steppe and west and central Pontic herb-rich grass steppe zone; □ – kurgans in the forest steppe zone (not considered in the present study).

Designations (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.

Originally there were about half a million kurgans in the current territory of Ukraine. Today, many of them have been destroyed as they constituted an obstacle to the large-scale agriculture. The number of mounds is estimated at 100,000 (50,000–150,000 according to various sources, e.g. 35).

Our studies on the flora of barrows showed that approximately 20–25% of the 450 relatively large (over 4 m high) mounds which we visited in the steppe and forest steppe zones are floristically valuable. The total number of species listed on the 106 most interesting kurgans exceeded 700. Depending on the zone, steppe species comprised 41–49% of the kurgan flora. Among the

a.

b.

c.

Fig. 2. Anthropogenic elements of the Ukrainian landscape: a) large field; b) kurgans; c) windbreaks

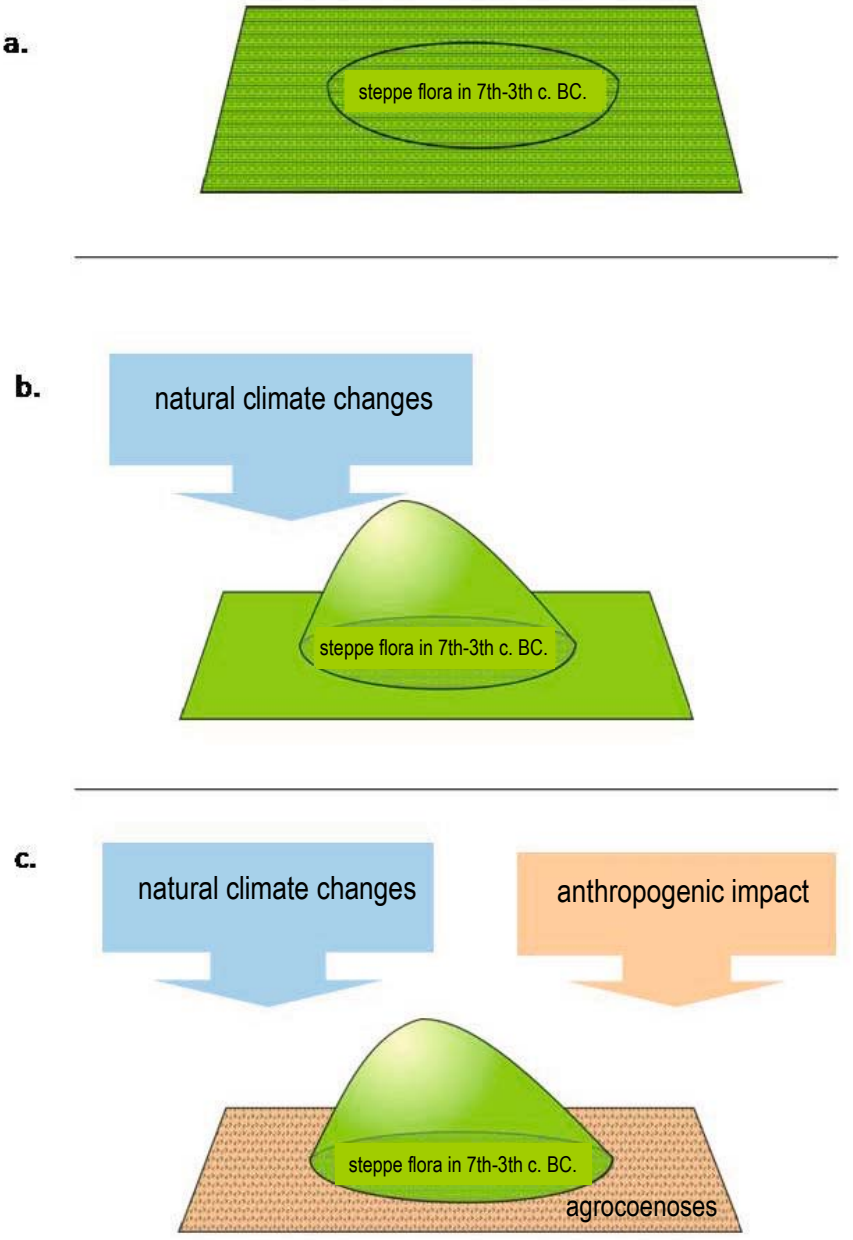

Fig. 3. The history of a Scythian kurgan in the steppe area in southern Ukraine: a) the starting point – the floristic composition of the steppe about 2.5 thousand years ago (the Scythian times); b) kurgans and their surroundings up to the days of Catherine II (18th century) – the floristic composition of the steppe and kurgans was similar and affected by natural climate changes; c) after "taming" of the steppe – natural climate influences as well as anthropogenic impact are marked: steppes have been converted into fields and pastures, while the steppe vegetation survived on many kurgans

Fig. 4. Microhabitats on kurgans: T – top, Ss – southern slope, Sn – northern slope, Bs – the southern foot, Bn – the northern foot. The best preserved steppe vegetation survived on the slopes of the kurgan. The top is often disturbed (triangulation tower, measuring equipment, pillars etc.). The foot of kurgans is inhabited by species with higher requirements for moisture, and weeds from adjacent fields

microhabitats distinguished on the mounds (Fig. 4), the slopes supported the most interesting species (39).

A total number of 69 sozophytes (protected species and those listed in Red Data Books) were recorded on the mounds (23, 24, 26, 37). These results confirm the floristic value of the kurgans (see also: 2, 3, 13, 15). The barrows were characterized by:

– relatively high species richness, resulting from, among others, the habitat differentiation of the kurgans;

– the presence of rare and protected species – hence the mounds can be considered as refugia of the steppe flora as well as habitat islands ("hot spots");

In addition, the structure of the flora of the kurgans in each of the climate-vegetation zones corresponds to the structure of the flora of these zones (15, 41).

The establishment of windbreaks or protective forest belts in the steppes of southern Ukraine is closely associated with the history of "taming of the steppe". The first windbreaks were planted at the beginning of the 19th century, and on a massive scale – in 1950-1970. Windbreaks (especially in the grass steppe zone) form a characteristic grid pattern, consisting of rows of trees which intersect each other at right angles (Fig. 2c). The nodes of the grid are spaced fairly regularly (about one to several km apart). The dendroflora of windbreaks in Ukraine contains about 80 species and includes both native (e.g. *Acer tataricum, A. campestre, A. platanoides, Fraxinus excelsior, Quercus robur, Ulmus minor and U. laevis*), and alien species, mainly those that are able to persist in deforested areas (*Elaeagnus angustifolia, Robinia pseudoacacia, Ulmus pumila, Ailanthus altissima, Fraxinus pennsylvanica, Gleditsia triacanthos*). Windbreaks play an important ecological role (e.g. 47, 49), as they: reduce the speed of wind; prevent wind erosion and dust storms; stabilize the snow cover; improve soil moisture conditions; act as barrier for tumbleweeds (the "perekatipole"); constitute potential "sources" of non-prairie species; – act as ecological corridors.

Now, in Ukraine lively discussions are conducted on the role, current state and the future of the windbreaks (10, 28, 29, 44).

THE ROLE OF KURGANS AND WINDBREAKS IN THE LOCAL RESTORATION PROCESS OF THE STEPPE – SOME EXAMPLES

The diagrams present three examples of the steppe grasslands returning to areas excluded from agricultural use (pastures, orchards and fields) in three different climate-vegetation zones (Fig. 1): desert steppe zone, west Pontic grass steppe zone and Pontic herb(-rich) grass steppe zone (the classification of climate-vegetation zones according to the *Map of the Natural Vegetation of Europe* (5). Special attention is paid to how the local restoration process of the steppe proceeds. The effectiveness of the process and the role of alien tree species is also assessed.

Example 1 (Fig. 5a-c)

Location: desert steppe zone, with enclaves of solonchak and solonetz vegetation (Fig. 6a), in the vicinity of the Black Sea Biosphere Reserve.

Former land use: intensively used pastures where large herds consisting of more than twenty thousand sheep were grazed. Numerous kurgans and windbreaks are surrounded by the pastures. The windbreaks are mainly composed of *Elaeagnus angustifolia*. A lower proportion of such species as *Robinia pseudoacacia* and *Gleditsia triacanthos* is also recorded in the windbreaks.

Changes in land use: the Ukraine agriculture faced crisis in the 1980s and 1990s. Large herds of sheep were eliminated and replaced by herds of cattle. However, the number of cattle is much lower now and extensive grazing is only noted.

Consequences: the desert steppe regenerates quickly in areas which are not under high herbivore pressure. At the same time young specimens of *E. angustifolia* are locally abundant in the vicinity of the windbreaks. We provisionally referred to this type of synanthropic vegetation as "park-steppe" (Fig. 6b).

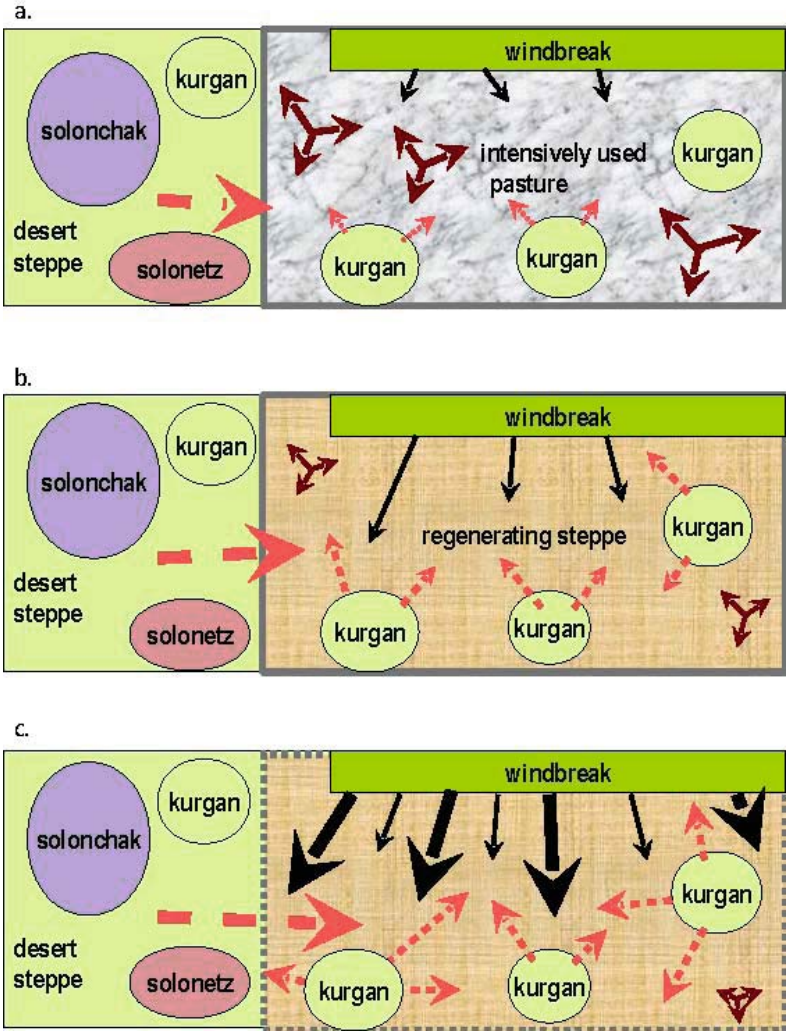

Fig. 5. Stages of restoration of the desert steppe (with enclaves of salt soils such as solonchak and solonetz), including the role of kurgans and windbreaks built by *Elaeagnus angustifolia*: a) initial state – up to the 1980s and 1990s: desert steppe, where very large herds of sheep were grazed (weeds – triple arrow); b) several years after: the cessation of grazing due to the crisis in Ukraine agriculture; trees from windbreaks (black arrows), and steppe species (broken arrows) from enclaves of natural vegetation and kurgans encroach on abandoned pastures – the beginning of the restoration process of the desert steppe; c) more than 20 years after the large herds of sheep were replaced by small herds of cattle: *Elaeagnus angustifolia* spreads throughout the regenerating desert steppe

Comments: It may be inferred from Figures 5a-c that the regeneration process of the natural steppe vegetation involves changes in the internal structure of the vegetation cover that previously existed in this area (during intensive grazing period). The composition of the flora is significantly affected by the presence of kurgans as well as by windbreaks built mainly by *E. angustifolia* and located in the immediate vicinity of the investigated area.

a.

b.

Fig. 6. The desert steppe in southern Ukraine: a) undeveloped, with enclaves of solonchak and solonetz vegetation and kurgans; b) "park steppe" with *Elaeagnus angustifolia*

Russian olive is an Iranian-Turanian species that is resistant to drought and extreme temperatures. It also tolerates elevated salinity levels. The fruits are dispersed by water or wind. The seeds are propagated mainly by birds and small mammals. On the northern Black Sea coast Russian olive is considered to be an invasive species (9, 30, 31). Species introduced to North America also became an invasive plant and causes a number of problems, especially in the semidesert zone (7, 8, 16, 51).

Our investigations (43) confirmed that *E. angustifolia* trees (not older than 20–25 years) which had "escaped" from the windbreaks could establish themselves in places where cultivation and intensive grazing had ceased. The analysis of phytosociological material (relevés with and without Russian olive) showed that *E. angustifolia* could impede the regeneration of the desert steppe. The nitrogen-fixing actinomycetes which form a symbiotic association with *Elaeagnus* (genus *Frankia* in the root nodules) seem to play an important role in this process. The area under the crown of the trees provides 'refuge' for weed species. Therefore, Russian olive creates favourable conditions for the growth and persistence of alien as well as native nithrophilous and shadow loving weeds.

It should be noted that the negative impact of *E. angustifolia* on the desert steppe vegetation is so strong that it is necessary to implement active protection measures as there is already a plan to establish a scenic park "Valley of the kurgans" in this area (21). To prevent the further spread of the species, small herds of sheep should be introduced into this area.

Example 2 (Fig. 7a-c)

Location: west Pontic grass steppe zone, in the vicinity of Kherson.

Former land use: an orchard has been cultivated for about 20–30 years in the vicinity of three kurgans that occur within a short distance of each other. The plant cover on the kurgans is well preserved, especially on the slopes where a high number of steppe species is recorded. There are no windbreaks in the immediate vicinity of the orchard. The nearest windbreak is located about 300 m from the orchard.

Changes in land use: the orchard has been cut down. No signs of human interference have been observed over the last 4–6 years (Fig. 8a).

Consequences: patches of steppe vegetation are found within 100–150 m of the foot of the kurgan. These mainly include clonal species. Characteristic coloured patches of steppe species are visible from the top of the kurgans (Fig. 8b). A more detailed study (Moysiyenko, Sudnik-Wójcikowska, unpublished data) showed that 4–6 years after the orchard had been abandoned, 74% of the 97 steppe species recorded on the kurgans appeared in the vicinity of the barrows between tree stumps. Among grass species which make up the steppe phytocenoses are: *Stipa capillata, S. ucrainica, Festuca valesiaca, Koeleria cristata, Agropyron pectinatum.* Steppe herbs are represented by: *Tanacetum millefolium, Artemisia austriaca, Kochia prostrata, Falcaria vulgaris, Coronilla varia, Linaria biebersteinii,* and *Ranunculus scythicus.* Sprouts are observed on some single tree stumps that remained after the fruit trees had been cut down. However, the seedlings of fruit trees and of other trees occur less frequently.

Comments: in this case windbreaks are quite a distance away from the orchard. Therefore the steppe seems to have a greater chance of successful regeneration. In the west Pontic grass steppe zone the competition from trees (especially native species) is more limited than in the case of zones that are located further to the north.

Example 3 (Fig. 9a-d)

Location: Pontic herb(-rich) grass steppe zone: "Elanetski Steppe" reserve and its vicinity (Fig. 10a).

Former land use: intensively cultivated fields in the vicinity of the reserve. On the edge of the fields there are windbreaks composed of one dominant tree species (e.g. *Ulmus pumila, Cotinus coggygria* and *Armeniaca vulgaris*)

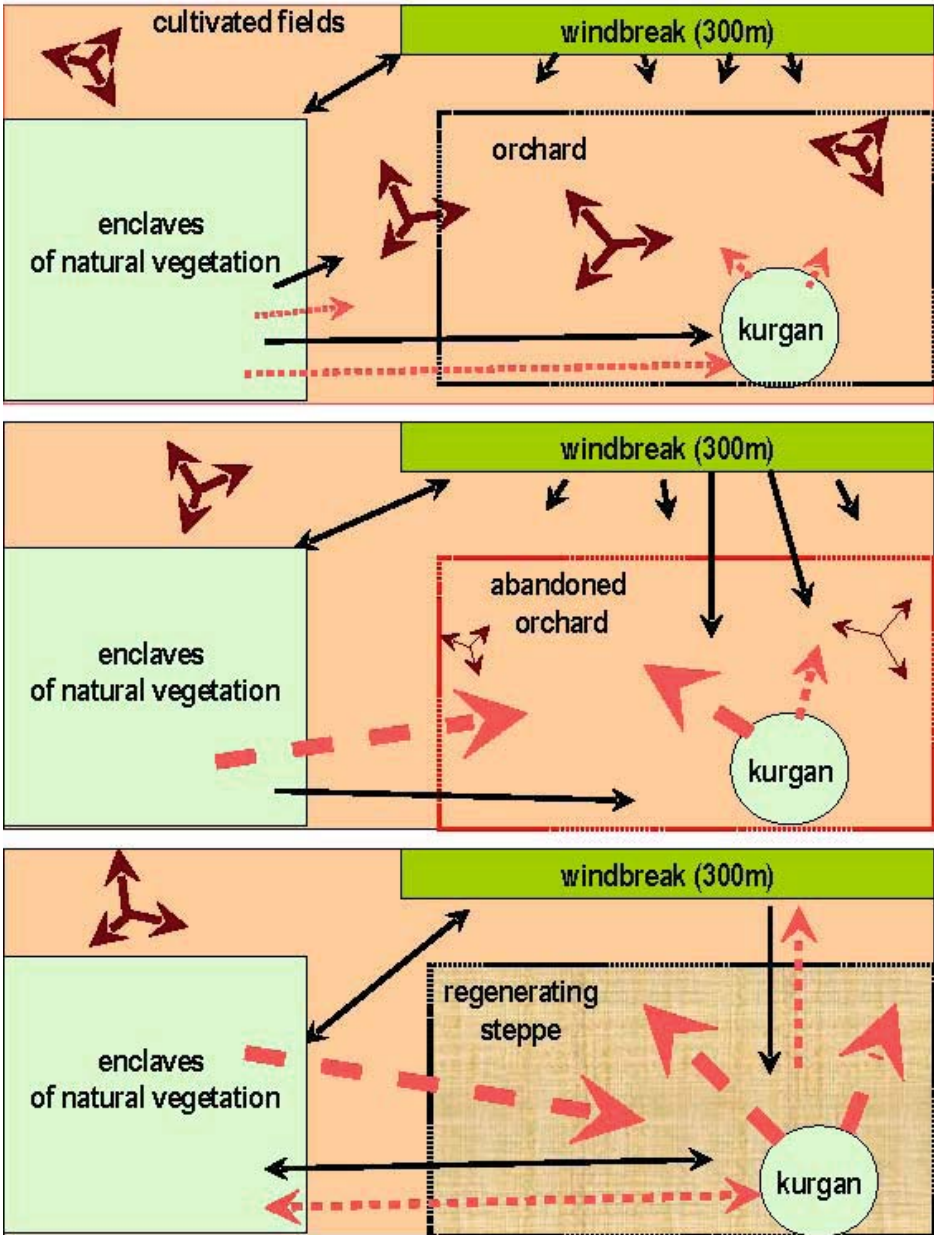

Fig. 7. Stages of regeneration of the steppe vegetation in the west Pontic grass steppe zone, in areas where cultivated fields have been abandoned, including the role of kurgans and windbreaks: a) the initial state – intensive farming; b) abandonment of fields – trees from windbreaks, as well as steppe and tree species from kurgans and enclaves of natural vegetation encroach on the abandoned fields c) regeneration of steppe vegetation with a relatively low percentage of tree species. Explanation of symbols – see Fig. 5.

a.

b.

Fig. 8. The area surrounding the kurgans in the west Pontic grass steppe zone: a) immediately after the orchard was cut down; b) a few years after the fruit trees were eliminated – ”patches” of vegetatively expanding clonal steppe species are visible from the top of the kurgan

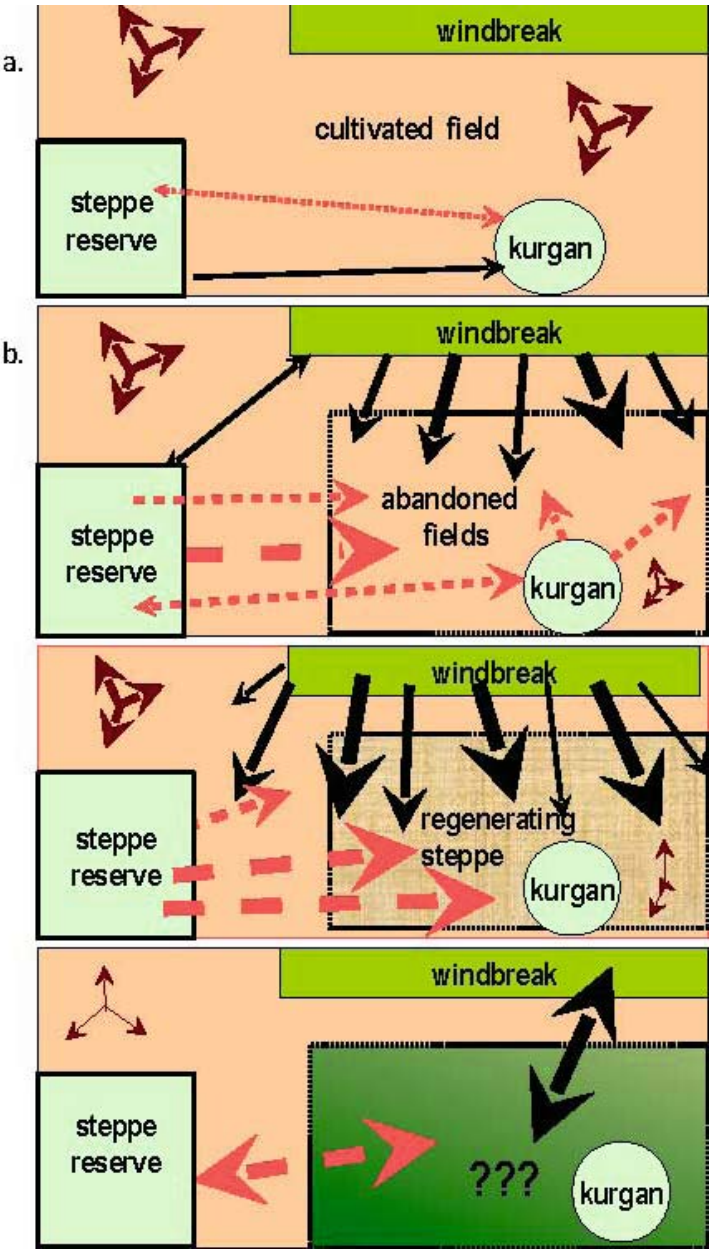

Fig. 9. The role of kurgans and windbreaks in the regeneration process of steppe vegetation in areas where fields have been abandoned near the "Elanetski Steppe" reserve in the Pontic herb(-rich) grass steppe zone: a) the initial state – intensive agricultural activities around the reserve; b) a few years after the fields were abandoned; c) about 10 years later; d) competition between trees and steppe plants – the results of competition are difficult to predict. Explanation of symbols – see Figure 5

a.

b.

c.

d.

Fig. 10. “Elanetski Steppe” reserve and its immediate surroundings: a) the Pontic herb(-rich) grass steppe protected in the reserve. Species escaping from windbreaks after the abandonment of fields in the vicinity of the reserve: b) *Cotinus coggygria*; c) *Ulmus pumila*; d) competition between trees and steppe plants

Changes in land use: the agricultural fields have not been cultivated since the end of the 1990s and have been incorporated into the reserve.

Consequences: the seedlings and juvenile tree specimens are densely distributed in the abandoned agricultural fields. The species composition of the dendroflora depends on the floristic composition of the windbreaks. In the "Elanetski Steppe" reserve young specimens of *Cotinus coggygria* (Fig. 10b) and *Ulmus pumila* (Fig. 10c) are particularly abundant.

Comments: Several years after the agricultural fields were abandoned, there is a clear competition between turf grasses which have expanded out of the reserve and trees escaping from the windbreaks (Fig. 10d). In the first few years trees have an advantage over the grass species as the turf grass cover is rare. In addition, livestock grazing has ceased completely. The natural soil cover has been transformed due to years of continuous cultivation of the land (changes in the hydrological regime, soil profile and structure). Some authors point that there is a tendency towards a more humid climate in this zone, which is close to the forest-steppe zone. As a result, the fires are less likely to occur, which favours the growth of trees. However, further studies should be conducted within the "Elanetski Steppe" to determine whether a forest or a steppe will develop in the future.

It is interesting to note that the expansion of trees takes place only in the abandoned fields. However, tree species are unlikely to penetrate the steppe slopes within the reserve boundaries. This indicates that abandoned fields have much more favourable growth conditions for trees than the steppe. The following management practices and activities should be considered when creating a plan for the expansion of the reserve area at the expense of the agricultural fields:

– windbreaks should be removed before cultivation has ceased, which would limit the influx of diaspores of tree species (however, the seed bank remains in the soil);

– controlled, small fires should be ignited immediately after cultivation has ceased;

– moderate grazing intensity and mowing should be advocated and maintained for several years to protect grass species and reduce the excessive number of tree seedlings and juvenile tree specimens.

FINAL REMARKS

As stated earlier, the level of land utilization for agricultural purposes is very high in Ukraine. The presented examples show that not only preserved enclaves of natural vegetation, such as steppe reserves, canyons, balkas and slopes of river valleys, but also kurgans, particularly in areas where they are abundant, could play an important role in the restoration process of the steppe in areas which are not subject to anthropogenic pressure. However, the windbreaks play the negative role in this process.

Following the recommendations for the sustainable agriculture development, the area of arable land should not exceed 50% of the total land area used for agriculture. According to these recommendations, arable fields on the slopes of the mounds, as well as fields contaminated with salt should be converted into pastures or fodder fields (27).

Measures to promote the regeneration of the steppe in abandoned fields are complex and expensive (14, 33, 46). The regeneration could be supported, when a well preserved kurgan or kurgans are located among abandoned fields. It can be predicted then what type of plant communities will regenerate and what their

species composition will be. In contrast to balkas and ravines, barrows are of convex shape and therefore, the spread of seeds ("rain of diaspores") is more effective. This process occurs continuously only when the area around the kurgans has not been ploughed. Steppe plants can spread to further areas. In Ukraine northeastern winds prevail. There is a tendency for diaspores to be spread unevenly throughout the area surrounding the barrows. Therefore, steppe plants are able to colonize the south-west side of the kurgans more effectively.

The restoration process of the steppe in abandoned agricultural land may be disturbed when the kurgans are situated in the immediate vicinity of the forest belts, especially those built by foreign, hardy tree species. Moreover, the anthropogenic transformation of the soil cover and perhaps the tendency for the climate to become more humid (which has been registered by climatologists for the last 25 years; 11, 12), facilitate the expansion of trees. In these cases, active management is needed to halt the expansion of trees. In the reconstruction or planting of new windbreaks, the most expansive tree species such as *Ailanthus altissima, Amorpha fruticosa, Elaeagnus angustifolia, Fraxinus pennsylvanica, Ulmus pumila*, etc. should not be planted. However, in areas where steppe restoration is planned, the windbreaks should be removed as soon as possible, and abandoned fields mowed for several years after the cessation of cultivation. Extensive grazing is also recommended.

Further research is needed to investigate the competition between steppe and forest species, as well as the scale and efficiency of colonization of abandoned fields and pastures by both steppe species and trees.

The following question remains unanswered: what role do native trees and shrubs play in the restoration process of the steppe. There is still a lively debate about what actual climax vegetation would develop if the steppe zone was influenced by climate factors only. Some authors (e.g. 50) suggest that the vegetation would consist of shrub and semishrub species (the contribution of tree species would increase towards the north). However, such factors as fires or grazing also affect the plant cover in the steppe areas (6, 19, 20, 45).

ACKNOWLEDGEMENTS

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.

REFERENCES

1. Artemenko I. I., (ed.) 1985–1986. Archeologiya Ukrainskoj SSR. Vol. 1. Pervobytnaja archeologia. Vol. 2. Skifo-sarmatskaya i antichnaya archeologiya. Naukova Dumka, Kiev.

2. Barczi A. 2003. Data for the botanical and pedological surveys of the Hungarian kurgans (Great Hungarian Plain, Hortobágy). Thaiszia – Journal of Botany 13, 113–126.
3. Barczi A., Penksza K., Joó K. 2004. Research of soil-plant connections on kurgans in Hungary. Ekologia (Bratislava) 23, Supplement 1/2004, 15–22.
4. Bibikov S. M. 1971. Arkheologiia Ukrainskoi RSR. Naukova Dumka, Kyiv.
5. Bohn U., Gollub G., Hettwer C., Neuhäuslová Z., Raus T., Schlüter H., Weber H. (eds). 2000. Karte der natürlichen Vegetation Europas, Maßstab 1:2 500 000. (Map of the Natural Vegetation of Europe. Scale 1: 2 500 000). Bundesamt für Naturschutz, Bonn.
6. Borovik L. P., Borovik E. N. 2006. Problema rhezhima sokhranienia stepi v zapovednikakh: primier Streleckoi stepi. Stepnoi Bulletin 20. http://ecoclub.nsu.ru/books/Stepbull-20/07.htm
7. Brock J. H. 1998. Invasion, ecology and management of *Elaeagnus angustifolia* (Russian olive) in the southwestern United States. [In:] Plant Invasions: Ecological Mechanisms and Human Responses. U. Starfinger, K. Edwards, I. Kowarik, M. Williamson (eds). Backhuys Publishers, Leiden, 123–136.
8. Brock J. H. 2003. *Elaeagnus angustifolia* (Russian olive) seed banks from invaded riparian habitats in northeastern Arizona. [In:] Plant Invasions: Ecological Threats and Management Solutions. L. Child, J. H. Brock, G. Brundu, K. Prach, P. Pyšek, P. M. Wade, M. Williamson (eds). Backhuys Publishers, Leiden, 267–276.
9. Burda R. 2003. Alien trees and shrubs in the Ukrainian agricultural landscape. [In:] Phytogeographical Problems of Synanthropic Plants. A. Zając, M. Zając, B. Zemanek (eds). Institute of Botany Jagiellonian University, Cracow, 11–16.
10. Chirkova O. V. 2010. Struktura lisosmug yak skladovykh elementiv ekologichnoi merezhi. Problemi ekologii ta okhoroni pryrody tekhnogennogo regionu. DonNU, Donetsk 1.10, 97–104.
11. Chornyi S. G. 2004. Klimat ta eroziini procesy na pivdni Ukrainy. Visnik Agrar. Nauky 4, 52–55.
12. Chornyi S. G., Khotynenko O. 2005. Suchasna zmina klimatu v stepu Ukrainy ta protydefliatsiina nebezpeka. Zbirnyk naukovych prats 'Regionalni problemy Ukrainy: geografichnii analiz ta poshuk shliakhiv vyrishennia. PP. Vishemirskii, Kherson, 43–46.
13. Cwener A. 2004. Rośliny naczyniowe kurhanów w dorzeczu dolnej Szreniawy i Nidzicy (Wyżyna Małopolska, południowa Polska). Fragm. Flor. Geobot. Polonica 11, 27–40.
14. Dzybov D. S. 2001. Metod agrostepei (uskorennoe vosstanovlenie prirodnoi rastitelnosti). Nauchnaia Kniga, Saratov.
15. Dzybov D. S. 2006. Kurgany – drevnieishie ekotopy genofonda fragmentov flory ekosistem yuga Rossii. Materials of Science-Practic Conference. Stavropol, 2005 November 29–30. Stavropol: Stavropolskoe Knizhnoe Izdatelstvo, 95–100.
16. Katz G. L., Shafroth P. B. 2003. Biology, ecology, and management of *Elaeagnus angustifolia* L. (Russian olive) in western North America. Wetlands 23.4, 763–777.
17. Khodarkovsky M. 2009. Na granicach Rosji. Budowanie imperium na stepie 1500–1800. Państwowy Instytut Wydawniczy, Warszawa.
18. King Ch. 2006. Dzieje Morza Czarnego. Państwowy Instytut Wydawniczy, Warszawa.
19. Lysenko G. N. 2005. V kakom rhezhimie sokhranitsia step „Mikhailovskoi Celiny". Stepnoi Bulletin 18: http://ecoclub.nsu.ru/books/Stepbull-18/03.htm
20. Lysenko H. M. 2008. Pirogennye aspekty abioticheskoi regulacii stepnykh rezervatnykh ekosystem. Ekologia ta noosferologiya 19.1–2, 143–147.
21. Moysiyenko I. I., 2006. Tsinna v sozologichnomu vidnosheni Prymorska solonchakova rivnyna „Dolyna Kurganiv" (Khersonska oblast, Ukraina). 1st Vidkrytii zizd fitobiologiv Khersonshchyny. Zbirnyk tez dopovidei; 2006 April 6. Ailant, Kherson, 74.

22. Moysiyenko I. I., Sudnik-Wójcikowska B. 2006. The flora of kurgans in the desert steppe zone of southern Ukraine. Chornomorski Bot. Journ. 2.1, 5–35.
23. Moysiyenko I. I., Sudnik-Wójcikowska B. 2008a. Kurgani – refugium stepovogo raslinnovo pokrivu v agrolanschafti pivdnia Ukrainy. Ekol. Zhurnal Zhiva Ukraina 1–2, 16–20.
24. Moysiyenko I. I., Sudnik-Wójcikowska B. 2008b. Sozofity u flori kurganiv – refugiumiv stepovoi flori na pivdni Ukrainii. Zapovidna Sprava v Ukraini 14.1, 16–24.
25. Moysiyenko I. I., Sudnik-Wójcikowska B. 2009. Flora of kurgans in the Pontic herb(-rich) grass steppe zone in Ukraine. Chornomor. Bot. Journ. 5.3, 333–369.
26. Moysiyenko I. I. Sudnik-Wójcikowska B. 2010. Kurgans in Ukraine as a refuge of steppe flora. Bull. Eur. Dry Grassl. Group IAVS 6, 6–10
27. Patyka V. P. et al. 2003. Perspektyvy vykorystannia, zberezhennia ta vidtvorennia agrobioriznomanittia v Ukraini. Khimdzhest, Kyiv.
28. Popkov M., Polyakova L., Radchenko O. 1995. Stepnoye lesovyrashchivanie v Ukrainie: istoriya, problemy, perspektivy. Lisovyi Byulleten 1, 1–13. www.fmsc.com.ua. Cited 11.08.2011.
29. Popkov M. 2011. Ob itogakh i perspektivakh stepnogo lesorazvedeniya. Stepnoi Byulleten 32, 53–56.
30. Protopopova V. V., Shevera M.V., Mel'nyk R. P. 2006a. The history of introduction and present distribution of *Elaeagnus angustifolia* L. in the Black Sea Region of Ukraine. Chornomor. Bot. Journ. 2.2, 5–13.
31. Protopopova V. V., Shevera M. V., Mosyakin S. L. 2006b. Deliberate and unintentional introduction of invasive weeds: A case study of the alien flora of Ukraine. Euphytica 148, 17–33.
32. Rowińska A., Sudnik-Wójcikowska B., Moysiyenko I. I. 2010. Kurhany – dziedzictwo kultury w krajobrazie antropogenicznym strefy stepów i lasostepu – oczami archeologa i botanika. Wiadomości Botaniczne 54.3/4, 7–20.
33. Shamsutdinov Z.Sh., Shamsutdinov N. Z. 2002. Metody ekologicheskoi restavracii aridnykh ekosistem v raionakh pastbishchnogo zhivotnovodstva. Stepnoi Byulleten. 11, 21–26.
34. Shilov Ju. A. 1991. Itogi 20-letnich issledovanii kurganov Khersonshchiny. [In:] A. V. Gavrilov (ed.). Problemy archeologii severnogo Prichernomor`ya. Materialy Yubileinoi Konferencii posvyashchennoi 100-letiju osnovaniya Khersonskogo Muzeya Drevnostei, 1991. Kherson: Khersonskii Kraevicheskii Muzei, 21–26.
35. Skorii S.A., Kyslii O. E. 2008. Kurgan, nadmogilnyi pagorb. Entsyklopediia istorii Ukrainy. Vol. 5. Naukova Dumka, Kyiv, 518–519.
36. Smirnov A. 1974. Scytowie. Państwowy Instytut Wydawniczy, Warszawa.
37. Sudnik-Wójcikowska B., Moysiyenko I. I., Zachwatowicz M., Jabłońska E. 2011. The value and need for protection of kurgan flora in the anthropogenic landscape of steppe zone in Ukraine. Plant Biosystems 145.3, 638–653.
38. Sudnik-Wójcikowska B., Moysiyenko I. I. 2006. The flora of kurgans in the west Pontic grass steppe zone of southern Ukraine. Chornomorski Bot. Journ. 2.2, 14–44.
39. Sudnik-Wójcikowska B., Moysiyenko I. I. 2008. The floristic differentiation of microhabitats within kurgans in the desert steppe zone of southern Ukraine. Acta Soc. Bot. Pol. 77.2, 139–147.
40. Sudnik-Wójcikowska B., Moysiyenko I. I. 2010a. Flora of kurgans in the forest steppe zone in Ukraine. Chornomor. Bot. Journ. 6.2, 162–199.
41. Sudnik-Wójcikowska B., Moysiyenko I. I. 2010b. Zonal character of the flora of kurgans in central and southern Ukraine. Biodiv. Res. Conserv. 17, 47–52.

42. Sudnik-Wójcikowska B., Moysiyenko I. I., Slim P. A. 2006. Dynamics of the flora of windbreaks in the agricultural landscape of steppes in southern Ukraine. Biodiv. Res. Conserv. 1–2, 77–81.
43. Sudnik-Wójcikowska B., Moysiyenko I. I., Slim P. A., Moraczewski I. R. 2009. Impact of the invasive species *Elaeagnus angustifolia* L. on vegetation in Pontic desert steppe zone (southern Ukraine). Pol. J. Ecol. 57.2, 269–281.
44. Tkach L. I., Gladun G. B. 2003. Optymizaciia stvorennia ta vyroshchuvannnia zakhysnykh lisovykh smug u stepovii zoni Ukrainy. Naukovii visnyk 13.3, 245–253.
45. Tkachenko V. S. 2004. Fitotsenotichnyi monitoring reservatnykh suktsesiy v Ukrainskomu stepovomu pryrodnomu zapovidnyku. Fitosotsiotsentr, Kyiv.
46. Vedenkov E. P. 1997. O vosstanovlenii estestvennoi rastitelnosti na yuge stepnoi Ukrainy. Biosfernyi zapovednik Askania-Nova im. F. E. Falts-Feina, Askania-Nova.
47. Visotskii G. N. 1983. Zashchitnoe lesozavedenie. Naukova Dumka, Kiev.
48. Wasyluk A., Burkowski A. 2010. Stepy Ukrainy na krawędzi unicestwienia. Dzikie Życie 11/197 http://pracownia.org.pl/dzikie-zycie. Cited 11 Jan 2011.
49. Wojewoda D., Russel S. 2003. The impact of the shelterbelt on soil properties and microbial activity in an adjacent crop field. Pol. J. Ecol. 51.3, 291–307.
50. Zaicev M. L., Prozorov A. A. 2009. K voprosu o zonalnom statusie stepnoj rastitelnosti. Materials of the Fifth International Symposium "Steppes of Northern Eurasia", Institute of the Russian Academy of Sciences, The Ural Branch Institute of Steppe, Orenburg, 05. 2009, 303–305.
51. Zouhar K. 2005. *Elaeagnus angustifolia*. [In:] Fire Effects Information System. USDA Forest Service. Rocky Mountain Research Station, Fire Sciences Laboratory. www.fs.fed.us/database/feis/plants/tree/elaang/all.html. Cited 17 Jan 2006.