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Kurgans help to protect endangered steppe species in the Pontic grass steppe zone, Ukraine

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Summary: The steppe vegetation has been destroyed to the greater extent than any other type of zonal vegetation in Europe. Ancient mounds (barrows, kurgans, tumulus) persisted in the large-scale, intensively cultivated land and constitute the isolated micro-hot spots of steppe biodiversity. In the present paper floristic value of 26 kurgans among 120 visited in the West Pontic grass steppe zone was assessed and compared to the flora of steppe reserves ('Askania-Nova', 'Yakovlivskyi', 'Lesovyi Canyon') located within the zone. Particular attention was paid to the richness and structure of the flora (proportions of: steppe species, species of special concern, alien weeds).The relationships between the flora of kurgans and the reserves, based on the total species diversity were analyzed using indirect ordination techniques (PCA). The flora of the investigated reserves was typical of the West Pontic grass steppe zone but differed with regards to the local habitat conditions. The flora of kurgans is representative of the zone to a similar extent as the flora of reserves located on the loess substratum. Kurgans contribute to the conservation of valuable steppe species outside legally protected steppe areas. Therefore, in the places where they are abundant, they could play an important role in the future restitution of the European and Eurasian steppes.

Keywords: cultural and natural heritage, steppe flora, micro-hot spots, floristic diversity, nature conservation

The steppe areas lie within the southern middle part of Europe (Hungary; so called 'puszta') and in south-eastern Europe (Ukraine, southern Russia), central Asia (Kazakhstan, Mongolia) and within the temperate continental climate zone of the North and South America (known as 'prairie' and 'pampa'). The most typical and valuable steppe vegetation in Europe is in the area of today's Ukraine.

Although the steppe and forest steppe zones comprise 73% of the total area of Ukraine (440 000 km^2), the actual plant cover of the country consists of only 10–18% of the primeval vegetation. The steppe vegetation has been destroyed to the greater extent than any other type of zonal vegetation in Europe. It was strongly reduced especially during the last 200 years, as a consequence of so called 'taming of the steppe' and the most typical West Pontic grass steppe (Ukrainian: 'plakornyi step') was destroyed as the first one and is actually nearly vanished from the Ukrainian landscape. Nowadays, the third part of the Ukrainian Red List (Didukh 2009) consists of the most valuable steppe species, which are unable to exist in any other type of habitat.

The loss of landscape connectivity caused by habitat fragmentation and changes to land use (urbanization processes, intensive agricultural practices and afforestations) is considered one of the greatest threats to biodiversity of the steppe habitats. Nowadays, the steppe flora remains only fragmentary, attached to small and isolated natural or semi-natural vegetation patches (e.g. steppe reserves, ravines, dry slopes, river valleys, etc.) but is also associated with mounds or barrows, in South-East Europe known as kurgans, ancient man-made objects, which due to their cultural role

Figure 1. Kurgan in Ukrainian landscape in the grass steppe zone, surrounded by arable fields.

persisted among the intensively cultivated arable fields of Ukraine and constitute a characteristic element of rural landscape (Fig. 1). Most of the mounds served as landmarks.

Kurgans – conical or dome shaped burial mounds with a wooden, stone or wood-stone construction – are usually 1–10 m high and range in size from 8 to 100 m in diameter. They usually contain one or several urn graves or skeleton graves dating back thousands of years (yet, some of them have been used as cemeteries up to the present time, Fig. 2).

The earliest mounds in Eurasia were built over 5 500 years ago and the most recent ones are over 700 years old, dating back from the Eneolithic Age, the Bronze Age, the early Iron Age, Pre-Roman and Roman Times, the Migration Period and the Middle Ages. They were constructed by nomadic populations (cultures of Cimerians, Scythians, Sarmatians, Thracian, Bulgarians, Huns, Magyars, Polovtsians, Nogays and others) and can be found throughout the temperate zone of Eurasia (e.g. Great Britain, the Netherlands, Germany, Poland, Hungary, Romania, Bulgaria, Greece, Russia, Kazakhstan, Mongolia). Correspondingly, the indigenous Indians, e.g. Adena, Hopewell and Mississippi cultures raised mounds in North American prairies over thousands of years before America was discovered by Christopher Columbus.

The most numerous occurrence of European barrows was reported from Ukraine, where initially over 500 000 kurgans existed, and although only 50 000–100 000 of them have survived until today, their spatial concentration is still absolutely unique, e.g. over 5 000 of kurgans have been reported only from the Kherson Region, which comprises the area of 28 500 km^2 (Moysiyenko & Sudnik-Wójcikowska 2006a).

Figure 2. Kurgan in Ukrainian landscape still used as a cemetery.

The archaeological value of the Eurasian barrows has been widely recognized and appreciated. However, not much is known about the natural value of these structures. Although kurgans occur in Ukraine in a great number, they were not explored more thoroughly by botanists in the 20th century (compare Paczoski 1933). At the beginning of the 21st century kurgans became the object of greater interest to a number of Ukrainian and Russian scientists. Recently, several ecological organizations have also pointed to the necessity of kurgan protection (Andrienko 1999; Melnyk 2001; Boreiko et al. 2002; Bozhko 2008; Fisun 2008; Lystopad 2009).

Our complex and long-term (2004–2011) Polish-Ukrainian studies of the flora of kurgans located in different climate-vegetation zones (3 steppe zones and one forest steppe zone), covering a total area of nearly 32 000 km^2, showed that kurgans play an important role as refuge for steppe species in the intensively transformed agricultural landscape of southern Ukraine and their flora preserves the zonal character (Moysiyenko & Sudnik-Wójcikowska 2006b, 2008a, 2008b, 2010; Sudnik-Wójcikowska & Moysiyenko 2008a, 2008b, 2010; Sudnik-Wójcikowska et al. 2009, 2011). These ancient mounds have existed within the steppes for centuries, thus their plant cover was similar to the surrounding steppe vegetation. Some of the larger kurgans were never ploughed over or destroyed and have survived till today. Therefore, they resemble unique 'steppe islands' in a 'sea of agricultural fields' (see Fig. 1).

The aim of the present study was to determine the degree to which the flora of kurgans located in the West Pontic grass steppe reflects the natural flora of this zone. The composition of the flora of kurgans was, therefore, compared to the flora of three steppe reserves which constitute enclaves of natural vegetation characteristics of the West Pontic grass steppe zone.

Materials and methods

We compared the kurgans and the three reserves in terms of species richness and floristic value. In order to recognize the specificity of the kurgans and their role in preserving the natural plant cover in the West Pontic grass steppe, we visited over 120 kurgans located in this zone and chose 26 best preserved for further studies. The floristic investigations have been conducted for four years during the three growing seasons. The following criteria were used to select the kurgans subjected to analysis:

• the height: those less than 3 m in height were omitted;

• the state of preservation: kurgans destroyed or severely altered by human activity (e.g. due to extraction of soil, presence of trenches or water tanks on the top, intensive use as cemeteries, other strong disturbances) were not considered;

• the state of persistence of the plant cover: it was assumed that the presence of typical steppe species (tuft grasses such as *Festuca valesiaca* Gaudin, *Koeleria cristata* (L.) Pers. or *Stipa capillata* L. as well as *Bothriochloa ischaemum* (L.) Keng and *Cleistogenes bulgarica* (Bornm.) Keng) is an indicator of a relatively good condition of the plant cover.

We compared the species composition and the structure of the flora of the 26 kurgans to the flora of the 3 steppe reserves ('Askania-Nova', 'Yakovlivskyi' and 'Lesovyi Canyon') located in the same zone.

We defined the flora according to shares of some groups of species in floristic lists of reserves and kurgans. We concentrated on indices, such as the proportions of particular groups of species: steppe species (i.e. species attaining optimum growth in the plant communities of the syntaxonomic class or order: *Festuco-Brometea*, *Festucetea vaginatae*, *Galietalia veri* and *Polygono-Artemisietea*), sozophytes (i.e. species of high floristic value, which are protected by law and included in international, European, Ukrainian and local red lists; see Sudnik-Wójcikowska et al. 2011) and aliens in the flora of the kurgans and the reserves. The proportions of steppe species and sozophytes were treated as determinants of the floristic value of our research objects. Species nomenclature was given according to Mosyakin & Fedoronchuk (1999).

In order to evaluate the relationships between the flora of the kurgans and the 3 steppe reserves, we performed the indirect ordination analyses (Canoco for Windows Version 4.0, Ter Braak & Šmilauer 1998) of floristic lists. Firstly, the DCA (Detrended Correspondence Analysis, Legendre & Legendre 1998) was used to choose between unimodal or linear ordination methods on the basis of lengths of gradients. As the lengths of gradients in DCA did not exceed 3 SD, we applied a method appropriate for linear data analysis (PCA – Principal Components Analysis).

Study area

The 26 kurgans and 3 reserves investigated in this study are located in the West Pontic grass steppe zone (Fig. 3). The zone is characterized by the mean annual temperature of 9–11°C, total precipitation in a range of 350–400 mm and the soils of chernozem type. The West Pontic grass steppe zone adjoins the desert steppe to the south and the herb-grass and forest steppe to the north. The main differences between these zones are featured by climatic characteristics (with

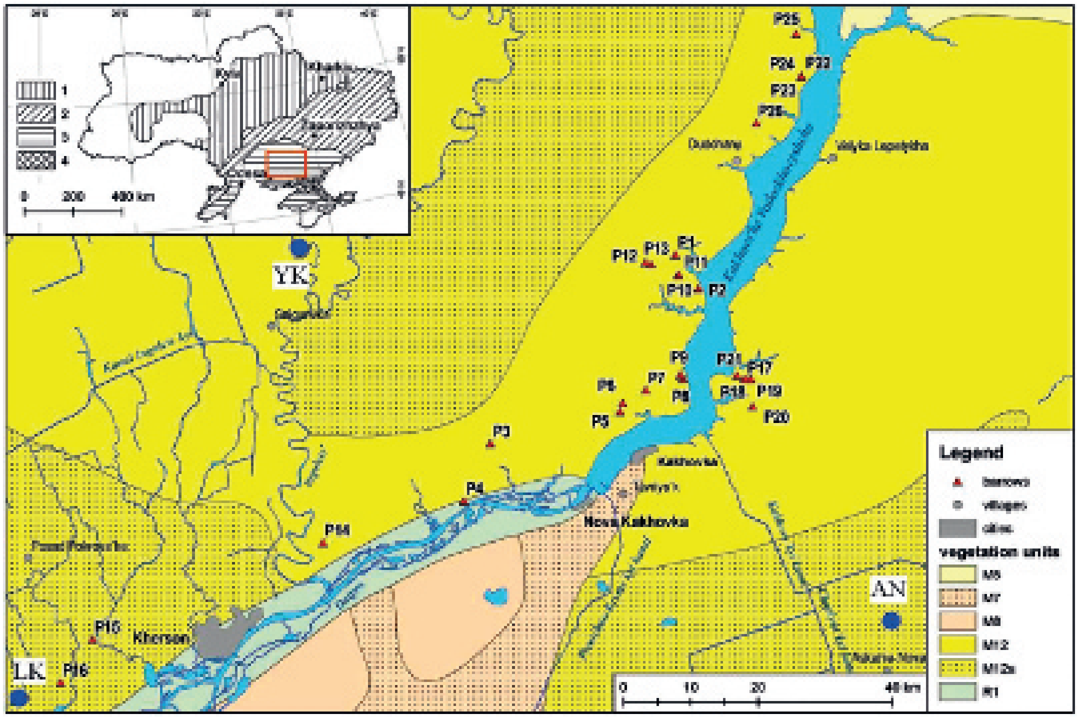

Figure 3. Location of the 26 investigated kurgans and 3 reserves in the West Pontic grass steppe zone: AN – 'Askania-Nova', LK – 'Lesovyi Canyon', YK – 'Yakovlivskyi'. Legend (according to Bohn et al. 2000): M5 – western and central Pontic herb-grass steppes; M7 – Pontic hemi-psammophytic herb grass steppes; M8 – Pontic psammophytic herb grass steppes; M12 – West Pontic grass steppes; M12a – West Pontic grass steppes in combination with halophyte vegetation (solonchak); R1 – freshwater tall reed swamps.

the mean annual temperature decreasing and the precipitation growing from the south to the north) and local pedological conditions.

Due to the variety of soil conditions and bedrock types within the zone, some considerable differences between the three reserves should be noted:

1) 'Askania-Nova' Biosphere Reserve (AN: 46°27'33.34"N, 33°52'05.62"E; area: 11 059 ha; Chaplinski District, Kherson Region) protects a part of the herb-grass steppe. The vegetation grows on mature soils with fully developed horizons. The reserve contains significant areas of the steppe as well as shallow depressions with no outflow called 'pods'. The latter features distinguish the 'Askania-Nova' reserve (Veden'kov 1989) from the other two reserves studied. The biggest 'Chapelskij Pod' covers an area of approximately 27 km^2. The presence of smaller pods is also noted. At the bottoms of pods meadow, swamp and water plant species can be found.

2) Floristic reserve 'Yakovlivskyi' (YK: 47°10'38.08"N, 32°55'51.75"E; area: 35 ha; Snigurivka District, Mykolaiv Region). The flora of this reserve (Moysiyenko 2005) is characterized by a high number of typical steppe species as well as relatively high proportion of petrophilous plants (xerophilous and thermophilous vegetation on outcrops). The steppe plant communities can be found on eroded slopes of gullies (called here 'balkas'), where the soil has been washed away and limestones or clays exposed at the surface. The east-west orientation of the Yakovlivska Balka and the presence of very steep slopes (particularly the northern ones) contribute to the development of trees and shrubs as well as meadow and scrub species.

Table 1. Number and percentage of particular groups of species in the flora of kurgans and 3 reserves (percentage values given in relation to the total flora of each of the reserves investigated or to the total flora of 26 kurgans).

Group of species	Total 26 kurgans (KG)		'Lesovyi Canyon' (LK)		'Yakovlivskyi' (YK)		'Askania Nova' (AN)	
	No.	%	No.	%	No.	%	No.	%
Total flora of the kurgans/reserves	352	100	222	100	383	100	495	100
Steppe species	197	56	132	60	223	58	226	46
Sozophytes	18	5	13	6	29	8	31	6
Non-synanthropic	137	39	87	39	185	48	239	48
Aliens (anthropophytes)	104	30	54	24	78	20	106	22
Aliens established before A. D. 1 500 (archaeophytes)	54	15	30	13	41	11	59	12
Newcomers, aliens established after A. D. 1 500 (kenophytes)	43	12	24	11	35	9	47	10

3) The planned 'Loess Canyon' Scenic Reserve ('Lesovyi Canyon', LK: 46°34'44.93"N, 32°10'53.77'E; area of approximately 10 ha; Belozerka District, Kherson Region) consists of deep gullies developed on loess and clay originated soils with the bedrock exposed due to erosion. The reserve with a north-south orientation is located at the southernmost edge of the grass steppe zone. In spite of the presence of steep gully walls, the mesophilic vegetation and dendroflora are poorly represented in this reserve (Moysiyenko 2007).

The total area of the kurgans was estimated at 20 ha (their coordinates were given in an earlier paper, see Moysiyenko & Sudnik-Wójcikowska 2006a).

Results

The total number of species in the flora of the 26 kurgans (352 species: Table 1) is considerably high in relation to their total area (about 20 ha) and comparable to the 'Lesovyi Canyon' (10 ha: 222 species) and 'Yakovlivskyi' (35 ha: 383 species) reserves. The kurgans also support a significant diversity of species compared with the 'Askania-Nova' reserve (11 059 ha: 495 species). Of the 721 species recorded at all areas sampled, 127 species (17.6%) were common to both kurgans and the reserves. The kurgan flora is, in many respects, similar to that of the reserves and representative of the grass steppe zone (Table 1).

The indices defined as 'the proportion of non-synanthropic species', 'the proportion of steppe species in the flora' and 'the proportion of sozophytes in the flora' reflect the role of kurgans as refugia of the steppe flora. The percentage of steppe species in the flora of the kurgans, the 'Yakovlivskyi' and the 'Lesovyi Canyon' reserves varied from 56% to 60% (Table 1). The proportion was slightly lower in the case of the 'Askania-Nova' reserve (about 46%). The percentage of sozophytes ranged from 5% to 8% – the kurgans had the lowest proportion of this group, whereas the 'Lesovyi Canyon' reserve presented the highest one.

With regard to the proportion of native and alien weeds (Table 1), the flora of the kurgans was most similar to that of the 'Lesovyi Canyon' reserve. The kurgans supported a slightly higher

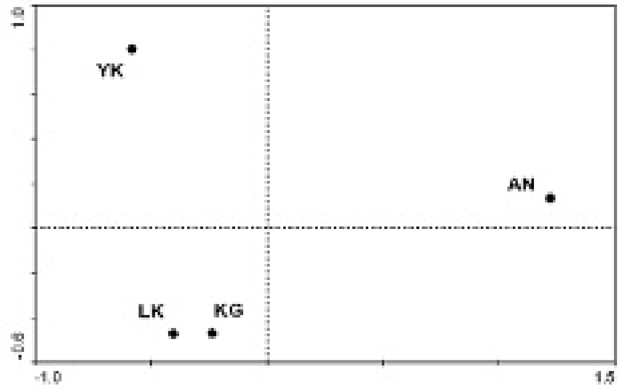

Figure 4. PCA analysis of species lists from the investigated sites (KG – 26 kurgans, AN – 'Askania-Nova', LK – 'Lesovyi Canyon', YK – 'Yakovlivskyi'). Eigenvalues: I – 0.511, II – 0.278, III – 0.211, IV – 0.000.

proportion of alien species, which had spread from the nearby fields. The number of alien species common to kurgans and the reserves was relatively low (24 species) and the species introduced before A. D. 1500 (so called 'archaeophytes') prevailed in this group, while remaining species were relatively recent newcomers.

With regard to the total flora, the first two PCA axes explained nearly 79% of the variability in species data (Fig. 4). The first axis clearly separates the flora of 'Askania-Nova' reserve from that of the kurgans and the other 2 reserves. The second axis distinguishes the 'Yakovlivskyi' reserve from the 'Lesovyi Canyon' reserve and the kurgans. The greatest similarity in species composition occurred between the 'Lesovyi Canyon' reserve and the kurgans.

Discussion

We assessed the floristic value of kurgans by comparison of the kurgan flora to the flora of steppe reserves in the same climate-vegetation zone. The flora of the investigated reserves is typical of the West Pontic grass steppe zone but differs with regards to the local habitat conditions. The flora of kurgans is representative of the zone to a similar extent as the flora of reserves located on the loess substratum.

The representation (qualitative composition) of steppe species and sozophytes in the flora of the kurgans is comparable to that of the 'Lesovyi Canyon' and 'Yakovlivskyi' reserves. However, it should be noted that the high proportion of steppe species in the flora of 'Yakovlivskyi' reserve is associated with the presence of species typical of the petrophilous habitats (limestone outcrops), which are absent on kurgans. In the case of the 'Lesovyi Canyon' reserve the high percentage of steppe species can be ascribed to the presence of loess and chernozem soils, characteristic of the grass steppe zone (the soils on the kurgans are of chernozem type formed on loess, as well). The lower share of the steppe species in the species pool of the 'Askania-Nova' reserve is associated with the presence of 'pods' (aforementioned unique habitats supporting a number of aquatic, waterside and meadow species) which modify the floristic composition of the area.

The increased share of native and alien weeds (synanthropes) in the flora of the kurgans in comparison to the reserves can be explained by intense edge effects. The kurgans are located within intensively used agricultural areas and constitute 26 separate 'islands' surrounded by arable fields (the problem of isolation of kurgan flora is the subject of current investigations). The flora of the kurgans is enriched by mesophilous and weed species originating from nearby fields. The flora synanthropization process is strongly associated with the length of the contact zone. The boundary separating the kurgans from the fields is relatively longer in the case of the small-size kurgans than in the case of the large and compact areas of the reserves.

With respect to the proportion of native and alien weeds, the total flora of the investigated kurgans is most similar to that of the 'Lesovyi Canyon' reserve. As a result of intensive erosion processes, in some places the natural vegetation cover of 'Lesovyi Canyon' has been almost completely destroyed. The places devoid of vegetation became colonized by more resistant weed species. The kurgan flora synanthropization proceeded in a different manner, but the final share of synanthropes remains comparable in both habitats.

In PCA analysis we observed two gradients of floristic variability (Fig. 4). Along the first gradient, correlated with the 1st ordination axis, 'Askania-Nova' reserve differed significantly from other sites. It could be a result of the specificity of the 'Askania-Nova' reserve consisting of moist habitats associated with pods. Such type of habitats does not occur within kurgans. Therefore, it could be assumed that the 1st ordination axis represents a soil moisture gradient. The variability along the 2nd ordination axis could be explained by presence of limestone outcrops covered by thermophilous vegetation. So the 2nd ordination axis may represent soil temperature and alkalinity gradient. These estimations indicate that the variability of the local habitat conditions explain the dissimilarity of the floras analyzed. Further analysis is needed to explore the gradients – our ongoing research examines the steppe species pool and the synanthropic species pool separately, making use of the plant ecological niches indicative values.

It is difficult to make a comparison of our findings to the results of other authors, because only few studies on kurgan flora conducted in other regions of Eurasia exist. The persistence of steppe species in the kurgan flora was reported from Hungary (Barczi & Joó 2002; Barczi 2003; Barczi et al. 2004; Joó et al. 2007), Russia (Dzybov 2006) and Poland (Małopolska Upland; Cwener 2004, 2005).

The flora of Polish kurgans was estimated at 228 species (with 44 to 81 species per kurgan of 13 kurgans sampled). Native species dominated and anthropophytes comprised 23% of the total flora. Among the most valuable species were: *Adonis vernalis* L., *Anemone sylvestris* L., *Stipa capillata* L., *Ranunculus illyricus* L., *Verbascum phoeniceum* L. and *Rosa gallica* L.

The presence of rare and endangered species e.g. *Stipa caspia* K. Koch, *S. pennata* L., *S. pulcherrima* K. Koch, *S. ucrainica* P. Smirn., *Tulipa gesneriana* L. (syn. *T. schrenkii* Regel), *T. biebersteiniana* Schult. & Schult. f. s.l., was also reported by Dzybov (2006) for kurgans located in Stavropolskii Krai in Russia.

Some of over 40 000 kurgans persisting in Hungary were investigated by botanists. On the best documented Csípő-halom kurgan (Great Hungarian Plain, Hortobágy) 72 species were recorded within the barrow and its close vicinity. The larger part of the barrow was characterized by a common presence of *Poa angustifolia* L., but the plant cover consisted also of the species reported from Hortobágy Region, i.e. *Festuca valesiaca* Gaudin, *F. rupicola* Heuff., *F. javorkae* (Majovsky) emend. Margr., *Agropyron pectinatum* (M. Bieb.) P. Beauv. and *Erodium cyconium* (L.) L'Her.

Within the large area of Kherson Region, where the kurgans investigated by us were dispersed, the diversity of native species, which have survived locally in the immediate vicinity of kurgans

Figure 5. The slopes of kurgan as refuge for steppe species (e.g. *Stipa ucrainica*, Red Data Book of Ukraine) the West Pontic grass steppe zone.

(e.g. in 'balkas', canyons, river valleys, dry slopes), tends to be high. This may contribute to a greater overall diversity of species on the kurgans. The survival of steppe plant species was possible also due to a variety of microhabitats on the kurgans (Sudnik-Wójcikowska & Moysiyenko 2008a). It should be noted that the largest number of steppe species characteristic of the climate-vegetation zone and about 90% of the sozophytes recorded on the kurgans attain optimum development on their slopes, where anthropogenic influences are limited (Fig. 5). These species are associated mainly with the classes *Festuco-Brometea* and *Festucetea vaginatae*.

Similarly, in case of Polish kurgans the slopes supported some of the most valuable steppe species (Cwener 2004, 2005). Hungarian scientists observed that kurgan slopes were covered with the weedless loess grasses. Also Dzybov (2006), who investigated kurgans in Russia, noticed specific microhabitats within the kurgans. In spite of many methodological differences between the studies, the general conclusions on the specific role of kurgan slopes in preserving the original steppe vegetation remain convergent.

Implications

Kurgans, persisting in the intensively cultivated land of Ukraine, constitute the unique enclaves of natural, properly developed steppe flora, typical for an exact climate-vegetation zone. Together with other fragmentary remaining natural or semi-natural steppe vegetation patches, they could play a significant role in restoration of European steppes (Sudnik-Wójcikowska & Moysiyenko 2011). These 'micro hot spots' of floristic diversity provide an exceptional gene bank developed in situ and could act as donors of diaspores for the areas set free from intensive agricultural practices.

The importance of kurgans increases where their number is particularly high and where they are connected to each other via other marginal sites. Therefore, the most critical necessity is to assure the integrated land management in order to increase the connectivity in cultural landscape.

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