Chapter

REGULARITIES AND FEATURES OF DIFFERENTIATION AND ANTHROPOGENIC TRANSFORMATION OF STEPPE VEGETATION

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ABSTRACT

The questions of phytobiota evolution and formation of steppes in the vast region of the south of East European plain are reviewed. The main stages, aspects and ways of flora formation under increased anthropogenic impacts on steppe ecosystems are identified. Isolation and differentiation of different flora types at the present stage of development are shown. Their structure is determined by individuality of natural and anthropogenic interaction. The classification scheme of vegetation on the ecological-phytocenotic basis is developed and the vegetation types, formation classes, formations and associations are pointed out, using the results of long-term steppe phytocenoses research. The phytocenotic diversity of steppe vegetation in the systems of dominant and floristic classifications is characterized. The floristic richness, phytocoenotic diversity, uniqueness, stenotopic features, endemism, relictness, area-marginality of syntaxons are defined in the article. Rare for the region plant communities were identified. Regularities and peculiarities of the geographic and edaphic distribution of different level syntaxons of the south of East European plain steppe vegetation were established. It is shown that flora gene pool that has been preserved over centuries in the barrows and derelict lands can be used for eco-efficiency assessment of programs for the zonal steppe vegetation reconstruction.

INTRODUCTION

The steppes on Earth cover more than 6% of the land area and are one of the main biomes, accumulating energy resources in humus-rich chernozem soils, which ruthless exploitation leads to a widespread degradation. Steppe are characterized by high biotic diversity and domination of xerophilous herbaceous vegetation, with sod grasses in base. High floristic richness, complex spatial structure, polydominancy, pluristratal organisation, seasonal aspects change, summer dormancy are characteristic for steppe phytocoenoses.

Currently, the development of flora and vegetation of the steppe zone in modern conditions is influenced by the growing anthropogenic impact leading to a change in the natural distribution of elements in soils and water imbalance. In this regard, steppe ecosystems go through significant changes under the influence of edaphic, geochemical and andrological neofactors. The appearance of such artificial anthropogenic ecotopes, having no natural alternative, leads to the formation of specific plant communities and floras, adapted to the extreme environmental conditions.

The steppe is the least protected biome according to all indicators: the least coverage of protected areas, the least biome fraction in national protected natural areas, the least average area of protected areas, etc. For main subdivisions of the steppe biome the proportion of the area under protection is evaluated nationally – 3–10% and for the total biome and all levels of conservation is not exceeding 5% (Smelansky, Tishkov, 2012). If we evaluate the reduction in the area that take natural ecosystems, the steppes are the most affected by human activity biome in the temperate zone (Henwood, 1998; Groom et al., 2006).

The region of Azov-Donetsk under study covers a large part of the Donetsk upland, southern spurs of the Central Russian upland, the Eastern part of the Azov upland and the Black sea lowlands.

EVOLUTION AND FORMATION OF STEPPE PHYTOBIOTA IN THE SOUTH OF EAST EUROPEAN PLAIN

Differentiation of anthropogenically transformed flora types of the steppe zone occurs in time and in space. Their evolution proceed alongside with the development of the natural flora within the natural ecotopes. According to A.N. Krishtofovich (1945) the formation of typical steppe in the geological past originated either autochthonously, or with the participation of foreign elements and was connected primarily with the aridity of climatic conditions.

Flora of Ancient Midlands influenced significantly the steppe flora formation and especially the appearance of petrophyton later (Lavrenko, 1970). It is noted that currently petrophyton is heterogeneous and heterochronic formation (Burda, 1991). It has formed, likely due to ancient plant species of the Miocene-Pleistocene period, among which an important role was played by the autochthonous species of Ancient Midlands, though it may be partially due to anthropogenic origin of petrophyton. Unique floral set of psammophyton is recognized by many authors as quite ancient and highly endemic complex, formed in specific conditions of isolated sandy terraces due to climatic changes. The formation of halophilous complex is associated with the littorals of the marine basins in arid areas, from which plants spread across saline habitats inland.

Total synantropization of plant cover in the steppe zone has led to the formation of holocene neocomplexes of ruderal and weed-grown floras. Human impact on the vegetation of the Azov-Donetsk region was growing as a result of human activity since the Palaeolithic age. Local impact: gathering, farming, cattle breeding, the first mining with the appearance of cities has been replaced by more intensive forms: plowing, mowing, grazing, deforestation, that contributed to the formation of pro-synanthropic floristic complex.

In the XIX century the industrial development has led not only to the destruction of large areas of vegetation, but also to development of entirely new groups of plants from anthropogenic ecotopes in steppe communities (Tokhtar, Petin, 2012). The formed complexes of pro-synanthropic flora were the first anthropogenic groups that formed and separated under the influence of anthropogenic factor. The increase of intensity and diversity of anthropogenic impact led to the formation of various stable types of anthropogenic flora transformation. R.I. Burda (1991) identified the following anthropotolerant flora types for the steppe zone of the study region: flora of nature reserve fund territories, depleted flora of the natural ecotopes, self-regenerative flora, cultivated flora of semi-natural ecotopes, urbanoflora, flora of agrophytocenoses and flora of technogenic ecotopes, having no natural equivalents.

Thus, the formation of the modern flora in the steppe zone occurred gradually and, obviously, has common traits with the same floras in the other regions, that indicates their unification. Under these conditions, initially, as the result of vegetation evolution, specific ammophilous, petrophilous, in particular, calcipetrophilous complexes were formed. There coexist steppe, forest-steppe, ammophilous, petrophilous, halophilous and hydrophilous floristic complexes, which became the “material” base for the anthropogenic evolution of vegetation cover in steppe zone.

At the ancient stage of flora development the main anthropogenic factors were fire, tree cutting, selective gathering and grazing, that lead to formation of pyrogenic steppes, steppes disturbed by pasture and deforestation. This resulted in irreversible transformation of ecotopes: sorting of soils, salinization-desalinization, development of erosional and alluvial processes. The next stage of anthropogenic evolution of vegetation cover in steppe and forest-steppe zones has become a large-scale economic development of the region, which resulted in the formation of agricultural landscape – a combination of arable land, pastures and hayfields. Under these conditions, there was the intensification of the formation of segetal floristic synanthropic complexes and steppe complexes disturbed by pasture, various anthropogenic modifications of ecosystems appeared (seeded forage lands, shelterbelts, gardens, unsurfaced roads, artificial reservoirs, canals, irrigation ditches).

In this context we can observe global synantropization, the increase in number of adventive species (Burda, Tokhtar, 1992; Wittig, Lenker, Tokhtar, 1999; Wittig, Tokhtar, 2003), and vegetation halophitization in some cases. Anthropogenic flora changes occur due to the expansion of artificial areas of ecotopes and spread of indigenous and adventive species of apophytes (Tokhtar et al, 2011; Tokhtar, Groshenko, 2014).

The Phytocenotic Diversity of Steppe Vegetation in the Systems of Dominant and Floristic Classifications

One of the important directions in formation of the basic elements of phytobiota monitoring is to develop a classification of vegetation of the observed area. The two main principles of vegetation classification became widespread among the phytocenologists: ecologo-phytocenotic (the dominant) and ecologo-floristic. Both approaches can be used for monitoring studies because each of them reveals the essence of plant communities from different sides. However, as stressed by J.R. Sheljag-Sosonko (Sheljag-Sosonko, 2007), this dominant classification, which displays the coenotic role of species, is a true vegetation classification. It should therefore be the basis for vegetation monitoring (Ostapko, Prikhodko, 2010). Previously this approach was made in the classification of feather-grass steppes of the region (Kondratjuk, Chuprina, 1992).

In the classification scheme developed on the ecologo-phytocenotic base the vegetation types, classes of formations, formations and associations are singled out. Formations are determined by the main dominants, and associations are defined on the ratios of the dominant and the subdominant. For multilayered vegetation associations were established through correlation of dominant species of each layer. Phytocenotic diversity was investigated at the level of the smallest units of vegetation differentiation, which typically have the greatest degree of homogeneity and stability of composition and structure of plant communities, which coincide with the category of association in syntaxonomy of the dominant classification (Aleksandrova, 1969; Ipatov, 1999; Methodology..., 1991; Yurtsev, 1991). Phytocenotic studies were performed by the routing method with the preparation of geobotanical descriptions by the standard technique (Program..., 1974). The names of plants are given according to modern nomenclature (Ostapko et al., 2010).

After the publication of prodromus of the natural vegetation of the South-East of Ukraine on the dominant basis in 1995 (Ostapko, 1995) many new associations and formations were revealed, which is partly reflected in the publications (Glukhov et al., 2010; Ostapko et al., 2007, 2008, 2011, 2012; Ostapko, 2005, 2011; Ostapko, Polyakov, 2003; Ostapko, Kupryushyna, 2010; Ostapko et al., 2011; Kupryushyna et al., 2011; Regional, 2011; Chuprina, 1999). Further study of phytocoenotic diversity has led to the construction of vegetation classification on the dominant basis (Prikhodko et al., 2012), the structure of which is presented in the Table 1.

Table 1. Structure of the natural vegetation of the Azov-Donetsk region on the dominant basis

Vegetation type (number of associations)	Class of formations	The number		A/F
		formations (F)	associations (A)	
Steppe – Steppa (1163)	Typical steppe – Steppa genuina	64	763	11,9
	Shrub steppe – Steppa fruticosa	14	135	9,6
	Stony steppe – Steppa petrophyta	25	123	4,9
	Calciphyte steppes – Steppa calcephyta	8	23	2,9
	Meadow steppe – Steppa pratensis	33	118	3,6
	Desert steppe – Steppa deserta	6	13	2,2

Vegetation type (number of associations)	Class of formations	The number		A/F
		formations (F)	associations (A)	
	Clay steppe – Steppa argillosa	4	10	2,5
	Channery-psammophyte steppe – Steppa detritica	5	11	2,2
Petrophyte – Petro-phyta (144)	Cretophyte – Cretophyta	21	65	3,1
	Calciphyte – Calcephyta	32	130	4,1
	Granitophyte – Granitophyta	19	56	2,9
Tomillare (137)	Tomillares – Tomillares	13	138	10,6
Psammo-phytic – Psammo-phyta (162)	Riverine sands – Psammophyta subriparia	17	58	3,4
	Seaside sands – Psammophyta submarina	12	22	1,8
	Terrace sands– Psammophyta supraterrasae	22	82	3,7
Forest – Silvae (379)	Coniferous forest– Silvae acicularea	1	8	8
	Broad-leaved coniferous forests – Silvae aciculari-latifoliosae	1	2	2
	Small-leaved coniferous forests – Silvae aciculari-parvifoliosae	3	16	5,3
	Broad-leaved summer-green forest – Silvae folioaestilignosa	12	353	29,4
Meadow – Prata (354)	Genuine Meadows – Prata genuina	43	229	5,3
	Steppe meadows – Prata substepposa	16	86	5,4
	Swampy meadows – Prata paludosa	19	49	2,6
Saline – Galophyta (212)	Saline meadows – Prata galophyta	42	172	4,1
	Genuine salt marshes – Eugalophyta	13	40	3,1
Aquatic – Hydrophyta (99)	Natural aquatic – Vegetalia aquatica	22	39	1,8
	Coastal aquatic – Vegetalia subaquatica	28	61	2,2
Swamp – Paludes (54)	Eutrophic swamps – Paludeseutrophicae	27	51	1,9

Table 1. (Continued)

Vegetation type (number of associations)	Class of formations	The number		A/F
		formations (F)	associations (A)	
	Mesotrophic swamps – Paludes mezotrophicae	2	3	1,5
Shrub – Frutectosa (47)	Mesophytic shrubs – Frutectosa mesophyta	4	7	1,8
	Xerophytic shrubs – Frutectosa xerophyta	12	42	3,5

Natural vegetation of the region is represented by 10 types, which allocated 30 classes of formations. In total 2905 association of 540 vegetation formations were found in the region on the principle of dominance. This diversity of associations reflects multiple successional series, which are formed due to anthropogenic transformations of vegetation.

The diversity of extrazonal vegetation of broad-leaved forests, especially ravine oak forests, with proportion of the associations to the formation is 29.4, is widely represented. It's connected with a complex storeyed forest ecosystem, which reflects the peculiarities of geomorphic structure of ravine-frame systems.

The intrazonal vegetation of saline soils and hydrophytic ecosystems, that occupy small area in the region, are represented less diverse.

Intrazonal meadow vegetation is typical for the river valleys and ravine-frame systems flowing into them, as well as for the coastal line of the Azov sea, and it is represented by 78 formations and 354 associations, many of which are certain stages in the succession series, often caused by the anthropogenic influence.

But the most diverse at the level of associations is zonal steppe vegetation, that is proved by the high ratio of associations to formations, that is 11.9. The richest in associations formations of the typical steppe: *Festuceta valesiacae* (114 associations), *Elytrigieta repentis* (54), Stipeta *capillatae* (51), *Stipeta lessingianae* (37), *Poeta angustifoliae* (35)*, Bromopsieta ripariae* (34), *Stipeta grafianae* (33), *Stipeta ucrainicae* (27), *Stipeta tirsae* (26)*, Elytrigieta trichophorae* (22)*, Bromopsieta inermis* (18), *Stipeta dazyphyllae* (18).

Considerable diversity is characteristic not only for the typical steppe, but also for its climatic and edaphic variants. In particular, many associations of meadow steppe are formed in the highest part of the Donetsk ridge and along the slopes of northern exposition (*Elytrigieta repentis* – 10, *Poeta angustifoliae* – 10, *Galatelleta dracunculis* – 10, *Filipenduleta vulgaris* – 9, *Stipeta tirsae* – 8).

The high diversity of shrub steppes is also significant (*Caraganeta ˙fruticis* – 41, *Amygdaleta nanae* – 32 associations*, Caraganeta scythicae* – 9 (Figure 1a), *Spiraeeta hypericifoliae* – 8*, Calophaceta wolgaricae* – 7) and *petrophyte steppes (Stipeta capillatae* – 13, *Crinitarieta villosae* – 13*, Jurineeta brachycephalae* – 11*, Stipeta lessingianae* – 9*, Lineta czerniaëvii* – 9*, Salvieta nutantis* – 9 (Figure 1b), *Stipeta graniticolae* – 6, they formed due to natural vegetation succession of rock outcrops towards the climax stage.

The vegetation of the rock outcrops is varied, with many of the plant communities of stenotopic character formed here, endemic (*Stipeta graniticolae* (Figure 1c), *Euphorbieta cretophilae, Onosmateta tanaiticae, Artemisieta nutantis, Helianthemeta cretophilae,* *Thymeta pseudogranitici,* etc.) and relic *(Calophaceta wolgaricae, Artemisieta hololeucae, Thymeta kondratjukii, Hedysareta cretacei, Erodieta beketowii,* etc.).

Petrophyton can be easily divided into cretophyte, calciphyte and granitophyte group according to the floristic composition and structure of the formations. These florocomplexes formed during florogenesis as edaphic variants of steppophyton for a long period of time with simultaneous allopatric and parapatric speciation in some genera (*Thymus, Scrophularia, Asperula, Jurinea, Linum, Elytrigia*, etc.).

Cretophyta are represented by many endemic stenotopic associations, such as *Anthericetum (ramosi) helianthemosum (cretophili), Bromopsietum (ripariae) schivereckiosum (mutabilis), Caricetum (humilis) elytrigiosum (stipıfoliae), Centaureetum (ruthenicae) purum, Crinitarietum (villosae) koeleriosum (talievii), Diplotaxietum (cretaceae) pimpinellosum (titanophilae), Hedysaretum (cretaceı) artemisiosum (hololeucae), Hedysaretum (cretaceı) festucosum (cretaceae), Matthioletum (fragrantis) purum, Pimpinelletum (titanophilae) artemisiosum (hololeucae), Pimpinelletum (titanophilae) euphorbiosum (cretophilae), Scrophularietum (cretaceae) artemisiosum (hololeucae), Scrophularietum (cretaceae) thymosum (cretaceı), Stipetum (joannis) anthericosum (ramosı), Stipetum (joannis) elytrigiosum (cretaceae), Thymetum (cretaceı) helianthemosum (cretophilı)* (Figure 1d) etc., widespread in Seversky Donets basin, mostly in its left-bank tributaries.

Calciphyte complex Calcephyta is richer, it's connected with the outcrops of limestones, sandstones and shales of different genetic types mainly on the Donetsk upland and a little in the Azov area. The specific communities are: formation of *Thymeta calcarei* (18 associations), associations of *Artemisietum (marshallianı) pimpinellosum (titanophilae), Botriochloetum (ischaemı) anthemidosum (subtinctoriae), Caricetum (supinae) linosum (czerniaëvii), Cephalarietum (uralensis) thymosum (calcareı), Crinitarietum (villosae) ephedrosum (distachiae), Festucetum (valesiacae) achilleosum (leptophyllae), Pimpinelletum (titanophilae) silenosum (supinae), Pimpinelletum (titanophilae) thymosum (calcareı), Rosetum (chrshanovskiı) melicosum (transsylvanicae), Rosetum (subpygmaeae) hylotelephiosum (decumbentis), Silenetum (supinae) atraphaxiosum (frutescentis), Stipetum (capillatae) thymosum (calcareı), Thymetum (dimorphı) centaureosum (carbonatae),* etc.

Granitophyta focuses on the Azov upland and is represented by a complex of endemic communities with the participation of a number of relict species. The most varied formations in its composition are *Thymeta granitici* (15 associations), *Erodieta beketowii* (8), *Thymeta pseudogranitici* (6), *Thymeta dimorphi* (6). The unique associations are *Achilleetum (glaberrimı) purum, Achilleetum (leptophyllae) asperulosum (graniticolae), Aurinietum (saxatilis) festucosum (valesiacae), Festucetum (valesiacae) jurineosum (graniticae), Scrophularietum (donetzicae) melicosum (transsylvanicae), Stipetum (graniticolae) thymosum (granitici*).

It should be emphasised that tomillares, common on the outcrops of chalk and limestone, are characterized by a small number of formations, presented by a very wide variety of associations (associations to formations ratio is 10.6) and is caused by both natural successions and pastoral pressure on these communities. In particular, these are *Thymeta cretacei* (32 associations), *Artemisieta tanaiticae* (18), *Hyssopeta cretacei* (13), *Jurineeta brachycephalae* (12), *Onosmateta tanaitici* (11), *Artemisieta hololeucae* (10), *Genisteta scythicae* (8), *Helianthemeta cretophili* (6).

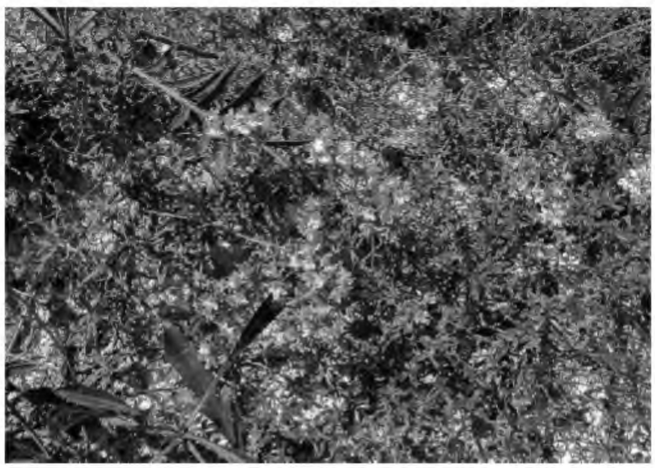
Vegetation of the open sands is quite varied, but is poorer compared with other types. At the same time it is characterized by high specificity and endemic species are among the dominants. On the terraces of river valleys the sandy grasslands and pioneer vegetation of open sands are developed. The richest characteristic formations are: *Festuceta beckeri* (14), *Agropyreta lavrenkoani* (6), *Artemisieta tscherniaevianae* (6), *Cariceta colchicae* (6), *Koelerieta sabuletori* (5). In the coastal zone of the Azov sea the characteristic community formations of *Agropyreta lavrenkoani, Cakileta maritimae, Cariceta colchicae, Crambeeta ponticae, Cynancheta acuti, Ephedreta distachyae, Eringieta maritimi, Euphorbieta seguieranae, Festuceta beckeri, Glycyrrhizeta glabrae, Leymeta sabulosi* (Figure 1e) are widespread on the sandy, shell substrate. Psammophyte steppes at the outputs of paleogenic sands, occasionally seen in the region are of special attention. They are quite diverse, represented by such formations as *Festuceta beckeri* (18), *Stipeta borysthenicae* (13), *Koelerieta sabuletori* (9), *Cariceta colchicae* (5), etc.

a

b

Figure 1. (Continued)

c



d

e

Figure 1. (Continued)

f

Figure 1. Typical (b, d, e) and rare (a, c, f) plant communities occured in steppe zone of the South in the Middle Russian Upland: a) *Caraganeta scythicae,* b) *Salvieta nutantis,* c) *Stipeta graniticolae,* d) *Thymetum (cretacei) helianthemosum (cretophili),* e) *Leymeta sabulosi,* f) *Centaureeta ruthenicae.*

SYNTAXONS OF XEROTHERMIC STEPPE PETROPHYTE AND PSAMMOPHYTE VEGETATION OF THE REGION, SELECTED BY THE METHOD OF BRAUN-BLANQUET

At the present stage of phytobiota development the anthropogenic influence in the region is extending, the structure of ecosystems is changing, invasive species are brought (Burda, Tokhtar, 1992). But in general, the vegetation is characterized by a large diversity of plant communities, including endemic, as their dominants are local or regional endemics and subendemics, relict species, regionally rare species due to stenotropic conditions of extention of phytocenoses edificators, their border-areal location, as well as restrictions on their localization under the influence of anthropogenic factor. Rare fraction of phytocoenofund in the region accounts for about 15% of associations and 23% of formations of the dominant vegetation classification (Prikhodko et al, 2012).

Rare fraction of steppe and petrophyte vegetation is represented by syntaxons included in the Green book of Ukraine (Green ..., 2009), namely the following formation: *Genisteta scythicae* (8 associations), *Calophaceta wolgaricae* (7), *Caraganeta scythicae* (19), *Stipeta braunerii* (3), *Stipeta capillatae* (65), *Stipeta tirsae* (26), *Stipeta graniticolae* (6), *Stipeta borysthenicae* (13), *Stipeta zalesskii* (15), *Stipeta lessingianae* (44), *Stipeta grafianae* (35), *Stipeta joannis* (14), *Stipeta dasyphyllae* (19), *Stipeta ucrainicae* (28), *Amygdaleta nanae* (32), *Cariceta humilis* (5*)*, *Elytrigieta stipifoliae* (13), *Glycyrrhiseta glabrae* (10), *Hyssopeta cretacei* (13), *Erodieta beketowii* (9), *Artemisieta hololeucae* (9), *Helianthemeta cretophili* (6). Rare fraction of xerothermic vegetation also comprises regional rare plant communities, dominants and codominants of which are species subjected to special protection, and also extremely rare associations of stenotopic habitats. They include the following formations: *Achilleeta glaberrimi* (1 association), *Anemoneta sylvestris* (2), *Anthericeta ramosi* (2), *Artemisieta nutantis* (3), *Artemisieta tanaiticae* (18), *Astragaleta albicaulis* (2), *Aurinieta saxatilis* (2), *Cariceta pediformis* (3), *Centaureeta ruthenicae* (1) (Figure 1f), *Convolvuleta lineati* (2), *Cotoneastereta melanocarpi* (4), *Crambeeta ponticae* (1), *Diplotaxieta cretaceae* (2), *Ephedreta distachyae* (2), *Eringieta maritimi* (2), *Euphorbieta cretophilae* (5), *Festuceta cretaceae* (5), *Hedysareta grandiflori* (3), *Inuleta hirtae* (1), *Krascheninnikovieta ceratoidis* (2), *Matthioleta fragrantis* (1), *Onosmateta tanaitici* (15), *Paeonieta tenuifoliae* (8), *Roseta chrshanovskii* (2), *Roseta subpygmaeae* (5), *Scrophularieta cretaceae* (6), *Scrophularieta donetzicae* (1), *Scutellarieta creticolae* (2), *Sileneta cretaceae* (1), *Tamariceta gracilis* (7), *Teucrieta chamaedryos* (1), *Thymeta didukhii* (1), *Thymeta kondratjukii* (5), *Thymeta pseudogranitici* (6).

The general scheme of xerothermic steppe, petrophyte and psammophyte vegetation in the region according to the method of Braun-Blanquet (Solomakha, 2008; Tyschenko, 2006) includes the following syntaxons:

***Classis.* Festuco-Brometea Br.-Bl. et R.Tx. in Br.-Bl. 1949.**
***Ordo.* Festucetalia valesiacae Br.-Bl. et R.Tx. 1943.**
***Alliancia.* Festucion valesiacae Klika 1931.**
***Suballiancia.* Festucenion valesiacae Kolbek in Voravec et al. 1983.**
Associatio. Salvio nemorosae-Festucetum valesiacae Korotchenko et Didukh 1997.
Associatio. Festucetum rupicolae Soo 1940.
Associatio. Festuco valesiacae-Stipetum capillatae Sill. 1937.
Associatio. Plantagini stepposae-Stipetum pulcherrimae V.Solomakha 1995.
Associatio. Stipo ucrainicae-Agropyretum pectinatae Tyschenko 1996.
Associatio. Salvio nemorosae-Elytrigietum intermediae Tyschenko 1996.
Associatio. Euphorbio segieranae-Koelerietum cristatae Smetana, Derpoluk, Krasova 1997.
Associatio. Medicago romanicae-Crinitarietum villiosae Smetana, Derpoluk, Krasova 1997.
Associatio. Festucetum valesiacae Solodkova et al. 1986.
Associatio. Festuco valesiacae-Caraganetum frutici Smetana, Derpoluk, Krasova 1997.
Associatio. Festuco valesiacae-Koelerietum cristatae Smetana, Derpoluk, Krasova 1997.
***Suballiancia.* Achilleo setaceae-Poenion angustifoliae Tkachenko, Movchan et V.Solomakha 1987.**
Associatio. Medicago romanicae-Poetum angustifoliae Tkachenko, Movchan et V.Solomakha 1987.
Associatio. Achilleo setaceae-Poetum angustifoliae Marjuschkina et V.Solomakha 1986.
Associatio. Elytrigio trichophorae-Poetum angustifoliae (Kost. et al. 1984) V.Solomacha 1995.
Associatio. Verbasco lychnitis-Koelerietum cristatae Smetana, Derpoluk, Krasova 1997.
***Suballiancia.* Coronillo variae-Poenion angustifoliae Smetana, Derpoluk, Krasova 1997.**
Associatio. Coronillo variae-Poetum angustifoliae Smetana, Derpoluk, Krasova 1997.
***Alliancia.* Cirsio-Brachypodion pinnati Hadac et Klika 1994 em Krausch 1961.**
Associatio. Thymo marschalliani-Caricetum praecocis Korotchenko et Didukh 1997.
***Alliancia.* Fragario viridis-Trifolion montani Korotchenko et Didukh 1997.**
Associatio. Medicago-Festucetum valesiacae Wagner 1940.

Associatio. Betonico officinalis-Trifolietum montani Popova in Popova et al. 1986.
Associatio. Salvio pratensis-Poetum angustifoliae Korotchenko et Didukh 1997.
Associatio. Veronico austriacae-Chamaecythisetum austriaci Korotchenko et Didukh 1997.
Associatio. Agrimonio eupatoriae-Galietum ruthenici Smetana, Derpoluk, Krasova 1997.
Associatio. Bromopsio ripariae-Plantagetum lanceolatae Smetana, Derpoluk, Krasova 1997.
***Alliancia.* Astragalo-Stipion Knapp 1944.**
Associatio. Stipetum pennatae R. Jovanovic 1956.
Associatio. Astragalo austriaci-Salvietum nutantis Korotchenko et Didukh 1997.
Associatio. Thymo marschalliani-Crinitarietum villosae Korotchenko et Didukh 1997.
Associatio. Stipetum lessingianae Soo 1948.
Associatio. Vinco herbaceae-Caraganetum fruticis Korotchenko et Didukh 1997.
Associatio. Eryngio campestri-Achilletum nobilis Smetana, Derpoluk, Krasova 1997.
Associatio. Marrubio praecoci-Euphorbietum stepposae Smetana, Derpoluk, Krasova 1997.
***Alliancia.* Artemisio-Kochion Soo 1969.**
Associatio. Agropyro pectinato-Kochietum prostratae Zolyomi 1958 corr. Soo 1959.
***Alliancia.* Artemisio marschalliani-Elytrigion intermediae Korotchenko et Didukh 1997.**
Associatio. Astragalo dasyanthi-Elytrigietum intermediae Korotchenko et Didukh 1997.
***Alliancia.* Chamaecythision ruthenici Smetana, Derpoluk, Krasova 1997.**
Associatio. Plantagini stepposae-Chamaecytisetum ruthenici Smetana, Derpoluk, Krasova 1997.
Associatio. Potentillo argenteae-Thymetum dymorphi Smetana, Derpoluk, Krasova - 1997.
Associatio. Crinitario villosae-Chamaecytisetum ruthenici Smetana, Derpoluk, Krasova 1997.
***Classis.* Helianthemo-Thymetea Romaschenko, Didukh et V.Sl. 1996.**
***Ordo.* Thymo cretacei-Hyssopetalia cretacei Didukh 1989.**
***Alliancia.* Artemisio hololeucae-Hyssopion cretacei Romaschenko, Didukh et V.Sl. 1996.**
Associatio. Artemisio nutantis-Plantaginetum salsae Didukh 1989.
Associatio. Artemisio hololeucae-Polygaletum cretaceae Didukh 1989.
Associatio. Onosmo tanaiticae-Androsacietum kozo-poljanskii Romaschenko, Didukh et V.Sl. 1996.
Associatio. Scrophulario cretacei-Helianthemetum cretacei Romaschenko, Didukh et V.Sl. 1996.
***Alliancia.* Euphorbio cretophilae-Thymion cretacei Didukh 1989.**
Associatio. Jurineo brachicephalae-Helianthemetum cretophilae Romaschenko, Didukh et V.Sl. 1996.
Associatio. Euphorbio cretophilae-Jurinetum brachicephalae Didukh 1989.
***Alliancia.* Centaureo carbonatae-Koelerion talievii Romaschenko, Didukh et V.Sl. 1996.**
Associatio. Jurineo brachicephalae-Koelerietum talievii Romaschenko, Didukh et V.Sl. 1996.

Associatio. Gypsophilo oligospermae-Campanuletum sibiricae Romaschenko, Didukh et V.Sl. 1996.

Associatio. Bupleuro falcatae-Stipetum capillatae Romaschenko, Didukh et V.Sl. 1996.

Associatio. Androsacio kozo-poljanskii-Caricetum humilis Korotchenko et Didukh 1997.

***Classis.* Glycyrrhizetea glabrae V. Golub et Mirkin in V. Golub 1995.**

***Ordo.* Glycyrrhizetalia glabrae V. Golub et Mirkin in V. Golub 1995.**

***Alliancia.* Glycyrrhizion glabrae V. Golub et Mirkin in V. Golub 1995.**

Associatio. Glycyrrhizetum glabrae Tyschenko 1998.

***Classis.* Ammophiletea Br.-Bl. et R.Tx. 1943.**

***Ordo.* Elymetalia gigantei Vicherek 1971.**

***Alliancia.* Elymion gigantei Morariu 1957.**

Associatio. Elymio-Astrodaucetum littoralis Korzh., Volkova et Klukin 1984.

Associatio. Tournefortietum sibiricae Popescu et Sanda 1975.

Associatio. Elymetum gigantei Morariu 1957.

Associatio. Salsoletum sodae Slavnic 1939.

Associatio. Artemisietum arenariae Popescu et Sanda 1975.

Associatio. Crambo pontici-Leymetum sabulosi Tyschenko 1998.

Associatio. Agrostio maeoticae-Gypsophillietum perfoliatae Umanets O.Yu., Voityuk B.Yu., Solomakha I.V. 2001.

Associatio. Secalio-Seselietum tenderiense Umanets O.Yu., Voityuk B.Yu., Solomakha I.V. 2001.

***Classis.* Festuco-Limonietea Karpov et Mirk. 1986.**

***Ordo.* Festuco-Limonietalia Mirk. in V.Golub et V.Sl. 1988.**

***Alliancia.* Festuco-Limonion gmelini Mirk. in V.Golub et V.Sl. 1991.**

Associatio. Salvio tesquicolae-Koelerietum cristatae Saveljeva et V.Golub 1991.

***Classis.* Agropyretea repentis Oberd., Th.Mull. et Gors in Oberd. et al. 1967.**

***Ordo.* Agropyretalia repentis Oberd., Th.Mull. et Gors in Oberd. et al. 1967.**

***Alliancia.* Convolvulo-Agropyrion repentis Gors 1966.**

Associatio. Agropyretum repentis Gors 1966.

Associatio. Anisantho-Artemisietum austriacae Kost. 1986.

Associatio. Calamagrostietum epigeios Kost. in V.Sl. et al. 1992.

***Classis.* Festucetea vaginatae Soo 1968 em Vicherek 1972.**

***Ordo.* Festucetalia vaginatae Soo 1968 em Vicherek 1972.**

***Alliancia.* Festucion beckeri Vicherek 1972.**

Associatio. Centaureo odessanae-Festucetum beckeri Vicherek 1972.

Associatio. Anisantho tectori-Medicagetum kotovii Tyschenko 1996.

Associatio. Anisantho tectori-Medicagetum kotovii syntrichietosum ruralis Tyschenko 2000.

Associatio. Centaureo odessanae-Caricetum colchicae Tyschenko 1999.

Associatio. Anisantho tectori-Helichrysetum arenarii Tyschenko 1999.

Associatio. Inulo sabuletori-Rumicetum acetoselliae Umanets, Solomakha 1999.

***Alliancia.* Verbascion pinnatifidii Korzh. et Kljukin 1990.**

Associatio. Astragalo borysthenici-Ephedretum Korzh. et Kljukin 1990.

Associatio. Bassio laniflorae-Bromion tectorum (Soo 1957) Borhidi 1996.

Associatio. Secali sylvestris-Brometum tectorum Hargitai 1940.

Thus, the ecological-floristic classification of the xerophytic vegetation of the region consists of 7 classes, 7 orders, 16 alliances, 3 suballiances, 67 associations. Among them the proper steppe type includes plant communities of 3 classes (*Festuco-Brometea, Agropyretea repentis, Glycyrrhizetea glabrae*), petrophyte vegetation includes 1 class (*Festuco-Brometea*), tomillares include 1 class (*Helianthemo-Thymetea*), psammophyte vegetation include 3 classes (*Ammophiletea, Festucetea vaginatae, Festuco-Limonietea*). This scheme demonstrates that method of Braun-Blanquet gives a very fragmentary study of the vegetation in the region. In particular, there is no data on the syntaxonomic structure of vegetation, formed at the outputs of granites, limestones, paleogene sands, carbon shale – ecotopes, which are characterized by specific floristic complexes containing paleo- and neoendemics types, vicarious and border areal elements.

In accordance with the ecological-floristic classification it is difficult to distinguish plant communities requiring special measures of protection, as even the associations are rather extensive units, including both common and rare plant communities in terms of the dominant approach. Special protection can be attributed to the class *Glycyrrhizetea glabrae*, alliance *Artemisio hololeucae-Hyssopion cretacei*, associations of *Plantagini stepposae-Stipetum pulcherrimae, Stipetum pennatae, Stipetum lessingianae, Astragalo borysthenici-Ephedretum, Jurineo brachicephalae-Helianthemetum cretophilae, Androsacio kozo-poljanskii-Caricetum humilis, Crambo pontici-Leymetum sabulosi.*

Idle Lands and Barrows As Potential Sources of Steppe Vegetation Restoration

The analysis of land management forms connected with plant substance alienation in zonal phytocenosis allows us to correct productivity changes caused by an anthropogenic factor in different historic and ecological periods (Lisetskii, Chernyavskikh, Degtyar,' 2011).

The reduction of farming lands has become a worldwide trend since the middle of last century. During the period of 1961-2003, there were left up to 223 million hectares of arable land, most of which (58.3 million hectares) were left in Russia. Till the end of XX century the process of arable land reduction in Russia was a part of the national economy crisis, caused by political and socioeconomic transformations that took place in Russia in 1990s. Since the beginning of the XXI century, according to the official statistics, in the European part of Russia the dynamics of the acreage reduction at first slowed down and then balanced at the level of 50 million hectares. The study of cultivated lands of the European part of Russia with the use of geoinformation technologies based on the analysis of Earth remote sensing data also confirm this trend (Schierhorn et al., 2013; Prishchepov et al., 2014; Kitov, Tsapkov, 2015).

The study of long-term idle lands is of special scientific interest. The territory on the Tarkhankut Peninsula in north-west Crimea was occupied by nomadic indigenous communities and reveal that the site shared the fate of the entire Chersonesean *chora*, meeting a violent end in the early part of the third century BC (Stolba & Andresen, 2015). Here and in other northern regions of the Black Sea area there were found post-antique idle lands that have been discovered due to the wide availability of highly detailed, multi-temporal, frequently updated, space imagery data, results of which made possible a review study of boundary systems in the area of the ancient statehood of the Northern Black Sea region (Lisetskii et al., 2013; Lisetskii, Rodionova, 2015; Lisetskii, Stolba, Marinina, 2015; Smekalova et al., 2015).

Reconstructive successions of multi-temporal idle lands have the structure of the epiterranean layer phytomass, which is different from the indigenous communities (Table 2-3).

Table 2. The structure of epiterranean layer phytomass in terms of virgin and idle lands (May) (Lisetskii et al., 2015)

Type of land[a]	H, cm	TPC, %	Number of plant species	Composition of herbage[b]	Mass of dry substance[c], g/m^{-2}		
					F	*R*	*SC*
VL	36	75	17	1+2+14	159.16	254.52	182.00
PIL	32	95	12	4+2+6	85.56	181.68	112.04
MIL	29	70	12	2+1+9	118.88	117.56	61.00

Abbreviations: H – height of herbage; TPC – total projective cover.
[a]VL – virgin lands; PIL – post-antigue idle land; MIL – idle land in the modern era.
[b] The numbers specify respectively graminoids + legumes + herbs.
[c] F – green phytomass; R – plant debris; SC – litter.

Table 3. Higher vegetation phytomass supply (g/m-2) in terms of idle lands (October)

Type of land	H, cm	epiterranean phytomass		subterranean phytomass in layer, sm			
		F+R	SC	0-10		0-20	
				green mass [b]	mortmass	green mass [b]	mortmass
	Ground 1						
MIL	94	723.2	337.8	1273.7	1140.7	1556.3	1649.8
PIL	66	323.0	186.7	632.8	795.7	753.8	972.4
MIL	110	194.8	239.5	216.7(354.2)	529.3	328.5(415.7)	665.6
	Ground 2						
PIL	40	134.4	68.0	1349.9(136.6)	1088.9	1508.2(136.6)	1355.8
PIL	50	127.4	77.4	1956.2	959.2	2081.3	1196.9
MIL	43	88.6	187.9[a]	498.5(83.5)	786.6	709.1(83.5)	954.0

Abbreviations. [a] Besides, ground litter contains sheep excrement weighing 50.2 g/m^{-2}
[b] The additional weight of roots are noted within brackets (diameter > 0.6 mm).

The proportion of steppe grasses, which transfer from rootstock grasses to sod grasses stage of demutation with idle land aging, is the biggest in post-antique idle lands (*Stipa sp., Festuca valesiaca Gaudin, Bromopsis cappadocica (Boiss. & Balansa) Holub*) and new idle land (*Stipa lessingiana Trin. & Rupr., Koeleria cristata (L.) Pers.*), and in terms of virgin land one dominant species remains (*Stipa capillata L.*).

In spring (in May) when fescue, and not feather, as it will be later, becomes the main edificator of steppe (Table 1), the above-ground dry mass (F+R) of multiple-aged idle lands is

39% inferior to virgin soil. In autumn (October) in low grazing conditions on black earth soils, when the role of *Stipa capillata* becomes dominant, the weight (F+R) is by 55% (post-antique idle lands) and 73% (new idle lands) less than in virgin soils (Table 2).

The deposition of the aboveground mortmass (R+SC) depends on the magnitude of maximum green mass (F) and the speed of mortmass decomposition. The more active the production process is, a relative measure of which is F, and slower the speed of destruction, the more aboveground mortmass is accumulated. In these conditions, the maximum aboveground mortmass is noted in the terms of virgin land (436 g/m^{-2}), and in idle lands it decreases, and also new idle lands are inferior in this index to post-antique idle lands in 1.6 times.

The landscape of virgin steppe is inseparable from barrows, which were dominant, occupying the commanding heights. This remarkable feature of the steppe was noted by its first explorers. There is a great number of barrows in the steppes, but the rate of their loss is progressive. For example, in the Volgograd region there are more than 200,000 barrows (176 per 100 km^2), in Kalmykia there are 70 000 barrows (92 per 100 km^2), on the flat part of the Crimea (59 per 100 km^2). The number of barrows gets a sequence higher, if low barrows are found. Often they can be identified on lands with long-term cultivation and then magnetic investigations is used (Smekalova et al., 2005).

A barrow is a local geocomplex with dome-shaped top facies with xeromorphic vegetation, often anthropogenically disturbed, differently exposed slopes and a ditch with mesophytic vegetation. As a result of applicative evolution, the unique soils coordinated by topogradient in catena, are formed in the humus barrow fill. There still can be found the giant barrows of the steppe Scythia. For example, Oguz and Chertomlyk, volume of each reaches 8 thousand m^3. They are not only the unique monuments of archeology, but undoubtedly the most remarkable monuments of nature. The synthesis of complex natural science results of barrows research (Barczi, 2003; Sudnik-Wójcikowska, Moysiyenko, 2012 et al.) reveals the potential of barrows as non-reproducible natural ecosystem models for exploring a wide range of scientific problems.

High barrows, like the ones we studied, are not cultivated, they are surrounded by agricultural landscapes and represent island ecosystems, which have inherited particular flora features of previously undisturbed ecological background and have specific soil cover. It is a temporary stage of achieving soil climax with inherited properties of transplanted and mixed soils. Using the results of the preliminary surveys 106 barrows with a height of > 4 m, for which the typical vegetation was diagnosed by the presence of steppe flora and vegetation elements, especially turf grasses of the genera *Stipa, Festuca, Koeleria* (Sudnik-Wójcikowska, Moysiyenko, 2012), the most representative objects of study in transzonal view were identified. They are a well-preserved earth tombs with a height of 6-7.5 m, which are located in climatically different conditions of forest-steppe and steppe zones of the East European plain (Lavrenko, Karamysheva, Nikulina, 1991): in Cherkasy (F), Nikolaev (R) and Kherson (P, D) regions of Ukraine (Figure 2).

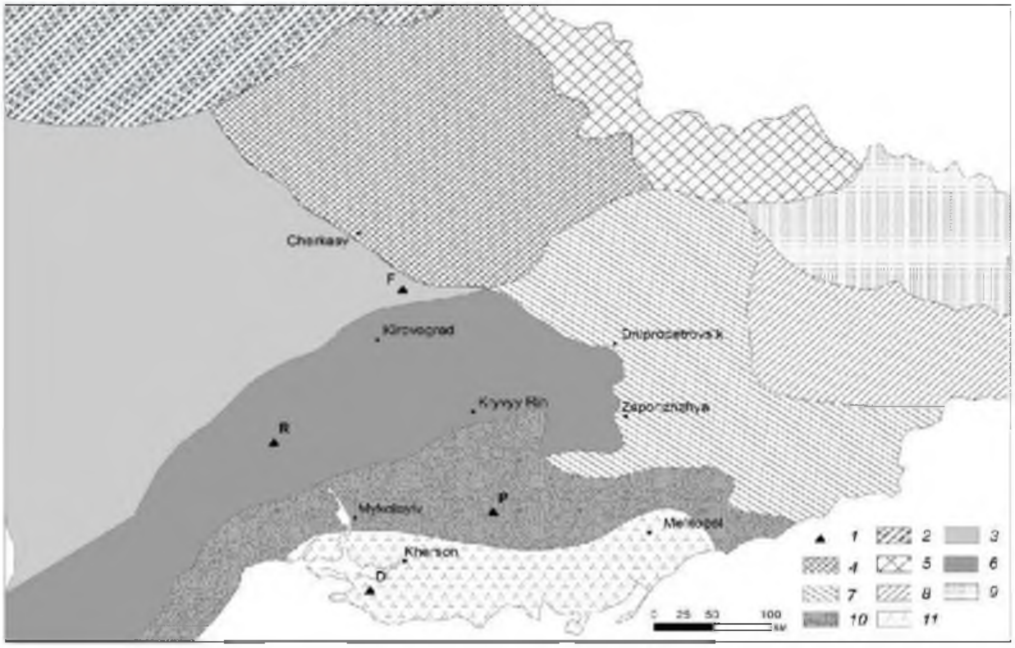


Figure 2. The location of the key objects of study – barrows in the forest-steppe and steppe in the scheme of physical-geographical zoning. *1* – barrows (F, R, P, D); *2* – Polesie province (coniferous-broadleaved zone). Forest-steppe zone: *3* – Dniester-Dnepr, *4* – Left-Bank Dnepr, *5* – Central Russian forest-steppe province. The steppe zone: *6* – Dniester-Dnepr, *7* – Left-Bank Dnepr-Azov, *8* – Donetsk, *9* – Donetsk-Don north steppe province (north steppe subzone). *10* – Black Sea middle steppe province (middle steppe subzone). *11* – Black Sea-Azov steppe province (dry steppe subzone).

For quite a long period of renaturation barrows form soil-vegetable cover, by topogradient corresponding to microlandscapes conditions of ecotopes: the heights, differently exposed slopes and foothills. Achieving a state of climax in plant community is determined by the ecosystem component with the largest characteristic time – edaphotope (Lisetskii, 1998). Known from the literature time estimations of full recovery of plant communities at idle lands overgrowing vary considerably from 50 to 200 years. It is therefore important to assess the degree of maturity of both plant communities and soils which recovered in different ways in separate ecotypes of a barrow since the construction of embankments.

The developed method of soil-genetic chronology (Goleusov, Lisetskii, 2008) is a new method of age determination of anthropogenic structures based on mathematical dependencies of irreversible genetic soil properties on time, determines the relevance of soil science for the attribution and protection of cultural heritage. In particular, this method allows to determine the last time humus material was added to the barrows (Lisetskii, 2012). However, in addition to absolute age of different barrow locations the soils and plant communities differ in relative age.

The analysis of the similarities and differences of individual edaphotopes by the combination of soil properties (agrochemical properties directly relevant to plant growth (8 indicators) and geochemical properties (18 indicators)) indicates some trends in the formation of specific consolidated groups on the southern slopes, which the tops of the barrows tend to.

The northern slopes are of a great variety of properties. In separate barrow ecotopes due to the objectively existing differences in age (“maturity”) of soils and vegetation the individual development course is implemented. Thus, the slopes of the barrows are formed by the maximum (in comparison with other barrow ecotypes) representation of steppe vegetation classes in the phytosociological spectrum (Lisetskii et al., 2014). Therefore, the slope locations of barrows contain the most valuable genetic and coenotic flora fund, which is useful for ecological restoration of the zonal steppe vegetation in conditions of flat interfluves.

CONCLUSION

Thus, xerothermic steppe vegetation in the Azov-Donetsk region is very diverse due to the diversity of ecotopes, long-term evolution and anthropogenic influence. The formation of the modern flora in the steppe zone occurred gradually and, obviously, has something in common with the same floras in the other regions, indicating their unification. Under these conditions, initially, in the evolution of vegetation, specific ammophilous, petrophilous, in particular, calcipetrophilous complexes formed. Currently there coexist steppe, forest-steppe, ammophilous, petrophilous, halophilous and hydrophilous floristic complexes, which became the “material” for the present anthropogenic evolution of vegetation cover in steppe zone. Its natural differentiation is associated with geomorphological and geological factors, which caused subclimax vegetation formation on undeveloped and washed away soils, underlain by sands and sandstone of various genesis, chalk, limestone and granites. This led to the formation of a specific floristic complexes and corresponding syntaxons of vegetation. Due to anthropogenic factors successional series of vegetation increasing the diversity of plant communities and complicating their classification have formed. In sozological regard the vegetation of the region is saturated with syntaxons that are subject to special protection.

In separate barrow ecotopes due to the objectively existing differences in the age of the soils and vegetation the individual development course is implemented. The southern slopes always form the most favourable conditions for the continuous combination and recombination of species in the community. Slope ecotope of the barrow is characterized by a maximum (in comparison with other barrow ecotypes) representation of steppe vegetation classes in the phytosociological spectrum. Therefore, the slope locations of barrows contain the most valuable coenotic of flora fund, which is useful for ecological restoration of the zonal steppe vegetation in conditions of flat interfluves.

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Research interests: ecology, soil science, soil geography, geomorphology, geoarchaeology, pedoarchaeology, the study of ancient systems of land use new scientific methods (GIS, remote sensing).

Professional Appointments:

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Manager of the year in the nomination "Science"	2008
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Publications Last 3 Years:

Journal Publications

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