

Chapter

REGULARITIES AND FEATURES OF DIFFERENTIATION AND ANTHROPOGENIC TRANSFORMATION OF STEPPE VEGETATION

*F. N. Lisetskii, V. K. Tokhtar, V. M. Ostapko,
S. A. Prykhodko and T. V. Petrunova*

Belgorod State National Research University, Belgorod, Russia

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, relictiness, 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 valesiaca* (114 associations), *Elytrigietta repentis* (54), *Stipeta capillatae* (51), *Stipeta lessingiana* (37), *Poeta angustifoliae* (35), *Bromopsieta ripariae* (34), *Stipeta grafiana* (33), *Stipeta ucrainicae* (27), *Stipeta tirsae* (26), *Elytrigietta 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 (*Elytrigietta repentis* – 10, *Poeta angustifoliae* – 10, *Galatellata 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 lessingiana* – 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 (*Calophaeta wolgaricae*, *Artemisieta hololeuca*, *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) helianthemum (cretophili)*, *Bromopsietum (ripariae) schivereckiosum (mutabilis)*, *Caricetum (humilis) elytrigosum (stipifoliae)*, *Centaureetum (ruthenicae) purum*, *Crinitarietum (villosae) koeleriosum (talievii)*, *Diplotaxietum (cretaceae) pimpinellosum (titanophilae)*, *Hedysaretum (cretacei) artemisiosum (hololeuca)*, *Hedysaretum (cretacei) festucosum (cretaceae)*, *Matthioletum (fragrantis) purum*, *Pimpinelletum (titanophilae) artemisiosum (hololeuca)*, *Pimpinelletum (titanophilae) euphorbiosum (cretophilae)*, *Scrophularietum (cretaceae) artemisiosum (hololeuca)*, *Scrophularietum (cretaceae) thymosum (cretacei)*, *Stipetum (joannis) anthericosum (ramosi)*, *Stipetum (joannis) elytrigosum (cretaceae)*, *Thymetum (cretacei) helianthemum (cretophili)* (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 (marshalliani) pimpinellosum (titanophilae)*, *Botriochloetum (ischaemi) anthemidosum (subtinctoriae)*, *Caricetum (supinae) linosum (czerniaevii)*, *Cephalarietum (uralensis) thymosum (calcarei)*, *Crinitarietum (villosae) ephedrosom (distachiae)*, *Festucetum (valesiaca) achilleosum (leptophyllae)*, *Pimpinelletum (titanophilae) silenosum (supinae)*, *Pimpinelletum (titanophilae) thymosum (calcarei)*, *Rosetum (chrshanovskii) melicosum (transsylvanicae)*, *Rosetum (subpygmaeae) hylotelephiosum (decumbentis)*, *Silenetum (supinae) atraphaxiosum (frutescentis)*, *Stipetum (capillatae) thymosum (calcarei)*, *Thymetum (dimorphi) 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 (glaberrimi) purum*, *Achilleetum (leptophyllae) asperulosum (graniticola)*, *Aurinetum (saxatilis) festucosum (valesiaca)*, *Festucetum (valesiaca) jurineosum (granitica)*, *Scrophularietum (donetizica) melicosum (transsylvanica)*, *Stipetum (graniticola) 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 tanaitica* (18), *Hyssopeta cretacei* (13), *Jurineeta brachycephalae* (12), *Onosmateta tanaitici* (11), *Artemisieta hololeuca* (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 tscherniaeviana* (6), *Cariceta colchicae* (6), *Koelerieta sabuletori* (5). In the coastal zone of the Azov sea the characteristic community formations of *Agropyreta lavrenkoani*, *Cakileta maritima*, *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 borysthonicae* (13), *Koelerieta sabuletori* (9), *Cariceta colchicae* (5), etc.



a

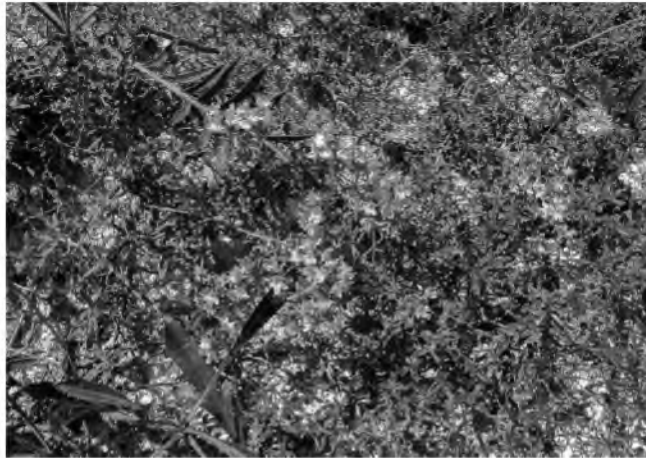


b

Figure 1. (Continued)



c



d



e

Figure 1. (Continued)



f

Figure 1. Typical (b, d, e) and rare (a, c, f) plant communities occurred in steppe zone of the South in the Middle Russian Upland: a) *Caraganeta scythicae*, b) *Salvieta nutantis*, c) *Stipeta graniticolae*, d) *Thymetum (cretacei) helianthemum (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 (Prihodko 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 borysthennicae* (13), *Stipeta zalesskii* (15), *Stipeta lessingiana* (44), *Stipeta grafiana* (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 hololeuca* (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 stenotropic habitats. They include the following formations: *Achilleeta glaberrimi* (1 association), *Anemoneta sylvestris* (2), *Anthericeta ramosi* (2),

Artemisieta mutantis (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 valesiaca Br.-Bl. et R.Tx. 1943.**
- Alliancia. Festucion valesiaca Klika 1931.**
- Suballiancia. Festucion valesiaca Kolbek in Voravec et al. 1983.**
- Associatio.* Salvia nemorosae-Festucetum valesiaca Korotchenko et Didukh 1997.
- Associatio.* Festucetum rupicola Soo 1940.
- Associatio.* Festuco valesiaca-Stipetum capillatae Sill. 1937.
- Associatio.* Plantagini stepposae-Stipetum pulcherrimae V.Solomakha 1995.
- Associatio.* Stipo ucrainicae-Agropyretum pectinatae Tyschenko 1996.
- Associatio.* Salvia nemorosae-Elytrigietum intermediae Tyschenko 1996.
- Associatio.* Euphorbio segieranae-Koelerietum cristatae Smetana, Derpoluk, Krasova 1997.
- Associatio.* Medicago romanicae-Crinitarium villiosae Smetana, Derpoluk, Krasova 1997.
- Associatio.* Festucetum valesiaca Solodkova et al. 1986.
- Associatio.* Festuco valesiaca-Caraganetum frutici Smetana, Derpoluk, Krasova 1997.
- Associatio.* Festuco valesiaca-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.Solomakha 1995.
- Associatio.* Verbasco lychnitis-Koelerietum cristatae Smetana, Derpoluk, Krasova 1997.
- Suballiancia. Coronillo varia-Poenion angustifoliae Smetana, Derpoluk, Krasova 1997.**
- Associatio.* Coronillo varia-Poetum angustifoliae Smetana, Derpoluk, Krasova 1997.
- Alliancia. Cirsio-Brachypodium pinnati Hadac et Klika 1994 em Krausch 1961.**
- Associatio.* Thymo marschalliani-Caricetum praecocis Korotchenko et Didukh 1997.
- Alliancia. Fragario viridis-Trifolium montani Korotchenko et Didukh 1997.**
- Associatio.* Medicago-Festucetum valesiaca Wagner 1940.

- Associatio.* Betonico officinalis-Trifolietum montani Popova in Popova et al. 1986.
- Associatio.* Salvia 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-Crinitarium villosae Korotchenko et Didukh 1997.
- Associatio.* Stipetum lessingianae Soo 1948.
- Associatio.* Vinco herbaceae-Caraganetum fruticis Korotchenko et Didukh 1997.
- Associatio.* Eryngio campestri-Achilietum 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-Chamaecythisetum ruthenici Smetana, Derpoluk, Krasova 1997.
- Associatio.* Potentillo argenteae-Thymetum dymorphi Smetana, Derpoluk, Krasova - 1997.
- Associatio.* Crinitario villosae-Chamaecythisetum ruthenici Smetana, Derpoluk, Krasova 1997.
- Classis. Helianthemo-Thymetea Romaschenko, Didukh et V.Sl. 1996.**
- Ordo. Thymo cretacei-Hyssopetalia cretacei Didukh 1989.**
- Alliancia. Artemisio hololeucaae-Hyssopion cretacei Romaschenko, Didukh et V.Sl. 1996.**
- Associatio.* Artemisio nutantis-Plantaginetum salsae Didukh 1989.
- Associatio.* Artemisio hololeucaae-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.* Salvia 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-Agropyron 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 hololeucaae-Hyssopion cretacei*, associations of *Plantagini stepposae-Stipetum pulcherrimae*, *Stipetum pennatae*, *Stipetum lessingiana*, *Astragalo borysthenici-Ephedretum*, *Jurineo brachicephalae-Helianthemum 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.

^aVL – virgin lands; PIL – post-antique idle land; MIL – idle land in the modern era.

^bThe numbers specify respectively graminoids + legumes + herbs.

^cF – green phytomass; R – plant debris; SC – litter.

Table 3. Higher vegetation phytomass supply (g/m²) 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. ^aBesides, ground litter contains sheep excrement weighing 50.2 g/m⁻²

^bThe 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/m²), 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 km²), in Kalmykia there are 70 000 barrows (92 per 100 km²), on the flat part of the Crimea (59 per 100 km²). 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 m³. 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 (Barczy, 2003; Sudnik-Wójcikowska, Moysiyyenko, 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, Moysiyyenko, 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).

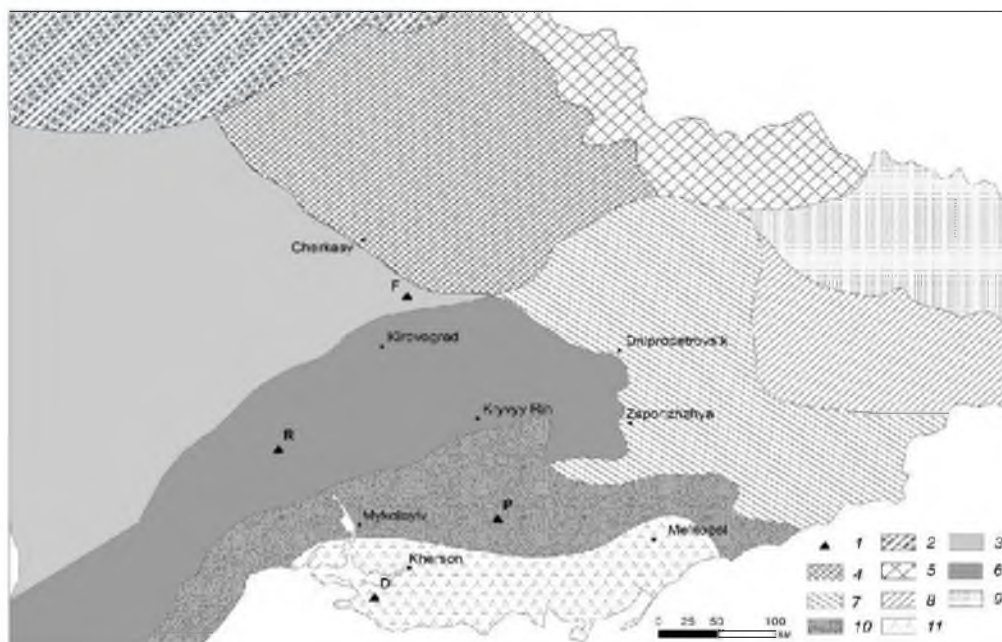


Figure 2. The location of the key objects of study – barrows in the forest-steppe and steppe in the scheme of physical-geographical zoning. 1 – barrows (F, R, P, D); 2 – Polesie province (coniferous-broadleaved zone). Forest-steppe zone: 3 – Dniester-Dnepr, 4 – Left-Bank Dnepr, 5 – Central Russian forest-steppe 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 zoological 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.

REFERENCES

- Alexandrova, VD. The classification of vegetation. Leningrad: *Nauka*, 1969. (in Russian).
Barczy, A. Data for the botanical and pedological surveys of the Hungarian kurgans (Great Hungarian Plain, Hortobagy). *Thaiszia–J. Bot.*, 2003 v 13, 113-126.
Burda, RI. Anthropogenic transformation of flora. Kiev: Naukova Dumka, 1991. (in Russian).
Burda, RI; Tokhtar, VK. Invasion, distribution and naturalization of plants along railroads of the Ukrainian south-east. *Ukr. Botan. Journ.*, 1992. v 49 no 5, 14-18.

- Chuprina, TT. Syntaxonomic variety psammophytic steppes in the south-east of Ukraine. Introduction and acclimatization of plants, 1999 no 32, 116-121. (in Russian).
- Glukhov, AZ; Ostapko, VM; Prikhodko, CA. Phytodiversity regional landscape park "Meotida." Landscapes, vegetation and fauna of the regional landscape park "Meotida." Donetsk: *Noulidzh* 2010, 15-78. (in Russian).
- Goleusov, PV; Lisetskii, FN. Soil development in anthropogenically disturbed forest-steppe landscapes. *Eurasian Soil Science*, 2008 v 41 no 13, 1480-1486. DOI: 10.1134/S1064229308130188.
- Green Book of Ukraine. Didukh YP, editor. Kyiv: Alterpres, 2009. (in Ukrainian).
- Groom, MJ; Meffe, GK; Carroll, CR. Principles of conservation biology (pp. 174-251). Sunderland: Sinauer Associates. 2006.
- Henwood WD. An overview of protected areas in the temperate grasslands biome. *Parks*, 1998 v 8 no 3, 3-8.
- Ipatov, VC. Phytocenology. SPb: Publishing House of St. Petersburg University Press, 1999. (in Russian).
- Kitov, MV; Tsapkov, AN. Assessment of the area of fallow land in the Belgorod Region and other regions of European Russia for the period 1990-2013 years. *Belgorod State University Scientific Bulletin. Natural sciences*, 2015 no 15(212) issue 32, 163-171.
- Kondratyuk, EN. Feather grass steppes of Donbass. Kiev: *Naukova Dumka*, 1992. (in Russian).
- Krishtofovich AN. The main way of development of flora and vegetation in the Cenozoic (the presentation of the report at a meeting of the Standing Committee on the history of flora and vegetation of the USSR in 1945). *Soviet botany*, 1945 no 5, 47-48. (in Russian).
- Kupryushyna, LV.; Ostapko, VM; Kolomiychuk VP. Phytocoenotic features *Caragana scythica* (Kom.) Pojark. (Fabaceae Lindl.) in Donetsk-Azov region. *Chernomorsky Botanical Magazine*, 2011 v 7 no 3, 238-252. (in Ukrainian).
- Lavrenko, EM. The provincial division of the Black sea-Kazakhstan subregion steppe region of Eurasia. *Botanical Magazine*, 1970, v 55 no 5, 609-625. (in Russian).
- Lavrenko, EM; Karamysheva, ZV; Nikulina, RI. *Steppes of Eurasia*. Leningrad: *Nauka*; 1991. (in Russian).
- Lisetskii, F; Stolba, V; Ergina, E; Rodionova, M; Terekhin, E. Post-agrogenic evolution of soils in ancient Greek land use areas in the Herakleian Peninsula, South-West Crimea. *The Holocene*, 2013 no 4, 504-514. DOI: 10.1177/0959683612463098.
- Lisetskii, F; Stolba, VF; Marinina, O. Indicators of agricultural soil genesis under varying conditions of land use, Steppe Crimea. *Geoderma*, 2015 v 239-240, 304-316.
- Lisetskii, FN. Autogenic succession of steppe vegetation in postantique landscapes. *Russ. J. Ecol.*, 1998 v 29 no 4, 217-219.
- Lisetskii, FN. Soil reproduction in steppe ecosystems of different ages. *Contemporary problems of ecology*, 2012 v 5 no 6, 580-588. DOI: 10.1134/S1995425512060108.
- Lisetskii, FN; Chernyavskikh, VI; Degtyar, OV. Pastures in the zone of temperate climate: trends for development, dynamics, ecological fundamentals of rational use. Pastures: Dynamics, Economics and Management. Ed. by N.T. Procházka. *Nova Science Publishers, Inc.*, 2011, 51-83.
- Lisetskii, FN; Goleusov, PV; Moysiyenko, II; Sudnik-Wojcikowska, B. Microzonal distribution of soils and plants along the catenas of mound structures. *Contemporary Problems of Ecology*, 2014 v 7 no 3, 282-293.

- Lisetskii, FN; Rodionova, ME. Transformation of dry-steppe soils under long-term agrogenic impacts in the area of ancient Olbia. *Eurasian Soil Science*, 2015 v 48 no 4, 347-358. DOI: 10.1134/S1064229315040055.
- Ostapko, VM. Eydologic, population and cenotic population and phytosozology bases in the south-east of Ukraine. Donetsk Ltd. "Lebed," 2005. (in Russian).
- Ostapko, VM. Phytobiota regards cenotic diversity in southeastern Ukraine and its protection. *Ukrainian Botanical Journal*, 1999 v 56 no 5, 536-543. (in Ukrainian).
- Ostapko, VM. Prodrum natural vegetation of the south-east of Ukraine. *Donetsk*, 1995. (in Russian).
- Ostapko, VM. Sozological assessment and protection of the natural vegetation of Azov region of Donetsk. Network key botanical areas in the Azov region. Kiev: *Alterpres* 2011, 27-30. (in Russian).
- Ostapko, VM; Boyko, AV; Mosyakin, SL. Vascular plants of the south-east of Ukraine. Donetsk: *Noulidzh*, 2010. (in Russian).
- Ostapko, VM; Glukhov, AZ; Blakbern, AA; et al., Donetsk regional ecological network areas: concept, program and location. Ostapko VM, editor. Donetsk: *Tehnopak*, 2008. (in Ukrainian).
- Ostapko, VM; Kozub-Ptiza, VV; Ibatulina, YV; Hnatiuk, NY. Phytosozological assessment of the tract wide beam (Donetsk region). *Industrial botany*, 2011 no 11, 97-104.
- Ostapko, VM; Kupryushina, LP; Mulenkova, EG. Sozological justification for the establishment of the botanical reserve "Gruzskolomovsky" (Donetsk region). *Industrial botany*, 2007 no 7, 85-90. (in Russian).
- Ostapko, VM; Kupryushina, LV. Phytocoenotic variety of shrub steppes in the south-east of Ukraine and its sozological score. *Industrial botany: status and prospects. Donetsk*, 2010, 346-349. (in Russian).
- Ostapko, VM; Mulenkova, EG; Hnatiuk, NU; Zybenko OV. Phytosozological study for the establishment of the regional landscape park "Skelevoy" (Donetsk region). *Industrial botany*, 2008 no 8, 62-69. (in Russian).
- Ostapko, VM; Polyakov, AK. Phytosozological assessment of the regional landscape park "Zuevsky." *Industrial botany*, 2003 no 3, 44-51. (in Russian).
- Ostapko, VM; Prikhodko, CA; Vereshchetin, IM. Phytocoenotic bases expand the territory of the regional landscape park "Donetsk ridge" and its zoning. Preservation, restoration and stabilization of steppe ecosystems. *Mariupol: Renata*, 2011, 96-102. (in Ukrainian).
- Ostapko, VM; Sova, TV; Nazarenko, AS; Ibatulina, YV. Flora and vegetation Branch "Trehizbenskaya steppe" Luhansk Nature Reserve. *Industrial botany*, 2012 no 12, 67-74. (in Russian).
- Prikhodko, CA; Ostapko, VM; Kupryushina, LV. Syntaxonomical variety of vegetation in the South-East Ukraine aspect synfitosozology. *Industrial botany*, 2012 no 12, 53-60. (in Ukrainian).
- Prishchepov, AV; Radeloff, VC; Dubinin, M; Alcantara, C. The effect of Landsat ETM/TM+ image acquisition dates on detection of agricultural land abandonment in Eastern Europe (accessed 15 November 2014). Available from: <http://www.R-project.org>.
- Program and methods biogeocenological research. Dylis NV, editor. Moscow: *Nauka* (Science), 1974. (in Russian).
- Red Book of Ukraine. Flora. Didukh YP, editor. Kiev: *Global consulting*, 2009. (in Ukrainian).

- Schierhorn, F; Müller, D; Beringer, T. Post-Soviet cropland abandonment and carbon sequestration in European Russia, Ukraine, and Belarus. *Global Biogeochemical Cycles*, 2013 v 27, 1175-1185.
- Shelyag-Sosonko, YP. Biodiversity: paradigm and definitions. *Ukrainian Botanical Journal*, 2007 v 64 no 6, 777-796. (in Ukrainian).
- Shelyag-Sosonko, YP; Krisachenko, VS; Movchan, YI. Methodology geobotany. Kiev: *Naukova Dumka*, 1991. (in Russian).
- Smekalova, T; Voss, O; Smekalov, S; Myts, V; Koltukhov, S. Magnetometric investigations of stone constructions within large ancient barrows of Denmark and Crimea. *Geoarchaeology*, 2005 v 20 no 5, 461-482.
- Smekalova, TN; Bevan, BW; Chudin, AV; Garipov, AS. The Discovery of an Ancient Greek Vineyard. *Archaeological Prospection*, 2015. DOI: 10.1002/arp.1517
- Smelansky, IE; Tishkov, AA. The Steppe biome in Russia: Ecosystem services, conservation status, and actual challenges. Eurasian Steppes. Ecological problems and livelihoods in a changing world. 2012. *Springer Netherlands*, 45-101.
- Solomaha, VA. Ukraine syntaxonomy vegetation. The third approach. Kiev: *Fytosociocentre*, 2008. (in Ukrainian).
- Stolba, VF; Andresen, J. Unveiling the hinterland: a new type of Hellenistic rural settlement in Crimea. *Antiquity*, 2015 v 89(344), 345-360.
- Sudnik-Wójcikowska, B; Moysiienko, II. Kurhany na "Dzikich Polach" – dziedzictwo kultury i ostorja ukraińskiego stepu. Warszawa, 2012.
- Tishchenko, OJ. Vegetation coastal spits northern coast of the Azov Sea. Kiev: *Fytosociocentre*, 2006. (in Ukrainian).
- Tokhtar, VK; Groshenko, SA. Differentiation of the Climatic Niches of the Invasive *Oenothera* L. (Subsect. *Oenothera*, *Onagraceae*) Species in the Eastern Europe. *Advances in Environmental Biology*, 2014 v 8 no 10, 529-531.
- Tokhtar, VK; Petin, AN. Evolution and differentiation of phytobiota under anthropogenous impact in steppe and steppe-forest zone. *Bulletin of the Russian Academy of Sciences. Ser. Geography*, 2012 no 6, 83-91.
- Tokhtar, VK; Vinogradova, YK; Groshenko, SA. Microevolution and Invasiveness of *Oenothera* L. Species (Subsect. *Oenothera*, *Onagraceae*) in Europe. *Russian Journal of Biological Invasions*, 2011 v 2 no 4, 273-280.
- Wittig, R; Lenker, K-H; Tokhtar, VK. Zur Sociologie von Arten der Gattung *Oenothera* L. im Rheintal von Arnheim (NL) bis Mülhouse (F). *Tuexenia*, 1999 v 19, 447-467.
- Wittig, R; Tokhtar, VK. Die Häufigkeit von *Oenothera*-Arten im westlichen Mitteleuropa. *Feddes Repertorium*, 2003 v 114 no 5-6, 372-379.
- Yurtsev, BA. The study of biological diversity and comparative floristry. *Botanical Magazine*, 1991 v 76 no 3, 305-313. (in Russian).

BIOGRAPHICAL SKETCH

Name: Fedor Lisetskii

Affiliation: The chairmen of the Environmental Management and Land Survey Chair,
The director of the Federal-regional centre of aerospace and surface monitoring of the objects
and natural resources,

Doctor of geography, Professor

Date of Birth: 03.08.1958

Education: Degrees: D.Sc. (Biogeography and Soil Geography), 1994; Ph.D.
(Biogeography and Soil Geography), 1984. All three degrees were received from the Odessa
State University (now - Odessa National University), Ukraine.

Address: Russian Federation, 308015

Belgorod, Pobeda Street, 85

Tel.: 7(4722) 301370

Fax: 7(4722) 301371

E-mail: liset@bsu.edu.ru

Research and Professional Experience:

Institution. Belgorod State University Position, The director of the Federal-regional centre of aerospace and surface monitoring of the objects and natural resources	2006-present
Institution. Belgorod State University Position, The chairmen of the Environmental Management and Land Survey	1998-2010
Institution. Belgorod State University Position, The chief of the department of sciences and research, vice-rector in science	1999-2002
Institution. Belgorod State University Position, vice-director of the institute of natural-sciences problems (Belgorod)	1997-1999
Institution. Odessa State University Position, vice-director of the South centre of agroecology	1994-1995
Institution. Odessa State University Position, researcher	1983-1984

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:

Author, co-author of over 400 publications including 7 books, 40 papers in peer-reviewed journals, and 15 of the objects of intellectual property (databases, computer programs).

Honors:

diploma of the Russian ministry of Education	2013
Expert of the Russian ministry of Education	2011-present
Expert of the Russian Foundation for Basic Research (RFBR)	2011-present
Manager of the year in the nomination "Science"	2008
laureate of National ecological prize	2007
diploma holder of the National Ecological prize "EcoSpace"	2005
Expert of the Institute for Sustainable Communities	2002
Honorary worker of higher professional education of the Russian Federation	2002
diploma of the Russian ministry of Education	2001
full member (academic) of the International Science Academy of ecology and safety of the vital functions	2000
the corresponding member of Petrovskaya Academy of sciences and arts	1999
laureate of the South centre of scientific and technical activity contest, the investigations and social initiatives on the best scientific work in the sphere of ecology	1990

Publications Last 3 Years:*Journal Publications*

- Lisetskii F, Stolba V, Ergina E, Rodionova M, Terekhin E. Post-Agrogenic Evolution of Soils in Ancient Greek Land Use Areas in the Herakleian Peninsula, South-West Crimea. The Holocene. 2013. №4. C. 504-514.
- Lisetskii F. N., Goleusov P. V., Chepelev O. A. The Development of Chernozems on the Dniester–Prut Interfluvium in the Holocene // Eurasian Soil Science, 2013, Vol. 46, No. 5, pp. 491–504. DOI: 10.1134/S1064 229313050086.
- Lisetskii F.N., Pavlyuk Ya.V., Kirilenko Zh.A., Pichura V.I. Basin organization of nature management for solving hydroecological problems // Russian Meteorology and Hydrology. 2014. V. 39. N 8. P. 550-557.
- New opportunities of geoplanning in the rural area with the implementing of geoinformational technologies and remote sensing / Fedor N. Lisetskii, Alla V. Zemlyakova, Edgar A. Terekhin, Anastasiya G. Naroznyaya, Yaroslava V. Pavlyuk, Pavel A. Ukrainskii, Zhanna A. Kirilenko, Olga A. Marinina, Olga M. Samofalova // Advances in Environmental Biology. 2014. Vol. 8. No 10: June. pp. 536-539.
- Lisetskii F.N., Marinina O.A., Jakuschenko D.G. A new approach to dating the fallow lands in old-cultivated areas of the steppe zone // Research Journal of pharmaceutical, biological and chemical sciences. 2014. V. 5. No 6. P. 1325-1330.
- Lisetskii F., Chepelev O. Quantitative substantiation of pedogenesis model key components // Advances in Environmental Biology. 2014. Vol. 8. Number 4: March. pp. 996-1000.

- Lisetskii F. N., Goleusov P. V., Moysiyyenko I. I., Sudnik-Wojcikowska B., Microzonal distribution of soils and plants along the catenas of mound structures // Contemporary Problems of Ecology. 2014. Vol. 7. No. 3. pp. 282–293.
- Goleusov P. V., Lisetsky F. N. Restoration of soil and vegetation cover in post-mining geosystems and their renaturation prospects in the area of the Kursk Magnetic Anomaly Gornyi Zhurnal. 2014. №8. C. 69–74.
- Lisetskii F.N. Utilizzo come naturale antichi modelli di studio carriole pedo-geomorfologico rapporto. Italian Science Review. 2014; 6 (15). PP. 29-33. Available at URL: <http://www.ias-journal.org/archive/2014/june/Lisetskii.pdf>.
- Lisetskii F., Marinina O., Gadzhiev R. Trasformazione biomeccanica del profilo di suoli forestali. Italian Science Review. 2014; 12(21). PP. 134-137. Available at URL: <http://www.ias-journal.org/archive/2014/december/Lisetskii.pdf>.
- Lisetskii, F., Stolba, V.F., Marinina, O. Indicators of agricultural soil genesis under varying conditions of land use, Steppe Crimea (2015) Geoderma, 239-240, pp. 304-316. DOI: 10.1016/j.geoderma.2014.11.006.
- Lisetskii F.N., Pichura V.I., Pavlyuk Y.V., Marinina O.A. Comparative assessment of methods for forecasting river runoff with different conditions of organization // Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2015. Vol. 6. № 4. P. 56-60.
- Yermolaev O.P., Lisetskii F.N., Marinina O.A., Buryak Zh.A. Basin and eco-regional approach to optimize the use of water and land resources // Biosciences, Biotechnology Research Asia, September 2015. Vol. 12(Spl. Edn. 2), p. 145-158.
- Pichura V.I., Pilipenko Yu.V., Lisetskiy F.N., Dovbysh O.E. Forecasting of Hydrochemical Regime of the Lower Dnieper Section using Neurotechnologies // Hydrobiological Journal. 2015. Vol. 51. No 3. pp. 100-110. DOI: 10.1615/HydrobJ.v51.i3.80.
- Lisetskii F. N. and M. E. Rodionova. Transformation of dry-steppe soils under long-term agrogenic impacts in the area of ancient Olbia // Eurasian Soil Science. 2015. Vol. 48. No. 4. pp. 347–358. DOI: 10.1134/S1064229315040055.

Scopus, Author ID: 15731091700

<http://orcid.org/0000-0003-1273-5912>

KD