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Geobotanical study of ruderal vegetation in the geoecological monitoring program of roadside ecosystems of the Cherkasy oblast

Sergiy SONKO[1*] https://orcid.org/0000-0002-7080-9564
Tetiana MAMCHUR[2**] https://orcid.org/0000-0001-9320-814X
Iryna KRAVTSOVA[1***] https://orcid.org/0000-0003-3431-473X
Ivan MOSTOVYAK[3****] https://orcid.org/0000-0003-4585-3480
Yurii KISELOV[4*****] https://orcid.org/0000-0003-0530-1892

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RESEARCH ARTICLE

[1]Uman National University of Horticulture (Uman, Ukraine),
department of Ecology and Life Safety
[2]department of Biology
[3]department of Plant Protection and Quarantine
[4]department of Geodesy, Land management and Cadastre

Correspondence – *sp.sonko@gmail.com; **Mamchur-tv@ukr.net; ***irinakravzova@gmail.com;
****mostovjak@gmail.com; *****kyseljov@ukr.net

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Abstract: The article is devoted to the dynamics of the spread of ruderal vegetation in phytocenoses of the roadside ecosystems of the Cherkasy oblast. Due to the high plowed area of the region, roadside field protection strips, in which, in fact, phytocenoses with the participation of ruderal plants are formed, are mostly very narrow (on average 10–15 m). Such ecotopic limitation creates extremely harsh ecological conditions in which only competitive (and sometimes aggressive) species survive. Unlike most works devoted to the formation of the phytodiversity in roadside phytocenoses, the authors follow the concept of infraecosystems presented in previous publications. The main distinguishing feature of this concept is the assumption of different states of formation of natural ecosystems on roadsides. In particular, by comparing the available phytodiversity in roadside phytocenoses with the «National Catalog of Biotopes», the degree of completeness of ecosystem formation at 19 study sites was assessed. Highways in the meridional (11 polygons) and latitudinal (8 polygons) directions were investigated within the Cherkasy oblast.

Among the investigated phytocenoses at 19 polygons, only 4 phytocenoses, which spatially coincide with gas stations (Esco gas station, exit from the city of Uman, SOCAR gas station, near the village of Sharyn), or with relatively isolated settlements at the exits to the main route (Bilashki village, Rotmistrivka village). Invasive species (more than 10), which take an active part in the formation of the phytodiversity, were also found at all landfills. According to our estimates, the general trend of the formation of roadside ecosystems falls under the principle of Le Chatelier-Brown compensation, according to which the biosphere confirms its extraordinary ability to support life every time. After all, it can reduce, eliminate, and finally nullify any destructive (man-made) impact, filling existing and creating new ecological niches. Such an understanding of the geobotanical component in monitoring studies will help in the future to more correctly determine the role of man and the biosphere in the formation of anthropogenic landscapes, one of the more dynamic varieties of which are roadside landscapes.

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1. INTRODUCTION

Despite the fact that the study of ruderal, in particular, invasive flora is one of the branches of biological research, its study is also one of the directions of anthropogenic landscape science, the modern scientific foundations of which were developed by (Denysyk **1998**). Since anthropogenic changes in one of the components of the landscape lead to changes in the remaining components, the issue of the distribution of invasive species is also a geographical one (Kyselov,Polishchuk **2023**). At the same time, geobotanical studies of ruderal flora in the roadside ecosystems of communication routes in the central regions of Ukraine are at an initial stage, since they are few and narrowly focused (Davydov **2019**; Dziuba et al. **2019**; Osypenko **2013**; Protopopova et al. **2019**; Samoilenko, Osypenko **2019**).

At the Uman National University of Horticulture, such research is actively conducted since the beginning of implementation (in 2009) of the state budget topic «Development of methodological approaches and a practical mechanism of ecologically balanced nature management in the field of agricultural production» (state registration number – 0108U009772). This year, Vladyslav Parakhnenko has already defended his Ph.D. thesis in Earth Sciences, devoted to the invasive flora of railroad tracks in the Kirovohrad oblast.

Considering the ability of groups of ruderal vegetation in the process of their development to gradually change the aboriginal flora, displacing local species, and lead to the destruction of the original coenoses, as well as to transform entire ecosystems due to the presence of transforming species (Yeremenko **2017**) it was decided to investigate its participation in the formation of roadside biocenoses.

However, having «immersed» in the problem, the authors began to find parallels with other, wider methodological aspects. In particular, while developing the concept of noospheric ecosystems in previous works, one of the authors confirmed most of his assumptions during highway monitoring, in particular, using the example of the dynamics of infraecosystems formed in roadside biocenoses with the participation of ruderal vegetation (Sonko **2003**). Despite the obviousness of this opinion, the authors were impressed by the depth of the conclusions of our outstanding compatriot V.I. Vernadsky regarding the spread and omnipresence of life in the entire space of the oecumen.

2. ANALYSIS OF THE LATEST RESEARCH AND PUBLICATIONS

Developing ideas about the role of living matter in the formation of the biosphere, V.I. Vernadsky singled out one of its properties as an opportunity for free movement, thanks to which it is able to fill all possible space around it. This opinion, according to V.P. Kucheriavyi can be extrapolated to the process of formation of ruderal groups occupying almost all biotopes, where natural or not created agrophytocenoses have not formed. And indeed, according to V.I. Vernadsky, the main feature of living matter is the ability to restore and adapt biochemical and energy cycles to its needs. And what is the most important is the extremely large role of the phytocenotic cover in the creation of the humus layer of the soil, as well as in the course of successional processes (Kucheriavyi **2011**).

Therefore, the concept of the noosphere, which is based on the harmonious interaction of humanity and nature, should be taken as a basis for building a system of optimization measures for the benefit of society and the formation of a culture of tireless use of nature in general (Yeremenko **2017**).

According to many estimates, most species of ruderal flora are highly aggressive along with typical invasive species (Zavialova et al. **2021**). This extremely bright phenomenon, against the background of the insufficient study of the problem of the spread of invasive and ruderal flora, prompted the development of appropriate classifications not only of the plants themselves, but

also of their biotopes (Kuzemko et al. **2018**). It was the presence of such the catalogue that prompted us to include in the monitoring research program a comparison of the available observed plants with those «fixed» in the «Catalogue...» to certain biotopes.

In domestic botanical studios, a number of researchers note a certain list of problems mainly of a methodological nature. According to N.S. Yeremenko's works in the phytocenotic direction, as well as in the floristic direction, are fragmentary in nature. They were held in the central, western and southern regions. In particular, the author notes the lack of generalizing works for the entire territory of Ukraine, which would give a complete picture of the current state, syntaxonomy, structure, territorial differentiation, stages and nature of the transformation of ruderal vegetation (Yeremenko **2017**).

The discussion regarding the possibility (or impossibility) of compiling such classifications remains unfinished due to the high variability and dynamics of the species composition of ruderal coenoses. The issues of approximation of the classification to the natural one, which would reflect real changes in the composition of groups on the gradients of the ecotopes and successions, remain unresolved (Solomakha **2008**).

Since there is no single approach to the classification of ruderal vegetation, the authors use different methods. In particular, the presence of invasive species in the coenoses of ruderal vegetation is considered by some authors as a temporary phenomenon. These groups are distinguished as variants of associations formed by species of aboriginal flora (Matuszkiewicz **2001**). Others consider them diagnostic (Abduloieva, Karpenko **2009**). The place of certain associations in the syntaxonomic hierarchy remains a debatable issue, in particular *Arction lappae, Chenopodion rubri (Tx. 1960) Hilbig et Jage* 1972 and some others.

According to N.S. Yeremenko, the peculiarities of the genesis and structure of ruderal vegetation (spatial unevenness, variegation) make it difficult to diagnose its syntaxons. The lack of connections between ruderal species requires the use of descriptions of ruderal phytocenoses with large samples in the work.

There is also the problem of determining identical conditions of local growth (Solomakha **2008**).

Therefore, in the study of the ruderal vegetation of Ukraine, the primary tasks are the development of a syntaxonomy, the comparative structural analysis of coenoflora, the study of the dynamics of ruderal groups and the peculiarities of their territorial differentiation, and the development of typological schemes. The status of invasive species in coenoses of ruderal vegetation remains a matter of discussion (Yeremenko **2017**).

When conducting geobotanical studies, geographers state that the issues of geospatial distribution of adventitious flora in certain regions of Ukraine are poorly studied. Thus, although the spread of invasive species in the western and eastern regions has been satisfactorily studied, this cannot yet be said for the central and southern regions of our country (Kyselov, Polishchuk **2023**)

3. METHODOLOGY AND METHODS OF RESEARCH

Without resorting to detailing the methodology, actually, of geobotanical research from the above review of related works, we deliberately miss the problems of classification, syntaxonomy, and other specific aspects of such research. Monitoring studies of roadside biocenoses were carried out in accordance with a previously prepared program. The main theoretical basis of the research was the concept of noospheric ecosystems. It examines the evolution of the noospheric development of mankind, the main spatial consequence of which is the formation of three groups of elements of the territorial structure. These three groups form a modified ecological niche of our species. In particular, three types of noosphere ecosystems are distinguished – agroecosystems (planar, areal), urboecosystems (central, nodal) and infraecosystems (linear, network), which have all the features of

an ecosystem and are in complex interdependent relationships (Sonko **2019**). Thus, considering infraecosystems as part of the ecological niche of Homo Sapiens, we preserve the ecosystem essence of all road landscapes, since their artificial nature largely depends on man, who initially forms ecotopes of the ruderal flora.

Therefore, road landscapes (according to modern classification we will consider them as infraecosystems (from the term «infrastructure») according to the concept of noospheric ecosystems (Denysyk, Valchuk-Orkusha **2017**).

The main direction of the research is to determine the dynamics and directions of development of infraecosystems, namely: how significantly infraecosystems (in particular, the Vinnytsia-Cherkasy and Kyiv-Odesa routes within the oblast) differ from the natural ecosystems of this area based on the assessment of soil composition, hydrological regime, phyto- and zoodiversity, dustiness, noise pollution, radiation background, etc.; and how the infraecosystem adapts to the conditions of anthropogenic influence through a change in the species composition of plants and animals, the formation of new trophic relationships, etc.

Highways in the meridional (11 polygons) and latitudinal (8 polygons) directions were investigated within the Cherkasy oblast.

In the meridional direction, a route was worked out (advancing by car) from the city of Uman to the south to the border of the Cherkasy oblast («Batkivska Khata») and in the reverse direction to the borders with the Kyiv oblast (beyond the town of Zhashkiv), followed by a Uman turn and advance to the city of Uman. A total of 11 stops were made for the relevant measurements and sampling. Stops were made at branching points of side roads adjacent to the main road in order to move sideways (to the right or left) for a distance of up to 50 m in order to determine the degree of change in ecosystem relations as distance from the main road.

In the latitudinal direction, the route from the village was worked out. Sychivka (on the border with Vinnytsia oblast) to the east to the city of Cherkasy and in the opposite direction to the city of Uman. All landfills were chosen taking into account the current state of the environment of the Cherkasy oblast (Rehionalnyi zvit … **2022**).

At each training ground:

– fixation of geographical coordinates;
– measurement of the radiation background with the TERRA-P dosimeter;
– photographing flora and fauna right next to the road surface and 25-30 meters from it (Nikon 5000 camera);
– sampling of soil directly near the road surface and 25 meters from it (1 kg per bag) followed by chemical analysis (at 4 key test sites);
– noise level measurement (Benetech GM1351);
– fixing the number of vehicles;
– measurement of dustiness (sawmill PM2.5 Walcom SR-516A logger).

Based on this, plant species were verified in accordance with the rules of modern botanical nomenclature (Plants of the World Online) (POWO 2023) (Plants of the World Online 2023).

4. RESULTS AND DISCUSSION

As a result of the conducted monitoring studies, the current state of the infra-ecosystems of the main highways of the Cherkasy oblast was established.

Kyiv-Odesa highway:

In total, we discovered more than 85 species of ruderal plants (exact calculation of cereal plants in the lower tier was not carried out due to their large number, as well as self-sowing fruit trees). The most common types of plants (by frequency) along the Kyiv–Odesa highway were:

Achillea millefolium L. – 7; *Anthriscus cerefolium* (L.) Hoffm. – 11; *Arctium lappa* L. – 5; *Artemisia absinthium* L., *A. vulgaris* L. – 21; *Ballota nigra* L. – 7; *Cichorium intybus* L. – 8; *Chenopodium album* L. – 6; *Cirsium arvense* (L.) Scop. – 19; *Convolvulus arvensis* L. – 5; *Crepis tectorum* L. – 7; *Daucus carota* L. – 7; *Echium vulgare* L. – 7; *Elymus repens* (L.) Gould – 10; *Falcaria vulgaris* Bernh. – 5; *Hypericum perforatum* L. – 8; *Onopordum acanthium* L. – 17; *Poa trivialis* L. – 4; *Verbascum phlomoides* L. – 5; *V. Thapsus* L. – 4; *Conium maculatum* L. – 4.

The following invasive plants are found on roadsides: *Acer negundo* L. – 10; *Ambrosia artemisiifolia* L. – 3; *Centaurea stoebe* L. – 5; *Cyclachaena xanthiifolia* (Nutt.) Fresen. – 1; *Erigeron annuus* (L.) Desf – 11; *E. Canadensis* L. – 15; *Elaeagnus angustifolia* L. – 1; *Grindelia squarrosa* (Pursh) Dunal – 7; *Solidago canadensis* L. – 1; *Robinia pseudoacacia* L. – 1; *Ulmus pumila* L. – 10.

A comparison of the identified plant species with species from the «National Catalogue...» showed that the largest number of coincidences is inherent in those phytocenoses in which the total number of ruderal plant species is higher *(Fig. 1)*.

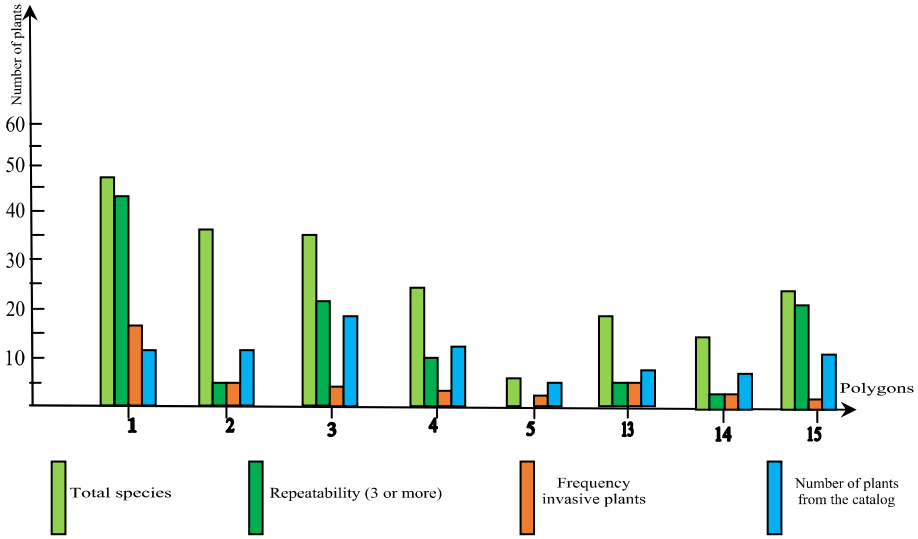


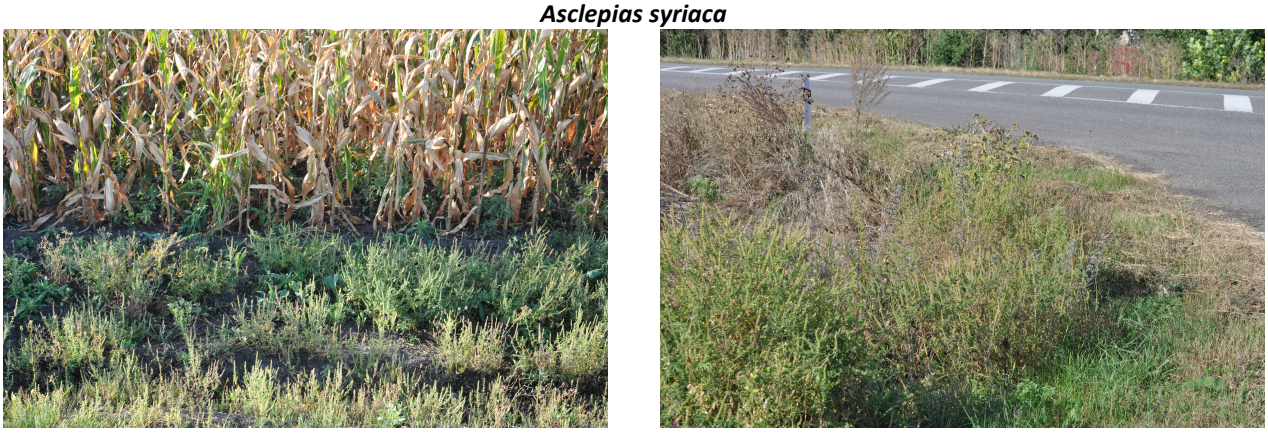
Fig. 1. Characterization of the degree of completeness of the formation of ecosystems on the roadside of the Kyiv-Odesa highway

Vinnytsia-Cherkasy highway:

In total, we discovered more than 100 species of ruderal plants (except cereals and self-seeded fruit trees). The most common types of plants (by frequency) along the Vinnytsia-Cherkasy highway were: *Acer campestre* L. – 11, *A. negundo* L. – 9, *Achillea millefolium* L. – 25, *Anthriscus cerefolium* (L.) Hoffm. – 6, *Ambrosia artemisiifolia* L. – 12, *Arctium lappa* L. – 12, *Artemisia absinthium* L. – 28, *A. vulgaris* L. – 6, *Asclepias syriaca* L. – 7 *(Fig. 2)*, *Ballota nigra* L. – 38, *Carduus acanthoides* L. – 17, *Centaurea stoebe* L. – 2, *Cichorium intybus* L. – 7, *Cirsium arvense* (L.) Scop. – 17, *Crepis tectorum* L. – 6, *Daucus carota* L. – 5, *Echium vulgare* L. – 5, *Elymus repens* (L.) Gould – 8, *Erigeron annuus* (L.) Desf – 26, *Fraxinus excelsior* L. – 8, *Heracleum sosnowskyi* Manden. – 1, *Lactuca serriola* L. – 5, *Linaria vulgaris* Mill – 24, *Lotus corniculatus* L. – 5, *Phragmites australis* (Cav.) Trin. Ex Steud. – 1, *Robinia pseudoacacia* L. – 1, *Sonchus arvensis* L. – 8, *Trifolium pratense* L. – 5, *Ulmus laevis* – 11.

The following invasive plants are found on roadsides: *Ambrosia artemisiifolia* – 12, *Asclepias syriaca* – 7, *Centaurea stoebe* – 2, *Elaeagnus angustifolia* – 1. *Erigeron annuus* – 26, *Heracleum sosnowskyi* – 1, *Phragmites australis* – 1, *Robinia pseudoacacia* – 1, *Ulmus pumila* – 11.

Asclepias syriaca



Ambrosia artemisiifolia

Fig. 2. Phytocoenoses with the participation of invasive species

Monitoring of the roadside ecosystems of Cherkasy oblast for the presence of ruderal plants was carried out, four wild introduced species – *Acer negundo, Asclepias syriaca, Robinia pseudoacacia, Solidago canadensis,* which are harmful, were found in the natural communities. They require the adoption of permanent measures to contain the consequences, spread and fight against them (Chorna, Mamchur **2020**).

A comparison of the identified plant species with species from the «National Catalogue...» showed that, just as on the Kyiv–Odesa route, the largest number of coincidences is characteristic of those phytocenoses in which the total number of ruderal plant species is higher *(Fig. 3)*.

5. CONCLUSIONS

1. The monitoring study of infra-ecosystems of the longest highways of the Cherkasy oblast allows us to draw the main conclusion about the existence of ecosystem relations developed to varying degrees in their different sections, since more than 120 species of the ruderal plants participate in their formation. Probably, the youth, maturity, old age and climactic state of such ecosystems depends both on the age of their existence and on the intensity of anthropogenic influence.

2. Among the investigated phytocenoses at 19 polygons, only 4 phytocenoses were found to have the greatest degree of completeness of formation, which spatially coincide with gas stations (Esco gas station, exit from the city of Uman, SOCAR gas station, near the village of Sharyn) or with relatively isolated settlements at the exit points to the main road (Bilashki village, Rotmistrivka village).

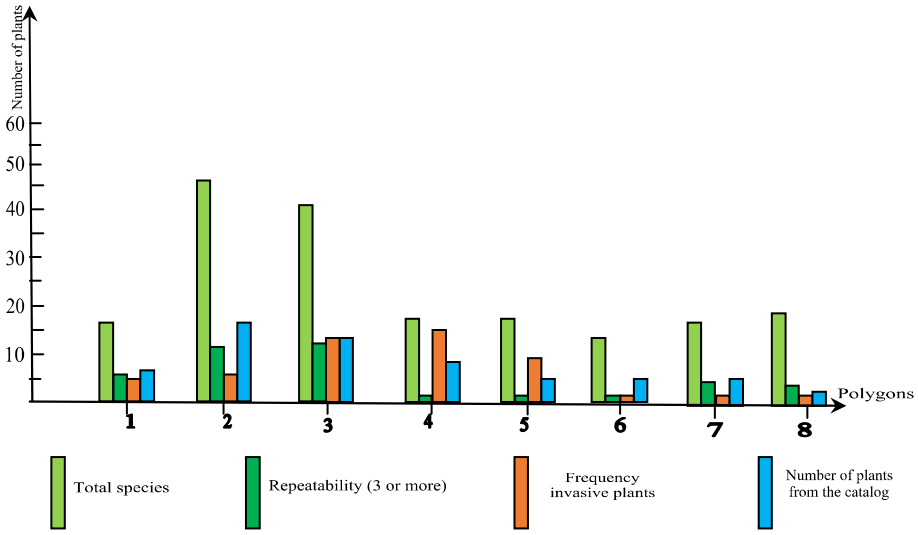


Fig. 3. Characterization of the degree of completeness of the formation of ecosystems on the side of the highway Vinnytsia–Cherkasy

3. Invasive species (more than 10) that take an active part in the formation of the phytodiversity were also found at all landfills: herbaceous plants – *Apiaceae: Heracleum sosnowskyi* – 1; *Asclepiadaceae: Asclepias syriaca* – 7; *Asteraceae: Ambrosia artemisiifolia* – 15, *Centaurea stoebe* – 7, *Cyclachaena xanthiifolia* – 1, *Erigeron annuus* – 37, *E. Canadensis* – 35, *Grindelia squarrosa* – 7, *Solidago Canadensis* – 1; *Poaceae: Phragmites australis* – 1; *woody plants – Elaeagnaceae: Elaeagnus angustifolia* – 2; *Sapindaceae: Acer negundo – 1*0; *Fabaceae: Robinia pseudoacacia* – 2; *Ulmaceae: Ulmus pumila* – 21.

4. According to our estimates, the general trend in the formation of roadside ecosystems falls under the principle of Le Chatelier-Brown compensation, according to which the biosphere confirms its extraordinary ability to support life every time. After all, it can reduce, eliminate, and finally nullify any destructive (man-made) impact, filling existing and creating new ecological niches.

Such an understanding of the geobotanical component in monitoring studies will help in the future to more correctly determine the role of man and the biosphere in the formation of anthropogenic landscapes, one of the more dynamic varieties of which are roadside landscapes.

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С. Сонько, Т. Мамчур, І. Кравцова, І. Мостов'як, Ю. Кисельов

Геоботанічне вивчення рудеральної рослинності у програмі геоекологічного моніторингу придорожніх екосистем Черкаської області

Ключові слова: рудеральні рослини, інфраекосистема, фітоценоз, інвазійні види.

Анотація: Стаття присвячена динаміці розповсюдження рудеральної рослинності у фітоценозах придорожніх екосистем Черкаської області. На відміну від більшості робіт, присвячених формуванню фіторізноманіття у придорожніх фітоценозах, автори дотримуються концепції інфраекосистем, головною відмінною рисою якої є припущення про різні стани сформованості природних екосистем на придорожніх смугах. Зокрема, шляхом порівняння наявного фіторізноманіття у придорожніх фітоценозах з «Національним каталогом біотопів» оцінено ступінь завершеності формування екосистем на 19 полігонах.

Серед досліджених найбільший ступінь завершеності формування виявили всього 4 фітоценози, які просторово збігаються з АЗС (АЗС Esco, виїзд з м. Умань, АЗС SOCAR, біля с. Шарин) або ж з відносно ізольованими населеними пунктами у місцях виїзду на головну трасу (с. Білашки, с. Ротмістрівка). На усіх полігонах були також виявлені інвазійні види (понад 10), які беруть активну участь у формуванні фіторізноманіття. За нашими оцінками загальний тренд формування придорожніх екосистем підпадає під принцип компенсації Ле-Шательє-Брауна, згідно якому біосфера щораз підтверджує свою надзвичайну здатність до підтримки життя. Таке розуміння геоботанічної складової у моніторингових дослідженнях допоможе в подальшому більш коректно визначити роль людини і біосфери у формуванні антропогенних ландшафтів, одним з динамічніших різновидів яких є придорожні ландшафти.

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