Hacquetia DOI: 10.3986/hacq-2025-0015 sciendo

Vegetation map of the nature reserve Mykhailivska Tsilyna (Ukraine)

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Key words: vegetation map, steppe vegetation, vegetation dynamics, problems of strict protection regime in the steppe.

Ključne besede: vegetacijska karta, stepska vegetacija, vegetacijska dinamika, težave strogega varstva v stepi.

Abstract

The nature reserve Mykhailivska Tsilyna is located in Sumy region, in the northern part of Forest-Steppe zone of Ukraine. The area of virgin northern meadow-steppe is protected there. A new, large-scale vegetation map (scale 1:10000) of the reserve (the first one in its new borders) had been created. The main units of mapping are complexes of plant communities in ranks of associations, subassociations and variants. In total, 27 such complexes and 10 units of another rank have been identified. The map shows vegetation cover changes over a period of strict protection (2011–2023). The most common classes of vegetation in the reserve are: *Molinio-Arrhenatheretea*, *Artemisietea vulgaris* and *Festuco-Brometea*. Main changes in the vegetation cover of the reserve's old territory are manifested in the form of steppe transformation: from meadow-steppe areas to more mesic shrub-steppe with dominating *Cytisus ruthenicus* and forb communities with dominating *Euphorbia semivillosa*. In these communities can be seen a decrease in the share of tussock grasses and an increase in the share of rhizomatous grasses. The same process is occurring in the reserve's new territory, but phytocenoses are different there.

Izvleček

Naravni rezervat Mykhailivska Tsilyna se nahaja v regiji Sumy v severnem delu gozdno-stepskega območja Ukrajine. Območje nedotaknjene severne travniške stepe je tam zavarovano. Izdelana je bila nova vegetacijska karta rezervata v velikem merilu (merilo 1:10000) (prva znotraj novih meja). Glavne enote kartiranja so kompleksi rastlinskih združb na nivoju asociacij, subasociacij in variant. Skupaj je bilo identificiranih 27 takšnih kompleksov in 10 enot drugih rangov. Zemljevid prikazuje spremembe vegetacije v obdobju strogega varstva (2011–2023). Najpogostejši razredi vegetacije v rezervatu so: *Molinio-Arrhenatheretea*, *Artemisietea vulgaris* in *Festuco-Brometea*. Glavne spremembe v vegetaciji starega ozemlja rezervata se kažejo v obliki preobrazbe stepe: od travniško-stepskih območij do bolj mezičnih grmičasto-stepskih s prevladujočo vrsto *Cytisus ruthenicus* in travniškimi združbami s prevladujočo vrsto *Euphorbia semivillosa*. V teh združbah je opaziti zmanjševanje deleža šopastih trav in povečanje deleža trav z živicami. Enak proces se dogaja na novem ozemlju rezervata, vendar so tam fitocenoze drugačne.

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Received: 2. 4. 2023
Accepted: 20. 1. 2025

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Introduction

Vegetation mapping is the one of the most important methods for studying vegetation. It gives us an opportunity to find out a current state of a vegetation. This is necessary for the right management of phytosystems (plant component of ecosystems) in protected areas, e.g. for conservation regimes development and for correction of it. Vegetation mapping is also important for long-term research of vegetation dynamics, which are regularly taking place on the base of nature reserves. To study vegetation dynamics a series of vegetation maps (with long time interval between them) is being made. In this way a vegetation dynamics was studying from 1957 in the nature reserve Mykhailivska Tsilyna. Since then, 7 serial mappings were made: 1957, 1963, 1971, 1981, 1991, 2001, 2011 (Bilyk, 1957; Sarycheva, 1966; Bilyk & Tkachenko, 1973; Tkachenko, 1984; Tkachenko et al., 1993, Tkachenko et al., 2003, Tkachenko & Fitsailo, 2016). During the mapping the state of "periodically mown steppe" (hereafter referred to as PMS) and "strictly protected steppe" (hereafter referred to as SPS) were compared. According to the result of the mapping, a conclusion about the course of succession was made and conservation regime was corrected, if it was necessary.

Nowadays, geobotanical mapping is carried out using classical field methods and relatively new methods of remote sensing (Leprieur et al., 2000; Laris, 2005; Akasheh et al., 2008; Mehrabian et al., 2009; Malatesta et al., 2013; Pedrotti, 2013; Rapinel et al., 2014; Davydova, 2022) or their combination.

In 2022–2023, I performed the eighth mapping of the reserve. The research on the one hand repeats the previous one, but on the other hand, it has some differences. All previous maps of the reserve's vegetation were made using the dominant species approach, when current map is based on the Braun-Blanquet approach (Braun-Blanquet, 1964). This map is also the first in the reserve, made with the use of GIS methods (in QGIS 3.22.9. software). But, the novelty of the presented material is not only in the changed methodology of mapping and classification of vegetation, and simple continuation of long term study of the vegetation dynamics, but also in the significantly enlarged mapping area. Current map covers not only old territory (202.5 ha of virgin land) of the reserve, as the previous maps, but also the new territory (680.4 ha of different age fallows, 1–20-year-old), which was included into the reserve in 2018 and now mapped for the first time. Thus, current map is also the basis for further studies of restorative successions towards the formation of a secondary steppe virgin lands in the new territory of the reserve. Another difference is that the most part of PMS is under the regime of strict protection during the last 11 years (2011–2022). It gives us an opportunity to study the changes of steppe vegetation cover in the form of mesophytization there (see below).

Before considering the results of last vegetation mapping of Mykhailivska Tsilyna, it is important to understand properly the causes of already mentioned process of mesophytization and its effect on the vegetation cover of the reserve.

Mykhailivska Tsilyna is a compact area of a virgin steppe, which occupies "isolated" position in the north-eastern part of Forest-Steppe zone of Ukraine and is located to the north of all other Ukrainian steppes. A level of humidity in the reserve is too high for steppe vegetation. V.V. Osychniuk (1979) pointed out, that tussock grasses under excessive humidity produce an excessive biomass, which is laid as a thick layer of steppe litter, that covers a soil. Rhizomatous grasses, that mainly reproduce vegetatively have advantages in this case and tussock grasses are disappearing gradually from the herbage, and a steppe is transforming into a meadow (Osychniuk, 1979). It is worth to note, that thick layer of litter increases humidity of soil additionally. This process of succession, if humidity is sufficient, would go further to shrub and tree communities, until the typical forest for this region will be formed. This is the essence of the process of mesophytization.

Serial mappings 1957–2011 (Bilyk, 1957; Sarycheva, 1966; Bilyk & Tkachenko, 1973; Tkachenko, 1984; Tkachenko et al., 1993; Tkachenko et al., 2003; Tkachenko & Fitsailo, 2016) fully confirmed existence of this process. As a conclusion, the authors pointed, that an absence of forest in Mykhailivska Tsilyna was a result of the external effects, steppe phytocenoses were called "exogenously stabilized" and the process of forming xeromorphic phytocenoses was designated artificial (Tkachenko, 2005; Tkachenko & Fitsailo, 2016). Negative effects of mesophytization are expressed quantitatively in form of dominance changes (Tkachenko & Fitsailo, 2016); decreasing of species number per unit of area (Bilyk & Tkachenko, 1972; Tkachenko et al., 1993; Rodinka & Shevchenko, 2014), changes of ratio between herbaceous vegetation (xerophytic and mesophytic) and tree and shrub vegetation (Tkachenko & Boichenko, 2015), and in synphytoindication indexes, that for 95 years (1927 – 2022) slowly change toward mesic habitats. Synphytoindication indexes (according to Ya.P. Didukh scale (Didukh, 2011)) were calculated for the reserve's plant communities by V.S. Tkachenko with co-authors (Tkachenko et al., 1993), by H.M. Lysenko (Lysenko, 2009) and by the author of this paper in 2022 (Larionov, 2024a) (see Table 1 and below).

Table 1: Changes of synphytoindication indexes (according to Ya. P. Didukh scale) of plant communities in the old territory of the reserve Mykhailivska Tsilyna during 95 years.

Tabela 1: Spremembe sinfitoindikacijskih indeksov (po lestvici Ya. P. Didukha) rastlinskih združb na starem ozemlju rezervata Mykhailivska Tsilyna v 95 letih**.**

Author	V. S. Tkachenko, H. M. Lysenko & A. P. Vakal							H. M. Lysenko			M. S. Larionov	
Year	1927	1971			1991			2003			2022	
Index	Mean	Mean	PMS	SPS	Mean	PMS	SPS	Mean	Min	Max	AFLs	EMS
Hd	8.90 ± 0.14	9.60 ± 0.60	9.60 ± 0.21	9.70 ± 0.24	10.11 ± 0.65	9.92 ± 0.15	10.23 ± 0.29	10.18	9.02	12.6	9.85 ± 0.04	10.04 ± 0.03
Rc	8.66 ± 0.21	8.27 ± 0.22	8.25 ± 0.09	8.23 ± 0.08	7.90 ± 0.24	7.99 ± 0.05	7.82 ± 0.11	8.23	7.26	8.65	8.47 ± 0.02	8.33 ± 0.02
Nt	4.36 ± 0.18	4.71 ± 0.40	4.72 ± 0.15	4.76 ± 0.13	5.04 ± 0.38	4.90 ± 0.09	5.12 ± 0.18	6.25	4.87	7.64	5.64 ± 0.03	5.88 ± 0.02
Sl	8.43 ± 0.24	8.25 ± 0.20	8.20 ± 0.06	8.36 ± 0.07	8.00 ± 0.22	7.99 ± 0.05	8.07 ± 0.06	-	-	-	8.18 ± 0.03	8.20 ± 0.03
Tm	8.82 ± 0.09	8.65 ± 0.20	8.64 ± 0.06	8.57 ± 0.07	8.40 ± 0.17	8.51 ± 0.06	8.44 ± 0.05	7.06	6.2	7.93	8.76 ± 0.02	8.70 ± 0.2
Regime	NR, mow. + gra.	mow. + strict	mow.	strict	mow. + strict	mow.	strict	mow. + strict	-	-	mow.	strict

Remark: Mean – mean value in the reserve, PMS – mean value in "periodically mown steppe", SPS – mean value in "strictly protected steppe" (strictly protected area from 1947 to the present), AFLs – mean value in mown "anti-fire lines" (territory of PMS, that still mown), EMS – mean value in "earlier mown steppe" (territory of PMS strictly reserved from 2011), Regime – regime of reservation, NR – not reserved, mow. – mowing, gra. – grazing, strict – strictly protected, Hd – soil humidity, Rc – soil acidity, Nt – nitrogen content in the soil, Sl – salt regime, Tm – thermal climate.

Opomba: Mean – srednja vrednost v rezervatu, PMS – srednja vrednost v »občasno pokošeni stepi«, SPS – srednja vrednost v »strogo zavarovani stepi« (strogo zavarovano območje od leta 1947 do danes), AFLs – srednja vrednost v pokošenih »protipožarnih pasovih" (ozemlje PMS, ki je še pokošeno), EMS – srednja vrednost v "prej košeni stepi" (ozemlje PMS strogo zavarovano od 2011), Režim – režim zavarovanja, NR – ni zavarovano, mow. – košnja, gra. – paša, strict – strogo zavarovane, Hd – vlažnost tal, Rc – kislost tal, Nt – vsebnost dušika v tleh, Sl –režim slanosti, Tm – toplota podnebja

In short, it can be seen, that mean values of soil humidity (Hd) were constantly increasing in period 1927 – 2003, but that increasing was faster in areas under strict protection and slower in mown areas, showing a positive effect of mowing. Increase in Hd led to changes in other indexes. It can be seen, that mean speed of increasing values of Hd was constantly growing until 1991 (from 0.16 per 10 years (in the period 1927–1971) to 0.26 units per 10 years (in the period 1971–1991), then the speed was slowing to 0.07 units per 10 years in 1991–2003). Slowdown of increasing Hd values coincides with the change of the regime of mowing in 1998 (from 1 year of mowing and 1 year of strict protection to 4 years of mowing and 1 year of strict protection) (Tkachenko et al., 2003). In AFLs, mowing takes place every year. The value of Hd in 2022 (Hd = 9.85, that lower than it was in 1991) showed positive effect of using this regime of mowing there. The value of Hd in EMS (Hd = 10.04, that greater than Hd in AFLs to 0.19 units) showed negative effect of 11 years (2011–2022) of strict protection there. All of the above manifested also in the form of vegetation changes (see below).

Summarized information about changes in abundance of dominant species of the reserve during all history of observation (Lavrevko & Zoz, 1928; Bilyk, 1957; Tkachenko & Fitsailo, 2016) is given in the Table 2.

Table 2: Changes in abundance of dominant species in the reserve Mykhailivska Tsilyna during the period 1927 – 2011 under different regimes of preservation.
Tabela 2: Spremembe abundance dominantnih vrst v rezervatu Mykhailivska Tsilyna v obdobju 1927–2011 v različnih režimih ohranjanja.

Not reserved	Periodically mown steppe					
1927	1956	1971	1981	1991	2001	2011
Festuca stricta subsp. *sulcata* (dom.), *Agrostis vinealis*, *Carex humilis*	*F. stricta* subsp. *sulcata* (dom.), *Stipa capillata* (dom.), *Bromopsis inermis* (>), *Calamagrostis epigejos* (>)	*B. inermis* (dom.), *C. epigejos* (>) tussock grasses (<) *Poa angustifolia* (<)	*Elytrigia repens* (>), *Cytisus ruthenicus* (>) *B. inermis* (<) *C. epigejos* (<) tussock grasses (<)	*C. ruthenicus* (dom.), *E. repens* (>) *P. angustifolia* (<)	*Arrhenatherum elatius* (dom.), *C. ruthenicus* (<), *E. repens* (>) *P. angustifolia* (>)	*A. elatius* (dom.), *E. repens* (<), tussock grasses (>)
non-controlled mow. & gra.	mow. 1 time per 5 years	mow. 1 time per 4 years	mow. 1 time per 3 years	mow. 1 time per 2 years	mow. 4 times per 5 years	
	Strictly protected steppe					
	1956	1971	1981	1991	2001	2011
	B. inermis (dom.), tussock grasses	*B. inermis* (dom.), *C. epigejos* (>), *P angustifolia* (>), tussock grasses (<)	*B. inermis* (dom.), E. repens (>), *P. angustifolia* (<), tussock grasses (<)	*E. repens* (dom.), mesic forb species (>), *B. inermis* (<)	*Urtica dioica* (dom.), *E. repens* (<), *C. ruthenicus* (>)	*U. dioica* (<), *E. repens* (<), *C. ruthenicus* (<) *C. epigejos* (>), *Prunus spinosa* (>)

Remark: dom. – main dominant, mow. – mowing, gra. – grazing, > – increasing of area, < – decreasing of area.
Opomba: dom. – glavna dominantna, mow. – košnja, gra. – paša, > – povečanje površine, < – zmanjšanje površine.

From Table 2 can be seen, that the plant communities, initially the same, went in two different directions of succession under the influence of two different preservation regimes. Vegetation in periodically mown steppe changed from xerophytic tussock grass communities to mesic rhizomatous grass communities and then, under pressure of the intensive mowing, succession went again toward tussock grass communities (in 2011 intermediate communities with domination of *Arrhenatherum elatius*, which include both rhizomatous and tussock grass, were formed). Vegetation in strictly protected steppe changed from xerophytic tussock grass communities to mesic rhizomatous grass communities and then, through complexes of rhizomatous grass and mesic forb communities with domination of *Urtica dioica*, to forest tree and shrub communities (in 2011 tree and shrub communities, mainly with the domination of *Prunus spinosa*, occupied 13.01 ha) (Lavrevko & Zoz, 1928; Bilyk, 1957; Tkachenko & Fitsailo, 2016).

The changes of ratio between herbaceous vegetation (xerophytic (X) and mesophytic (M)) and tree and shrub (TS) vegetation during the period (1971–2011) on the example of 46 ha of strictly protected steppe in Mykhailivska Tsilyna is also very revealing: 1971 (X=14.8%, M=83.2%, TS=0.1%); 1981 (X=1.8%, M=92.8%, TS=5.3%); 1991 (X=0.2%, M=92.3%, TS=7.7%); 2001 (X=0.1%, M=79.6%, TS=20.3%); 2011 (X=0.0%, M=71.4%, TS=28.5%) (Tkachenko & Boichenko, 2015). Thus, strict protection led to full disappearance of xerophytic component of plant communities on SPS.

Changes of plant species number per unit of area in the herbaceous communities of the reserve has been well documented: in 1971 31–90 species per 100 m^2 (Bilyk & Tkachenko, 1972), in 1991 up to 48 (Tkachenko et al, 1993), in 2008 in PMS 32–51, in SPS 15–27 (Rodinka & Shevchenko, 2014). That is correlated with Table 1. So, increasing of humidity level lead to species number decreasing.

Thus, the only way to preserve valuable steppe areas in this reserve is to extract excess plant biomass naturally or anthropogenically way to slow down mesophytization. That can be achieved by grazing of ungulates, periodical mechanized mowing or early-spring controlled burning. All these methods took place during 95 years of reservation and helped to slow down the mesophytization (Bilyk, 1957; Sarycheva, 1966; Bilyk & Tkachenko, 1973; Tkachenko, 1984; Tkachenko et al., 1993; Tkachenko et al., 2003; Tkachenko & Fitsailo, 2016; Larionov, 2022a; Larionov, 2022b).

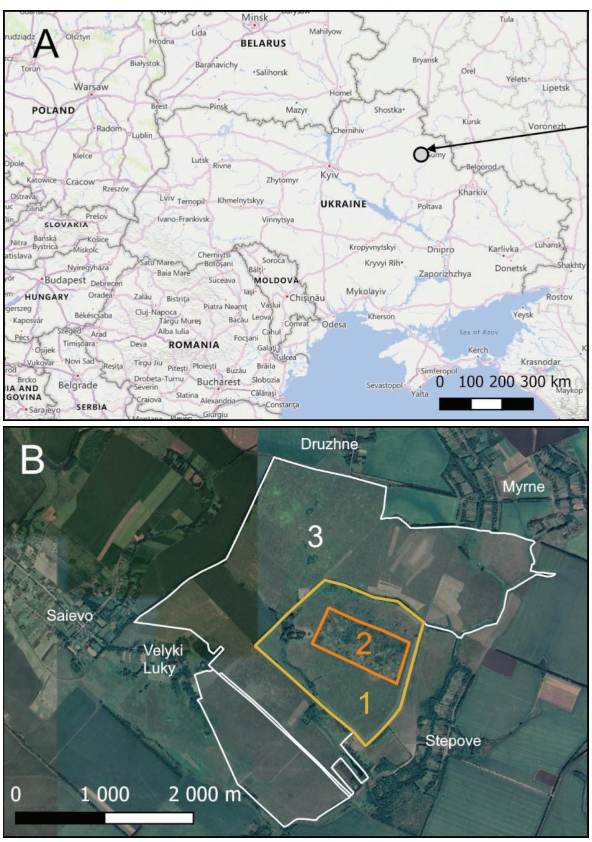
That is why, respectively to the above mentioned, all negative changes in vegetation cover of the reserve's old territory can be associated with abandonment of systematic mechanized mowing in the reserve's greater part, where now anti-fire lines are the last periodically mown areas.

Aim of the work: to conduct mapping of the current state of vegetation in the nature reserve Mykhailivska Tsilyna, to identify changes in vegetation and to assess their nature in the old territory of the reserve, to assess a state of vegetation in the fallow lands of different ages during the first mapping of the new territory of the reserve, and to identify a mechanism of succession of the fallow lands.

Materials and methods

Study area

The nature reserve Mykhailivska Tsilyna is located in Sumy region in the northern part of Forest-Steppe zone of Ukraine. The area of virgin meadow-steppe is protected here. The reserve has an area of 882.9 ha and consists of 2 parts: 1) "old territory" (hereafter referred to as OT) – 202.5 ha of virgin land included into the reserve in 1928; 2) "new territory" (hereafter referred to as NT) – 680.4 ha of different aged fallows (1-, 10-, 15-, 20-years-old) and gullies, which was included in the reserve in 2018. In OT, there is an area of about 46 ha, that was strictly protected from 1947 – "strictly protected steppe" (hereafter referred to as SPS) (Larionov, 2022a; Tkachenko, 2005) (see Figure 1).



Territory of the reserve is situated in Okhtyrsko-Sumskyi spur of Central Russian Upland. It is a wide hill, which gradually lowers in the southwest direction. Territory of the reserve is cut with long gullies. A lot of shallow circular depressions with diameter of 5–30 m and 1–2 m in depth also add variety to the relief of the reserve (Bilyk, 1957; Sarycheva, 1966; Hetman, 2018). The height above sea level varies from 197.1 m to 145.5 m. The gully "Verhni stavky" goes from north and northwest to southeast and has a pond in the end in Stepove village. The gully "Hosudareva hreblia" goes from north to south and to southwest, in its upper third part and lower part there are two small ponds also. There are also some smaller gullies without specific names.

The climate of the region is temperate continental. An average annual temperature is +6.5 °C, an average temperature of June is +19.9 °C, an average temperature of January is -6.4 °C. In spring and in summer, northwestern winds prevail, in autumn and in winter the southern and southwestern winds. The amount of rainfall is 500–550 mm per year (Bilyk, 1957). In eight years of observation carried out by Z.A. Sarycheva in the period 1957–1964, an average amount of rainfall was 498.9 mm per year (Sarycheva, 1966). Thus, precipitation of the region is high enough to support tree, shrub and herbaceous vegetation growth (Bilyk, 1957).

The soil cover of the reserve is represented by deep and superdeep chernozems with medium humus content on loess and loess-like loam parent materials, which include 3–5% of carbonates. In the gullies, there are meadow-chernozem soils with distinct gleying. Humus content in soils of the virgin land steppe is about 6–7%, soils of the gullies contain up to 12% of humus. Humus horizon of soils in the reserve is thick (sometimes up to 150 cm) (Sarycheva, 1966; Project… , 2021).

Figure 1: Map of study area: A – position in Europe; B – schematic map of the nature reserve "Mykhailivska Tsilyna": 1 – "old territory" of the reserve, 2 – "strictly protected steppe", 3 – "new territory" of the reserve.

Slika 1: Zemljevid raziskovanega območja: A – položaj v Evropi; B – shematski zemljevid naravnega rezervata "Mykhailivska Tsilyna": 1 - "staro ozemlje" rezervata, 2 - "strogo zaščitena stepa", 3 - "novo ozemlje" rezervata.

Methodology

Mapping. In order to study the modern differentiation of plant communities in the reserve, the large-scale vegetation map (scale 1:10000) has been made. Mapping was carried out with the use of free software package QGIS 3.22.9 (QGIS Development Team, 2022). In this paper, the map is presented in scale 1:35000 for convenience. Mapping work consists of following stages (Pedrotti, 2013; Davydova, 2022): 1) field data collecting; 2) field data processing; 3) the map legend development; 4) binding the raster base (in form of Sentinel satellite image (2022) to Google satellite image; 5) transferring the boundaries of plant communities from raster base to the map; 6) putting the dots with coordinates of vegetation plots on the base-map to clarify the form and positions of polygons; 7) analysis of spatial differentiation of syntaxa; 8) binding of the raster image of the previous map (2011) of the reserve (Tkachenko & Fitsailo, 2016); 9) comparison of the new map with the old one. For simplicity of orientation, a part of polygons had been numbered.

The complexes of plant communities with rank of associations, subassociations and variants were selected as the units of the map legend. The criterion for selecting these ranks for mapping was a reflection of the existent structure of vegetation and the scale of the map, that give an opportunity to use such level of details. Such approach is widely used in vegetation mapping (Hanganu et al., 2002).

The more detailed methodology of mapping is explained below. To obtain primary data about spatial differentiation of the plant communities, the reserve territory was surveyed on foot (first of all through ecological-phytocenotic profiles) with the printed satellite image and GPS-navigator with Google satellite map. Plant communities were matched with sites on this image and the position was checked with GPS-navigator regularly. The sites were circled, numbered and described, obtaining the so-called pre-map. Then, according to the results of the vegetation classification, small sites on the pre-map were combined into larger ones and the legend was compiled. Using QGIS software, these sites were manually transferred to the map and colored in accordance with the legend. Two satellite images were used as a background for mapping: Sentinel-2 (mainly for herbaceous vegetation) and Google (mainly for tree and shrub vegetation, which were visible there better). Main cause to use Sentinel-2 image was an absence of new Google satellite image for the study territory (newest one at the moment of mapping was dated in 2018).

Field data collecting (full vegetation plot records with coordinates collecting and ecological-phytocenotic profiling) was carried out in the period of 2021 – 2023. In total 811 vegetation plot records had been done and 3 ecological-phytocenotic profiles had been made. Ecological-phytocenotic profiling was carried out using a total station. During profiling the milestones (poles 2.5 m height) were installed every 250 m, coordinates of the milestones were collected. These milestones and their coordinates will help the researchers, who will carry out re-profiling or will study vegetation dynamics in the future in this reserve. The size of vegetation plots was 25 m^2 for herbaceous vegetation (10 m^2 – for wet meadows in the gullies), 100 m^2 for shrub and tree vegetation. Projective cover was determined by B.M. Mirkin scale: “+” – <1%, “1” – 1 – 5%, “2” – 6 – 15%, “3” – 16 – 25%, “4” – 26 – 50%, “5” – >50% (Mirkin et al., 2001).

Data processing. Vegetation plot records were entered into Turboveg database management system (Hennekens & Schaminee, 2001) and then were processed via Juice 7.1 software (Tichý, 2002). To identify vegetation units, a modified TWINSPAN cluster analysis algorithm (Roleček et al., 2009) with three pseudospecies cut-off levels (0, 5, 25%) was used. Whittaker’s beta was used as a measure of cluster heterogeneity (Whittaker, 1972). The structure of clusters was analyzed according to diagnostic, constant and dominant species. The phi-coefficient was used as a diagnostic parameter (Chytrý et al., 2002). Its threshold value was taken at the level of 0.25, those in which this coefficient exceeded 0.5 were considered as highly diagnostic species. Species with unreliable diagnostic value based on Fisher’s exact test ($P < 0.01$) were discarded. Species with a frequency of more than 30% were defined as constant, and with a frequency of more than 50% – as highly constant. The threshold value of the projective cover to recognize the species as dominant was taken at the level of 25%. To determine vegetation units, the obtained clusters were compared by the composition of diagnostic species with syntaxa described in the “Prodrome of the Vegetation of Ukraine” (Dubyna et al., 2019). The nomenclature of syntaxa is given according to the “Prodrome of the Vegetation of Ukraine” (Dubyna et al., 2019), in controversial issues, preference was given to the nomenclature according to Mucina et al. (2016). Vegetation of the forest belts had been classified on the basis of work I.V. Solomakha and V.L. Shevchyk (Solomakha & Shevchyk, 2020). Plant names had been given in accordance with The Euro+Med PlantBase (The Euro+Med PlantBase accessed in 15 October 2024).

Results

The classification scheme (listed below) was compiled on the base of the results of an analysis of a sample of 811 author’s vegetation plot records in Juice software (see above). In this work the scheme is presented only as the basis, on which the map legend was built (for understanding the origin of the plant community complexes listed in the legend). Part of this scheme (Cl. *Festuco-Brometea*) and more detailed analysis of it have already been published (Larionov, 2024a), the full results of the vegetation classification are given in the unpublished PhD thesis (Larionov, 2024b). They will be published in the future in other papers.

Hierarchical classification scheme of the vegetation of the nature reserve Mykhailivska Tsilyna

Cl.: *FESTUCO-BROMETEA* BR.-BL. ET TX. EX SOÓ 1947
Ord.: *Festucetalia valesiacae* Soó 1947
All.: *Festucion valesiacae* Klika 1931
Ass.: *Carici humilis-Stipetum pennatae* Tkachenko, Movchan et Solomakha 1987
Var.: *Vincetoxicum hirundinaria*
Var.: *Euphorbia semivillosa*
Ass.: *Carici humilis-Stipetum capillatae* Tkachenko, Movchan et Solomakha 1987
Ass.: *Salvio pratensis-Poetum angustifoliae* Korotchenko et Didukh 1997
Subass.: *knautietosum arvensi* subass. nova prov.
Subass.: *primuletosum veri* subass. nova prov.
Ass.: *Thymo marschalliani-Caricetum praecocis* Korotchenko et Didukh 1997
Cl.: *MOLINIO-ARRHENATHERETEA* TX. 1937
Ord.: *Galietalia veri* Mirkin et Naumova 1986
All.: *Agrostion vinealis* Sipaylova et al. 1985
Ass.: *Poëtum angustifoliae* Shelyag-Sosonko et al. 1986
Subass.: *typicum*
Var.: *typica*
Var.: *Arrhenatherum elatius*
Var.: *Equisetum arvense*
Var.: *Schedonorus pratensis*
Var.: *Fragaria viridis*
Var.: *Poa pratensis*
Subass.: *stipetosum pennati*
Cl.: *TRIFOLIO-GERANIETEA SANGUINEI* T. MÜLLER 1962
Ord.: *Antherico ramosi-Geranietalia sanguinei* Julve ex Dengler in Dengler et al. 2003
All.: *Geranion sanguinei* Tx. in T. Müller 1962
Ass.: *Origano-Vincetoxicetum hirundinariae* Kolbek et Petříček ex Wojterska 2003
Var. Euphorbia semivillosa
Var. Bromopsis inermis
Var. *Inula salicina*
Cl.: *PHRAGMITO-MAGNOCARICETEA* KLIKA IN KLIKA ET NOVÁK 1941
Ord.: *Phragmitetalia* Koch 1926
All.: *Phragmition communis* Koch 1926
Ass.: *Phragmitetum australis* Savič 1926
Var. *Filipendula ulmaria*
Comm. *Typha angustifolia*
Comm. *Typha latifolia*
Comm. *Schoenoplectus lacustris*
Cl.: *POTAMOGETONETEA* KLIKA IN KLIKA ET NOVÁK 1941
Ord.: *Potamogetonetalia* Koch 1926
All.: *Ceratophyllion demersi* Den Hartog et Segal ex Passarge 1996
Comm. *Ceratophyllum demersum*
Comm. *Stuckenia pectinata*
Comm. *Potamogeton lucens*
Cl.: *LEMNETEA* O. DE BOLÒS ET MASCLANS 1955
Ord.: *Lemnetalia minoris* O. de Bolòs et Masclans 1955
All.: *Lemnion minoris* O. de Bolòs et Masclans 1955
Comm. *Lemna minor*
Comm. *Lemna trisulca*
Comm. *Spirodela polyrhiza*
Cl.: *ARTEMISIETEA VULGARIS* LOHMEYER ET AL. IN TX. EX VON ROCHOW 1951
Ord.: *Agropyretalia intermedio-repentis* T. Müller et Görs 1969
All.: *Convolvulo arvensis-Agropyrion repentis* Görs 1967
Ass.: *Calamagrostietum epigei* Kostylev in Solomakha et al. 1992
Var. *typica*
Var. *Solidago canadensis*
Comm. *Solidago canadensis*
Ass.: *Agropyretum repentis* Felföldy 1942
Var.: *typica*
Var.: *Arrhenatherum elatius*
Var.: *Hieracium virosum*
Ord.: *Onopordetalia acanthii* Br.-Bl. et Tx. ex Klika et Hadač 1944
All.: *Arction lappae* Tx. 1937
Ass.: *Arctietum lappae* Felföldy 1942
Var.: *Urtica dioica*
All.: *Dauco-Melilotion* Görs et Rostański et Gutte 1967
Ass.: *Melilotetum albo-officinalis* Sissingh 1950
All.: *Onopordion acanthii* Br.-Bl. et al. 1936
Ass.: *Carduo acanthoidis-Onopordetum acanthii* Soó ex Jarolímek et al. 1997
Var.: *Cynoglossum officinale*

Cl.: *STELLARIETEA MEDIAE* TX. ET AL. IN TX. 1950
Ord.: *Atriplici-Chenopodietalia albi* (Tx. 1937) Nordhagen 1940
All.: *Panico-Setarion* Sissingh in Westhoff et al. 1946
Ass.: *Echinochloo-Setarietum pumilae* Felföldy 1942 corr. Mucina
Ord.: *Sisymbrietalia sophiae* J. Tx. ex Görs 1966
All.: *Atriplicion* Passarge 1978
Ass.: *Atriplicetum nitentis* Slavnić 1951

Cl.: *RHAMNO-PRUNETEA* RIVAS GODAY ET BORJA CARBONELL EX TX. 1962
Ord.: *Prunetalia spinosae* Tx. 1952
All.: *Prunion spinosae* Soó (1931) 1940
Ass.: *Prunetum spinosae* Tx. 1952

Cl.: *ROBINIETEA* JURKO EX HADAČ ET SOFRON 1980
Ord.: *Chelidonio-Robinietalia pseudoacaciae* Jurko ex Hadač et Sofron 1980
All.: *Geo-Acerion platanoidis* L. Ishbirdina et A. Ishbirdin 1991
Ass.: *Geo urbano-Fraxinetum* I. Solomakha et Shevchyk 2020

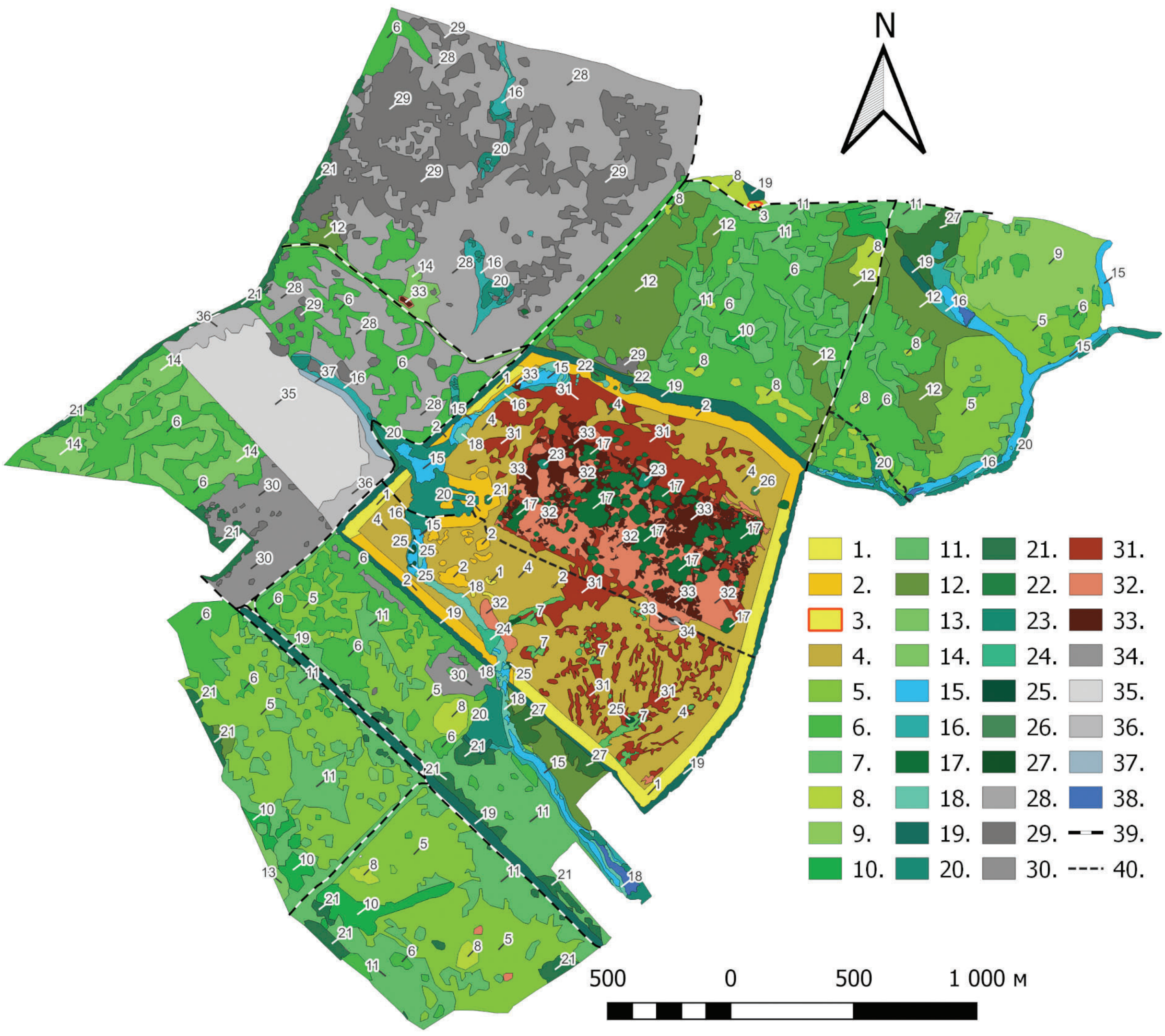


Figure 2: Vegetation map of the nature reserve Mykhailivska Tsilyna based on the research data (2021–2023).
Slika 2: Vegetacijska karta naravnega rezervata Mihailivska Tsilina narejena na podlagi raziskav v letih 2021–2023.

Legend of the map

I Steppe vegetation:

1. Complex with prevalence of the phytocenoses *Carici humilis-Stipetum capillatae* var. *Arrhenatherum elatius*, *Carici humilis-Stipetum pennatae* var. *Arrhenatherum elatius*, with an admixture of *Salvio pratensis-Poetum angustifoliae knautietosum arvensi*;
2. Complex with prevalence of the phytocenoses *Salvio pratensis-Poetum angustifoliae knautietosum arvensi*;
3. Complex with prevalence of the phytocenoses *Thymo marshchaliani-Caricetum praecocis* var. *Fragaria viridis*;
4. Complex with prevalence of the phytocenoses *Carici humilis-Stipetum pennatae* var. *Vincetoxicum hirundinaria* and *Salvio pratensis-Poetum angustifoliae primuletosum veri*, with an admixture of *Origano-Vincetoxicetum hirundinariae, Calamagrostietum epigei* var. *Cytisus ruthenicus, Carici humilis-Stipetum capillatae* var. *Cytisus ruthenicus.*

II Meadow vegetation:

5. Complex with prevalence of the phytocenoses *Poëtum angustifoliae* var. *typica*, with an admixture of *Poëtum angustifoliae* var. *Fragaria viridis*, single exemplars or thickets of *Fraxinus pennsylvanica*, *Acer negundo*, *Pyrus communis*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
6. Complex with prevalence of the phytocenoses *Poëtum angustifoliae var. Arrhenatherum elatius*, with an admixture of *Agropyretum repentis*, *Poëtum angustifoliae* var. *Fragaria viridis*, single exemplars or thickets of *Fraxinus pennsylvanica*, *Acer negundo*, *Pyrus communis*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
7. Complex with prevalence of the phytocenoses *Origano-Vincetoxicetum hirundinariae,* with an admixture of *Calamagrostietum epigei*;
8. Complex with prevalence of the phytocenoses *Poëtum angustifoliae stipetosum pennati*, *Poetum angustifoliae* var. *Fragaria viridis*, *Agropyretum repentis*, single exemplars or thickets of *Fraxinus pennsylvanica*, *Acer negundo*, *Pyrus communis*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
9. Complex with prevalence of the phytocenoses *Festuco valesiacae-Poetum angustifoliae* var. *Trifolium arvense* and *Poëtum angustifoliae*;
10. Complex with prevalence of the phytocenoses *Poëtum angustifoliae* var. *Equisetum arvense*, with an admixture of *Poëtum angustifoliae* var. *Schedonorus pratensis*, single exemplars or thickets of *Fraxinus pennsylvanica*, *Acer negundo*, *Pyrus communis*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
11. Complex with prevalence of the phytocenoses *Poëtum angustifoliae var. typica*, *Agropyretum repentis* var. *typica*, with an admixture of: *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *Fragaria viridis* and var. *Schedonorus pratensis*, *Melilotetum albo-officinalis*, *Agropyretum repentis* var. *Hieracium virosum*, single exemplars or thickets of *Fraxinus pennsylvanica, Acer negundo, Pyrus communis, Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
12. Complex with prevalence of the phytocenoses *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *typica* and var. *Fragaria viridis,* with an admixture of *Calamagrostietum epigei*, *Agropyretum repentis*, *Carduo acanthoidis-Onopordetum acanthii*, single exemplars or thickets of *Fraxinus pennsylvanica, Acer negundo, Pyrus communis, Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
13. Complex with prevalence of the phytocenoses *Poëtum angustifoliae* var. *Schedonorus pratensis* and var. *Tussilago farfara*;
14. Complex with prevalence of the phytocenoses *Poëtum angustifoliae* var. *Arrhenatherum elatius*, with an admixture of *Poëtum angustifoliae* var. *Fragaria viridis*, *Agropyretum repentis* var. *Arrhenatherum elatius*, *Calamagrostietum epigei*, *Melilotetum albo-officinalis* and *Carduo acanthoidis-Onopordetum acanthii*, single exemplars or thickets of *Fraxinus pennsylvanica, Acer negundo, Pyrus communis, Malus pumila*, *M. sylvestris* subsp. *praecox, Elaeagnus angustifolia* etc.;
15. Complex with prevalence of the phytocenoses *Phragmitetum australis* var. *Filipendula ulmaria*.
16. Complex of the communities *Lysimachia vulgaris*, *Urtica dioica*, *Cirsium arvense*, *Phragmites australis.*

III Shrub and tree vegetation:

17. Complex of the communities *Prunetum spinosae*, with an admixture of single exemplars and thickets of *Rhamnus cathartica*, *Sambucus racemosa*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Pyrus communis*, *Acer negundo*, *Acer tataricum*, *Rosa villosa*, *R. canina*, *R. corymbifera*;
18. Thickets of *Salix cinerea*;
19. Forest-belts and its fragments, which consist of complexes with prevalence of the phytocenoses *Geo urbano-Fraxinetum*, with an admixture of single exemplars and thickets of *Populus nigra*, *Robinia pseudoacacia*, *Tilia cordata*, *Gleditsia triacanthos*, *Acer tataricum*, *Pyrus communis*, *Prunus spinosa*, *Salix cinerea*, *Cornus*

sanguinea, *Elaeagnus angustifolia*, *Rosa canina*, *R. villosa*, *Ptelea trifoliata*, *Crataegus monogyna*;

20. Semi-natural forest stands of *Salix alba*, *S. viminalis*, *Populus nigra*, with an admixture of *Salix cinerea*, *Acer saccharinum*, *Fraxinus excelsior*, *F. pennsylvanica*, *Sambucus sp.*, *Prunus spinosa* and *Cornus sanguinea* (on the old territory of the reserve around the dried up ponds and the old homestead);
21. Thickets of *Acer negundo*, *Fraxinus pennsylvanica*, sometimes with an admixture of *Elaeagnus angustifolia* and *Robinia pseudoacacia*;
22. Thickets of *Fraxinus excelsior*;
23. Thickets of *Ulmus minor* and *U. laevis*;
24. Thickets of *Betula pendula*, with an admixture of *Salix cinerea*;
25. Thickets of *Sambucus nigra* and *S. racemosa*;
26. Thickets of *Cornus sanguinea*;
27. Thickets of *Pyrus communis*, with an admixture of *Malus pumila*, *M. sylvestris subsp. praecox*, *Prunus spinosa*.

IV Ruderal and forb vegetation:

28. Complex with prevalence of the phytocenoses *Calamagrostietum epigei*, with an admixture of *Poëtum angustifoliae* and *Agropyretum repentis*, clumps of *Prunus spinosa* and single exemplars and thickets of *Acer negundo*, *Fraxinus pennsylvanica*, *Pyrus communis, Malus pumila*, *M. sylvestris subsp. praecox*, *Elaeagnus angustifolia*;
29. Complex with prevalence of the phytocenoses *Calamagrostietum epigei* var. *Solidago canadensis*, with an admixture of clumps of *Prunus spinosa*, single exemplars and thickets of *Acer negundo*, *Fraxinus pennsylvanica*, *Pyrus communis, Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
30. Complex with prevalence of the phytocenoses *Calamagrostietum epigei*, with an admixture of *Melilotetum albo-officinalis*, *Carduo acanthoidis-Onopordetum acanthii*, Calamagrostietum epigei var. *Fragaria viridis*, single exemplars of *Acer negundo*, *Fraxinus pennsylvanica*, *Pyrus communis, Malus pumila*, *M. sylvestris* subsp. *praecox*, *Elaeagnus angustifolia* etc.;
31. Complex with prevalence of the phytocenoses *Carici humilis-Stipetum pennatae* var. *Euphorbia semivillosa*, with an admixture of *Cytisus ruthenicus*; or (in more wet conditions) *Origano-Vincetoxicetum hirundinariae* var. *Euphorbia semivillosa* and var. *Inula salicina*, with an admixture of *Calamagrostietum epigei*;
32. Complex with prevalence of the phytocenoses *Origano-Vincetoxicetum hirundinariae* var. *Bromopsis inermis* and *Calamagrostietum epigei*;
33. Complex with prevalence of the phytocenoses *Arctietum lappae* var. *Urtica dioica*;
34. Complex with prevalence of the phytocenoses *Convolvulo-Brometum inermis* var. *Astragalus cicer*;
35. Complexes: 2022 (1-st year of succession) – with prevalence of the phytocenoses *Echinochloo-Setarietum pumilae* and with an admixture of *Atriplicetum nitentis*; 2023 (2-nd year of succession) – with prevalence of the intermediate ruderal phytocenoses of alliances *Convolvulo arvensis-Agropyretum repentis* and *Arction lappae*, with domination of *Solidago canadensis* and with admixture of *Calamagrostis epigejos*.
36. Complexes: 2022 (1-st year of succession) – with prevalence of the phytocenoses *Echinochloo-Setarietum pumilae,* with an admixture of *Atriplicetum nitentis* and seedlings of *Fraxinus pennsylvanica* and *Acer negundo*; 2023 (2-nd year of succession) – with the prevalence of the intermediate ruderal phytocenoses of alliances *Convolvulo arvensis-Agropyretum repentis* and *Arction lappae*, with domination of *Solidago canadensis* and with an admixture of *Calamagrostis epigejos*, seedlings and juvenile exemplars of *Fraxinus pennsylvanica* and *Acer negundo.*
37. Complexes: 2022 (1-st year of succession) – with prevalence of the phytocenoses *Echinochloo-Setarietum pumilae* and with an admixture of *Atriplicetum nitentis*, *Equisetum arvense* L. and seedlings of *Fraxinus pennsylvanica* and *Acer negundo*; 2023 (2-nd year of succession) – with the prevalence of the intermediate ruderal phytocenoses of alliances *Convolvulo arvensis-Agropyretum repentis* and *Arction lappae*, with domination of *Solidago canadensis* and with an admixture of *Calamagrostis epigejos*, *Equisetum arvense*, seedlings and juvenile exemplars of *Fraxinus pennsylvanica* and *Acer negundo,*

V *Additional designations:*

38. Ponds;
39. Dirt roads;
40. Pathways.

Modern spatial differentiation of the reserve's vegetation

As already mentioned, the reserve consists of two territories: the old one (OT) and the new one (NT). The soil cover of OT and NT is the same, but the soils of OT (virgin land part) are more deep and more humus-rich (Bezrodnova & Loza, 2006). There are some smaller areas with different vegetation cover in OT: 1) periodically mown anti-fire lines (hereafter referred to as AFLs), 2) earlier mown steppe (hereafter referred to as EMS), which was not mown from 2011 till current time, 3) strict protected steppe (SPS), 4) gullies and dried-up ponds, 5) former homestead, 6) forest-belts. In NT there are some smaller areas also: 1) 1-year-old fallow, 2) 2-year-old fallow, 3) 10-year-old fallow, 4) 15-year-old fallows, 5) 20-year-old fallows, 6) gullies, 7) forest-belts. The main factors determining the nature of the vegetation of these areas are: the regime of reservation, the duration of absence of agricultural activity in the territory and the features of mesorelief.

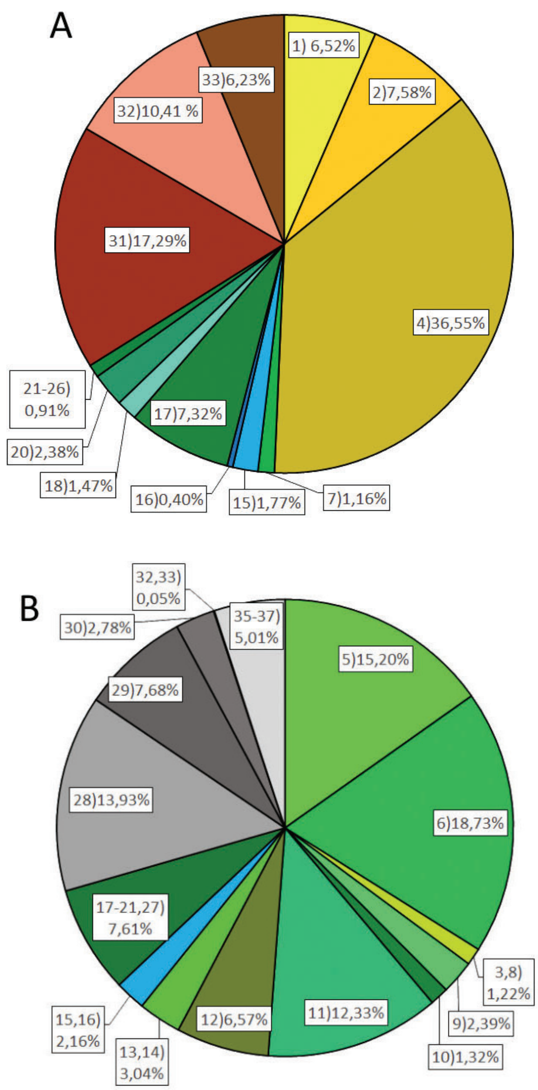


Figure 3: Percentage ratio between the areas occupied by the main complexes of phytocenoses of the reserve Mykhailivska Tsilyna.
Remarks: A – old territory of the reserve (OT), B – new territory of the reserve (NT), the number(s) in brackets – the number(s) of the complex(es) in the map legend listed above.

Slika 3: Razmerje v odsotkih med površinami, ki jih pokrivajo glavni kompleksi fitocenoz v rezervatu Mykhailivska Tsilyna.
Opombe: A – staro ozemlje rezervata (OT), B – novo ozemlje rezervata (NT), številka(-e) v oklepaju – številka(-e) kompleksa(-ov) v zgoraj navedeni legendi karte.

Calculations of areas occupied by the complexes shown on Figure 3 were made with QGIS tools on the basis of the vegetation map. The diagrams in the Figure 3 show, that the vegetation of OT consists mainly of significantly mesophytized steppe (in total – 50.65%: shrub-steppe – 36.55% and meadow-steppe – 14.10%) as well as forb and ruderal – 33.93%, tree and shrub – 12.08% and meadow – 3.33% complexes. In OT the most common complex of shrub-steppe vegetation is *Carici humilis-Stipetum pennatae* var. *Vincetoxicum hirundinaria* and *Salvio pratensis-Poetum angustifoliae primuletosum veri*, with an admixture of *Origano-Vincetoxicetum hirundinariae, Calamagrostietum epigei* var. *Cytisus ruthenicus, Carici humilis-Stipetum capillatae* var. *Cytisus ruthenicus*; of meadow vegetation – *Phragmitetum australis* var. *Filipendula ulmaria*; of forb vegetation - *Carici humilis-Stipetum pennatae* var. *Euphorbia semivillosa*, *Origano-Vincetoxicetum hirundinariae* var.. *Euphorbia semivillosa* and var. *Inula salicina*, with an admixture of *Calamagrostietum epigei*; of ruderal vegetation – *Arctietum lappae* var. *Urtica dioica*; of tree and shrub vegetation – *Prunetum spinosae*, with an admixture of single exemplars and thickets of *Rhamnus cathartica*, *Sambucus racemosa*, *Malus pumila*, *Pyrus communis*, *Acer negundo*, *Acer tataricum*, *Rosa villosa*, *R. canina*, *R. corymbifera*. The vegetation of NT consists mainly of meadow complexes (62.96%: mesic meadows – 57.19%, xerophytic – 3.61%, wet – 2.16%), as well as ruderal – 29.45% and tree and shrub – 7.61% complexes. In NT, among meadow vegetation, the most common are complexes: *Poëtum angustifoliae* var. *typica*, with an admixture of *Poëtum angustifoliae* var. *Fragaria viridis*; *Poëtum angustifoliae* var. *Arrhenatherum elatius*, with an admixture of *Agropyretum repentis*, *Poëtum angustifoliae* var. *Fragaria viridis*, among ruderal – *Calamagrostietum epigei*, among tree and shrub vegetation – forest belts complexes and the thickets of *Acer negundo*, *Fraxinus pennsylvanica*, sometimes with an admixture of *Elaeagnus angustifolia* and *Robinia pseudoacacia*. More detailed information is given below.

Characteristic of the vegetation of the reserve's OT

Steppe communities are concentrated in AFLs and EMS, meadow ones – in depressions of EMS and in gullies, shrub and tree ones – in SPS and in forest-belts, ruderal and forb ones – in SPS (ubiquitous) and in EMS (mostly in depressions).

Vegetation of AFLs. AFLs surround EMS around the perimeter. In AFLs mesophytized meadow-steppe vegetation is growing. In the part of AFLs, which is mown every year, the complex with prevalence of the phytocenoses

Carici humilis-Stipetum capillatae var. *Arrhenatherum elatius*, *Carici humilis-Stipetum pennatae* var. *Arrhenatherum elatius*, with an admixture of *Salvio pratensis-Poetum angustifoliae knautietosum arvensi* is growing. Phytocenoses of *Carici humilis-Stipetum capillatae* var. *Arrhenatherum elatius* are more common in southeast part of AFLs. The complex with prevalence of phytocenoses *Salvio pratensis-Poetum angustifoliae knautietosum arvensi* are more common in a part of AFLs, which is mown less often. Large share of rhizomatous grasses (*Arrhenatherum elatius*, *Elytrigia repens*, *Poa angustifolia*, *Elytrigia intermedia*, *Bromopsis inermis*, *Calamagrostis epigejos*) presents in these phytocenoses usually. They are dominant or subdominant often there. Diagnostic species (*Stipa pennata*, *S. capillata*, *Festuca valesiaca*, *Carex humilis, Salvia pratensis*, *Phlomis tuberosa* etc.) participate always in these communities, but their projective cover varies widely. Many other forb species occur there also. There are also a small quantity of shrubs (*Cytisus ruthenicus* and *C. austriacus*) depressed by mowing. The litter layer is thin or almost absent. These phytocenoses are transitional between shrub-steppe communities of EMS and typical meadow steppe ones. There is inverse proportional relationship between intensity of mowing and rhizomatous grasses and shrubs participation. Meadow-steppe communities of AFLs have the highest species richness in the reserve (up to 37 species per 25 m^2, 20–30 species per 25 m^2 on average) and highest conservation value.

Vegetation of EMS. EMS is the biggest part of OT. Mesophytized shrub-steppe, forb, ruderal and meadow vegetation grow in EMS.

Shrub-steppe communities occupy a greater part of EMS. They are represented by mesophytized complex with prevalence of the phytocenoses *Carici humilis-Stipetum pennatae* var. *Vincetoxicum hirundinaria* and *Salvio pratensis-Poetum angustifoliae primuletosum veri*, with an admixture of *Origano-Vincetoxicetum hirundinariae, Calamagrostietum epigei* var. *Cytisus ruthenicus, Carici humilis-Stipetum capillatae* var. *Cytisus ruthenicus.* Their species composition is the same to meadow-steppe phytocenoses of AFLs, but *Cytisus ruthenicucus* dominates, sometimes with an admixture of *C. austriacus,* or more often co-dominate with rhizomatous grasses (*Elytrigia repens*, *Arrhenatherum elatius*, *Bromopsis inermis*, *Calamagrostis epigejos*). Tussock grasses (*Stipa pennata*, *S. capillata*, *Festuca valesiaca*), *Poa angustifolia* and *Carex humilis* present mostly as an admixture. There are also a lot of forb species common for mentioned associations. An admixture of *Euphorbia semivillosa* is often presents here. The species richness of EMS phytocenoses is lower than in previous area (usually it does not exceed 30 species per 25 m^2, 15–17 species on average). The thickness of litter layer is up to 10–15 cm and more. The average projective cover is 90–100%. These phytocenoses are on the edge of full transformation into rhizomatous-grass-shrub communities, then – into phytocenoses the same to those in SPS (see below). That is indicated by significant distribution of meadow and edge forest species (*Stachys officinalis*, *Origanum vulgare*, *Arrhenatherum elatius* etc.) and of *Elytrigia repens*. To prevent the above mentioned, the plant communities of EMS require systematic mowing or its combination with moderate grazing.

Ruderal vegetation of EMS consists of the complexes with prevalence of the phytocenoses: *Arctietum lappae* var. *Urtica dioica.* Ruderal plant communities are common in EMS depressions, and parts located nearby to SPS.

Forb vegetation of the EMS consists of the complexes with prevalence of the phytocenoses: 1) *Carici humilis-Stipetum pennatae* var. *Euphorbia semivillosa*, with an admixture of *Cytisus ruthenicus*; or (in more wet conditions) *Origano-Vincetoxicetum hirundinariae* var. *Euphorbia semivillosa* and var. *Inula salicina*, with an admixture of *Calamagrostietum epigei*; 2) *Origano-Vincetoxicetum hirundinariae* var. *Bromopsis inermis* and *Calamagrostietum epigei.* Forb vegetation is common for depressions of EMS. But, in particular, phytocenoses with domination of *Euphorbia semivillosa* are actively spreading beyond their boundaries due to mesophytization. Phytocenoses with domination of *Euphorbia semivillosa* are the richest from them (up to 20 and sometimes more species per 25 m^2). In these phytocenoses rhizomatous grasses (*Calamagrostis epigejos*, *Elytrigia repens*) are co-dominants with *Euphorbia semivillosa*, often with a large admixture of: *Cytisus ruthenicus, Inula salicina*, *Bromopsis inermis, Poa angustifolia* etc. In these communities the total projective cover is 90–100%. The thickness of litter layer is 7–20 cm (in dependence mainly from projective cover of *Calamagrostis epigejos*).

Single trees and shrubs, and their groups (*Pyrus communis*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Prunus spinosa*, *Cornus sanguinea*, *Sambucus nigra*, *S. racemosa*, *Rosa pomifera*, *R. canina*, *R. corymbifera*, *Crataegus monogyna*) are also common in EMS.

Vegetation of SPS. SPS is the most mesophytized part of OT (with an exclusion of gullies and ponds). Shrub, tree, forb and ruderal vegetation grows here.

Shrub and tree vegetation of SPS is mainly represented by a complex with prevalence of the phytocenoses *Prunetum spinosae*, with an admixture of single exemplars and thickets of *Rhamnus cathartica*, *Sambucus racemosa*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Pyrus communis*, *Acer negundo*, *Acer tataricum*, *Rosa villosa*, *R. canina*, *R. corymbifera*; significant thickets of *Ulmus minor*, *U. leavis*, *Sambucus nigra*, *S. racemosa* and *Cornus sanguinea* present there also. Shrub and tree communities of SPS are species-poor, with an average species richness of 7 species per 100 m^2. The total projective cover is 100%, the litter layer is mainly about 5 cm. Herbaceous layer is usually slightly expressed, especially in the phytocenoses of *Prunetum spinosae.*

Ruderal vegetation of SPS is represented by the complex with prevalence of the phytocenoses *Arctietum lappae* var. *Urtica dioica.* Ruderal communities of SPS are species-poor with species richness up to 10 species per 25 m^2. The total projective cover is 90–100%, the thickness of litter is from insignificant – under almost pure thickets of *Urtica dioica* to 20 cm and more – when *Urtica dioica* is an admixture and rhizomatous grasses (*Elytrigia repens, Calamagrostis epigejos, Bromopsis inermis*) are dominants. A feature of ruderal communities of SPS is that, they were formed in the process of 75-year reserve-induced succession from plain steppe plots and they are quite stable.

Forb vegetation of SPS is represented by the complexes with prevalence of phytocenoses: 1) *Origano-Vincetoxicetum hirundinariae* var. *Bromopsis inermis* and *Calamagrostietum epigei* (this complex occupies the largest area among herbaceous vegetation of SPS); 2) *Origano-Vincetoxicetum hirundinariae* var. *Euphorbia semivillosa* and var. *Inula salicina*, with an admixture of *Calamagrostietum epigei*. In these communities forb species (*Euphorbia semivillosa*, *Inula salicina*, *Urtica dioica*) and rhizomatous grasses (*Elytrigia repens, Bromopsis inermis, Calamagrostis epigejos*) co-dominate, an admixture consists of *Poa angustifolia* and some forb species (*Galium verum*, *Trifolium alpestre*, *Leonurus quinquelobatus*, *Bunias orientalis*, *Convolvulus arvensis*, *Iris aphylla*, *Vincetoxicum hirundinaria*, *Cirsium arvense*, *Stachys officinalis* etc.). Forb communities of SPS are species-poor with species richness of 8–16 species (average 10 species) per 25 m^2. The total projective cover is 90–100%, the thickness of litter is 5–20 cm (and sometimes more under *Calamagrostis epigejos*).

Vegetation of the gullies, former ponds and former homestead. This area is occupied by hygrophytic and hygromesophytic meadow vegetation, and shrub and tree vegetation.

Meadow vegetation here is represented by the complexes with prevalence of the phytocenoses: 1) *Phragmitetum australis* var. *Filipendula ulmaria*; 2) complex of the communities *Lysimachia vulgaris*, *Urtica dioica*, *Cirsium arvense*, *Phragmites australis* (these communities occupy smaller area). Species richness of these phytocenoses is poor – on an average about 5–10 species per 10 m^2. The total projective cover is 100%. The litter layer is thin.

Shrub and tree vegetation of this area is represented by: 1) thickets of *Salix cinerea* and *Betula pendula* (mainly in the gullies); 2) Semi-natural forest stands of *Salix alba*, *S. viminalis*, *Populus nigra*, with an admixture of *Salix cinerea*, *Acer saccharinum*, *Fraxinus excelsior*, *F. pennsylvanica*, *Sambucus sp.*, *Prunus spinosa* and *Cornus sanguinea* (around the dried up ponds and the old homestead).

Vegetation of the forest belts. OT is surrounded by forest belts. Their vegetation is represented by the complex with prevalence of the phytocenoses: *Geo urbano-Fraxinetum*, with an admixture of single exemplars and thickets of *Populus nigra*, *Robinia pseudoacacia*, *Tilia cordata*, *Gleditsia triacanthos*, *Acer tataricum*, *Pyrus communis*, *Prunus spinosa*, *Salix cinerea*, *Cornus sanguinea*, *Elaeagnus angustifolia*, *Rosa canina*, *R. villosa*, *Ptelea trifoliata*, *Crataegus monogyna*. *Fraxinus pennsylvanica*, *Quercus robur*, *Acer saccharinum and Acer platanoides* dominate in their forest stand mainly.

Characteristic of the vegetation of the reserve's NT.

Meadow, ruderal, shrub and tree vegetation, as well, as steppe vegetation are spread in NT. Mesic meadow vegetation is concentrated in 15–20 year-old fallows. Xeromesophytic vegetation (in form of steppificated meadows) grows in 20-year-old fallows and in the areas, that were under grazing pressure in the recent past. Hygrophytic and hygromesophitic meadow vegetation are concentrated in the gullies. Ruderal vegetation is concentrated in 1–10 year-old fallows, 15 year-old fallows also have a significant admixture of ruderal vegetation, but the meadow one already dominates there. Shrub and tree vegetation is concentrated in forest belts and gullies. The compact area of typical meadow-steppe vegetation was revealed only on southeast slope of the mound in north part of NT. Tree and shrub species are actively spreading across the NT from nearby forest belts.

Vegetation of 1-year-old fallow. This fallow has an area of 34 ha and is located in the west part of NT. There grows the complex of ruderal vegetation with prevalence of the phytocenoses *Echinochloo-Setarietum pumilae*, with an admixture of *Atriplicetum nitentis*. In a part of the fallow nearby to the forest belt, there is an admixture of tree seedlings (*Fraxinus pennsylvanica*, *Acer negundo* etc.), and in the part nearby to the gully, there is a significant admixture of *Equisetum arvense.* The phytocenoses common on this fallow are pioneer. Their herbage is low and sparse with a projective cover of 30–50%. The litter layer is represented by corn stubble leftovers. The species richness is low (average 14 species per 25 m^2). In these communities the forb species are prevail. Grasses are represented by weeds (*Setaria viridis*, *Setaria pumila*, *Apera spica-venti*, *Echinochloa crus-galli*). Among forb species the highest projective cover have: *Lactuca serriola*, *Chenopodium album*, *Consolida regalis* subsp. *paniculata*, *Convolvulus arvensis*, *Fallopia convolvulus*, *Atriplex sagittata*, *Helianthus annuus*, *Chaenorhinum minus*, *Anagallis arvensis*, *Fumaria vaillantii*, *Sisymbrium polymorphum*, *S. loeselii*, *Sinapis arvensis* etc. Herbaceous invasive species (*Solidago canadensis*, *Asclepias syriaca*, *Iva xanthiifolia*, *Erigeron annuus*. and *Erigeron canadensis*) are actively spreading across the fallow. In this connection, it is necessary to accelerate demutation (by sowing with perennial grasses) and to control populations of invasive herbaceous species and trees on this fallow.

Vegetation of 2-year-old fallow. There grows the complex of ruderal vegetation with prevalence of the intermediate ruderal phytocenoses of *Convolvulo arvensis-Agropyretum repentis* and *Arction lappae*, with domination of *Solidago canadensis* and with admixture of *Calamagrostis epigejos*. In the part of the fallow nearby to the forest belts there is an admixture of tree seedlings and juvenile exemplars of *Fraxinus pennsylvanica*, *Acer negundo* etc., and in the part nearby to the gully there is a significant admixture of *Equisetum arvense.* As the previous fallow, this one require the same control measures to accelerate demutation.

Vegetation of 10-year-old fallow. 10-year-old fallow is located in the south from 1-year-old fallow. Its territory is occupied by ruderal vegetation of the complex with prevalence of the phytocenoses: *Calamagrostietum epigei*, with an admixture of *Melilotetum albo-officinalis*, *Carduo acanthoidis-Onopordetum acanthii*, *Calamagrostietum epigei* var. *Fragaria viridis*, and with compact sites of the phytocenoses *Calamagrostietum epigei* var. *Solidago canadensis.* In the plant communities of the fallow *Calamagrostis epigejos* dominates, an admixture of other rhizomatous grasses (*Poa angustifolia, Elytrigia repens*, *Arrhenatherum elatius*) is present also. Very thick litter layer (20–40 cm) forming under *Calamagrostietum epigei* communities inhibits most of herbaceous plants on this fallow, especially tussock grasses, which are completely absent here. The forb communities are concentrated here in form of compact sites, mainly between communities with domination of *Calamagrostis epigejos*. Invasive communities with domination of *Solidago canadensis* are beginning to spread here and still occupy relatively small area. Species richness of the fallow is poor (average 10–12 species per 25 m^2). The total projective cover is 60–90%. Tree and shrub species are actively spreading there, there are: mainly *Acer negundo* and to a lesser degree: *Pyrus communis*, *Robinia pseudoacacia*, *Ulmus minor*, *Morus nigra*, *Malus pumila*, *M. sylvestris* subsp. *praecox*, *Fraxinus pennsylvanica*, *Sambucus racemosa, Prunus spinosa*. The vegetation of 10-year-old fallow requires the measures of systematic mowing or moderate grazing, or combination of both measures, as well as cutting down excess trees.

Vegetation of 15-year-old fallows. These fallows are located in the southwest and southeast parts of the reserve. Their territory is occupied by the meadow complexes with prevalence of the phytocenoses: 1) *Poëtum angustifoliae* var. *Arrhenatherum elatius*, with an admixture of *Agropyretum repentis*, *Poëtum angustifoliae* var. *Fragaria viridis*; 2) *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *typica* and var. *Fragaria viridis,* with an admixture of *Calamagrostietum epigei*, *Agropyretum repentis*, *Carduo acanthoidis-Onopordetum acanthii*; 3) *Poëtum angustifoliae* var. *typica*, *Agropyretum repentis* var. *typica*, with an admixture of: *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *Fragaria viridis* and var. *Schedonorus pratensis*, *Melilotetum albo-officinalis*, *Agropyretum repentis* var. *Hieracium virosum.* Rhizomatous grasses are prevailing in the vegetation cover of this area. *Arrhenatherum elatius* dominate here, *Poa angustifolia*, *Calamagrostis epigejos* and *Elytrigia repens* are a significant admixture. Significant admixture of forb species typical for these communities grows here also. Among tree species, the most common are: *Fraxinus pennsylvanica*, *Acer negundo*, *Ulmus minor*, *Morus nigra*, *Elaeagnus angustifolia*. The vegetation of 15-year-old fallows is generally more diverse than the vegetation of 10-year-old fallow, mainly due to forb species diversity increasing. Species richness of these plant communities is rather high, up to 25–30 species per 25 m^2 (average about 18 species). The litter layer in these phytocenoses is thinner (thickness of 5–10 cm) than in phytocenoses of *Calamagrostietum epigei*, under the sites of forb phytocenoses it is weakly expressed at all. The vegetation of 15-year-old fallows requires the measures of systematic mowing or moderate grazing, or combination of the both measures, as well as cutting down excess trees.

Vegetation of 20-year-old fallows. These fallows are located in north, northwest, northeast and south areas of NT, they occupy greater part of it. Meadow and ruderal vegetation is growing there. Tree and shrub species are actively spreading there also. Meadow vegetation is represented by the complexes with prevalence of the following phytocenoses: 1) *Poëtum angustifoliae* var. *typica*, with an admixture of *Poëtum angustifoliae* var. *Fragaria viridis* (this complex is distributed mainly in the south and southwest part of the reserve); 2) *Poëtum angustifoliae* var. *Arrhenatherum elatius*, with an admixture of *Agropyretum repentis*, *Poëtum angustifoliae* var. *Fragaria viridis* (this complex is distributed in the form of large sites on the greater part of 20-year-old fallows); 3) *Poëtum angustifoliae stipetosum pennati*, *Poetum angustifoliae* var. *Fragaria* *viridis*, *Agropyretum repentis* (this xeromesophytic meadow complex is distributed in the form of small sites on 20-year-old fallows); 4) *Festuco valesiacae-Poetum angustifoliae* var. *Trifolium arvense* and *Poëtum angustifoliae* (this xeromesophytic meadow complex is distributed in the northeast part of NT, in the territory, that was previously under grazing pressure); 5) *Poëtum angustifoliae* var. *Equisetum arvense*, with an admixture of *Poëtum angustifoliae* var. *Schedonorus pratensis* (this complex is distributed in shallow gullies with gentle slopes and in other depressions); 6) *Poëtum angustifoliae* var. *typica*, *Agropyretum repentis* var. *typica*, with an admixture of: *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *Fragaria viridis* and var. *Schedonorus pratensis*, *Melilotetum albo-officinalis*, *Agropyretum repentis* var. *Hieracium virosum* (this complex is distributed through the whole territory of 20-year-old fallows); 7) *Poëtum angustifoliae* var. *Arrhenatherum elatius*, var. *typica* and var. *Fragaria viridis,* with an admixture of *Calamagrostietum epigei*, *Agropyretum repentis*, *Carduo acanthoidis-Onopordetum acanthii* (this complex is distributed in the north and northeast parts of 20-year-old fallows); 8) *Poetum angustifoliae*, with an admixture of *Agropyretum repentis* var. *Tussilago farfara* (the compact sites in the depression in the south part of the reserve). Ruderal vegetation of these fallows is represented by the complexes with prevalence of the phytocenoses: 1) *Calamagrostietum epigei*, with an admixture of *Poëtum angustifoliae* and *Agropyretum repentis* (on the 20-year-old fallow in the north and northwest parts of NT); 2) *Calamagrostietum epigei* var. *Solidago canadensis* (mostly on the 20-year-old fallow in the north and northwest parts of NT); 3) *Calamagrostietum epigei*, with an admixture of *Melilotetum albo-officinalis*, *Carduo acanthoidis-Onopordetum acanthii*, Calamagrostietum epigei var. *Fragaria viridis* (compact sites in the south part of NT).

Species richness of the meadow phytocenoses of the 20-year-old fallows is 20 – 30 species per 25 m^2. In xeromesophytic meadow communities it is greater than in mesic meadows. The total projective cover in the meadow communities is 60–100%. The thickness of litter layer under the meadow communities is 5–10 cm. The ruderal communities are species poor (about 10–12 species per 25 m^2). The total projective cover in the ruderal phytocenoses is 75–100%. Thickness of litter layer under the ruderal communities varies from weakly expressed (under pure *Solidago canadensis* thickets) to 20 cm (under *Calamagrostietum epigei*). Species composition of the meadow phytocenoses of 20-year-old fallows is mainly similar to 15-year-old ones. But, on the 20-year-old fallows more species of tussock grasses (*Festuca valesiaca*, *Festuca stricta* subsp. *sulcata*, Schedonorus pratensis, *Phleum phleoides*, *Deschampsia cespitosa*, *Stipa pennata*) appear, forb species are mostly similar, but the share of the ruderal species decreases, while the share of legumes increases. Labiales also become more diverse. However, on the meadows of the 20-year-old fallows the rhizomatous grasses (*Poa angustifolia*, *Arrhenatherum elatius*, *Elytrigia repens*) dominate almost everywhere, as well as in the north and northwest parts of NT the large areas are occupied by species-poor ruderal communities (*Calamagrostietum epigei* var. *typica*, *Calamagrostietum epigei* var. *Solidago canadensis*), which have not disappeared after 20 years of succession. In these ruderal communities, powerful competitive species *Calamagrostis epigejos* and *Solidago canadensis* dominate. Trees and shrubs (*Fraxinus pennsylvanica*, *Acer negundo*, *Pyrus communis*, *Malus pumila*, *Elaeagnus angustifolia*, *Prunus spinosa* etc.) are spreading across 20-year-old fallows also.

Above mentioned shows, that a gradual transformation of the vegetation of these fallows into meadow steppes with domination of tussock grasses during restorative succession will be difficult or, more likely, impossible without systematic mowing or moderate grazing. Tree species require certain control measures also.

Vegetation of the gullies is similar to that in the OT.

Vegetation of the forest belts in NT is similar, in general, to the same one in the OT. However, in the NT *Fraxinus pennsylvanica*, *Acer negundo*, *Quercus robur* dominate mainly in tree layer.

Vegetation of the mound. The mound is situated in the north part of NT. It is the highest point in the reserve (197.1 m above sea level). Meadow-steppe vegetation of the complex with prevalence of the phytocenoses: *Thymo marshchaliani-Caricetum praecocis* var. *Fragaria viridis* grows there. *Carex praecox* and *Stipa pennata* co-dominate in its vegetation cover, with a large admixture of *Fragaria viridis*, *Calamagrostis epigejos*, *Poa angustifolia*, *Bromopsis inermis*, *Elytrigia repens* and *Festuca valesiaca*. Among the forb species *Fragaria viridis, Thalictrum minus, Salvia nutans* and *Galium verum* are prevail, an admixture of *Thymus pulegioides* subsp. *pannonicus, Artemisia austriaca*, *Gypsophila paniculata*, *Nonea pulla, Campanula sibirica, Asperula cynanchica* etc. presents also. An average species richness is 25 species per 25 m^2, the total projective cover is 90%, the litter layer is thin, it does not exceed 5 cm. In my opinion, the reasons for the formation of a compact area of meadow-steppe vegetation on the slopes of this mound are long-termed non-plowing and sufficient steepness of the mound's slopes, that does not allow excess moisture to retain. The area of these phytocenoses, probably, will be expanding to nearby areas, if the suitable conservation regime (systematic mowing or moderate grazing, or combination of the both variants) is established there.

Discussion

Changes in vegetation cover of Mykhailivska Tsilyna during 11-year period of strict protection

Firstly, because the previous map (according to 2011 data) was based on the dominant classification (Tkachenko & Fitsailo, 2016), and the current map is based on the ecological-floristic classification, a direct comparison of these two maps is impossible. Secondly, the map by the data of 2011 covers only OT of the reserve, NT has been mapped for the first time by me. Due to the above, in order to identify 11-year changes in the reserve, should to compare the spatial differentiation of the main dominants, also taking into account the species that are the main admixture. In general, 11-year changes are shown on Figure 4.

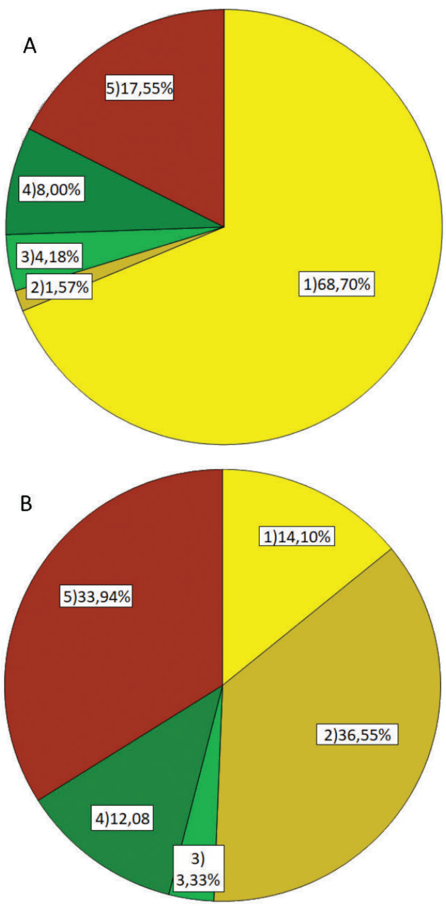


Figure 4: Generalized changes of the vegetation in the old territory of the nature reserve Mykhailivska Tsilyna. **Remarks:** A – state of the vegetation in 2011 (Tkachenko & Fitsailo, 2016), B – state of the vegetation in 2022, 1 – meadow-steppe communities, 2 – shrub-steppe communities, 3 – meadow communities, 4 – tree and shrub communities, 5 – ruderal and forb communities.

Slika 4: Splošne spremembe vegetacije na starem ozemlju naravnega rezervata "Mykhailivska Tsilyna". **Opombe:** A – stanje vegetacije v letu 2011 (Tkachenko & Fitsailo, 2016), B – stanje vegetacije v letu 2022, 1 – travniško-stepske združbe, 2 – grmiščno-stepske združbe, 3 – travniške združbe, 4 – drevesne in grmiščne združbe, 5 – ruderalne združbe in združbe steblik.

It can be seen, in general, that over a 11-year period of strict protection the area of meadow-steppe communities has decreased from 68.70% to 14.10%, the area of shrub-steppe communities has increased from 1.57% to 36.55% and they became the most common complexes, the area of ruderal and forb communities has increased from 17.55% to 33,94%, the area of tree and shrub communities has increased from 8.00 to 12.08%, the area of meadow communities decreased from 4.18 to 3.33%. So, the maim changes have occurred in the meadow-steppe vegetation, which was decreased the most (mainly due to increasing of area of shrub-steppe and ruderal and forb communities). Other communities have not changed as much. More detailed information is given below.

Changes of vegetation due to cessation of mowing are shown on Figure 5.

Figure A shows mesophytized meadow-steppe phytocenoses, Figure B – mesophtized shrub-steppe phytocenoses, Figure C – fragments of shrub and tree phytocenoses and formed for second time (due-to mezophitization of meadow-steppe vegetation) ruderal phytocenoses (*Arctietum lappae* var. *Urtica dioica*), which in the future will become the part of the forest communities forming there gradually.

Also an important criterion for assessment of the state of phytocenoses is their species richness per unit of area. The more species per unit of area of phytocenosis, the more valuable it is (especially in reserved territories). As a result of increasing mesophytization of the vegetation, due to the cessation of regular mowing, there is a significant decrease in species richness of the communities in the EMS compared to the communities of mown AFLs. In particular, in AFLs the species richness of communities usually does not exceed 40 species per 25 m^2, and in EMS it rarely exceeds 30 species per 25 m^2 (usually about 20–25 species). Moreover, as a rule, the greater the projective cover of *Cytisus ruthenicus* shrubs and high growing herbaceous plants *Euphorbia semivillosa* (which distribute due to mesophytization) the lower the species richness will be. That, among other things, confirms the harmfulness of the mesophytization process for the vegetation cover of the reserve.

Authors of the previous map called the state of periodically mown steppe (PMS) as "ryegrass". Phytocenoses with domination of *Arrhenatherum elatius,* with an admixture of *Cytisus ruthenicus* and *Elytrigia repens*, and

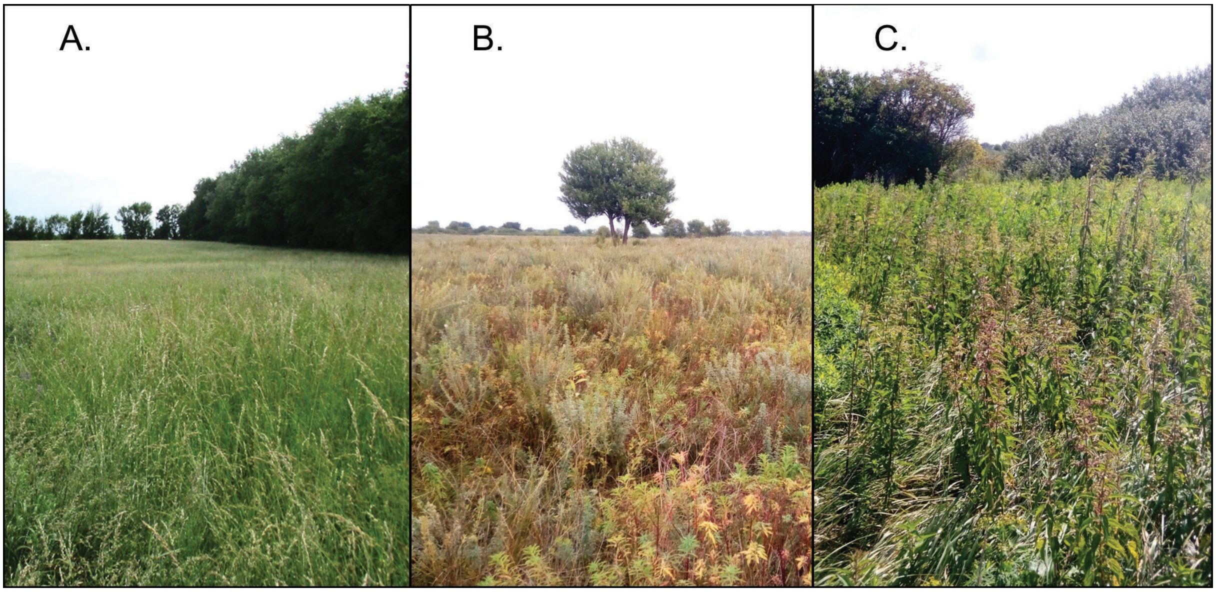


Figure 5. Influence of cessation of mowing on the steppe vegetation of the reserve. Remarks: A – vegetation of AFLs (every year mown area), B – vegetation of EMS (area that was not mown during 11 years), C – vegetation of SPS (area that was not mown during 75 years).

Slika 5: Vpliv opustitve košnje na stepsko vegetacijo rezervata. Opombe: A – vegetacija AFL (površina pokošena vsako leto), B – vegetacija EMS (površina, ki ni bila pokošena 11 let), C – vegetacija SPS (površina, ki ni bila pokošena 75 let).

with large admixture of *Stipa pennata*, *Festuca valesiaca*, *Poa angustifolia*, *Sanguisorba officinalis* and *Euphorbia semivillosa* were the most common in the reserve in that time. These phytocenoses occupied about 80 ha of PMS. Because the whole PMS (in 2011) was under the similar mowing regime (4 years of mowing and 1 year of strict protection), there were no AFLs then. Now the same mesophytized meadow-steppe phytocenoses (see Figure 5, A) with domination or subdomination of *Arrhenatherum elatius*, with large admixture (sometimes with subdomination) of *Elytrigia repens*, *E. intermedia*, *Bromopsis inermis*, *Calamagrostis epigejos*, *Poa angustifolia*, *Stipa pennata*, *Festuca valesiaca* and less often of *Stipa capillata*, with an admixture of *Carex humilis*, *Cytisus ruthenicus*, *C. austriaca* and forb species (*Salvia pratensis*, *Phlomis tuberosa* etc.) occupy mown AFLs only and sometimes occur in the form of small sites in EMS. Thus, there is a decreasing of area of *Arrhenatherum elatius* communities now.

The greater part of former PMS (PMS without AFLs), which was not mown during last 11 years is EMS (see above). EMS now is occupied by the complicated shrub-steppe complex of the phytocenoses, which are united by *Cytisus ruthenicus* domination or subdomination in them (see Figure 5, B). Large admixture of rhizomatous grasses (*Elytrigia repens*, *Arrhenatherum elatius*, *Calamagrostis epigejos*, *Bromopsis inermis*, *Poa angustifolia*), tussock grasses (*Stipa pennata*, *Festuca valesiaca, Phleum phleoides*), an admixture of steppe sedges (*Carex humilis*) and forb species presents in these phytocenoses also. In a lesser degree the complex of the forb phytocenoses with domination or subdomination of *Euphorbia semivillosa*, with a large admixture or subdomination of rhizomatous grasses (mainly *Calamagrostis epigejos*, *Elytrigia repens* and *Arhenatherum elatius*), with lesser admixture of other forb species and tussock grasses presents there also. Thus, now the plant communities with domination of *Cytisus ruthenicus* prevail and the communities with domination of *Euphorbia semivillosa* are actively spreading on EMS. In 2011, the phytocenoses of *Cytisus ruthenicus* occupied a small area, but the species was often present in different phytocenoses of PMS. I think, that the rapid expansion of these communities is connected with the absence of inhibitory factor (systematic mowing) during last 11 years. Phytocenoses with domination of *Euphorbia semivillosa* grew in 2011 only in depressions and SPS. However, they heavily expanded during last 11 years on the territory of EMS. The process happened probably due to accumulation of thick litter layer (10–15 cm) during this time and corresponding increasing of soil humidity level to a degree suitable for these communities. In 2011, a rather large area of PMS was occupied by the communities with domination of *Festuca valesiaca* and *F. stricta* subsp. *sulcata*, co-domination of *Poa angustifolia* and *Stipa pennata*, with large admixture of *Arrhenatherum elatius* and forb species and with small admixture of *Cytisus ruthenicus*. At that time, the phytocenoses of *Poa angustifolia* and meadow-steppe communities oppressed by mowing with unclear domination of forb components (*Phlomis tuberosa*, *Salvia pratensis, S. nutans, Thalictrum minus, Filipendula vulgaris*, *Galium verum*, *Scorzonera purpurea*, *Stachys officinalis*) and with co-domination of meadow-steppe grasses and shrubs were spread there also. Both of the above mentioned communities were transformed mostly into a shrub-steppe complex with domination of *Cytisus ruthenicus* and, less often, into communities with domination of *Euphorbia semivillosa*. But partially they were preserved in form of rather compact sites even on EMS.

In general, over 11-year period of strict protection on EMS, the shares of communities with domination of *Arrhenatherum elatius* and tussock grasses (*Stipa pennata*, *Festuca valesiaca*, *F. stricta* subsp. *sulcata*) decreased, while the shares of shrub-steppe communities with domination of *Cytisus ruthenicus* and forb communities with domination of *Euphorbia semivillosa* and some rhizomatous grasses (*Calamagrostis epigejos*, *Elytrigia repens*) increased. Vegetation on AFLs remains the similar to that on PMS 11 years before.

Vegetation of gullies, former ponds and former homestead remains similar too.

Vegetation of SPS remains almost similar also. The complex with domination of *Elytrigia repens*, often with co-domination of *Calamagrostis epigejos*, with an admixture of *Bromopsis inermis*, *Poa angustifolia*, some forb species (*Euphorbia semivilosa*, *Urtica dioica*, *Trifolium alpestre* etc.) prevails there among herbaceous communities, as in 2011. Phytocenoses with domination of *Urtica dioica*, often with an admixture of *Elytrigia repens* and *Bunias orientalis* are in the second place among herbaceous communities of SPS, while the phytocenoses with domination of *Euphorbia semivillosa*, with large admixture of *Calamagrostis epigejos* and other rhizomatous grasses – in the third place. Among shrub and tree vegetation the complex of *Prunus spinosa*, with an admixture of other shrubs and trees (*Sambucus racemosa*, *S. nigra*, *Rhamnus cathartica*, *Rosa pomifera*, *R. canina*, *R. corymbifera Malus pumila*, *Pyrus communis*, *Acer negundo*, *Acer tatarica* etc.) prevails as before. Compact elm thickets (with domination of *Ulmus minor* and *U. laevis*) occur here also. Changes in the vegetation of the SPS were mainly manifested in changes in the area of phytocenoses without a changes of dominant species.

Thus, over the 11-year period since the last mapping, negative changes have occurred in the OT of the reserve due to non-mowing and the resulting mesophytization of the vegetation cover. Meadow-steppe phytocenoses have been preserved better on the mown AFLs. On the EMS, which has not been mown since 2011, they have not been preserved and have mostly been replaced by a more mesophytic shrub-steppe and forb phytocenoses. That is shown on Figure 4, where the area of meadow-steppe communities has decreased by almost 5 times, and the area of shrub-steppe and forb phytocenoses has increased proportionally. The negative impact of mesophytization was also confirmed by the decrease in species richness of plant communities in territories, which were not mown.

Conclusions

During the mapping, negative changes of OT vegetation cover had been revealed. Author considers, that these changes had been caused by 11-year regime of strict protection. They manifest in decreasing of xerophytic tussock grass component and in increasing – shrub, rhizomatous grass and mesophytic forb components in vegetation of EMS, and in general decreasing of species richness of EMS phytocenoses in comparison with the phytocenoses of mown AFLs.

During first mapping of NT vegetation (mainly 1-, 2-, 10-, 15-, 20-year-old fallows) the course of the restorative succession had been clarified in general terms over 20 years. Schematically it goes from pioneer ruderal communities (1–2 years of succession) to rhizomatous grass communities with a large admixture of ruderal species (10-th year of succession), then to rhizomatous grass-forb communities (15-th year of succession) and in the end (20-th year of succession) to rhizomatous grass-forb communities with an admixture of tussock grasses or to species-poor communities of rhizomatous grasses. From this scheme, it can be seen, that rhizomatous grasses did not decline during 20 years of succession and were not replaced by tussock grasses. This is because of sufficient quantity of precipitation due to geographic location of the reserve. In the large area occupied during long time by species-poor communities with domination of *Calamagrostis epigejos*, the thick litter layer was accumulating in non-mowing conditions and suppressing tussock grasses and increasing soil humidity. Existence of this suppressive effect is proven by the fact, that on the rather steep slope of the mound (located nearby to communities of *Calamagrostis epigejos*), which ensures the drainage of excess water, meadow-steppe communities successfully grow. In this regard, the most perspective phytocenoses for the newly forming meadow-steppe areas are *Poëtum angustifoliae* var. *typica* and *Poëtum angustifoliae stipetosum pennati* in the southern part of the reserve on the south, southeast, southwest slopes with angles 7–15°, where *Calamagrostis epigejos* is almost absent, the layer of litter is thin and the slopes provide excess water drainage.

Thus, the data obtained from the current mapping generally fit into the patterns, outlined in the literature review in the introduction and prove unsuitability of strict protection for preserving the meadow-steppe plant diversity of the reserve.

Acknowledgements

The author is very grateful for help in work to Hryhorii Dudchenko, Mykola Piddubyna and other workers of the reserve and to Ruslan Shevchuk, PhD in geological sciences, for satellite image of the reserve and consultations on GIS software.

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Supplementary material

Vegetation map of the nature reserve Mykhailivska Tsilyna in full resolutiom

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