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First application of EDGG "normal plots" in grasslands of European Russia

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Abstract: We present the first results of the implementation of 10-m² plots for sampling grassland biodiversity in European Russia. We tested the method in two contrasting model sites: Valdaiskiy National Park as a Candidate Emerald Site (Novgorodskaya Oblast') and the lands of HC-Yug Ltd. agricultural enterprise (Tulskaya Oblast'). Four 10-m² plots were sampled in the first site and two in the second site. According to their species composition, the Valdai meadows clearly belong to the *Molinio-Arrhenatheretea* as evidenced by numerous diagnostic species of the class and the alliance *Cynosurion cristati*. The plots of the second site consist of a restored hayfield and pasture. Native plant species had lower cover but higher richness on the pasture compared to the hayfield. We conclude that the 10-m² plot size is appropriate to identify the essential proportion of plant species composition in a site. It is advisable to consider separately native and alien species when analysing species richness. The studied meadows on the edge of the Great Eurasian Natural Tract (Valdaiskiy National Park) are not impacted by alien species in contrast to the meadows surrounded by developed landscapes in Tulskaya Oblast'.

Keywords: grassland; hayfield; meadow restoration; *Molinio-Arrhenatheretea*; Novgorodskaya Oblast'; pasture; plant diversity; Russia; Tul'skaya Oblast'; Valdaiskiy National Park; vegetation plot.

Nomenclature: Cherepanov (1995) for vascular plants, Ermakov (2012) for plant communities, EUNIS for habitat types.

Abbreviations: EDGG = Eurasian Dry Grassland Group; GEANT = the Great Eurasian Natural Tract; HCY = HC-Yug Ltd Cattle Farm; VNP = Valdaiskiy National Park.

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Introduction

One of the main activities of the Eurasian Dry Grassland Group (EDGG) is the study of grasslands in various regions of Palaearctic (e.g. Biurrun et al. 2014; Polyakova et al. 2016; Aćić et al. 2017). Doing this, EDGG pays particular attention to the sampling of biodiversity with standardised methods. In June 2017 Elena Belonovskaya, Nikolay Sobolev and Nadezda Tsarevskaya took part in the 10th EDGG Field Workshop in the Central Apennines (Filibeck et al. 2018) with the main aim to learn the standard EDGG protocol of sampling grassland biodiversity.

This method was already applied in Russia to sample the biodiversity of dry grasslands in Khakassia (Janišová et al. 2013; Polyakova et al. 2016). We expand the use of this method in European Russia. In the future we expect to collect more data with such a standard protocol to achieve comparable results by relatively simple methods, especially when studying extra-large territories as for example the Great Eurasian Natural Tract (GEANT) from Fennoscandia to Far East (Sobolev & Rousseau 1998).

At present, the decline in the level of agricultural influence has caused a negative trend for biodiversity: many pastures, important for biodiversity conservation, are overgrown with secondary low-productive forests with species-poor flora and fauna. This makes grassland conservation measures important for maintaining the old agricultural forest-meadow-field landscape in the forest zone. These measures should benefit both the inhabitants of the local villages and the habitats of the protected area (Belonovskaya et al. 2016).

The purpose of this paper is to present preliminary results of our attempts to implement the 10-m² "normal plots" of EDGG (Dengler et al. 2016) in European Russia.

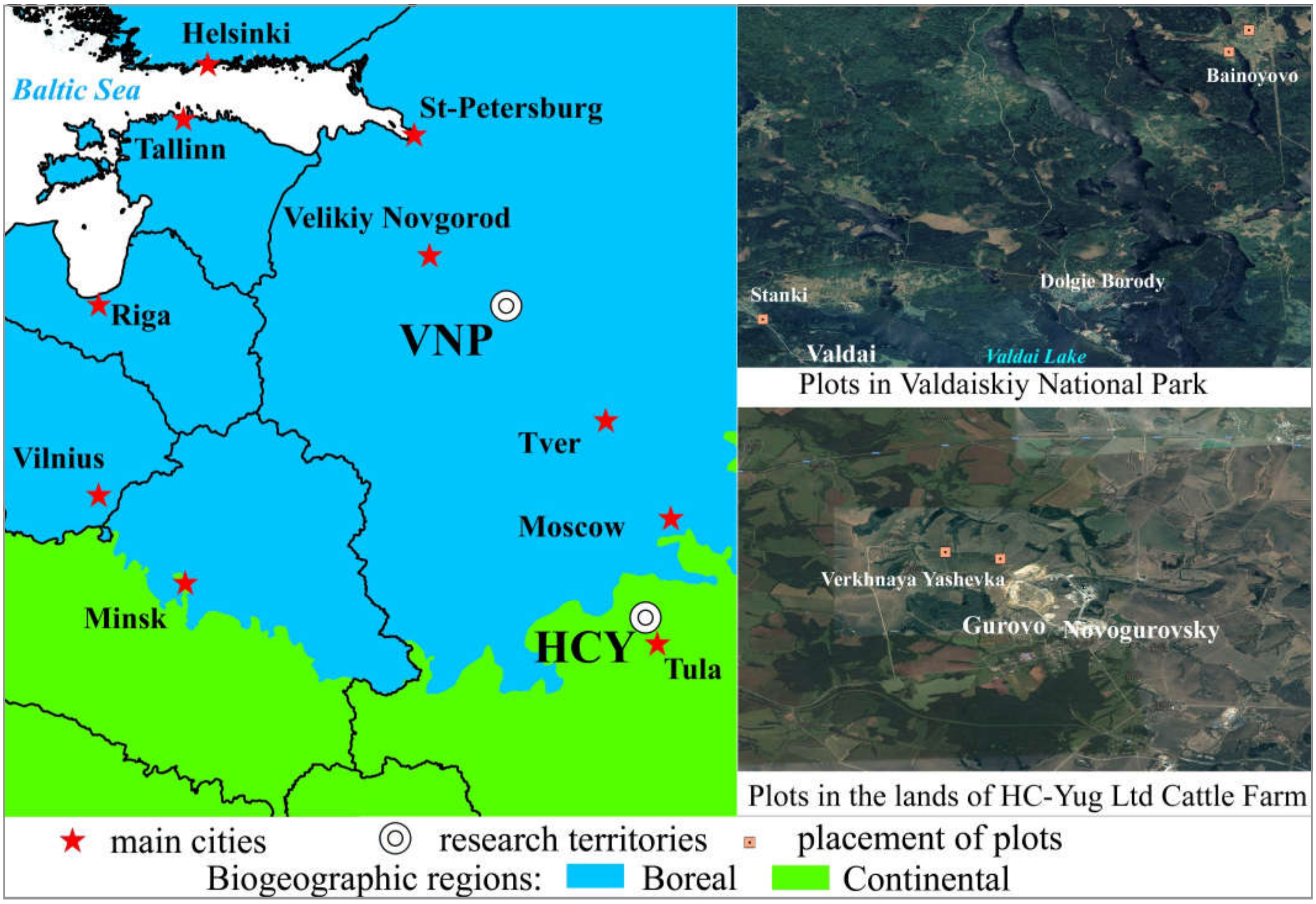

Fig. 1. Location of the study areas in European Russia (left) and of the plots within the areas (right).

Study areas

Our study was conducted in two contrasting areas of European Russia: 1) Valdaiskiy National Park (VNP) in Novgorodskaya Oblast', a Candidate Emerald Site near the southern edge of GEANT; 2) HC-Yug Ltd. Cattle Farm (HCY) in Tul'skaya Oblast', meadows under restoration after ploughing (Fig. 1).

VNP (57.887° N; 33.160° E; Novgorodskaya Oblast') is a Candidate Emerald Site (RU5300062) situated in the centre of the Valdai Upland, where we studied secondary meadows. The Valdai Upland is located at the edge of southern taiga and broadleaved coniferous forests (i.e. mixed forests with broadleaved and coniferous trees) (Gribova et al. 1980). It belongs to the Eastern European end moraine landscape with numerous lakes (Andreev et al. 2002). The high post-glaciation landscape diversity has significant influence on the diversity of plants and habitats and their distribution. Later anthropogenic deforestation impacted the landscape: centuries of land use shaped the mosaic of the vegetation cover, common for the old agricultural landscapes. Small patches of former arable lands, various types of grasslands, bogs, primary and secondary forests form the high diversity of habitats (Belonovskaya et al. 2014). The secondary meadows on the watersheds and slopes together with the flood plain meadows occupy 15.2% of the territory. For centuries they were used as hayfields and pastures. Long-term low-intensity agricultural use formed a stable floristic composition and structure of the grassland communities, inhabited by many rare and endangered plant and animal species (Belonovskaya et al. 2016). The grasslands of the region belong to the following habitat types of European importance (according to EUNIS classification): E3.4 Moist or wet eutrophic and mesotrophic grassland and E3.5 Moist or wet oligotrophic grassland.

Tulskaya Oblast' is located in the Central Russian Plain, occupying the northeastern part of the Central Russian Upland. The surface of the region is a hollow-wavy plain, intersected by river valleys and ravines. There are also karst forms. **HCY** (54.492° N; 37.304° E) occupies agricultural lands on the southern edge of the mixed forest zone with broadleaved and coniferous. HCY is a subsidiary of HeidelbergCement Group, which owns the site for limestone mining starting around 2025. HCY's task is to ensure the agricultural land use and thus reduce taxes for the mining company. The benefit derived from tax cuts allows us to conduct an experiment to restore meadows in place of arable land by using parts of the site as pastures (48.8 ha) and hayfields (30.3 ha). It is expected that the restoration of a meadow with high biodiversity will increase the quantity and quality of ecosystem services, including creating a rich soil for reclamation of fully exploited quarries, the use of which is completed. If successful, this can be an example for implementation in new development regions, which include the GEANT. The studied part of the pasture was last ploughed in 2005 and is now used for year-round grazing by cows with an approximate pasture load of 0.5 animal per hectare. The studied hayfield was established in 2014: it has been ploughed and then sown with *Phleum pratense*, *Dactylis glomerata*, *Poa pratensis*, *Lolium perenne*, *Festuca pratensis*, *Festuca rubra*, *Festuca arundinacea*, and together with them, unintentionally, many seeds of *Matricaria inodora*. The latter species one was removed in 2015 as far as possible. Every year the hayfield is mowed once in stages to preserve the fauna.

Methods

We sampled four 10-m² plots of *Molinio-Arrhenatheretea* secondary meadows in VNP (Figs. 2–3) and one 10-m² plot on the hayfield and other one on part of the cow pasture (Fig. 4) in HCY, using the sampling protocol for EDGG "normal plots" (Dengler et al. 2016). The four plots from VNP are already included in the GrassPlot database (Dengler et al. 2018), while those from HCY will be contributed in the near future.

Results and discussion

An ordered vegetation-plot table is presented in the Table 1.

As evidenced by the prevalence and abundance of diagnostic species, all plots in the VNP clearly belong to the class *Molinio-Arrhenatheretea*, order *Arrhenatheretalia* and the alliance *Cynosurion cristati*. The group of diagnostic species accounts for more than 57% of the species diversity of the meadows. The species of the group are characterized by considerable coverage and frequency. Unfortunately, it is impossible to reveal syntaxa of lower ranks because of the low number of replicates.

On the HCY lands, we can expect a tendency of the development of plant communities belonging to *Molinio-Arrhenatheretea*. Currently, plant species of the both sites belong to differ coenotic groups. In the future both communities can converge by the species composition and eventually one association might form. Species belonging to plant communities of the *Molinio-Arrhenatheretea* were more numerous and abundant in the hayfield. On the other hand, we must bear in mind that the predominating species in the hayfield, *Phleum pratense* and *Poa pratensis*, were sown there in 2014. The invasive *Solidago canadensis* is among the subdominants in the hayfield. The non-native species *Lolium perenne* was not identified in the hayfield two years after sowing. Invasive *Erigeron canadensis* and *E. annuus* predominate in the pasture. One could call this a derivate plant community (Kopecky & Hejny 1974) belonging to *Molinio-Arrhenatheretea*. Native plant species show a lower cover on the pasture than on the hayfield, but on the pasture their number is larger.

Fig. 2. Sampling data near Stanki village, VNP, Novgorodskaya Oblast. Photo: V. Vinogradova.

Fig. 3. Meadow opposite Bainyovo village, VNP, Novgorodskaya Oblast. Photo: E. Belonovskaya.

Communities of class *Molinio-Arrhenatheretea* are widespread in European Russia. Everywhere the variety of syntaxa of lower level is high and specific as demonstrated for Ryazanskaya Oblast' (Southern Nechernozem'e) (Voronov 1984), Republic Bashkotostan (Yamalov 2005; Yamalov & Bayanov 2008), Bryanskaya Oblast' (Bulokhov 2013, 2014), Pskovskaya oblast' (Cherednichenko & Borodulina 2017) Komi Republic (Shushpannikova & Yamalov 2014) and others. In our opinion, the essential characteristic of these communities may be not the numerical richness of syntaxonomic diversity but the presence of invasive species, especially among dominating species. Such analysis may be the issue of our next study.

Traditionally in Russia 100-m² plots are used for sampling geobotanical data. Which plot size is preferable, mostly depends on the research aim. For example, when we com-

Table 1. ***Description of the 10-m² plots in VNP and HCY: coverage (%) of plant species and other data. Diagnostic species of class and alliance indicated with (Cl) and (Al) respectively (according to Ermakov 2012, Mucina et al. 2016). Invasive alien species are in red font.***

Plots	**1**	**2**	**3**	**4**	**5**	**6**
Relevé number	**183**	**184**	**186**	**182**	**1**	**2**
Tree layer (%)	**0**	**0**	**0**	**0.2**	**0**	**0**
Shrub layer (%)	**0**	**0**	**0**	**0.1**	**0**	**0**
Herb layer (%)	**95**	**85**	**95**	**90**	**70**	**60**
Moss layer (%)	**30**	**30**	**5**	**0**	**-**	**-**
Altitude (m a.s.l.)	**201**	**202**	**208**	**221**	**-**	**-**
Aspect (°)	**90**	**90**	**45**	**270**	**-**	**-**
Inclination (°)	**2**	**2**	**1**	**5**	**-**	**-**
Species richness	**38**	**39**	**39**	**31**	**41**	**50**
Class: *Molinio-Arrhenatheretea* (Cl): Order *Arrhenatheretalia*:						
Alliance *Cynosurion cristati* (Al)						
Dactylis glomerata Cl	35	2	10	10	0.5	0.5
Agrostis tenuis Al	0.1	0.5	1	2	0.1	.
Festuca rubra Cl, Al	0.3	1	8	30	1	.
Phleum pratense Cl, Al	2	6	5	1	30	.
Stellaria graminea Cl	2	2	0.2	1	.	0.1
Rumex acetosella Cl	3	3	0.1	0.5	.	.
Plantago lanceolata Cl	0.3	1	0.4	0.1	.	.
Anthoxanthum odoratum Al	15	25	3	0.5	.	.
Achillea millefolium Cl	7	5	1	0.3	.	.
Galium album Cl	3	1	3	1	.	.
Veronica chamaedrys Cl	0.1	1	0.4	1	.	.
Potentilla argentea Cl	0.1	1	0.4	.	.	0.3
Leontodon hispidus Cl	5	5	.	3	.	.
Poa pratensis Cl	2	0.5	.	.	30	.
Leucanthemum vulgare Cl	2	.	10	0.5	.	1
Taraxacum officinale Cl	.	0.01	1	3	.	1
Centaurea jacea Cl	2	.	6	7	.	.
Campanula patula Cl	.	0.5	0.1	.	.	0.2
Ranunculus acris Cl	.	0.2	0.4	0.5	.	.
Vicia cracca Cl	0.2	0.5	3	.	.	.
Vicia sepium Cl	0.4	.	0.8	2	.	.
Trifolium pratense Cl	.	.	0.4	2	0.4	.
Cirsium arvense Cl	.	.	0.6	.	0.4	0.3
Plantago media Cl	.	0.3	0.1	.	.	.
Briza media Al	.	1	4	.	.	.
Amoria repens Cl, Al	2	5	.	.	.	.
Pimpinella saxifraga Cl	3	2	.	.	.	.
Ranunculus polyanthemus Cl	0.2	1	.	.	.	.
Carum carvi Cl	0.3	.	1	.	.	.
Knautia arvensis Cl	.	0.01	0.1	.	.	.
Amoria hybrida Cl	.	.	0.4	.	0.1	.
Deschampsia cespitosa Cl	.	.	6	.	1	.
Helictotrichon pubescens Cl	.	3	.	.	.	.
Succisa pratensis Cl	.	0.01	.	.	.	.
Centaurea phrygia Cl	.	.	12	.	.	.
Leontodon autumnalis Cl	.	.	6	.	.	.
Anthriscus sylvestris Cl	.	.	1	.	.	.
Ajuga reptans Cl	.	.	0.4	.	.	.
Heracleum sibiricum Cl	.	.	0.1	.	.	.
Clinopodium vulgare Cl	.	.	0.01	.	.	.
Lathyrus pratensis Cl	.	.	.	0.5	.	.
Rhinanthus minor Cl	.	.	.	0.1	.	.
Geranium pratense Cl	.	.	.	0.1	.	.
Carex leporina Cl	.	.	.	0.01	.	.
Rumex crispus Cl	.	.	.	.	2	.
Festuca arundinacea Cl	.	.	.	.	1	.
Festuca pratensis Cl	.	.	.	.	2	.
Alopecurus pratensis Cl	.	.	.	.	0.1	.
Rumex acetosa Cl	.	.	.	.	0.1	.
Bromopsis inermis Cl	.	.	.	.	.	0.5
Plantago major Cl	.	.	.	.	.	0.5
Prunella vulgaris Cl	.	.	.	.	.	0.4
Galium mollugo Cl	.	.	.	.	.	0.3
Stachys palustris Cl	.	.	.	.	.	0.2
Lychnis flos-cuculi Cl	.	.	.	.	.	0.1
Other species						
Alchemilla sp.	0.5	.	0.6	4	.	.
Dianthus deltoides	0.1	0.1	.	0.001	.	.
Hypericum maculatum	1	.	0.6	2	.	.
Equisetum arvense	.	.	0.6	.	0.1	0.3
Euphrasia officinalis	0.7	10	.	.	.	.
Hieracium umbellatum	4	2	.	.	.	.
Solidago virgaurea	1	2	.	.	.	.
Artemisia campestris	.	0.3	0.3	.	.	.
Melampyrum nemorosum	.	.	2	2	.	.
Trifolium medium	.	2	.	3	.	.
Artemisia vulgaris	.	.	.	.	0.5	0.2
Solidago canandensis	.	.	.	.	2	0.2
Cirsium polonicum	.	.	.	.	0.3	0.5
Convolvulus arvensis	.	.	.	.	0.3	0.3
Tripleurospermum inodorum	.	.	.	.	0.3	0.3
Hypericum perforatum	.	.	.	.	0.2	0.4
Tanacetum vulgare	.	.	.	.	0.2	0.3
Campanula rotundifolia	0.3	.	.	.	.	.
Fragaria vesca	0.2	.	.	.	.	.
Medicago falcata	0.1	.	.	.	.	.
Veronica officinalis	0.1	.	.	.	.	.
Myosotis arvensis	0.01	.	.	.	.	.
Pilosella officinarum	.	2	.	.	.	.
Erigeron acris	.	0.1	.	.	.	.
Vicia angustifolia	.	0.01	.	.	.	.
Viola sp.	.	.	0.4	.	.	.
Anthyllis vulneraria	.	.	.	2	.	.
Festuca ovina	.	.	.	2	.	.
Gnaphalium sylvaticum	.	.	.	0.001	.	.
Sonchus arvensis	.	.	.	.	0.3	.
Medicago lupulina	.	.	.	.	0.2	.
Calamagrostis epigejos	.	.	.	.	0.1	.
Thlaspi arvense	.	.	.	.	0.1	.
Erigeron canadensis	.	.	.	.	.	7
Erigeron annuus	.	.	.	.	.	5
Vicia hirsuta	.	.	.	.	.	0.5
Senecio vulgaris	.	.	.	.	.	0.4
Trifolium arvense	.	.	.	.	.	0.3
Vicia tetrasperma	.	.	.	.	.	0.3
Chamaenerion angustifolium	.	.	.	.	.	0.2
Cerastium holosteoides	.	.	.	.	.	0.2
Cichorium intybus	.	.	.	.	.	0.2
Carduus crispus	.	.	.	.	.	0.1
Myosotis micrantha	.	.	.	.	.	0.1
Cryptogam layer						
Mnium/Plagiomnium sp.	12	10	.	0.01	.	.
Bryum sp. 1	6	.	.	.	.	.
Bryum sp. 2	6	.	.	.	.	.
Bryum sp. 3	6	10	.	.	.	.
Pleurozium schreberi	.	10	.	.	.	.

Locations and dates:

Plot 1 Stanki village, N 58.01610, E 33.21612, 24.07.2017;

Plot 2 Stanki village, N 58.01630, E 33.21655, 24.07.2017;

Plot 3 Bainyovo village N 58.09642 , E 33.3557 , 29.07.2017;

Plot 4 Left side of the Shchegrinka-river valley, N 58.10297, E 33.36168, 23.07.2017;

Plot 5 HCY hayfield, N 54.49552, E 37.29877, 13.07.2017;

Plot 6 HCY pasture N 54.49318, E 37.31563, 14.07.2017.

pare the relevés of the meadow communities in the VNP on the 10-m² plots of 2017 with three approximately 100-m² plots sampled at the same sites in previous years (Belonovskaya et al. 2016), we found no clear relationship of the species richness in the differently sized plots. In one case species richness was higher in the bigger plot (41 species on the 100-m² plot vs. 31 in the 10-m² plot in the Shchegrinka-river valley), once nearly the same (38–39 species in the two plots near Stanki village) and once even lower (34 species in the 100-m² plot vs. 39 in the 10-m² plot near Bainyovo village). The group of diagnostic species was almost complete in the plots of different sizes. Differences between other species composition are difficult to interpret. The unexpected lack of a clear species-area relationship can have different causes, including not exact relocation of the plots, different phenology due to different weather conditions in the two years or less comprehensive sampling in the first year on the bigger plots. So, we can consider that in the most cases for description of vegetation the use of 10-m² plots seems to be enough for identifying the syntaxon, to which the community refers, as well as the set of dominating species. Due to the lower amount of time needed to record a smaller plot, 10-m² plots seem to be more convenient.

Author contributions

E.B., N.S. and N.T. planned the research; E.B., N.S., N.T., I.S., V.V. and L.V. did the field sampling and made the plot descriptions; E.B. and N.S. wrote the paper.

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Fig. 4. The self-restored pasture, HCY. Photo: N. Sobolev.