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Short Communication: Biodiversity of weeds in Ilmen State Reserve, Russia

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Abstract. *Mashkova IV, Krupnova TG, Kostryukova AM, Vlasov NE. 2018. Short Communication: Biodiversity of weeds in Ilmen State Reserve, Russia. Biodiversitas 19: 106-111.* Weeds are a synanthropic flora. Human exposure to the natural landscape leads to the spread of synanthropic plant species, so weeds begin to occupy a significant place in the structure of ecosystem biodiversity. The aim of this study was to investigate the weeds biodiversity structure and to assess the extent of invasion of weeds into the territory of the Ilmen State Reserve in South Urals, Russia. This paper presents the results of study of weeds during the vegetation period in 2013–2017. Fifty one species of weeds distributed in four genera and six families were found on the territory of the Southern Forestry of the Ilmen State Reserve. Besides, the differences between species diversity of weeds on three types of roads (gravel, earth and foot) and on two types of forests (birch and pine) were also discovered in this study . The greatest degree of invasion was discovered for foot roads. It was noted that pine forest is the most resistant the invasion of weeds.

Keywords: Biodiversity, biological invasion, protected areas, synanthropic flora, weeds

INTRODUCTION

The composition and structure of the world's flora irreversibly changes under the influence of anthropogenic activity (Pitman and Jørgensen 2002). One of the problems arising from the anthropogenic activity is that invasive weeds can displace wild plants from established natural communities (McKenney et al. 2007; Puliafico et al. 2011). The problem of synanthropic species is one of the facets of the global biodiversity problem (Orrock et al. 2008). Biodiversity is the main parameter of the evolutionary process, at the same time its outcome and the factor acting on the principle of feedback (Cardinale et al. 2012). A sufficient level of biodiversity is a necessary condition for the normal functioning of natural ecosystems (Bukvareva 2014).

Preservation of the species composition of background ecosystems is called for to implement protected areas, and in this regard there is reason for an optimistic approach (Krupnick and Knowlton 2017). However, creation of a network of protected areas does not solve the problem, and the problem of biological invasion is becoming increasingly important not only for economically exploited territories, but also for protected ones (Iacona et al. 2016; Florens et al. 2017; Ngugi and Neldner 2017; van Wilgen et al. 2017). One of the reasons for this is that even in protected areas it is impossible to completely protect phytocenosis from human influence. For example, economic and scientific activity in these territories is associated with the formation of various types of roads. The roadside environment promotes the spread of plants (Uchida et al. 2014; Bagavathiannan and Norsworthy 2016) and roads become corridors for invasive plant species (Meunier and Lavoie 2012).

The Ilmen State Reserve serves as a reserve for the genetics and central fund of the flora of the South Urals and a reference for background plant communities. It can be used for comparison in the context of environmental monitoring of phytocoenosis beyond its borders, which are at different stages of anthropogenic transformation (Kostryukova et al. 2017).

The effectiveness of practical activities for monitoring vegetation cover largely depends on the development of theoretical questions of plant cover synanthropisation. It is very important to build the process of tracking the natural or artificial enrichment of the local flora. The special complex of climatic and ecological-phytocenotic factors is observed in the South Urals region. In the literature there is little data on weeds of the Ilmen State Reserve (Gorchakovskiy and Kozlova 1998; Gorchakovskiy et al. 2005; Koroteeva et al. 2014). Degree of invasion was 47.2 % and 45.6 % in 1998 (Gorchakovskiy and Kozlova 1998) and 2005 (Gorchakovskiy et. al. 2005) respectively.

Taking into account the tendency to increase the share of weed plants and the proportion of invasive species, these data undoubtedly need to be updated. The aim of this work was to study weeds biodiversity structure of the Ilmen State Reserve and to identify a role of some factors (forest and roads types) in the invasion success of adventive weeds species.

MATERIALS AND METHODS

Study area

The Ilmen State Reserve, Chelyabinsk, Russia is located on the eastern macroslope of the South Urals between 54°58'–55°20' N and 60°07'-60°21' E and is a part of the South Ural physical-geographical region of the Ural Mountains. The reserve preserves the habitats of endemic and relict plants, as well as rare and protected species.

In the scheme of geomorphological zoning of the Chelyabinsk region, the Ilmen State Reserve is included in the erosion-denudational relief region of the eastern foothills of the Southern Urals, developed on a complex of igneous rocks. The study area is located at the southern tip of the Ilmen Ridge (Figure 1), which is a gently sloping terrain slope that ends on the shore of Lake Ilmenskoe. The coordinates of the sampling sites: site 1–55° 0'13.28"N, 60°10'26.98"E; site 2–54°59'52.91"N, 60° 9'56.01"E; site 3–54°59'32.52"N, 60°10'54.98"E; site 4–54°59'57.00"N, 60°11'30.34"E; site 5–54°59'29.69"N, 60°10'29.14"E; site 6–54°59'21.32"N, 60°10'46.77"E.

The studied territory is interesting for the boundary location between the steppe and forest-steppe zones, complex relief, and a variety of rocks. All this led to a high floral and phytocenotic variety of vegetation. The terrain of the territory is longitudinally ridged and steep (400–300 m above sea level). According to botanical-geographical zoning, the study area is located within the subzone of the forested-birch forest in the southern taiga forest zone. In the west, this subzone borders on dark coniferous forests of watershed ridges, in the east - on the forest-steppe of the Trans-Ural Peneplain. Variegated vegetation cover was formed under the influence of complex climatic and geological processes (Gorchakovskiy et al. 2005).

The territory of the Ilmen State Reserve is 90 % covered by forests, which are classified as the South Ural region pine forest and larch-pine forest. The main forest-forming species are pine and birch, occupying 56 % and 40 % of the reserve area, respectively. The area occupied by vegetation of paths and roads makes approximately 6.4 % of the entire protected area (Gorchakovskiy et al. 2005).

On the territory of the the Southern Forestry of Ilmen State Reserve, where studies were conducted, the forest is represented by two types of biotopes–birch and pine.

Sample collection

Studies were conducted during the vegetation period in 2013–2017. Six sampling sites were selected (Figure 1) depending on two types of forests (in the birch forest with snelte-mixed-grass-grass and pine forest with green mixed-grass-grass) and three types of roads (gravel, earth and foot). Figure 2 shows pictures which were taken at each sampling sites.

The collection was carried out according to generally accepted procedures. The work was attended by 30 students and teachers of the South Ural State University, Chelyabinsk, Russia.

The choice of sampling sites was associated with landscape features, the distribution of vegetation, as well as the anthropogenic load exerted on these landscapes. Expedition routes were planned on the basis of analysis of natural zoning schemes of the territory, remote sensing materials of the Earth (Landsat/ETM+ space images); with an assessment of the landscape diversity of the territory.

The total length of the routes was about 10 km. Generalization and comparison of geographically linked data was carried out in the geographic information system (GIS). In total, about 1000 plants were processed. Species were identified using the handbook by Gubanov et. al. (1992).

Figure 1. Map of the studied sites of , Chelyabinsk, Russia i.e., the Southern Forestry of Ilmen State Reserve: 1, 4–grave roads, 2, 5–earth roads, 3, 6–foot paths.

Figure 2. Types of studied plant complexes of the road network of the Ilmen State Reserve, Russia. A. Site 1, B. Site 2, C. Site 3–pine forest: gravel, earth and foot roads, respectively; D. Site 4, E. Site 5, F. Site 6–birch forest: gravel, earth and foot roads, respectively

Species diversity of weeds was defined for each sites selected structure unit of roads with area 25 m^2. We have identified local and invasive species on the basis of five-year studies. We calculated the degree of invasion, % (D_i) by the formula (Gorchakovskiy et al. 2005) for each sites :

$$D_i = N_i/N_w,$$

Where, N_i : the number of invasive species in site, N_w : the total number of weeds in site.

We analyzed the data using graphs. The graphs were constructed by the method of calculating the similarity on the basis of the Jacquard coefficient as an index of generality, taking into account the positive coincidences for cluster analysis. Graphs were calculated using a special program module "GRAPHS" (Nowakowski 2004).

RESULTS AND DISCUSSION

Species of weeds

We found 51 species of weeds, 37 and 14 of them are local and invasive species, respectively. The composition and structure of weed plants on the roads of pine and birch forests is different. We found that the birch forest was characterized by a great biodiversity of weeds than the pine forest. This is consistent with the literature data (Gorchakovskiy et al. 2005). Intensity of introduction into natural phytocenosis of invasive species of weeds is related to the type of roads. When comparing the species abundance of weed plants of different types of roads, it was noted that along the gravel and earth roads the species diversity and the abundance of weeds was higher both in pine and birch forests (Table 1). This is due to the condition of the soil along these roads. Soil quality deteriorates for foot roads.

The results are consistent with the literature data. Stagnant phenomena, water logging, acidification of soil, increase in nitrates (Koroteeva et al. 2014) are observed in the inter-wheel space and tracks that form along the dirt road. Background plant species are not able to withstand such anthropogenic pressure. Weeds begin to dominate the emerging new groupings and communities, replacing the background species (Gorchakovskiy et al. 2005). In the course of such transformations, flora depletion occurs, and the stability of phytocenoses decreases. On the site of indigenous plant communities, new ones are formed, in which the cenotic positions of the background species seriously change.

In the birch pine forest, the number of weeds species is higher than in the pine forest. However, extremely adapted weeds species was found, which spread both in pine and birch forests (Figure 4). *A. pilosa*, *E. repens, G. pratense, G. hederacea, P. major, P. angustifolia, P. caeruleum, S. officinalis, T. officinale, V. chamaedrys, V cracca* is weed species encountered on all sites. Of them *P. major* and *T. officinale* is invasive species for territory of the Southern Forestry of the Ilmen Reserve. According to Koroteeva et al (2014) these two species are antropofites. Their appearance was noted on the embankments of the railway on the border of the Ilmen Reserve in the previous studies (Gorchakovskiy et al. 2005).

Table 1. The composition and structure of weed plants on the roads of pine and birch forests

Weeds species	**Native (N)**	**Adventive (A)**	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
			N	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**	**N**	**A**
Achillea millefolium L.	+		+	–	+	–	–	–	+	–	+	–	+	–
Adenophora lilifolia (L.) A. DC.	+		–	–	–	–	–	–	+	–	+	–	+	–
Aegopodium podagraria L.	+		+	–	+	–	–	–	+	–	+	–	+	–
Agrimonia pilosa Ledeb.	+		+	–	+	–	+	–	+	–	+	–	+	–
Alopecurus pratensis L.	+		+	–	–	–	–	–	–	–	–	–	–	–
Amaranthus retroflexus L.		+	–	–	–	–	–	–	–	+	–	–	–	–
Amoria repens (L.) C. Presl	+		+	–	+	–	–	–	+	–	+	–	–	–
Arctium lappa L.		+	–	–	–	–	–	–	+	–	+	–	–	–
Artemisia absinthium L.	+		–	–	–	–	–	–	+	–	+	–	+	–
Artemisia vulgaris L.	+		–	–	–	–	–	–	+	–	+	–	+	–
Barbarea vulgaris W.T.Aiton	+		+	–	–	–	–	–	+	–	+	–	–	–
Carduus crispus L.		+	–	–	–	–	–	–	–	+	–	–	–	–
Carum carvi L.	+		–	–	–	–	–	–	+	–	+	–	+	–
Carex digitata L.	+		–	–	–	–	–	–	+	–	+	–	–	–
Capsella bursa-pastoris L.		+	–	+	–	+	–	+	–	+	–	+	–	–
Chenopodium album L.	+		–	–	–	–	–	–	+	–	+	–	+	–
Deschampsia caespitosa L.	+		–	–	–	–	–	–	+	–	+	–	–	–
Echinochloa crus-galli (L.) Beauv.		+	–	–	–	–	–	–	+	–	+	–	+	–
Elytrigia repens (L.) Nevski		+	–	+	–	+	–	+	–	+	–	+	–	+
Euphorbia esula L.	+		+	–	+	–	–	–	+	–	+	–	–	–
Galeopsis bifida Boenn.		+	–	–	–	–	–	–	+	–	+	–	–	–
Geranium pratense L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Geranium pseudosibiricum J.Mayer	+		+	–	+	–	–	–	+	–	+	–	+	–
Geum urbanum L.	+		–	–	–	–	+	–	+	–	+	–	+	–
Glechoma hederacea L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Heracleum sibiricum L.	+		–	–	–	–	–	–	–	–	–	–	+	–
Leucanthemum vulgare Lam.	+		+	–	+	–	–	–	+	–	+	–	+	–
Luzula pilosa (L.) Willd.	+		–	–	–	–	+	–	–	–	–	–	–	–
Oberna behen (L.) Ikonn.	+		+	–	+	–	–	–	+	–	+	–	–	–
Phleum pratense L.	+		+	–	+	–	–	–	–	–	–	–	–	–
Pimpinella saxifraga L.	+		–	–	–	–	–	–	–	–	+	–	–	–
Plantago major L.		+	–	+	–	+	–	+	–	+	–	+	–	+
Plantago media L.		+	–	–	–	–	–	+	–	–	–	+	–	+
Poa angustifolia L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Poa annua L.	+		+	–	–	–	–	–	–	–	–	–	–	–
Polemonium caeruleum L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Polygonum arenastrum Boreau		+	–	–	–	–	–	–	–	+	–	+	–	+
Pulmonaria mollis Wulf. ex Hornem.	+		–	–	+	–	+	–	–	–	–	–	–	–
Ranunculus acris L.	+		–	–	–	–	+	–	+	–	+	–	+	–
Senecio jacobaea L.	+		–	–	–	–	–	–	+	–	+	–	+	–
Setaria viridis L.		+	–	–	–	+	–	–	–	–	–	+	–	+
Sonchus arvensis L.		+	–	–	–	–	–	–	–	+	–	+	–	+
Stachys officinalis (L.) Trevis.	+		+	–	+	–	+	–	+	–	+	–	+	–
Stellaria graminea L.	+		–	–	+	–	+	–	+	–	+	–	+	–
Stellaria media (L.) Vill.		+	–	+	–	+	–	–	–	+	–	+	–	–
Taraxacum officinale Wigg.		+	–	+	–	+	–	+	–	+	–	+	–	+
Tripleurospermum inodorum L.		+	–	–	–	–	–	–	–	+	–	+	–	+
Urtica dioica L.	+		–	–	–	–	+	–	+	–	+	–	+	–
Veronica chamaedrys L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Vicia cracca L.	+		+	–	+	–	+	–	+	–	+	–	+	–
Viola canina L.	+		+	–	+	–	–	–	–	–	–	–	–	–
Sum			20	5	19	6	14	5	31	10	32	10	24	8
Sum weeds	37	14	25		25		19		41		42		32	
Degree of invasion, %			20.0		24.0		26.3		24.4		23.8		25.0	

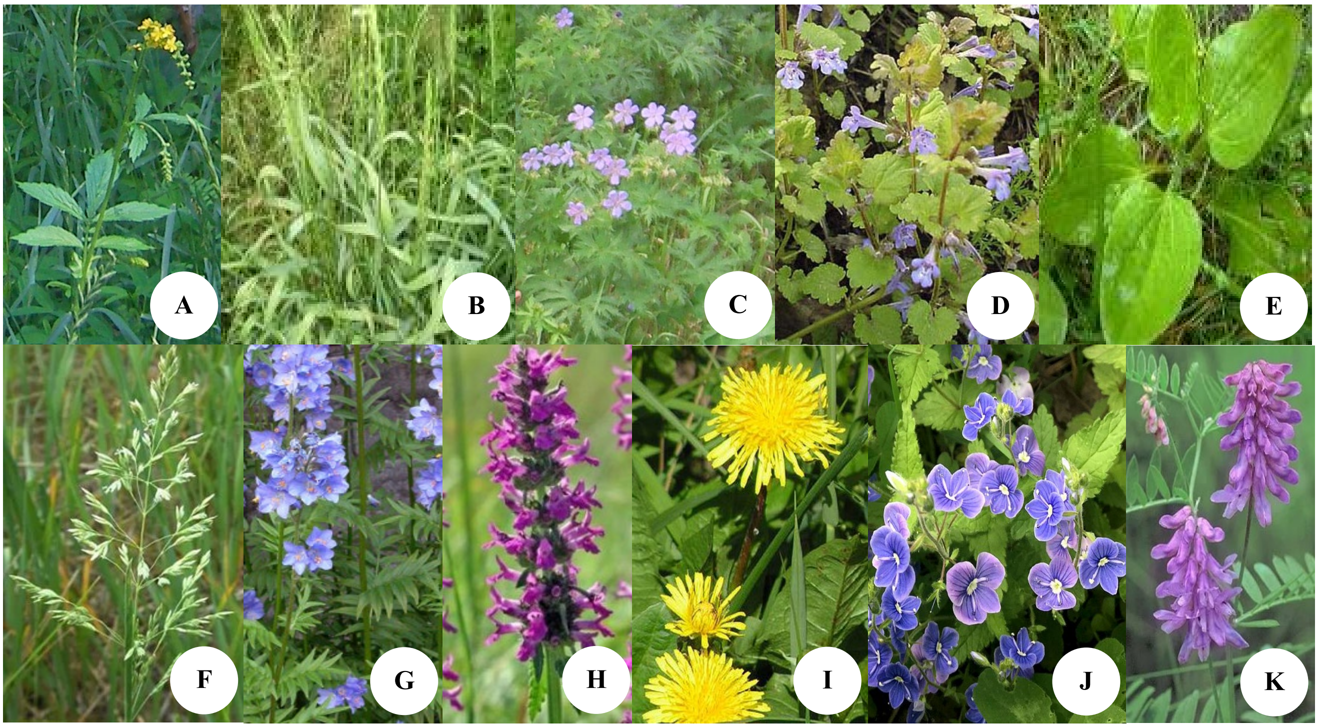

Figure 4. Types of plants common along all types of roads in pine and birch forests: A. *A. pilosa*, B. *E. repens*, C. *G. pratense*, D. *G. hederacea*, E. *P. major*, F. *P. angustifolia*, G. *P. caeruleum*, H. *S. officinalis*, I. *T. officinale*, J. *V. chamaedrys*, K. *V. cracca*

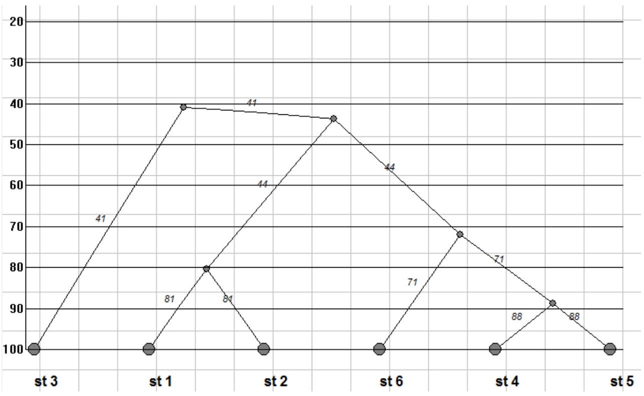

Figure 5. Distribution of stations on clusters on the basis of weed plants biodiversity (the Jacquard coefficient is qualitative)

A large number of species in the birch forest is associated with more favorable conditions for the growth of grass and shrub species in comparison with the pine forest. Firstly, birch forests are more passable than pine forests, there are more paths in them. The road-trail network of birch forests is used much more often than pine forest. Therefore, in the birch forest, the spread of the seeds of weeds by humans is more likely. Secondly, it is lighter in the birch forest, moderate humidity, slightly higher air temperature because broad leaves generally contain more water than needles (Blauw et al 2017).

Influence of various factors on degree of invasion

The greatest degrees of invasion were obtained for the foot road. This suggests that it should not underestimate the danger of the foot road in protected areas. So, the foot roads play a crucial role in the invasion success of adventive weeds. A greater number of seeds transferred on clothing and shoes than on tires of cars traveling on gravel and earth roads.

It is noted that the degree of invasion defined in the present study is two times less than the literature data for 1998 and 2005 (Gorchakovskiy and Kozlova 1998; Gorchakovskiy et al. 2005). There was difficult social and economic situation in protected areas, but situation has improved over recent years. This was reflected in the degree of invasion.

The distribution of clusters on the basis of weeds biodiversity using the Jacquard coefficient (Figure 5) showed that the most affected were the phytocenoses of birch forests. So the stations of the birch forest (Site 4, 5, 6) form a single cluster and for them the similarity of the synanthropic flora is 71 %. Stations of pine forests form two clusters with a low similarity Jacquard coefficient for weeds 41 %. This can be seen from Figure 5.

Based on the above study, it is concluded that the increase in the number of species in the weed of the reserve are attributed to the action of the anthropogenic factor. The intensity of the use foot routes should be reduced in protected areas. The degree of invasion, which characterizes the strength of anthropogenic impact, has declined in recent years for all types of roads in birch and pine forests. The most resistant to the introduction of weeds is the pine forest.

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