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The value of floodplain meadows of polar latitudes and the need for their monitoring and protection

T Parinova¹, I Amosova¹ and A Volkov¹

¹Northern (Arctic) Federal University named after M.V. Lomonosov. Higher School of Natural Sciences and Technologies. Department of biology, ecology and biotechnology. Arkhangelsk, Russian Federation

E-mail: t.parinova@narfu.ru

Abstract. In this paper, we present the results of our research into the value of the floodplain meadows in the polar latitudes, and provide the rationale for their value and the need for their monitoring and protection. We made use of more than 1000 own geobotanical and 200 descriptions of soil. Presented is also the vector map of the meadows located on the insular part of the Northern Dvina River floodplain (created in the GIS program ArcGIS 10.3).

1. Introduction

Meadow vegetation belongs to the intrazonal type. It is dispersed throughout the planet without forming a zone of its own and has specific characteristics of the composition and structure of the communities in each natural zone. The largest areas of meadows are concentrated in the temperate zone of the Northern hemisphere, primarily in Russia and Western Europe, but also in New Zealand. In Russia, meadows occupy about 80 million hectares [1].

Floodplain lands account for about 4.8 % of the planet's soil reserves. Floodplain meadow vegetation occupies less than 3% of the total land area of the Earth but is one of its integral and most important structural parts.

Floodplain meadows and meadow vegetation are of exceptional ecological, economic and social importance. Revealing the value of floodplain meadows, we can note the following global and regional ecosystem functions and types of relevant resources [1-3]:

1. Production functions:
 - 1.1 Production of useful plants – natural raw materials (medicinal, nectariferous, food plants, plant for technical use);
 - 1.2 Animal feed production, the existence of an environment that provides better living conditions (hayfields, pastures, feed for wild animals, including waterfowl, an important source of nectar for pollinating insects such as bumblebees and hoverflies);
 - 1.3 Production of resources for introduction and selection (genetic resources);
 - 1.4 Production of seeds (source of seeds to maintain and restore meadows);
 - 1.5 Commercial fauna (especially waterfowl);
 - 1.6 The production of soil – humus (soil fertility).
2. Environmental:
 - 2.1 Landscape-ecological (ecological framework of landscape, ecological corridors, refugia, nutrient and energy cycles, biodiversity, resilience);



2.2 Regulation of the atmosphere and climate (carbon deposition; regulation of the atmospheric composition and climate, regulation of hydrological regime, biological treatment of water and air);

2.3 Formation and protection of soils (soil formation, anti-erosion).

3. Cultural:

3.1 Health and recreation (recreational and wellness);

3.2 Ethical and aesthetic (ethnoecological, provide a link to the past, a living reminder of the traditional rural landscapes and the way of life that created them);

3.3 Cognitive (educational).

In Russia, floodplain lands account for about 29.2 million hectares, which is less than 2% of the total area of the country. Moreover, 1.2% are concentrated in Siberia and the Far East, the floodplain lands' European territory accounting for less than 1%.

In the Arkhangelsk region, floodplain lands occupy, according to different sources, between 1.8% and 4.9% of the total land and soil reserves [4-6], in which floodplain meadows account for 3%.

Floodplain meadows are of high natural and economic value. Compared to other ecosystems, they are particularly dynamic and undergo significant changes over time. Their areas, the degree of moistening, the composition of the herbage can be said to be constantly changing. Therefore, it is important to have a reliable and affordable way of remote meadow registration and evaluation.

2. Materials and Methods

We have used several data sources for thematic interpretation of meadow ecosystems. Our investigation covered, among others, floristic composition and soils in the communities under study, using standard geobotanical methods. The majority of the communities belong to the meadow type of vegetation. In total, we analyzed more than 1000 geobotanical descriptions, including 786 descriptions on trial plots of 1 m², and 250 descriptions on trial plots of 100 m². During field expeditions in 2011-2017, in the floodplain of the Northern Dvina River, we were identifying and locating meadows. Later they were complemented by satellite images and used as reference sites. We used satellite images from Sentinel-2 (07/24/2017) with a spatial resolution of 10, 20 and 60 m/pixel, depending on the channel. All spectral channels from MSI were included in the analysis. To improve the accuracy of the classification, we used satellite-derived data, such as the vegetation index: NDVI (which reflects the relative amount of photosynthetically active biomass) and CI Green (the index of photosynthetic activity of the vegetation cover, used in assessing the chlorophyll a and b content in plant leaves). Using ArcGIS, we created a vector polygonal layer with known natural objects: meadows, arable land, forests, reed beds, marshes, water and anthropogenic. For each class we created 1000 random points and extract values from all data sets. Then, we exported the data to an csv file and analyzed it in R. Multidimensional scaling with Bray-Curtis distance used for searching the differences between classes. Multidimensional scaling makes it possible to visualize multidimensional feature data in a two-dimensional space of coordinates based on the distance matrix. In addition, it is possible to find a correlation with the factors, determine their influence on the differentiation of objects and display them in the form of vectors on the graph. The interpretation was also carried out in R using the "random forest" method which is an ensemble learning method for classification that operates by constructing a multitude of decision trees at training time and outputting the class that is the mode.

3. Results

Floodplain meadows are one of the centres of biodiversity in our region. The flora of the Arkhangelsk region numbers, according to V.M. Schmidt [7], 1098 species of vascular plants. Of these, 34.6 per cent grow in the meadows and 10.3 per cent are plants commonly occurring on meadows. The floodplain meadows of the Northern Dvina estuary are home to at least 200 species of vascular plants. This area is inhabited by the flora and fauna species listed in the Red Book of Arkhangelsk Region [8]: 24 of 78 species of vascular plants; 1 of 3 species of insects; 2 of 3 species of reptiles; 2 of 22 species of birds.

Most of the area's meadows, both continental (upland, lowland) and floodplain, are secondary and require that sustainable, economic measures (planned mowing, controlled grazing) are implemented regularly in order to maintain them at their meadow stage of development. However, the mass cessation in the economic use of meadows in the Arkhangelsk region over the recent decades, has led to their degradation and overgrowing by tree-shrub species, which leads to partial or even complete loss of most of the ecosystem functions of the meadows. In particular, according to our latest data, there is a reduction in floodplain meadow areas throughout the region, that manifests itself in the loss of biological diversity and economic value, reinforced by mass resettlement of such plant species as *Filipendula ulmaria*, *Deschampsia cespitosa*, *Cirsium arvense*, *Heracleum sibiricum*, *H. sosnowskyi*. The Red Book listed and threatened plant species, including orchids, are vanishing from the meadows. For instance, on the territory of the Belomorsky reserve, such degradation of grassland ecosystems threatens rare plant species – *Anemone ranunculoides*, *A. altaica*, *Corydalis solida*, *Ficaria verna*, *Gagea lutea*, *Gentiana pneumonanthe*, *Epipactis atrorubens*, *E. helleborine*.

There is a real threat of habitat loss not only for flora but also for fauna. For example, according to the results of the analysis given in the 2008 Report on the Scientific Research "Fauna of terrestrial vertebrates of the Belomorsky state natural biological reserve of regional importance", the wellbeing of 3 out of 4 amphibians, 41 out of 230 birds, and 6 out of 38 mammals is associated with the wellbeing of floodplain meadows in the Belomorsky reserve.

With exceptional economic, natural and scientific value, the floodplain meadows of the Arkhangelsk region are now degraded and remain poorly explored. Along with forests and swamps, the floodplain meadows are an integral ecosystem element of many of the Arkhangelsk's protected areas. At the same time, in the majority of publications available on systematic, multifaceted conducted on the territory of the protected areas [9-17], meadow vegetation type is given but little attention. No information is available on the specific localization of floodplain meadows; size; ecological conditions of formation; and succession stage of development. The bryoflora, algal flora, mycobiota and lichen biota of the meadow remain underexplored.

We have initiated work to deal with these challenges which include, among others, the challenge of assessing the areas and places of floodplain meadows localization. We have identified criteria and developed scientific and methodological framework for identifying, evaluating and monitoring ecosystems on the mosaic of the vegetation cover. As a research method, we opt for remote sensing and interpretation of space images. Based on our study of spectral characteristics of different types of land use and the set identification criteria, we have created a vector map of the meadows located on the insular part of the Northern Dvina floodplain (scale 1: 270 000).

Based on the deciphered data, the vector map was created in GIS program ArcGIS 10.3 (Figure 1).

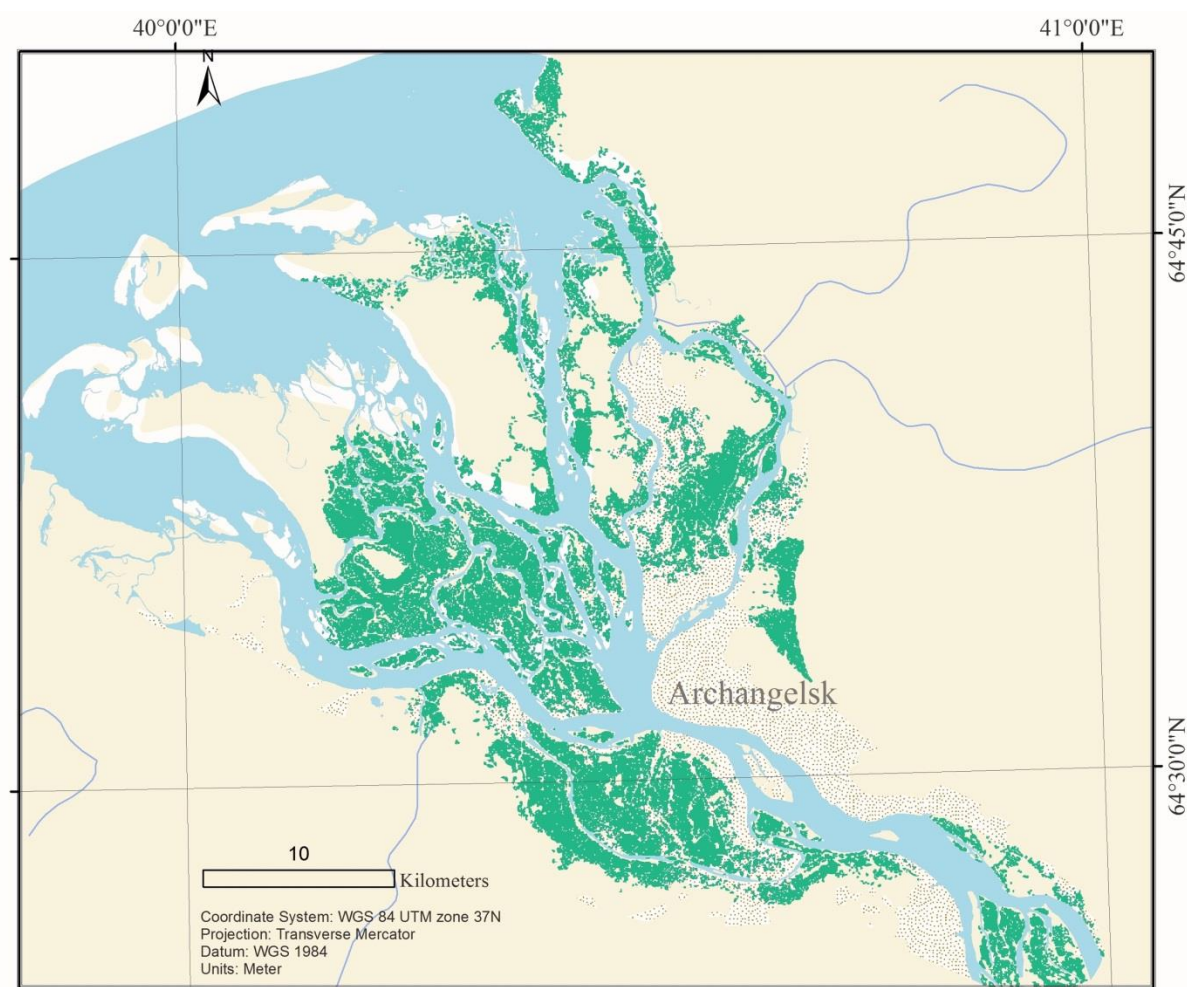


Figure 1. Map of the meadows located on the insular part of the Northern Dvina floodplain

4. Conclusion

In further studies, we plan to study the differences in spectral characteristics within the class of meadow vegetation to divide it into pastures, hayfields and deposits.

The relevance of a comprehensive study of floodplain meadows and the need to preserve them is undeniable and increases every year. At the moment, we can state the need for clear official recommendations on how meadow and meadow-like communities should be maintained within the protected areas of the Arkhangelsk region.

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