Biodiversity of Birch Forests in Mariy Chodra National Park

G O Osmanova¹, I I Firulina² and A G Rozenberg³

¹Mari State University, Yoshkar-Ola, Russia
²Samara State University of Economics, Samara, Russia
³Samara Federal Research Scientific Center RAS, Institute of Ecology of Volga River Basin RAS, Togliatti, Russia

E-mail: firulinairina@gmail.com

Abstract. In recent decades, the interest of scientists and the entire world community in the problems of studying and preserving biological diversity has increased. Fundamental knowledge about the flora and fauna of specific areas, especially protected natural areas, should become the basis for the rational use of biological diversity as a potential for their socio-economic development. The aim of this research is to characterize the typological, taxonomic and structural diversity of birch forests in Mariy Chodra National Park, the Republic of Mari El. In this paper, the authors carried out a comprehensive study of the birch forests of Mariy Chodra National Park, where such study has not been carried out before. The classification of birch forests is fraught with significant difficulties, since their overwhelming majority occurred by changing the most diverse associations of spruce, pine, and partly oak plantations. Moreover, the birch forests themselves represent only a certain stage of forest development. In natural environment, birch forests play a vital part in the restoration of pine and spruce plantations. One can combine the associations of birch plantations into the following groups: green moss birch forests, long moss birch forests, sphagnum birch forests, herbaceous birch forests, grassy marsh birch forests, complex birch forests. Of these associations, the most common are birch forests: with spruce undergrowth, linden and spruce-linden. Other associations occupy small areas and are found mainly in the zone of significant development of oak forest elements. In this paper, the authors analyzed for the first time the biodiversity of birch forests of Mariy Chodra National Park in The Mari El Republic. The authors identified 14 types of birch forests in rather contrasting habitat conditions. The assessment of ecological conditions also showed that the studied communities are in rather contrasting habitat conditions, which made it possible to more fully assess the diversity of the analyzed territory.

1. Introduction
Birch forests have a wide range and grow in different natural zones from forest-tundra to semi-deserts. Most of the birch forests are secondary [1, 2]. An inventory of the diversity of Russian forests at the genetic, species and ecosystem levels is extremely important [3, 4]. Mariy Chodra National Park (hereinafter Mariy Chodra) is no exception. Despite the fact that the Park was founded a long time ago (in 1985), in terms of biodiversity assessment, it remains insufficiently studied. In this paper, the authors analyzed the materials of geobotanical descriptions of the Mariy Chodra birch forests, which were carried out on a previously unresearched territory.
Forests are one of the main natural resources of the Republic of Mari El and are of great importance in the economy of the republic. The forest fund of the republic is determined by the total forested area of 1080.1 thousand hectares. The main forest-forming tree species in Mari El are: Pinus sylvestris L., Picea x fennica (Regel) Kom., Abies sibirica Ledeb., Quercus robur L., Betula pendula Roth, Populus tremula L., Tilia cordata Mill., Alnus glutinosa (L.) Gaertn., some species of Salix, Populus alba L. Arboreal and shrubby plants participate in the addition of the main forest associations: Acer platanoides L., Ulmus glabra Huds., Sorbus aucuparia L., Padus avium Mill., Euonymus verrucosa Scop., Frangula alnus Mill., Lonicera xylosteum L., Viburnum opulus L., Juniperus communis L., Corylus avellana L., Chamaecytisus ruthenicus (Fisch. ex Vorosch.) Klask., and various species of Salix, Poza [5]. Betula is the most widespread hardwood. The plantations of other deciduous species account for only 16% of the area.

Four Betula species are found on the territory of Mari El: Betula pendula, Betul pubescens Ehrh., Betula nana L. (often found on mossy soils in low places) and rarely found in the larger sphagnum bogs Betula humilis Schrank [5]. Betula pendula is the dominant species of small-leaved forests on the territory of Mar'y Chodra [6]. Birch forests occupy the third place by area after Pinus sylvestris and Picea x fennica. Their area is systematically increasing, as evidenced by the predominance of young birch forests. The productivity of birch plantations in Mari El is quite high: the bulk of plantations in terms of area (56%) has the 2nd degree forest quality. Birch forests in Mari El are found in all districts, but most of all they are confined to the areas of pine and spruce forests from the group of green moss. In the northwestern part of the republic, birch forests cover significant areas of lowland bogs.

Mar’y Chodra, located in the Ilet River basin, is part of the Ilet high-plain southern taiga region and is located on the southern border of the coniferous-broad-leaved forests of the subtaiga zone, and floristically, at the junction of the European and Western Siberian provinces of the Euro-Siberian floristic region [7]. The geographical location and natural conditions have left a kind of imprint on the formation of the park’s vegetation – it is distinguished by significant diversity. The park is dominated by forest vegetation, where the largest share is pine forests (50.1%) [8].

2. Materials and Methods
The authors conducted a study on the territory of the Yalchinsky forestry of Mar’y Chodra. Birch forests became the objects of the research.

At the first stage of our study, we obtained general information about the nature of the vegetation cover of the territory. The authors analyzed the literature material about the vegetation of the study area, its geology, climate, soil cover, as well as materials of forest inventory descriptions. In addition, the authors collected the necessary cartographic material: plans for afforestation of the Yalchinsky forestry in 1984 and 1994 (1: 25000) and maps obtained with the help of the automated workstation "Lesfond" (1: 25000).

We carried out route studies at the second stage of the research. We entered the results of these studies into the forms of geobotanical descriptions, and then transferred them to a database developed on the basis of the Microsoft Access program. We laid test plots of 100 m² in the most typical places for the selected section. We determined the geographic coordinates of the areas using the GPS "Garmin 12". In some cases, using the Haglof age drill, we determined the age of the trees. In this research, we used the dominant classification [9].

The third stage was an assessment of the ecological conditions of the studied cenoses for each trial plot by processing geobotanical descriptions according to D.N. Tsyganov [10]. His scales contain point assessments of the ecological properties of species included in the composition of the phytocenosis for various environmental factors [11]. We processed the floristic lists using the Ecoscale program by the weighted average of the interval on the scales of moisture, variability of moisture, soil trophicity, and also on the scales of illumination and soil nitrogen richness [12]. To determine the classes of occurrence of species, we processed geobotanical descriptions using the Syntaxon program [13].
The fourth step was to assess the taxonomic and structural diversity of communities. To assess alpha diversity, we used two parameters: species saturation and species richness. We used the Whittaker index $\beta_w$ (Whittaker, 1960, cited in [14]) and Jaccard's coefficient [15] to estimate beta diversity.

We used the classification of ecological-coenotic groups (ECG) of vascular plant species in the European part of Russia to analyze the ecological-coenotic composition of birch forests. This classification was compiled by O.V. Smirnova and L.B. Zaugolnova based on the ecological groups of A.A. Nitsenko [16] taking into account the historical suites of vegetation by G.M. Zozulin [17, 18]. Analysis of life forms of plants according to the ecological and morphological classification of I.G. Serebryakova [19] and T.I. Serebryakova [20] helped us to identify the biomorphological composition of communities.

3. Results and Discussion

3.1. Typological diversity of the studied community

Based on the research results, the authors distinguish the following types of birch forests.

1. Bilberry birch forests (BBF). This is one of the main and widespread types of birch forests arising from pine forests and blue spruce forests. In this type of forest, we identified three associations: bilberry proper, molinia-bilberry, and green moss-bilberry.

The stand consists of *Betula: Betula pubescens* prevails in wetter habitats, and *Betula pendula* prevails in drier habitats. The undergrowth in blueberry birch forests is formed by *Picea x fennica* (Regel) Kom., what is more the closeness of this undergrowth is quite significant - 20-40%. *Tilia cordata*, *Betula pendula*, *Quercus robur*, and *Populus tremula* are much less common in the undergrowth. *Frangula alnus* Mill. is the most constant in the undergrowth; *Sorbus aucuparia* L. is found, *Juniperus communis* L. is found less often; *Euonymus verrucosus* Scop. and *Salix aurita* L. occur singularly. *Vaccinium myrtillus* L. dominates in the herbage, the most abundant are *Molinia caerulea* (L.) Moench, *Rubus saxatilis* L., *Calamagrostis arundinacea* (L.) Roth), *Vaccinium myrtillus* L.; rather common - *Convallaria majalis* L., *Maianthemum bifolium* (L.) F.W. Schmidt, *Tridentis europaea* L., *Dryopteris carthusiana* (Vill.) H.P. Fuchs, *Luzula pilosa* (L.) Willd. The cover of the moss-lichen layer can be both insignifcant (0.5%) and significant (40%). It is dominated by green mosses *Dicranum polysetum* Sw., *Pleurozium schreberi* (Brd.) Mitt., *Polytrichum commune* Hedw., *Brachythecium oedipodium* (Mitt.) Jaeg. *Sphagnum girgensohnii* Russ is found from sphagnum.

2. Lily of the valley birch forests (LVBF). They are most often derived from lily of the valley proper. The authors identified one association - the lily of the valley proper. *Betula pendula* forms the stand in these communities; *Populus tremula* can act as an admixture, *Pinus sylvestris* occurs less often. Density of crowns is 0.35-0.4. Undergrowth in lily of the valley birch forests is poorly developed. It contains *Pinus sylvestris*, *Populus tremula*, *Picea x fennica*, rarely *Betula pendula*. The abundance of all these species is insignificant. In the undergrowth, *Chamaecytisus ruthenicus* is most often found, often - *Juniperus communis*, *Frangula alnus*, rarely - *Sorbus aucuparia*, *Euonymus verrucosa*. In the herb-shrub layer, *Calamagrostis arundinacea* (L.) Roth, *Fragaria vesca* L. are the most abundant, as well as *Convallaria majalis* L. The species of *Achillea millefolium* L., *Hieracium umbellatum* L., *Rubus humilifolius* C.A. Mey., *Solidago virgaurea* L. are constantly found. In most cases, the moss-lichen layer is absent. Its overall coverage is no more than 1% when it’s available. Green mosses (Dicranum polysetum Sw., Dicranum scoparium Hedw. Pleurozium schreberi (Brd.) Mitt., Polytrichum juniperinum Hedw.) account for no more than 0.5%, the rest are lichens (*Cladonia cornuta* (L.) Hoffm., *Cladonia rangiferina* (L.) Weber ex F. H. Wigg.).

3. Ground elder birch forests (GBEF) are represented by descriptions, in which three associations are distinguished: the ground elder, wild ginger- mercury - ground elder n stone bramble – ground elder. Soils are sandy, in places peaty. The stand is formed by *Betula pendula* and *Betula pubescens*. *Pinus sylvestris*, *Populus tremula*, and *Tilia cordata* were found in A2 with sufficient abundance as an admixture. Crown closure varies from 0.2 to 0.5. The undergrowth is well developed, dominated by
Acer platanoides and Picea x fennica, while Ulmus glabra Huds is less abundant. Corylus avellana, Frangula alnus, and Sorbus aucuparia play a significant role in the undergrowth. Euonymus verrucosa is rare. The herbaceous layer is dominated by Aegopodium podagraria L.; codominants are Mercurialis perennis L., Asarum europaeum L. Менее обилины Dryopteris filix-mas (L.) Schott, Epipactis helleborine (L.) Crantz, Equisetum pratense Ehrh. Moss layer in most cases is absent; in some places about 2% is represented by Dicranum polysetum Sw., Cladichium dendroides (Hedw.) Web. et Mohr., Campylium polygamum (B.S.G.) C. Jens., Brachythecium oedodium (Mitt.) Jaeg.

4. Linden birch forests (LBF) are formed on the site of complex pine and spruce forests, mainly as a result of felling and fires [5]. Soils are sandy and sandy loam. One association is highlighted - actually a linden one. The stand is composed of Betula pendula and Betula pubescens; Betula pendula prevails. Tilia cordata is also significant in the first tier. Populus tremula, Picea x fennica, and Acer platanoides are found as admixtures. Crown density varies from 0.25 to 0.45. In the undergrowth, Tilia cordata and Picea x fennica are constantly found, and in some places Acer platanoides is abundant. The undergrowth is represented by Euonymus verrucosa, Sorbus aucuparia; Frangula alnus and Padus avium are rarely found. The herbage is well developed. It is dominated by Rubus humulifolius, Asarum europaeum L., Carex digitata L. The species of Aegopodium podagraria L., Calamagrostis arundinacea, Maianthemum bifolium (L.) F.W. Schmidt, Pulmonaria obscura Dumort., Solidago virgaurea L are constantly present.

5. Lingonberry birch forests (LbBF) are represented in the research by two associations - lingonberry proper and lily of the valley-lingonberry. The soils are sandy, and inclusions of coal are common. The stand of this type of forest can be dominated by both Betula pendula and Betula pubescens. Pinus sylvestris is always present. Crown closure varies from 0.2 to 0.5. The undergrowth contains Betula pendula and Betula pubescens, Quercus robur, Acer platanoides, Pinus sylvestris, Populus tremula L. The undergrowth is poorly developed: Juniperus communis, Sorbus aucuparia, and Frangula alnus are noted singularly or with an insignificant abundance. Convallaria majalis and Vaccinium vitis-idaea L. are dominant in the grass-shrub layer. The participation of other species is insignificant. The moss cover is formed by Dicranum polysetum Sw., Pleuroziun schreberi (Brd.) Mitt.Sw; less common are the species of Brachythecium salebrosun (Web. et Mohr) Schimp. и Lophocolea heterophylla (Schrad.) Dum. In the lichen cover the following species are noted Cladonia rangiferina (L.) Weber ex F. H. Wigg. и Cladonia fuscata (Huds.) Scharb.

6. Bracken birch forests (BrBF) are represented by two associations: bracken proper and lily-of-the-valley bracken. They are located mainly in the karst valleys of the lakes. The soils are sandy. The stand can consist of Betula pendula and B. pubescens, or both. Pinus sylvestris may be present. Density of crowns is 0.25-0.4. Undergrowth in bracken birch forests is formed by Quercus robur, Picea x fennica, Acer platanoides, rarely Betula pubescens, Populus tremula, Ulmus glabra Huds. The species of Sorbus aucuparia is constant in the undergrowth; Frangula alnus, Sorbus aucuparia are met less often; Padus avium, Salix cinerea L., Euonymus verrucosa, Rubus idaeus L. are rare. The herbage is dominated by Pteridium aquilinum (L.) Kuhn, Convallaria majalis. The species of Calamagrostis arundinacea, Fragaria vesca, Rubus saxatilis are abundant; Hieracium umbellatum L., Solidago virgaurea, Vaccinium myrtillus L., Viola canina L are constantly present. The cover of the moss-lichen layer is insignificant - 0.5%; it includes the following species Dicranum polysetum Sw., Pleuroziun schreberi (Brd.) Mitt.Sw, Polytrichum juniperinum Hedw., Lophocolea heterophylla (Schrad.) Dum.

7. Mercuries birch forests (MBF) are represented by two associations: mercuries proper and ground elder - mercuries. Soils are sandy, sandy loam. The stand in these communities is formed by both Betula pendula and Betula pubescens; Tilia cordata, Picea x fennica, and, less often, Populus tremula can act as an admixture. Density of crowns - 0.35-0.4. The undergrowth is well developed. In its composition, Acer platanoides is most abundant; Picea x fennica, Ulmus glabra are constant; and Tilia cordata, Abies stbirica Ledeb are found less often. The undergrowth is practically absent; single specimens of Corylus avellana and Euonymus verrucosa were found. In the herb-shrub layer the most abundant are the following species: Mercurialis perennis L., Asarum europaeum, Galium odoratum
Density of crowns is 0.6. In the undergrowth, Frangula alnus, Betula pubescens. Sorbus aucuparia and Frangula alnus are found in the undergrowth with a small abundance. The herbage is dominated by Rubus saxatilis L., Carex digitata L.; Convallaria majalis is less abundant. Dryopteris carthusiana (Vill.) H.P. Fuchs, Orthilia secunda (L.) House are constantly present.

8. Stone bramble birch forests (SBBF) are represented by the following associations: stone bramble proper and finger sedge-stone bramble. Soils are sandy, sandy loam. The stand consists of either Betula pendula or Betula pubescens with an admixture of Picea x fennica, or Betula pubescens. Crown closure varies from 0.1 to 0.4. The undergrowth contains Tilia cordata, Picea x fennica, less often Acer platanoides, Quercus robur L., Betula pubescens. Sorbus aucuparia and Frangula alnus are found in the undergrowth with a small abundance. The herbage is dominated by Rubus saxatilis L., Carex digitata L.; Convallaria majalis is less abundant. Dryopteris carthusiana (Vill.) H.P. Fuchs, Orthilia secunda (L.) House are constantly present.

9. Motley grass birch forests (MGBF). The stand consists of either Betula pendula with an admixture of Picea x fennica, or Betula pubescens with an admixture of Tilia cordata. The closure of the crown is 0.5-0.55. In the undergrowth, Tilia cordata and Picea x fennica are well developed, in some places the species of Acer platanoides are found. The undergrowth is represented by Euonymus verrucosa, Sorbus aucuparia; Frangula alnus, Lonicera xylosteum, Padus avium Mill. The herbage is dominated by Rubus saxatilis, редко Pulmonaria obscura, Lathyrus vernus (L.) Bernh., Aegopodium podagraria, Melica nutans L., Viola mirabilis L. The species of Carex digitata, Dryopteris filix-mas (L.) Schott, Equisetum pratense Ehrh., Maianthemum bifolium, Trientalis europaea L. are constantly present.

10. Green moss birch forests (GMBF) are a derived type of green moss pine forests and spruce forests. We distinguish two associations: lingonberry-green moss and lily of the valley-green moss. Soils are sandy. Betula pendula with an admixture of Pinus sylvestris form a stand. Density of crowns is 0.3-0.35. Undergrowth contains Betula pendula; the species of Populus tremula and Pinus sylvestris occur singularly. Sorbus aucuparia, Frangula alnus, Chamaecytisus ruthenicus (Fisch. ex Vorosch.) Klas., Genista tinctoria L. are found in a single specimen. The moss-shrub layer are Convallaria majalis, Vaccinium vitis-idaea L. The species of Antennaria dioica (L.) Gaertn., Carex rhizina Blytt ex Lindblom, Polygonatum odoratum (Mill.) Druce, Pulsatilla patens (L.) Mill., Solidago canadensis occur quite often. The moss cover is formed by Dicranum polysetum Sw., Pleurozium schreberi (Bridd.) Mitt.Sw.; Polytrichum juniperinum Hedw. is less often. The species of Cladonia rangiferina (L.) Weber ex F. H. Wigg. are found on one of the sites in the lichen layer.

11. Reed grass birch forests (RGBF) are represented by only one description, on the basis of which the association of bilberry-reed grass birch forest was distinguished. This site is located on the slope of the mesoscale. The soils are sandy with inclusions of coal. The stand is formed by Betula pendula and Betula pendula with a predominance of the former. Pinus sylvestris and Picea x fennica are found as an admixture. Density of crowns is 0.19. The undergrowth is rare, formed by Picea x fennica, singularly by Pinus sylvestris, Acer platanoides, Tilia cordata, Quercus robur. In the undergrowth, Juniperus communis is most abundant; Frangula alnus is recorded singularly. The herbaceous layer is dominated by Calamagrostis arundinacea and Vaccinium myrtillus; the species of Vaccinium vitis-idaea, Rubus humulifolius, Convallaria majalis, Pteridium aquilinum (L.) Kuhn are quite abundant. The coverage of other species is insignificant. The moss layer is poorly represented (3%) by the following species: Dicranum polysetum Sw., Pleurozium schreberi (Bridd.) Mitt.Sw.

12. Hairy sedge birch forests (HSBF) have been noted only once and are represented by the association of a hairy sedge itself. The soils are sandy. The stand consists of Betula pendula with an admixture of Picea x fennica. Density of crowns is 0.6. In the undergrowth, Tilia cordata is most abundant. Picea x fennica is noted with a lesser abundance. Acer platanoides and Abies sibirica Ledeb. are recorded singularly or with an insignificant abundance. The underbrush contains the species of Corylus avellan, Sorbus aucuparia, Daphne mezereum L., and Frangula alnus. The herbage is clearly dominated by Carex pilosa Scop.; the species of Vaccinium myrtillus, Dryopteris filix-mas are less abundant.
13. Cotton grass birch forests (CGBF) has one description. This community is assigned to the sphagnum-cotton grass birch forest association. This area is located at the bottom of the mesoscale and is characterized by excessive moisture; groundwater occurs at a depth of 10-15 cm; soils are peaty. The microrelief is formed by hummocks of *Eriophorum vaginatum* L., near-stem elevations of *Betula pendula*, *Betula pubescens*, and *Pinus sylvestris*. The stand consists mainly of *Betula pubescens*, and *Betula pendula* Roth is found singularly. Density of crowns is 0.6. *Betula pubescens* and *Pinus sylvestris* are found in rare undergrowth. *Frangula alnus* and *Salix cinerea* L. are found in the undergrowth with a small abundance. The grass stand is dominated by cotton grass, the cover of other species is insignificant. The total cover of the moss-lichen layer is 15%, of which 5% is green mosses (*Dicranum polysetum* Sw.). The remaining 10% is sphagnum mosses (*Sphagnum fallax* (Klinggr.).

14. Meadowsweet birch forests (MBF) has one description, on the basis of which one association is distinguished - sedge-lady fern-meadowsweet. Soils are sandy. This area is characterized by excessive moisture; groundwater occurs at a depth of 20 cm. Only *Betula pubescens* is present in the stand. Density of crowns is 0.5. The undergrowth is well developed. *Picea x Fennica* clearly dominates; *Alnus glutinosa* (L.) Gaertn is also noted. The undergrowth includes *Frangula alnus*, *Rubus idaeus*, *Salix cinerea* and *Viburnum opulus*. The herb-shrub layer is dominated by *Filipendula ulmaria* (L.) Maxim., *Athyrium filix-femina* (L.) Roth and *Carex cespitosa* L. The species of *Angelica sylvestris* L., *Pyrola rotundifolia* L. and *Poa palustris* L. are less represented. Other species are characterized by insignificant abundance. The moss layer is very poorly represented (0.7%). It is formed by the green mosses *Climacium dendroides* (Hedw.) Web. et Mohr., *Brachythecium oedipodium* (Mitt.) Jaeg.

After processing the geobotanical descriptions, the authors received the following estimates: soils differ from poor to rather rich, from very poor / poor in nitrogen to sufficiently supplied with nitrogen, from acidic to slightly acidic; moistening of soils differs from dry-meadow / wet-meadow, from relatively stable to slightly variable; lighting conditions range from semi-open spaces to light forests. Therefore, based on the data obtained, we assume that the studied communities are in rather contrasting habitat conditions, which makes it possible to more fully assess the biodiversity of birch forests.

### 3.1.1. Taxonomic diversity of birch forests

The flora of the studied phytocenoses includes 179 species of vascular plants belonging to 50 families. The Poaceae family is the most represented in the studied communities. 19 species belong to this family (figure 1).

![Figure 1. The spectrum of the leading families in the studied cenoses](image-url)
The families *Compositae* (12 species) and *Rosaceae* (11 species) rank second and third, respectively; followed by *Fabaceae* (10 species), *Cyperaceae* (9 species), *Violaceae* (8 species), *Labiatae*, *Scrophulariaceae* (7 species each), *Aspidiaceae*, *Orchidaceae* (6 species each), *Liliaceae*, *Rubiaceae* and *Umbelliferae* (5 species each). 61.45% of the total flora of the studied birch forests belongs to the listed families. We should note that 21 families are represented by only one species.

Bilberry birch forests are characterized by the highest species richness: they have cenopopulations of 79 plant species. Significant species richness is noted in bracken birch forests (73 species), lily of the valley birch forests (71 species), and ground elder birch forests (68 species). The minimum value of this indicator is noted in cotton grass birch forests (13 species). This is due to two reasons: the growing conditions of plants (boggy) and the fact that this type of forest is represented by only one description.

The species saturation (SS) in the studied sample plots varies greatly (table 1). The minimum value of this parameter is noted in the sphagnum-cotton grass birch forest (13 species / 100 m²), the maximum - in the stone bramble - ground elder birch forest (53 species / 100 m²). The average species saturation is maximum in the meadowsweet birch forests. The value of this indicator is also great in the hairy-sedge birch forests; however, these communities are represented by only one description, therefore, the values of this indicator are not sufficiently accurate. Among forest types represented by more than one description, the average SS is maximum in bracken birch forests, followed by motley grass birch forests, then the ground elder ones. The minimum average SS is noted in cotton grass birch forests, represented by the same description. Among the communities represented by more than one description, the smallest value of this indicator is noted in green moss birch forests (table 1).

The calculated values of the Whittaker index show that bilberry birch forests have the greatest differentiating diversity among the studied cenoses, followed by lily of the valley birch forests (table 1). In other forest types, the value of this index does not exceed 1. The smallest differentiating diversity is observed in mercuries birch forests, where the value of the Whittaker index is 0.32.

### Table 1 α- and β-diversity of the studied communities

| Associations a | Species saturation (min) | Species saturation (max) | Species saturation (average) | Species richness | βw  |
|----------------|--------------------------|--------------------------|------------------------------|-----------------|-----|
| BBF            | 9                        | 37                       | 21,2                         | 79              | 2,73|
| LVBF           | 27                       | 35                       | 30,6                         | 71              | 1,32|
| GEBF           | 23                       | 53                       | 34,3                         | 68              | 0,98|
| LBF            | 24                       | 31                       | 27,7                         | 47              | 0,7 |
| LbBF           | 19                       | 30                       | 24,5                         | 39              | 0,59|
| BrBF           | 29                       | 43                       | 36,7                         | 73              | 0,99|
| MBF            | 18                       | 26                       | 22                           | 29              | 0,32|
| SBF            | 24                       | 25                       | 24,5                         | 41              | 0,67|
| MGBF           | 31                       | 39                       | 35                           | 52              | 0,49|
| GMBF           | 16                       | 17                       | 16,5                         | 23              | 0,39|
| RGBF b         | 19                       | 19                       | 19                           | 19              | —   |
| HSBF b         | 38                       | 38                       | 38                           | 38              | —   |
| CGBF b         | 13                       | 13                       | 13                           | 13              | —   |
| MBF b          | 46                       | 46                       | 46                           | 46              | —   |

a abbreviations: BBF – bilberry birch forests, LVBF – lily of the valley birch forests, GEBF – ground elder birch forests, LBF – linden birch forests, LbBF – lingonberry birch forests, BrBF – bracken birch forests, MBF – Mercuries birch forests, SbBF – stone bramble birch forests, MGBF – motley grass birch forests, GMBF – Green moss birch forests, RGBF – reed grass birch forests, HSBF – hairy sedge birch forests, CGBF – cotton grass birch forests, MBF – Meadowsweet birch forests.

b data is based on 1 description
The authors calculated the Jaccard coefficient to assess the floristic similarity of the studied types of birch forests (table 2).

**Table 2. Coefficients of Jaccard floristic similarity between the studied types of birch forests**

|       | LVBF | LVBF | LVBF | LVBF | LVBF | LVBF | LVBF | LVBF | LVBF | MBF |
|-------|------|------|------|------|------|------|------|------|------|-----|
| BBF   | 0.38 | 0.41 | 0.38 | 0.35 | 0.35 | 0.28 | 0.41 | 0.32 | 0.23 | 0.33 |
| LVBF  | 0.26 | 0.31 | 0.46 | 0.44 | 0.15 | 0.3 | 0.26 | 0.27 | 0.23 | 0.21 |
| GEBF  | 0.46 | 0.29 | 0.33 | 0.35 | 0.35 | 0.45 | 0.17 | 0.21 | 0.38 | 0.08 |
| LBF   | 0.32 | 0.3 | 0.41 | 0.44 | 0.5 | 0.17 | 0.22 | 0.52 | 0.05 | 0.13 |
| LbBF  | 0.42 | 0.16 | 0.38 | 0.23 | 0.36 | 0.33 | 0.28 | 0.11 | 0.19 |
| BrBF  | 0.19 | 0.34 | 0.28 | 0.23 | 0.24 | 0.22 | 0.09 | 0.09 |
| MBF   | 0.23 | 0.29 | 0.06 | 0.17 | 0.34 | 0.05 | 0.09 |
| SbBF  | 0.35 | 0.16 | 0.3 | 0.39 | 0.1 | 0.21 |
| MGBF  | 0.09 | 0.15 | 0.38 | 0.03 | 0.23 |
| GMBF  | 0.31 | 0.15 | 0.16 | 0.11 |
| RGBF  | 0.19 | 0.19 | 0.12 |
| HSBF  | 0.09 | 0.18 |
| CGBF  | 0.07 |

The greatest similarity can be traced between linden and hairy-sedge birch forests (0.52). This indicator is slightly lower between linden and motley grass birch forests (0.5). The lowest value of this indicator is noted when comparing cotton grass and motley grass birch forests (0.03). This is due to the very different growing conditions of plants, first of all, the level of moisture and acidity of the soil. This, most likely, explains the low similarity of the floristic composition between cotton grass birch forests and all other types of forest (0.05-0.19). We should note that there is also a low coefficient of similarity between green moss birch forests and mercury and meadowsweet birches (0.09). In general, we can say that the values of the floristic similarity coefficient between the studied types of birch forests are not large and, in most cases, do not exceed the threshold of 50%.

Also, to analyze the biodiversity of communities of different groups of associations of birch forests, we used the Shannon diversity index and the Shannon evenness index (table 3). High values of this index were noted for bracken birch forests (3.37), ground elder birch forests (3.32), lilac of the valley (3.29), linden (3.25) and meadowsweet birch forests (3.24). The lowest rates are typical for cotton grass (2.14) and green moss (2.24) birch forests. The Shannon evenness index varies from 0.66 (blueberry birch forest) to 0.88 (reed birch forest).

The authors found that on the examined test plots, 1 species, *Picea X fennica* (Regel) Kom., belongs to the V class of occurrence (the species was recorded on more than 80% of the test plots), but it was not recorded at all plots. I class of occurrence (the species was recorded on less than 20% of the sample plots) includes 138 species, 68 of them were recorded only on one of the plots.

Occurrence classes were also calculated for species in different forest types. It turned out that 4 species belong to the V class of occurrence - these are *Betula pendula*, *Frangula alnus*, *Picea x fennica* and *Rubus humulifolius*. I class of occurrence includes 93 species, of which 71 species are found only in one of the types of birch forests.
Table 3. The Shannon diversity index and the Shannon evenness index in the studied types of birch forests

| Associations | Range of values of the Shannon diversity index | Shannon diversity index | Shannon evenness index |
|--------------|-----------------------------------------------|-------------------------|-----------------------|
| BBF          | 2.23-3.31                                     | 2.89                    | 0.66                  |
| LVBF         | 3.24-3.48                                     | 3.29                    | 0.77                  |
| GEBF         | 2.91-3.87                                     | 3.32                    | 0.79                  |
| LBF          | 3.13-3.37                                     | 3.25                    | 0.84                  |
| LbBF         | 2.79-3.22                                     | 3.08                    | 0.84                  |
| BrBF         | 3.11-3.52                                     | 3.37                    | 0.79                  |
| MBF          | 2.67-2.73                                     | 2.7                     | 0.8                   |
| SbBF         | 2.75-2.89                                     | 2.82                    | 0.76                  |
| MGBF         | 2.85-3.1                                      | 2.98                    | 0.75                  |
| GMBF         | 2.23-2.25                                     | 2.24                    | 0.71                  |
| RGBF         | 2.59                                          | 2.59                    | 0.88                  |
| HSBF         | 2.9                                           | 2.9                     | 0.8                   |
| CGBF         | 3.24                                          | 3.24                    | 0.85                  |
| BBF          | 2.14                                          | 2.14                    | 0.83                  |

Structural diversity. The authors note the species of 7 ecological-coenotic groups (ECG) in the studied birch forests: nemoral, meadow, boreal, upland, nitrophilic, water-coastal and oligotrophic groups.

The group of nemoral species (Nm) is the most represented - 50 species (figure 2). The second and third places are taken by meadow (35) and boreal (30) ECG. The species of the upland ecological-coenotic group (25) are slightly less represented, followed by nitrophilic species (18), coastal water (14), and oligotrophic bog species (7).

Figure 2. Ecological-coenotic composition of the studied communities:
- ecological-coenotic groups (ECG): Nm - nemoral, Md - meadow, Br - boreal, Pn - upland, Nt - nitrophilic, Wt - coastal water, Olg - oligotrophic

The authors determined the ecological-coenotic affiliation of the species most often found on the studied sample plots, i.e. those that have the IV-V class of occurrence. Seven species were assigned to the boreal ECG (Betula pendula, Picea x fennica, Frangula alnus, Sorbus aucuparia, Maianthemum bifolium, Rubus humilifolius and Vaccinium myrtillus), two species are nemoral (Calamagrostis arundinacea and Convallaria majalis). Compared to the general spectrum for all birch forests (figure 2), the spectra plotted for individual types of birch forests are very different (table 4). Recall that in the general spectrum there are 7
ECG species, among which nemoral species predominate; the second, third and fourth places are occupied by the meadow, boreal, and upland groups. We found all ECGs in bilberry, ground elder, bracken, stone bramble, and meadowsweet birch forests (table 4).

The nemoral and boreal ECG species are dominant in blueberry, stone bramble, motley grass, and hairy sedge birch forests. In blueberry and hairy sedge birch forests, the proportion of these groups is practically the same; in stone bramble birches, boreal dominates, and in motley grass birches, nemoral ECG prevails. Moreover, here nemoral species occupy exactly half of all species found in this group of associations. In bilberry birch forests, stone bramble and hairy sedge, meadow and pine forest species have the same participation, and their share is greatest in bilberry birch forests (12.82 and 11.54%, respectively). In the motley grass birch forests, upland species are absent, but due to the higher humidity in comparison with the above types of forest, the proportion of nitrophilous species is higher.

Table 4. Ecological-coenotic structure of the studied groups of associations of birch forests

| ECG                        | Nm  | Md  | Br  | Pn  | Nt  | Wt  | Olg |
|----------------------------|-----|-----|-----|-----|-----|-----|-----|
| Bilberry birch forests     | 29.49 | 12.82 | 33.33 | 11.54 | 7.69 | 3.85 | 1.28 |
| Lily of the valley birch forests | 25.35 | 22.54 | 22.54 | 26.76 | 2.82 | —    | —   |
| Ground elder birch forests | 47.06 | 5.88 | 25   | 4.41 | 13.24 | 2.94 | 1.47 |
| Linden birch forests       | 26.44 | 50.57 | 19.54 | 1.15 | 2.3  | —    | —   |
| Lingonberry birch forests  | 20.51 | 10.26 | 30.77 | 35.9 | —    | —    | 2.56 |
| Bracken birch forests      | 28.77 | 19.18 | 20.55 | 17.8 | 4.11 | 8.22 | 1.37 |
| Mercuries birch forests    | 75.86 | —    | 24.14 | —    | —    | —    | —   |
| Stone bramble birch forests| 31.71 | 9.76 | 39.01 | 9.76 | 4.88 | 2.44 | 2.44 |
| Motley grass birch forests | 50   | 7.69 | 30.77 | —    | 11.54 | —    | —   |
| Green moss birch forests   | 17.39 | —    | 30.43 | 47.83 | —    | 4.35 | —   |
| Reed grass birch forests   | 21.05 | 5.26 | 47.37 | 26.32 | —    | —    | —   |
| Hairy sedge birch forests  | 42.11 | 7.89 | 39.48 | 7.89 | 2.63 | —    | —   |
| Cotton grass birch forests | —    | —    | 23.08 | 15.38 | —    | 15.38 | 46.16 |
| Meadowsweet birch forests  | 13.04 | 6.52 | 30.43 | 4.35 | 26.09 | 17.4 | 2.17 |

The species of upland ECG dominate in lily of the valley birch forests (26.76%). The share of nemoral species is practically the same and amounts to 25.35%, in third place is the boreal and meadow ECG (22.54%). The dominance of the upland group is also noted for lingonberry and green moss birch forests. In the second place in the last two groups of associations is the boreal ECG, in the third place is the nemoral one. Meadow species are absent in green moss birch forests and in the lingonberry ones their proportion is about 10.26%. In the lingonberry birch forests there is an insignificant proportion of oligotrophic bog species, and in the green moss birch forests there are coastal aquatic species.

The species of nemoral ECG dominate in bracken and mercuries birch forests. In the second and third places in bracken birch forests are boreal and meadow species, followed by pine forests. Coastal aquatic, nitrophilous and oligotrophic species have an insignificant share. In mercuries birch forests, the ECG spectrum is represented by only two groups: in addition to the nemoral group, the species of which occupy ¾ of all types of this group of associations, there is a boreal ECG.

In ground elder birch forests, almost half of all species are nemoral (47.06%), in the second place are boreal species (25%), and in the third place are nitrophilic species (13.24%). The conditions are more humid here, and the proportion of nitrophilic species is rather high compared to other groups of associations.

Meadow ECG dominates in linden birch forests. It should be noted that of all the groups of associations studied here, its share is the largest (50.57%). The second and third places are occupied
by nemoral (26.44%) and boreal (19.54%) species. Also, nitrophilic and upland species are identified here (their share is small and amounts to 2.3 and 1.15%, respectively).

Of all the groups of associations in the reed birch forests, the proportion of boreal species is the largest (47.37%). Next come the species of upland (26.32%), nemoral (21.05%) and meadow (5.26%) ECGs. In the meadowsweet birch forests, characterized by good soil conditions and somewhat excessive moisture, the dominance of boreal species is also noted, which make up almost a third. Nitrophilic species are slightly less represented. In the third and fourth places, with rather large shares, are coastal water (17.4%) and nemoral (13.04%) species. Also, in this type of forest, species of meadow (6.52%), upland (4.35%) and oligotrophic (2.17%) ECGs are observed.

In cotton grass birch forests, almost half of the species belong to oligotrophic ECG (46.16%). The second place belongs to boreal species; their share is 23.08%. The third and fourth places are occupied by upland and water-coastal species (15.38% each).

An analysis of the ecological-coenotic confinement of species with the 5th class of occurrence in the studied forest types showed that all 4 species - *Frangula alnus* Mill., *Betula pendula* Roth, *Picea X fennica* (Regel) Kom. и *Rubus saxatilis* L. - belong to the boreal ECG.

The biomorphological composition of the studied birch phytocenoses is represented by seven classes of life forms. Most of the species belong to herbaceous polycarpic plants (72.78%), among which the long-rhizome (27.22%) species prevail. Next are the plants belonging to the short-rhizome (13.33%) biomorph. The rest of the life forms of polycarpic herbs are much less represented. The share of monocarpics in our studies is insignificant and amounts to 3.33%. In the studied communities, the total share of herbaceous plants is 76.11%. A rather high proportion of woody plants (17.22%) is also noted, among which trees and shrubs dominate, represented by 15 and 16 species, respectively. Shrubs are represented by three types. Other classes of life forms are represented insignificantly: semi-woody plants - by three species, lianas and saprophytes - by two, succulents and semi-parasites - by one.

Summarizing the above, we can conclude that the predominance of long-rooted herbaceous plants and the minimum number of monocarpic plants are most likely associated with the low efficiency of seed renewal in forest phytocoenoses, which gives an advantage to species with the ability to vegetative reproduction.

4. Conclusions

The studied birch forests of the Yalchinsky forestry in Mariy Chodra National Park are characterized by a fairly high diversity. The authors identified 14 types of birch forests in rather contrasting habitat conditions. The assessment of ecological conditions also showed that the studied communities are in rather contrasting habitat conditions, which made it possible to more fully assess the diversity of the analyzed territory. The flora of the studied phytocoenoses includes 179 species of vascular plants belonging to 50 families. The most represented families are *Poaceae* (17 species), *Compositae* (12 species) and *Rosaceae* (11 species). The species saturation varies greatly. The minimum value of this parameter is noted in the sphagnum-cotton grass birch forest (13 species/100 m²), the maximum - in the stone bramble - ground elder birch forest (53 species/100 m²). The study of the structural diversity of the studied birch forests allowed us to identify 7 ecological-coenotic groups: nemoral, meadow, boreal, upland, nitrophilic, water-coastal and oligotrophic, as well as seven classes of life forms (arboreal, semi-arboreal, herbaceous, lianas, succulents, semi-parasites, and saprophytes).

**Funding**

This work was carried out within the framework of the Program of Fundamental Research of the State Academies of Sciences in 2013-2020 (projects nos. AAAA-A17-117112040040-3 and AAAA-A17-117112040039-7).
References

[1] Bukhtynov A D, Groshev B I and Krylov G V 1981 Forests (Moscow: Thought)
[2] Yaroshenko A Yu, Potapov P V and Turubanova S A 2001 The last intact forest landscapes of Northern European Russia (Moscow: Greenpeace Russia)
[3] Degteva S V, Zheleznova G V, Pystina T N and Shubina T P 2001 Coenotic and floristic structure of deciduous forests of the European North (St. Petersburg: Nauka)
[4] Isaev A S, Nosova L M and Puzachenko Y G 1995 General concepts of biological diversity Biological diversity of forest ecosystems 3-11
[5] Danilov M D 1956 Vegetation of the Mari ASSR (Yoshkar-Ola: Mari Book Publishing House)
[6] Turmukhametova N V and Bekmansurov M V 2005 Silver birch Biodiversity of plants in the ecosystems of Mariy Chodra National Park pp 40-46.
[7] Mariy Chodra National Park (Mari forest) 2007 Eds Alekseev I A, Alyabyasheva E A, Mikheeva A V et al.
[8] Abramov N V 2000 Flora of the Republic of Mari El: inventory, zoning, protection and problems of rational use of its resources (Yoshkar-Ola: Publishing House of the Mar. state University)
[9] Andreeva E N, Bakkal I Yu, Gorshkov V V et al 2002 Methods for studying forest communities
[10] Tsyganov D N 1983 Phytoidication of ecological regimes in the subzone of coniferous-deciduous forests (Moscow: Nauka)
[11] Zaugolnova L B 2000 Assessment and conservation of forest biodiversity in reserves of the European part of Russia (Moscow: Scientific World)
[12] Zobkova E V, Khanina L G, Grokhлина М.: Научный мир Т I and Dorogova Yu A 2008 Computer processing of geobotanical descriptions on ecological scales using the program "EcoScaleWin"(Yoshkar-Ola: Publishing House of the Mar. state University)
[13] Zaugolnova L B et al 1995 Information and analytical system for assessing the successional state of forest communities: Preprint (Pushchino: ONTI PNC RAS)
[14] Magurran A E 1992 Ecological Diversity and Its Measurement (Moscow: World)
[15] Schmidt V N 1984 Mathematical Methods in Botany (Leningrad: LSU Publishing House)
[16] Nitsenko A A 1969 On the study of the ecological structure of the vegetation cover Botanical journal 54 1002-1014
[17] Zozulin G M 1970 Historical formations of vegetation Botanical journal 55 23-33.
[18] Zozulin G M 1973 Historical formations of vegetation of the European part of Russia Botanical journal 58 1081-1092.
[19] Serebryakova T I 1971 Shoot morphogenesis and evolution of life forms of cereals (Moscow: Nauka)
[20] Serebryakov I G 1964 Life forms of higher plants and their study Field geobotany 146-209