UDC 528.946; 58.002 DOI:10.30533/0536-101X-2021-65-6-647-654

VEGETATION COVER STUDYING AND DETAILED MAPPING OF THE SOUTH PART OF THE KUNASHIR ISLAND (KURIL ISLANDS)

Mikhail Yu. Grishchenko[1,2,3*], **Ekaterina Yu. Zhdanova**[1,4], **Tatyana Yu. Ivleva**[5]

[1] Lomonosov Moscow State University, Faculty of Geography, Moscow, Russia
[2] HSE University, Faculty of Geography and Geoinformatics, Moscow, Russia
[3] State nature reserve «Kurilsky», Yuzhno-Kurilsk, Sakhalinskaya oblast, Russia
[4] Institute of Geography RAS, Glaciological Department, Tree-Ring Laboratory, Moscow, Russia
[5] A.N. Severtsov Institute of Ecology and Evolution RAS, V.N. Sukachev laboratory of biogecenology, Moscow, Russia

* m.gri@geogr.msu.ru

Citation: Grishchenko MYu, Zhdanova EYu, IvlevaTYu. Vegetation cover studying and detailed mapping of the south part of the Kunashir Island (Kuril Islands). *Izvestia vuzov. Geodesy and Aerophotosurveying*. Moscow. 2021;65(6): 647-654. (In Russian). DOI:10.30533/0536-101X-2021-65-6-647-654

Keywords. Kunashir Island, geobotanical mapping, large-scale maps, vegetation, ecomorphological classification, South Kurils, field interpretation, highly detailed thematic cartography, vegetation cover, vegetation cover spatial variation.

Acknowledgements
The authors are grateful to the staff of the Kurilsky State Nature Reserve for their invaluable assistance in the work performance.

Abstract
The article discusses the results of work on detailed mapping of the vegetation cover within a part of the Aliokhinsky cluster of the Kurilsky state nature reserve. The area of interest is characterized by a low degree of knowledge in general; the vegetation cover of Kunashir has been studied on a lower scale. This paper is in line with the work on large-scale thematic mapping of the territory of the Kurilsky state nature reserve and its buffer zone, carried out by a team of employees of the reserve and the Faculty of Geography of Lomonosov Moscow State University. The investigated area stretches along the coast of the Sea of Okhotsk and extends inland for 3-7 km. Field work was carried out in 2015-2018 and 2020 and included field interpretation of very high spatial resolution satellite images and compilation of field geobotanical descriptions using standard techniques. The area of the study area was 62 km2. The following groups of formations have been identified: coniferous forests and light forests, mixed forests and light forests, broadleaf and parvifoliate forests and sparse forests. The categories of non-forest formations are arranged in the legend titles in such a way as to emphasize the transitional nature of the formations, especially pronounced in the conditions of the Southern Kurils: meadows and tall grasses, thickets and bushes. As a result of the work carried out, the spatial heterogeneity of the vegetation cover of this territory was revealed, within which several geobotanically different regions can be distinguished: the caldera of the Golovnin Volcano, the coast

of the Sea of Okhotsk north of the Golovnin Volcano, the ancient lava plateau, the Sernovodsky isthmus and adjacent hills. The regularity of the distribution of plant communities in the mapped area can be characterized as the predominance of large-contour massifs of coniferous and birch-coniferous forests in the near-watershed part of the island and the location of many small contours of mixed and broadleaf forests on the slopes of hills closer to the sea coast.

1. Introduction

The vegetation of the Southern Kurils and, specifically, the Kunashir Island in particular, is characterized by specificity and diversity. Considering the poor knowledge of this region associated with its inaccessibility and tortuous geopolitical history, it should be noted that the vegetation cover, along with vulcanism, is one of the most studied components of local geosystems.

The vegetation cover of the island was studied far back by Japanese scientists during the period of Japanese development of this region. Today, the vegetation cover is studied mainly by domestic researchers who currently have compiled the most complete descriptions [1–3]. It is worth to pay attention to the works of V.Y. Barkalov. He is the author of the most relevant descriptions to date [3, 4]. However, these works investigate either flora or vegetation on a relatively small scale whereas there are very few examples of cartographic works devoted to the vegetation cover of the Kunashir Island [5]. The most complete cartographic set of data on the vegetation of Kunashir is presented in the Atlas of the Kuril Islands (2009), but there are no large-scale maps in this atlas. The study and mapping of the local vegetation cover on a large scale is an urgent task, given the high value of island biocenoses in terms of biodiversity conservation, ensuring the functioning of the Kurilsky State Nature Reserve on the island, and also considering Kunashir as a potential investment point for recreational zones development.

Kunashir is the most southern island of the Greater Kuril ridge. It is the fourth by area (1,500 km^2) among all the Kuril Islands. The island is washed from the west by the Sea of Okhotsk, and from the east by the Pacific Ocean. Kunashir is separated from the Japanese island of Hokkaido by the Kunashir and Izmeny Straits, from Iturup by the Catherine Strait, and from the islands of the Lesser Kuril Ridge by the South Kuril Strait.

Since 1984, the Kurilsky State Nature Reserve has been opened on the territory of Kunashir Island. The study area is located in the northern sector of the Aliokhinsky cluster of the reserve. The total land area is 62 km^2. The investigated area is the Golovnin Volcano massif and its northern sector formed by an ancient lava plateau. The boundary of the mapped area runs roughly along the watershed of the island. The northern part of the study area is the Sea of Okhotsk sector of the Sernovodsky isthmus separating the massifs of the Golovnin and Mendeleev volcanoes.

Golovnin Volcano is one of two caldera-type volcanoes in the Kuril Islands. It is active like the other three volcanoes of Kunashir Island. The caldera of the Golovnin Volcano has a diameter of 4.5 km and a depth of about 250 m. There are two lakes in the caldera: the Goryachee Lake, 2.5×1 km, occupies its northern half. The Kipyashchee Lake, 200×300 m, occupies a crateral depression in the center of the caldera. Several extrusive domes and solfatara fields are connected with the Golovnin Volcano. There are two large extrusion domes in the center of the caldera – Central East and Central West. The largest volcano fields of the same name are confined to them. Another large extrusion dome, Vneshny, is located north of the caldera, its slopes descending to the Sea of Okhotsk. A group of South Aliokhinsky thermal springs is confined to its foot; on the slope of the dome, there is a large Vneshny solfatara field.

Today, the northern macroslope of Golovnin Volcano is a series of rounded-topped hills and ridges up to 250 m high, separated by river valleys. The surface of the Sea of Okhotsk sector of the Sernovodsky isthmus is rugged by a dune field of aeolian origin. There is a series of multilevel marine terraces on the Sea of Okhotsk coast, that are more or less distinct on various parts of the coast.

The study area receives a lot of precipitation (1,200 mm per year). Moisture stagnation does not occur due to the sufficient infiltration of local soils and a

rather dense watercourses network. The region is characterized by an oceanic climate with cool winters and warm summers. Increased relative atmospheric humidity is observed all year around, and fogs are frequent.

The study area is high forestry, which is characteristic of the entire Kunashir area. Mixed coniferous and broad-leaved forests are widespread here. Their forest stand is dominated by *Abies sachalinesis, Betula ermanii, Picea jezoensis,* and *Quercus crispula. Sasa kurilensis* most often dominates in the grass-shrub stratum. Its projective cover decreases in dense forests with the prevalence of conifers, and it gives way to other species. The forests are rich in lianas. Unforested areas are featured by thickets of elfin, bamboo, tall-grasses, and meadows of marine terraces. Thickets of cedar elfin wood *Pinus pumila* are especially widespread in the caldera of Golovnin Volcano. Thickets of the Kuril bamboo *Sasa kurilensis* occupy the tops of the hills and a significant part of the caldera bottom of the Golovnin Volcano. They are common in almost all unforested island areas. Tall-grass bushes occupy stream valleys and small lows on marine terraces. Peculiar meadow communities with dominated *Leymus mollis, Glehnia litoralis, Rosa rugosa,* and other forbs are confined to the marine terraces.

The topsoil of the mapped area mostly contains brown soils.

The investigated site is located in the territory of the Kurilsky State Nature Reserve and its protective zone. Therefore, economic activity here is minimal. The vegetation is impacted only by tourists visiting Goryachee and Kipyashchee lakes and the southeastern sector of the Golovnin Volcano caldera, as well as cattle grazing in certain limited areas of the buffer zone. However, before the formation of reserve in 1986, agricultural and forestry activities that are common for the Kuril Islands were conducted in the territory: fishing, cattle grazing, vegetable gardening, wild crop harvesting, and timber harvesting. There were large rural settlements in the Alyokhino, Seseki, Znamenka, and Danilovo areas. In the times of Japanese land reclamation, the economic activity was probably more buoyant. Small settlements were also located at the mouths of the Troinoy spring, the Ozernaya river and in the caldera of the Golovnin Volcano, where a small sulfur plant operated. Seemingly, there was a large-scale deforestation.

2 Methods and materials

The map was compiled on the basis of field surveys conducted in 2015–2018 and 2020. During the map creation, a multispectral satellite image from the Pleiades 1B satellite was decoded in the optical range obtained on June 1, 2015. The spatial resolution of the image is 0.5 m in the panchromatic range, and 2 m in narrow spectral ranges. Spectral and radiometric characteristics of this space image enable interpretation of individual open-stand large trees and sparse forests; differences in the spectral image pattern and texture of various tree species in the forested area also determine its high efficiency. When interpreting meadow and tall grass communities, we can clearly distinguish gramineous meadows, bamboos and tall grass area. In addition to the space image, topographic maps were used as sources of the vegetation map compilation. They provide detailed (as much as possible) information about the topographical relief.

At the intermediate stage of the map compilation, the analysis of field geobotanical descriptions was conducted, and the resulting table was created. This was done to arrange the names of plant communities in the legendary data. The names of plant associations are grouped into the largest categories, specifically, by group of formations. The following groups of formations have been identified: coniferous forests and light forests, mixed forests and light forests, broad-leaved and small-leaved forests and light forests. The categories of non-forest formations are arranged in the legend titles in order to emphasize their transitional nature, especially distinct in the conditions of the Southern Kurils: meadows and tall-grasses, thickets, and shrubs. In the study area, only one group of associations was found, which can be attributed to marsh vegetation. However, this community has a separate title in the legend. The latter group of communities, which includes plant communities of sandy and pebble beaches, also includes communities of solfatara fields. They have an essential similarity to beaches: immature topsoil, an abundance of areas completely devoid of vegetation, and intrazonal communities.

The transition from object classification to legendary data was the first step towards cartographic generalization and organization of the available material [6]. The map legendary data (Fig. 1) are

based on the ecological and morphological classification. This classification suggests the consideration of structural and morphological characteristics of plant communities and the composition of their dominant and differentiating species. Thus, the systematization of plant communities is based on the dominance of species of a certain ecobiomorph as part of the main strata of plant community. The legendary data are built on a hierarchical basis and consist of two- units of strata patterns: associations and groups of associations. The first-level designations are formations (elfin, bamboo) and vegetation types (forests, woodlands, and swamps). Such diverse levels better reflect the differentiation of the vegetation cover of a given area.

Fig. 1. The part of the legend to the geobotanical map of the southern part of the Kunashir Island at the scale of 1 : 25,000 (Fig. 2)

The map was compiled at the scale of 1 : 25,000 (Fig. 2). For the map design, a color scheme was chosen that is well-established in the domestic geobotanical mapping [7].

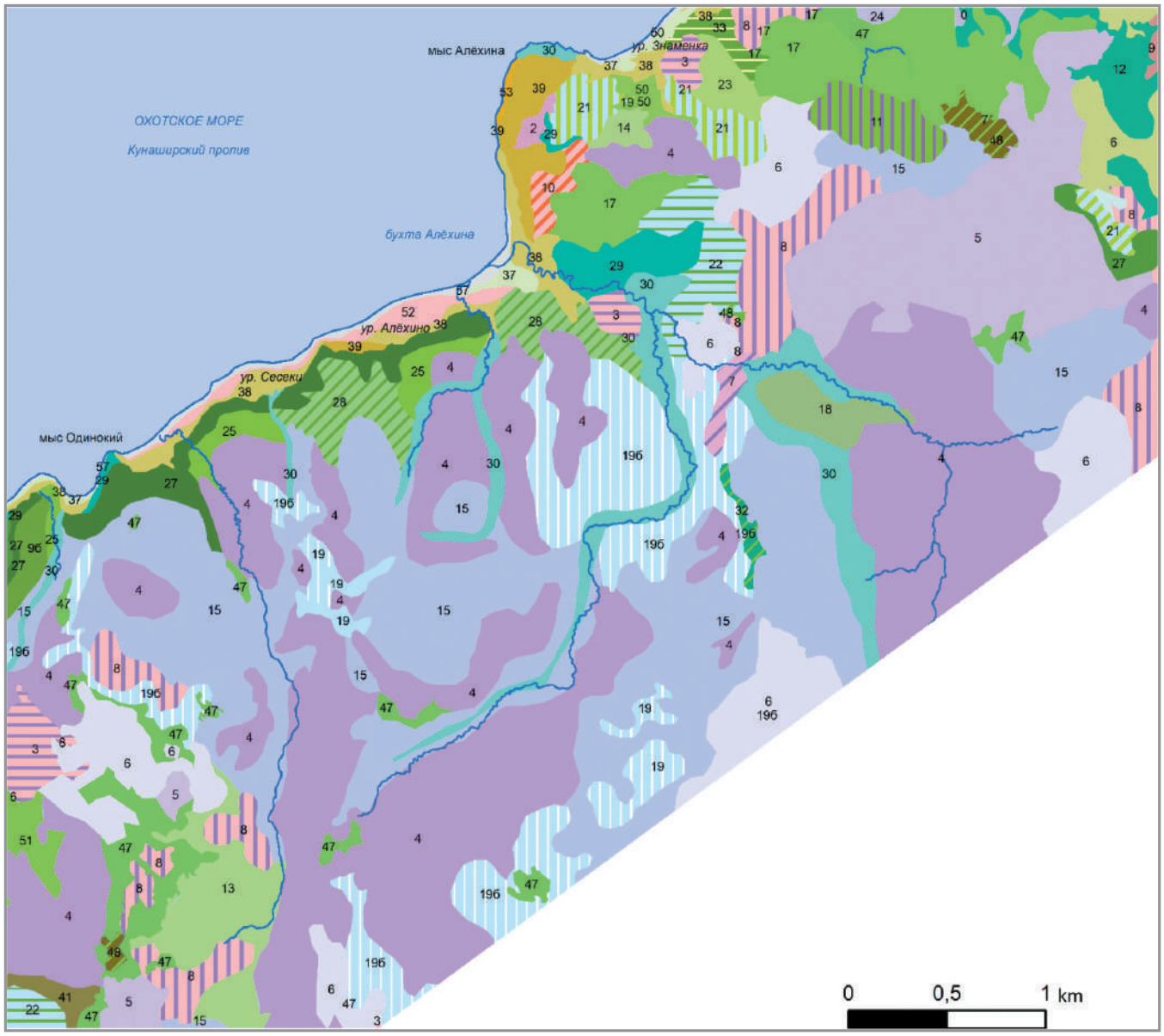

Fig. 2. The geobotanical map tile image of the southern part of the Kunashir Island on a scale of 1: 25,000 (Fig. 1)

3 Results

As a result of the compiled map analysis, it was revealed that the largest area of the study site is occupied by spruce bamboo forests. Sakhalin fir (*Abies sachalinensis*) is one of the background forest species on the Kunashir Island. Fir forests are widespread in the study area throughout the polygon. However, these trees tend to spread to the northern part and to the places with more severe habitat conditions. For example, prevailing strong wind in the Trekhozernaya valley create the flag-like life conifer forms. Among the main species, fir forests include *Picea jezoensis, Picea glehnii, Taxus cuspidata, Betula ermanii, Kalopanax septemlobus, Quercus crispula, Sorbus commixta, Acer mayrii,* and some others. The ratio of these tree species is unique for each geobotanical description. Therefore, it is difficult to classify fir forests in more detail. As a rule, Sakhalin fir trees are 1.5–2 fold more frequent compared of than all other species altogether. Forest stand density ranges from 50 to 80 %, the tree stratum has an average height of up to 16 m. There is often a well-developed shrub stratum consisting of *Hydrangea paniculata, Rubus matsumuranus, Ribes sachalinense, Toxicodendron orientale, Padus ssiori,*

and *Euonymus planipes*. The grass-shrub stratum is not developed everywhere: areas with an absolute fir predominance, as a rule, are dead cover. Their projective cover is not more than 10%. *Oxalis acetosella* and several other species grow here. Such areas are found on steep slopes. In general, the dominant species in the grass-shrub stratum of fir forests are *Sasa kurilensis, Pteridium aquilinum*, and *Carex sp.* They are most often supplemented by *Cirsium kamtschaticum, Celastrus strigillosa, Chamaepericlymenum canadense, Impatiens noli-tangere, Viola selkirkii*, as well as about 36 grass species. An extensive area of fir forests with a predominance of ferns in the grass-shrub stratum is confined to the northwestern spur of Danilovsky volcanic hill. There is a large number of lianas (woody vines) in fir forests *Toxicodendron orientale, Hydrangea petiolaris, Actinidia kolomikta, Actinidia arguta,* and *Vitis coignetiae*. The total species wealth of fir forests is about 60 species.

The second largest area is occupied by cedar elfin wood thickets, specifically, cedar elfin wood cornel wild rosemary bamboo thickets. Such communities are not widely spread on the Kunashir Island as a whole, but occupy a large area in the caldera of Golovnin Volcano. There they form the main vegetation community. Cedar elfin wood thickets are good marks for habitats with poor stony immature soils. There is no a full-range tree stratum in such communities; however, individual trees *Betula ermanii, Quercus crispula, Sorbus commixta, Abies sachalinesis,* and *Picea jezoensis* are often found. The shrub layer is formed by *Pinus pumila*. Their projective cover varies from 30 to 100%; individual specimens of *Hydrangea paniculata* are found. In the grass-shrub stratum, *Sasa kurilensis* is dominant, *Ledum hypoleucum* is widespread, and *Chamaepericlymenum canadense* is slightly less common. In general, such communities are characterized by a very low species diversity, which is due to the habitat specificity.

The third largest area is occupied by fir-spruce bamboo forests and light forests. In a dense forest stand of *Abies sachalinesis* and *Picea jezoensis* the shrub layer may be completely absent. In sparse forest stands, *Pinus pumila* plays an important role in the shrub stratum. Such communities occupy elevated areas of volcanic hills with an absolute height of more than 50 m. There are *Betula ermanii, Quercus crispula, Taxus cuspidata, Acer mayrii,* and *Sorbus commixta* in the second layer of the tree stratum, in addition to the main species. Density of crowns is about 70%. Spruce trees, as a rule, are higher and can reach 21 m, while the average height of other species is 12–15 m. The spruce crowns can be 4–5-fold larger in diameter than the fir crowns. Lianas and shrubs are represented by the same species as in fir forests, though *Aralia elata* and *Schisandra chinensis* are also common here. *Sasa kurilensis* dominates with a projective cover of 45 to 80% of the grass-suffruticose layer. It is combined with small quantities of *Oxalis acetosella, Clintonia undensis, Maianthemum dilatatum,* and *Cirsium kamtschaticum*. The total species wealth of this group of associations is 37 species (9 - arboreal, 7 - shrub, 15 - grass species, and 6 lianas).

Stone-birch bamboo forests are of utmost importance in the formation of vegetation cover of the study area. These are deciduous forests; the absolute dominant in their tree stratum is Erman's birch (*Betula ermanii*). This formation in the study area is represented by monodominant forests and light forests, as well as forests sparsely mixed with other tree species (for example, maple-stone birch). In addition to the edifier, the forest stand may include *Sorbus commixta, Kalopanax septemlobus, Duschekia maximowiczi,* and *Quercus crispula.* The forest stands of Erman's birch are characterized by low crown density (closure) of 40–50% and a height of 9–13 m. This formation is characterized by significant abundance of shrubs, due to the low degree of closure: *Hydrangea paniculata*, *Euonymus macroptera*, and *Morus australis*. In the lower layer of stone birch communities, thickets of *Sasa kurilensis* are completely dominant. The projective cover can reach 100%, which probably prevents the formation of a denser forest stand. This formation is featured by 36 species: 9 trees, 6 shrubs, 17 grass species and 4 species of lianas.

Kuril bamboo *Sasa kurilensis* is one of the edificators of plant communities on Kunashir Island, especially in its southern part. Bamboo formations are represented by three groups of associations: bamboo forbs, bamboo monodominant, and bamboo with clumps of cedar elfin wood *Pinus pumila*. Bamboo is the background landscape view. It can be found everywhere, from coniferous forests to meadows on marine terraces. Bamboo can have a projective

cover of up to 90-100 % and reach a height of about one and a half meters. Bamboos are very peculiar communities. There, under the canopy of bamboo, additional layers of vegetation are often formed. In the bamboo thickets, you can find more than 45 grass species, for example: *Lathyrus japonicus, Artemisia montana, Thalictrum thunbergii, Calamagrostis langsdorffii, Geranium erianthum, Vicia japonica,* and others.

Very distinctive communities are formed by *Betula ermanii, Picea jezoensis,* and *Abies sachalinensis* forests. They are represented by massifs of different sizes at heights above 30–40 meters. This is a variation of the most common forest communities in the site with a predominance of Sakhalin fir *Abies sachalinensis*. However, the dominant feature here is Erman's birch *Betula ermanii*. It should be noted that in some areas spruce does not participate in the forest stand and is represented by dead individuals, due to the influence of the typographer bark beetle (*Ips typographus*) [8]. *Sasa kurilensis* is the predominant species in the grass-shrub stratum.

We also believe that it is necessary to mention the species that are not widely spread, but are also the representative communities which characterize the specific geographic features of the local level, which is no doubt important for large-scale mapping. These include, for example, dead-cover spruce forests with *Picea glenhii* in the forest stand.

This forest massif is confined to the southern part of the Golovnin Volcano caldera. Glen spruce trees form a dense forest stand with a projective cover of up to 80 %. The sun rays do not penetrate under the crown of this stand and it does not allow the formation of other layers of vegetation. Probably, such communities are confined to ancient solfatara fields. Under the *Picea glenhii* canopy, there are quite a few dead *Pinus pumila* cedar elfin wood trees. This speaks in favor of this theory, considering little needs of these trees.

Quercus crispula oak trees are represented by a group of oak-bamboo associations. These are typical secondary communities of Kunashir. Such forests occupy small areas on the slopes of volcanic hills of various exposures, rising through them up to 90 m above sea level. As a rule, oak forests tend to spread towards the Sea of Okhotsk coast. In addition to oaks, *Acer mayrii, Sorbus commixta,* and *Padus ssiori* are found in the tree stratum with a crown density of 50 to 70 % and a height of about 10 m. There are stone-birch-oak bamboo and forb, maple-oak forb-bamboo forests. Tree trunks are often bizarrely twisted by climatic factors. The undergrowth is implicit. The grass-shrub stratum, as a rule, has a projective cover of more than 70 %. *Sasa kurilensis* dominates here. However, there are also such species as *Maianthemum dilatatum, Clintonia udensis, Cirsium kamtschaticum,* and *Thalictrum thunbergii.* Lianas are very abundant and most often represented by the species *Toxicodendron orientale* and *Actinidia arguta*. The species wealth of oak forb-bamboo forests is about 30 species.

On the marine terraces of Kunashir, peculiar geomorphological and climatic conditions were formed, which led to the development of gramineous-forb meadows here. Most often, such areas are not sufficiently moisturized. In addition to marine terraces, meadow communities occupy the dune surfaces on the Sernovodsky isthmus. The associations of gramineous-forb meadows are characterized by a high diversity of species (58 species in the descriptions). The projective cover can vary from 30 to 90 %. The height of the grass stand rarely exceeds 40 cm. Gramineous-forb meadows are formed mainly by thickets of *Leymus mollis, Anaphalis margaritacea,* and *Poa eminens.*

The projective cover of *Leymus mollis* in meadow communities reaches its maximum near the Lake Peschanoe shores. The communities are supplemented by such species as *Plantago camtschatica, Artemisia montana, Geranium yesoense, Iris setosa, Petasites amplus*, and some others.

There is also *Sasa kurilensis* bamboo on marine terraces, but it is found here in the form of single clumps of no more than 25 cm high. In the area of the Danilovo tract, numerous bunches of *Ophelia tetrapetata* and *Cardiocrinum cordatum* grow. *Rubus parvifolius* and *Rosa rugosa* occupy a significant place the most important role in such communities. Their habitats are confined to areas with a more developed soil cover. The bushes height varies from 30 to 90 cm.

The plant communities located close to the solfatar fields are very peculiar. The harsh conditions created by release of volcanic gases lead to formation of boreal communities from *Pinus pumila* and *Empetrum nigrum* here.

4 Conclusion

The partitioning pattern of plant communities in the mapped area can be characterized as the predominance of large-contour massifs of coniferous and birch-coniferous forests in the near-watershed part of the island and the location of many small massifs along the contour area of mixed and broad-leaved forests on the volcanic hill slopes closer to the sea coast. The vegetation of the seaward slopes of the volcanic hills is especially diverse. It is the place with specific plant communities rare for Kunashir. Another center for the formation of atypical communities is the Golovnin Volcano. Its salt fields and acid lakes allow the formation of a distinguished range of unique communities. Alder forests grow in the valleys along large waterways. Tall grass communities also grow in the valleys of medium, small and temporary watercourses. On marine terraces and seaward slopes, gramineous-forb meadows, rosehips and tall-grass communities are widespread.

References

1. Vorob'yov DN. Rastitel'nost' Kuril'skikh ostrovov [Vegetation of the Kuril Islands]. Moscow, Leningrad: Izd-vo AN SSSR. 1963. 92 p. (In Russian)
2. Alekseyeva LM. Flora ostrova Kunashir (sosudistyye rasteniya) [Flora of Kunashir Island (vascular plants)]. Vladivostok: DVNTS AN SSSR. 1983. 132 p. (In Russian)
3. Barkalov VY. Flora Kuril'skikh ostrovov [Flora of the Kuril Islands]. Vladivostok: Dal'nauka. 2009. 468 p. (In Russian)
4. Yeryomenko NA, Barkalov VY. Sezonnoye razvitiye rasteniy yuzhnykh Kuril'skikh ostrovov [Seasonal development of plants in the Southern Kuril Islands]. Vladivostok. Dal'nauka. 2009. 266 p. (In Russian)
5. Alekseyenko NA, Grishchenko MY. Kartografirovaniye rastitel'nosti yuzhnoy chasti ostrova Kunashir s tsel'yu yeyo monitoringa [Mapping the vegetation in the southern part of Kunashir Island for the purpose of its monitoring]. *Izvestia vuzov. Geodesy and Aerophotosurveying*. 2017;6: 75–81. (In Russian)
6. Yemel'yanova LG, Ogureyeva GN. Biogeograficheskoye kartografirovaniye [Biogeographic mapping]. Moscow. Geograficheskiy fakul'tet MGU. 2006. 132 p. (In Russian)
7. Lukicheva AN. Printsipy podbora tsvetovykh oboznacheniy dlya melkomasshtabnykh geobotanicheskikh kart [Principles of color coding for small-scale geobotanical maps]. In: Printsipy i metody geobotanicheskogo kartografirovaniya [principles and methods of geobotanical mapping]. Moscow, Leningrad. 1962. P. 244-253. (In Russian)
8. Pirtskhalava-Karpova NR, Karpov AA, Grishchenko MY, Kozlovskiy EE. Issledovaniye uchastkov lesa, podverzhennykh vliyaniyu koroyeda-tipografa (Ips typographus) v zapovednike Kuril'skiy (o. Kunashir) [Study of forest areas affected by the typographer bark beetle (Ips typographus) in the Kurilskiy nature reserve (Kunashir island)]. *Lesotekhnicheskiy zhurnal*. 2020;1: 50–59. (In Russian) DOI: 10.37482/0536-1036-2021-4-55-67

Mikhail Yu. Grishchenko
Lomonosov Moscow State University, Faculty of Geography, Cartography and Geoinformatics Department, senior associate; HSE University, Faculty of Geography and Geoinformatics, professor assistant; State Nature Reserve "Kurilskiy", leading research associate; PhD in Geographics
ORCID: 0000-0003-3223-7697
Ekaterina Y. Zhdanova
Lomonosov Moscow State University, Faculty of Geography, academic program "Climate and Environment"; Master's degree student
ORCID: 0000-0002-7938-5470
Tatyana Y. Ivleva
A.N. Severtsov Institute of Ecology and Evolution RAS, V.N. Sukachev labaratory of biogecenology, junior research associate
ORCID: 0000-0001-7253-056X

Received 2021.04.09. Revised 2021.12.14. Accepted 2021.12.20