Interactive mapping and ecological educational functions of geosystems of the SPNAs of the Baikal Region

A V Myadzelets¹, N M Luzhkova¹,² and Z Li³

¹ Sochava Institute of Geography SB RAS, Irkutsk, Russia
² FSU Zapovednoe Podlemorie, Ust-Barguzin, Russia
³ Institute of Geographic Sciences and Natural Resources Research CAS, Beijing, China

E-mail: anastasia@irigs.irk.ru

Abstract. Ecological educational functions of geosystems are to be separately highlighted and considered for the scientific substantiation of this work. Information about the ecological educational functions of geosystems is visualized using interactive geoinformation maps of various thematic content. As an example, an interactive map of vegetation “Along Doppelmair’s trail” is presented, which is being developed for one of the remote and closed areas of the Barguzinskii nature reserve of the FSU Zapovednoe Podlemorye. We used both traditional geographic approaches and methods (field research, geobotanical and landscape descriptions) and modern geoinformation technologies (creation of database for every plot on a general landscape basis, interpretation of space images, visualization with infograms, etc.) to create the map. The map shows the characteristic types of vegetation, succession stages of pyrogenic dynamics of forest geosystems that have arisen over a century. The infograms provide information on the places of meeting animals, distribution of plants, features of local landscapes and photographic materials collected during field research. The presented map is one of the ways to popularize environmental protection, solve environmental education issues and represent the educational functions of geosystems. A set of interactive maps of different content is the basis for determining the natural educational potential of geosystems and can be used to improve models of environmental management and nature conservation activities.

1. Introduction

National parks and zapovedniks belong to the category of specially protected natural areas (SPNA), where the established environmental regime is maintained legislatively, and anthropogenic impact is controlled and limited, and natural geographic processes and phenomena are studied. At the same time, environmental and educational activities are also an important task and an essential part of the overall work of institutions performing the functions of managing national parks and zapovedniks in Russia. Hence, it is necessary to separately highlight and consider the ecological educational functions of the geosystems of these territories for the scientific substantiation of this work.

Considering the fact that the access to many protected areas in Russia is legally limited for population due to the special status, allocation of appropriate functional zones or the significant remoteness and geographic inaccessibility, the educational events, as a rule, take place on specially designed and separately allocated ecological routes. They can be located in different areas: in the core of the national park, within the buffer zone, in visitor centers and museums located in cordon and in
central offices. Besides, the scientific departments of the protected areas also organize field events in schools, universities and other institutions. At the same time, the lack of programs in the development of environmental and educational activities of many reserves is the lack of visual aids and maps, various illustrations and interactive materials describing the features of flora and fauna, excursion routes, interesting facts about the unique local nature, accessible and understandable to a wide user [1, 2].

In recent years, the Internet space has developed as an important information platform, informing not only about the current activities of protected areas, but also providing vivid visual content for exploring the sights of the area [3]. Thus, virtual tours and interactive maps posted on the official websites of environmental organizations are very popular among visitors. The most common are separate virtual tours in the form of panoramic shots and 3D models. As a rule, attractive areas are captured here without geographical reference, for instance, a 3D tour through the zapovednik. Virtual tour, and Virtual tours through the zapovednik. A combination of a virtual tour and a set of interactive maps can be considered as a more complex product. This example has been implemented for the reserves Magadanskii and Olekminskii. For some territories, such projects are created with reference to various cartographic services, for instance, Google Maps in the Altai and Putorana zapovedniks, Bing in the Kronotski zapovednik. However, the analysis of Internet materials has shown, that the total number of such products on the sites of federal protected areas is small: out of 226 reserves, national parks and federal reserves (as of 09/19/2018), interactive cartographic material of varying complexity covers only certain plots of some protected areas. This is how we revealed a significant methodological and substantive deficit for solving the ecological and educational tasks of specially protected areas in general and reserves in particular [4].

As part of the educational work of the Federal State Budgetary Institution Zapovednoe Podlemorye to popularize knowledge about the K.A. Zabelin Barguzinskii State Natural Biosphere Reserve, the Zabaikalskii National Park and the State Reserve of federal significance Frolikhinskii constantly develops and improves printed and electronic materials of geographical, biological and ecological content. In this organizational and managerial activity, they got an idea to repeat the route of the scientific expedition of 1914-1915, (resulted in the establishment of the first currently functioning state reserve in Russia), and to update information on the state of ecosystems and prepare for tourists updated information about the local nature in an accessible form as a series of interactive maps of various content. This expedition is called "Along Doppelmair’s Trail – We Preserve the Nature of the Barguzinskii Reserve for 100 Years". This work became a natural continuation of cooperation of the scientific department of the Federal State Budgetary Institution Zapovednoe Podlemorye and the V.B. Sochava Institute of Geography SB RAS, which includes monitoring studies, joint expeditions, study of natural and anthropogenic dynamics and functions of ecosystems, the use of landscape and geoinformation mapping approaches to solve geographic fundamental and practical issues [4], including identification of the educational potential of ecosystems for planning educational tourism and improvement of nature protection activities of protected areas. The result was a visual interactive map containing the digitised expedition's materials and detailed descriptions of vegetation types along the historical route in the central part of the reserve.

2. Models and methods
The work is based on classical approaches of physical-geographical and landscape research, geoinformation methods and principles of landscape-interpretive mapping [5]. The introduction of information and geoinformational approaches in geographical research over the past decades enabled not only extension of this scientific area, but also change the idea of their cognitive and educational aspects [6], which can be usefully applied to environmental educational problems of protected areas. Nowadays, for the presentation of special geographic data for a wide range of users we developed interactive maps, accompanied by infograms, or infographics, i.e. special information images that, in addition to artistic and aesthetic value, have useful properties. If they are rarely used in scientific papers and special maps, then for environmental education of the population and the popularization of
scientific knowledge, when not so much formal data are needed, but a high level of attractiveness to
draw attention of a wide range of users to maps with geographic themes, such images are in great
demand. Infograms allow to present special data in an accessible way, invite attention, providing
"boring scientific facts" with colors and metaphors, save or fill space (depending on the tasks of the
map) [7]. Interactive maps created using geoinformation methods and infograms, filled with reliable
thematic information, are convenient for remote acquaintance with the territory, cultural, historical and
geographical objects, and, moreover, they are confirmed by various sociological studies of tourist
preferences in relation to information cartographic products [8]. They are actively developed and
widely used by environmental, scientific and educational organizations, government bodies for
submitting scientific and statistical reports on web services, for solving problems of environmental
education and the formation of cognitive interest in people [2, 9, 10].

While mapping vegetation cover we used traditional methods of data collection: field, descriptive
and comparative geographical (descriptions of landscapes and their components, geobotanical
characteristics of the territory), as well as methods of geoinformation mapping using high-resolution
remote sensing data (series of Landsat satellite images for 2009-2018).

The modern route repeated the route of one of the sections of the Sobolinya Expedition of 1914-
1915 under the leadership of Georgii Georgievich Doppelmair, which is an original series of
comprehensive studies of the western slope of the Barguzinskii range from the main watershed to the
coast of Lake Baikal. The results with a description of geological characteristics, physical and
geographical features, vegetation, floristic composition, areas of certain animal species, peculiarities
of fishing, hunting and everyday life of the population are presented in the final monograph by G.G.
Doppelmair “Sable hunting on the north-eastern coast of Lake Baikal” [11]. The materials are of great
value for long-term monitoring work. The parameters given in the book provide information for
comparing the state of natural components over a century. The collection of data on the territory and
descriptions of landscapes were carried out within the boundaries of the drainage basins of several
rivers from the Bolshoi Chivyrkui in the south to Shirilda in the north.

Figure 1. Expedition route “Along Doppelmair’s trail – 100 years later”. 
During the expedition in 2018 (figure 1) we decided to follow one of the historical routes of 1914-1915 in the middle part of the Barguzinskii range. The Tarkulik river valley was chosen as a model site, which originates in the main watershed of the Barguzinskii range, through the Doppelmair pass, named after Georgii Georgievich who described it in detail. The pass is located on the border of the reserve and connects the Tarkulik and Kurumkan river valleys. We planned a circular route with the starting point in the mouth of the Davsha river to ensure a sufficient completeness of comparison of the descriptions of the current situation with the data of G.G. Doppelmair. Then the route runs along the Davsha river to its upper reaches, through a significant part of the highland landscapes and descends from the source of the Tarkulik river to Baikal.

The results of the field research, their visualization and creation of an interactive map of vegetation for the study area are presented in the form of a universal hierarchical scheme of geoinformation mapping of vegetation (figure 2). In the applied aspect, they can be used to solve environmental education issues by educational, public, scientific and environmental organizations and to popularize natural science knowledge.

![General geoinformation mapping scheme for creating an interactive vegetation map.](image)

At the first stage we revealed problems and deficiencies in the field of environmental education of protected areas and possible ways of solving them. Then, data on the study area is systematized, if necessary, collection of missing data is organized (field work, statistical materials, etc.). At the second stage we created a geoinformation base and a database (DB) premised on the collected information using electronic topographic maps, Earth remote sensing data (ERS), and other maps of special
content. The original vegetation map includes plotting a grid of boundaries of landscape units with different types of relief, nature of the vegetation cover, identification of different types of forest, moisture conditions, exposure, etc., and the formation of a database for each unit. Then, we developed a legend, which defines and characterizes the main types of vegetation. They correspond to certain plots. The result will be a geoinformation map with the corresponding database containing the entire set of landscape characteristics for identifying the vegetation type. An important step is validation, including refinement of boundaries of the objects and correspondence of classification types of the legend and the objects on the map. In the final stage the map is supplemented with photos, infograms and other environmental educational information necessary for potential users, using built-in interactive tools. The final interactive map is posted on the site of the SPNA and can be adjusted over time.

3. Results and discussion
The preliminary stage defined that the main routes will be located outside the economic areas and ecological (excursion) trails, so that when creating an interactive map, the demonstration of the natural features of the functional zone of the SPNA’s core would act as a solution to the ecological and educational task. Thus, the map should be presented as an interesting visual material that allows visitors to learn more about the protected nature in the territory closed to the public access. Therefore, within the framework of the expedition we set the task to collect as much data as possible, bearing not only scientific, but also general educational value.

During the expedition we carried out more than 40 partial and complex descriptions at key points, characteristic of various types of vegetation and animal habitats (figure 1). The collected materials were systematized in the form of a geoinformation database, processed and presented graphically and cartographically. They were augmented with information obtained from space imagery data, materials from the Doppelmaier expedition and own monitoring observations of the scientific department of the Zapovednoe Podlemorye. During the field work we clarified several descriptions given in the monograph [11], compiled a list of avifauna, monitored vegetation disturbance and changes in species composition in areas where there are signs of natural pyrogenic successions, revealed minimal anthropogenic impact, limited by the main route along the Davsha and Tarkulik rivers. These ecosystems are conditionally undisturbed and can be a reference for various monitoring in geographic and ecological studies. The exclusion of anthropogenic impact enables identifying the natural processes of dynamics and evolution of geosystems and to compare authentically landscapes and their components with the data of the expedition of 1914-1915.

We revealed separate and described classes of facies, components of ecosystems, features of altitudinal zonation and other characteristics of landscapes, which formed the basis for the characteristics, classification of types of vegetation in the study area and the legend of the final map. In order to compile infograms of the interactive map we additionally assessed the occurrence of various species of birds, rare and endemic plants, animals (bear, roe deer, reindeer, black-capped marmot, and other various species of small rodents).

Golets belt. In places it is covered with thickets of Siberian dwarf pine, in places with birch yerniks, in higher places with thickets of *Betula exilis*. There is a moss cover of low power, lichens in a large number of different species. *Rhododendron chrysanthum* is everywhere, a lot of *Juniperus*. Alpine meadows are composed of alpine forbs up to 15 cm high. Species composition consists of as follows *Aquilegia gen.*, *Anemone baicalensis*, *Polygonum aviculare*, *Carex, Gramineae, Vaccinium myrtillus*, etc. Species diversity is average.

Podgolets belt. There are many raised bogs. Vegetation: large and medium wet grass (first layer up to 50-60 cm, second – up to 15-20 cm), moss cover. Shrubs: birch yerniks, willows (thickets near streams) and Siberian dwarf pine. The border of the forest begins with individual birches (crooked forest) or with a parklike birch forest. Further, fir joins (up to 10 m high) and looks like a mixed forest with birch domination. There are many swampy wet meadow communities. The herbaceous cover in open places can be higher than 1 m. The species composition is sedges, grasses, large grasses. In
hollows there are thickets of yernik (willow and birch), difficult to pass. On the flattened areas (terraces), there are mainly birch thickets, on steep slopes with outcropping of rocks – Siberian dwarf pine. The herbaceous cover is diverse. In drier places, there are thickets of *Bergenia crassifolia* and *Vaccinium myrtillus*; there are fewer forbs, sedges and cereals. In humid, more open areas, sedges, grasses, and taiga herbs dominate. Moss cover is almost everywhere and lichens are found.

Forest zone. Fir-Siberian stone pine forests. Fir forests begin above the tree line on the slopes. The steeper slopes are occupied by Siberian dwarf pine and *Rhododendron chrysanthum*. Dwarf fir is not found. The stand contains individual trees of overmature Siberian stone pine (over 300 years old), as well as mature birch. The undergrowth is not pronounced, but sometimes *Lonicera* is found. The herbaceous cover consists of sedges, grasses, and taiga forbs (in more open places with good humidity, in hollows and spruit beds). On drier slopes, darkened by a forest stand, *Pteridium aquilinum* is found, and forbs are present (species diversity is low). The moss cover is present.

Spruce-fir and fir-spruce forests. Spruce-fir and fir-spruce forests grow down the slope; Siberian stone pine is also present. Fir and spruce dominate in the undergrowth, Siberian stone pine in small quantities (it appears and becomes noticeable lower). The undergrowth consists of *Lonicera*, sometimes *Rosa* appear, and rarely *Sorbus*. The herbaceous cover is similar to that in fir-Siberian stone pine forests, but the species diversity increases, especially in sunlit areas. *Bergenia crassifolia* and *Vaccinium myrtillus* grow in shady areas. The moss cover is present. As the height decreases, *Populus* appear along the river bed, very high and old (possibly relict). The banks of the river in flatter areas are damp, overgrown with willows and other bushes. The herbaceous cover in these areas is high wet grass, sedges, and grasses. The moss cover is present.

Siberian stone pine, fir-Siberian stone pine, Siberian stone pine-fir forests. Siberian stone pine, fir-Siberian stone pine, Siberian stone pine-fir forests begin above the zone of spruce-fir and fir-spruce forests, in which spruce (individual trees) occurs. The second storey mainly consists of fir. In the undergrowth there are Siberian dwarf pine and *Juniperus*. The undergrowth is very scarce, it mainly consists of fir, Siberian dwarf pine (or Siberian stone pine- it is not clear). Birch grows in the form of a thin-bore crooked forest of low height. The herbaceous cover consists mainly of *Vaccinium myrtillus*. The moss cover is very abundant (more than 7-10 cm thick).

Pine-Siberian stone pine and Siberian stone pine–pine forests. Pine-Siberian stone pine and Siberian stone pine–pine forests are located in approximately the same zone, on high, dry, sunlit areas of slopes (flattened upper parts). There is also Siberian dwarf pine and dwarf fir appears. Fir dominates in the second storey and spruce is less common. The undergrowth consists of Siberian stone pine, fir and rarely spruce. There is abundant undergrowth in places where there is no Siberian dwarf pine. *Lonicera* and *Rosa* are found in the undergrowth. The herbaceous cover consists of taiga herbs, *Carex*, *Gramineae* and *Vaccinium myrtillus*. *Vaccinium vitisidaea* appears.

Then, on the flattened river terrace, Siberian stone pine, fir-Siberian stone pine and Siberian stone pine–pine forests begin again, *Ribes* appears near the river. In waterlogged areas *Pteridium aquilinum*, *Equisetum*, as well as *Carex*, *Gramineae*, wet forbs, and *Ledum palustre* grow abundantly. *Vaccinium uliginosum* appear in large quantities. The herbaceous cover also consists of *Pteridium aquilinum*, *Equisetum*, *Carex*, *Gramineae*, taiga forbs, and *Ledum palustre*. *Allium ursinum* is added and species diversity is increased. *Bergenia crassifolia* disappears.

Larch forests. There are mainly mixed larch-Siberian stone pine, Siberian stone pine–larch, larch-pine, pine-larch, larch forests. The undergrowth is composed of blueberries. The herbaceous cover includes *Vaccinium uliginosum*, taiga forbs, *Carex*, *Gramineae*, *Rubus saxatilis* and *Rubus arcticus*. The species diversity is very high. *Equisetum*, *Carex*, *Gramineae* and *Ledum palustre* are also abundant in areas with increased soil moisture levels.

At the mouth of the Tarkulik river in the coastal zone there are meadow, meadow-bog communities and hydrophilous herbaceous vegetation. Shrubs are represented by *Juniperus* and others.

The recent evaluation of landscapes and vegetation resulted in comparison of the current state of the territory with the data of the Doppelmair’s expeditions as accurately as possible. Insufficient variations in the composition of tree species were revealed, as well as pyrogenic successions of
various stages in certain areas, which are the result of natural processes (fires as a result of dry thunderstorms, true of the area in summer).

Cartographic work was carried out in ArcMAP. We used a series of Landsat satellite images for 2009-2018 as a basis. The generated shape-files include the expedition route, description points, campsites, boundaries of landscape units of vegetation, reserve boundaries, hydrography, and other layers. At the current work stage the final interactive map of the area along the route contains particular types of vegetation, their brief description, succession stages of woody vegetation that have arisen in the last century. Wildlife watching points (mammals, birds, reptiles and amphibians), Red Book plants in the reserve, as well as information about the peculiarities of local landscapes are presented in the form of infographics linked to certain objects and appearing at the user's request in the form of pop-up windows. The infographics contain the following information: name of vegetation type, its description, pictures taken during the expedition, description according to Doppelmair (if any).

Nowadays, the technical procedure for submitting an interactive map on the site of the Federal State Budgetary Institution Zapovednoe Podlemorye is under development. Access is provided only in test mode upon request through the specialist of the scientific department (Natalia M. Luzhkova, Dr. Sc. (Geogr.), e-mail: luzhkova@pdmr.ru).

The map shows 14 natural and recovering vegetation types typical of the study area. These are mountain tundra, mountain alpine-type meadows and wastelands, subgolets sparse forest and bushes, dark-coniferous mountain-taiga forests, light-coniferous mountain-taiga forests, light coniferous foothill-hollow forests, light coniferous foothill-hollow forests mixed with dark coniferous, yerniks, swamps and meadows, meadows and hydrophilic communities, various pyrogenic series of dark coniferous forests (birch-aspen, Siberian stone pine-fir-aspen and Siberian stone pine-fir-birch), light coniferous forests (birch-aspen with pine and larch), light coniferous and dark coniferous forests without growing stand, anthropogenic series of sedge-cereal forb meadows (territory of the Davsha cordon).

Each type of vegetation is supplemented with infographics with their brief characteristics, habitats of various representatives of the avifauna, habitats of rare and unique plant species. Additionally, the map shows hydrographic objects, topographic base elements, itinerary, processed image, interesting objects. A fragment of the map for the high-mountainous part of the study area is shown in the figure 3.

4. Conclusion

The presented map is one of the ways to popularize environmental protection, solve environmental education issues and represent educational functions of geosystems. A remote user can:

- virtually visit a difficult research route along the Davsha and Tarkulik rivers;
- get acquainted with the main landscapes, described in an accessible popular language and supplemented with images of their species;
- get information about some of the typical flora and fauna, specific to the area, and local attractions;
- compare the results of expeditions in 1914-1915 and 2018;
- study the history of nature reserve management on the example of the first reserve in Russia and evaluate the scale of nature conservation and scientific activities of the organization.

In accordance with the objectives and functions of Russian SPNAs, the created interactive map has a number of scientific and applied aspects. In particular, it is possible to highlight the tourist and environmental-educational goals of using such maps. They show the presence of appropriate infrastructure, various elements, natural attractions, developed routes, some types of tourism print products (schematic maps, etc.). The scientific content is associated with a coordinate-based image, description and typification of various elements of geosystems and their components, dynamics and projections, the results of the impact of negative processes (e.g., the pyrogenic factor), etc. The created interactive map is one of the intermediate stages of mapping vegetation on the entire territory of the Barguzinskii reserve and the Zabaikalskii national park and landscape and other maps in the future. In
environmental terms, based on the developed map, which presents the characteristics of vegetation, geosystems and their components, it is possible to improve the management of these territories, to map various violations (if any), to develop preventive measures, etc.

The first version of the interactive map certainly needs clarification. It would serve as the basis for subsequent landscape studies, studying the natural dynamics of geosystems, monitoring pyrogenic successions, analyzing the potential for vegetation restoration without anthropogenic interference, identifying ecological educational functions and many other areas of scientific work of the reserve and the national park. Areas with overmature stands, for instance have already been identified, where it is possible to carry out dendrochronological observations for more than 200 years. These studies analyze climate change, its impact on the formation of vegetation and the dynamics of geosystems. During field work and processing satellite images we identified areas with various pyrogenic series in the study area. Parallel observations of successive processes are carried out in areas with different local physical and geographical features, which will further identify the nature of reforestation, depending on local conditions, including determining the role of microclimate, soil characteristics and other natural factors on the processes of natural dynamics of geosystems and concern other scientific subjects in the infograms.
Modern methods of geoinformation mapping, remote sensing data, special types of surveys, supplemented by scientific geographical approaches to the study of geosystems are used to obtain high-precision information even about isolated area, systematize and create complex integrated databases, process this heterogeneous information and interpret it in accordance with specific practical tasks. Interactive geographic maps will become an integral part of nature conservation, they perform both managerial and scientific, as well as environmental and educational functions, allowing to solve educational tasks set for the administrations of SPNAs. An important component of such maps is visualization, since landscape and other thematic maps are of little interest to visitors. However, supplemented by infograms with panoramic views and remarkable thing, they provide accessible information for tourists. The interactive map of vegetation "Along Doppelmair’s trail" enables remote study of vegetation types change, acquaintance with the characteristic, including the Red Data Book species of flora and fauna, learning interesting facts from the history of protected areas, getting an idea of the uniqueness and fragility of local nature and the importance of environmental protection. It can be considered as the final product of environmental educational activities of especially protected areas of various levels.

Acknowledgements
The reported study was funded by RFBR and NSFC according to the research project No. 20-55-53030 NSFC_а».

References
[1] Alekseenko N A and Arshinova S N 2012 Cartographic support of the russian national parks activities Izvestiya RAS Series Geographical 1 91-5 (In Russian) https://doi.org/10.15356/0373-2444-2012-1-91-95
[2] Di Pasquale D, Lerariob A, Maiellarob N and Scala P L 2013 Open source interactive map of albania cultural heritage IERI Procedia 4 383-90 Doi.org/10.1016/j.ieri.2013.11.055
[3] Smukavič M, Poslončec-Petrić V and Frangeš S 2014 Interactive hiking map – example of the National Park Paklenica Geonauka 2(4) 15-22
[4] Myadzelets A V and LuzhkovaN M 2020 GIS mapping to fulfill environment education tasks: interactive map of vegetation “Along the Doppelmair’s trail” Geodesy and Cartography 1(81) 7-18 (In Russian) DOI: 1022389/0016-7126-2020-955-1-7-18
[5] Bessolitsyna E P et al. 2005 Landscape-Interpretation Mapping (Novosibirsk: Nauka) p 424 (In Russian)
[6] Beshentsev A N 2018 Theory and practice of the information concept cartographic research method Geodesy and Cartography 6(79) 26-36 (In Russian) DOI: 10.22389/0016-7126-2018-936-6-26-36
[7] Artyuhin V V 2012 Science graphics and Infographics areas of application, current issues and evaluation criteria Applied Informatics 6(42) 114-32 (In Russian)
[8] Tarkhanova N P and Romanov V A 2017 Determinants of use of information products in tourism Bulletin of the Sankt-Peterburg State University 4(49) 224-9 (In Russian)
[9] Levin G L 2015 Information resource of a city on the example of the Guide Map of Pereslavl-Zalesskii Project Culture and Life Quality 1 396-402 (In Russian)
[10] Sharova I S, Timovkina L Yu, Romanova A A and Bezuglova M S 2018 Analysis of existential dynamics of especially protected landscapes of the lowed reaches of the Volga delta Geology, Geography and Global Energy 2018 2(69) 161-7 (In Russian)
[11] Sable Hunting on the North-Eastern Coast of Lake Baikal. Materials of the Barguzin Expedition G G Doppelmair 1914-1915 1926 (Verkhneudinsk, Leningrad: Gosplan BMASS) p 272 (In Russian)