DATASET FOR VASCULAR PLANTS IN THE RED DATA BOOKS OF TRANSBAIKALIA: SPECIES DISTRIBUTION AND PATHWAYS TOWARDS THEIR CONSERVATION

Denis V. Sandanov[1,2,*], Elena P. Brianskaia[1], Anastasiia S. Dugarova[1]

[1]*Institute of General and Experimental Biology of the Siberian Branch of the RAS, Russia*
[2]*Tunkinsky National Park, Russia*
**e-mail: denis.sandanov@gmail.com*

Received: 06.07.2021. Revised: 27.01.2022. Accepted: 30.01.2022.

The dataset of the Red Data Book vascular plants of Transbaikalia was created based on the latest editions of the Red Data Book of the Republic of Buryatia and the Red Data Book of the Zabaikalsky Krai (Russia). The dataset provides the most updated information regarding the distribution of 271 rare vascular plants (2920 distribution records). The distribution of the studied species was recorded during field surveys using GPS navigators, georeferenced from herbarium specimens, and digitised from printed distribution maps. Each entry in the dataset has various attributes, including belt zone, distribution, ecological, and life-form group features. Distribution patterns for various groups of rare and endangered species were analysed by means of QGIS 3.10 software. Our study has revealed a number of localities of vascular plants listed in the Red Data Book and clarified their distribution within the federal Protected Areas of Transbaikalia, among which Tunkinsky National Park has the highest diversity. Distribution of some rare and endangered species falls under federal protection, but some plants, including endemic species, require better protection. Analysis of various belt zones and distribution groups showed their distinct spread within the study region. Among the studied species, mesophytes and short rhizome perennial plants prevailed. It is also important to preserve vascular plants in the Red Data Book outside Protected Areas. Hence, information from our dataset can be useful for conservation monitoring programmes. Our study provides a basis for future conservation activities and can be applied in the establishment of new Protected Areas or Important Plant Areas in Transbaikalia.

Key words: dataset, GIS analysis, rare and endangered species, Republic of Buryatia, Zabaikalsky Krai

Introduction

One of the general topics of biodiversity conservation refers to studies of rare and endangered plants species (Balding & Williams, 2016). Habitat loss, fragmentation, degradation, overexploitation, penetration of invasive species, pollution, and anthropogenic climate change are the main threats leading to a decreased plant diversity (Corlett, 2016). The complex approaches used in studies of rare and endangered plant species have been increasingly applied over the last decades (Heywood & Iriondo, 2003). Previous studies revealed three national biodiversity hotspots in Russia: North Caucasus, South Siberia, and Far East (Venevsky & Venevskaia, 2005). Also, a recent paper on the global distribution of endemic plants has recognised Crimea, North Caucasus, and the southern part of the Russian Far East as the centres of endemism within Mediterranean, Iran-Turanian, and East-Asian floras (Hobohm et al., 2019).

The first data on rare and endangered plant species of Transbaikalia were summarised by Boikov (1999) and later extended for the whole area of Central Siberia (Boikov, 2005). These studies were based on the data from previous editions of the Red Data Books of the Republic of Buryatia (hereinafter also – Buryatia) and Zabaikalsky Krai. Later, in 2012, the list of rare vascular plants for Protected Areas of Buryatia was completed (Krasnopevtseva & Krasnopevtseva, 2012). Recent studies have resulted in the identification of new localities of Transbaikalian rare plants, together with research into their conservation status and conditions. Based on these findings, the species list of Transbaikalian rare plants has been revised and published in the new editions of the Red Data Book of the Republic of Buryatia (2013) and the Red Data Book of the Zabaikalsky Krai (2017).

Consolidating species distribution records in a specific dataset can help with various statistical analyses to determine ecological factors limiting the distribution of certain species (Sandanov, 2019), which informs us how to prioritise rare plant monitoring (Laskey et al., 2020). Species occurrence data can be applied in the analysis of eco-geographic patterns of species richness (Sandanov et al., 2020). Moreover, available information (population quantity, seed dispersal and productivity, growth forms, ecological preferences) about rare and endangered plants can be applied in further conservation activities.

The aim of this study was to develop a GIS analysis approach to elucidate distribution patterns of rare and endangered vascular plants of Transbaikalia. For this purpose, we established three research tasks: (i) to compile distribution records for vascular plants listed in the Red Data Books for the Republic of Buryatia and Zabaikalsky Krai; (ii) to make specific layers for GIS and organise them into one single spatial dataset; (iii) to test distribution patterns of the focal plants on various levels. We hypothesised that the analysis of various Red Data Book vascular plant attributes can reveal particular biological and ecological features of species, which will be helpful in organising future conservation activities.

Material and Methods

Study area

Transbaikalia represents a large region of Southern Siberia consisting of numerous mountain ranges within the upper basins of three large rivers: River Amur (Pacific Ocean basin), River Yenisei, and River Lena (Arctic Ocean basin). The study area is located within 49.22°–58.30° N and 98.60°–121.95° E. The major part of Transbaikalia area is covered by forests. However, the steppe vegetation is an inherent component in its southern parts. Steppes are widely represented within the steppe and forest-steppe mountain belts, as well as in the vast plains of the southeastern part of the studied area.

Data compilation

Some data of rare plants in Buryatia were recorded by using GPS navigators (i.e. Garmin eTtrex 10 and Garmin eTtrex 20 with WGS84 co-ordinate system) during field surveys. Other data were geo-referenced from herbarium vouchers. Distribution records were imported into QGIS v. 3.10 to create species distribution maps for the Red Data Book of the Republic of Buryatia (2013). A preliminary analysis of the distribution of rare plants in Buryatia was presented previously (Sandanov, 2016). Distribution maps for rare plants in the Zabaikalsky Krai have been made in raster format, and species localities were marked on the map using the graphic editor Adobe Photoshop. These maps have not been previously digitised. Both bordering regions are usually united as Transbaikalia and have similar eco-geographic features. These factors were the reason to develop one dataset for the whole area.

The dataset containing the occurence of species was registered in GBIF (Sandanov et al., 2021). Later this dataset has been enlarged by adding attributive information for each species. Species belt zone confinement and their distribution were identified according to Malyshev & Peshkova (1984). Ecological groups and life forms were compiled according to Boikov (2005). Ecological groups are represented by the following categories: euxerophyte, xerophyte, xeromesophyte, mesoxerophyte, mesophyte, eumesophyte, mesohygrophyte, hygromesophyte, hygrophyte, and hydrophyte. Original data on life forms were detailed following the Russian botanical tradition, including tree, shrub, woody liana, subshrub, dwarf shrub, dwarf subschrub, bunchgrass, compact-tussock grass, long rhizome, short rhizome, taproot, bulbous, bulbotuberiferous, roottuberous, short-lived, and annual. However, for a general view, we unified several biomorphs into groups. For example, subshrubs, dwarf shrubs, and dwarf subshrubs are included in a group of dwarf shrubs; bunchgrass and compact-tussock grass in bunchgrass; bulbous and bulbotuberiferous plants in bulbous plants; short-lived plants and annuals in annuals. Long rhizome plants are characterised by a leptocaul subterranean rhizome that sends out shoots from its nodes. Short rhizome plants have pachycaul subterranean rhizome, which permanently grows from the apical side and dies from the basal side. Missing data for other attributes were obtained from the literature survey and the results of our own field observations. All data were merged in the spatial dataset in QGIS 3.10. Altitude data presented by the GTOPO30 digital altitude model are available at http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30_info.

Digitisation of distribution maps of the species found in Zabaikalsky Krai was performed in QGIS 3.10 software by means of the georeferencing tool. Source raster maps were georeferenced by snapping control points to a destination vector shapefile, which in our case was the border of Zabaikalsky Krai. We used control points (usually 5–8) to link raster maps to the destination shapefile, which was resulted in the transformation of the maps according to the spatial projection of destination features (WGS84). Subsequently, species distribution locations were digitised from each map. The coordinates of each location were calculated in the attribute table. The accuracy of digitised records of Zabaikalsky Krai was tested arbitrarily for a randomised set of rare species, ranging from 1.5 km to 6 km. Relatively low accuracy (up to 6 km) is not suitable for analysing the local environment of species. However, it is sufficient to study rare species distribution patterns at the scale of Zabaikalsky Krai with a low digitisation accuracy.

Results

The dataset of rare vascular species contains 1216 distribution records of 157 plant taxa for the Republic of Buryatia (Sandanov, 2016) and 1704 distribution records of 164 plants for Zabaikalsky Krai, totally 2920 distribution records of 271 vascular plants. The distribution of Red Data Book vascular plants is mostly associated with river valleys and mountains (Fig. 1). The eastern area of Buryatia and central area of the Zabaikalsky Krai, from 52° N to 55° N, have a small number of rare species. Many species and their localities are observed in the steppe zone of the Zabaikalsky Krai.

In the study area, the taxonomic diversity of the Red Data Book vascular plants is 268 species and three subspecies from 164 genera and 73 families. The top ten families hold almost half of the species (50.6%) and distribution records (49.3%) (Table 1).

Table 1. Taxonomic distribution of top ten families of the Red Data Book vascular plants in Transbaikalia

Family	Number of genera	Leading genera (number of rare species in the genus)	Number of species	Number of records
Fabaceae	10	*Oxytropis* (14), *Astragalus* (7)	28	194
Orchidaceae	10	*Cypripedium* (5), *Platanthera* (4)	21	388
Ranunculaceae	11	*Aquilegia* (5), *Aconitum* (3)	19	182
Poaceae	11	*Festuca* (4), *Calamagrostis* (2)	16	123
Rosaceae	6	*Cotoneaster* (4), *Potentilla* (3)	15	145
Liliaceae	4	*Lilium* (4), *Gagea* (2)	9	203
Boraginaceae	6	*Mertensia* (3)	8	63
Asteraceae	7	*Artemisia* (2)	7	50
Cyperaceae	4	*Carex* (4)	7	26
Lamiaceae	5	*Dracocephalum* (3)	7	67

Note: Families are listed in descending order according to the number of species.

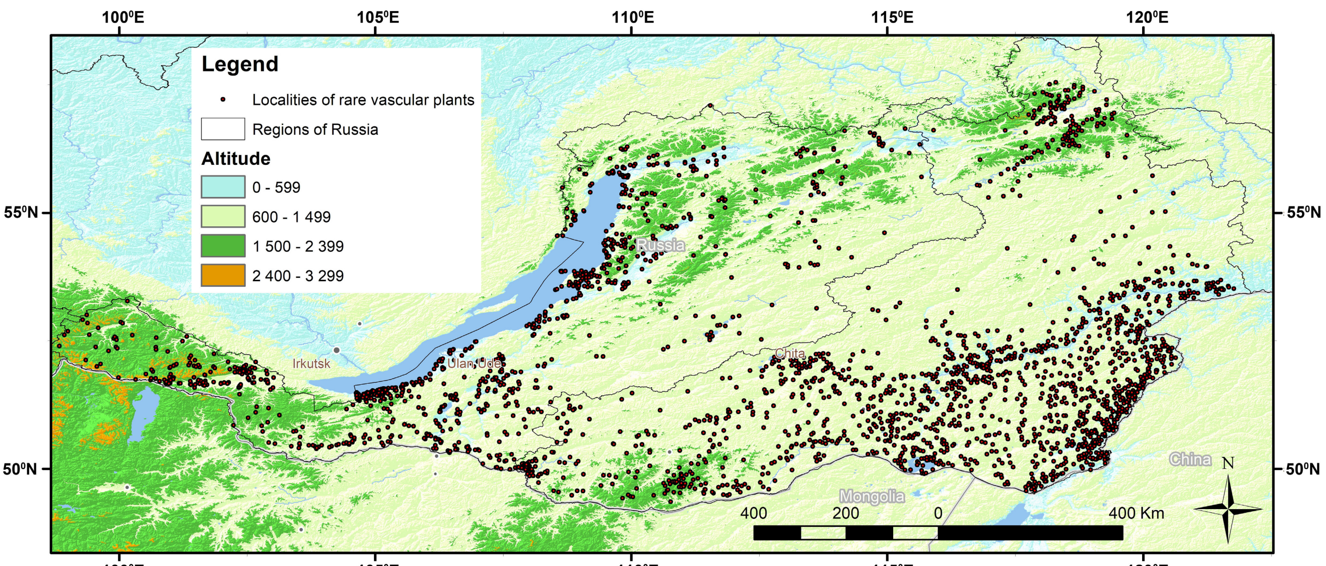

Fig. 1. The distribution of the Red Data Book vascular plants in Transbaikalia.

One of the key questions in plant conservation is how many rare species are distributed within Protected Areas. Our data is taken from 14 federal Protected Areas in the study area, including state nature reserves, national parks, and sanctuaries (Table 2).

Tunkinsky National Park was found to have the highest number and diversity of the Red Data Book vascular plants. A high species diversity was also observed in the Baikalsky State Nature Reserve, Barguzinsky State Nature Reserve, Sokhondinsky State Nature Reserve, and Zabaikalsky National Park. Two records of two rare species (*Sorbus sibirica* (Hedl.) Prain and *Berberis sibirica* Pall.) were found in Alkhanai National Park. Only one rare species with eight records was observed for Kabansky Sanctuary (*Nymphaea tetragona* Georgi), while the adjacent Altacheisky Sanctuary was found to have no rare plant species. Dolina Dzerena Sanctuary was found to have the highest diversity of rare species out of all the sanctuaries surveyed.

The analysis of species diversity in Tunkinsky National Park revealed that two species, *Fornicium carthamoides* (Willd.) Kamelin and *Nimphaea tetragona*, were distributed within this area, but their localities were absent on the distribution maps of the Red Data Book of the Republic of Buryatia (2013). Therefore, the actual rare species diversity in Tunkinsky National Park is 51 species of vascular plants. This Protected Area is characterised by unique landscapes and habitats, where species, such as *Aconitum tanguticum* (Maxim.) Stapf, *Euonymus sacrosancta* Koidz., *Lycopodiella inundata* (L.) Holub, *Megadenia bardunovii* Maxim., *Mannagettaea hummelii* Harry Sm., *Oxytropis nitens* Turcz., *Viola alexandrowiana* (W. Becker) Juz., *V. irkutica* Turcz., can be found at one location within the whole study area. Other species, including *Asplenium nessi* H. Christ, *Cyrcaea caulescens* (Kom.) Hara, *Cypripedium ventricosum* Sw., *Eutrema cordifolium* Turcz. ex Ledeb., *Viola trichosepala* (W. Becker) Juz., have the main part of their distribution here within Transbaikalia.

The dataset gives additional information for rare plants such as their confinement to belt zones, distribution, ecological groups, and data on their life forms. A thorough analysis of this information may reveal interesting features and distribution patterns for rare vascular plants. Distribution patterns for various belt-zones groups (alpine, meadow, and typical steppe) show their distinct spread in Transbaikalia (Fig. 2). Analysis in QGIS helped us to estimate their differences in altitude ranges. Alpine species mostly occur at altitudes of 1600–2200 m a.s.l. (44.9% of distribution records). The dispersion of alpine species distribution points at various altitudes was found to be 2000–2500 m a.s.l. (13.4% of distribution records), 1500–1999 m a.s.l. (39.5%), 1000–1049 m a.s.l. (26.8%), and 500–999 m a.s.l. (20.1%). Rare steppe species were spread across the southern part of the region and within Eravna, Barguzin, and Upper Chara depressions. The latter two depressions are the most northern boundaries of steppe communities in Transbaikalia. The typical steppe beltzone group usually occupies altitudes from 500 m a.s.l. to 1100 m a.s.l. Meadow species, such as *Gastrolychnis popovii* Peschkova, *Iris sanguinea* Hornem., and *Turczaninowia fastigiata* (Fisch.) DC. occur at the Vitim Plateau in the northeastern part of Buryatia. The latter two species are also found in the Zabaikalsky Krai. *Turczaninowia fastigiata* has only two records in the southeastern part, while *Iris sanguinea* is widely distributed throughout the region. The altitude preferences of meadow species vary from 500 m a.s.l. to 1500 m a.s.l.

Table 2. Distribution of the Red Data Book vascular plants in the federal Protected Areas in Transbaikalia

Protected Area	Number of species	Number of records
Barguzinsky State Nature Reserve	24	48
Baikalsky State Nature Reserve	24	80
Dzherginsky State Nature Reserve	8	10
Daursky State Nature Reserve	4	4
Sokhondinsky State Nature Reserve	23	27
Tunkinsky National Park	49	143
Zabaikalsky National Park	30	81
Alkhanai National Park	2	2
Kabansky Sanctuary	1	8
Altacheisky Sanctuary	0	0
Frolikhinsky Sanctuary	8	10
Burkalsky Sanctuary	4	4
Tsasucheisky Bor Sanctuary	3	3
Dolina Dzerena Sanctuary	11	13

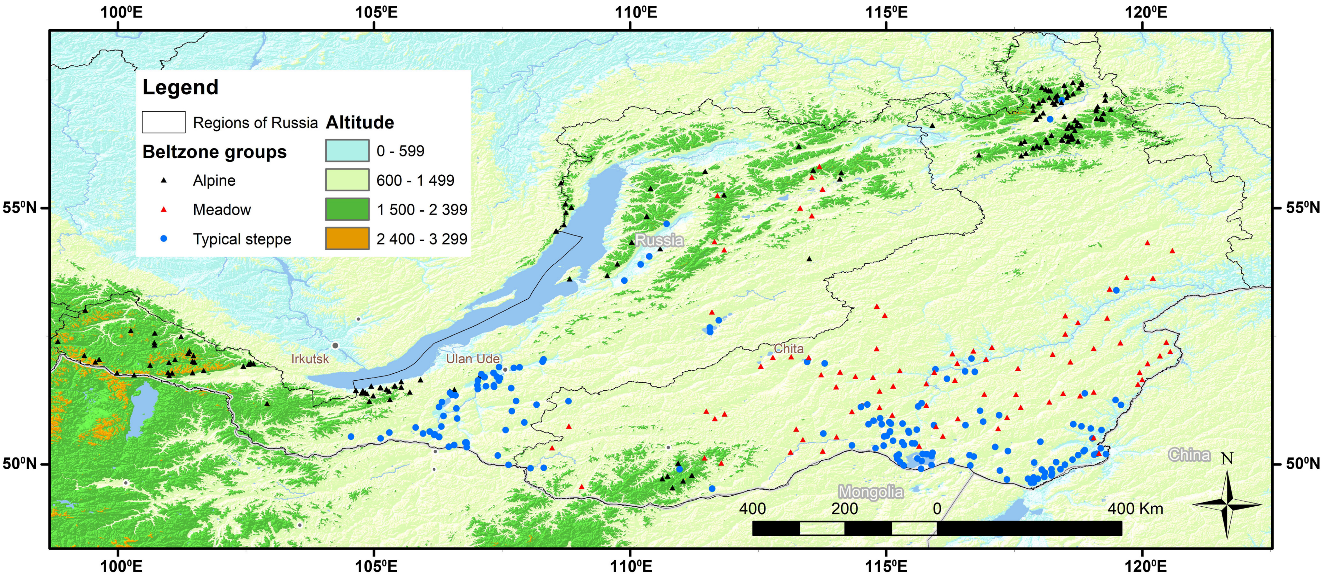

Fig. 2. Distribution of the Red Data Book vascular plants from various beltzone groups in Transbaikalia.

It is interesting that rare species from hypoarctomontane group (plants that occur in various mountain belts and hyparctic phytogeographical belt), such as *Adoxa orientalis* Nepomn., *Astragalus frigidus* (L.) A. Gray, and *Dryopteris fragrans* (L.) Schott, can be found only in the Zabaikalsky Krai. The first species is a rare relict endemic with small populations on the east of the region. The latter two species are widespread throughout Northern Eurasia; however, they are rare in Zabaikalsky Krai.

One of the main features of the dataset we developed was the analysis of the distribution patterns of rare vascular plants. This can be done under the analysis of various distribution groups (Fig. 3). Red Data Book vascular plant species with East-Asian distribution are the most prevalent in the study area. Endemic species have a high species diversity with a low number of distribution points. Rare endemic species are mostly represented by alpine plants (ten species with 50 distribution records, 23.8% of the total number). Some groups presented in various floristic provinces can be easily distinguished (Fig. 4).

Our analysis of rare endemic species distribution shows that Buryatia (34 species with 207 distribution records) has a diversity three times higher than Zabaikalsky Krai (11 species with 44 distribution records). A considerable number of endemic species in Zabaikalsky Krai (seven species with 29 distribution records) are concentrated in the northern part of Stanovoye highlands (mountain ridges of Kodar, Udokan, and Kalarskii). Other species are distributed within the steppe zone in the south of the region.

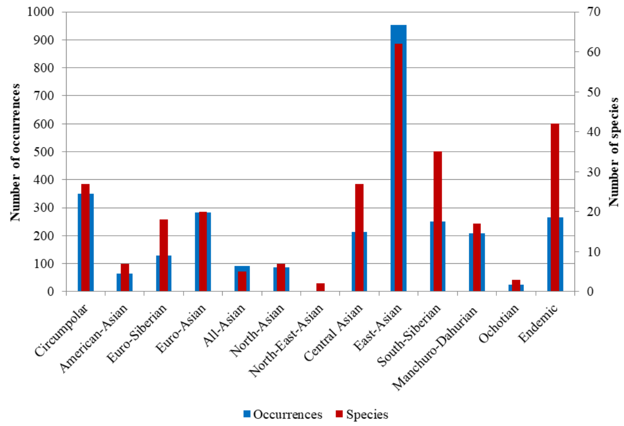

Fig. 3. Numbers of species and records for various distribution groups in Transbaikalia.

Analysis of ecological groups revealed the prevalence of mesophyte plants (Fig. 5A). Eumesophytes and mesophytes represented more than half of the rare vascular species recorded (54%). Mesophytes are well presented in forest beltzone areas, including the preboreal group (31 species with 340 distribution records), groups of light-coniferous forests (24 species with 385 distribution records), and dark-coniferous forests (11 species with 134 distribution records). These plants are also abundant in highlands within alpine (23 species with 120 distribution records) and mountainous (11 species with 125 distribution records) beltzone groups. Mesoxerophytes and xerophytes have an average proportion among studied species (15% and 12%, respectively). They are formed mainly by groups from mountain steppe (30 species), typical steppe (23 species), and desert steppe (11 species). These steppe plants usually belong to taproot or short rhizome growth forms, which are dominant among the study species (Fig. 5B).

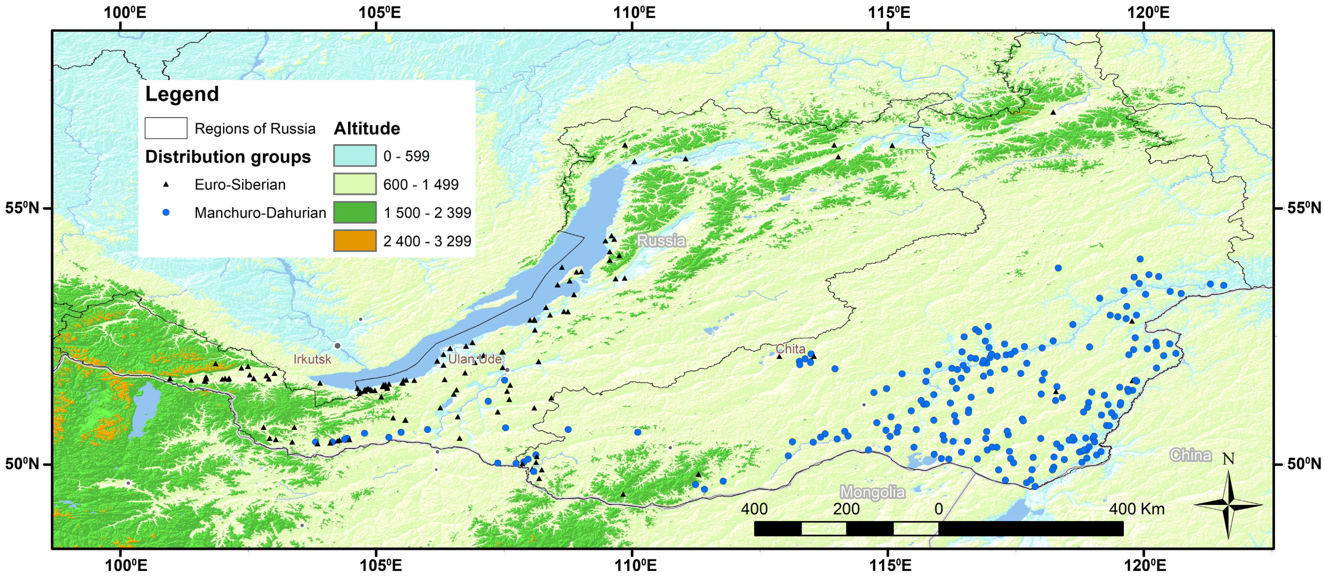

Fig. 4. Distribution of Euro-Siberian and Manchuro-Dahurian rare species in Transbaikalia.

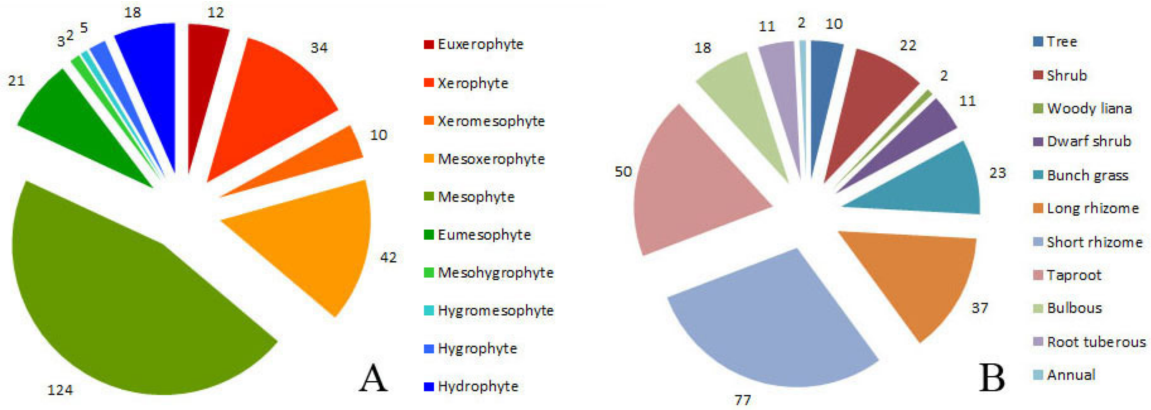

Fig. 5. The number of the Red Data Book vascular plants of Transbaikalia according to classifications of ecological groups (A) and life forms (B).

Short rhizome plants (29% of the total number of rare species) are often observed among species from Orchidaceae and Ranunculaceae families. A high percentage of long rhizome plants (14% of the total number of rare species) is mainly observed for forest plants. Plants of other life forms cover less than 10% for each group and in total represent 38% of the studied species.

Discussion

Overall this research revealed that rare and endangered vascular plants of Transbaikalia are well studied but there still remain territories that have a small number of known localities for these plants (Fig. 1). The low diversity is observed where the dominant type of plant communities is floristically pure such as larch forests, meadows, and swamps, which mostly contain common and widely distributed plant species. A high diversity of rare and endangered vascular species is observed in mountainous areas, which is a clear pattern on the local (Sandanov, 2016), regional (Venevsky & Venevskaia, 2005), and global scales (Noroozi et al., 2018; Muellner-Riehl et al., 2019). It is also true that in Transbaikalia, many rare species are found in highlands and mountain ridges, and many of them are endemic. This also explains why this study found the highest number of localities and highest rare species diversity in Tunkinsky National Park, an area that contains the eastern part of the East Sayan mountains and the southeastern part of the Big Sayan Mountains.

The present analysis was focused on many federal Protected Areas in the study region, and we found that these Protected Areas do not contain the majority of rare species diversity (Table 2). The species distribution within Protected Areas is uneven, with most species having only one or two localities, and only a few can usually be found in Protected Areas. A similar situation was observed for the neighbouring Jewish Autonomous Region (Rubtsova & Gaidash, 2007). A recent review also highlighted conservation activities within Protected Areas but concluded that there is a need to invest significantly more efforts in plant conservation outside of them (Heywood, 2019).

The prevalence of rare species with East-Asian distribution was also previously observed for Baikal Siberia (Boikov, 2005). These species have the northwest edges of their distribution in Transbaikalia with a low population quantity (Peshkova, 1968; Boikov, 2005), vitality (Sandanov, 2009), low projective cover in plant communities, biomass, and seed productivity (Sandanov, 2010). For example, the distribution and population features of the East Asian rare species *Scutellaria baicalensis* Georgi in Transbaikalia fit with an «abundance-centre model», where the edge populations of the species have the lower population quantity and vitality (Sandanov et al., 2017). This pattern is also connected with regional and local environmental factors (Sandanov & Rosbakh, 2019) and proved by a sharp floristic gradient on the western part East-Asian phytogeographical region (Krestov, 2005; Galanin & Belikovich, 2006). In general, among the rare vascular plants, species of Asian origin were the most dominant type. It is similar with the flora of Baikal Siberia (Malyshev & Peshkova, 1984) and the steppe flora of South Siberia (Peshkova, 2001), which support the idea of indigenous origin of these floras.

Buryatia has a smaller number of species and localities of Red Data Book vascular plants compared to the Zabaikalsky Krai, which could refer to differences in floristic provinces. This is consistent with a recent study that revealed confinement of rare flora of Buryatia to South Siberia, while the Red Data Book species list for the Zabaikalsky Krai floristically was close to the Far-East regions of Russia (Khapugin et al., 2020). The area of Buryatia is situated within various floristic provinces where many plant species are located at the limits of their ranges (Namzalov, 2009; Kamelin, 2013). Here we can find many rare and endangered plant species on the western and eastern part of their distribution (Fig. 3, Fig. 4), as well as northern limits for some species widely distributed in Mongolia (Kamelin, 2013). The heterogeneity of the Buryatia landscape results in a high diversity of endemic species. Moreover, recent botanical studies in Buryatia have discovered many new localities of rare endemic species (Selyutina et al., 2016, 2019; Chimitov et al., 2017; Chimitov & Imetkhenova, 2019; Sandanov, 2020). Similar investigations reporting new findings of endemic species are also known in the Zabaikalsky Krai (Popova et al., 2020). These data are not included in our dataset, allowing us to have a similar time-scale of data for the whole study area. A future revision of the rare species lists in the subsequent editions of the Red Data Books and compilation of the new distribution data will finally improve our dataset.

The high ratio of alpine plants among endemic species is similar to the flora of Baikal Siberia and can be explained by a high level of ecological isolation in the highlands in comparison with mountain ridges as a whole (Malyshev & Peshkova, 1984). The conservation of endemic species within habitats outside Protected Areas is one of the main priorities (Douma et al., 2012; Heywood, 2019), as was shown in a study revealing ten endemic species found outside Protected Areas in Buryatia (Sandanov, 2016). Moreover, the number of non-protected localities is twice as high as those under protection (Sandanov, 2020). The conservation of endemic species of vascular plants in the Magadan Region faces the same problem. Ten species out of 17 endemics are found outside Protected Areas (Khoreva & Mochalova, 2012). In the Zabaikalsky Krai, the situation is of higher concern, with only two localities of *Aquilegia turczaninovii* Kamelin & Gubanov and *Rhodiola pinnatifida* Boriss., found in the Sokhondinsky State Nature Reserve. A high diversity of endemic species in the Stanovoye highlands is observed in the Kodar National Park and the neighbouring Vitimsky State Nature Reserve (Irkutsk Region). To better preserve endemic species of Transbaikalia, it is necessary to extend the territories of Protected Areas or organise specific buffer zones with a high concentration of endemic species, revise the schemes of functional zoning for national parks or establish Important Plant Areas with detailed descriptions of species habitats. These studies need to be complemented by a detailed analysis of the population structure of rare plants to inform the planning of more effective conservation activities (McDonald-Madden et al., 2008; Selyutina & Sandanov, 2018).

Available data about ecological and biological features of Red Data Book vascular plants can provide more details for better conservation. For example, the high ratio of mesophytes among studied species can be explained by the mountainous landscape and prevalence of forests in Transbaikalia. There are many species from forests and highlands that are usually characterised by humid conditions. Rapid climate warming in Transbaikalia (Ippolitov et al., 2007) connected to the drought period (Obyazov, 2010) has led to high rates of aridisation over the last decades. These processes can be one of the main challenges in the conservation of rare mesophytic plants in the future.

Confinement of the plants to specific life forms and consolidating these data within the dataset is a good tool for studies of species richness and its determinants (Liu et al., 2019; Sandanov et al., 2020), for analysis of growth-form plasticity in rare and endemic species (Mills & Schwartz, 2005), and for detection of rare plants using remote sensing (Cerrejón et al., 2021). Our results revealed the prevalence of short rhizome plants among rare and endangered species. This can be explained by a high ratio of orchids, which are usually represented in regional Red Data Books as well (Khapugin et al., 2020). In forest communities, a high number of long rhizome plants is observed due to the thick organic soil layer formed by detritus and leaf litter (Bezdeleva, 2015). This data matches species ecology well because orchids and forest long rhizome plants usually grow in mesophytic habitats.

Conclusions

Our studies reveal the main distribution patterns of the Red Data Book vascular plants of Transbaikalia. The highest rare and endangered species diversity and number of localities is observed in Tunkinsky National Park. Our results show that the distribution of some rare and endangered species falls under federal protection, but some plants, including endemic species, need stricter protection. It is also essential to preserve vascular plants included in the Red Data Book from outside Protected Areas, and information from our dataset will be useful for conservation monitoring programs. The compilation of additional information for each species is helpful for the detailed analysis of their distribution and a better understanding of their ecological and biological features. Complex studies using the same techniques could add more meaningful information to the current dataset and could be helpful during the planning and implementation of future conservation activities.

Acknowledgements

We specially thank Stuart Paterson, Henry Rees, and Kate Tointon (Fauna & Flora International) for their help reviewing the English version of the manuscript. This research was funded by the Russian Federal Budget (project number 121030900138-8) and partially by RFBR (project number 20-45-380009).

References

Balding M., Williams K.J.H. 2016. Plant blindness and the implications for plant conservation. *Conservation Biology* 30(6): 1192–1199. DOI: 10.1111/cobi.12738

Bezdeleva T.A. 2015. The biomorphological adaptation of herbaceous plants to environmental conditions in the Korean pine-needle fir forest. *Bulletin of the Botanical Garden-Institute of FEB RAS* 13: 49–65. [In Russian]

Boikov T.G. 1999. *Rare plants and communities of Transbaikalia: Biology, eco-geographical aspects and conservation*. Novosibirsk: Nauka. 265 p. [In Russian]

Boikov T.G. 2005. *Unique objects of plant world of Central Siberia: diversity, spatial and time distribution, features and perspectives of conservation*. Novosibirsk: Nauka. 181 p. [In Russian]

Cerrejón C., Valeria O., Marchand P., Caners R.T., Fenton N.J. 2021. No place to hide: Rare plant detection through remote sensing. *Diversity and Distributions* 27(6): 948–961. DOI: 10.1111/ddi.13244

Chimitov D.G., Imetkhenova O.V. 2019. Records of rare and endemic species of plants in the Republic of Buryatia. *Botanicheskii Zhurnal* 104(2): 301–304. DOI: 10.1134/S0006813619020030 [In Russian]

Chimitov D.G., Imetkhenova O.V., Naydanov B.B., Sandanov D.V., Krivenko D.A. 2017. New data relating to the distribution *Oxytropis triphylla* (Fabaceae) and *Stipa glareosa* (Poaceae) in the Republic of Buryatia. *Flora and Vegetation of Asian Russia* 1(25): 10–18. DOI: 10.21782/RMAR1995-2449-2017-1(10-18) [In Russian]

Corlett R.T. 2016. Plant diversity in a changing world: Status, trends, and conservation needs. *Plant Diversity* 38(1): 10–16. DOI: 10.1016/j.pld.2016.01.001

Douma J.C., Witte J.P.M., Aerts R., Bartholomeus R.P., Ordoñez J.C., Venterink H.O., Wassen M.J., van Bodegom P.M. 2012. Towards a functional basis for predicting vegetation patterns; incorporating plant traits in habitat distribution models. *Ecography* 35(4): 294–305. DOI: 10.11 11/j.16 00 -0587.2011.07140.x

Galanin A.V., Belikovich A.V. 2006. Dauria as the subregion of Dahuro-Manchurian botanico-geographical region. *Komarovskie chteniya* 53: 9–31. [In Russian]

Heywood V.H. 2019. Conserving plants within and beyond protected areas – still problematic and future uncertain. *Plant Diversity* 41(2): 36–49. DOI: 10.1016/j.pld.2018.10.001

Heywood V.H., Iriondo J.M. 2003. Plant conservation: old problems, new perspectives. *Biological Conservation* 113(3): 321–335. DOI: 10.1016/S0006-3207(03)00121-6

Hobohm C., Janišova M., Steinbauer M., Landi S., Field R., Vanderplank S., Beierkuhnlein C., Grytnes J.-A., Vetaas O.R., Fidelis A., de Nascimento L., Clark V.R., Fernández-Palacios J.M., Franklin S., Guarino R., Huang J., Krestov P., Ma K., Onipchenko V., Palmer M.W., Simon M.F., Stolz C., Chiarucci A. 2019. Global endemics-area relationships of vascular plants. *Perspectives in Ecology and Conservation* 17(2): 41–49. DOI: 10.1016/j.pecon.2019.04.002

Ippolitov I.I., Kabanov M.V., Loginov S.V. 2007. Spatiotemporal scales of warming observed in Siberia. *Doklady Earth Sciences* 413(1): 248–251. DOI: 10.1134/S1028334X07020250

Kamelin R.V. 2013. Mongolia on the map of the phytogeographical division of Palaeoarctics. *Turczaninowia* 13(3): 5–11. [In Russian]

Khapugin A.A., Kuzmin I.V., Silaeva T.B. 2020. Anthropogenic drivers leading to regional extinction of threatened plants: insights from regional Red Data Books of Russia. *Biodiversity and Conservation* 29(8): 2765–2777. DOI: 10.1007/s10531-020-02000-x

Khoreva M.G., Mochalova O.A. 2012. Endemic species of vascular plants in wildlife reserves of the Magadan Region. In: B.F. Bugaev, A.M. Tokranov, O.A. Chernyagina (Eds.): *Conservation of biodiversity of Kamchatka and coastal waters*. Petropavlovsk-Kamchatsky: Kamchatpress. P. 281–288. [In Russian]

Krasnopevtseva A.S., Krasnopevtseva V.M. 2012. The rare species of highest vascular plants in Buryatia and their preservation. *Proceedings of Samara Scientific Centre RAS* 14: 2147–2150. [In Russian]

Krestov P.V. 2005. Suggestions to floristic subdivision of northern Asia on the base of comparative analysis of regional floras on the genus level. *Komarovskie chteniya* 51: 15–56. [In Russian]

Laskey H., Crook E.D., Kimball S. 2020. Analysis of rare plant occurrence data for monitoring prioritization. *Diversity* 12(11): 427. DOI: 10.3390/d12110427

Liu Y., Su X., Shrestha N., Wang S., Xu X., Li Y., Wang Q., Sandanov D., Wang Z. 2019. Effects of contemporary environment and Quaternary climate change on drylands plant diversity differ between growth forms. *Ecography* 42(2): 334–345. DOI: 10.1111/ecog.03698

Malyshev L.I., Peshkova G.A. 1984. *Peculiarities and genesis of flora of Siberia (Western and Eastern Baikal region)*. Novosibirisk: Nauka. 264 p. [In Russian]

McDonald-Madden E., Baxter P.W.J., Possingham H.P. 2008. Subpopulation triage: how to allocate conservation effort among populations. *Conservation Biology* 22(3): 656–665. DOI: 10.1111/j.1523-1739.2008.00918.x

Mills M.H., Schwartz M.W. 2005. Rare plants at the extremes of distribution: broadly and narrowly distributed rare species. *Biodiversity and Conservation* 14(6): 1401–1420. DOI: 10.1007/s10531-004-9666-6

Muellner-Riehl A.N., Schnitzler J., Kissling W.D., Mosbrugger V., Rijsdijk K.F., Seijmonsbergen A.C., Versteegh H., Favre A. 2019. Origins of global mountain plant biodiversity: Testing the 'mountain-geobiodiversity hypothesis'. *Journal of Biogeography* 46(12): 2826–2838. DOI: 10.1111/jbi.13715

Namzalov B.B. 2009. Baikal phytogeographic node as the newest center of endemism of Inner Asia. *Contemporary Problems of Ecology* 2(4): 341–347. DOI: 10.1134/S1995425509040079

Noroozi J., Talebi A., Doostmohammadi M., Rumpf S.B., Linder H.P., Schneeweiss G.M. 2018. Hotspots within a global biodiversity hotspot – areas of endemism are associated with high mountain ranges. *Scientific Reports* 8(1): 10345. DOI: 10.1038/s41598-018-28504-9

Obyazov A.A. 2010. Adaptation to the climate changes: regional approach. *Geography and Natural Resources* 2: 34–39. [In Russian]

Peshkova G.A. 1968. Features of flora and vegetation on south-eastern part of Dauria (Nerchinsko-Zavodskoi region). *Botanicheskii Zhurnal* 53(7): 990–992. [In Russian]

Peshkova G.A. 2001. *Florogenetic analysis of steppe flora of the Southern Siberia*. Novosibirisk: Nauka. 192 p. [In Russian]

Popova O.A., Chashchina N.A., Leskov A.P., Shcheglova S.N., Andrievskaya E.A., Namzalov B.B. 2020. New localities of rare plant species in Trans-Baikal Territory. *Turczaninowia* 23(2): 85–90. DOI: 10.14258/turczaninowia.23.2.12 [In Russian]

Red Data Book of the Republic of Buryatia: Rare and endangered species of animals, plants, and fungi. Ulan-Ude: Buryat Scientific Center Publishing House, 2013. 688 p. [In Russian]

Red Data Book of the Zabaikalsky Krai. Plants. Novosibirsk: Dom mira, 2017. 384 p. [In Russian]

Rubtsova T.A., Gaidash E.M. 2007. Rare species of vascular plants of Jewish Autonomous Region: eco-coenotic analysis and distribution on protected areas. *Regional Problems* 8: 114–120. [In Russian]

Sandanov D.V. 2009. Vitality of individuals and cenopopulations of *Sophora flavescens* Soland. *Contemporary Problems of Ecology* 2(6): 576–580. DOI: 10.1134/S1995425509060149

Sandanov D.V. 2010. Assessment of East-Asian plants population traits in different parts of their area. *Flora and Vegetation of Asian Russia* 2(6): 80–87. [In Russian]

Sandanov D.V. 2016. GIS-analysis of rare vascular plants distribution on the territory of Buryatia. *Uchenye Zapiski Zabaykalskogo Gosudarstvennogo Universiteta* 11: 38–45. [In Russian]

Sandanov D.V. 2019. Modern approaches to modeling plant diversity and spatial distribution of plant species: Implication prospects in Russia. *Vestnik Tomskogo Gosudarstvennogo Universiteta, Biologiya* 46: 82–114. DOI: 10.17223/19988591/46/5 [In Russian]

Sandanov D.V. 2020. Rare Legumes (Fabaceae Lindl.) in Buryatia: geographic distribution, eco-coenotic confinement, population diversity, and conservation challenges. *Journal of Siberian Federal University. Biology* 13(1): 81–93. DOI: 10.17516/1997-1389-0287 [In Russian]

Sandanov D.V., Rosbakh S. 2019. Demographic structure of *Scutellaria baicalensis* Georgi depending on climatic gradients and local factors. *Russian Journal of Ecology* 50(4): 404–407. DOI: 10.1134/S1067413619040131

Sandanov D.V., Naidanov B.B., Shishmarev V.M. 2017. Influence of regional and local environmental factors on the distribution and population structure of *Scutellaria baicalensis* Georgi. *Vestnik Tomskogo Gosudarstvennogo Universiteta, Biologiya* 38: 89–103. DOI: 10.17223/19988591/38/5 [In Russian]

Sandanov D.V., Liu Y., Wang Z., Korolyuk A.Yu. 2020. Woody and herbaceous plants of Inner Asia: species richness and ecogeorgraphic patterns. *Contemporary Problems of Ecology* 13(4): 360–369. DOI: 10.1134/S1995425520040101

Sandanov D., Brianskaia E., Dugarova A. 2021. *Rare vascular plant species of Transbaikalia (Republic of Buryatia and Zabaikalsky Kray), Russia*. Institute of General and Experimental Biology of SB RAS. Occurrence dataset. Available from https://doi.org/10.15468/rh8s6n

Selyutina I.Yu., Sandanov D.V. 2018. Demographic structure and population size of rare endemic *Oxytropis* species from Priol'khonye steppe. *Flora and Vegetation of Asian Russia* 1(29): 14–23. DOI: 10.21782/RMAR1995-2449-2018-1(14-23) [In Russian]

Selyutina I.Yu., Konichenko E.S., Dorogina O.V., Sandanov D.V. 2016. Genetic diversity of the endangered endemic milkvetch *Astragalus sericeocanus* Gontsch., Fabaceae from the Lake Baikal region. *Biochemical Systematics and Ecology* 68: 163–169. DOI: 10.1016/j.bse.2016.07.011

Selyutina I.Yu., Pyzhikova E.M., Tsyrenova M.G., Sandanov D.V. 2019. The condition of the coenopopulations of rare *Oxytropis triphylla* (Fabaceae) species on the areal east border. In: *The role of scientific studies in management and development of Protected Areas*. Irkutsk: Institute of Geography SB RAS Publishing House. P. 181–185. [In Russian]

Venevsky S., Venevskaia I. 2005. Hierarchical systematic conservation planning at the national level: Identifying national biodiversity hotspots using abiotic factors in Russia. *Biological Conservation* 124(2): 235–251. DOI: 10.1016/j.biocon.2005.01.036

НАБОР ДАННЫХ ПО РЕДКИМ СОСУДИСТЫМ РАСТЕНИЯМ ЗАБАЙКАЛЬЯ: РАСПРОСТРАНЕНИЕ ВИДОВ И ПУТИ ИХ СОХРАНЕНИЯ

Д. В. Санданов[1,2,*], Е. П. Брянская[1], А. С. Дугарова[1]

[1]*Институт общей и экспериментальной биологии СО РАН, Россия*
[2]*Тункинский национальный парк, Россия*
**e-mail: denis.sandanov@gmail.com*

На основе информации из последних изданий Красных книг Республики Бурятия и Забайкальского края подготовлен набор данных по редким сосудистым растениям Забайкалья. Набор данных представляет актуальную информацию по распространению 271 вида редких сосудистых растений (2920 точек распространения). Местонахождения изученных видов регистрировались спутниковыми навигаторами и согласно результатам полевых обследований, остальные данные были получены с помощью геопривязки гербарных образов и оцифровки карт распространения видов. Для каждого вида собрана различная атрибутивная информация, включающая поясно-зональное распределение, хорологию, приуроченность к экологическим группам и жизненным формам. Распространение редких сосудистых растений проанализировано с использованием ГИС-пакета QGIS 3.10. Наше исследование выявило распространение редких сосудистых растений и число их местонахождений на федеральных особо охраняемых природных территориях (ООПТ) Забайкалья, среди которых Тункинский национальный парк характеризуется наибольшим разнообразием. Распространение некоторых редких и исчезающих видов охвачено охраной на федеральном уровне. Часть растений, включая эндемичные виды, нуждаются в более строгой охране. Анализ для различных поясно-зональных и хорологических групп показал их сегрегированное распределение в изучаемом регионе. Изученные виды характеризуются преобладанием мезофитов и коротко-корневищных растений. Важным аспектом также является охрана редких сосудистых растений за пределами ООПТ. Следовательно, информация из набора данных может быть полезной для мониторинговых природоохранных программ. Наше исследование предоставляет основу для будущей природоохранной деятельности и может быть использовано при организации новых ООПТ или ключевых ботанических территорий в Забайкалье.

Ключевые слова: геоинформационный анализ, Забайкальский край, набор данных, редкие и исчезающие виды, Республика Бурятия