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RESEARCH ARTICLE

# Principles of the online Red Data Book development using biodiversity datasets: the Altai Mountain Country case

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## Abstract

Rare and endemic plant species could serve as a litmus test for analyzing current state of ecosystems that are rapidly changing under the anthropogenic pressure. Undisturbed foothills and mountainous areas are key places to conserve as they still retain the natural conditions as the human activity there is limited because of their difficult accessibility. We used biodiversity informatics methods for preparation of the online Red Data Book (plants) within the borders of particular natural unit – the Altai Mountain Country (AMC). The Herbarium ALTB (Barnaul) served as the empirical basis for the current study, and it is the largest plants collection from transboundary territory of the AMC and the main material of the "Flora Altaica" project. Thanks to the Herbarium ALTB digitizing, it becomes possible to identify endemics of the AMC transboundary territory and to establish the specificity of the flora without government and language barriers. Online Red Data Books created for the natural units are prospective for revealing of the endemism level and plants rarity rank. Our initial experience in the online Red Data Book development allow us to formulate some principals and approaches.

## Keywords

Altai Mountain Country, ALTB, endemic, GBIF, GeoJSON, Herbarium, plants, rare species

## Introduction

Over the last decades, the anthropogenic pressure on the natural complexes highly increased as a result of population growth and expanding human needs. Undisturbed foothills and mountainous areas are key places to conserve as they still retain the natural conditions as the human activity there is limited because of their difficult accessibility (Kollmair et al. 2005; Tishkov and Belonovskaya 2012). In such circumstances, it is essential to analyze the current state of ecosystems and plants could serve as a litmus test. For instance, the lack of rare and endangered species (including endemics) on the territory highlights that ecosystem is ruined and viseversa their presence shows natural state of area. Rare and endangered species are especially valuable categories for environmental protection. Efforts to conserve rare plant species can be limited by a lack of time and funding for monitoring. Understanding the species occurrence and distribution patterns within existing protected habitat and throughout the entire species range can help stewards prioritize rare plant monitoring (Laskey et al. 2020).

One category of plant species that shows territorial specificity is endemics. It is commonly accepted that endemic species are taxa that are spread only on the territory of studied flora and do not exceed its boundaries. Thereby, endemics show specificity of flora, demonstrate the level of endemism and serve as its absolute markers that differ it from all other floras (Zernov 2010). For instance, in the project UNDP-GEF "Biodiversity conservation in the Russian portion of the Altai-Sayan Ecoregion" the endemism level and the number of rare and endangered plant species have been successfully used as indicators for biodiversity evaluation and establishing of ecosystem condition (Vaganov 2009; Yashina 2010). Endemics are also an important category in the Red List IUCN (http://www.iucnredlist.org). It includes a search filter that allows finding a list of endemic taxa (i.e., taxa that are recorded as being native to only one country) (IUCN 2020).

Usually, local Red Lists or Red Data Books (we use these terms as the same in our work) are prepared based on the state of populations only within an administrative unit, without taking into account species distribution in the entire natural botanical and geographic unit in which they occur. At the (sub-) national level regional IUCN criteria (Gaerdenfors et al. 2001; IUCN 2012) are used, although some countries implement specific regional national criteria or local expert judgements to produce Red Lists. Sometimes Red Data Books of adjacent regions have controversial and even contradictory information using different evaluation systems (Crain and White 2011; Khapugin et al. 2017; California Native Plant Society, Rare Plant Program 2021). Some researchers show that although IUCN Red List criteria are largely quantitative, the interpretation of the criteria and the data availability still differs strongly among European countries (Maes et al. 2019).

Natural factors (biotic, geographic isolation, climate, soil) influence on endemism level. Therefore, the revealing of endemics is possible only within boundaries of natural ecosystems (Orsenigo et al. 2018). Thus, if we study endemics of natural

ecosystems (e.g., the Altai Mountain Country), we will have an opportunity for the adequate evaluation of each plant species rarity taking into account the anthropogenic load. Afterwards we can extrapolate data of species rarity on the administrative units (countries, districts, areas etc.). That, in turn, is essential for government decision-making on the countries level in the field of environmental management. With information on the distributions and habitat requirements of rare plants, local governments, researchers, and private stakeholders can acquire, regulate and manage land to sustain existing populations and to facilitate range expansion or migration (Press et al. 1996; Fiedler et al. 2007; Kelly and Goulden 2008).

Revealing of endemics not for countries with their artificial borders but for natural ecosystems currently is not the easiest task. It is rather difficult, because a natural ecosystem can lie within the boundaries of several states and data on rarity can be found only from local Red Data Books and Lists, frequently using different methodology without considering international nomenclature codes, current GIS-data and open sources. Processing additional information on species ecology and factors that influence populations is complicated, because the sources of such information are published in different languages and often do not follow international standards.

In such cases, using the Global Biodiversity Information Facility data (GBIF, http://www.gbif.org) may help in the evaluation of species rarity. It is a strikingly successful example of integrating disparate data on the world's biological diversity. GBIF as an international network provides open access to a huge array of standardized primary information on biodiversity that is attractive for creating the List of rare and endemic species for any natural territory. Users can establish exact occurrence of each species both within limits of administrative units (country, district, etc.) and within any optional territory needed for conservation purposes.

In this work, we formulate methodological approaches and principles for the development of online Red Data Book within boundaries of a natural unit.

## Material and methods

The Altai Mountain Country (AMC) is located close to the center of Eurasia, more-or-less equidistant from the Atlantic and Pacific, and Arctic and Indian Oceans. It lies at the junction of Russia (south-eastern part of Western Siberia), north-west China, eastern Kazakhstan and Western Mongolia (Pyak et al. 2008). The biodiversity of the AMC territory has been exploring for over 200 years. More than 2700 plants grow in this territory, 300 of which are endemic (Flora Altaica 2005).

The AMC is the highest modern uplift among the continental mountain countries of Siberia, and at the same time, it is the most favorable place for the development of organic life in Siberia (and, in general, in North and Central Asia). The topography of the mountainous country is extremely complex, since it combines latitudinal and meridian extending ridges, regions of typically small hills, intermontane basins, high plateau and vast highlands (Kamelin 1998).

For preparation of the online Red Data Book within the borders of the AMC we used biodiversity informatics methods. The Herbarium ALTB (Barnaul, Russia) served as the empirical basis for the current study. As a result of many big expeditions, in a rather short period a large amount of herbarium material was collected, numbering more than 450 000 sheets. The Herbarium ALTB digitizing started relatively recently (Vaganov et al. 2021a, 2021b) and is ongoing with involvement of three key elements: the "Flora Altaica" project (altaiflora.asu.ru), publication of data to GBIF and the using data standards Darwin Core and GeoJSON. Through them, the steps of work with the herbarium collection have moved to the new, wider, qualitative and automated level (Vaganov and Medvedeva 2020). The Darwin Core standard (Wieczorek et al. 2012) effectively solved the major impediment to sharing plant diversity data from AMC and adjacent regions in a multilingual environment. The compilation of the initial list of plants for the Red Data Book of AMC is based on the revision of existing Red Data Books of the Russian Federation (2008), Kazakhstan (2014), Mongolia (2013), and the Xinjiang Uygur Autonomous Region of Republic of China (Rare endangered … 2006), as well as regional Red Data Books of Russia: Altai Krai (2016), Republic of Altai (2017), Kemerovo Oblast (2012), Krasnoyarsk Krai (2012), Republic of Tuva (2018), and the Republic of Khakassia (2012). We formed the list of plants taking into account their distribution within the boundaries of the AMC with the obligatory indication of the rarity status (using local evaluation systems).

We determined the boundaries of the AMC according to the 19 botanical and geographical regions identified by R.V. Kamelin in the first volume of "Flora Altaica" (2005). To identify the borders of the AMC and all botanical and geographical regions, we made polygons based on topographic maps (scale – 1 : 500 000) using the WP Google Maps plugin (WGS 84). The resulting sets of coordinates were converted into GeoJSON format (Vaganov et al. 2019). To work with AMC polygons (borders and regions of the AMC, WGS 84 coordinate system) in various GIS applications, we prepared original shapefiles (*shp). GeoJSON shapefiles and polygons can be freely downloaded in the "AMC Map" section of the "Flora Altaica" project (http://altaiflora.asu.ru). The AMC polygon in the GeoJSON can be used in the ″Location″ filter of the "Occurrence" search tab in the GBIF portal.

Map of occurrences was designed in QGIS3.14 program. Plant nomenclature was standardized following the International Plant Names Index – IPNI (http://ipni.org).

## Results

The inventory of all national and regional Red Data Books has resulted in a list of rare and endemic plant species. The list contains 583 taxa of higher vascular plants for the AMC. We took this list as a basis for the preparation of a consolidated da-

tabase. The database includes the names of the taxa with the author(s), the name of the red data book(s) from which they were compiled and the status(es) of rarity.

Two datasets were prepared using the database. The first dataset – "Red List of Altai Mountain Country (plants)" – includes a complete list of rare and endemic plant species of AMC (data type "Checklist") comprising the following Darwin Core terms: id, taxonID, acceptedNameUsageID, kingdom, scientificName, genus, specificEpithet, nomenclaturalCode, taxonomicStatus, taxonRank, basisOfRecord (Vaganov et al. 2021c). The second dataset – "Red Book of Altai Mountain Country (plants)" (data type "Occurrence") – contains the following Darwin Core terms: occurrenceID, references, basisOfRecord, country, countryCode, family, genus, specificEpithet, scientificName, catalogNumber, recordedBy, verbatimLocality, verbatimCoordinates, decimalLatitude, decimalLongitude, verbatimElevation, verbatimEventDate, eventDate, identifiedBy, typeStatus, locationRemarks (Vaganov et al. 2020). It is planned to republish the "Red Book of Altai Mountain Country (plants)" dataset regularly, to add information about new locations and taxa to the list, as they appear in the ALTB Herbarium.

**Data resource:**

Name: "Red List of Altai Mountain Country (plants)"

Resource link: https://doi.org/10.15468/uwre7d

Name: "Red Book of Altai Mountain Country (plants)"

Resource link: https://doi.org/10.15468/oxgtcb

The map of occurrences (Fig. 1) reflects a correspondence of herbarium records with existing roads. The territory of the AMC is vast (550 000 km$^2$), and there is still a lack of information on distribution of endemic species in high mountainous areas.

A taxonomic analysis of the 1320 records from the "Red Data Book of the Altai Mountain Country (plants)" occurrence dataset in GBIF showed the following sharing groups of plants: ferns (Polypodiopsida) – 52 records, monocotyledons (Liliopsida) – 370, and dicotyledons (Magnoliopsida) – 898 records (Fig. 2).

## Discussion

The datasets created by our research team can help to solve the major impediment that appears when using Red Data Books of adjacent regions for evaluation of plant species rarity rank. For instance, Allium altaicum Pall. has different categories of rarity in Red Data Books of neighboring administrative units: in Altai Krai, in Mongolia, in Tuva, and in the Red Data Book of Russian Federation it has category – near threatened, in Republic of Altai – vulnerable, and in China – endangered. On the other hand, *Allium altaicum* is not included in the Red Data Book of Kazakhstan as it is not at risk in that territory. In fact, without taking into account the borders of the countries, it is not necessary to give status of rarity in some administrative units. This species is widely distributed in Republic of Altai, in Mongolia and in the steppe part of Kazakhstan and is limited in Altai Krai only by lack of natural habitats

and in China, where it is reasonable to include it in Red Data Books with relevant category (Figs 3 and 4).

The development of such datasets helps to determine the exact coordinates of species according to the administrative division, which allows evaluating the rarity of taxa for different territories, due to the possibility of accurate accounting of the species occurrences.

Despite the fact that a large share of plant records from the AMC is in the ALTB Herbarium, there are certainly many other collections containing an information about rare and endemic plant species from this territory. In the previous study on assessing the data on phytodiversity in the territory of the AMC, Vaganov et al. (2019) identified 44 world scientific repositories containing at least 10 herbarium sheets from the AMC and available in GBIF.

Therefore, any interested user can choose a taxon from the "Red List of Altai Mountain Country (plants)" and perform the necessary type of analysis (geographical, taxonomic, phenological, etc.) in GBIF using the AMC polygons in the GeoJSON format according to data for more than 200 years of observation. The analysis can be done according to administrative unit, original GeoJSON polygons (ridge, river basin, etc.), collection dates, datasets, and other requests available in the GBIF "Occurrence" section. In addition, information on the exact distribution of taxa from the Red Data Book of AMC can be downloaded in the Darwin Core format from GBIF and used in GIS programs to prepare maps for rare and endemic plant species, adding personal records and field observations.

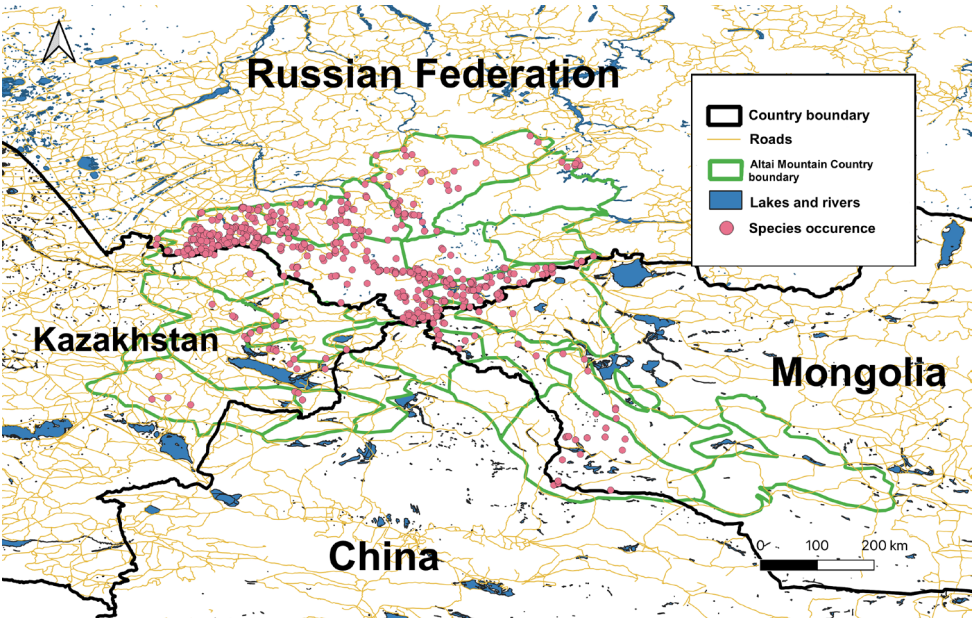


**Figure 1.** Occurrences in dataset "Red Data Book of the Altai Mountain Country (plants)".

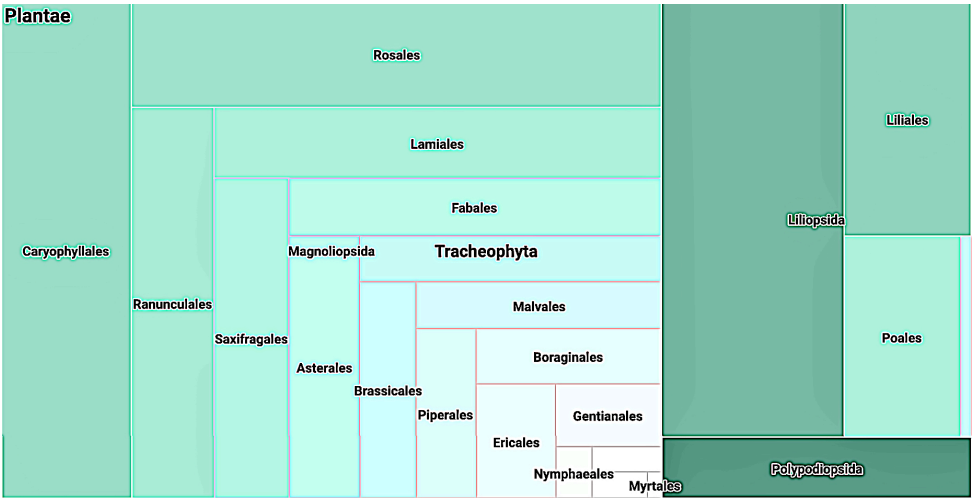


**Figure 2.** Taxonomic distribution of species in the dataset "Red Data Book of the Altai Mountain Country (plants)".

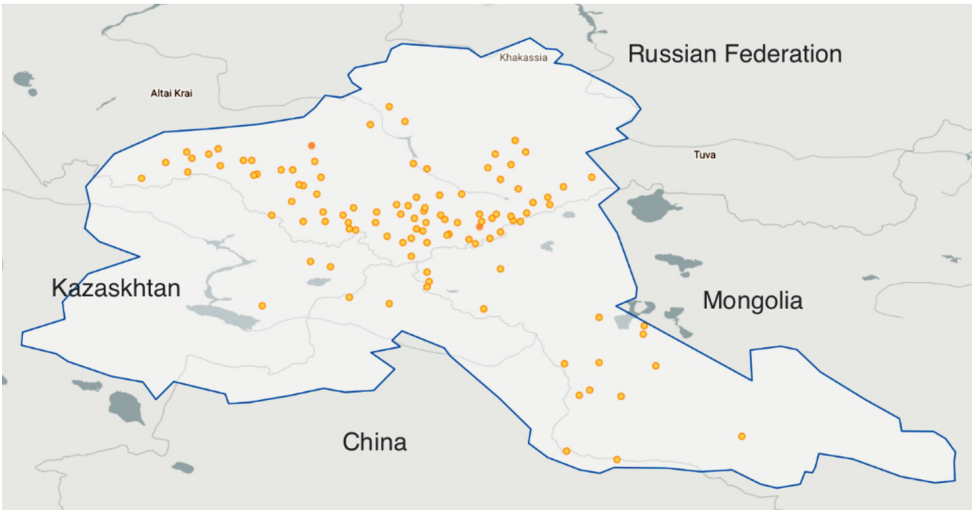


**Figure 3.** Distribution of *Allium altaicum* in the AMC according to all data from GBIF (blue line: border of the Altai Mountain Country).

The approach proposed by the authors on distribution of rare and endangered plant species in the AMC compiled from the Red Data Books of Russia, China, Kazakhstan, Mongolia could be helpful for the next updating IUCN Red List, because GBIF data is integrated with IUCN (Hobern 2012). It also should be mentioned that one of the IUCN goals is the establishment of the "Barometer of Life". However, for this purpose it is necessary to increase the number of assessments for animal, fungi and plant species. Especial attention was paid to fungi and plant species, as they are

less concern in IUCN Red List, which was one of the targets set out in the Strategic Plan for Biodiversity 2011–2020 (IUCN, 2020). Our datasets of rare plant species in the AMC can help to achieve these targets.

Our online Red Data Book has a key opportunity of open access on the Internet and can be used for different analysis such as have been implemented in Napa County, California on overlapping between the local distribution of rare plants and land-cover types (i.e., habitat types) (Crain & White 2011). Specially protected natural areas can use our database for rare plant species prioritization and monitoring efforts (Viciani et al. 2018; Laskey et al. 2020). For example, this information can be useful for specially protected areas situated in the Russian part the AMC that corresponds to IUCN categories 1 (Strict Nature Reserves / Wilderness Area) and 2 (National Park) such as Altai Biosphere Reserve, Katun Nature Reserve, Saylyugemsky National Park, Tigirekskiy Nature Reserve.

Our dataset is dynamic and, in the future, while the number of occurrences in GBIF datasets concerning the AMC will increase other analysis and assessments could be revealed for different environmental properties. In addition, other anthropogenic factors could be involved in the analysis implementation using GBIF tools or local GIS-programs.


**Figure 4.** Distribution of *Allium altaicum* in the AMC according to all data from GBIF (blue line: border

## Conclusion

The development of the online Red Data Book of the AMC and experience of the integration with GBIF allow us to formulate some principals and approaches:

1. The first step is conversion of physical herbarium sheets to the digital and integration with global open access platforms (e.g., GBIF) for the following data keeping and processing.
2. Darwin Core is the most used data sharing standard concerning environmental issues for multinational territories.
3. Capturing geographic information in GeoJSON format is easy and efficient for zoning of any ecosystem out of political boundaries.
4. Nomenclature should be standardized following a declared authoritative source, such as the International Plant Names Index (IPNI).

Usually the traditional (off-line) Red Data Books are updated only once every 10 years, which makes population monitoring for changing category of rarity a very inert process. In addition, frequently the replacement of the Red Lists in neighboring territories (regions, countries) is made asynchronously that leads to the lack of system approach in records of exact taxon occurrences in the frame of its range. Thus, the information contained in online Red Data Book will be of the highest relevance because of regular updating geospatial data on the exact distribution of rare and endemic plants. New principles will contribute active monitoring of rare and endemic species and accurate recording of their numbers.

Our final dataset "Red Book of Altai Mountain Country (plants)" published in GBIF has a key opportunity of open access on the Internet for the exchange of information on species occurrences and following data accumulation and analysis. It acts as an interface for the further data processing in conjunction with other GBIF datasets across the AMC territory. Our datasets could be a background for further monitoring using online tools with the purpose of plants conservation.

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## References

California Native Plant Society, Rare Plant Program (2021) Inventory of Rare and Endangered Plants of California (online edition, v8-03 0.39). http://www.rareplants.cnps.org

Crain BJ, White JW (2011) Categorizing locally rare plant taxa for conservation status. Biodiversity and Conservation 20: 451–463. http://dx.doi.org/10.1007/s10531-010-9929-3

Fiedler P, Keever M, Grewell B, Partridge D (2007) Rare plants in the Golden Gate Estuary (California): the relationship between scale and understanding. Australian Journal of Botany 55: 206–220. http://dx.doi.org/10.1071/BT06069

Gaerdenfors U, Hilton-Taylor C, Mace GM, Rodriguez JP (2001) The application of IUCN Red List criteria at regional levels. Conservation biology 15 (5): 1206–1212. https://doi.org/10.1111/j.1523-1739.2001.00112.x

Hobern D (2012) Leveraging government investment in data mobilization, informatics standards and capacity to support IPBES. https://www.iucn.org/downloads/gbif_180412_panama.pdf

IUCN 2012. Guidelines for Application of IUCN Red List criteria at regional and national levels: Version 4.0. Gland, Switzerland and Cambridge, UK: IUCN, 41 pp.

IUCN 2020. The IUCN Red List of Threatened Species. Version 2020-2. https://www.iucnredlist.org

Flora Altaica V. 1. (2005) Kamelin RV (Ed.) AzBuka, Barnaul, 338 pp. [In Russian]

Kamelin RV (1998) Materials on the History of the Flora of Asia (Altai Mountain Country). Altai State University Press, Barnaul, 240 pp. [In Russian]

Kelly A, Goulden M (2008) Rapid shifts in plant distribution with recent climate change. Proceedings of the National Academy of Sciences of the United States of America 105: 11823–11826.

Khapugin AA, Silaeva TB, Vargot EV, Chugunov GG, Grishutkina GA, Grishutkin OG, Pismarkina EV, Orlova JuS (2017) Estimation of taxa included in the first volume of the Red Data Book of the Republic of Mordovia (Russia) using the IUCN Red List categories and criteria. Nature Conservation Research 2 (Suppl. 1): 164–189. https://doi.org/10.24189/ncr.2017.004

Kollmair M, Ghana S, Gurung GS, Hurni K, Maselli D (2005) Mountains: Special places to be protected? An analysis of worldwide nature conservation efforts in mountains. International Journal of Biodiversity Science & Management 1 (4): 181–189. https://doi.org/10.1080/17451590509618091

Laskey H, Crook ED, Kimball S (2020) Analysis of rare plant occurrence data for monitoring prioritization. Diversity 12 (11): 427. https://doi.org/10.3390/d12110427

Maes D, Verovnik R, Wiemers M, Brosens D, Beshkov S, Bonelli S, Buszko Ja, Cantú-Salazar L, Cassar L-F, Collins S, Dincă V, Djuric M, Dušej G, Elven H, Franeta F, Garcia-Pereira P, Geryak Yu, Goffart Ph, Gór Á, Hiermann U, Höttinger H, Huemer P, Jakšić P, John E, Warren MS (2019) Integrating national Red Lists for prioritising conservation actions for European butterflies. Journal of Insect Conservation 23: 301–330. https://doi.org/10.1007/s10841-019-00127-z

Mongolian Red Book (2013) Ulaanbaatar, Mongolia, Admon print Press, 454 pp.

Orsenigo S, Montagnani Ch, Fenu G, Gargano D, Peruzzi L, Abeli Th, Alessandrini A, Bacchetta G, Bartolucci F, Bovio M, Brullo C, Brullo S, Carta A,Castello M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Rossi G (2018) Red Listing plants under full national responsibility: Extinction risk and threats in the vascular flora endemic to Italy. Biological Conservation 224: 213–222. https://doi.org/10.1016/j.biocon.2018.05.030

Press D, Doak D, Steinberg P (1996) The role of local government in conservation of rare species. Conservation Biology 10: 1538–1548. http://www.jstor.org/stable/2387025

Pyak AI, Shaw SC, Ebel AL, Zverev AA, Hodgson JG, Wheeler BD, Gaston KJ (2008) Endemic plants of the Altai Mountain Country. Old Basing, Wild Guides Ltd, 368 pp.

Rare endangered endemic higher plants in Xinjiang of China (2006) CIP, 159 pp.

Red Data Book of Altai Republic (plants) (2017) Maneyev AG (Ed.) Gorno-Altaisk, 267 pp. [In Russian]

Red Data Book of Altai Territory. Vol. 1. Rare and endangered species of plants and fungi. (2016) Shmakov AI, Silantyeva MM (Eds) Altai State University Press, Barnaul, 292 pp. [In Russian]

Red Data Book of Kazakhstan. V. 2: Plants (2014) TOO ArtPrintXXI, Astana, 452 pp. [In Russian]

Red Data Book of Krasnoyarsk territory. The Rare and Endangered Species of Wild Plants and Fungi (2012) Stepanov NV (Ed) SFU, Krasnoyarsk, 572 pp. [In Russian]

Red Data Book of Kemero Oblast: V. 1 rare and endangered plants and fungi (2012) Kupriyanov AN (Ed.) Azia print, Kemerovo, 208 pp. [In Russian]

Red Data Book of Khakassia Republic: rare and endangered plant and fungi species (2012) Nauka, Novosibirsk, 288 pp. [In Russian]

Red Data Book of Russian Federation (plants and fungi) (2008) Tov. nauchn. izd. KMK, Moscow, 855 pp. [In Russian]

Red Data Book of Tyva Republic (animals, plants and fungi) (2018) Ondar SO, Shaulo DN (Eds) Favorit, Kyzyl, 564 pp. [In Russian]

Tishkov A, Belonovskaya E (2012). Mountain natural biodiversity conservation in Russia. Geography, environment, sustainability 5 (2): 51–67. https://doi.org/10.24057/2071-9388-2012-5-2-51-67

Vaganov AV (2009) Database «Biodiversity of the Altai-Sayan ecoregion». In: Formation of databases on biodiversity – experience, problems, solutions. Proceedings of the international scientific-practical conference. Publishing house ARTIKA, Barnaul, 72–76. [In Russian]

Vaganov AV, Shmakov AI, Gudkova PD (2019) Global data on biodiversity of the Altai mountain country, presented in the world's scientific depositories. Acta Biologica Sibirica 5 (2): 95–101. https://doi.org/10.14258/abs.v5.i2.5937 [In Russian]

Vaganov AV, Medvedeva KE (2020) Current state and prospects of development of the digital collection "Virtual Herbarium ALTB". Problems of botany of South Siberia and Mongolia 19 (1): 260–263. https://doi.org/10.14258/pbssm.2020051 [In Russian]

Vaganov A, Shibanova A, Medvedeva K, Shmakov A, Zholnerova E, Zaikov V (2020) Red Book of Altai Mountain Country (plants). Version 1.7. Altai State University. Occurrence dataset. https://doi.org/10.15468/oxgtcb

Vaganov AV, Shmakov AI, Smirnov SV, Usik NA, Shibanova AA, Kechaykin AA, Kosachev PA Kopytina TM, Zholnerova EA, Medvedeva KE, Zaikov VF, Sinitsyna TA, Shalimov AP, Antonyuk EV, Gudkova PD, Dmitriev DA, Batkin AA, Kasatkin DE, Belkin DL (2021a). Virtual Herbarium ALTB: collection of vascular plants of the Altai Mountain Country. Biodiversity Data Journal 9: e67616. https://doi.org/10.3897/BDJ.9.e67616

Vaganov A, Shmakov A, Zaikov V, Zholnerova E, Shalimov A, Belkin D, Batkin A, Kasatkin D, Kosachev P, Antonyuk E, Medvedeva K, Usik N, Gudkova P, Kriuchkova E, Ryzhakova D, Dmitriev D (2021b) Virtual Herbarium ALTB (South-Siberian Botanical Garden).

Version 1.32. Altai State University. Occurrence dataset. https://doi.org/doi:10.15468/y6xmme

Vaganov A, Shmakov A, Zholnerova E (2021c). Red List of Altai Mountain Country (plants). Version 1.3. Altai State University. Checklist dataset. https://doi.org/doi:10.15468/uwre7d

Viciani D, Geri F, Agostini N, Gonnelli V, Lastrucci L (2018) Role of a geodatabase to assess the distribution of plants of conservation interest in a large protected area: A case study for a major national park in Italy. Plant Biosystems – An International Journal Dealing with all Aspects of Plant Biology 152 (4): 631–641. https://doi.org/10.1080/11263504.2017.1308974

Wieczorek J, Bloom D, Guralnick R, Blum S, Döring M, Giovanni R, Robertson T, Vieglais D (2012) Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. PLOS ONE 7 (1): e29715. https://doi.org/10.1371/journal.pone.0029715

Yashina TV (2010) System of the state indicators of biodiversity and ecosystems in specially protected areas of the Altai-Sayan ecoregion. In: Monitoring of biodiversity in specially protected natural areas (proceedings of regional scientific-practical conference devoted to 10th anniversary of Tigirekskii reserve). Publishing house ARTIKA, Barnaul, 3–18. [In Russian]

Zernov AS (2010) Some debatable questions about the geographical structure of the flora. In: Rosenberg GS, Saksonov SV (Eds) Theoretical problems of ecology and evolution. Range Theory: Species, Communities, Ecosystems (V Lyubischev Readings). IEVRB RAS, Tolyatti, 245–248. [In Russian]