Modern computer technologies in Biology: a scientific depository of phytodiversity of the transboundary territory of the Altai highland country

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Abstract. In the modern period of biodiversity development, when studying the territory of the mountainous countries of the world, the active influence of such trends as genomics and digitalization is noted. Within Russia, Kazakhstan, Mongolia and China, the Altai highland country (AHC) is the highest uplift of North Asia, its biodiversity level is three times richer than it is in the West Siberian Plain. The collected material in the herbarium collections of the Altai State University (ASU, Barnaul) is more than 450 thousand herbarium leaves (ALTB Herbarium), and it is the biological repository of unique genetic material on AHC, along with other large depositories of the world (herbariums, zoological collections, etc.). The concerted actions of many countries of the world have already allowed to aggregate large data on the biodiversity of many mountain countries in order to ensure the sustainable development of these unique natural complexes. During our project, ASU scientists have developed a scientific depository with the possibility of integrating bio data into the Global Biodiversity Information Fund (GBIF). Today, data from ASU and other GBIF operators allow digital resources to be integrated across the whole spectrum of living organisms in the AHC, from genes to ecosystems. They allow linking them to issues important to science and society using GIS tools. Also, in this study, we produced a modern botanical and geographical zoning of the territory of the AHC, using open GIS systems (GeoJSON).

1. Introduction

Biological diversity is an essential component of the environment, directly and indirectly affecting the state of global ecosystems and the planet’s climate. Activities for the study and preservation of living organisms should be carried out according to international standards and at the highest methodological level. As this process directly influences strategic national priorities related to health and food security. The publication of data on plant distribution within the Altai highland country (Russia, Kazakhstan, Mongolia, China) in the global biodiversity information system (GBIF.org) is one of the indicators of the country’s active work in the field of biodiversity informatics at the level of contemporary standards. The Altai Region and the territory of the Altai highland country are included in the 200 key ecoregions of the world, to which the attention of the United Nations and the scientific world community are currently drawn. One of the key priorities of the UN is the conservation and study of biological diversity.
An important basis for organizing activities for the study and preservation of biological diversity and maintaining the integration processes of data on biological diversity in the world is the Convention on Biological Diversity (CBD) (https://www.cbd.int). In 1995, the Convention was ratified by Russia. The Article No. 17 of the Convention postulates the need to pool the efforts of all countries to assess their own biological resources. Obviously, the study of biological diversity at the world level or the level of large regions is possible only through the concerted actions of many countries. In 2010, the Parties to the Convention adopted a Strategic Plan for the Conservation and Sustainable Use of Biodiversity for 2011–2020, together with targets (the so-called Aichi Biodiversity Targets – https://www.cbd.int/sp/targets). The Target No. 19 of this list aims at improving, sharing and applying knowledge, scientific data and technologies in the field of biodiversity research. This task is impossible without further digitization of biological collections and the discovery of data on the distribution of species and the dynamics of their ranges [1].

The AHC (Altai highland country) among the continental mountainous countries of Siberia (and in general in Northern and Central Asia) is at the same time both the highest contemporary uplift and the space in Siberia most favorable for the development of organic life. Due to the fact that the latitudinal and meridional stretching intermontane depressions, ridges, high-altitude plateaus, areas of typical low-hill areas and vast highlands are combined here, the relief is considered extremely complex [4], [5].

With its relatively small territorial area, the AHC is inhabited by a large number of biological objects. D. Olson and E. Dinerstein [2] rank the territory of the Altai and Sayans among the two hundred priority ecoregions of the world for global biodiversity conservation. They note that in the 200 ecoregions that make up only 10% of the land area, up to 90% of the planet’s biodiversity is concentrated.

2. Materials and Methods
In December 2017, the ASU received an official registration in the GBIF network (www.gbif.org/publisher/943a5811-d56e-4c37-853d-bd64957d3833, see also the agreement with the data publisher GBIF). To date, the university has published 5 databases (Datasets GBIF). The key dataset of ASU is “Virtual Herbarium ALTB (South-Siberian Botanical Garden)” (Occurrence dataset https://doi.org/10.15468/y6xmme). The herbarium of the Altai State University (ALTB) is the core of the current scientific depository on phytodiversity of the AHC [3].

In order to unite researchers-systematists studying the flora of the AHC, in 2018, the “Flora of Altai” project was launched and posted in the Internet at the following address: www.altaiflora.asu.ru. The site is based on the Word Press platform. It is an open source content management system. For the preparation of the section containing the AHC map (altaiflora.asu.ru/kart/AHC/) with nineteen botanical and geographical areas according to R.V. Kamelin (2005), we have drawn 19 polygons using the WP Google Maps plugin. The basis for drawing polygons is topographic maps on a scale of 1: 500,000. The obtained sets of coordinates of all polygons were edited in the modern specification of creating geographic structures GeoJSON. GeoJSON is an open format for storing geographic data structures. The format is based on JSON (Java Script Object Notation); JSON is a text-based data interchange format. The AHC boundary, including 19 botanical and geographical areas (polygons) in the GeoJSON format, was obtained.

Directly, the procedure for publishing data through GBIF.org is carried out using special IPT software (Integrated Publishing Toolkit), written in Java and functioning as a server application with a visual interface accessible via a browser. The IPT running Apache web server and TomCat 7 web application services are also used. Label tables for empirical depository materials are integrated into GBIF via IPT in Darwin Core format.

3. Results
As of now (April 10, 2019), the ASU has transferred to the GBIF a total of 5075 records with a digital image of the herbarium leaf and geolocation. So far, the resulting registry with records of species locations in the AHC for the “Flora of Altai” project and the global scientific community mostly includes representatives from such plant families as in Caryophyllaceae, Ranunculaceae, Fabaceae, Liliaceae.
Sets of maps with accurate geolocation of the spatial distribution of rare, endemic, invasive species of economic value in the Altai Region and the Altai highland country have been obtained. A total of eight final papers with an interdisciplinary approach, using a variety of techniques from the field of information technology, GIS technology and bioclimatic modeling, have been prepared.

In the course of conducting the “Virtual Herbarium ALTB (South-Siberian Botanical Garden)” dataset, taxonomists identify new plant locations, describe new species, monitor the dynamics of habitats to obtain information about the predictive locations of promising plant species. Due to the active uploading of data on biota of AHC, research teams enter into partnership with other international organizations, such as: Catalogue of Life partnership, Biodiversity Information Standards (TDWG), International Barcode of Life project (iBOL), Encyclopedia of Life (EOL) и GEO.

4. Discussion
In the coming years, besides the increase in the number of publications in the GBIF, we also expect an increase in citation of datasets, which will eventually lead to an increase in Altai State University in the world rankings (THE, QS and Webometrics), due to the increasing interest of research teams in empirical data on AHC. As of today, the “Virtual Herbarium ALTB (South-Siberian Botanical Garden)” dataset also solves many other important problems: the study of the flora and vegetation of the AHC and individual taxa; the preservation of fragile and aging material in digital form; continuation of the publication of the printed multivolume report “Flora of Altai”.

5. Conclusion
In total in our country, 38 organizations (of which only 6 universities) are the official publishers publishing data in the GBIF. At the same time, the contribution of operators of Russia to the data placed in the GBIF is no more than 0.5%, which indicates to us the enormous amount of work, given the scale of our country.

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