THE ECOLOGICAL ATLAS OF THE BAIKAL BASIN

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MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT OF THE RUSSIAN FEDERATION

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THE ECOLOGICAL ATLAS OF THE BAIKAL BASIN

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MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT OF THE RUSSIAN FEDERATION
Commissioner

The federal executive authorities of the Russian Federation is carrying out state administration in the field of environmental management, environmental protection and environmental safety. mnr.gov.ru

FUND FOR PROTECTION OF LAKE BAIKAL
Partner

The main goals and objectives FPLB: support for large-scale research projects and research aimed at the preservation of Lake Baikal; develop scientific and practical recommendations based on these studies; promoting the development of new environmentally benign technology and their industrial implementation; conservation of biological diversity of the lake and the Baikal region. www.baikalfund.ru

RUSSIAN GEOGRAPHICAL SOCIETY
Partner

It is bringing together professionals in the field of geography, ecology, assisting in the preservation of the natural wealth of Russia. www.rgo.ru

V.B. SOCHAVA INSTITUTE OF GEOGRAPHY SB RAS
Principal Executing Agency

Principal scientific directions: state and development of natural geosystems and their components; geographic basis for sustainable development of the regions of Siberia.
The main purpose is to conduct basic and applied research to create the foundations of forecasting, monitoring and adjustment of the dynamics of geosystems, developing geographic bases of the territorial organization of production and the formation of the population and mapping system. www.irigs.irk.ru

INSTITUTE OF GEOGRAPHY AND GEO-ECOLOGY OF THE MONGOLIAN ACADEMY OF SCIENCES
Principal Executing Agency

Principal directions of the Institute: Physical Geography: geomorphology, the study of lakes, geography of soils and soil science, the study of permafrost;
Economic Geography: A Study of Regional Development, the study of nomadic animal industry; cartography; geoecology; environmental management.

BAIKAL INSTITUTE OF NATURE MANAGEMENT SB RAS
Co-Executing Agency

Principal scientific directions: fundamental scientific research in the field of interaction of natural and socio-economic systems; chemical elements and compounds in natural and artificial environments; the creation of new materials and resource; environment-friendly technologies, chemical aspects of environmental management. www.binm.ru

LIMNOLOGICAL INSTITUTE SB RAS
Co-Executing Agency

Principal scientific directions: Limnology: mechanisms of formation, biodiversity, evolution of lake systems; current status and development forecast reservoirs and water land; living systems: a comprehensive study of aquatic methods of classical and molecular biology and related sciences. www.lin.irk.ru

DEPARTMENT OF GEOGRAPHY OF IRKUTSK STATE UNIVERSITY
Co-Executing Agency

Research areas: modeling of mesoscale processes in the atmosphere, hydrosphere, and to address the underlying surface diagnostic and prognostic problems of meteorology, hydrology, geo-ecology and natural resources; development of conceptual, organizational and methodological the foundations of mapping the territory ecological framework, the level and quality of life in the region for the purposes of management of regional development; thematic mapping: geomorphological, ecological, socio-economic and recreational. www.geogr.isu.ru

INSTITUTE OF NATURAL RESOURCES, ECOLOGY AND CRYOLOGY SB RAS
Co-Executing Agency

Principal scientific directions: patterns of evolution of ecosystems and geological mountain areas (geological, biological and cryological aspects), including mineral resources and forest complexes; ecological, economic and socio-demographic factors of development of border areas. inrec.sbras.ru

INSTITUTE OF THE EARTH'S CRUST SB RAS
Co-Executing Agency

Principal scientific directions: modern endo- and ekzogeodinamika, geological environment and seismic processes, resources, groundwater dynamics and geo-ecology; internal structure, paleogeodynamics endogenous processes and fluid dynamics of the continental lithosphere. www.crust.irk.ru

The Ecological Atlas of the Baikal basin is prepared in the framework of the UNDP-GEF
«Integrated Natural Resource Management in the Baikal Basin Transboundary Ecosystem»
http://baikal.iwlearn.org/

Dear Readers!

You are holding a unique publication. It may truly be called a hands-on guide and encyclopedia of the Baikal Nature Territory.

This is the first time such a systematic approach has been applied to provide information about the natural conditions, state of the environment, and the impacts caused by social and economic development of adjacent territories on the basin of the unique Lake Baikal.

The Atlas examines the spatial patterns affecting the state of the environment of the entire Baikal watershed area, making it possible to determine and justify an environmentally balanced and sustainable approach to developing the region.

That is especially important in light of the efforts to implement the Federal Special-Purpose Program "Protection of Lake Baikal and the Socio-Economic Development of the Baikal Nature Territory in 2012-2020," which is currently a priority state project.

The negative impact of industrial facilities, housing and public utilities, and transportation on the ecosystems of the region currently remains to be a major environmental problem of the Baikal Nature Territory. Poaching also presents a serious threat to the preservation of Baikal's flora and fauna. Overfishing or breach of fishing quotas presents one of the most common violations. Illegal hunting of Baikal ringed seals is considered to be a major environmental crime; however, the majority of violations involve illegal cutting of trees and shrubs, and inflicting damage to forests.

That is the reason why the Ministry of Natural Resources and Environment of Russia is consistently developing regulations aimed at reversing the environmental damage done in the past and minimizing the harm from current economic activity and other factors.

The Interdepartmental Committee for the Protection of Lake Baikal was established in 2007. It coordinates the work to study, reproduce, use, and protect the natural resources of the Baikal Nature Territory, and also to preserve biological diversity, ensure environmental safety and compliance, and address the region's socio-economic issues on the principles of sustainable development.

In 2014, the Government of the Russian Federation approved the Regulations on state environmental monitoring of the unique ecosystem of Lake Baikal developed by the Ministry.

In 2015, the Ministry of Natural Resources and Environment of Russia established a special expert group to study the problems of Lake Baikal. The group is now actively involved in integrated studies of prolonged periods of low water levels in the lake, and establishing the connection between efforts to regulate water runoff at the Irkutsk reservoir, which is connected to Lake Baikal, and the environmental state of the lake. A meeting of the Interdepartmental Committee for the Protection of Lake Baikal to discuss the first results of this work will be held in July 2015.

I am confident that the integrated approach to the study of the Baikal Nature Territory and cooperation with the Global Environment Facility, the United Nations Development Programme, and other nature protection organizations whose support was instrumental in developing and publishing the Environmental Atlas, will generate sustained interest in the issues involving the protection of Lake Baikal from broad segments of the population in this country and abroad.

Sergei E. Donskoi
Minister of Natural Resources and
Environment of the Russian Federation

Publication of the Ecological Atlas of the Baikal Basin,which includes maps of extensive stretches of land in the transboundary territories between Mongolia and Russia, is a major contribution to concerted efforts aimed atprotecting the environment, fostering rational use of natural resources, and implementing the green development concept in the region. The Atlas provides an integrated analysis of the state of the environment in the entire Lake Baikal Basin and examines the impacts of a range of different natural-resource, social, and economic factors that determine the changes under way in the environment. This up-to-date information is presented in the form of geographical maps and accompanying texts, which have special scientific, educational, and practical significance.

Many centuries ago the ancestors of the Mongols were struck by the extraordinary beauty of surrounding nature and the grandeur of the unfathomable freshwater lake. They gave the lake an extraordinary name – "Baigal", which means "Beauty". The sacred name "Baigal nuur" (Lake Baikal) constantly reminds us, the current generation, of the noble tradition of our ancestors who shared a steadfast belief that it was necessary to protect and support Mother Nature.

After UNESCO decided to include Lake Baikal in the list of World Natural Heritage Sites, the lake has been attracting more and more attention from the international community. A graphic example of such attention is the Ecological Atlas of the Baikal Basin, which has been prepared with the support and financial assistance of the Global Environment Facility and the United National Development Programme within the framework of the international project of Integrated Natural Resource Management in the Baikal Basin Transboundary Ecosystem (the "Baikal Project").

The project has been commissioned by the Ministry of Environment, Green Development and Tourism of Mongolia and the Ministry of Natural Resources and Environment of the Russian Federation.

The cartographic data and statistics included in the Atlas will undoubtedly be used for the purposes of setting the guidelines for environmentally balanced and sustainable development in the region.

May I take this opportunity to express my deep gratitude to the Baikal Project, to Russian and Mongolian scientists, researchers, members of the editorial board, engineers and technical staff for taking part in developing the Atlas and contributing their professional expertise, talent and creative skills to make it all happen.

Magvansuren Khurelsukh
Deputy Ministerof Environment, Green Development and Tourism

Geographical maps offering a clear picture of how great and at the same time how tiny our world of Planet Earth is accompany one's life journey for the most of its part. Earth still has places, where wonderful landscapes of untouched nature have been preserved. Among them is Lake Baikal — one of the most beautiful places attracting tourists from all over the world.

In 1996, by UNESCO's decision Lake Baikal was listed as a World Heritage Site. In doing so, Russia and Mongolia jointly with the international community took responsibility to protect its nature. However, both the lake itself and its surrounding territory, where over three million people live, cannot be turned into a nature reserve. In our plans, here there should be a modern, high-tech, and environmentally friendly economy ensuring the necessary living standards for the local community.

A poor and deprived individual cannot protect the environment. He or she is more concerned about providing food, clothes, and other necessary resources for oneself and family. From this perspective, the Baikal basin has all the riches to have spiritually and materially affluent people living on its shores.

In order to achieve this, both local residents and visitors should have ample information to develop the economy and address social issues. This Atlas has been created precisely for this purpose. It includes data about the structure and wealth of mineral resources, flora, and fauna, climate, and hydrosphere. Some of the maps feature information, which helps understand the impact of the anthropogenic activity on the environment.

Arnold K. Tulokhonov
Chair of Editorial Council

The publication of the Ecological Atlas of the Baikal Basin is a landmark event in the efforts to study and preserve the unique Lake Baikal. The Atlas has incorporated the most recent data and analyses of the natural conditions, resources, and current state of the Baikal Nature Territory, which will help solve a range of different economic, resource management, and environmental problems facilitating all-round development of the region.

We should commend the experts who participated in compiling the Atlas, including local and foreign geographers, environmental specialists, biologists, soil scientists, and experts in rational use of natural resources. They have contributed to an honorable and much-needed undertaking.

Lake Baikal is a natural laboratory filled with a multitude of mysteries and legends. At the same time Lake Baikal is a natural wonder, a gemstone of Russia, and its living symbol. Baikal's beauty dazzles and its greatness astounds.

The prominent Russian writer Valentin Rasputin wrote: "Baikal… It is one of a kind on our planet –a unique, majestic Sphinx, whose mysteries we are yet to solve… It existed when human civilization was in its infancy, and it will still be here when the human era will come to an end."

I can confidently say that Lake Baikal is the mainstay of our society ensuring the welfare of our children and grandchildren. It is our sacred duty to preserve Lake Baikal for future generations.

Mikhail V. Slipenchuk
Deputy Chairman of the Committee for Natural Resources, Environmental Management and Ecology of the State Duma of the Federal Assembly of the Russian Federation, Doctor of Economics, professor

The Project «The Ecological Atlas of the Baikal Basin» has been commissioned by and implemented with the support of the Global Environment Facility. It aims to integrate current information and knowledge about the key factors driving the development of the environmental situation in the Baikal basin and the existing state of natural environment. It presents this information in a form, which is adequate for addressing the issues of economically and environmentally balanced development of the region.

The Atlas considers the Baikal basin as a special trans-borderand inter-regional development system and part of the all-Russian and all-Mongolian territorial development systems. Therefore, the creation of the Atlas required an integrated study of environmental problems from both territorial and content-related perspectives. From the territorial perspective, the formed structure of the Atlas database comprehensively localizes municipalities of the second level (city and municipal districts) on the Russian part of the Baikal basin and aimags on the Mongolian part. In terms of the content, the combination of economic, social, demographic, natural resource, and biotic factors of the development of the environmental situation became possible thanks to a purposefully developed and integrated program of environmental mapping. The state-of-the-art developments in the thematic atlas mapping, GIS-technologies, remote sensing techniques, and constantly supplemented and updated databases of the research organizations-executing agencies of the Project, such as the V.B. Sochava Institute of Geography SB RAS, Limnological InstituteSB RAS, Institute of the Earth's Crust SB RAS, Irkutsk State University (Irkutsk), Baikal Institute of Nature Management SB RAS (Ulan-Ude), Institute of Natural Resources, Ecology and Cryology SB RAS (Chita), and the Institute of Geography and geo-ecology of the Mongolian Academy of Sciences (Ulaanbaatar) were used to create this Atlas.

The mapping of the Baikal basin was carried out using two main scale levels: 1:5 000 000 for physical maps and 1: 6 000 000 for the maps showing social and economic factors of the development of the environmental situation. The thematic database of the map series had the following requirements: it must be contemporaneous, i.e. its quantitative data on all variables must belong to the same point in time; sufficiently detailed; positionally accurate; completely compatible with other data; adequately reflect the nature of phenomena; and be available to users. When developing the content of the maps, even when referring to individual topics, not to mention complex characteristics, the task was not just to show the actual state of the mapped phenomenon or process, but also to emphasize the patterns in their development and highlight the dynamic aspects as far as possible. For the first time ever, the Atlas reflects spatial patterns of the development of the environmental situation within the whole catchment basin of Lake Baikal and its water area, which makes it possible to define and substantiate the directions for environmentally balanced and sustainable territorial development.

Structurally, the Atlas consists of eight blocs, including an introduction and seven thematic sections: 1) Natural conditions of the development of the environmental situation; 2) Resource factors of the development of the environmental situation; 3) Socio-economic factors of the development of the environmental situation; 4) Environmental transformation; 5) Medico-ecological situation, 6) Environmental protection; and 7) Ecological state of Lake Baikal.

The Atlas is published in digital and hard-copy formats. A digital copy of the Atlas will be incorporatedas an electronic resource with a databaseinto the Geoportal of the Baikal Region, which is being created by the Global Environment Facility. A hard-copy of the Atlas will be released as a fundamental reference atlas.

The Atlas is a collective work of many scientists who are experts in various fields of knowledge. The maps were created using library and published statistical materials provided not only by research institutions, but also by government authorities of the regions of the Russian Federation: Irkutsk oblast, Republic of Buryatia and Zabaikalsky krai, as well as research organizations and government authorities of Mongolia, and the authors of the Atlas are deeply grateful for it.

Victor M. Plyusnin
Chair of Editorial Board

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62	Construction *Scale1:6 000 000*	75	T.I. Zabortseva	D.A. Gales	O.A. Ignatova, L.M. Handazhapova	A.R. Batuev
63	Transportation *Scale1:7 000 000*	76	Ts.B. Dashpilov	V.N. Bogdanov		L.M. Korytny, J. Oyuungerel
64	Density of population *Scale1:10 000 000*	77	A.N. Vorobiev	A.N. Vorobiev	J. Oyuungerel	A.R. Batuev, N.V. Vorobiev, D. Enhtayvan
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66	Density of rural population and population size of urban settlements (as of 1.1.2013) *Scale1:10 000 000*	78	A.N. Vorobiev	A.N. Vorobiev	J. Oyuungerel	A.R. Batuev, N.V. Vorobiev, D. Enhtayvan
67	Natural increase of population *Scale1:10 000 000*	78	N.V. Vorobiev	A.N. Vorobiev	J. Oyuungerel	A.R. Batuev, D. Enhtayvan
68	Dynamics of the population size (1989-2013) *Scale1:10 000 000*	79	A.N. Vorobiev	A.N. Vorobiev		A.R. Batuev, N.V. Vorobiev, J. Oyuungerel
69	Urbanization of the territory *Scale1:10 000 000*	80	N.V. Vorobiev	A.N. Vorobiev	J. Oyuungerel	A.R. Batuev, D. Enhtayvan
70	Migratory increase of population *Scale1:10 000 000*	80	N.V. Vorobiev	A.N. Vorobiev	J. Oyuungerel	A.R. Batuev, D. Enhtayvan
71	Functional types of settlements *Scale1:7 000 000*	81	A.V. Bardash	A.V. Bardash	A.R. Batuev	N.V. Vorobiev, D. Enhtayvan

72	Housing *Scale1:6 000 000*	82	T.I. Zabortseva	D.A. Gales	O.A. Ignatova	A.R. Batuev
73	Urban amenities of the housing fund in the Russian part of the basin *Scale1:6 000 000*	82	T.I. Zabortseva	D.A. Gales	O.A. Ignatova	A.R. Batuev
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75	Cultural establishments *Scale1:10 000 000*	84	T.N. Shekhovtsova	D.A. Gales	N.G. Turkina, J. Oyuungerel	M.V. Ragulina, D. Enhtayvan
76	Education *Scale1:10 000 000*	84	T.N. Shekhovtsova	D.A. Gales	N.G. Turkina, C. Otgonhuu	M.V. Ragulina, D. Enhtayvan
77	Religion *Scale1:10 000 000*	86	V.G. Saraev	D.A. Gales	N.G. Gomboeva, J. Oyuungerel	A.R. Batuev, D. Enhtayvan
78	Tourism *Scale1:5 000 000*	87	O.V. Evstropeva	A.V. Kazakov	D. Enhtayvan	A.R. Batuev, J. Oyuungerel
SECTION IV. Environment transformation in the Baikal basin						
79	Trends in air temperature *Scale1:6 000 000*	90	N.N. Voropai	A.A. Sorokovoy	A.A. Sorokovoy	L.M. Korytny
80	Trends in rainfall *Scale1:6 000 000*	90	E.V. Maksyutova	A.A. Sorokovoy	A.A. Sorokovoy	L.M. Korytny
81	Atmospheric air condition *Scale1:3 000 000*	91	S.Zh. Vologzhina	A.A. Shagdurov	V.K. Arguchintsev, A.V. Arguchintseva	A.R. Batuev, L.M. Korytny
82	The frequency of exceeding the daily average MPC nitrogen dioxide *Scale1:200 000*	91	A.V. Ahtimankina	A.A. Shagdurov	A.V. Arguchintseva	A.R. Batuev, L.M. Korytny
83	Isolines absolute concentrations of soot in the winter in Irkutsk *Scale1:200 000*	91	S.Zh. Vologzhina	A.A. Shagdurov	V.K. Arguchintsev, A.V. Arguchintseva	A.R. Batuev, L.M. Korytny
84	The frequency of exceeding the daily average MPC nitrogen dioxide in Ulan-Ude in december *Scale1:200 000*	92	S.Zh. Vologzhina	A.A. Shagdurov	A.V. Arguchintseva	A.R. Batuev, L.M. Korytny
85	Isolines concentration (mg/m^3) dust in Ulan-Bator west wind at 5 m/s *Scale1:200 000*	92	V.K. Arguchintsev	A.A. Shagdurov	A.V. Arguchintseva, B.- E. Ariunsanaa	A.R. Batuev, L.M. Korytny
86	The frequency of exceeding the daily average MPC dust in december at the airport in Ulan-Bator *Scale1:30 000*	92	A.V. Arguchintseva	A.A. Shagdurov	V.K. Arguchintsev, B.- E. Ariunsanaa	A.R. Batuev, L.M. Korytny
87	Quality of surface waters *Scale1:5 000 000*	93	O.V. Gagarinova	A.V. Bardash	G. Davaa, V.S. Molotov	L.M. Korytny, D. Dorzhgotov
88	Environmental impact of mining industry *Scale1:5 000 000*	95	A.D. Abalakov, N.B. Bazarova	V.N. Bogdanov	D. Enhtayvan, E. Odbaatar, V.S. Batomunkuev	A.R. Batuev, L.M. Korytny, J. Oyuungerel
89	Soil degradation and contamination *Scale1:5 000 000*	97	I.A. Belozertseva	A.A. Sorokovoy	O. Bathishig, T. Oyuunchimeg, A.N. Beshentsev, Z.Z. Pahahinova	A.R. Batuev, D. Dorzhgotov
90	Pasture degradation *Scale1:5 000 000*	98	I.A. Belozertseva	A.A. Sorokovoy	A.N. Beshentsev, Z.Z. Pahahinova S. Shiyrev-Adya	A.R. Batuev, D. Dorzhgotov
91	Vegetation disturbance *Scale1:5 000 000*	99	L.P. Sokolova	S.A. Sedykh		A.V. Belov, A.R. Batuev
92	Disturbance of forest land *Scale1:7 000 000*	100	E.L. Makarenko	D.A. Lopatkin	I. Tuvshintogtoh	A.R. Batuev, D. Dorzhgotov
93	Disturbance of fauna *Scale1:5 000 000*	102	V.A. Prelovsky	S.A. Sedykh		A.V. Belov, A.R. Batuev
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96	Medical service density – doctors *Scale1:10 000 000*	105	V.G. Saraev	D.A. Gales	J. Oyuungerel, N.G. Gomboeva, E.V. Pomazkina, Y.B. Zhamyanova	S.V. Ryashchenko, D. Dorzhgotov
97	Medical service density – nursing staff *Scale1:10 000 000*	106	V.G. Saraev	D.A. Gales	J. Oyuungerel, N.G. Gomboeva, E.V. Pomazkina, Y.B. Zhamyanova	S.V. Ryashchenko, D. Dorzhgotov
98	Hospital bed capacity *Scale1:10 000 000*	106	V.G. Saraev	D.A. Gales	J. Oyuungerel, N.G. Gomboeva, E.V. Pomazkina, Y.B. Zhamyanova	S.V. Ryashchenko, D. Dorzhgotov
99	General population morbidity *Scale1:10 000 000*	107	V.G. Saraev	D.A. Gales	J. Oyuungerel, N.G. Gomboeva, E.V. Pomazkina, Y.B. Zhamyanova	S.V. Ryashchenko, D. Dorzhgotov
100	Infectious and parasitic diseases *Scale1:10 000 000*	107	V.G. Saraev	D.A. Gales	J. Oyuungerel, Y.B. Zhamyanova N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko
101	Respiratory diseases *Scale1:10 000 000*	108	V.G. Saraev	D.A. Gales	J. Oyuungerel, Y.B. Zhamyanova, N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko
102	Digestive system diseases *Scale1:10 000 000*	108	V.G. Saraev	D.A. Gales	D. Baasandorzh, Y.B. Zhamyanova, N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko, J. Oyuungerel
103	Genitourinary system diseases *Scale1:10 000 000*	109	V.G. Saraev	D.A. Gales	D. Baasandorzh, Y.B. Zhamyanova, N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko, J. Oyuungerel
104	Injuries and toxications *Scale1:10 000 000*	109	V.G. Saraev	D.A. Gales	D. Baasandorzh, Y.B. Zhamyanova, N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko, J. Oyuungerel
105	Malignant neoplasms *Scale1:10 000 000*	110	V.G. Saraev	D.A. Gales	J. Oyuungerel, Y.B. Zhamyanova, N.G. Gomboeva, E.V. Pomazkina	S.V. Ryashchenko
106	Adult population disability *Scale1:10 000 000*	110	V.G. Saraev	D.A. Gales	V.N. Veselova, S.M. Samohvat, Y.B. Zhamyanova	S.V. Ryashchenko
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107	Environment-protection infrastructure *Scale1:7 000 000*	112	T.I. Zabortseva	V.N. Bogdanov	O.A. Ekimovskaya, J. Oyuungerel, O.A. Nimaeva	N.M. Sysoeva, D. Enhtayvan

108	Recommended regimes of natural resources management *Scale1:5 000 000*	113	T.I. Kuznetsova	D.A. Lopatkin	A.R. Batuev, A.V. Bardash D. Enhtayvan, E. Avirmed	L.M. Korytny
109	Rare species of vascular plants *Scale1:5 000 000*	114	N.I. Novitskaya	D.A. Lopatkin	D. Bayasgalan	A.V. Belov, D. Dorzhgotov
110	Rare species of vascular plants of regional conservation *Scale1:6 000 000*	116	N.I. Novitskaya	D.A. Lopatkin		A.V. Belov
111	Endangered vegetation communities *Scale1:6 000 000*	116	N.I. Novitskaya	D.A. Lopatkin		A.V. Belov
112	Distribution of rare animal species. Fish *Scale1:5 000 000*	117	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
113	Distribution of rare animal species. Amphibians *Scale1:5 000 000*	118	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
114	Distribution of rare animal species. Birds: pelicans, storks, and geese *Scale1:5 000 000*	119	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
115	Distribution of rare animal species. Birds: birds of prey and owls *Scale1:5 000 000*	120	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
116	Distribution of rare animal species. Birds: galliformes, cranes, and wading birds *Scale1:5 000 000*	121	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
117	Distribution of rare animal species. Birds: piciformes, coraciiformes, and passeriformes *Scale1:5 000 000*	122	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, D. Dorzhgotov
118	Distribution of rare animal species. Mammals *Scale1:5 000 000*	123	V.A. Prelovsky	A.V. Bardash		U.S. Malyshev, A.R. Batuev
119	Protected areas *Scale1:7 000 000*	124	T.P. Kalikhman	V.N. Bogdanov	B. Oyuungerel, D. Enhtayvan	A.R. Batuev
120	Environmental non-profit organizations *Scale1:10 000 000*	126	V.G. Saraev	D.A. Gales	D. Enhtayvan, E.A. Batotsyrenov	A.R. Batuev
121	Borders of the water protection zone of lake Baikal established by act no. 52 of the council of ministers of the ussr on january 21, 1969 *Scale1:6 000 000*	126		A.N. Beshentsev, A.V. Kazakov		V.M. Plyusnin
122	Borders of the water protection zone of lake Baikal according to the comprehensive territorial system of nature protection of the Baikal basin (approved by the council of ministers of russia in 1989) *Scale1:6 000 000*	127		A.N. Beshentsev, A.V. Kazakov		V.M. Plyusnin
123	Borders of ecological zones of the Baikal natural territory according to federal law no. 94 «on protection of lake Baikal», dated may 1, 1999 *Scale1:6 000 000*	127		A.N. Beshentsev, A.V. Kazakov	D.A. Batuev	V.M. Plyusnin
124	Environmental zoning of the Baikal basin *Scale1:5 000 000*	128	D.A. Batuev V.N. Bogdanov	A.V. Kazakov		V.M. Plyusnin
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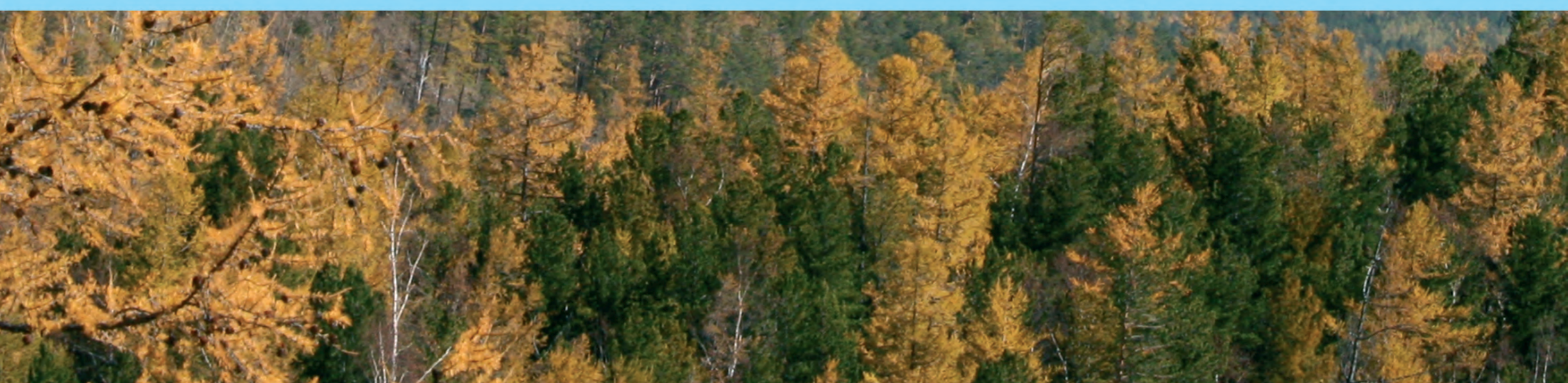
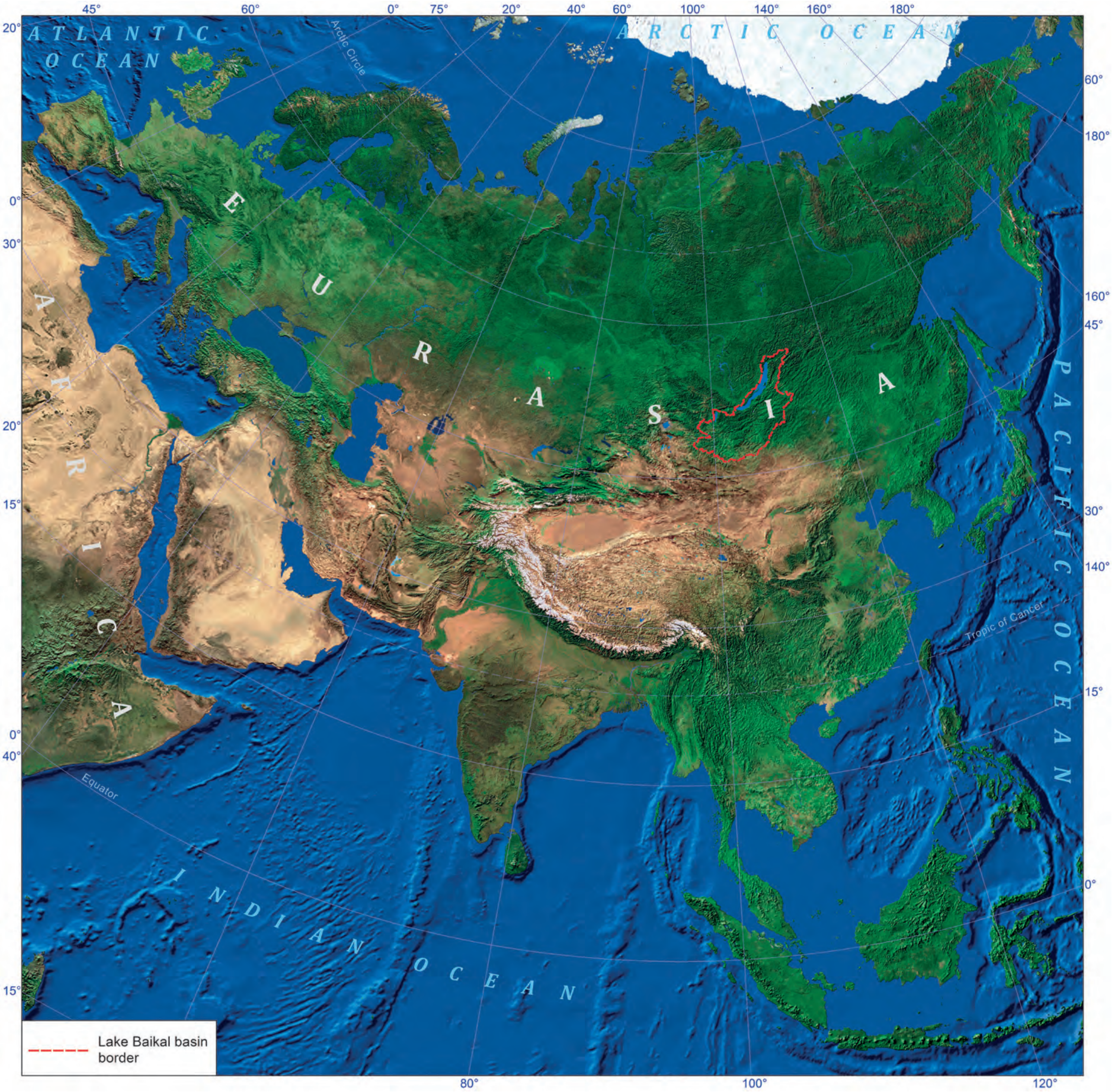
126	Slope inclination *Scale1:2 500 000*	131	P.P. Sherstyankin	D.A. Lopatkin	S.P. Alekseev, M. Canals, M. De Batist	A.R. Batuev
127	Slope exposure *Scale1:2 500 000*	131	P.P. Sherstyankin	D.A. Lopatkin	S.P. Alekseev, M. Canals, M. De Batist	A.R. Batuev
128	Cloud cover *Scale1:8 000 000*	132	V.L. Potemkin	A.A. Shagdurov		L.M. Korytny
129	Fogs *Scale1:4 000 000*	132	O.P. Osipova	A.A. Shagdurov		L.M. Korytny
130	Radiation balance *Scale1:6 500 000*	133	V.L. Potemkin	A.A. Shagdurov		L.M. Korytny
131	Thermal balance *Scale1:6 500 000*	133	V.L. Potemkin	A.A. Shagdurov		L.M. Korytny
132	Air temperature *Scale1:5 000 000*	134	M.N. Shimaraev	A.A. Shagdurov		L.M. Korytny
133	Temperature of water surface according to satellite data *Scale1:5 000 000*	135	M.N. Shimaraev	A.A. Shagdurov		L.M. Korytny
134	Ice regime *Scale1:2 500 000*	135	M.N. Shimaraev	A.A. Shagdurov		L.M. Korytny
135	Currents *Scale1:3 000 000*	136	M.N. Shimaraev	A.A. Shagdurov		L.M. Korytny
136	Uninodal (bimodal, trinodal and quadrinodal) seiche oscillations *Scale1:3 500 000*	137	K.M. Kucher	D.A. Lopatkin	I.A. Aslamov, S.V. Smirnov	A.R. Batuev
137	Gas bubble emissions from bottom sediments *Scale1:2 500 000*	138	M.M. Makarov	D.A. Lopatkin	N.G. Granin	A.R. Batuev, E.E. Kononov
138	Baikal gas hydrates *Scale1:2 500 000*	139	O.M. Khlystov	A.A. Shagdurov	Sh. Hitoshi, M. De Batist	A.R. Batuev, E.E. Kononov
139	Hydroacoustic measurement of the Baikal omul resources *Scale1:2 500 000*	140	A.I. Degtev, E.V. Dziuba	V.N. Bogdanov	M.M. Makarov, K.M. Kucher, A.M. Mamontov, I.A. Nebesnyh, I.V. Khanaev	A.R. Batuev
140	Recreation on lake Baikal *Scale1:2 500 000*	141	V.M. Hromeshkin	A.A. Shagdurov	V.V. Kozlov, V.A. Pankov	V.M. Plyusnin
141	The aesthetic image of the Baikal coastal area *Scale1:2 500 000*	143	V.M. Hromeshkin	A.A. Shagdurov	V.V. Kozlov, V.A. Pankov	V.M. Plyusnin
142	Ecological state of the central ecological zone of the Baikal natural territory *Scale1:2 500 000*	144	I.N. Vladimirov	V.N. Bogdanov		V.M. Plyusnin

INTRODUCTION



1. LAKE BAIKAL BASIN ON EURASIA MAP




Cape Burhan on Olkhon.

INTRODUCTION (1 — 5)

Patterns of territorial combinations of conditions and factors of the development of environmental problems in the Baikal basin are, to a large extent, determined by the basin's location in the northern temperate latitudes of Eurasia, in its inner ultracontinental sector, and by its natural isolation from adjacent territories. The Baikal basin has all the features of the landscape and ecological integrity and economic and cultural unity. The region is home to one of the world's major watershed divides between the catchment areas of the Arctic Ocean (the Yenisei and Lena basins), Pacific Ocean (the Amur basin), and the drainless region of Central Asia. It is precisely here, on orographic barriers, where airflows from the Atlantic and Pacific Oceans, the Arctic, and southern territories subside.

Lake Baikal is the oldest, deepest, and largest by volume lake among the great rift lakes of the world. The lake is situated at an elevation of 455.5 m above sea level, between 51°28' — 55°47'N and 103°43' — 109°58'E. The Baikal basin's catchment area is located in the heart of Asia on the territory of two states – Russia and Mongolia — between 46°20' — 56°40'N and 96°50' — 114°10'E. It has an elongated shape stretching from southwest to northeast.The total area of the Baikal basin is 576.5 km^2, including the water area of Lake Baikal — 31.7 km^2. 44.6 % of the catchment area is located in the Russian Federation (31.8 % in the Republic of Buryatia, 10.2 % in Zabaikalsky krai, 2.2 % in Irkutsk oblast, and 0.4 % in the Republic of Tuva) and 55.4 % in Mongolia.

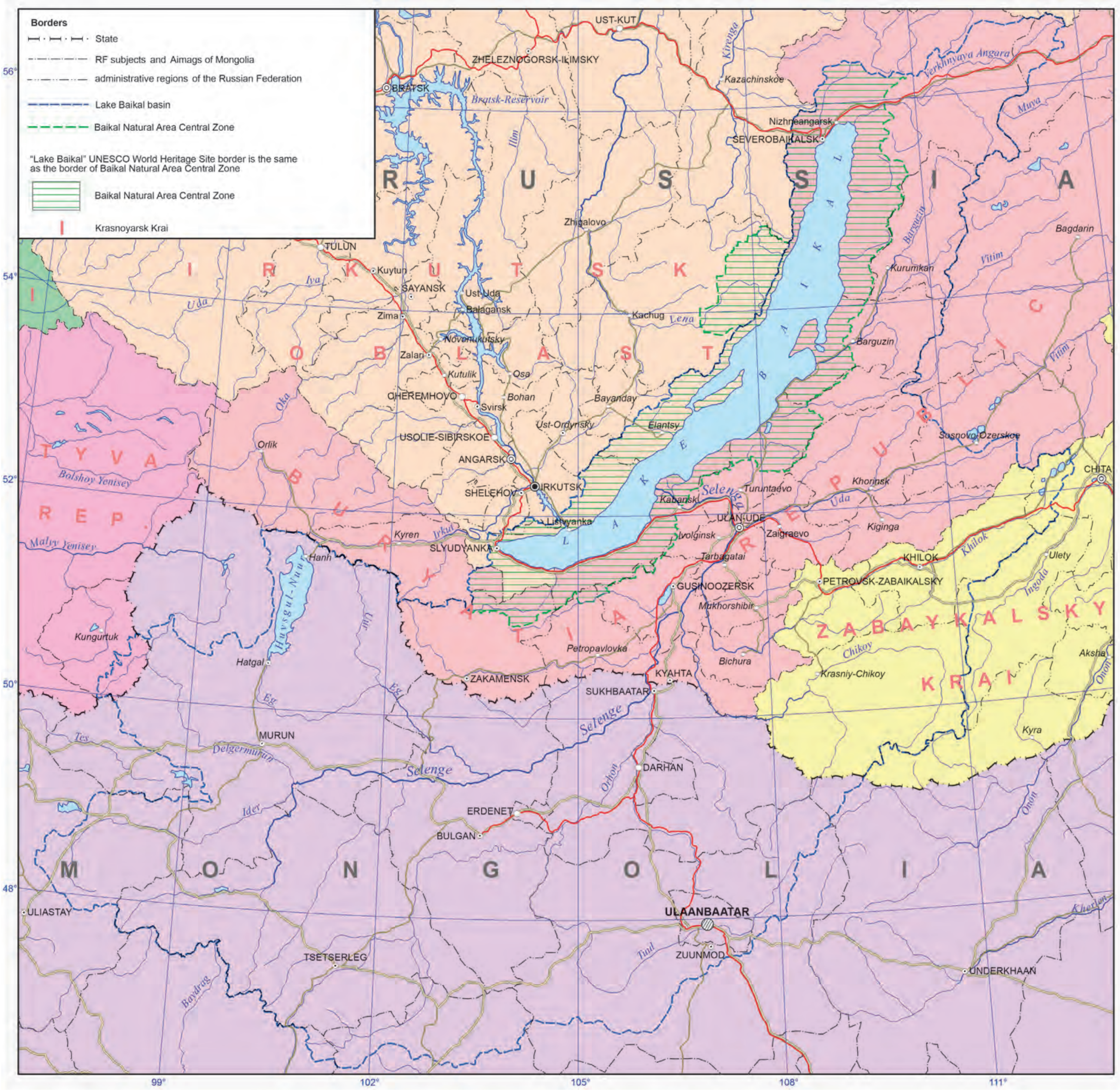
2. SATELLITE IMAGE

About 53 % of the volume of river water is formed in Buryatia, 27 % in Mongolia, 16 % in Zabaikalsky krai, and 4 % in Irkutsk oblast.

In general, due to its geographical and geopolitical location, as well as natural, resource, economic, ethnic, cultural, and human resources potential and the lake itself, the Baikal basin represents a key strategic region in eastern Russia and northern Mongolia — a major foothold for social and economic development of the two countries. However, such development has its own peculiarities, because the Baikal basin has a special regime of natural resources management. The fact that Lake Baikal and its surrounding territory was listed as a UNESCO World Heritage Site has attracted attention of the global community. It also underlined the role of the great lake as both a unique natural phenomenon and a place for establishing a recreation zone of the planetary significance, as well as a source of the exclusively eco-oriented land management and business in the future. Over the long term, in the context of the growing deficit of freshwater in the world, Lake Baikal's water will become the most important strategic resource of the world. Therefore, the water factor of development is a priority. Reproduction and recovery of the lake's water take place on the territory of the whole Baikal basin, which predetermines a particular attention towards nature protection in this region and dictates the prohibition of numerous types of production in order to prevent environmental pollution and preserve the

Lake Baikal.

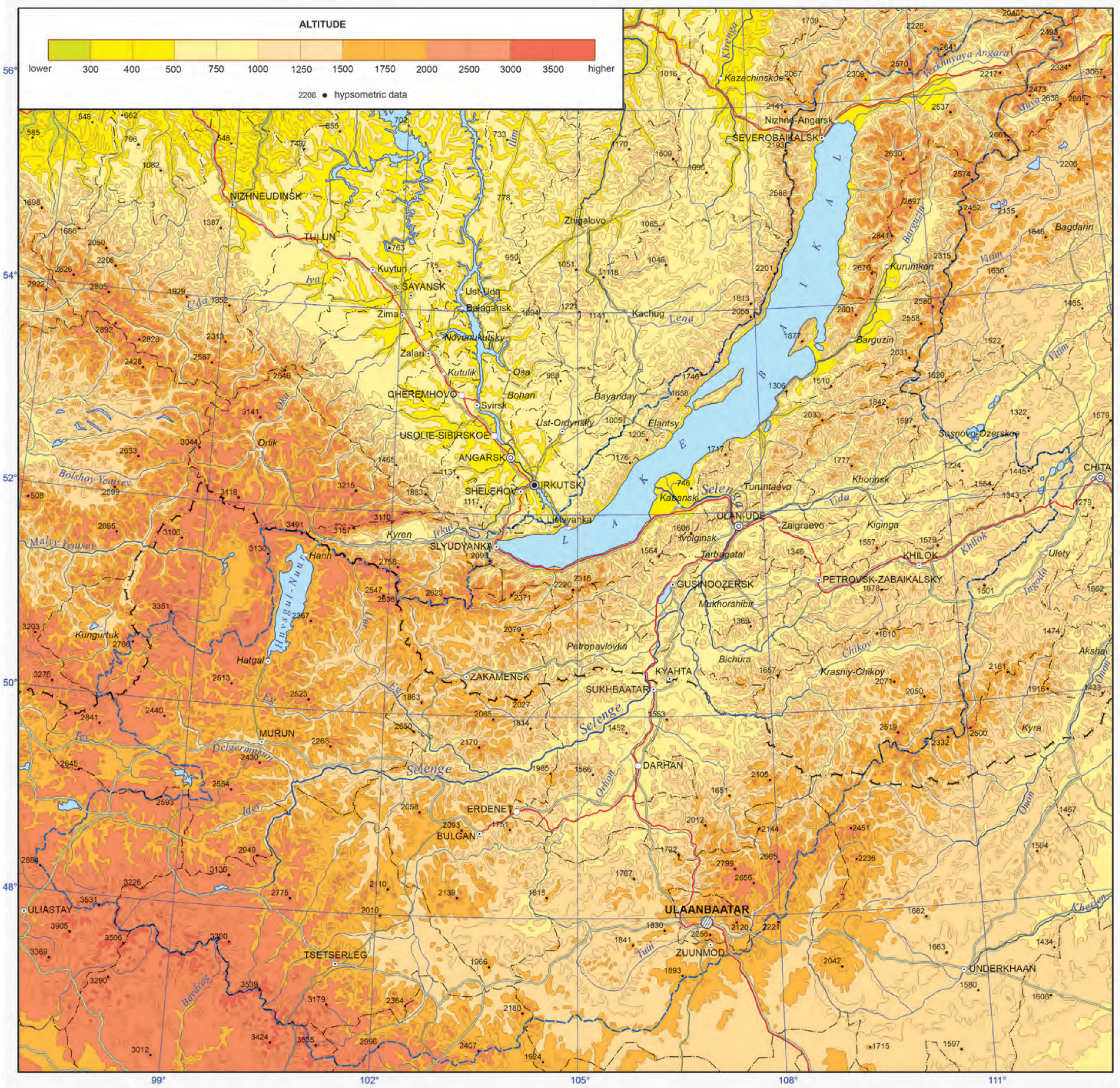
3. LAKE BAIKAL BASIN BORDERS AND STRUCTURE



Olkhon Gate Strait.

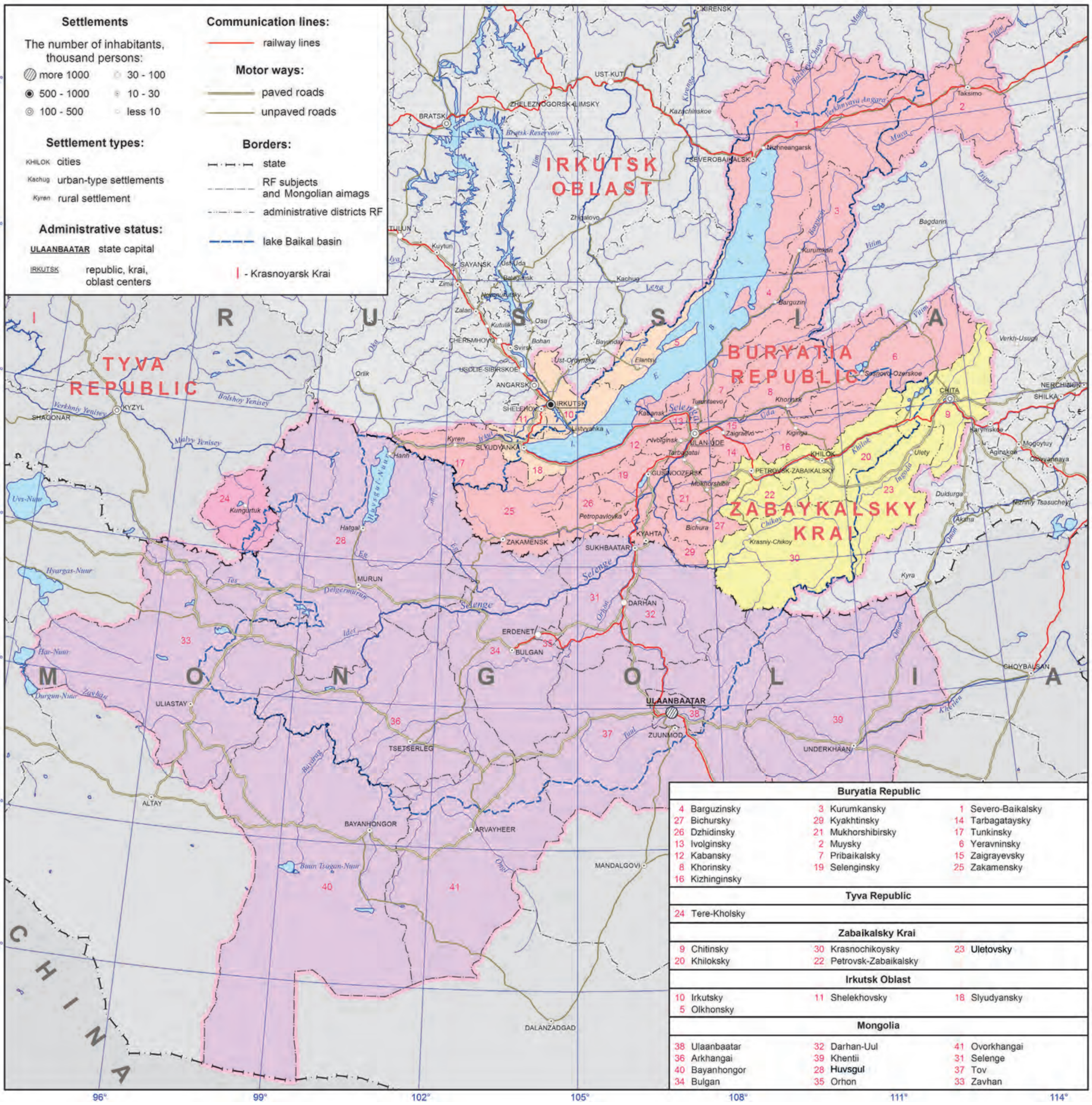
Baikal water for humankind. Presently, the necessity of nature protection activities for maintaining the unmatched biological and landscape diversity of the lake's basin has emerged as a result of the intensive use of natural resources in different parts of the basin, where anthropogenic impact of varying degree and type is observed. Only responsible use of the complex of adaptive techniques and methods of organization of economic activity with due consideration to the special environmental and resource-related role and strategic importance of the Baikal region can make it, as early as in the first third of the 21st century, one of the full-fledged subjects of economic, geopolitical, and geo-demographic processes and relations of global significance.The Ecological Atlas of the Baikal Basin will be quite helpful in this endeavor. For the first time ever, the maps of this Atlas will reflect spatial patterns of the development of the environmental situation within the whole catchment basin of Lake Baikal and its water area, which makes it possible to define and substantiate the directions of environmentally balanced and sustainable territorial development of Russia and Mongolia in the future.

4. HYPSOGRAPHIC MAP



Barguzin ridge.

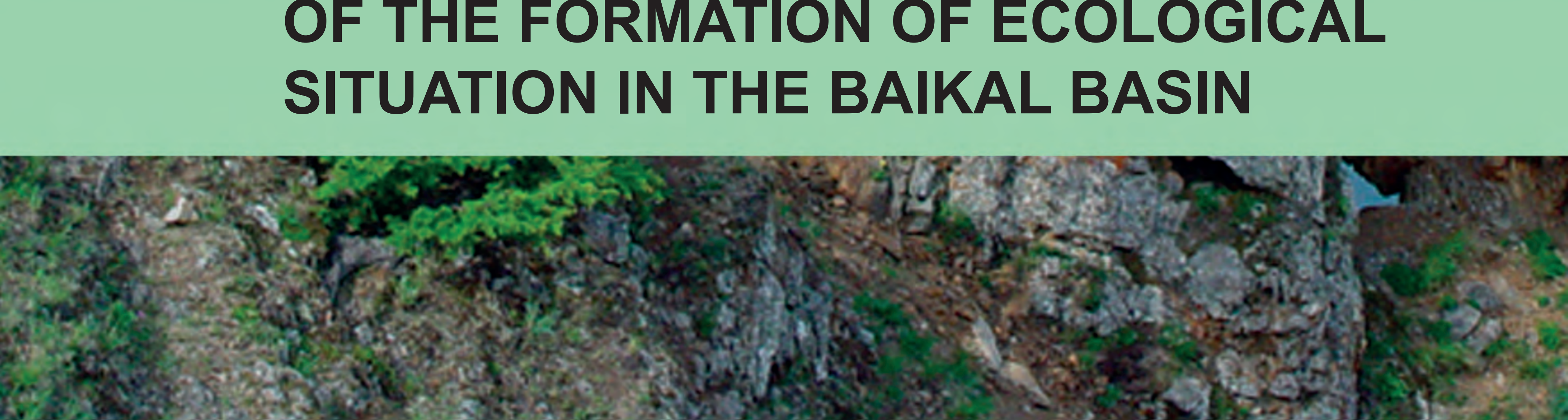
5. ADMINISTRATIVE-TERRITORIAL SYSTEM

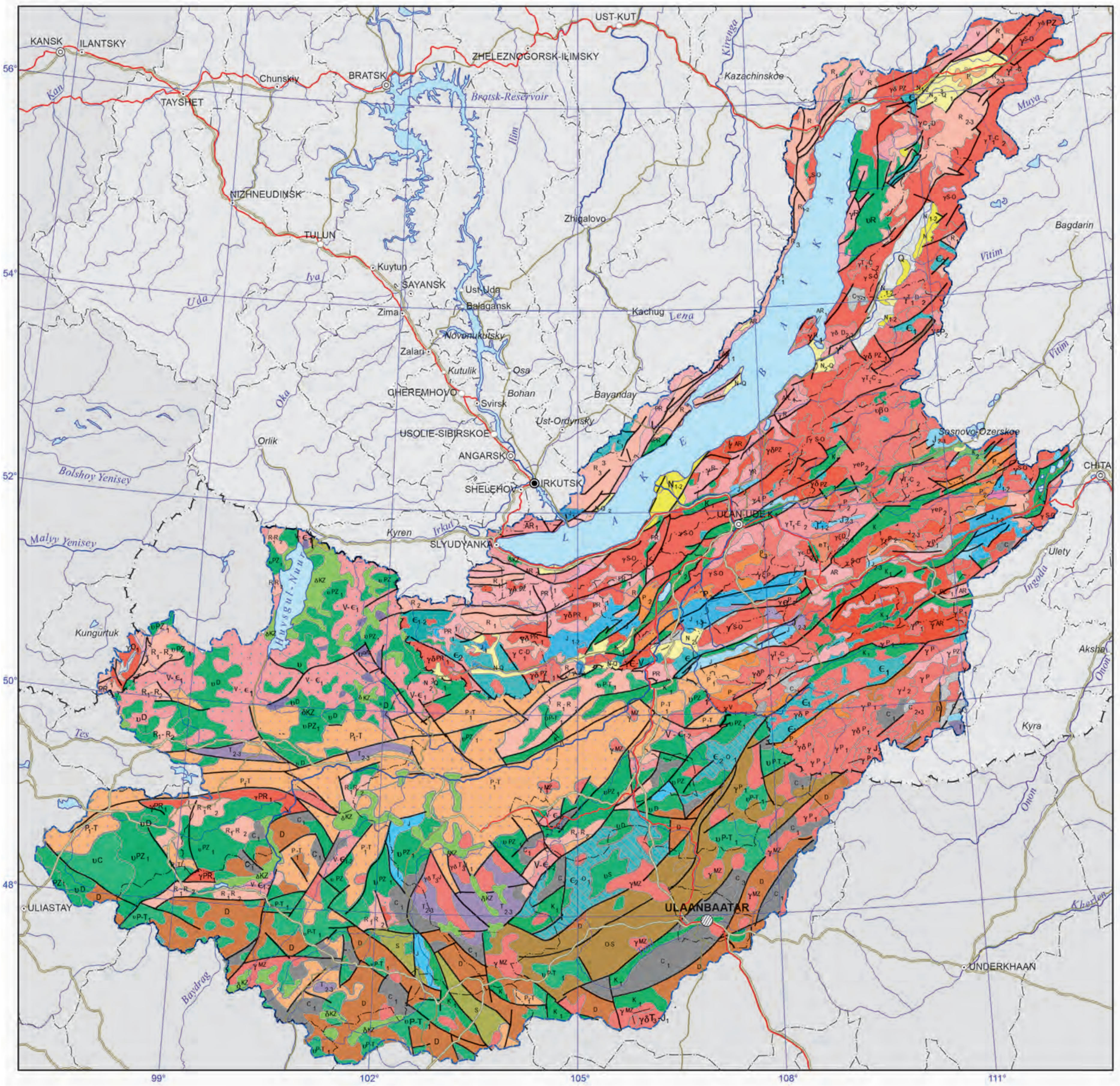


Temple «Megzhid Zhanrayseg» Ulan Bator.

The central part of the city of Ulan Bator.

SECTION I. NATURAL CONDITIONS OF THE FORMATION OF ECOLOGICAL SITUATION IN THE BAIKAL BASIN





GEOLOGICAL STRUCTURE (6)

Many features inherent in the geological structure of the territory of the watershed basin are due to the fact that the territory lies at the interface between the two main lithospheric plates of East Siberia, namely the old Siberian platform, and the younger Central-Asian mobile belt. Formation of the geological structure of both Russian and Mongolian parts of the territory began in the Early Precambrian. For this reason, the geological structures, presented on the map, preserved traces of both Precambrian and Phanerozoic eras of tectogenesis.

Precambrian formations have been ascertained essentially within the mountain framing of the Baikal hollow and to the south and south-west of it, within the north-west of Mongolia.

The Precambrian sedimentary-metamorphic complexes within the mountain framing of the Baikal hollow, presumably of Archean age, are separated into three series differing in the set of rocks building them up, the degree of metamorphism, the type of magmatic manifestations, and the pattern of fold structures: the Sharyzhalgai, Khamar-Daban and Olkhon series. The occurrence area of rocks of the Sharyzhalgai series in the south is clearly delineated – it is a near-rectilinear shore of Lake Baikal between the source of the Angara river and the settlement of Kultuk, and in the south-west – by the zone of the Main Sayan Fault. Its composition includes rocks of two types: biotite, biotite-garnet and biotite-hypersthene migmatizated gneisses among which there occur, in the form of separate interlayers and thicker bedsets, amphibolites, pyroxene and amphibolite-pyroxene schists as well as granites differing in composition and structural-textural characteristics. The complex of sedimentary-metamorphic formations of the Khamar-Daban series is of widespread occurrence along the southern shores of Lake Baikal and within the confines of the Khamar-Daban mountain range. The composition of the series is notable for the Slyudyanka and Kharangul subseries. The Slyudyanka subseries is comprised of thick terrigenous-carbonate layers (carbonate bedsets, and specific silicious-dolomite apatite-bearing rocks), while the Kharangul subseries is dominated by flyschoid deposits (aluminous slates, and gneisses with rarely occurring interlayers and bedsets of carbonates). Deposits of the Olkhon series occur widely in Priolkhonie and on Olkhon Island; they are represented by marbles, pyroxene-plagioclase crystalline schists, amphibole-biotite gneisses, and magmatites with interbeds of amphibolites and quartzites. The Precambrian ophiolitic complex, confined to the suture zones of the fold belt, is registered in the north-western part of Mongolia.

The Lower-Proterozoic deposits of the Muya series are exposed on the watersheds of the Primorskii ridge along the coastal stripe of Maloe More and are represented by quartzites, slates and metamorphized effusives.

The Upper-Proterozoic (Riphean) deposits occur mainly within the Baikal mountain region. The Patom series occurs in the north of the region and divides into the Ballaganakh, Kadalikan and Bodaibo subseries which, in turn, subdivide into formations. In Western Cisbaikalia there occurs the Baikal series of the Upper Proterozoic consisting of three formations: the Goloustnoe, Uluntui and Kachergat formations. In the south, within the Olkha−Goloustnoe plateau there occur deposits of the Ushakovka formation of the Moty series.

Cambrian rocks occur widely in the Middle-Vitim, Angara-Barguzin, and Khamar-Daban mountain regions as well as in the mountain framing of Lake Khovsgol, and within the Uda river basin. The composition of Cambrian deposits is quite varied, ranging from conglomerates and sandstones to very fine carbonate differences. The Devonian deposits are represented by a rather broad spectrum of separate isolated areas; they are arbitrarily subdivided into two stratigraphic complexes. The lower Devonian layers are dominated by carbonate deposits, while the upper level is comprised of terrigenous and volcanogenic-terrigenous deposits. The Carboniferous deposits occur in many isolated areas. The Carboniferous is represented largely by terrigenous marine deposits (sandstones, aleurites, gravelites, conglomerates, and slates). The Permian deposits are also extremely isolated. The largest field of Permian deposits is the Borzya deposit; it lies in Eastern Transbaikalia, and in Western Transbaikalia in the Khilok area. They are represented by relatively uniform terrigenous (and very rarely, carbonate) rocks of a marine and continental origin.

The Triassic deposits include widely occurring volcanogenic formations that are assigned to the Dzhida-Khilok series occurring with scouring on Paleozoic granitoids and other rocks. The lower layers are comprised of the Chernoyarovo formation consisting of major effusives, tuff conglomerates and tuff sandstones. The upper layers include the Tamirskaya formation consisting of acid effusives and their tuffs, and aleurites. Sedimentary and sedimentary-volcanic deposits of the Triassic occupy large areas in the western part of Mongolia, where they are interrupted in some places by the Jurassic sediments. The Lower-Jurassic formations are dominant in the eastern part of Transbaikalia, while

Geochronological scale

Eon	Era	Period	Epoch	Index	Description
Phanerozoic	Cenozoic	Quaternary		Q	Deluvial-proluvial, alluvial and lake sands, clays, aleurites, gravels, boulders, blocky-detritus and crushed stony sediments.
		Neogene	Pliocene	$N_2^3-Q_1$	Adyanskiy alluvium. Sandy-gravel and bench-gravel sediments
				N-Q	Neogene-Quaternary sediments, undivided
				N_2-Q_1	Akhalikskaya suite. Tuff, tuffite, tuffaceous sandstone, sand, aleurolite nd basalst. Shankhainskaya suite. Boulder-gravels, sandy-gravel sediments. Podtokskaya and Manzurskaya suites – river sands, gravels. Clays of Kharancinskaya suite.
				δKZ	Basalts.
				N_2	Anosovskaya suite. Sandy clays, boulders, pebbles, gravel of Tologoyskaya suit. Red deluvial, deluvial-proluvial clays and clay loam.
			Miocene	N_{1-2}	Tankhoyskaya suit. Sands, aleurolites, argillites, brown coals, layers of chalky clays, basalts. Tagaysky suite – gypsiferous, calcareous clays with debris and detritus. Sasinskaya suite – clays and aleurolites, sands, debrises.
		Paleogene		₽	Dzhilindinskaya suite. Sands, gravels, aleurites, diatomites, vivianite aerates.
				γMZ	Granitoids.
	Mesozoic	Cretaceous	Late	K_2	Mokheyskaya suite. Boulder beds, gravel, sands, clays.
				$υδK_1$	Basalts, andesite-basalts, andesites, trachybasalts.
			Early	K_1	Limnetic-continental deposits of Gusinoozerskaya sedimentary sequence. Murtoyskaya suit. Conglomerate, gravelites, sandstones. Kizhinginskaya suite. Conglomerate, gravelites, sandstones trachyandesitic-basalts and their tuffs.
		Jurassic	Late	J_3	Covers of acid effusives of Balzayskaya Dzhargalantuyskaya suites. The lover part of Gusinoozerskaya sedimentary sequence.
				J_{2-3}	Balzayskaya and Dzhargalantuyskaya suites. Covers of acid effusives, conglomerates, sandstones and tuffites.
			Middle	$γJ_2$	15.Gudzhirskiy complex – leucocratic granites, quartz porphyries aplites.
				J_2	Series of conglomerates, sandstones, aleurites, argillites with layers of coal.
			Early	J_{1-2}	Ichetuyskaya suite. Trachyandesites, trachybasalts, trachytes, their tuffs, conglomerates, sandstones, aleurolites.
				J_1	Matakanskaya suite. Aleurolites, sandstones with layers of different pebble conglomerates.
				$γδT_3-J_1$	19.Basalts, andesite-basalts, andesites, trachybasalts.
		Triassic	Late	$ξT_3$	Syenites.
				$γT_3$	Syenites.
				T_{2-3}	Tamirskaya suite. acid effusives and their tuffs, aleurolites.
			Middle	T_2	Volcanic units of Dzhida-Khilokskaya sedimentary sequence.
				T_1	Chernoyarovskay suite. Basic rocks, tuffaceous conglomerates, tuffaceous sandstones.
			Early	$ξT_1$	Alkaline granites.
				$υP-T_1$	Gabbroids, gabbroic anorthosite.
				$γT_1-C_2$	Malokunaleysky sedimentary sequence of granitoids.
				$P-T_1$	Sedimentary volcanic units.
	Paleozoic	Permian	Late	P	Undivided terrigenous, very seldom carbonaceous rocks of marine and terrestrial origin.
				$γξP_2$	Alkaline granites.
				P_2	Alentuyskaya suite. Andesite, andesite-basalt porphyries, trachytes, ignimbrites, tuffaceous conglomerates, tuffaceous sandstones.
			Early	$γP_1$	Sogotinskiy volcanic-plutonic sedimentary sequence - leucocratic, alaskitic, granophyric granites, granite-porphyries.
				$γδP_1$	Granites, granodiorites.
				P_1	Ungurkuyskaya and Tamirskaya suites. Andesite-basalts, trachybasalts, tuffs, ignimbrites, conglomerates, gravelites, sandstones.
		Carboniferous	Late	$C-P_1$	Gunzanskaya series. Tuffs of acid and medium rock composition with layers of conglomerates, gravelites, sandstones, schists.
				C_3	Kharashibirskaya and Shazagatuyskaya suites.
			Middle	C_{2-3}	Sedimentary volcanic series. Felsites, felsite-porphyries, porphyries with layers of silicious schists, tuff breccia, tuff conglomerates.
				C_2	Tutkhaltuyskaya suite.
				υC	Gabbroids, gabbroic anorthosite.
			Early	C_1	Terrigenous marine sediments (sandstones, aleurolites gravelites and conglomerates, lime shale) of Tournay stage. Syrykhskaya suite. Flushoid-terrigenous sediments.
				$γC_1-D$	Vitimkanskiy and Bichurskiy sedimentary sequences undivided leucocratic biotitic, biotitic - corniferous granites.
		Devonian	Late	D	Ileyskaya series. Quartziferous, felsitoid porphyries, orthophyre, dacitic and andesitic porphyries, tuffs, tuffaceous sandstones tuffaceous conglomerates.
				υD	Gabboroids, gabbroic anorthosite.
			Middle	D_3	Terrigenous, volcanogenic – terrigenous sediments of Tocherskaya, Bagdarinskaya, Lanovskaya, Neryundinskaya, Mukhtunnaya suites.
				$γξD_{2-3}$	Granosyenites.
			Early	D_{1-2}	Calciferous, terrigenous- calciferous sediments of Orochonskaya and Ozerninskaya suites.
				γS-D	Dzhidinsky sedimentary sequence - leucocratic amphibole-biotitic, two-mica gneissoid granites.
		Silurian		S	Sedimentary volcanic units.
				υS	Sedimentary volcanic units.
				O-S	Sedimentary volcanic units.
		Ordovician		υβO	Gabboro- dolerites, dolerites.
				$γO_1$	Granites.
				$γδPZ_1$	Dzhidinsky sedimentary sequence - diorites, granodiorites, leucocratic granites, syenites, granosyenites.
		Cambrian	Late	$Є_2-O_1$	Undivided sediments. At the lower layers- sandstones, aleurolites, chlorite slates, at the upper layers - speckled sandstones, interlaid with chlorite and sericitic schists and aleurolites.
			Middle	Є	Undivided Cambrian sediments.
				$Є_2$	Khokhyurtovskaya sedimentary sequence. Marbles, biotitic and amphibolitic slates.
				$υPZ_1$	Dzhidinsky sedimentary sequence - gabbro, gabbro-norite, norite, diabase.
			Early	$Є_{1-2}$	Dzhidinsky suite. Sandstones, aleurolites, limestones, shists, conglomerates.
				$Є_1$	Hokhyurtovskaya sedimentary sequence. Marbles, biotitic and amphibolitic slates.
				$V-Є_1$	Sedimentary volcanic units.
Proterosoic	Neoproterozoic	Late Vendian		γЄ-V	Granites.
		Early Vendian		V	Oselkovaya sedimentary series. Sandstones, aleurolites, dolomites.
				γV	Granitoids.
	Mesoproterozoic			R_3	Zhuinskaya sedimentary series. Limestones, chalky clays, aleurolites.
				R_3^3	Motskaya sedimentary series. Ushakovskaya suite. Sandstones, conglomerates, aleurolites.
				R_3^2	Baikalskaya. Kachergatskaya suite. Sandstones, aleurolites, schists.
				υR	Dovyrenskiy and Ikatskiy sedimentary sequence - gabbro, gabbro - diabases, diabases, gabbro-norites, gabbro- pegmatites, gabbro-diorites.
				R_{2-3}	Bodaybinskaya sedimentary series. Sandstones, limestones, schists, aleurolites.
				R_2	Ballaganakhskaya sedimentary series. Metasandstones, phyllites, metsaleurolites, gravelites.
				R_1-R_2	Sedimentary volcanic units.
				γR	Barguzinskiy Sandstones, conglomerates - biotitic, corniferous - biotitic, porphyraceous and gneissoid granites.
				R_1	Utulikskaya sedimentary series. schists, sandstones, conglomerates.
	Paleoproterozoic			$γPR_1$	Kitoysky sedimentary sequence - biotitic, biotitic - corniferous, biotit-hypersthenic gneissogranites, granites, aplites, pegmatites. Khamar-Dabanskiy complex sedimentary sequence - two-mica gneissoid granites and plagiogranites, gneissogranites. Primorskiy sedimentary sequence of granites.
				PR_1^1	Khangarulskaya sedimentary subseries. Biotitic, granite - biotitic, sillimanitic gneisses, marbles, chlorite-biotitic sericitic schists, andalusite – staurolite shists, sillimanitic plagiogneisses with biotite and muscovite, sandstones, aleurolites, amphibolites.
Archean	Late Archean	Late Lopian		[illegible]R	The sedimentary sequence of basic rocks and ultrabasic deep-seated (dunnites, peridotites, pyroxenite, gabbro), effusive (basalts and tuffs) rocks.
		Middle Lopian		AR	Undivided Archean rocks.
				γAR	Gneissogranite, granite-gneisses, pegmatoid granites, granitoids.
		Early Lopian		AR_2	Olkhon sedimentary series. Marbles, pyroxene- plagioclase crystalline shists, adergneisses, amphibolites, quartzrocks. Khamar-Dabanskiy sedimentary series. Biotitic gneisses, biotite - garnetiferous, hypersthenic crystalline shists, marbles, chlorite-sericitic and chlorite-biotitic sericitic shists.
	Early Archean			AR_1	Sharyzhalgaisky sedimentary series. Biotitic gneisses, biotit - garnetiferous, biotite-hypersthenic gneisses. amphibolites, pyroxene crystalline shists, adergneisses, granites, gneissoid granites, charnokites.

Faults

Thrust fault

marine deposits of the Lower- and partially Mid-Jurassic period are found only in the central part of Eastern Transbaikalia. In the north-west and south-east marine deposits are replaced by continental formations. Starting largely in the Mid-Jurassic period, the western and northern parts of Transbaikalia had been accumulating layers of conglomerates, sandstones, aleurites and argillites with interbeds of bituminous coal. The upper division includes covers of acid effusives. Such effusive-sedimentary formations also extend over the Vitim upland. The syncline cores, usually with their north-eastward strike line, occur in the area of Cretaceous freshwater-continental deposits. The lower part of these deposits refers to the Jurassic, while the upper part corresponds to the Cretaceous. The lower Cretaceous layers are comprised of conglomerates, sandstones, aleurites, slates and strata of brown coal, whereas the upper layers include boulder beds, shingle, sands and clays of the Mokheiskaya formation. In the central parts of Mongolia Cretaceous deposits are somewhat controlled spatially by deep faults and unconformably lie on the Devonian and Cambrian deposits.

Paleogene deposits occur very fragmentarily and are most commonly regarded as Upper Cretaceous−Paleogene deposits, because their detailed partition is unfeasible to date. They are represented by covers of red and variegated-red clays, sandy-shingle deposits and lacustrine clays. Paleogene deposits are characterized by successive link of their composition with the laterite-kaolinite weathering crust. Miocene deposits of the Tankhoi formation are of widespread occurrence on the south-eastern shore of the lake; they were also found at different depths in the course of drilling in the sediments of the Ust-Selenginskaya depression, within the Barguzinskaya depression, and in intermountain depressions of Northern Pribaikalie. In the Dzhida mountainous area and on the Khamar-Daban range, basalt covers, overlaying the watershed areas, belong to the Miocene. On Olkhon Island, deposits of the Tagai formation, which are overlapped with an angular unconformity by deposits of the Sasinskaya formation (Upper Miocene - Lower Pliocene), are referred to the Lower-Middle Miocene. The Upper Pliocene and Eo-pleistocene in most cases compose a single rock mass, which resists dissection. Deposits of this age are registered in South Baikal (Shankhaikhinskaya formation), and in a number of areas of the eastern, western and southern surrounding of the Baikal hollow. On Olkhon Island the Upper Pliocene is represented by clays of the Kharantsy formation. Quaternary formations are characterized by a diversity of lithogenetic and facial types and occupy different geomorphological positions. Most often, the lower half of the profile of the quaternary system clearly shows a thick, complicated sandy layer, while the upper layers of the Pleistocene and Holocene are dominated by rudaceous deposits, including morainic.

The Siberian block of the Eurasian plate and adjoining spaces which, as a result of a long-lasting development, had transformed to the Sayan-Baikal orogenic belt, were characterized by the differing trends of geological events.

In the Early Precambrian, the sialic masses that merged together to form a single block, i.e. Siberia, comprised several Archean blocks with the well-developed continental crust. They were separated by proto-oceanic basins. Toward the end of the Early Proterozoic, the proto-continental blocks had formed a massif with a mature continental crust, i.e. a basement of the Siberian platform. As a result of the Early-Proterozoic orogeny, the marginal zone of the continent developed the mountain terrain which had been destroyed by the beginning of the Riphean. The Mid-Riphean stage started to accumulate the proper sedimentary cover of the Siberian platform. At the close of the Riphean−Vendian time, most of the paleocontinent was covered by the sea. On the other hand, orogenic movements resulted in the formation of elevated blocks of the Barguzin and Bokson−Khovsgol microcontinents. They produced a discontinuous chain of mountain ridges separating the Siberia paleocontinent from the Paleo-Asian Ocean. In the late Vendian−early Cambrian, the mountain massifs underwent substantial planation. Starting in the early Cambrian and during the Ordovician−Silurian, the eastern and southern margins of the basements of the microcontinents were represented by shelf zones, and by the upper parts of the continental slope of the oceanic basin. In the latter half of the early Paleozoic and at the beginning of the late Paleozoic, the collision of the Barguzin microcontinent with the Siberian platform triggered the formation of Barguzin granitoids. The latter half of the Paleozoic witnessed the collision of the Barguzin, Bokson-Khovsgol and other microcontinents with the margin of the Siberia paleocontinent. The Paleo-Asian Ocean stretched out southward of the Siberia paleocontinent. In the Hercynian era, the active processes in the Mongol−Okhotsk belt were responsible for the tectonic-magmatic intensification of the Sayan-Baikal region and the southern part of the Siberian platform. At the beginning of the Mesozoic, an attenuation of the vertical tectonic movements led to peneplanation with the formation of a thick weathering crust. The subsequent Mesozoic intensification was responsible for a growth of the mountains in the Sayan-Baikal region, and for an intensification of intrusive magmatism.

The end of the Cretaceous−Paleogene was marked by a long-lasting period of peneplanation and crust formation which preceded directly the Cenozoic riftogenesis and the formation of the morphostructural plan of the Baikal Rift Zone and the Baikal basin.

The distinguished tectonic stages are very clearly registered in three tectonic blocks in the territory of Mongolia, namely: western – Caledonian; central – Early Caledonian, with numerous outthrusts of rocks of the crystalline basement and Hercynian and Mesozoic structures overlaying them, and southern – Hercynian. In general, the modern overlapped-folded structure of the Mongolian territory outlines certain spatial and temporal patterns, consisting in a directional change of more ancient structures, located in the north and west, by younger ones, clearly manifested in the south.

The territory of the the Baikal basin is unique as regards the occurrence, range and diversity of granitoids, which occupy more than 70% of the area, while the formation of acid magmas was taking place from the Archean to the early Cretaceous. They tend to occur within the Mongol−Okhotsk (Mongol-Transbaikalian) mobile belt, having a complex long-lasting history. The following stages of magmatism are identified:

1. Archean early-orogenic – formation of migmatites and lenticular concordant bodies of gneissogranites and granites. Archean late-orogenic − intrusive bodies of pink and red leucocratic significantly potassic granites and alaskites.

2. Early Proterozoic late-orogenic fissure intrusions of the seaside granite complex.

3. Late Baikalian−early Caledonian (Vendian−early Cambrian) – basic volcanism, ultrabasic intrusions.

4. Late Caledonian (Cambrian−Silurian) – formation of granitoids on a mass scale.

5. Early Hercynian (Devonian) – local occurrence of acid and mixed volcanism. Intrusions of alkali-earth syenites, granites, and alaskite granites.

6. Late Hercynian (Carboniferous−Permian) – intrusive series of gabbro-monzonite-syenite, alkali-syenite and alkali-granite composition.

7. Triassic−Cretaceous – series of tectono-magma activations with the establishment of volcano-tectonic structures, formation of intrusions of normal and alkali-earth granodiorite−leucogranite series and effusion of basaltoids.

8. Quaternary period – riftogenesis and effusion of alkali basaltoids.

SEISMIC ZONING. EPICENTERS OF STRONG EARTHQUAKES (7)

Seismic zoning implies mapping of seismic risk due to maximum seismic impact, which might originate over this area and be exceeded with a certain probability during the assigned time interval [Ulomov and Bogdanov, 2013].

Total seismic zoning (TSZ) is implemented on the basis of studying regional and global seismicity-generating structures (SGS), determining recent geodynamics, seismicity and seismic regime over territories of states. TSZ serves as the foundation for a rational land use and securing the antiseismic construction. To specify the degree of seismic risk in appropriate regions and over the local areas the supplementary field surveys are performed, including instrumental surveys.

The map of seismic zoning over the territory of the Lake Baikal catchment area depicts the materials collected through a systematic study of active faults within the territories of Cisbaikalia and Mongolia, where the strongest earthquakes might be the case. This type of mapping is methodologically based on the geological and geophysical evidence specifying the features of seismic and tectonic development of the territory including the elements of historic-structural, tectonophysic and paleo-seismic approaches applied for recognizing the zones of probable earthquake foci (PEF). The main goal of identified PEF zones is a maximally reality-approached reflection of projections of future focal zones of earthquakes of varying magnitude (M) occurring with a certain repeatability. Construction of PEF zones also includes extrapolation of possible M of earthquakes occurred in known geologic-geophysical environs onto the morphology-structural fault complexes with similar conditions, but in which the respective earthquakes have not taken place yet. This seismotectonic approach proposed by I.E. Gubin (1950) is applicable so far. On the map of seismic zoning from PEF zones with a certain seismic potential (M of an earthquake), according to a decay of seismic waves from quake epicenters, seismic zones are outlined following the MSK-64 intensity scale units [New map…, 1996; Recent geodynamics…, 1996].

The map of seismic zoning may be regarded as the long-term prognosis of strong earthquakes during 1000 years. The map was based on seismic statistical data on the seismicity recorded over the regional territory for over 100 years period of observations, as well as seismogeological evidence and maps of active faults [Smekalin et al., 2011].

The main goal of the map of seismic zoning is to reflect the realistic level of seismic risk as a magnitude in each point of the surveyed territory considering the quantification of the boundaries of regions with different seismic risk measured in probabilistic values.

The map representing modern concepts of seismogeological analysis developed by seismologists of Irkutsk [Seismic zoning…, 1977] distinctly displays a linear elongated mode of isolines with different seismic risk expressed in magnitude. This is because configuration of all these lines lies upon seismic lineaments. They represent the axes of the upper edges of 3D seismically active fault structures, related structured seismicity and framework of the lineament-domain-focal (LDF) model applied in this study.

The entire area of the Baikal basin is outlined by the intensity 7 to 9 isolines of seismic risk. As this takes place, the narrow linear zones of possible quakes with intensity 10 (on the map intensity >9) are common for the southern termination of the lake basin, and they are associated with the Main Sayan fault and numerous paleo-seismic dislocations located nearby. The paleo events, they are related to, could generate quakes with intensity 10 to 11. The other similar spot of quakes with intensity 10 is located in the north of the lake, in the region of the Kichera paleo dislocations occurring within the Kichera seismically active faults capable to generate earthquakes with magnitude M= 7.0 – 7.5. The third spot in the Selenga river delta is linked with the Delta seismically active fault, its plane comprising the focus of the catastrophic Tsagan earthquake of 1862 with M=7.5 (with the M=10 effects observed on the surface). All the water area of Lake Baikal is contoured by the M=9 isoseism.

The isoline of M=8 intensity turns over M=9 isoseisms and extends in the north-eastern direction on both sides from Lake Baikal. This area includes such large populated localities as the cities of Irkutsk, Ulan-Ude and Ulaanbaatar. Over the Mongolian territory, to the south of Lake Khovsgol, there is a sublatitudinal zone of M=10 quakes (intensity > 9 on the map), associated with the area of two faults, in which planes the foci of the Bolnay and Tsetserleg earthquakes of 1905 occur. These seismic events are referred to the strongest intra-continent earthquakes on the Earth of instrumental period (M=8.5, intensity 11-12). Lake Khovsgol and adjacent territories lie within the zone of intensity-9 quakes.

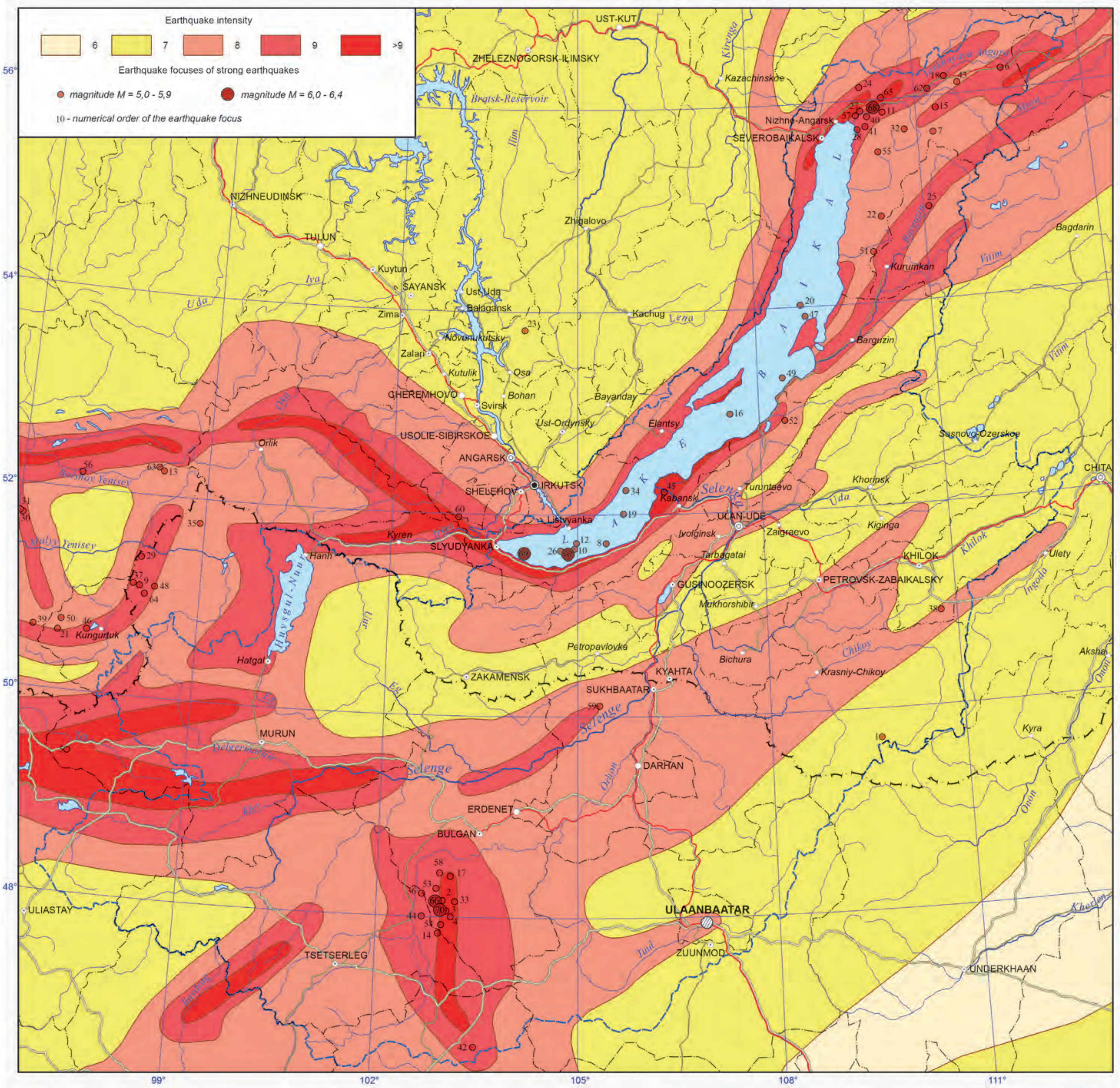
The city of Ulaanbaatar sits within the zone with seismic effect of intensity-8 quakes. This zone is contoured on both sides by M=7 isoseisms stretching northeastward to the city of Chita. The area of possible intensity-7 quakes extends from Ulan-Ude in the north to Sukhe-Baatar (Mongolia) in the south.

These materials were used as the basis to construct a new map of seismic zoning over the RF territory TSZ-2012, which in the future will become the normative and reference document for all research and design project organizations of Russia [Ulomov, Bogdanov, 2013].

Epicenters of strong earthquakes

1. 01.06.1963. M=5
2. 07.01.1967. M=5
3. 20.01.1967. M=5
4. 20.01.1967. M=5
5. 07.06.1967. M-5
6. 22.08.1967. M=5
7. 05.12.1979. M=5
8. 11.05 1987. M=5
9. 23.12.1991. M=5
10. 26.02.1999, M=5
11. 31.05.1999. M=5
12. 31.05.2000. M=5
13. 16.08.2008. M=5
14. 20.01.1967. M=5,1
15. 26.11.1963. M=5,1
16. 09.03.1972. M=5,1
17. 13.12.1974. M=5.1
18. 02.11.1976. M=5,1
19. 22.05.1981. M=5.1
20. 27.05.1981. M=5,1
21. 16.08.1981. M=5,1
22. 14.01.1982. M=5,1
23. 30.07.1982. M=5.1
24. 26.10.1990. M=5,1
25. 12.09.1991. M=5,1
26. 25.02.1999. M=5,1
27. 27.05.1999. M=5.1
28. 11.12.2006. M=5,1
29. 19.01.2003. M=5,1
30. 26.02.2012. M=5,1
31. 06.06.2012. M=5,1
32. 15.01.1967. M=5,2
33. 22.01.1967. M=5,2
34. 23.03.1970. M=5,2
35. 29.11.1974. M=5,2
36. 27.10.1975. M=5,2
37. 01.04.1976. M=5.2
36. 10.09.1977. M=5.2
39. 20.01.1984. M=5,2
40. 30.05.1999. M=5,2
41. 04.12.2006. M=5,2
42. 16.07.2011. M=5.3
43. 01.12.1963. M=5.3
44. 13.01.1967. M=5,3
45. 11.02.1967. M=5,3
46. 26.02.1972. M=5.3
47. 14.02.1992. M=5,3
48. 27.04.2005. M=5,3
49. 20.05.2008. M=5,3
50. 04.03.2009. M=5.3
51. 19.03.2010. M=5.3
52. 16.07.2011. M=5.3
53. 05.01.1967. M=5.4
54. 23.04.1963. M=5.4
55. 04.07.2007. M=5,4
56. 03.03.1973. M=5.5
57 21.12.1999. M=5.5
58. 06.01.1967. M=5.6
59. 13.05.1989. M=5,6
60. 29.06.1995. M=5,6
61 24.09.1993. M=5.6
62. 16.09.2003. M=5.6
63. 16.03.2003. M=5,7
64. 27.12.1991. M=5,8
65. 21 03.1999. M=5,9
66. 05.01.1967. M=6
67. 25.02.1999. M=6
68. 21.03.1999, M=6
69. 27.03.2008. M=6,3
70. 20.01.1967. M=6,4

7. SEISMIC ZONING. EPICENTERS OF STRONG EARTHQUAKES



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GEOMORPHOLOGY MAP (8)

The Baikal basin is located in the center of Eurasia, which determines its specific traits as well as the main features of nature. Paleogeography and geology of the region govern its peculiar landforms.

Vertical tectonic movements of the Late Mesozoic and the Cenozoic developed a mountain-basin type of topography.

The orographic structure of the Baikal basin is rather complex. The topography as a whole is a unified Pliocene-Quaternary formation [Ecosystems, 2005]. Significant subsidence of individual blocks in the midst of general uplift developed grabens of two types. The first type (the Baikal type) is associated with the intensification of tectonic activity in the inland Baikal Rift Zone. The amplitude of vertical neotectonic movements, as well as the thickness of loose deposits reach their maximum here. Crustal movements in this area are still quite intense; they cause a high seismic activity with frequent and sometimes strong earthquakes. The second type (the Transbaikalian type) is represented by wide intermountain lowlands, which are very common in the Selenga river basin. They formed as a result of recent deep-seated tectonic dislocations superimposed on the rejuvenated Mesozoic depressions.

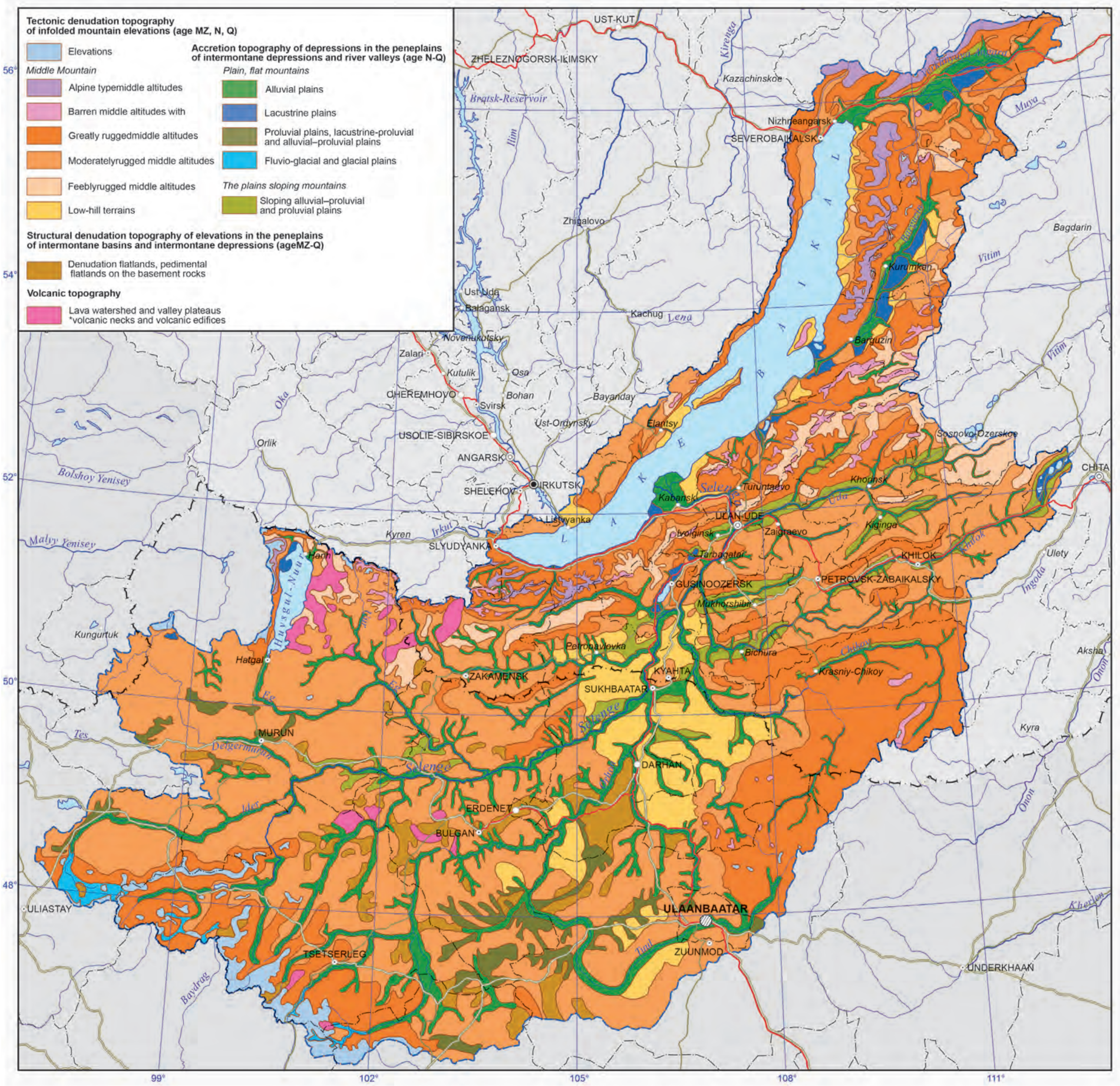
Intermountain basins are separated by mountain ranges varying in height and geological structure. They are noticeably dissected by exogenous processes of erosion.

In the Quaternary, the highest orographic units (the Baikalsky, Verkhneangarsky, Barguzinsky, Khamar-Daban, Khangai and other mountain ranges), especially their north-western and northern slopes, were exposed to glaciation, which is indicated by the presence of the alpine landforms (cirques, avalanche chutes, through valleys, moraines, etc.)

Both positive and negative landforms within the Selenga river catchment area basin and up to the Uda river mouth are generally directed northeastward with a dominant altitude lowering northward. The mountains surrounding of three Baikal intermountain basins (Barguzin, Verkhneangarsk and Khovsgol lowlands) are characterized by higher absolute altitudes and deeply cut river valleys. These factors predetermine a wide range of elements typical of mountain landform, or plain landform in the wide intermountain basins.

According to the geomorphological zoning [Highlands…, 1974; National Atlas of the Mongolian People's Republic, 1990] the area of the Baikal basin is made up of the following features: Khangai and Khentei-Dauria highlands, Khovsgol mountains, Orkhon-Selenga middle mountains and its continuation in the north - Selenga (Selenginskaya Dauria) middle mountains, mountain systems of the Dzhidinsky mountainous region, mountain ranges of Khamar-Daban, Ulan-Burgasy, Ikatsky, Barguzinsky, Verkhneangarsky, Severomuisky, Baikalsky, and Primorsky, and the western side of the Vitim Plateau. Minimum absolute altitude is the Lake Baikal waterline; since it is regulated, it is subjected to slight fluctuations at around 460 m a.s.l. Maximum absolute altitude is 3,539 m a.s.l. (the Khangai Highland).

8. GEOMORPHOLOGY MAP



The highest mountain range in the area is the Khangai Highland located in the south-western part of the basin; it has generally subdued delineation and slight changes of relative altitudes. The mountains become more prominent towards the central part of the basin due to Alpine landforms. Tarbagatai and Telin-Tsagan are the largest northern spurs of Khangai Highlands with individual peaks reaching 2,500 m.

The maximum altitudes of the Khentei Highland mountains go up to 2,200-2,400 m a.s.l. Their wide and long spurs stretch westward and eastward, forming a large highland, gradually descending to low hills in the west and in the south, and joining the mountains of Transbaikalia in the north. Generally, this is a gently sloping landscape with wide-spread residual hills, rocks, and scattered stones. Traces of ancient glaciation are preserved to a limited extent.

The Orkhon-Selenga middle mountains are located in the central part of the watershed basin between the ranges of the Dzhida river basin in the north and the Khentei Highlands in the south. It features a flattened relief and its spatial configuration resembles a huge amphitheater descending towards the northeast.

The Selenga middle mountains consist of sublatitudinal medium-altitude mountain ranges with rounded summits (Tsagan-Daban, Borgoisky, Chikoysky, Tsagan-Khurteisky, Zagansky, and others) separated by wide intermountain valleys distinctly stretching along the main riverbeds. The valley bottoms are drained by the Selenga tributaries (Chikoy, Khilok, Uda, Dzhida) and composed of alluvial and proluvial deposits of different age arranged in terraces and wide piedmont plains. The Selenga river valley lies among low hills with granite residuals, rocks, and cliffs.

The Khovsgol area relief has a complex structure. Its west side features sharp-crested, steep-sided, and hard to access ridges of Bayan-Ula and Khoridol-Saryag. The outlines of the mountains to the east of Lake Khovsgol resemble those of the northern Khentei with altitudes over 2,000 m. Extensive Late Cenosoic lava plateaus are specific features of these mountains.

The Dzhida and Khamar-Damban Mountain Ranges have a lot in common. They stretch from the south-west to the north-east. In the west, they are relatively flattened and marked by bald peaks, gradually turning into the alpinotype middle mountains of the Big Khamar-Daban Mountain Range, which drops steeply to the shores of Lake Baikal. In the east, the mountains have a lower altitude. The Selenga river cuts through their spurs.

The northern part of Lake Baikal and the Verkhneangarskaya basin are surrounded by Alpine landforms with harsh outlines of the axial and piedmont parts of the Baikalsky, Verkhneangarsky, Severomuisky, and Barguzinsky mountain ranges. In spite of the relatively moderate elevations, there are many glacial traces here, and in some places there are small vanishing mountain glaciers (e.g. the Chersky Glacier – about 0.4 km²) The Vekhneangarsky basin relief shows little elevation changes at the bottom. It is formed by the alluvial deposits of the Verkhnyaya Angara (the Upper Angara) river, and by lacustrine alluvial deposits of paleobasins. Extensive proluvial and fluvioglacial piedmont plains are typical of the basin.

The structure of the Barguzinskya basin is typical of the Baikal-type depressions: large swampy plain areas at the basin bottom, and relatively uplifted ancient alluvial lacustrine terraces made of sandstone deposits. The presence of large areas of sandstone deposits predetermines high eolian activity.

In the south, the Barguzinskaya depression is framed by massive, but relatively flat landforms of the Ikatsky range. The highest summits of the Ikatsky range as well as those of the ranges lying further south (Ulan-Burgasy and Kurbinsky ranges) are treeless and flat with mountain terraces.

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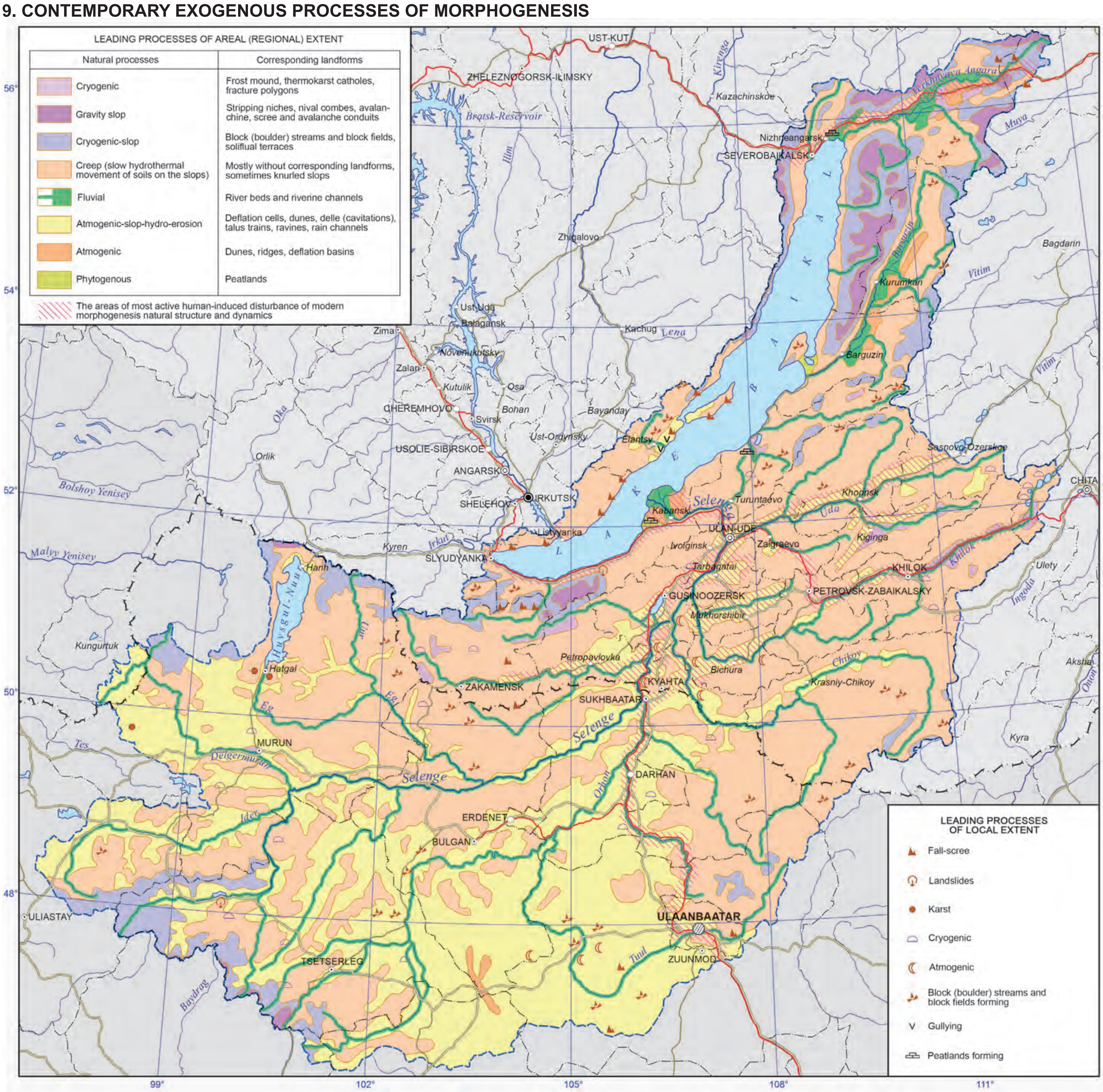
9. CONTEMPORARY EXOGENOUS PROCESSES OF MORPHOGENESIS



CONTEMPORARY EXOGENOUS PROCESSES OF MORPHOGENESIS (9)

For purposes of mapping, the leading processes were identified on the basis of a classification of the exogenous processes of morphogenesis of land, suggested by V. B. Vyrkin [1986], from taxonomic geomorphological units in accordance with the scale. At a small scale, the objects of geomorphological mapping are the types, subtypes and complexes of topography which are basic to identifying classes and groups of leading processes. The legend is based on identifying one leading process (the one exception to this rule is represented by the display of areas on the map where the contemporary morphogenesis is due to a combination of two leading classes of processes). Identification of the leading processes of the territory took into account their three main parameters: the coverage area, the duration of a continuous occurrence, and the intensity of development.

The process is identified through a process interpretation of the relief, deposits, landscapes, vegetation and other natural formations. The procedure brings to the fore the interpretation of the relief, its morphology, genesis and age, and the identification of the genetic types of deposits. Only an integral investigation into the landforms and correlative deposits, complemented with station-based observations of the intensity of processes, does make it possible to identify in the mapping procedure the leading processes, and of paramount importance is a knowledge of the geomorphological structure of the region being mapped. Vital to the generation of small- and medium-scale maps of the processes, especially for poorly explored spaces of Siberia and Mongolia, are space images. In Siberia's remote regions difficult of access, space images provide the main information base for map compilation.

Thus the methodological framework for mapping the contemporary exogenous processes of morphogenesis involves determining and depicting the leading processes. Maps as produced by such a method offer a means of investigating the structure and functioning of the processes of contemporary exogenous morphogenesis. They can be used in developing and generating regionalization schemes for contemporary exogenous processes of morphogenesis.

The map as created on the basis of the aforementioned principles constitutes a wealth of information which can be employed in dealing with issues relating to rational management of natural resources, assessments of the relief and contemporary morphogenetic processes, and to implementation of measures for the protection of land surface against hazardous and adverse geomorphological processes.

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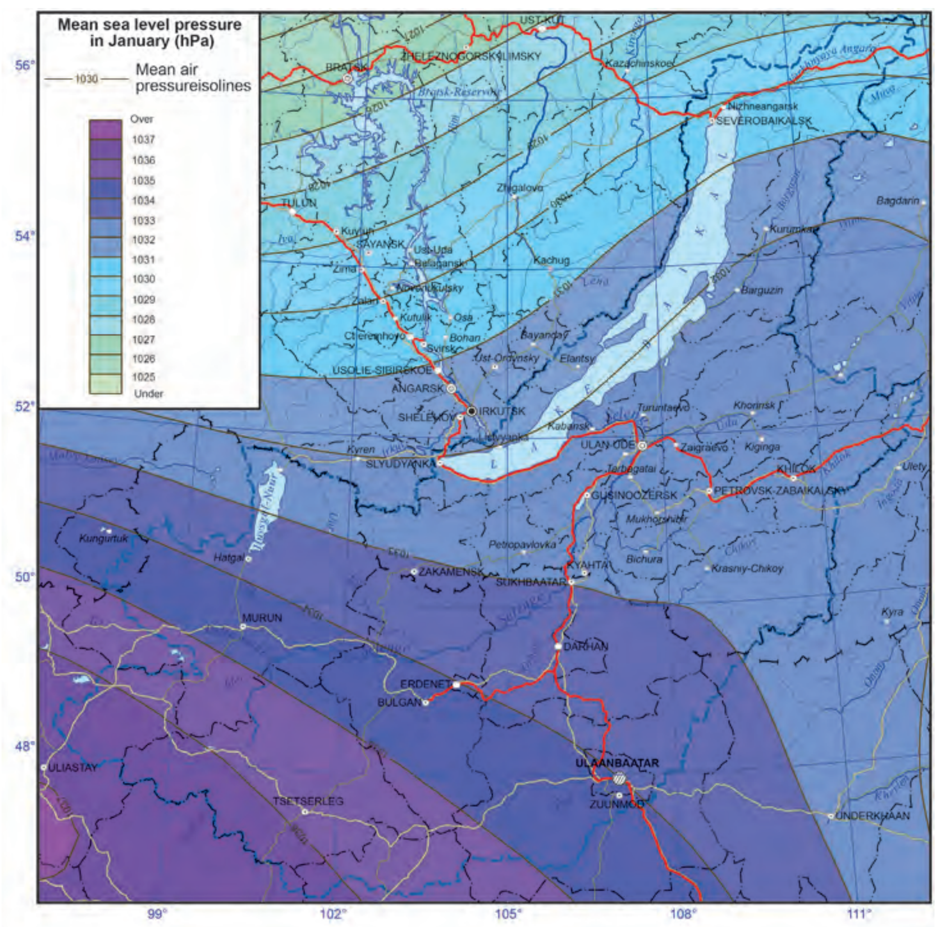
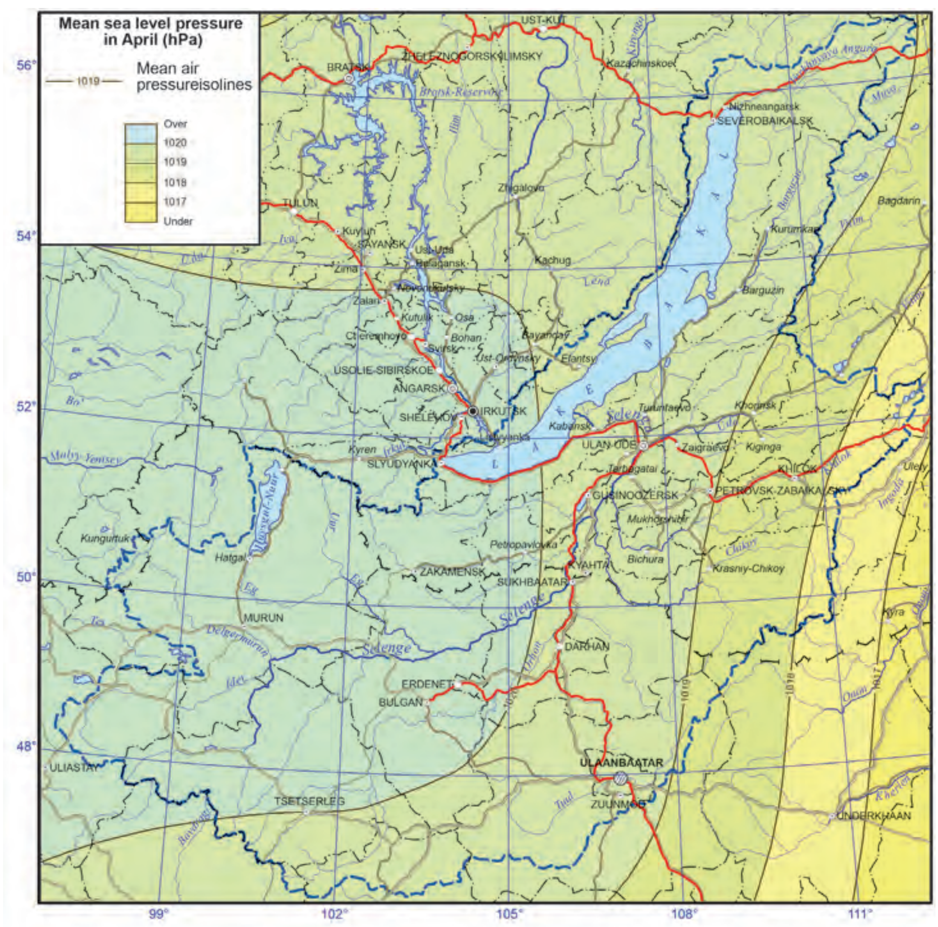
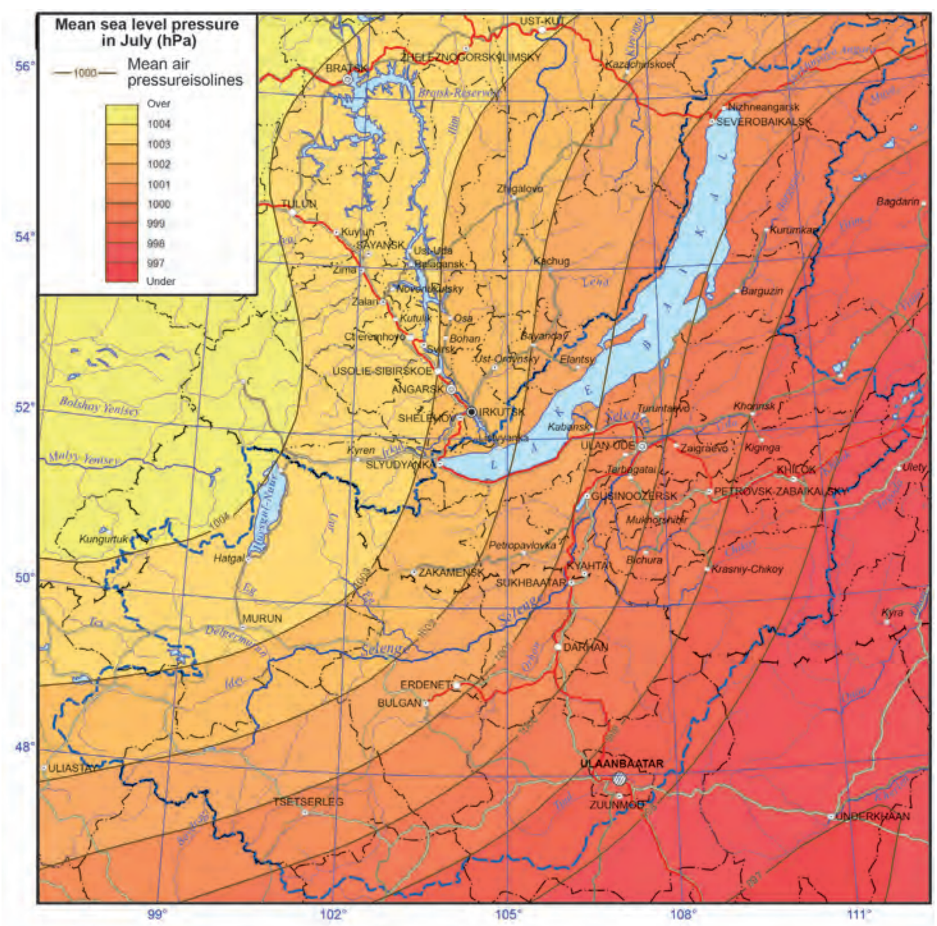
10. ATMOSPHERIC PRESSURE. JANUARY



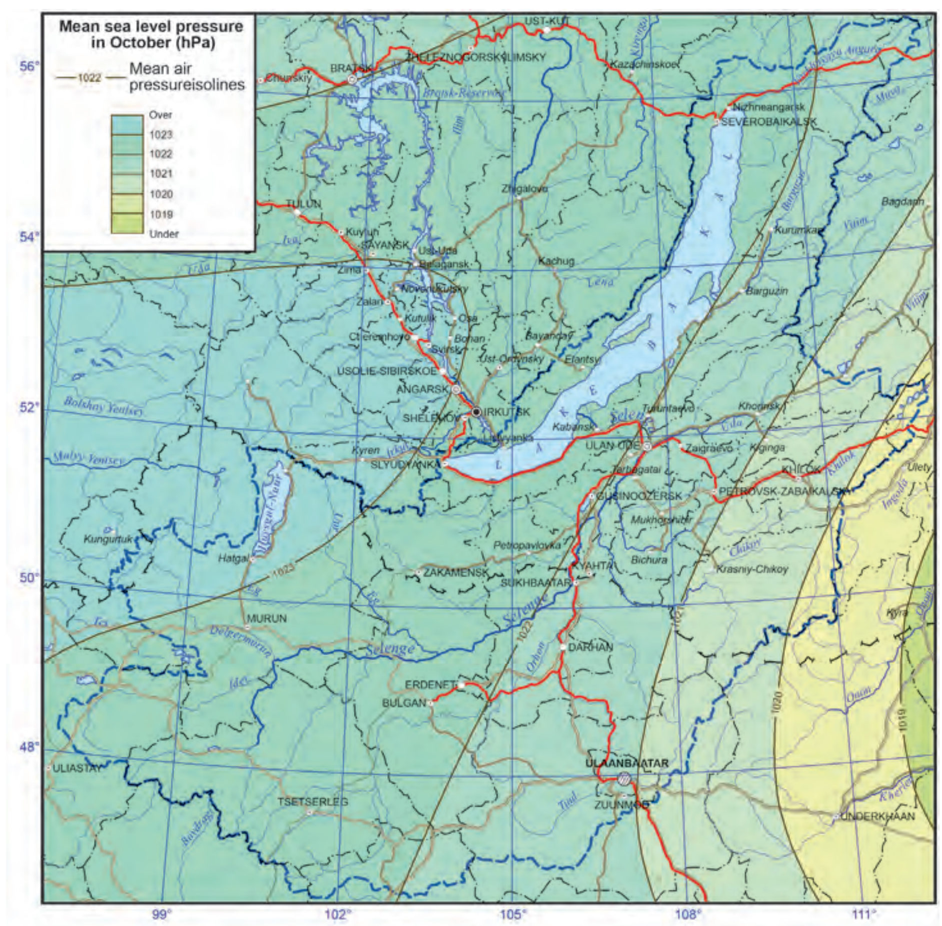
11. ATMOSPHERIC PRESSURE. APRIL



12. ATMOSPHERIC PRESSURE. JULY



13. ATMOSPHERIC PRESSURE. OCTOBER



CLIMATE

Observational data of meteorological stations on the air temperature and precipitation in the period of 1961 to 2008 serve as initial data for climate maps here. Mean monthly and annual values are considered.

ATMOSPHERIC PRESSURE (10-13)

A primary role in shaping climate is played by atmospheric circulation - one of the main climate factors. Atmospheric circulation is presented in the maps of pressure fields in the central months of seasons. The maps are compiled based on the monthly mean pressure values reduced to sea level (NCEP / NCAR reanalysis base). In winter, the main pressure system at the surface is Asian (Siberian) anticyclone centered on the north-west of Mongolia, reaching maximum development in January. In spring, the action of the Asian maximum weakens. Differences in the properties of the underlying surface of the continent and ocean reduce dramatically, thereby the zonal circulation factors begin to dominate, that determine the west-east transport. Together with the transfer of pressure formations from west to east the cyclones outputs from Central Asia and Kazakhstan are observed in spring. Summer circulation processes are characterized by the weakening of the west-east transport. The pressure field of low pressure dominates at the earth's surface. When the blocking warm anticyclone locates over the central regions of Yakutia, south cyclones from Mongolia move to the Baikal region and then they slowly travel to the west or northwest. Central forms of summer circulation, which are characterized by blockage of the zonal flow and split of planetary altitude frontal zone (PAFZ) of temperate latitudes, occur conditioned upon intensive development of the typical summer tall crests and troughs. Circulation conditions of the autumn period are characterized by the development of general west-east transport, which is interrupted by meridional invasions of cold air masses from the north. Siberian anticyclone is in its formation stage. Compared with the spring season the autumn west-east movement of pressure systems is slower. Final transition to winter conditions of circulation takes place around the middle of November, when the Siberian anticyclone is sufficiently stable.

AIR TEMPERATURE (14-16)

Lake Baikal influences the climate of the surrounding area within the Baikal hollow. The climate of inland areas of Irkutsk oblast, Republic of Buryatia, Zabaikalsky krai, and Mongolia may be called sharply continental, and the climate of the shore of Lake Baikal is close to the coastal one. Winter month's temperature on the shores of southern Baikal is on average 5°C higher than in the central areas, and summer month's temperature is lower at the same rate. In summer temperature inversions are observed over the cold lake surface that impedes upward motions. The set of radiation and circulating factors and local conditions determine the features of the thermal regime.

In winter, due to the predominance of anticyclonic weather, the air temperature depends mainly on the radiation conditions, and the air cools over the underlying surface. In summer, radiation factors also play a dominant role in the temperature regime formation.

Long-term mean annual temperature is almost everywhere negative. At stations located on the shores of Lake Baikal, air temperature is higher than on the continental stations located at the same latitudes. The coldest month is January, and the warmest one is July.

MEAN ANNUAL PRECIPITATION (17)

Particular features of the mountainous topography have a significant impact on the formation and distribution of precipitation over the study area. The altitude and especially the location of mountains with respect to moisture-laden air flows lead to uneven distribution of precipitation. Different precipitation amount is observed

Embacles on Lake Baikal.

at the same altitudes of mountain ranges. The greatest precipitation amount characterizes the north-western and western slopes of primary (with regard to prevailing air flows) ridges bordering Lake Baikal, i.e. up to 1400 mm; on the windward slopes of secondary ridges and within the plateau inner areas it reaches up to 400-700 mm. Precipitation amount of 200-250 mm fall out in the steppe part of the western shore of Lake Baikal and on its islands, and up to 300 mm precipitate in the intermontane depressions and in the Selenga and Uda river valleys.

Annual precipitation amount of 250-300 mm falls out in the mountains of Khentei at altitudes above 1000 m, in the mountains of the Khovsgol area at altitudes above 1500 m, and in the mountains of Khangai at altitudes above 2000 m. Summer precipitation predominate, constituting 60-70% of the annual amount.

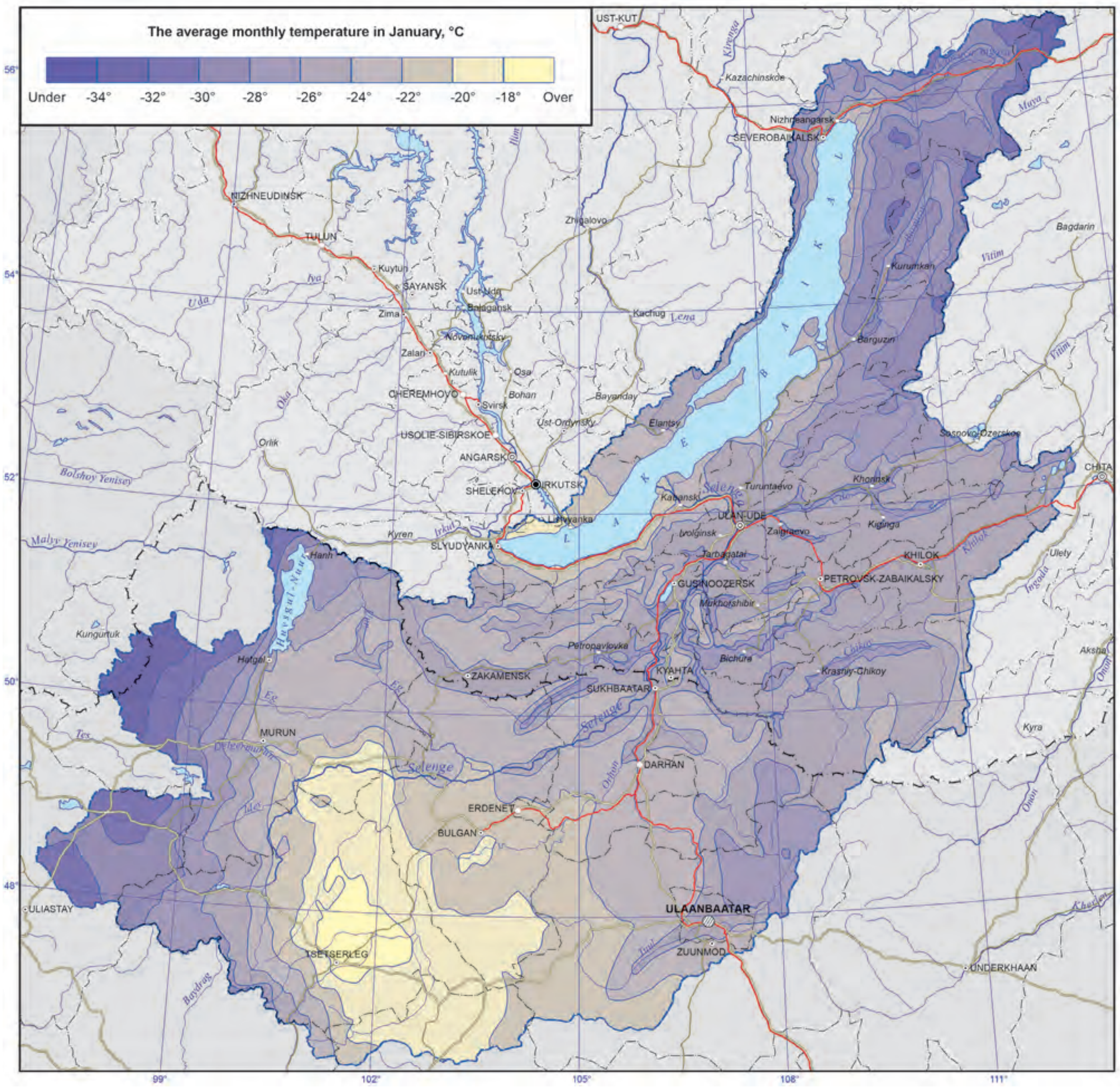
SNOW COVER DEPTH (18)

Mapping fields of snow cover, as well as any geographical fields, are characterized by their spatial and temporal patterns on topological, regional and planetary levels. Information about snow cover is mainly represented by measurements at meteorological stations located in homogeneous standard locations. Snow covers countless diverse landscapes, the characteristics of which are not reflected in meteorological information. Therefore, the primary issue of snow cover mapping is substantiation of its spatial and temporal changes. This goal was achieved by the search of further information through the real data links with better known characteristics of geospace. This approach is implemented on the principles of geographical similarity of processes and statistical regularities.

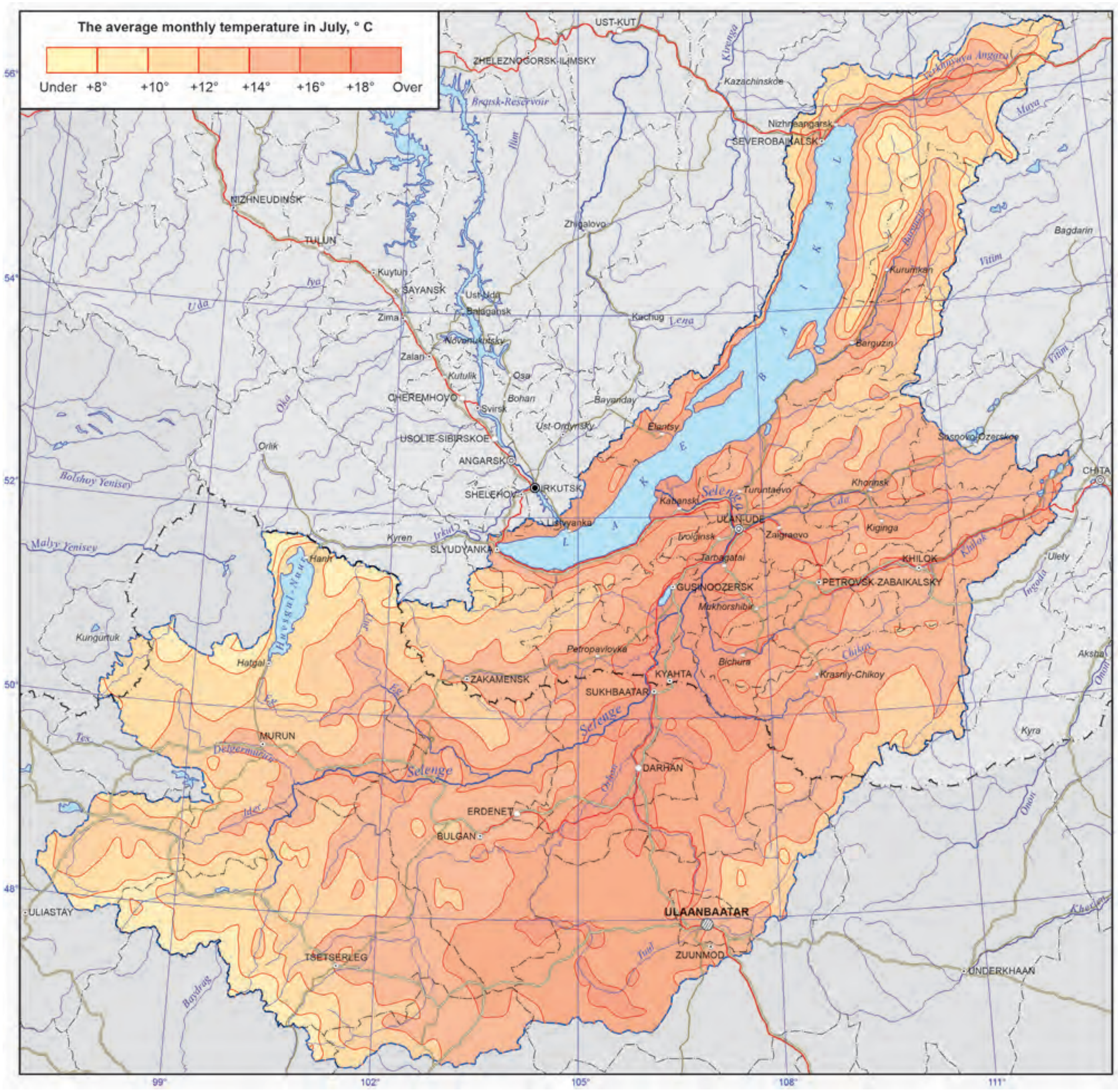
There was a need to solve a number of other key issues. The first one is dictated by current climate warming. We have complete information on snow cover only till warming, according to the data from references representing measurements for the period up to 1968 [References..., …1968]. Other publications include maps of individual components of snow cover of the late 20th century [Atlas of Irkutsk oblast, 1962; Cisbaikalia and Transbaikalia, 1965; Atlas of Transbaikalia, 1967]. At the same time, thanks to the field work within the Baikal-Mongolia region and personal contacts of the authors, there was an opportunity to get acquainted with climate data of 1951-2010 and 1976-2010 in Transbaikalia and Mongolia, and, accordingly, to fix a tendency of temporarily change of parameters of snow cover in the up-to-date period.

The snow cover of the Baikal basin is formed inhomogenously. Its height decreases on the northeast of the Lena-Angara plateau (50-80 cm) to 5-10 cm in the vast plains of Mongolia and Transbaikalia. This is caused by the interaction of powerful north-western air

14. AIR TEMPERATURE. JANUARY



15. AIR TEMPERATURE. JULY



flows with weakened Pacific ones, as well as by precipitation increasing with the altitude and by an increase in the share of their solid constituents. Therefore, in the valleys the snow depth is small, and in the mountains of Cisbaikalia and on the Stanovoe highland it reaches up to 60-100 cm.

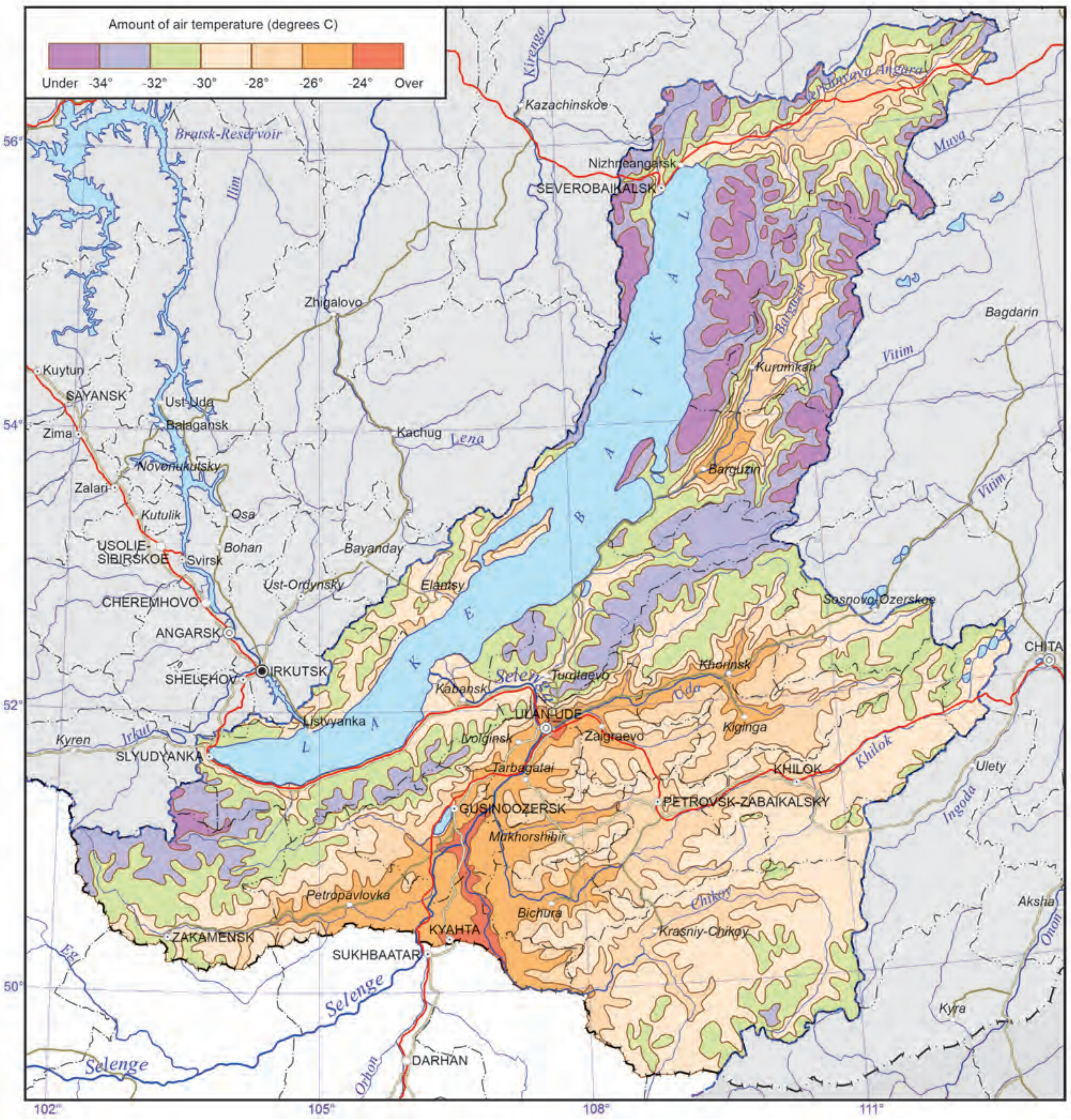
Continuous snow cover is typical for the whole Baikal basin, but due to wind transport within basins with inversions, on the windward and leeward slopes it occurs unevenly. These factors make it difficult to reflect its spatial and temporal state, which is traced according to the data of the snow cover measurements. So, on the shores of Lake Baikal within 460-500 m there are about 70 meteorological stations, and on the slopes of the ranges there are no more than 5 stations. This factor defined the search for correlations of the measurement data of snow depth with better studied factors: with precipitation of the cold period, and with altitudes of the area. In this respect, the snow cover was analyzed at least on 900 meteorological stations within the entire Baikal region and adjacent territories. At the same time, a geographical-functional approach to spatial and temporal analysis of the snow cover was developed. Particular attention was given to determining the depth of snow on the slopes of different exposures. On the windward slopes the snow depths increase up to 70 cm at 1500 m of true altitude and up to 125 cm at 2000 m. Within the goletz zone on the leeward slopes the snow cover is constantly reducing up to 7-12 cm at 2000 m. On the plains its average height ranges from 30 to 40 cm. The exception is provided by the Mongolian Plateau, where in February and March, the snow depth does not exceed a few centimeters.

All contemporary background information is presented in references on climate, published at the end of the last century. Therefore a map of snow depths based on the data obtained till 1968 was compiled. Further, a correlation between the components of the snow cover of the last century with contemporary data for the warming period (1976-2010) is revealed. Using this approach, the opportunity to evaluate the past changes in snow cover over recent decades presented itself.

From 1975 to 2010, the average annual temperatures increased by 2ºC in extremely arid deserts of southern Mongolia, and by 1ºC in the northern mountain Transbaikalia. However, in Northern Transbaikalia the growth $\Sigma T \geq 10ºC$ turned out to be more, i.e. 600ºC, and in arid deserts only 200ºC. In the mountain-taiga landscapes the precipitation remained intact and in arid landscapes it decreased. Consequently, the height of the snow cover in the mountain-taiga landscapes decreased, and the avalanche danger became less threatening. At the same time Mongolian ice coating in Dauria became more active. Thus, according to the identified correlations, the snow cover map compiled according to the data till 1968 can be considered a basic one.

Regional peculiarity of snow depth formation should be emphasized. First of all, it is dictated by the meeting of wet air masses with the surface of mountain slopes. It is possible to distinguish graphically the snow accumulation on the windward and leeward slopes. Air masses, transporting over the water surface of rivers and lakes, are saturated with water and enhance the amount of snow on opposite slopes. These are the locations of weather stations near Vydrino, Snezhnaya, Tankhoi, Vorontsovka and others. The effect of windward and leeward slopes is leveled by depression inversion and generally irregular dynamics of air masses. The data of meteorological stations are more reliable. On their basis, the reading of snow changes according to the generalized spatial and temporal altitudinal gradient is carried out. So, at the levels of 1000 and 1500 m, the snow depth is 58 - 90 and 56 - 86 cm on the north-western slope and on the south-eastern slope, respectively.

16. THE SUM OF AIR TEMPERATURES ABOVE 10 ° C



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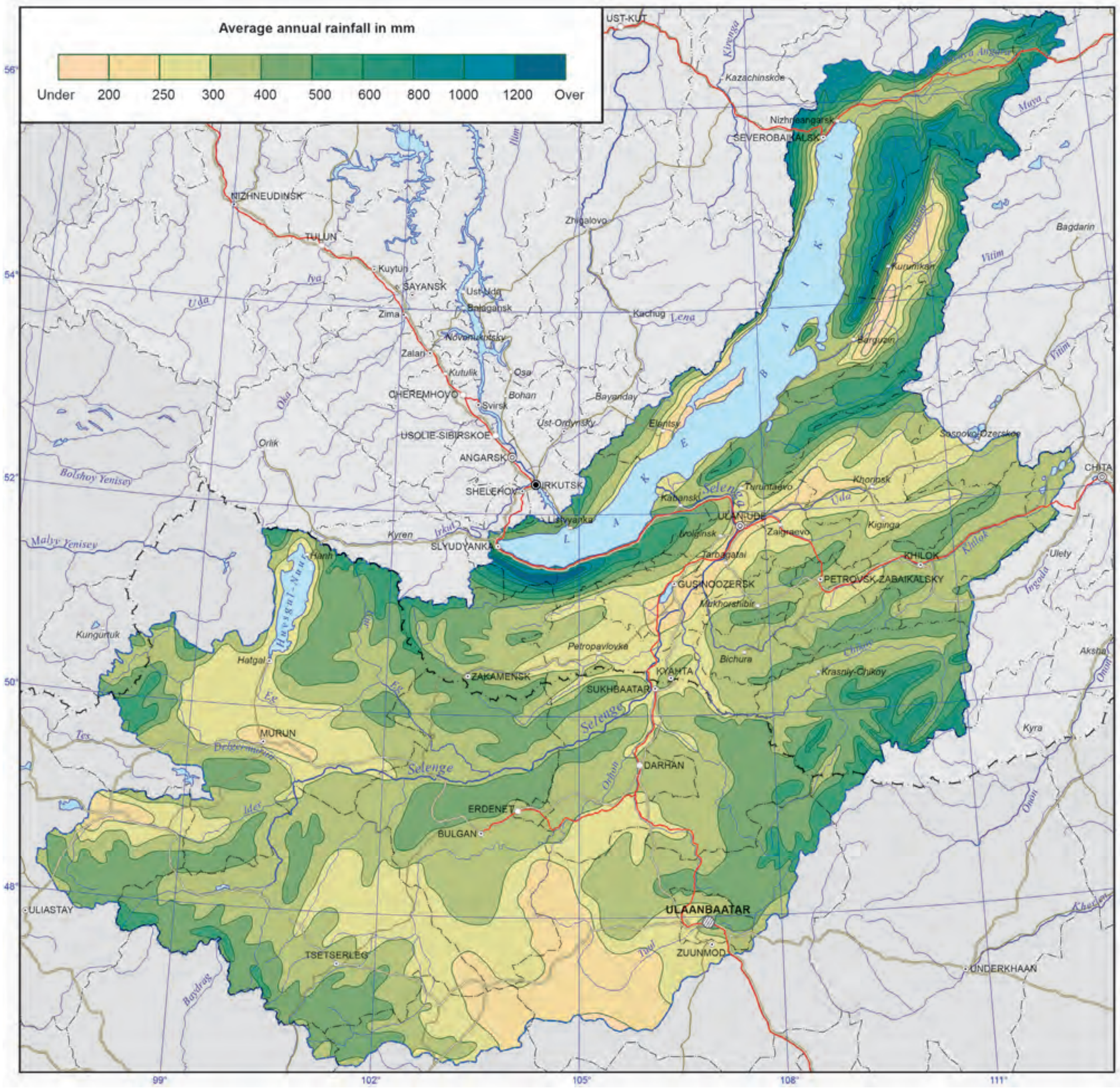
DISCOMFORT OF CLIMATE (19)

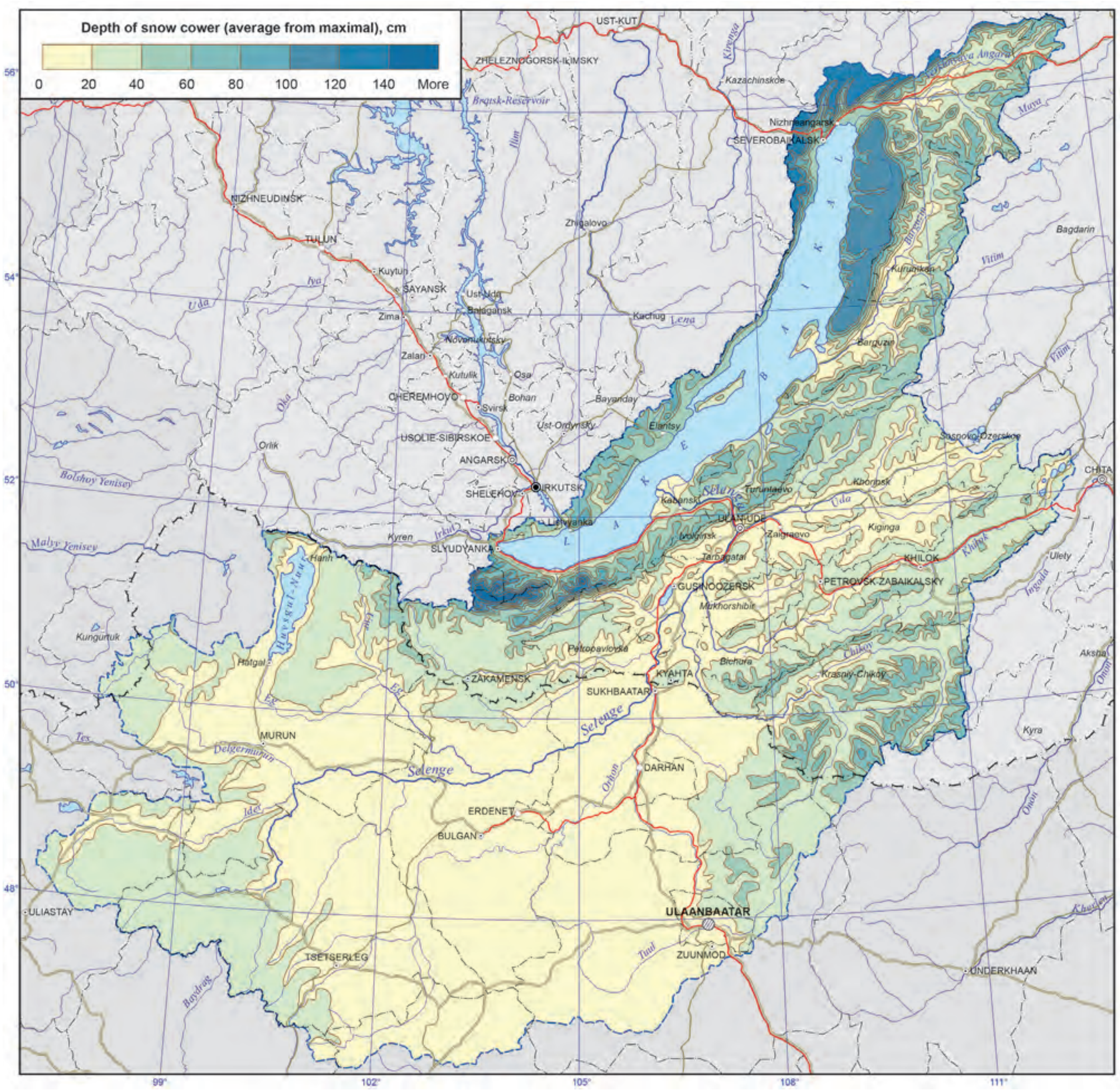
The influence of climate on human beings manifests itself in a variety of fashions, primarily through man's thermal state governed by external effects as well as by internal physiological processes. A comfortable perception of heat occurs when the input of heat and the thermal discharge in human body are in equilibrium. With an intensification of

Lake Baikal at the source of the Angara in the spring.

17. MEAN ANNUAL PRECIPITATION



18. SNOW COVER DEPTH



heat or cold, there is an increase in the tension of the physiological systems, which ensures this equilibrium. The intensity and duration of the impact from significant environmental parameters are responsible for the level of expenditures connected with the attainment of physiological comfort of the human life.

The number of days with normal-equivalent-effective temperature (NEET) above 8 °C is said to characterize indirectly the degree of comfort of a warm period for sensibly dressed people. The duration of periods with daily mean air temperatures below −25 °C and the sums above 10 °C represent the territory's resources of heat and cold. The contrasts of the frost-free period determine the need for and the reliability of covering materials used in vegetable farming. In addition, a combination of low temperatures with wind velocity acts to enhance heat output from open surfaces of human body. The risk of cold weather injuries when the values of reduced temperatures are below −32 °C serves as a forewarning in the case of arranging recreation and working in the open air [Khairullin and Karpenko, 2005]. The duration of the heating period makes it possible to calculate the future expenditures of heat necessary for heating various premises.

The spatial differentiation of the indices under consideration is important within the confines of the basin [Scientific-applied…, 1989, 1991; http://www.meteo.ru]. The mean daily temperature in the high mountains does not reach 10 °C, and its sum varies from 2400 °C in the southern part of the basin to 500 °C along the northeastern shores of Lake Baikal. The mean monthly NEET do not reach 8 °C in separate sections of the shores of Khovsgol and Baikal, and across the remaining territory they vary from 40 to 110 days. The frost-free period varies between 0 to 110 days. The smallest spatial fluctuations correspond to the duration of the heating season (230−305 days). The number of days with the mean daily air temperature below −25 °C is largest in the bottoms of closed depressions and valleys of the western part of the basin. With the wind factor taken into account, the differentiation of the severity of climate is enhanced. The mean values of reduced January temperature drop below −37 °C in Tosontsengel and Khatgal. In the former case, this is due to low air temperatures, whereas the increased wind activity is responsible for this in the latter case.

The combined effect of climatic resources has a substantial influence upon the aggregate volume of expenditures connected with the provision of physiological comfort for humans and the manufacture of products. The background characteristic features of the combined effect of the meteoparameters under consideration on humans and of their duration upon the degree of discomfort of habitation were revealed by using the resource-assessment approach [Bashalkhanova et al., 2012].

Throughout most of the basin's territory the level of climatic discomfort is moderate, whereas it is strong on the northern, northwestern and western margins. The circle diagrams show the volume of the most differentiated parameters of climatic discomfort. The vertical axis is graduated in points from 1 to 5, and reflects the conditions of warm and cold periods. The diagrams corresponding to the most contrasting locations display the leading attributes of climatic discomfort of these territories.

A strong level of discomfort in the northern and western parts of the basin is due largely to the preceding low air temperatures, while on the shores of Khovsgol and in Tariat it is, to a larger extent, caused by a low heat availability in the summertime and, in the aggregate, by increased wind activity. The life of the population on such territories is more expensive and involves a limitation of the kinds of economic activities, shorter periods of stay in the open air, the requirement for a higher energy value of food, heat insulation of clothes and rooms, and a necessitous adjustment of production technologies, equipment and systems to low temperatures. On the other territory, the total duration of impacts of the parameters under consideration lies within moderate limits. The low duration of the period with NEET <5 °C (within 40−70 days) in the middle mountains is compensated by favorable winter conditions.

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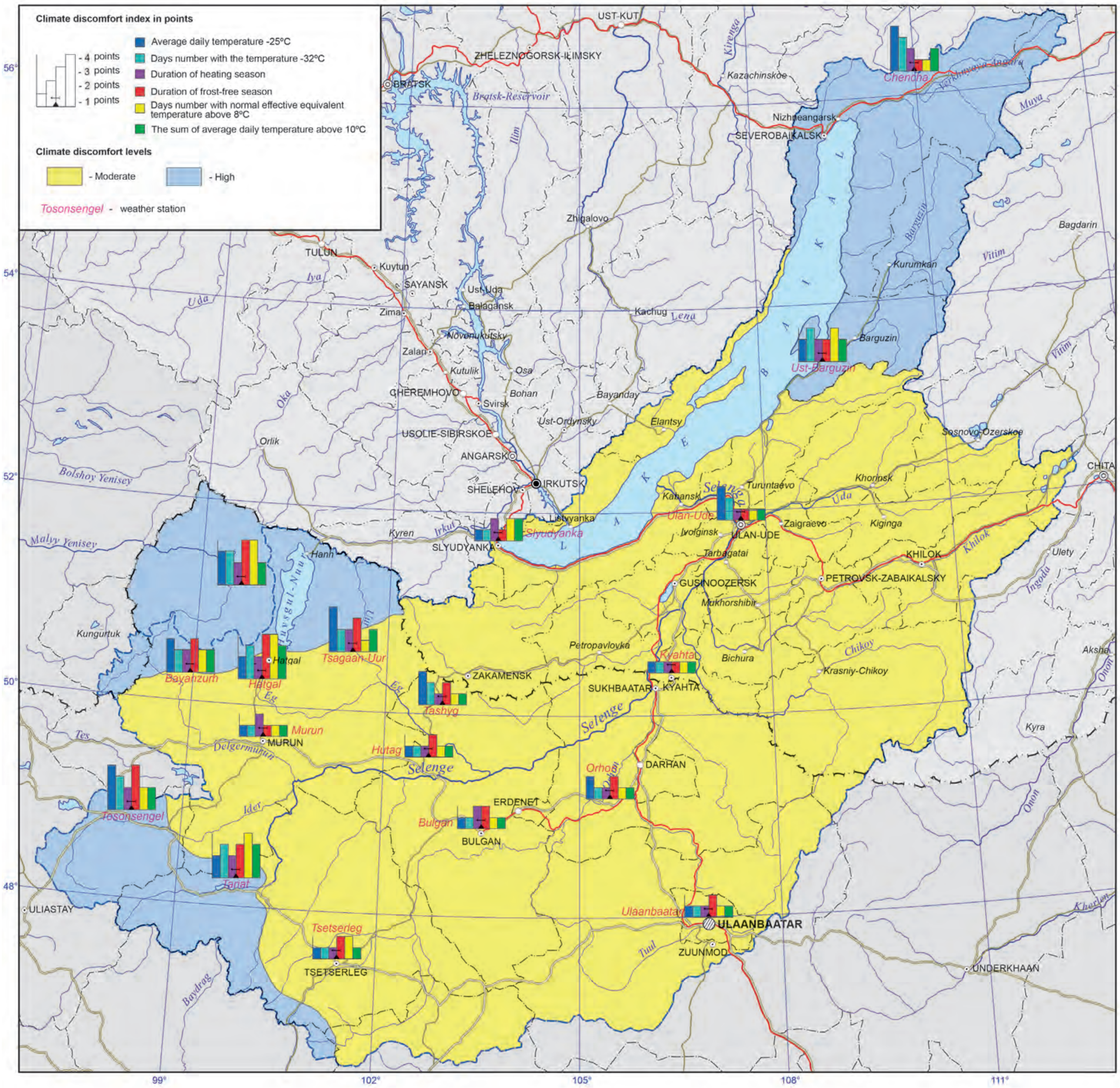
19. DISCOMFORT OF CLIMATE



SELF-PURIFICATION CONDITIONS OF THE ATMOSPHERE (20)

The self-purification capacity of the atmosphere (SCA) over the continental part of the Asian mainland is largely determined by a combination of the interaction of its general circulation with the underlying surface. Because of the influence of regional characteristics of orographic systems, such as an alternation of dissected depressions, large mountain ridges and narrow valleys, this area is characterized by the formation of seasonal local baric centers. In winters, these are the fields of increased pressure in valleys and intermontane depressions, united into the Asian anticyclone centered over the north of Mongolia, whereas regions of closed thermal depressions are typical of summers. In water-filled depressions (such as the Baikal hollow), because of the influence of the water masses, the local field of increased and decreased pressure is observed in summer and winter, respectively. The strength of local baric centers determines the processes of energy and mass exchange with neighboring territories.

Under anticyclone conditions, a standard decrease in air temperature with height (vertical gradient 0.65 °C/100 m) is distorted, and its rise is observed. The mean thickness of sustained winter inversions approximates the anticyclone height, and its largest maximum intensity in January over the even lands (4-5 °C) and over the mountain depressions significantly differ [Sevastyanov, 1998].

Over the narrow valleys of the Russian part of the Baikal basin (Krasnyi Chikoy) the formation of a stable inversion is registered from November, and in some years, from October to March. The inversion intensity is largest in January, and the temperature difference at the station's level and the 850 mb surface reaches 10−11 °C. With an enhancement in ruggedness of relief, there is an increase in the thickness and recurrence frequency of the number of days with surface inversion [Zhadambaa, 1972; Beresneva, 2006]. Thus, the average and the largest thicknesses of inversions over Ulaanbaatar and over the depressions in Western Mongolia can differ by a factor of 1.5 to 2. The highest recurrence frequency of inversions (about 50%) is observed when its thickness ranges from 500 to 1000 m in the former case, and from 1500 to 2500 m in the latter case. In the latter case the temperature difference on its upper and lower boundaries can reach 15−20 °C. Also, the deepest inversions with their high recurrence frequency and the lowest temperatures in the ground layer of atmospheric air are observed in stagnant locations. Due to the formation of inversions most stable in the cold year season over the area under study the free air exchange in the atmospheric boundary layer is disturbed. In such a situation, the quality of the atmospheric air in the ground layer will, to a significant extent, depend on local conditions, namely the recurrence frequency of calms and weak wind velocities, the precipitation amount, and on the amount of incoming impurities.

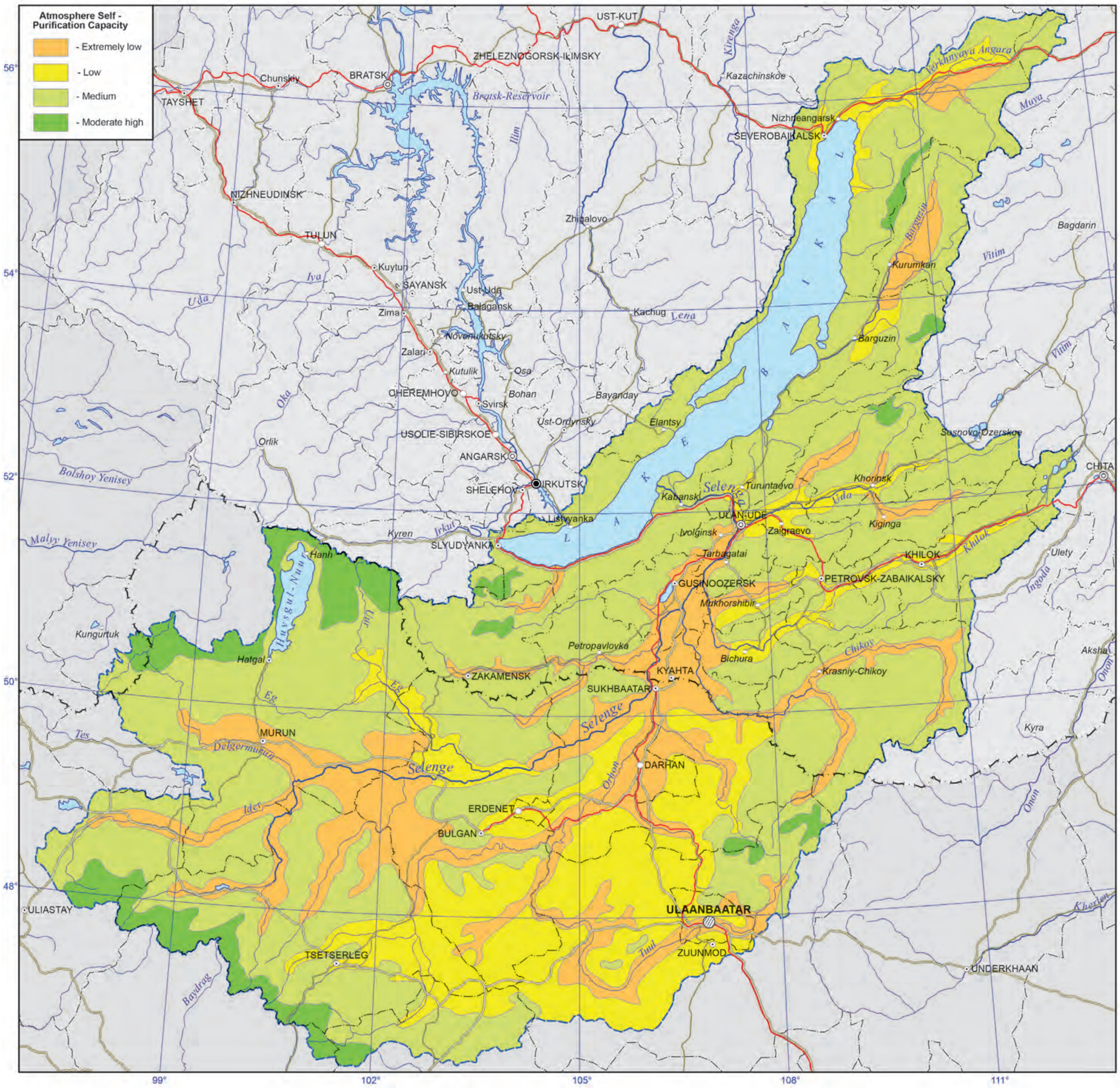
The SCA was assessed following the technique reported by V.V. Kryuchkov [1979] in which it is assumed that almost no self-purification of the atmosphere occurs in the event of the mean annual wind velocity and the recurrence frequency of calms characterizing stagnant phenomena, and with the smallest precipitation amount (table). The SCA manifests itself with an enhancement in wind velocity, a decrease in recurrence frequency of calms, and with an increase in precipitation amounts.

In real situations, the indices show broader combinations. The use of the points-assessment approach makes it possible (by summing up the points of the indices) to take into account the diversity of the existing combinations of SCA: 3−4 points – extremely low, 5 – low, 6−7 – moderate, 8 – moderately high, and 9 – high [Bashalkhanova et al., 2012]. With reference to the mountain territories, allowance was made for the known regularities inherent in changes of climatic indices depending on the location of orographic systems relative to the main transport of air masses. We assumed that with the slope steepness varying from 6 to 20° and the altitude of the location in the range 1500−2000 m,

Indices of self-purification capacity of the atmosphere

Indices	SCA		
	Extremely low (1 point)	Moderate (2 points)	High (3 points)
Recurrence frequency of calms, %	75−50	30−50	< 30
Wind velocity, m/s	< 3	3−5	> 5
Precipitation amount, mm	< 300	300−450	> 450

20. SELF-PURIFICATION CONDITIONS OF THE ATMOSPHERE



average conditions are created for the atmosphere's self-purification. With an increase in slope steepness >20° and with altitudes >2000 m, the probability of a good SCA increases.

What has been outlined above was used in analyzing material reported in thus making it possible to identify in the study area four SCA levels. A moderately high SCA is characteristic for open steep-slope summit planes. A moderate SCA is intrinsic in elevated locations, slope surfaces, and in the shores of Lake Baikal and Lake Khovsgol. On the shores of Lake Baikal, however, Large temperature differences between land and lake contribute to a simultaneous development and superposition of the local forms of circulations, the maximal activity of which occurs in the zone below the height of the surrounding mountain ridges [Lake Baikal Atlas…,1993]. Therefore, here, despite sufficient wind activity (moderate SCA), the removal of pollutants beyond the depressions will be made difficult. A low SCA corresponds to gently rolling interfluves, river valleys, and to the lower parts of slopes. An extremely low SCA is set up in closed intermontane depressions and in the river valleys of the southwestern part of the basin nearby the anticyclone core, and along its periphery – in the areas of river valleys perpendicular to the base flow of air masses.

It should be noted that by taking into consideration the mesoclimatic differences, it is possible to obtain a more differentiated assessment of SCA. It is known that the deviations of the mesoclimatic characteristics from the background ones are most clearly expressed in the wind velocity, temperature and precipitation regimes. Wind velocity change coefficients in various terrain conditions may vary from 0.6 to 2.0 in comparison with the wind velocity at open even spaces [Romanova, 1977; Linevich, Sorokina, 1992], their minimal values are characteristic of the lower parts of slopes, while maximum values are characteristic of the upper parts of windward slopes and peaks. The mesoclimatic differences in moisture conditions are also closely connected with the position of the slopes toward the main air-mass transport, their steepness and character of the geological substate. An increase in the rainfall with the altitude increase and its significant differences on windward and downwind slopes are known.

Furthermore, the seasonal differences in SCA across the study territory will be substantial because of the characteristic features of the atmospheric circulation. Therefore, when planning the siting of production facilities in a particular territory, it is necessary to assess the mesoclimatic potential of SCA.

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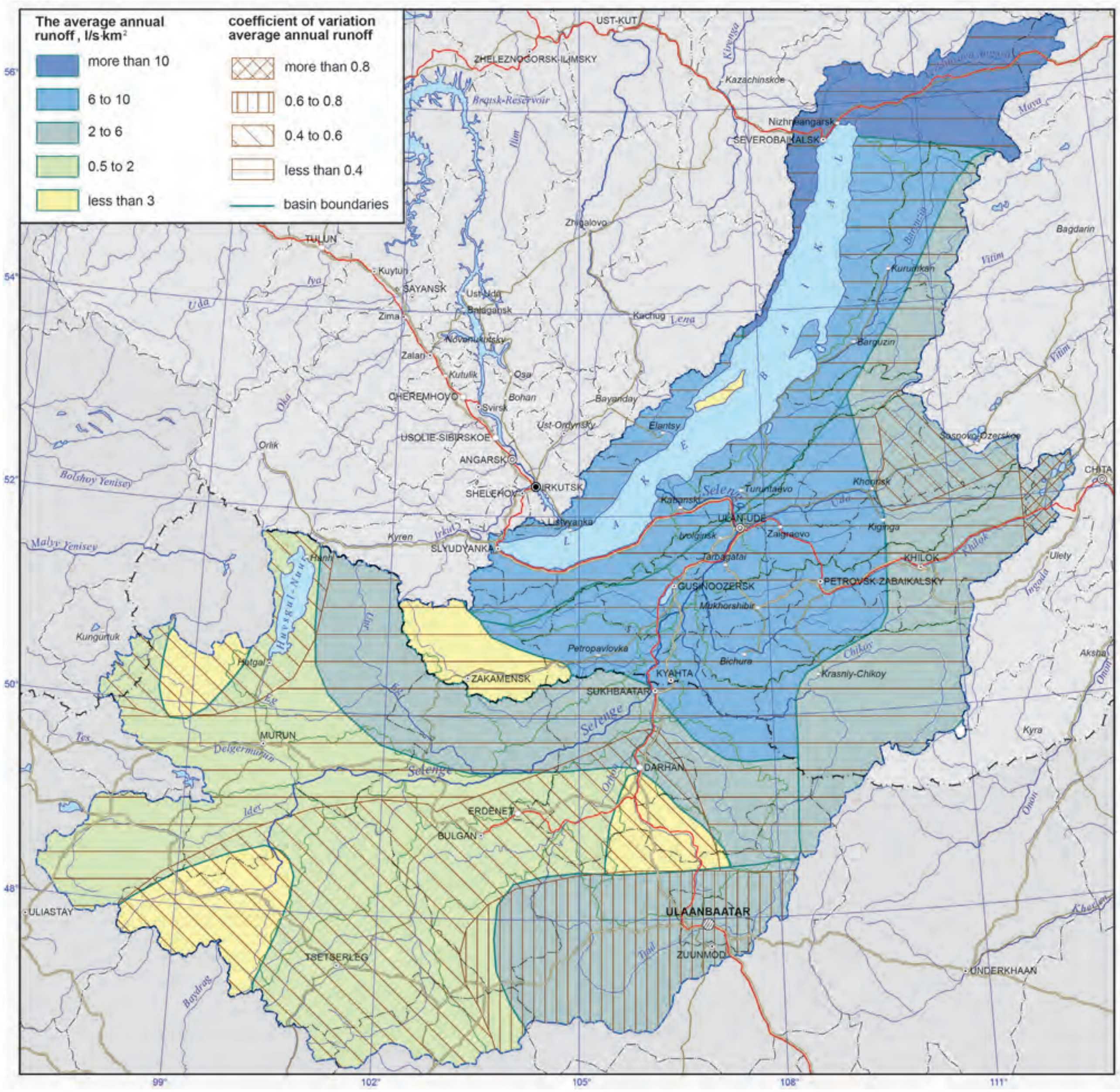
ANNUAL RIVER RUNOFF (21)

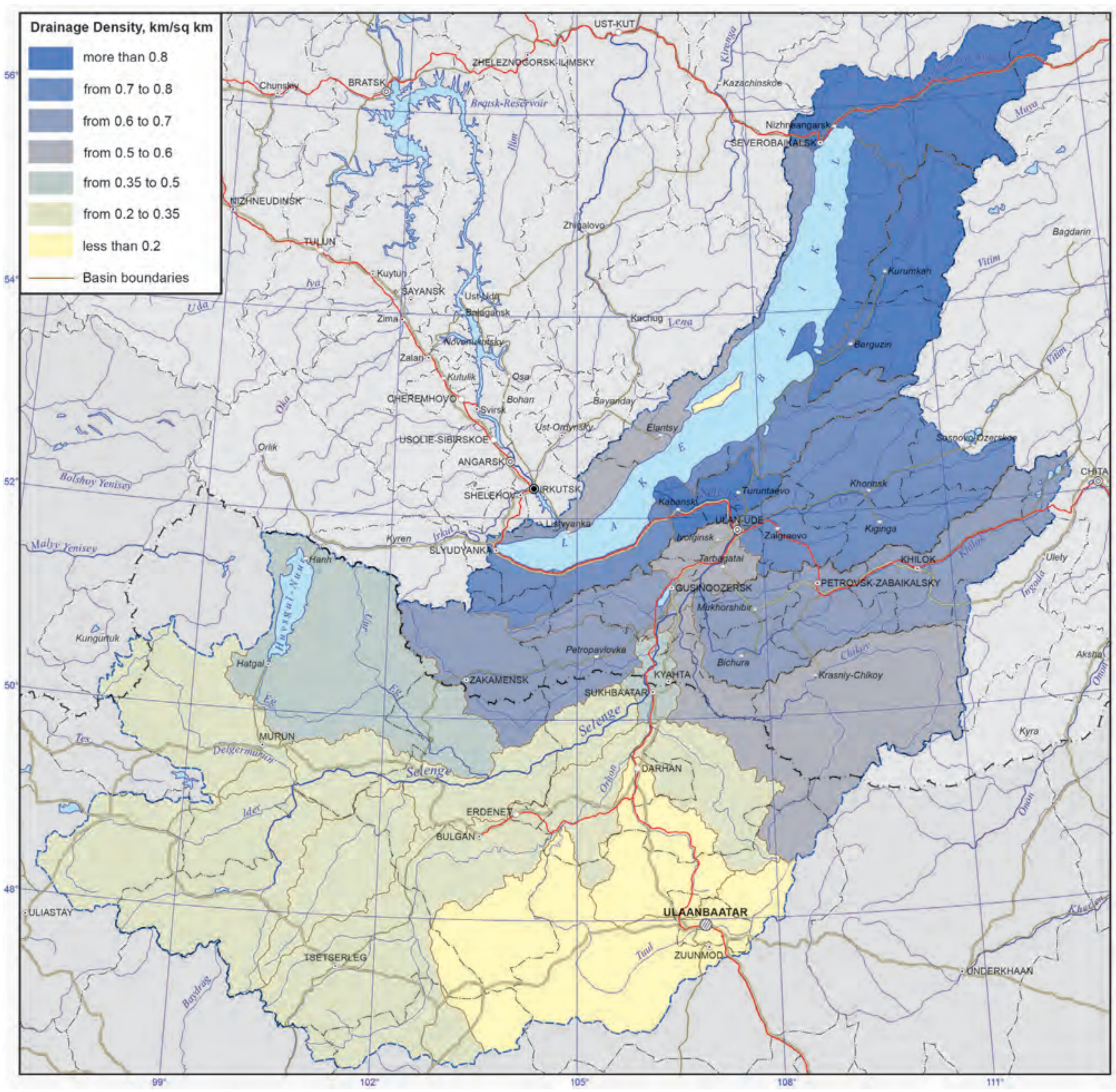
The main rivers of the Baikal basin are the Selenga, giving about a half of the river flow into the lake, with its tributaries, namely, the Chikoy, Khilok, Orkhon, and Uda, as well as the Upper Angara, Barguzin, Turka, etc.

Diversity of natural conditions of the Baikal basin causes large fluctuations in water content of rivers within the territory. The norm of the annual runoff varies from 0.62 to 27.8 L/s km^2. Its value decreases from north to south, in accordance with a general decrease in precipitation and an increase in evaporation discharge. The maximum water content (from 12.7 to 27.8 L/s km^2) is characteristic of the northmost rivers (the Upper Angara with its tributaries: Rel, Tyya, and Kholodnaya), as well as the rivers that originate on the slopes of the Khamar-Daban range (Bol'shaya Rechka, Snezhnaya,

21. ANNUAL RIVER RUNOFF



22. DEGREE OF CHANNELIZATION



Khara-Murin, and Utulik). The rivers of the Ulan-Burgasy range, namely, the Turka and Kika, are characterized by high water content. The increased water content of 5.63 L/s km^2 (r. Eroo) to 9.70 L/s km^2 (r. Chikoy) is characteristic of the rivers of the Khentei-Chikoy highlands. The increased water content in the same range is also observed in the rivers of the Barguzin basin and in the watersheds of the Temnik and Tsakirka rivers, carrying their waters from the northern slopes of the Khamar-Daban.

The rivers of the Selenginskoe middle mountains and watercourses of the Mongolian part of the Baikal basin are characterized by the lowest water content (except for the above mentioned r. Eroo, a relatively high water content amounting to 4.65 L/s km^2 is descriptive of the Tuul River with, which originates in the Khentei mountains). For all other river basins the norm of annual runoff ranges from about 1 to 3 L/s km^2. The average annual runoff of the highly located watersheds of the rivers of the Khangai and Khovsgol regions is in the same range, which is due to the limited access of the moisture-bearing air masses. The greatest differences in the water content are observed in the Orkhon River basin due to combined effects of orography, terrain elevation, latitude, and soil-geological conditions.

The value of the variability of annual runoff has a general tendency of increasing from north to south and varies from 0.15 to 0.65 within the territory under consideration. Exceptions are provided by the sections of the upper reaches of the Khilok and Tuul rivers, where the values of the variation coefficient are much higher. For example, in the r. Khilok–st. Sokhondo section line (A= 1900 km^2) Cv = 1.32. The annual runoff module at this point varies from 0.01 (1978) to 5.84 L/s km^2 (1984). In winter, the river freezes over every year, and dries out in the summer low water years, and in some years there is no river runoff during 9 months (1965, 1967). In the r. Tuul–Ulaanbaatar section line (A = 6300 km^2) Cv= 0.82, which is due to drying and through freezing of the river frequently observed here, as well as to a significant anthropogenic load. In this section line the average water consumption vary within wide limits and their values can vary up to 13 times. For example, Qav. amounted to 5.00 m^3/s in 1972, 60.5 m^3/s in the following 1973, 65.3 m^3/s in 1993, and 7.76 m^3/s in 1996; there was no winter runoff in 60% of cases of the entire observation period.

DEGREE OF CHANNELIZATION (22)

Differentiation of the degree of channelization of the Baikal basin has a clearly pronounced zonal nature: from 0.1 km/km^2 at the south-eastern boundary to 0.9 km/km^2 on the coastal ridges and in the northern territories. A high degree of channelization is characteristic of the taiga zone, especially of ranges and valleys immediately adjacent to the lake. In general, the northern part of the basin is characterized by favorable conditions of flow. Mountainous terrain, steep slopes and the presence of permafrost contribute to a rapid discharge of water into the main water streams, namely, the Upper Angara and the Barguzin, and to the development of the river network. The highest density is specific to the western slopes of the Barguzinsky (0.92 km/km^2) and Khamar-Daban (0.69 km/km^2) ranges. Among the plain territories, the most water-abundant areas are the Barguzin valley (0.89 km/km^2) and the area of the Selenga river delta (0.68 km/km^2).

The middle part of the basin is characterized by the mid-mountain terrain and a high occurrence of sandy and sandy loam soils. The presence of these factors provides for the average degree of channelization ranging from 0.35 km/km^2 in the middle reaches of the Selenga river and 0.55 km/km^2 for the Chikoy river basin to 0.61 km/km^2 for the Khilok and Dzhida river basins.

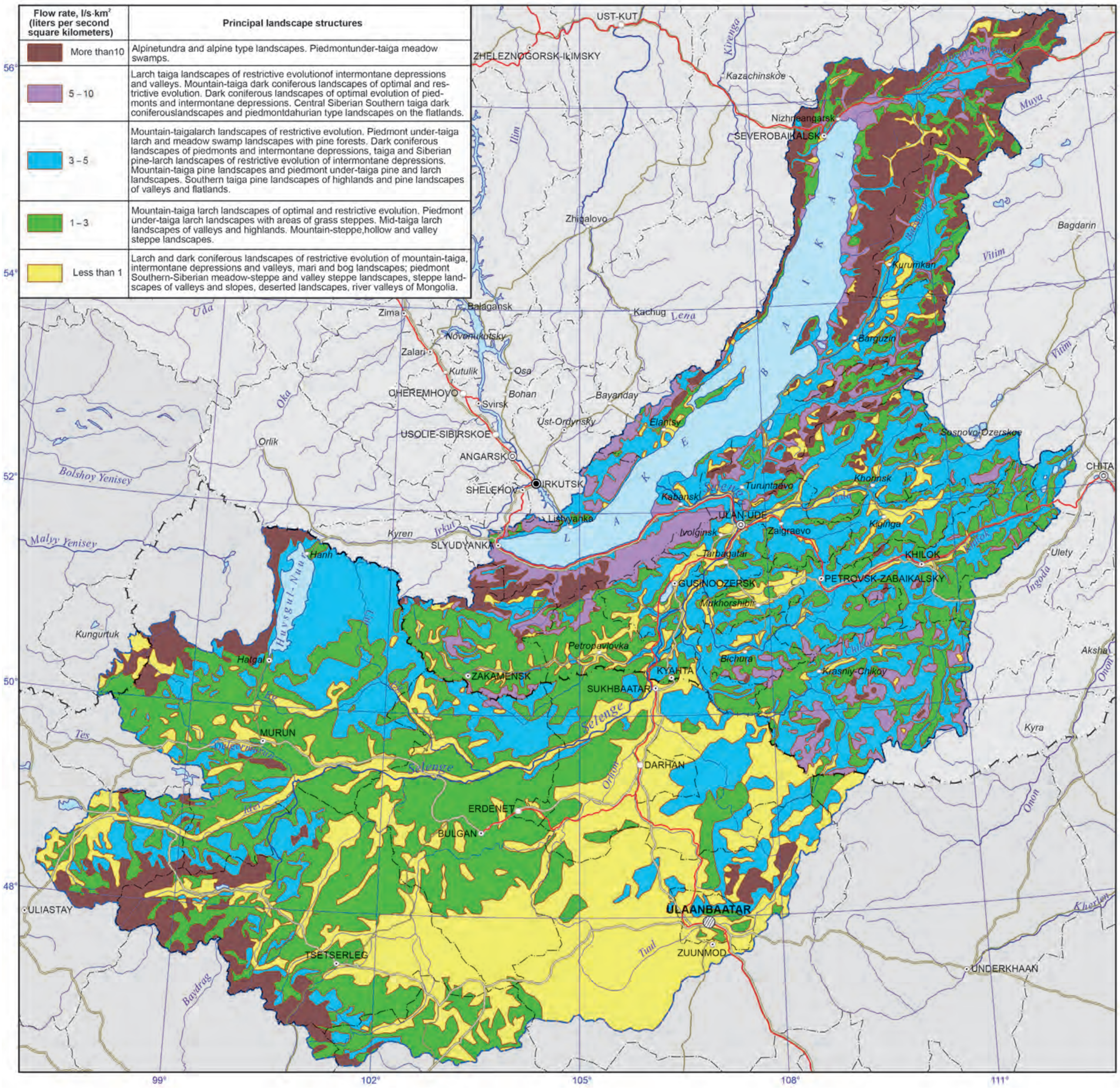
In physical-geographical terms, the south-western part of the basin, i.e. the area of Lake Khovsgol, represents a forest-steppe with the high-mountain depression terrain, and is characterized by a lower degree of channelization ranging from 0.32 km/km^2 for the Delger-Muren river basin to 0.34 km/km^2 for the Egiin-Gol river basin. In the southern dry steppe part of the basin a low degree of channelization is registered. This is especially typical for the Tuul and Kharaa river basins; here this index is below 0.2 km/km^2.

FLOW (23-25)

The map “Mean annual flow” reflects the formation patterns of the water regime of the territory, which are determined by the properties of landscapes to transform atmospheric moisture into the runoff.

For a water body basin, the surface runoff is the total amount of water loss from the watershed landscapes. The runoff rate from landscape complexes is determined by solving the inverse problem, i.e. identification of the connection of flow rate at the main stream station of a catchment with the runoff from landscapes, occupying its area, and is calculated based on the equation $Q_j = \sum q_i f_{ij}$, where j is the index of the river basin, Q_j is its runoff, L/s; q_i is a modification of flow from the i-th landscape complex, L/s km^2; f_{ij} is an area of the j-th basin occupied by the i-th landscape, km^2. Long-term average runoff

23. MEAN ANNUAL FLOW



data for small and medium-sized rivers of theLake Baikal basin were used in calculations for the map construction [Long-term…, 1986, http://www.r-arcticnet.sr.unh.edu]. Characteristics of landscape components were obtained on the basis of the materials on landscape of the Baikal region [Landscapes…, 1977, Natural..., 2009, Landscapes…, 1990, Lysanova et al., 2009]. In accordance with the regional dimension, generalization degree is chosen at the geom level, and their average annual flow moduli are determined. The territory on the map is divided into regions according to five gradations of the module - from less than 1 to more than 10 L/s km^2.

The catchment area of the lake covers a variety of landscape zones and altitudinal belts, which makes a great contrast between the runoff rates. The highest annual flow moduli are formed within the goletz and mountain-taiga landscapes. Steppe and forest-steppe areas are distinguished by the minimum runoff rates, and in the desert regions of Mongolia (the Selenga river basin) flow formation almost does not take place.

The maps of minimum and maximum flow were compiled based on the typological landscape classification represented on the map [Landscapes…, 1977]. In the course of investigation, landscapes of different types were generalized by identifying the most hydrologically informative properties (morphological characteristics, vegetation structure, altitudinal zonation, etc.). As a result, more than 200 landscapes were combined into sixteen types of natural complexes, and runoff rates were determined for them. The moduli of maximum snow runoff and minimum summer runoff were calculated as described above.

Areas with the highest runoff of floods are confined to the mountain ranges and systems with goletz open woodlands and mountain-taiga landscapes. The main areas, distinguished by formation of frequent and high floods are the Baikalsky Range on the north-eastern end of the lake; Barguzinsky Range, located in the south-eastern part of the catchment, and the Khamar-Daban, covering the south-western shore of Lake Baikal. The values of the maximum flow modification are shown in three gradations on the map, namely: less than 25, 25-70, and more than 100 L/s km^2.

Features of formation of the minimum summer runoff in the Baikal basin are associated with the regime of atmospheric moisture, as well as with the effects of altitude and exposition. The calculations and analysis of the minimum summer runoff have shown a relatively high water yield in the low-flow period from high-mountain taiga landscapes and extremely low river flow formation in the central areas of the Selenga river catchment and in Priolkhonie, which are covered with light coniferous landscapes and steppe complexes on slopes and plains. The map shows the value of the minimum flow in three gradations, namely: less than 1.5, 3.0-5.0, and more than 5.0 L/s km^2.

Landscape-hydrological mapping based on the quantitative characteristics of water yield of landscape complexes objectively reflects the hydrological organization of the territory.

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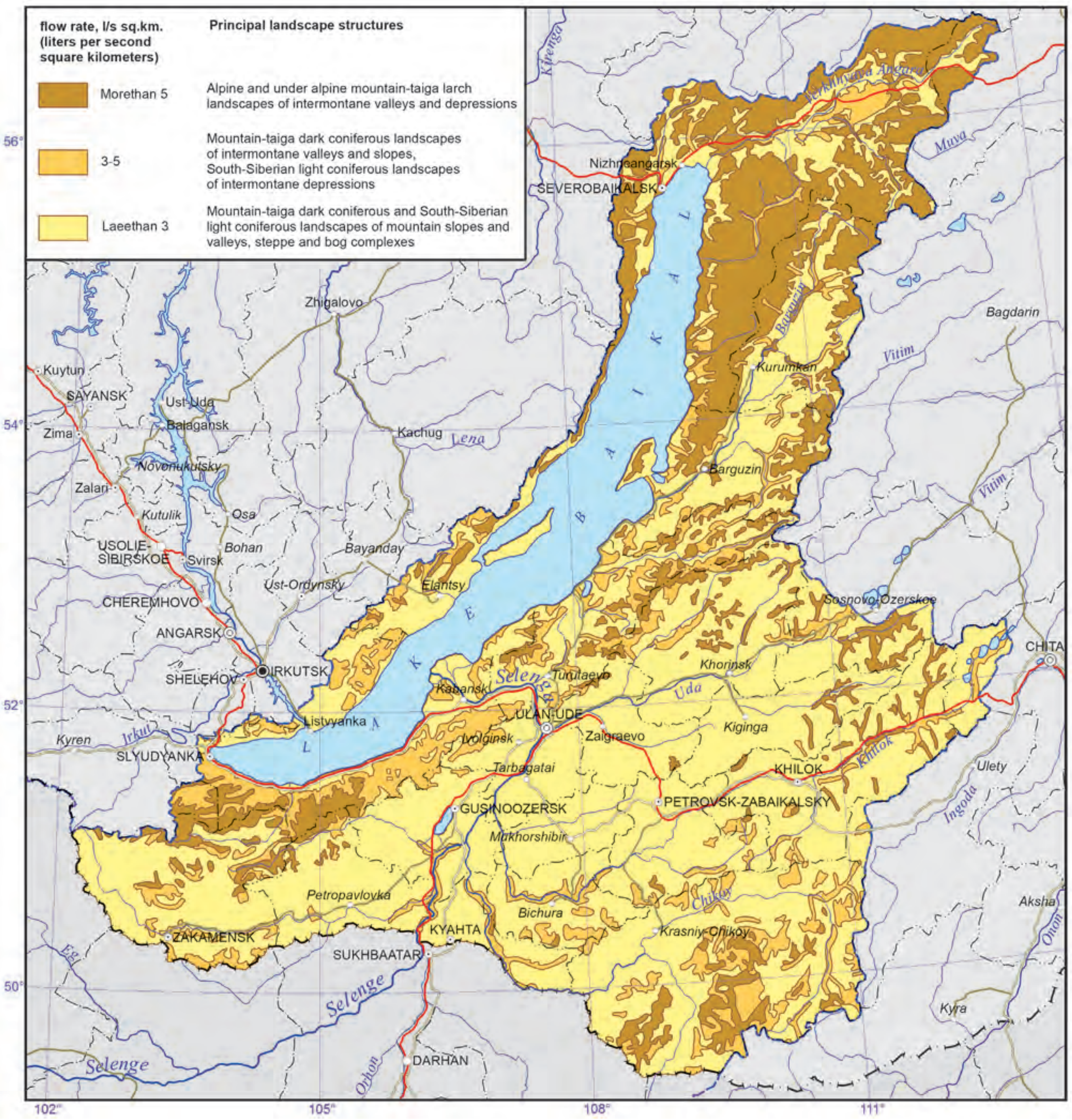
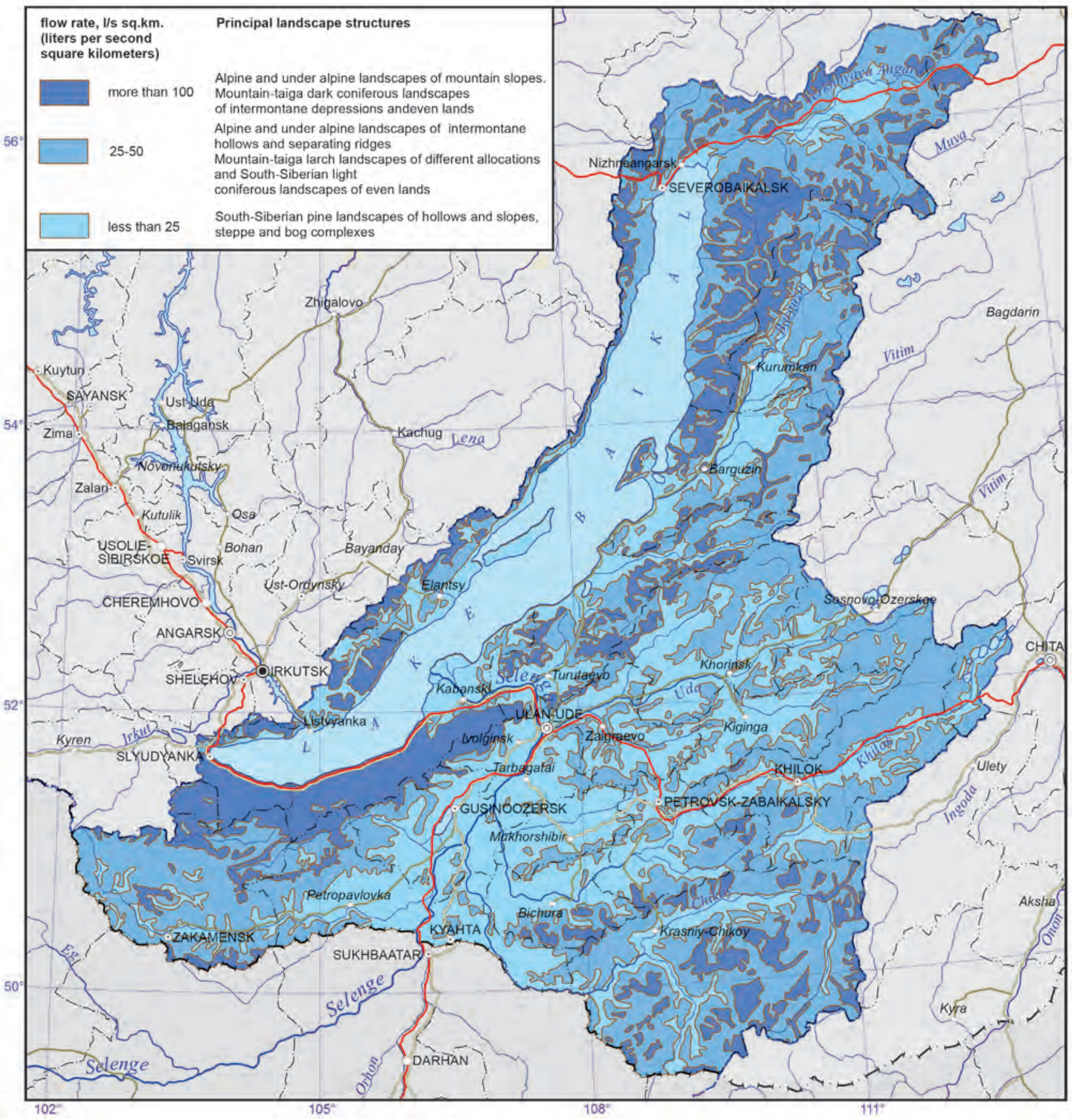
24. MINIMUM SUMMER FLOW



25. MAXIMUM RUNOFF DURING THE FLOOD



FLOODS (26)

The aim of the flood map is to give an insight into distribution of flooding risk on the territory, and level of its danger to human activity and facilities of national economy. The map was compiled on the basis of reference materials of the national water resource inventory [Long-term…, 1986; Resources …, 1973], data on the flooding damage, and archival and cartographic materials.

Flood hazard is characterized by their genesis, recurrence, impact, damage, possibility and appropriateness of forecasting a dangerous situation. T.A. Borisova and A.N. Beshentsev determined the integral risk of floods from the territorial assessment of risk caused by floods [Borisova, 2013] using private maps of disturbances of land of different categories and population (based on the estimation of physical, economic and social risks). Flood danger for the rivers of Southern Baikal flowing from the Khamar-Daban Ridge is determined through an expertise as there are no appropriate calculated data.

Severe floods take place at the Selenga, Khilok, Uda, Upper Angara, and Barguzin rivers. The depth of floodplain inundation does not exceed 0.5-1 m during common floods and reaches 1.8-3 m during severe floods. The height of the water layer increases downstream the rivers: for example, its height at the Selenga river near the settlement of Ust-Kyakhta is 1 m and near the city of Ulan-Ude increases up to 3 m. The longest floods (30-90 days) are observed in the valley of the Selenga river and downstream the river. Shorter floods (up to 25 days) are recorded in the basins of the Barguzin, Upper Angara, Uda, Dzhida, and other rivers. The duration of floods at small rivers, flowing directly to Lake Baikal, is, as a rule, 3-7 days.

The increase of water levels and flow rates in the rivers under study are observed during spring floods caused by thawing of snow cover and glaciers and during summer rain floods. High water floods are not characteristic of rivers located in the southern part. Spring floods are observed in the rivers of the Selenga basin, as well as in the streams running from the Khamar-Daban and Primorsky Ridges. The rivers with spring-summer floods are located in the northern part of the territory (Upper Angara, Barguzin, Turka, Tyya, Rel, Goudzhekit, and others).

Breakup of the ice is often accompanied by ice jams resulting in sharp short-term water level increases. Such local floods are confined to certain areas of narrowing riverbeds or river oxbows. Areas where ice jams are most likely to occur are noted on the Selenga River (Omulyovka Mountain – village of Voznesenovka – Mostovoy sidetrack – settlement of Reid, etc.).

Rain floods usually start from the decrease of spring flood and are observed during the entire summer period. The highest water levels are usually recorded in July-August. The highest intensity of the water level increase is registered at the rivers of the Selenga basin. For instance, during the highest flood in 70 years on the Dzhida River (19/1) it was 4.5 m per day (Khamney level gauge) and 2.79 m per day (Dzhida level gauge). Besides, rapid water level increases of a number of mountain stream tributaries (Khamney, Kurba, Ona, etc.) are associated with their location in the permafrost zone which considerably decreases the infiltration capacity of the soils. Fluctuations of water levels in the Selenga river and in the lower reaches of its tributaries are smoother, which is attributed to the spreading of floods and regulatory influence of the plains. However, the damage from the floods in this area is the most severe as the floodplains are the deepest and flooding is the longest. Moreover, this territory is highly developed economically and densely populated.

Maxima of rain floods on the territory under study significantly prevail over the maxima of spring floods in both absolute value and their number of the total annual maxima [Kichigina, 2000]. The first ones are the most dangerous for the flood formation. The exception is some rivers in the northern regions (Upper Angara, Barguzin, Rel, and Tyya) where the spring flood is the main water regime phase. The map represents the distribution of cross-sections with the dominance of rain flood maxima and with comparable contribution of spring and rain flood maxima. Rain floods cause huge damage as they are widely spread, repeat many times and have a high rate of formation. They can flood both separate small basins and vast territories. Their timely and precise forecast is, as a rule, low. For example, the destructive rain flood that happened in July of 1966 caused a 3 m water increase in the Tuul river, and for several hours the city of Ulaanbaatar submerged and 130 people drowned. Only for the Republic of Buryatia the damages in the Selenga river basin amounted to about 1.4 billion roubles in 1971, 0.7 billion roubles in 1973 and 40 billion roubles in 1993 (based on current prices). In Mongolia the damages are considerably lower due to the specific settlement patterns and the unique features of the economic use of alluvial lands.

On the southern coast of Lake Baikal (from the Mysovka River mouth to the Angara River outlet), on the south-eastern slope of the Baikal Ridge and in a number of the Selenga River tributaries, floods are often aggravated by mud flows [Makarov, 2012]. Mud floods are caused by heavy rains at the sites with significant slope steepness and easily washed-away loose soil. Mud flow processes mostly develop in the near-mouth areas of the rivers of the northern slope of the Khamar-Daban Ridge and along the Circum-Baikal railway. Mud flows have very destructive force, and they are able to cause significant damages. The increase of water level in such small rivers as the Pokhabikha, Tiganchikha and others can be caused by thawing of ice crust formed as a result of freezing of their river beds.

In general the rivers in the Baikal basin are related to high flood probability ones. Small floods on certain rivers are registered almost annually. Recurrence of severe floods over the period from 1936 to 2012 amounts to 5-12%. According to statistics the most severe last century's floods were registered in 1932, 1936, 1971, 1973, 1993 and 1998.

The height of the water level on the floodplain and the duration of high water stand are important characteristics. The height depends on both severity of a flood and hydrological and morphological properties of a river. During floods on the Selenga river near the village of Ust'-Kyakhta is comes to 1-2 meters; in the conditions of a narrowing valley and a sufficient stream supply by the Dzhida and Chikoy rivers near the village of Novoselenginsk it sharply rises and may exceed 4 meters. By the city of Ulan-Ude it drops down to 2.2 meters and to 1 meter in the vast delta.

The duration of high water stand varies. Long-term water floods on a floodplain (25-40 days) are observed in the valley of the Selenga river and in the lower course of the Chikoy river. Shorter-term floods (up to 25 days) are registered in the basins of the Barguzin, Upper Angara, Uda and Dzhida and other rivers. On small mountain streams floods usually do not exceed 3-7 days.

3 to 5% of the basin's territory is exposed to recurrent floods. However, these are largely the most developed and settled lands. For instance, within the Russian part of the Selenga river basin about 4.000 sq km of inundated landscapes may be exposed to flooding; 231.600 hectares or 9.5% are agricultural lands. On the rivers of the northern part (the Barguzin, the Upper Angara) almost 2.000 sq km are flooded, a quarter of them agricultural lands.

The list of settlements on the territory of the Baikal basin, which are at risk of flooding, was compiled using summarized archival and reference data. In total, 75 settlements were included into the flood zone. The settlements with the highest risk of flooding are marked on the map.

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SELF-CLARIFICATION OF SURFACE WATERS (27)

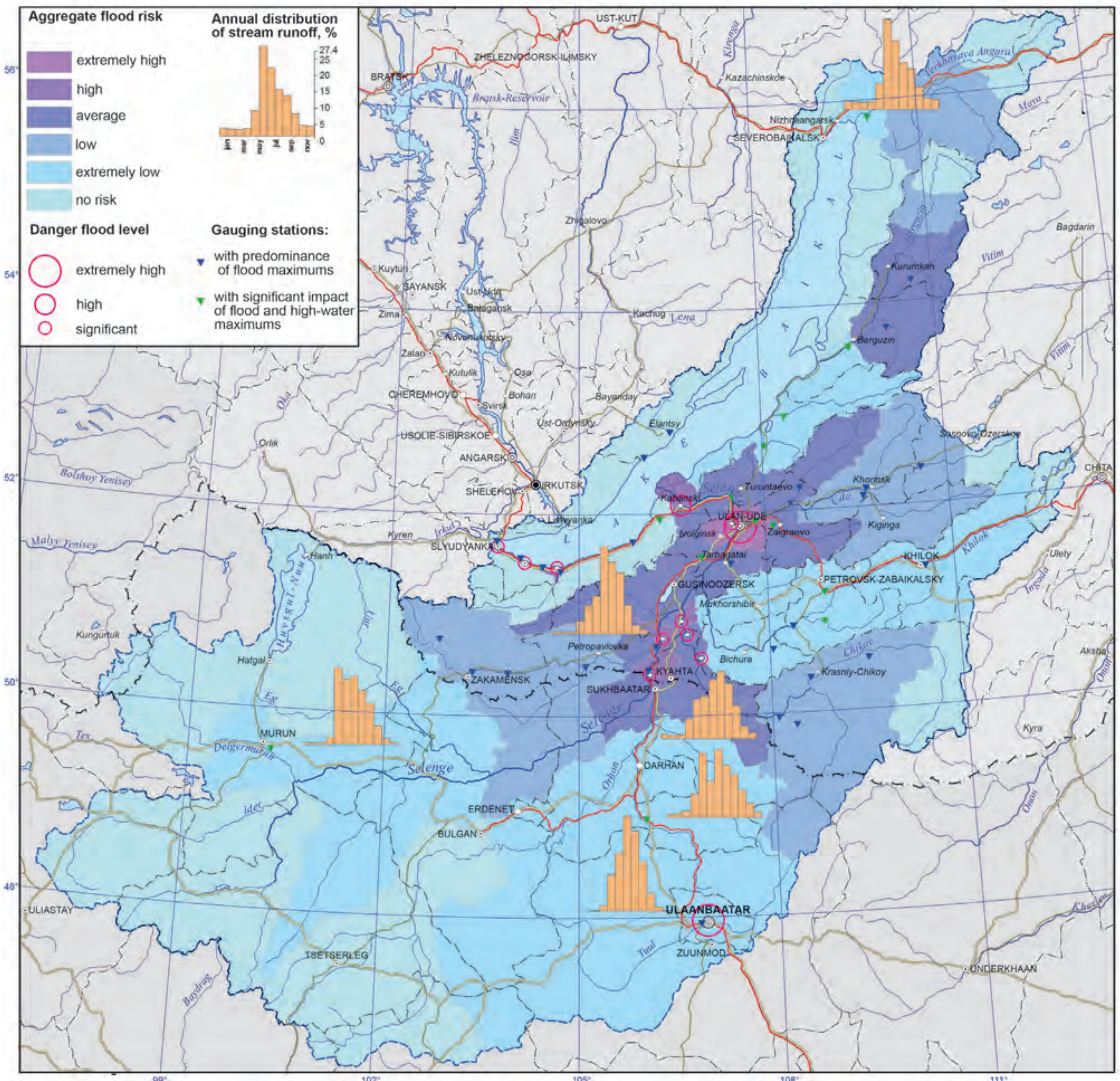
The map «Self-clarification of surface waters» reflects the potential of natural waters of the territory to neutralize the introduction of pollutants into water bodies and to restore the original properties and composition of water. The self-clarification capacity of water bodies is formed by chemical, physical and biological processes; the dominant role here is played by dilution and oxidation.

The process of dilution of pollutants with the waters of rivers and water bodies is directly dependent on the amount of water mass, and it can be characterized by the influx of water into a reservoir and the water flow rates in rivers during the minimum runoff (the largest environmental stress conditions). Given the lack of material on the inflow for the majority of the lakes, the evaluation of diluting ability was carried out according to the average annual water volume in the reservoirs.

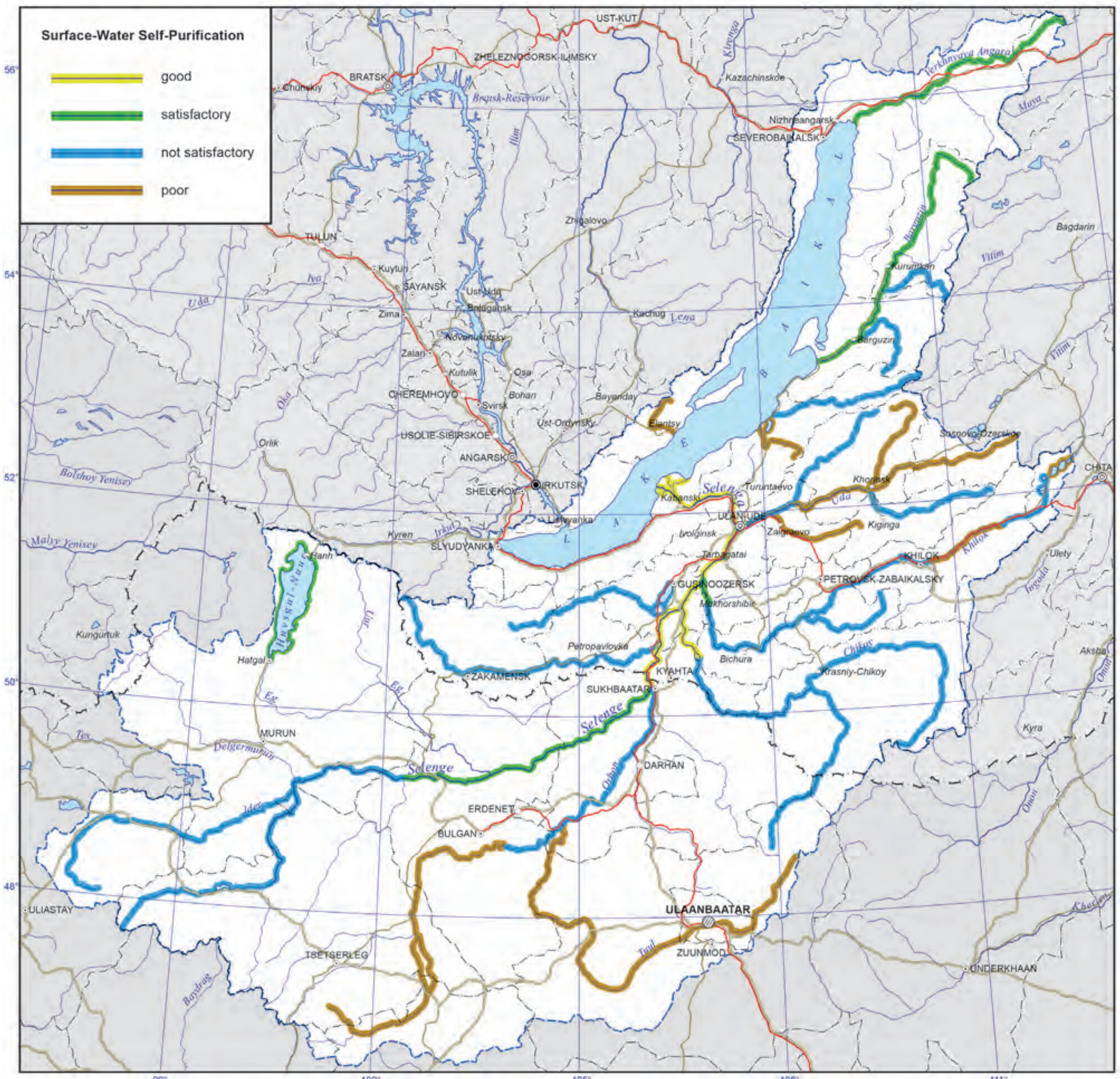
The oxidation of organic substances depends on the amount of oxygen from the atmosphere, and is determined by the conditions of mixing and temperature control of water bodies. The amount of oxygen required for oxidation of the process is specified as the biochemical oxygen demand (BOD5 and COD) and standardized for various substances at the water temperature of 20ºC. Because of insufficient data on BOD5 and COD, the oxidative reactions intensity was assessed indirectly based on the average temperature within the warm period and the intensity of water overturn.

The water overturn in the reservoirs is influenced

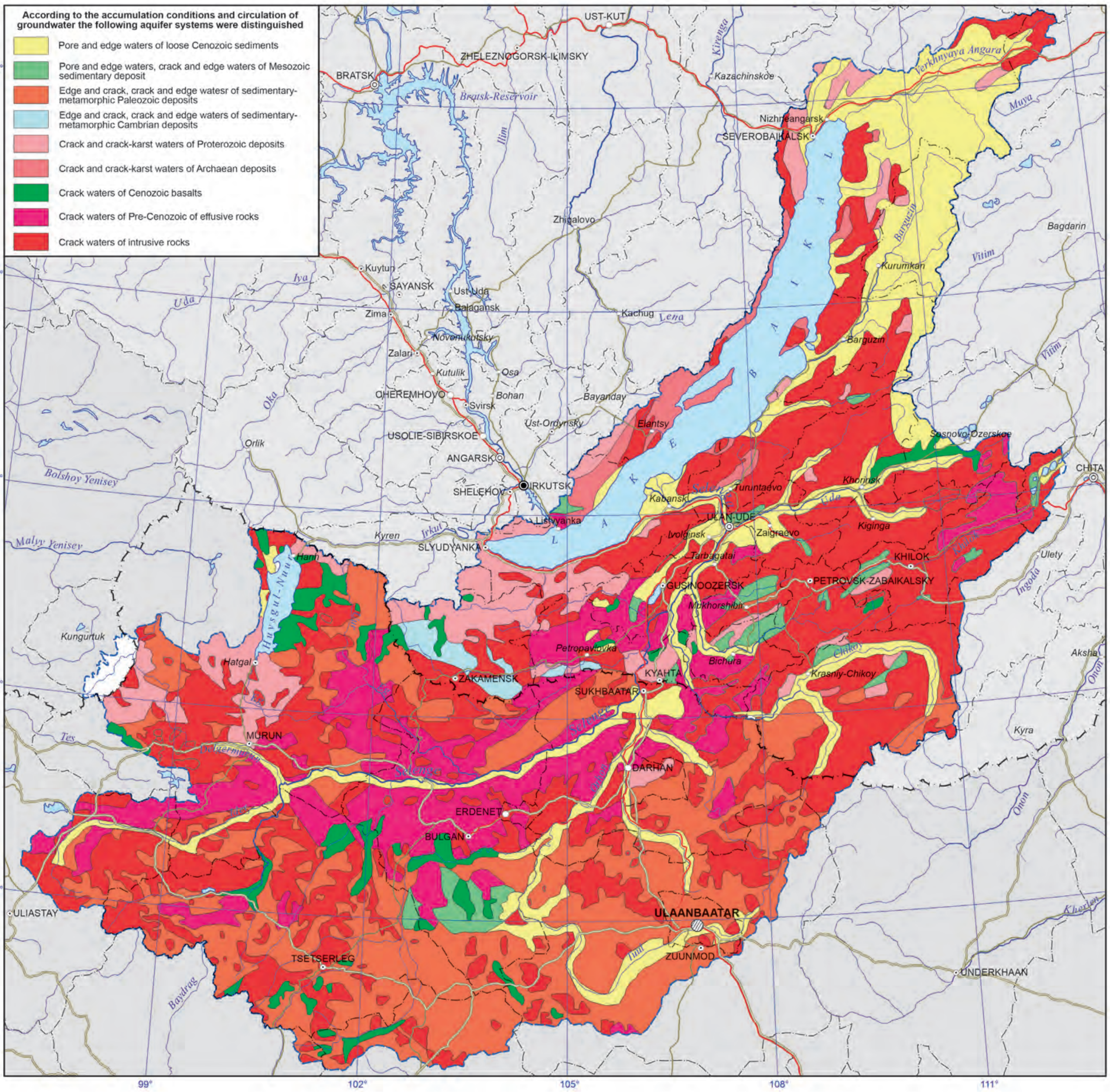
26. FLOODS



27. SELF-CLARIFICATION OF SURFACE WATERS



28. GROUNDWATERS



by the differences of density and dynamic parameters, such as churning, wind-induced surges, etc. The data on churning observations (as well as the inflow observation) for the waters of the Baikal region are not sufficient, that is responsible for indirect assessment of dynamic performance. Here, morphometric parameters are used as an indicator of overturn intensity, namely: the ratio of depth and area of the mirror, which characterizes the potential churning power. In watercourses the channel slopes are criterial for the overturn degree; the flow velocity depends on them.

As a result, the assessment criteria of self-clarification conditions of surface waters are temperature, flow rate and volume of water, stream slopes and morphometric parameters of reservoirs. According to the regional dimension of the territory the analysis was performed for medium and large catchment areas of the rivers (4 – 6th according to Strahler's stream order) and lakes.

The parameterization of these characteristics is carried out with the help of statistical methods and comparative analyzes with the development of special scales and matrices. The inventory data on more than 200 waterways and 12 lakes and reservoirs of the Baikal basin was used for the map construction [Long-term…, 1986; Surface water resources..., 1972, 1973]. For most rivers on the territory the overturn intensity was determined for sections according to a longitudinal gradient. The range of slopes is divided into four groups: from the minimum values (0-2 ‰) for plain areas to the maximum (over 15 ‰) in the mountainous areas. The water temperature during the warm period was calculated as the average for four months (June - September), as on the rivers of the region's the water temperature transition over 0 °C is registered in May and October. The temperature scale is divided into three intervals - less than 10, 10 to 15, and above 15ºC. The water volume required to dilute pollutants was determined on the basis of the minimum 30-day river flow rates (seven gradations - from less than 10 to more than 800 m^3/s) and the average annual water amount in water bodies (four gradations - from less than 10 to more than 500 m^3).

Determination of the self-clarification conditions of rivers and water bodies was carried out in stages. Primarily, transformation of pollutant by biochemical processes was estimated, and then pollutant dilution conditions were analyzed. As a result, four categories of self-clarification degrees of water bodies were defined.

On the map the self-clarification conditions of water bodies are shown with colored along-channel linear curves and with shadings. The most favorable self-clarification conditions within the Baikal basin develop in some areas of the Selenga river. Most of the water bodies of the territory are classified as having satisfactory conditions.

The self-clarification capacity can be regarded as the criterion of sustainability (preservation of properties) of aquatic ecosystems to anthropogenic impact, and the map can be considered an element of environmental potential assessment of the area.

References

Long-term data on the regime and surface water resources. The Baikal basin. (1986). Vol. 1, no. 14, Leningrad: Gidrometeoizdat, 361 p.

Surface water resources of the USSR. (1972). Vol. 16, no. 3. Leningrad: Gidrometizdat, 595 p.

Surface water resources of the USSR. (1973). Vol.16, no. 3, Gidrometeoizdat, 400 p.

GROUNDWATERS (28)

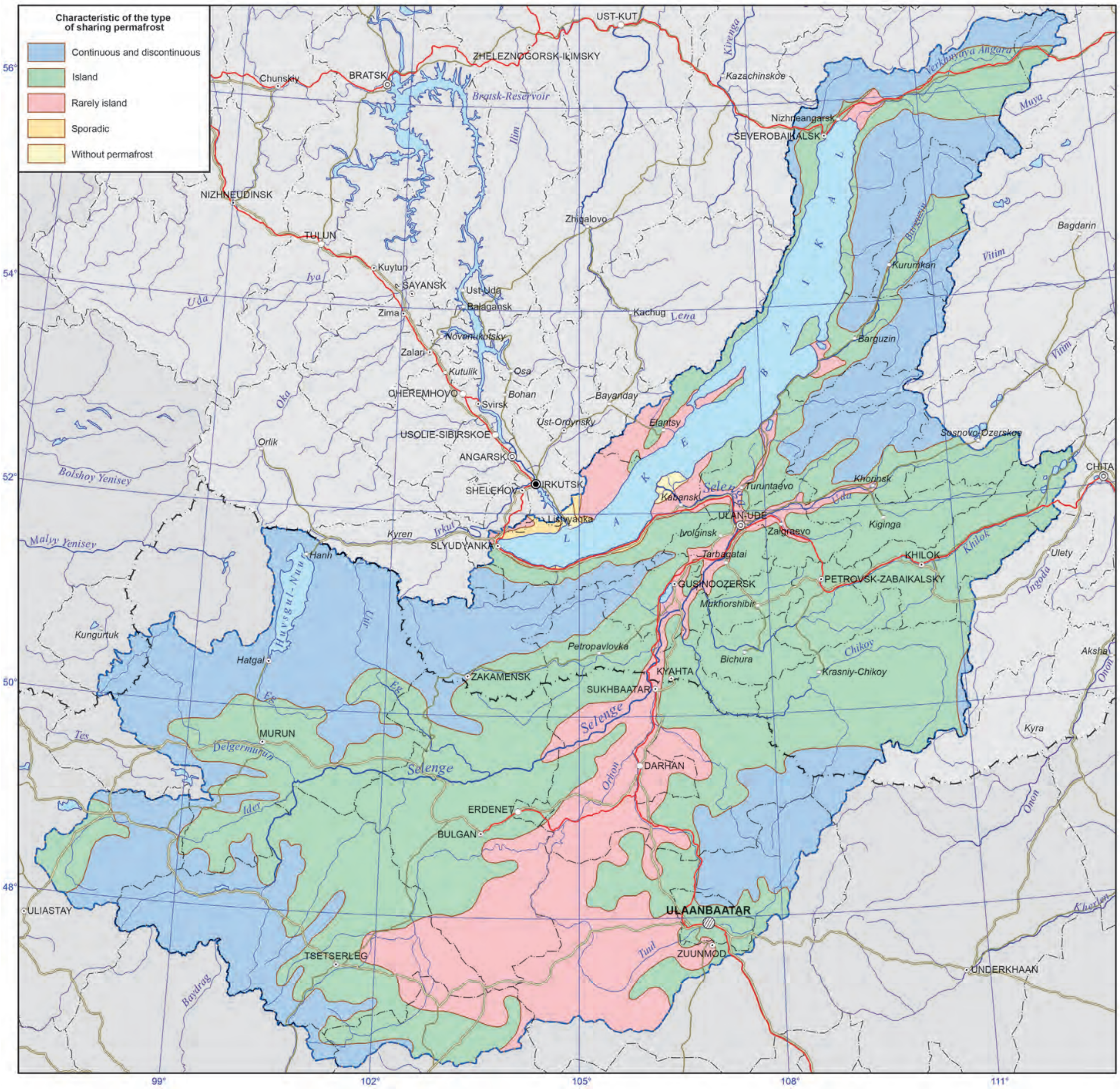
The map is based on generalizing materials of the Institute of the Earth's Crust, and the Geological Surveys of Buryatia, Chita and Irkutsk using hydrogeological maps of 1:5000000 [Atlas..., 1983] and 1:4500000 scales [National Atlas ..., 1990].

During mapping the method of mapping the main aquifers (hydrogeological formations) was applied. Aquifers are distinguished according to structural and hydrogeological features, the prevailing type of water-ermeability, and reservoir properties of rocks.

In the Baikal basin pore-edge waters, confined to loose unconsolidated sediments of Mesozoic and Cenozoic age, have a wide distribution, as well as crack waters in all lithified metamorphic, igneous and sedimentary rocks of different ages from the Archaean to the end of the Paleozoic - Mesozoic inclusive.

Hydrogeologically, the Baikal basin is a complex

29. PERMAFROST ZONING



system of artesian basins and hydrogeological massifs. Artesian basins occupy intermontane depressions composed of loose rocks of the sedimentary cover and crystalline basement rocks. They are characterized by pore-edge waters of the zone of active water exchange and crack waters, often pressure waters, and foundation waters. Hydrogeological massifs are composed with crystalline rocks of mountain- folded frame and can accommodate crack waters of exogenous fissuring. Thickness of the zone of active water exchange does not exceed 100-150 m.

Most watered are karst carbonate rocks, as well as zones of tectonic dislocations, intersecting the cropping-out foundation or spread along the contacts of sedimentary-metamorphic rocks with igneous and metamorphic rocks. They are often traced by upward unloading both of cold and thermal waters.

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National Atlas of the Mongolian People's Republic / Ch. Ed. Mongolian Academy of Sciences Sh Tsegmid, member-correspondent. USSR Academy of Sciences VV Vorobyov - Ulan Bator - Moscow, 1990.

PERMAFROST ZONING (29)

Permafrost occurs in abundance within the Baikal basin. According to the extent of spreading, thickness of a permafrost section and its temperature, the following five types of areas of permafrost distribution are distinguished: 1) continuous and discontinuous, 2) insular, 3) sparsely insular, 4) sporadic, and 5) without permafrost.

Continuous and discontinuous permafrost is developed on all relief features in the mid- and high-mountain and goletz areas. Unfrozen rocks occur only under large rivers, lakes and in the zones of tectonic faults with the discharge of subsurface water, along the fissures of exogenous weathering, as well as on sands, gravels and karsted rocks. The permafrost thickness reaches 100-300 m, and up to 500-600 m on watersheds. The average annual temperature ranges from -0.5 ºC to -3 ºC. Frost mounds, thermokarst, frost weathering, aufeis formation, kurum (rock stream) formation, and solifluction should be mentioned among the prevailing cryogenic processes and phenomena.

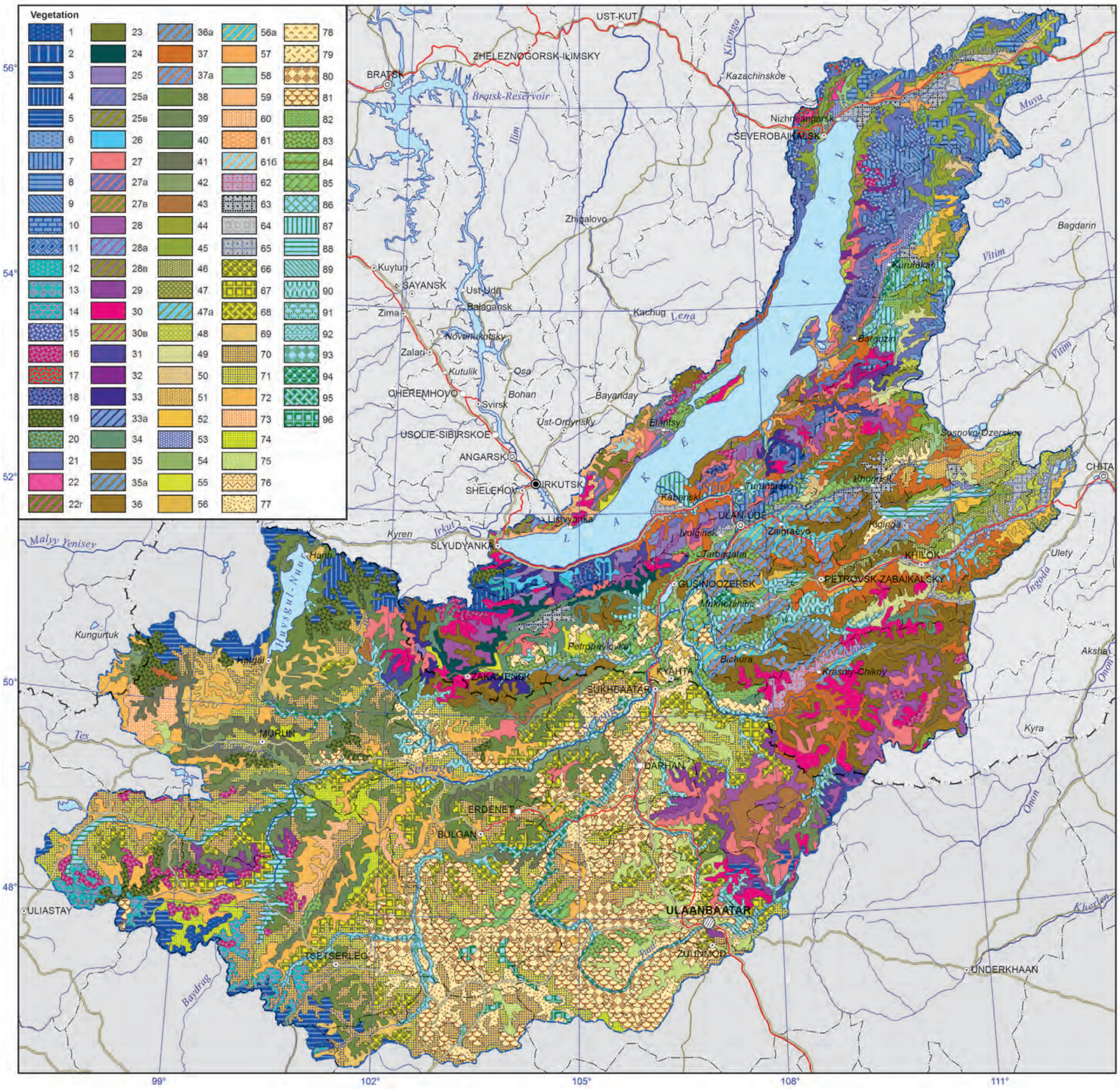
Insular permafrost. The permafrost thickness reaches 50-80 m. Islands of permafrost occur on all relief elements, but usually only in wet, waterlogged or shaded areas, and in mountains above abs. alt. of 1000-1200 m. Sand massifs and karsted rocks are usually unfrozen. The average annual temperature of permafrost ranges from -0.2 ºC to -1ºC. Thermokarst, frost mounds, aufeis formation, solifluction, and frost fracturing of soil are distinguished among the prevailing cryogenic processes and phenomena.

Sparsely insular permafrost occurs in waterlogged areas in valley bottoms, and at the bottom parts of northern slopes of hills, composed of peaty (from the surface) clay rocks. The permafrost thickness reaches 20-30 m. The average annual temperature of permafrost ranges from -0.1ºC to -0.5ºC.

Sporadic permafrost. Individual islands and lenses of permafrost occur only in wet lowlands, composed of peaty (from the surface) clay loams and sandy loams. The permafrost thickness reaches 10-15 m. The average annual temperature of permafrost varies from 0ºC to -0.2ºC. Seasonal frost mounds, relic thermokarst, and frost fracturing of soil are distinguished among the prevailing cryogenic processes and phenomena.

The area of *only seasonal* soil freezing has become of widespread occurrence in the Angara river valley and the Selenga river delta. Permafrost patches and neoformations are possible when developing a territory, composed of clay rocks. The depth of winter freezing of rocks ranges from 2-2.5 m in clay loams to 2.5-3 m in sands. Ground heaving, frost fracturing of soil, and relic thermokarst should be mentioned among the prevailing cryogenic processes and phenomena.

30. VEGETATION



VEGETATION (30)

The map “Vegetation” is an overview-reference geobotanical map. All available different-scale cartographic materials on the vegetation of southern East Siberia of the Russian Federation, literary and archival sources, and forest inventory data were used when compiling the map. For the territory of Northern Mongolia, basic cartographic and literary materials on the vegetation of this region of Central Asia were involved. For the entire area of the Baikal basin modern satellite images from the Internet resources (Google Earth) were used. Their processing was carried out with the use of GIS technologies.

When creating the legend to the vegetation map of the Baikal region, well-tested geographical-genetic and structural-dynamic principles of a multi-dimensional and multi-stage vegetation classification, developed by Academician V.B. Sochava, were applied. Accordingly, the legend of the map has a multi-stage structure.

All higher subdivisions of vegetation in the map legend are united by specific taxa of plant communities, typed according to the flora-coenotic and dynamic features of their structure. When typing an epitaxon principle was followed, according to which on the basis of structural-dynamic and topological similarity indigenous communities are joined together with derivatives into common epitaxa. The lowest unit of indigenous communities being mapped is a class-group of associations. On the total the map legend contains 96 numbers of epitaxa of indigenous and derivative vegetation. Each taxon singled out in the legend has a detailed floristic, structural-coenotic and ecological-topological characteristics. Due to the complexity of the spatial structure of the vegetation cover, combinations and complexes of plant communities, which are the most characteristic of a particular type of vegetation or area, are almost universally used.

The highest level of the legend is formed by the following vegetation types: goletz (alpine), taiga (boreal) and steppe, communities of which form the modern vegetation cover of the Baikal basin. Each type of vegetation is presented by its set of communities of genetically close phratries of formations and their regional groups of formations.

Taiga (boreal) vegetation covers the main areas of the Baikal basin both in the plains and high plateaus, and in the mountains, forming a mountain-taiga altitudinal belt and a belt of subgoletz sparse forests. According to the landscape features of the region, taiga (boreal) vegetation is represented in the legend and in the map by several groups of formations, namely: subgoletz sparse forests with thickets of shrubs, mostly of Siberian dwarf pine, mountain-taiga forests, piedmont-hollow forests, and forests of plains and plateaus.

The first three groups represent an altitudinal-belt structure of vegetation of mountain ranges. Altitudinal-belt groups of formations of taiga (forest) vegetation are represented by communities of different origin and territorial confinedness.

In the contact zones of the taiga and steppe (in the form of islands) vegetation forest-steppe complexes are formed; they are mostly of expositional-conditional nature. Southern warm and dry slopes of mountains and hills are occupied, as a rule, by steppe groups, while northern and eastern cold slopes are covered with forest taiga and in some places steppificated communities. In accordance with the terrain features, these complexes are represented by three groups, namely: mountain, of plains and plateaus, and piedmont ones.

Steppe vegetation occupies large areas in the south of the Baikal basin and in northern Mongolia. Here there is an important biogeographical barrier that separates two large flora-coeno-genetic groups of western North Kazakhstan and eastern Central Asia steppes, representing Trans-Volga-Kazakhstan and Mongolian-Chinese phratries of formations, respectively.

Legend to the "Vegetation" map

GOLETZ (HIGH-MOUNTAIN) VEGETATION

MOUNTAIN TUNDRAS

PAN-ATLANTIC PHRATRY OF FORMATIONS

South-Siberian formations

1. Stony tundras with the predominance of crustose lichens (species of genera *Cetraria* Ach., *Cladonia* Hill ex P. Browne, and *Alectoria* Ach.), in places with clumps of fruticose lichens and with sparse vegetation groups of *Hierochloë alpina* (Sw.) Roem. et Schult., *Luzula confusa* Lindeb., *Saussurea congesta* Turcz., on stony placers, comprised of granitoids in the upper parts of the goletz zone, combined with subshrub (*Rhododendron aureum* Georgi, *Ledum palustre* L., *Dryas oxyodonta* Juz.)-lichen (*Alectoria ochroleuca* (Hoffm.) A.Massal., *Cetraria islandica* (L.) Ach.) tundras on flat tracts, covered with fine detritus of shale rocks or gneiss with mountain arctic-tundra primitive soils

2. Moss-lichen (*Aulacomnium turgidum* (Wahlenb.) Schwägr., *Dicranum elongatum* Schleich. ex Schwägr., *Cetraria cucullata* (Bellardi) Ach.) tundras on stony sunlit slopes, combined with alpine-type small meadows (*Ptilagrostis mongholica* (Turcz. ex Trin.) Griseb., *Festuca sphagnicola* B.Keller, *Kobresia myosuroides* (Vill.) Fiori) on rubble-silt talus fans in places of deep snow banks

3. Mountain avens (*Dryas oxyodonta* Juz., D. *punctata* Juz.)-lichen (*Flavocetraria cucullata* (Bellardi) Kärnefelt et A.Thell) tundras on stony-rock-debris mountain ranges and convex sodded tracts with fine skeleton substrates, combined with crowberry (*Empetrum sibiricum* V.N.Vassil)-yernik (*Betula rotundifolia* Spach) communities on flat uplands with loose fine earth and in wide hollows of mountain slopes

4. Grass (*Festuca ovina* L., *Carex ensifolia* Turcz. ex Gorodk., *Pedicularis oederi* Vahl.)-lichen (*Cladonia alpestris* (L.) Rabench.) tundras often with shrubs (*Betula rotundifolia* Spach., *Rhododendron aureum* Georgi, *Salix glauca* L.) on gentle slopes and well drained flat tracts with mountain-tundra humic gley soils, combined with subshrub (*Empetrum sibiricum* V.N.Vassil, Dryas *oxyodonta* Juz.)-moss (*Cetraria laevigata* Rass., *Cladonia stellaris* (Opiz) Pouzar et Vězda) tundras on concave tracts with peaty-gley soils

North-Mongolian formations

5. Lichen (*species of genera Cladonia* Hill ex P. Browne, *Cetraria* Ach., *Alectoria* Ach., *Stereocaulon* Schreb.) and moss (*species of genera Aulacomnium* Schwägr., *Polythrichum* Hedw., and others) tundras on mountain-tundra underdeveloped and destructive soils among stony placers and taluses in the goletz zone, combined with sedge, kobresia (*Kobresia myosuroides* (Vill.) Fiori, K. *sibirica* (Turcz. ex Ledeb.) Boeck.)-sedge (*Carex melanantha* C.A.Mey, C. *macrogyna* Turcz. ex Steud) and subshrub (*Dryas oxyodonta* Juz, *Arctous alpina* (L.) Niedenzu, *Rhododendron aureum* Georgi)-lichen (*Cetraria laevigata* Rass., *Cladonia stellaris* (Opiz) Pouzar et Vězda) tundras in high-mountain rigions on semi-sodded stony slopes with mountain-tundra humic-peaty-gley soils and on convex mountain slopes with mountain-tundra soddy and humic-soddy soils

PAN-PACIFIC PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations

6. Stony tundras with the sparse lichen cover (*Alectoria ochroleuca* (Hoffm.) Mass., реже with *Cetraria nivalis* (L.) Ach., C.*cucullata* (Bell.) Ach.) and singly occurring vegetation groups (*Potentilla elegans* Cham. et Schlecht., *Sibbaldia procumbens* L.) in the upper parts of the goletz zone with mountain arctic-tundra primitive soils

7. Lichen (*Cetraria nivalis* (L.) Ach., C.*islandica* (L.) Ach., C.*chrysantha* Tuck., C.cucullata (Bell.) Ach.) tundras in the upper parts of goletz plateaus on convex land forms with ledges of crystalline rocks, combined with mountain avens (*Dryas punctata* Juz.)-lichen rock debris tundras on dry slopes with gravelly peaty-loamy soils

8. Grass (*Calamagrostis lapponica* (Wahlenb.) Hartm., *Carex globularis* L., C. *ensifolia* Turcz. ex V.I. Krecz. , *Hierochloe alpina* (Sw.) Roem. et Schult.)-lichen (*Cladonia alpestris* (L.) Rabench., C. *sylvatica* (L.) Hoffm., C. *rangiferina* (L.) Web.) dry tundras in the middle and lower parts of the goletz zone and in the subgoletz zone on slopes and placers with fine-earth peaty substrates, combined with subshrub (*Empetrum sibiricum* V.N.Vassil, *Cassiope ericoides* (Pallas) D.Don.)-Cladonia tundras and tracts of kobresia (*Kobresia myosuroides* (Vill.) Fiori) heathlands and high-mountain fescue (*Festuca lenensis* Drob.) steppes on flat summits and gentle concave slopes with mountain tundra-meadow soils

9. Subshrub (*Ledum decumbens* Small.)-moss (*Drepanocladus uncinatus* (Hedw.) Warnst., *Racomitrium canescens* (Hedw.) Brid.)-lichen (*Cetraria islandica* (L.) Ach., *Cladonia rangiferina* (L.) Web.) tundras on slopes with mountain-tundra humic-carbonate soils, combined with wet tundras (*Carex tristis* M. Bieb., *Ledum palustre* L., *Aulacomnium turgidum* (Wahl.) Schwaegr.) and nival small meadows (*Bistorta vivipara* (L.) Delarbe, *Allium malyschevii* N.V.Friesen) in saddles and microdepressions with mountain tundra-meadow soils

10. Subshrub (*Vaccinium myrtilus* L.)-bergenia (*Bergenia crassifolia* (L.) Fritsch)-lichen (*Stereocaulon paschale* (L.) Fr., *Cladonia alpestris* (L.) Rabench., C.*rangiferina* (L.) Web.) tundras (heathlands), in places with golden rhododendron, Siberian dwarf pine and Middendorff's dwarf birch on summit surfaces and convex stony slopes with mountain-meadow light loamy gravelly soils, combined with nival small meadows on flat and concave slopes with mountain-meadow loamy soils

11. Tundras turned to meadows (*Festuca ovina* L., *Lycopodium alpinum* L., *Hierochloe alpina* Roem. et Schult.) on sodded tracts of stony and rocky slopes, combined with alpine-type small meadows (*Anemone sibirica* L., *Oxytropis kusnetzovii* Kryl.) on concave and flat surfaces with soddy mountain-meadow light loamy soils, as well as dwarf Siberian mountain pine (*Pinus pumila* (Pallas) Regel) and yernik (*Betula divaricata* Ledeb.) vegetation on stony slopes with gravelly weakly-humic soils

MOUNTAIN (ALPINE-TYPE) MEADOWS AND HEATHLANDS

ALTAI-TIAN-SHAN PHRATRY OF FORMATIONS

South-Siberian formations

12. Alpine-type (*Trollius sajanensis* (Malyschev) Sipliv., *Aquilegia glandulosa* Fischer ex Link) and subalpine-type (*Geranium albiflorum* Ledeb., *Saussurea latifolia* Ledeb.) meadows on flat sodded tracts on bottoms of kars and on gently sloping plots with mountain tundra-meadow soils, combined with shrubs vegetation (*Betula rotundifolia* Spach, *Duschekia fruticosa* (Rupr.) Pouzar, *Salix glauca* L.) on flat and concave slopes with mountain-tundra peaty-gley soils

North-Mongolian formations

13. High-mountain cryophyte meadows and heathlands (*Cerastium pseudosibiricum* J.Mayer, *Dryadanthe tetrandra* (Bunge) Juz., *Valeriana petrophylla* Bunge) in the transition area from the goletz to subgoletz zone on valley bottoms and at the foot of slopes with mountain tundra-meadow soils, combined with sedge-kobresia, kobresia-sedge and waterlogged sedge (*Carex macrogina* Turcz. ex Steud., C. *orbicularis* Boott, C. *bigelowii* Torr.) meadows on mountain-meadow soddy-humic gleyic and cryogenic-meadow peaty-humic-gleyic soils

14. Kobresia (*Kobresia bellardii* (All.) Degl.) and sedge (*Carex rupestris* All., C. *stenocarpa* Turcz.)-kobresia meadows and heathlands on flat summits of ranges, gentle slopes of all aspects, and in bottoms of non-waterlogged hollows with mountain tundra-meadow soils, combined with stony-rock-debris placers and patches of high-mountain steppes (*Kobresia simpliciuscula* Mack., *Ptilagrostis mongolica* Griseb., *Festuca supina* Schur., F. *brevifolia* R. Br., F. *sphagnicola* B. Keller) on concave slopes and in wide bottoms of intermontane depressions with tundra-meadow rich humus soils

TAIGA (BOREAL) VEGETATION

SUBGOLETZ SPARSE FORESTS AND SHRUBS VEGETATION

URAL-SIBERIAN PHRATRY OF FORMATIONS

South-Siberian formations
Dark-coniferous (*Pinus sibirica* Du Tour, Abies sibirica Ledeb., *Picea obovata Ledeb.) sparse forests*

15. Spruce Siberian dwarf pine (*Pinus pumila* (Pallas) Regel) moss (*Pleurozium schreberi* (Brid.) Mitt., *Ptilium crista-castrensis* (Hedw.) De Not.)-lichen (*Cladonia mitis* Sandst, *Cetraria islsndica* (L.) Ach., *Stereocaulon paschale* (L.) Hoffm.) sparse forests on flat saddles, concave surfaces and slopes to river valleys with mountain cryogenic-taiga soils, combined with stony tundras and placers on convex tracts with mountain-tundra soils

16. Siberian stone pine and larch (*Larix sibirica* Ledeb.)-Siberian stone pine yernik (*Betula rotundifolia* Spasch) subshrub (*Vaccinium vitis-idaea* L., V. *uliginosum* L.)-moss (*Dicranum scoparium* Hedw., *Pleurozium achreberi* (Brid.) Mitt.)-lichen (*Cladonia turgida* Hoffm., C.*uliginosa* (Ahti) Ahti) sparse forests on stony slopes and plateau-like rocky surfaces with mountain cryogenic-taiga soils, combined with grass-shrubs vegetation in microdepressions and sodded tracts with mountain-tundra soils

17. Siberian stone pine with spruce and larch (*Larix sibirica* Ledeb.) dwarf Siberian mountain pine (*Pinus pumila* (Pallas) Regel) cowberry (*Vaccinium vitis-idaea* L., *Ledum palustre* L.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* (Hedw.) B.S.G.) sparse forests on convex watersheds and steep slopes of different aspects with shallow rank nonpodzolized soils, combined with Siberian stone pine cowberry forests on gentle and planate tracts with cryogenic-taiga soils

18. Fir and spruce-fir sparse forests, in places with lanate birch (*Betula lanata* (Regel) V.N.Vassil.), with golden rhododendron (*Rhododendron aureum* Georgi) and dwarf Siberian mountain pine (*Pinus pumila* (Pall.) Regel) tall-grass (*Pteridium aquilinum* (L.) Kuhn., *Dryopteris fragrans* (L.) Schott, *Athyriium filix-femina* (L.) Roth, *Anemone baicalensis* Turcz., *Bupleurum multinerve* DC.) on stony slopes with mountain podzolic gravelly-sandy-loamy shallow soils, combined with tracts of subalpine-type meadows (*Geranium krylovii* Tzvelev, *Aconitum baicalense* Turcz. ex Rapaics, *Carex aterrima* Hoppe) in near-brooks habitats with mountain tundra-meadow soils

Light-coniferous (*Larix sibirica* Ledeb.) sparse forests

19. Larch and Siberian stone pine-larch yernik (*Betula rotundifolia* Spach, B. *exilis* Sukaczev, *Salix glauca* L.) grass (*Festuca ovina* L., *Bistorta elliptica* (Willd. ex Spreng.) Kom., *Artemisia dolosa Krasch.*)-moss (*Hylocomium splendens* (Hedw.) Bruch et al., *Rhytidium rugosum* (Hedw.) Kindb.), in places with lichens (*Cladonia alpestris* (L.) Rabenh., C.*rangiferina* (L.) Web.), sparse forests on steep slopes, aprons and high river terraces with cryogenic-taiga peaty-gleyic soils, combined with larch marsh tea-cowberry sparse forests on less steep slopes with the same soils and patches of grass-lichen-moss tundras on convex well drained surfaces with mountain arctic-tundra sandy and sandy-loamy shallow soils

ANGARIDE PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations
Light-coniferous (*Larix dahurica* Laws.) sparse forests

20. Larch sparse forests with dwarf Siberian mountain pine (*Pinus pumila* (Pal.) Regel), dwarf birch (*Betula divaricata* Ledeb.), in places with Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) moss (*Dicranum elonganum* Schleich. ex Schwaegr., *Aulacomnium turgidum* (Wahl.) Schwaegr., *Rhytidium rugosum* (Hedw.) Kindb.)-lichen (*Cladonia alpestris* (L.) Rabench.) on planate surfaces and gentle stony slopes with mountain cryogenic-taiga surface-ferruginized soils, combined with shrubs (*Benula nana* L.) vegetation on convex and flat surfaces with fine skeleton soils and patches of alpine-type small meadows (*Anemone sibirica* L., *Aquilegia glandulosa* Fisch. ex Link, *Festuca altaica* Trin.) on sodded tracts on bottoms of kars and concave slopes with mountain-meadow soddy-humic light loamy soils

BERINGIAN PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations
Dwarf Siberian mountain pine (*Pinus pumila* (Pallas) Regel) vegetation

21. Dwarf Siberian mountain pine vegetation with singly occurring trees (*Larix dahurica* Laws., *Pinus sibirica* Du Tour., *Betula lanata* (Regel) V.N.Vassil.) on slopes with coarse stony substrates and stony-rank immature soils, combined with subshrub (*Cassiope ericoides* (Pall.) D.Don, *Ribes fragrans* Pall.) and meadow (*Festuca altaica* Trin., *Dracocephalum grandiflorum* L., *Aquilegia glandulosa* Fisch. ex Link) communities in microrelief lows with mountain tundra-meadow soils

MOUNTAIN-TAIGA FORESTS

URAL-SIBERIAN PHRATRY OF FORMATIONS

Middle-Siberian formations
Dark-coniferous (*Abies sibirica* Ledeb., *Pinus sibirica* Du Tour, and *Picea obovata* Ledeb.) forest

22. Fir-Siberian stone pine subshrub (*Ledum palustre* L., *Vaccinium vitis-idaea* L., *Vaccinium uliginosum* L.)-grass (*Pyrola rotundifolia* L., *Linnaea borealis* L., *Carex macroura* Meinsh., in places with tall grass - *Valeriana alternifolia* Ledeb., *Silene amoena* L., *Brachypodium pinnatum* (L.) Beauv., *Trollius asiaticus* L., *Pulmonaria mollis* Wulfen ex Hornem.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* Bruch et al.) forests on summits and slopes of high watersheds with coarse-skeleton soddy-pozdolic soils

22d. Larch-pine with Siberian stone pine and fir subshrub-grass-true-moss anthropogenic series

Light-coniferous (*Larix sibirica* Ledeb.) forests

23. Larch and pine-larch cowberry-forb (*Saussurea controversa* D.C., *Polygala sibirica* L., *Scabiosa ochroleuca* L., *Carex macroura* Meinsh., *Calamagrostis arundinacea* (L.) Roth.) forests on slopes of different steepness with soddy-forest weakly podzolic or soddy-carbonate leached soils

24. Larch with the inclusion of Siberian stone pine and spruce, in places with undergrowth of yernik (*Betula fruticosa Pallas*) subshrub (*Ledum palustre* L., *Vaccinium uliginosum* L.)-moss forests in the lower parts of slopes of different aspects, in weakly waterlogged river terraces, drained creek valleys and in river valleys with podzolic deeply-freezing or seasonally-cryogenic soils

South-Siberian formations
Dark-coniferous (*Abies sibirica* Ledeb., Picea obovata Ledeb., *Pinus sibirica* Du Tour) forests

25. Siberian stone pine-fir bilberry (*Vaccinium myrtillus* L.)-grass (*Equisetum sylvaticum* L., *Moneses uniflora* (L.) A. Gray, *Trientalis europaea* L., *Carex iljinii* V. Krecz.)-true-moss (*Hylocomium splendens* (Hedw.) B.S.G., *Polytrichum commune* Hedw.) forests in interfluves on heads of watersheds and upper parts of slopes with podzolic sandy-loamy and light loamy soils

25a. Aspen-birch with fir and Siberian stone pine bilberry-grass-true-moss anthropogenic series

25c. Larch with Siberian stone pine, fir, birch bilberry-grass-true-moss anthropogenic series

26. Siberian stone pine-fir with spruce and larch (*Larix sibirica* Ledeb.) bilberry (*Vaccinium myrtillus* L.)-bergenia (*Bergenia crassifolia* (L.) Fritsch)-true-moss (*Hylocomium splendens* (Hedw.) B.S.G., *Polytrichum commune* Hedw.) forests in the upper parts of the forest zone on convex surfaces, steep stony shady slopes and slopes to river valleys with weakly podzolic gravelly soils

27. Fir-Siberian stone pine with spruce bilberry-small grass (*Mitella nuda* L., *Trientalis europaea* L., *Stellaria bungeana* Fenzl.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Ptilium crista-castrensis* (Hegw.) De Not.), in places with bergenia (*Bergenia crassifolia* (L.) Fritsch), forests on convex surfaces and steep stony slopes with shallow gravelly-loamy moistened soils

27a. Aspen-birch with Siberian stone pine and fir bilberry-small grass-true-moss anthropogenic series

27c. Pine-larch with Siberian stone pine, fir, birch, aspen bilberry-small grass-true-moss anthropogenic series

28. Siberian stone pine with undergrowth of golden rhododendron (*Rhododendron aureum* Georgi) bilberry-cowberry-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Dicranum congestum* Brid.), in places with bergenia, forests on mountain ranges and their slopes with humic weakly podzolized moderately loamy soils

28a. Siberian stone pine-birch with undergrowth of golden rhododendron bilberry-cowberry-true-moss anthropogenic series

28c. Larch with Siberian stone pine with undergrowth of golden rhododendron bilberry-cowberry-true-moss anthropogenic series

29. Siberian stone pine with larch (*Larix sibirica* Ledeb.) (in places with fir and spruce) subshrub (*Vaccinium myrtillus* L., *Ledum palustre* L.)-grass (*Bergenia crassifolia* (L.) Tritsch, *Carex iljinii* V. Krecz. in places with tall grass)-true-moss forests on gentle shady slopes, saddles, and in intermontane depressions with cryogenic-taiga peaty-gley and peaty-weakly podzolic soils

30. Siberian stone pine with the inclusion of spruce and larch marsh tea-cowberry-true-moss (*Pleurozium schreberi* (Brid.) Mitt.) forests in the middle and the upper parts of steep sunlit slopes with soddy-forest brown-colored shallow fresh soils, in places combined with bergenia Siberian stone pine woodlands, on narrow crests of watersheds and their steep stony slopes with podzolic coarse-skeleton soils

30c. Larch with Siberian stone pine Marsh tea-cowberry-true-moss, in places with bergenia, anthropogenic series

31. Siberian stone pine-spruce with larch, in places fir-spruce with Duschekia and wild ash in the underwood, subshrub (*Vaccinium vitis-idaea* L., *V.myrtilus* L., *Rubus arcticus* L.)-grass (*Linnaea borealis* L., *Pyrola rotundifolia* L., *Equisetum palustre* L., *Goodyera repens* (L.) R. Br., *Lusula parviflora* (Ehrh.) Desv.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Polytrichum commune* Hedw.) forests in the lower parts of gentle undulating shady slopes, intermontane depressions and on slopes to river valleys with loamy and peaty-humic wet soils

32. Spruce with larch, in places with poplar (*Populus suaveolens* Fischer, P. *laurifolia* Ledeb.), grass (*Calamagrostis arundinacea* (L.) Roth, C. *langsdorffii* (Link) Trin., *Delfinium elatum* L., *Viola uniflora* L., *Vicia cracca* L., *Orthilia secunda* L. Garcke., *Sanguisorba officinalis* L.)-subshrub (*Vaccinium vitis-idaea* L., V. *uliginosum* L.) forests in waterlogged valleys of brooks and rivers with peat-bog deeply freezing soils

33. Poplar (*Populus suaveolens* Fischer)-fir with spruce tall-grass (*Solidago dahurica Kitag*., *Calamagrostis obtusata* Trin, *Hieracium umbellatum* L., *Agrostis stolonifera* L.) forests along rivers on channel deposits, in creek valleys, wide concave depressions with deep sandy-loamy-humic soils

33a. Fir-birch with poplar and spruce tall-grass anthropogenic series

Light-coniferous (*Larix sibirica* Ledeb, *Pinus sylvestris* L.) forests

34. Larch with undergrowth of small-leaved rhododendron (*Rhododendron parvifolium* Adams) and round-leaved birch (*Betula rotundifolia* Spach)-grass (*Pedicularis verticillata* L., *Delfinium crassifolium* Schrad. ex Spreng., *Carex amgunensis* F.Schmidt)-moss (*Rhytidium rugosum* (Hedw.) Kindb) forests on planate surfaces, rather steep sunlit slopes and on slopes of mountain valleys with soddy-carbonate leached soils

35. Siberian stone pine-larch and larch with Siberian stone pine cowberry (*Vaccinium vitis-idaea* L., *Ledum palustre* L., *Calamagrostis lapponica* (Wahlenb.) Hartm.) forests on gentle slopes and aprons of different aspects, as well as on terraces of different levels with soddy-forest weakly podzolic loamy and sandy-loamy fresh soils

35a. Larch-birch cowberry anthropogenic series

36. Larch and pine-larch with undergrowth of rhododendron (*Rhododendron dauricum* L., реже Rh. *ledebouri* Pojark.) marsh tea-cowberry-true-moss forests on planate surfaces and slopes of different aspects with weakly podzolic sandy-loamy cryogenic soils

36a. Birch with larch and pine with undergrowth of Daurian rhododendron marsh tea-cowberry-true-moss anthropogenic series

37. Pine and larch-pine with undergrowth of Daurian rhododendron (*Rhododendron dauricum* L.) and fruticose Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) grass (*Geum aleppicum* Jacq., *Crepis praemorsa* (L.) Tausch, Euphorbia jenisseiensis Baikov., Crepis praemorsa (L.) Tausch, *Anemone crinita* Juz., *Saussurea controversa* D.C.) forests on gentle slopes in the middle and lower parts of the forest zone, in intermontane depressions, and on slopes of different aspects to river valleys with soddy weakly podzolic soils

37a. Birch with larch and pine with undergrowth of rhododendron and Duschekia grass anthropogenic series

North-Mongolian formations
Light-coniferous (*Larix sibirica* Ledeb., *Pinus sylvestris* L.) forests

38. Siberian stone pine-larch grass (*Linnaea borealis* L., *Vicia baicalensis* (Turcz.) B.Fedtsch., *Calamagrostis obtusata* Trin.)-subshrub (*Vaccinium vitis-idaea* L., V. *uliginosum* L.)-true-moss (*Hylocomium splendens* (Hedw.) B.S.G., *Pleurozium schreberi* (Brid.) Mitt.) forests in the upper parts of the forest zone on planate surfaces and the upper parts of slopes with peaty-weakly podzolic cryogenic soils

39. Larch with Siberian stone pine subshrub (*Ledum palustre* L., *Vaccinium vitis-idaea* L.)-bergenia (*Bergenia crassifolia* Trisch)-true-moss (*Hylocomium splendens* (Hedw.) Bruch et al., *Pleurozium schreberi* (Brid.) Mitt.) forests on shady slopes, aprons, high terraces with soddy deeply-cryogenic shallow soils

40. Larch with spruce, Siberian stone pine, less often fir with undergrowth of rhododendron (*Rhododendron dahuricum* L.), cowberry-true-moss (*Pleurozium schreberi* (Brid.) Mitt.) forests on steep stony slopes often to river valleys with soddy shallow rank soils

41. Larch forb-Rhytidium and sedge-Rhytidium (*Festuca altaica* Trin., *Carex amgunensis* Fr. Schmidt, *Pedicularis verticillata* L., *Delphinium crassifolium* Schrader ex Sprengel, *Rhytidium rugosum* (Hedw.) Kindb.) forests of the middle and lower parts of shady slopes with soddy nonpodzolized, humic and peaty soils

42. Larch (in places with pine) with undergrowth of Daurian rhododendron cowberry-grass (*Carex iljinii* V.I.Krecz., *Maianthemum bifolium* (L.)F.W.Schmidt, *Equisetum arvense* L.) forests in the middle and lower parts of predominantly shady slopes and on slopes to river valleys

with soddy taiga deeply-cryogenic deep soils

43. Pine, in places birch-pine, with undergrowth of Daurian rhododendron forb and cowberry-forb (*Pyrola chlorantha* Swartz, *Maianthemum bifolium* (L.) F.W. Schmidt, *Trientalis europaea* L.) forests on mountain slopes with soddy-forest, in places with weakly podzolic soils

ANGARIDE PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations

Light-coniferous (*Larix dahurica* Laws., *Pinus sylvestris* L.) forests

44. Larch with undergrowth of dwarf Siberian mountain pine and golden rhododendron (*Rhododendron aureum* Georgi) small grass (*Carex iljinii* V. Krecz., *Linnaea borealis* L., *Calamagrostis obtusata* Trin.)-moss (*Pleurozium schreberi* (Brid.) Mitt.)-lichen (*Cladonia alpestris* (L.) Rabench, C. *mitis* Sandst.) forests in the upper parts of the forest zone and subgoletz on convex surfaces and steep slopes of different aspects with peaty-humic acid длительно cryogenic loamy soils

45. Larch, in places sparse, with undergrowth of dwarf Siberian mountain pine (*Pinus pumila* (Pallas) Regel), marsh tea (*Ledum palustre* L.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Polytrichum commune* Hedw.) forests in the upper parts of the forest zone on watershed surfaces and stony slopes of different steepness and aspects, often on slopes of river valleys with loamy stony soils

46. Larch with undergrowth of yernik (*Betula middendorffii* Trautv. et Mey.) and Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) subshrub (*Vaccinium vitis-idaea* L., *Ledum palustre* L.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt.) forests in the middle and lower parts of stony slopes of different aspects, on watershed surfaces and on slopes to river valleys with loamy cryogenic soils, in places with crystalline rock debris

47. Larch with undergrowth of Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) cowberry-grass (*Vaccinium vitis-idaea* L., *Calamagrostis lapponica* Hartm., *Carex cespitosa* L., *Equisetum palustre* L.) forests in the middle and lower parts of gentle predominantly shady slopes with soddy-podzolic soils

47a. Birch with undergrowth of Duschekia cowberry-grass anthropogenic series

48. Larch subshrub (*Vaccinium uliginosum* L., *Ledum palustre* L.)-moss (*Pleurozium schreberi* (Brid.) Mitt., *Polytrichum commune* Hedw.) forests on weakly waterlogged river terraces and aprons of slopes with peaty-gley alluvial cryogenic soils

49. Larch with undergrowth of Daurian rhododendron (*Rhododendron dahuricum* L.) grass-cowberry-true-moss (*Pleurozium schreberi* (Brid.) Mitt., *Vaccinium vitis-idaea* L., *Carex iljinii* V.I. Krecz., C. *globularis* L., *Linnaea borealis* L.) forests on planate surfaces, in the middle and lower parts of slopes and drained tracts of valleys with soddy-podzolic soils

50. Larch with undergrowth of yernik (*Betula middendorfii* Trautv. et Mey., B. *exilis* Sukaczev) forests, in places sparse, on waterlogged tracts of above-floodplain terraces and mountain creek valleys with peaty-slimy-gley soils, combined with spruce-larch and larch-spruce forests in the lower parts of gentle slopes of different aspects with peat wet soils

51. Larch with undergrowth of yernik (*Betula fruticosa* Pall., B. *middendorffii* Trautv. et Mey.) waterlogged forests in the middle and lower parts of gentle and concave slopes and valleys of rivers and brooks with peaty-bog soils, combined with yerniks vegetation and grass-moss (*Tomenthypnum nitens* (Hedw.) Loeske, *Tuidium abietinum* (Schwaegr.) Dr. Sch. et Gmb., *Rhytidium rugosum* (Hedw.) Kindb., *Carex dioica* L., C. *limosa* L., *Caltha palustris* L., *Equisetum fluviatila* L., *Cicuta virosa* L., *Epilobium palustre* L.) bogs in waterlogged floodplains of streams and gentle slopes to river valleys with peat sphagnous-bog shallow wet soils

52. Larch-pine with undergrowth of Daurian rhododendron (*Rhododendron dahuricum* L.) cowberry (*Vaccinium vitis-idaea* L.)-forb (*Calamagrostis arundinacea* (L.) Roth, *Geranium pseudosibiricum* J. Meyer, *Viola uniflora* L.) forests in the upper and middle parts of slopes of different aspects with moderately podzolic soils

53. Larch-pine with undergrowth of Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) and Middendorff's birches (*Betula middendorffii* Trautv. et Mey., B. *exilis* Sukaczev) bilberry (*Vaccinium myrtillus* L. with the inclusion of *V. vitis-idaea* L., *Ledum palustre* L.)-true-moss (*Pleurozium schreberi* (Brid.) Mitt.) forests on flat summits of low ranges and on their slopes with moderately podzolic heavy loamy soils

54. Larch-spruce (*Picea obovata* Ledeb.) with Chosenia (*Chosenia arbutifolia* (Pall.) A.K.Skvortsov) and poplar (*Populus suaveolens* Fischer) subshrub (*Vaccinium vitis-idaea* L., V. *uliginosum* L., *Ledum palustre* L.)-forb (*Galium boreale* L., *Veratrum lobelianum* Bernh., *Trollius asiaticus* L., *Thalictrum minus* L, *Linnaea borealis* L., *Maianthemum bifolium* (L.) F.W.Schmidt.)-true-moss (*Hylocomium splendens* (Hedw.) Bruch et al., *Pleurozium schreberi* (Brid.) Mitt., *Dicranum undulatum* Schrad. ex Drid., *Ptilium crista-castrensis* (Hegw.) De Not) forests on pebble-beds along river channels and on floodplains with soddy-podzolic sandy-loamy soils

PIEDMONT-DEPRESSION FORESTS

URAL-SIBERIAN PHRATRY OF FORMATIONS

South-Siberian formations

Light-coniferous (*Larix sibirica* Ledeb, *Pinus sylvestris* L.) forests

55. Larch and pine-larch small reed-forb (*Calamagrostis arundinacea* (L.) Roth, C. *epigeios* (L.) Roth s. str., C. *langsdorffii* (Link) Tzvelev, *Serratula coronata* L., *Euphorbia borealis* Baikov., *Stellaria graminea* L., *Carex pallida* C.A.Meyer) forests in the lower parts of southern slopes with soddy forest soils, in places combined with steppizated grass larch woods and tracts of steppes, on sunlit low slopes and planate surfaces with rank and stony soils

56. Pine with undergrowth of spiraea (*Spiraea media* Franz Schmidt), cotoneaster (*Cotoneaster melanocarpus* Fisch. ex Blytt.), prickly wild rose (*Rosa acicularis* Lindley) grass (*Pulsatilla patens* (L.) Miller, *Artemisia desertorum* Sprengel.) steppizated forests on sunlit slopes with sandy skeleton-stony soils, combined with steppe formations on the upper parts of waterless creek valleys with sandy-loamy soils and tracts of blown sands

56a. Pine-birch grass series of anthropogenic transformation.

57.Pine and larch-pine cowberry-bearberry (*Arctostaphylos uva-ursi* (L.) Sprengel) with patches of lichens (*Cladonia alpestris* (L.) Rabench., C. *amaurocreae* (Flörke) Schaer, *Cladonia rangiferina* (L.) Web.) forests on gentle sandy sunlit slopes and planate surfaces with rank shallow soils

ANGARIDE PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations

Light-coniferous (*Larix dahurica* Laws.) forests

58. Larch with undergrowth of fruticose willows (*Salix lanata* L., S. *rosmarinifolia* L., S. *pyrolifolia* Ledeb.) sedge (*Carex diandra* Schrank, C. *meyeriana* Kunth, C. *capitata* L., C. *irriqua* (Wahlenb.) Hiitonen)-moss (*Aulacomnium palustre* (Hedw.) Schwägr., *Sphagnum warnstorfii* Russow, *Sph. teres* (Schimp.) Engstr., *Tomenthypnum nitens* (Hedw.) Loeske) waterlogged forests in lower tracts of valleys with peaty cryogenic soils

SUBTAIGA (PIEDMONT) FORESTS

URAL-SIBERIAN PHRATRY OF FORMATIONS

Middle-Siberian formations

Light-coniferous (*Pinus sylvestris* L., *Larix sibirica* Ledeb.) forests

59. Pine and larch-pine with undergrowth of rhododendron (*Rhododendron dauricum* L.) cowberry-grass (*Vaccinium vitis idaea* L., *Pulsatilla patens* (L.) Mill., *Aquilegia sibirica* Lam., *Limnas steleri* Trin., Cypripedium guttatum Sw., Vicia cracca L., Trifolium lupinaster L.) forests on planate surfaces and sunlit slopes with soddy forest and podzolic sandy and sandy-loamy soils, combined with cowberry-bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) forests on dry sandy terraces and low slopes with sandy well-heated soils

60. Pine and larch-pine grass (*Saussurea propinqua* Iljin, *Latthyrus humilis* (Ser.) Spreng., *Maianthemum bifolium* (L.) F.W.Schmidt, *Aegopodium alpestre* Ledeb., *Carex pediformis* C.A.M.)-cowberry forests on flat lows and slopes of different aspects with soddy-forest weakly podzolic soils, combined with gramineous (*Brachypodium pinnatum* (L.) Beauv., *Calamagrostis arundinacea* (L.) Roth)-forb (*Zigadenus sibiricus* (L.) A.Gray, *Euphorbia borealis* Baikov., *Stellaria graminea* L., *Euphorbia jenisseiensis* Baikov., *Cirsium serratuloides* (L.) Hill.) forests on planate surfaces and gentle low slopes often to river valleys with soddy-forest and soddy-carbonate soils

61. Pine and larch-pine with undergrowth of Duschekia (*Duschekia fruticosa* (Rupr.) Pouzar) cowberry-forb (*Vaccinium vitis-idaea* L., *Calamagrostis arundinacea* (L.) Roth., *Viola uniflora* L., *Galium boreale* L., *Trollius asiaticus* L., *Sanguisorba officinalis* L.) often with marsh tea (*Ledum palustre* L.) and whortleberry (*Vaccinium uliginosum* L.) forests in the lower parts and on aprons of slopes, as well as along river banks with peaty-podzolic sandy-loamy soils

61b. Birch-aspen with pine and larch cowberry-forb with marsh tea and whortleberry anthropogenic series

YERNIKS, BOGS AND MEADOWS

URAL-SIBERIAN PHRATRY OF FORMATIONS

Middle-Siberian formations

62. Subshrub (*Vaccinium uliginosum* L., *Chamedaphne calyculata* (L.) Moench)–sedge (*Carex meyeriana* Kunth)-hypnum (*Drepanocladus vernicosus* Warnst., D. *sendtneri* (H.Muell.) Warnst., *Meesia triquetra* (Richter) Aongstr.) bogs on overmoistened tracts are often enclosed by peat bogs, combined with marsh tea-moss pine forests, in floodplain depressions with peaty wet soils and sedge meadows in interior deltas on more drained tracts of bogs with silt deposits and light loamy soils

ANGARIDE PHRATRY OF FORMATIONS

Baikal-Dzhugdzhur formations

63. Yernik (*Betula fruticosa* Pallas, B. *exilis* Sukaczev) vegetation with singly occurring larch (*Larix gmelinii* (Rupr.) Rupr.) and birch trees (*Betula platyphylla* Sukaczev) in valleys and floodplains of rivers and brooks and lower tracts with peaty soils, combined with grass bogs in low floodplains and sedge-small reed meadows on river banks, along-channel natural levees and on gentle slopes to river valleys with loamy moist soils

64. Sphagnum (*Sphagnum warnstorffii* Russ., S. *teres* (Schimp.) Aongstr. ex Hartm.) oligotrophic bogs in river floodplains, on gentle poorly drained slopes of ouvals, in saddles, in the upper reaches of brooks and creek valleys, on low flat watersheds and summits of столовых возвышенностей with overmoistened soils and permafrost, combined with willow (*Salis viminalis* L., S.*rosmarinifolia* L., S.triandra L.) vegetation in the along-channel parts of rivers with грубыми sandy отложениями

65. Small reed-sedge and sedge (*Carex pseudocuraica* Fr. Schmidt, C. *wiluica* Meinsh., C. *enervis* C.A.M.)-small reed (*Calamagrostis langsdorffii* Trin.) valley overmoistened meadows on peaty-gley cryogenic soils, in places combined with shrubs vegetation (*Rosa acicularis* Lindl., *Spiraea salicifolia* L., *Betula exilis* Sukaczev, *Salis rosmarinifolia* L.) on summits of along-channel natural levees and low ridges of the central floodplains with sandy-loamy and loamy soils

FOREST-STEPPE COMPLEXES

MOUNTAIN

URAL-SIBERIAN PHRATRY OF FORMATIONS

North-Mongolian formations

Light-coniferous (*Larix sibirica* Ledeb., *Pinus sylvestris* L.) steppizated forests with tracts of steppes

66. Complex of larch (*Larix sibirica* Ledeb.) and birch (*Betula platyphylla* Sukaczev)-larch grass (*Calamagrostis obtusata* Trin., *Carex amgunensis* Fr. Schmidt, *Iris ruthenica* Ker-Gawler s str., *Paeonia anomala* L., *Lilium pumilum* Delile, *Anemone crinita* Juz.) steppizated forests and forb-sedge-oat-grass steppes predominantly on shady slopes with meadow-forest глубоко cryogenic soils

67. Complex of pine (*Pinus sylvestris* L.) and birch (*Betula platyphylla* Sukaczev)-pine xerophytic-forb (*Festuca lenensis* Drob., *Artemisia frigida* Willd., A. *laciniata* Drob., *Oxytropis oligantha* Bunge, O. *chionophylla* Schrenk) steppizated forests and shrubs (*Ulmus pumila* L., *Cotoneaster melanocarpus* Fisch. ex Blytt) vegetation on planate surfaces, mountain slopes and river terraces with weakly podzolic sandy soils

PIEDMONT

URAL-SIBERIAN PHRATRY OF FORMATIONS

Middle-Siberian formations

Light-coniferous (*Pinus sylvestris* L.) forests with tracts of steppes

68. Complex of pine steppizated sparse-grass (*Scabiosa ochroleuca* L., *Dracocephalum nutans* L., *Silene nutans* L., *Elymus gmelinii* (Ledeb.) Tzvelev, *Calamagrostis epigeios* (L.) Rhot.) forests and steppe formations on convex surfaces, dry pine-forest terraces, lower watersheds and their gentle slopes with fine sandy-loamy or loamy soils

STEPPE VEGETATION

STEPPES OF MOUNTAINS MONGOLIAN-CHINESE PHRATRY OF FORMATIONS DRY STEPPES

South-Siberian formations

69. Kobresia (*Kobresia myosuroides* (Vill.) Fiori, K. *humilis* Meadow.)-fescue (*Festuca lenensis* Drobow) high-mountain steppes on convex surfaces and stony-rock debris slopes with mountain steppe carbonate-free soils, combined with moss-lichen and lichen-moss tundras on flat lows with tundra peaty-gley soils

North-Mongolian formations

70. Forb-bunchgrass (*Festuca lenensis* Drobow, F. *sibirica* Hackel ex Boss., *Poa attenuata* Trin., *Koeleria cristata subsp. mongolica* Tzvelev, *Carex pediformis* C.A.Meyer, *Stellera chamaejasme* L., *Alyssum lenense* Adams, *Oxytropis nitens* Turcz., *Phlojodicarpus sibiricus* Koso-Pol.,) with shrubs (*Cotoneaster melanocarpus* Fisch. ex Blytt., *Ribes pulchellum* Turcz., *Pentaphylloides parvifolia* (Fischer ex Lehm.) Sojak) steppes on high planate tracts and in the upper parts of slopes of different aspects with mountain chernozems and dark-chestnut soils, combined with forb-fescue and sedge-fescue steppe communities on gravelly-stony and stony-rock debris slopes

71. Forb-Leymus-feather-grass (*Stipa capillata* L., S. *krylovii* Roshev., *Leymus chinensis* (Trin.) Tzvelev, *Bupleurum scorzonerifolium* Willd., *Galium verum* L., *Aconogonon angustifolium* (Pallas) Hara, *Oxytropis filiformis* DC., *Astragalus melilotoides* Pallas) steppes on high plains, on sunlit slopes, in steppizated river valleys on low ridges and pebble-beds with dark-chestnut light loamy soils with the feaures of meadow soils in combination with birch (*Betula platyphtlla* Sukaczev) and aspen (*Populus tremula* L.) grass (*Fragaria orientalis* Losinsk., *Geranium pseudosibiricum* J.Meyer, *Campanula glomerata* L. s.str., *Valeriana dubia* Bunge, *Vicia unijuga* A. Br.) steppizated forests on northern slopes with soddy-forest and meadow-forest deeply cryogenic soils

Central-Asian formations

72. Forb-fescue and forb (*Rhinactinidia eremophylla* (Bunge) Novopokr. s. str., *Peucedanum morisonii* Besser ex Sprengel, *Dracocephalum foetidum* Bunge, *Oxytropis oligantha* Bunge, *Saussurea sajanensis* Gudoschn., *Potentilla fragarioides* L.)-wheatgrass (*Agropyron cristatum* (L.) Beauv.)-fescue (*Festuca lenensis* Drobow) steppes on summits of watersheds and ranges with parent rock outcrops and in the upper parts slopes with mountain steppe carbonate-free soils, combined with kobresia and sedge steppes in depressions, along river valleys and creek valleys with clay soils

73. Forb (*Carex pediformis* C.A.Mey, *Aster alpinus* L., *Artemisia frigida* Willd., *Galium verum* L.)-gramineous (*Festuca valesiaca* Gaudin s. str., *Poa attenuate* Trin. s. str.) steppes on stony slopes of different aspects, comprised of quartz-clay sandstones, combined with forb-Koeleria and fescue-Leymus steppe groups on dry slopes with light-chestnut and rank soils

74. Forb (*Serratula centauroides* L. s. str., *Astragalus brevifolius* Ltdeb., *Cleistogenes squarrosa* (Nrin.) Keng, *Asterothamnus heteropappoides* Novopokr., *Vincetoxicum sibiricum* (L.) Decne)-gramineous (*Agropyron criststum* (L.) Beauv.)-feather-grass (*Stipa glareosa* P. Smirnov, S. *krylovii* Roshev) with shrubs (*Krascheninnikowia ceratoides* (L.) Gueldenst., *Caragana bungei* Ledeb.) desert steppes on rock debris slopes, among rocks, in intermontane valleys and slopes with sandy-loamy and rank-sandy-loamy soils

MEADOW STEPPES

North-Mongolian formations

75. Rich-forb-sedge-bluegrass (*Poa attenuate* Trin., P. *altaica* Trin., *Festuca lenensis* Drobov, *Carex pediformis* C.A.Mey, *Filifolium sibiricum* (L.) Kitam., *Scabiosa comosa* Fisch. ex Roem.et Schult.) meadow steppes, combined with forb-gramineous meadow-steppe communities on planate surfaces, gentle sunlit slopes and in intermontane valleys with mountain chernozems and dark-chestnut soils

STEPPES OF FOOTHILLS, PLATEAUS AND HUMMOCKS

TRANS-VOLGA-KAZAKHSTAN PHRATRY OF FORMATIONS MEADOW STEPPES

Middle-Siberian formations

76. Complex of saz (*Leymus paboanus* (Claus) Pilger, *Achnatherum splendens* (Trin.) Nevski) and Nitraria-sagebrush steppes with halophytic (*Plantago cornuti* Gounan, *Limonium gmelinii* (Willd.) Kuntze) meadows on shores of salt lakes, in the near-terrace part of steppe valleys, saline bottoms of waterless creek valleys and microdepressions with meadow carbonate alkali soils

MONGOLIAN-CHINESE PHRATRY OF FORMATIONS DRY STEPPES

Central-Asian formations

77. Feather-grass (*Stipa krylovii* Roshev., S. *baikalensis* Roshev., S. *grandis* P.Smirn.) steppes on planate tracts, gentle slopes, piedmont aprons with sandy-loamy soils, as well as on solonetzic heavy-textured soils and on deluvium of limestones and carbonate rocks, combined with wheatgrass, Leymus and leistogenes communities, in places with patches of allium polyrrhizum steppes in the same habitats with light-textured soils

78. Leymus (*Leymus chinensis* Tzvel.) steppes on planate and hilly tracts with sandy or solonetzic soils, combined with Koeleria-fescue communities and patches of halophytic (*Puccinelia tenuiflora* Krecz., P. *macranthera* Norlindh.) meadows on gentle sunlit slopes and on bottoms waterless creek valleys with sandy and sandy-loamy soils

79. Filifolium (*Filifolium sibiricum* (L.) Kitam.) steppes on slopes and plateau-like summit surfaces, comprised of quartz-clay sandstones, combined with steppe shrubs vegetation and steppizated meadows in the upper parts gentle slopes with drift sandy and sandy-loamy soils

80. Pea shrub (*Caragana microphylla* Lam., C. *stenophylla* Pojark.)-Leymus-feather-grass (*Stipa baikalensis* Roshev., S. *grandis* P.Smirn.), in places feather-grass-pea shrub steppes on gentle slopes and ouvals with loose chestnut and light sandy-loamy soils, combined with feather-grass and cleistogenes communities on sandy slopes and high above-floodplain terraces

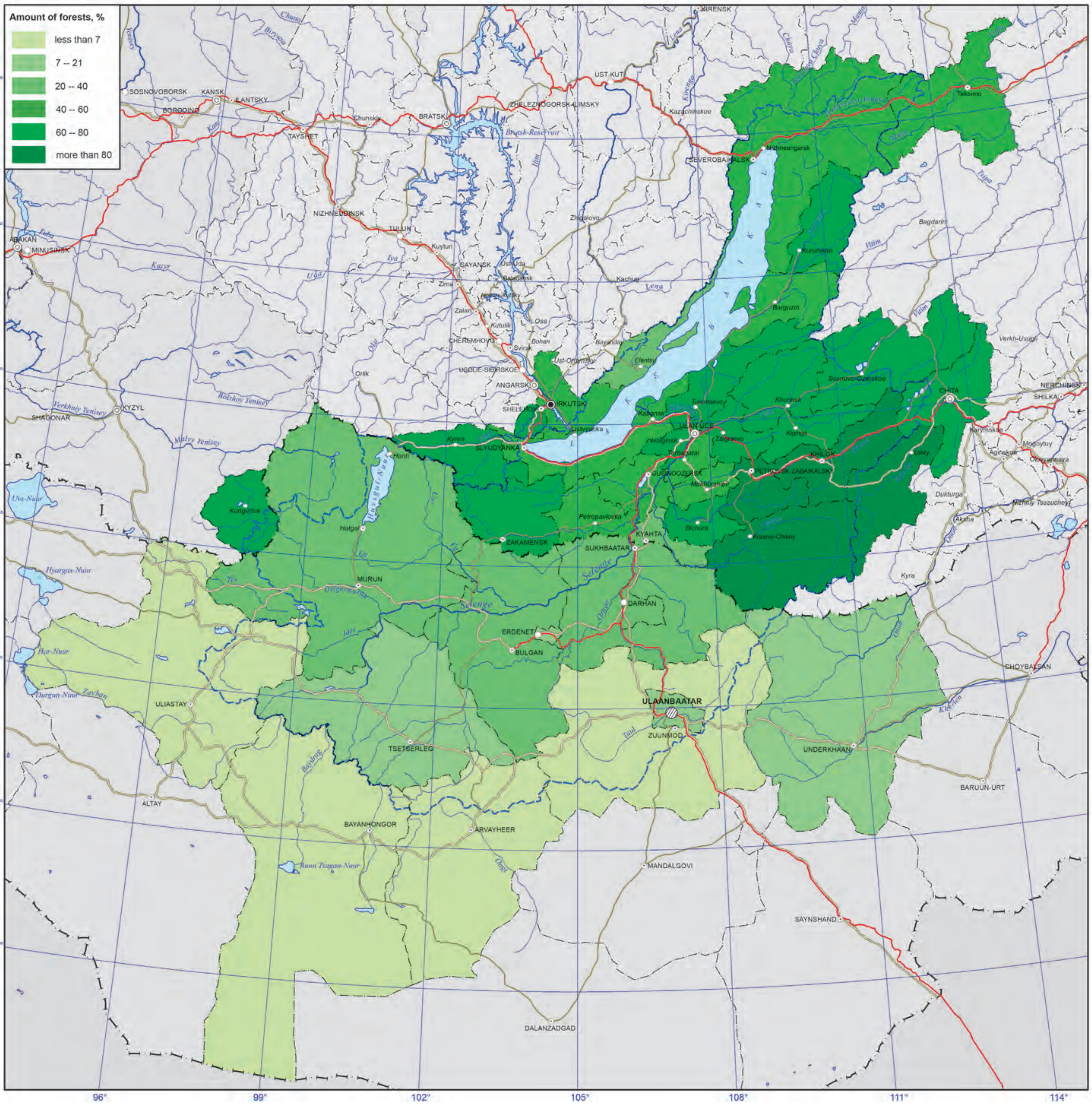
81. Forb-feather-grass (*Stipa klemenzii* Roshev., S. *sibirica* (L.) Lam., *Artemisia frigida* Willd., A. *scoparia* Waldst.end Kit., *Cymbaria dahurica* L., *Veronica pinnata* L., and others) and gramineous-feather-grass (*Stipa krylovii* Roshev., *Agropyron cristatum* (L.) Beauv., *Festuca valesiaca* Gaudin, *Cleistogenes squarrosa* (Trin.) Keng, *Leymus chinensi* (Trin.) Tzvelev), in places shrub (*Caragana microphylla* (Pall.) Lam., C. *Bungei* Ledeb., C. *pigmaea* (L.) DC., C. *stenophylla* Pojark. On rare occasions - *Spiraea hypericifolia* L.) steppes on planate surfaces and gentle slopes of hummocks and hills with light sandy-loamy and light loamy soils, combined with forb-fescue, Leymus and cleistogenes steppe communities on rocky and stony surfaces

MEADOW STEPPES

South-Siberian formations

82. Wheatgrass, feather-grass-wheatgrass (*Agropyron cristatum* (L.) Beauv., *Stipa krylovii* Roshev.) in places forb-fescue-wheatgrass (*Agropyron cristatum, Festuca lenensis, Artemisia argirophylla, Oxytropis chionophylla*) with kobresia (*Kobresia humilis*) steppes on steep stony sunlit slopes, on aprons of mountains and in wide lows with light-textured soils, combined with Koeleria and tall-grass (*Serratula centauroides L., Scabiosa comosa* Fischer ex Roemer et Schultes) steppes on gentle

31. FOREST COVER



Two groups of formations are clearly distinguished; they are mountain steppes and steppes of foothills, elevated plains and hummocks. In each of them, large ecological-morphological groups – meadow and dry steppes – are distinguished according to the nature of steppe vegetation. For each of these groups within the respective phratries of formations independent regional steppe complexes are identified, namely: Southern Siberian, northern Mongolian and Central Asian formations. The main areas, both in the mountains and on the plains and hummocks, are occupied by dry steppes of the Mongolian-Chinese phratrie of formations.

In general, the map reveals in details the spatial flora-coenotic structure of the vegetation cover of the Baikal basin in its evolutionary-genetic and dynamic dependence. Regional-geographical features of the coenotic diversity are well identified, taking into account their zonal-subzonal or altitudinal development conditions.

FOREST COVER (31)

Forest cover is a parameter reflecting the ratio of the total forested area (on forest lands and lands of other categories where forests are located) to the area of the municipality (district or aimag). Forest cover is an important indicator characterizing the forest availability, and, consequently, the ecological security and the features of the socio-economic development of a territory.

Average forest cover of the Baikal watershed basin within the Russian territory is 62.5 %. Forest cover fluctuates here from 26.4 % in Kyakhtinsky district, located in the steppe part of the Republic of Buryatia, to 82-89 % in Krasnochikoisky, Petrovsk-Zabaikalsky, Uletovsky, and Khiloksky districts of Zabaikalsky krai. In Mongolia, the average forest cover is significantly lower than in the Russian part of the basin amounting to 11.5 %, and it ranges from 0.75 % (Uverkhangay aimag) to 35.0 % (Darkhan aimag).

Over the last decade (2000-2010) a decrease in forest cover in the most developed parts of the Baikal watershed basin is registered. This is associated with the reduction of forested lands due to areas, subjected to fire, cutting, and insect pests.

Wooden house and burning fuel.

slopes and bottoms of depressions with good soil moistening with sandy-loamy and steppe carbonate-free soils

83. Fescue (*Festuca lenensis* Drobov) and bluegrass (*Poa botrioides* (Griseb.) Roschev) in places mixed small-bunchgrass with forbs (*Kobresia filifolia, Oxytropis oligantha, O. chionophylla, Saussurea saichanensis, Potentilla nivea*) steppes on slopes and on bottoms of depressions with dark-chestnut and steppe carbonate-free soils, combined with steppe shrubs vegetation (*Cotoneaster melanocarpus* Fisch. ex Blytt, *Spiraea media, S.pubescens, Ribes diacantha*), kobresia (*Cobresia filifolia* (Turcz.) Clarke) and sedge meadows (*Carex pediformis* C.A.Meyer) on stony slopes and rocks with clay soils

84. Pea shrub (*Caragana micriphylla Lam., C. pygmaea D C.*)-wild rye (*Leymus secalinus* (Georgi) Tzvelev)-wheatgrass (*Agropyrum michnoi* Roshev.) steppes on blown sands and sandy soils, combined with thyme and fescue communities, as well as elm (*Ulmus pumila L.*) woods on slopes, rocks and cliffs with arid sandy-stony soils

85. Sagebrush (*Artemisia frigida* Willd.) and low-grass (*Chamaerhodes altaica Bge., Arctogeron gramineum* D C., *Arenaria capillaries Poir., and others*) lithophilous steppes on steep sunlit slopes and planate surfaces with stony-rank soils, combined with fescue and petrophyte-forb-small-bunchgrass (*Stipa krylovii, Festuca lenensis, Agropyron cristatum, Krylovia eremophylla, Agropyron cristatum, Allium eduardii, Potentilla sericea, Arenaria meyeri Peucedanum histris, Dracocephalum foetidum*) groups on rocks and taluses

MEADOWS AND HYDROPHILOUS COMMUNITIES

TRANS-VOLGA-KAZAKHSTAN PHRATRY OF FORMATIONS

Middle-Siberian formations

86. Sedge (*Carex enervis* C.A.Meyer)-gramineous (*Hordeum brevisubulatum* (Trin.) Link)-forb (Iris biglumis Vahl) alkaline meadows in the near-terrace and central parts of floodplains with saline soils, comprised of fine fractions of alluvium

87. Sedge-gramineous predominantly alkaline meadows (*Hordeum brevisubulatum* (Trin.) Link., *Agrostis mongolica* Roshev., *Puccinellia tenuiflora* (Griseb.) Scribner et Merr.) in kettle depressions of salt lakes, on natural levees and along-channel floodplains, comprised of alluvium of coarse fractions, combined with sedge bogs and willow stands (*Salix dahurica* Turcz., S. *rossica* Nas.) in lower tracts of floodplains with waterlogged peaty soils

MONGOLIAN-CHINESE PHRATRY OF FORMATIONS

South-Siberian formations

88. Low-grass partially steppizated meadows (*Agrostis trinii* Turcz., *Carex pediformis* C.A.M., *Kobresia filifolia* Meinsc.) in river valleys on flat and wide low ridges, as well as on bottoms of creek valleys with floodplain-meadow sandy-loamy and loamy soils, combined with yernik (*Betula gmelinii* Bge.) vegetation on sides of ravines and banks of streams and kobresia-fescue steppes on higher tracts of floodplains with pebble and sand deposits

89. Gramineous (*Leymus chinensis* Tzvel., *Carum buriaticum* Turcz., *Coeleria cristata* (L.) Pers.s.str., *Cleistogenes squarrosa* (Trin.) Keng, *Agropyron repens*) and forb (*Geranium pretense, Sanguisorba officinalis, Valeriana oficinalos, Trifolium lupinaster, Orostachys spinosa, Thymus dahuricus*)-gramineous steppizated meadows with poplar (*Populus suaveolens* Fish.) and willow shrubs (*Salix rorida* Laksch.) in river floodplains and on along-channel pebble-beds with saline soils

90. Grass (*Leymus secalinus* Tzve, *Poa pretensis* L., *Elytrigia repens* (L.) Nevski, *Agrostis mongolica* Roshev., *Bromus sekalinus* L, *Sanguisorba officinalis* L., *Medicago falcata* L.) meadows with shrubs (*Salix microstachya* Turcz., *Hippophae rhamnoides* L., *Ulmus pumila* L.) and sigly occuring poplar trees (*Populus laurifolia* Ledeb.) on sufficiently moistened tracts of large rivers and in the mouths of small rivers with loose peaty soils

91. Reed (*Phragmites communis* Trin.), small reed (*Calamagrostis langsdorffii* Trin.), sedge (*Carex orthostachys* C.A.Mey.) and horsetail hydrophilous communities in the along-channel zones of rivers on newly formed alluvium with cryogenic floodplain waterlogged soils

92. Waterlogged sedge (*Carex lithophila* (Turcz.) Hämet-Ahti, C. *schmidtii* Meinsh., C. *cespitosa* L.) and gramineous-forb (*Ranunculus sceleratus* L., R. *propinquus* C.A.Mey, *Rumex gmelinii* Turcz. ex Ledeb., *Stachys aspera* Michaux, *Calamagrostis langsdorffii* Trin., C. *neglecta* (Ehrh.) Gaertner) meadows in floodplain, often flooded lows on meadow-bog cryogenic soils, combined with shrubs vegetation (*Salix kochiana* Trautv., S. *viminalis* L.) and waterlogged larch (*Larix sibirica* Ledeb.) forests in river valleys with gleyed slightly peaty soils with close occurence of permafrost

93. Sedge (*Carex cespitosa* L., C. *karoi* Freyn, C. *orthostachys* C.A.M., C. *rynchophysa* C.A.M.) meadows, combined with shrubs (*Salix viminalis* L., S. *rhamnifolia* Pall., *Caragana spinosa* (L.) DC.) and spruce (*Picea obovata* Ledeb.) (along the Tesiin-Gol river) forests on edges of lakes and in river valleys with loamy soils

Central-Asian formations

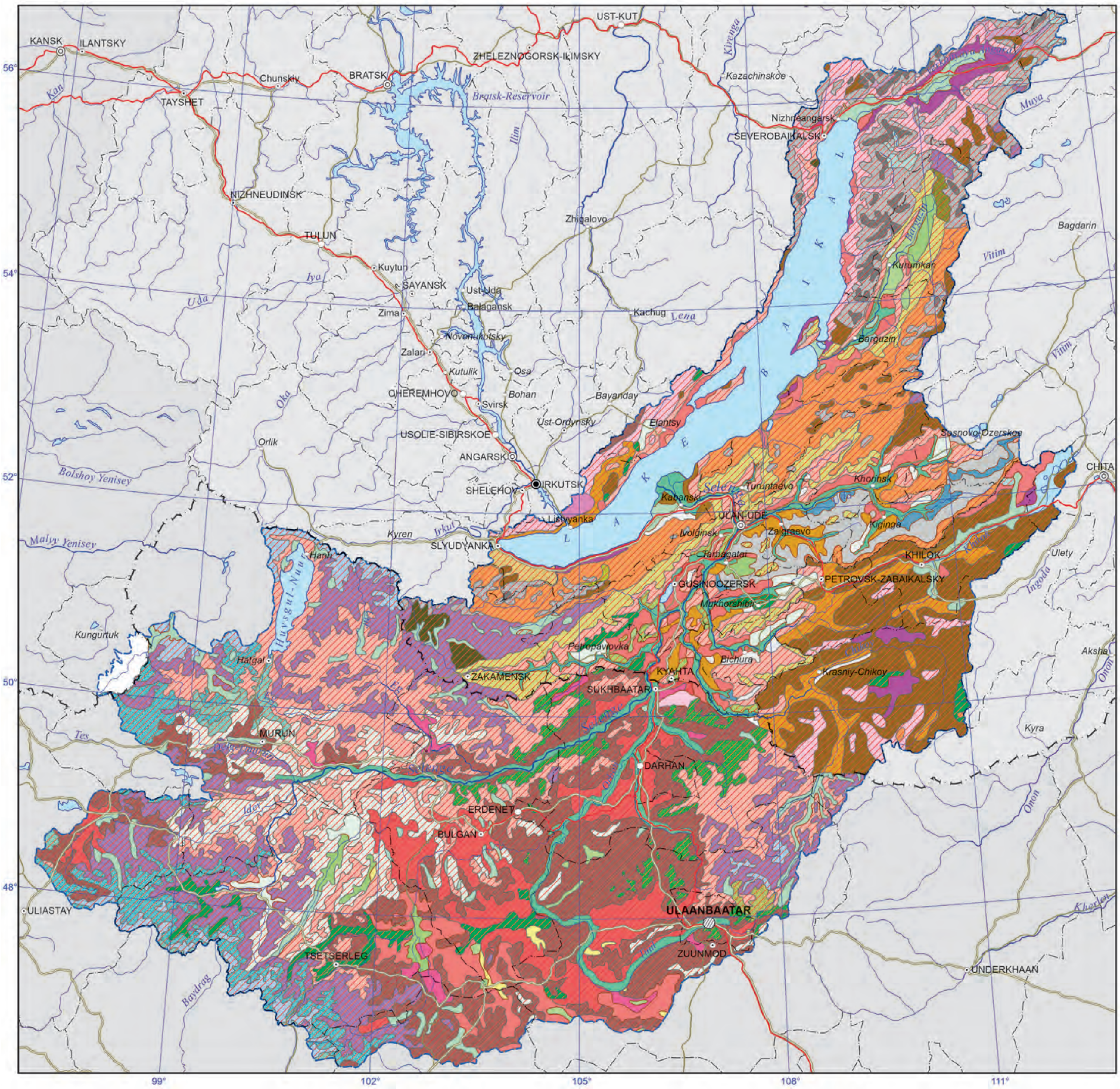
94. Iris (*Iris biglumis* Vahl.) meadows on river terraces and along-channel tracts with loamy soils, combined with Leymus steppes and solonchak communities in floodplains and kettle depressions of salt lakes with well-drained alluvial sandy soils

95. Forb-gramineous (*Elytrigia repens* (L.) Nevski, *Geranium pretense L., Sanguisorba afficinalis L.*) meadows along river valleys with cryogenic soddy-gley and meadow-bog soils, combined with shrubs (*Salix pentandra* L., S. arbuscula L., *Dasiphora fruticosa* (L.) Rydb., *Betula fruticosa* Pall.) (along the Tesiin-Gol river – *Populus laurifolia* Ledeb.) along rivers and lower parts of slopes with boggy moistened peaty-meadow soils

96. Halophytic-forb (*Halerpestes salsuginosa* (Pallas ex Gejrgi) *Greene, Iris biglumis* Vahl.), halophytic-gramineous (*Achnatherum splendens* (Trin.) Nevski) and sedge (*Carex enervis* C.A.M., C. *duriuscula* C.A.M.) meadows, in places with the inclusion of willow stands (*Salix ledebouriana* Traunv.), on edges of solonchak depressions, lakes, terraces and along banks of steppe rivers and brooks with meadow-solonchak soils, combined with alkaligrass (*Puccinellia tenuiflora* (Griseb.), Scribn. Et Merr., P. *Hauptiana* V.I.Krecz.) and saltwort (*Salsola corniculata* (C.A.Meyer) Bunge, s. str.) meadows on solonchaks, on bottoms of saline lowlands and around intermittent lakes with meadow-solonchak-like soils in the steppe and forest-steppe zones, predominantly in the east and in the central part of Mongolia

	Soils of mountainous areas	Accompanying (about 15-20 % to the surface area of contour)	Occurring (about 5-10 %)
		Soils mountain areas	
	lithozems, petrozems	cryozems, podburs	gleyzems, podzols
	lithozems	petrozems	podburs
	coarse humus cryo-lithozems	gleyzems, podburs	petrozems
	humic-dark-humus cryo-lithozems	gleyzems	dark-humus cryo-carbo-lithozems
	dark-humus lithozems	gray-humus lithozems	dark-humus cryo-lithozems
	gleyzems	peat-gleyzems	peat-lithozems
	peat-gleyzems	peat-lithozems	gley peat-podburs
	dark-humus carbo-lithozems	humic-dark-humus carbo-lithozems	humic carbo-lithozems
	humic carbo-lithozems	dark-humus carbo-lithozems	humic-dark-humus carbo-lithozems
	humic-dark-humus	humic-cryometamorphic	humic
	cryozems	podburs	peat-lithozems
	peat-cryozems	peat-podburs	peat-gleyzems
	typical and coarse humic podburs	sod-podburs, peat-podburs	coarse humus burozems
	podzolized podburs	illuvial-ferruginous podburs	illuvial-humus podburs
	podburs, coarse humus burozems	sod-podburs podzolized	podzolic
	podburs, podzols	sod-podzols	sod-podburs
	coarse humus burozems	dark-humus residual-carbonate	podburs
	sod-podzols and podzols	sod-podzolic	podzolic
	sod-podburs	podzolized sod-podburs	dark-humus residual-carbonate
	typical dark-humus	dark-humus metamorphized	dark-humus gleyic
	dark-humus metamorphized	dark-humus gleyic	dark-humus residual-carbonate
	light-humus	chestnut	gray-humus
	dark-humus residual-carbonate	dispersive-carbonate chernozems	dark-humus metamorphized
	mountain dispersive-carbonate shallow rank chernozems	shallow rank chernozems	hydrometamorphized chernozems
	mountain dark-chestnut shallow rank	dark-chestnut	dark-chestnut hydrometamorphized
	mountain chestnut shallow rank	chestnut	chestnut hydrometamorphized
		Soils of high plains and intermontane depressions	
	podzols	sod-podzols	podzolic
	sod-podzolic	podzolic	podzolized sod-podburs
	slightly-podzolic of pine-forest sands	slightly-podzolized sandy	sod-podzolic sandy
	gley sod-podzols	sod-podzol-gley	gleyic sod-podzols
	sod-podburs and gray metamorphic	coarse humic podburs	gray
	sod-podburs and humus psammozems	podburs	psammozems
	dark-gray	dark-gray metamorphic	dark-gray gley
	gray metamorphic	gray	dark-gray
	humus-hydrometamorphic	dark-humus	humic-dark-humus
	humic-gley	humic-quasi-gley	humic-humus gley
	quasi-gley chernozems	hydrometamorphized chernozems	clay-illuvial quasi-gley chernozems
	chernozem-like	dark-humus metamorphized	textural-carbonate quasi-gley chernoze
	dispersive-carbonate chernozems	hydrometamorphized chernozems	chernozem-like
	dark-chestnut	dark-chestnut turbic	dark-chestnut hydrometamorphized
	chestnut	shallow chestnut	chestnut hydrometamorphized
	chestnut hydrometamorphized	chestnut turbic	dark-chestnut
	peat eutrophic (gley)	humus-hydrometamorphic, humic- hydrometamorphic	peat-cryozems
	alluvial gray-humus and dark-humus	alluvial dark-humus gley, stratified, humic-gley	alluvial peat-mineral, peat-gley, peat-cryozems gleyic
	solonchaks, solonetzes	light-humus saline, chestnut saline (solonetzic)	saline (solonetzic) chernozems
	humus-hydrometamorphic saline, humic-hydrometamorphic saline	humus-hydrometamorphic solonetzic	humic-hydrometamorphic solonetzic
	sands		

32. SOILS



SOILS (32)

Soil associations are presented in the contours on the map. Combinations of soils, united in a contour, are associated with the altitudinal and expositional differentiation, and are determined by the character of mesorelief (combinations) and microrelief (complexes), and by the heterogeneity of the soil-forming material (mosaic). The predominant soil is the first in the legend, followed by accompanying and occurring soils. Most soils are distinguished at the type level, rarely at the subtype level, according to the classification of soils for Russia and Mongolia [Dorjgotov, 1976; 2003; Shishov..., 2015; Ubugunov и др., 2012; Vorobeva 2009].

The great extension of the territory of the Baikal basin from south to north determines latitudinal variations of the thermal factor and the associated vegetation and soil cover. In addition to these basic regular patterns, the influence of exposure and meridional arid mountain zonality is manifested here. The role of permafrost and heterogeneity of parent rocks, complicated and insufficiently clear evolution of landscapes in the past, and their changing as a result of the human impact are essential.

Within the mountain taiga, independent contours are distinguished in the south-western and north-eastern parts of Cisbaikalia. They are represented by combinations of soils with the eluvial-illuvial and undifferentiated profile. The Baikalsky Ridge and the North-Baikal Highland are dominated by podzols and podburs, involving peat-podburs and sod-podzols. They are characterized by a thin profile, which averages 30 cm in podzols of the highland, while in the mountains of Cisbaikalia it is about 40 cm. Thickness of the profile of podburs, which can be regarded as being in the early stage of soil formation, is even less.

Soils of piedmont dry steppes of Cisbaikalia are common in the Priolkhonie region and on Olkhon Island. Formation of dry steppe landscapes with chestnut soils is due to the arid mountain zonality (location in the rain shadow). The lack of atmospheric moistening is compounded here by a high water penetration capacity of woody-loamy soils. The territory is similar to that of the dry steppe of Kazakhstan in the nature of moistening, and to the middle taiga of Yakutia in heat supply. A consequence of the extreme soil-climatic conditions is a low biological productivity. Agroecosystems here are in a state of crisis; the vegetation and soil cover undergoes degradation.

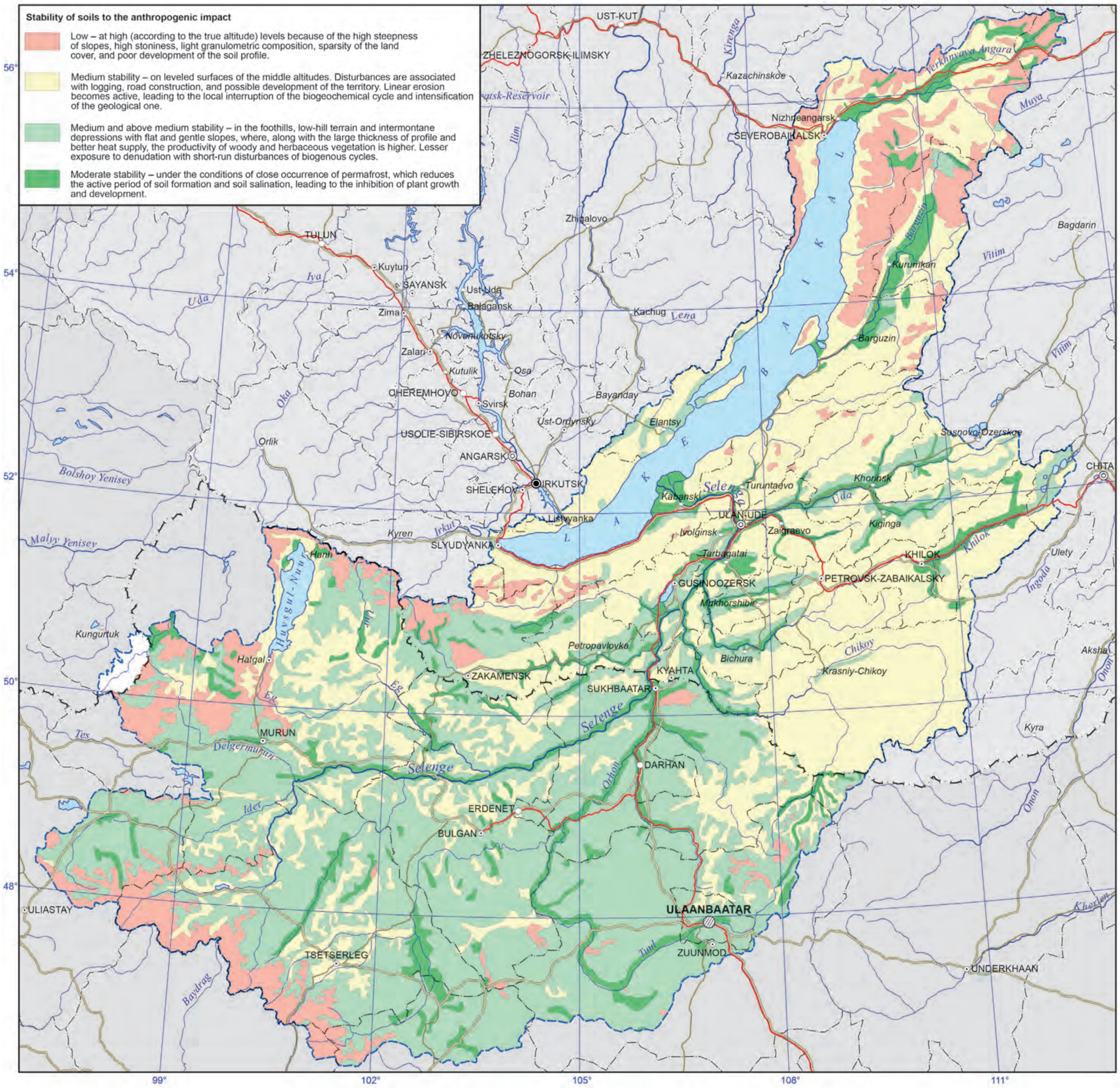
In the high-mountain part of the Khamar-Daban, Muisky, Verkhne-Angarsky and Barguzinsky ridges the basic soils are petrozems, peat-lithozems, and coarse humus lithozems. Coarse humus, humic and humic-dark-humus soils are formed under the sub-alpine meadows. On the northern slopes, in relatively low relief elements, and in areas composed of parent rocks of heavier particle-size distribution, gley podburs are formed.

Cryo-lithozems, petrozems and cryo-carbo-lithozems accompany nival dissected landscapes of the Khangai region of Mongolia. Cryozems (coarse humus) and peat-cryozems are developed in the sub-goletz altitudinal belt, locating in a relatively narrow band near the forest line. In soils of taiga massifs permafrost areas are of frequent occurrence; moreover, seasonal frost is longstanding, and cryoturbation phenomena and solifluction are usual.

The structure of the soil cover of the mountain-taiga zone of Transbaikalia is heterogeneous and is largely associated with the manifestation of vertical zonality, slope exposure, and permafrost. The main soil background is comprised of podburs, podzols, sod-podzols, sod-podburs, gray-humus, humic, humic-dark-humus soils and coarse humus burozems. The main background of the soil cover of taiga territories of Mongolia includes cryozems, podburs and dark-humus soils. Soils of podzolic type are rare here. In the upper part of the taiga belt, cryozems and podburs are formed; higher there are peat-lithozems. In mountainous taiga there occur steppe «islands» with chernozem-like soils. They can be found on steep parts of the southern slopes, facing the broad areas of intermontane depressions.

The natural-climatic zone of forest-steppe is dominated by gray metamorphic soils, which are formed on the foothill areas of depressions and on the northern slopes of hills inside intermontane lows or at the bottom part of the forested slopes of ridges, facing the steppe depressions. These soils occupy the largest areas in the forest-steppe of the southern part of the Trans-Baikal middle mountains. In the forest-steppe landscape belt of Mongolia of light-coniferous and mixed subshrub and herbaceous facies there occur dark-humus metamorphosed soils, located mainly along the southern slopes of ridges and hills. Gray humus

33. SOIL STABILITY



soils formed under woody communities with forbs on carbonate rocks. This combination of soils, characteristic of different environmental conditions, is the main feature of the soil cover at the junction of taiga and steppe.

In steppe landscapes of Transbaikalia the main background of the soil cover is comprised of chernozems. They are formed under meadow and true steppes. The main massifs of these soils are located in the Tugnui-Sukhara basin: on the Tugnuisky ridge and on the southern slopes of the Zagansky ridge, on the northern slopes of the Kudarinskaya range and the Small Khamar-Daban, Monostoisky, and Borgoisky ridges. In the more northern part of the territory, chernozems are formed in individual spots on the north-western slopes of the Unegeteisky ridge and along the Uda and Itantsa river valleys.

The soil cover of dry steppe is dominated by chestnut soils. They occupy vast tracts in the Udinskaya, Priselenginskaya, and Borgoiskaya steppes, and wide gently sloping terraces in the valleys of large rivers; they are common on the southern slopes of the ridges. On the watersheds of high ridges there occur soils of the lithozem group. Humus psammozems are formed on aeolian sand deposits of the dry steppe zone, especially in the Selenga-Chikoy and Chikoy-Khilok interfluves, and on pine-forest sands.

Soils of the river valleys of Cisbaikalia and Transbaikalia are represented mainly by alluvial humic-gley, peat-gley, dark-humus, gray-humus, and dark-humus quasi-gley soils. In the structure of the soil cover of the floodplains of the upper and middle reaches of the rivers stratified alluvial soils are of frequent occurrence. In the steppe and especially in the dry steppe zones of Transbaikalia solonchaks and less frequently solonetzic soils are formed in the river floodplains. They occupy mostly lacustrine depressions and lower parts of gentle slopes, generally adjacent to the river floodplains, where there is a zone of accumulation of waters of the valley runoff enriched with soluble salts or a discharge of mineralized groundwaters. The most common types of salinization of solonchaks and solonetzic soils are sulfate-soda, soda-sulfate, sulfate, and chloride-sulphate. Large massifs of saline soils are widespread in the Borgoiskaya steppe and lacustrine lows of Lakes Verkhnee Beloe and Nizhnee Beloe. Their proportion in the Ivolginskaya depression is quite substantial. Solonetzic soils and solonchaks also occur in lacustrine depressions of the Bichursky district and the Tugnuiskaya steppe. In the Selenga river delta, in the Barguzin river valley, and in some other regions relatively large massifs are covered with bogs, where mainly peat eutrophic and peat eutrophic gley soils develop.

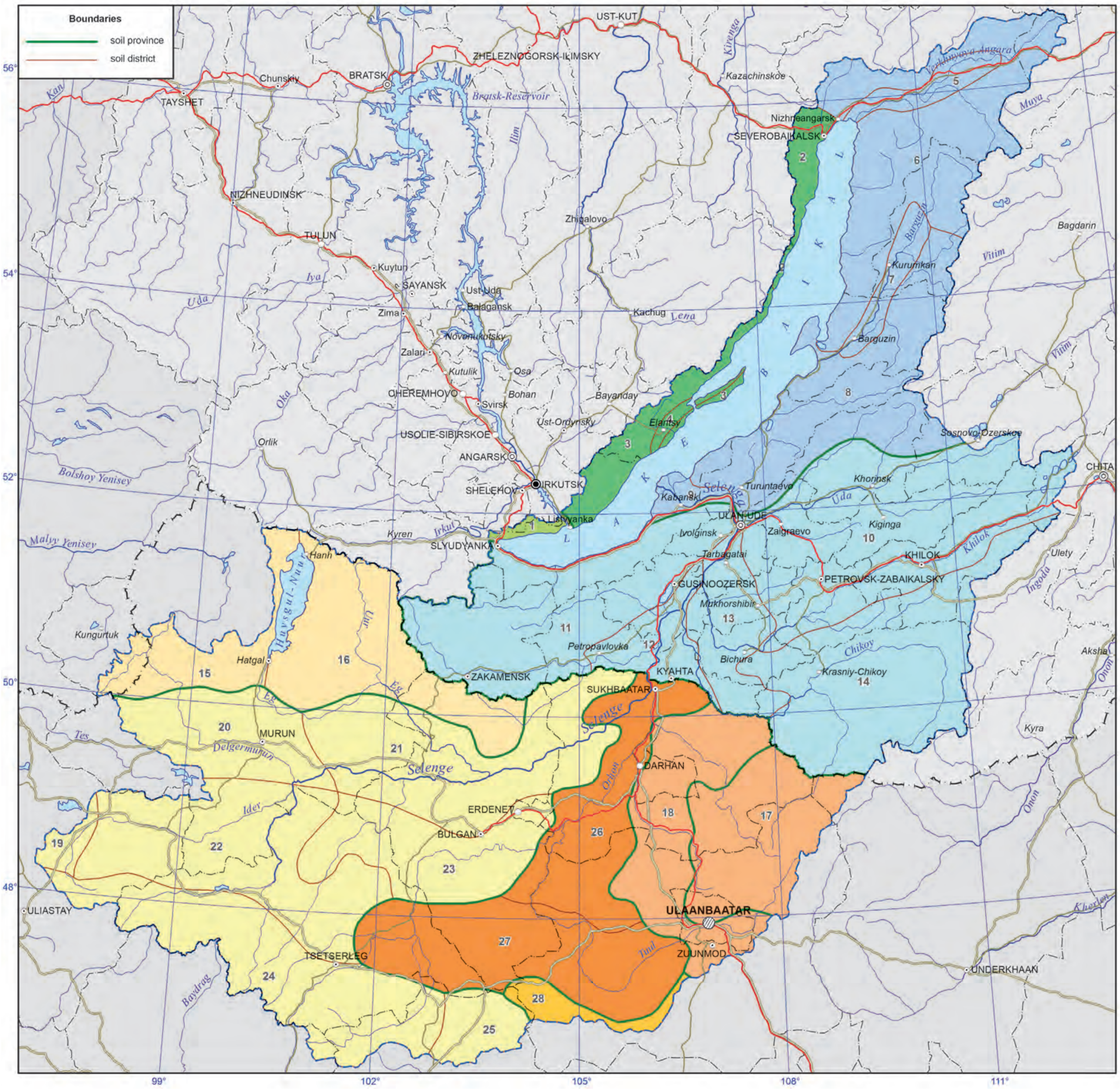
Soils of waterlogged meadows and lacustrine-boggy complexes of Mongolia are widespread in the near-shore zone of Lakes Khovsgol and Doot-Nur, in the Dzhargalant-Gol and Mungaral-Gol interfluve, in the northern and southern part of the Darkhatskaya depression, and along river valleys. Alluvial dark-humus soils are formed in river floodplains on elevated areas, in deltas, and on alluvial fans of temporary streams. Alluvial humic gley soils are formed under the conditions of additional inflow of moisture. In elevated locations of the riverbed floodplain of mountain rivers on sandy-gravel deposits gray-humus alluvial and stratified soils were formed. Alluvial peat-gley (peat-mineral) soils are formed in relatively low locations of river floodplains with the conditions of long-term surface and subsurface moistening, as well as on the edges of water bodies overgrown with bog vegetation. Humus-hydrometamorphic seasonally freezing for a long time soils are formed in the central floodplain of the rivers. In the lacustrine part of the depressions humic-hydrometamorphic (silty-humic) cryogenic soils are developed.

In the territory of Mongolia a series of relatively small contours of saline soils occurring in different parts of the country was distinguished. Processes of erosion and deflation are widespread, which is due to the shower precipitation pattern, and periodic occurrence of dust storms and strong winds, especially in spring when soil is dry and vegetation grows poorly.

SOIL STABILITY (33)

A qualitative assessment of the soil stability (i.e. the resistance to external effects and the ability to restore the disturbed properties) was made with regard to the external and internal factors. In general, the stability decreases from low graded surfaces or gentle slopes with an increase in an altitude and steepness of slopes. In the same direction a change from loamy deposits to stony deposits with small thickness of the loose mass takes place, and heat supply changes for the worse. In total, four large subdivisions of soils were distinguished according to different degrees of stability: low, medium, medium and above medium, and moderate. Their characteristic is given in the legend to the map of the soil stability to the anthropogenic impact.

34. SOIL-ECOLOGICAL ZONING



SOIL-ECOLOGICAL ZONING (34)

The principles of “Soil-ecological zoning of Irkutsk oblast” [Kuzmin, 2004], “Soil zoning of the Baikal region” [Kuzmin, 1993], and “Soil-geographical zoning of Mongolia” [Dorzhgotov, 2009], the map of the soil cover, information on soils, their connections with the natural conditions, obtained as a result of the in-house long-term research, and materials on geology, topography, and other natural components were used when developing the zoning.

In the map of the soil-ecological zoning, nine provinces are singled out, reflecting the peculiarity of the surface topography, since the ratio of the heat and moisture balance, which serves as the basis for zoning, manifests itself against the background of the complex orography. Here bioclimatic factors play a key role. Twenty-eight districts are distinguished in the provinces according to the lithologic-geomorphological features. From the standpoint of the structural approach, the districts are regarded as territories with a specific regular change of several types of the soil cover structure, associated with the features of terrain and parent rocks.

The complex of all natural conditions that influence the formation of the soil cover is taken into consideration in the soil-ecological zoning. Connections of soils with other components of the landscape are identified. It is necessary to consider regional features of the soil cover when planning the distribution of agricultural production, while knowledge of the interrelations of soils with the natural conditions is essential to develop the measures aimed at avoidance of negative consequences of the anthropogenic impact.

The maps of soil cover can be used as independent scientific works, characterizing the soil cover of the area, which is an important component of the landscape, as a starting material for the soil (land) resources accounting, as a support material for planning the chemicalization of the agricultural production, agroforestal and erosion control measures, development of forest resources, environmental protection, as a basis for various types of zoning, and as a manual for students of higher education institutions.

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TAXONOMIC DIVERSITY OF INVERTEBRATE COMMUNITIES (35)

Cartographic analysis of the spatial distribution of taxonomic diversity of invertebrate communities was carried out on the basis of the vegetation map of the Baikal basin.

The object of the analysis is the species (taxonomic) diversity of terrestrial invertebrates, forming community and having systemic and functional relationships. The main focus is on the mesopopulation (supraspecific taxonomic level), i.e. on relatively large invertebrates inhabiting soil and its surface.

The data were obtained as a result of a detailed study of the quantitative characteristics of invertebrate communities on key testing areas in taiga, mountain taiga and steppe geosystems of the Baikal basin. Numerous published and cartographic materials, information on soil cover and vegetation state were analyzed, and data on the heat and moisture supply to soils are taken into account. A method of soil-zoological and biogeocenotic studies with the application of the

Legend to the "Soil-ecological zoning" map

I - EASTERN-SAYANSKAYA HIGH- AND MID-MOUNTAIN PROVINCE

of medium thick, loamy, acid, slightly acid soils with a high absorption capacity, moderately and weakly moistened, cold, freezing for a long time, providing the growth of forests of medium and high productivity

1 – mid-mountain district of the South-Western Pribaikalie of podzols, podburs and sod-podzolic soils.

II – PRIBAIKALSKAYA PIEDMONT, HIGH-, MID- AND LOW-MOUNTAIN PROVINCE

of predominantly medium thick, loamy, slightly acid, neutral and slightly alkaline, moderately and regularly insufficiently and weakly moistened, cold, freezing for a long time soils of medium and low natural fertility

2 – high- and mid-mountain Baikal district of peat-podburs, podburs and coarse humus burozems;
3 – mid- and low-mountain Primorsky district of podzolized podburs, sod-podburs, coarse humus burozems, and sod-podzolic soils;
4 – piedmont and low-mountain district of Olkhon Island and the Priolkhonie of chestnut soils, locally sod-podburs and podburs.

III – BAIKALO-DZHUGDZHURSKAYA HIGH-, MID-MOUNTAIN-TAIGA, DEPRESSION - VALLEY PROVINCE

of shallow to relatively thick, predominantly loamy acid, neutral and slightly alkaline, moderately moistened, very cold and freezing for a long time soils, providing from low to medium biological productivity of vegetation

5 – depression-valley Verkhneangarsky district of podzolic, peat eutrophic and alluvial soils;
6 – high-mountain Barguzinsko-Verkhneangarsky district of lithozems, petrozems, humic carbo-lithozems, sod-podzols, podzols, gleyzems, and typical and coarse humic podburs;
7 – depression-valley Barguzinsky district of chestnut, alluvial, peat eutrophic and podburs;
8 – mid-mountain Ulan-Burgassko-Ikatsky district of podburs, coarse humus burozems, sod-podzols (gley), and podzols;
9 – valley district of the Selenga river lower reaches of alluvial, peat eutrophic soils, sod-podzols, sod-podburs and gray metamorphic soils.

IV – KHAMARDABANO-SOUTHERN-TRANSBAIKALSKAYA MID-MOUNTAIN-TAIGA, FOREST-STEPPE AND MOUNTAIN-DEPRESSION-STEPPE PROVINCE

of medium and relatively thick, predominantly loamy, acid, neutral and slightly alkaline, insufficiently and temporarily excessively moistened, moderately cold and moderately freezing for a long time soils with vegetation of medium and high productivity

10 – mountain-valley Udinsko-Khiloksky district of sod-podburs, podburs, coarse humus burozems, alluvial, chernozems, chernozems-like, quasi-gley chernozems, chestnut soils, and a complex of saline soils;
11 – high- and mid-mountain Khamar-Dabansky district of podburs, coarse humus burozems, sod-podzols, podzols, cryozems, lithozems, and humic carbo-lithozems;
12 – depression and low-mountain Dzhidinsko-Chikoisky district of chestnut, chernozems, light-humus, alluvial, solonetzes, and solonchaks;
13 – low-mountain-valley Chikoisko-Khiloksky district of sod-podburs, sod-podzols, podzols, gray metamorphic, alluvial, chestnut and chernozems, and a complex of saline soils;
14 – mid-mountain Verkhnechikoisky district of sod-podburs, podburs, sod-podzols, podzols and coarse humus burozems.

V – KHUBSUGULSKAYA HIGH-MOUNTAIN-DEPRESSION PROVINCE

of shallow and medium thick, predominantly sandy-loam, sandy, rank, slightly acid, neutral, slightly alkaline and alkaline, moderately and weakly moistened, cold, freezing for a long time soils of low natural fertility

15 – high-mountain South-Western Prikhubsugulsky district of coarse humus cryo-lithozems, humic-dark-humus cryo-lithozems, sod-podburs, dark-humus, and locally peat eutrophic and humus-hydrometamorphic soils;
16 – high-mountain and depression-valley Eastern-Prikhubsugulsky district of coarse humus cryo-lithozems, dark-humus lithozems, cryozems, sod-podburs, dark-humus, and locally mountain dark-chestnut shallow rank, alluvial and peat eutrophic soils.

VI – KHENTEISKAYA HIGH-, MID-, LOW-MOUNTAIN, MOUNTAIN-VALLEY PROVINCE

of predominantly medium thick, sandy-loam, rank, slightly acid, neutral, slightly alkaline and alkaline, moderately and weakly moistened, cold, freezing for a long time soils, providing medium productivity of vegetation

17 – high- and mid-mountain Northern-Khenteisky district of sod-podburs, cryozems with coarse humus cryo-lithozems, dark-humus, mountain dark-chestnut shallow rank, mountain dispersive-carbonate shallow rank chernozems;
18 – low- and mid-mountain-valley South-Western Khenteisky district of mountain dark-chestnut shallow rank, dark-humus metamorphized, dark-chestnut with dark-humus typical, alluvial, and locally peat eutrophic soils.

VII – KHANGAISKAYA HIGH-, MID-MOUNTAIN-TAIGA, MOUNTAIN-VALLEY, PATCHY FOREST-STEPPE PROVINCE

of shallow and medium thick, predominantly sandy-loam, rank, slightly acid, neutral, slightly alkaline and periodically insufficiently and weakly moistened, cold, freezing for a long time soils of low to medium natural fertility

19 – high- and mid-mountain-taiga Telmensky district of mountain dark-chestnut shallow rank, dark-chestnut, dark-humus lithozems, locally with sod-podburs;
20 – mid-mountain-valley Delger-Murensky district of cryozems, sod-podburs, mountain dispersive-carbonate shallow rank chernozems, mountain dark-chestnut shallow rank, dark-humus, chestnut hydrometamorphized and alluvial soils;
21 – mid-mountain-taiga and forest-steppe Selenginsky district of sod-podburs, cryozems, mountain dark-chestnut shallow rank, mountain dispersive-carbonate shallow rank chernozems, chestnut hydrometamorphized, and dark-humus soils;
22 – high- and mid-mountain Northern-Khangaisky district of cryozems, humic-dark-humus cryo-lithozems, sod-podburs, mountain dark-chestnut shallow rank, mountain dispersive-carbonate shallow rank chernozems, dark-humus, dispersive-carbonate chernozems, peat eutrophic, humus-hydrometamorphic saline, and humic-hydrometamorphic saline soils;
23 – mid-mountain-taiga Khanuy-Orkhonsky district of mountain dark-chestnut shallow rank, mountain dispersive-carbonate shallow rank chernozems, dark-chestnut, dispersive-carbonate chernozems, locally sod-podburs, cryozems, peat eutrophic, humus-hydrometamorphic saline, humic-hydrometamorphic saline, and dark-humus metamorphized soils;
24 – high-mountain Khangaisky district of cryozems, sod-podburs, coarse humus cryo-lithozems, humic-dark-humus cryo-lithozems, dark-humus lithozems, mountain dispersive-carbonate shallow rank chernozems, mountain dark-chestnut shallow rank, dark-humus, locally dark-chestnut, humic-hydrometamorphic and peat eutrophic soils;
25 – low- and mid-mountain Eastern-Khangaisky district of mountain dark-chestnut shallow rank, chestnut, chestnut hydrometamorphized, humic-hydrometamorphic, peat eutrophic, with cryozems in places.

VIII – ORKHON-TUULSKAYA FOREST-STEPPE PROVINCE

of medium and relatively thick, predominantly sandy-loam and sandy, neutral, slightly alkaline and alkaline, periodically insufficiently moistened, moderately cold and moderately freezing for a long time soils with vegetation of medium and high productivity

26 – forest-steppe valley Orkhon-Shaamarsky district of dark-chestnut, mountain dark-chestnut shallow rank, humic-hydrometamorphic, peat eutrophic, alluvial, solonetzes, solonchaks, and chestnut saline soils.
27 – forest-steppe Tuul-Dashinchilensky district of dark-chestnut, chestnut, mountain dark-chestnut shallow rank, chestnut hydrometamorphized, dark-humus, humus-hydrometamorphic saline, humic-hydrometamorphic saline, peat eutrophic, alluvial, eolian sands, locally solonetzes and solonchaks.

IX – BURDSKAYA STEPPE PROVINCE

of shallow and medium thick, sandy and sandy-loam, neutral, slightly alkaline and alkaline, periodically and insufficiently moistened, cold, freezing for a long time soils of low to medium natural fertility

28 – steppe Burdsky district of chestnut, mountain dark-chestnut shallow rank, mountain dispersive-carbonate shallow rank chernozems, dark-humus soils, locally eolian sands.

comparative-geographical approach was used in formulating and carrying out the work. Opportunities of landscape indication, based on theoretical concepts about the relation and interdependence of all natural components within a certain genetically homogeneous space, were used to compile map models of distribution of soil-biotic communities.

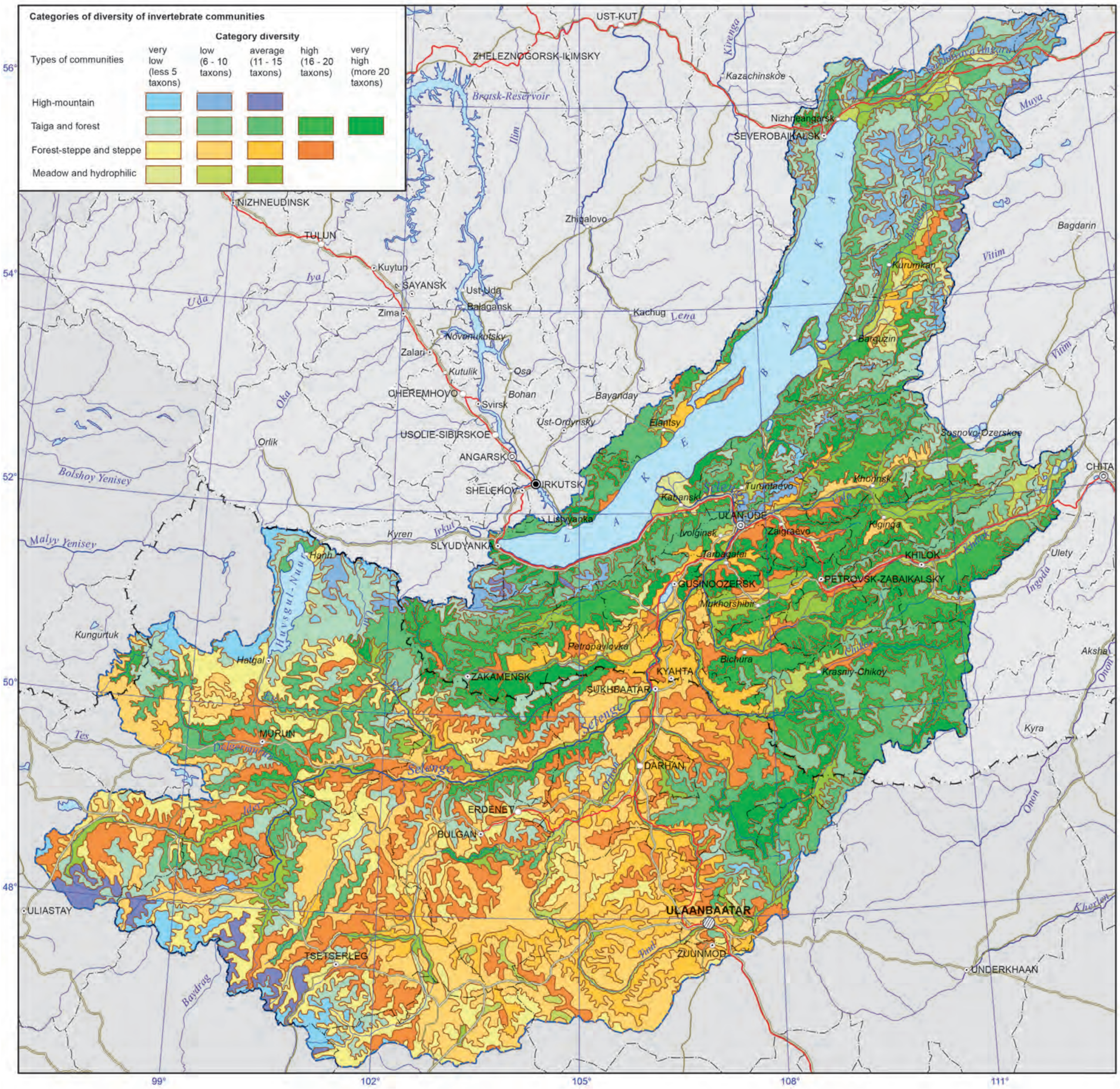
The structure of the animal population corresponding to the specific range of edaphic conditions ensuring normal functioning of soil organisms, was interpreted from the standpoint of the landscape-typological approach, i.e. correlation and subsequent identification (experimentally) of soil invertebrates in specific conditions of their habitat.

Spatial patterns of change in species diversity in gradients of environmental factors such as altitudinal zonality, temperature regime and moisture content of soil were identified on the most well-studied model groups of invertebrates in the Baikal region, namely, the representatives of the Lumbricidae, Carabidae, Staphylinidae, and Elateridae families.

As a result of a unified research methodology the communities of terrestrial invertebrates were united into four groups: alpine, taiga and forest, forest-steppe and steppe, and meadow and hydrophilic. Five categories

Khoboy Cape on Olkhon.

35. TAXONOMIC DIVERSITY OF INVERTEBRATE COMMUNITIES



of diversity of the structure were identified in each group according to the number of taxonomic units in a community: 1 - very low diversity (less than 5 taxa), 2 - low (6-10 taxa), 3 - medium (11-15 taxa), 4 - high (16-20 taxa), and 5 - very high (more than 20 taxa).

On the basis of the structural-dynamic analysis of differences in habitats and corresponding invertebrate complexes on the macrogeographical level, two main types of community structure are distinguished: mesothermohygrophile with a relatively small fraction of insects and a large fraction of annelids, and xeroresistant with significant participation of the class of insects. The first type includes zoocomplexes of taiga, forest and meadow biogeocenoses, represented mainly by moisture-loving forms, and the second one includes zoocomplexes of steppificated, steppes and radically anthropogenically disturbed biogeocenoses, dominated by insects with relatively short development cycles and largely adapted to moisture deficit. This corresponds to two main types of natural environment: of excess moisture - taiga with humid climate, and insufficient moisture - steppe with semihumid climate.

ICHTHYOFAUNA (36)

Ichthyofauna of Lake Baikal and its basin comprises 67 species and subspecies including 6 naturalized ones. Within the bounds of the lake 57 species and subspecies are registered. Out of this number 34 are endemic golomyanka-goby fishes (Cottoidei) (Table) [The freshwater fish atlas…, 2003; Fishes of…, 2007; Fishes of the Mongolian…, 1983; Sideleva, 2003]. A certain conventionality in the assessment of the fish population composition according to species and subspecies should be highlighted. In terms of biodiversity such accounting is to an extent justified, but such characterization is insufficient for the assessment of ecosystem's operation. For instance, omul which occupies a 350-meter water column comprises 3 morphoecological fish groups with various morphological diagnoses, behavior, rates of growth, deposition of fat and breeding grounds. The same can be noted in the case of cisco (3 morphogroups) and black and white graylings. These are young "endemic" forms. Their age is within the limits of the Holocene, but they are new stable structural-functional formations "in the bioenergetic sense equivalent" to species [Reshetnikov, 1980]. With them considered the total fish composition of the basin increases to 71, and 61 in Lake Baikal. The results of immigration of various fish species in Lake Baikal for naturalization carried out in the 20th century testify to the fact that zones of life in the lake and its food supplies are quite rigidly fixed. Out of 33 species and intraspecific forms tested for immigration only the Amur carp, catfish, sleeper and Caspian bream survived in the lake (mostly in its "peripheries"), while peled survived in the lakes of the watershed basin. Rejection of non-Baikal fish species by Lake Baikal was also reflected in the analysis of the causes of "unmixing" of the Baikal fauna with the life around the lake.

According to current concepts [Vereshchagin, 1935; Kozhov, 1962; Taliev, 1955, etc.], Baikal's ichthyofauna is divided into two ecologically and genetically diverse complexes: European-Siberian and native Baikal ones. In the recent years the "neoendemics" or new young endemic offshoots of widely spread species have been registered [Timoshkin, 1995].

The faunal classification by G.V. Nikol'sky (1953, 1980) is usually used in the course of analysis of fish distribution according to their biotope [Kozhov, 1960]. Despite some shortcomings [Sychevskaya, 1983] this classification is rather appropriate for reflecting the ecological specificities of the faunal complexes in the conditions of one and the same water body. It enables to observe their rigid differentiation in Lake Baikal [Mamontov, 1977; Sorokin, Sorokina, 1988].

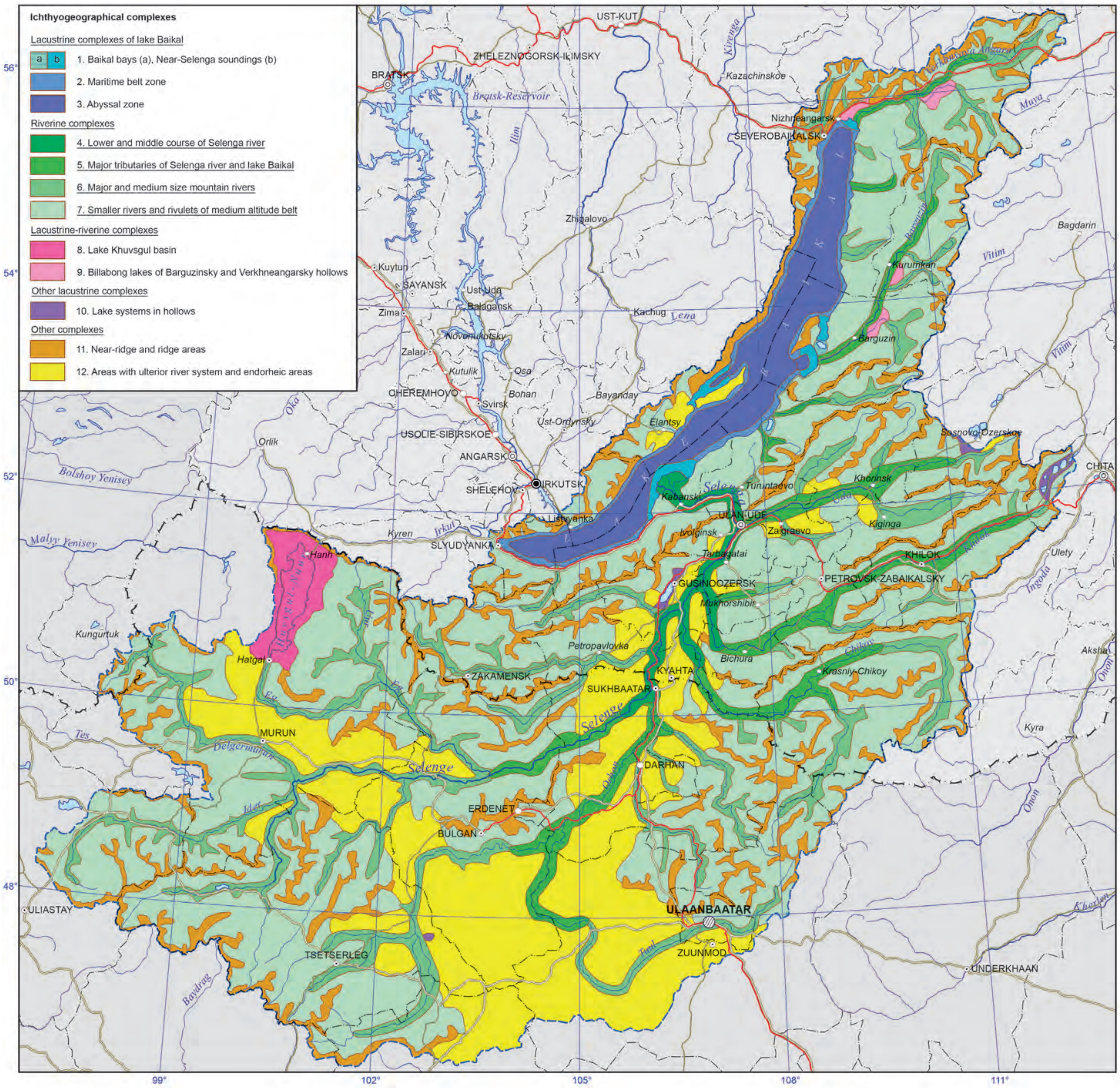
The ichthyogeographic complexes

Lake Baikal

1. System of lakes, sors, bays and near-delta shallow waters of Lake Baikal. Inhabits the boreal plain complex – limnophiles of the coastal-sor fish group (roach, perch, pike, orfe, crucian carp, etc.) occupy the entire system of interconnected lakes, bays and sors of Lake Baikal to a depth of 10-50 m. Sturgeon is the only exception for particular distribution to depths of 180 m. In Baikal it occupies an area of limnorheophiles. The lakes near Lake Baikal (Kotokel', Dukhovoe, and Barmashovoe) can also be included here. Their ichthyofauna composition and productivity are dependent on a degree of their connection with Lake Baikal. The highest productivity occurs with the maximum, but not complete, disjunction with Baikal. Lake Kotokel', one of the most productive lakes, is inhabited by 15 fish species (catfish, carp, bream, roach-bream hybrid, roach, dace, nerfling, crucian carp, river perch, sand sculpin, and stoneloach). Lake Barmashovoe, previously uninhabited by fish, is now inhabited by river perch, roach, dace, and pike, which migrated there from sor-lake Arangatuy during water level increase on Lake Baikal [Fishes of…, 2007].

2. Coastal zone of open Baikal- the boreal piedmont

36. ICHTHYOFAUNA



complex - limnorheophiles of littoral and partially sublittoral areas (taimen, grayling, lenok, minnow, loach, etc.) occupy Baikal coastal open waters to a depth of 20-70 m, rarely up to 100 m.

3. Abyssal zone. Arctic freshwater complex (cisco, lawyer, omul) populate the slope and pelagic zone to a depth of up to 350 m — the Baikal autochthonous complex. It includes endemic Baikal scorpion fish: bullheads, deep dwelling Baikal sculpins and Baikal oilfish (golomyanka) that took the entire water column of the lake with the greatest diversity of benthic forms at depths of 600-700 m.

Due to the fact of high capacity of proper Baikal conditions qualitative changes in fish caused quantitative expression: higher environmental capacity corresponds to the density of endemic fish population (about 65 % of the fish biomass of the lake). This complex becomes the main one ensuring successful existence of the first three, including the Baikal seal, owing to fish diet [Sideleva, 2003].

A complex set of species of different faunal assemblages and goby fish has led to a number of features in the structure of the fish community of Lake Baikal. According to the nature of habitat and behavior of species the Baikal communities include features of ocean ecotone communities, and according to the type of population dynamics (explosive nature) and to the composition they correspond to the Siberian biocoenoses [Mamontov, 1977].

By the abundance of fish Baikal belongs to the golomyanka-goby fish type of a water body [Koryakov, 1972]. Success in assimilating the biotic and abiotic environment of Baikal by fish species of this complex lies primarily in their original biological qualities – absence of a swim bladder (and therefore availability to the deep-dwelling habitation), increased fertility, protection of spawn, occupation of all zones for spawning within the open Baikal, and finally, removal of the embryonic development of eggs in golomyankas in pelagic zone - in the body of a female, functioning as spawning substrate [Chernyaev, 1973, 1974]. These issues are important in theoretical and practical investigations of fish fauna and its rational use.

Increase in the number of individuals in a behavior homogeneous group leads to their increased consumption, and in the future to an increase in the population, group or other biological heterogeneity, reducing predation pressure on certain groups. This developmental pattern became widespread among Baikal slow-moving benthic organisms. The development of variability of morphological characters, color and behavior accelerated their speciation. Among 34 endemics, 28 (82.5 %) are typically benthic forms.

Necessity of multivariancy of individuals in a population of the pelagic fish group weakens due to the formation of a high population size of the few species with small size of their body. This vector of species evolution became possible on the basis of the pelagic larval-fry stage which contributed to dispersal and acquisition of the entire littoral zone for spawning. They include sand sculpin and yellowfin Baikal sculpin. These species occupied biotopes from the shore area to a depth of 500-700 m. Further oecizing of Lake Baikal was feasible due to vivaparity of Baikal oilfish [Taliev, 1955; Chernyaev, 1973]. As a result it became possible to disseminate fry within the confines of general currents facilitating its dispersal in the water area and to settle practically the entire water column. By the number and rate of reproduction, pelagic species prevail over other species so much that they are used in the diet of Baikal seals (nerpa) and almost all the fish of the lake, including cannibalism of gobies themselves on their own fry. This leads to the populating of Lake Baikal by fish of the common Siberian complex and the entire Lake Baikal's ecosystem stability in time.

River and lake systems of the basin reflect the interchange of mountain and plain spaces. They are inhabited by interpenetrating species of the boreal piedmont, boreal plain and Arctic freshwater complex of the Arctic province. The contemporary Arctic ichthyofauna is a derivate of a more thermophilic Neogen Euro-Siberian ichthyofauna that existed in the temperate zone of Eurasia. Its modern distribution is defined by a sharp differentiation of landscape and drainage system following the Alpine orogeny at the boundary of the Pliocene and the Pleistocene accompanied by a more pronounced delimitations of climatic zones [Sychevskaya, 1983].

Water bodies of the watershed area are inhabited by 33 species, including 27 species in the Selenga river

Species of pisciforms and fish	Ichthyogeographical complexes 1a 1b	2	3	4	5	6	7	8	9	10	11	12
Order – STURGEONS - ACIPENSERIFORMES Family - Sturgeons –Acipenseridae Genera- Sturgeons –Acipenser												
Baikal sturgeon –A. baeriibaicalensis	+	+		+	+							
Order – SALMONIDS –SALMONIFORMES Family – Salmonids–Salmonidae Genera Brachymystax–Brachymystax												
Lenok –B.lenok	+	+		+	+	+	+	+				
Genera Taimen–Hucho												
Taimen –H. taimen	+	+		+	+	+						
GeneraSalvelinus –Salvelinus												
Арктический голец (даватчан) –S. alpinus (erythrinus)*						+	+					
Family Coregonidae–Coregonidae Genera Coregonus–Coregonus												
Humpback whitefish –C. (lavaretus) pidschian	+	+		+	+	+						
Baikal whitefish (Sig) –C. (lavaretus) baicalensis	+	+	+									
Arctic cisco (Baikal omul) –C. (autumnalis) migratorius	+	+	+	+	+			+				
Family Graylings –Thymallidae Genera Graylings –Thymallus												
Black Baikal Grayling –Th. (arcticus) baicalensis	+	+		+	+	+	+	+				
White Baikal Grayling –Th.(arcticus) brevipinnis	+	+		+	+							
Baikalolensky Grayling –Th. Baicalolenensis**						+	+					
Kosogol Grayling –Th. (arcticus) nigrescens								+				
Suborder Esocoidei (Pikerels) –ESOCOIDEI Family Esocidae–Esocidae Genera Esox –Esox												
Northern Pike –E. lucius	+			+	+	+			+	+		
Order Cyprinid fishes–CYPRINIFORMES Family Cyprinid fishes–Cyprinidae Genera abramis –Abramis												
Bream –A. brama	+			+						+		
Genera Leuciscus –Leuciscus												
Ide –L. idus	+			+					+	+		
Siberian Dace –L. leuciscusbaicalensis	+	+		+	+	+			+	+		
Genera Alay Diptychus –Oreoleuciscus												
Dwarf Altai Diptychus –O. Humilis***					+	+	+					
Genera Phoxinus–Phoxinus												
PhoxinusChekanovsky –Ph. czekanowskii						+	+				+	
PhoxinusLyagovsky, AmurPhoxinus –Ph.Lagowskii****							+				+	
Lake Phoxinus –Ph. perenurus				+						+		
Phoxinus (Eurasian minnow) –Phphoxinus	+	+		+	+	+	+	+	+	+	+	+
Genera Rutilus –Rutilus												
Roach –R.rutilus	+			+	+			+	+	+		
Genera Gudgeons –Gobio												
Siberian Gudgeon –G. gobio cynocephalus				+								
Genera Carassius –Carassius												
Crucian –C. auratus	+			+					+	+		
Genera Cyprinus –Cyprinus												
Amur carp –C. carpiohaematopterus	+			+						+		
Genera Tinca –Tinca												
Tench –T. tinca									+			
Family Balitoridae–Balitoridae Genera Barbatula –Barbatula												
Stone loach –B. toni	+	+		+	+			+				
Family (Loaches) Cobitidae–Cobitidae Genera Cobitis –Cobitis												
Siberian spined loaches –C. melanoleuca	+			+	+			+		+		
Order Siluriformes–SILURIFORMES Family Siluridae–Siluridae Genera Parasilurus –Parasilurus												
Amur catfish –P. azotus	+			+	+					+		
Order Anacanthinse –GADIFORMES Family Lotidae –Lotidae Genera-Lota –Lota												
Burbot –L. lota	+	+		+	+			+	+			
Order Rerciformes–PERCIFORMES Family Percidae–Percidae Genera Perca –Perca												
River perch –P. fluviatilis	+			+	+	+		+	+			
Family (Loachgobies) Eleotrididae–Eleotrididae Genera (Sleepers) Perccottus –Perccottus												
Amur sleeper –P. gleniiDybowski	+	+		+						+		
ORDER (SCORPION FISHES) SCORPAENIFORMES–SCORPAENIFORMES Family (bullheads)–Cottidae Family (bullheads) – Cottidae–Batrachocottus												
Baikal big-headed sculpin –B. baicalensis	+	+	+									
Spottedfinsculpin –B. multiradiatus		+	+									
Nikolskysculpin –B. nikolskii			+									
Talievsculpin –B. talievi			+									
Род Желтокрылки –Cottocomephorus												

Yellowfin Baikal sculpin –C. grewingkii		+	+									
Nothern Baikal yellowfin Baikal sculpin –C. alexandrae		+	+									
Longfin Baikal sculpin –C. inermis		+	+									
Genera Stone (sculpins) Paracottus –Paracottus												
Stone sculpin –P. knerii		+	+									
Genera (sand sculpins)–Leocottus												
Sand sculpin–L. kesslerii	+	+	+	+	+					+		
Family (Baikal oilfishes)–Comephoridae Genera Baikal oilfishes –Comephorus												
Big Baikal oilfish –C. baicalensis			+									
Small Baikal oilfish –C. dybowski			+									
Family(abyssal Baikal sculpins) Abyssocottidae–Abyssocottidae Genera abyssal Baikal sculpins–Abyssocottus												
Elokhinskysculpin –A. elochini			+									
White sculpin –A. gibbosus			+									
Smalleyesculpin–A. korotneffi			+									
Genera Rough sculpins –Asprocottus												
Abyssal sculpin –A. abyssalis			+									
Rough sculpin –A. herzensteini			+									
Koryakovsculpin –A. korjakovi			+									
Small Koryakovsculpin –A. korjakovi minor		+	+									
Shielded sculpin –A. parmiferus		+	+									
Flatheadedsculpin –A. platycephalus		+	+									
Sharpnosedsculpin –A. pulcher		+	+									
Genera Humpbacksculpins –Cyphocottus												
Widefinsculpin –C. eurystomus		+	+									
Humpback sculpin –C. megalops		+	+									
Genera short-headed sculpin–Cottinella												
Short-headed sculpin–C.boulengeri			+									
Genera Neocottus –Limnocottus												
Berg's abyssal sculpin –L. bergianus			+									
Marble sculpin –L. godlewskii		+	+									
Dark sculpin –L. griseus			+									
Narrow sculpin –L. pallidus			+									
Genera Neocottus –Neocottus			+									
Crumbly sculpin –N.werestschagini			+									
Warmwatersculpin –N.thermalis			+									
Genera Red sculpins –Procottus												
Red sculpin –P. jeittelesii		+	+									
Ghotos' sculpin –P. gotoi		+	+									
Dwarf red sculpin –P. gurwici			+									
Big red sculpin –P. major			+									

**In the basins of Frolikha and Svetlaya rivers*
***In the basins of Verkhnyaya Angara and Barguzine rivers*
****In the basins of Orkhon, Tuul, Selenga (within Mongolia) rivers*
*****In the basins of Khilok and Uda rivers*

(20 local species, two Baikal endemics, six natiralized species and dwarf Altai osman that has recently penetrated the Selenga river basin), and nine species in Lake Khovsgol, including the endemic Kosogol grayling and naturalized Baikal omul. The endemic Baikal-Lena grayling was detected in the fluviolacustrine system of northern mountain streams, while in the Upper Kichera lakes an isolated population of coastal-pelagic omul and homotypical ichthyocenoses formed by the Baikal-Lena grayling and Arctic char (Verkhneuyakchinskie lakes) (Table) [Fishes of Lake…, 2007].

4. Lower and upper courses of the Selenga river – packings and spawning migrations of omul, sturgeon and Siberian whitefish, habitation and spawning of Siberian whitefish, graylings, lenok, burbot, taimen, dace, roach, pike, etc.

5. Large tributaries of the Selenga river and of Lake Baikal – packings and migration of omul, lenok, grayling, taimen, burbot, dace, carp, bream, dwarf osman, etc.

6. Large and medium mountain streams and drainage high altitude lakes – habitation of grayling, lenok, taimen, common minnow, spined loach, Siberian stone loach, dace, perch, roach and pike. The Upper Kichera lakes, Kulinda and Verkhnekicherskoe – habitation of omul, pike, burbot, Siberian stone loach, grayling, sand sculpin, stone sculpin, and common minnow. Svetlinskoe lake – habitation of three species: Arctic char, common minnow and Siberian stone loach. Lake Frolikha – 11 species, including lenok, Arctic char, grayling, pike, roach, perch, burbot, lake minnow and common minnow, spined loach, sand sculpin and stone sculpin. The Verkhneyakchinskie lakes (the Yakchai river) – habitation of Arctic char (small and dwarf) in one lake and one species of Baikal-Lena grayling in the other.

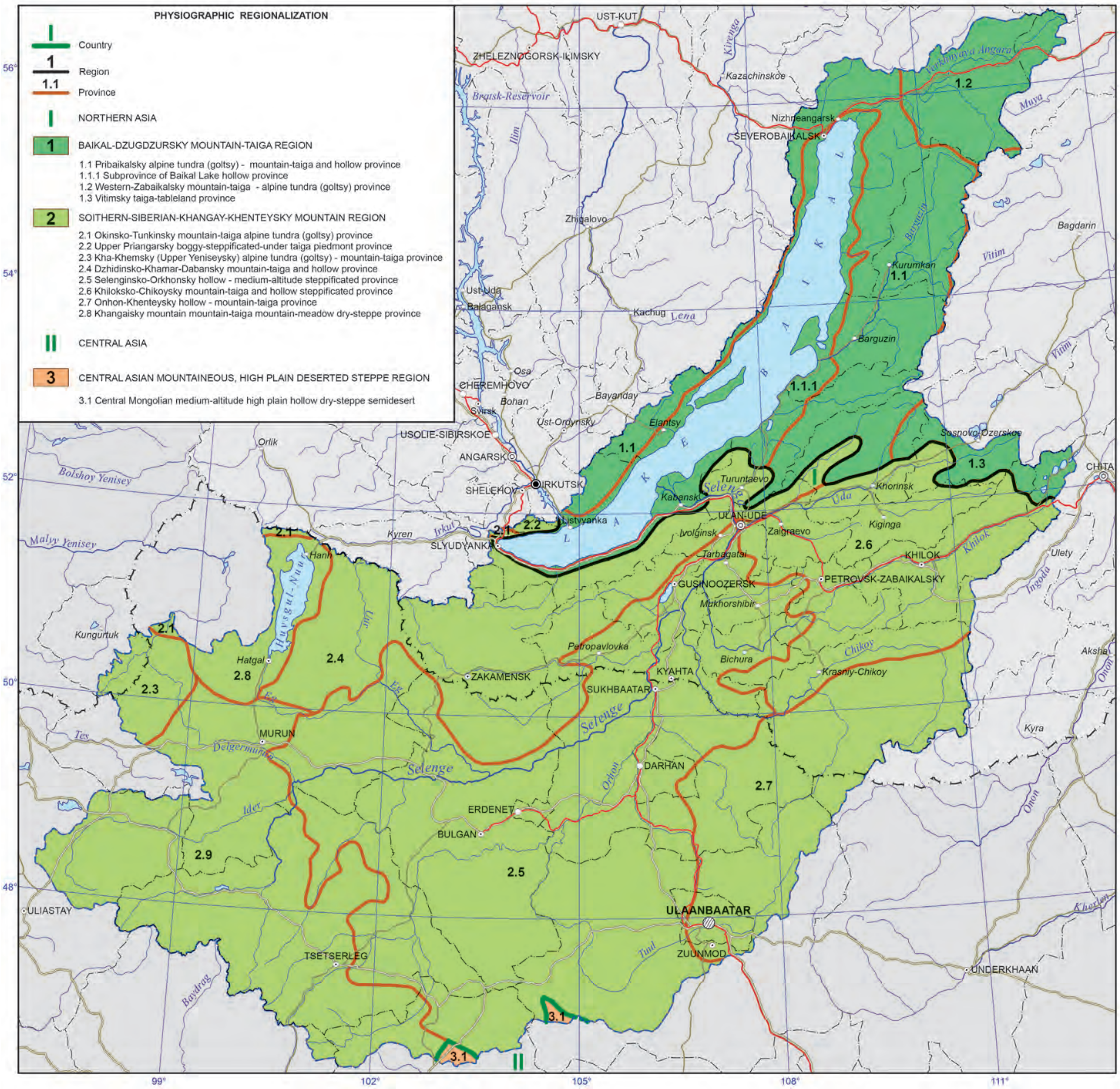
7. Small streams and creeks of the medium-altitude mountain belt – possible habitation of minnows and temporary entries of grayling for spawning.

8. Lake system of the hollows – water bodies diversified in size, hydroclimatic conditions and fish composition. A cluster analysis of interrelationship of fish species was carried out in order to characterize Transbaikalian ichthyocenoses [Biodiversity…, 1999]. Two fish complexes determine the ichthyocenoses structure of the lakes: 1 – roach, perch and pike; 2 – lenok and grayling. Other fish species have subdominant value and build up the distinctness of communities. The first complex is connected with the lake limnogenesis processes, while the second – with the tectonic processes, specific for the Baikal type intermontane hollows. The Eravna lakes: in the Shchuchye lake (one of the Eravna lakes) there are peled, perch, roach and pike. Fishes from this lake underwent a thorough study of their productional characteristics. The results were used for the analysis of fishes in the water bodies of the Eravna-Kharginsk lake system. The Gusino-Ubukinskaya group, small water bodies (roach-perch lake Shchuch'e, crucian carp lakes Kamyshovoe, Krugloe, Chernoe, and perch-dace Abramovskoe lake). The total of 10 species registered: Amur sleeper, sand sculpin, spined loach, perch, burbot, lake minnow, crucian carp, dace, roach, peled and omul. Lake Gusinoe is the largest one. It is inhabited by 22 species: taimen, lenok, carp, bream, Amur catfish and Amur sleeper and farmed omul and peled. The Ivano-Arakhlei lakes (Arakhlei, Shaksha, Undugun, and Irgen) are inhabited by 16 species. Mostly they are pike, roach, dace, crucian carp, European cisco, peled and omul.

9. Meander lakes of the Verkhneangarskaya and Barguzinskaya hollows. The major lake complexes host 15 to 20 species, such as roach, perch, pike, nerfling, crucian carp, tench, carp, catfish, bream and others. There are about 7000 lakes in the Upper Angara and Kichera basins. The largest one is the eutrophic Irkana lake hosting nine species, such as roach, perch, pike, crucian carp, dace, nerfling, lake minnow, burbot and tench. The Barguzin basin lakes (4918 lakes) are inhabited by 19 fish species. In the upper course (mesotrophic) lakes there are taimen, lenok, grayling, common minnow, burbot, sand sculpin, Siberian spined loach and stoneloach. In the middle course (eutrophic) lakes there are pike, roach, perch, nerfling, crucian carp, bream, burbot, catfish, tench, carp, lake minnow, etc. In the lower course eutrophic lakes there are pike, roach, perch, dace, nerfling, crucian carp, catfish and lake minnow.

10. Ichthyocenosis of Lake Khovsgol. Nine species. The species composition has been forming since the post-glacial period. In 1957 the Baikal omul was introduced. Nowadays the water body is characterized as the lenok-grayling type of water bodies [Tugarina, 2002; Fishes…, 1983]. The majority of fishes inhabit coastal areas (grayling dwells at depths down to 25 meters, burbot – down to 30 meters) with the highest concentration in the bay and the mouth of the Khankh-Gol river. In 1957 10 million Baikal omul eggs were additionally incubated in the mouth of the Ikh- Khankh-Gol river by Professor A. Dashidorzhi of the Mongolian University. The first omul was detected in the mouth of the Ikh-Khankh-Gol river in 1971. Beyond the bay area omul has not yet been detected. Lenok inhabits the depths of 7 to 12 meters. Habitation limits in the open littoral of the western shore are confined to the 25-30 meter isobaths. The generative river form of grayling inhabits the area from the edge of water to the 25-30 meter isobaths while the generative lake form reaches down to the 80-100 meter isobaths. The roach habitation zone is limited to depths of down to 15 meters. Minnow inhabits the shore edge down to the depth of 1-1.5 meters while stoneloach – down to 1-1.3 meters. These are usually backwaters.

37. PHYSICAL-GEOGRAPHICAL REGIONALIZATION



Siberian spine loach inhabits the areas with sand and slimy ground down to the depths of 3 to 5 meters. Perch is common in the littoral at the depths down to 10-15 meters. Burbot is common everywhere within the depths of down to 40 and rarely 70 meters. All deep tributaries of Lake Khovsgol are mainly used as spawning grounds of lenok, grayling, burbot, etc. The meander lakes of the Ikh-Khoroo-Gol and Egiin-Gol rivers as well as the Ongolik Bay are the spawning grounds of perch, roach and minnow.

11. Near water-divide and water-divide areas. Small fishless lakes.

12. Territories with ulterior river net and closed drainage areas are located beyond the limits of the ichthyogeographic complexes.

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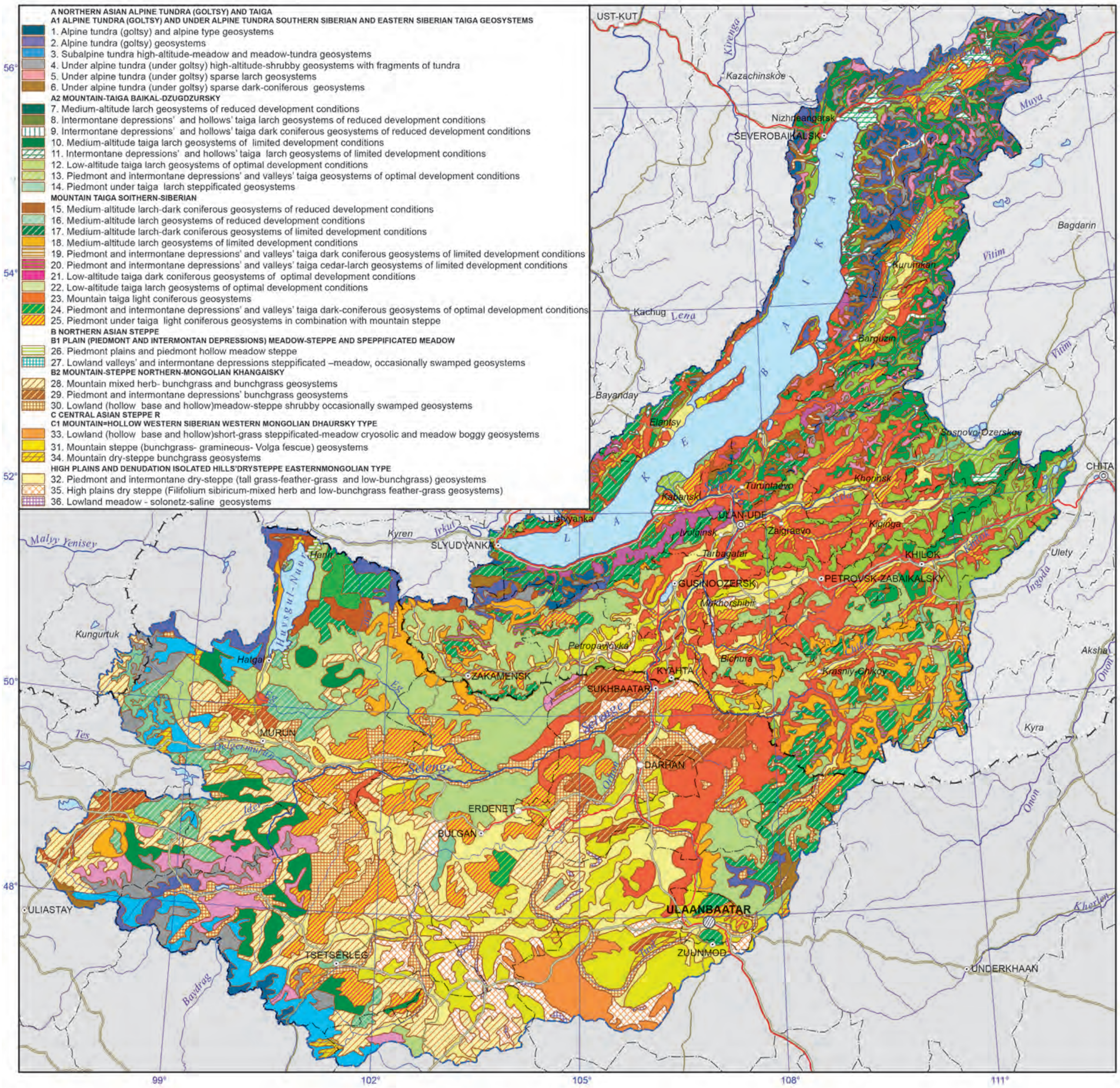
PHYSICAL-GEOGRAPHICAL REGIONALIZATION AND THE LANDSCAPE-TYPOLOGICAL STRUCTURE (37-38)

The materials presented uniformly consider physical-geographical regionalization and the landscape-typological structure of the Baikal basin. Map compilation was based on the idea of geosystems classification and the resultant works, including cartographic works on physical-geographical differentiation of the territory in the Russian Federation and Mongolia, which are presented below [Preobrazhensky et al., 1959; Mikheev, Ryashin, 1967; Sochava, Timofeev, 1968; Landscape..., 1977; Batjargal et al., 1989; Fadeev et al., 1989; Mikheev, 1990; Dash D. et al., 1990].

The boundaries of physical-geographical structures (individual and typological) were integrally positioned on the same topographic base in the Mapinfo environment

38. GEOSYSTEMS



Irkutsk Reservoir.

and verified according to the Landsat 7 multispectral satellite images (2000).

The physical-geographical regionalization map reflects individual heterogeneous regional natural formations. The featured physical-geographical regions and provinces characterize the territories with a similar geographical location, manifestation of morphotectonic geological and geomorphological features, latitudinal, vertical and bioclimatic zonation. Physical-geographical regions, countries and provinces are comparable across different research. Mountain areas of North Asian mountain megalocation on the edge sphere of the continent (Baikal-Dzhugdzhurskaya and South-Siberian-Khangai-Khentei) and their contact with the Central Asian desert-steppe region of the Central continental megalocation are presented within this territory. Intraregional differentiation into provinces is related to the specific manifestations of altitudinal differences and geological and geomorphological features in mosaics of geosystem types and their mobile components of soils and vegetation. The map shows three physical-geographical areas and 12 provinces.

Landscape-typological structure shows the features of spatial mosaic of individual physical-geographical units, their internal structure of relatively homogeneous combinations of physical-geographical conditions. In accordance with the small scale, 39 geom groups are shown on the map. The geoms are distinguished according to the indicators of topological order, but generalized to the regional level [Sochava, 1978]. They combine topogeosystems of the certain zone or belt (within a physical-geographical region) characterized by similar structural features of soil cover, vegetation and hydrothermal regime. The vegetational component of a geom is adequate to a formation, soil one is close to the subtype of soils, and the climate regime is close to the modification of climate of a subzone, which arose under the influence of the structural properties of other components.

Geosystems specific to North and Central Asia form the regional classification range. Their location, interpenetration and uniqueness of landscape situations in the Baikal basin are presented. Regional interpretation of landscape-typological units (geom groups on the geasystem map) characterizes their latitudinal and altitudinal differences, as well as shows their relation to various regional and typological complexes of natural conditions that may be disclosed in detail on a larger display scale of landscape structures and geosystem components.

Multiscale mosaic character of the natural-territorial structure determines the landscape complexity of the territory, the local «contrasts» of economic use, and specificity of different local options of development.

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LANDSCAPE STABILITY (39)

Landscape stability is one of the most important parameters determining the state of the environment and changes occurring in it under the influence of natural and anthropogenic factors. The nature of landscape changes depends on the location in the geographical environment, their properties, and type and extent of the anthropogenic impact. Of particular importance is the estimation of landscapes stability of the Baikal basin, which is an environmentally critical area.

Landscape stability is a property of a geosystem to maintain its structure and the mode of functioning under changing conditions of its environment [Protection of landscapes..., 1982]. An assessment and mapping of landscapes stability are made according to the complex of natural and anthropogenic factors of influence. The natural factor is mainly determined by the influence of climate (indicators of heat-moisture supply) and the properties of lithological-and-geomorphological basis. The anthropogenic influencing factor is associated with the background nature management, which is based on spatially extensive use of natural resources, and lands, closely related to the zonal-belt features of natural landscapes. The background types of nature management in the study area include agriculture, mainly in steppe landscapes, forestry in taiga landscapes, as well as recreation.

Stability is considered in relation to landscapes of two levels: regional (geoms) and topological (groups of facies). A landscape map, compiled by the authors on the basis of landscape maps of the territory under consideration [Landscapes..., 1977; Landscapes..., 1990], was used for its mapping.

Stability of landscapes of the regional level – geoms – is determined based on the level of natural ecological potential of a landscape (EPL), the main indicator of which is the index of biological effectiveness of climate (TK) according to N.N. Ivanov [Ecological..., 2007, Ecological..., 2007]. Characterization and comparative assessment of this indicator is based on the ratio of heat and moisture, on which the biological productivity of a landscape and ecological capacity primarily depend. At the same time, the influence of latitudinal and altitudinal zonality on their distribution is traced. A single and continuous process of moisture and heat exchange not only forms the spatial differentiation and a type of a landscape, but also determines its stability. Landscapes with high values of TK and EPL are the most stable, while low values of these parameters characterize unstable landscapes.

Twenty-two geoms are represented in the landscape structure of the territory under consideration. Mountain terrain predominates in the catchment area of Lake Baikal. Therefore, this territory is characterized by the altitudinal belt differentiation of landscapes, which determines the degree of their stability.

At the regional level, according to the values of these indicators, landscapes are subdivided into five ecological groups of geoms, to which the corresponding values of stability, ranged on a five-point scale, are assigned. These values are considered as the starting point, or background stability.

A geom unites groups of facies similar in structural-dynamic characteristics [Sochava, 1978]. This taxonomic unit is important in generalization of geotopological works. Inside a geom, stability was readjusted in respect of groups of facies with different dynamic categories. A set of variable states of these categories includes indigenous, pseudo-indigenous, serial and derivative geosystems under one epifacie. The highest natural and anthropogenic stability characterizes indigenous landscapes with well-established intrasystemic and external relations; many of them are notable for durability. Pseudo-indigenous landscapes, unlike indigenous ones, are modified as a result of hypertrophy of one of the components of the system. Serial facies in most cases are nondurable, quickly alternating with each other spontaneous geosystems, formed under the significant hypertrophy influence of various natural factors. In a range of transformation of geosystems they are characterized by the greatest variability and are prone to damage, and therefore they are classified as landscapes unstable to anthropogenic impacts. Derivative landscapes are variable states of geosystems caused by human influence. They are characterized by different degrees of stability.

The highest values of stability, considered as the initial point corresponding to the background rate of stability of a geom, are set for indigenous facies. Further on, the initial point is reduced to three gradations, namely, for pseudo-indigenous, serial and derivative facies. For pseudo-indigenous facies a decrease in the stability by 1 point in relation to the initial point is possible; for serial facies it can amount to 1-2 points. For derivative facies deviations from the norm can reach 1-2 points towards an increase or decrease in the stability depending on the type of succession, namely, progressive stabilizing or digressive destabilizing.

To assess the anthropogenic stability of landscapes an analysis was made of disturbances of natural environment, arising under the influence of various types of human activities related to the background land use. According to the predominant nature of the background land use, the following types of functional load on the environment were distinguished: agricultural arable and grazing (mainly for steppe and forest-steppe landscapes), and forestry (for taiga landscapes) and recreation.

Stability of arable lands was largely determined by the intensity of erosion loss, soil deflation and pesticide pollution, and natural self-purification potential of soils. Stability of natural-forage lands was determined in respect of plant communities to grazing and haymaking and was assessed according to the degree of degradation of hayfields and pastures, susceptibility to erosion and deflation, and recoverability of vegetation and soils.

The most significant impact on the state of forests is made by commercial logging using the clear felling approach. Stability of forest landscapes was determined according to the degree of disturbance of forests by felling and fires, recreation, and agricultural use. Reforestation is influenced by changing temperature conditions, hydrophysical properties of soils, evolving erosion and cryogenic processes, deflation and waterlogging in felled and burnt areas. An important criterion for stability, i.e. forest bonitet, is an indicator of productivity and environmental growth conditions, evaluated by richness (trophicity) and moisture content of soil. Environmental factors, spontaneous and associated with the human activity, prevent natural reforestation; their progressive successions do not reach the original state. Such landscapes fall in the category of the most unstable.

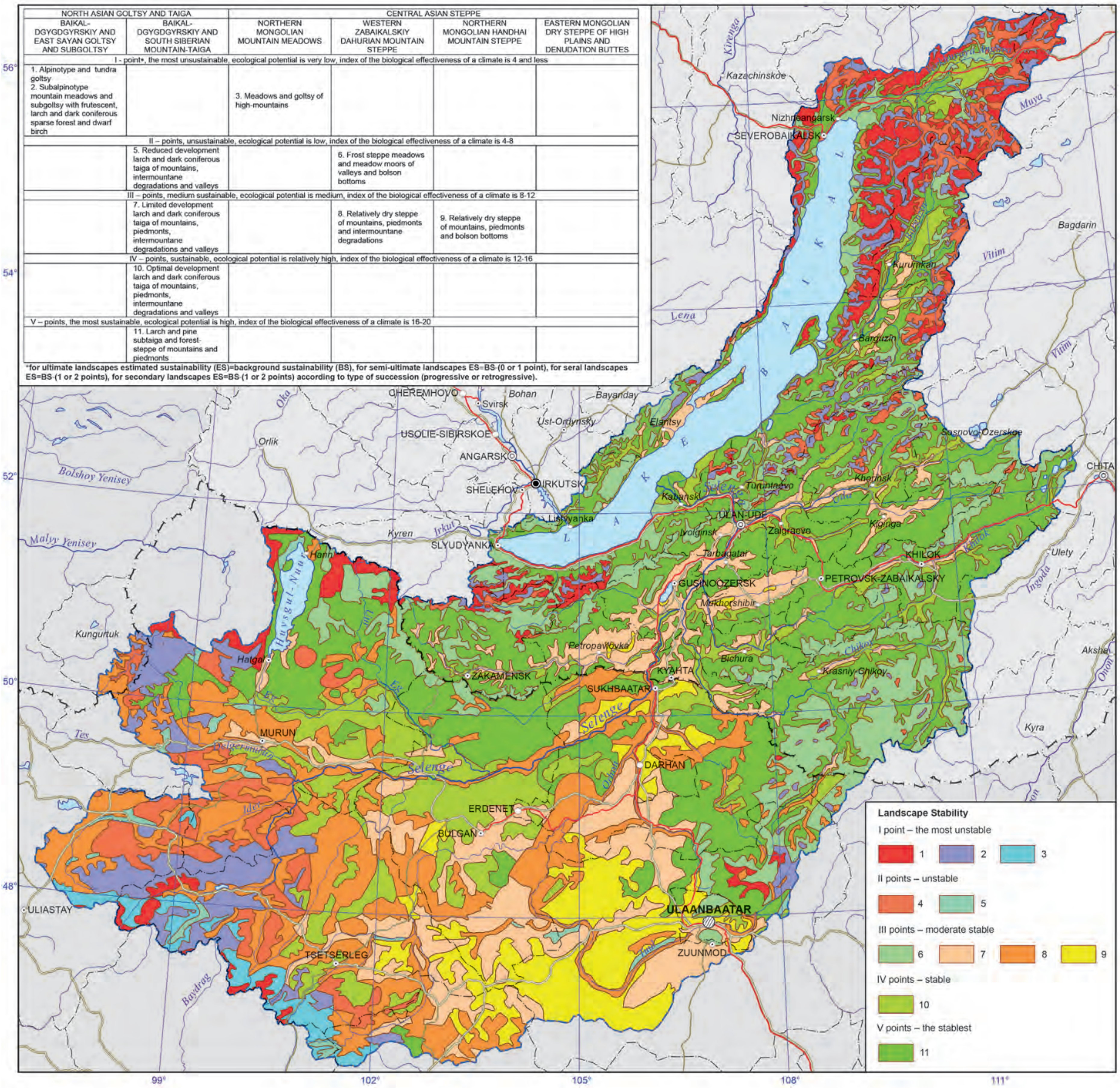
Recreational stability is assessed referring to the mass recreation and tourist-excursion activities. Indicators of the degree of recreational digression of landscapes, depending on the type and intensity of recreational influence, sensitivity and recoverability of landscapes, which together define their recreational potential, served as stability criteria. Stability of landscapes is a key indicator, based on which the regulation of recreational loads is made.

The compiled map reflects the territorial diversity of landscape stability, characteristics of which is presented in the table.

The lowest and low (I-II points) stability characterize goletz and sub-goletz landscapes presented in major mountain ranges in the north-eastern and south-western parts of the territory. In the north-east, they are goletz and sub-goletz landscapes of the Baikalsky, Verkhne-Angarsky, Barguzinsky, and Ikatsky ridges in the framing of the Severo-Baikalskaya, Verkhne-Angarskaya and Barguzinskaya depressions. In the Khovsgol region and in Southern Cisbaikalia they include the Eastern Sayan mountain structures. In the south-west, alpine meadows, and subalpinotype and subgoletz landscapes

Primorskiy ridge at the source of the Angara.

39. LANDSCAPE STABILITY



NORTH ASIAN GOLTSY AND TAIGA		CENTRAL ASIAN STEPPE			
BAIKAL-DGYGDGYRSKIY AND EAST SAYAN GOLTSY AND SUBGOLTSY	BAIKAL-DGYGDGYRSKIY AND SOUTH SIBERIAN MOUNTAIN-TAIGA	NORTHERN MONGOLIAN MOUNTAIN MEADOWS	WESTERN ZABAIKALSKIY DAHURIAN MOUNTAIN STEPPE	NORTHERN MONGOLIAN HANDHAI MOUNTAIN STEPPE	EASTERN MONGOLIAN DRY STEPPE OF HIGH PLAINS AND DENUDATION BUTTES
I - point*, the most unsustainable, ecological potential is very low, index of the biological effectiveness of a climate is 4 and less					
1. Alpinotype and tundra goltsy 2. Subalpinotype mountain meadows and subgoltsy with frutescent, larch and dark coniferous sparse forest and dwarf birch		3. Meadows and goltsy of high-mountains			
II – points, unsustainable, ecological potential is low, index of the biological effectiveness of a climate is 4-8					
	5. Reduced development larch and dark coniferous taiga of mountains, intermountane degradations and valleys		6. Frost steppe meadows and meadow moors of valleys and bolson bottoms		
III – points, medium sustainable, ecological potential is medium, index of the biological effectiveness of a climate is 8-12					
	7. Limited development larch and dark coniferous taiga of mountains, piedmonts, intermountane degradations and valleys		8. Relatively dry steppe of mountains, piedmonts and intermountane degradations	9. Relatively dry steppe of mountains, piedmonts and bolson bottoms	
IV – points, sustainable, ecological potential is relatively high, index of the biological effectiveness of a climate is 12-16					
	10. Optimal development larch and dark coniferous taiga of mountains, piedmonts, intermountane degradations and valleys				
V – points, the most sustainable, ecological potential is high, index of the biological effectiveness of a climate is 16-20					
	11. Larch and pine subtaiga and forest-steppe of mountains and piedmonts				

*for ultimate landscapes estimated sustainability (ES)=background sustainability (BS), for semi-ultimate landscapes ES=BS-(0 or 1 point), for seral landscapes ES=BS-(1 or 2 points), for secondary landscapes ES=BS-(1 or 2 points) according to type of succession (progressive or retrogressive).

of the Khangai and Khentei uplands are characterized by low stability.

Ecological potential of these landscapes is very low; TK is less than 8. The structure of geoms is dominated by serial groups of facies. They are characterized by severe climatic conditions and dissected mountainous terrain, active development of exogenous geological processes, and lack of heat and excess of moisture. The same values of stability are assigned to steppe landscapes of depressions and valley bottoms, characterized by the excess of heat together with the lack of moisture, with manifestations of cryomorphism, waterlogging, water erosion and deflation, and soil salinization.

In general, the Baikal basin is dominated by moderately stable and stable landscapes (III-IV points), distributed mainly in the central part of the territory. They are characterized by medium and relatively high ecological potential; the index of biological effectiveness of climate amounts to 8-16. Pseudo-indigenous geosystems with a relatively stable landscape structure predominate.

Landscapes of reduced development of mountain-taiga and taiga intermountain depressions and valleys, having dispersed distributional pattern and occurring in the Selenga-Vitim interfluve and to the north of the Khangai upland, are referred to the stability of III points.

The stability of III points also characterizes piedmont and plain relatively dry and arid steppes. They are located in the Barguzinskaya depression, in hollows of the Trans-Baikal type, to the north of the Khangai upland, and in the surroundings of the Khentei upland.

The group of geoms with the stability of IV points includes mountain-taiga landscapes of restrictive and optimal development, taiga piedmont landscapes of intermontane depressions and valleys of restrictive development, mountain low-bunchgrass and forbs-bunchgrass, and mountain dry steppes. The main areas of development of taiga landscapes of this stability group are low- and middle mountains to the south of the Eastern Sayan, the Primorsky ridge, Selenginskoe middle mountains, Vitimskoe plateau, Olekminsky Stanovik, Khentei-Chikoy upland, and others. Mountain steppes with IV points of stability are most commonly found in the Selenge-Orkhon interfluve.

Landscapes with the highest ecological potential for the region, and TK amounting to 16-20, are classified as the most stable (V points). In the Russian part of the territory, they are landscapes of piedmont and intermountain depressions of optimal development, as well as piedmont subtaiga landscapes. They are found in the Verkhne-Angarskaya and Barguzinskaya depressions, in the Selenga river delta, and in depressions of the Trans-Baikal type. In Mongolia they are represented by mountain subtaiga landscapes, the large area of which is middle and low mountains lying to the north of the Khangai upland in the central part of the basin of the Selenge and Orkhon rivers. The structure of geoms is dominated by pseudo-indigenous and indigenous geosystems. They are the nuclei of the ecological stability and reproduction of the environment [Mikheev, 2001]. In the landscape structure of the region their distribution area is in the transition zone between taiga and steppe landscapes with low background stability.

The conducted mapping of landscape stability is the basis for the assessment of the anthropogenic impact on the environment, and for substantiation of environmentally acceptable nature management in the Baikal basin.

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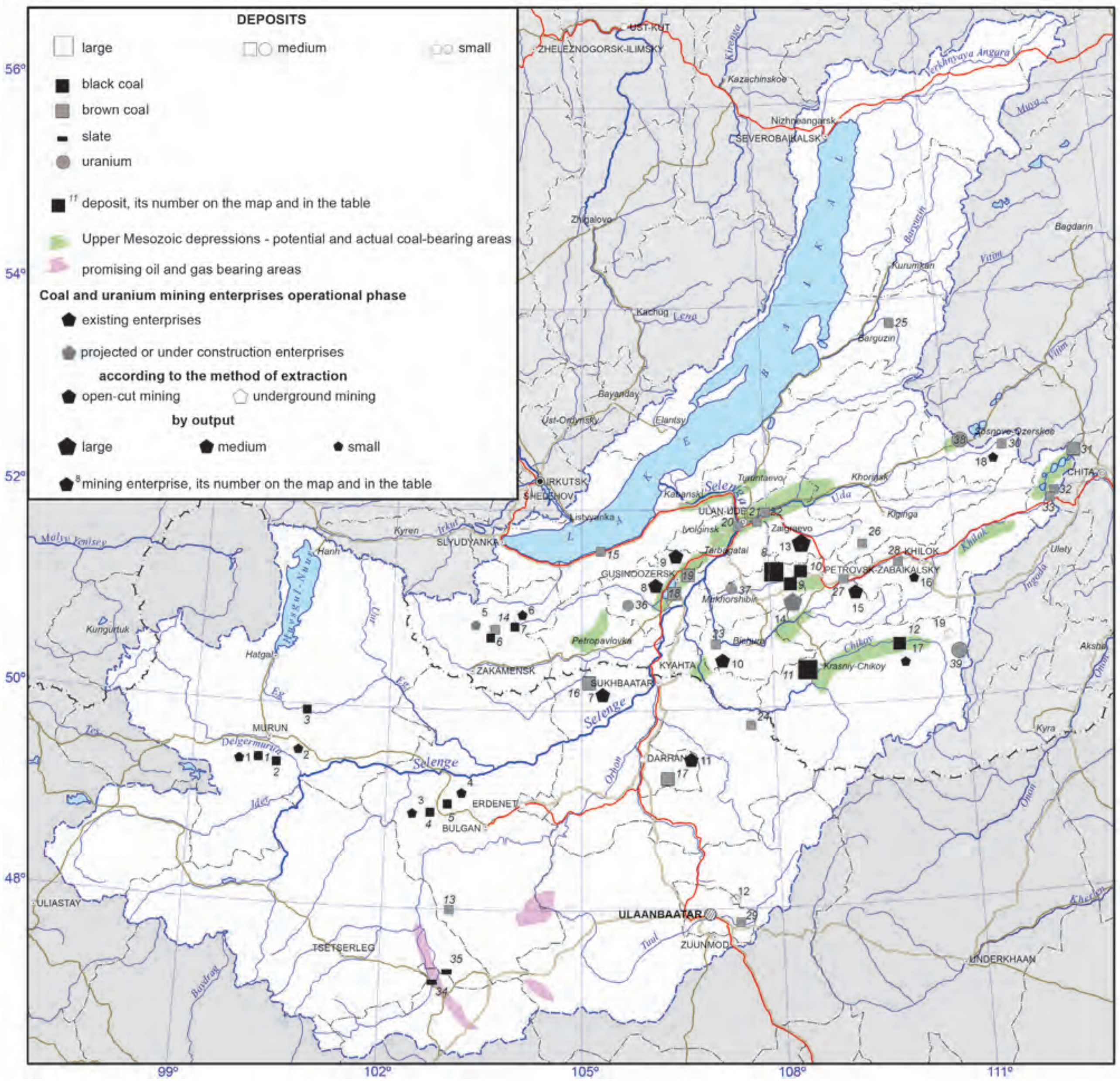
SECTION II. RESOURCE FACTORS OF ECOLOGICAL SITUATION FORMING IN THE BAIKAL BASIN

40. FUEL AND ENERGY RESOURCES AND THEIR DEVELOPMENT



FUEL AND ENERGY RESOURCES AND THEIR DEVELOPMENT (40)

Fuel and energy resources of the Baikal basin are represented by deposits of solid fossil fuels (black and brown coals of different ranks), oil shales and uranium.

Coal deposits are confined to the Upper-Mesozoic depressions of the Transbaikalian type, the most significant of which are the Tugnuiskaya, Gusinoozerskaya, Udinskaya, Chikoiskaya and others. The main reserves of black coals within the territory under consideration are concentrated in the Erdem-Galgataiskoe, Krasnochikoyskoe, Nikolskoe, Olon-Shibirskoe, and Zashulanskoe deposits, while the reserves of brown coals are localized in the Gusinoozerskoe, Zagustaiskoe, Taseiskoe, Sharyngol, and Ulaan-Ovoo deposits. The largest deposits are located in economically developed regions with an extended infrastructure, including the presence of traffic arteries in the form of railways and auto-roads. Out of 33 coal deposits, located within the territory of the Baikal basin, sixteen are currently under development.

To date the largest coal producer not only in this area, but in the entire East Siberia and the Far East is the Tugnuisky open-pit coal mine, which mines the Olon-Shibirskoe deposit (97% of the reserves occur within the Petrovsk-Zabaikalsky municipal district of Zabaikalsky krai, and 3% are deposited in the Mukhorshibirsky district of the Republic of Buryatia). Due to the introduction of the cutting-egde high-efficiency equipment produced by the world-renowned manufacturers, coal extraction here more than doubled in three years reaching about 13 million tons in 2012.A coal-preparation plant equipped with unique technologies was built in order to increase marketability of the produced coal. Currently, the capacity of this plant has reached nine million tons. Coal is mainly exported to Japan, Korea, China and other APAC countries.

The coal industry of Buryatia experienced a significant decline after closing in the early 1990s of the major coal producers of the time such as the Kholboldzhinsky open-pit mine and the Gusinoozerskaya mine (Selenginsky district). Currently, the OAO (Open Joint Stock Company) “Ugolnaya kompaniya Bain-Zurkhe” holds licenses for the Bain-Zurkhe and Kholboldzhinsky sites of the Gusinoozerskoe deposit. This company has resumed the coal feed from the deposit to the Gusinoozerskaya state district power plant. A radically new development technology – a highwall mining complex is applied. There is a gradual growth in coal production (932 thousand tons in 2012).

Over the recent years, the OOO (Limited Liability Company) “Ugolny razrez” mining the Okino-Klyuchevskoe brown coal deposit in the Bichursky municipal district of the Republic of Buryatia has expanded its production capacities. It is expected to increase the capacity of this enterprise to five

Fuel and energy materials deposits

No. on map	Name of deposit	Mineral product	Degree of development	Size of deposit	Region
1	Nuurstein am	Coal	Mined deposit	Small	Mongolia
2	Zhulchig bulag	Coal	Mined deposit	Small	Mongolia
3	Egiin gol	Coal	Undeveloped	Small	Mongolia
4	Saikhan ovoo	Coal	Mined deposit	Small	Mongolia
5	Ereen	Coal	Mined deposit	Small	Mongolia
6	Bayangolskoe	Coal	On standby	Small	Republic of Buryatia
7	Khara-Khudzhirskoe	Coal	Mined deposit	Small	Republic of Buryatia
8	Erdem-Galgataiskoe	Coal	On standby	Major	Republic of Buryatia
9	Nikolskoe	Coal	Developing	Medium	Republic of Buryatia
10	Olon-Shibirskoe	Coal	Mined deposit	Medium	Zabaikalsky krai
11	Krasnochikoiskoe	Coal	On standby	Major	Zabaikalsky krai
12	Zashulanskoe	Coal	Mined deposit	Medium	Zabaikalsky krai
13	Bayanduurekh	Brown coal	Undeveloped	Small	Mongolia
14	Sanginskoe	Brown coal	On standby	Small	Republic of Buryatia
15	Pereemninskoe	Brown coal	Undeveloped	Small	Republic of Buryatia
16	Ulaan ovoo	Brown coal	Mined deposit	Medium	Mongolia
17	Sharyn gol	Brown coal	Mined deposit	Medium	Mongolia
18	Gusinoozerskoe	Brown coal	Mined deposit	Medium	Republic of Buryatia
19	Zagustaiskoe	Brown coal	Mined deposit	Medium	Republic of Buryatia
20	Mukhinskoe	Brown coal	Undeveloped	Small	Republic of Buryatia
21	Lysogorskoe	Brown coal	Undeveloped	Small	Republic of Buryatia
22	Erkhirikskoe	Brown coal	Undeveloped	Small	Republic of Buryatia
23	Okino-Klyuchevskoe	Brown coal	Mined deposit	Small	Republic of Buryatia
24	Tsogt	Brown coal	Undeveloped	Small	Mongolia
25	Bodonskoe	Brown coal	On standby	Small	Republic of Buryatia
26	Manai-Azhilskoe	Brown coal	Undeveloped	Small	Republic of Buryatia
27	Tarbagataiskoe	Brown coal	Mined deposit	Small	Zabaikalsky krai
28	Burtuiskoe	Brown coal	Mined deposit	Small	Zabaikalsky krai
29	Nalaikh	Brown coal	Mined deposit	Small	Mongolia
30	Daban-Gorkhonskoe	Brown coal	Mined deposit	Small	Republic of Buryatia
31	Taseiskoe	Brown coal	On standby	Medium	Zabaikalsky krai
32	Irgenskoe	Brown coal	On standby	Small	Zabaikalsky krai
33	Sokhondinskoe	Brown coal	Unexplored	Small	Zabaikalsky krai
34	Khugshin gol	Oil shale	Undeveloped	N/A	Mongolia
35	Zuun bulag	Oil shale	Undeveloped	N/A	Mongolia
36	Slantsevoe	Uranium	Undeveloped	Small	Republic of Buryatia
37	Zhuravlinoe	Uranium	Undeveloped	Small	Republic of Buryatia
38	Buyanovskoe	Uranium	On standby	Medium	Republic of Buryatia
39	Gornoe	Uranium	Developing	Medium	Zabaikalsky krai

Fuel and energy materials mining enterprises

No.	No. on map	User of mineral resources / mined deposit	Mineral product	Development phase	Size of mining enterprise	Stoping method
1	1	N/A / Nuurestein am	Coal	Operating	Small	Open-cut mining
2	2	N/A / Zhulchig bulag	Coal	Operating	Small	Open-cut mining
3	3	N/A / Saikhan ovoo	Coal	Operating	Small	Open-cut mining
4	4	N/A / Ereen	Coal	Operating	Small	Open-cut mining
5	5	N/A / Sanginskoe	Coal	Under construction	Small	Open-cut mining
6	6	OAO Zakamenskaya PMK (Open Joint Stock Company) / Khara-Khuzhirskoe	Coal	Operating	Small	Open-cut mining
7	13	OAO Tugnuisky open-pit coal mine(Open Joint Stock Company) /Olon-Shibirskoe	Coal	Operating	Large	Open-cut mining
8	14	OAO Tugnuisky open-pit coal mine(Open Joint Stock Company) /Nikolskoe	Coal	Under construction	Large	Open-cut mining
9	17	OAO Zashulansky open-pit coal mine (Open Joint Stock Company) / Zashulanskoe	Coal	Operating	Small	Open-cut mining
10	7	Prophessy coal / Ulaan ovoo	Brown coal	Operating	Medium	Open-cut mining
11	8	OOO Bain-Zurkhe open-pit coal mine (Limited Liability Company) / Gusinoozerskoe	Brown coal	Operating	Medium	Open-cut mining
12	9	OOO Buryatugol (Limited Liability Company) / Zagustaiskoe	Brown coal	Operating	Medium	Open-cut mining
13	10	OOO Open-pit coal mine (Limited Liability Company) / Okino-Klyuchevskoe	Brown coal	Operating	Medium	Open-cut mining
14	11	OAO “Sharyn Gol” (Open Joint Stock Company) / Sharyn gol	Brown coal	Operating	Medium	Open-cut mining
15	12	N/A /Nalaikh	Brown coal	Operating	Small	Подземный
16	15	OOO Open-pit coal mine Tigninsky (Limited Liability Company) / Tarbagataiskoe	Brown coal	Operating	Medium	Открытый
17	16	OAO Burtui ((Open Joint Stock Company) / Burtuisky open-pit coal mine	Brown coal	Operating	Small	Открытый
18	18	OOO Buryatugol (Limited Liability Company) / Daban-Gorkhonskoe	Brown coal	Operating	Small	Открытый
19	19	ZAO Uranium mining company Gornoe (Closed Joint Stock Company) / Gornoe	Uranium	Projected	Small	Подземный

million tons per annum and continue the construction of the railway spur to the Khoronkhoy station for coal conveying to the Gusinoozerskaya state district power plant. Besides, in order to provide the thermal energy facilities of the Republic of Buryatia with the locally produced coal, a construction of a large Nikolsky open-pit mine along with a coal-preparation plant on the basis of the balance reserves of the same-name coal deposit is planned. In the Selenginsky municipal district the OOO (Limited Liability Company) "Buryatugol" currently develops the Zagustaiskoe deposit. It produces more than 200 thousand tons of brown coal per annum.

The remaining coal producers of Zabaikalsky krai and the Republic of Buryatia within the territory of the Baikal basin mine small volumes (10-50 thousand tons per annum), mainly for housing and public utility sector needs. They are the Daban-Gorkhonsky, Khara-Khuzhirsky, Zashulansky, and Burtuisky open-pit mines. An exception is the OOO (Limited Liability Company) "Razrez Tigninsky" developing the Tarbagataisky deposit in the Petrovsk-Zabaikalsky district. In 2012 it produced 260 thousand tons of brown coal significantly exceeding the level of 2010-2011. All coal is extracted by open-cut mining.

Mongolia's oldest coal producer is the "Nalaikha" mine where small scale extraction was launched in 1912. After the reconstruction in the 1950s the capacity of the mine was brought up to 600-800 thousand tons of brown coal per annum. The mine is the economic mainstay of the town of Nalaikh and was originally the only source of fuel for thermal power plants under construction in Ulaanbaatar. After the official mine shutdown due to the impossibility of its safe operation the former professional miners became engaged in artisanal mining on the facility.

The Sharyngol brown coal deposit was discovered by Soviet geologists in the 1930s, but the development of the deposit began only in 1961, after additional exploration. In the 1980s, the open pit capacity reached the maximum values of 2.5 million tons per annum. Currently, the company is privatized; in 2010 the production was about one million tons and open-cut mining is used.

In the Selenge aimak, the Ulaan-Ovoo high-energy brown coal deposit is currently developed. At the moment the Canadian company "Prophessy Coal" holds the development license of this deposit. Coal mining began in 2010.

Small scale coal mining is underway on Zhulchig bulag, Nuurestein am (Khuvsgel aimak), Saikhan ovoo and Ereen (Bulgan aimak) deposits.

Nowadays two small deposits of uranium raw material (Slantsevoe in the Dzhidinsky municipal district and Zhuravlinoe in the Mukhorshibirsky municipal district of the Republic of Buryatia; both deposits belong to the Selenginsky uranium ore region; a preliminary exploration was conducted on the deposits), and two medium ones, namely, Buyanovskoe in the Eravninsky district of Buryatia (Eravninsky uranium ore region; the deposit is on government standby) and Gornoe in the Krasnochikoysky municipal district of Zabaikalsky krai (Chikoysky uranium ore region) are known within the boundaries of the Baikal basin. The latter deposit is prepared for industrial development to produce natural uranium concentrate. It is planned to construct an underground mine and a heap leach pad for processing mined uranium ore.

Besides solid fuel the territory of the Baikal basin, was recognized as promising for the discovery of commercial deposits of raw hydrocarbons, especially natural gas within the Selenginskaya and Ust-Barguzinskaya rift troughs. According to the results of the prospecting and evaluation works carried out in the Ust-Selenginskaya depression in 1955, 1962, and in the 1990s, its prospective hydrocarbon resources were estimated at 364 million tons of oil, and 520 billion m^3 of natural gas (C3 category). Prospect assessment works on the Barguzinskaya depression are in progress.

Due to their small scale and low resin content (8-10%) oil shale deposits are of no commercial interest.

The map "Fuel and energy resources and their development" displays deposits of solid fossil fuels (black coal, brown coal and uranium) designated by various symbols. The symbol size is determined by the size of a deposit. Mining companies are also shown using symbols. The symbol size depends on the average production output over the last 3-5 years (for operating enterprises), or on the design capacity (for companies projected or under construction). The following ranking of enterprises was adopted: large ones with the production of over one million tons, medium ones – from 100 thousand tons to one million tons, and small ones – less than 100 thousand tons per annum for coal mining enterprises; the projected uranium mining company "Gornoe" is a small one with the production of less than one thousand tons of uranium per annum. Circled symbols show the underground mining method, while color indicates the operational stage of an enterprise (operating or projected and constructed). Areals depict the Upper-Mesozoic depressions - potential and actual coal-bearing regions and prospective oil and gas areas.

RESOURCES OF FERROUS, NONFERROUS AND RARE METALS AND THEIR MINING (41)

Geological exploration exposed over 150 deposits of metallic minerals within the Baikal basin.

Ferrous metals are represented by a number of iron ore deposits of different genetic types, including two small magnetite deposits, namely, Balbagarskoe in the territory of the Khorinsky municipal district of the Republic of Buryatia and Baleginskoe in the Petrovsk-Zabaikalsky district of Zabaikalsky krai. In the 18th-19th centuries the Baleginsky mine supplied iron ore to the Petrovsky plant to procure iron and steel for the mines of the Nerchinsky district. In the Olkhonsky municipal district of Irkutsk oblast small iron ore deposits are known; they are mainly represented by brown iron ore deposits (Borsoiskoe, Kuchelginskoe, etc.). In the first half of the 18th century, ore from these deposits was used for the needs of the Anginsky (Laninsky) ironworks. The most promising iron ore deposits of Mongolia are the skarn type deposits such as Tumurtolgoy, Bayangol, and Tumurtey, forming the Bayangol iron ore zone in the north of the country. Currently, iron ore deposits in the region are developed only in the territory of Mongolia: small scale extraction of iron ore is underway on the Zakhtsag and Tamir gol deposits; over the recent years, the production on the deposits of the Bayangolskaya iron ore zone amounted to more than five million tons; primary processing is performed at the cleaning plants near the deposits; iron-ore concentrate is exported to China.

The Oldakit manganese deposit, medium in terms of reserves, is located in the Severobaikalsky municipal district less than 30 km from the Baikal-Amur Mainline. Given the fact that Russia is currently experiencing shortage of this raw material, the deposit may be of some interest. Moreover, several small deposits of manganese are known within the boundaries of the Baikal basin, including the Ozerskoe deposit (Olkhonsky district) developed in the 19th century for the needs of the Nikolaevsky ironworks.

Nonferrous metals. Almost all reserves and resources of copper ores of the region are concentrated in complex copper-molybdenum and molybdenum-tungsten deposits of Mongolia, located within the Selenginsky volcanoplutonic belt. From 1978 to present a large deposit Erdenetiyn ovoo has been developed; on its basis a joint Soviet-Mongolian venture, the Erdenet Mining Company was established. The plant is engaged in open-pit mining and primary processing of copper-molybdenum ores and is one of the world leaders in the production of copper concentrate. Currently, the production output amounted to more than 25 million tons of ore, while the production of copper concentrate is about 350 thousand tons. In a globalizing world economy, the company faces the challenge of marketability of its products, which necessitates the construction of a copper-smelting plant. At present, the Erdenet Mining Company comprises a pilot plant for the production of pure cathode copper from off-balance and storage ore dump piles of KOO (Limited Liability Company) "Erdmin", which is a joint venture of Erdenet Mining Company and the American company RCM.

Within the Baikal basin, the largest Kholodninskoe deposit of lead-zinc sulfide ores is explored and prepared for industrial development; its reserves amount to 11.2% of Russia's total lead reserves and 34.1% of Russia's total zinc reserves. Based on the economic indicators of development, the deposit is on par with the best world analogues. According to the feasibility study of final mining parameters, the annual production of the underground mine at the deposit should amount to three million tons of ore, 504 thousand tons of zinc concentrate, and 60.3 thousand tons of lead concentrate. In order to ensure environmental safety of production, provision is made for a circulating water supply system, transportation of wastes of the ore-dressing plant outside the catchment area of Lake Baikal using pipelines, and a number of other environmental measures. However, due to the fact that the deposit is located in the Central Ecological Zone of the Baikal Natural Territory (BNT), where mining activity is banned, the production license, owned by the KOO (Limited Liability Company) "InvestEuroCompany" was suspended until 2015. Among other objects of polymetallic raw materials in the region, the medium Davatkinskoe deposit, discovered and assessed in the Khorinsky municipal district of the Republic of Buryatia, should be pointed out.

In Buryatia there are two large deposits of molybdenum ores, namely, Zharchikhinskoe and Malo-Oinogorskoe, and small Pervomaiskoe (abandoned) and Dolon-Modonskoe (undeveloped) deposits. There is a project of the construction of the Pribaikalsky mining and processing plant on the basis of the Zharchikhinskoe deposit, located 40 km to the south of Ulan-Ude in close proximity to the highway and railway, with the molybdenum content in the ore of more than 0.1% and high technological and technical-economic indicators. Its effective development is possible, provided that all necessary environmental requirements are observed.

Tungsten in the region belongs to widespread elements. In the territory of the Zakamensky municipal district there is the Inkurskoe deposit of the stockwork geological-industrial type, which is comparable to the largest similar deposits of the world in terms of its reserves and tungsten content. The Kholtosonskoe deposit, located to the west of the Inkurskoe one, is the largest deposit of the vein type in Russia, and is considered to be unique not only in Russia but also in the world as to its characteristics. The Dzhidinsky tungsten-molybdenum mill operated from 1934 to 1996 on the basis of these two deposits as well as the Pervomaiskoe molybdenum deposit. After the closure of the mill, the tailings pond remained over the area of more than one km^2, forming the man-made Barun-Narynskoe deposit, the development of which has been started by OAO (Open Joint Stock Company) "Zakamensk" since 2010. A reclamation plant recycling the mill's waste was built 1.5 km from the town of Zakamensk; the concentrate production amounts to about 300 tons per annum. ZAO (Closed Joint Stock Company) "Tverdosplav" is engaged in the construction of mining sites at the Inkurskoe and Kholtosonskoe deposits. It is planned to build a modern ore-dressing plant and a hydrometallurgical workshop for the processing of tungsten concentrates to produce commercial refined tungsten compounds. In the Petrovsk-Zabaikalsky municipal district of Zabaikalsky krai the prospectors' artel "Kvarts" mines the medium Bom-Gorkhonskoe tungsten deposit by the underground mining method. In recent years, the concentrate production amounted to around 600 tons. The remaining tungsten deposits within the territory of the Russian part of the Baikal basin are temporarily abandoned or are on the governmental standby.

A number of tungsten deposits are known in Mongolia. A small tungsten refinery plant was built on the Tsagaan davaa deposit; the concentrate production amounts to about 40 tons per annum; the final production is exported to the United States and China.

Tin deposits located in the Krasnochikoysky district are small in terms of reserves and are currently mothballed.

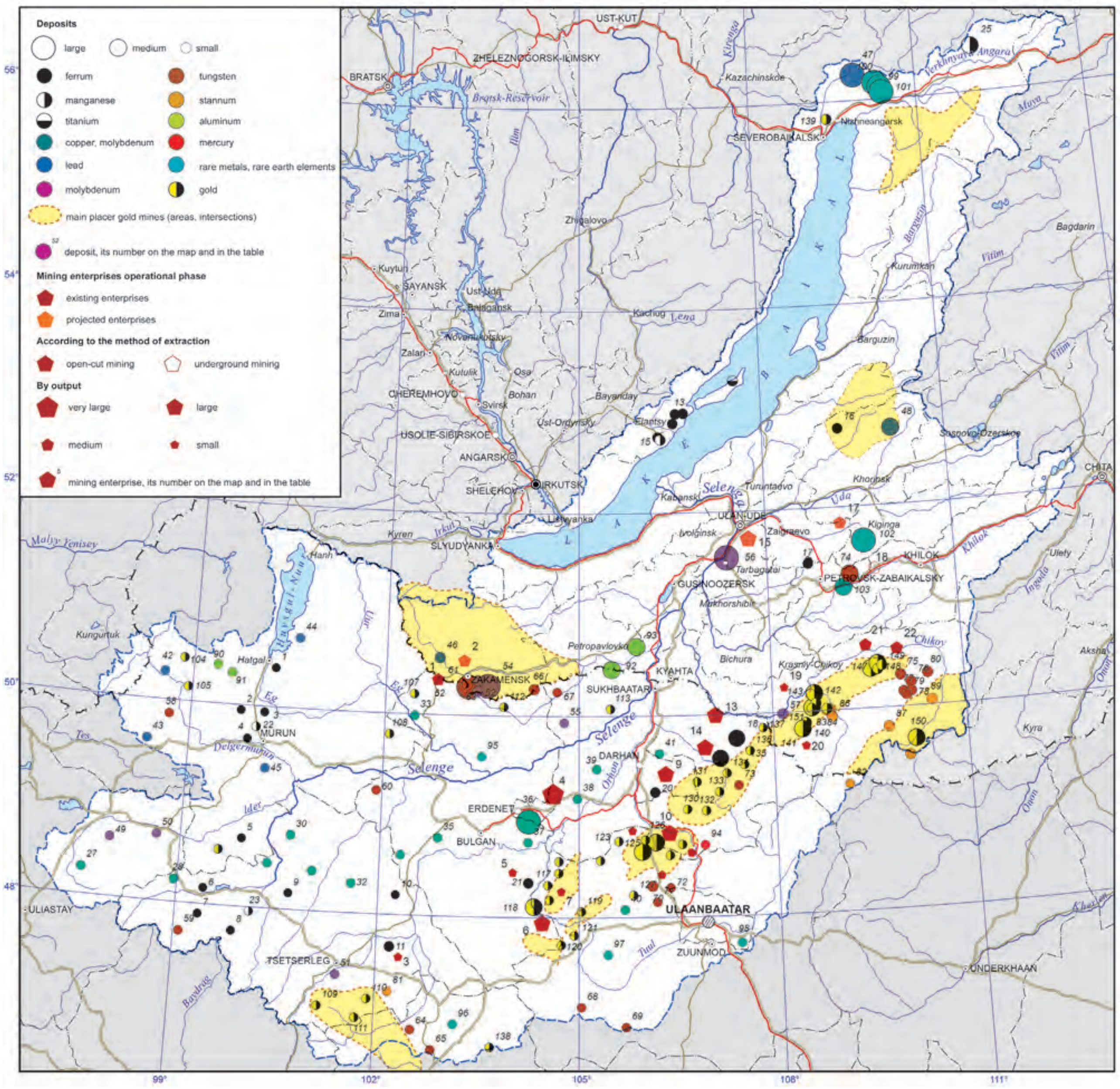
In the Dzhidinsky district of Buryatia the medium Borgoiskoe (Al_2O_3 – 19.8% on average) and Botsinskoe (21.44%) deposits of nepheline-bearing rocks are prospectively explored; currently they remain undeveloped.

Rare metals. In the Kizhinginsky municipal district of the Republic of Buryatia there is the Ermakovskoe deposit of beryllium ores containing 80% of the total beryllium reserves of Russia and unique as to the grade of ore. From 1978 the deposit was developed by the Zabaikalsky mining and processing plant; in 1990 the enterprise was mothballed. Beryllium is a strategic metal essential for the development of nuclear, aerospace, and aviation industry, and instrument engineering; it is used in the manufacture of telecommunications equipment. Currently, Russia's demand of this metal is met through imports. Whereas it is necessary to restore the raw material and production independence of the country in beryllium, it is expected to resume the production of ore on the deposit, and create production on primary processing of ore, as well as hydrometallurgical production, the end product of which – beryllium hydroxide – will be delivered to the Ulbinsky metallurgical plant in Kazakhstan for processing and producing beryllium alloying compositions and metal. The work to create the beryllium production is included in the Federal Target Program on rare metals of paramount importance.

In the Severobaikalsky municipal district within the Central Ecological Zone of the BNT, three subsoil plots of the Federal importance with large prognostic resources of rare earth elements of the yttrium group are on the governmental standby. They are the Chestenskoe, Akitskoe and Pryamoy-II deposits.

Noble metals. Within the Russian part of the Baikal basin there are no lode gold deposits (except the mined-out Voskresenskoe deposit in the Krasnochikoysky municipal district). Placer gold deposits are small or medium and are grouped into the gold-placer regions, namely: Dzhidinsky, Namaminsky, Yambuy-Tolutaisky, Chikoysky, and Baldzhikansky. In the Republic of

41. RESOURCES OF FERROUS, NONFERROUS AND RARE METALS AND THEIR MINING



Metallic minerals mining enterprises

No.	No. on map	User of mineral resources / mined deposit	Mineral product	Development phase	Size of mining enterprise	Stoping method
1	9	N/A / Tumurtolgoy	Iron	Operational	Large	Open-cut mining
2	13	N/A / Tumurtey	Iron	Operational	Large	Open-cut mining
3	14	N/A / Bayangol	Iron	Operational	Large	Open-cut mining
4	5	N/A / Zakhtsag	Iron	Operational	Large	Open-cut mining
5	3	N/A / Tamir gol	Iron	Operational	Large	Open-cut mining
6	4	SP Erdenet (Joint Venture) / Erdenetiin ovoo	Copper, molybdenum	Operational	Very large	Open-cut mining
7	16	OOO InvestEvroKompani (Limited Liability Company) / Kholodninskoe	Lead, zinc	Projected	Large	Open-cut mining
8	15	OOO Pribaikalsky GOK (Limited Liability Company) / Zharchikhinskoe	Molybdenum	Projected	Large	Open-cut mining
9	18	OOO Staratelskaya artel Kvarts (Limited Liability Company) / Bom Gorkhonskoe	Tungsten	Operational	Medium	Open-cut mining
10	11	N/A / Tsagan davaa	Tungsten	Operational	Small	Open-cut mining
11	2	ZAO Tverdosplav (Closed Joint-Stock Company) / Inkurskoe, Kholtosonskoe	Tungsten	Under construction	Medium	Open-cut mining
12	1	ZAO Zakamensk (Closed Joint Stock Company) / Barun-Narynskoe, the Inkur river placer	Tungsten	Operational	Medium	Open-cut mining
13	17	OOO Yaruuna Invest (Limited Liability Company) / Ermakovskoe	Beryllium, fluorspar	Under construction	Medium	Open-cut mining
14	8	N/A / Narantolgoy	Hardrock gold	Operational	Small	Open-cut mining
15	20	ZAO (Closed Joint Stock Company) Slyudyanka / Chikokon river	Placer gold	Operational	Small	Open-cut mining
16	19	OOO Sirius (Limited Liability Company) / Khilkotoi river	Placer gold	Operational	Small	Open-cut mining
17	21	OOO Taiga Limited Liability Company) /Atsa-Kunaleiskoe	Placer gold	Operational	Medium	Open-cut mining
18	22	OOO ZAS Vertikal Limited Liability Company) / Kunalei river	Placer gold	Operational	Medium	Open-cut mining
19	12	N/A /Gachuurt	Placer gold	Operational	Small	Open-cut mining
20	7	N/A / Nariin gol	Hardrock gold	Operational	Small	Open-cut mining
21	10	Boroo Gold (Centerra Gold) / Boroo	Hardrock gold	Operational	Large	Open-cut mining
22	6	Bumbat Gold Fields (Mongolia Gold Resources, Ltd) Bumbat	Hardrock gold	Operational	Large	Open-cut mining

Buryatia within the territory under consideration gold practically has not been produced over the recent three years (economically advantageous deposits are mined-out, and exploration and appraisal works require substantial expenditures); in the Krasnochikoysky district of the Zabaikalsky krai, four prospectors' artels produce 300-400 kg of gold annually using the open-pit hydromechanical method.

Gold is the second most significant mineral resource of Mongolia after copper. The industrial mining of gold ores in the country was launched in the early 20th century by the Russian-Mongolian joint-stock company "Mongolor" in the Iro-Gol river basin, in the Khovsgol region and in the Boroo area. Primary deposits are usually of the vein type, more rarely – mineralized zones. The most significant primary deposits in terms of reserves include the Boroo deposit in the Boroo-Zuunmod region and the Bumbat deposit in the Zaamarsky gold field. The metal content in individual layers reaches 10 g/t. The deposits are developed by Canadians with the annual production of five and 1.5 tons of metal, respectively. Moreover, gold is currently mined on the Narantolgoy and Nariyn gol deposits.

Among the placers small and medium ones predominate, and only single ones are large placers in terms of reserves. Most placers are shallow single-layer, rarely double-layer; in rare cases deep placers occur. Dredging and separate production techniques are applied at the placer deposits. After mining by large companies, the remaining gold is mined by individual prospectors, whose number exceeded 10 thousand people according to the official data alone. In river valleys, where mining is possible, huge settlements are formed. As a result, in recent years the country faced an intensive shallowing and pollution of rivers, shrinking of grazing lands for cattle, and a process of desertification of the southern territory, and drinking water shortages for population occur. This is largely due to huge volumes of gold mining in the river valleys, illegal use of mercury and cyanides, and almost total lack of reclamation.

The map symbols show metallic mineral deposits depending on their size and type of commercial minerals. Mining companies are also shown with symbols. The size of a symbol corresponds to the production output. The group of large companies include ferrous, nonferrous and rare metals producing enterprises with production ranging from 1 to 10 million tons of ore per annum, the group of medium ones comprises the production output of 0.1-1 million tons per annum, and small ones produce less than 0.1 million tons per annum. The Erdenet Mining Company is highlighted as a very large enterprise with an annual production of more than 20 million tons. The following gradation is accepted for gold mining: large companies are gold mines with the production of more than one ton per annum, medium companies are those producing 0.1-1 ton, and small ones are those with less than 0.1 tons produced. The color of the symbol corresponds to the exploitation phase of an enterprise: operating or projected and under construction; additional outline corresponds to the underground mining method. Gold-placer regions of the given territory are depicted by areals.

THE MAIN TYPES OF NONMETALLIC RAW MATERIALS: RESOURCES AND DEVELOPMENT (42)

Nonmetallic mineral resources of the region are of great industrial importance. Within the Baikal basin there are deposits of mining-chemical, thermo-chemical, and optical raw materials, construction materials, mineral fertilizers, ornamental and precious stones.

Deposits of raw quartz belong to strategic types of mineral resources. The region has a large raw materials base explored and prepared for industrial development: there are deposits of especially pure granular quartz (Chulbonskoe, Nadyozhnoe, Goudzhekitskoe, and others) and quartzites (Cheremshanskoe and Goloustenskoe). The vast majority of deposits are located in the territory of Buryatia; there are all prerequisites for creating a large complex of plants for deep processing of raw quartz for high-tech industries. In prospect, the republic can become the largest producer and exporter of polysilicon and total energy systems. Currently, there is a development project of the Chulbonskoe granular quartz deposit in the Severobaikalsky municipal district to get the end-product in the form of photovoltaic systems.

Quartzites of the mined Cheremshanskoe deposit are of exceptionally high raw materials quality meeting industrial requirements for the production of industrial silicon, silicon carbide and ferrosilicon; in recent years, research is carried out on the purest varieties to produce high-purity silicon for helioenergetics and growing of single crystals of piezoelectric quartz. The deposit has been mined since 1992 by ZAO (Closed Joint Stock Company) "Cheremshansky quartsit" with an annual output of about 200 thousand tons and is a mineral resource base of ZAO (Closed Joint Stock Company) "Kremniy" of the OK (United Company) RUSAL, one of the most cutting edge silicon production facilities in Russia and the country's only producer of refined silicon .

Quartzites of the Goloustenskoe deposit can be used in metallurgy, and in the production of silica bricks. Sources of high-quality abrasive raw materials are microquartzites of two large deposits, located in the Olkhonsky municipal district on the eastern slope of the Baikal Range, namely, Srednekedrovoe and Zavorotninskoe. The latter was developed from 1975 till 1993 by "Baikalkvartssamotsvety"; currently, the deposits are on the governmental standby.

Considerable reserves of raw fluorspar were explored in the Baikal basin in the Republic of Buryatia. Currently, one deposit is mined here. It is the medium Egitinskoe deposit in the Eravninsky district; extracted ore is processed at the ore-dressing plant of the Zabaikalsky mining complex. The Naranskoe deposit in the Selenginsky district was prepared for operation and was mined for some time. The Kyakhtinskaya fluorspar factory operated near the settlement of Khoronkhoy from 1966; first

Metallic minerals deposits

No. on map	Name of deposit	Mineral product	Degree of development	Size of deposit	Region
		Ferrous metals			
1	N/A	Iron	N/A	N/A	Mongolia
2	N/A	Iron	N/A	N/A	Mongolia
3	N/A	Iron	N/A	N/A	Mongolia
4	N/A	Iron	N/A	N/A	Mongolia
5	N/A	Iron	N/A	N/A	Mongolia
6	N/A	Iron	N/A	N/A	Mongolia
7	N/A	Iron	N/A	N/A	Mongolia
8	N/A	Iron	N/A	N/A	Mongolia
9	N/A	Iron	N/A	N/A	Mongolia
10	N/A	Iron	N/A	N/A	Mongolia
11	Tamir gol	Iron	Mined deposit	Small	Mongolia
12	Naryn-Elginskoe	Iron	Undeveloped	Small	Irkutsk oblast
13	Kuchelginskoe	Iron	Undeveloped	Small	Irkutsk oblast
14	Borsoiskoe	Iron	Undeveloped	Small	Irkutsk oblast
15	Popovskoe	Iron	Undeveloped	Small	Irkutsk oblast
16	Balbagarskoe	Iron	Undeveloped	Small	Republic of Buryatia
17	Baleginskoe	Iron	Suspended	Small	Zabaikalsky krai
18	Tumurtey	Iron	Mined deposit	Medium	Mongolia
19	Bayangol	Iron	Mined deposit	Medium	Mongolia
20	Tumurtolgoy	Iron	Mined deposit	Small	Mongolia
21	Zakhtsag	Iron	Mined deposit	Small	Mongolia
22	N/A	Manganese	N/A	N/A	Mongolia
23	N/A	Manganese	N/A	N/A	Mongolia
24	Ozerskoe	Manganese	Undeveloped	Small	Irkutsk oblast
25	Oldakit	Manganese	Undeveloped	Medium	Republic of Buryatia
26	Peschanoe	Titanium	Undeveloped	Small	Irkutsk oblast
		Non-ferrous metals			
27	N/A	Copper	N/A	N/A	Mongolia
28	N/A	Copper	N/A	N/A	Mongolia
29	N/A	Copper	N/A	N/A	Mongolia
30	N/A	Copper, molybdenum	N/A	N/A	Mongolia
31	N/A	Copper	N/A	N/A	Mongolia
32	N/A	Copper	N/A	N/A	Mongolia
33	N/A	Copper, gold	N/A	N/A	Mongolia
34	N/A	Copper, molybdenum	N/A	N/A	Mongolia
35	Nomgon	Copper, molybdenum	N/A	N/A	Mongolia
36	Erdenetiin ovoo	Copper, molybdenum	Mined deposit	Major	Mongolia
37	Shand	Copper, molybdenum	N/A	N/A	Mongolia
38	N/A	Copper, platinum	N/A	N/A	Mongolia
39	N/A	Copper, molybdenum	N/A	N/A	Mongolia
40	N/A	Copper, gold	N/A	N/A	Mongolia
41	N/A	Copper, molybdenum	N/A	N/A	Mongolia
42	N/A	Lead, zinc	N/A	N/A	Mongolia
43	N/A	Lead, zinc	N/A	N/A	Mongolia
44	N/A	Lead	N/A	N/A	Mongolia
45	N/A	Lead	N/A	N/A	Mongolia
46	Tarbagatayskoe	Lead	Undeveloped	Small	Republic of Buryatia
47	Kholodninskoe	Zinc, lead, silver, gold	Developing	Major	Republic of Buryatia
48	Dovatka	Zinc, lead, silver	On standby	Medium	Republic of Buryatia
49	Naranbulag	Molybdenum	N/A	N/A	Mongolia
50	Zost tolgoy	Molybdenum	N/A	N/A	Mongolia
51	N/A	Molybdenum	N/A	N/A	Mongolia
52	Pervomaiskoe	Molybdenum	Abandoned	Small	Republic of Buryatia
53	Dolon-Modonskoe	Molybdenum	Undeveloped	Small	Republic of Buryatia
54	Malo-Oinogorskoe	Molybdenum	On standby	Major	Republic of Buryatia
55	N/A	Molybdenum	N/A	N/A	Mongolia
56	Zharchikhinskoe	Molybdenum	Developing	Major	Republic of Buryatia
57	Gutaiskoe (Chikoiskoe)	Molybdenum	Mined-out	Small	Zabaikalsky krai
58	N/A	Tungsten	N/A	N/A	Mongolia
59	N/A	Tungsten, molybdenum	N/A	N/A	Mongolia
60	N/A	Tungsten, molybdenum	N/A	N/A	Mongolia
61	Inkurskoe	Tungsten, gold	Developing	Major	Republic of Buryatia
62	Kholtosonskoe	Tungsten	Developing	Medium	Republic of Buryatia
63	Barun-Narynskoe	Tungsten	Mined deposit	Small	Republic of Buryatia
64	N/A	Tungsten, tin	N/A	N/A	Mongolia
65	N/A	Tungsten	N/A	N/A	Mongolia
66	Buluktaiskoe	Tungsten	Undeveloped	Small	Republic of Buryatia
67	Bulagtay	Tungsten, molybdenum	N/A	N/A	Mongolia
68	Ongon Khairkhan	Tungsten	N/A	N/A	Mongolia
69	Ikh Khairkhan	Tungsten	N/A	N/A	Mongolia
70	Tsagaan davaa	Tungsten	Mined deposit	Small	Mongolia
71	N/A	Tungsten	N/A	N/A	Mongolia
72	N/A	Tungsten, tin, beryllium	N/A	N/A	Mongolia
73	N/A	Tungsten, tin	N/A	N/A	Mongolia
74	Bom-Gorkhonskoe	Tungsten, bismuth	Mined deposit	Medium	Zabaikalsky krai
75	Kunaleiskoe	Tungsten	On standby	Small	Zabaikalsky krai
76	Studencheskoe	Tungsten	Suspended	Small	Zabaikalsky krai
77	Ust-Serginskoe	Tungsten, gold	Proven	Small	Zabaikalsky krai
78	Molodezhnoe	Tungsten	On standby	Small	Zabaikalsky krai
79	Shumilovskoe	Tungsten	Suspended	Small	Zabaikalsky krai
80	Khrebtovskoe	Tungsten	Suspended	Small	Zabaikalsky krai
81	N/A	Tin	N/A	N/A	Mongolia
82	N/A	Tin	N/A	N/A	Mongolia
83	Kostrechikhinskoe	Tin	Suspended	Small	Zabaikalsky krai
84	Mysovskoe	Tin	Suspended	Small	Zabaikalsky krai
85	Nizhne-Elovskoe	Tin	Suspended	Small	Zabaikalsky krai
86	Verkhne-Elovskoe	Tin	Suspended	Small	Zabaikalsky krai
87	Chikokonskoe	Tin	Suspended	Small	Zabaikalsky krai
88	Badzhiraevskoe	Tin	Suspended	Small	Zabaikalsky krai
89	Shiretuiskoe	Tin	Suspended	Small	Zabaikalsky krai
90	N/A	Aluminum	N/A	N/A	Mongolia
91	N/A	Aluminum	N/A	N/A	Mongolia
92	Botsinskoe	Aluminum	Undeveloped	Medium	Republic of Buryatia
93	Borgoiskoe	Aluminum	Undeveloped	Medium	Republic of Buryatia
94	N/A	Mercury	N/A	N/A	Mongolia
		Rare metals, rare earth elements			
95	N/A	Rare earth elements	N/A	N/A	Mongolia
96	N/A	Beryllium	N/A	N/A	Mongolia
97	N/A	Tantalum, niobium	N/A	N/A	Mongolia
98	N/A	Тантал, ниобий	N/A	N/A	Mongolia
99	Chestenskoe	Rare earth elements (yttrium group)	Undeveloped	Major	Republic of Buryatia
100	Pryamoy II	Rare earth elements (yttrium group)	Undeveloped	Major	Republic of Buryatia
101	Akitskoe	Rare earth elements (yttrium group)	Undeveloped	Major	Republic of Buryatia
102	Ermakovskoe	Beryllium, fluorspar	Developing	Major	Republic of Buryatia
103	Tarbagataiskoe	Germanium	On standby	Medium	Zabaikalsky krai
		Noble metals			
104	N/A	Gold	N/A	N/A	Mongolia
105	N/A	Gold	N/A	N/A	Mongolia
106	N/A	Gold	N/A	N/A	Mongolia
107	N/A	Gold	N/A	N/A	Mongolia
108	N/A	Gold	N/A	N/A	Mongolia
109	N/A	Gold	N/A	N/A	Mongolia
110	N/A	Gold	N/A	N/A	Mongolia
111	N/A	Gold	N/A	N/A	Mongolia
112	Tsagaan zhalga	Gold	N/A	N/A	Mongolia
113	N/A	Gold	N/A	N/A	Mongolia
114	N/A	Gold	N/A	N/A	Mongolia
115	N/A	Gold	N/A	N/A	Mongolia
116	Nariyn gol	Lode gold	Active deposit	N/A	Mongolia
117	N/A	Gold	N/A	N/A	Mongolia
118	Bumbat	Lode gold	Active deposit	Medium	Mongolia
119	N/A	Gold	N/A	N/A	Mongolia
120	N/A	Gold	N/A	N/A	Mongolia
121	N/A	Gold	N/A	N/A	Mongolia
122	N/A	Gold	N/A	N/A	Mongolia
123	Zhavkhlant (Zhargalant)	Gold	N/A	N/A	Mongolia
124	Khavchuu	Gold	N/A	N/A	Mongolia
125	Narantolgoy	Lode gold	Active deposit	Medium	Mongolia
126	Boroo	Lode gold	Active deposit	Medium	Mongolia
127	N/A	Gold	N/A	N/A	Mongolia
128	Suzhigtey	Lode gold	N/A	N/A	Mongolia
129	Gachuurt	Placer gold	Active deposit	N/A	Mongolia
130	N/A	Gold	N/A	N/A	Mongolia
131	N/A	Gold	N/A	N/A	Mongolia
132	N/A	Gold	N/A	N/A	Mongolia
133	N/A	Gold	N/A	N/A	Mongolia
134	N/A	Gold	N/A	N/A	Mongolia
135	N/A	Gold	N/A	N/A	Mongolia
136	N/A	Gold	N/A	N/A	Mongolia
137	N/A	Gold	N/A	N/A	Mongolia
138	N/A	Gold	N/A	N/A	Mongolia
139	Kavynakh	Placer gold	Undeveloped	Small	Republic of Buryatia
140	Chikokon river	Placer gold	Active deposit	Medium	Zabaikalsky krai
131	Khilkotoy river (terrace)	Placer gold	On standby	Small	Zabaikalsky krai
142	Melnichnaya river	Placer gold	On standby	Medium	Zabaikalsky krai
143	Bolshaya river	Placer gold	Active deposit	Medium	Zabaikalsky krai
144	Gutay river	Placer gold	Active deposit	Small	Zabaikalsky krai
145	Khilkotoy river	Placer gold	Active deposit	Small	Zabaikalsky krai
146	Atsa-Kunaleiskoe	Placer gold	Active deposit	Medium	Zabaikalsky krai
147	Gornachikha and Glubokaya rivers	Placer gold	Active deposit	Medium	Zabaikalsky krai
148	Fedotovka river	Placer gold	On standby	Small	Zabaikalsky krai
149	Asakan river	Placer gold	On standby	Small	Zabaikalsky krai
150	Verkhne-Chikokonskoe	Placer gold	Active deposit	Medium	Zabaikalsky krai
151	Voskresenskoe	Lode gold	Mined-out	Small	Zabaikalsky krai

it worked on local raw materials, and then on raw materials imported from Mongolia. Currently, the factory is out of operation.

The region possesses large reserves of chemically pure limestones: in the Olkhonsky municipal district there is the Ust-Anginskoe deposit, and in the Zaigraevsky district there is the Bilyutinskoe deposit developed for the production of calcium carbide and the Tatarsky Klyuch for the paint and coatings industry. Dolomites of the Tarabukinskoe deposit are used as a raw material for glass and metallurgical production.

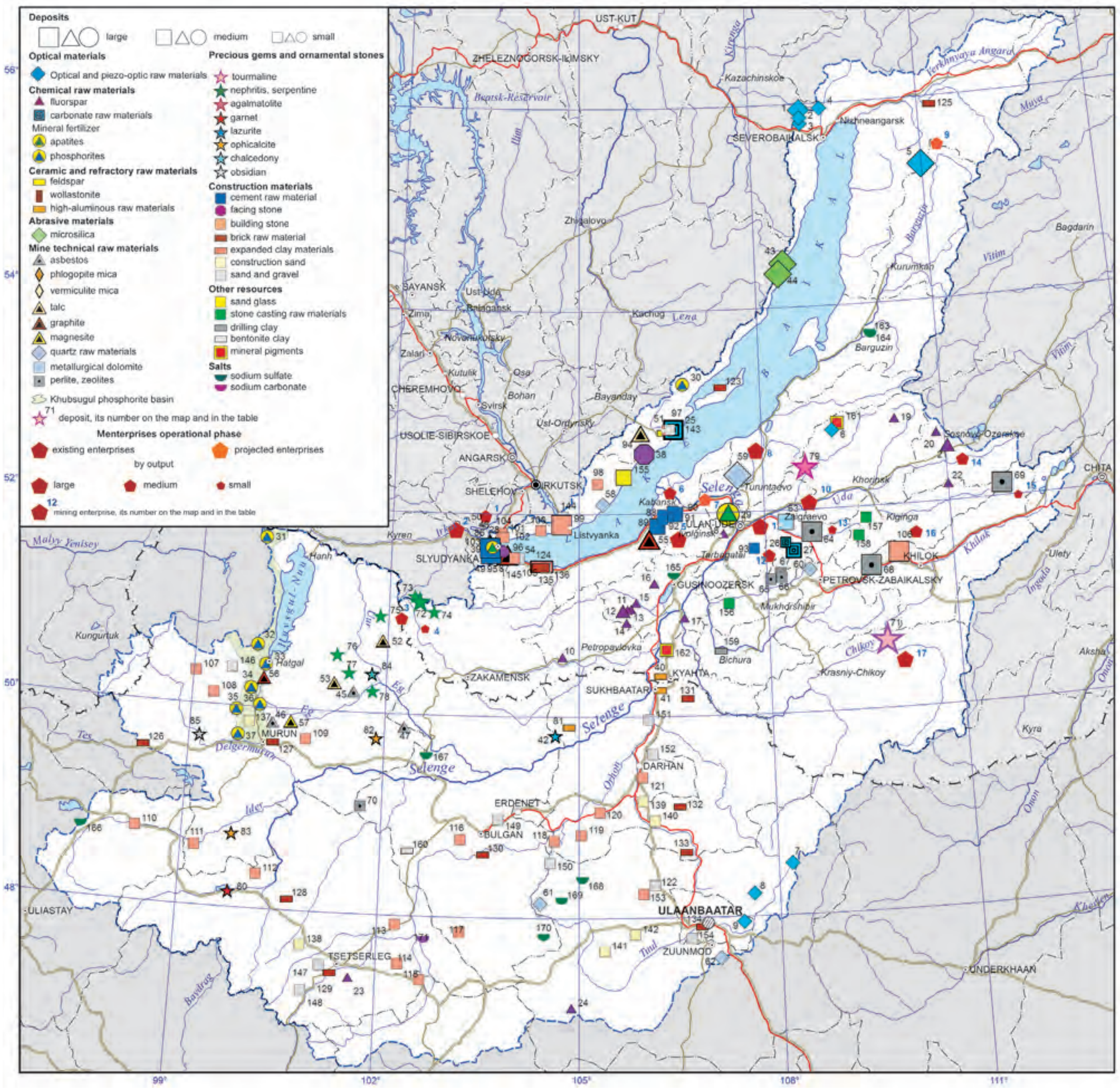
Deposits of phosphate raw materials are known in Cisbaikalia. They are the Sarminskoe phosphorite deposit in the Olkhon municipal district and the Slyudyanskoe apatite deposit in the Sludyansky municipal district; in northern Mongolia large reserves of formation phosphorites in the Khovsgol phosphorite basin were discovered and previously explored. The main deposits of the basin are located in the immediate vicinity of Lake Khovsgol, which is an obstacle to their development. The large Oshurkovskoe apatite deposit is prepared for exploitation near the city of Ulan-Ude. On the basis of the approved ready reserves the Zabaikalsky apatite plant was under construction; it was closed down at the building phase of an ore-dressing plant because of possible deterioration of the environmental situation in the Baikal basin. Currently, there is a project of the deposit's development based on environmentally friendly technologies for the extraction and beneficiation of ores. Taking into account a sustained deficit of phosphate raw materials in the country, an increase of the raw materials base for the production of phosphate fertilizers is a matter of economic security of Russia. The planned standard of production of apatite concentrate is 500 thousand tons per annum. Breakstone will be produced as a by-product in the same amount of 500 thousand tons per annum.

Considering the ceramic and fire-resisting raw materials, deposits of Irkutsk oblast should be pointed out. They are the Naryn-Kuntinskoe microcline pegmatite deposit, developed earlier for the needs of the “Sibfarfor” factory, the Kharginskoe glass sands deposit, on the basis of which the Taltsy plant was established in 1784 producing a variety of glass products for 170 years, and the Asyamovskoe deposit of wollastonite, a relatively new kind of mineral products with a number of unique properties and a growing range of applications. In the south of Buryatia a sillimanite (high-alumina) shales deposit named Chyornaya Sopka is known; its ores have simple mineral composition and are easily dressed. On the basis of the deposit a non-waste production with the release of sillimanite and quartz as commercial products can be created. All the above mentioned deposits are currently on the governmental standby.

Phlogopite mica deposits in the south of Lake Baikal have been known since the second half of the 18th century. Its regular commercial production using a ramified system of underground (tunnels, mines) and open (open pits) mine openings began in 1924 with the development of the electrical engineering industry in the country and lasted until 1973. From four to seven thousand tons of high-quality raw materials were mined annually in the Sludyansky district.

Graphite is represented in the region by two large deposits, namely, the Bezymyannoe (the Slyudyansky municipal district) and Boyarskoe (the Kabansky municipal district) deposits. Ores of the Bezymyannoe deposit are high quality and free-milling according to the manufacturer’s tests, but the deposit is located in close

42. THE MAIN TYPES OF NONMETALLIC RAW MATERIALS: RESOURCES AND DEVELOPMENT



Fuel and energy materials producing enterprises

No.	No. on map	User of mineral resources / mined deposit	Mineral product	Development phase	Size of mining enterprise	Stoping method
1	9	OOO Chulbonsky GOK (Limited Liability Company) / Chulbonskoe	Optical quartz	Projected	Medium	Open-cut mining
2	14	OOO Ros-Shpat (Limited Liability Company) / Egitinskoe	Fluorspar	Operating	Medium	Open-cut mining
3	11	OOO Gornaya kompaniya (Limited Liability Company) / Tatarsky klyuch	Limestone for paint manufacture	Operating	Major	Open-cut mining
4	12	OOO Gornaya kompaniya (Limited Liability Company) / Bilyutinskoe	Limestone for chemical industry	Operating	Medium	Open-cut mining
5	7	OOO Daksi LTD ((Limited Liability Company) / Oshurkovskoe	Apatite	Projected	Medium	Open-cut mining
6	8	ZAO Kremniy (Closed Joint Stock Company) / Cheremshanskoe	Quartzite	Operating	Major	Open-cut mining
7	10	OAO Karier Dolomit (Open Joint Stock Company) / Tarabukinskoe	Furnace dolomite	Operating	Major	Open-cut mining
8	13	OAO Perlit (Open Joint Stock Company) / Mukhor-Talinskoe	Pearlite	Operating	Small	Open-cut mining
9	15	OOO Kholinskie tseolity (Limited Liability Company)ООО Холинские / Kholinskoe	Zeolite	Operating	Small	Open-cut mining
10	17	ZAO Turmalkhan (Closed Joint Stock Company) / Malkhanskoe	Tourmaline	Operating	Major	Open-cut mining
11	3	ZAO MS Holding (Closed Joint Stock Company) / Khamarkhudinskoe	Jade	Operating	Medium	Open-cut mining
12	4	OOO Kaskad PTP (Open Joint Stock Company) / Khargantinskoe	Jade	Operating	Small	Open-cut mining
13	2	OAO Angarskiy tsementno-gornyi kombinat (Open Joint Stock Company Angarskiy integrated cement and mining enterprise) / Slyudyanskoe (Pereval)	Marble (cement raw material)	Operating	Major	Open-cut mining
14	5	OOO Timlyuisky tsementnyi zavod (Limited Liability Company Timlyuisky cement plant) / Tarakanovskoe	Limestone (cement raw material)	Operating	Major	Open-cut mining
15	6	OOO Timlyuisky tsementnyi zavod (Limited Liability Company Timlyuisky cement plant) / Timlyuiskoe	Loam (cement raw material)	Operating	Medium	Open-cut mining
16	1	OAO Rossiiskie zheleznye dorogi (Open Joint Stock Company) / Angasolskoe	Granite (building stone)	Operating	Medium	Open-cut mining
17	16	OAO Rossiiskie zheleznye dorogi (Open Joint Stock Company) / Zhipkhegenskoe	Granite (building stone)	Operating	Medium	Open-cut mining

proximity to Lake Baikal. The Boyarskoe deposit has the largest reserves. Economic efficiency of its development in compliance with all environmental requirements can be quite high despite low average graphite content in the ore, thanks to its favorable transportation and geographical location.

In the past, a considerable part of the Baikal basin experienced intense volcanic activity, the product of which is pearlite deposits, among which the largest ones are Mukhor-Talinskoe, Zakultinskoe, and Kholinskoe. Currently, this raw material is produced by OAO (Joint Stock Company) "Perlit" on the Mukhor-Talinskoe deposit with the production output amounting to 1-10 thousand m^3 of raw material per annum over the last three years. The Kholinskoe pearlite and zeolite deposit is located on the border of the Republic of Buryatia and Zabaikalsky krai; the mining OOO (Limited Liability Company) "Kholinskie tseolity" develops the deposit. Nowadays, the capacity of the company mining such a valuable kind of mineral product as zeolites is small and amounts to only about 0.8 thousand tons.

Within the region there are a number of deposits of precious and ornamental stones. In Zabaikalsky krai, ZAO (Closed Joint Stock Company) "Turmalkhan" develops a unique deposit of jewelry tourmaline, which is the only one in Russia to date. In the Republic of Buryatia, OOO (Limited Liability Company) "Kaskad" exploits the Khargantinskoe deposit with an annual production of 20 tons of raw jade; ZAO (Closed Joint Stock Company) "MS Holding" started to develop the Khamarkhudinskoe jade deposit, where 510 tons were produced in 2012.

To meet the needs of the construction industry the region possesses significant resources of mineral construction materials: numerous deposits of cement, brick, sand and gravel raw materials, building and facing stone are explored in the area. The raw materials base of the Angarsky cement plant is the large Slyudyanskoe deposit of cement marbles, being developed by the OOO (Limited Liability Company) "Karyer Pereval" with an annual output of about 900 thousand tons. The Tarakanovskoe deposit of cement limestone and Timlyuiskoe deposit of loam supply the Timlyuisky cement plant with raw materials. OOO (Limited Liability Company) "Timlyuitsement" produces 250-400 thousand tons of limestone and 20-35 thousand tons of loam annually.

Facing stone deposits are located on the western and south-eastern shores of Lake Baikal; they are Burovshchina and Novo-Burovshchinskoe deposits of pink marbles and Buguldeiskoe deposit of highly-ornamental statuary marble of various color shades: from snow-white to smoky-gray. Currently, stone is not produced on any of these deposits. Among building stone deposits AO (Joint Stock Company) RZhD exploits two: one of them is the medium Angasolskoe deposit in Irkutsk oblast and the other is the large Zhipkhegenskoe deposit in Zabaikalsky krai forming the raw materials base of the same-name crushed stone plants. Several deposits of building stone are situated in the coastal zone of Lake Baikal, namely, Baikalskoe, Ermolaevskoe, Dinamitnoe and others, rendering their development impossible.

The following deposits of brick and keramzite claysand loams were discovered: the Murinskoe and Khuzhirskoe deposits in Cisbaikalia and Irkaninskoe deposit in the Severobaikalsky municipal district, deposits of sand-gravel mix, including the Utulikskoe deposit of high-quality raw materials, the Pankovskoe deposit of building sands, and so on.

Among other mineral resources of the region, the Zangodinskoe and Kalinishenskoe deposits of mineral paints, Khayanskoe deposit of drilling clays, several deposits of raw materials for stone casting, as well as deposits of mineral salts (sodium sulfate) should be mentioned. All deposits of these raw materials are small in terms of reserves and are on the governmental standby.

In Mongolia small deposits of asbestos, gypsum, graphite, talcum, magnesite, bentonite, ornamental stones (nephrite, serpentinite, lapis lasuli, ophicalcite, chalcedony, etc.), raw quartz, and mineral salts are known within the Baikal basin. As for construction materials there are deposits of building sand, brick, keramzite and ceramic clays, sand-gravel mix, building stone, etc.

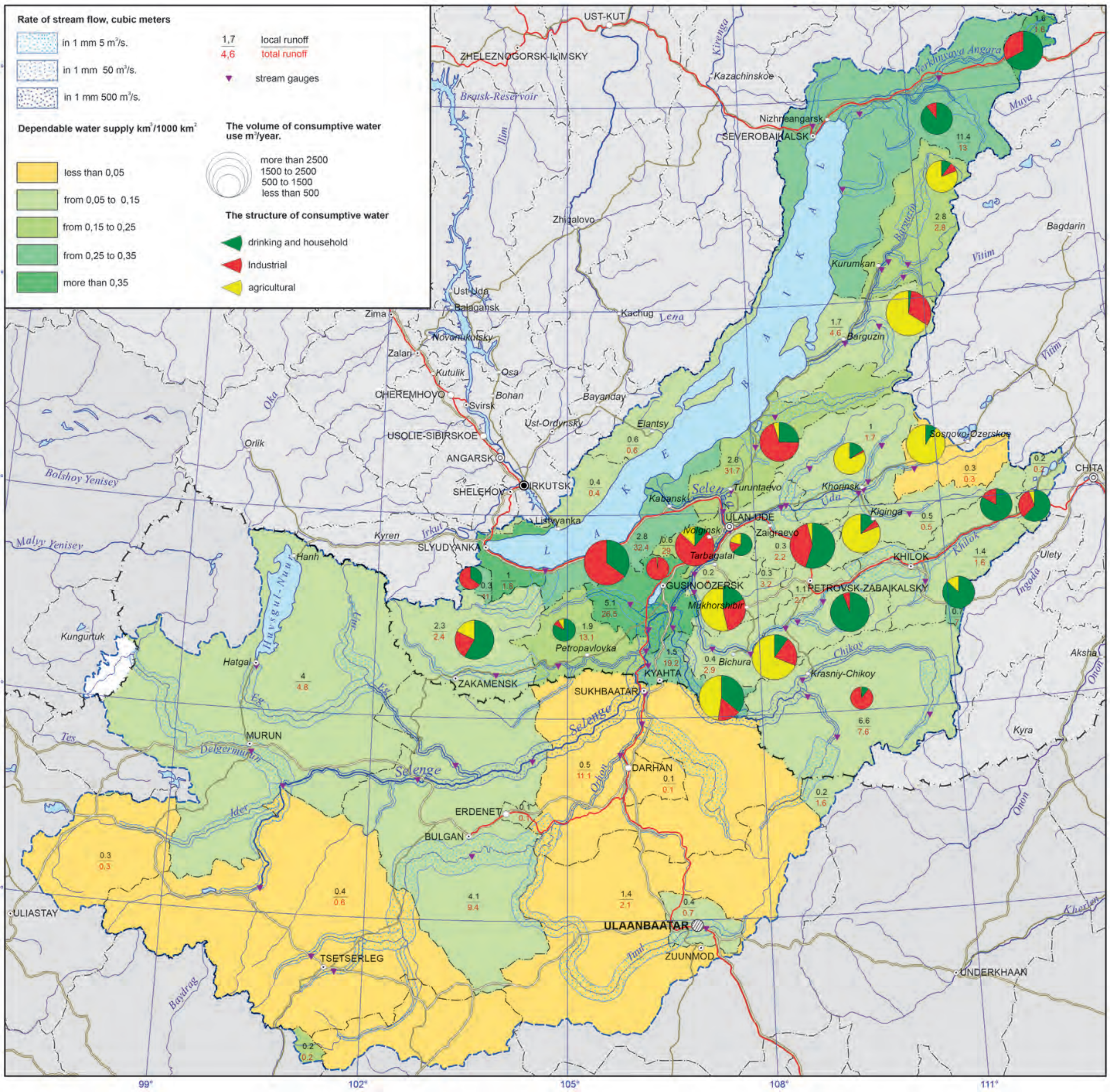
The map presents the main nonmetallic mineral raw materials deposits, depending on their size and type of mineral product, as well as mining companies using symbols. The size of the symbol designating a company depends on the average production output over the recent three to five years or on the planned capacity of the objects designed and under construction; gradation is presented in the summary table. The color of the symbol corresponds to the operational phase of an enterprise. The Khubsugulsky phosphorite basin is shown with an areal.

Map construction required the use of the materials of the Regional Funds of Geological Information, maps of mineral resources of the A.P. Karpinsky Russian Geological Research Institute; materials of State Reports "On the Condition of Lake Baikal and Measures of its Protection" for 2010–2012; "National Atlas of the Mongolian People's Republic" (1990), "Atlas of Mongolia" in the Mongolian language (2010), and "Atlas of Socioeconomic Development of Russia" (2009). Information on deposits according to the types of raw materials and on mining companies is presented in the summary table.

Main deposits of non-metalliferrous minerals

No. on map	Name of deposit	Mineral product	Degree of development	Size of deposit	Region
		Optical materials			
1	Nadyozhnoe	Optical quartz	On standby	Medium	Republic of Buryatia
2	Promezhutochnoe	Optical quartz	On standby	Small	Republic of Buryatia
3	Goudzhekitskoe	Optical quartz	On standby	Small	Republic of Buryatia
4	Tyiskoe	Optical quartz	On standby	Small	Republic of Buryatia
5	Chulbonskoe	Optical quartz	Developing	Major	Republic of Buryatia
6	Atarkhanskoe	Optical quartz	On standby	Small	Republic of Buryatia
7	N/A	Optical quartz	N/A	N/A	Mongolia
8	N/A	Optical quartz	N/A	N/A	Mongolia
9	N/A	Optical quartz	N/A	N/A	Mongolia
		Chemical raw materials			
10	Khuraiskoe	Fluorspar	Explored	Small	Republic of Buryatia
11	Naranskoe	Fluorspar	On standby	Medium	Republic of Buryatia
12	Ubur-Tashirskoe	Fluorspar	On standby	Small	Republic of Buryatia
13	Barun-Ulskoe	Fluorspar	On standby	Small	Republic of Buryatia
14	Ara-Tashirskoe	Fluorspar	On standby	Small	Republic of Buryatia
15	Kheltegeiskoe	Fluorspar	Explored	Small	Republic of Buryatia
16	Sharaldato	Fluorspar	On standby	Small	Republic of Buryatia
17	Nizhne-Chikoiskoe	Fluorspar	On standby	Small	Republic of Buryatia
18	Ivolginskoe	Fluorspar	On standby	Small	Republic of Buryatia
19	Nefyodovskoe	Fluorspar	On standby	Small	Republic of Buryatia
20	Dabkharskoe	Fluorspar	On standby	Small	Republic of Buryatia
21	Egitinskoe	Fluorspar	Mined deposit	Medium	Republic of Buryatia
22	Osennee	Fluorspar	On standby	Small	Republic of Buryatia
23	N/A	Fluorspar	N/A	N/A	Mongolia
24	N/A	Fluorspar	N/A	N/A	Mongolia
25	Ust-Anginskoe	Limestone	On standby	Major	Irkutsk oblast
26	Tatarsky Klyuch	Limestone	Mined deposit	Small	Republic of Buryatia
27	Bilyutinskoe	Limestone	Mined deposit	Medium	Republic of Buryatia
		Mineral fertilizers			
28	Slyudyanskoe	Apatite	Suspended	Small	Irkutsk oblast
29	Oshurkovskoe	Apatite	Developing	Major	Republic of Buryatia
30	Sarminskoe	Rock phosphorite	On standby	Small	Irkutsk oblast
31	N/A	Rock phosphorite	N/A	N/A	Mongolia
32	Khatgal (Ikh uul)	Rock phosphorite	N/A	N/A	Mongolia
33	Baga teeg	Rock phosphorite	N/A	N/A	Mongolia
34	Nergui	Rock phosphorite	N/A	N/A	Mongolia
35	N/A	Rock phosphorite	N/A	N/A	Mongolia
36	N/A	Rock phosphorite	N/A	N/A	Mongolia
37	N/A	Rock phosphorite	N/A	N/A	Mongolia
		Ceramic and fire-resisting raw materials			
38	Naryn-Kuntinskoe	Ceramic pegmatite	On standby	Small	Irkutsk oblast
39	Asyamovskoe	Wollastonite	On standby	Small	Irkutsk oblast
40	Chyornaya sopka	Sillimanite shale	On standby	Small	Republic of Buryatia
41	N/A	Andalusite, sillimanite	N/A	N/A	Mongolia
42	N/A	Andalusite, sillimanite	N/A	N/A	Mongolia
		Abrasive materials			
43	Srednekedrovoe	Microquartzite	On standby	Major	Irkutsk oblast
44	Zavorotninskoe	Microquartzite	On standby	Major	Irkutsk oblast
		Raw materials for mine engineering			
45	N/A	Asbestos	N/A	N/A	Mongolia
46	N/A	Asbestos	N/A	N/A	Mongolia
47	N/A	Asbestos	N/A	N/A	Mongolia
48	Talovskoe	Phlogopite mica	On standby	Medium	Irkutsk oblast
49	Slyudyanskoe	Phlogopite mica	On standby	Major	Irkutsk oblast
50	Bolshaya Talaya	Vermiculite mica	On standby	Small	Irkutsk oblast
51	Khara-Zhelginskoe	Talcum	On standby	Medium	Irkutsk oblast
52	N/A	Talcum	N/A	N/A	Mongolia
53	N/A	Talcum	N/A	N/A	Mongolia
54	Bezymyannoe	Graphite	On standby	Major	Irkutsk oblast
55	Boyarskoe	Graphite	On standby	Major	Republic of Buryatia
56	N/A	Graphite	N/A	N/A	Mongolia
57	N/A	Magnesite	N/A	N/A	Mongolia
58	Goloustenskoe	Quartzite	On standby	Small	Irkutsk oblast
59	Cheremshanskoe	Quartzite	Mined deposit	Major	Republic of Buryatia
60	Kvartsevaya gora	Quartz	On standby	Small	Zabaikalsky krai
61	N/A	Quartz raw materials	N/A	N/A	Mongolia
62	N/A	Quartz raw materials	N/A	N/A	Mongolia
63	Tarabukinskoe	Dolomite	Mined deposit	Medium	Republic of Buryatia
64	Mukhor-Talinskoe	Pearlite, zeolites	Mined deposit	Major	Republic of Buryatia
65	Naryn-Shibirskoe	Pearlite	Undeveloped	Small	Republic of Buryatia
66	Bryanskoe	Pearlite	Undeveloped	Small	Republic of Buryatia
67	Shenestuiskoe	Pearlite	Undeveloped	Small	Republic of Buryatia
68	Zakultinskoe	Pearlite	On standby	Major	Zabaikalsky krai
69	Kholinskoe	Pearlite, zeolites	Mined deposit	Major	Zabaikalsky krai
70	N/A	Pearlite	N/A	N/A	Mongolia
		Precious and ornamental stones			
71	Malkhanskoe	Tourmaline	Mined deposit	Unique	Zabaikalsky krai
72	Khangarulskoe	Jade	On standby	Small	Republic of Buryatia
73	Khamarkhudinskoe	Jade	Mined deposit	Medium	Republic of Buryatia
74	Khargantinskoe	Jade	Mined deposit	Small	Republic of Buryatia
75	N/A	Serpentinite	N/A	N/A	Mongolia
76	N/A	Serpentinite	N/A	N/A	Mongolia
77	N/A	Jade	N/A	N/A	Mongolia
78	N/A	Jade	N/A	N/A	Mongolia
79	Byrkhe-Shibirskoe	Agalmatolite	On standby	Major	Republic of Buryatia
80	N/A	Garnet	N/A	N/A	Mongolia
81	N/A	Lapis-lazuli	N/A	N/A	Mongolia
82	N/A	Ophicalcite	N/A	N/A	Mongolia
83	N/A	Ophicalcite	N/A	N/A	Mongolia
84	N/A	Chalcedony	N/A	N/A	Mongolia
85	N/A	Rock glass	N/A	N/A	Mongolia
		Construction materials			
		Cement raw materials			
86	Komarskoe	Marble	On standby	Major	Irkutsk oblast
87	Slyudyanskoe (Pereval)	Marble	Mined deposit	Major	Irkutsk oblast
88	Tarakanovskoe	Limestone	Mined deposit	Medium	Republic of Buryatia
89	Bolsherechenskoe	Limestone	On standby	Small	Republic of Buryatia
90	Pravoelovskoe	Limestone	On standby	Small	Republic of Buryatia
91	Timlyuiskoe	Loam	Mined deposit	Medium	Republic of Buryatia
92	Nikitinskoe	Limestone	On standby	Small	Republic of Buryatia
93	Doschatoe	Limestone	On standby	Small	Republic of Buryatia
		Facing stone			
94	Buguldeiskoe	Marble	On standby	Major	Irkutsk oblast
95	Burovshchina	Marble	Mined deposit	Small	Irkutsk oblast
96	Novo-Burovshchinskoe	Marble	On standby	Small	Irkutsk oblast
		Building stone			
97	Anginskoe	Granite gneiss	On standby	Small	Irkutsk oblast
98	Malogoloustenskoe	Limestone	Developing	Small	Irkutsk oblast
99	Baikalskoe	Granite	Undeveloped	Major	Irkutsk oblast
100	Uchastok 106-y km (106th km section)	Granite gneiss	On standby	Small	Irkutsk oblast
101	Angasolskoe	Granite	Mined deposit	Small	Irkutsk oblast
102	149 –y km (149th km)	Granite gneiss	On standby	Small	Irkutsk oblast
103	Dinamitnoe	Marble	Mined deposit	Small	Irkutsk oblast
104	Slyudyanskoe (Pad Pokhabikha)	Gneiss	On standby	Small	Irkutsk oblast
105	Ermolaevskoe	Gneiss	On standby	Small	Irkutsk oblast
106	Zhipkhegenskoe	Granite	Mined deposit	Major	Zabaikalsky krai
107	N/A	Basalt	N/A	N/A	Mongolia
108	N/A	Marble	N/A	N/A	Mongolia
109	N/A	Building stone	N/A	N/A	Mongolia
110	N/A	Limestone	N/A	N/A	Mongolia
111	N/A	Dolomite	N/A	N/A	Mongolia
112	N/A	Basalt	N/A	N/A	Mongolia
113	N/A	Limestone	N/A	N/A	Mongolia
114	N/A	Basalt	N/A	N/A	Mongolia
115	N/A	Basalt	N/A	N/A	Mongolia
116	N/A	Basalt	N/A	N/A	Mongolia
117	N/A	Basalt	N/A	N/A	Mongolia
118	N/A	Building stone	N/A	N/A	Mongolia
119	N/A	Limestone	N/A	N/A	Mongolia
120	N/A	Limestone	N/A	N/A	Mongolia
121	N/A	Limestone	N/A	N/A	Mongolia
122	N/A	Building stone	N/A	N/A	Mongolia
		Brick earth and ceramsite clay			
123	Khuzhirkskoe	Loam	On standby	Small	Irkutsk oblast
124	Murinskoe	Brick clay	Developing	Medium	Irkutsk oblast
125	Irkaninskoe	Clay	On standby	Small	Republic of Buryatia
126	N/A	Clay	N/A	N/A	Mongolia
127	N/A	Clay	N/A	N/A	Mongolia
128	N/A	Clay	N/A	N/A	Mongolia
129	N/A	Clay	N/A	N/A	Mongolia
130	N/A	Clay	N/A	N/A	Mongolia
131	N/A	Clay	N/A	N/A	Mongolia
132	N/A	Clay	N/A	N/A	Mongolia
133	N/A	Clay	N/A	N/A	Mongolia
134	N/A	Clay	N/A	N/A	Mongolia
135	Murinskoe	Ceramsite clay	On standby	Major	Irkutsk oblast
		Building sands and sand and gravel mix			
136	Pankovskoe	Sands	On standby	Small	Irkutsk oblast
137	N/A	Sands	N/A	N/A	Mongolia
138	N/A	Sands	N/A	N/A	Mongolia
139	N/A	Sands	N/A	N/A	Mongolia
140	N/A	Sands	N/A	N/A	Mongolia
141	N/A	Sands	N/A	N/A	Mongolia
142	N/A	Sands	N/A	N/A	Mongolia
143	Ulan-Anginskoe	Sand and gravel mix	On standby	Small	Irkutsk oblast
144	Bolsherechenskoe	Sand and gravel mix	On standby	Small	Irkutsk oblast
145	Utulikskoe	Sand and gravel mix	On standby	Small	Irkutsk oblast
146	N/A	Sand and gravel mix	N/A	N/A	Mongolia
147	N/A	Sand and gravel mix	N/A	N/A	Mongolia
148	N/A	Sand and gravel mix	N/A	N/A	Mongolia
149	N/A	Sand and gravel mix	N/A	N/A	Mongolia
150	N/A	Sand and gravel mix	N/A	N/A	Mongolia
151	N/A	Sand and gravel mix	N/A	N/A	Mongolia
152	N/A	Sand and gravel mix	N/A	N/A	Mongolia
153	N/A	Sand and gravel mix	N/A	N/A	Mongolia
154	Bekheg	Sand and gravel mix	N/A	N/A	Mongolia
		Other minerals			
155	Kharginskoe	Quartz sand (glass sand)	On standby	Medium	Irkutsk oblast
156	Zandinskoe	Dolerite (cast stone material)	On standby	Small	Republic of Buryatia
157	Ilyushkin klyuch	Basalt (cast stone material)	On standby	Small	Republic of Buryatia
158	Zun-Shibirskoe	Dolomite (cast stone material)	On standby	Small	Republic of Buryatia
159	Khayanskoe	Clay (drill)	On standby	Small	Republic of Buryatia
160	N/A	Bentonite clay	N/A	N/A	Mongolia
161	Zangodinskoe	Ochre	On standby	Small	Republic of Buryatia
162	Kalinishchenskoe	Ochre	On standby	Small	Republic of Buryatia
		Salts			
163	Solonchak	Salt cake	On standby	Small	Republic of Buryatia
164	Alginskoe	Salt cake	On standby	Small	Republic of Buryatia
165	Selenginskoe	Salt cake	On standby	Small	Republic of Buryatia
166	N/A	Salt cake	N/A	N/A	Mongolia
167	N/A	Salt cake	N/A	N/A	Mongolia
168	N/A	Salt cake	N/A	N/A	Mongolia
169	N/A	Salt cake	N/A	N/A	Mongolia
170	N/A	Salt cake	N/A	N/A	Mongolia
171	N/A	Soda	N/A	N/A	Mongolia

43. WATER RESOURCES AND WATER CONSUMPTION



WATER RESOURCES AND WATER CONSUMPTION (43)

The river network of the Baikal basin comprises about 10.4 thousand streams. The catchment area of Lake Baikal is asymmetrical; large river systems drain the south-eastern and north-eastern parts of the basin. The most significant river systems are the Selenga river and its right tributaries, namely, the Chikoy, Khilok, and Uda rivers, as well as the Barguzin and Upper Angara rivers. About 53% of river waters are formed in the territory of the Republic of Buryatia, 27% - in the territory of Mongolia, 16% - in the territory of Zabaikalsky krai, and 4% - in Irkutsk oblast. Annually about 60 km³ of water flow in and out of Lake Baikal with water streams and through the Angara river.

The origins of most rivers are located on slopes of mountain ranges at altitudes of 1200-1400 m. Therefore, in the upper reaches, and for many rivers along their entire length, they are of mountain character. Riverbeds with deep erosional incisions are rocky. Within the greater part of their valleys a floodplain is almost absent. Only large rivers in the middle and lower reaches have a character close to the plain one [Hydroclimate… , 2013].

The most ancient river systems drain the western slopes of the mountains surrounding Lake Baikal; they are the Sarma, Buguldeika, and Anga rivers. The class of such systems also includes basins of the largest Selenga and Barguzin rivers. The river systems of the south-eastern and northern macroslopes of Lake Baikal, namely, the Utulik, Tyya, Upper Angara, Turka, etc., are relatively young.

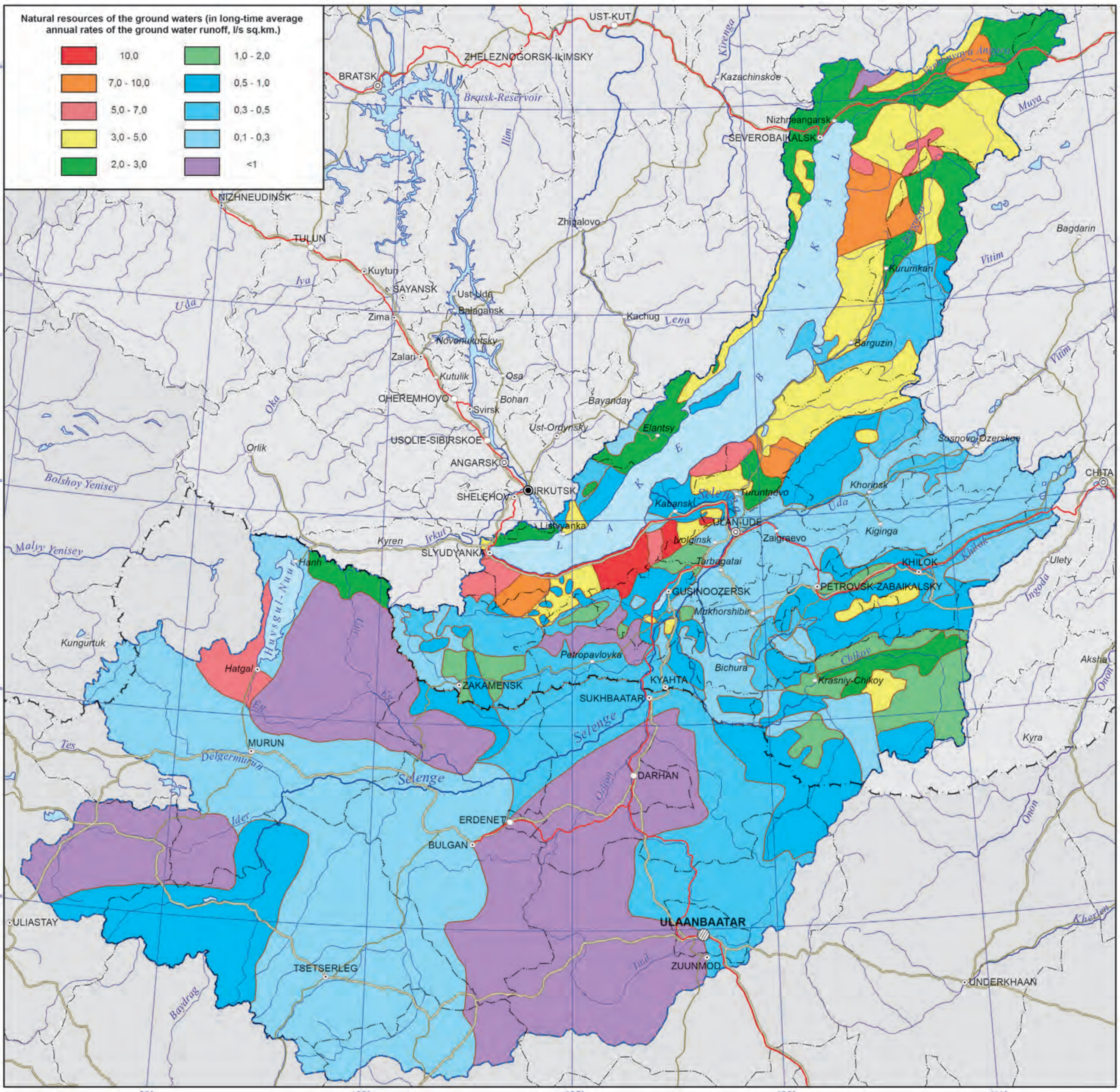
Methods of structural hydrography were used to compile a map of the rate of stream flow. Calculations of the river flow were made for the entire river network of the basin and were based on the close connection between the structure of the river network and its average rate of stream flow at any point of the system [Amosova, Ilyicheva, and Korytny, 2012]. Based on topographic maps, a graph of the river network was constructed, and then structural parameters for each point of the confluence of streams were calculated. Structural modules, representing the ratio of the water flow rate (Q, m³/s) to the structural measure at the given point, were determined. Data of reference materials on all hydrometeorological sections on the average long-term runoff from 105 gauges served as initial hydrological information [Surface water resources ..., 1972; Hydrological ..., 1977].

The rate of stream flow of the river systems is shown as an along-riverbed scale band (curve). This technique is usually called the method of localized diagrams, which is a method of cartographic representation of phenomena that have a continuous or linear (band) distribution. In the present case, the curves are referred to a linear element of the space, i.e. to a riverbed. The curves are drawn on both sides of the riverbed; they are proportional to the stream flow. The width of the curves varies along the length of a river and at the points of confluence with tributaries, depending on their rate of stream flow. Three gradations of the rate of stream flow are distinguished due to the large range of water flow rates (more than 500 m³/s, 50-500 m³/s, and 5-50 m³/s), which largely corresponds to the division of rivers according to their size. The mapping starts with the average long-term water flow rate of at least 5 m³/s, as values of lower rate of stream flow are difficult to represent [Korytny, 2001].

Within the boundaries of the administrative units, the volumes of local and general stream flow are calculated. Available water supply of the territory with the local stream flow is shown using five gradations. Mountain areas with the river systems of the northern and southern parts of the Baikal depression are characterized by the largest water supply. Administrative units of the Mongolian part of the Selenga river basin are generally poorly provided with local resources of river flow (less than 0.05 and 0.05-0.15 km³ per year).

The structure of water consumption is displayed using pie charts, the diameter of which corresponds to the volume of water consumption, and the area of sectors corresponds to the water use for various purposes, expressed as a percentage. On the whole, for the Baikal basin water consumption amounted to 502.050 thousand m³ in 2011, of which 56.440 thousand m³ were taken for drinking and household purposes, 389.170 thousand m³ - for production, and 56.440 thousand m³– for agricultural purposes. The main share of the river waters is drawn from the rivers of the Selenga basin. The largest consumers in the basin are the cities of Ulan-Ude and Severobaikalsk.

44. NATURAL GROUNDWATER RESOURCES



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NATURAL GROUNDWATER RESOURCES (44)

The map is based on the monograph by B.I. Pisarsky (1987) using medium-scale hydrogeological maps for Irkutsk oblast, the Republic of Buryatia and Tyva, Transbaikalia and Mongolia. The area principle of mapping of natural groundwater resources (in units of groundwater flow) was applied, as the complex hydrological and geochemical method of partitioning the hydrograph of the total stream flow was the principal one in the course of its comprehensive assessment. Mapping was carried out by the reference catchments located within the same aquifer system and characterized by the homogeneity of geological and hydrogeological conditions and sufficiently long series of runoff observations. For part of the territory where information was either not available or sparse, the mapping method was based on hydrological and hydrogeological analogy.

The color map is based on the energy principle. Cold colors correspond to low values of the rate of subsurface water flow, warm colors to the high values. Extremes of the spectrum of white correspond to the extreme values of the intensity of subsurface flow. Ranking of values of natural groundwater resources and class gradation are brought into compliance with that existing in this area [Natural Resources..., 1976]. A more fractional division of low classes is caused by the low values of rate of subsurface water flow in the territory of Mongolia, occupying a significant part of the Baikal basin.

Distribution of natural groundwater resources in the Baikal basin is extremely uneven; nevertheless it is generally subject to the vertical zonation and latitudinal zonality. Anomalous values of the rate of subsurface water flow are confined to the basins with complex hydrogeological conditions.

References

Natural groundwater resources in southern East Siberia. (1976). - Novosibirsk: Nauka. - 127 p.

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MINERAL SPRINGS (45)

The map is based on generalizing monographs, maps of mineral waters and field research data obtained by the authors.

The map depicts mineral springs, the water of which can be used for balneological purposes according to its physical and chemical properties. These characteristics include: water temperature (hot springs); radon content (cold radon springs), content of free carbon dioxide (carbonic cold springs), content of sulphate sulfur (cold hydrogen sulfide springs) and iron (ferrous cold springs).

This map can be used for the organization of sanatorium-and-spa construction, as well as for planning of underground thermal water use in thermal engineering.

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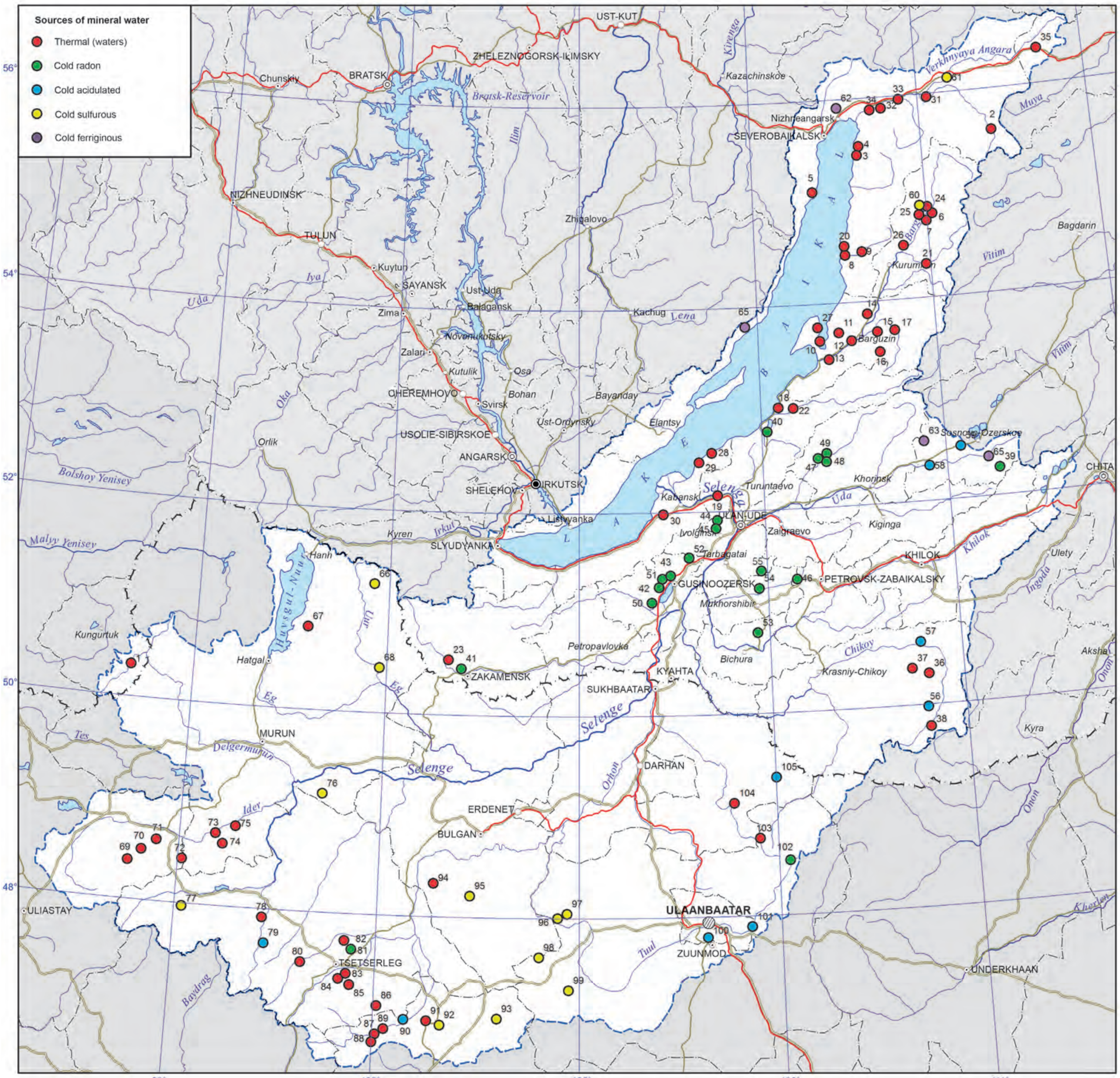
45. MINERAL SPRINGS



The numbers on the map:

1. Taryssky
2. Goryachiy Klych
3. Frolihinsky
4. Hakussky
5. Kotelnikovsky
6. Megdylkon
7. Seyuysky
8. Davshinsky
9. Bolsherechye
10. Culinye bolota
11. Nechaevsky
12. Tolstihinsky
13. Gusihinsky
14. Bystrinsky
15. Alginsky
16. Urinsky
17. Ineky
18. Goryachinsk
19. Pitatelevsky
20. Yazovsky
21. Garginsky
22. Zolotoy Klych
23. Engorboysky
24. Umheysky
25. Kuchegersky
26. Allinsky
27. Zmeyiniy
28. Well in Sukhaya
29. Well in Noviy Enkhaluk
30. Well in Bolshaya Rechka
31. Irkaninsky
32. Korikeysky
33. Dzelindinsky
34. Verhniya Zaimka
35. Turikansky
36. Esutaysky
37. Kunaleysky
38. Semiozersky
39. Moheysky
40. Kotokelsky
41. Well in Zakamensk
42. Urminsky
43. Zagustaysky
44. Halyutinsky
45. Otobulak
46. Shinistuysky
47. Tegdinsky
48. Dargituysky
49. Hasurtaevsky
50. Sangina
51. Uleabortoysky
52. Ubukunsky
53. Ust-Orshansky
54. Akshangineky
55. Anninsky
56. Zasulansky
57. Yamarovka
58. Poperechinsky
59. Pogrominsky
60. Pineserikta
61. Ust-Kotersky
62. Kholodninsky
63. Marowsky
64. Ongurensky
65. Daban-Gorhon
66. Sarvaslag
67. Bulnay
68. Armagh
69. Hozhuul
70. Haluun Us
71. Zart
72. Tsetsuuh
73. Honzhil
74. Tsuvraa
75. Salbart
76. Rashaant turuu
77. Noën Khangai
78. Chuluut
79. Ulaan Ereg
80. Huyten
81. Shivert
82. Khuree-Nutag
83. Tsenkher
84. Gyalgar
85. Bor Tal
86. Tsagaan Sum
87. Hyamar
88. Gyatruun
89. Mogoitui
90. Urtyn Tohoy
91. Huzhirt
92. Shara Shoroot
93. Navchtin Haluun
94. Sayhan Huldzh
95. Doshiyn Hurem
96. Holbodzhiyn Bulag
97. Shaahaat
98. Uuriyn their Ortiyn Rashaant, Argalin, Tayzhiyn buleg rashaan
99. Devsen Bulag
100. Orgil
101. Ar-Zhanchivlin
102. Gutai
103. Estiy
104. Eroo
105. Minzh

RECREATIONAL CLIMATE RESOURCES (46)

A complex of several climatic factors, such as high sunshine duration (from 2800 hours per annum in the south of the basin to 1500 hours per annum in the north), wide range of heat supply (the sum of mean daily temperatures above 10° C varies from 2400 in the south of the basin to 244 in the highlands), sustained low temperatures in the hollow land forms, and predominantly low wind velocities contribute to the formation of local climates with highly varied suitability for seasonal recreation. Background climatic characteristics of diverse territories, such as hollow, valley, low-, mid-, and high-altitude vary considerably. Their main features in this case are characterized by a number of differently directed indices, whose combined impact on humans can have a similar effect. The same air temperature has a dissimilar thermal effect on a human body in the case of different wind velocities and different air humidity.

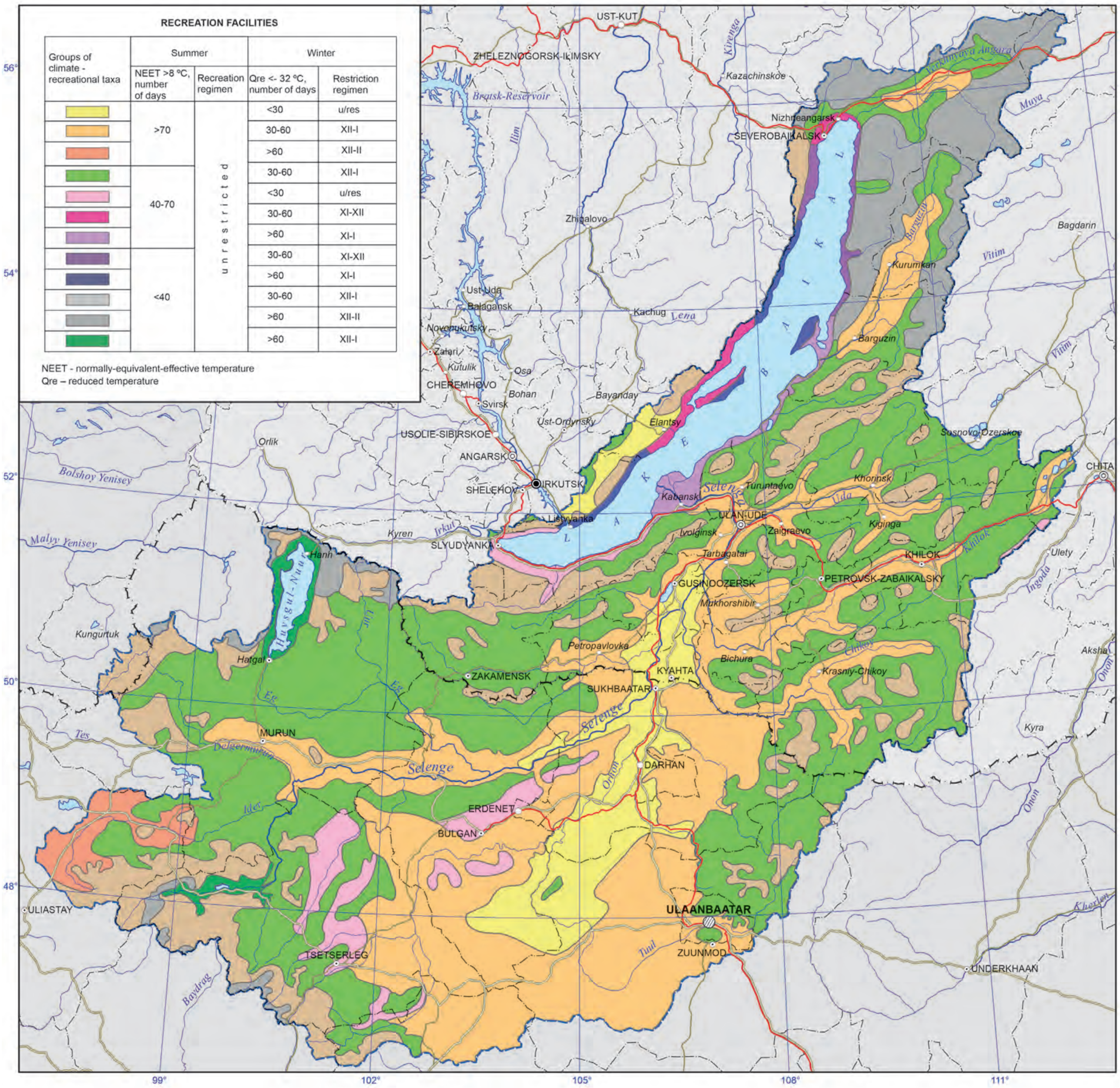
Normal-equivalent-effective temperature (NEET) method is often used to take into consideration their combined influence upon the thermal state of man. The levels of comfortable perception of heat according to the NEET scale vary within a broad range depending on the degree of man's adaptation to environmental conditions. The use of the duration of NEET values above 8 °C for the background assessment of contrasting territories demonstrated its validity [Bashalkhanova et al., 2012].

Reduced temperature (Qred) indicates heat losses from the open surface of human body in the wintertime under a combined effect of air temperature and wind velocity [Khairulin and Karpenko, 2005]. With Qred below −32 °C, the risk of frostbite increases, so recreation in the open air is limited.

In the total form the complex of the most important characteristics of climatic resources favorable for recreation is represented by the duration of periods with NEET above 8 °C and those limiting it – by Qred below −32 °C.

Spatial distribution of indicators under study is dependent on a complex interaction of the main climate forcing factors, such as radiative and circulatory ones as well as the underlying surface properties, which provide a variety of mesoclimatic conditions, manifestation of latitudinal and altitudinal zonality elements and local patterns for recreational activity

46. RECREATIONAL CLIMATE RESOURCES



In summer the variety of landscape conditions exerts considerable influence on climatic regimes formation alongside with the latitudinal factor. The plain-valley mesoclimates combining the steppe, steppificated, and subtaiga piedmont pine landscapes of slopes, plains and river valleys are characterized by the broadest possibilities for recreation and treatment of the population [Landscapes…, 1977; National…1990]. The duration of days with the NEET above 8 °C is highest. Recreational resources of the climate of uplands and mountainous territories are substantially lower; they are characterized by a shorter duration of the favorable period. The duration decreases dramatically depending on the latitudinal and altitudinal location of natural complexes. For instance, for the dark coniferous landscapes of uplands, dark coniferous and larch piedmont and intermontane depressions as well as bogged larch depressions on the plains its duration is from 40 to 70 days. In the mountain-taiga landscapes of flat (sometimes slope) surfaces as well as in dark coniferous landscapes of high slopes and plateaus, this period is less than 40 days. In high mountains with goletz, subgoletz and, partly, mountain-taiga larch forests, the mean monthly NEETs do not reach 8 °C.

The low recreational potential of the climate in winter is conditioned by circulation and astronomical factors. In the subtypes of climates weakly differing in summer (plain-valley, narrow valley and highlands) elements of latitudinal zonality are clearly traced. The period of possible limitation of recreation in the open air in the northern and southern parts of the basin can differ nearly twofold. Meanwhile the stagnant phenomena in orographically isolated intermontane depressions and closed river valleys are accompanied by the longest period of Qred below −32 °C, which reveals more favorable conditions on their slopes. The severity of winters for open surfaces of slopes and summits obeys the wind regime.

Quite special conditions occur on the shores of Lake Baikal. The warming (in winter) and cooling (in summer) influence of the lake's water masses showed a shift toward a decrease in climatic-physiological comfort of landscapes when compared with their counterparts outside the influence zone. This is largely due to the large horizontal temperature gradients between land and lake, which are often the cause of strong winds, the exceptional variety, unpredictability and velocity of which are well known. For that reason, on certain parts of the shore, especially in the west, in the mountain-taiga pine and larch landscapes the number of days with the NEET above 8 °C is lowest (less than 40 days). Meanwhile, in the wind-proof parts of the shore (Peschanaya Bay, the Kuchelga river valley, etc.) the conditions for recreation are optimal. In winter the dependence of the climatic-recreational potential on the location grows even further. In some shore areas relatively favorable in the summer season, the length of the period of reduced temperature below −32 °C differs substantially.

On the whole, the recreation resources of the climate across the territory are relatively varied. Given the availability of mud-bath resources in the depressions and broad river valleys with a shorter length of the limiting period, there is a possibility of launching the sanatorium-and-spa treatment. Of considerable interest are the middle mountains of Khangai and the interfluves of the Selenga and Orkhon rivers. The climatic resources of other territories are more suitable for extensive development and promotion of tourism and stationary recreation. Because of the low heat availability and abrupt fluctuations in the temperature-wind regime, the shores of Lake Baikal and Lake Hovsgol are favorable for recreation of healthy people only. Obviously, depending on the characteristics of heat and moisture exchange and on the regime of the local circulation, the period for different kinds of recreation is variable. Thus, the slopes of the Khamar-Daban on the southern shores of Lake Baikal are most favorable for the winter kinds of recreation due to the abundance of snow, and the appropriate combination of temperature and wind regimes. The shores of Middle Baikal characterized by a long duration of sunshine are more favorable for summer recreation.

The experience of the cartographic analysis and multiscale assessment of recreational resources of the climate showed that in a number of cases climate resources essential for the recreation of people and conditioned by microclimatic differences may considerably exceed their latitudinal background parameters. Thus, a comprehensive expert examination of the recreational resources of the climate is important when a certain area is selected for implementation of investment projects.

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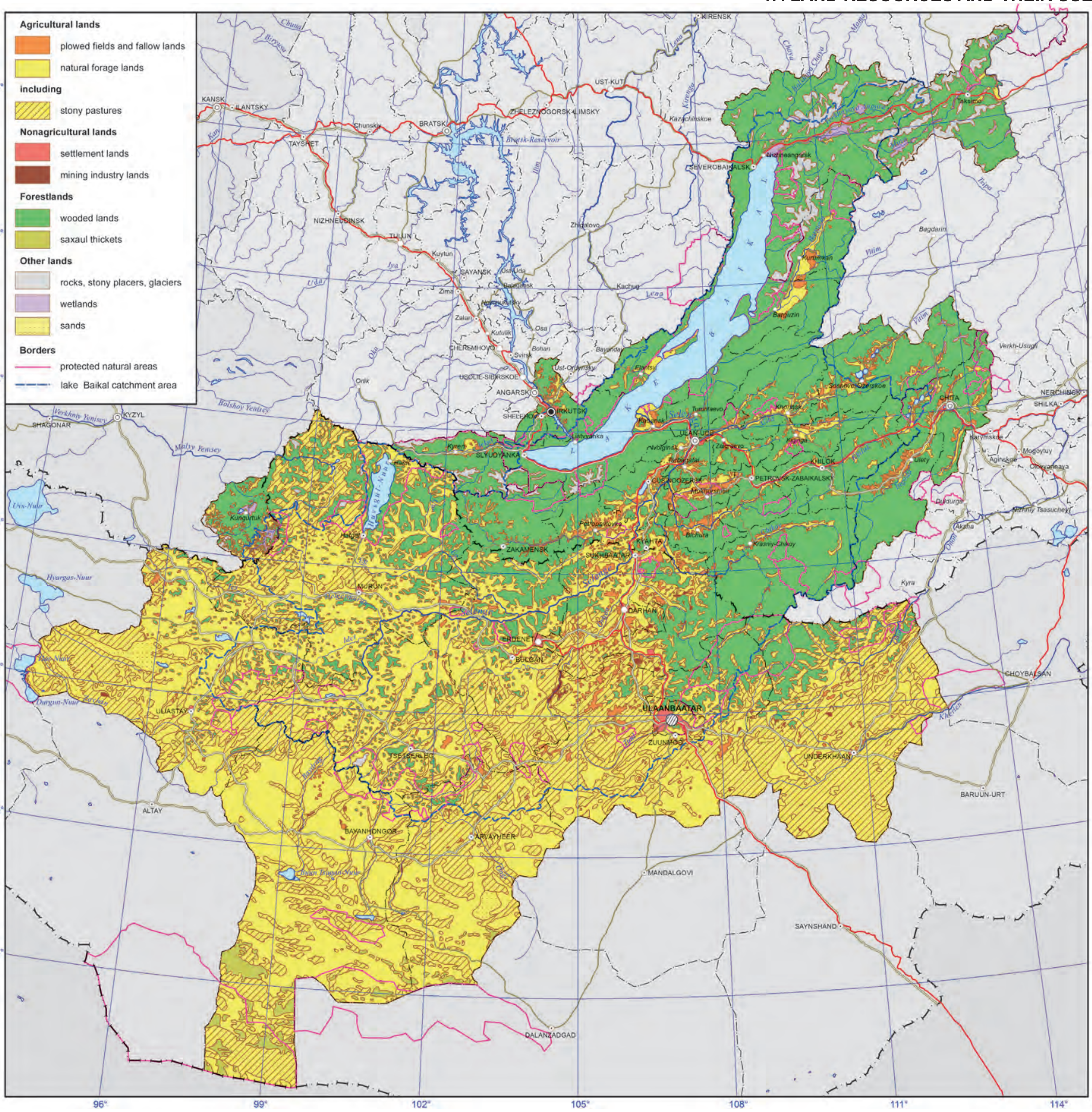
47. LAND RESOURCES AND THEIR USE



LAND RESOURCES AND THEIR USE. AVAILABILITY OF AGRICULTURAL LANDS TO POPULATION AND LAND USE CATEGORY (47 — 48)

Land resources are the main spatial basis, a store of various types of mineral resources for many branches of industry, as well as a basic means of production for agriculture and forestry. For the latter branches land resources and soil fertility are important means of growing crops and forest stands. For other types of land use (residential, transport, etc.) the role of land resources is reduced mainly to the role of the operational basis for spatial location of specific objects inherent to these types of land use.

Under the working legislation and established practice state land registration in the Russian Federation is carried out on land categories and agricultural lands, forms of ownership and types of land rights, as well as their use for agricultural production and other needs. Land registration in Mongolia is carried out similarly (with minor changes).

On the basic map the land fund structure on agricultural lands is presented as a quality background. The latter ones are defined as land, systematically used or usable for specific economic purposes and different in their natural and historical features. Land carries material properties typical of land use as an economic phenomenon.

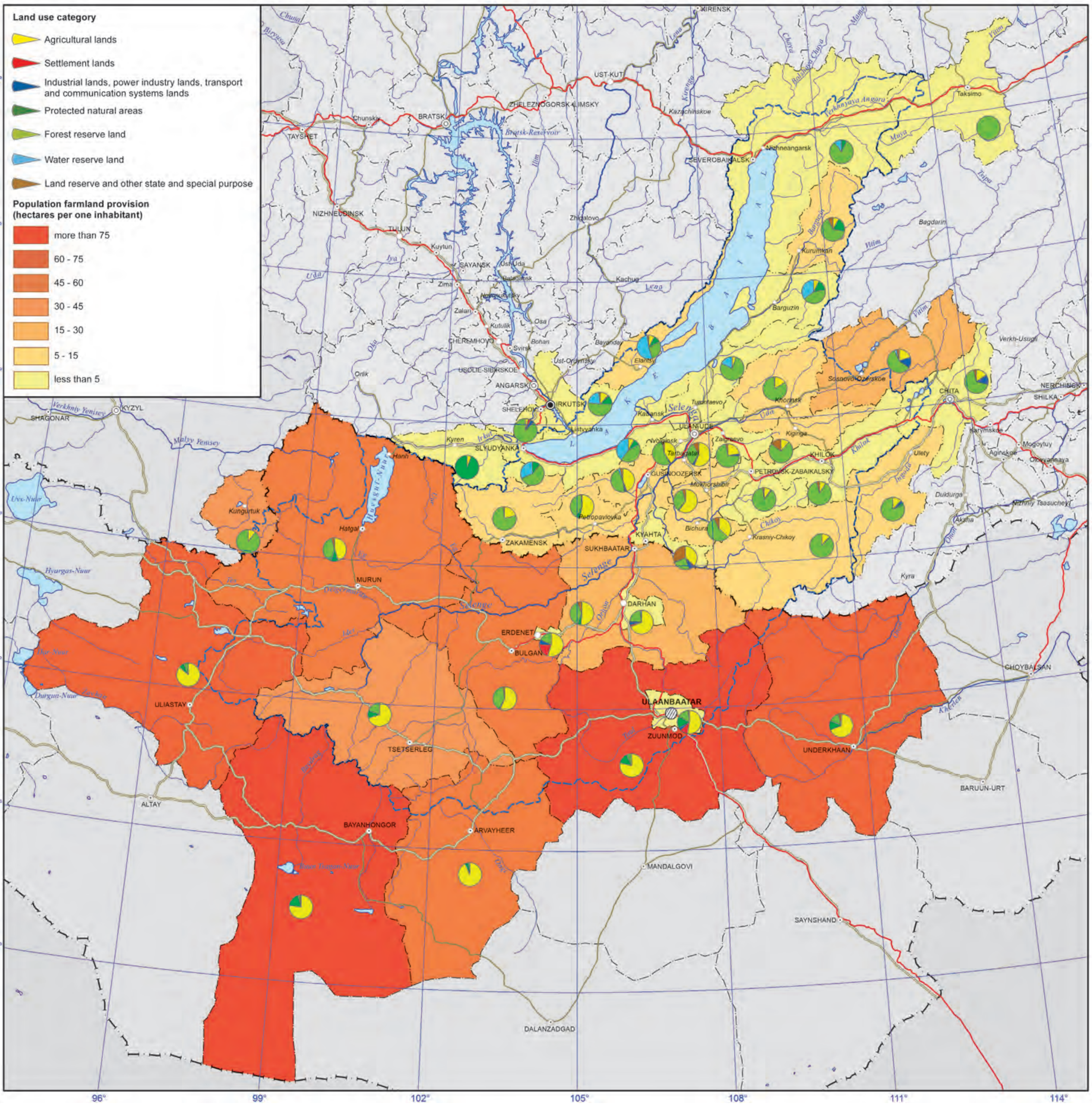
The second map and the Table represent the layout of the land fund on land categories and the index of availability of agricultural land. Land categories are land plots distinguished according to their intended use (agricultural land, settlements, industry, energy, transport, communication, defense and security, etc., forest, water resources, reserves, etc.). Mongolia is characterized by the absence of the concept of «land reserve». However, a large share of the land fund structure there belongs to public land for special purposes, which consists not only of lands of defense and security and protected areas,

Distribution of land fund categories on lands within the Baikal basin as of January 1, 2011 , thousand ha

Subjects of the Russian Federation	Total	Agricultural lands	Settlements	Industrial lands	Protected Areas	Forest Fund areas	Water Fund areas	Reserve lands
Irkutsk oblast	3584,2	271,6	55,90	21,6	352,9	1554,3	126,4	63,8
Republic of Buryatia	25851,9	3599,6	142,10	485,4	2136,5	16657,6	2124,6	706,0
Zabaikalsky krai	8452,6	974,7	38,10	286,2	90,8	6869,2	15,4	178,1
Republic of Tyva	1005,0	107,5	0,13	0,6	0	890,8	3,5	2,4
Mongolia	67034,8	46427,2	25,30	279,8	693,1	1137,4	377,7	1466,0
Lake Baikal basin, total	105928,5	51273,1	261,53	1073,6	3273,3	27109,3	2647,6	2416,3

Note: * Industrial transport, defense, communications, energy industry lands.

48. AVAILABILITY OF AGRICULTURAL LANDS TO POPULATION AND LAND USE CATEGORY



but lands, used in ways uncharacteristic of Russia. Therefore, in the map legend the category «lands of state and special purpose» applies only to Mongolia, excluding the land of specially protected natural areas and defense and security lands. The latter ones are included in the respective land categories.

The availability index of farmland is the ratio of agricultural land area (in hectares) belonging to the agricultural land to the number of residents living in the municipality. Farmland is an essential part of land, which is a potential resource for the formation of local food base. The average area of agricultural land per capita (within Russian territory, except Tere-Khol district of the Republic of Tyva) amounts to 3.7 hectares; it ranges from 0.06 ha within Sludyansky district of Irkutsk oblast to 22.9 ha in the Eravninsky district of the Republic of Buryatia. Within the Mongolian territory the indicators of the agricultural land per aimak inhabitant, is on the average significantly higher than in the Russian part of the basin as it amounts to about 45 hectares. Minimum rates are found in the Ulaanbaatar, Darkhan, and Orkhon aimaks, which is connected, first of all, with the high population numbers in these aimaks and relatively smaller areas of agricultural land compared to other aimaks.

In 1990 – 2010 the reduction of agricultural area for most municipalities is registered in the Russian part of the basin, which is directly linked to their withdrawal from agricultural use. The main reason of the reduction of such agricultural areas was shutdown of many agricultural enterprises, organizations, and farms and transfer of the withdrawn lands, for the most part, to the land redistribution fund. Another reason is the expiration of the land leasehold (or temporary use) and non renewal of its agricultural productivity. The agricultural land reduction is caused by negative processes became widespread due to the sharp reduction of valuable land protection measures from water and wind erosion, flooding, bogging, waterlogging and other processes. It should be noted that the actual outflow of productive land is much higher. Previously transferred farmland reserves are overgrown with shrubs and low forests and lose their agricultural value.

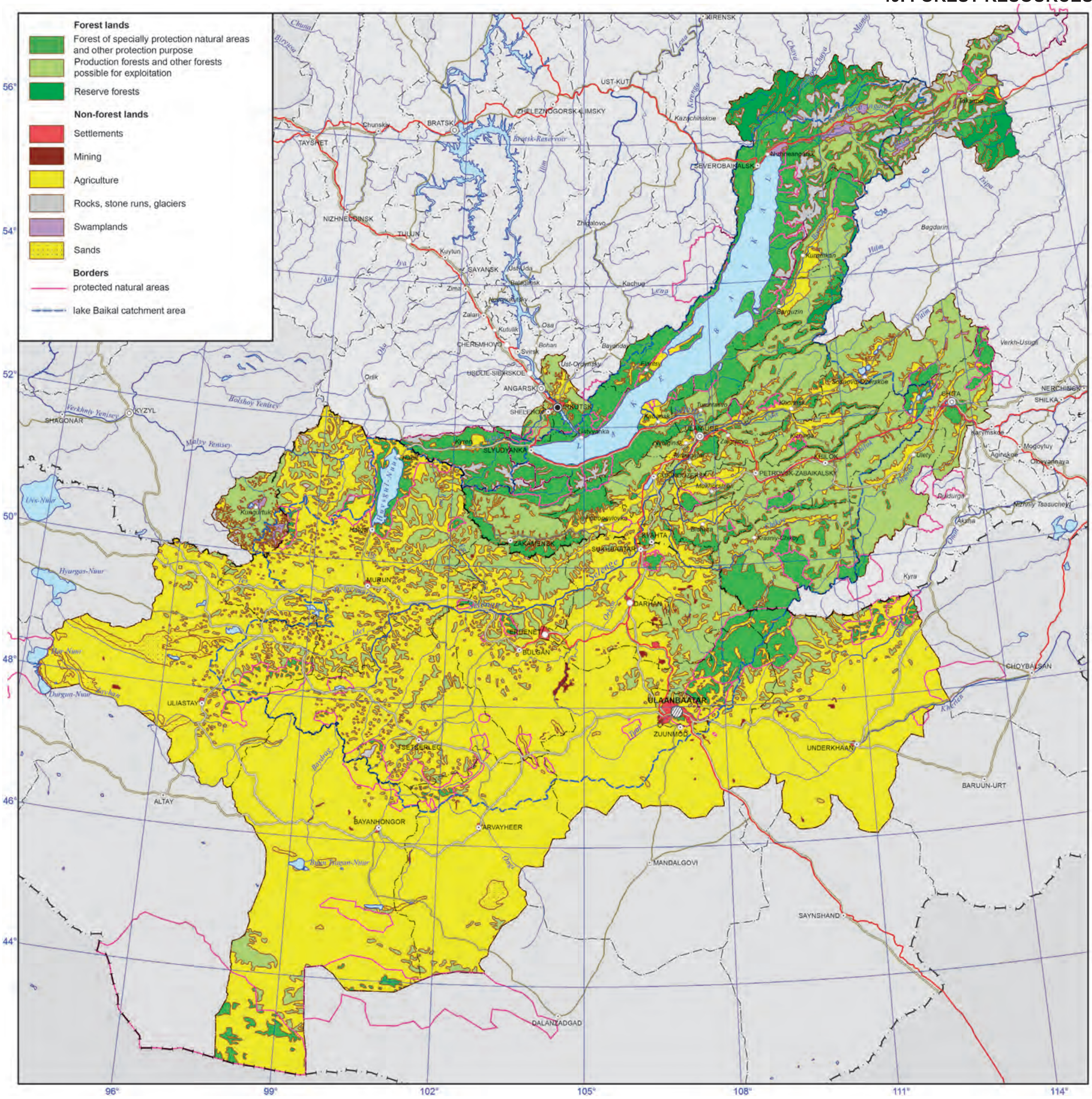
In Mongolia problems of agricultural lands reduction are currently not registered because of their significant amount due to natural factors and historical specific features of agriculture.

FOREST RESOURCES. THE STAND OF THE MAIN GROUPS OF FOREST FORMING SPECIES (49 — 50)

The Baikal basin is a truly enormous treasury of «green gold.» As of January 1, 2011 the forest area is 32103.6 thousand hectares in the Russian part of the basin and 10354.3 thousand hectares in Mongolia. Total timber reserves in the Russian part of the basin are 2,795,800,000 m^3, with a stock of the conifers 2.443.000.000 m^3 (87.4 %). In Mongolia the total timber reserves is 1.373.100.000 m^3.

The basic map shows the forests of nature conservation and other preservation patterns, as well as merchantable and other forests, suitable for commercial use, and reserved forests. It should be said that the division of forest lands into protected, merchantable and reserved is characteristic only of the Russian Federation. However, in the territory of Mongolia forests of special importance and in need of protection are distinguished, such as forest areas up to 100 hectares, forests on the slopes of the mountain areas of more than 30 degrees, etc.

49. FOREST RESOURCES

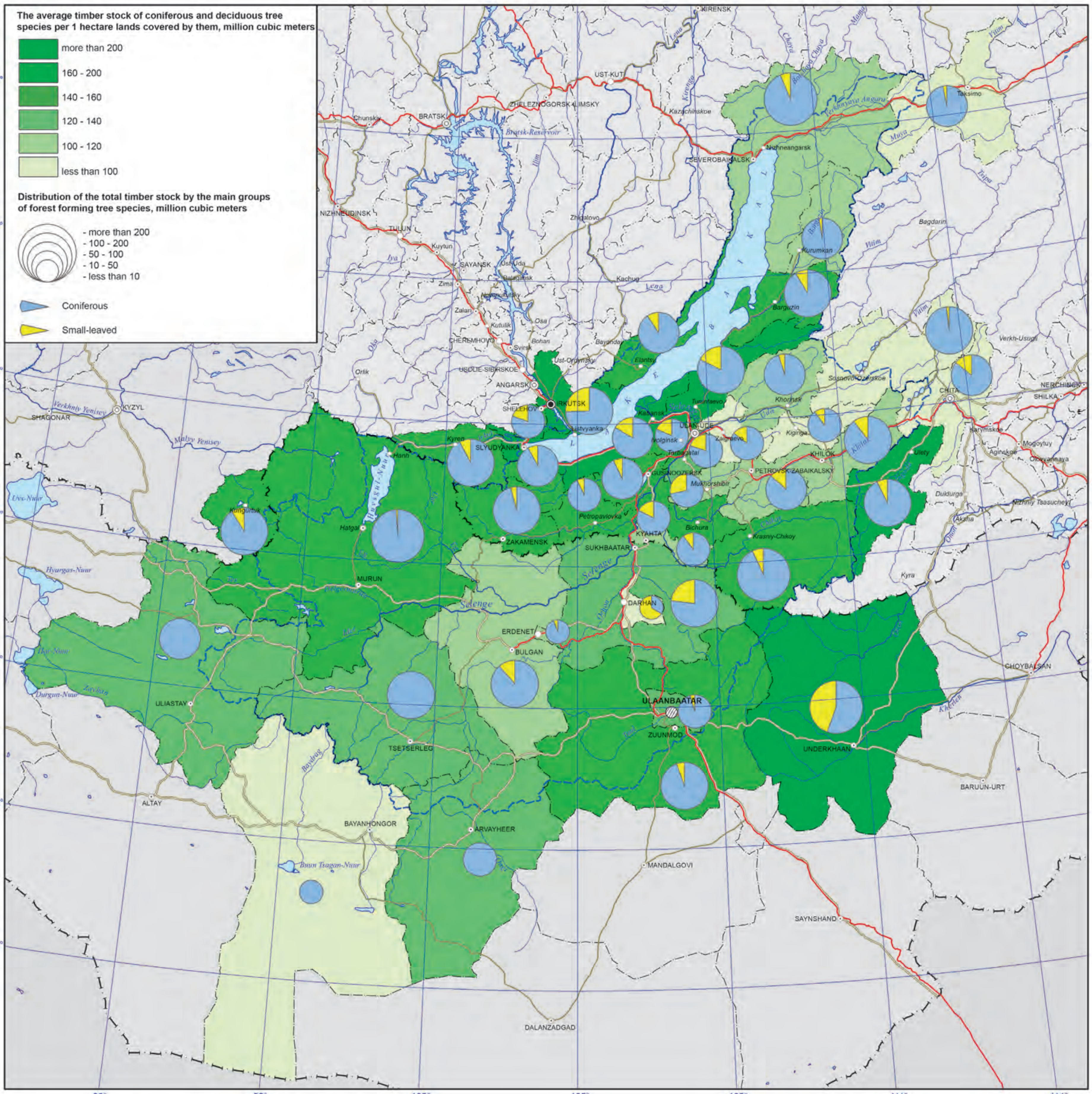


Protected forests in Russia include forests subject to reclamation in order to maintain environmental, water protection, safety, sanitation, health and other useful features while using these forests providing compatibility with their intended purpose. Within the Baikal basin there is a high proportion of protected forests, due their ecosystemic, environment protection and water protection functions, as well as the important ecological role of montane forests. Merchantable forests are those which should be developed for the purposes of sustainable, maximum-efficiency rate production of high quality wood and other forest resources, as well as their conversion products ensuring the preservation of beneficial functions of forests. As far as the reserved forests are concerned, those are the forests not planned for logging for next twenty years. These forests are mostly located in the northern part of the region, in the permafrost zone, off-road area and are unattractive for development.

The insert map «Timber reserves by groups of the major forest forming species» shows the average reserves of softwood and hardwood forests (m^3) per hectare of land covered by them. The average stand of timber per unit of the covered area is one of the indicators characterizing the productivity of forests, depending on growing conditions of stands, their species, and stands sparsity. The average stand of conifers and deciduous trees per hectare in the Russian part of the Baikal basin is 132.5 m^3 (the global average is 100 m^3/ha), and it is fluctuating from 79-82 m^3/ha (mostly in the steppe regions of Zabaikalsky krai, the Republic of Buryatia (Zaigraevsky, Chita districts) to 160 -170 m^3/ha and up in the mid- and north areas (Uletovsky district of Transbaikalia, Kabansky and Severobaikalsky districts of the Republic of Buryatia, Irkutsky and Slyudyansky districts of Irkutsk oblast). Within the Mongolian part

Dark coniferous forest on Olkhinskoye plateau.

50. THE STAND OF THE MAIN GROUPS OF FOREST FORMING SPECIES



of the basin the average reserve of coniferous and deciduous tree stands is 126.6 m³ per one hectare with fluctuations in the aimaks from 81 to 205 m³ per ha. The highest average stand of timber per unit of forest area is characteristic of the northern mountainous areas of Mongolia.

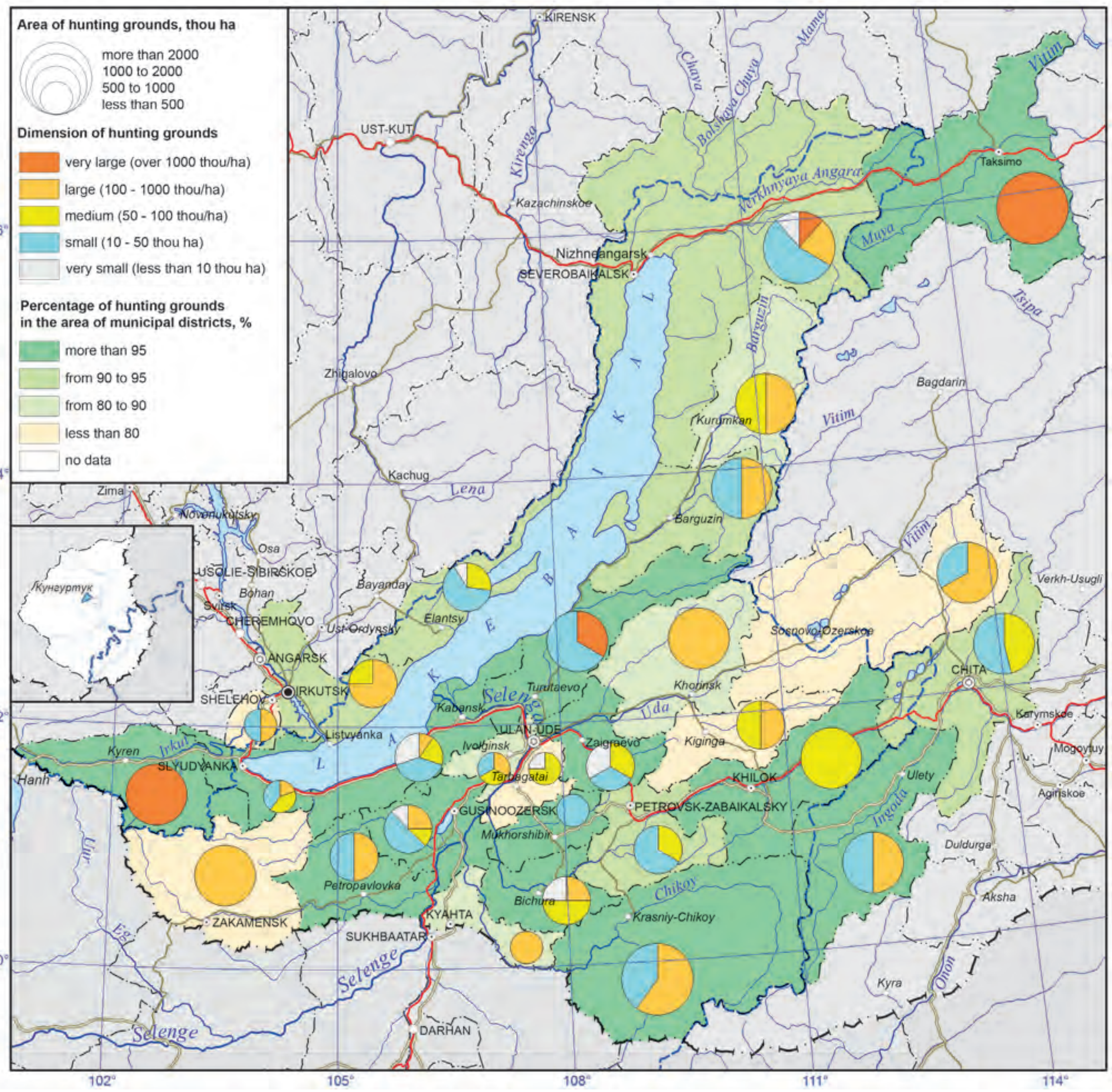
The west coast of the lake Baikal.

Also this map shows the distribution of the total stand of timber by major groups of forest forming species (in million m³) with the method of cartodiagram. This index demonstrates forest-resource security area, which varies significantly in the districts of the Russian part of the basin and Mongolian aimaks (from 1.5 to 481 million m³). For correct depiction of the amount of total stand of timber within municipalities a conventional stepped scale for the circular cartodiagram was worked out, which enables to judge about the stands of timber for each group using the percentage between the major groups of forest forming species (coniferous, deciduous and shrubs).

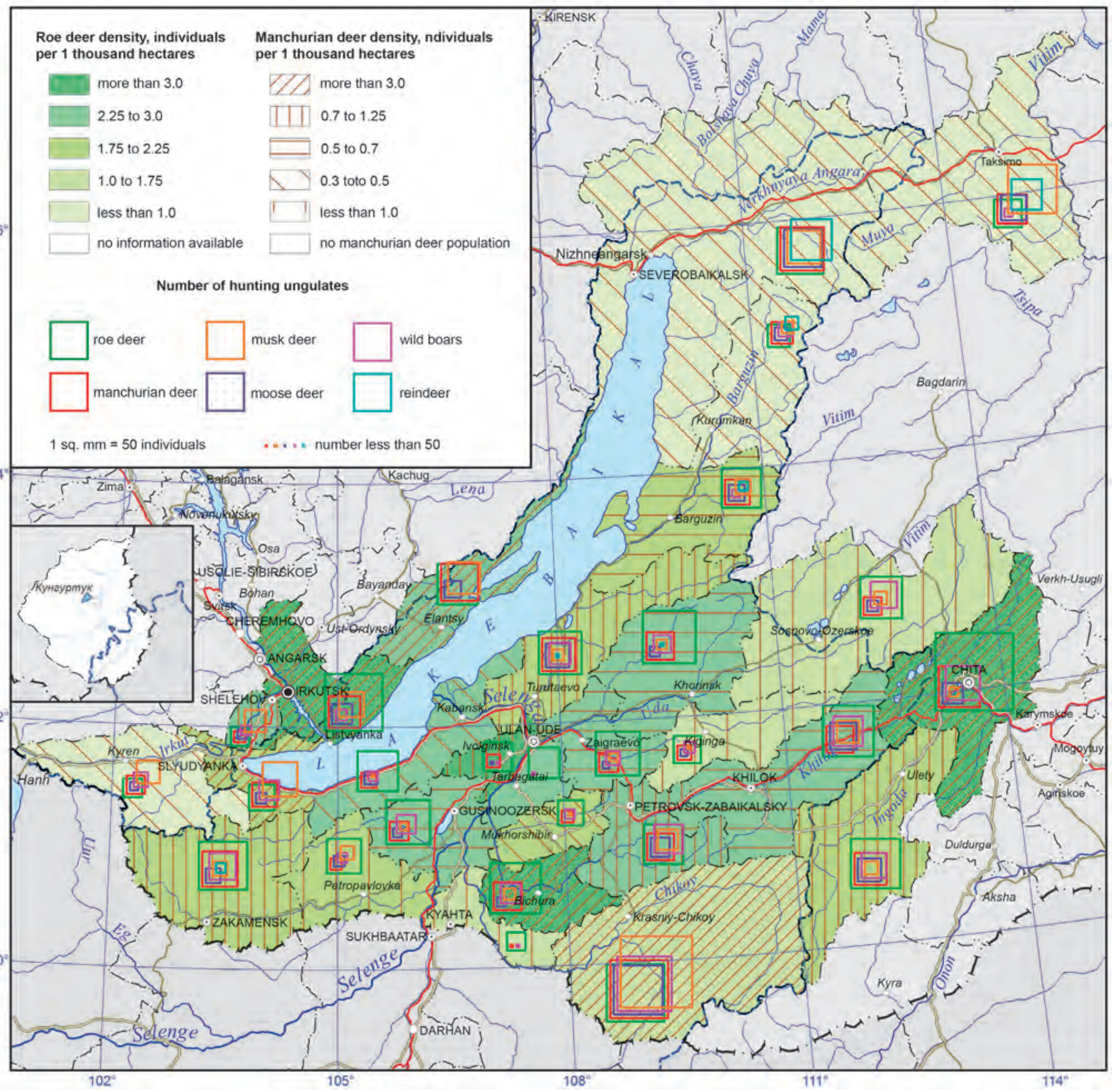
Forest use is determined by the activities that have priority development within the forest vegetation areas. Timber harvesting is most developed among all kinds of forest utilization in the Russian part of the Baikal basin regulated by allowable cutting rates. Forests are actively used for recreation, hunting activities, etc.

In the analysis of forest utilization the following trends for all forests of the Baikal basin are revealed in recent years. They are reduction of coniferous stands, mostly maturing and mature stands; replacement of coniferous species by deciduous ones; widespread illegal logging, reduction of forested area due to fires, forest damage by pests, deforestation, and insufficient reforestation.

51. HUNTING GROUNDS AND FACILITIES



52. THE RESOURCES OF GAME ANIMALS. HOOF



GAME ANIMALS (51-56)

The resource potential of game animals of the Baikal basin has long been characterized by the abundance and high species diversity. This is due to the location of the territory at the intersection of Central-Asian, European-

Fawn. Northern Baikal.

Siberian and East-Asian faunas, where representatives of all of these complexes, including species valuable for hunting, are found. Within the region, there are four typological landscape complexes, corresponding to the zonal and regional landscape subdivisions, namely: mountain-taiga, goletz, forest-steppe, and steppe. Each of them is characterized by a set of habitat types, the quality and quantity of which influence the number of animals.

The wildlife of the mountain taiga is the richest and most diverse; there manifestations of latitudinal zonality in the distribution of vegetation are complicated by the features of altitudinal zonality of its location in the mountains depending on the steepness and exposure of slopes. This creates prerequisites to spread the spectrum of landscape-ecological diversity of the conditions of animal habitats, and possibilities for most of them to choose the most valuable biotopes and, eventually, to increase in the number. In the mountain taiga squirrel, hazel grouse, sable, bear, and in some places musk deer are numerous. Siberian stag and roe deer inhabiting light slopes, forest openings and woodlots, as well as elk, inhabiting waterlogged intermountain depressions, creek valleys and wide plots of terraces in the coastal area of Lake Baikal, are common. Wolf is numerous in some places; wood grouse and fox are common; lynx and wolverine are less common. Unique populations of reindeer and black-capped marmot survived in high-mountain belts of ridges on both sides of Lake Baikal thanks to the good protection.

Nerpa (Baikal seal) occupies a special place, being the only representative of the family of pinnipeds on Lake Baikal. Its largest rookery is located on the Malye Ushkanyi Islands.

The goletz complex is characterized by a significantly lower abundance of game animals. Willow and rock ptarmigan, reindeer and ermine belong to permanent residents. This complex can be roughly considered a complementing link to the mountain-taiga one since so many game animals, especially the ungulates, as well as bear, are connected with the highlands by systematic seasonal migrations.

The forest-steppe and steppe complexes stretch in narrow discontinuous bands in the south of the region. They are represented by the Central-Asian mountain steppes and are not distinguished by the abundance of game animals. Only roe deer in the forest-steppe continues to hold the background position among other species, while tarbagan, once numerous in the steppe, has lost its former significance as a result of plowing of the Transbaikalian steppes and its extermination as a carrier of epizootic plague in the course of antiplague measures. Other species characteristic of the forest-steppe zone, namely, badger and raccoon dog, and of the steppe zone, namely, tolai hare, manul, and dzeren, are small in number. Some of them (dzeren and manul) are protected.

The status of game animals is examined only for the Russian part of the Baikal basin. In connection with the reorganizational measures in the Russian hunting sector over the past two decades, some negative manifestations can be noticed in the usage patterns of species valuable for hunting and in the dynamics of their numbers. A number of problems arose, connected mainly with wild ungulates, especially Siberian stag, roe deer, elk, wild reindeer, and in some places musk deer. Concerning these species an undisputed conclusion was made (as, indeed, for other regions) that "the current dynamics of populations of wild ungulates in Russia is determined mainly by hunters (poachers to a greater extent), large predators, and, locally, snowy winters, and not by a natural cyclicity and changes in the productivity of phytocenoses" [Kozhichev, 2002; Danilkin, 2010].

Among large predators the greatest harm is done by wolves. The wolf problem arose due to the loosening of its control. The damage from this predator to the ungulates (Siberian stag and, especially, roe deer) in different regions of Buryatia reaches 8-30% of the autumn herd [Noskov, 2008]. In recent years, in consequence of the irregular decrease in the number of Siberian stag (poaching and death by predators) in conjunction with the legal shooting in Buryatia a crisis situation with the population of this deer was created [Noskov, 2008]. The damage from wolves only in Transbaikalia in 2011 amounted to11.6 million roubles to agriculture and 70-80 million rubles to hunting [Samoilov, Kayukova, 2013]. Because of the large number of wolves in some areas of Transbaikalia an emergency situation was declared [Samoilov, Kayukova, 2013].

In the current situation, the negative effects are smoothed out to some extent through a network of specially protected natural areas. Thus, in Buryatia, 7-8% of the total number of Siberian stag and roe deer are protected within the territories of 13 nature reserves (zakazniks) and 3 reserved areas (zapovedniks) [Noskov, 2008]. Reindeer is listed in the Red Book of the Republic of Buryatia. Measures to protect the hunting grounds, especially in the areas of concentration of animals, are taken.

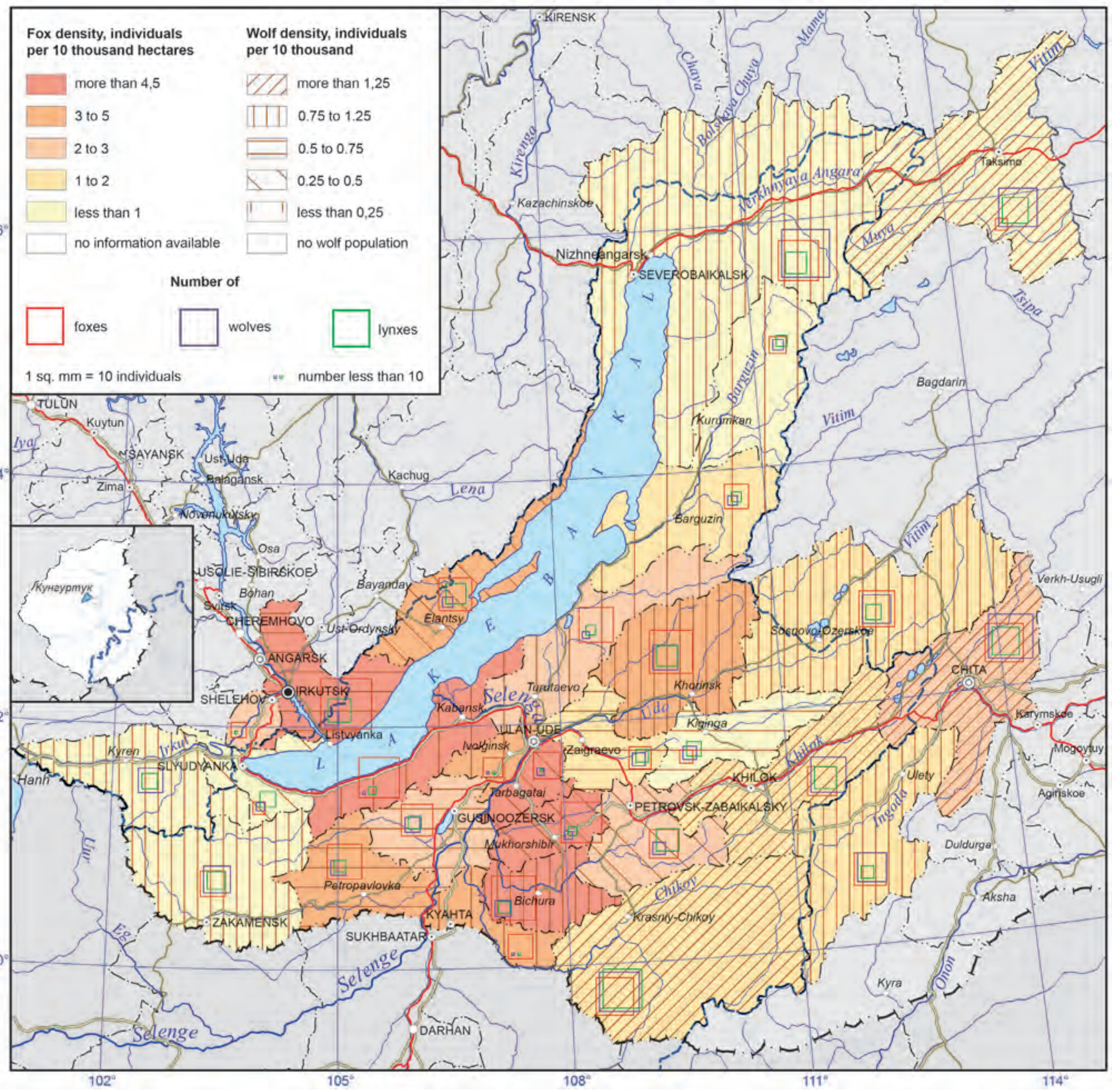
Another situation formed with respect to fur-bearing species of hunting. This is due to the fall in world prices for raw fur. Eighteen million pelts of caged mink from China were mass-marketed [Romanov, 2008]. Because of low prices for Chinese mink, squirrel or muskrat fur coats turned out to be more expensive. As a result, squirrel and muskrat are in little demand on the market. The same situation takes place with other species, namely: fox, Siberian weasel, and ermine. Rare lynx and wolverine pelts are used mainly on the domestic market.

A diametrically opposite situation is with sable enabling Russia to achieve a dominant position in the world market as an exclusive supplier of sable fur. Demand and prices for sable pelts have increased. The price for a sable at an auction averages 220-250 dollars. As opposed to the past years, sable is not endangered as there are less professional hunters. Besides, remote hunting lands are not utilized. They have become a kind of sable reserves, where sables multiply and settle throughout the taiga.

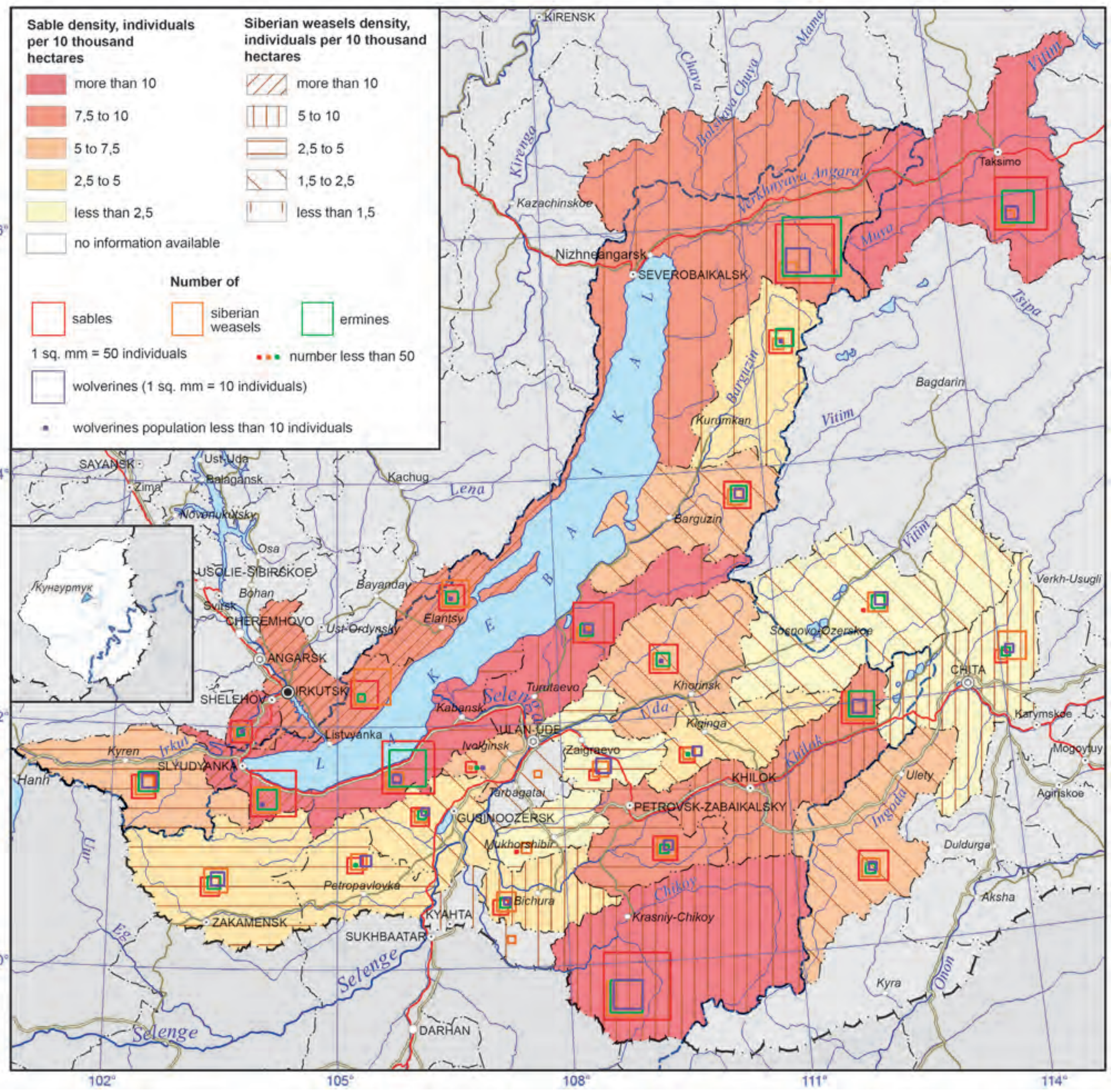
The analysis of the status of hunting fauna in the Baikal basin revealed a number of trends in the features of its use, also characteristic of other regions of the country, in particular, the problem of protecting ungulates. A positive phenomenon is a continued status of sable as the leader in the world fur market, and a removal of the danger of its extermination due to changes in socio-economic conditions, which is important in contrast with previous years.

At the same time, unlike the majority of Siberian regions where a trend of rapid increase in the area of publicly available lands accelerated, in the region under consideration this phenomenon is minimized. This is indicative of targeted optimization of the utilization of game animals resources on the basis of improving forms of hunting management and prospects of its development in the region. Thus, the calculations [Dambiev et al., 2011] made it possible to estimate the socio-economic significance of hunting nature management in the Republic of Buryatia in 2010 as amounting to 1.1 billion roubles. Among them natural products of hunting (furs, meat, etc.) are estimated at 150 million roubles, while the social impact of tourism associated with hunting reaches 450 million roubles. The remaining portion is accounted for by other socio-economic relevance. Therefore, the current state of game fauna in the study region is characterized as conditionally stable. As a result of satisfactory organization of protection of game animals in the region, their number corresponds to a primitive stage of market hunting management.

53. THE RESOURCES OF GAME ANIMALS. CANINE AND FELINE



54. THE RESOURCES OF GAME ANIMALS. MUSTELIDS



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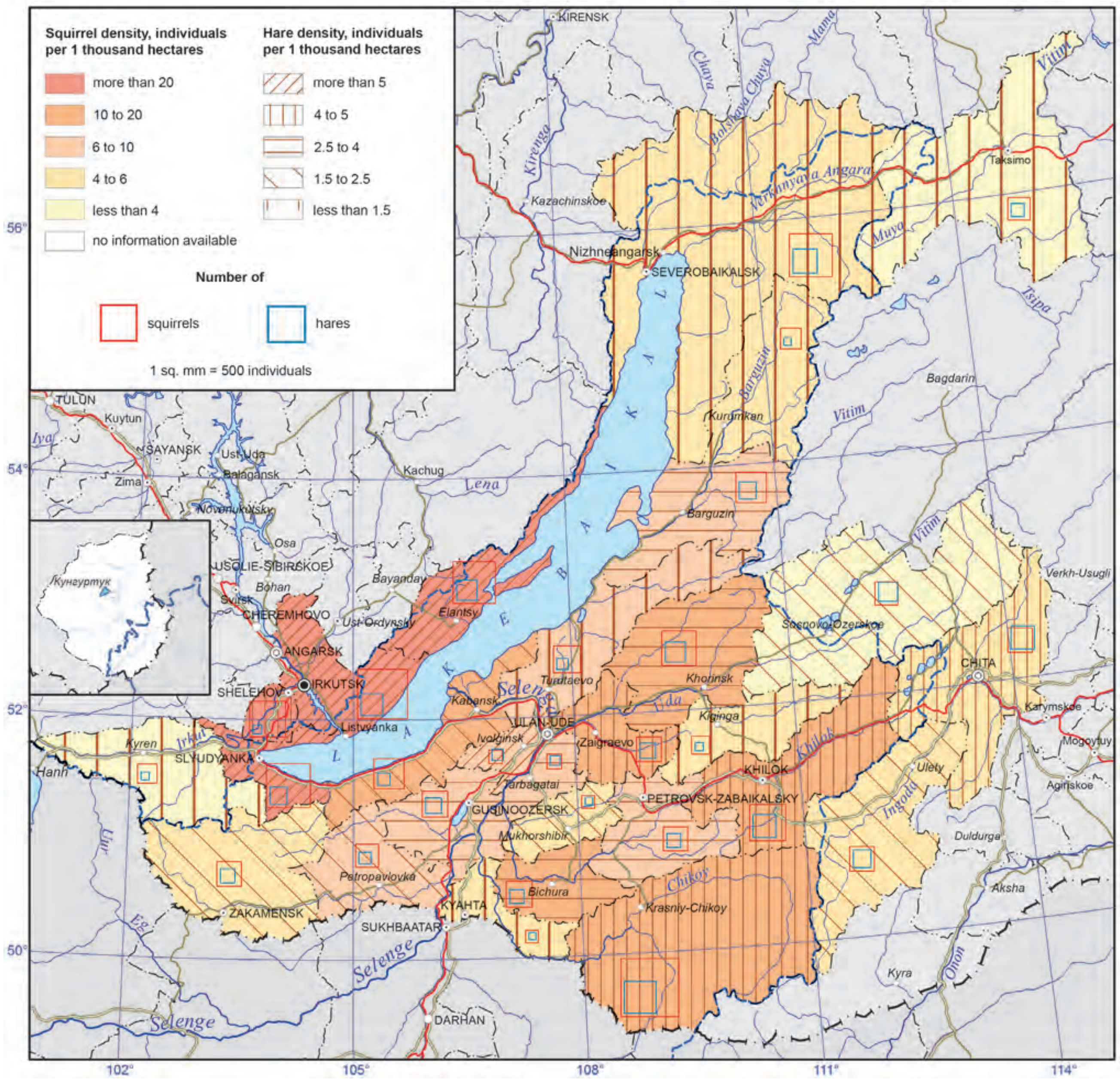
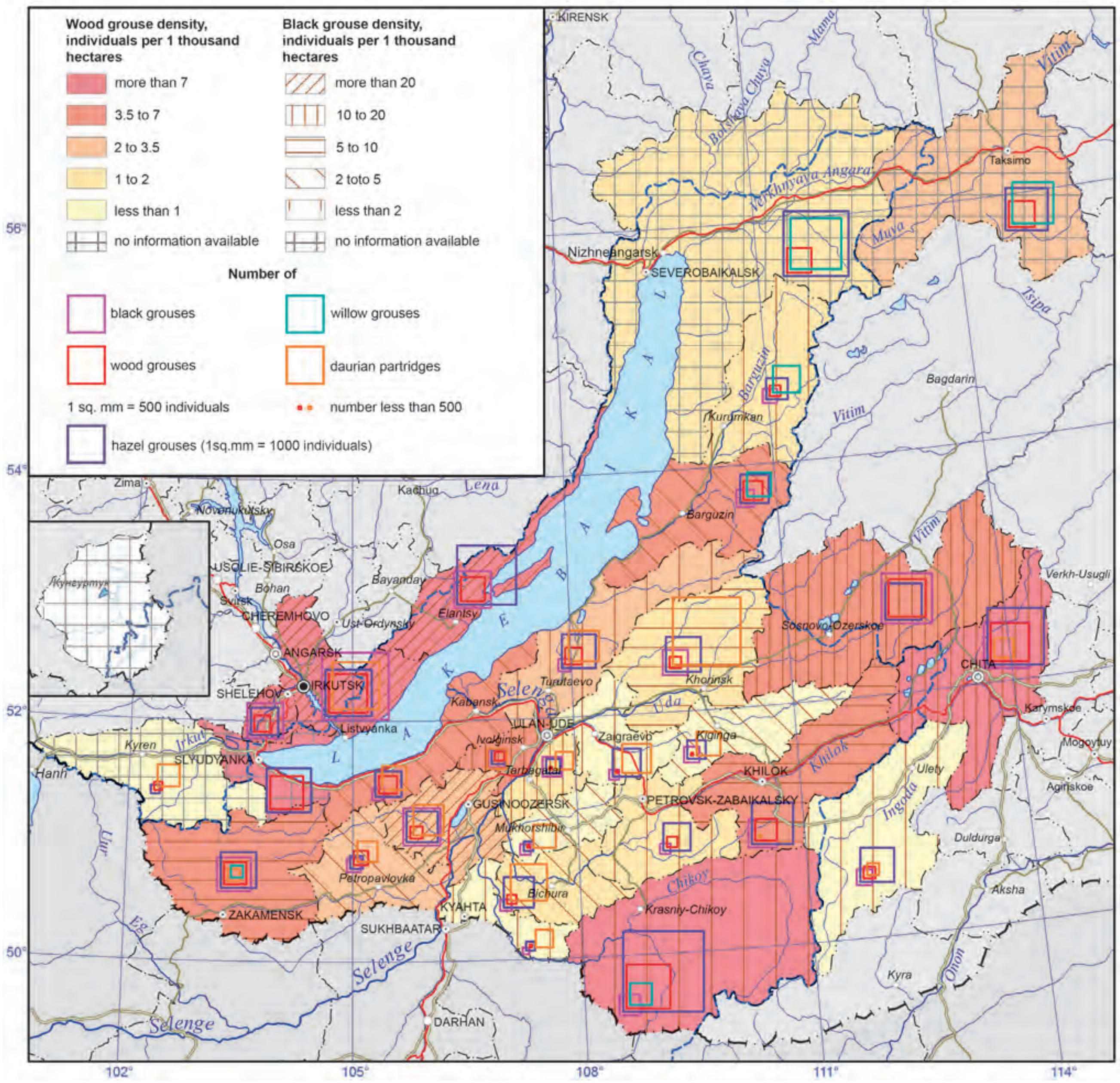
55. THE RESOURCES OF GAME ANIMALS. SQUIRREL AND HARE



56. THE RESOURCES OF GAME ANIMALS. UPLAND GAME



ENVIRONMENT RESOURCES: ECOLOGICAL RESOURCES OF LANDSCAPES IN THE BAIKAL BASIN (57 – 60)

This package contains small-scale overview maps with the most common patterns of ecological resources of landscapes in the Baikal basin. The definition "ecological resource", which is identical to the definition "ecological potential", means the ability of landscapes to provide people with all necessary conditions for existence, i.e. to create specific local environment.

The structure of the map package was developed as applicable to the solution of practical problems of information support of regional programmes on rational use and protection of natural landscapes. The information base of the package consists of literature sources [Geosystems …, 1991; Isachenko, 1990; Mikheev, 1987, 1988; Polikarpov et al., 1980; Sochava, 2005], cartographic material [Atlas …, 2004; National Atlas …, 1990; Correlation …, 1977; Landscapes …, 1977; Eco-geographic …, 1996] and Internet resources.

LANDSCAPE-ECOLOGICAL COMPLEXES (57)

This map is a mosaic of 16 structural landscape subdivisions belonging to 2 subcontinents (Northern and Central Asia) and 3 types of natural conditions (arctic-boreal, semiarid and arid) [Geosystems …, 1991].

Typological classification of landscapes (goletz, subgoletz, upper taiga, taiga, subtaiga and steppe) reflects altitude-zonal differentiation of environmental conditions, as well as depression and piedmont effects of their manifestation. Regional range of landscapes classification (Baikal-Dzhugdzhurskiye, South-Siberian, Central Asian, Khangaisko-Daurskiye, Srednekhalkhasko-Mongolian) includes sector differentiation of environmental conditions formed under the influence of prevailing air masses of different direction (mainly western and eastern transfer), as well as interpenetration and uniqueness of natural phenomena in the basin of Lake Baikal.

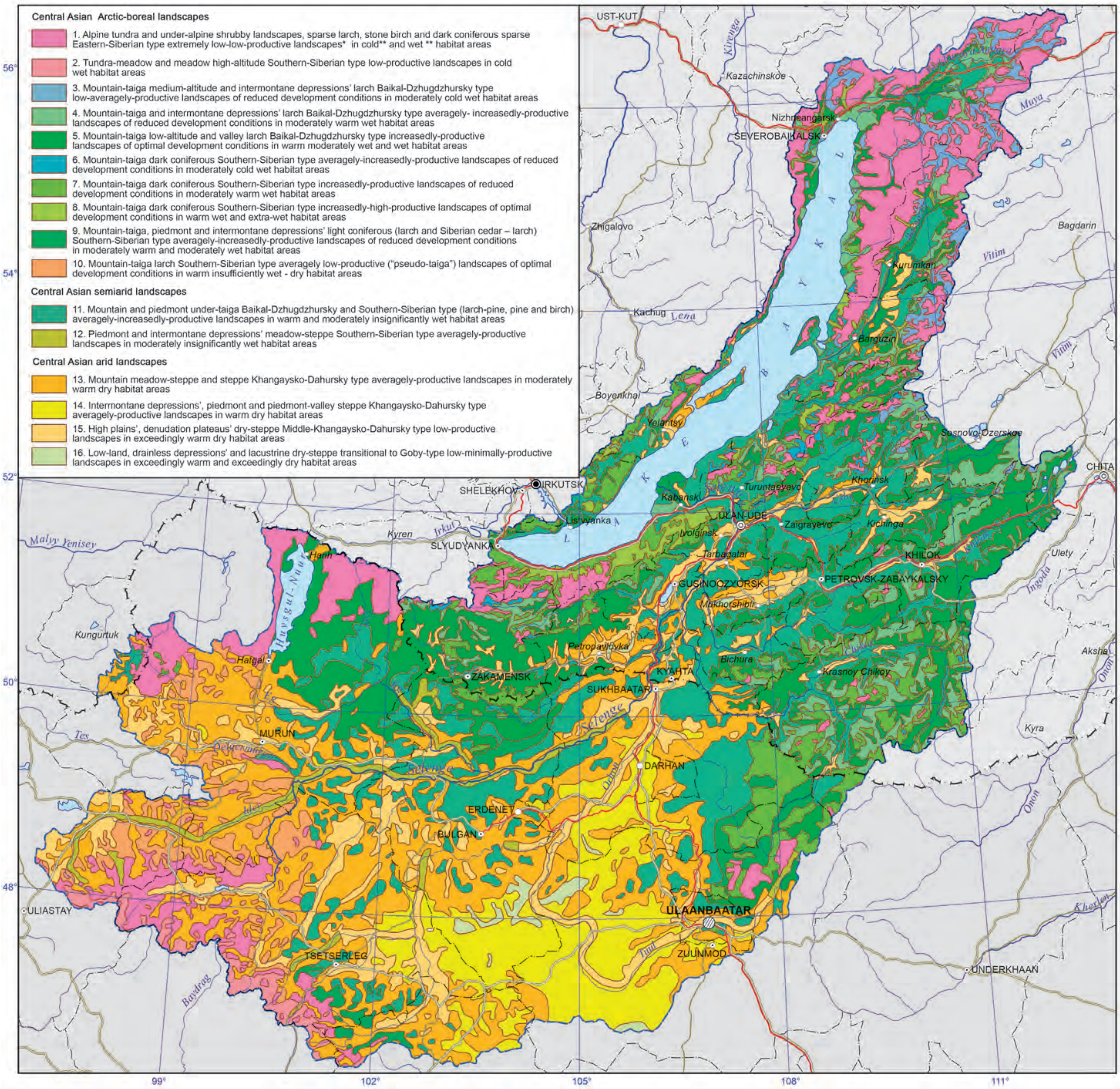
According to the material and energy exchange, the North-Asian goletz, taiga and subtaiga landscapes are subdivided into subgroups of natural conditions: extreme, reduced, limited and optimal development. South-Siberian and Central Asian steppe landscapes are subdivided into arid, dry and very dry landscapes depending on moisture supply of these landscapes.

The legend of the map also presents numerical values of integral intensity of landscape functioning (heat and moisture supply of landscapes and plant biological productivity) [Eco-geographic …, 1996]:

- heat supply (total mean daily temperatures over 10ºC): cold (600-800ºC), moderately cold (800-1200 ºC), moderately warm (1200-1600 ºC) and warm (1600-2000 ºC);
- moisture supply (radiation dryness index according to M. Budyko): perhumid (less than 0.5), humid (0.5-0.9), subhumid (1.0-1.4), insufficiently humid (1.5-1.9), dry (2.0-2.4), and very dry (over 2.5);
- plant biological productivity (annual growth of plants at appropriate values of heat and moisture expressed in dry mass of organic matter of terrestrial and underground parts of plants): very low (less than 20 metric centners/ha), low (20-40 metric centners/ha), mean (40-60 metric centners/ha), elevated (60-80 metric centners/ha), and high (over 80 metric centners/ha).

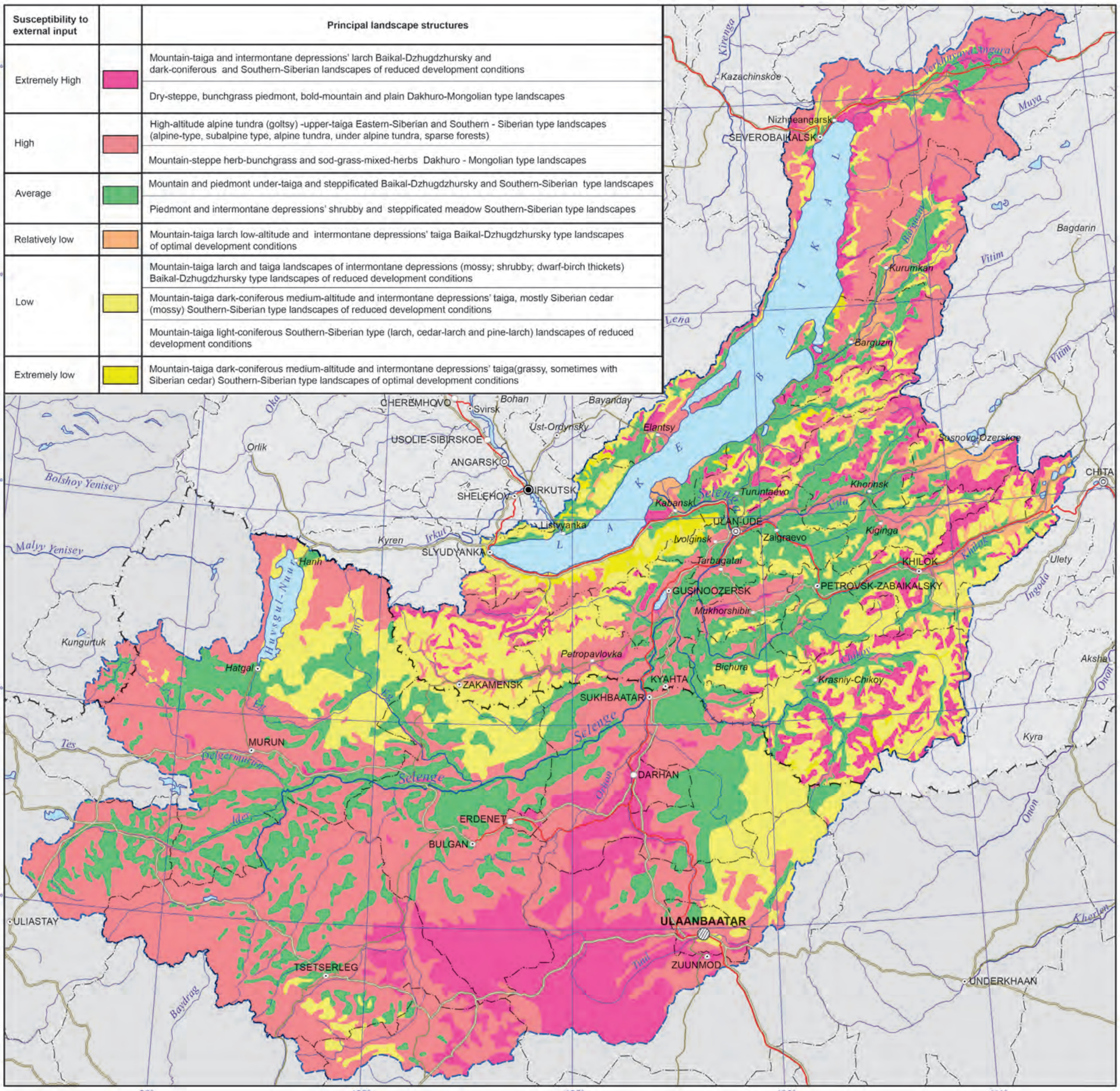
This map is used as an interpretation basis for the development of derived assessment and recommendation maps of the environment.

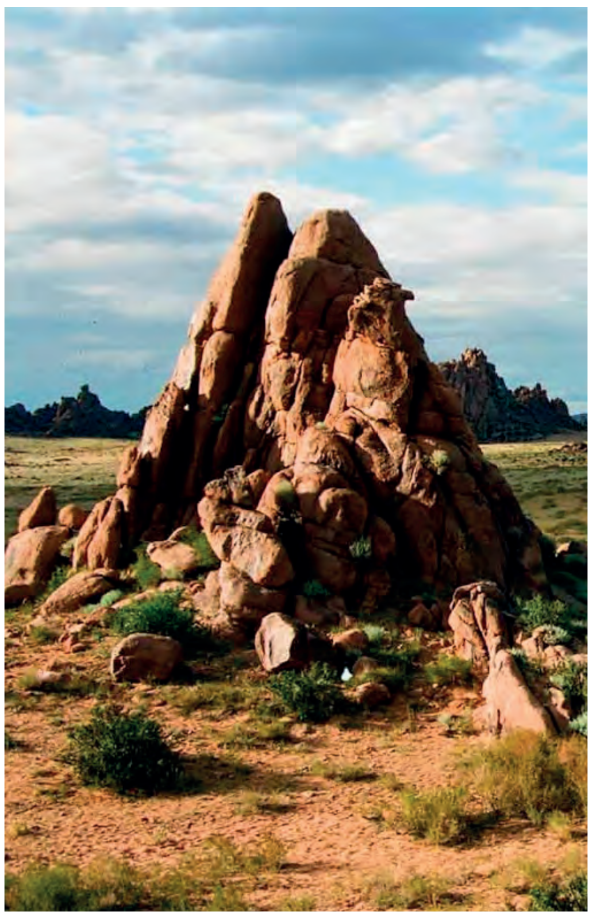
57. LANDSCAPE-ECOLOGICAL COMPLEXES



Northern coast of Lake Hovsgol.

58. LANDSCAPE SENSITIVITY TO EXTERNAL EFFECTS





The semi-desert areas in Mongolia.

LANDSCAPE SENSITIVITY TO EXTERNAL EFFECTS (58)

The map of landscape sensitivity characterizes common respond of landscapes to external effects including the anthropogenic impact. Landscape sensitivity is defined by "self-regulation" [Sochava, 2005] – an ability to retain the structure of landscapes within the certain boundaries for a certain period of time.

Landscape sensitivity in the Baikal basin is strongly interdependent on landscape types. "Integral intensity of functioning … and productivity of landscapes" [Isachenko, 1990] are indicators of sensitivity. Sensitivity correlates with heat and moisture supply of landscapes "according to the optimality principle", as well as with plant biological productivity "according to the maximum principle: the more the better" [Sochava, 2005].

Sensitivity increases as the deviation of heat and moisture ratio from the ecological optimum rises. Landscapes with optimal combinations of heat and moisture supply and with high biological productivity are less sensitive to anthropogenic pressure. The most sensitive landscapes are with low and very low biological productivity, which develop under extreme conditions.

The sensitivity in the map legend is characterised by relative estimating categories such as "very high", "high", "moderate", "low", and "very low".

ECOLOGICAL LANDSCAPE POTENTIAL (ELP) (59)

The map characterises the ability of landscapes to create specific local human environment. It was compiled on the basis of ecological interpretation of landscape characteristics and consequent zoning of the Baikal basin taking into account comfort level of landscapes for human activity.

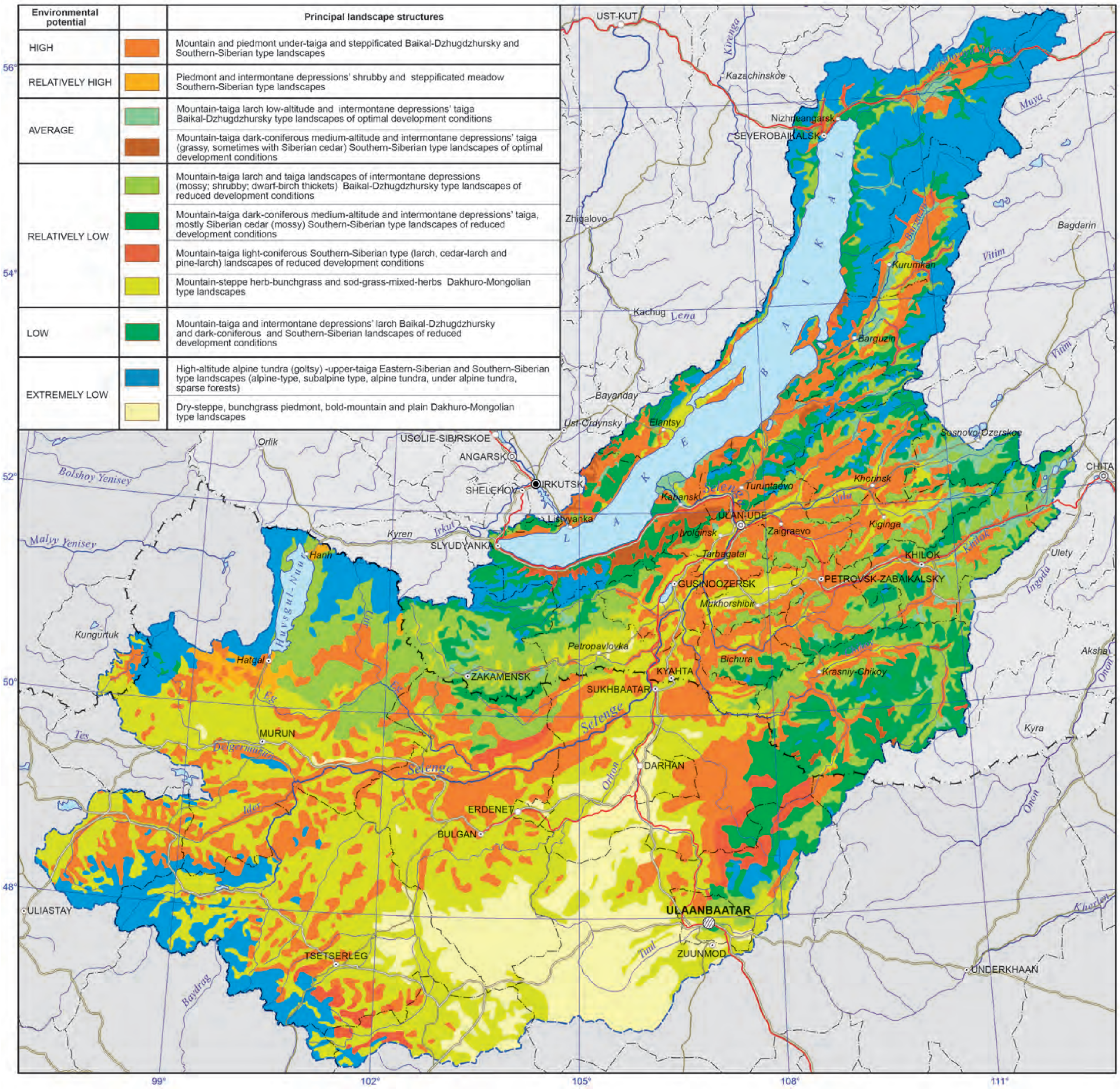
The ratio of heat and moisture supply of landscapes, as well as productivity of their plant (low, moderate, elevated, and high), was used to indicate ecological comfort of landscapes (lack of heat, excess of moisture, etc.).

Relative estimating categories (very low, low, moderate, high, and very high) are used for ELP characterisation. In the map legend, they are correlated with factors of integral functioning intensity.

ECOLOGICAL FUNCTIONS OF LANDSCAPES (60)

This map represents the groups of landscapes with similar nature protecting (ecological) functions [Polikarpov et al., 1980, p. 184-194]. They are divided into groups depending on these functions: environment-forming function of geospheric and regional significance, environment-regulating, environment-stabilising, and environment-protective.

59. ECOLOGICAL LANDSCAPE POTENTIAL



The landscapes of goletz, tundra and sparse wood perform the main environment-forming "water-production" function. Of special significance is their snow and water collecting function. These landscapes experience large hydrological loads as they transform the water and transfer it to the subsurface flow. To date, the production of pure water is the most important ecological function as pure water is becoming the most valuable product on the planet. The significance of these landscapes increases due to the protection of depth and purity of Lake Baikal waters.

The environment-stabilizing function is characteristic of all mountain-taiga (moss) landscapes of reduced and limited development – from mountain-taiga shrub-moss dark coniferous and larch communities to shrub and moss-shrub dark coniferous and larch-taiga landscapes in the intermountain depression and valleys with yernik and mixed undergrowth. Their moss cover provides certain ecological conditions. These landscapes are more stable and after external pressure they, as a rule, recover fast. Together with goletz and upper-taiga landscapes, they determine the fundamental set of mechanisms of internal and external interactions of landscapes.

South Siberian and Central Asian (Daurian-Mongolian) steppe landscapes are referred to the group with environment-regulating functions. On the whole, they are characterized by insufficient wetness [Geosystems …, 1991; Eco-geographic …, 1996]. Their role in the flow regulation is rather small. However, under conditions of intense water evaporation they have a very important regulating significance: plant components of these landscapes support the existing ecological balance whose changes can cause the disturbance of the moisture regime and, as a result, the landscape structure. This function specifically intensifies under the conditions of anthropogenic pressure. As a result, all steppe landscapes share high soil-protective significance as they fulfil a technogenic barrier function.

"Herb" landscapes perform environment-protective function: mountain-taiga larch landscapes of optimal development, piedmont and larch-taiga landscapes of optimal development in intermountain depressions, piedmont sub-taiga larch, mountain-taiga pinewood, piedmont sub-taiga pinewood landscapes. Insufficient moistening is characteristic of these landscapes, and changes of their vegetative component can cause changes in hydrological regime towards aridity and, as a result, disruption of landscape structure. Their water and soil-protective role increases. They are characterised by high concentration of different economic activity. Therefore, these landscapes are of technogenic barrier significance.

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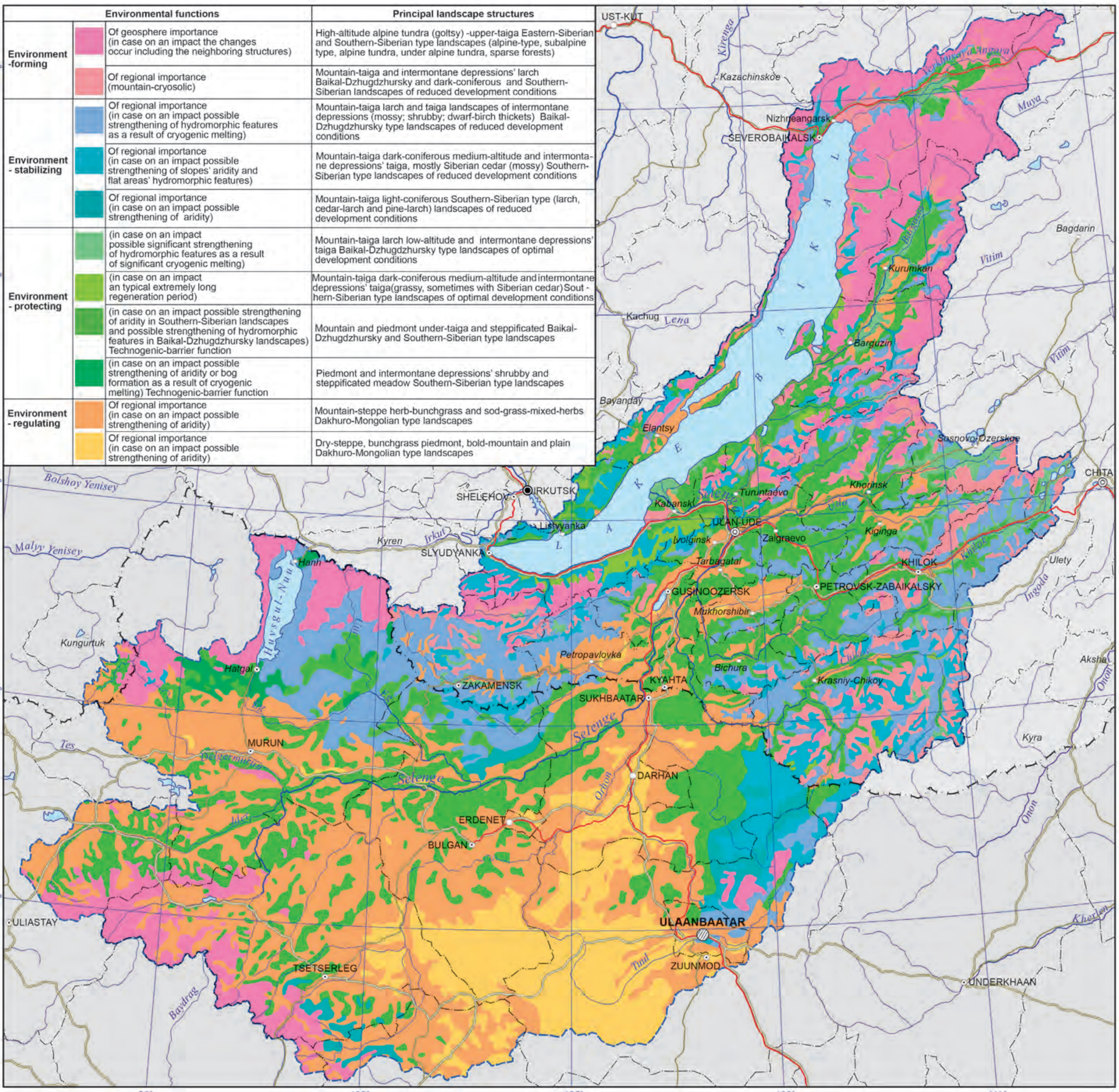
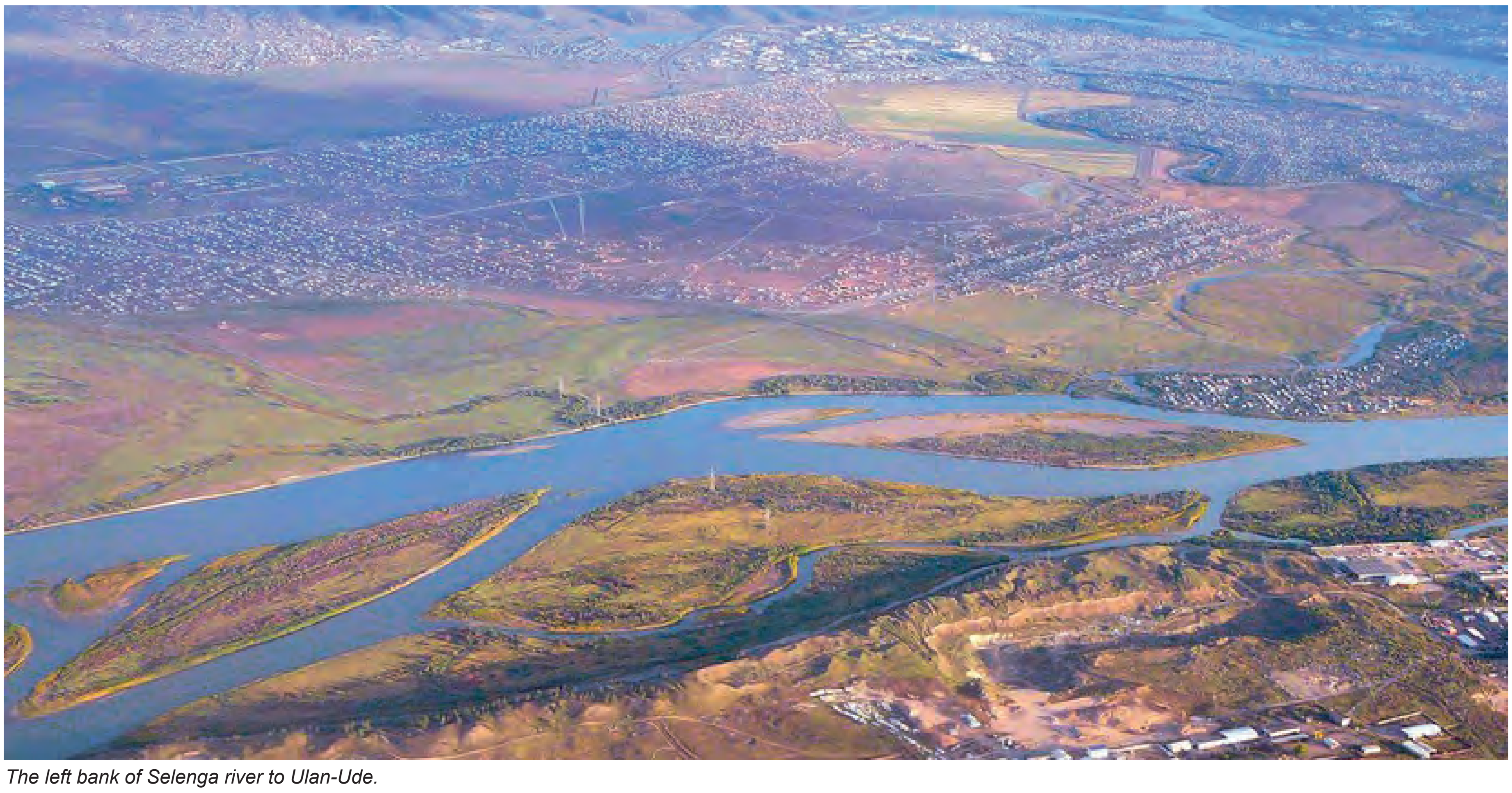
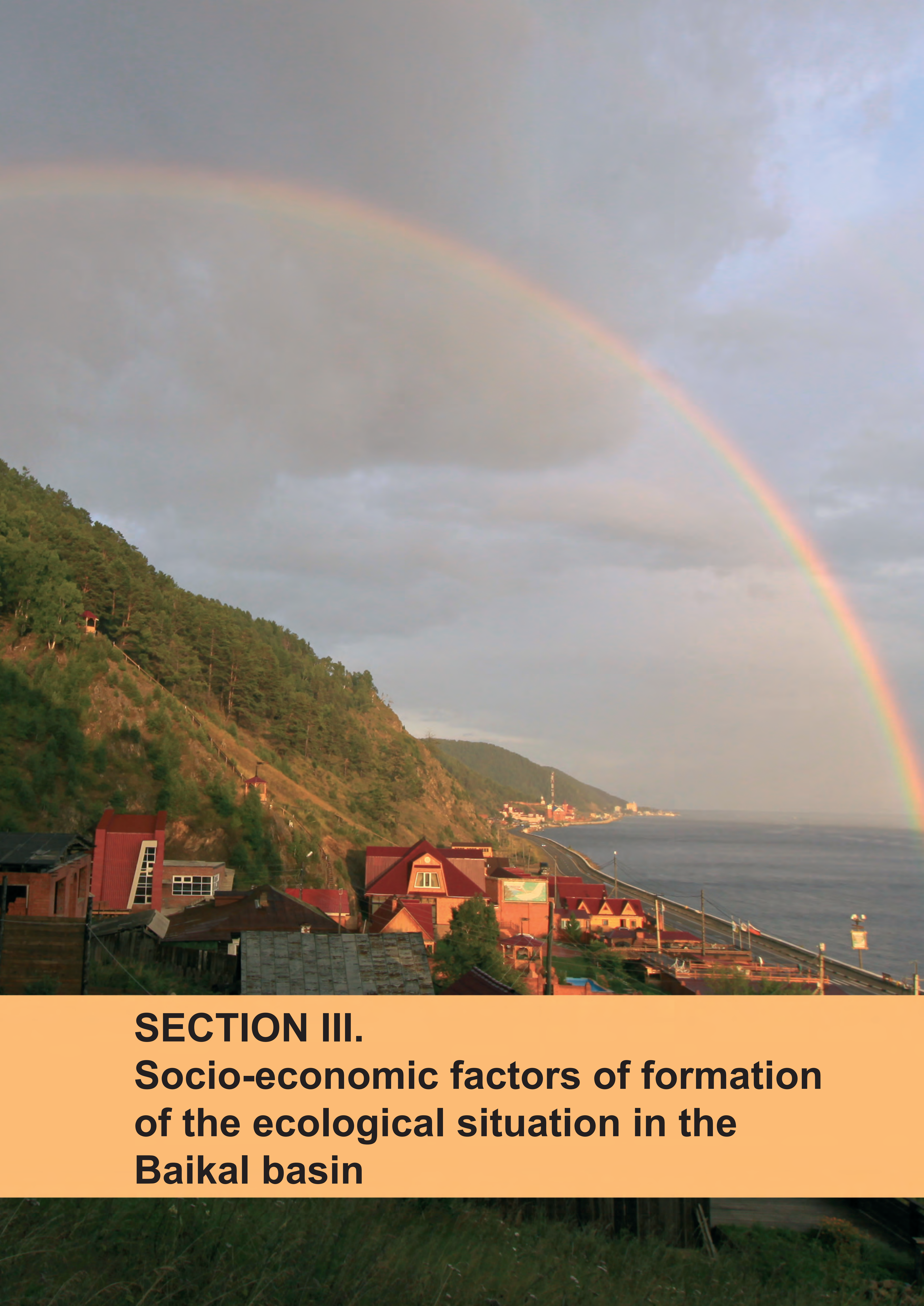
60. ECOLOGICAL FUNCTIONS OF LANDSCAPES



Environmental functions			Principal landscape structures
Environment -forming	(pink)	Of geosphere importance (in case on an impact the changes occur including the neighboring structures)	High-altitude alpine tundra (goltsy) -upper-taiga Eastern-Siberian and Southern-Siberian type landscapes (alpine-type, subalpine type, alpine tundra, under alpine tundra, sparse forests)
	(light red)	Of regional importance (mountain-cryosolic)	Mountain-taiga and intermontane depressions' larch Baikal-Dzhugdzhursky and dark-coniferous and Southern-Siberian landscapes of reduced development conditions
Environment - stabilizing	(light blue)	Of regional importance (in case on an impact possible strengthening of hydromorphic features as a result of cryogenic melting)	Mountain-taiga larch and taiga landscapes of intermontane depressions (mossy; shrubby; dwarf-birch thickets) Baikal-Dzhugdzhursky type landscapes of reduced development conditions
	(cyan)	Of regional importance (in case on an impact possible strengthening of slopes' aridity and flat areas' hydromorphic features)	Mountain-taiga dark-coniferous medium-altitude and intermontane depressions' taiga, mostly Siberian cedar (mossy) Southern-Siberian type landscapes of reduced development conditions
	(teal)	Of regional importance (in case on an impact possible strengthening of aridity)	Mountain-taiga light-coniferous Southern-Siberian type (larch, cedar-larch and pine-larch) landscapes of reduced development conditions
Environment - protecting	(light green)	(in case on an impact possible significant strengthening of hydromorphic features as a result of significant cryogenic melting)	Mountain-taiga larch low-altitude and intermontane depressions' taiga Baikal-Dzhugdzhursky type landscapes of optimal development conditions
	(yellow-green)	(in case on an impact an typical extremely long regeneration period)	Mountain-taiga dark-coniferous medium-altitude and intermontane depressions' taiga(grassy, sometimes with Siberian cedar) Southern-Siberian type landscapes of optimal development conditions
	(green)	(in case on an impact possible strengthening of aridity in Southern-Siberian landscapes and possible strengthening of hydromorphic features in Baikal-Dzhugdzhursky landscapes) Technogenic-barrier function	Mountain and piedmont under-taiga and steppificated Baikal-Dzhugdzhursky and Southern-Siberian type landscapes
	(dark green)	(in case on an impact possible strengthening of aridity or bog formation as a result of cryogenic melting) Technogenic-barrier function	Piedmont and intermontane depressions' shrubby and steppificated meadow Southern-Siberian type landscapes
Environment - regulating	(orange)	Of regional importance (in case on an impact possible strengthening of aridity)	Mountain-steppe herb-bunchgrass and sod-grass-mixed-herbs Dakhuro-Mongolian type landscapes
	(yellow)	Of regional importance (in case on an impact possible strengthening of aridity)	Dry-steppe, bunchgrass piedmont, bold-mountain and plain Dakhuro-Mongolian type landscapes

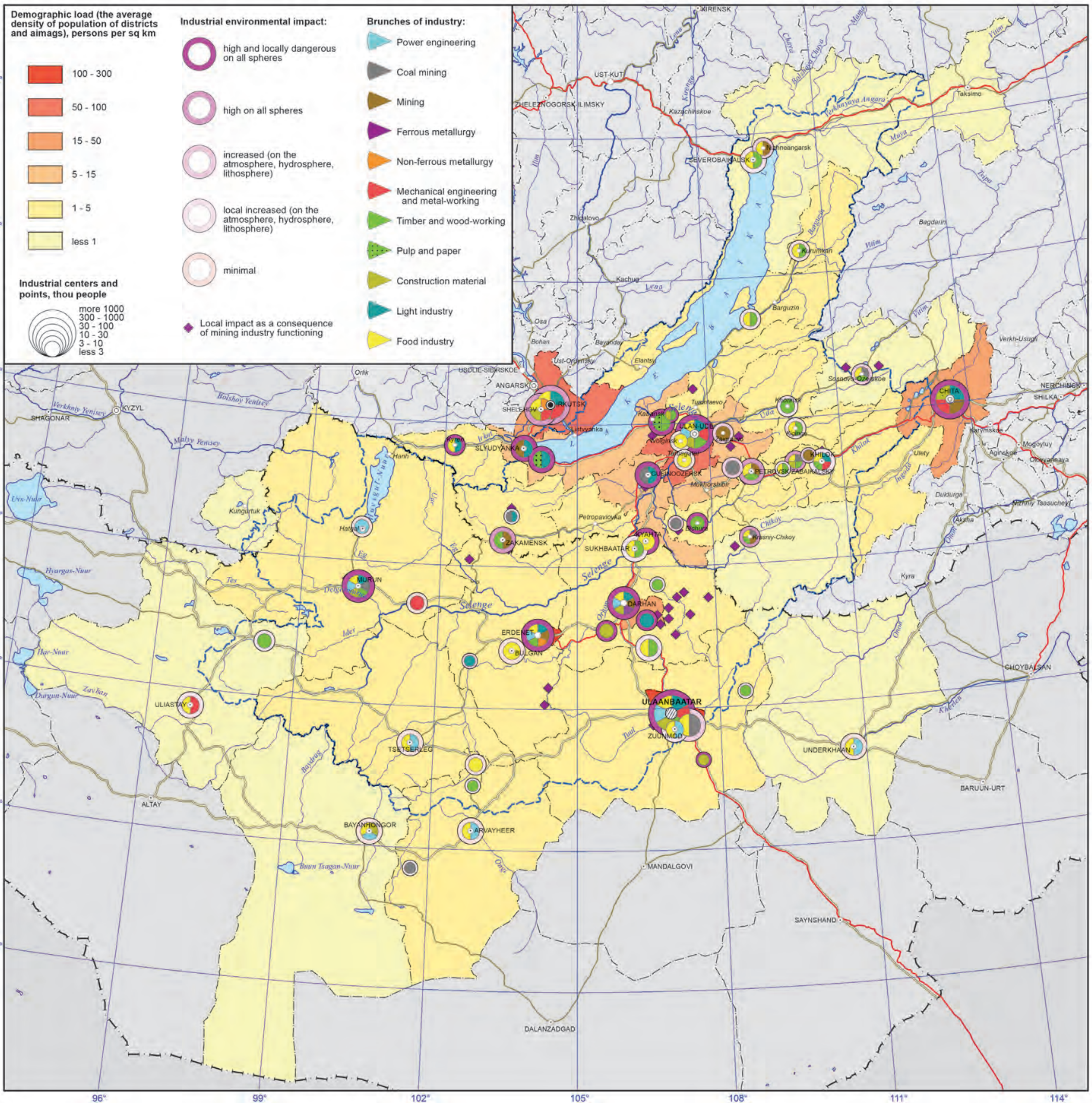


The left bank of Selenga river to Ulan-Ude.



SECTION III. Socio-economic factors of formation of the ecological situation in the Baikal basin

61. INDUSTRY AND ITS IMPACT ON THE ENVIRONMENT



INDUSTRY AND ITS IMPACT ON THE ENVIRONMENT (61)

Today, economic activity significantly influences the environment, and the main impact factor is the industry. The higher the concentration of industrial facilities, the more extensive the area of environmental changes is. This can be seenin the Baikal basin. Any change in one of the areas of the environment is reflected in the other (lithosphere disturbances indirectly affect the surface water and groundwater regimes, predetermining the dust and gas pollution, etc.).

The map "Industry and its impact on the environment" presents the results of the research of the industrial impact on the environment in the Baikal basin. The object of the map is an industrial center, as it is one of the most common forms of the territorial organization of industrial production representing a local group of companies (within the boundaries of a settlement).

The map depicts industrial centers with symbols. The symbol's size shows the total population, the inner sectors – industry branches, circled sectors – the dominant impact on the environmental components. The areas disturbed by the mining industry (open-pits, waste heaps, dumps, etc.) and emissions (for large settlements) are shown separately. The areas with a maximum impact on the environment are identifiedbased on the analysis of the industry's impact on different environments.

The research results make it possible to draw the following conclusions.

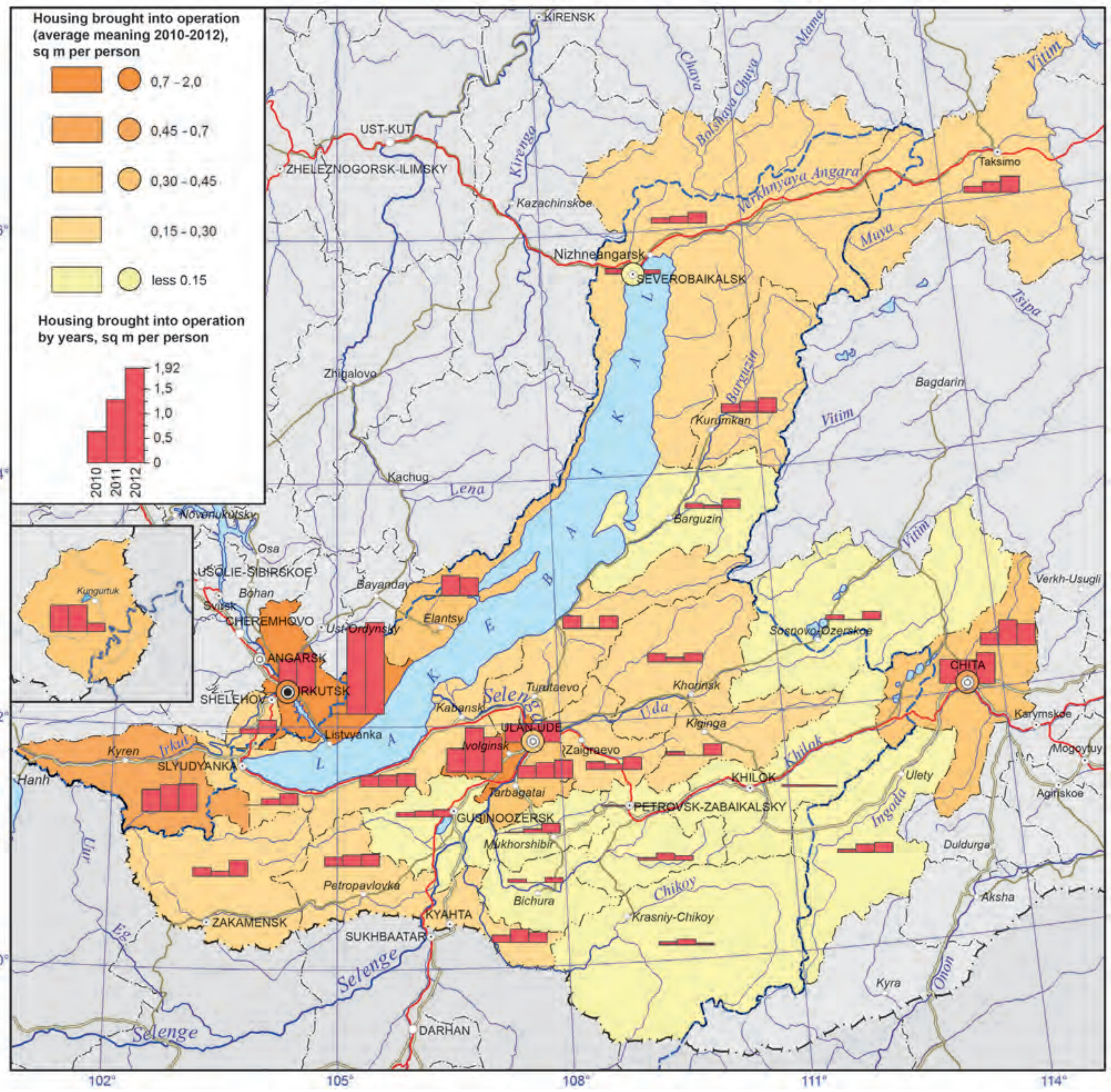
The maximum industry impact on the environment is registered in the Republic of Buryatia. The impact on the environment is observed in all its settlements. The areas of the maximum negative impact on all environments are the Zakamensky, Kyakhtinsky, Gusinoozersky, Nizhne-Selenginsky and Ulan-Ude industrial hubs.

Major industries have negative impacts, e.g. the fuel and energy, mining, pulp and paper, and food industries. The main pollutants are the Ulan-Ude Central Heating Power Plant (CHPP)-1, Aviation Plant, Locomotive Repair Plant, glass factory, Selenginsky Pulp and Cardboard Mill, as well as light and food industries. Large and medium-sized waste dumps of consumer and industrial waste also significantly damage the environment [Impact...].

In Zabaikalsky krai,there is a local impact on the environment by the electrical energy, mining, and food industries. The largest area of a negative impact on the environment is the Chita industrial hub, where the main polluters are fuel-and-energy companies (the Chita Thermal Power Plant (TPP)-1 and TPP -2), mechanical engineering and metalworking plants, and transportation.

Industrial development in the part of Irkutsk oblast included into the Baikal basin is rather weak with the exception of the towns of Baikalsk and Slyudyanka. Here, the main polluters are mining (marble mining), transportation, and energy companies. In Baikalsk, the main source of pollution – the Baikalsk Pulp and Paper Mill – is currently closed, but the consequences of its activities in the form of pollution of the adjacent portion of the lake and the huge volume of stockpiled solid wastes still remain. Fuel and energy companies and transportation still significantly contribute to the air pollution. The administrative center of Irkutsk oblast – Irkutsk –has been continuously listed as one of the most polluted cities. The main air pollutants in Irkutsk are vehicle exhaust gas (52% of emissions) and unfiltered thermal power supply (46% of emissions). Manufacturing is responsible for about 2% of all emissions. Under certain circulatory patterns, some portion of atmospheric pollutants from Irkutsk can get into the Baikal basin and the lake's water area. Therefore, according to the environmental zoning, this city is included into the zone of atmospheric impact. Irkutsk Aviation Plant is the main source of wastewater discharge into the Angara river, while the Irkutsk Furniture Factory — into the Irkut river. However, this pollution does not get into the Baikal catchment area. A growing number of unauthorized

62. CONSTRUCTION



landfill sites around the city represents a particular problem.In the Olkhon district, the major source of environmental pollution is recreational activity resulting in the problem associated with the disposal of solid waste.

In Mongolia, among the main areas of industrial impact on the environment are industrial centers, where the majority of population is concentrated and industrial enterprises are located (Ulaanbaatar, Darkhan, Erdenet, etc.), as well as local mining areas and light industry companies (wool and leather processing). In Mongolia, the impact of industry on water resources is particularly acute. In the last 20 years, out of five thousand rivers and lakes 852 rivers and 1,131 lakes have dried up due to mining [Basayev]. In addition, intensive water pollution (water quality of Pollution Class 3-4) is observed in all selected areas and large industrial centers. The main water pollutants are oil products and phenols. Increased oxidation isalso registered.

Uneven economic development of the territory is accompanied by an unequal impact on the environment. As a result, the most negative impact takes place in large industrial centers with a high concentration of industrial enterprises that are characterized by significant emissions of air pollutants and large-volume wastewater discharges. The natural resources potential of the area has determined the development of the mining industry, which poses the greatest risk of pollution by toxic substances from tailings ponds to the land and surface and groundwater.

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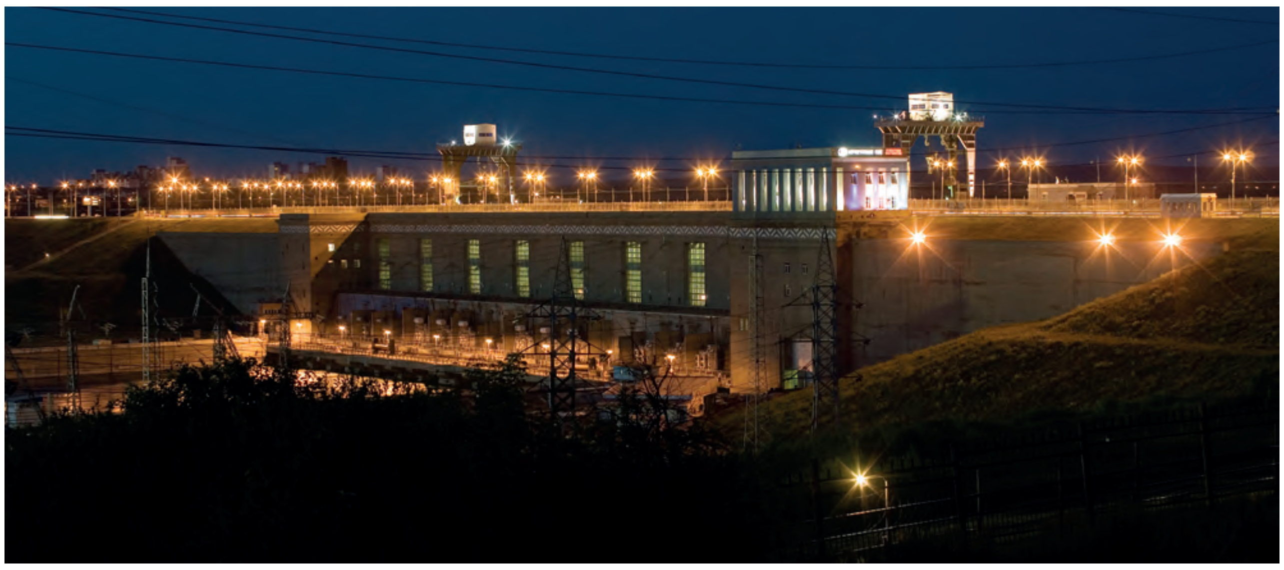

Irkutsk hydroelectric power plant.

CONSTRUCTION (62)

Construction industry in the Baikal basin is one of the growth points of its economy and ecological well-being. One of the main indicators of the construction industry is the square meterage of the built civil and industrial facilities. Generally, it reflects its social and economic status in some regions. A current characterization of a segment of the construction sector – the residential construction – is conductedbased on the observation of governmental statistical data [Districts…, 2013; Construction in Zabaikalsky krai, 2013; Construction in Russia, 2012; Construction and commissioning…, 2013] and the Internet resources [Federal State Statistics Service].

In the past three years (2010 to 2012), construction put-in-place increased three-fold (from 0.4 to 1.2 million sq. m). Judging by the growth of the absolute values of the residential construction put-in-place, Irkutsk oblast – the most urbanized region in the basin – tops the list with over a half of the volume of commissioned residential housing in the Baikal basin (2012). The Republic of Buryatia is the second (26.2 %), and Zabaikalsky krai is the third (19.3 %).

The most important characteristics of residential development is the annual square meterage of the built housing (m²/person), which is presented as a background indicator of the map. By absolute indicators, Russia reached the pre-reform level of residential development in 2007. However, the specific indicator of the floor space of commissioned housing both in the country in general and in the Baikal basin in particular does not exceed 0.5 m²/person (in developed countries the annual construction capacity is at least 1 m² per capita, while the annual growth of housing put-in-place is 4.5-5.0 %) [Federal State Statistics Service]. Territorial differentiation of municipalities of the region according to this important indicator is quite contrasting. High specific indicators and the stable growth dynamics as a result of the implementation of targeted state programs facilitating residential development are observed across the whole territory except for the Republic of Tuva. Irkutsk oblast is leading, with its indicators being twice as high as the indicators of other regions (0.81 m²/person against the average regional indicator of 0.45 m²/person).

The residential construction sector of the region is distinguished by:

− The contrasting nature of its geography both in absolute and standard specific basic values;

− The current focal points of growth – Irkutsk and the Ivolginsky district (Republic of Buryatia).

The most important instruments for improving residential development are targeted state programs of regional and municipal levels. These programs focus on the implementation of comprehensive measures for the development of large-scale residential construction in the region. The key “driver” of the so-needed residential development in the municipalities of the lower level is the social and economic planning using various regional programs.

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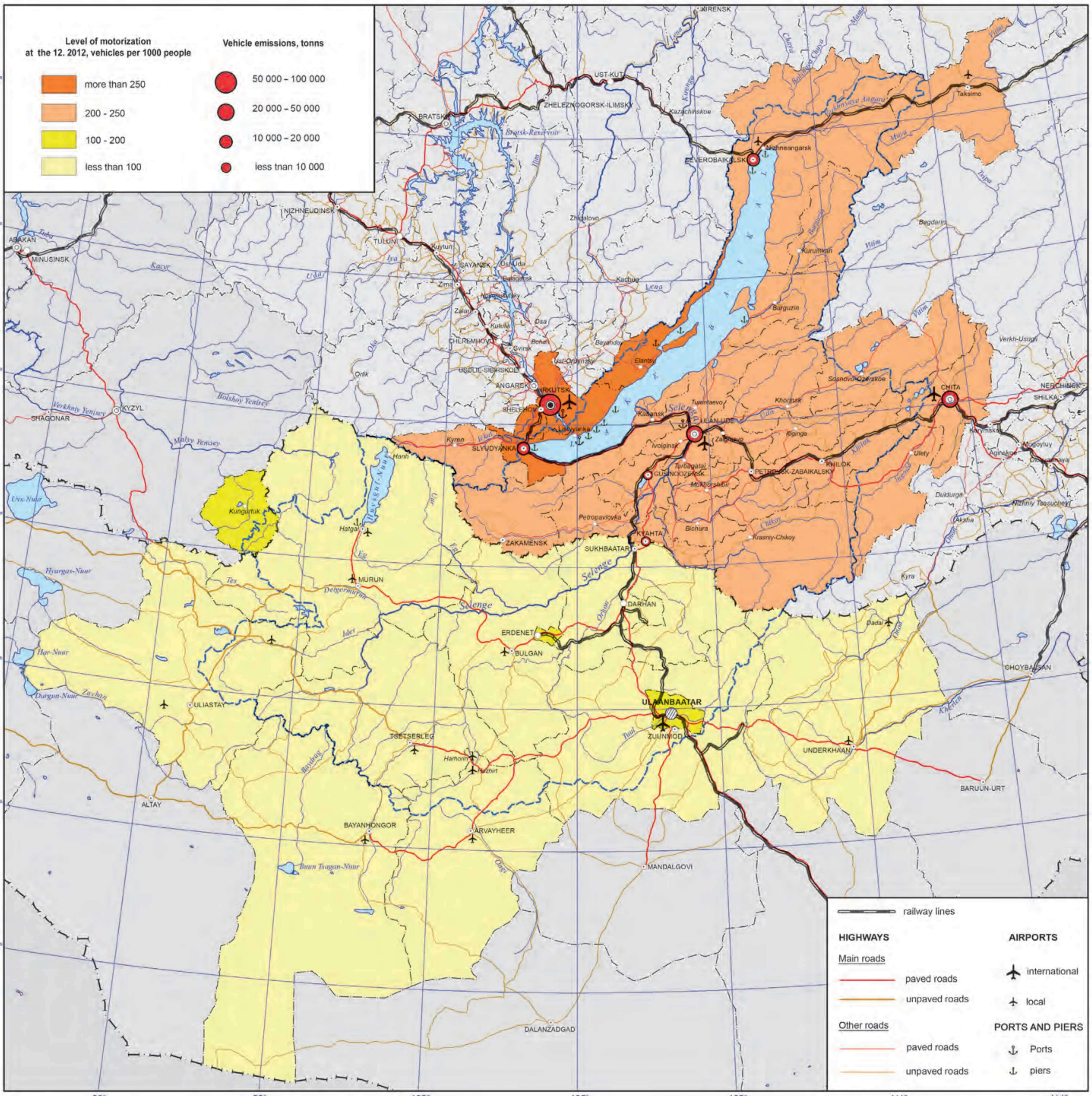
63. TRANSPORTATION



TRANSPORTATION (63)

Transportation infrastructure of the Baikal basin is a constituent part of the transportation systems of Irkutsk oblast, Republic of Buryatia, Zabaikalsky krai, and Mongolia. This territory has almost all modes of transportation, namely, railways, roads, shipping, and air transportation.The cities of Irkutsk and Chita located outside the Baikal basin are also considered, as they are important logistics hubs of the Baikal basin.

Railways in the Russian part of the basin are part of the East Siberian Railway. Railway serves the Southern and Northern Baikal region. The Baikal-Amur Mainline runs along the northern shore of Lake Baikal and along the valley of the Upper Angara river. A short segment of the Trans-Siberian Railway runs along the southern shore of Lake Baikal and further to the east. In the Baikal basin, it forks into two railways – the Circum-Baikal Railway (84 km) and the Ulan-Ude – Naushki Railway (253 km), which runs all the way to Mongolia, where it connects to the Ulaanbaatar Railway. In Mongolia, the major railway is the one running from the Russian border through Ulaanbaatar to the border with China and further to Beijing. In the Baikal basin, this railway has branches to Erdenet, Sharyn Gol, and Baganuur.

The effect of the railway transportation on the environment includes the impact on the atmosphere in the districts, where diesel locomotives are used. Transportation of explosives, chemicals, and other hazardous cargo is also potentially dangerous.

The most important motorway is the federal highway Irkutsk – Ulan-Ude – Chita (a segment of the Moscow Highway), which runs parallel to the Trans-Siberian Railway. Besides this highway, the segments of the motorways Kultuk–Mondy, Irkutsk – Listvyanka, Magistralny – Severobaikalsk –Uoyan – Taksimo, Taksimo – Bodaibo, Bayanday – Elantsy – Khuzhir, Ulan-Ude – Turuntaevo–Kurumkan, Ulan-Ude – Kyakhta with a branch to Zakamensk, Ulan-Ude – Bichura, Ulan-Ude– Sosnovo-Ozerskoe – Bagdarin, Chita – Bagdarin, Chita – Aginskoe, etc. also run across this territory. In Mongolia, a hard surface highway runs from the Russian border to Ulaanbaatar and further to the border with China. There is a branch of this highway connecting Darkhan, Erdenet, and Bulgan. There are two more paved motorways running from Ulaanbaatar to Tsetserleg and Underhaan. The rest of Mongolian motorways are dirt roads. The main motorways shown on the map are federal highways in Russia and major inter-aimag roads in Mongolia.

Motor vehicles are the most intensive source of environmental pollution. On average, one vehicle consumes about four tons of oxygen from the atmosphere annually and emits about 800 kg of carbon oxide, 40 kg of nitrogen oxide, and almost 200 kg of different carbons [1]. This pollution is more pronounced in settlements. Thus, in Ulan-Ude it makes 58% of the total pollutant emission, in Chita – 72%. The increased pollution in larger cities is associated with a more intensive use of auto transportation and high rates of car ownership among the general population. Moreover, noise from motor vehicles also negatively impacts people's health in the cities. The impact of motor vehicles on the environment outside of settlements occurs along highways. The concentration of heavy metals along the highways increases 10 to 20 times as compared to the background level. Another factor of the impact of motor vehicles is the dust formation in the air near the ground especially on dirt and gravel roads. Off-road driving in Mongolian steppes and on the shores of Lake Baikal is also a problem, as it damages vegetation of local landscapes.

Motor vehicle pollution in the Baikal basin is the major type of the impact of transportation on the environment and, especially, on human health.

Ship traffic in this territory takes place on Lake Baikal and Lake Khovsgol, as well as on the Angara and Selenga rivers. The fleet used on Lake Baikal in 2012 and registered by the East-Siberian Branch of the Russian River Register includes: 1) general service and recreational boats and search and rescue vessels; 2) dry cargo, passenger, expedition, and research vessels; 3) freight and passenger-and-freight ferries; 4) self-propelled tugboats; 5) dynamically supported ships; 6) buoy tenders [2].

Passenger service runs from Irkutsk to Olkhon Island, Severobaikalsk, and Nizhneangarsk. There are

Number of vessels by class on the lake Baikal, units

Class	Years		
	2010	2011	2012
1. Ownerships of vessels:			
- departmental	59	58	44
- commercial organizations	110	105	101
- personal use	92	82	54
Total:	261	245	199
2. Types of vessels:			
self-propelled, incl			
- towboats	30	29	15
- travel types	159	146	115
- situational	3	3	3
- cargo-passenger	28	27	27
- research	6	6	6
- other	34	34	33
Total:	261	245	199
3. The mode of navigation:			
- transport of people	28	23	23
- economic activity	233	222	176
Total:	261	245	199

also other routes from Irkutsk to Ust-Barguzin, Bolshie Koty, and Peschannaya Bay. Segments of the Selenga (274 km), Barguzin (138 km) and Upper Angara (254 km) rivers are also suitable for navigation [*Rosgeolfond..., 2012*].

The impact of water transportation is associated with the spillage of oil products during loading and unloading operations in ports and wastewater discharge. Oil, unburned fuel, and other particles get into the water along with the exhaust fumes from ship engines. There is only one place for collecting waste and bilge water from ships on Lake Baikal – Port Baikal, which leads to an uncontrolled discharge of wastewater all around the lake's water area. This problem has become a priority among the environmental issues of this great lake.

Four international airports in Irkutsk, Ulan-Ude, Chita, and Ulaanbaatar hold the main share of air transportation in the region. They offer direct domestic (to Moscow and other Russian cities) and international (to China, Japan, South Korea, and Germany) flights. In 2012, passenger traffic originating from Russian airports totaled 1,097,000 passengers, while passenger traffic from Mongolian airports was 770,010 passengers.

The main form of pollution from aviation is noise, which significantly reduces the living standards in the residential areas located in the vicinity of airports.

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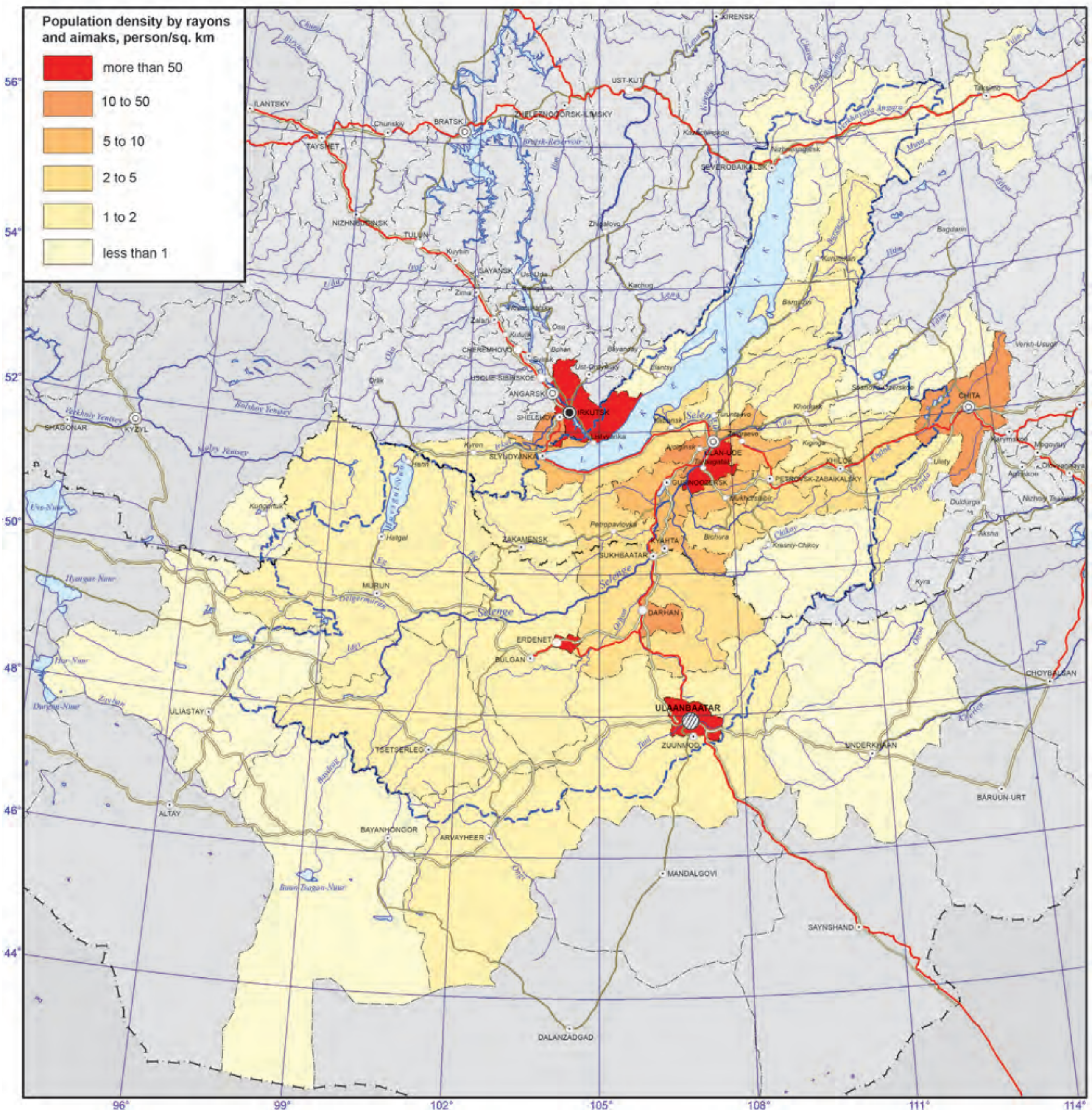
POPULATION (64 — 70)

The population maps focus on current patterns of the settlement and demographic situation in the Baikal basin. They relate to a complex of underlying social, economic and ecological factors.

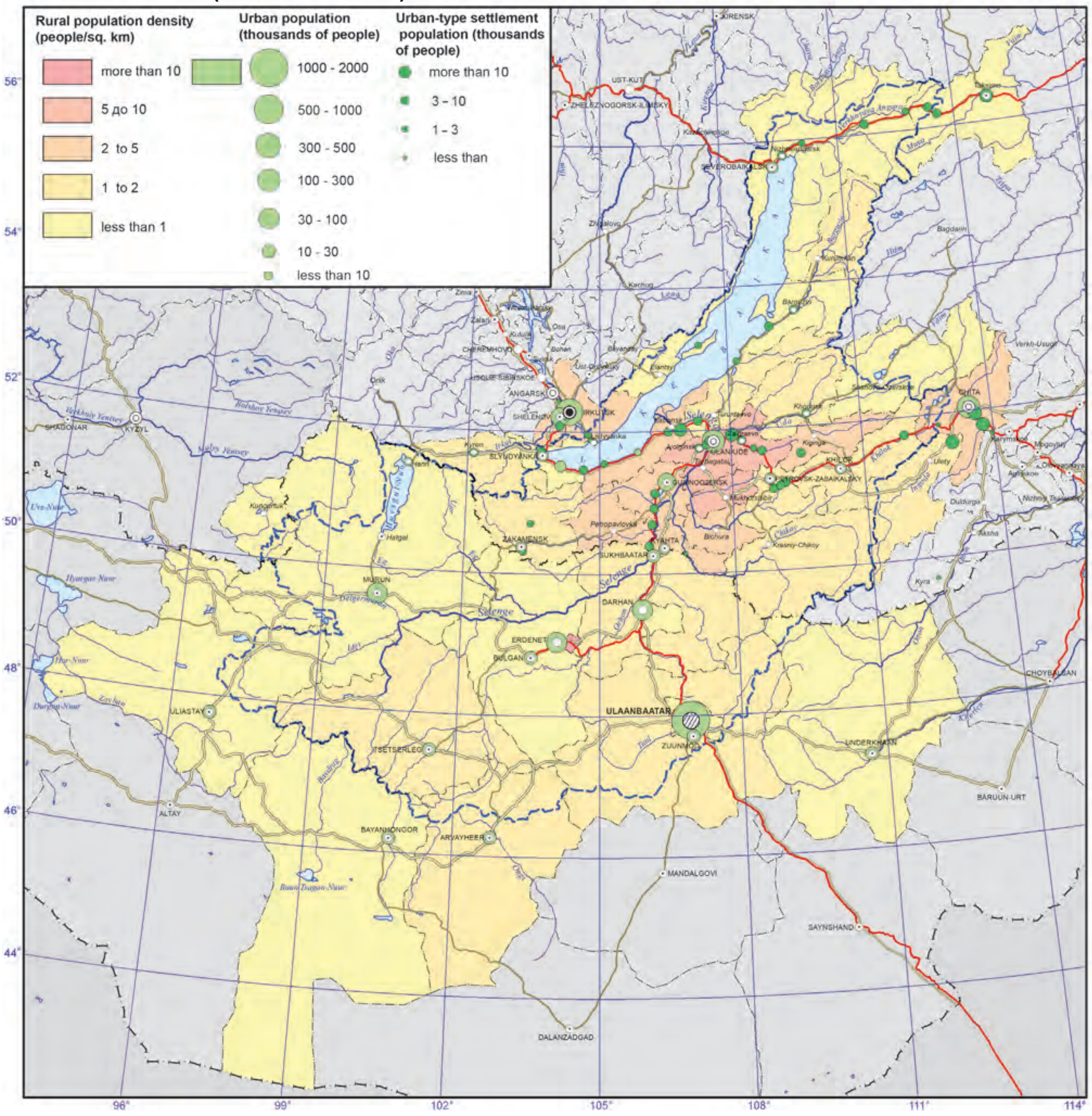
The population maps of the Baikal basin are based on the statistical data of the Federal State Statistics Service of the Russian Federation and National Statistical Office of Mongolia [*Federal*..., *Federal*..., *Federal*..., 2012, *Federal*..., 2013, *All-Russia*..., 1991, *Federal*..., *National*..., 2011, National...]. Also important were the data from population censusesof Russia and Mongolia and the data of the current measurements of demographic events. The authors used statistical sources to calculate indicators for territories included into the Baikal basin.

The distribution of settlements within the Baikal basin is quite irregular. There are four locations of the regional concentration of the population. In Irkutsk oblast, the main settlement belt along the Trans-Siberian Railway stretches from the western border of the region up to Lake Baikal. Here, there are many agricultural settlements and the majority of large administrative and economic centers, where manufacturing sector dominates the economy. Irkutsk – a large multi-functional center – tops the group of these settlements. Only sparsely populated the Olkhon and Slyudyankadistricts and part of the Irkutsk district fully lie within the Baikal basin. In the

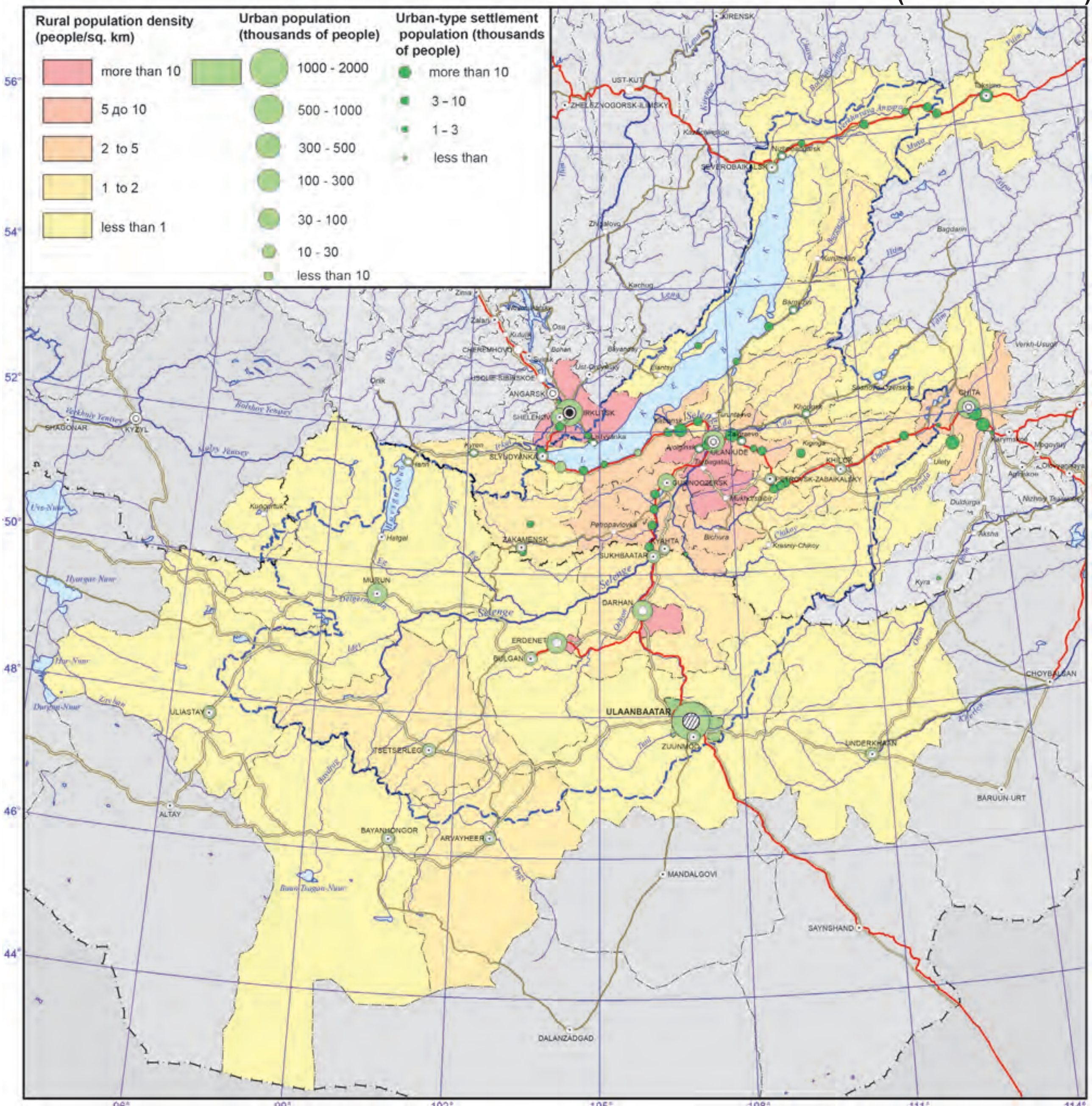
64. DENSITY OF POPULATION



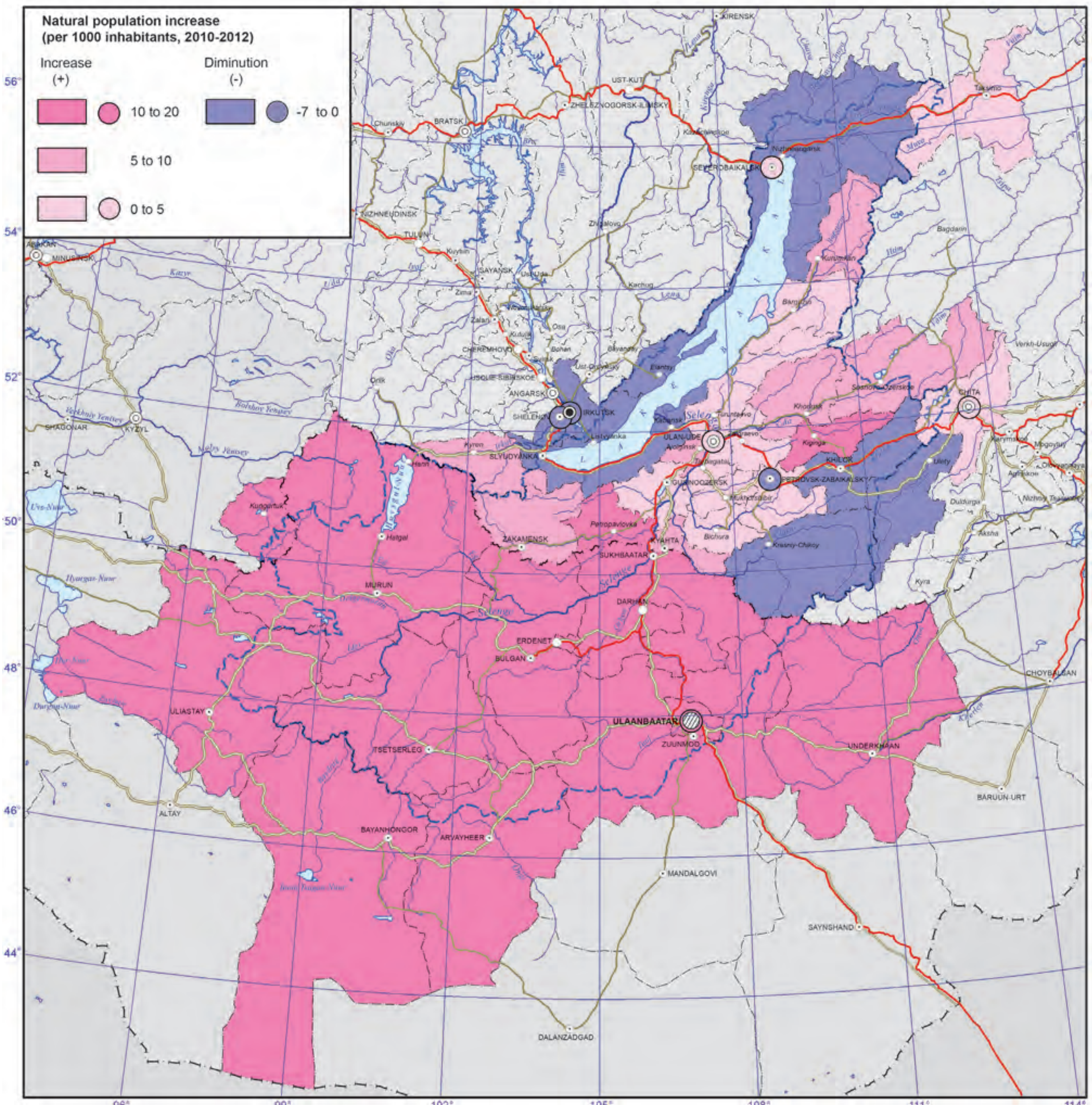
65. DENSITY OF RURAL POPULATION AND POPULATION SIZE OF URBAN SETTLEMENTS (AS OF 1.1.1989)



66. DENSITY OF RURAL POPULATION AND POPULATION SIZE OF URBAN SETTLEMENTS (AS OF 1.1.2013)



67. NATURAL INCREASE OF POPULATION



direct vicinity of Lake Baikal, but in the Angara basin, there are cities of Irkutsk and Shelekhov. In the Republic of Buryatia, there is a major settlement area around Ulan-Ude with a maximum concentration to the south of the city. Geographic differences in the specialization of settlements have emerged. Settlements involved in manufacturing and transportation are overwhelmingly dominant along the Trans-Siberian Railway. In Southern Buryatia, there are mostly agricultural settlements. In Zabaikalsky krai, there are three settlement networks: settlements involved in manufacturing and transportation located along the railway; mining settlements near deposits; and agricultural settlements located south of Chita in the forest-steppe and steppe zone. In Mongolia, the population is mainly concentrated in the central region – from Ulaanbaatar in the south to Sukhbaatar in the north. Three largest cities of the country and more than a half of its population are located in this area. The other territories of the Mongolian part of the Baikal basin are sparsely populated.

Distribution of the population and the degree of the settlement of the territory are displayed on the maps “Density of population (as of 1.1.2013)”; “Density of rural population and population size of urban settlements (as of 1.1.1989)”; “Density of rural population and population size of urban settlements (as of 1.1.2013)”.

The Baikal region belongs to sparsely and unevenly populated territories. The population density of the Baikal basin is 17 times lower than the world’s average of 53 persons/km^2. The population density in the Russian part of the basin is 2.9 persons/km^2, which is nine times lower than in the European part of Russia (26 persons/km^2).

The intra-regional differentiation of settlement patterns is stipulated by several spatial gradients of the population density decrease, with the main gradient leading from the center (capitals and administrative centers) to the periphery. Other gradients are also present in particular territories. Thus, in the Russian part of the basin, the population density tends to decrease as it goes from the south to the north and from the west to the east. The Russian-Mongolian border for the most part rather separates than unites the areas of settlement, except for one direction. The core of this direction is the Selenga Valley, where an area with a highly dense population has formed between Ulaanbaatar and Ulan-Ude.

The territories around large cities, like the regional centers Irkutsk, Ulan-Ude and Chita, are most densely populated. Along with the areas with dense population, there are also virtually unpopulated territories of tens of thousands square kilometers in area. The distribution of rural population is less contrasting than the urban one. The main clusters of rural population are located in the forest-steppe and steppe zones, where the density of population may reach 10-20 persons/km^2. Rural population is mainly concentrated in the south of Irkutsk oblast (around Irkutsk) and in the central part of Buryatia (south of Ulan-Ude).

The major cities of the Russian part of the basin grew along the transportation lines. Thus, 11 out of 13 towns are located along the railways. Only Zakamensk and Kyakhta are located away from the railroad. In the Mongolian part of the basin, the connection of urban settlements to transportation lines is less pronounced with onlyfive out of 12 towns being situated on the railways.

The map “Dynamics of the population size (1989-2013)” shows considerable changes in the population size – a situation, where a high concentration of the population in a few largest centers is followed by depopulation of vast territories.

In the Russian part of the basin, there were two clear patterns of the population size dynamicsfrom 1989 to 2013. Firstly, the decrease of population tends to be more pronouncedfrom the southwest to the northeast. Secondly, the population dynamics in regional centers (Irkutsk, Ulan-Ude, and Chita) and their suburbs is relatively positive. Population growth is observed only in the Irkutsk, Shelekhov, and Olkhon districts of Irkutsk oblast, Ivolga districtof the Republic of Buryatia and Chita district of Zabaikalsky krai. The record level growth of population (over 160 %) was recorded in the suburban Ivolginsky and Irkutsk districts. The biggest drop in the population takes place in the localities that are classified as districts of the Far North, with the Muisky and Severobaikalskydistricts of the Republic of Buryatia loosing over half of their population.

In the Mongolian part of the Baikal basin, population growth is registered on over a half of the nation’s territory. The main Mongolian cities – Ulaanbaatar, the capital of Mongolia, (244 % to the level of 1989), Erdenet, and Darkhan are the fastest growing cities. The Khovsgol and Selenga aimags also demonstrate a significant growth of population. The populationin the four aimagsof

Arkhangai, Zavkhan, Tov, and Khentei decreases due to an outward migration of residents.

The contrasting nature of the population dynamics within the Baikal basin is quite distinct:

– The Russian part of the Baikal basin is characterized by the type of the population dynamics, where an outward migration is several times higher than a natural population decline;

– The Mongolian part is characterized by the type of the population dynamics, where a natural increase of population prevails over inward migration.

Territorial specifics of demographic development are shown on the map “Natural increase of population”.

In the Baikal basin, different modes of reproduction of population exist along with a wide variety of quantitative parameters of demographic processes. In general, it is possible to identify two types of population reproduction. Thus, all of Mongolia, Tuva and part of Buryatia are characterized by an expanded type of reproductionwith high birth rates, average mortality, and a significant natural growth. The Baikal region of Irkutsk oblast, Zabaikalsky krai, and most of Buryatia ischaracterized by a narrow type of reproduction with low birth rates, high mortality, and a natural population decline or insignificant natural growth. The annual natural growth of the population in Mongolian aimagsis 17-19%. In the Russian part of the basin, natural movement of the population led to mixed results, where 23 municipalities showed population increase, while 10 municipalities had natural decline. With an average natural population increase of 1.4 per mille, there were significant variations – from the decline ranging from -5 to -6% (in the Petrovsk-Zabaikalsky, Irkutsk and Olkhon districts) to the increase exceeding 10 pro mille (10.4% in the Dzhida district, 12.1%in the KizhingaDistrict, and 16.0%in theTere-Khol district). The natural population increase in the Mongolian capital Ulaanbaatar was 17.2%, while the increase in the Russian regional centers Ulan-Ude and Chita was 4.3% and 3.4%, respectively, with the decline of -2.7 %in Irkutsk.

The map “Urbanization of the territory” shows the proportion of urban population in Russian municipal districts and Mongolian aimags. The share of urban population exceeds 74% of the entire population and is composed of a few territories. The level of the urbanization of the population exceeds the world’s average (51%) by nearly one and half times, however, the level of the urbanization of the territory is low. Urban territories mainly include settlements located along the railways, as well as densely populated administrative centers. In the Mongolian part of the Baikal basin, only Ulaanbaatar and the Orkhon and Darkhan-uul aimags are highly urbanized, while the remaining nineaimags have only a small share of urban population (17.5%-34.9 %).In Mongolia,administrative centersof every aimagmust be urban settlements. However, in Russia, the legislation does not mandate municipalities to have urban settlements. Therefore, in the Russian part of the basin, as of 2013, 14 districts did not have urban population at all. Some settlements (Barguzin, Ivolginsk, Kyren, and Khorinsk) rejected their urban statusin the process of municipal reforms of the 2000s. The population of Mongolian towns within the basin nearly doubled in 1989-2013, with the population of Ulaanbaatar growing from 540.6 to1,318.1 thousand people. The population of the largest cities in the Russian part of the basin did not change that much: in Irkutsk,it grew from 572.4 to 606.1 thousand people, in Ulan-Ude – from 352.5 to 416.1, while in Chita it declined from 365.8 to 331.3 thousand people.

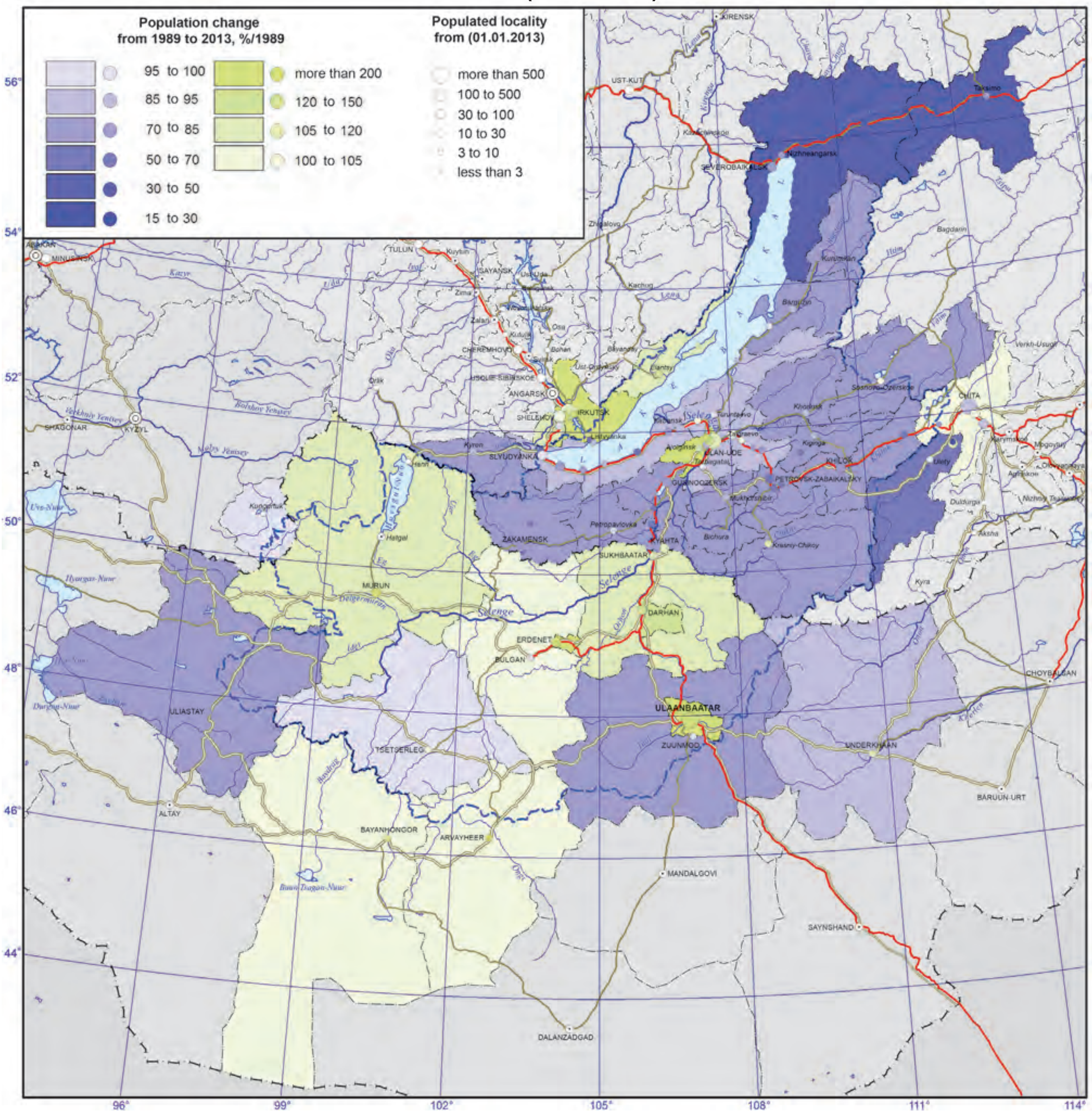
The main results of migration processes in 2010-2012 are shown on the map “Migratory increase of population”.

In Russia, including the Baikal basin, the last two decades witnessed a significant decrease of migration activity of the population. However, outward migration from the region remains high and reproduces almost annually from the mid-1990s up to now. Population movement has mostly become intra-regional – the intra-regional migration turnover makes about 2/3 of relocations in the Baikal basin. The intra-Russian interregional migration causes migration losses, while migratory relationships with the CIS countries contribute to a considerable growth of population.

Redistribution of the population between the constituent parts of the Baikal region is intensiveincluding some tens of thousands people annually. In 2010-2012, on average 66.5 thousand people arrived, and 58.6 thousand left. In the Baikal region, the average annual migration increment was 7.9 thousand people. However, it was due to the growth in the attractive for migrants cities of Irkutsk and the Irkutsk district (+9.3 thousand people), Ulan-Ude (+3.4 thousand people) and Chita (+2.9 thousand people). The total growth of the population in these cities was 15.6 thousand people. The rest of the region experienced the outflow of residents totaling 7.7 thousand people. Migration redistribution leads to the growth of the population in regional centers and their suburbs. Only 10 municipalities had a migratory growth, while the rest 24 showed a decline. The intensity of migrant arrivals is highest (twice as high as average) in the suburban Irkutsk and Ivolginskydistricts, while the intensity of departures is highest (twice as high as average) in the undeveloped Dzhida, Kizhinga and Muiskydistricts. Against this backdrop, the Russian part of the Baikal basinhas two migration poles – the Irkutsk and Dzhida districts, where an average annual migration balance is +47.4% and -46.0%, accordingly.

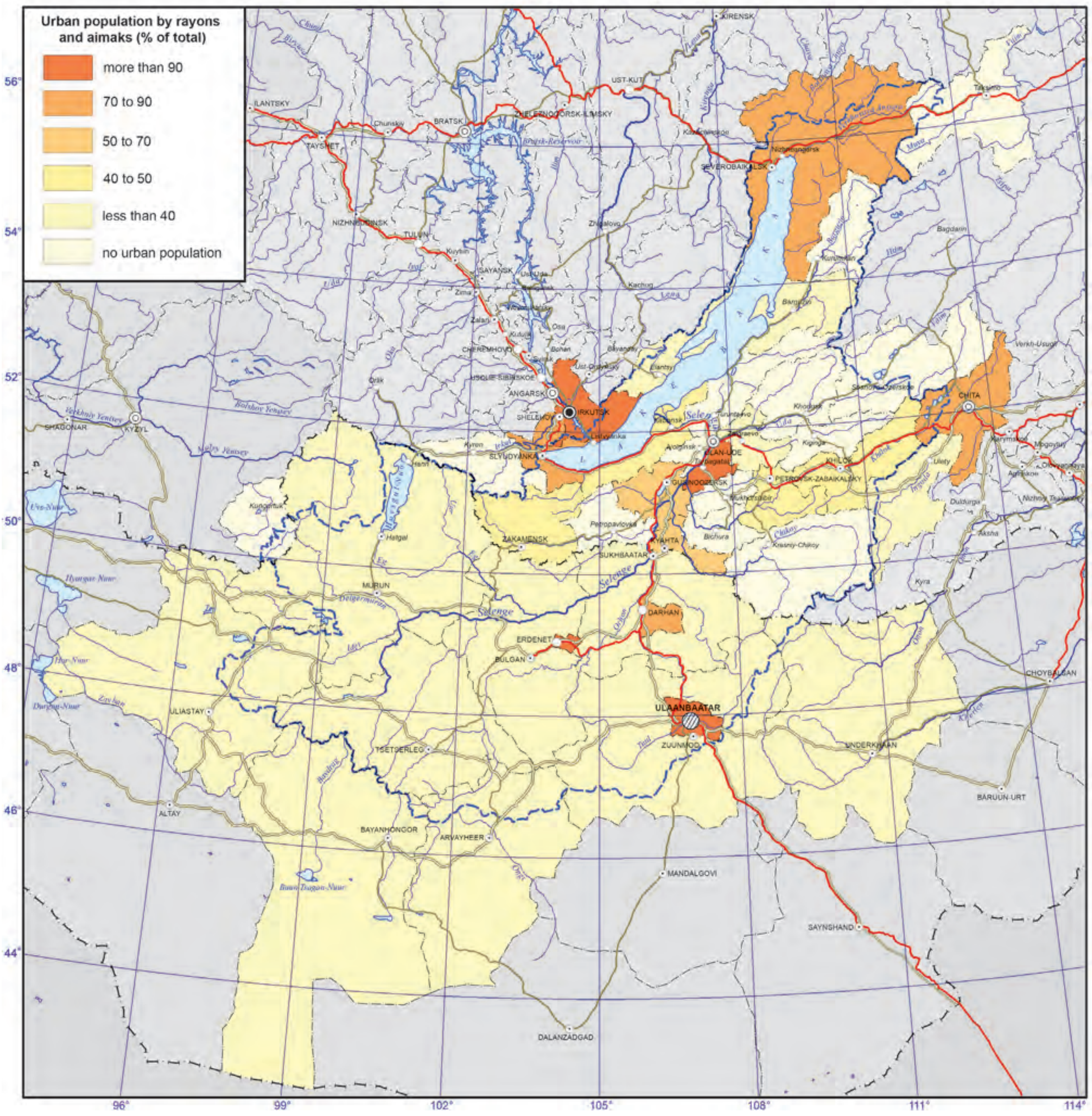
In general, the majority of territories ischaracterized by a progressive outward migration, which is compounded by unfavorable structural features of the outflow (with young and educated groups of people leaving the region). The results of migration movement are clearly expressed in terms of the center-periphery relationship: there are three areas of migration growth in the Russian part of the basin (Irkutsk, Ulan-Ude, and Chita with their suburban districts) and one in the Mongolian part, which combines the capital Ulaanbaatar and the aimagslying

68. DYNAMICS OF THE POPULATION SIZE (1989-2013)

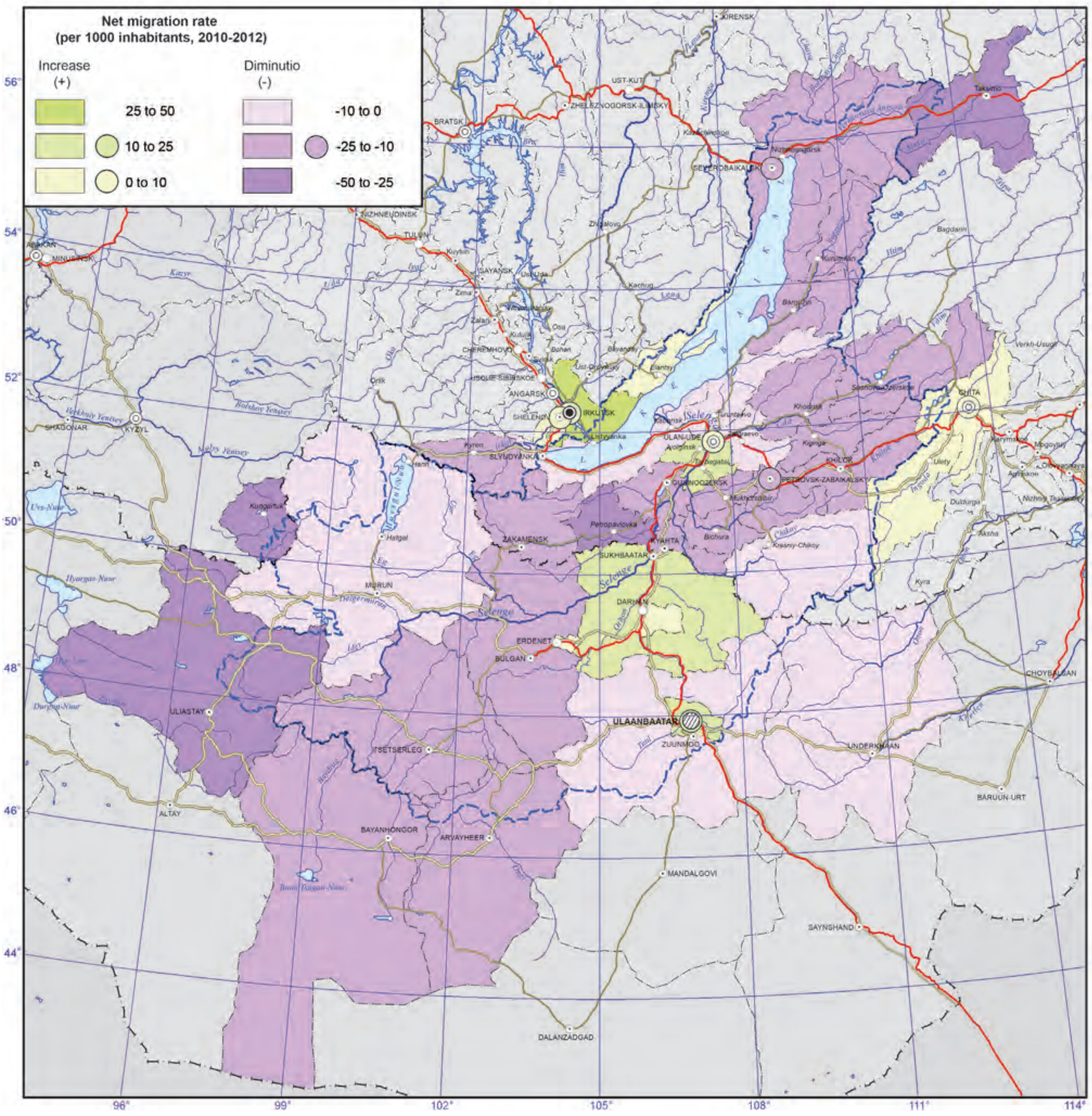


Christmas tree in Irkutsk.

69. URBANIZATION OF THE TERRITORY



70. MIGRATORY INCREASE OF POPULATION



to the north of it – Selenge, Orkhon, and Darkhan.

FUNCTIONAL TYPES OF SETTLEMENTS (71)

The map “Functional types of settlements”is created using conventional symbols. It shows the distribution of settlements within the Baikal basin and their economic significance. The main content of the map is the network of urban and rural settlements with their population. The size of population is shown by the symbols of different sizes in accordance with the selected scale of nine gradations of the population size. The color of symbols shows the functional typeofsettlements determined based on the structure of employment of the local population in various sectors of economy.

A dominant role in the settlement network formed in the Baikal basin is played by large multi-functional industrial-transport, administrative-cultural, and scientific centers of the state (Ulaanbaatar) and regional (Irkutsk, Ulan-Ude, and Chita) significance.

Various specialized industrial and transport centers are almost exclusively confined to the railway lines. Local organizational-economic centers performing the nodal functions of serving their hinterlands are scattered over a greater part of the territory. The dispersed pattern of settlement is especially clearin the Mongolian part of the Baikal basin, where each aimagis dominated by a corresponding administrative center with a sparse network of agricultural settlements.

Quantitatively, the region’s territory is dominated by small rural settlements with agricultural functions; their predominance is especially high in Mongolia. They are scattered within the steppe areas and in the southern part of Buryatia, where they are confined to river valleys.

Settlements with the predominance of recreational functions are few in number and are mainly confined to the shore of Lake Baikal (Listvyanka, Utulik, Khuzhir), to the shore of Khovsgol (Khatgal), and to the Tunkinskaya Valley (Arshan).

Large-scale inset maps “Irkutsk”, “Ulan-Ude”, and “Chita” demonstrate functional types of settlement in the areas of direct influence of the respective regional centers, around which the specifics of the suburban type of settlement is clearly manifested.

The assessment of the demographic potential in the Baikal basin allows to identify the following key predetermining factors:

— Ultra-continental geographic location in harsh environmental conditions and at a very large distance from densely populated areas of Eurasia;

— Low investment activity, which slows down economic development and hampers structural shifts towards the innovation sector of the region;

— Low demand for the region’s workforce potential from the existing economy, which is indicated by low wages and continuous outbound migration from the Russian part of the Baikal basin;

— Territorial contrasts in the settlement patterns, social and demographic structures, employment, and living standards of the population between different localities, which is especially pronounced when comparing the Mongolian and Russian parts of the lake’s basin.

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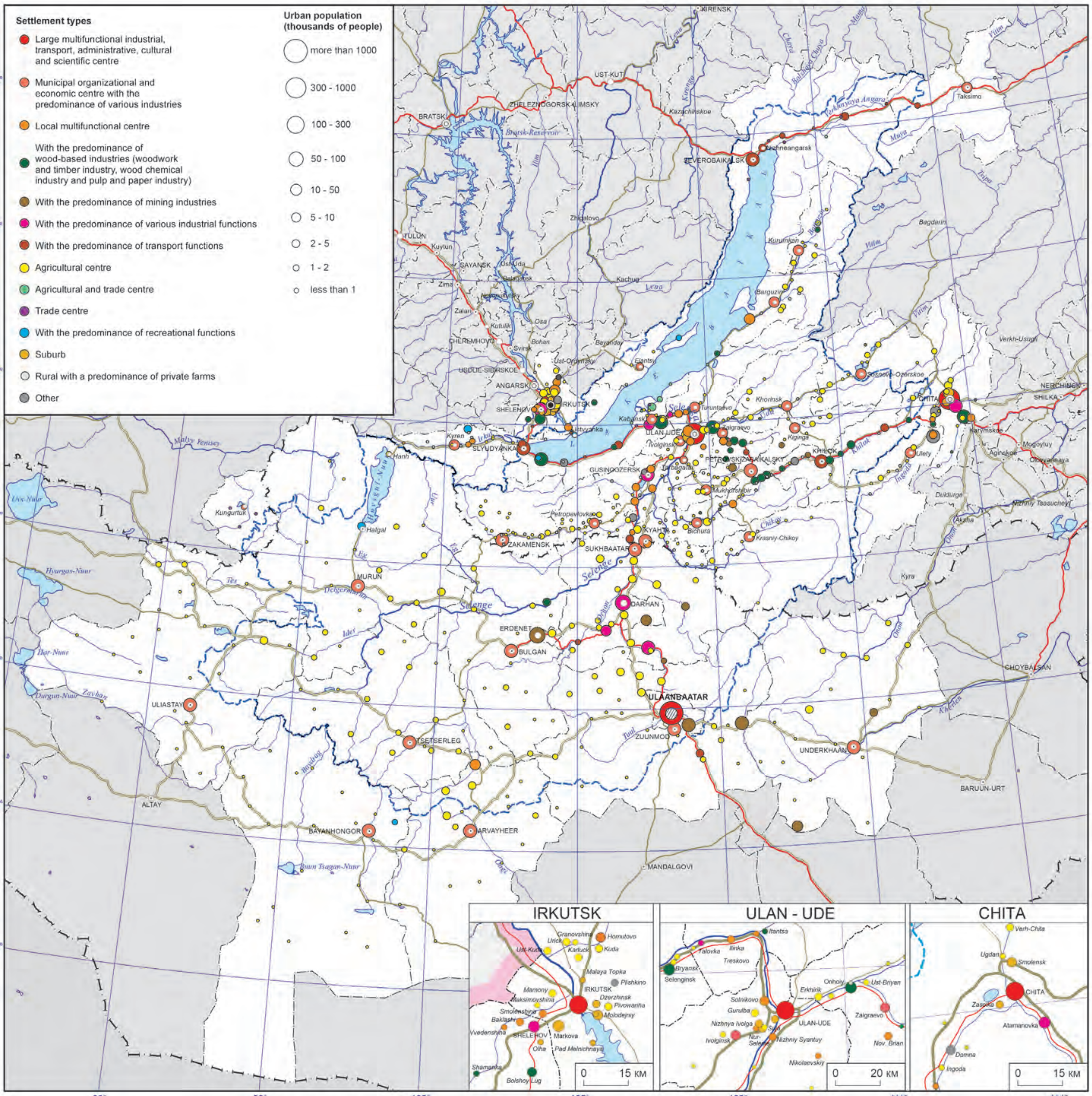
71. FUNCTIONAL TYPES OF SETTLEMENTS



from http://www.nso.mn/

HOUSING (72)

The most important indicator of the quality of modern life is the characterof living conditions ("roof over head"), which combines a specific indicator of housing supply and an especially important from the ecological standpoint specific indicator of the meterage of old and dilapidated housing. The main information resources used for calculations included the data of the territorial bodies of the Federal State Statistics Service of Irkutsk oblast, the Republics of Buryatia and Tuva, and Zabaikalsky krai, as well as online resources.

Spatial differences in the living conditions in the low-level administrative divisions (district municipalities) and urban settlements (urban municipalities) are represented by: a) a total indicator and b) a specific per capita (m²/person) indicator. According to Russian definitions, a housing fund is a collection of all housing properties regardless of the forms of ownership including residential properties, special properties (hostels, shelters, temporary public housing, nursery homes for lonely seniors, orphanages, boarding homes for persons with disabilities and veterans, and boarding schools), apartments, residential properties of businesses, and other residential properties in buildings suitable for residence. Meanwhile, the housing fund does not include residential properties of the cottage-recreational complex, i.e. summer cottages, sports and tourist facilities, rest homes and other. It should be noted that the total area of residential buildings does not include communal space (stairwells, elevator lobbies, common corridors, lobbies and other), as well as non-residential space occupied by any institutions.

The background of the map is the per capita housing supply in administrative districts and cities. The cartogram shows a specific provision of the population with housing in district municipalities and urban entities. This rate for all four subjects of Russia in the basin is much lower than both the Russian and Siberian Federal District (SFD) averages (23.4 m²/person and 22.1 m²/person, respectively).

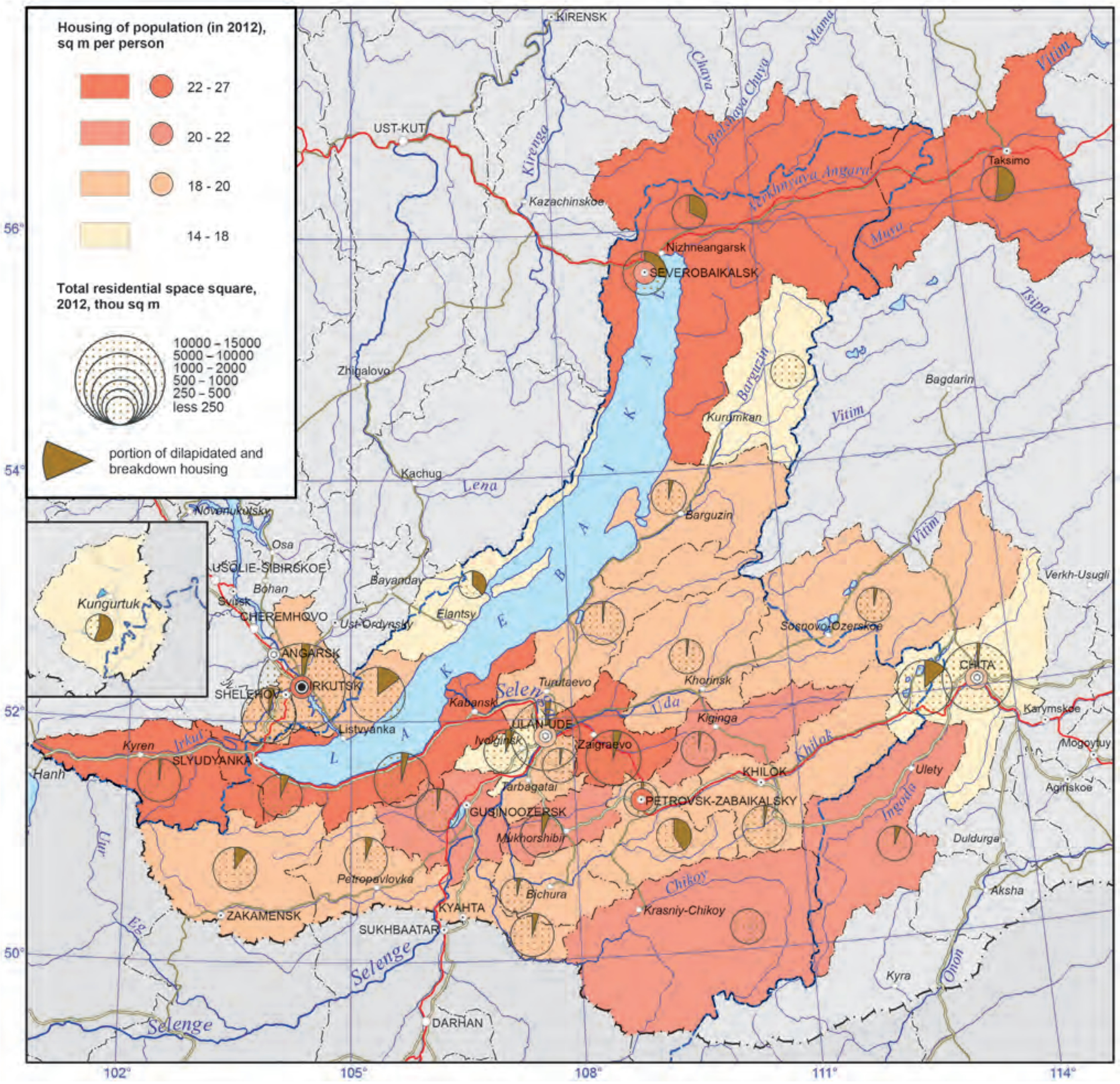
Spatial differences in the region according to this indicator of housing conditions are quite sharp (a two-fold difference between the minimum and maximum values – 14.1 and 29.9 m²/person (in the Tere-Khol district of the Republic of Tuva and the Zaigraevskydistrict in the Republic of Buryatia, respectively). Among urban settlements,Petrovsk-Zabaikalsky has the highest per capita rate of housing provision – 23.4 m²/pers., which equals to the average Russian indicators (2012), while the outsider is Chita (19.9 m²/person).

In terms of specific housing supply, all district and urban entities in the region are divided into four groups taking into account the average index for the SFD (22.1 m²/person). The category of high-status areas (Group 1 with more than 22.1 m²/person) includes slightly over 20% of the total number of territories. Thus, almost 4/5 of municipalities of the district and city levels in the Baikal basin belongto the areas, where a specific housing supply indicator is lower than the average for the SFD.

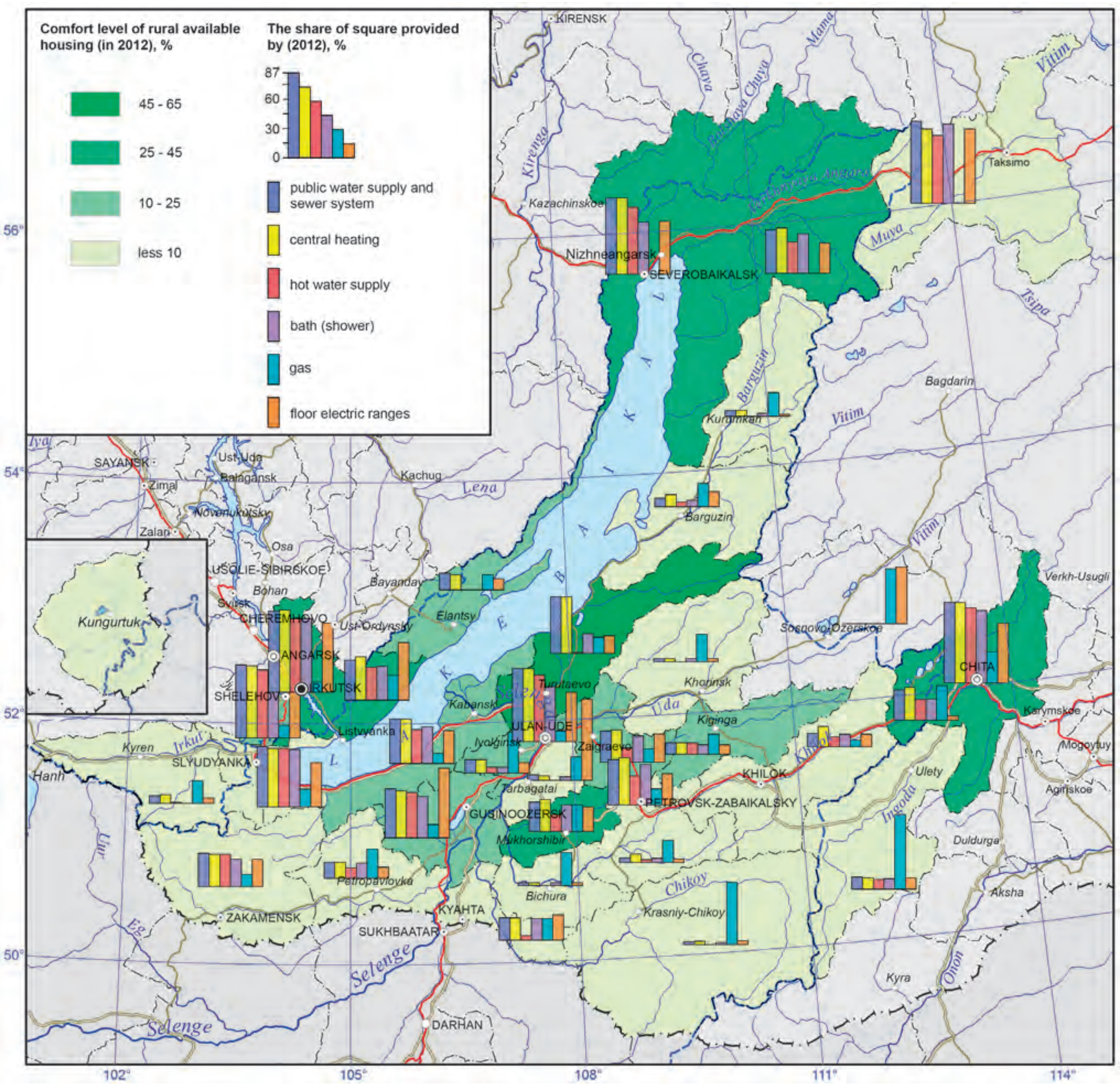
The housing fund in the Baikal basin is 46.8 million m² (2012). More than two fifths of it belong to the Republic of Buryatia(41.3 %), about two fifths to the Irkutsk oblast (37.5%), and more than one fifth to the Zabaikalsky krai (21.5%), while the contribution of Tuva is only 0.1%. The urban sector predominates – more than 3/4 (75. 8%). In the Baikal basin's regions,this picture is highly contrasting: in Irkutsk oblastthe share of the urban housing fund exceeds 9/10 (90.7%), while in the neighboring Republic of Buryatia it is less than 2/3 (59.8%).

The share of old and dilapidated housing is an indicative negative indicator of the quality of the housing fund. It represents a total share of more than 5% (this

72. HOUSING



73. URBAN AMENITIES OF THE HOUSING FUND IN THE RUSSIAN PART OF THE BASIN



indicator has increased manifold in comparison with 1990).

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URBAN AMENITIES OF THE HOUSING FUND IN THE RUSSIAN PARTOF THE BASIN (73)

The share of housing properties with urban amenities is an important factor for ecological well-being of the Baikal basin. Russian statistical data identify the following components of urban amenities: running water, sewage, central heating, hot water supply, baths (showers), and gas and electric stoves. According to the current statistical regulations, all housing properties today are considered to be equipped with central heating irrespectively of the source of heat supply (heat and electric power plant, industrial or local boiler plants, individual boilers). As a rule, the characteristics of the degree of provision with urban amenities is calculated using relative indicators – a percentage of the area of housing properties equipped with the above listed amenities compared to the total area of the housing fund (in %).

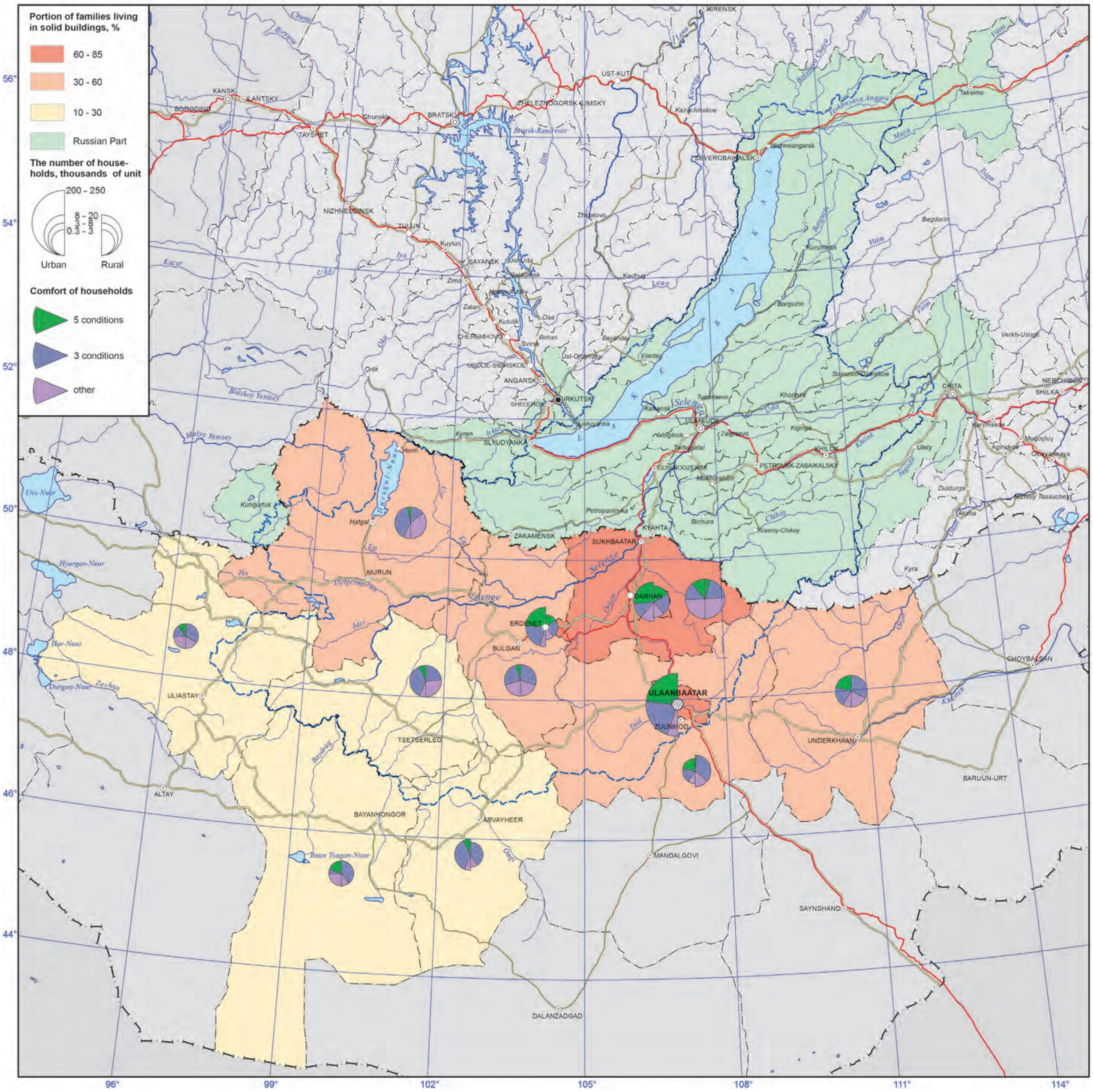
Spatial differences in the comfort level are quite significant in the region. Such regional centres as Irkutsk, Chita, and Ulan-Ude, as well as a town of the republican subordination Severobaikalsk have relatively high levels of urban development.However, a specific share of the housing fund equipped with urban amenities of every second administrative district of the region is less than 25%. Engineering amenities are absent in theTere-Kholdistrict of Tuva, YeravnaDistrictof Buryatia (except for gas and electric stoves), and Olkhon district of Irkutsk oblast (indicators for running water, heating, gas and electric stoves donot exceed 20%).

The standard indicators of engineering amenities exceed 50% only in every sixth administrative district. The leaders are the Muisky districtin Buryatia(due to new housing built during the Baikal-Amur Mainline construction) and Shelekhov and Slyudyanka Districts in the industrial belt surrounding Big Irkutsk (Irkutsk oblast). Almost half of the housing in three more districts has water supply, sewage and central heating: the Severobaikalsk and Kabanskdistricts in the Republic of Buryatia and the Irkutsk district in Irkutsk oblast.

Rural housing of the region has the lowest indicators of the degree of provision with urban amenities. The map shows the degree of availability of engineering amenities in rural settlements in administrative districtssplit into four conventionally identified groups according to the first four amenity indicators (i.e., without gas and electric stoves, as it will artificially improve the situation). In every second rural district, less than 10% of housing facilities are equipped with water supply, sewage, central heating, and baths(4th group). In five districts, this indicator is 10-25% (3rd group) (an average level for the region, but two times lower than the average for rural areas of the SFD): the Zaigraevsky, Ivolginsky, Kabansky and Kizhingskydistricts in the Republic of Buryatia and Chita district in Zabaikalsky krai. The leader is the Pribaikalsky district of the Republic of Buryatia (1st group: 45-65 %, which is close to the average indicator of the SFD). This district is followed by three other districts with relatively high levels of development of the rural housing fund: the Severobaikalsky and Selenginsky districts in the Republic of Buryatia and the Irkutsk district in Irkutsk oblast (2nd group).

The analysis of indicators of housing development (as of 2012) in the administrative districts of the Russian part of the Baikal basindemonstrates a very low level of modern housing development, high contrasts between urban and rural settlements, and an extremely low level

74. URBAN AMENITIES OF THE HOUSING FUND IN MONGOLIA



of comfort of rural territories.

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URBAN AMENITIES OF THE HOUSING FUND IN MONGOLIA (74)

The map shows a proportion of households in the country (%) living in residential houses with foundations (in permanent buildings – multi-apartment and low-rise buildings). According to the estimates, they account for over 17% of the housing fund of the country. Living conditions of households (families) in Mongolia that are statistically observed include the following five conditions:

- Households with a reliable source of drinking water, including households that have a reliable source of drinking water connected to a centralized system, protected well, or spring, as well as households that use purified and bottled water;
- Households with a source of electricity (electricity is supplied by the state electric power system, diesel power plants, renewable electric energy facilities, and smallpower generators);
- Households with a sewage system (inside or outside the house, but used only by the household);
- Households with a centralized and non-centralized sewage system for the disposal of wastewater through the central sewage system, independent system of sewage disposal, or cesspool;
- Households dispose of solid wastes through service companies or transport solid wastes to the designated areas or landfills themselves.

In Mongolia, more than two fifths of households (42.3%) living in permanent structures (buildings) use a centralized sewerage system, 0.4% use an independent sewage system, almost a half of households (48.3%) discharge wastewater into cesspools and 9% – on the terrain (directly into the ground).

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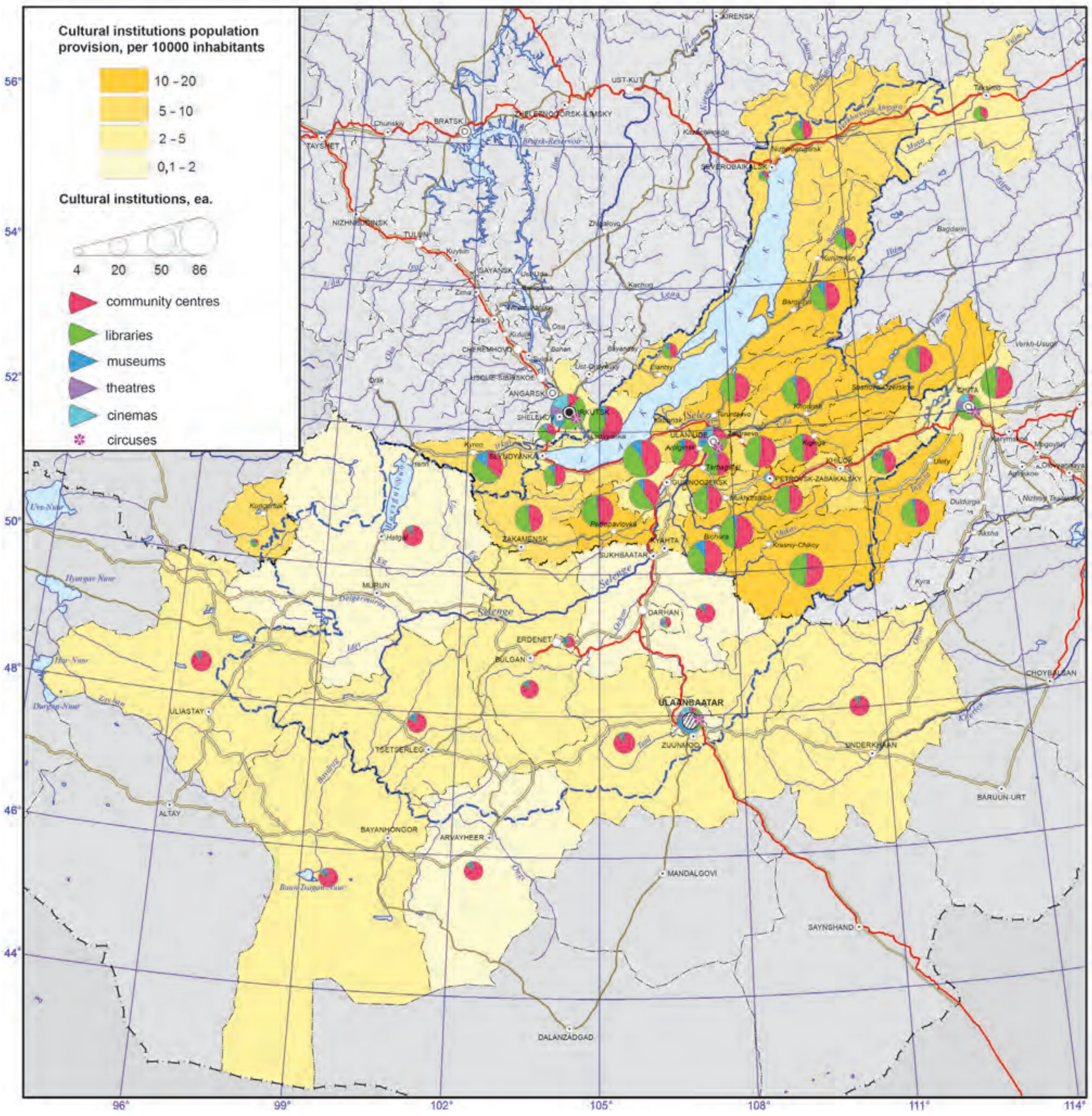
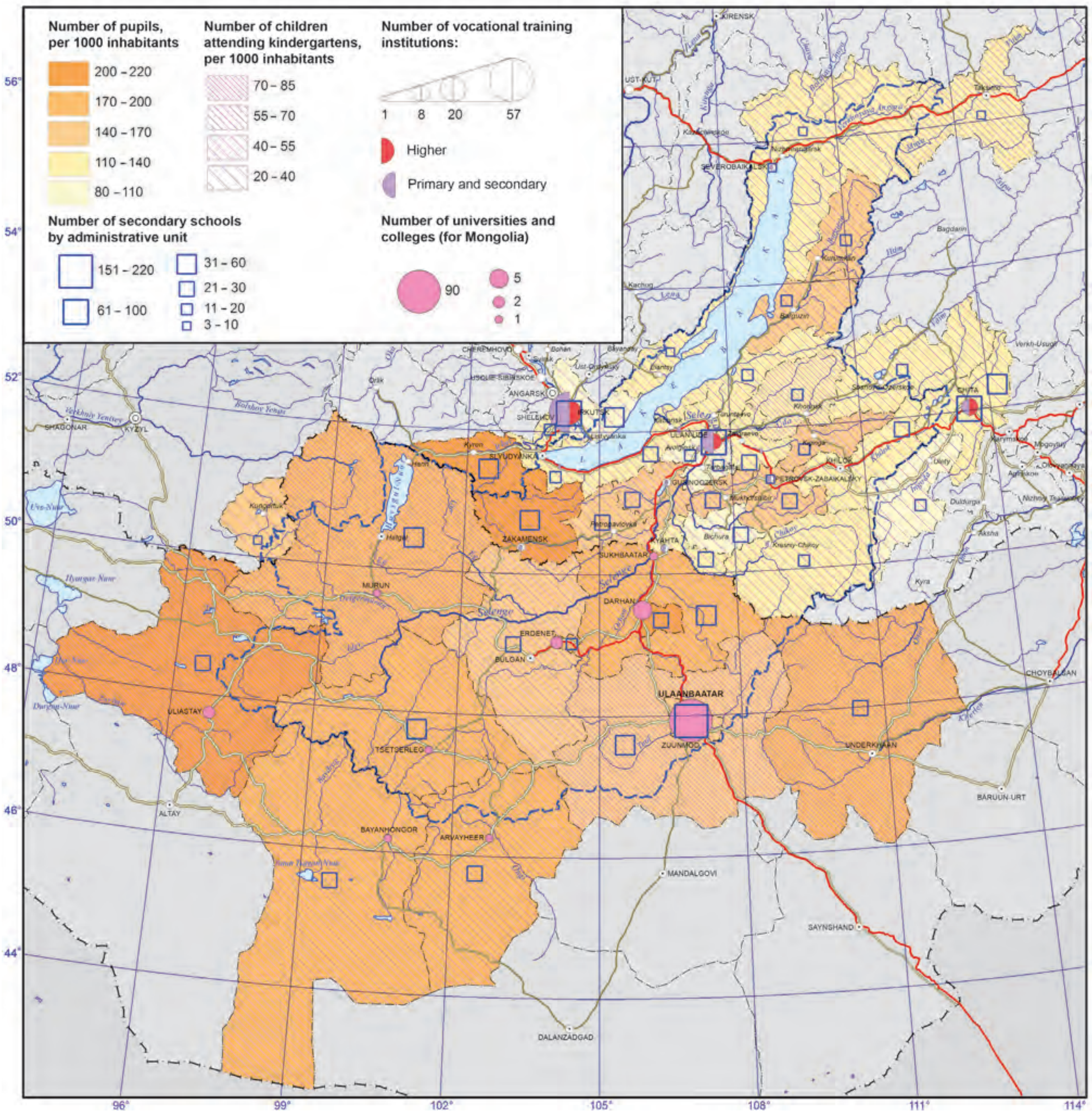
75. CULTURAL ESTABLISHMENTS



76. EDUCATION



CULTURE AND EDUCATION

Education and culture are important parameters of the quality of life of population in particular areas. To some extent, they characterize the standard of life and "spiritual environment". The main source of information for creating these maps included official statistical data for 2012 (in some cases for 2011). Materials of the Russian Federal State Statistics Service and Mongolian statistical yearbooks were also used in this work.

CULTURAL ESTABLISHMENTS (75)

Cultural establishments are keepers and successors of the historical and cultural memory of the people, as well as mediators in its transfer to the next generations. Usually, cultural establishments include libraries, museums, theaters, clubs, cultural centers, cinemas, leisure centers, and cultural complexes.

In the Baikal basin, there are about 1,770 cultural establishments. The total number is: 875 cultural-and-leisure centers, 720 libraries, 106 museums, 30 theaters, 36 cinemas, and 4 circuses [Federal…, National… 2012, 2013]. Each administrative district has cultural-and-leisure centers (clubs) and libraries. Most of the districts also have museums. Cultural life is most vividly represented in the major cities of Ulaanbaatar, Irkutsk, Chita, and Ulan-Ude. There are famous theaters, museums, circuses, large libraries, and cinemas.

Museums serve as the main tool of memory materialization. Often, they focus on local history and ethnography. Museums give tourists information emphasizing the originality and specificity of a particular place, its nature, history, and culture. Thematically, museums of regional centers (Ulaanbaatar, Irkutsk, Ulan-Ude, and Chita) are quite diverse. In the Irkutsk part of the basin, the most valuable collections are kept at the oldest museums, such as the V.P. Sukachev Museum of Art, Irkutsk Museum of Regional Studies, Taltsy Museum of Wooden Architecture and Ethnography, Historical and Memorial Museum of Decembrists. Among the largest museums in the Republic of Buryatia are the Sampilov Museum of Fine Arts, Museum of Natural History of Buryatia, and Ethnographic Museum (all in Ulan-Ude), as well as the Obruchev Kyakhta Museum of Regional Studies. The prevailing type of museums in Zabaikalsky krai are historical museums of regional studies illustrating the rich history of the region's development and the life of Decembrists and other exiles. There are the Kuznetsov Zabaikalsky Museum of Regional Studies and Archeology Museum. The State Central Museum of Mongolia holds a comprehensive and unique collection of artifacts offering an opportunity to learn about the country's natural history.

Theatrical life in the region is represented by a number of establishments. There are the Okhlopkov Academic Drama Theatre, Zagursky Musical Theatre, Puppet Theatre "Aistenok", Vampilov Youth Theatre. In the Republic of Buryatia there are the Buryat State Academic Opera and Ballet Theatre, steeped in tradition the Khotsa Namsaraev Buryat State Academic Drama Theatre, and the Bestuzhev State Russian Drama Theatre. In Chita there are the Zabaikalsky Regional Drama Theatre and Zabaikalsky Puppet Theater "Tridevyatoe Tsarstvo" ("Far Away Kingdom"). The famous Mongolian theatres include the State Academic Opera and Ballet Theatre and the Mongolian State Drama Theater (D. Natsagdorzh State Drama Theatre).

Libraries collect books and other publications andspecifically process them. They also promote and organize mass campaigns with readers. Libraries have different specializations and subject matters. There are libraries of the Ministry of Culture, schools, universities and colleges, departmental libraries, and so on. In Irkutsk there is the Molchanov-Sibirsky Irkutsk State Universal Scientific Library. In Ulan-Ude there is the National Library of Buryatia, which is a modern informational institution. In Chita there is the Pushkin Zabaikalsky Regional Universal Scientific Library. In Ulaanbaatar there is the State Public Library of Mongolia.

Irkutsk Academic Drama Theatre NP Okhlopkova.

Cinemas are designed to entertain the population. Modern cinemas also perform different forms of leisure functions. In Irkutsk, Ulaanbaatar, Ulan-Ude, and Chita, there are 15, 6, 5, and 4 cinemas, respectively.

There are circus in Irkutsk, Ulan-Ude, Ulaanbaatar and Chita. The Mongolian circus exists for more than 60 years and is the "Brand of Mongolia". It has a circus school.

EDUCATION (76)

Education is an important factor of economic and social development. An individual, her or his knowledge and skills, and the ability to make nonstandard decisions in a rapidly changing economic environment are the most valuable element of society. Educational services can become a lever that can push the economy to a qualitatively new stage of development.

Preschool education aims to support mental, personal, and physical development of children aged 2 to 8 years. Within the study area, there are 1,436 preschool educational institutions with about 237.6 thousand children [Federal…, National… 2012, 2013] [Federal…, National… 2012, 2013].

Secondary education gives children basic knowledge and skills. In the Baikal basin there are 1,412 secondary schools with about 637.5 thousand children.

In the Irkutsk part of the basin there are 206 kindergartens with 35,268 children and 182 secondary schools with 86,982 students. In the Republic of Buryatia there are 394 kindergartens with 45,007 children and 517 secondary schools with 123,362 students. In Zabaikalsky krai there are 150 kindergartens with 24,119 children and 187 secondary schools with 57,210 students [Federal…]. In Mongolia there are 685 kindergartens with 133,239 children and 523 secondary schools with 369,900 students [National… 2012, 2013].

Secondary vocational education aims to train practical specialists and mid-level employees for all industries. Today, there are 100 secondary vocational schools in the Russian part of the Baikal basin. In Mongolia, secondary vocational education is represented by 35 professional and technical schools.

Higher professional education (HPE) Higher professional education provides a set of systematic knowledge and practical skills that allow us solving theoretical and practical problems in the professional profile.

Higher professional education in the Russian territory of the Baikal basin is provided by 40 universities (state and private and their branches). In the Mongolian part, there are 29 state and 40 private universities, mostly located in the capital.

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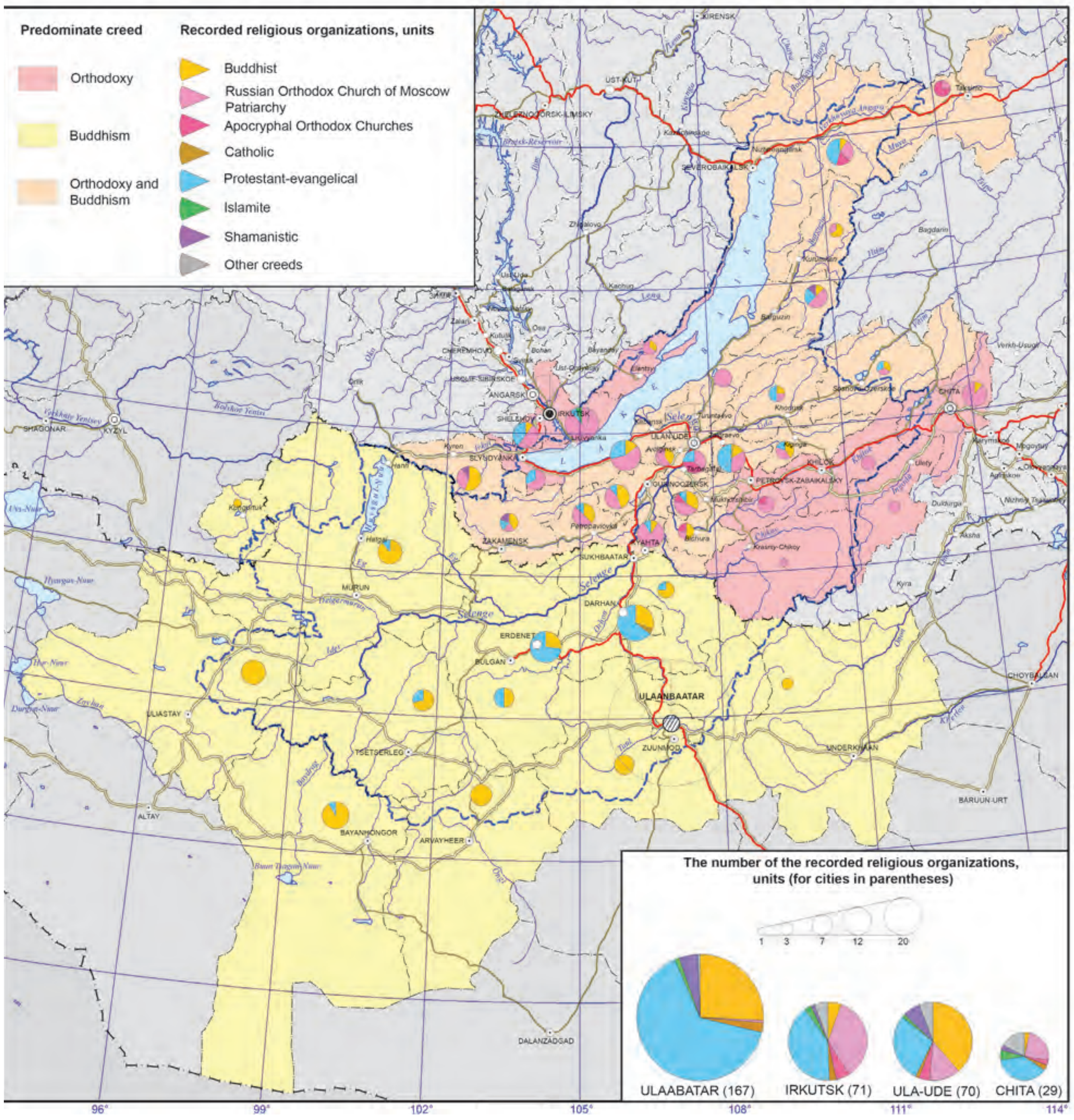
Irkutsk Musical Theater NM Zagurskiy.

77. RELIGION



RELIGION (77)

Traditional religions in the Baikal basin include Shamanism, Buddhism in the form of Lamaism, and Russian Orthodox Christianity. Current religious situation is, to a large measure, determined by political reforms that were carried out in Mongolia and Russia in the 1990s. Now, there are a plethora of religious denominations and practices.

The majority of the population is religious. In most cases, undecided and non-believers still associate themselves with a particular traditional religion. In Mongolia, for example, about 90% of the population identify themselves with Buddhism, while 6% - with Shamanism. On the other hand, according to the 2010 census, 61.4% of the population 15 years of age or older identified themselves as believers. Buddhists, Muslims, Shamanists, Christians and adherents of other religions constituted 53, 3, 3, 2, and <1%, respectively. In Buryatia, the most widespread self-identifications are with two religions: Buddhism and Russian Orthodox Christianity. In Zabaikalsky krai and Irkutsk oblast, the overwhelming majority of the people identify themselves as Russian Orthodox Christians, whereas Buddhism holds the lead in Tuva. According to the opinion poll data collected in 2012 by the Nonprofit Research Service "Sreda", the proportion of residents professing Buddhism in the aforementioned regions constituted, respectively, 20; 6; <1; 62; Christianity: 32; 32; 48; 2 (including Russian Orthodox: 27; 25; 41; 1), Islam: <1; <1; 7; ; <1; Shamanism: 2; <1; 1; 8; and other religions: <1; <1;<1; <1%.

Although religious organizations must register, there are some unregistered groups. They steadily grow in number with the fastest growth among Protestant and Evangelical groups.

The population is tolerant toward different religions. Contradictory and mixed religious views often coexist.

Buddhism in the Baikal basin (its concepts, rites, rituals, mythology, and spirits) was influenced by the religious customs that had existed before it was introducedin this region.

Buddhist monasteries take an important place in the social (and ecological) life. They organize the dialog with science and education. Not only Buddhist monks, but also secular specialists are invited to give lecturesat monasteries. Publishing is a major activity of monastic centers. Much attention is given to the formation and preservation of the cultural memory of the people, as well as to the issues related to the adjustment of the Buddhist teaching to current conditions and its further development, including among the ethnically Russian population.

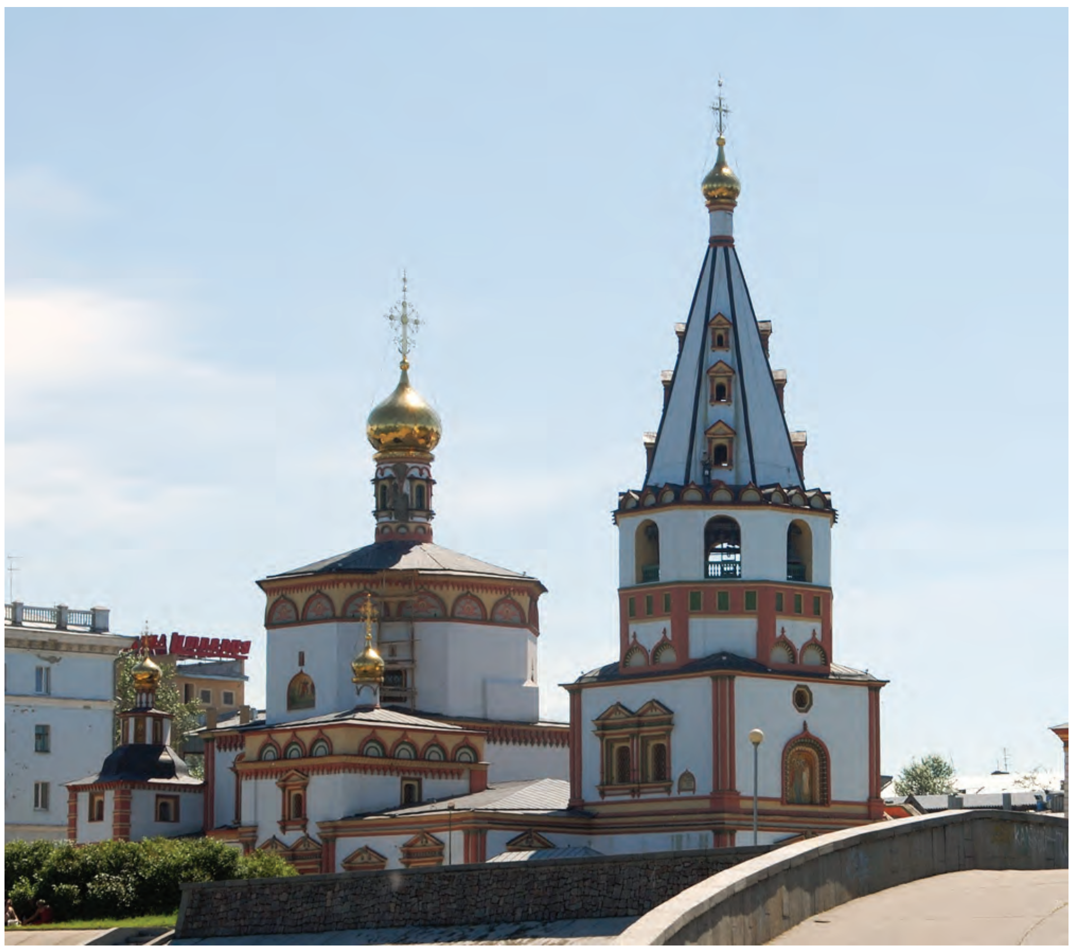
Christianity in the Russian part of the Baikal basin is mostly represented by the Russian OrthodoxChurch. In the Mongolian part of the basin, it is mainly Protestant and Evangelical organizations (90% Protestants, mainly Evangelicals and Baptists, 9% Mormons, 1% Catholics and Russian Orthodox believers).

Christianity views the resolution of environmental issues as a component of the ministerial and missionary services to God. According to the Bible, everything on Earth was created by God. Nature was created to satisfy human needs. However, it is not just a reservoir of resources for egoistic and irresponsible consumption, but a temple, in which an individual serves God. The individual is responsible for his/her thoughts and acts and must treat the nature with care. Life in all its different manifestations has a sacred character; its destruction or disturbance is a challenge to God.

According to Christianity, ecological problems are the consequences of egoistic and consumer impulses. Therefore, ecological activity will fail to reach the desired results, unless people begin to live by Christian commandments.

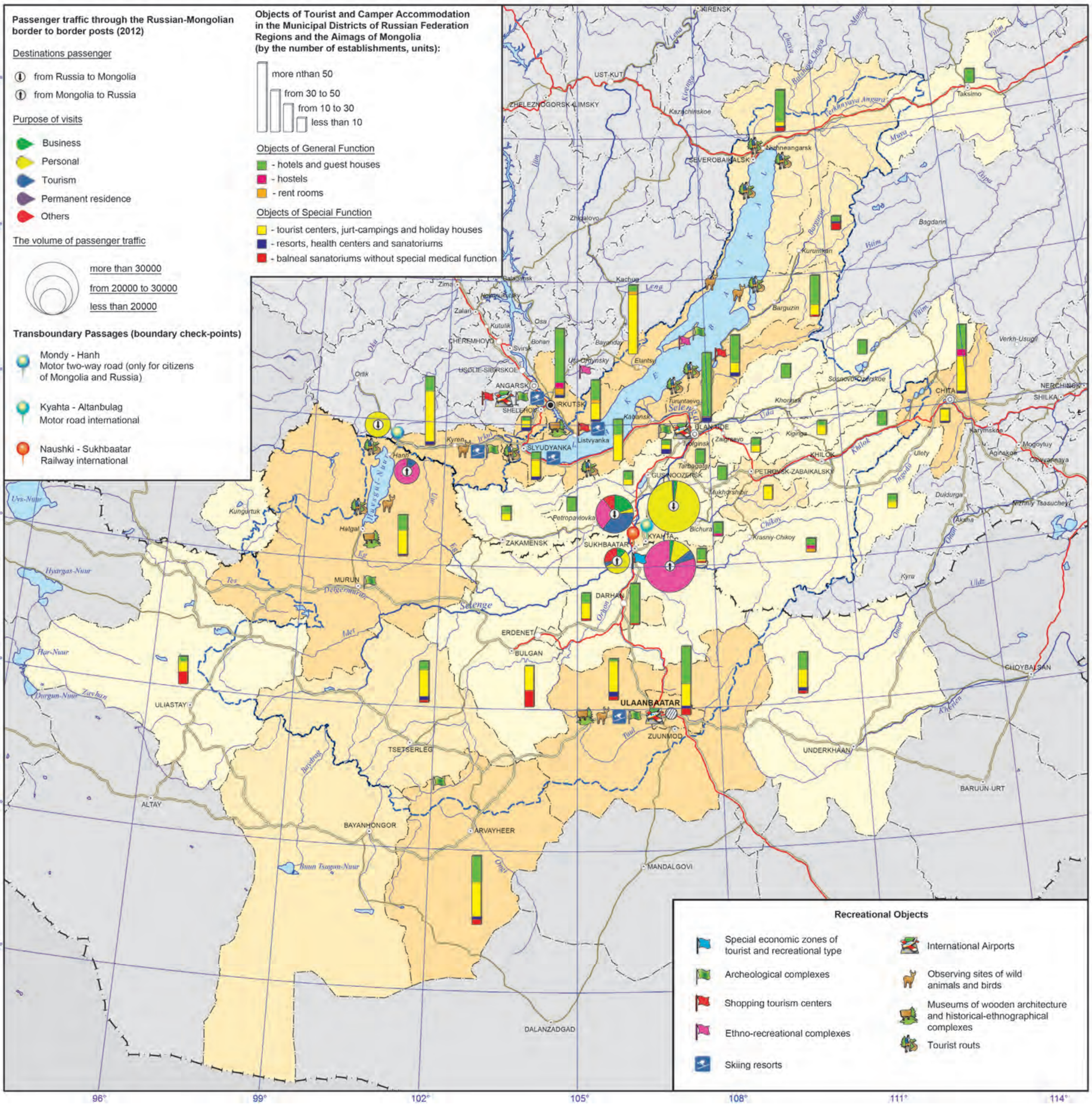
Islam (mostly Sunni Islam) has an ethnic character. In the Russian territory, the majority of Muslims are ethnic Tatars. In Mongolia, they are the not-so-numerous Kazakhs, Uzbeks, Uighurs, Tatars, and other Muslim ethnicities.

Kazan Church. Irkutsk



Epiphany Cathedral. Irkutsk

78. TOURISM



According to theQuran, the Man and the Nature are the great sacred creations of Allah. People are responsible for the preservation, purity, and beauty ofthe nature. All living beings on Earth are like the Man. Torturing them is absolutely prohibited. Any good done to an animal is equally beneficial as any good done to the Man. The efforts of the Man to do good to the nature is regarded as a virtue, which helps him or her gain blessings and Paradise in the future life.

Islam pays much attention to the improvement in the condition of Earth with human hands. It poses the question about the union of science and religion in dealing with environmental problems.

Shamanism is the oldest religion of Siberia and Central Asia. It is thought to be originated on Olkhon Island (on Lake Baikal), which is considered to be a sacred place. According to the concepts of Shamanism, there are three worlds: upper (heavenly), middle (terrestrial), and lower (subterranean). Nowadays, Shamanism also includes the followers of Tengrism, a global religion, which demonstrates a tendency towards a philosophical-metaphysical monotheism practiced by early nomadic communities in Mongolia.

A careful use of natural resources is basedon the cultural and religious traditions. Local natural sites play an important role in the concepts of the universe. Previously, Shamanism “served” the communal-tribal sphere, and each tribe and clan had their own sacred places, where rituals were conducted. In such places, they builtovoos and tied ribbons to tree branches.

The ecological concepts of other religions in the Baikal basin are also directed towards nature conservation.

According to all religions, the resolution of environmental problems must begin with the spiritual and moral improvement of human beings.

Criteria for evaluation			Entry tourist flows		
			International	National	Regional
			H	M	L
Dominanting accommodation facilities and tourist	Hotels, inns, motels and resorts with special medical care, special economic zones recreation	H	H	H	M
	Tourist centers, jurt-campings, holiday houses and tourist centers	M	H	M	L
	Private houses, campgrounds	L	M	L	L

H - High, M - Medium, L - Low

TOURISM (78)

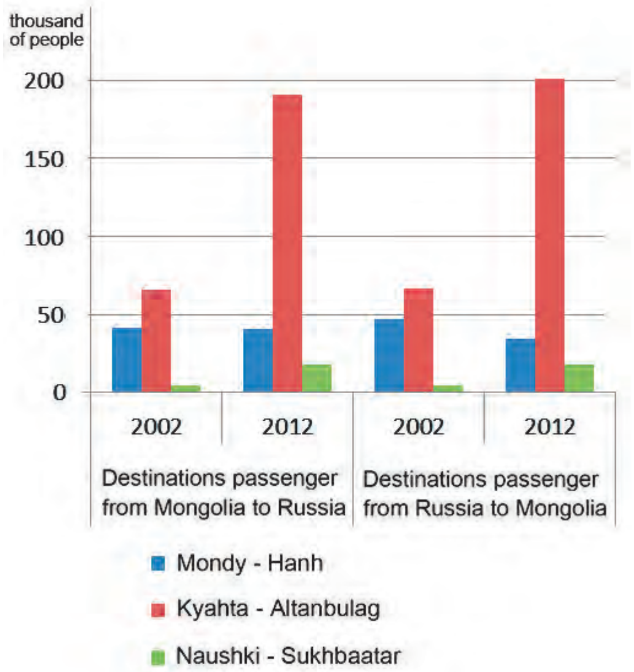
The Baikal basin is a unique area that draws attention of tourists from all over the world. Its location in the heart of the Eurasian landmass has defined its high ethno-cultural and natural diversity. The history of development of the lands around Baikal is connected with the rise of two giant empires – Mongolian and Russian, as well as with the historical development of trade and transport routes.

The natural and resource nucleus of the recreationalsystem of the Baikal basin is the oldest and deepest lake in the world itself. Infrastructural centers for tourism development are major cities of Ulaanbaatar, Irkutsk, and Ulan-Ude. They play the role of major international transport hubs and have administrative, educational, and cultural tourism resources, as well as a significant hospitality potential. In 2012, Ulaanbaatar had the largest hotel fund (over 170 hotels). There were about 80 hotels in Irkutsk and up to 20 in Ulan-Ude. In general, the transboundary area of the Baikal basin has over a thousand places for tourist accommodation of general and special purpose.

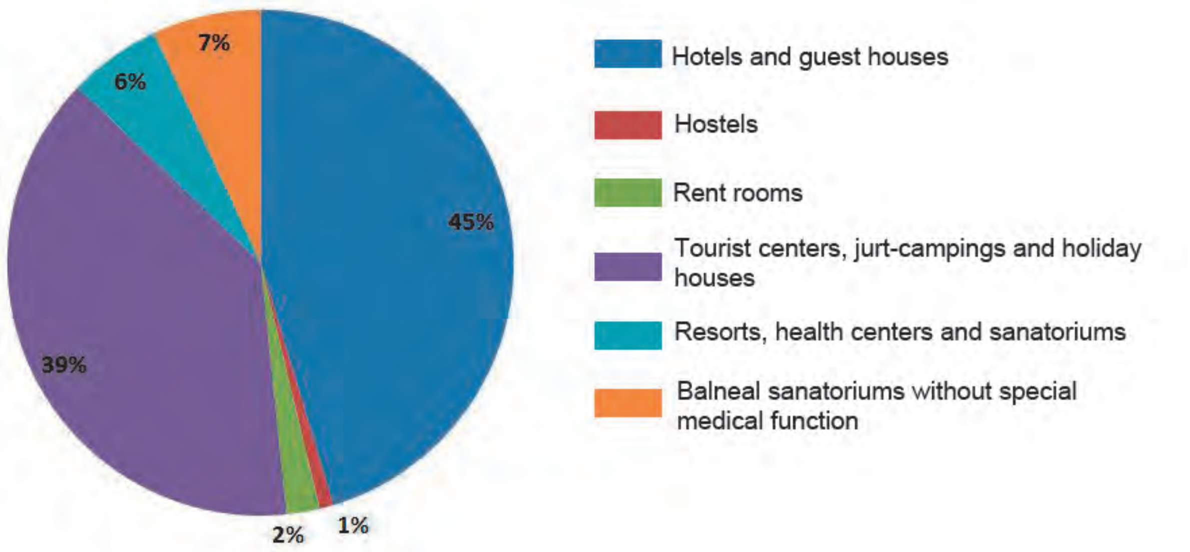
The number of accommodation facilities, as well as the level of offered services in conjunction with the configuration and nature of the tourist traffic help identify the most important areas for the tourism industry, assess the degree of tourism development, and get a general picture of a territorial structure of recreational activities. A matrix integrating the character of tourist traffic and a predominant type of accommodationwas used as the basis for the expert assessment of tourism development of administrative units of Russia and Mongolia.

The main distinctive characteristics of the recreational system of the Baikal basin is its transboundary position. Therefore, the neighboring aimags of Mongolia and administrative districts of Irkutsk oblast and the Republic of Buryatia that are located along the state border and have cross-border corridors (ports of entry) are of a special significance.

The process of development of cross-border tourism in the neighboring territories of Russia and Mongolia is taking place under conditions, where both countries with a unique culture and nature are an integral part of the international recreational space, have a special interest for tourists from other countries, and make mutual contribution to the formation of the inbound tourist traffic. The Russian-Mongolian border, which crosses the basin, has three checkpoints that not only facilitate the exchange of foreign and domestic tour groups, but alsoserve as a prerequisite for the development of cross-border trade. Within 10 years, the total volume of passenger traffic through the existing checkpoints has more than doubled – from 229 thousand people in 2002 to 502.5 thousand people in 2012.



Passenger traffic through the Russian-Mongolian border [Mongolian..., 2013; Mongolian ..., 2006]



Recreational accommodation facilities in the transboundary Baikal basin [Business of the Angara region…, 2012; Activities of tourism firms..., 2011; Culture, tourism, and recreation…, 2012; Tourism in Sunny Buryatia, 2011; Soyol ..., 2013]

Development of cross-border tourism requires joint decisions to promote a common tourism product on the state level. Such projects as “Baikal-Khovsgol”, which connects two great lakes of Asia, and “The Tea Road” have already become popular. The establishment of transboundary special protected areas have great prospects for the bilateral cooperation in the field of eco-tourism. They represent a particular organizational resource, which is important not only for the resolution of shared environmental problems, but also for the coordination of efforts aimed at implementing cross-border tourism projects.

Active cooperation between Russia and Mongolia in promoting tourism within the unique natural object – the Baikal basin not only opens the possibilities for increasing inbound foreign tourism in both countries, but also contributes to the expansion of similar relationships with other neighboring countries, such as China, Kazakhstan, and Japan.

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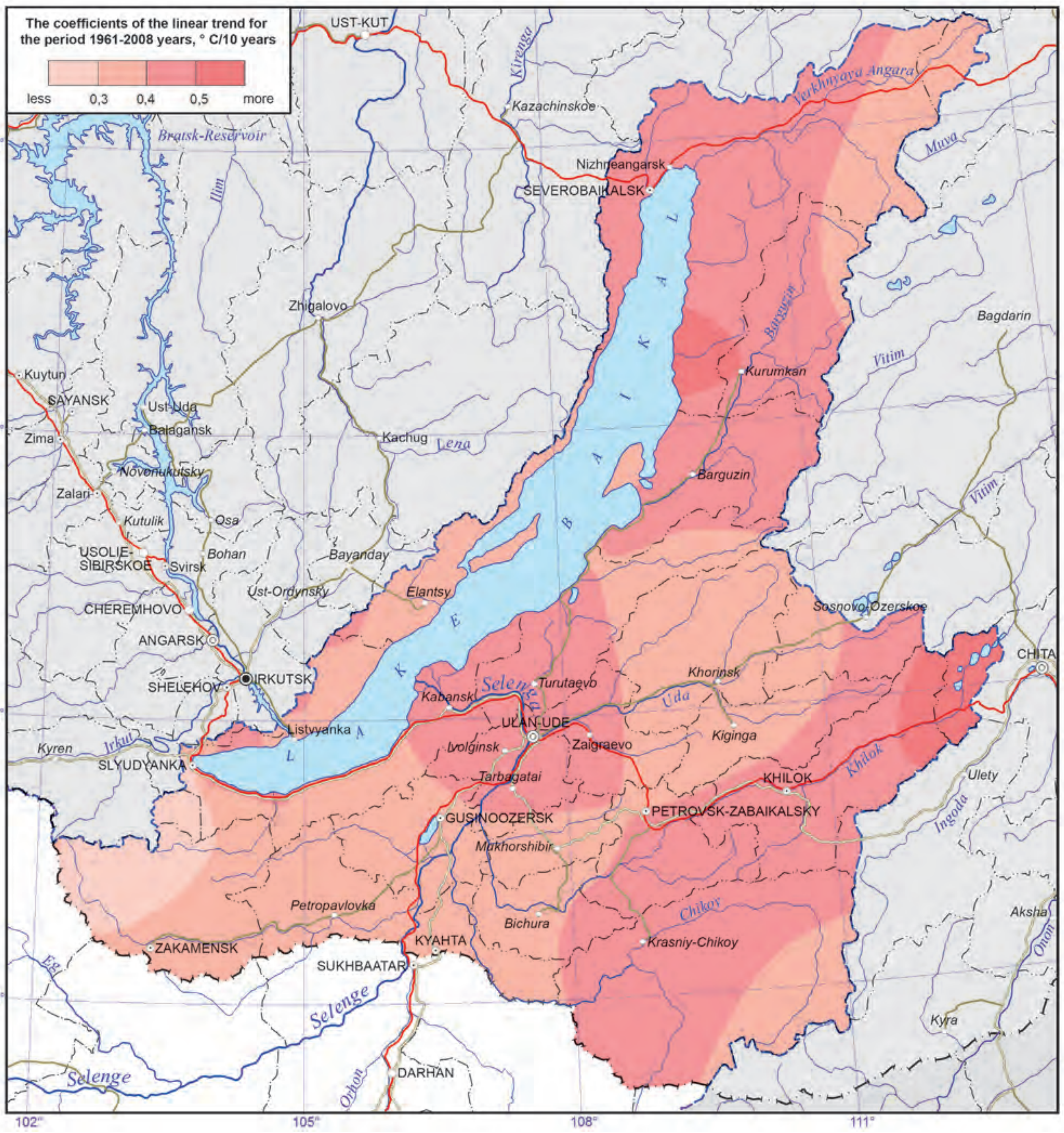
Hotel in Listvyanka

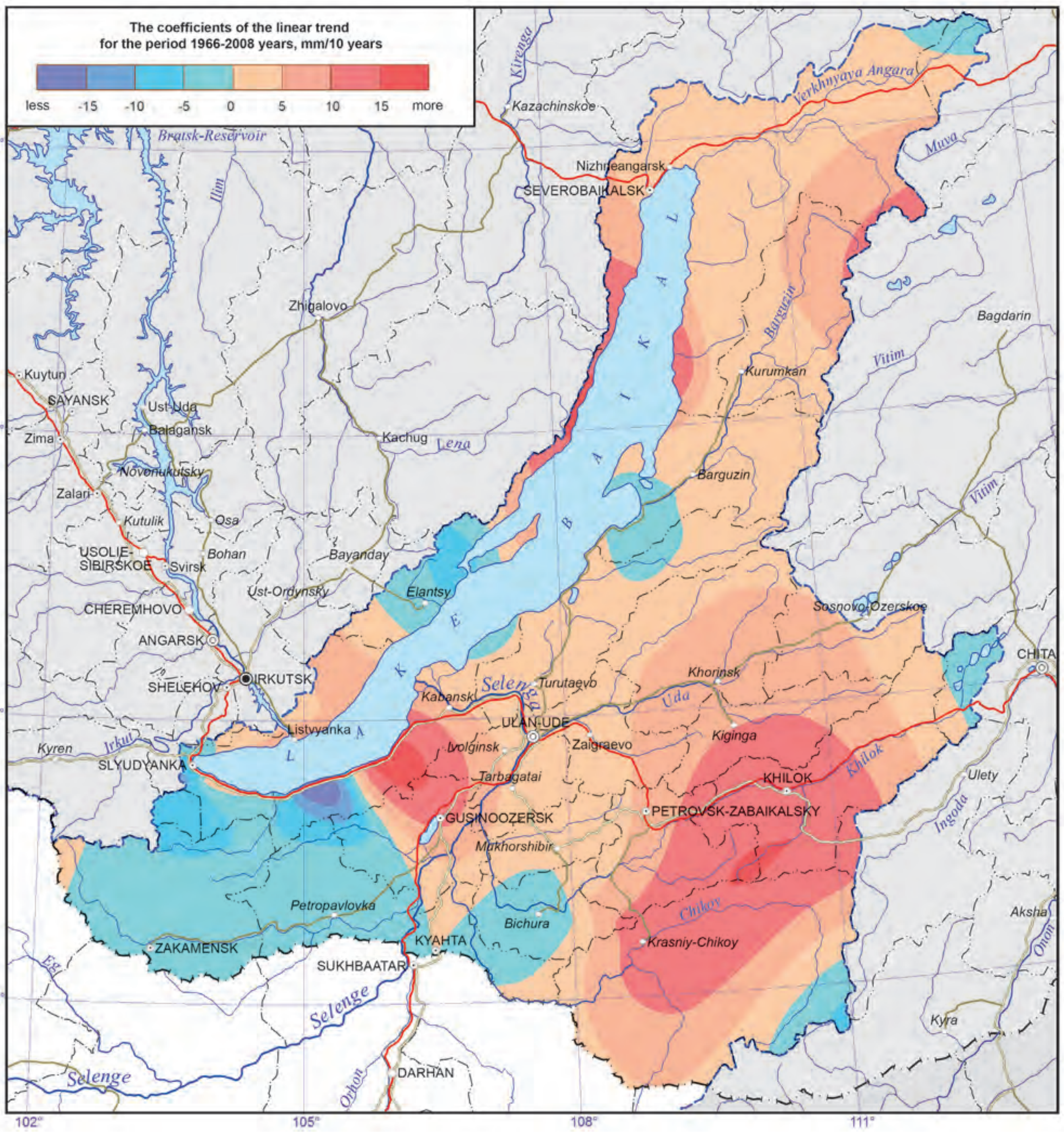
Camping at Lake Hovsgol

SECTION IV.
Environment transformation in the Baikal basin

79. TRENDS IN AIR TEMPERATURE



80. TRENDS IN RAINFALL



CLIMATIC CHANGES (79-80)

The ratio of a linear trend, which is determined by the least square technique and characterizes the average rate of the climatic variable corresponding to the trend, was used as a measure of intensity of climatic changes within a specified period of time.

Annual temperature of the lower layer of air is used to describe the current climatic changes. The physical sense of this climatic characteristic is determined by an almost linear dependence of longwave radiation coming from the top border of the atmosphere on the temperature of the lower air layer. Given this dependence, the assessment of the indicated temperature is largely analogous to the estimation of the average outgoing longwave radiation, which can be used to determine the speed of heating or cooling of the Earth's surface.

Annual temperature trend values in 1961-2008 were positive and ranged from 0.24° to 0.52° C/10 years, which is an order of magnitude higher than similar ratios calculated on the average for the Northern Hemisphere. Maximum values of the trend are observed in the north of the study area. One of the centers is located in the Barguzinsky reserve. This area (on the northeastern coast of Lake Baikal) is also interesting, as unlike other weather stations it has the same high trends throughout the year. The majority of these locations is characterized by the annual variation of the coefficients describing the linear trend of air temperature, with a peak in February and a minimum in the summer months. July has an asymmetric distribution of trend values. Although they are all statistically significant, their maximum clearly shifts to the territory of Zabaikalsky krai. The foothills of the Khamar-Daban (the Khamar-Daban station) and the upper Lena river (the Kachug station) can be called the local areas of minimal trends during all months of the year.

A quite different pattern is observed for the trends in annual precipitation. Positive trends take place approximately on the two thirds of the basin, where there are two places with maximum values exceeding 10-15 mm/10 years – in the basins of the rivers Khilok and Chikoy and in the town of Babushkin and its adjacent mountainous area. On the other hand, negative trends in precipitation with the gradient of -15 mm/ 10 years are observed in the most part of the Khamar-Daban mountain range, southern Buryatia, the Olkhon area, the coastal area of Barguzinsky Bay, and some other territories.

ATMOSPHERIC AIR CONDITION (81 — 86)

The atmospheric air deterioration in populated areas continues to be the result of:

1. Emissions from industrial enterprises:
   - – Due to the use of raw products with a high content of pollutants;
   - – Due to the substantial aging of equipment and/or absence of the waste treatment facilities;
   - – Due to breakdowns in technological processes, etc.
2. Vehicle emissions:
   - – Due to the growing number of motor vehicles including old cars;
   - – Due to poor technical condition of vehicles;
   - – Due to numerous traffic jams [On the sanitary and epidemiologic situation…, 2012].

Emissions from industrial enterprises and vehicles have a very high concentration of various pollutants, such as sulfur dioxide, dust, carbon oxide, nitrogen oxides, benzopyrene, methylmercaptan, and so on that enter the air basin from numerous sources. As a result of photochemical reactions with oxygen and hydrocarbons, these substances generate other pollutants. Therefore, the study of spatiotemporal volatility of air pollutants remains a topical issue. Moreover, it appears important to determine not only the way pollutants spread through the atmosphere around industrial centers, but also the way they distribute over reference areas, one of which being the Baikal basin.

The wind regime over the Baikal shores is composed of windblasts resulted from the macro-scale processes of general circulation and of local origin that include breezes, highland-valley circulation, and gravity windblasts. The basic large-scale windblast over the Baikal basin and its shores is the northwestern air-mass transport. However, under the influence of complex orographic conditions, some typical Baikal winds are also observed here. In the cold period of the year, off-shore winds along with a large-scale air transport are observed at the coast. In the warm period – onshore winds, which is common to seashores. This fact has an apparent impact on the spread of pollutants from industrial enterprises of Irkutsk oblast and the Republic of Buryatia.

Today, almost entire coastal territory of the lake is under a protected status aiming to preserve Lake Baikal and its surroundings. However, despite the existence of specially protected territories around the lake, industrial activity continues to negatively impact the lake's environment.

The main economic specialization of the Baikal Region is determined by its considerable fuel-and-power and primary natural resources. This fact stipulated the development of energy-intensive industries – ferrous and non-ferrous metallurgy, mining, chemical, wood-processing, pulp and paper, and fuel and energy industries. Enterprises of the above-listed industries emit such common pollutants as dust, channel black, sulfur and nitrogen oxides, heavy metals, etc. Moreover, every production has its own specific list of pollutants.

Atmospheric pollution in the basin of Lake Baikal was assessed using a numerically simulated model based on analytical calculations of the differential equation of the transmission and eddy mixing of pollutants. The characteristics of the area of the atmosphere polluted from anthropogenic sources were evaluated. In addition, the critical concentration excess zones (MPC daily average), as well as the duration of such excess in hours per month were determined.

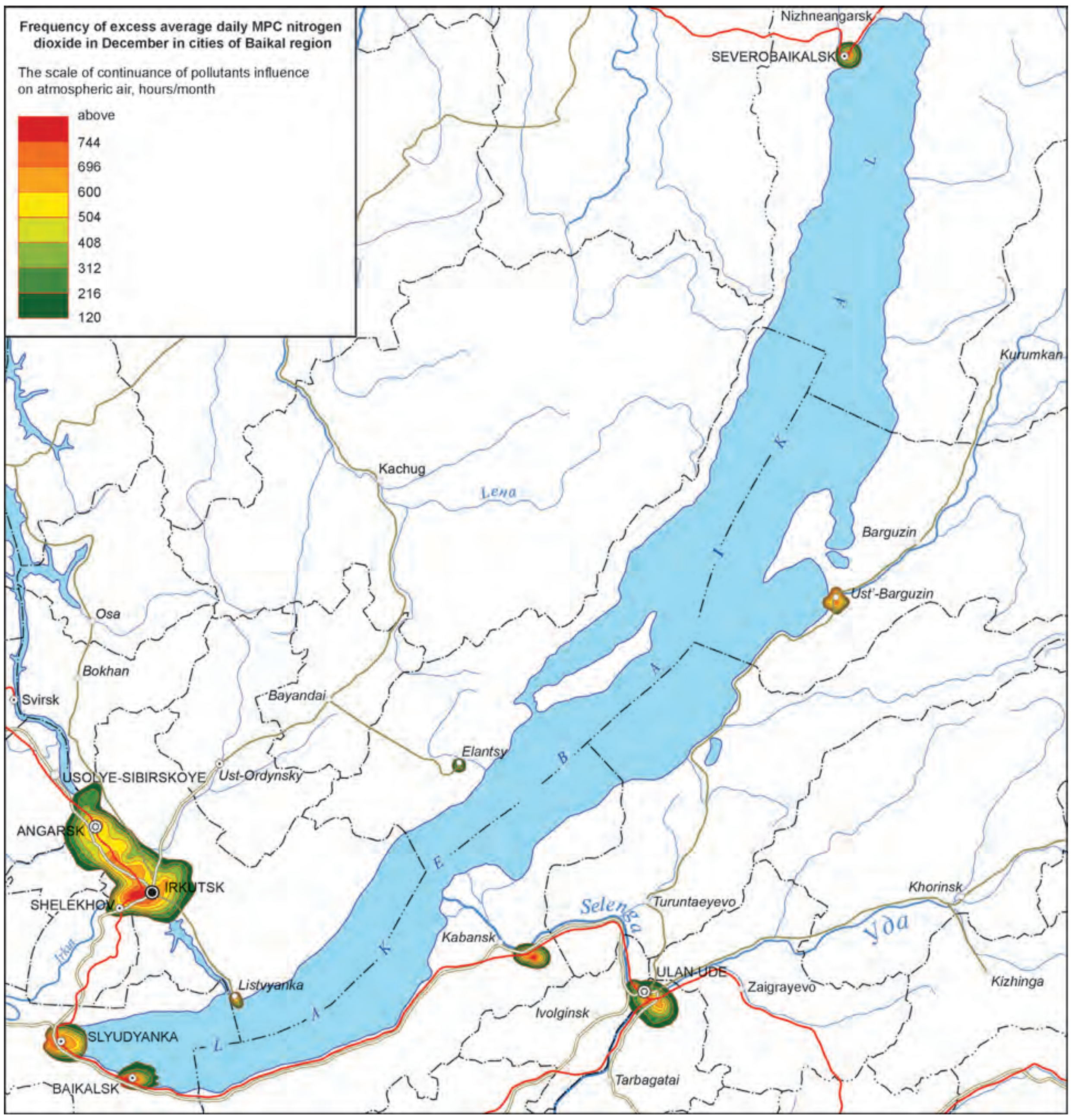
Inventory data on the parameters of the emission sources and long-term data of wind velocity and air temperature derived from daily weather observations conducted every 8 hours were used as input information for calculations to obtain statistically stable climatological characteristics.

The results demonstrate that the environmental situation in several settlements of the Baikal region does not meet the established standard (MPC daily average) for air quality. Furthermore, pollutants from industrial enterprises spread not only over the territory of the settlement, but go far beyond it.

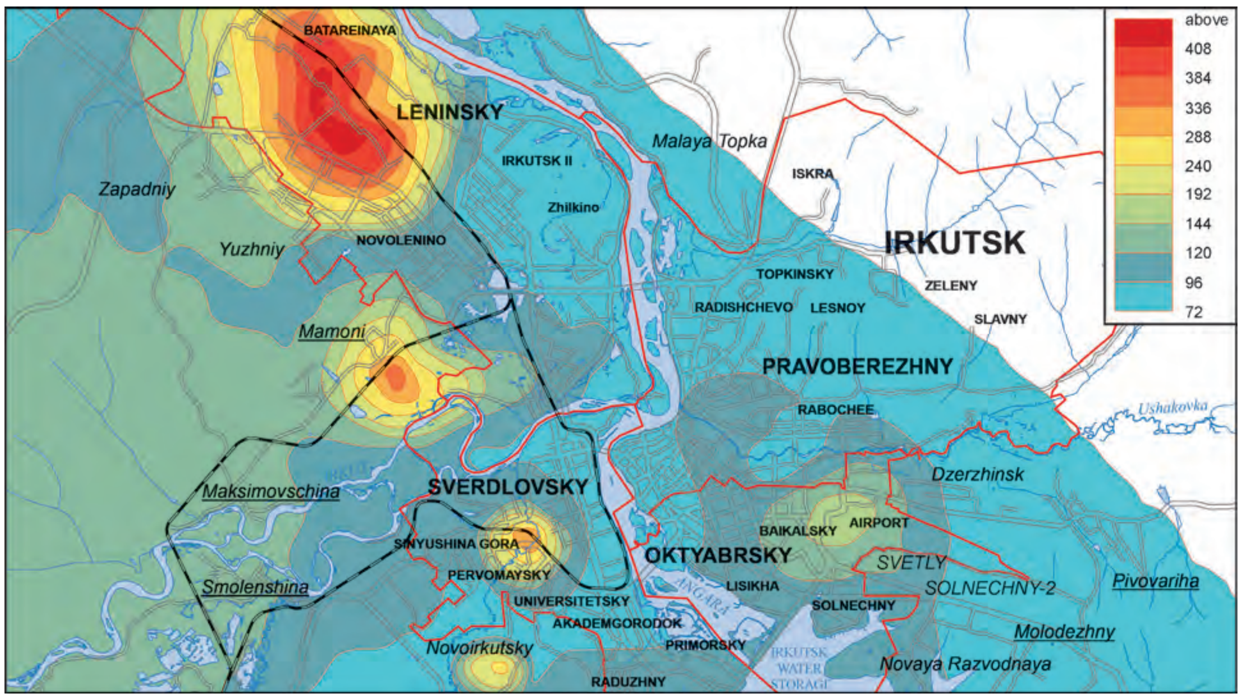
In Irkutsk, there are approximately 250 industrial enterprises with over 3,000 stationary anthropogenic air pollution sources. They emit 113 different pollutants and cause a high level of pollution. It is proved by the fact that for the past 10 years Irkutsk has been regularly listed as a top-priority Russian city with the highest level of air pollution. The main production enterprises contributing to the increase of the concentration of harmful substances are JSC "Irkutskenergo" (contributes about 52.9% of pollutants), JSC "Baikalenergo", and JSC "Irkut Corporation". It should be noted that the energy sector is the leading industry in terms of air pollution emissions accounting for 82.7% of the total emissions of pollutants into the atmosphere of Irkutsk [Akhtimankina, 2013]. According to the results of calculations, almost the whole territory of the city is affected by the concentration of air pollutants exceeding the established hygienic standards and reaching maximum values in the vicinity of emission sources. Especially difficult situation takes place in winter months.

The main stationary air pollution sources in Ulan-Ude are the city's Central Heating and Power Plant (CHHP)-1 and CHPP-2, Locomotive Repair Plant, Aviation Plant, as well as construction and food processing companies and other enterprises [On the state of …, 2009] that have about 2,000 point-source and distributed pollution sources. The fuel-and-power complex of Ulan-Ude emits almost half of the total volume of the citywide pollution. Combustion gases from cogeneration and boiler plants and other power facilities travel long distances with the prevailing winds (about several kilometers) contributing to the regional environmental pollution. However, the most harmful emissions in Ulan-Ude are those that settle on the territory in the immediate vicinity of the pollution sources within the area of the so-called intensive technogenic pollution. This risk is further compounded by the fact that the majority of the fuel-and-power enterprises are located near the densely populated areas of the city (e.g. CHPP-1). Together with flue gases from power plants, a great number of solid and gaseous pollutants, such as refuse burnout, carbon oxide, and sulfur and nitrogen dioxides also get into the air basin. Machine building enterprises emit dust, various acids and lye, nitriles and other compounds, phenol, methanol, polycyclic aromatic hydrocarbons, solvents vapors (toluene, xylol, paint thinner, benzene chloride, dichloroethane, spirits, acetates, etc.), ingredients of organic and inorganic fillers (salts and oxides of titanium, zinc, lead, chrome and other metals), as well as components of the film-forming agents (styrole, formaldehyde, etc.). Major contamination sources are galvanizing, paint, and foundry plants, galvanic and accumulator shops, repair workshops, etc [Imetkhenov, 2001]. The research has also demonstrated that the environmental situation in Ulan-Ude is unfavorable due to, on the one hand, the high level of technogenic stress, and, on the other, poor dissipative capacity of the atmosphere resulting in the long-lasting persistence of

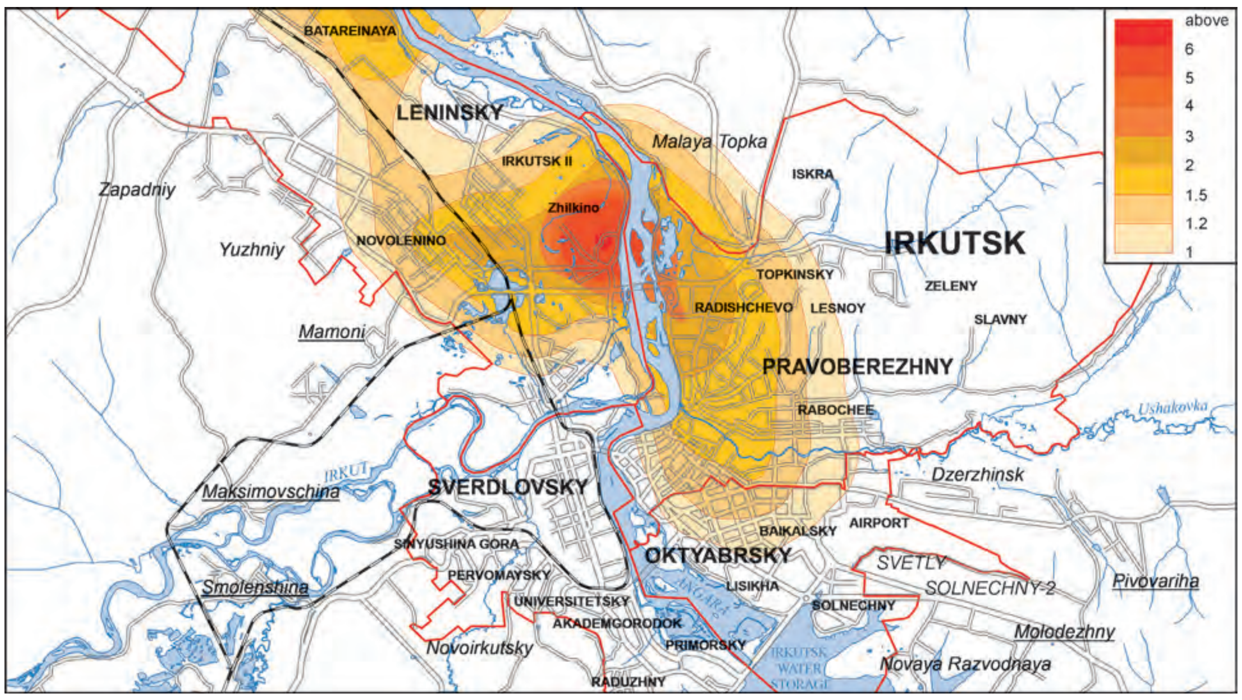
81. ATMOSPHERIC AIR CONDITION



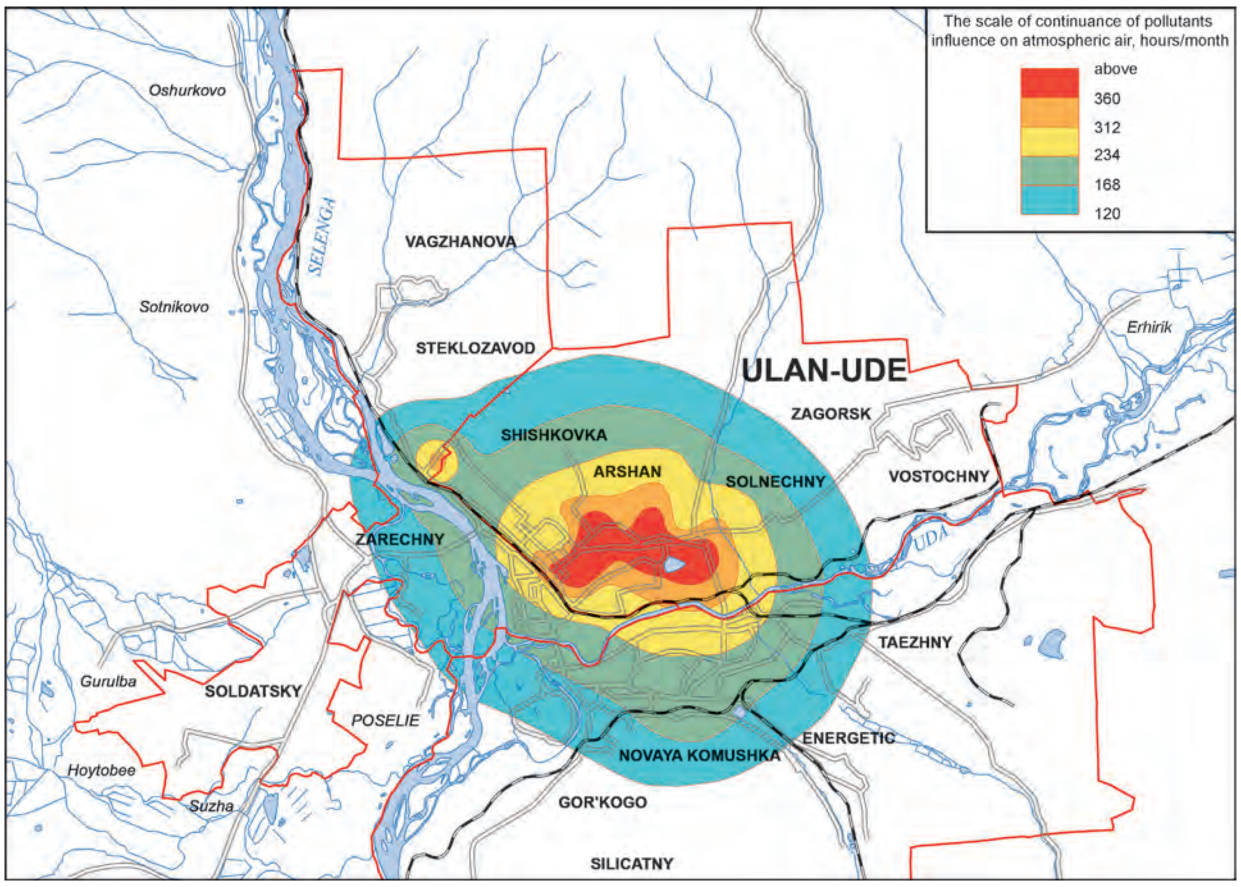
82. THE FREQUENCY OF EXCEEDING THE DAILY AVERAGE MPC NITROGEN DIOXIDE IN IRKUTSK IN DECEMBER



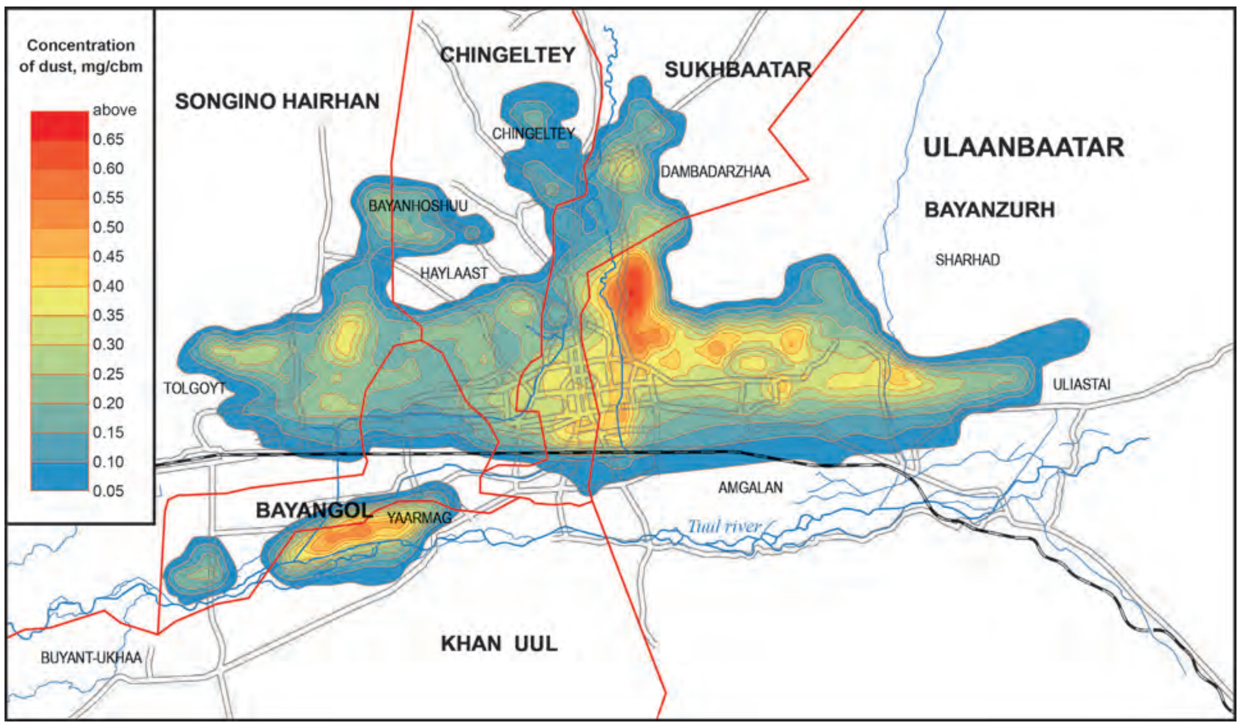
83. ISOLINES ABSOLUTE CONCENTRATIONS OF SOOT IN THE WINTER IN IRKUTSK



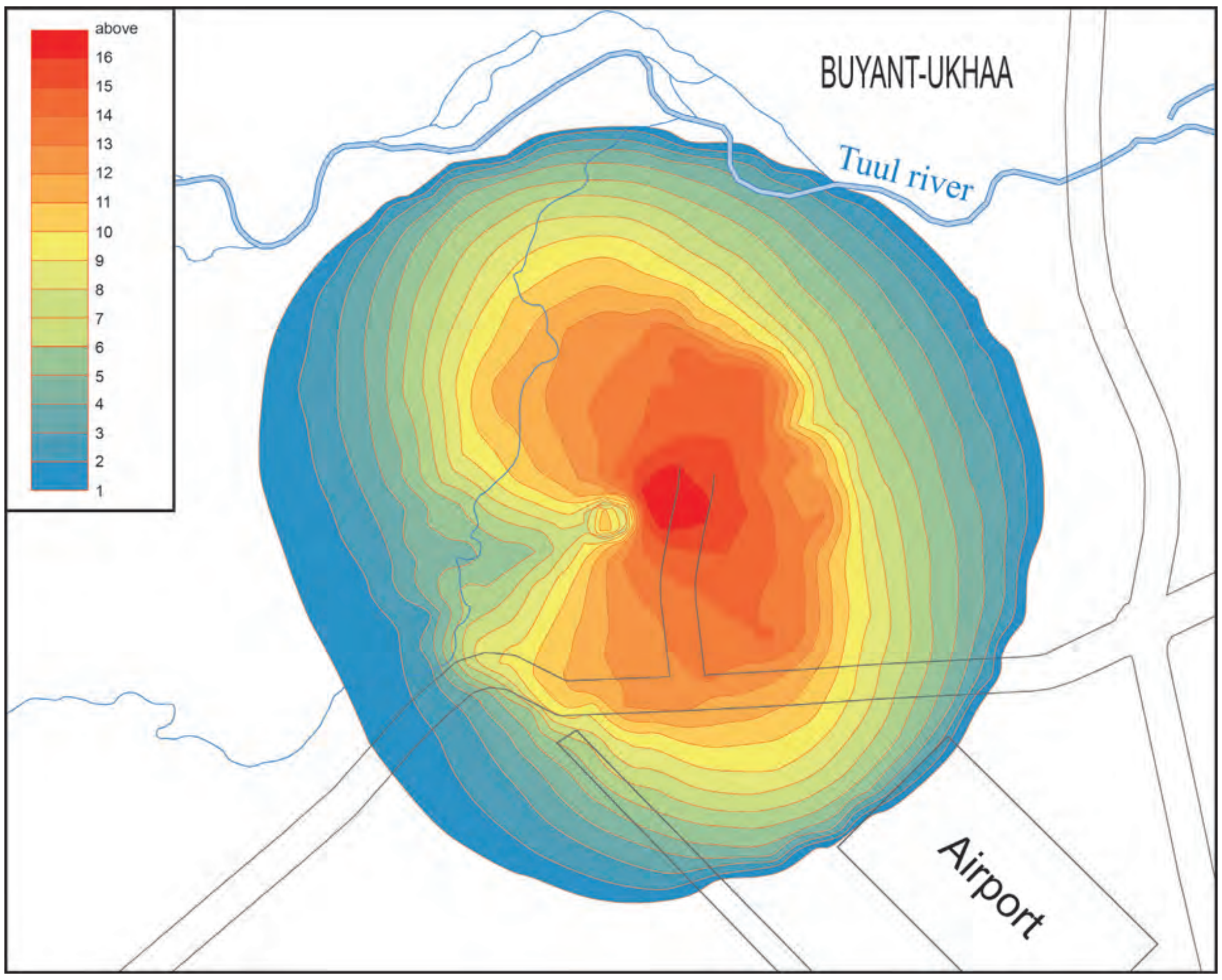
84. THE FREQUENCY OF EXCEEDING THE DAILY AVERAGE MPC NITROGEN DIOXIDE IN ULAN-UDE IN DECEMBER



85. ISOLINES CONCENTRATION (MG/M^3) DUST IN ULAN-BATOR WEST WIND AT 5 M/S



86. THE FREQUENCY OF EXCEEDING THE DAILY AVERAGE MPC DUST IN DECEMBER AT THE AIRPORT IN ULAN-BATOR



polluted air. The city's location in an intermountain basin contributes to the accumulation of industrial emissions.

In Ulaanbaatar, there are 860 areal sources of pollution that mostly represent household ovens [Arguchintseva, 2011]. According to the results of calculations, the highest level of air pollution was registered in the areas of concentration of gers (traditional mobile homes) that make up the entire northern part of the city and stretch from the west to the east from the center of Ulaanbaatar. Another high-level air pollution zone is situated on the southwestern edge of the city near Buyant-Ukhaa Airport, where there is a ger village. Here, the wind direction and relief facilitate the transmission of emissions towards the airport. Air emissions from heating in the ger village lead to the continuous excess of maximum permissible concentrations of pollutants in the area of the airport. Combined with unfavorable meteorological conditions, this means that the airport can experience difficulties with take-off and landing operations for almost half a month, which leads to risks and considerable financial losses due to the idling of aircrafts.

These data demonstrate that many settlements in the Baikal basin, especially large ones, have an unfavorable environmental situation, which undoubtedly affects the health of local communities. The population continuously living in the conditions of atmospheric pollution experiences an overall deterioration of health and higher disease incidence especially affecting the respiratory system.

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QUALITY OF SURFACE WATERS (87)

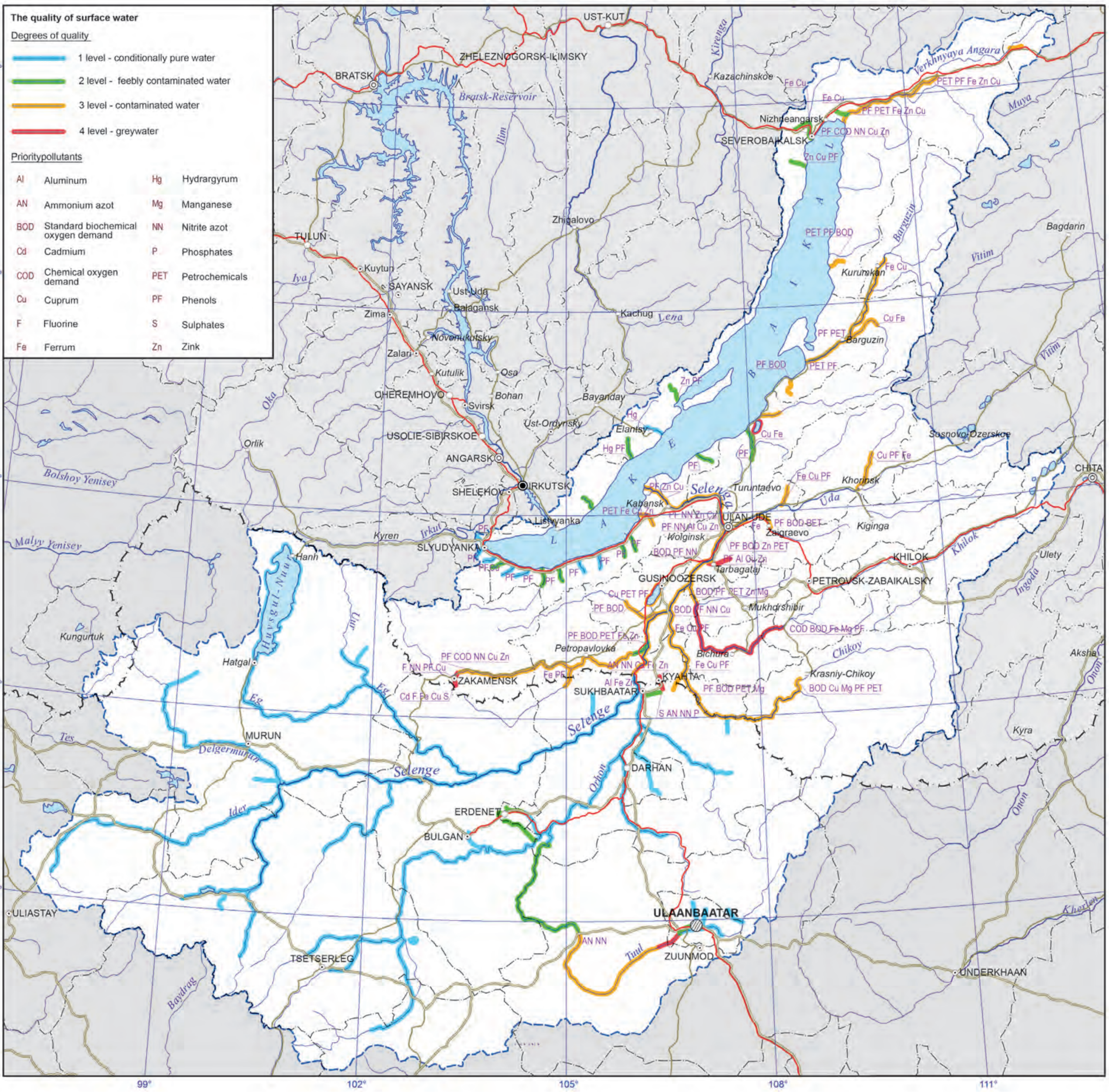
The quality of surface water depends on the combination of natural properties, conditions of self-purification of water bodies, and the input of contaminants from ambient environments. Hydrochemical and hydrobiological parameters are the main characteristics for water quality assessment. They are measured at the network of observations sites in accordance to a standard procedure, as well as by sanitary-epidemiological organizations and appropriate agencies.

Water quality is one of the main parameters of human activity, and it is strictly regulated in Russia and other countries. Exploitation of water bodies for different economic purposes is stipulated by several standards defining the list of chemical and biological elements in the water and their permissible concentrations. The water designated for household and recreational purposes has the strictest requirements to the water quality. The standards for water bodies designated for fisheries are less strict and used in comparative assessments of the quality of natural waters.

Qualitative characteristics of surface water summarised from the territorial reports are presented in the form of a map "Quality of surface water", whose scale and information fullness are determined by the size of the lake's catchment area. The original information for this map was taken from the governmental reports "On the state of Lake Baikal and measures for its protection" of the Republic of Buryatia and Irkutsk oblast'', Annual report on ''the quality of surface waters of the Russian Federation", and the data provided by Mongolian scientists [National …, 2011, 2012; National …, 2013; Annual …, 2012]. To assess the state of water bodies, a specific index of water pollution (SIWP) was calculated from the most common contaminants of surface waters (see Methodology Instructions RD 52.24 643-2002). Water quality was assessed using SIWP and, as a result, five classes (categories) of water quality were identified in the examined water objects.

The water quality in the basin of the Selenga (the largest tributary of Lake Baikal) on the territory of Mongolia was classified according to the procedure similar to the Russian one. The main list and standards

87. QUALITY OF SURFACE WATERS



of chemical elements (dissolved oxygen, suspended particles, acidity, etc.) are almost identical for both countries [The harmonised monitoring program…, 2012]. The final classification of water bodies of the Selenga basin on the Mongolian territory was based on the calculated values of the water pollution index [Davaa, http://fofj.org] and brought into conformity with Russian classification.

On the map, the water quality classes of water bodies are depicted by colored lines and supplemented by marks showing the places where samples of chemical elements that were the main pollutants for the given segment of the water body were taken. In the lake's catchment area, the integral characteristic of the quality of surface water varies over a wide range from "conditionally clean" to "dirty" preeminently due to the different levels of economic development of the region.

The major part of the lake catchment area belongs to the Selenga basin; the upper and central parts of the river are in Mongolia. The Selenga and a number of its large tributaries mainly cross underdeveloped territories and are not subject to significant pollution. The main large rivers of this area (the Delger-Muren, Ider, Orkhon, and Selenga) are characterized by high environmental indicators and practically pure (Class 1). The water in some areas of the hydrographic network of these streams that are adjacent to developed regions and subject to anthropogenic effect belong to Class 2 ("slightly polluted"). The Tuul river experiencing a severe anthropogenic impact (around Ulaanbaatar) significantly differs from other streams on the Mongolian territory: its surface water quality is classified as Class 4 ("dirty"). The main pollutants of this river are ammonium and nitrite nitrogen, phosphate, and sulphate. However, due to its self-purification processes occurring in the mouth area at the confluence with the Orkhon river the Tuul river water recovers to Class 1. The water in the Khiagt river on the northern border of Mongolia is also of low quality. This river brings its Class 4 waters to the territory of Buryatia (the Kyakhtinka river). Relatively low characteristics of the water quality (Classes 2 and 3) are recorded in some developed areas – in the Khangol (the town of Erdenet) and Orkhon (the town of Sukhbaatar) rivers.

Up to the confluence with the Orkhon, the water quality of the Selenga in Mongolia is regarded as Classes 1 and 2. Further, below Sukhbaatar and the Orkhon's mouth, the Selenga crosses the border to Russia. In Buryatia, its water quality is classified as Class 3 ("polluted"). The main pollutants of the river at the cross-section of Naushki are compounds of aluminium, iron and copper, the values of which exceed maximum permissible concentrations. Furtheron, the Dzhida river (together with the Modonkul river – Class 4) and the Kyakhtinka river (Class 4) join the Selenga. The first one is affected by the discharges of mine and drainage waters from the non-functional company JSC "Dzhida Combine", while the second one contains elevated maximum permissible concentrations of 11 elements due to the transboundary transfer (the Khiagt river).

Large tributaries of the Selenga joining this river downstream bring polluted waters of Class 3. The most unfavourable situation is observed at some sites of the rivers Kuitunka, Chikoy, Khilok, and Uda, whose water quality is regarded as "polluted". The main pollutants are different forms of nitrogen, organic substances, and phenol. The water in the lower Selenga is characterised as Class 3.

The quality of surface water in other largest tributaries of Lake Baikal is also low. Such large rivers as the Upper Angara, Barguzin and Turka have polluted waters of Class 3, whilst the water in smaller rivers such as the Tiya, Kholodnaya, Kika, Snezhnaya, Utulik, Buguldeika, and other are of Class 2. Phenols in combination with oil products, zinc, copper, and organic substances are typical contaminants of these rivers.

There is a scarce information on water quality in the lakes located on the examined territory as no monitoring has been conducted there. The exception is Lake Gusinoe, whose water quality is of Class 3 ("polluted"). The main pollutants of this lake are phenols, oil products, copper, and other substances. Moreover, the lake is subject to thermal pollution from the Gusinoozerskaya Thermal Power Plant. Another water body, Lake Kotokel, located within the Baikal basin has a very low water quality. The use of its water is prohibited for any purposes, except for technical use, which is confirmed by Decree No. 4 "On the Initiation of Restrictive Measures at Lake Kotokel" of the Chief Sanitary Inspector of the Republic of Buryatia, dated June 6, 2009, [On the state of …, 2013].

It should be noted that against the backdrop of the increased water discharge into water bodies of this territory in 2012, there is a trend of significant improvement of surface water quality of the Baikal basin. The water quality indicators in the majority of water bodies have been improved by 1-2 classes as compared to 2011 and previous years (On the state of …, 2012, 2013; Annual report …, 2012).

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ENVIRONMENTAL IMPACT OF MINING INDUSTRY (88)

Mining industry is one of the sectors strongly and comprehensively affecting the environment. The intensive use of land lots for mining mineral resources leads to the destruction of the surface ground layer, creation of mining openings, disturbance of the hydrological regime of rivers, soil and surface and underground water pollution, and destruction of the environmental integrity and natural landscapes.

The importance of mining industry for Siberia and Mongolia is explained by their mineral resources specialization. Within the context of transitioning to sustainable (balanced) development, the high cost-effectiveness of the mining industry along with environmental compliance and the increase of social and living standards of the population are especially important.

This map reflecting the impact of mining on the environment was created to reveal the ecological component of sustainable development in the Baikal basin.

In the process of creating this map, the following library and published data were used: "National atlas of the Mongolian People's Republic" (1990), "The ecological and geographic map of the Russian Federation" (1996), "Atlas of social and economic development of Russia" (2009), and "National atlas of Mongolia" (2009), etc. High-resolution satellite images (made in 2010-2013) were deciphered and used to examine the landscape structure of the territory. The state of the industrial sector and environment in the areas of mineral resources management was determined.

The objects of ecological evaluation were mineral deposits and mining enterprises. The information about them is provided on the basic maps that are part of this Atlas: "Fuel-energy resources and their development", "Resources of ferrous, non-ferrous, and rare metals and their extraction", "Basic types of nonmetallic materials, resources, and development".

The biggest part of the researched area is part of the central and buffer zones of the Baikal Natural Territory within the Russian Federation. The Baikal basin in Mongolia is a natural continuation of this buffer zone. According to the Russian law "On the Protection of Lake Baikal", the ecological zoning of the Baikal Natural Territory is the main tool for its implementation. Specific conservation restrictions are applied in the central ecological zone surrounding the Lake Baikal depression. Among the types of activities prohibited in this zone are the extraction of crude oil, natural gas, and radioactive and metal ores and the exploration and mining of previously undeveloped new deposits. The extraction of mineral resources within the water area of Baikal, in its water-protection zone, and in spawning rivers and their water-protection zones is prohibited.

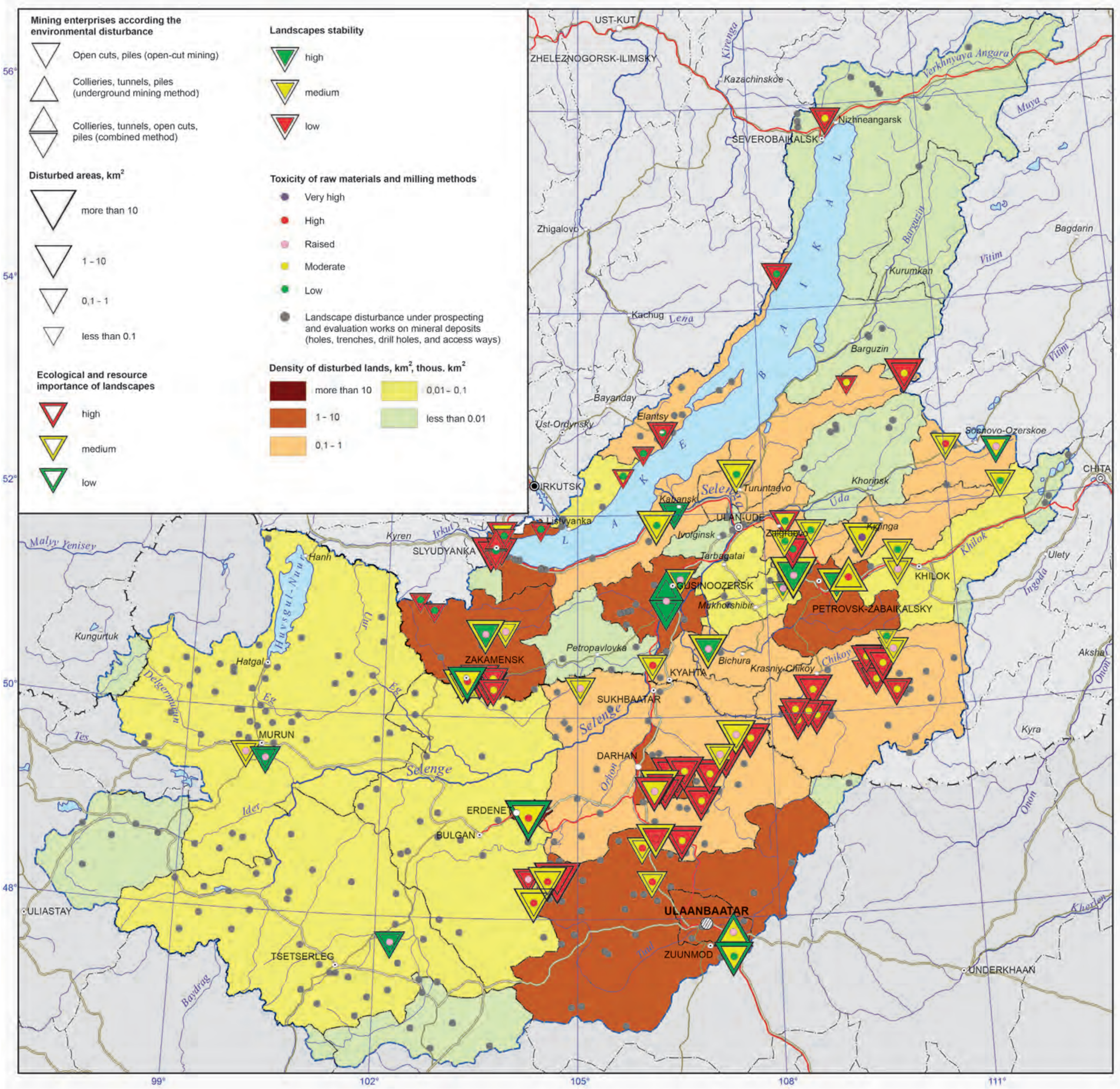
In the buffer zone, the prospected and prepared for the development deposits, as well as mining operations are located within the ecological districts of Type 6, which

The nature of soil degradation at the Gusinoozersk brown coal field: open pits filled with water and waste rock dumps.

Technogenic damages to the Tuul valley landscapes at a placer gold mine.

Boroo gold mine: open pit is in the southwestern part of the photo, tailings pond is in the northeastern part of the photo.

88. ENVIRONMENTAL IMPACT OF MINING INDUSTRY



Production and social infrastructure facilities at the copper molybdenum deposit Erdenetiyn Ovoo. There is a tailings pond in the northern part of the photo. The open pit is shown in the southern part, while production and residential zones – in the southwest.

includes industrial districts with a regulated intensive development. This type of districts is characterized by highly valuable landscapes and their components with an average or low sensitivity to stress. They mostly include the valley, piedmont, steppe and sub-taiga landscapes. The reason for singling out these districts is the importance of mining for the economy of the region. However, mining operations should not negatively affect the ecological system of Lake Baikal.

The cartographic evaluation of the technogenic disturbances of landscapes within the studied territories is provided for 380 mineral deposits. At present, 75 deposits are being developed. At 12 deposits mining operations are suspended, and they are either mothballed or turned into reserves. The impact of mining enterprises on the environment is primarily determined by mining methods, the toxicity of raw materials and reagents used in processing, and landscape features.

The maximum impact on the environment, which is manifested in the drastic transformation of the relief with the formation of the technogenic denudation and accumulated forms, is caused by open-pit mining operations that remain a preferred mining method in the majority of cases due to economic considerations. On the territory under observation, 73 deposits are being developed by the open-pit mining method, and only 2 deposits are developed by the underground mining methods (the Bom-Gorkhon tungsten deposit and Nalaikh brown coal deposit). The main indicator

Natural differentiation of the territory and the potential threat of pollution to the soil

Natural region	Natural province	Soils	Geochemical classes	Intensity of material migration	Potential threat of technogenic and chemical pollution
South Siberian	East Sayan mountain taiga	Soddy-podzolic soils, illuvial ferrous podzol, podzolized brown soil, coarse humus, incl. mold humus	Transitional from acidic to calcium coupled with acid [H-Ca] with [H]	Contrast (from moderate to high)	From moderate to weak
	Khamar Daban-South Baikal mid-mountain taiga, forest-steppe, and mountain-depression and steppe	Brown soil, soddy brown soil, coarse humus brown soils, podzol, cryogenic soils, lithogenic soils, carbon lithogenic mold humus, gray metamorphic black soils, black soil-like, quasi-gley black soils, chestnut soils, light humus, alluvial soils with patchy solonetz and salt marshes	Acidic, transitional from acidic to calcium, ferrous oxide, calcium, patchy solonetz and salt marsh [H, H-Ca, O-Fe], [Ca], and [Ca-Na-Cl, SO]	Contrast (from weak to high)	From strong to weak
Baikal-Dzhugdzhur	Baikal mid-mountain, piedmont, low-mountain mid-taiga	Peat-brown soils, brown soils (incl. podzolized brown soils), coarse humus brown soils, soddy brown, soddy-podzolic and chestnut soils	Calcium and transitional from acidic to calcium [Ca, H-Ca]	Medium	Medium
	Baikal-Dzhugdzhur high-mountain and mid-taiga, depression and valley	Typical brown and coarse humus brown soils, soddy brown, podzolic soils, soddy-podzolic (gley) soils, podzolic, coarse humus brown soils, lithogenic soils, petrogenic soils, carbon-lithogenic mold humus soils, gley soils, peat- eutrophic soils, alluvial, chestnut and gray metamorphic soils	Acidic and ferrous oxide, partially transitional from acidic to calcium [H, O-Fe], [H-Ca]	Intensive	Very weak
Khangai	Khovsgol high-mountain-depression	Cryo-lithogenic coarse humus soils, cryo-lithogenic mold and dark humus soils, dark humus lithogenic soils, cryogenic soils, soddy-brown soils, dark humus, patchy mountain dark-chestnut thin rank soils, alluvial, humus-hydro-metamorphic and peat-eutrophic soils	Calcium and transitional from acidic to calcium [Ca, H-Ca]	High and medium	Weak and medium
	Khentei high-, mid-, and low-mountain, mountain and valley	Cryogenic soils, cryo-lithogenic coarse humus soils,soddy-brown soils, dark humus, mountain dark-chestnut thin rank soils, dark humus metamorphic soils, mountain black disperse -carbon thin rank soils with dark-chestnut, alluvial, and patchy peat-eutrophic soils	Calcium and transitional from acidic to calcium [Ca, H-Ca]	Medium	Medium
	Khangai high- and mid-mountain taiga, mountain and valley, sporadically forest-steppe	Cryo-lithogenic mold-dark humus soils, cryo-lithogenic coarse humus soils, dark humus lithogenic soils, cryogenic soils, soddy-brown soils, mountain dark-chestnut thin rank soils, mountain black disperse-carbon thin rank soils, dark-chestnut, chestnut, and chestnut hydro-metamorphic soils, dark humus, black soils, mold hydro-metamorphic soils (incl. saline), humus hydro-metamorphic (incl. saline), peat-eutrophic and alluvial	Acidic and ferrous oxide, partially transitional from acidic to calcium [H, O-Fe], [H-Ca]	Intensive	Very weak
	Orkhon-Tuul forest-steppe and steppe	Dark chestnut, mountain dark chestnut thin rank soils, mountain black disperse-carbon thin rank soils, chestnut, dark-chestnut, and chestnut hydro-metamorphic soils, dark humus, humus hydro-metamorphic (incl. saline), mold hydro-metamorphic soils (incl. saline), peat-eutrophic, alluvial, windblown sands, patchy solonetz and salt marshes	Calcium and transitional from acidic to calcium, patchy solonetz and salt marsh [Ca, H-Ca], Ca-Na-Cl, SO_1]	Contrast (from weak to high)	Very weak

Degree of degradation of agricultural soils

	Diagnostic symptoms of soil degradation of ploughlands	Diagnostic symptoms of degradation of pasture soil environment	Soil erosion of ploughlands and pastures, % of the total area of agricultural lands	Degree of degradation of agricultural soils
	All genetic horizons of soils are preserved in the soil profile	Small soil compaction within the background, reducing the productivity of below-ground biomass to 1.6 times	< 10	Low
	Low-lying genetic horizons of the upper part of the profile (agri-soils, agri-black soils etc.) are preserved under the plough layer.	Soil compaction to 1.21 g / cm^3, a decrease in below-ground biomass to 5 times	10-25	Moderate
	Deeply transformed soils. There are transformed genetic horizons or rock (agri-soil) in their profile under the plough level.	Soil compaction to 1.46 g / cm^3, the destruction of the sod horizon, below-ground biomass decrease up to 22 times	> 25	High

The degree of excess over the maximum permissible concentration (MPC) of toxic substances in soil

a) Urban areas
b) Settlements

- 1-10 MPC
a) b)

- Lands damaged by mining (open pits, waste piles, dumps, and so on)

Borders

Regions
Provinces
Agricultural lands

of technogenic impact on the lithosphere is the area of disturbed land in square km, which is assessed using the following grades: I – over 10 km^2 – the strongest impact, II – 1-10 km^2 – strong impact, III – 0.1-1 km^2 – moderate impact, IV – less than 0.1 km^2 – weak impact. The largest disturbed land areas have been formed as a result of mining operations at the deposits of Erdenetiyn ovoo, Gusinoozersky, and Olon-Shibirskoe.

Sizable areas of disturbed lands in river valleys form due to the placer gold mining, which results in the intensification of erosion, change of structure and productivity of floodplains, pollution and deformation of riverbeds, decrease of groundwater level, and destruction of biotic components of ecosystems. On the surveyed territory, there are about 30 sites, where placer gold is being mined. Nearly all of them are located in the mountain river valleys of the Krasny Chikoy and Zakamensk district and the Selenge and Tov aimags. The maximum size of the disturbed land (about 40 sq. km) was found in the Tuul river valley.

At the undeveloped deposits, the main source of the impact on the lithosphere are exploration works, including the development of drill holes and trenches, drilling, construction and exploitation of temporary roads and settlements. The area of such disturbances is relatively small and conventionally accepted as 0.01 sq. km.

The background indicator of technogenic disturbances of lands is the density (prevalence) of disturbances. This indicator is determined as a ratio of the total area of the disturbed land in an administrative district to the total area of this district. The following grades of disturbance are used (sq. km / thou. sq. km): I – over 10 – very high, II – 1.0 to 10 – high, III – 0.1 to 1.0 –intermediate, IV – 0.01 to 0.1 – low, V – less than 0.01 – lowest. Using this scale, the following aimags and districts have been classified as territories with a very high and high levels of land disturbance: the Orkhon, Darkhan-Uul, and Tuv aimags, Ulaanbaatar, the Petrovsk-Zabaikalsky, Zakamensky, Slyudyansky and Selenginsky districts.

At several operating mines, such as Olon-Shibirsky (coal), Tumurtolgoy (iron), Erdenetiyn ovoo (copper, molybdenum), Bom-Gorkhon (tungsten), Boroo (gold), etc., the extracted mineral resources undergo primary processing. In order to store or bury tailings, tailings ponds and dumps are created. If built without paying due attention to filtering and other factors, they pose environmental risks and become the source of contamination of surface and ground water, as well as the atmosphere (dust). The most serious environmental consequences are found at the tailings ponds of the Erdenet Mining Company, Dzhidinsky tungsten-molybdenum mill (now shut down) and Kyakhta mill (currently not operating).

Extracted raw materials and enrichment products are classified into five categories of toxicity according to the degree of their ecological risk: I – very high: rare metal and radioactive ores, II – high: ores of nonferrous and precious metals, fluorite, III – increased: coal and brown coal, iron ores, IV – moderate: placer gold and tungsten, V – low: nonmetallic raw materials.

For every mining enterprise, environmental components (nature, economy, and people's health) are differentiated by the degree of technogenic impact.

A negative impact on the environment and health is exemplified by the dumps and tailings ponds of the non-operating Dzhidinsky tungsten-molybdenum mill, which is located within the administrative borders of Zakamensk (Fig. 5). The production waste accumulated during the 50 years of the mill's operations is a strong source of pollution contaminating the surface and ground water with toxic components and the air (dusting).

The mining enterprises are shown as symbols of varying shapes, sizes, structures and colors. The shape designates a mining method, the size shows the degree of land disturbance. The external contour (rim) shows landscape stability, while the internal contour points at its significance. The color of the contour corresponds to the values of indicators. A circle in the center of the map and its color show the level of toxicity or ecological risk of extracted materials and their enrichment products. The circles on the map designate the deposits undergoing different stages of geological exploration. The density of disturbed lands in administrative districts is reflected on the map using the quantitative background technique.

The map shows that the majority of mining enterprises is concentrated in the central most developed part of the territory. On the southwestern flank within the Mongolian part of the basin, there are many deposits, the majority of which are currently not developed. The lands are least disturbed in the northeast. In the central ecological zone of the Baikal Natural Territory, there are three operating non-ore deposits (the Angasolka deposit of construction stone, Slyudyanka cement marble deposit, and Tarakanovsky cement limestone deposit) located over 4 km away from the coast of Lake Baikal. The extracted materials belong to the low class of ecological risk. The development of these deposits is not included into the types of activities prohibited in the central ecological zone of the Baikal Natural Territory and does not significantly affect the ecosystem of Lake Baikal.

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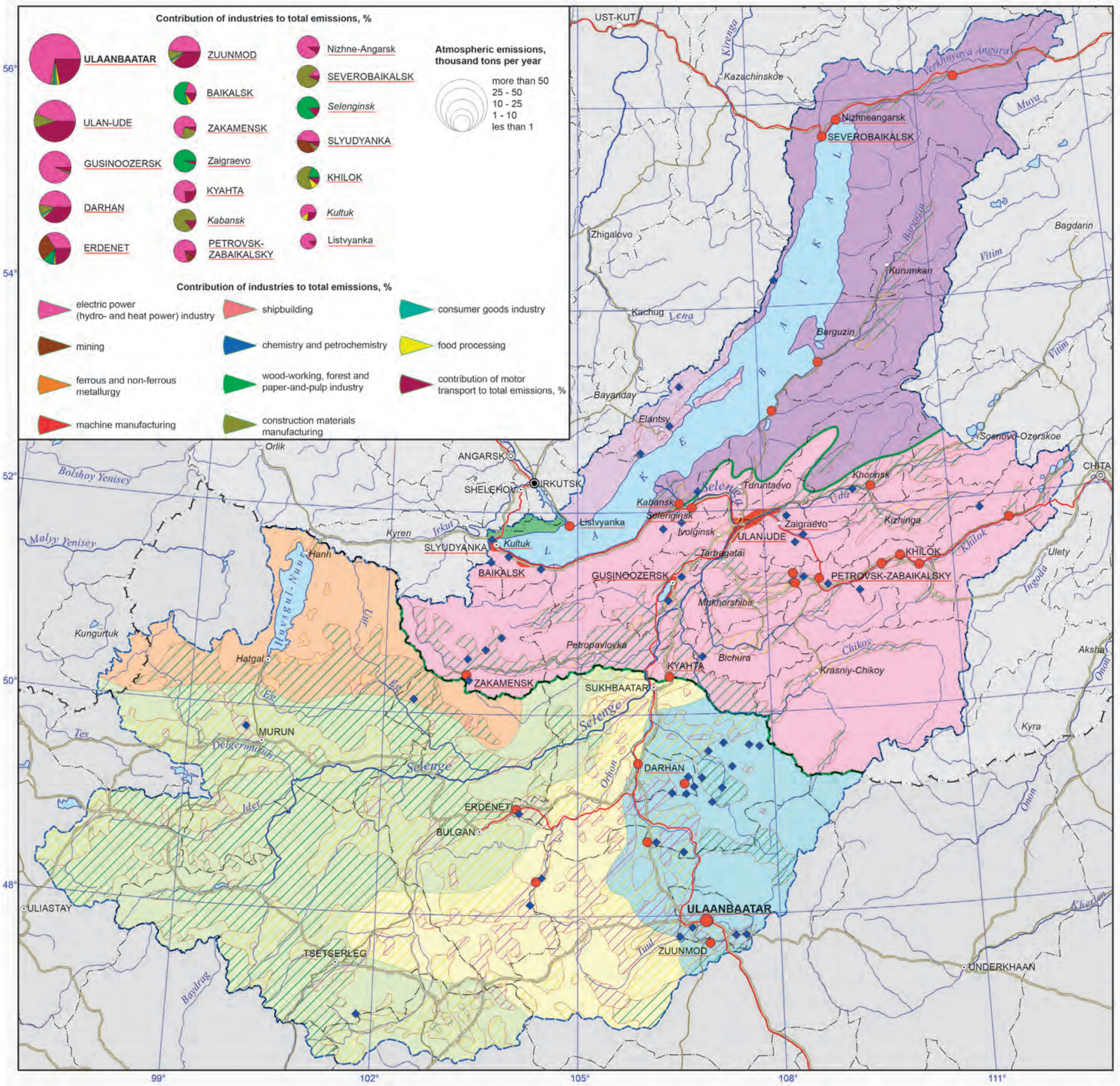
SOIL DEGRADATION AND CONTAMINATION (89)

89. SOIL DEGRADATION AND CONTAMINATION



The background basis of this map is the differentiation of the soil cover according to the conditions of its self-purification capacity, controlled by the processes of migration and accumulation of chemical elements. In this regard, the largest territory units are landscape-geochemical areas. They are distinguished based on the boundaries of the major lithological-geomorphological structures and bioclimatic conditions.

More fractional territory subdivisions are landscape-geochemical provinces, singled out based on a complex of factors of potential contamination of soils and their degradation in the process of different types of nature management. Among these factors is the zonal and altitude-belt specificity of bioclimatic conditions, determined by hydrothermal parameters of the territory. The possibility of involving elements-pollutants of the environment in the biological cycle and the food chain of living organisms depends on them. The rate of development of biochemical processes of pollutants transformation in the soil medium and neutralization of their toxic action also depends on the amount and ratio of heat and moisture. Another equally important factor of self-purification of the soil cover is the water migration of material. Criteria for determining the differentiation of the territory according to the intensity of material migration (IMM) are topography and true altitude (TA) of the area. Weak IMM is peculiar to lowland plain surfaces with TA below 200 m; medium IMM – to low-mountain relief terrain, and high and low plateau with TA from 400 to 600 m; high IMM – to middle altitudes and steep slopes with TA of 600-1000 m; and intensive IMM – to high mountains with TA above 1000 m. Mountain-depression landscapes widespread within the given territory are characterized by contrast migration: from intense to weak.

Geochemical classes, denoted by the indices of typomorphic elements, contain the integral characteristics of the soil medium, which is depositing with respect to the pollutants. The classes reflect alkaline-acid and redox conditions of the environment peculiar to different landscapes: the main factors of functioning of the migration-accumulation mechanism in soils and formation of various geochemical barriers, where elements-pollutants may deposit.

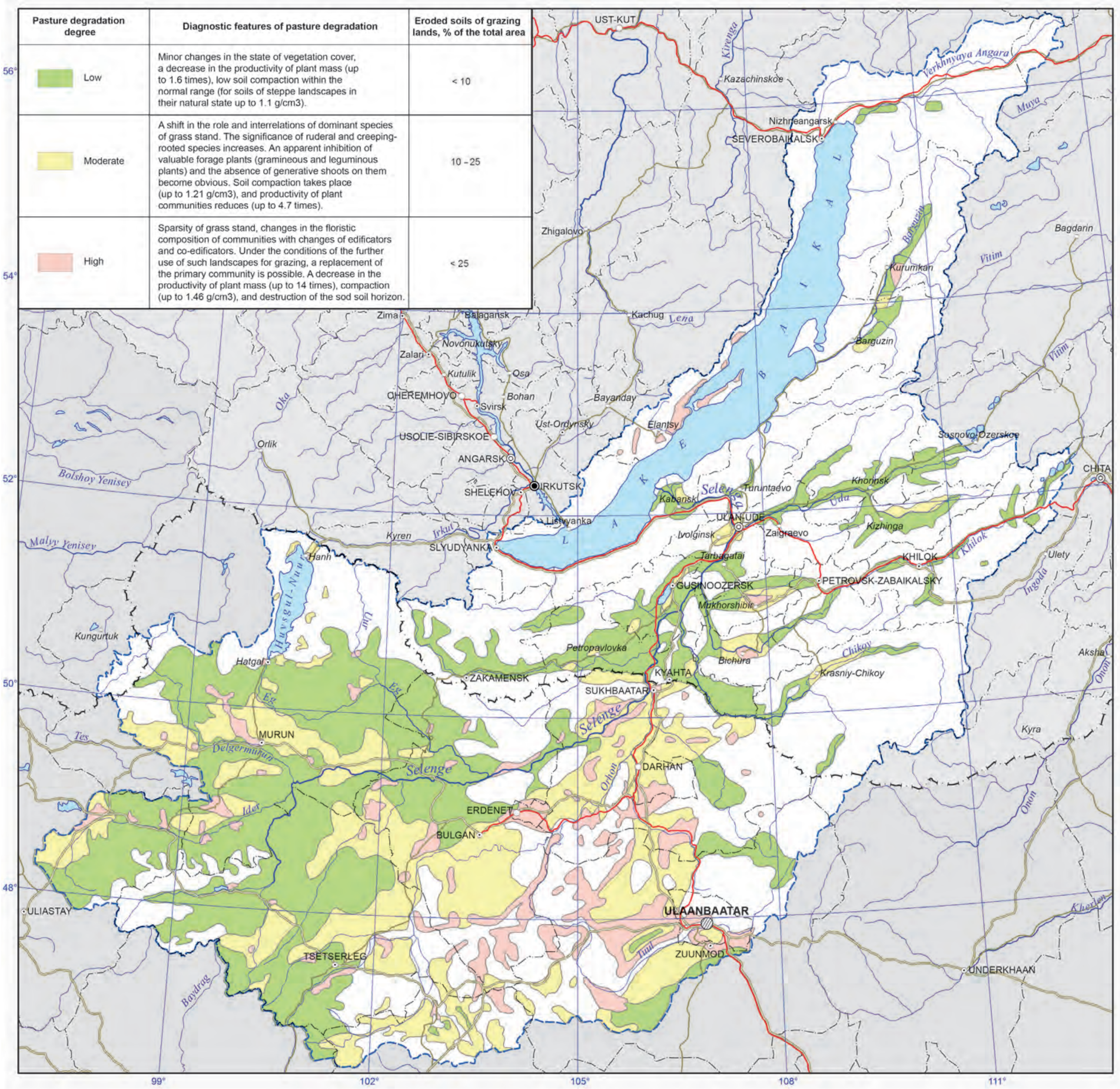
Based on these main criteria for evaluating the self-purification capacity of soils taking into account the location of currently functioning sources of industrial emissions into the environment within the territory, an assessment of the hazard level of its technogenic-chemical pollution was made.

Against the background of the degree of the potential hazard of soil contamination estimated according to the natural factors, the main sources of pollution are shown. They are industrial and boiler facilities of the towns of Slyudyanka, Baikalsk, Severobaikalsk, Nizhneangarsk, Listvyanka, Ulan-Ude, Gusinoozersk, Petrovsk-Zabaikalsk, Kyakhta, Ulaanbaatar, Darkhan, Erdenet, Zuunmod, etc. Virtually all industrial complexes are located in the conditions with insufficient self-purification of the environment, and those ones, emissions of which are heading toward the Baikal depression, represent a factor of environmental risk for it. The map shows the areas of soil contamination with the exceedance of pollutants MPC, their total emissions, industrial sources, and their contribution to air pollution. The pollution halos, 1-10 times exceeding the MPC values in the sum of the priority toxic elements (hazard class I-III), are contoured with a linear map sign. Emission rates into the atmosphere are presented in a pie chart for the sources with emissions of more than one thousand tons per year. The proportion (%) of different industries in the gross emissions is marked in the diagram. Halos with the emission sources of less than one thousand tons per year cover a small area, and in the given scale they are marked with point signs.

A significant contribution to the mechanical degradation and contamination of the soil cover in the Baikal basin, rich with various mineral resources, is made by their industrial development. Conventional signs mark the lands of mining industry (quarries, terricones, dumps, etc.). The most significant in size and intensive in the degree of disturbance of the soil cover and the geological environment are objects, registered in the Gusinoozersky and Erdenetsogt coal basins.

PASTURE DEGRADATION (90)

90. PASTURE DEGRADATION



is classified as slightly or moderately disturbed.

Under the conditions of a complex geomorphological structure of the territory, uneven particle-size distribution, and often thin profile of soils, degradation processes are dominated by linear and sheet erosion. Based on the intensity of development of water erosion and deflation processes and, consequently, different disturbances of the soil profile, as well as according to the results of evaluating the areal development of all types of erosion processes, three degrees of land degradation are shown on the map in shading: slight, moderate, and severe. They were determined by the share of the main categories of eroded soils as a percentage of the agricultural lands area. Twenty-four percent, up to 42%, 47%, and more than 60% of developed lands are eroded in varying degrees in the Baikal region, in the territory of the Republic of Buryatia, in the Olkhon district, and in some areas of Mongolia, respectively.

As a result of a special analysis and assessment of the pasture condition, three categories of the degree of their degradation are distinguished in the map "Pasture degradation", namely: low, moderate, and high. The map's explanatory note explains the diagnostic features of pasture degradation. The predominant part of pastures experiencing moderate anthropogenic impact is classified as slightly or moderately disturbed.

In general, the map is the basis for preventing the development of dangerous geo-ecological situations in the region, organizing environmental activities, and optimizing the management of the biogeochemical environment of the population's life-sustaining activities.

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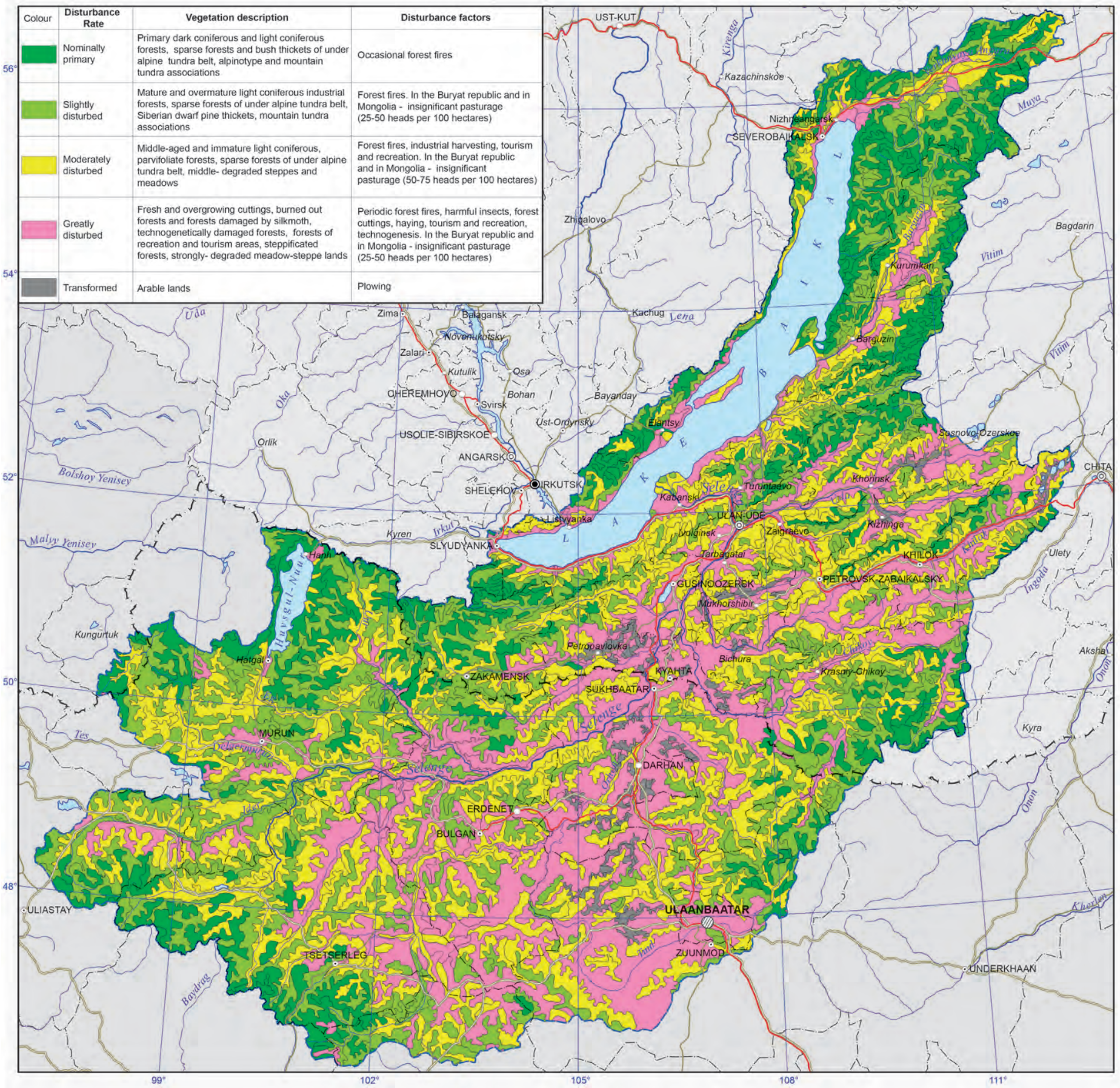
VEGETATION DISTURBANCE (91)

91. VEGETATION DISTURBANCE



Colour	Disturbance Rate	Vegetation description	Disturbance factors
(dark green)	Nominally primary	Primary dark coniferous and light coniferous forests, sparse forests and bush thickets of under alpine tundra belt, alpinotype and mountain tundra associations	Occasional forest fires
(light green)	Slightly disturbed	Mature and overmature light coniferous industrial forests, sparse forests of under alpine tundra belt, Siberian dwarf pine thickets, mountain tundra associations	Forest fires. In the Buryat republic and in Mongolia - insignificant pasturage (25-50 heads per 100 hectares)
(yellow)	Moderately disturbed	Middle-aged and immature light coniferous, parvifoliate forests, sparse forests of under alpine tundra belt, middle- degraded steppes and meadows	Forest fires, industrial harvesting, tourism and recreation. In the Buryat republic and in Mongolia - insignificant pasturage (50-75 heads per 100 hectares)
(pink)	Greatly disturbed	Fresh and overgrowing cuttings, burned out forests and forests damaged by silkmoth, technogenetically damaged forests, forests of recreation and tourism areas, steppificated forests, strongly- degraded meadow-steppe lands	Periodic forest fires, harmful insects, forest cuttings, haying, tourism and recreation, technogenesis. In the Buryat republic and in Mongolia - insignificant pasturage (25-50 heads per 100 hectares)
(grey)	Transformed	Arable lands	Plowing

A cartographic evaluation of the anthropogenic disturbance of vegetation is the most effective method for solving numerous issues of environmental protection and the rational use of biotic resources in the Baikal basin. It was carried out taking into account the major changes in the floristic composition and cenotic structure of vegetation, which is developing mainly under the influence of anthropogenic factors. The degree of anthropogenic disturbance of the vegetation was determined by deviation criteria of the composition and structure of plant communities from their native state.

The evaluation is based on a modern universal map “Vegetation of the Baikal basin” 1:4, 000,000, which is created on the principles of a structural-dynamic classification of vegetation taking into account its main regional-typological features and dynamic processes caused by human and natural factors. Thus, invariants of epistructures of plant communities were established and thereby the base (zero) estimation level was defined, which was the starting point for the countdown of actual spontaneous and human-induced changes in the vegetation cover.

Besides the universal geobotanic map, basic cartographic sources were used in assessing the vegetation disturbances. These sources provide information about the boundaries of arable land and farmland and forests damaged by technogenesis, recreation, and harmful insects, burnt sites and regenerated cutover stands. Forest and land use management materials and Google 2013 surveying satellite images were used.

The disturbance of vegetation of the Baikal basin is determined primarily by its use as an industrial and agricultural resource, which is based on forests, grasslands and steppes.

Industrial logging leads to a change of indigenous coniferous stands to small-leaved, less valuable for the economy. Abandoned semi-subsistence raw materials on slashes increase forest fire debris and entomological danger. Light coniferous forests located in the riversides, especially on fertile soils used for agriculture, are often cut.

Besides logging, the forests in Irkutsk oblast, the Republic of Buryatia, Zabaikalsky krai, as well as in Mongolia are annually exposed to forest fire. Fire damages not only the forest but also the community of other vegetation types - mountain tundra, subalpine elfin cedar thickets, yerniks, steppes and others. That leads to the accumulation of large burnt areas, replacing native forests derivatives.

Negative impact on the steppe vegetation is also caused by plowing and irrational use of grazing territory. As for the pastural digression of vegetation, it has completely or partially changed the floristic composition and structure of many steppe and meadow communities.

In Mongolia, grazing currently remains the main type of agriculture. Here they raise cattle, sheep, camels, goats and horses, as well as Mongolian yaks and reindeer. Alpine pastures are even mountain-tundra, cryophyte steppe, marshy meadow and steppe. Vegetation communities of middle mountain, foothill, lowland areas and basins are widely used for pasture. Vegetation communities of floodplains and lakeshores with forest, meadow, prairie and wetland vegetation are especially strongly disturbed [Banzragch, et al, 1990].

In general, in Mongolia, as well as in Irkutsk oblast, the Republic of Buryatia and Zabaikalsky krai in the remote and undeveloped alpine areas, where there is no human activities, undisturbed (indigenous) vegetation is provisionally preserved. According to the development and availability of the areas, the assessment of vegetation disturbance is changing.

As a result of the analysis and assessment of vegetation communities, five categories of vegetation disturbance are identified on the map – conditionally drastic, weakly, moderately, and strongly disturbed and reformed.

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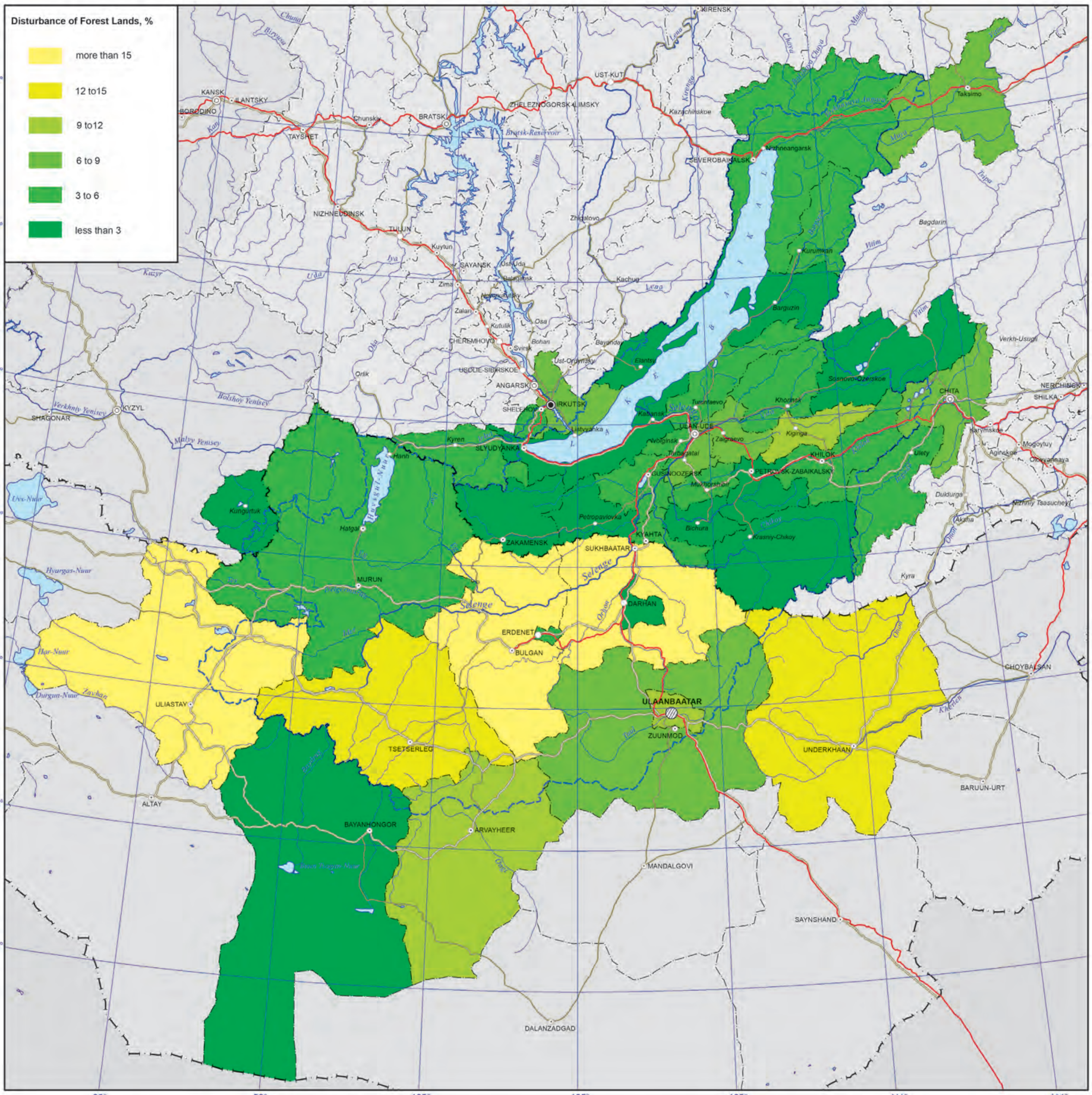
92. DISTURBANCE OF FOREST LAND



DISTURBANCE OF FOREST LAND (92)

Under the disturbed land we understand the value that reflects the ratio of the reforestation fund area to the area of forest lands (on the forest fund lands and other land categories, where forests are located). Reforestation Fund consolidates the areas of forest land with stands, damaged by fires, pests and logging. Forest land in contrast to non-forest one represents a category with the following main functions: cultivation, conservation, improving the properties of the main forest forming species. The major part of the forest land is forested and the rest is not covered by forest (burnt areas, dead stands, slashes, clearing sand wastelands). There the reforestation measures are conducted, thus, they contribute to natural regeneration.

On the territory of the Russian part of the Baikal basin, the average disturbance of forest land is 6.1%. It is fluctuating from 0.06 % in the Krasnochikoysky district of Zabaikalsky krai to 9% in the Kizhinginsky district of the Republic of Buryatia. In the Mongolian part of the basin, the disturbance of forest land is higher than in Russia – on the average 9.7%. However, in aimags it is fluctuating from 0.1 to 19.9 %. In six aimags the disturbance of forest lands is more considerable – more than 10%. Such a situation in Mongolia is possibly caused by more accurate description of forest areas with damaged forest stands.

Wild tourism in the bays of the Small Sea strait.

DISTURBANCE OF FAUNA (93)

The growth of industry and agriculture, increase of population and its demands from the second half of the 20th century have interfered with the Lake Baikal ecosystems, leaving very few places untouched by people's activities. Anthropogenic impact on the wild animals of the Baikal basin was also quite considerable. Indigenous animals and intact habitats are preserved only on the restricted territories, where human activities are limited by special factors (reserve status, hard access, harsh natural conditions, etc.)

The disturbance of wild animals is regarded as any change of the existing populations and communities manifested in the decrease in size, loss, and fragmentation of habitats, variations in species composition, including introduction of new species, and changes in the ecosystems. As a result, the indigenous species or communities can no longer exist [Belov et al., 2002] The disturbance of zoocenosis directly correlates with the intensity of human activities. As a rule, the mostly disturbed fauna complexes are located in the basins of major rivers, where people settled long time ago. The composition of species in these areas is represented by flexible eurytopic species, as well as synanthropic and invasive animals. Quite often the species not common for the biocenosis of some ecosystems start to dominate, when the ecosystem has been disturbed.

Plowing, cattle grazing, forest cuts, fires, construction works, mining, and solid and gaseous pollutant emissions influence the vertebrates fauna directly or indirectly causing changes of ecosystems, reduction in the size of animal populations, and fragmentation or full transformation of communities. Agriculture is the major factor that determines the fauna of the most part of the basin. Overgrazing and plowing deteriorate habitats, transform structure and species composition of vertebrates, and destroy nests of ground-nestling birds. Fauna complexes of the steppe zone suffer most from the abovementioned two factors. In highly degraded steppes, vertebrates are extinct almost totally. Logging and steppe and forest fires greatly affect the habitats of vertebrate animals, its species' composition, structure, and abundance of certain species. A complex multilayered ecosystem is replaced by open spaces with altered protective, feeding, and microclimatic conditions that bring about significant changes of vertebrates. Post-fire changes in ecosystems are so drastic that restoration of certain species of vertebrates does not happen for decades.

Invasive alien species are justly regarded as one of the two most hazardous threats to biodiversity, coming second only to the devastation of habitats. In the XX century, intentional and unintentional introduction of various animals as a result of intensive economic activities became a global problem of the biotic exchange between biogeographical regions [Tishkov et al., 1995]. The significance of this problem has not been fully recognized yet. In the Baikal basin, the zones where fauna suffers from the introduction of alien species, are localized in the areas of long-term anthropogenic activities; however, there is a clear trend towards areal expansion of the adventive species of fauna. Introduction of alien species has an adverse impact on biodiversity and the structure and functioning of ecosystems. Synanthropes invade settlements, warehouses, industrial buildings, causing economic loss.

Diversity of fauna and the abundance of animals made hunting very attractive in the Baikal basin. As a result of long-term and intensive harvesting of birds and animals, their populations were put at risk of extinction; many of these species were listed in the regional Red Books. At present, hunting is not so popular, which has an ambiguous effect on the animal populations. Some species (Far Eastern red deer, wolf, squirrel, muskrat, Siberian striped weasel, and ermine) grow in number due to the reduced harvesting pressure and the extension of the areas disturbed by anthropogenic factor (deforested and post-fire lands). Populations of other species (roe deer, Siberian musk deer, and sable) are shrinking in size due to poaching. Hoofed mammals in Mongolia are on the margin of their habitats; therefore, their populations are rather small and require special protection and size regulation. Populations of other species are stable in size over the years, and the fluctuations are determined by natural dynamics.

Pollution and drainage of water bodies, changes in their hydrological regime due to damming, increase of water intake, disposal of wastewater by dilution, and unlimited fishing had a negative effect on the populations of many fish species, especially valuable commercial species. The rise of the Baikal water level by one meter after the construction of the Irkutsk hydro power plant reduced spawning areas of some fish species, changed nutritive base and feeding places that caused weight loss of some fish species [Monitoring …, 1991; Hydropower …, 1999] Some nestling grounds of semi-aquatic birds in the river estuaries were flooded. There is also evidence that some species of fish and freshwater seal (nerpa) accumulate heavy metals, radioactive isotopes, and chlororganic compounds [Grachev, 2002].

The map "Disturbance of fauna" gives an idea about the present state of the communities of the vertebrate animals in the Baikal basin. The map was created with the use of methodological guidelines for making evaluation maps developed by scientists at the V.B. Sochava Institute of Geography SB RAS [Belov et al., 2002]. The key information about the changes of the regional fauna complexes was obtained from the cartographic materials, Landsat space images, statistics on forest fires, forest cuts, and industrial pollution, and from other published materials [Atlas of the Trans-Baikal region, 1967; National atlas: Mongolian People's Republic, 1990; Atlas of ecosystems of Mongolia, 2005]. The map was developed on the basis of vegetation maps and flora disturbance maps published in the abovementioned atlases. The map's explanatory note distinguishes three stages of disturbance of the indigenous ecological fauna complexes and ichthyofauna. Additionally, we provide information about extinct and near-extinct vertebrate animals and primary causes of the fauna complexes' disturbance and degradation. This map can serve as a resource for developing recommendations on the protection and rational use of the Baikal basin's wildlife.

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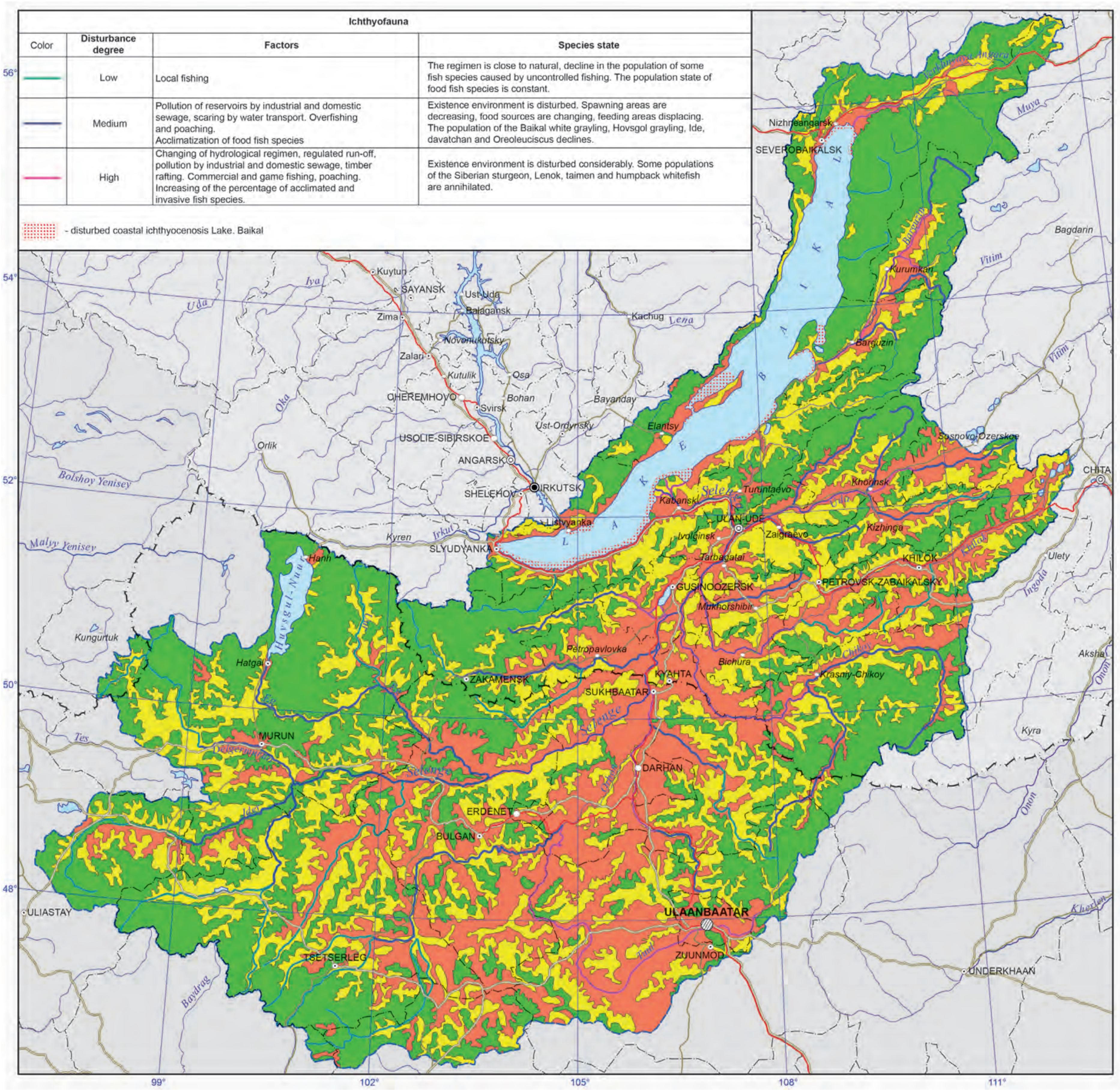
Baikal self-contained paper mill in the period of activity.

93. DISTURBANCE OF FAUNA

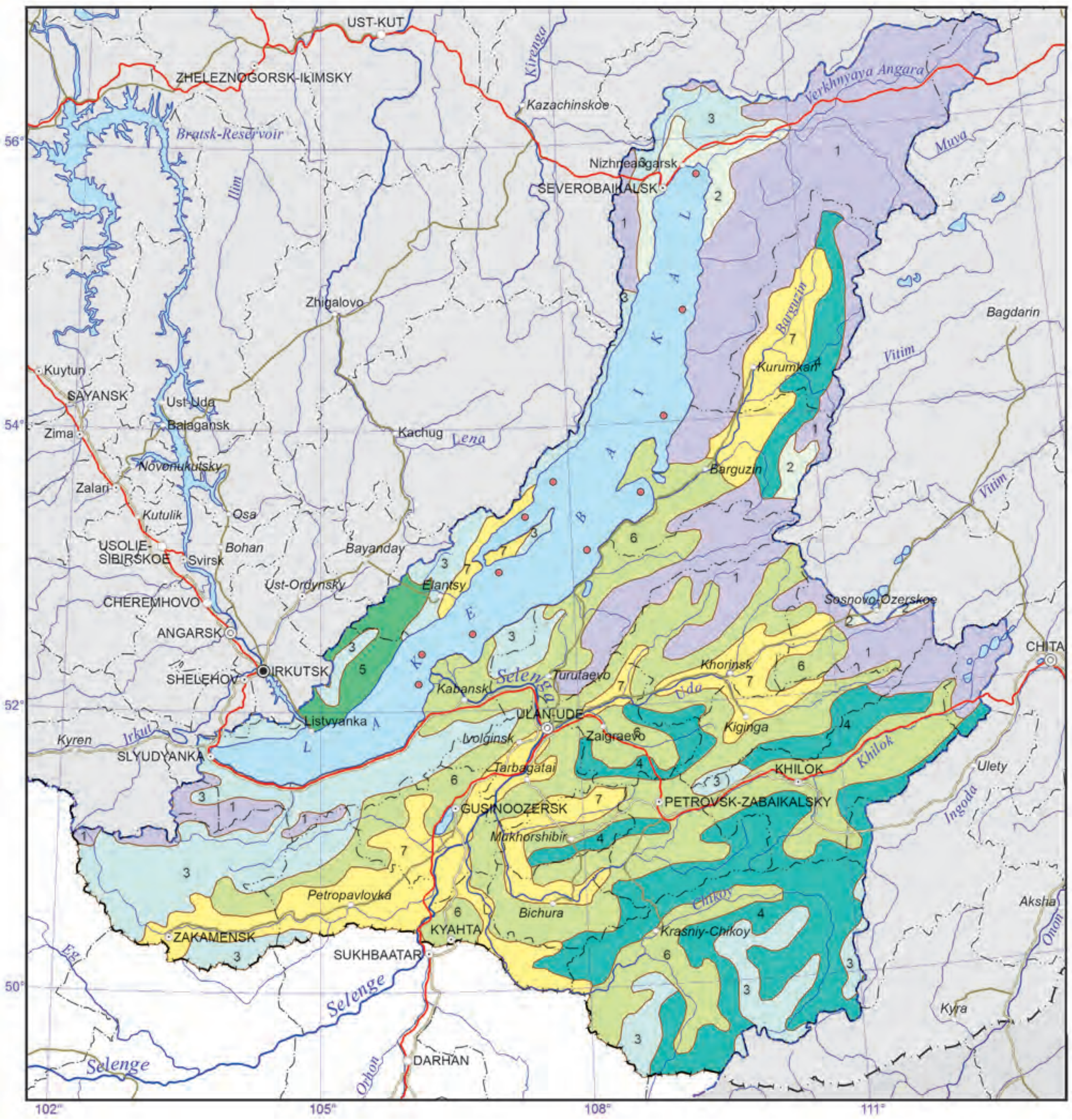


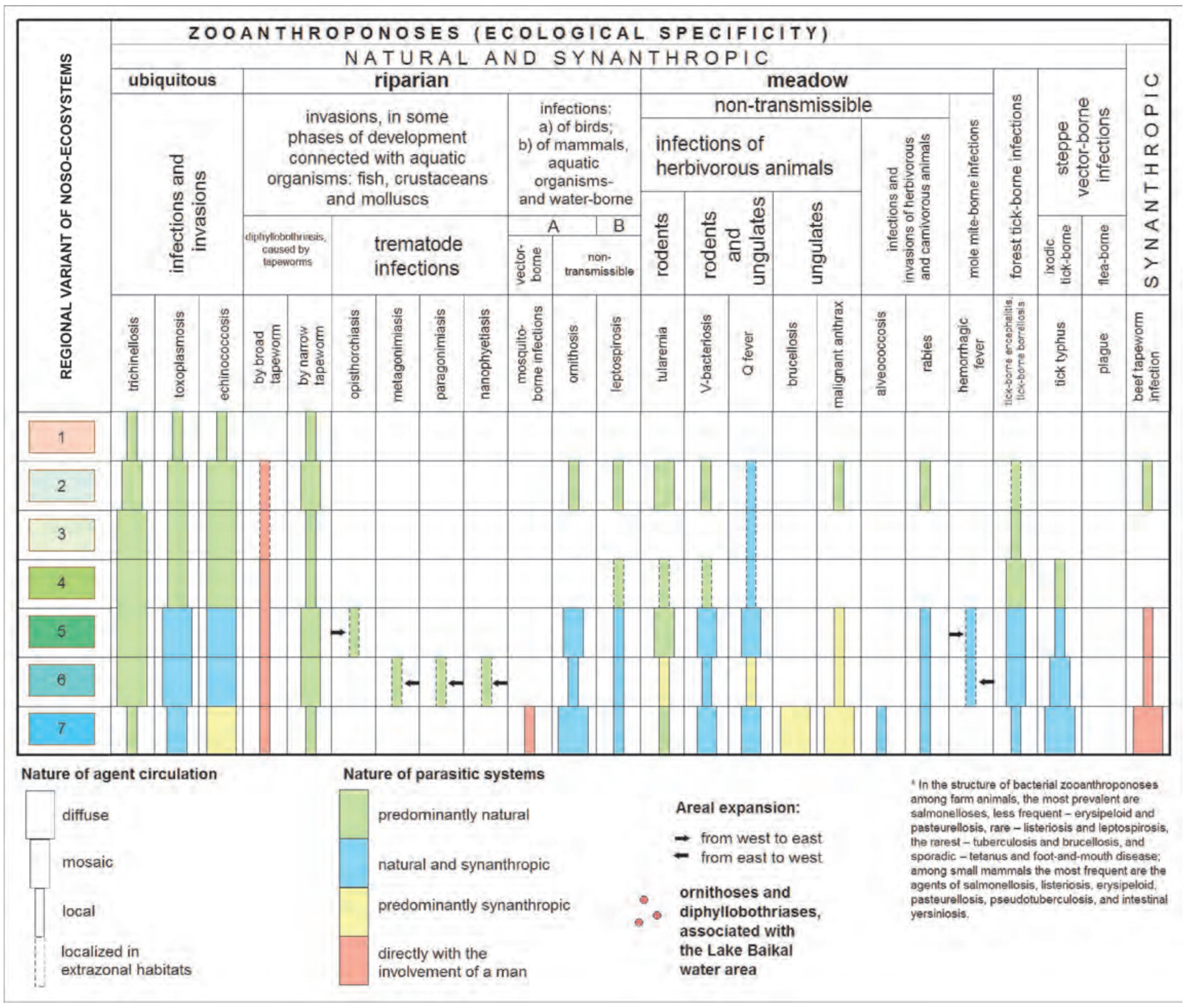
Terrestrial vertebrate species

	The degree of disturbance	Factors	Status of species	Status of game species
	Weak, less than 30% of the occupied area.	Forest and steppe fires, small in size. Hunting and fishing, poaching. low grazing (25-50 cattle per 100 hectares) in Buryatia and Mongolia. Active tourism.	Reducing the number of Siberian salamander in Mongolia, common viper in Buryatia. It noted the general decline and disappearance of certain populations of the red wolf, snow leopard, arkhar, Siberian ibex. To reduce the number of flight and ground nesting taiga Bean goose, Swan Goose, merlin, peregrine falcon, hooded crane, white-naped crane (in Zabaikalskyi krai).	Condition of most species is stable. Downsizing possible to by-individual sections of the hunting grounds.
	Average, to 50% of the occupied area.	Forest and steppe fires covering large areas. Deforestation, damage harmful insects. Plowing, mowing, intensive grazing (50-75 cattle per 100 hectares) in Buryatia and Mongolia. Pollution of ecosystems by industrial and domestic waste. Fishing and sport hunting and fishing, overfishing and poaching, dispersal acclimatized and invasive species. Local recreation.	Downward trend in the number and a reduction in habitat Mongolian toad in Olkhon, Mongolian lizard and sand lizard in Buryatia, Dione snake and ringed snake - everywhere. Require special protection measures Olkhon vole in the Irkutsk region, otters and reindeer in Buryatia, tarbagan and otters in Zabaikalskyi krai, tarbagan, moose, musk deer, red deer and Przewalski's horse in Mongolia. Reduce the number of breeding and migration or disappear entirely separate population of the black stork piskulki, small swan kloktun, Booted Eagle, steppe eagle, golden eagle, bearded vulture, Saker, Altai ular, gray crane and belladonna, stilt, avocet, Asian Dowitcher, owl, Scops Owl, dun Shrike and Dubrovnik.	There remains a relative diversity of game species. It reduces the number of seats or completely disappear furry animals (sable, Solongo, ermine), large predators (bear, wolverine, lynx), ungulates (elk, north and red deer, musk deer). Adapted to life in modified biocenoses squirrels, hares, marmots, badgers, foxes, wolves, wild boars (Buryatia) and roe deer. The number of some of them may exceed that in slabonarushennyh grounds. Reduced diversity of game birds during migration and breeding areas. The high number of damaged biocenosis can reach grouse, partridge and some duck.
	A strong 80% of the occupied area.	Frequently Forest (1-2 times in 3-5 years) and steppe (1-3 times per season) fires. Damage harmful insects large areas (silkmoth). Formation agrotcenosis with agrophilous gemiafilous fauna, mechanical haying, overgrazing (more than 75 cattle per 100 hectares). Overexploitation. The technogenic pollution of ecosystems. The accumulation of repugnant substance in animals. Formation of recreational areas. The dominance of synanthropic fauna in the settlements, storage facilities, farms and so on.	In the critical state of the population of Dalmatian Pelican, cemetery, greater spotted eagle, eagle eagle and Pallas, the Great Bustard.	Disappear completely sable, ermine, bear, wolverine, lynx, moose, musk deer with possible stopovers in some years time, or migrations. Destroyed or fragmented nesting place for many types of ducks, geese, shorebirds, grouse and pheasant.

SECTION V.
Medico-ecological situation

94. ENVIRONMENTAL PREREQUISITES OF THE SPREAD OF ZOOANTHROPONOSES





ENVIRONMENTAL PREREQUISITES OF THE SPREAD OF ZOOANTHROPONOSES (94)

The synthetic map "Environmental prerequisites of the spread of zooanthroponoses" is intended primarily for institutions working on the issues of nature conservation, environmental management, and human safety (in a broad sense of the term), as well as for the territory development planners. In the process of compiling the map, an ecological classification of zooanthroponoses was developed based on their relations with natural complexes and groups of animals. This classification subdivides them into ubiquitous (widely, almost universally spread), riparian, meadow, forest, and steppe groups. Each of these groups combines ecologically close species of pathogens with similar needs for heat and moisture and circulating in the same type of biocenosis.

The map shows a territorial distribution of spatial units of the nosoecological division of different taxonomic ranks: nosoecological belts, zones, and regional variants of zonal nosoecosystems. The aforementioned ecological groups of pathogens dominate in corresponding nosoecosystems of the high rank (zonal). In this case, representatives of other ecological groups are usually widespread in local habitats. The map gives a key to the development of a strategy aimed at preventing the spread of zooanthroponoses in the system of sustainable environmental management. There is a reason to believe that different ecological groups of pathogens perform different roles in maintaining the stability of biocenoses and preserving the natural environment. Representatives of the riparian and meadow groups regulate the quantitative composition of the vertebrate animals' population (mostly rodents), stopping their mass reproduction and thus preventing the destruction of vegetation. Apparently, pathogens of the forest group (in particular, the tick-borne encephalitis virus) are able to regulate the qualitative composition of a biocenosis, protecting it from alien species, i.e. inhabitants of other (neighboring) terrain types (meadow, steppe), the number of which is subject to significant fluctuations. In seems that pathogens of the group of ubiquitous zooanthroponoses can perform various functions regulating qualitative and quantitative characteristics, but only in the group of parasites associated with vertebrates in a given biocenosis, thereby ensuring survival and well-being to their hosts.

These functional differences can become the basis for the development of a system of the differentiated (by landscape types) prevention of the spread of zooanthroponoses taking into account the issue of the nature and human health protection. The current level of research gives grounds to consider the regulation of the epizootic process as reasonable in those parasitic systems (riparian and meadow), where the function of pathogens is the reduction of the hosts' number. The prevention of the spread of most zooanthroponoses (included in the riparian and meadow groups) should be carried out to optimize the density of animal population through a sustainable use of meadow vegetation by humans and the timely crops harvesting. The consequences of the human intervention in the process of circulation of pathogens regulating qualitative parameters of the structure of biocenoses are less obvious. The intensity of pathogen circulation of almost all zooanthroponoses (infections and invasions) increases in habitable and populated areas, which is due both to the introduction of farm animals, the increased concentration of which favors the development of infections, and to the human impact on the environment accompanied by the increase in the number of rodents, a change in the chemistry of soils, creation of artificial ponds, etc.

HEALTHCARE (95 — 106)

Harsh climatic conditions across the entire territory of the Baikal basin and the surface and ground water used for drinking and food purposes that do not meet the drinking water quality standards (first and foremost in Mongolia and Buryatia) coupled with atmospheric emissions from industrial facilities and motor vehicles (in some parts of the territory) are responsible for the state of human health influencing the organization of healthcare. The ecological situation becomes substantially worse during winter months, which is encouraged by the topography of the terrain. In Mongolia, the spring period is very hard time to bear, with sharp temperature differences, abrupt variations in atmospheric pressure, and frequent dust and magnetic storms.

The organizational pattern of healthcare in Russia and Mongolia has much in common. This is a result of the cooperation of the two countries in this sphere and the fact that medical education and healthcare in Mongolia are organized using Russian experience. Today, Mongolian medical facilities operate on the principles of the state-private partnership concurrent with the demonopolization of the state system of medical services. The country has a mandatory and voluntary medical insurance system, in which state-owned and private medical institutions take part. The country also has various health institutes and centers.

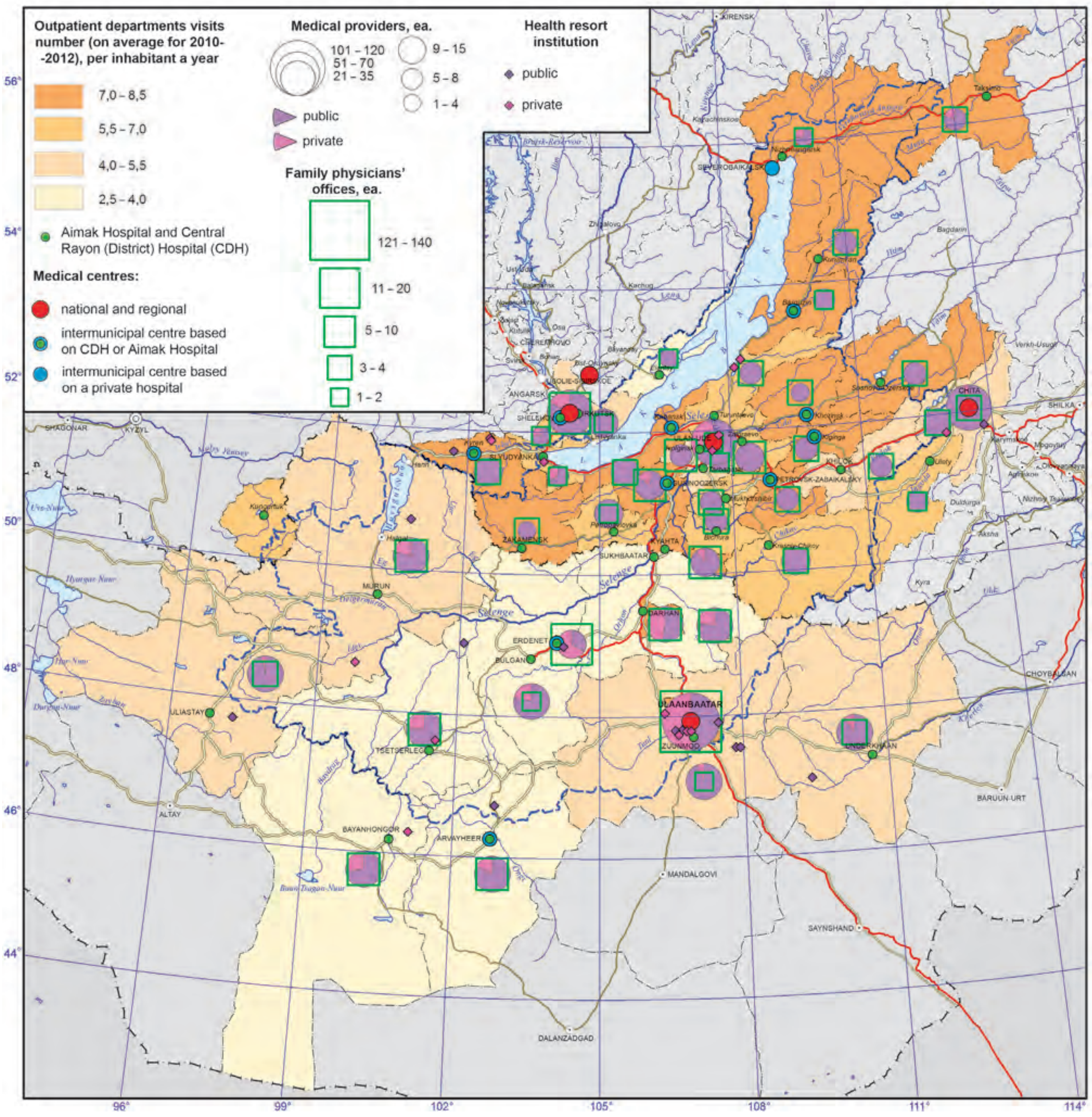
The territory of the Baikal basin is experiencing a deficit of medical workers. As of 2012, the availability of physicians varied from 13.8 to 30.1 per 10,000 people in Russian districts and from 16.1 to 29.0 per 10,000 people in Mongolian aimags. The availability of nurses varies from 25.1 to 112.2 per 10,000 people in Russian districts and from 26.4 to 38.2 per 10,000 people in Mongolian aimags. In Ulan-Ude, these indicators have the values of 53.9 and 117.3, while in Ulaanbaatar – 44.1 and 41.2, respectively.

The ratio of doctors and nurses in the Russian part of the basin is between 1:2 to 1:4, while in the Mongolian part it does not exceed 1:2. The World Health Organization (WHO) recommends that this ratio should be 1:4. A narrowing of this indicator causes imbalances in the healthcare system thereby limiting possibilities for further development of the after-treatment, casework and rehabilitation services.

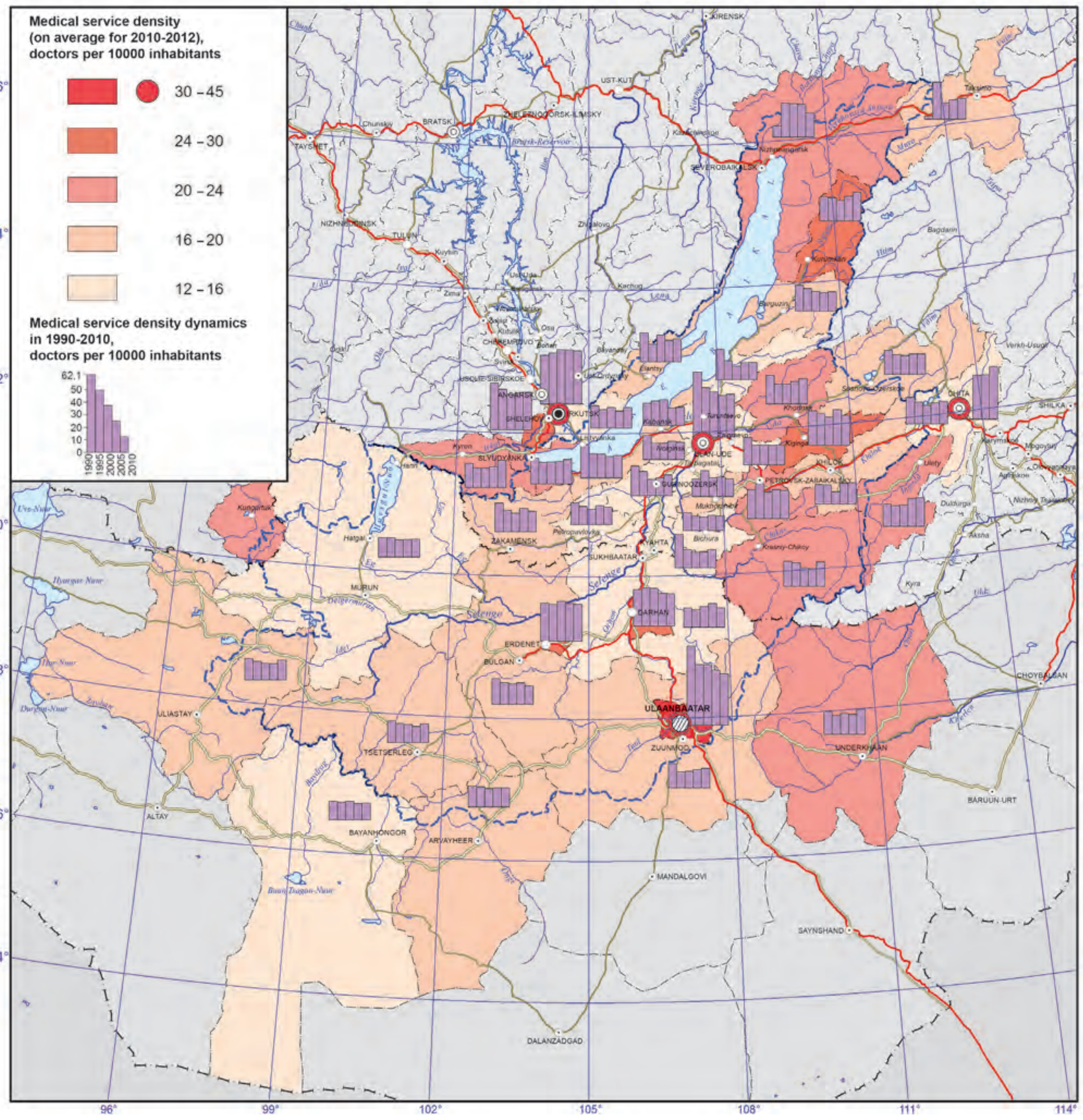
Target indicators of healthcare activity are the standard volume of medical care per inhabitant. Currently, there are plans to decrease the per capita volume of in-patient services and increase the per capita volume of the hospital-replacing care. Accordingly, the number of hospital beds available 27/7 will decrease, while the number of beds in day hospitals will grow. Overall, the available number of hospital beds complies with the calculated standards and meets the demand of the population for the in-patient medical aid.

As of today, in Russia, there is an array of problems relating to the high level of illnesses and disability incidences among the population, and these indicators are continuously growing. Such a situation is the result of inadequate preventive

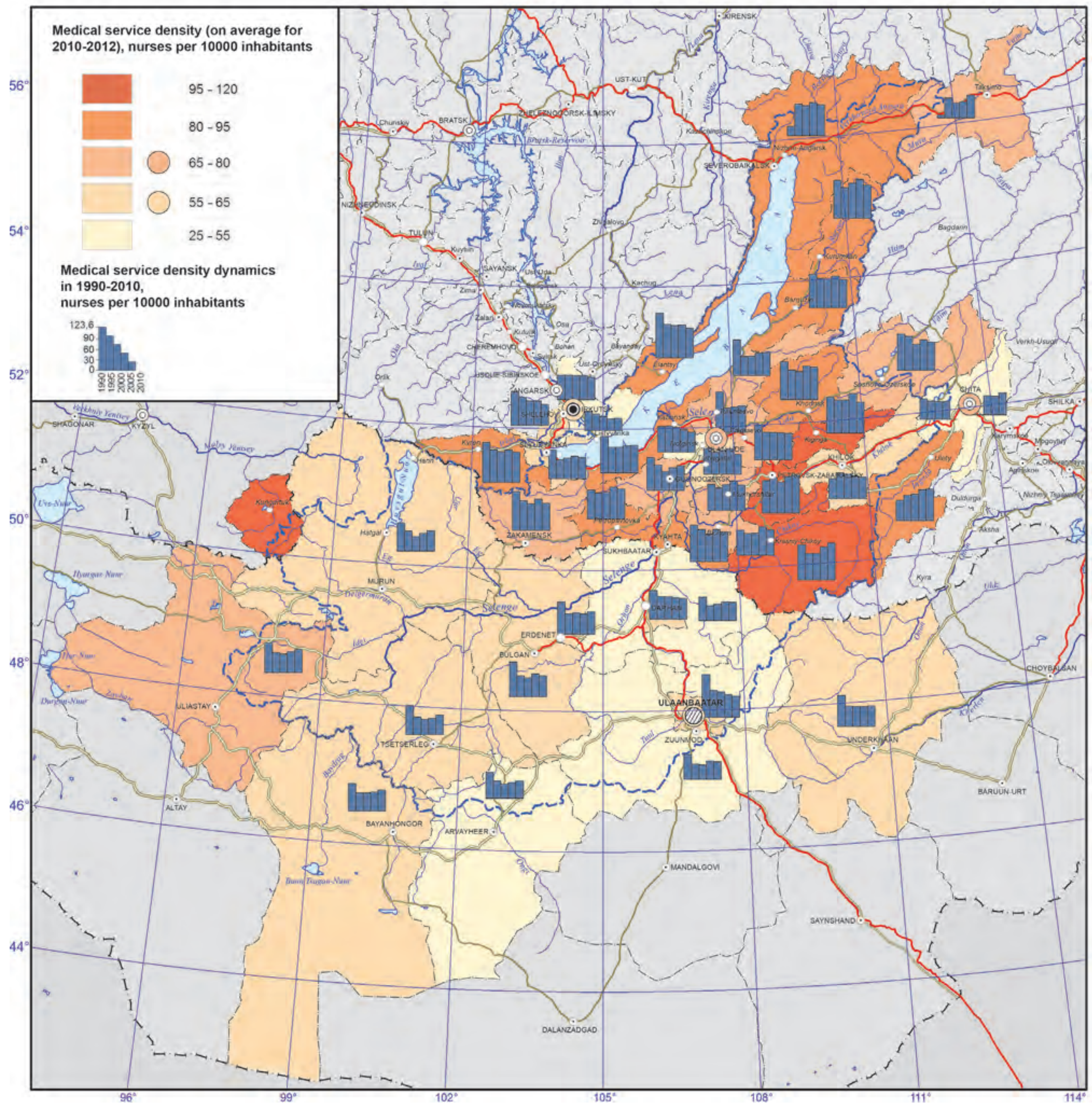
95. FREE MEDICAL CARE SYSTEM



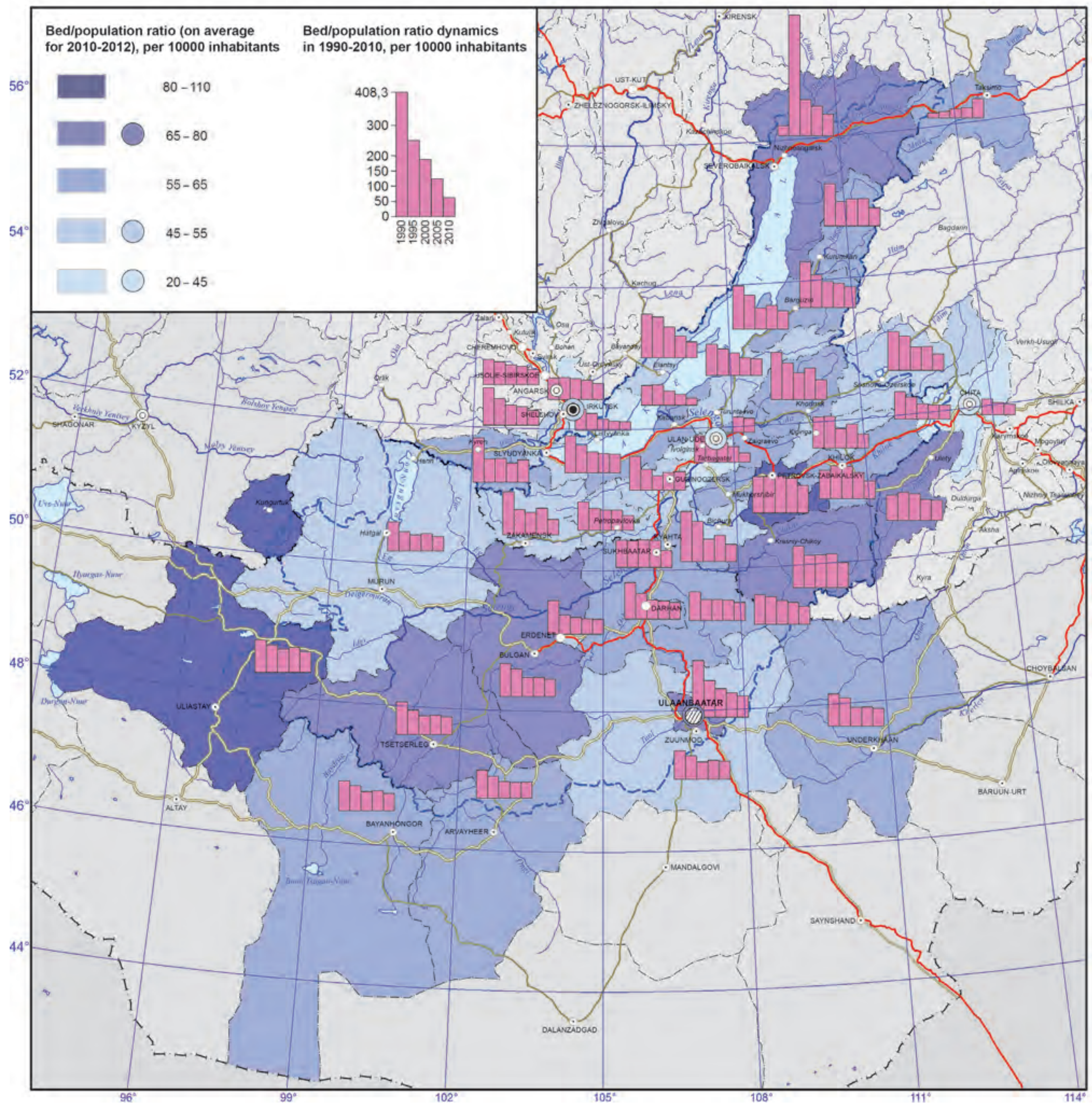
96. MEDICAL SERVICE DENSITY – DOCTORS



97. MEDICAL SERVICE DENSITY – NURSING STAFF



98. HOSPITAL BED CAPACITY



measures. Another important contributing factor to this situation is the increase of the proportion of elderly population and the improved effectiveness of illness detection using new diagnostic methods in the process of the increased number of medical checkups.

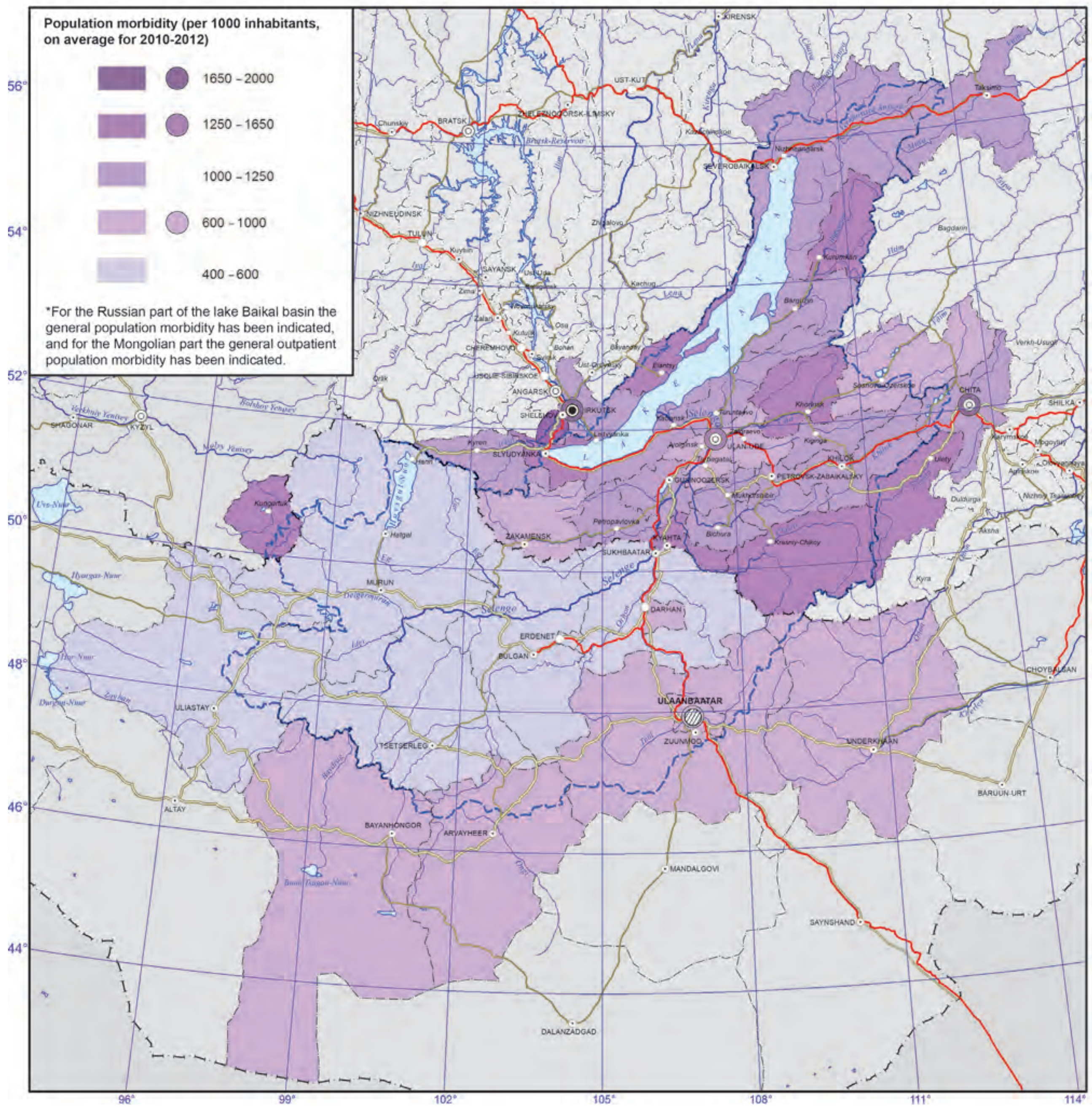
The leading illnesses in the structure of morbidity are respiratory illnesses, bloodstream, eye, and digestive and musculoskeletal system diseases, as well as traumas. For many years, circulatory system diseases, neoplasms, and injuries have been the main causes of mortality and disability among the population.

A complex of anthropogenic environmental factors contributes to the growth of morbidity and disability rates among the population with the most important one being air pollution. According to the WHO, atmospheric air pollution is the cause of up to 23% of all illnesses. The amount of pollutant emissions in the atmosphere produced by static sources in different administrative divisions in the Baikal basin differs by more than a thousand times. The most polluted air in the Baikal basin is in the Selenginsky district of Buryatia.

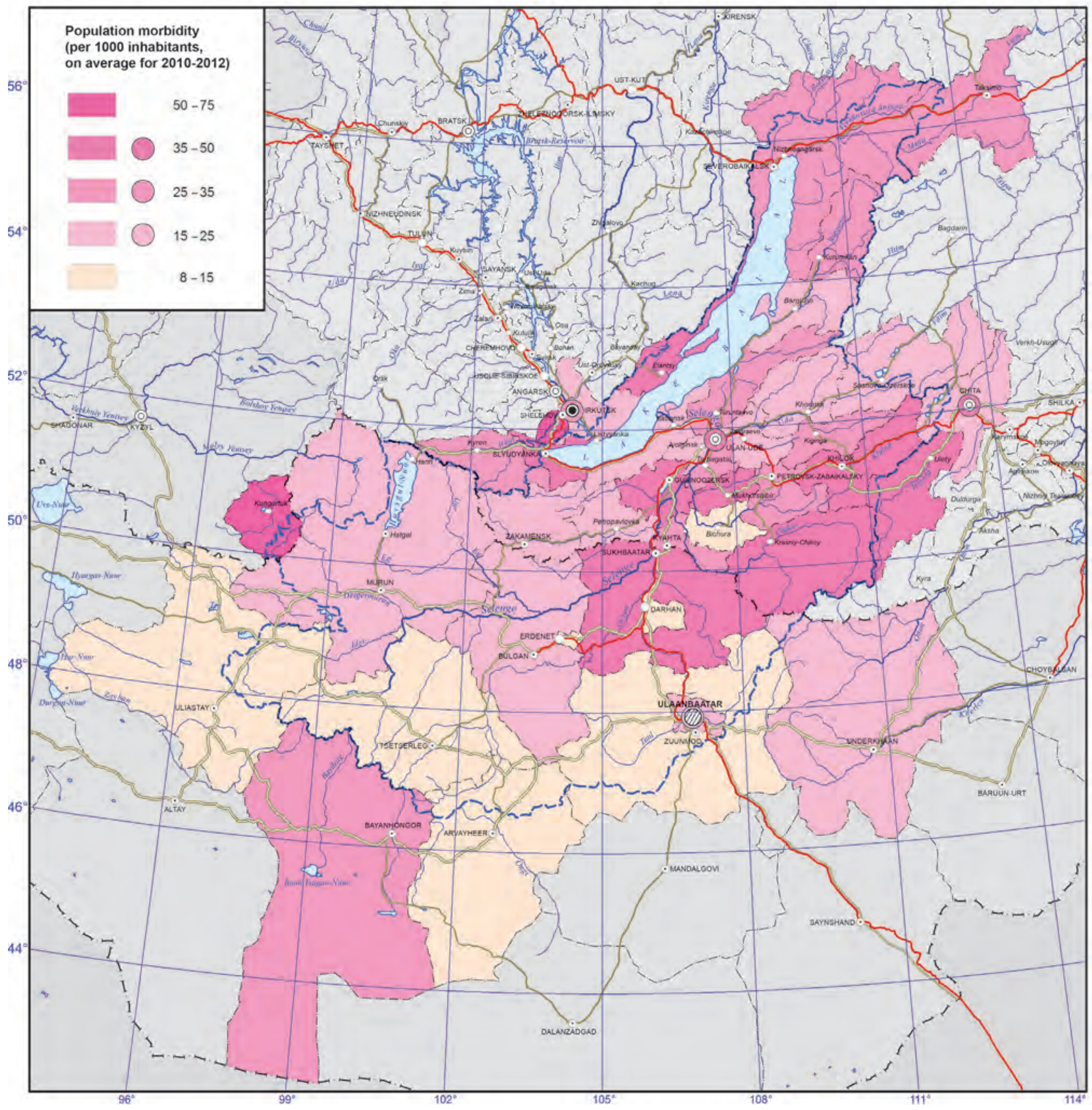
The health of the population and further development of healthcare depend on ecological, social, and economic factors. These problems can be resolved only through comprehensive approaches to the improvement of the quality of life of the population.

The strategic goal of the healthcare systems of Russia and Mongolia is to build a system, which ensures the quality and accessibility of medical services, primarily first aid, and increases the efficiency of medical services, based on the improvement of territorial planning of healthcare. The volume, types, and quality of these services should correspond to the rate of morbidity, population requirements, and the latest achievements of medical science, based on perfecting the system of territorial planning of public health services.

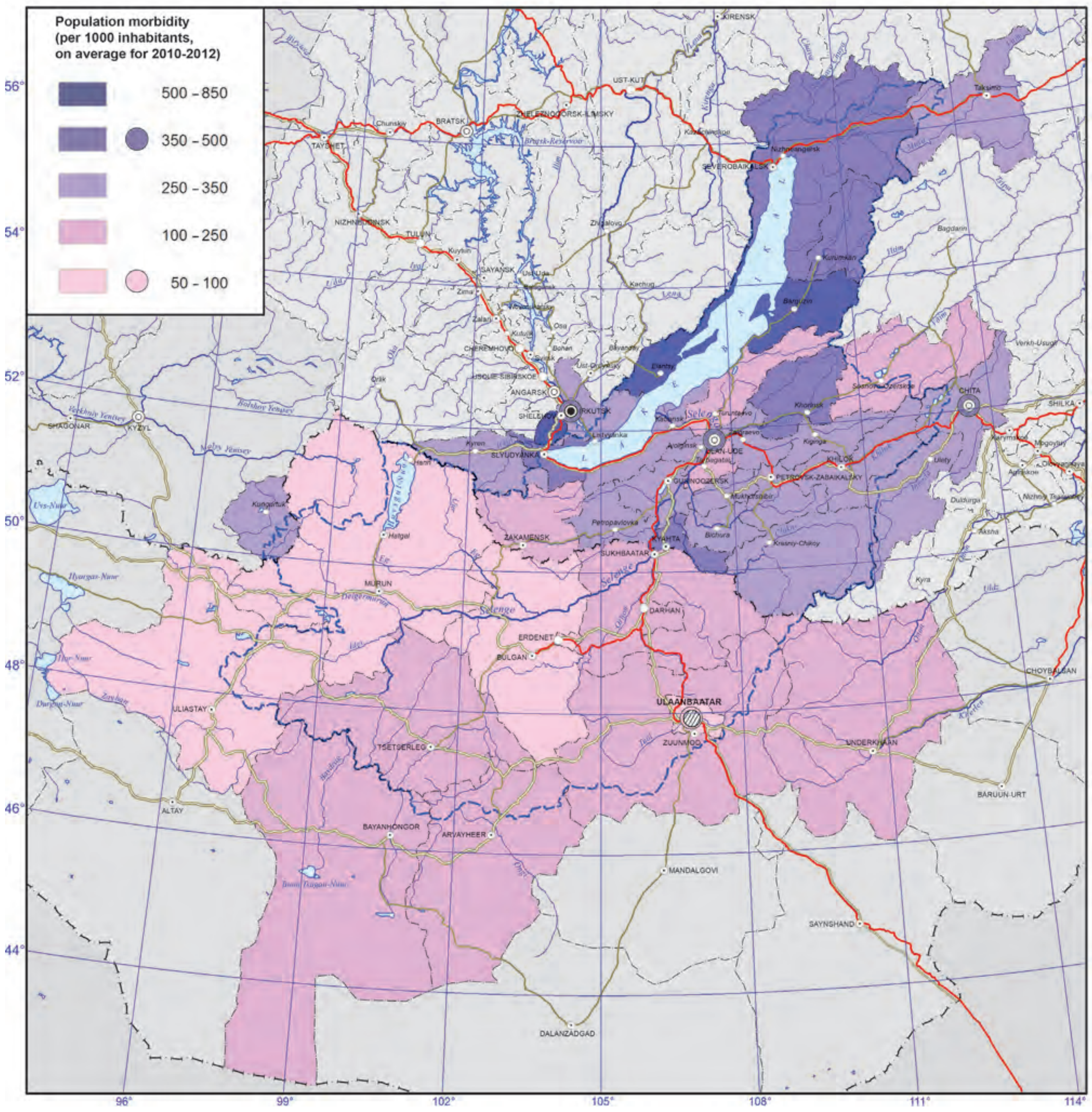
99. GENERAL POPULATION MORBIDITY



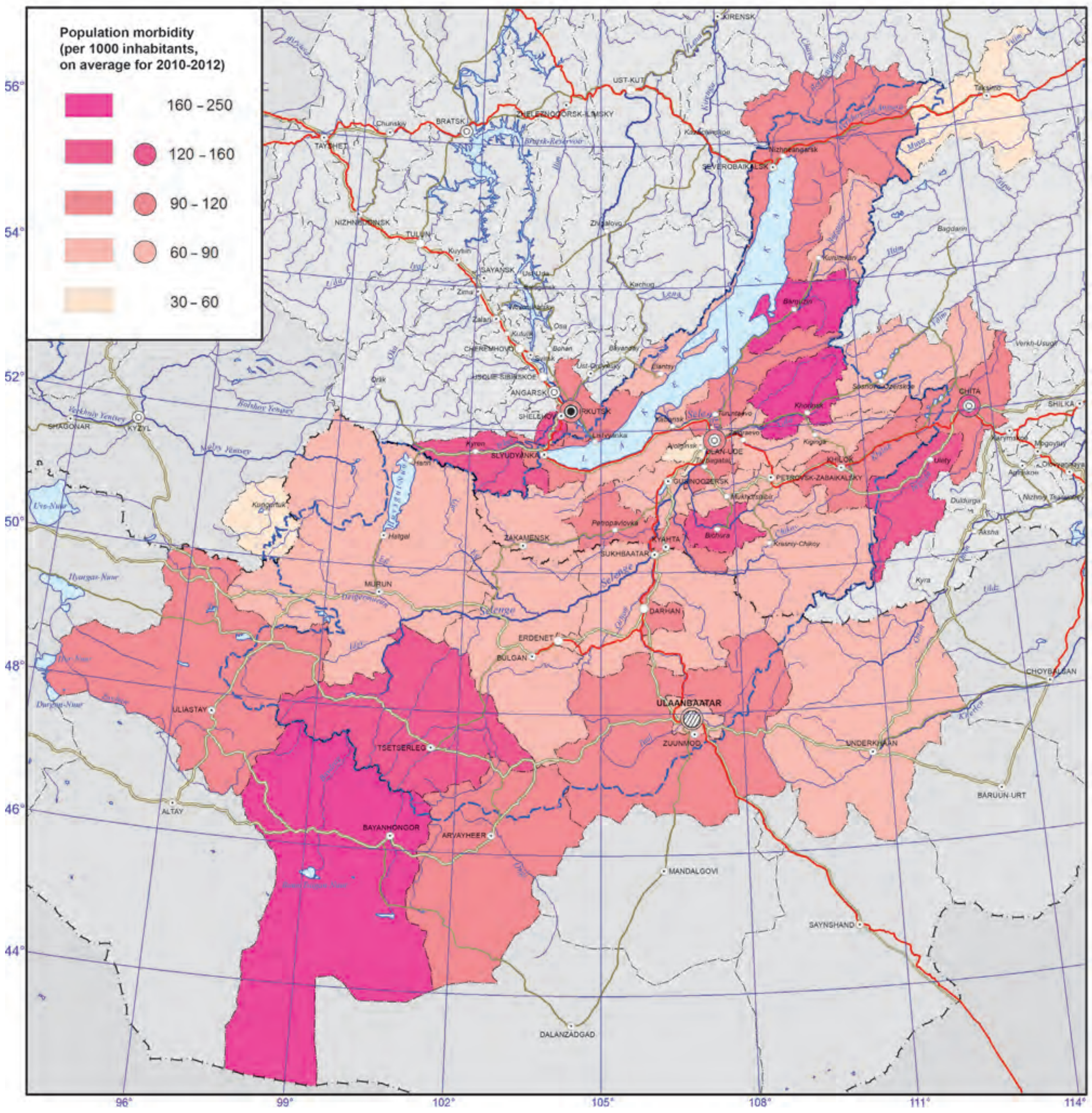
100. INFECTIOUS AND PARASITIC DISEASES



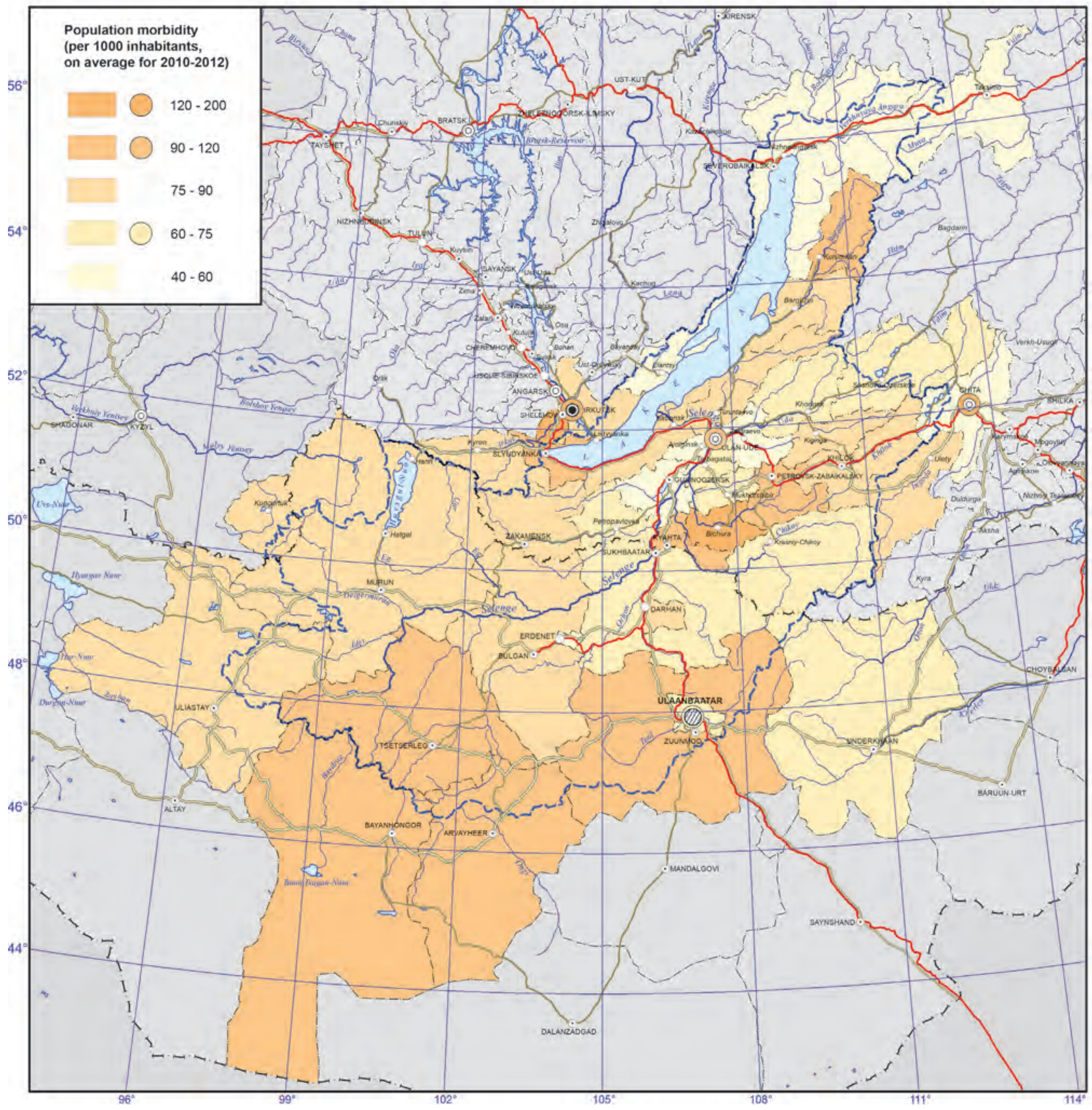
101. RESPIRATORY DISEASES



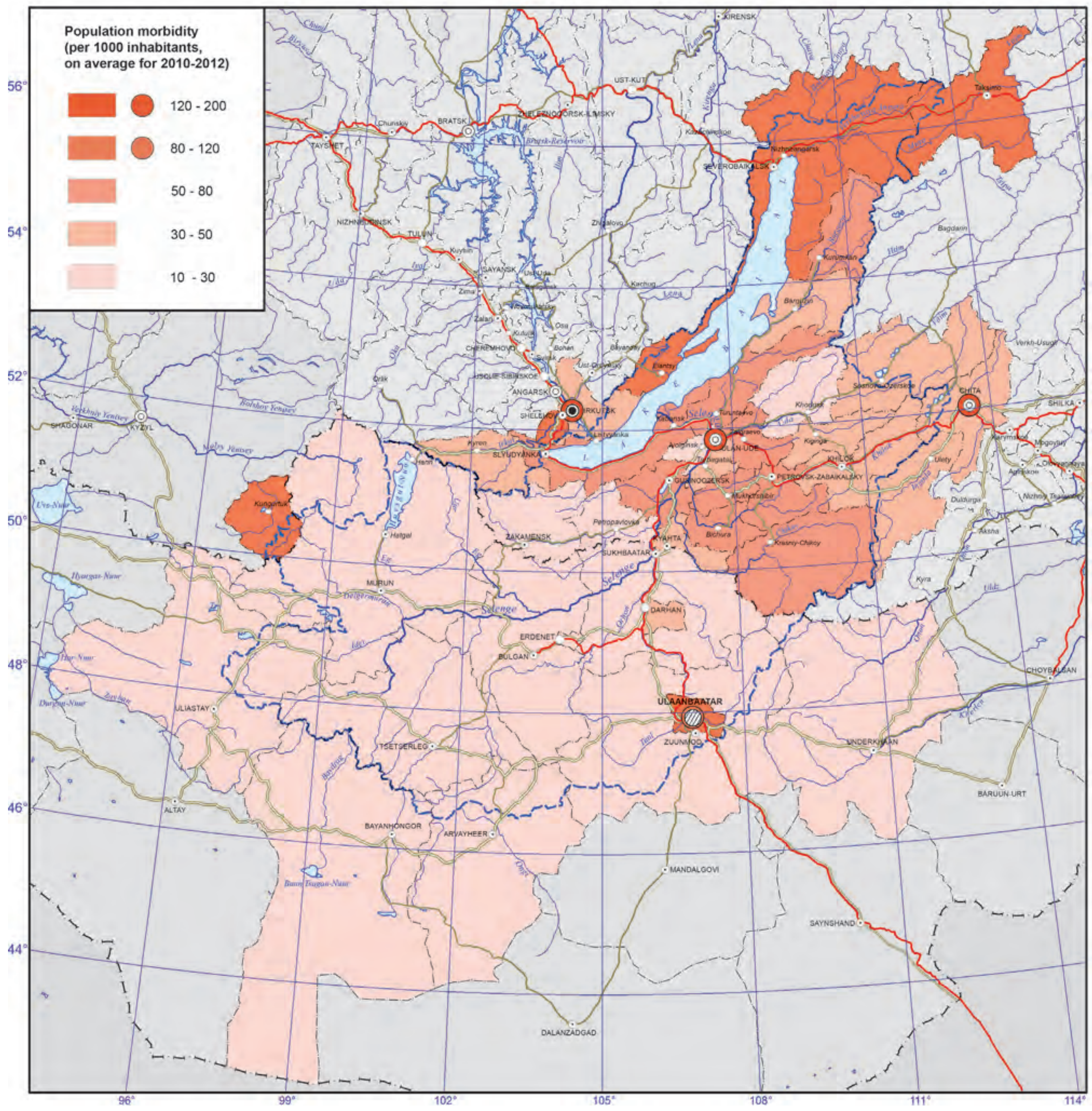
102. DIGESTIVE SYSTEM DISEASES



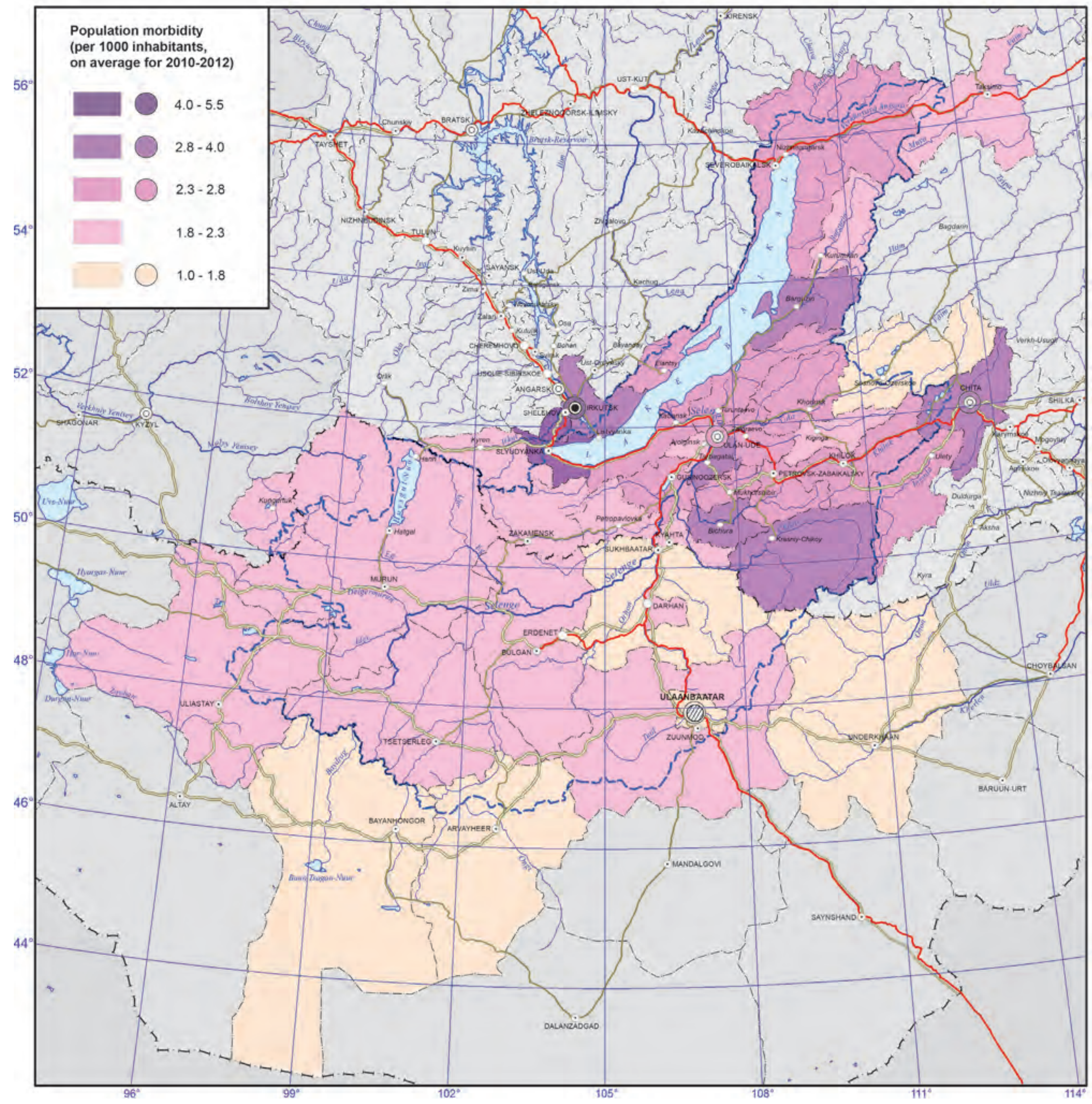
103. GENITOURINARY SYSTEM DISEASES



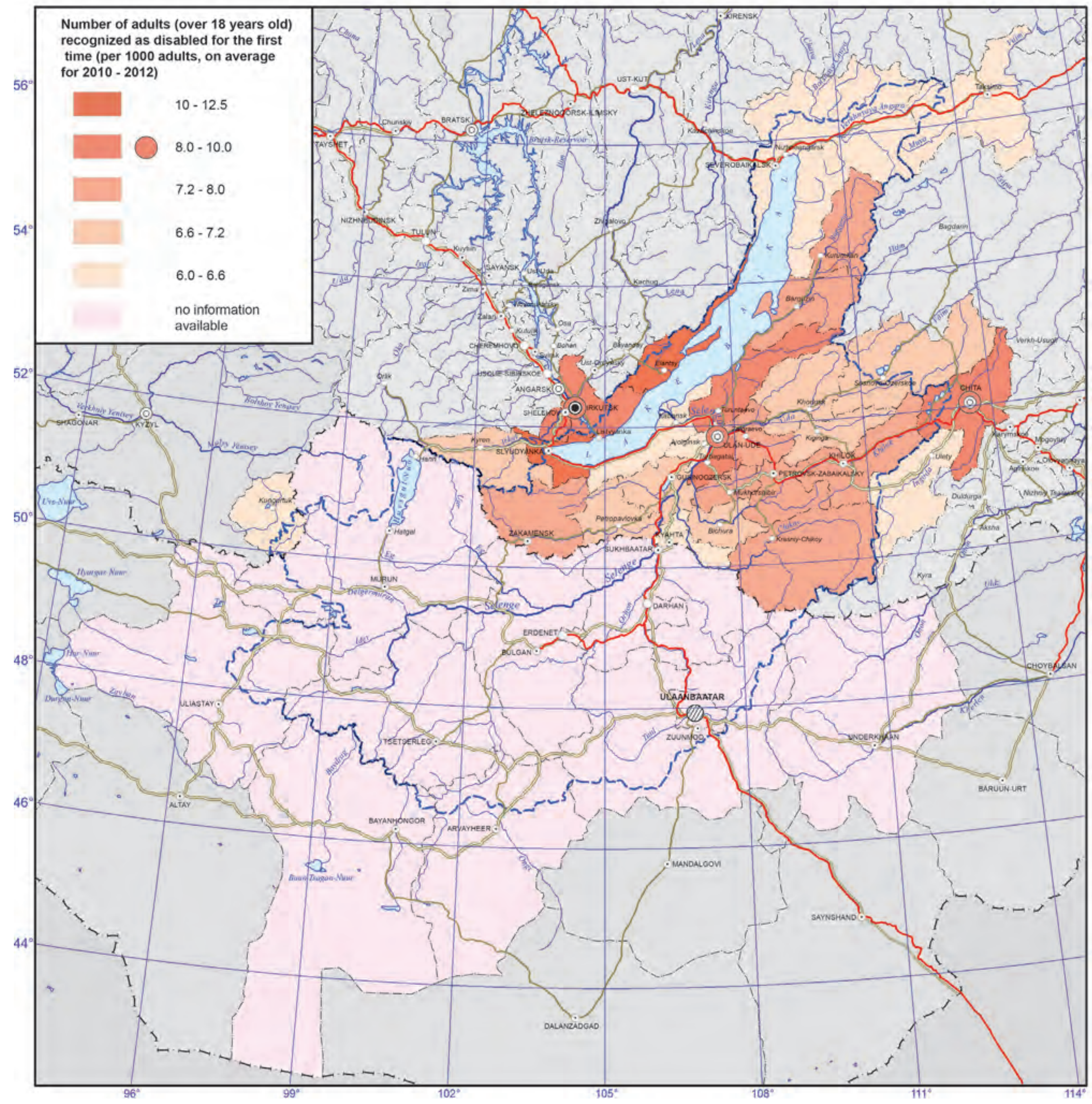
104. INJURIES AND TOXICATIONS



105. MALIGNANT NEOPLASMS

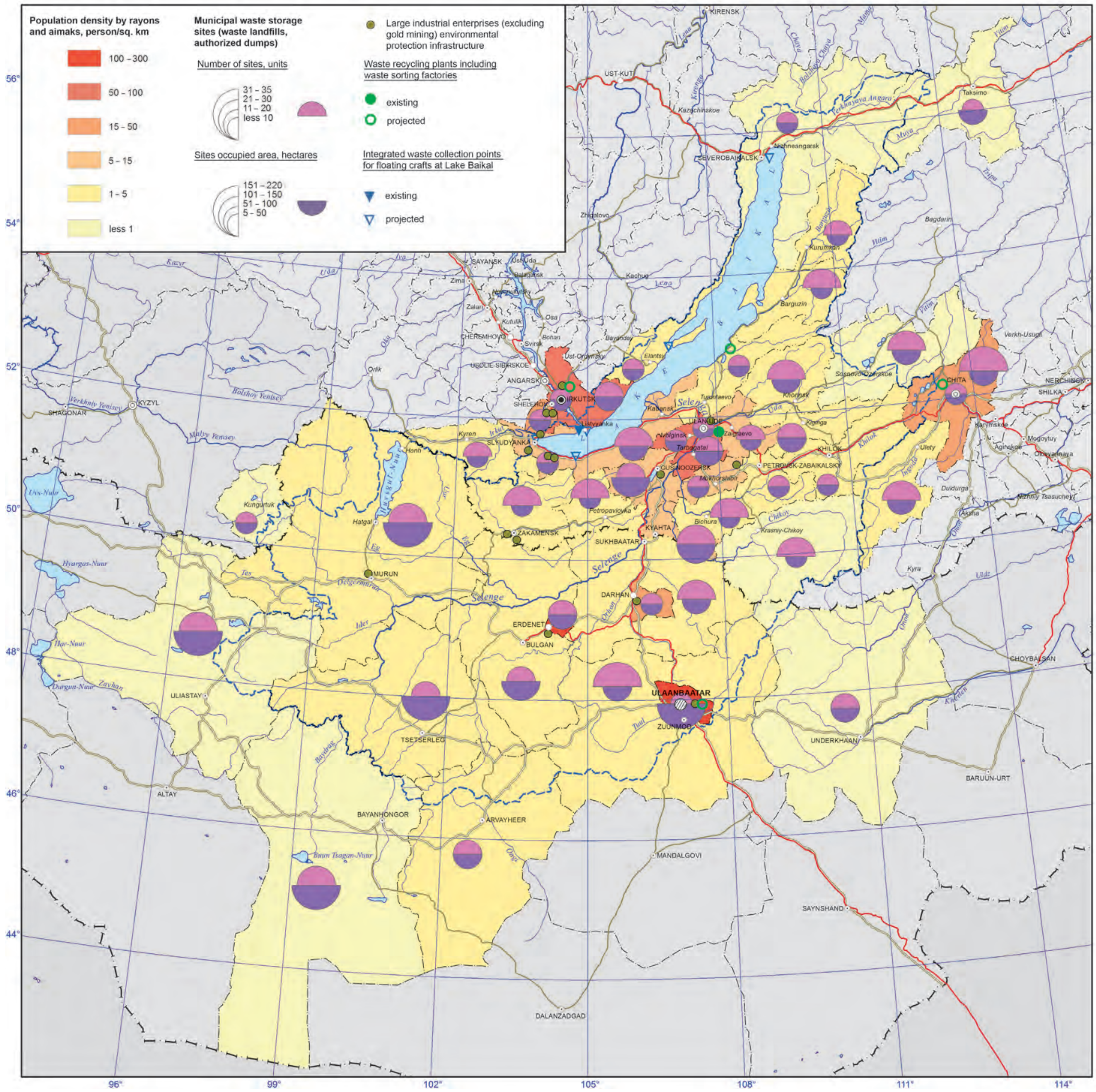


106. ADULT POPULATION DISABILITY



SECTION VI.
Environment protection

107. ENVIRONMENT-PROTECTION INFRASTRUCTURE



ENVIRONMENT-PROTECTION INFRASTRUCTURE (107)

The environment-protection infrastructure (EPI) is a component of ecological infrastructure and the most important sector of the current economic complex of the territory. The basic function of the EPI is to minimize the effect on the environment of deposited and utilized wastes (on the territory), discharges (into water bodies), production and consumer emissions (into the atmosphere), provided there is a developed selective (separate) collection of the secondary material resources. The EPI activity helps preserve a favorable environment for humans and use the territory's resources in a rational manner. This map reflects only the EPI that deals with solid production and consumer wastes, with the latter often referred to as "municipal wastes" in the international practice.

The database includes the data of territorial offices of the Ministry of Natural Resources of Russia, the Russian governmental report on the state of Lake Baikal and measures for its protection (2013), Ministry of Nature, Environment and Tourism of Mongolia (2012), as well as project materials of regional development initiatives. It should be noted that the register of sites for storing (stockpiling or deposition) and burying of production and consumer wastes for individual regions is far from complete (based on Form 2-TP (Wastes)).

In the Baikal catchment zone (in the lower level administrative districts of the Russian part and aimags in Mongolia), the annual volume of production and consumer waste reaches about 86 million tons. The majority of these wastes goes to the EPI facilities of production enterprises (sludge dumps, tailings ponds, mining waste piles, slag and ash dumps, etc.) and municipalities (predominantly waste dumps and landfills). The official statistics recorded over 600 sites for depositing waste. There is a waste recycling plant (WRP) in Ulan-Ude. There are plans to build three more WRPs (Irkutsk, Ulaanbaatar, and the Special Economic Zone "Baikal Harbor" in the Republic of Buryatia), a waste sorting plant in Chita (Zabaikalsky krai), and several waste collection facilities for processing waste from ships on Lake Baikal.

The total volume of production and consumer waste generation in the Baikal basin is growing annually. The leader is Zabaikalsky krai with almost 2/3 of all registered wastes in the Baikal basin. Irkutsk oblast is leading in terms of the speed of waste generation per unit of Gross Regional Product (tons/million rubles). In terms of the number of registered EPI facilities and their area, Mongolia tops the list, with Buryatia being the second, which corresponds to the territory they occupy in the Baikal basin. The average size of EPI facilities of municipalities and aimags is 4.3 hectares. The size of EPI facilities of Mongolian aimags (6.3 ha) exceeds this indicator by almost 1.5 times, while the size of such facilities in Irkutsk oblast exceeds the average by 1.3 times. There are plans to restart the selective (separate) collection of the utilized portion of generated consumer wastes in the future, which will significantly reduce the size of authorized waste dumps and landfills, as well as numerous unauthorized landfills of solid consumer wastes.

By the structure of economic activity, mining wastes and wastes generated by the thermal power sector make up the largest share in the total volume of generated waste (in Zabaikalsky krai, Irkutsk oblast, and Buryatia their share is over 90%). Wastes of mining companies weighing millions of tons, as well as construction wastes, slag, and ash are classified as Class V by their hazard impact on the environment (not dangerous or low-hazard wastes).

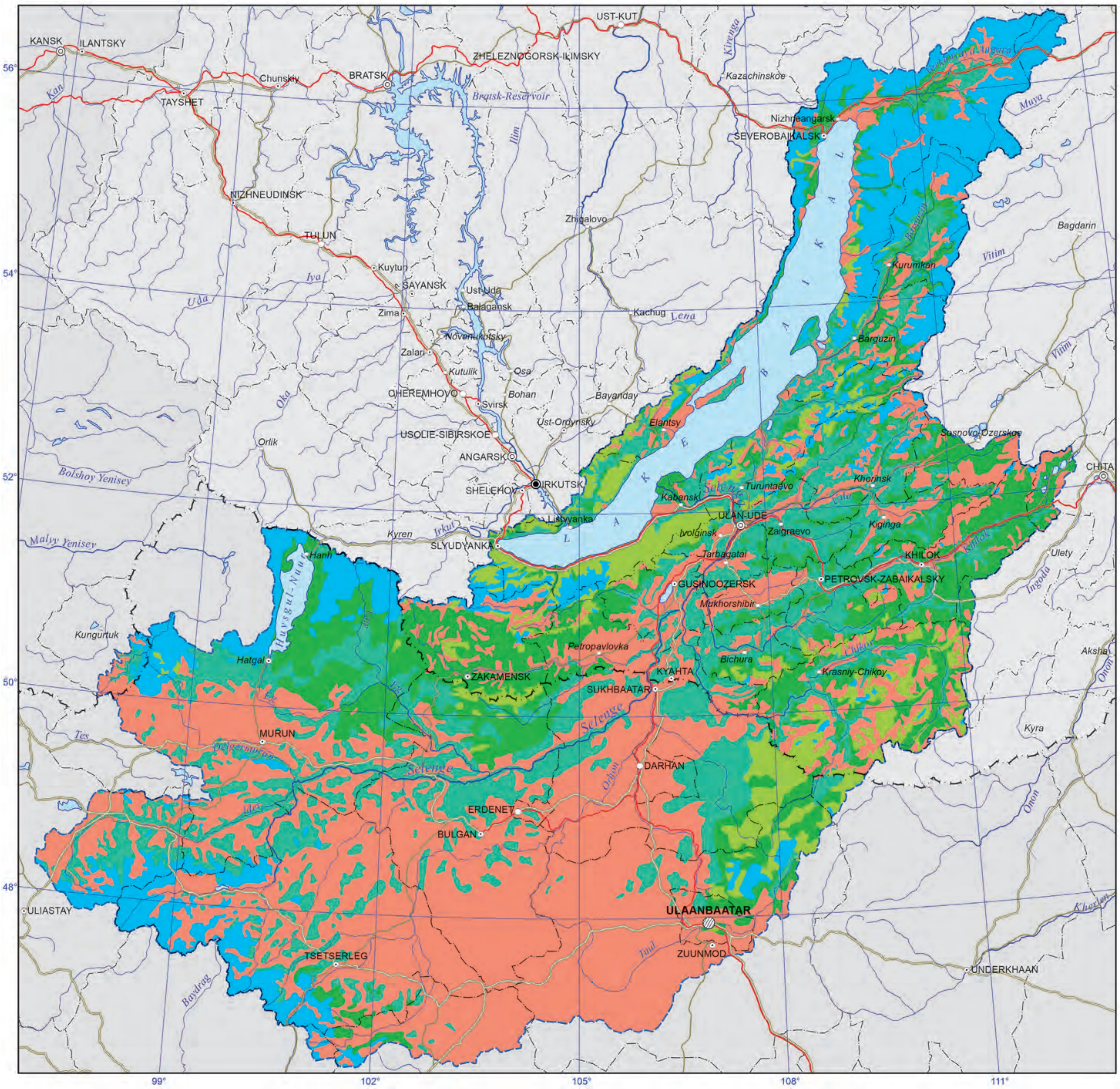
Reference

Rosgeolfond. Siberian Branch. (2013). On the state of Lake Baikal and measures for its protection in 2012: State report. Irkutsk: Rosgeolfond. p 436.

RECOMMENDED REGIMES OF NATURAL RESOURCES MANAGEMENT (108)

In this map, environmental functions of landscapes correlate with the recommended regimes of natural resources management. For example, a strictly protective regime of natural resources management is recommended for the goltsy-tundra-thin forest landscapes with the environment-forming function. This type of regime implies the implementation of preventive nature protection measures for any type of the use of the territory. These landscapes are characterized by their high sensitivity towards anthropogenic stresses. In this case, it is always necessary to consider the possibility of

108. RECOMMENDED REGIMES OF NATURAL RESOURCES MANAGEMENT



Recommended regimes of landscape use

	Recommended regimes of landscape use	Main landscape structures
	I. Strictly protective, high-mountainous (preventive nature protection measures for any types of land use).	High-mountainous goltsy-upper taiga of the Eastern Siberian and Southern Siberian types (alpinotype, sub-alpinotype, goltsy, sub-goltsy, thin forest).
	II. Operational-protective (strictly regulated use with separate protective zones for cedars).	Mountainous taiga and intermountain depression and valley landscapes, taiga larch forest of the Baikal-Dzhugdzhur type and dark coniferous forest of the Southern Siberian type for the reduced development conditions. Mountain-steppe forb-bunchgrass and mixed bunchgrass landscapes of the Daur-Mongolian type. Dry-steppe bunchgrass, piedmont, low uplands, and plain landscapes of the Daur-Mongolian type.
	III. Protective (for cedars) and protective-operational with the restoration of the used components of landscapes.	Mountainous taiga dark coniferous forest of mid-mountain belts and intermountain depressions, taiga and predominantly cedar (mossy) landscapes of the Southern Siberian type for the limited development conditions. Mountainous taiga and dark coniferous forest of mid-mountain belts and intermountain depressions, taiga (grassy with cedars) landscapes of the Southern Siberian type for the optimal development conditions.
	IV. Protective-operational with the restoration of the used components of landscapes.	Mountainous taiga larch forest and taiga of intermountain depressions (moss, shrubs, bushes) of the Baikal-Dzhugdzhur type for the limited development conditions. Mountainous taiga light coniferous forest of the Southern Siberian type (larch, cedar and larch, pine and larch) for the limited development conditions. Mountainous taiga larch forest of low-mountain belts and intermountain depressions, taiga of the Baikal-Dzhugdzhur type for the optimal development conditions.
	V. Operational with separate conservation zones	Mountainous and piedmont sub-taiga and steppificated landscapes of the Baikal-Dzhugdzhur and Southern Siberian types. Piedmont and intermountain depression, shrubby and steppificated meadows of the Southern Siberian type.

the development of any hazardous natural phenomena.

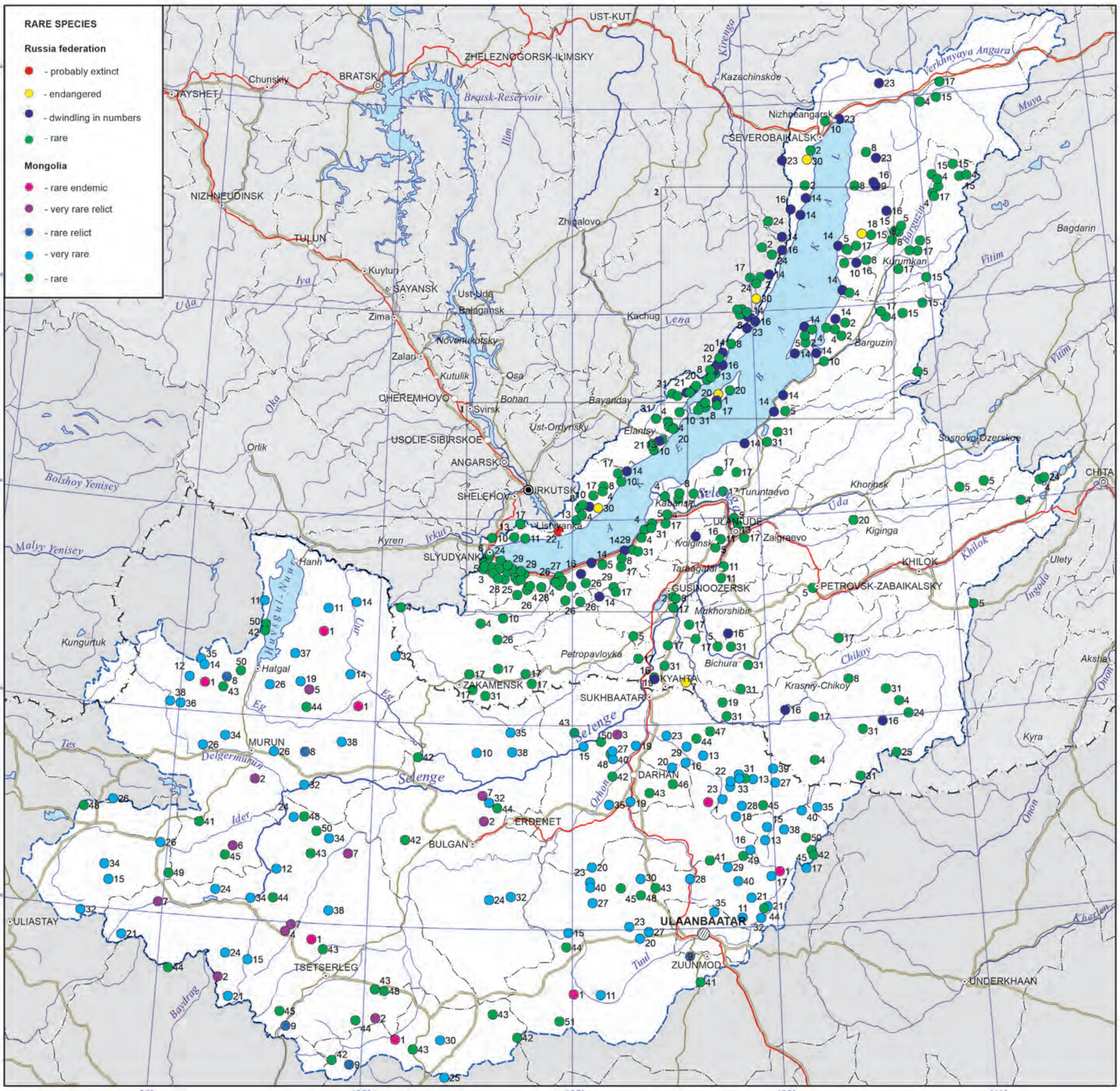
Steppe and dry steppe landscapes characterized by the moistening deficit are no less susceptible to anthropogenic stresses. They have a relatively low ecological potential. Steppe landscapes are more densely populated and developed by humans. Therefore, an operational-protective regime of natural resources management is recommended for these landscapes. It implies the continuous monitoring of the landscape's condition throughout its use and implementation of scheduled activities aimed at its improvement.

Dark coniferous forests with cedar stands belong to the category of protected forests and are used for cedar nut harvesting and hunting. A protection regime of natural resources management is recommended for these forests.

The operational-protective regime of natural resources management is recommended for moss landscapes with the environment-stabilising function. In these landscapes, anthropogenic impacts accompanied by logging may lead to the increase of soil drying on slopes, and, at the same time, cause marsh formation on flat surfaces with slow runoff. In order to preserve the mossy taiga, which has a great importance for the environment and forest management, it is necessary to constantly monitor its state and control the compliance to the rules of forest management.

The herb taiga and subtaiga landscapes with the environment-protection function are of great economic value. Therefore, a protective-operational regime of natural resources management is recommended for such

109. RARE SPECIES OF VASCULAR PLANTS



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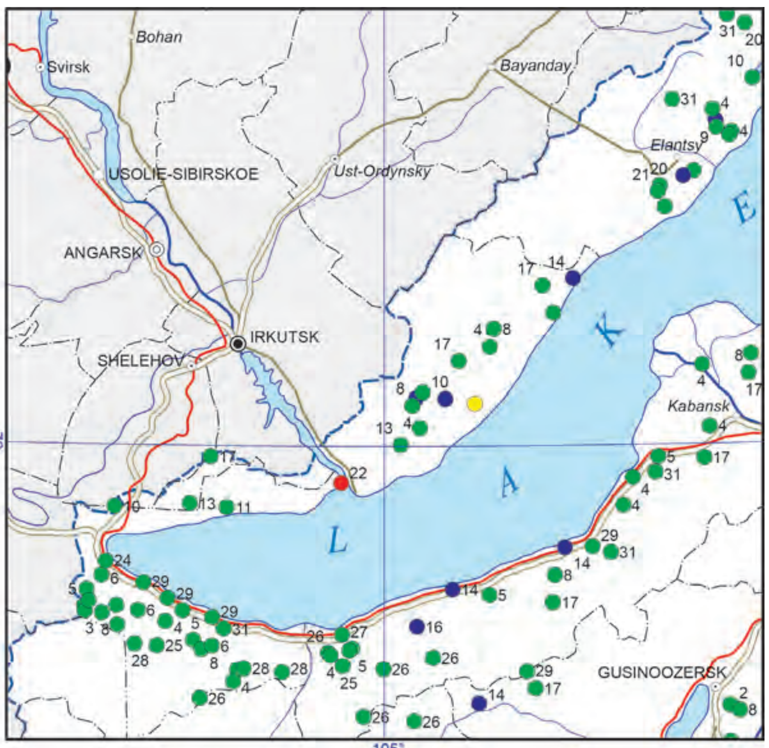

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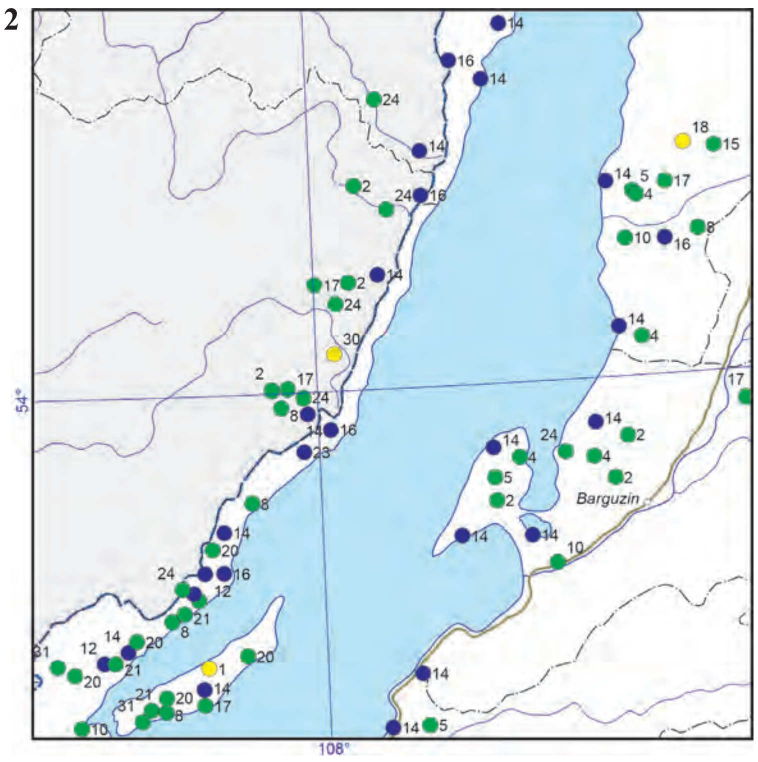

Banner in the national park.

Siberian Fir (P.V. Golyakov).

landscapes. These landscapes have a high ecological potential. Despite experiencing some moistening deficit, they are characterized by relatively favourable conditions for their natural resources management. Therefore, it is necessary to develop and comply to the production and environmental specialisation of nature protection measures.

RARE SPECIES OF PLANTS (109 — 111)

The habitats of rare species of plants in the Russian and Mongolian parts of the Baikal basin are visually presented on the map "Rare species of vascular plants" using the cartographic interpretation technique. In order to create this map for the Russian part of the basin, the authors used the lists and characteristics of rare species included in the Red Book of the Russian Federation (Plants and Fungi) [2008]. In this part of the basin, the map shows the habitats of 31 vascular plants (see the list) with different categories of the extinction risk according to the Red List of Threatened Species of the International Union for the Conservation of Nature [1978]. Category 0 (probably extinct, but the possibility of their preservation cannot be excluded) includes Isoetes lacustris. Category 1 (endangered) includes four species: Astragalus olchonensis, Vicia tsydenii, Festuca bargusinensis, and Viola incisa. Category 2 (decreasing in number) also includes four species: Caulinia flexilis, Hedysarum zundukii, Epipogium aphyllum, and Deschampsia turczaninowii. Category 3 (rare) includes 25 species represented by small populations that are currently not endangered and vulnerable. Often, these species are distributed within a limited area or have a narrow ecological amplitude.

For the map of the Mongolian part of the Baikal basin, we used information on the species composition and location of rare species of vascular plants from the electronic version of Mongolian Red Book [1999]. Habitats of 51 species are identified including a rare endemic species Saxifraga hirculus, six very rare relics: Adonis mongolica, Vicia tsydenii, Kobresia robusta, Nymphaea tetragona, Lancea tibetica, and Tulipa uniflora, as well as rare relics: Zigadenus sibiricus and Caryopteris mongolica are marked. Altogether, there are 31 very rare and 11 rare species.

The map "Rare species of vascular plants under regional protection" shows the Baikal basin's habitats of rare species under regional protection in Irkutsk oblast (Red Book of Irkutsk oblast) [2010], Buryatia (Red Book of the Republic of Buryatia) [2002], and Zabaikalsky krai (Red Book of Chita oblast) [2002]. Altogether, there are 868 habitats of 201 species of vascular plants listed in the regional Red Books and the Red Book of the Russian Federation. Species in different regions have different status depending on the state of species population. Among the regional species, Lagopsis eriostachya and Isoetes lacustris have Category 0 (probably extinct), while 28 species are endangered (Category 1).

The map "Plant communities requiring protection" uses conventional symbols and is created based on the information from the Green Book of Siberia [1996]. According to the Forest Code of the Russian Federation, forests under protection of Group 1 and forests in specially protected territories must be conserved in the Baikal basin because of their economic and social values. These forests serve to protect water resources, preserve the environment, and perform sanitary, hygienic, therapeutic, and other functions. The following communities also require protection due to their scientific importance as standards of indigenous vegetation: the Polygonum bistorta + Carex aterrima and Stemmacantha carthamoides meadows; Rhododendron aureum alpine tundras of the subalpine zone; Filifolium sibiricum, Festuca litvinovii, and Stipa klemenzii - S. Baicalensis - Eremogone capillaries steppes; Ulmus macrocarpa + Spiraea pubescens shrub steppe communities; Betula davurica - Artemisia desertorum + Calamagrostis brachytricha + Carex reventa forest communities; and Carex lasiocarpa + C. pseudocuraica + Iris laevigata marsh communities. Among the protected communities are very rare (Spodiopogon sibiricus; Armeniaca sibirica + Spiraea pubescens), relict (Arundinella anomala + Lespedeza hedysaroides), and unique (Stipa baicalensis + Paeonia lactiflora) communities, as well as communities located on the margins of their habitats (Pinus pumila; Caragana jubata) and reducing their habitat due to a high resource-related importance (Filifolium sibiricum + Phlojodicarpus sibiricus). The maps showing the distribution of rare vascular plant species and plant communities requiring protection can be used in the development of environmental policy aimed at optimizing nature resources management in the Baikal region to protect its biodiversity.

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RARE SPECIES OF FAUNA (112 — 118)

The animal kingdom of the Baikal basin is rich and diverse. The basin's fauna is unique due to a peculiar geographic location of this region, which explains the

Astragalus Olkhon (Ryabtsev V.V.).

Kopeechnik zunduksky (Ryabtsev V.V).

Rare species of vascular plants

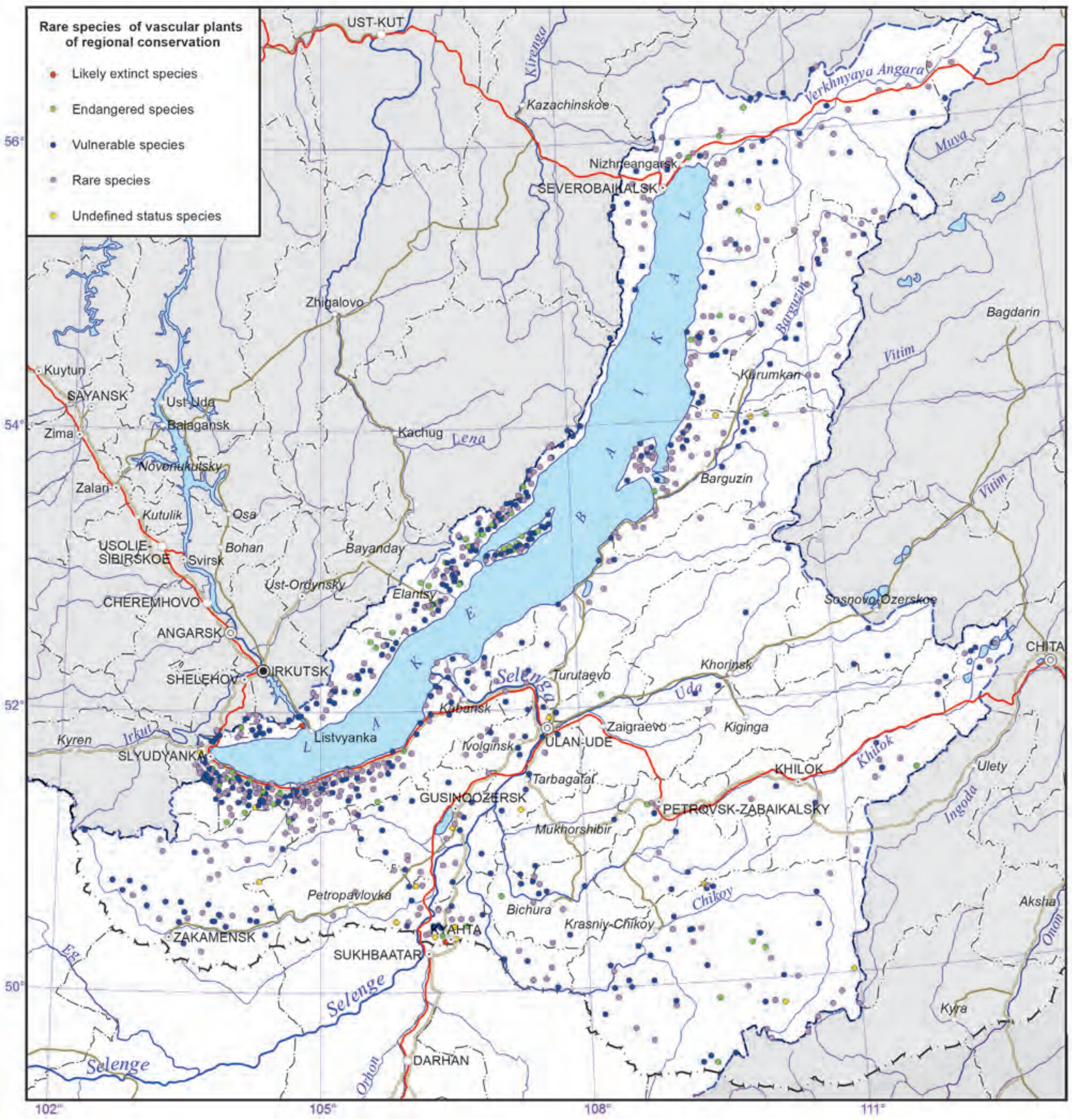
RUSSIA

1. Astragalusolchonensis
2. Borodinia macrophylla
3. Cypripediym ventricosum
4. Cypripedium macranthon
5. Cypripedium calceolus
6. Anemone baikalensis
7. Vicia tsydenii
8. Calypso bulbosa
9. Caulinia flexilis
10. Cotoneaster lucidus
11. Stipa pennata
12. Hedysarum zundukii
13. Astragalus olchonensis
14. Deschampsia turczaninowii
15. Mertensia serrulata
16. Epipogium aphyllum
17. Neottianthe cucullata
18. Festuca bargusinensis
19. Caryopteris monghoIica
20. Oxytropis triphylla
21. Primula pinnata
22. Isoëtes lacustris
23. Isoëtes setacea
24. Rhodiola rosea
25. Fritillaria dagana
26. Swertia baicalensis
27. Aegopodium latifolium
28. Stemmacantha carthamoides
29. Tridactylina kirilowii
30. Viola incise
31. Orchis militaris

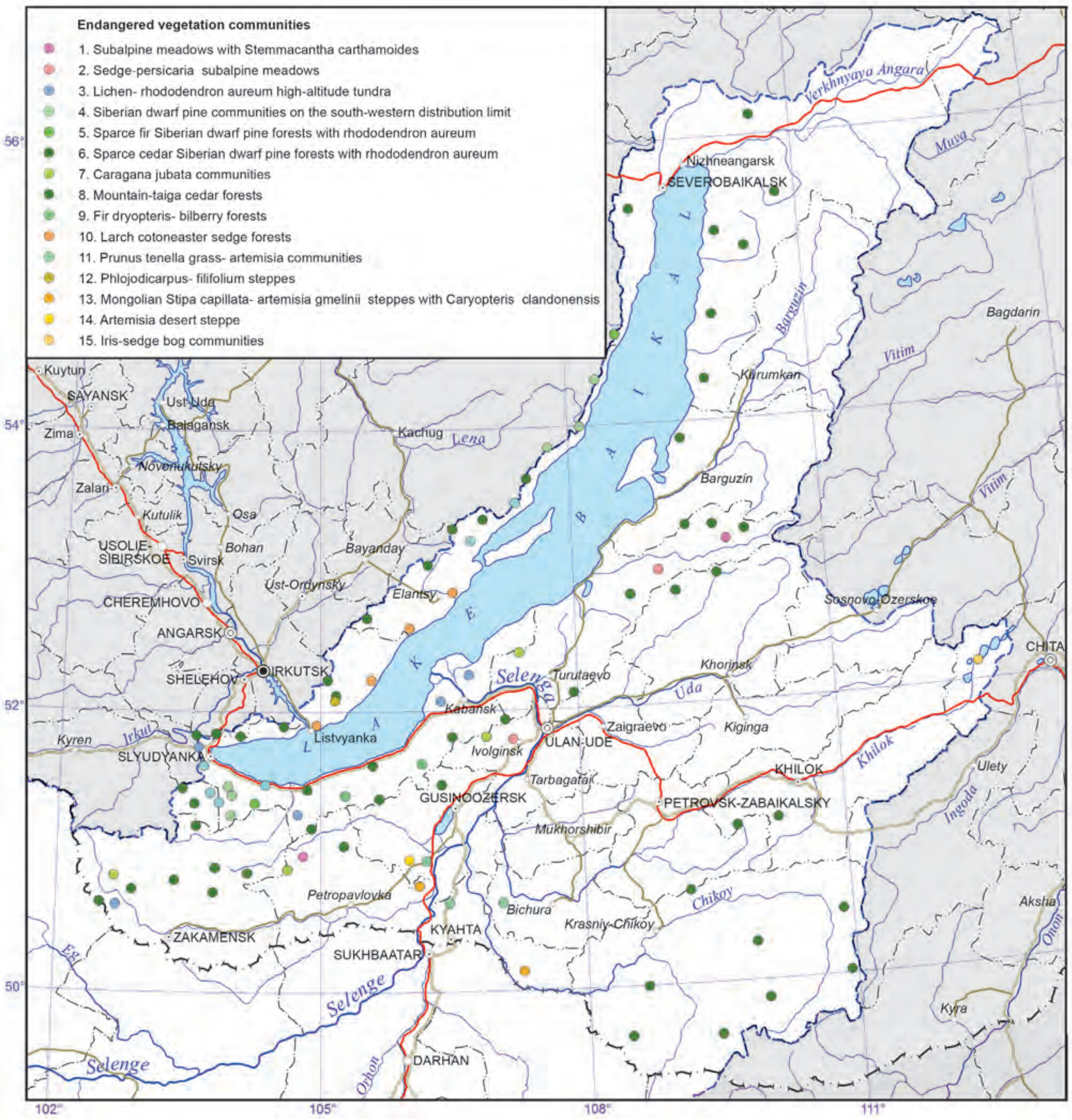
MONGOLIA

1. Saxifraga hirculus
2.Adonis mongolica
3.Vicia tsydenii
4.Kobresia robusta
5.Nymphaea tetragona
6. Lancea tibetica
7. Tulipa uniflora
8.Zigadenus sibiricus
9.Caryopteris mongolica
10. Acorus calamus
11.Sambucus manshurica
12. Gentiana algida
13.Botrychium lanceolatum
14.Neottia camtschatea
15.Neottianthe cucullata
16.Lycopodium alpinum
17. Pinus pumila
18.Convallaria keiskei
19.Lilium dahuricum
20.Platanthera bifolia
21.Juniperus sabina
22.Mitella nuda
23.Epipogium aphyllum
24.Carex parva
25.Carex selengensis
26.Oxytropis acanthacea
27.Orchis fuchsia
28. Abies sibirica
29.Lycopodium clavatum
30. Physochlana albiflora
31. Drosera anglica
32.Rhodiola rosea
33.Drosera rotundifolia
34.Rhododendron adamsii
35.Rhododendron dauricum
36.Rhododendron aureum
37.Rhododendron ledebourii
38.Rhododendron parvifolium
39.Vaccinium myrtilus
40. Orchis militars
41. Adonis sibirica
42.Valeriana officinalis
43.Stellaria dichotoma.
44. Aium altaicum
45.Juniperus pseudosabina
46.Melica nutans
47. Lycopodium complanatum
48.Paeonia anomala
49.Saussurea dorogostaiskii
50.Saussurea involucrate
51. Ephedra equisetina

110. RARE SPECIES OF VASCULAR PLANTS OF REGIONAL CONSERVATION



111. ENDANGERED VEGETATION COMMUNITIES



extreme diversity of the species composition including many genetically and environmentally heterogeneous elements. In this region, the contact and overlapping of many systemically and ecologically close species and subspecies take place. A large number of forms is represented by the periphery and even isolated populations preserved in the local refugiums since the last glacial period. As a rule, all these species are relatively rare and small in number, and their habitats cover a small territory. Therefore, all of them have been listed in the Red Books and require special protection.

A series of maps of this section provides an insight about the spread of rare species of animals grouped according to their systematic features into separate categories: fish, amphibians and reptiles, birds and mammals. The maps show the main habitats of rare species based on the literature and museum collection research, as well as personal observations of the authors. The maps also show home ranges of certain species.

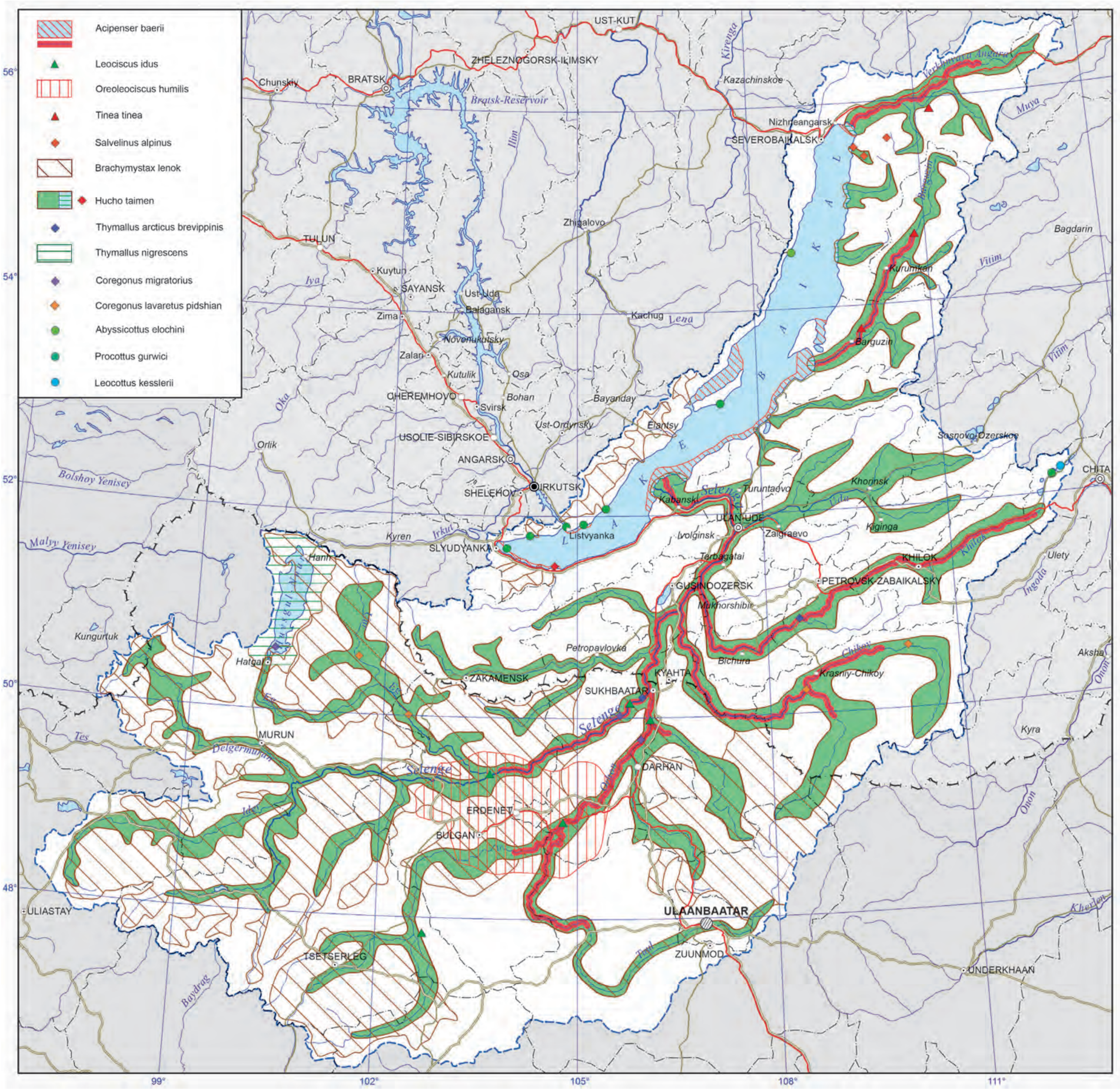
More than 60 species of fish live in rivers and water bodies of the Baikal basin with half of them being endemic or relict species. The indigenous ichthyofauna of the Baikal basin's rivers and lakes formed on the basis of the species of the boreal piedmont, boreal lowland, and arctic freshwater complexes; only the Siberian sturgeon and tench are remnants of the ancient late Tertiary faunal complex. Species representing other faunal complexes got into these water bodies as a result of introduction or invasion. In Lake Baikal, the level of endemism reaches 55% of all fish species, which is indicative of the autochthonous nature of the formation of the nucleus of the lake's ichthyofauna. Only 10 species of fish are found in Lake Khovsgol, with half of them being valuable commercial fishery species. More than a half of the fish species listed in the regional Red Books of the Russian Federation and Mongolia are valuable commercial fishery species. However, their number has been significantly reduced due to the intensive human economic activities over the past 100 years. Overfishing, construction of hydro-technical facilities, and water body pollution negatively impacted their population and resulted in the partial loss of habitat. Today, 15 fish species in the Baikal basin require protection and artificial breeding in order to restore their number.

The Baikal basin is characterized by a low diversity of species of the herpetofauna (altogether about 20 species) due to harsh weather conditions in the region and the history of faunal formation. On the other hand, the basin is a place of contact of the habitats of the Western and Eastern Palearctic species, while representatives of the Central Asian and Daur-Mongolian fauna are wedging in from the south. Half of the species inhabiting this area are located on the periphery of their habitats. Anthropogenic transformation of habitats, drainage and contamination of water bodies, frequent fires, high recreational stress, and extermination by humans decrease the number and fragment the habitats of many herpetofauna species. At present, four amphibian species and six reptile species need protection.

Peculiarity of natural landscapes, climatic and geomorphological conditions, and the historical process of the formation of the ornithofauna resulted in its species diversity. The nucleus of the structure of the population of the basin's ornithofauna is composed by representatives of the Siberian, Mongolian, Chinese, European and Arctic types of fauna. Transpalearctic species also make up a sizable proportion. Species of the Tibetan and Mediterranean types of fauna make up only a small share of species. Modern ornithofauna of the Baikal basin includes over 400 species; about 100 of them need protection. Human economic activity ambiguously impacts the structure of the ornithofauna. Transformation of the environment as a result of logging, fires, overgrazing, or steppe ploughing may decrease the number of some species, but, on the other hand, it may expand the habitats or the number of other species. Stenobiontic species are affected by economic activity the most. Transformation of habitats, changes in the hydrological regime of certain rivers and Lake Baikal, poaching, logging, fires, and technogenic emissions, all against the backdrop of fluctuations of environmental and climatic conditions, result in the decrease of diversity and number of the majority of bird species.

The fauna of mammals is quite specific and diverse including over 90 species. Many of these species are located on the periphery of their ranges. The modern mammal fauna of the basin is represented by almost 20 faunulas, the largest of which in terms of the number of species are the following: the Holarctic arctic boreal, taiga Palearctic, western Palearctic taiga, Holarctic tundra and golets, steppe southern Palearctic, and Central Asian elements, as well as the East Asian and southern Palearctic flying mammals. A small number of species of the basin either acclimatized or followed the humans. Compared to other animals, mammals are more affected by the direct anthropogenic impact.

112. DISTRIBUTION OF RARE ANIMAL SPECIES. FISH



Categories of species and subspecies by the degree of endangerment (marked with numbers and letters)

Irkutsk oblast, Republic of Buryatia, and Zabaikalsky krai

Category 0 – Probably extinct

Category I – Endangered: species (subspecies) whose number has decreased to a critical level

Category II– Decreasing in number: species (subspecies) whose number is steadily decreasing

Category III – Rare: species (subspecies) that are small in number and/or have a limited territory

Category IV – Status undetermined: species (subspecies) of undetermined status that possibly belong to one of the categories listed above

Category V – Rehabilitating and being rehabilitated: species (subspecies) that have been rehabilitated or are undergoing rehabilitation

Category VI – Rare species (subspecies) that stay only for irregular periods of time

Category VII– Species (subspecies) not endangered in Buryatia, but listed in the Red Books of Russia, Mongolia, and neighboring regions

Mongolia

Regionally Extinct (RE) – spicies, disappeared in the region.

Critically Endangered (CR) – spicies is critically endangered.

Endangered (EN) – spicies endangered.

Vulnerable (VU) – spicies is vulnerable.

Near Threatened (NT) – spicies close to the vulnerable situation.

Least Concern (LC) – spicies under the lowest threat.

Data Deficient (DD) – insufficient data on the spicies.

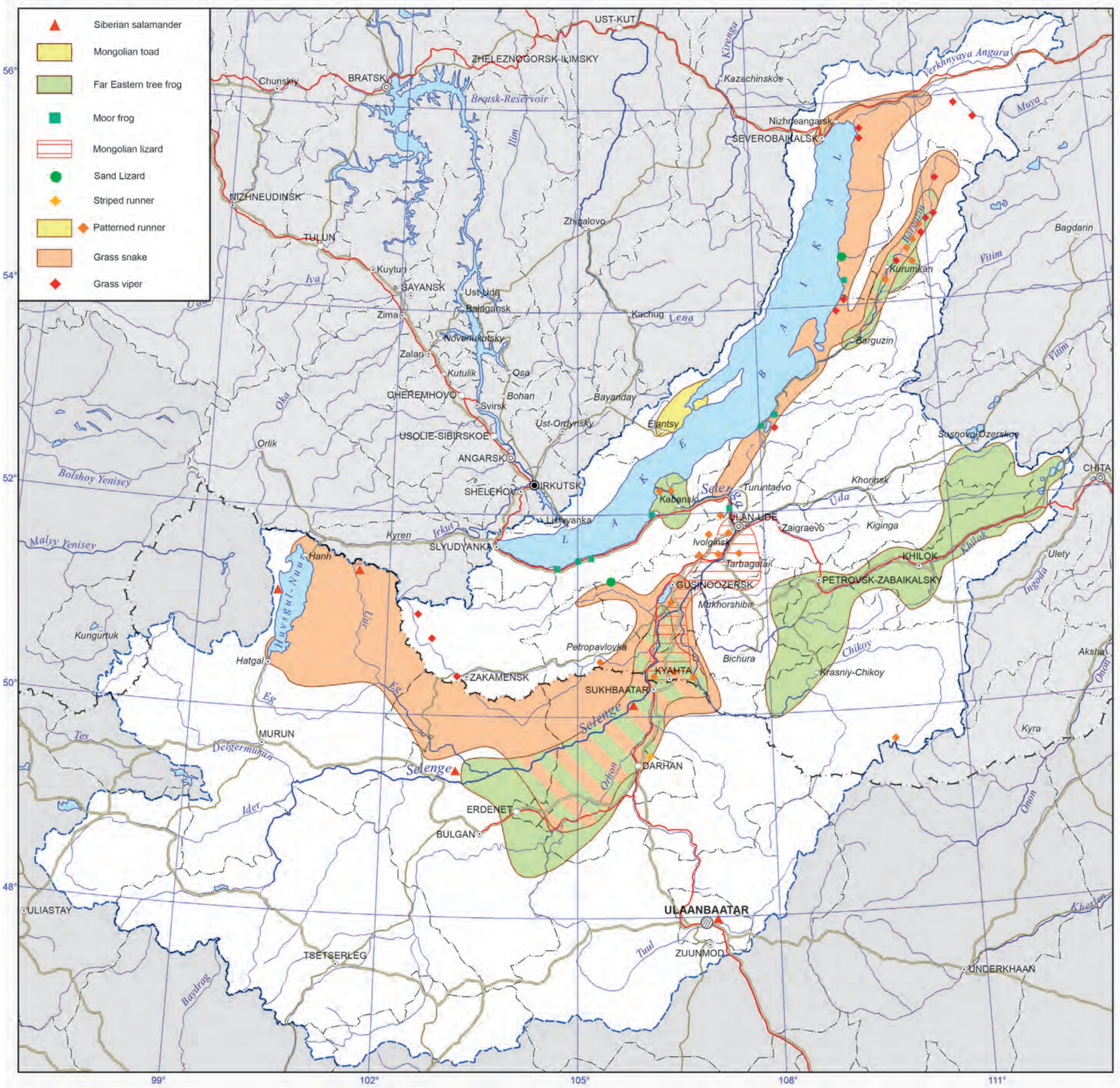
«*» marked species listed in the Red Book of the Russian Federation (2008).

«-» marked species do not occur in the territory or not listed in the Red Book.

Species	Irkutsk oblast	Republic of Buryatia	Zabaikalsky krai	Mongolia
Fish				
Siberian sturgeon Acipenser baerii*	I	II	I	CR
Ide Leuciscus idus	-	-	-	NT
Dwarf Altai osman Oreoleuciscus humilis	-	-	-	VU
Tench Tinea tinea	-	III	-	-
Arctic char Salvelinus alpinus	-	II	-	-
Lenok Brachymystax lenok	II	-	-	VU
Taimen Hucho taimen	I	IV	I	EN

White Baikal grayling Thymallus arcticus brevippinis	-	-	IV	NT
Khovsgol grayling Thymallus nigrescens	-	-	-	EN
Baikal omul Coregonus migratorius	-	-	-	DD
Siberian whitefish Coregonus lavaretus pidshian	-	-	II	EN
Elochin sculpin Abyssocottus elochini	III	-	-	-
Dwarf sculpin Procottus gurwici	III	-	-	-

113. DISTRIBUTION OF RARE ANIMAL SPECIES. AMPHIBIANS



Thus, the majority of mammals listed as rare species in the near past were or still are considered as game animals, but their population was sharply reduced due to unregulated hunting and poaching. It is not uncommon that the activities aimed at preventing zoonotic infectious diseases led to a sharp decrease of infection hosts – rodents. Logging, steppe ploughing, overgrazing, frequent fires, and the fragmentation of natural territories devastatingly impacted the majority of mammalian species inhabiting the Baikal basin. Therefore, over 30 species now require special protection and reproduction.

The Red Books of the Russian Federation (2001) and Mongolia (2006 a,b,c,d), as well as regional Red Books of Irkutsk oblast (2010), Republic of Buryatia (2013), and Zabaikalsky krai (2012) were created to protect rare and endangered species. The categories set forth in the Red Book of the Russian Federation (2008) were used as a basis for the development of the regional categories of rarity and the degree of endangerment. Minor amendments were introduced to reflect regional characteristics of the biota. In particular, two regional categories (VI) and (VII) were included due to geographic features of the Republic of Buryatia (location near state border, existence of major biogeographic boundaries and important migration routes, and so on). The categories of the IUCN were used for rare species of vertebrate animals in Mongolia.

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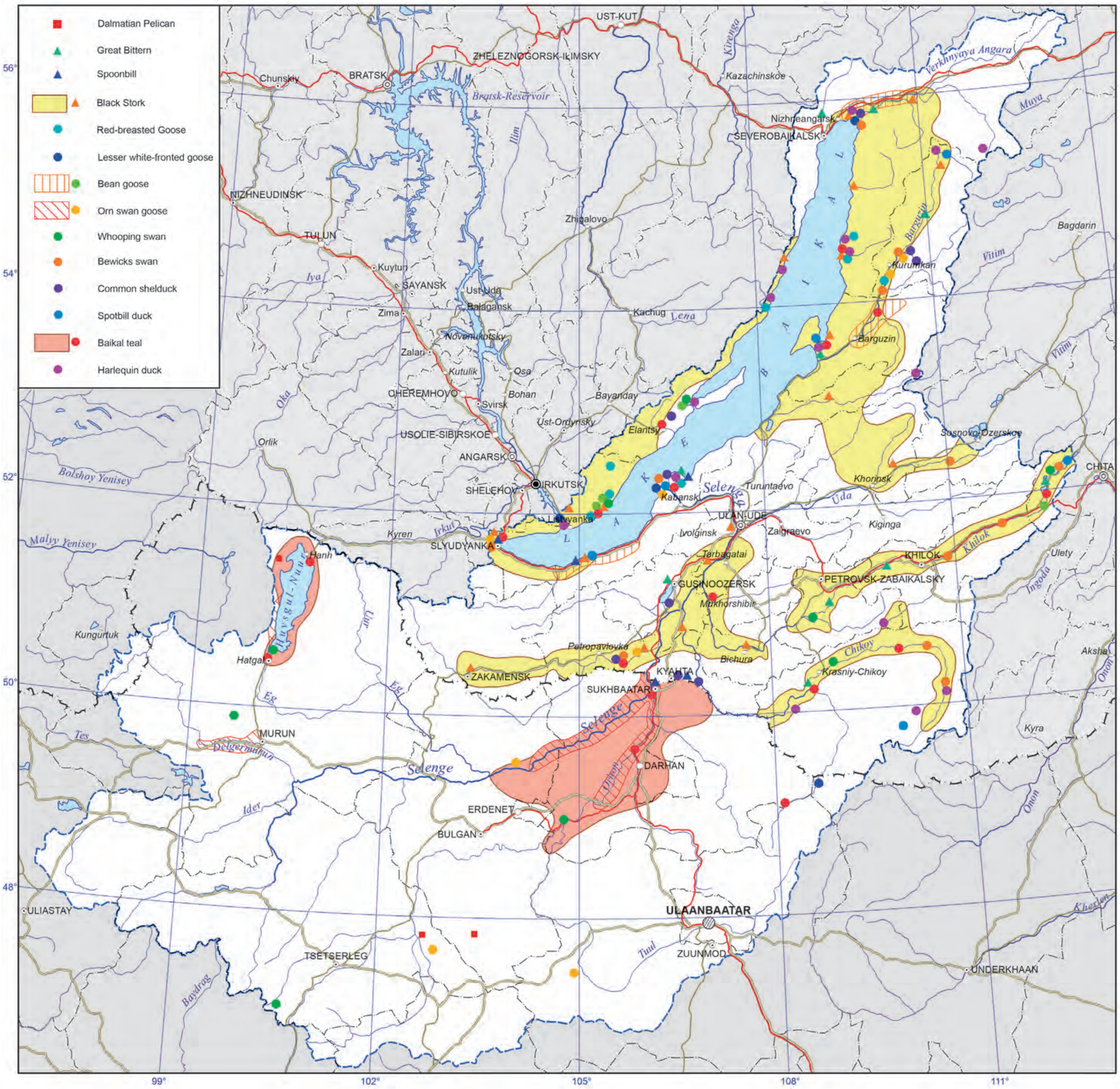
Siberian sturgeon (J.L. Hlasek).

Dubrovnik (V.Y. Ivushkin).

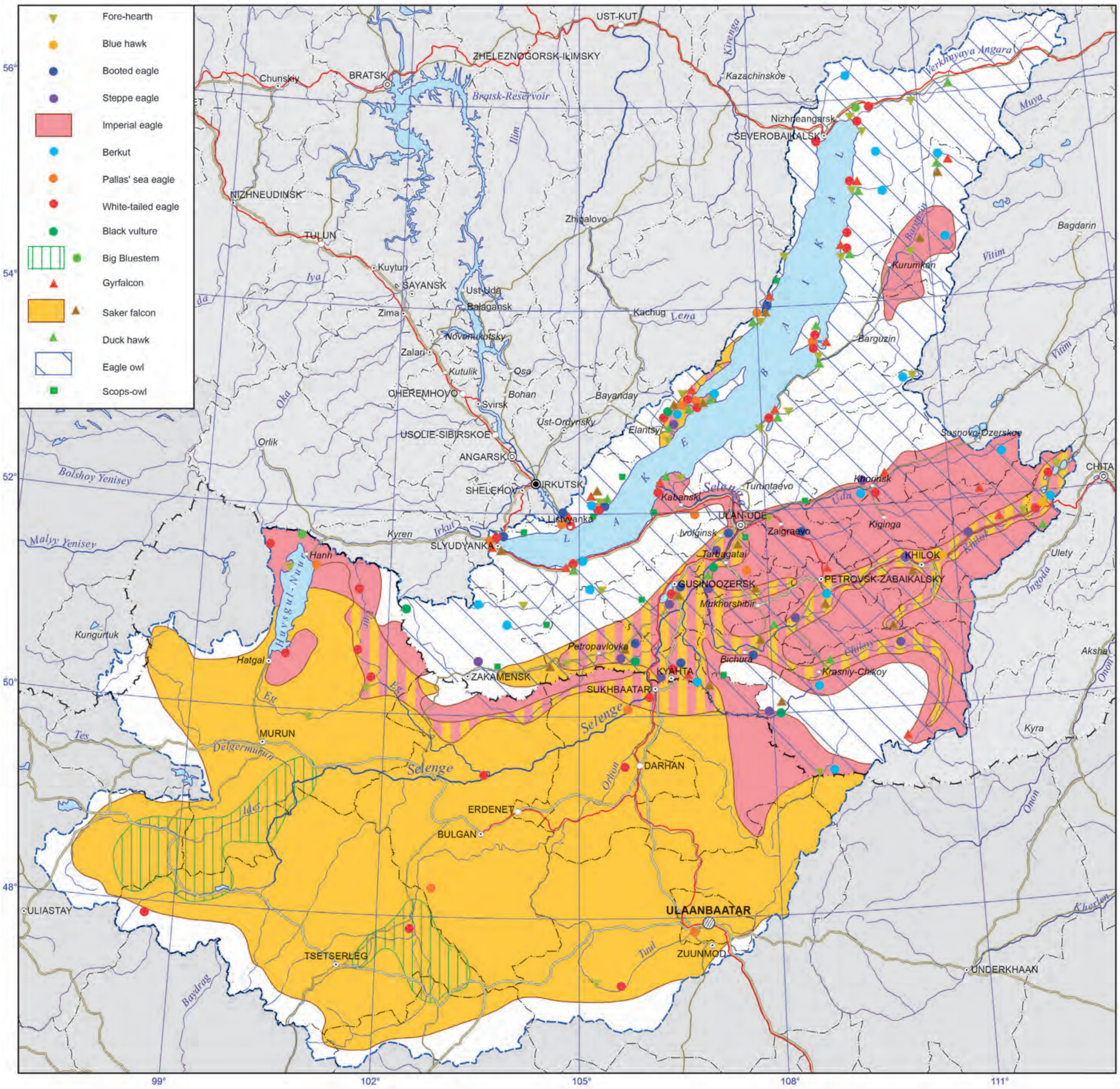
114. DISTRIBUTION OF RARE ANIMAL SPECIES. BIRDS: PELICANS, STORKS, AND GEESE



Kessler's sculpin Leocottus kesslerii	-	-	IV	-
Amphibians				
Siberian salamander Salamandrella keyserlingii	-	-	-	VU
Mongolian toad Bufo raddei	II	-	-	LC
Japanese tree frog Hila japonica	-	III	III	VU
Moor frog Rana arvalis	-	III	-	-
Reptiles				
Mongolian racerunner Eremias argus	-	II	-	LC
Sand lizard Lacerta agilis	-	III	-	-
Striped racer Coluber spinalis	-	-	-	NT
Dione rat snake Elaphe dione	II	II	III	LC
Grass snake Natrix natrix	-	II	III	NT
Common northern viper Zootoca vivipara	-	0	-	VU
Birds: Pelicans, Storks, and Geese				
Dalmatian pelican Pelecanus crispus*	0	-	-	CR
Eurasian bittern Botaurus stellaris	-	III	-	-
Eurasian spoonbill Platalea leucorodia*	IV	VI	-	LC
Black stork Ciconia nigra*	III	III	-	LC
Red-breasted goose Branta ruficollis*	III	III	-	-

Lesser white-fronted goose Anser erythropus*	III	IV	-	VU
Bean goose Anser fabalis	I	III	-	LC
Swan goose Anser cygnoides*	0	III	I	NT
Whooper swan Cygnus cygnus	III	-	II	LC
Tundra swan Cygnus bewickii*	III	II	I	LC
Common shelduck Tadorna tadorna	III	III	-	LC
Spot-billed duck Anas poecilorhyncha	-	III	II	LC
Baikal teal Anas Formosa*	I	III	II	VU
Harlequin duck Histrionicus histrionicus	III	III	IV	-
Birds: Birds of Prey and Owls				
Osprey Pandion haliaetus*	III	III	I	LC
Hen harrier Circus cyaneus	-	-	II	LC
Booted eagle Hieraaetus pennatus	III	III	-	LC
Steppe eagle Aquila nipalensis*	III	V	III	LC
Eastern imperial eagle Aquila heliaca*	III	I	I	VU
Golden eagle Aquila chrysaetos*	III	III	I	LC
Pallas's fish eagle Haliaeetus leucoryphus*	VI	I	-	EN
White-tailed eagle Haliaeetus albicilla*	III	I	I	NT

115. DISTRIBUTION OF RARE ANIMAL SPECIES. BIRDS: BIRDS OF PREY AND OWLS



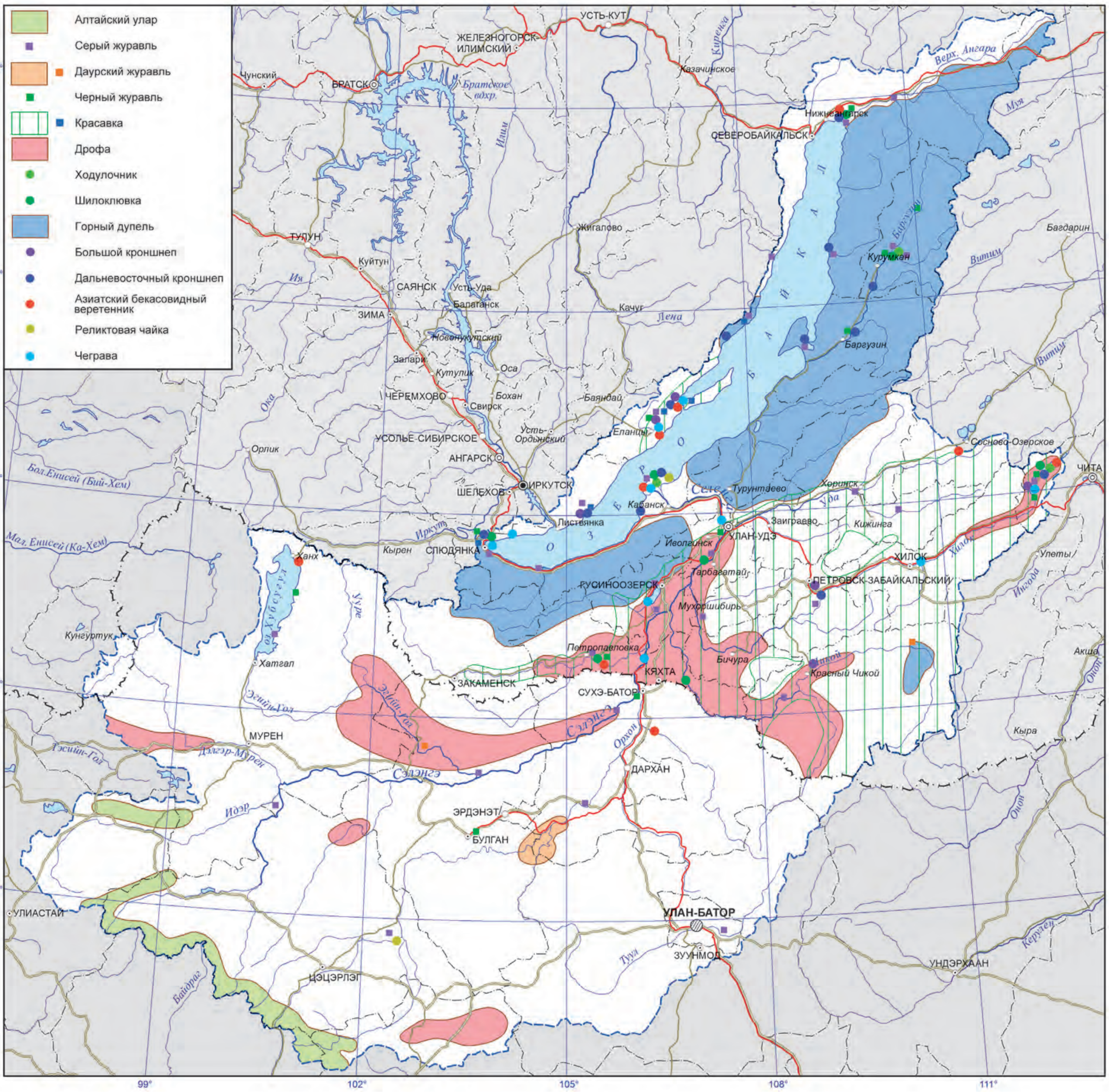
Black Stork (D.A. Andronov).

Kloktun (J.L. Hlasek).

Belladonna with chick (A.V. Choline).

Saker Falcon (A.V. Choline).

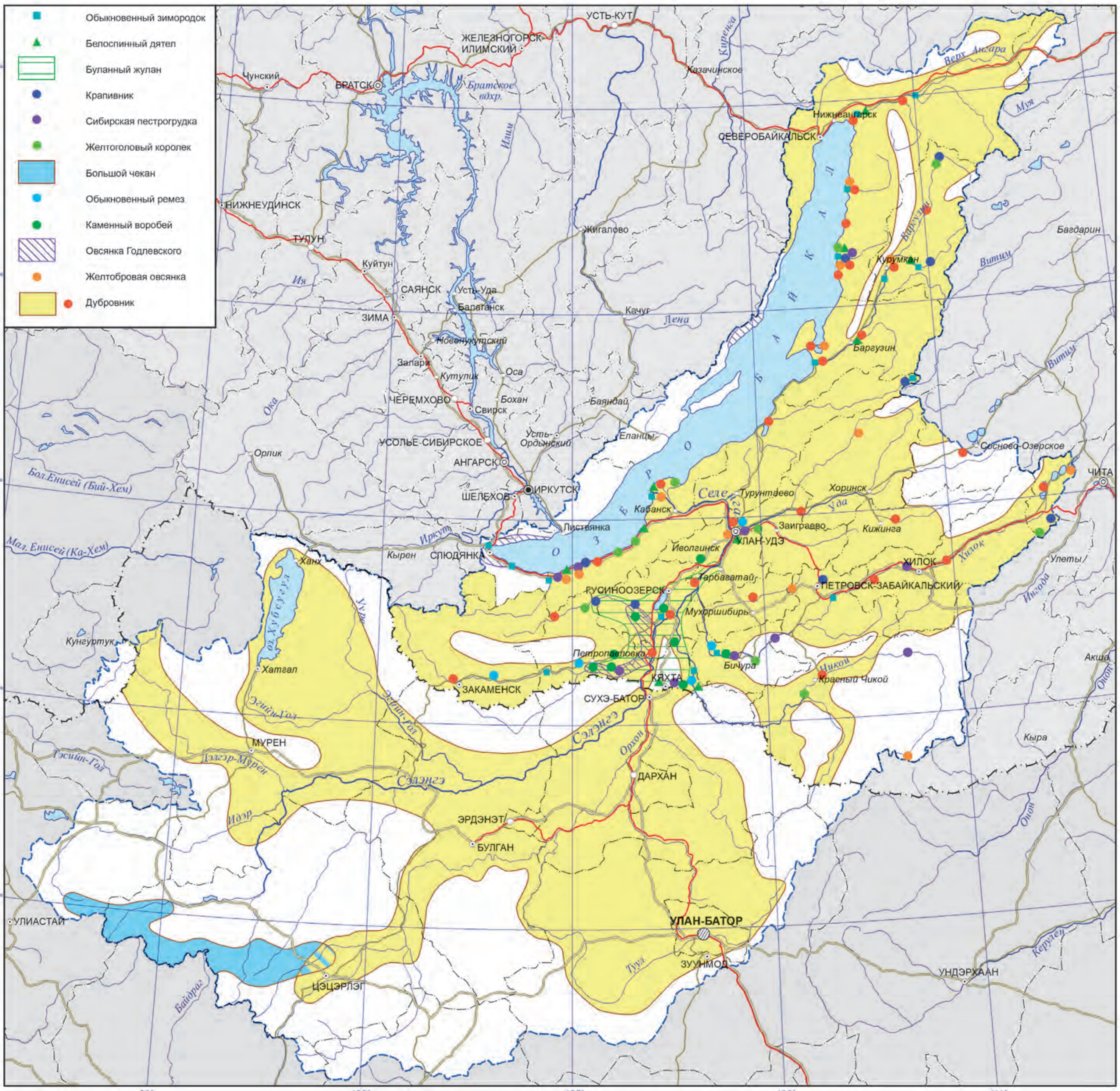
116. DISTRIBUTION OF RARE ANIMAL SPECIES. BIRDS: GALLIFORMES, CRANES, AND WADING BIRDS



Cinereous vulture Aegypius monachus*	III	III	I	LC
Bearded vulture Gypaetus barbatus*	-	III	-	VU
Gyrfalcon Falco rusticolus*	III	I	I	DD
Saker falcon Falco cherrug*	III	III	I	VU
Peregrine falcon Falco peregrinus*	III	III	I	DD
Eurasian eagle-owl Bubo bubo	III	III	I	LC
European scops owl Otus scops	III	III	-	LC
Birds: Galliformes, Cranes, and Wading Birds				
Altai snowcock Tetraogallus altaicus	-	III	-	NT
Common crane Grus grus	III	III	III	NT
White-naped crane Grus vipio*	III	-	-	VU
Hooded crane Grus monacha*	IV	IV	-	VU
Demoiselle crane Anthropoides virgo*	III	VII	-	LC
Great bustard Otis tarda*	0	III	-	VU
Black-winged stilt Himantopus himantopus*	-	III	-	LC
Pied avocet Recurvirostra avosetta*	IV	III	I	LC
Solitary snipe Gallinago solitaria	III	IV	III	LC
Eurasian curlew Numenius arquata*	III	-	III	LC
Far Eastern curlew Numenius madagascariensis*	IV	III	I	LC

Asian dowitcher Limnodromus semipalmatus*	I	III	I	VU
Relict gull Larus relictus*	-	VI	I	EN
Caspian tern Hydroprogne caspia*	IV	III	I	LC
Birds: Piciformes, Coraciiformes, and Passeriformes				
Common European kingfisher Alcedo atthis	IV	III	-	LC
White-backed woodpecker Dendrocopos leucotos	-	III	-	-
Isabelline shrike Lanius isabellinus	-	II	-	-
Eurasian wren Troglodytes troglodytes	-	III	IV	LC
Siberian warbler Tribura tacsanowskia	-	III	IV	LC
Goldcrest Regulus regulus	-	III	II	LC
White-throated bush chat Saxicola insignis	-	-	-	NT
Eurasian penduline tit Remiz pendulinus	-	III	-	LC
Rock sparrow Petronia petronia	-	III	II	LC
Godlewski's bunting Emberiza godlewskii	III	III	-	LC
Yellow-browed bunting Ocyris chrysophrys	-	III	II	LC
Yellow-breasted bunting Ocyris aureolus	-	II	II	NT

117. DISTRIBUTION OF RARE ANIMAL SPECIES. BIRDS: PICIFORMES, CORACIIFORMES, AND PASSERIFORMES

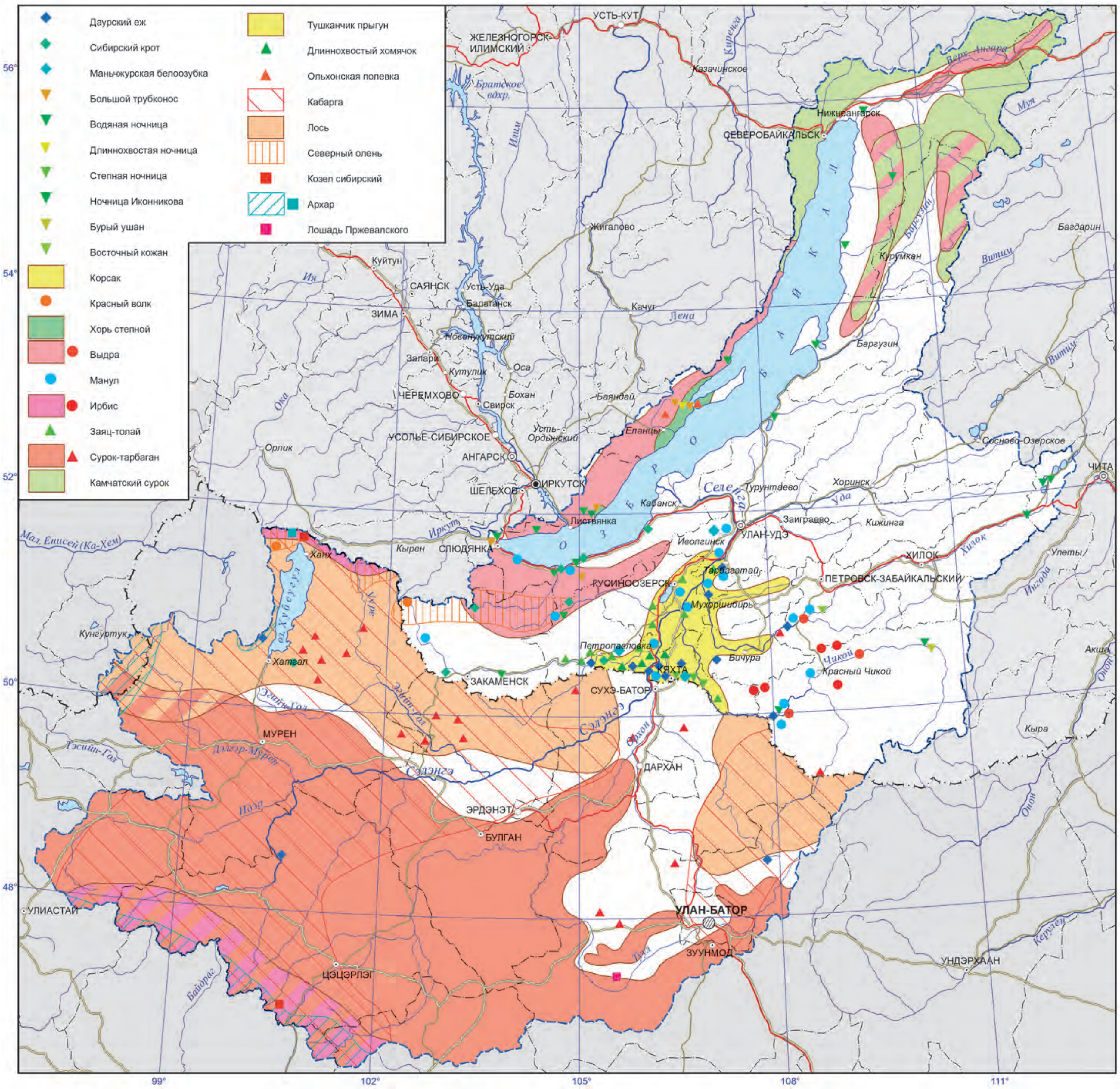


Snow leopard (A. Abrosimov).

Kamchatka marmot (A.P. Sofronov).

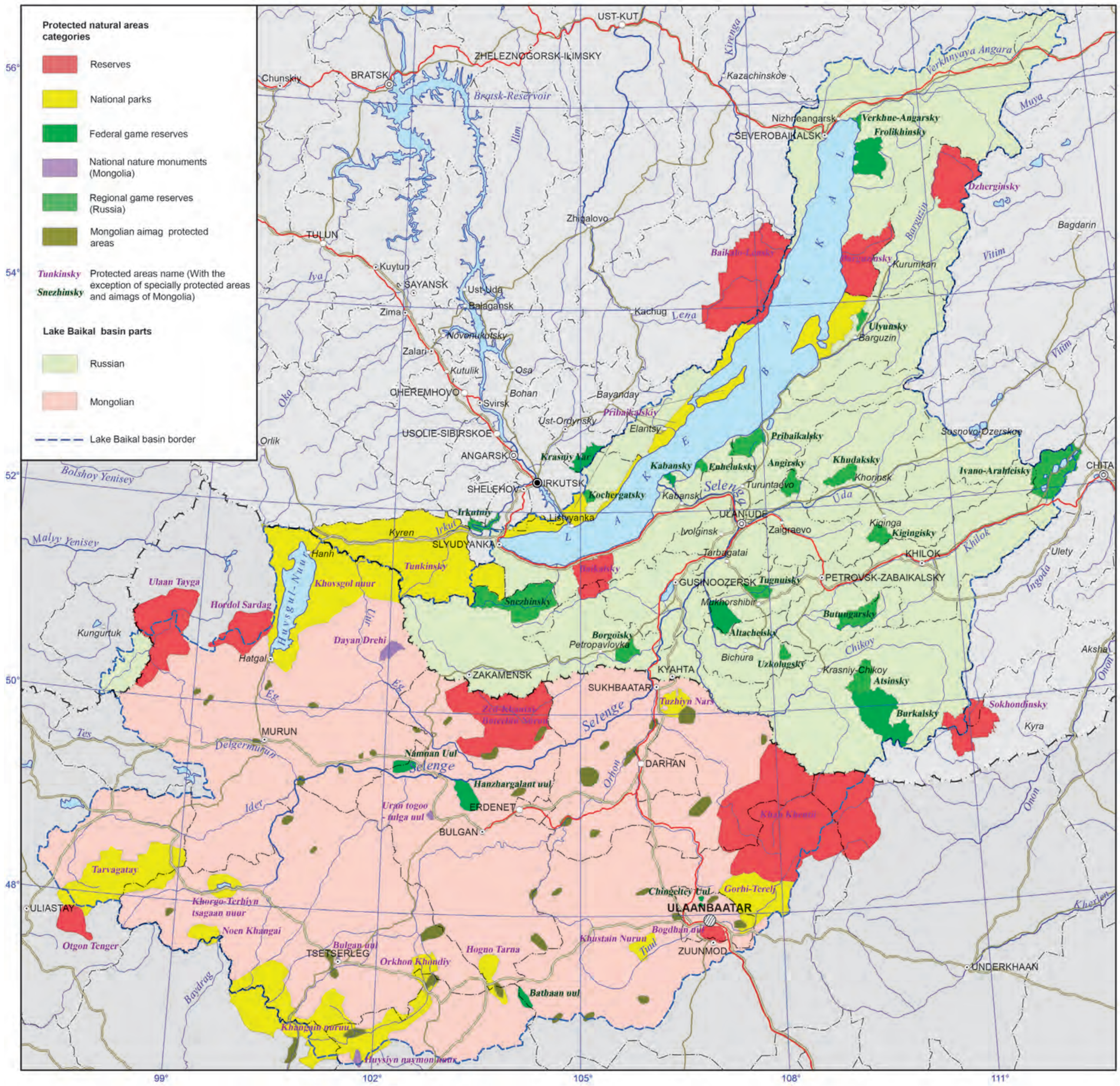
Daurian hedgehog (D.A. Emelyanov).

118. DISTRIBUTION OF RARE ANIMAL SPECIES. MAMMALS



Mammals				
Daurian hedgehog Hemiechinus dauuricus*	-	III	V	LC
Altai mole Talpa altaica	-	III	-	DD
Asian lesser white-toothed shrew Crocidura shantungensis	-	IV	-	-
Greater tube-nosed bat (Murina hilgendorfi	III	III	-	-
Daubenton's bat Myotis daubentonii	-	-	III	-
Long-tail vesper bat Myotis frater	III	-	-	-
Steppe whiskered bat Myotis aurascens	-	III	-	-
Ikonnikov's bat Myotis ikonnikovi	III	III	IV	-
Brown long-eared bat Plecotus auritus	-	-	III	-
Asian particolored bat Vespertilio sinensis	-	-	III	-
Corsac fox Vulpes corsac	-	III	-	-
Dhole Сион alpinus*	I	VI	-	RE
Steppe polecat Mustela eversmanni	III	-	-	-
European otter Lutra lutra	III	II	I	-
Pallas's cat Otocolobus manul*	IV	III	V	-
Snow leopard Uncia uncia*	I	I	I	EN
Tolai hare Lepus tolai	-	III	-	-

Tarbagan marmot Marmota sibirica*	-	-	I	EN
Black-capped marmot Marmota camtschatica*	III	III	II	-
Mongolian five-toed jerboa Allactaga sibirica	-	III	-	-
Long-tailed dwarf hamster Cricetulus longicaudatus	-	III	-	-
Olkhon vole Alticola olchonensis	II	-	-	-
Siberian musk deer Moschus moschiferus	-	-	-	EN
Moose Alces alces	-	-	-	EN
Reindeer Rangifer tarandus*	III	II	-	VU
Siberian ibex Capra sibirica	-	II	-	NT
Argali Ovis ammon*	-	VI	-	EN
Przewalski's Horse Equus przewalskii	-	-	-	CR



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Mongolian Red List of reptiles and amphibians. (2006 d). Ulaanbaatar: ADMON Printing. p 68.

PROTECTED AREAS (119)

The Baikal basin is a unique region with a high biotic and landscape diversity. Specially protected areas ensure the protection of the ecosystems of the basin.

The importance of the principle of territorial nature protection is shown by the history of creation of protected natural territories (PNT). The first protected area in the Baikal basin – near the Bogd mountain range – was created in 1778, which is documented in the Mongolian written sources. Barguzinsky Reserve, founded in 1916, became the first of the currently operating Russian state reserves. The international significance of PNTs in the Baikal basin is underlined by the inscription of Lake Baikal on the UNESCO World Heritage list, as well as by the inclusion of four PNTs of the basin into the network of natural biosphere reserves run by the UNESCO program “Man and Biosphere” (MAB). In the recent years, determining factors of environmental policy included the implementation of the concept of sustainable development and Convention on Biological Diversity and other international environmental conventions ratified by Russia, as well as the compliance with the requirements concerning the ecosystem of Lake Baikal as a World Heritage Site.

A special federal law «On the Protection of Lake Baikal» was passed by Russia to preserve the World Heritage Site. This law established two ecological zones – central and buffer zones – within the Russian part of the Baikal basin, which, in turn, is part of the Baikal Natural Territory (BNT). In order to determine the nature protection regime in each of the category of PNTs in Russia and Mongolia, quite similar laws were passed in both countries including the Russian federal law “On Specially Protected Areas” (dated March 14, 1995) and national law of Mongolia “On Specially Protected Areas” (dated November 15, 1994, entered into force on April 1, 1995) [Mongolian…, 1996]. Due to the differences in the definition, we use the general term “Protected Natural Territory” (PNT).

It should be noted that a significant number of PNTs are divided by the basin’s borders. Nevertheless, they are also discussed in this Atlas.

The PNTs within the basin are unevenly distributed [Savenkova, 2001, 2002]. The Irkutsk part of the basin is almost completely covered by the reserve regime (Pribaikalsky National Park, Baikal-Lena Reserve, Kochergatsky wildlife refuge) and represents an almost uninterrupted protected belt along the western shore of the lake. In Buryatia, the largest protected areas are located near Lake Baikal, while the rest represent only small-sized sanctuaries. In the Zabaikalsky part of the basin, PNTs are small, but they help protect the environment at the sources of key rivers. In the Mongolian part of the basin, PNTs are distributed along the basin’s boundary. Their number in the center of the basin is small. A small national park Tuzhiyn Nars can be mentioned among them. Thus, the ecosystems in the nearest surroundings of Lake Baikal are sufficiently protected, although the PNT distribution on the rest of the basin and the protection of the lake’s water area are not always optimal.

List and summary of the existing PNTs in the Baikal basin

Title	Administrative region	District, Aimag	Area, ha	Year of creation
Reserves				
1. Baikal-Lena	Irkutsk oblast	Olkhonsky, Kachugsky	659919	1986
2. Baikalsky (biosphere)	Republic of Buryatia	Kabansky, Selenginsky, Dzhidinsky	165724	1969
3. Barguzinsky (biosphere)	Republic of Buryatia	Severobaikalsky	374346	1916
4. Bogdhan Uul (biosphere)	Mongolia	Tov	41651	1778
5. Dzherginsky*	Republic of Buryatia	Kurumkansky	238594	1992
6. Sokhondinsky (biosphere)	Zabaikalsky krai	Krasnochikoysky, Kyrinsky, Uletovsky	210988	1973
7. Khan Khentii	Mongolia	Tov, Khentii	1227074	1992
8. Khordol Sardag	Mongolia	Khovsgol	188634	1997
9. Zed-Khantai-Buteeliin Nuruu	Mongolia	Bulgan	604266	2011
10. Ulaan Taiga	Mongolia	Khovsgol	431694	2011
			4142890	
National Parks				
1. Noen Khangai	Mongolia	Arkhangai	59088	1998
2. Zabaikalsky	Republic of Buryatia	Barguzinsky	269002	1986
3. Pribaikalskiy	Irkutsk oblast	Olkhonsky, Irkutsky, Slyudyansky	417297	1986
4. Tarvagatay	Mongolia	Arkhangai, Zavkhan	525440	2000
5. Tunkinsky	Republic of Buryatia	Tunkinsky	1183662	1991
6. Tuzhiyn Nars	Mongolia	Selenge	70119	2002
7. Gorhi-Terelj	Mongolia	Tov	293168	1993
8. Khangain Nuruu	Mongolia	Arkhangai, Ovorkhangai, Bayanhongor	888455	1996
9. Khovsgol nuur	Mongolia	Khovsgol	838070	1992
10. Hogno Tarna	Mongolia	Arkhangai, Ovorkhangai, Bulgan	83612	1996
11. Khorgo-Terhiyn tsagaan nuur	Mongolia	Arkhangai	77267	1965
12. Khustain Nuruu	Mongolia	Tov	50620	1998
13. Orkhon Khondiy	Mongolia	Ovorkhangai	353036	2006
			4866668	
Wildlife refuges and sanctuaries				
1. Altacheysky ***	Republic of Buryatia	Mukhorshibirsky	71627	1966
2. Angirsky	Republic of Buryatia	Zaigraevsky	40380	1968
3. Atsinsky	Zabaikalsky krai	Krasnochikoysky	64500	1968
4. Bathaan Uul ***	Mongolia	Ovorkhangai, Tov	58800	1957
5. Borgoyskoy	Republic of Buryatia	Dzhidinsky	42180	1979
6. Burkalsky ***	Zabaikalsky krai	Krasnochikoysky	195700	1978
7. Butungarsky	Zabaikalsky krai	Petrovsk-Zabaikalsky	73500	1977
8. Verkhne-Angarsky	Republic of Buryatia	Severobaikalsky	12290	1979
9. Ivano-Arakhleysky	Zabaikalsky krai	Chita	210000	1993
10. Kabansky ***	Republic of Buryatia	Kabansky	12100	1967
11. Kizhinginsky	Republic of Buryatia	Kizhinginsky	40070	1970
12. Kochergatsky region	Irkutsk oblast	Irkutsk	12428	1967
13. Namnan Uul ***	Mongolia	Bulgan, Khovsgol	29600	2003
14. Baikal	Republic of Buryatia	Pribaikalsky	73170	1981
15. Snezhinskiy	Republic of Buryatia	Zakamensky	230000	1976
16. Tugnuisky	Republic of Buryatia	Mukhorshibirsky	30000	1977
17. Uzkolugsky	Republic of Buryatia	Bichursky	15330	1973
18. Ulyunsky	Republic of Buryatia	Barguzinsky	18350	1984
19. Frolikhinsky ***	Republic of Buryatia	Severobaikalsky	109200	1976
20. Khanzhargalant Uul	Mongolia	Bulgan	60000	2003
21.Khudaksky	Republic of Buryatia	Khorinsky	50000	1976
22. Enheluksky	Republic of Buryatia	Kabansky	14570	1995
23. Chingeltey Uul	Mongolia	Ulaanbaatar District	4386	2012
			1432613	
		TOTAL	10442171	

Notes:
* 1/3 of its territory belongs to the buffer ecological zone of the BNT;
** 1/10 of its territory belongs to the central ecological zone of the BNT and the World Heritage Site «Lake Baikal»;
*** PNT has a federal (Russia) or national (Mongolia) status

As of 2009, there are 46 PNTs of the main categories (see table) with a total area of 10442,171 thousand hectares within the Baikal basin. They include 10 reserves (incl. four biosphere reserves), 13 national parks, 23 wildlife refuges and sanctuaries. Moreover, in the Russian part of the basin, there are the so-called recreational areas, which are basically PNTs under district jurisdiction. In the Mongolian part of the basin, there are PNTs under aimag jurisdiction [Mongolia's Wild Heritage…, 1996; Mongolia's tentative…, 1999; Savenkova, Erdentsetseg, 2000, 2002; Oyungerel, 2009]. The map also shows four National Natural Monuments of Mongolia: Khuisiin Naiman Nuur, Uran Togoo-Tulga Uul, Bulgan Uul, and Dayan Derkhi.

There are plans to create 20 new PNTs of different categories in the Baikal basin.

In the Russian part these will include the "Selenga Delta" (Buryatia) and "Ikh Tayrisin" (Tuva) reserves, national parks «Chikoysky» (Zabaikalsky krai) and «Onotsky» (Irkutsk oblast), wildlife sanctuaries "Verhneulkansky" (Buryatia/Irkutsk oblast), «Khila» (Buryatia/Zabaikalsky krai), «Malkhansky» (Zabaikalsky krai), «Talovsky Lakes» (Irkutsk oblast), as well as the most numerous type of PNT – natural parks «Arey», «Yamarovka» (Zabaikalsky krai), «Utulik - Babkha», «Chersky Peak», «Warm Lakes» (Irkutsk oblast), «Upper Angara», «Kurkulinsky», «Mezhdurechye», «Posolsky Sor»,» Slyudyanskiye Lakes», «Tagley», «Khakusy», «Yarki» (Buryatia) [Kalikhman, 2007].

In the Mongolian part of the basin, 11 territories will become new PNTs, including «Burengiyn Nuruu» reserve and nature reserves «Arkhan Buural-Badaryn Nuruu», «Bohloo-Chagtayn Nuruu», «Ikh Tunel-Emged Ovgod», «Tovhonhaan uul», «TerhenTsagaan uul», «Khalkhan bulnai» [Kalikhman, 2011; Special Protected Areas…, 2000].

Moreover, there are plans to organize five transboundary PNTs in the basin: «The Amur Source «, «Khentei – Chikoyskoye Highlands», «Selenga», «From Khovsgol to Baikal», «Delger - Muren» [Savenkova, 2001; Oyungerel, Savenkova, 2004]. A relative similarity in the legislature concerning the PNTs in Russia and Mongolia helps coordinate their activities, as well as the general nature protection efforts on neighboring territories. It can be proved by the already operating transboundary Russian-Mongolian PNTs outside the Baikal basin: the trilateral cluster transboundary reserve «Dauria», which includes the Russian reserve «Daursky» (Zabaikalsky krai), Mongolian reserve «Mongol Daguur», and Chinese reserve «Dalainor», has been working since 1994. A cluster transboundary World Heritage Site «The Uvs Nuur Basin» was founded in 2003. It consists of 12 different areas, five of which are in Mongolia and seven – in the Republic of Tuva, Russia [Kalikhman, 2012].

In general, it is possible to conclude that the currently existing system of the PNTs in the Baikal basin does not fully cover the region's ecosystems and is unevenly distributed. In this regard, an increase in the number and size of PNTs is expected in order to improve the effectiveness of conservation measures.

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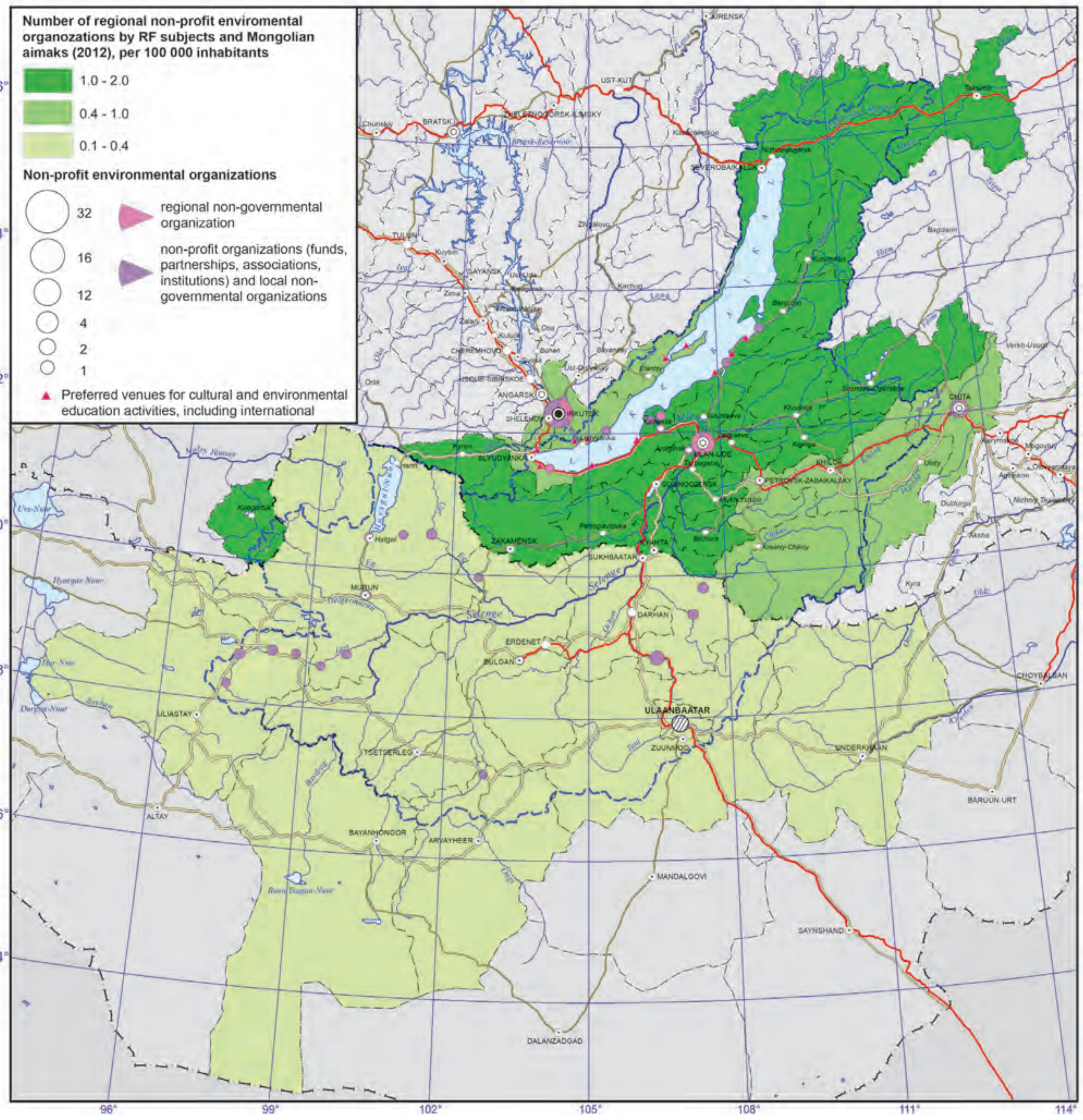
120. ENVIRONMENTAL NON-PROFIT ORGANIZATIONS



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ENVIRONMENTAL NON-PROFIT ORGANIZATIONS (120)

The environmental well-being of the Baikal basin is largely determined by the activities of environmental non-governmental organizations (eco-NGOs). The main purpose of eco-NGOs is to protect nature. They see the foundation for sustainable development of society in nature preservation. Their effectiveness is determined by personal qualities and civic engagement of their activists and, especially, their leaders.

The number of eco-NGOs significantly increased in the 1990s, which was determined by state reforms in Russia and Mongolia and the growing interests of citizens towards the state of the environment.

Eco-NGOs operating in the Baikal basin differ by their territorial status (international, national, inter-regional, regional and local) and organizational and legal forms (community associations: community-based organizations, community-based foundations, community-based institutions, and community movements; nonprofit organizations: autonomous nonprofits, nonprofit foundations, nonprofit partnerships, associations (unions, alliances) of legal persons, and nonprofit institutions).

In Mongolia, the creation of eco-NGOs is mainly associated with the efforts to protect the Selenga and its tributaries from negative impacts of mining, construction of hydro-power plants, and the transfer of the Orkhon water to arid areas of the Gobi desert. Eco-NGOs are also created in all river basins, where open-pit mining operations are active. The largest community associations are the "United Movement of Rivers and Lakes of Mongolia" and "Nature Protection Coalition of Mongolia". Eco-NGO campaigns usually involve 300-8,000 people.

In the Russian part of the Baikal basin, the organizations defining community-based environmental activities aimed to protect Lake Baikal are the community-based organization "All-Russian Nature Conservation Society" and the public organization "Russian Geographical Society". Branches of these organizations are located in all the regions of the Baikal basin. In 2012, among the participants of the project initiated by the All-Russian Nature Conservation Society and entitled «Clean Waters of the Baikal Region» were over 60 environmental organizations created at educational institutions of 23 districts of Irkutsk oblast. Members of the Russian Geographical Society include both private individuals and legal persons. A widely known member of the Russian Geographical Society is the "Fund for Protection of Lake Baikal" established by Metropol Group of Companies. A lot of work is done by the nonprofit organization «WWF - Russia» and other all-Russian organization.

As of the beginning of 2013, the total number of registered eco-NGOs in Buryatia, Zabaikalsky krai and Irkutsk oblast was about 100 organizations. The overwhelming majority of them are community associations and community-based organizations.

In Buryatia, the most famous eco-NGOs include regional community associations «The Buryat Regional Association on Baikal», «Baikal Information Center Gran», «Baikal-Eco», «Ecological Association LAT», «Ecological and Humanitarian Center ETNA», «Ecological center The Planet and Delta», «Ecoleague», nonprofit partnership «The Great Baikal Trail - Buryatia», and a local environmental NGO «Turka». In Irkutsk oblast, they include regional nonprofit organizations «Baikal Environmental Wave» (BEW), «The Baikal Ecological Network Association», «Baikal Environmental Patrol», Inter-regional community-based organization «The Great Baikal Trail», private non-state research institution «The Baikal Center of Field Studies "Wildlife of Asia", nonprofit partnership «Protecting Baikal Together», and the Irkutsk city community organization «Children's Ecological Union». In Zabaikalsky krai, there is a regional public institution "Public Environmental Center "Dauria". There are also many other successful organizations.

Regional and local eco-NGOs actively attract volunteers from different countries to implement their projects, so quite often these projects become international.

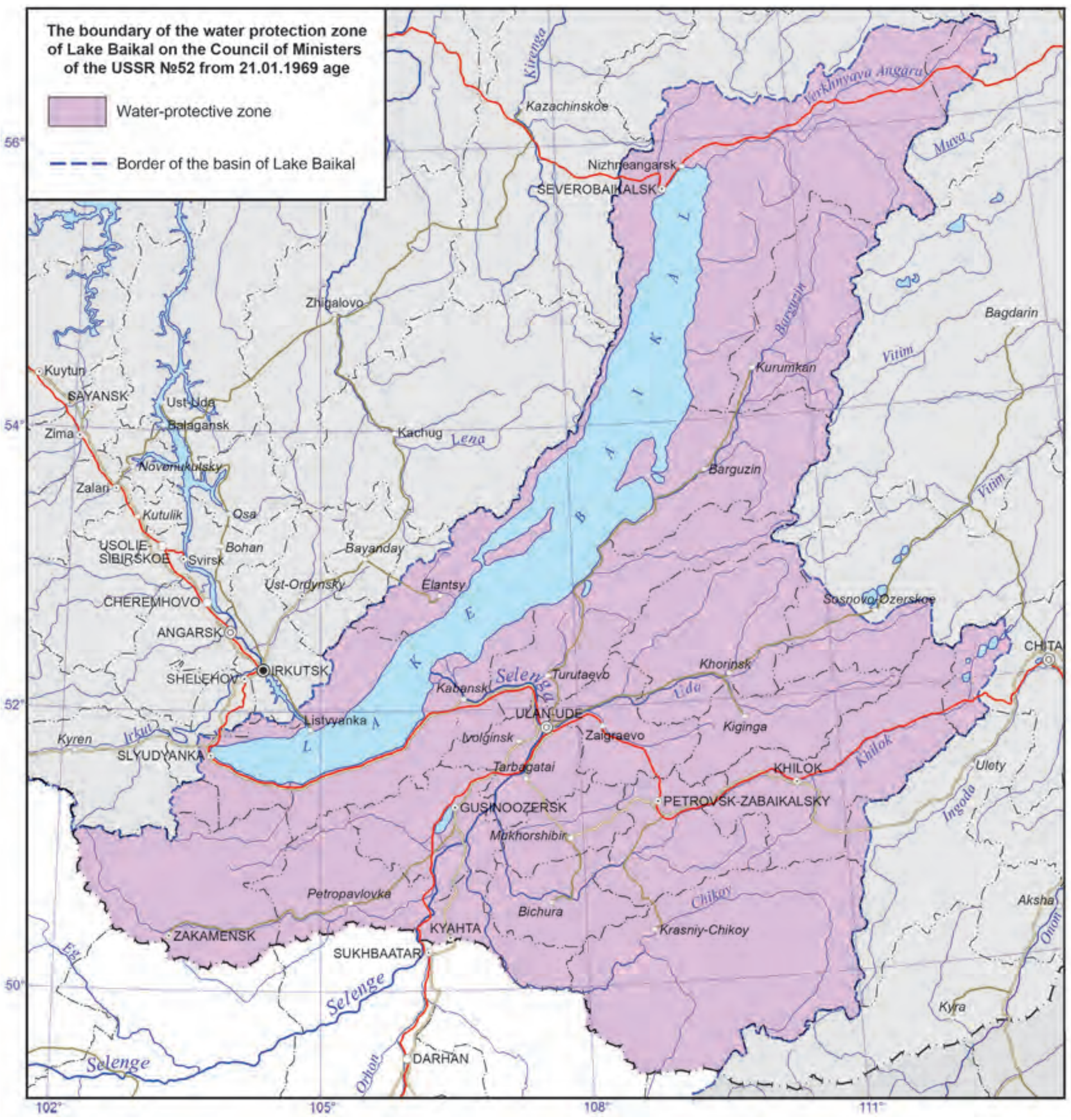
Information about the work of the most active eco-NGOs operating in the Russian part of the Baikal basin is provided in public reports on the state of Lake Baikal and governmental reports on the state and protection of the environment in Buryatia, Zabaikalsky krai and Irkutsk oblast. Brief descriptions about them in the form of short essays are also presented in the reference book entitled "The White Book", prepared by the eco-NGO "Ecoleague" and published in 2010.

Among the organizations whose head-quarters are located outside of Russia and Mongolia, the Russian branch of the international non-governmental non-profit organization Greenpeace conducts a very active work on Lake Baikal.

In the Baikal basin, eco-NGOs conduct research, educational, and outreach activities among the population, boost its environmental activity, and involve local communities in the decision-making process. They organize community oversight and participate in the preparation and discussion of laws aimed at optimizing natural resources management. They take part in public hearings on the development of deposits and construction of industrial facilities and participate in the creation of protected areas. They also develop eco-tourism, conduct cleaning works on the lake's shores and other activities, including the «Days of Baikal». Often, eco-NGOs receive federal or regional funding by winning competitions of socially-oriented projects.

Eco-NGOs help unite the efforts of government, science, business, and society in finding solutions of environmental problems. They become members

121. BORDERS OF THE WATER PROTECTION ZONE OF LAKE BAIKAL ESTABLISHED BY ACT NO. 52 OF THE COUNCIL OF MINISTERS OF THE USSR ON JANUARY 21, 1969



of public environmental councils in the regions and conduct conferences, round tables, telethons, presentations, seminars, courses, summer schools, etc. In 2013, BEW conducted an international conference in Irkutsk and Listvyanka («Rivers of Siberia and the Far East»,). Also in 2013, the Russian Society for Ecological Economics jointly with the Irkutsk branches of the Russian Geographical Society and All-Russian Nature Conservation Society conducted a conference in Irkutsk entitled "The management of ecological and economic systems: Interaction of government, business, science, and society".

The creation of eco-NGOs' coalitions and international cooperation is extremely important for reaching the goals of sustainable development of the regions. It determined the creation of a network of eco-NGOs in Buryatia and Mongolia called «Friends of Baikal» and a long-term cooperation with the US organization «Tahoe-Baikal Institute» to share best practices in natural resources management in the watershed basins of Lake Baikal, Tahoe, Khovsgol, and the Great Lakes. Other joint projects promoting sustainable development of communities of different levels are also being implemented.

It is mostly due to the work of eco-NGOs that Lake Baikal was inscribed on the list of World Heritage Sites, the Baikal Natural Territory was zoned, over 700 kilometers of trails were built, and the operation of several environmentally hazardous production facilities, including the Baikalsk Pulp and Paper Mill, was stopped. On the site of this Pulp and Paper Mill, in December 2013, Russian government decided to create a nature protection complex, which will include a museum and exhibition, as well as information and educational facilities. In order to manage this complex, the government jointly with the Charitable Foundation for Environmental Protection «Green Future» (NF, Moscow) created ANO "Expocenter "Reserves of Russia"". Often, the results of the work of eco-NGOs become the foundation of major federal and regional programs.

ENVIRONMENTAL ZONING (121 — 124)

Environmental zoning is conducted to protect the unique ecosystem of Lake Baikal and prevent negative impacts on its condition from economic and other activities. Environmental zoning represents a division of a certain territory into the areas that are recommended to preserve the existing state of the territorial use, the areas of social and economic development with restrictions concerning harmful impacts on the ecosystem of Lake Baikal, and the areas with the most urgent environmental problems, where any activity is prohibited in order to rehabilitate and restore this particular area.

Current concepts of environmental zoning are based on a spatially differentiated approach to the selection of areas of economic activity. When selecting such areas, the stress from and the degree of the impact of economic activity are considered, with the main prerequisite being the preservation of natural environment. Such conceptualization implies the necessity of a comprehensive acknowledgment of environmental factors that determine the character of human economic activity associated with the use of the natural and resource potential of the territory and making a certain impact on the environment.

The main principle of environmental zoning is to recognize the Baikal basin as a region with a special regime of natural resources management. According to this principle, strategic development of this region should be focused on directing all the activities carried out on its territory towards preservation of the unique resource – Lake Baikal. A protective principle of environmental zoning supplements the main one, because Lake Baikal and its vicinity was listed as a World Heritage Site in 1996 as an example of an extraordinary freshwater ecosystem of the Earth. Environmental zoning, first of all, aims to preserve the richest and unique ecosystem of Lake Baikal for the next generations. Three years after Baikal's inscription on the World Heritage List, Russia passed the Law on Baikal – the only nature protection law concerning a particular object introduced at the federal level.

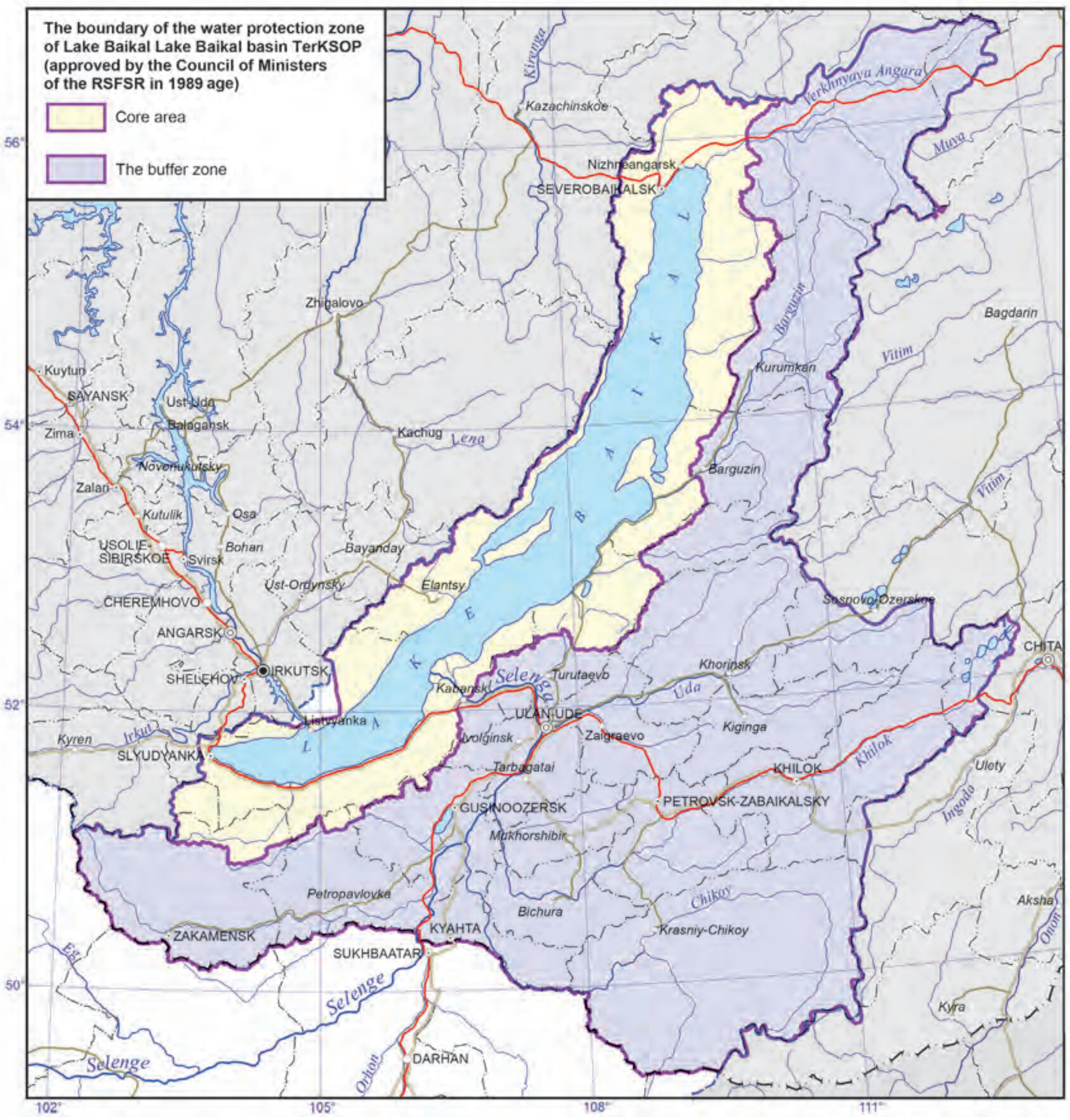
Environmental zoning evolved through a series of stages. The first systemic legislative act protecting Lake Baikal's ecosystem was Act No. 52 of the Council of Ministers of the USSR, dated January 21, 1969, "On measures for the protection and effective use of natural complexes of the Lake Baikal basin". This legislative act established a water protection zone of Lake Baikal within the borders of its catchment area (within the USSR) with a special regime of natural resources management (see Map 124a). One of the provisions of this Act was implemented right away – all forests of the Baikal basin in Irkutsk oblast and some forests in the Republic of Buryatia were classified as Group 1 forests, which excluded them from the list of the exploited and harvested forests.

In 1987, a new regulation was introduced – Act No. 434 of the Central Committee of the CPSU and the Council of Ministers of the USSR, dated April 13, 1987, «On measures for ensuring the protection and effective use of natural resources of the Lake Baikal basin in 1987-1995». This act confirmed the earlier establishment of the water protection zone of Lake Baikal within the borders of its basin (in the USSR) by the Act of the Council of Ministers of the USSR, dated January 21, 1969, and created a coastal protective belt around Lake Baikal, which included all specially protected areas adjacent to the lake, as well as logging enterprises located on the slopes of the lake's depression.

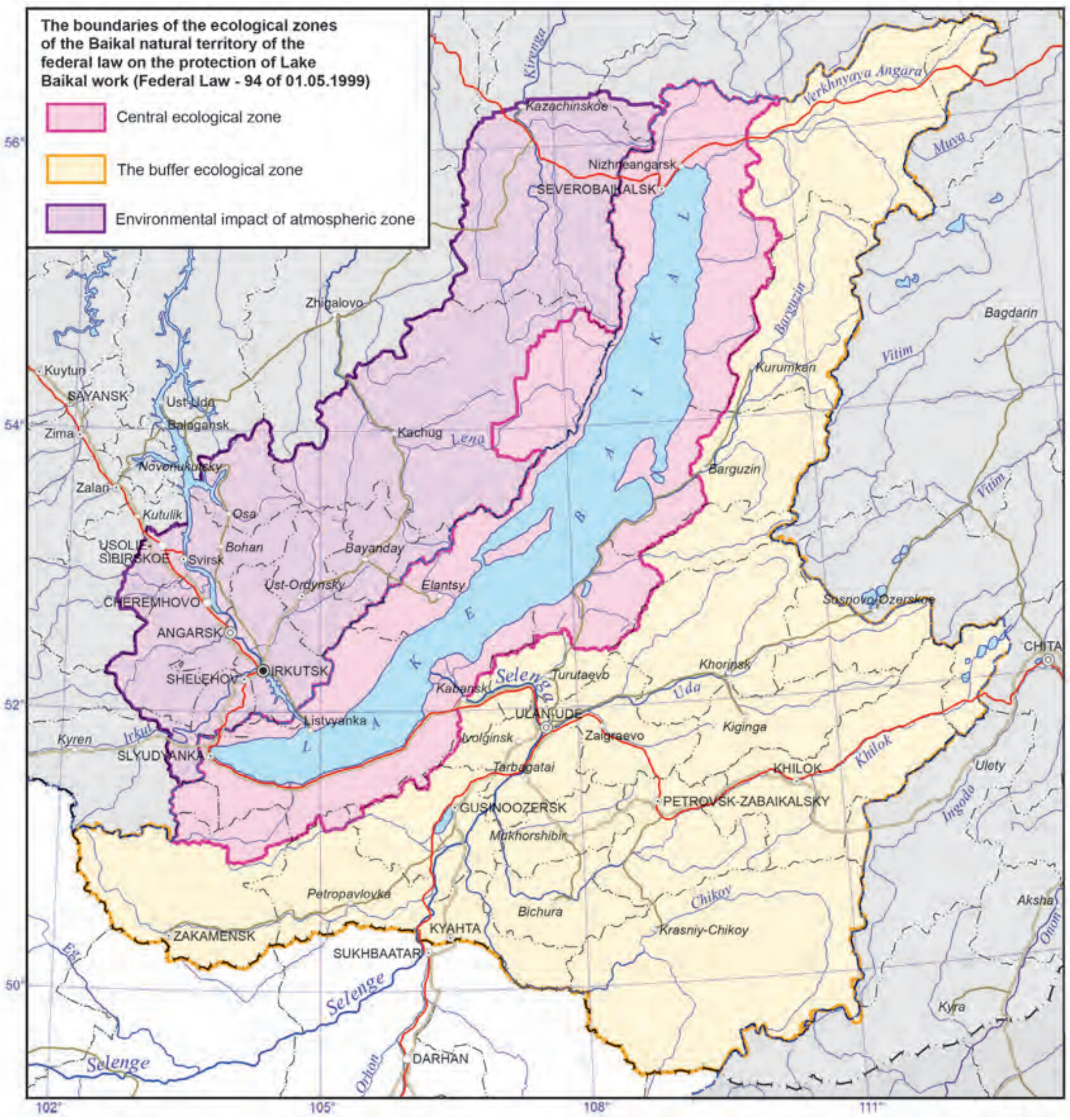
Moreover, Act No. 434 stipulated the development and approval by the Council of Ministers of Russia of a Comprehensive Territorial System of Nature Protection of the Baikal basin. It was approved by the Presidium of the Council of Ministers of Russia on April 14, 1990. (see Map 124b). However, this regulation was not implemented due to the economic crisis in Russia.

Only in 1999, the Law of the Russian Federation "On Protection of Lake Baikal" was passed. According to this law, environmental zoning is the main instrument for its implementation in the Russian part of the Baikal basin. Its preamble states that the Federal Law determines a legal framework for the protection of Lake Baikal, which is not only a unique ecosystem of the Russian Federation, but also a world heritage site.

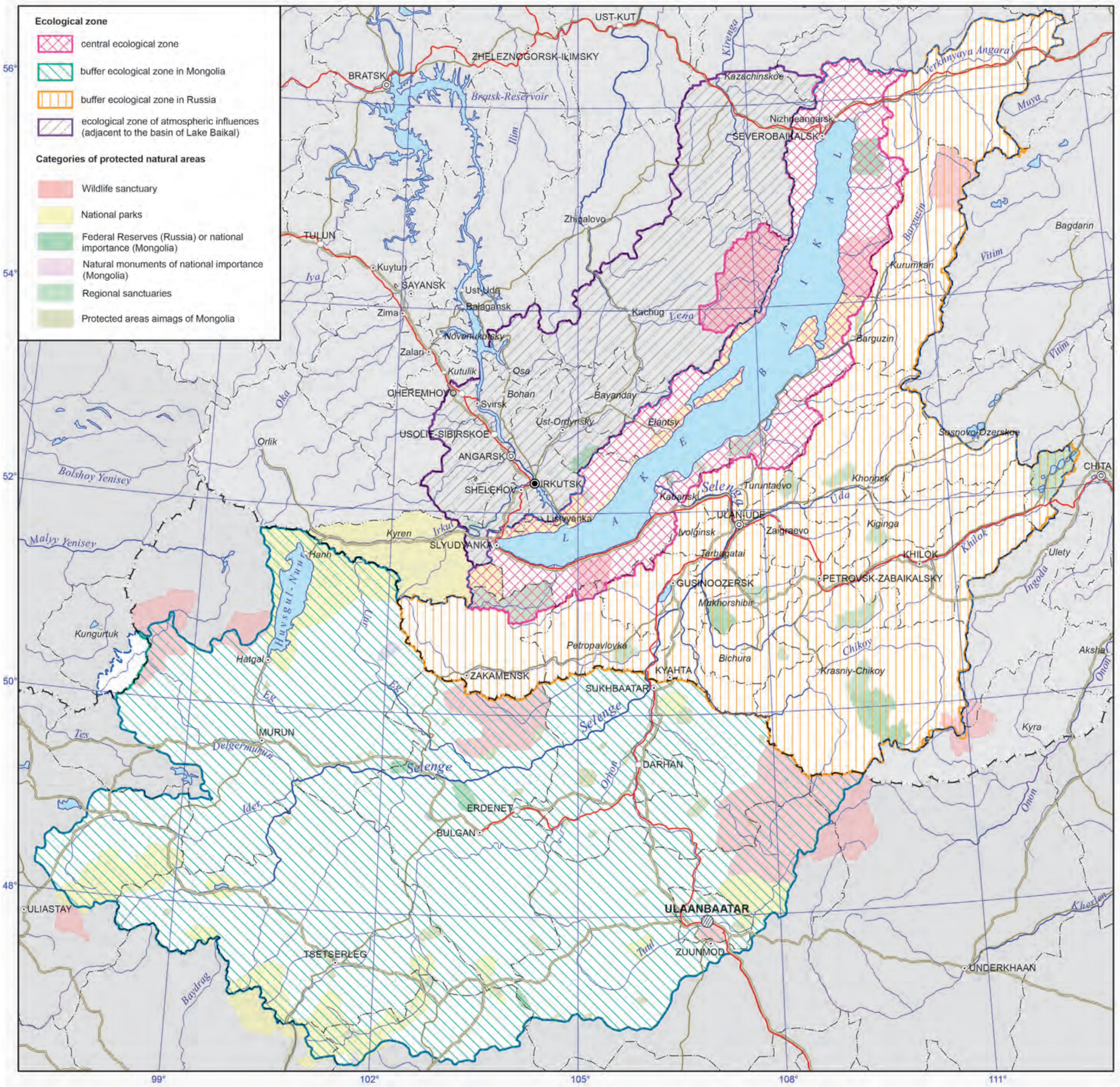
122. BORDERS OF THE WATER PROTECTION ZONE OF LAKE BAIKAL ACCORDING TO THE COMPREHENSIVE TERRITORIAL SYSTEM OF NATURE PROTECTION OF THE BAIKAL BASIN (APPROVED BY THE COUNCIL OF MINISTERS OF RUSSIA IN 1989)



123. BORDERS OF ECOLOGICAL ZONES OF THE BAIKAL NATURAL TERRITORY ACCORDING TO FEDERAL LAW NO. 94 «ON PROTECTION OF LAKE BAIKAL», DATED MAY 1, 1999



124. ENVIRONMENTAL ZONING OF THE BAIKAL BASIN



The V.B. Sochava Institute of Geography SB RAS developed a scheme of environmental zoning (see Map 124c) as an addition to this Law. It divides the territory of the Baikal basin and the adjacent territory of Irkutsk oblast from the west (the Baikal Natural Territory - BNT) into three environmental zones with different regimes of natural resources management.

The borders of the first protective zone of Lake Baikal – the zone with a strictly limited natural resources management – correspond to the borders of the World Heritage Site – the unique ecosystem of Lake Baikal.

The main goal of environmental zoning of the buffer zone of the BNT is to identify the types of environmental territories that to some extent regulate economic activities. In this zone, there are nine types of environmental territories that range from territories with total prohibition of any economic activity (reserves) to the territories with regulated intensive development with a maximum impact on the environment of the region. Between them, there are environmental territories that have some type of prohibitive or permissive categories.

The environmental zone of the BNT's atmospheric effect is the territory outside the catchment area of Lake Baikal in the Russian Federation with the width of up to 200 km in the western and northwestern parts. It has different economic entities that may negatively impact the unique ecosystem of Lake Baikal.

In the process of developing this Atlas, we additionally identified a buffer zone in Mongolia. Its borders are defined by the borders of the Baikal basin (see Map 124d). 61% of specially protected natural territories of the Baikal basin are located within the buffer zone in Mongolia.

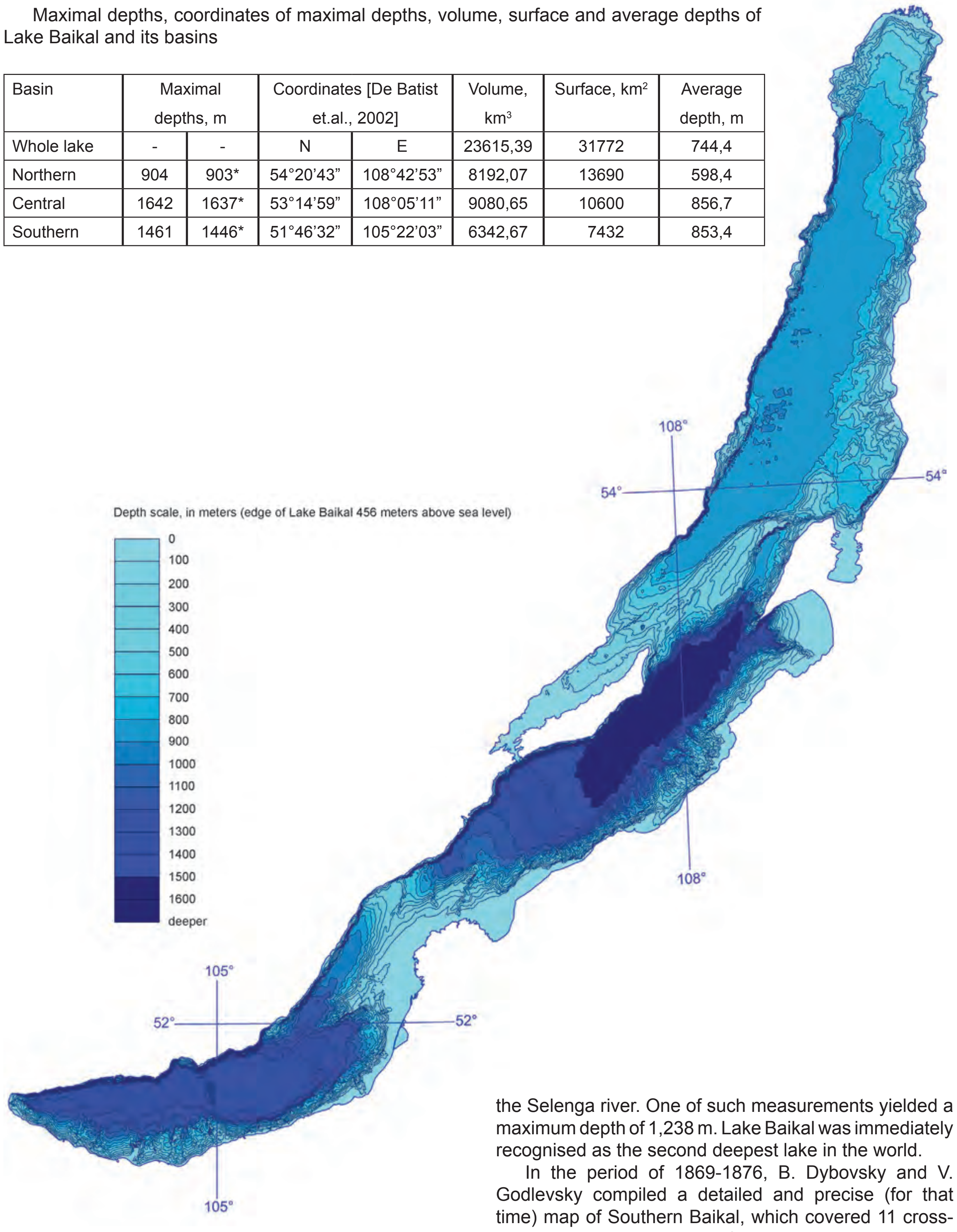
Lake Khovsgol.

SECTION VII.
Ecological state and protection of Lake Baikal

125. BOTTOM RELIEF

Maximal depths, coordinates of maximal depths, volume, surface and average depths of Lake Baikal and its basins

Basin	Maximal depths, m		Coordinates [De Batist et.al., 2002]		Volume, km³	Surface, km²	Average depth, m
Whole lake	-	-	N	E	23615,39	31772	744,4
Northern	904	903*	54°20'43"	108°42'53"	8192,07	13690	598,4
Central	1642	1637*	53°14'59"	108°05'11"	9080,65	10600	856,7
Southern	1461	1446*	51°46'32"	105°22'03"	6342,67	7432	853,4



BATHYMETRY OF LAKE BAIKAL (125-127)

The history of depth measurements in Lake Baikal goes back to 1798, when E. Kopylov and S. Smetanin, employees of a mine plant, carried out 28 measurements between the head of the Angara river and the mouth of the Selenga river. One of such measurements yielded a maximum depth of 1,238 m. Lake Baikal was immediately recognised as the second deepest lake in the world.

In the period of 1869-1876, B. Dybovsky and V. Godlevsky compiled a detailed and precise (for that time) map of Southern Baikal, which covered 11 cross-sections. Measurements of depth were carried out from the ice, which provided high accuracy [Dybovsky, Godlevsky, 1871, 1877].

Таблица 2. Sectional area from isobaths, km² [De Batist et.al., 2002].

Isobaths (m)	Whole Lake Baikal	Southern basin	Central basin	Northern basin
0	31722	7432	10600	13690
50		6681	9650	13842
100	27770	6315	9218	12664
150		6279	9078	12053
200	26290	6151	8803	11701
250		6041	8618	11271
300	24890	5871	8431	10916
350		5706	8189	10488
400	23260	5636	8026	9863
450		5512	7749	9371
500	21530	5341	7501	8902
550		5145	7270	8352
600	19630	4898	7029	7871
650		4693	6732	7399
700	17720	4484	6517	6840
750		4173	6244	6221
800	15360	4025	6121	5242
850		3652	5998	3049
900	9443	3597	5583	68,5
950		480	5489	
1000	8478	3382	5104	
1050		3298	4800	
1100	7703	3121	4588	
1150		2927	4237	
1200	6614	2889	3731	
1250		2594	3433	
1300	5428	2364	2879	
1350		1658	2707	
1400	3562	1021	2461	
1450		15,69	2106	
1500	31798		1799	
1550			1482	
1600	1091		1092	

Таблица 3. Volumes between isobath surfaces, km³ [De Batist et.al., 2002].

Isobaths (m)	Whole Lake Baikal De Batist et.al., 2002	Southern basin	Central basin	Northern basin
0-50		355	507	683
50-100	2894.950	325	472	663
100-150		315	457	618
150-200	2700.160	311	447	594
200-250		305	436	574
250-300	2558.930	298	426	555
300-350		289	416	535
350-400	2411.740	284	405	509
400-450		279	394	481
450-500	2240.230	271	381	457
500-550		262	369	431
550-600	2058.090	251	357	406
600-650		240	344	382
650-700	1868.860	229	331	356
700-750		216	319	327
750-800	1659.940	205	309	287
800-850		192	303	207
850-900	1338.580	181	290	77,9
900-950		177	277	
950-1000	887.896	172	265	
1000-1050		167	248	
1050-1100	811.060	160	235	
1100-1150		151	221	
1150-1200	716.666	145	199	
1200-1250		137	179	
1250-1300	606.627	124	158	
1300-1350		101	140	
1350-1400	452.442	67	129	
1400-1450		25,9	114	
1450-1500	243.954		97,6	
1500-1550			82,0	
1550-1600	148.175		64,4	
1600-1640	18.36			

Note: The volume for the whole Baikal counted in increments of 100 m between the contours, highlighted in red

In 1902 and 1908, the Pilot Chart of Lake Baikal and Atlas of Lake Baikal were published as a result of numerous hydrographic expeditions under the leadership of F. Drizhenko, in which the depths were shown in detail for the coastal areas of the lake.

In 1925, the USSR Academy of Sciences developed a long-term project under the supervision of G. Vereshchagin to study bathymetry of Lake Baikal. This initiative resulted in the organisation of Limnological Station, later reorganised into Limnological Institute. This project helped discover the deepest place in the lake and an underwater shallow ridge named the Akademichesky Ridge, which separates the northern basin from the central one. New bathymetric maps (scales 1:300,000 and 1:500,000) were compiled. They were demonstrated at the International Limnological Congress held in Rome in 1934.

In 1962, A. Rogozin and B. Lut compiled a new bathymetric map (scale 1:300,000) as a result of long-term bathymetric expeditions. Based on this map, the Central Department for Navigation and Oceanography of the Ministry of Defence of the USSR (CDNO) published maps "Northern and Southern Areas of Lake Baikal" in 1973 and 1974.

In the period of 1979-1985, CDNO carried out new systematic echo-sounding bathymetric measurements throughout the entire Lake Baikal. Traverses had a spacing of 100 and 250 m in the coastal waters and 1 km in the abyssal areas. As a result of these investigations, a four-sheet bathymetric map of Lake Baikal was published in 1992 (scale of 1:200,000). To date, this is the most reliable bathymetric map of Lake Baikal. However, it has some shortcomings:

– Bathymetry is based only on some available original data;

– Bathymetry is presented by the contours of isobaths that were taken manually;

– Bathymetry is mainly represented by isobaths with a step of 100 m up to a depth of 1,000 m and 500 m for depths exceeding 1,000 m;

– Recent investigations showed that significant discrepancies can exist between true depth values and echo-sounding measurements, which are attributed to discrepancies between the real acoustic speed in Lake Baikal and the calculated rate for the echo-sounder.

In 1999, an international group of experts was organised to jointly compile a new, more precise bathymetric map of Lake Baikal. It was necessary to carry out more detailed recalculations of measurement values, which were used for maps in 1992, to digitise and adjust them to the real acoustic speed, to integrate them with the echo-sounding data obtained earlier, and to compile a new more complete computer map of Lake Baikal based on all available measurement data. This project was financially supported by INTAS (International Association for the Promotion of Cooperation with Scientists from the New Independent States of the Former Soviet Union).

The CD-ROM is available with final results of this project. Coordinates of points are in a Mercator's projection, WGS 1984 ellipsoid. The latitude for all generated maps is 53° 0' 00'' N.

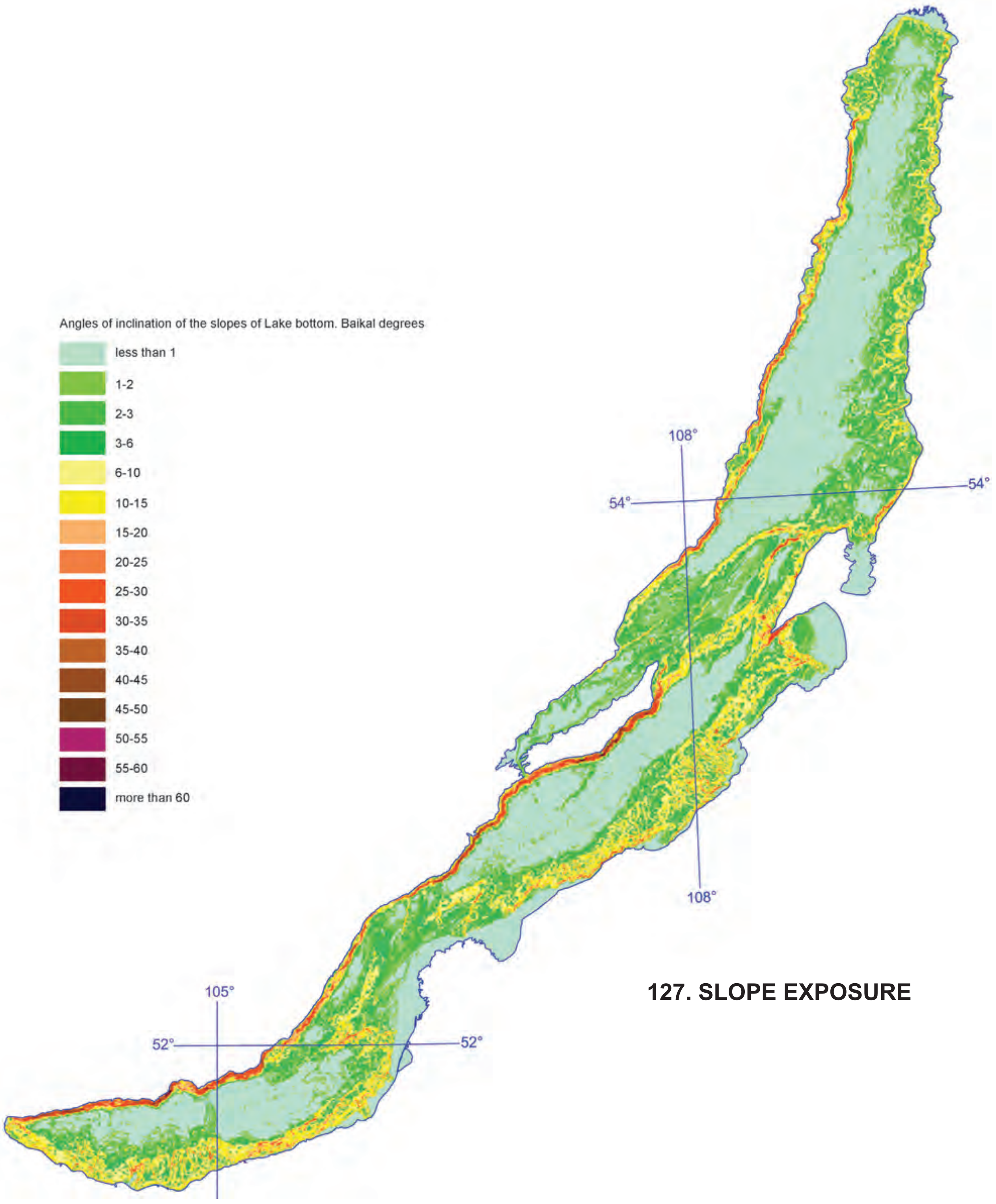
New bathymetric data made it possible to obtain specified morphometric information on Lake Baikal and to present it in tables. Taking into account that the lake surface is at 455.5 m a.s.l. (Baltic System of Heights), the deepest point of Lake Baikal is situated at 1186.5 m below the sea level.

The relief of the bottom of Lake Baikal is represented by isobaths with a step of 100 m. The lake consists of three basins: Northern basin – the most shallow one with a maximum depth of 904 m and an average depth of 598.4 m. Central basin is the deepest one. Its maximum depth is 1637 m, while the average depth is 856.7 m. Southern basin's maximum depth is 1461 m with the average depth of 853.4 m. The existing Baikal depression is asymmetric: its northern and northwestern slopes are very steep, while the southern and southwestern slopes are more flat. Maximum depths are located at a distance of one third of the lake's width from the steep northwestern slope. There is a shallow platform – a shelf - on the lake's northern and northwestern side, which is weakly developed. The shelf on the southern and southwestern coast is more pronounced.

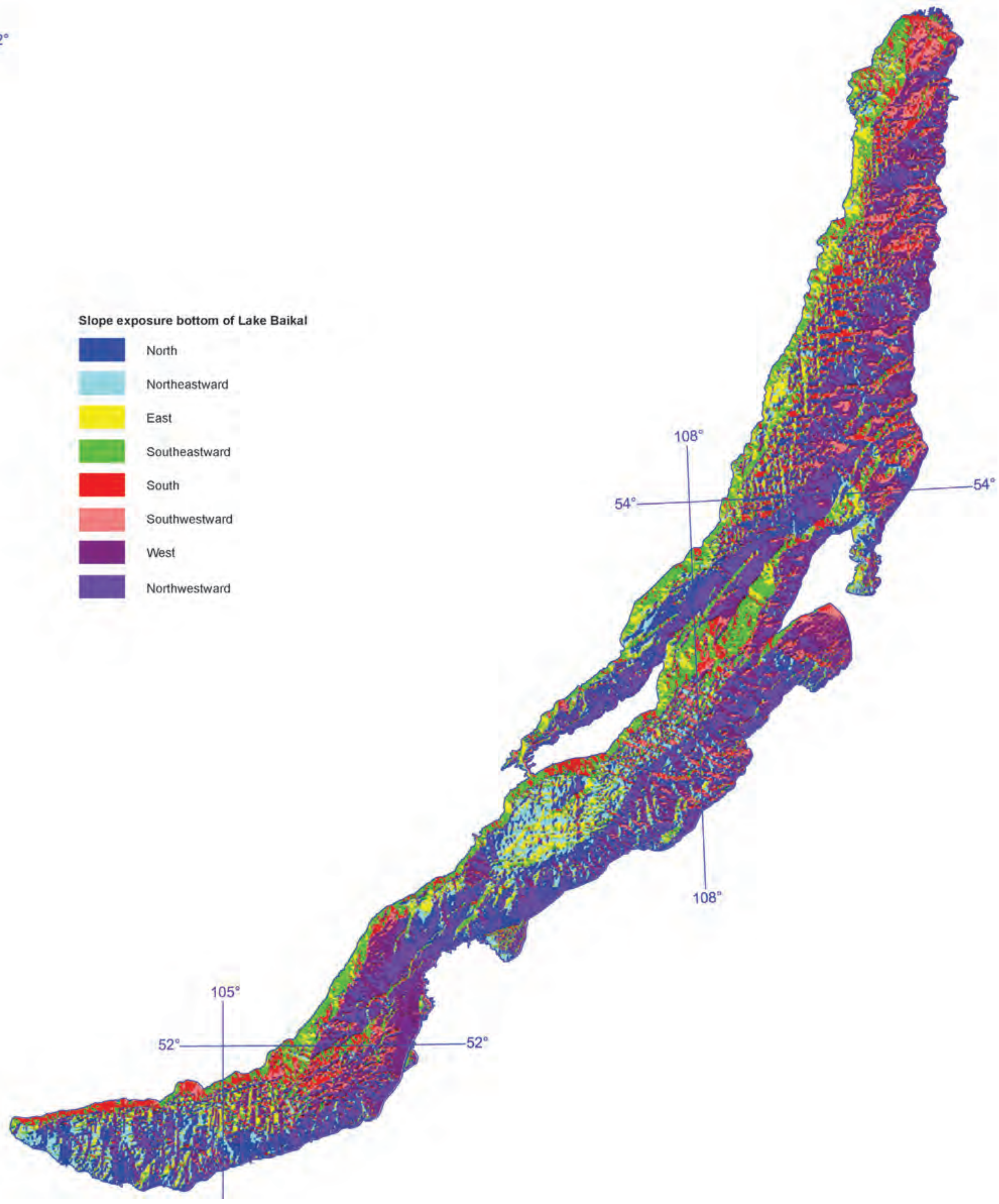
Measurement results demonstrated that in the place of the supposed maximum depth of 1741 m, according to G. Y. Vereschagin, the actual depth is less than 1600 m - 1593-1596 m. Based on the data derived from echo sounding, the deepest part of Central Baikal is located between Cape Izhimei and Otto-Khushun. In 1972, control measurements using the NEL-5 echo-sounder showed the depth of 1637 m [Lut, 1987].

Numerous underwater works using Pisces, Mir-1, and Mir-2 submersibles offered an opportunity to visually examine morphologic and morphometric features of the underwater slopes and compare these data with the

126. SLOPE INCLINATION



127. SLOPE EXPOSURE



results of echo sounding. Northern and northwestern slope is sporadically covered with silt deposits with bed rock monoliths protruding between silty patches.

The steepest part of the underwater slope is located on the northern side of the depression near Cape Kolokolny, about 40 km from the southern edge of the depression. The total steepness of the slope here reaches 60-65 degrees, however, its steepness is lower than the steepness on the Baikal side of Olkhon Island by 10-15 degrees [Lut, 1987]. The steepness of northern and northwestern slopes reaches 60-40 degrees. According to the Pisces XI expedition on September 22, 1991, negative slopes at the depth of more than 700 m were observed. The steepness of the southern and southeastern slope is five to six times lower. The average slope of the whole lake is four degrees.

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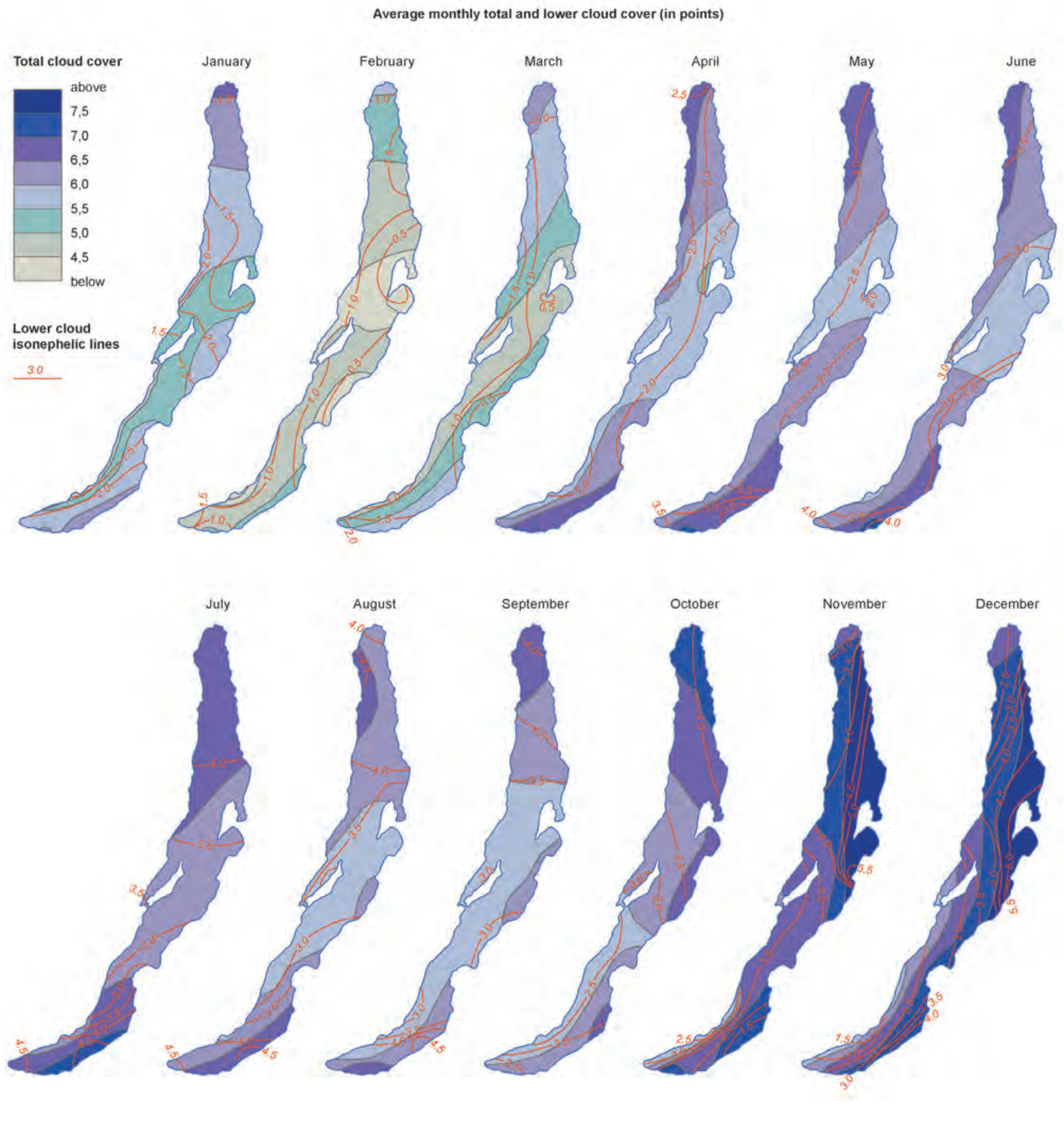
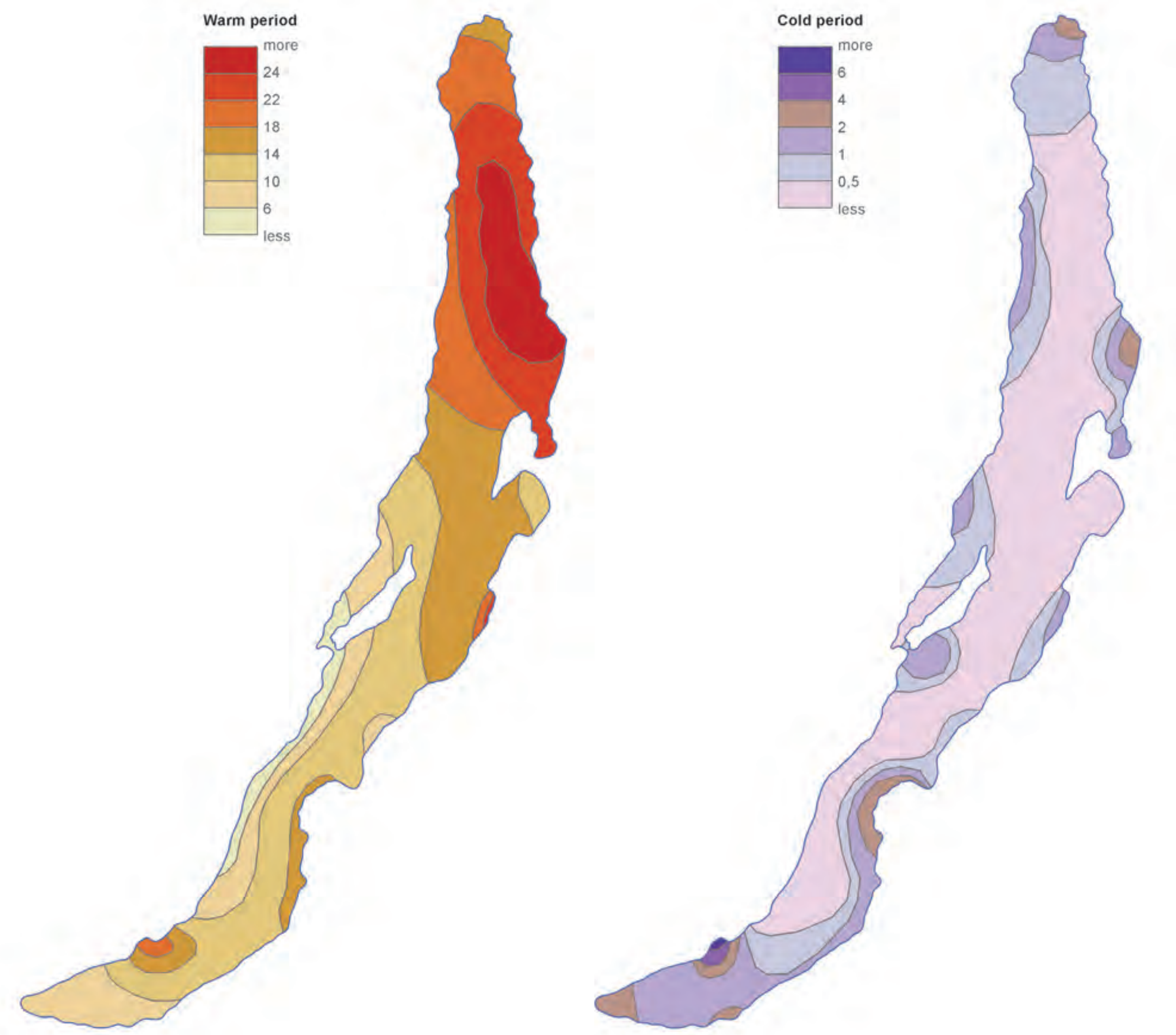
128. CLOUD COVER



129. FOGS



CLOUD COVER (128)

Two maxima are recorded in the annual trend of cloud cover: summer (June-July) and pre-freeze-up (November-December). The latter prevails. The highest cloud cover values (7-8 oktas) and increased recurrence of overcast days (up to 75-80%) are registered in December on the north-eastern coast of the lake, whereas the lowest values (no higher than 4 oktas) are observed in February-March on the western shore, particularly within the territory of Maloye More (Small Sea). The foehn effect plays a significant role during the transfer of air masses over the Primorsky and Baikal Ridges, which causes a considerable drop of air humidity. In October-December, the cloud cover is very low above Lake Baikal due to the intense water evaporation from the ice free surface of the lake.

FOGS (129)

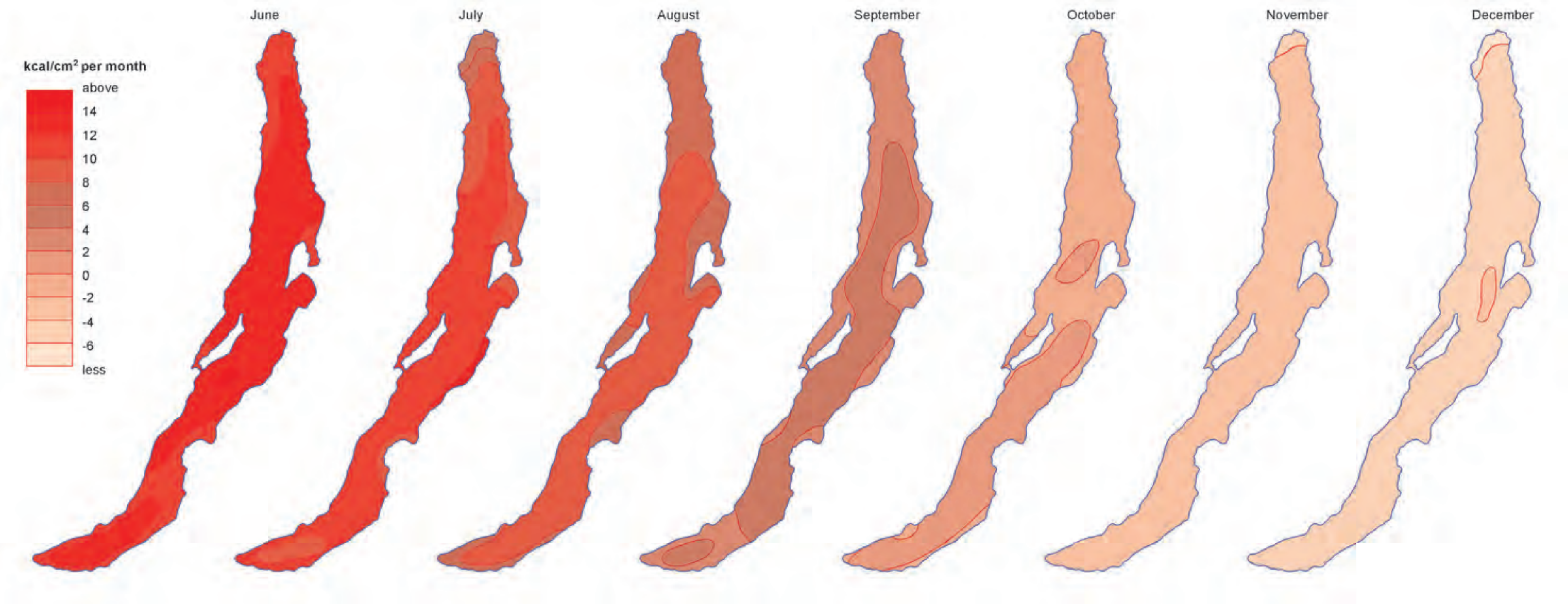
Fogs at Lake Baikal form corresponding to sea fogs: they correlate with the relatively consistent seasonal drifting of air masses and with the seasonal distribution of winds. However due to the isolated inland location of the lake and the influence of the surrounding continental landmass, the Baikal fogs are to be classified as a separate type of advection fogs of large inland lakes and water reservoirs. The number of foggy days is the highest along the Northeast coast of Lake Baikal, and the lowest in the Central and the Southwest parts of the lake. The fogs lie mainly in the curves of the coastline, bays, coves, mouths of the rivers, flowing into Lake Baikal, and the numerous creek valleys that open towards the lake. In the annual cycle, the fogs are most frequent in July. The Northern stations report higher frequency of fogs in summer and register a single sharp peak in July. The Southern stations report lower frequency of fogs in the annual cycle, while the annual peak is extended over June, July and August.

At Lake Baikal, condensation prevails in summer, and evaporation – in winter. In the warm season, fogs are formed by passing of a warm front, or within a diffused pressure field above the wet underlying terrain. These fogs are formed by condensation of vapor in a mass of air warmed up above the land as it passes over the cold water. Summer fogs are very dense and persistent, especially in the first half of summer.

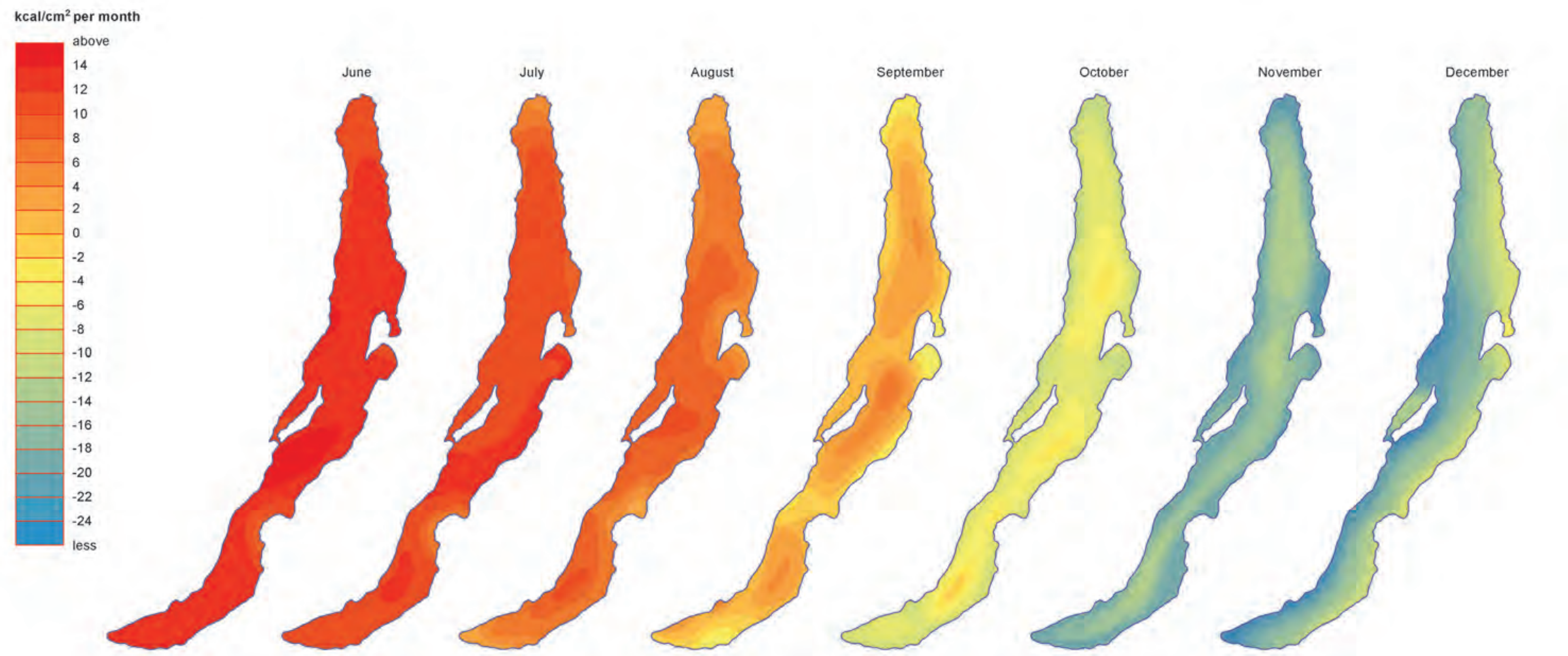
Evaporation fogs occur during the cold season. Until the lake freezes over, these fogs continuously stay above the water surface or can be lifted into low cloud. In winter, the Siberian Highland ground inversions accompanied by significant fall of temperature form radiation fogs. Winter fog formation is most commonly connected with advection of cold air over the warmer water surface. In cold season, as well as during the summer months, other types of fog can occur at Lake Baikal, caused by various reasons: temperature gradient between land and sea, the occurrence of floe patches and clear water surface, clearings in the fast ice of Lake Baikal.

Forecasting Baikal fogs requires an integrated approach with attention to such factors as their movability and the complexity of their formation processes. One has to take into account the general meteorological situation, the character of breeze/monsoon circulation in the area, the influence of coastline. It is important to consider the influence of West winds on the fog formation at the East coast, especially in winter.

130. RADIATION BALANCE

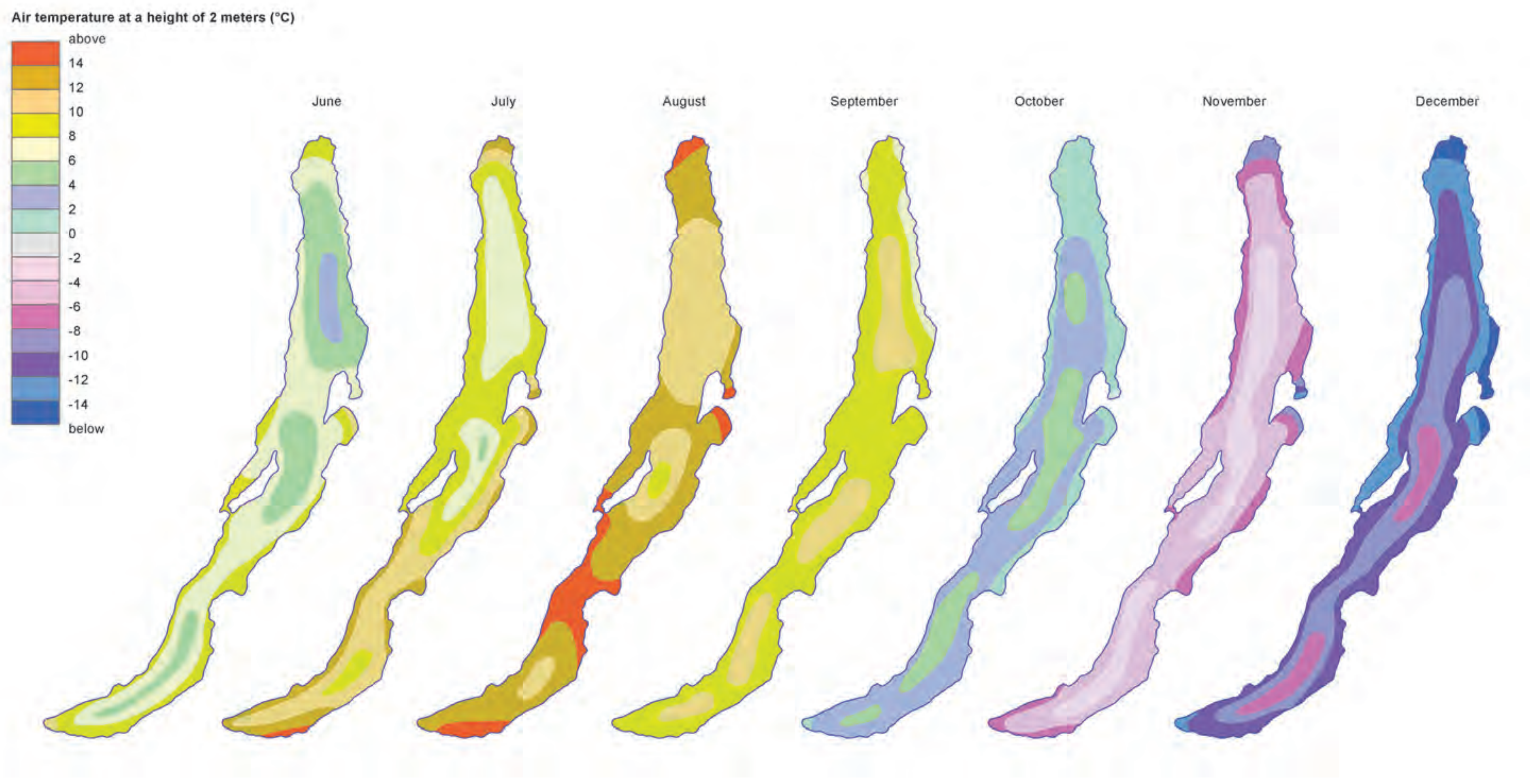


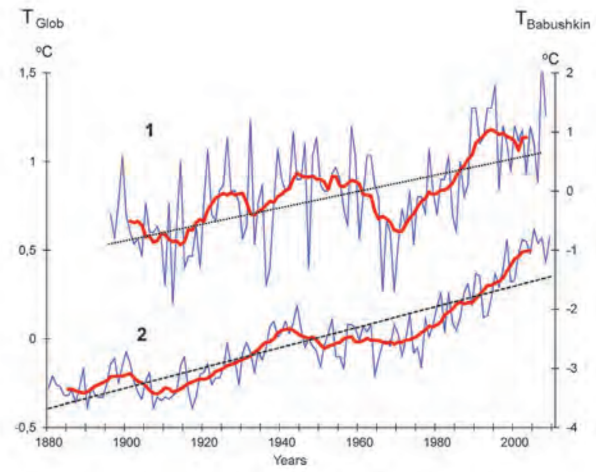
131. THERMAL BALANCE



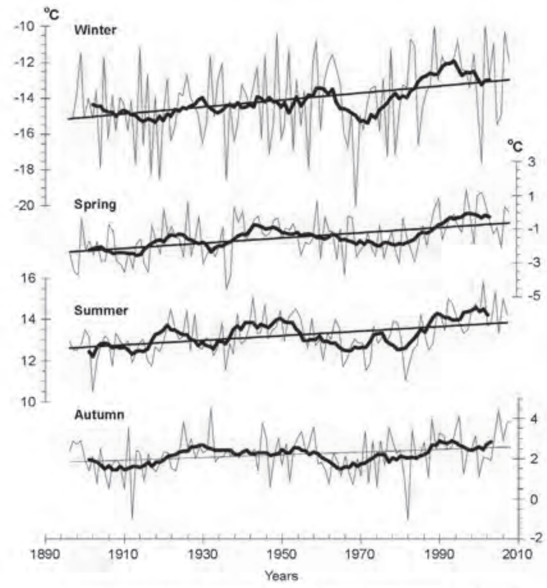
RADIATION AND THERMAL BALANCE OF WATER SURFACE (130-131)

Absorbed solar radiation is the main thermal source of the lake water column. It depends on incident solar radiation and the ratio of reflected radiation (albedo). Thus, it has a well-defined seasonal trend. Radiation balance of the Lake Baikal water surface is a sum of absorbed solar radiation and effective radiation of water surface. This balance is positive from April to September and negative from October to March. In general, radiation balance of the lake is positive throughout the year, changing from 1,900 MJ/m^2 in the Selenga river area to 700-800 MJ/m^2 in the northern part of the lake. Spatial distribution of radiation balance of the lake surface depends on cloud regime during warm period. Radiation balance varies insignificantly because of inconsiderable changes of the cloud cover. In cold period, the distribution of radiation balance is influenced not only by the cloud cover but also by the difference in the albedo of water and snow. Therefore, the radiation balance in Northern Baikal is much lower than that in Central and Southern Baikal. Radiation balance of the water surface is a determining element in the thermal regime of the lake. Because of high water heat capacity, constant time lag is recorded in the seasonal trend of temperature parameters in comparison with radiation characteristics. Therefore, maximal accumulated radiation and radiation balance are recorded at Lake Baikal in June and the highest air and water temperatures in August.





Changing seasonal air temperature at the meteorological station "Babushkin" in Southern Baikal in 1896-2010 years



Changing seasonal air temperature at the meteorological station "Grandmother" in the South Baikal

THERMAL AND ICE REGIMES (132-134)

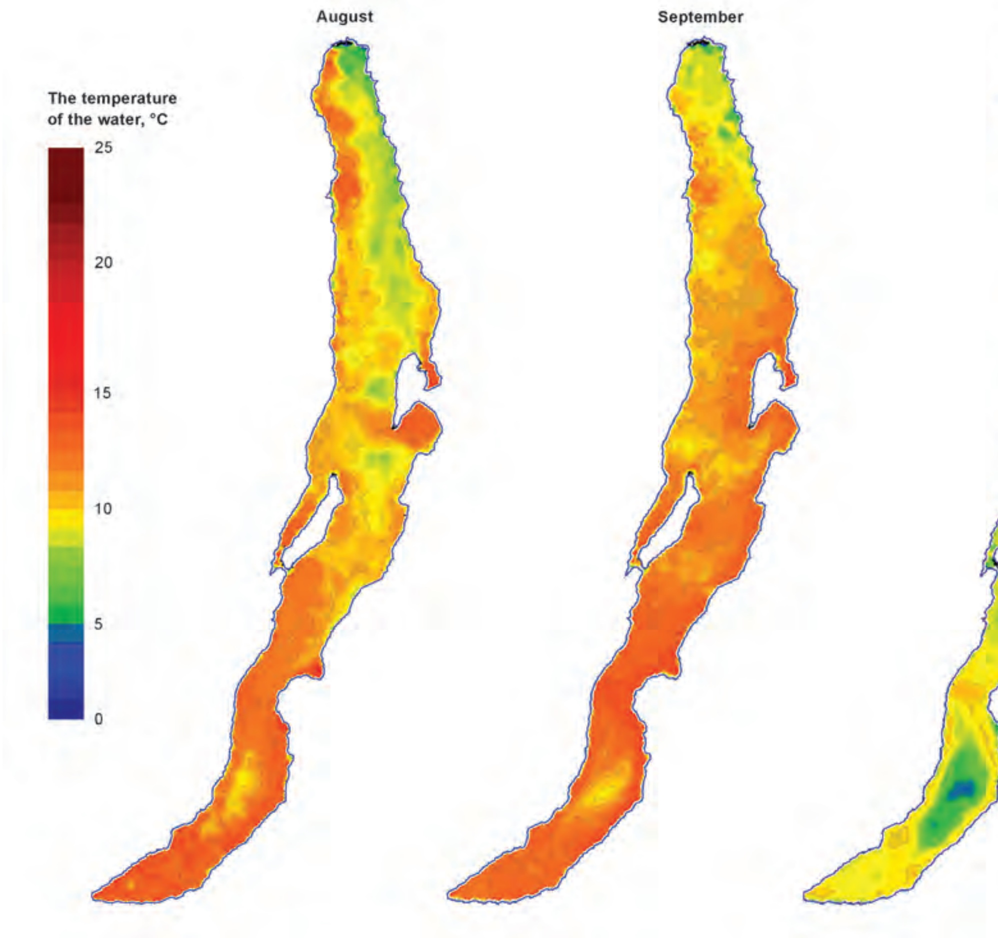
Air temperature. General trend of air temperature changes at Lake Baikal corresponded to the global temperature trend with its rise from the late 1910-s to the middle of the 20th century, to the temperature decrease by the early 1970-s and its significant rise by the end of the 20th century. The trend of annual temperature in the lake area (+1.2°C/100 years) was two times higher than the average Earth's trend (+0.6°C/100 years). The rise of air temperature was recorded for all seasons of the year from 1986 to 2008 with the trend of +1.9, +1.5, +1.1 and +0.66°C/100 years in winter, spring, summer and autumn, respectively. Maximal trend (+2.1-2.2°C) was registered in December and January and minimal trend (+0.1-0.5°C) in August, September and October. Statistical analysis showed both short-term (2-7 years) and long-term inter-annual (about 20 years) cycles with well-defined phases of increase and decrease of air temperature. The 20th century had two complete cycles (1912-1936 and 1937-1969) and phases of two incomplete cycles – decrease from 1896 to 1911 and increase from 1970. The increase phase at the end of the century to the mid 1990-s was characterized by anomalously long duration (25 years) and rise of air temperature (by 2.1°C). Beginning from 1995, there was a tendency to annual temperature decrease, which may be regarded as the beginning of the temperature drop phase in the current inter-annual climate cycle.

Temperature of water surface. The temperature of water surface increased together with the rise of air temperature due to global warming. According to the observation data since 1941, the average temperature of water surface in Southern Baikal (the settlement of Listvennichnoye) decreased insignificantly in May-September from the 1950-s to the 1970-s, and then sharply increased by the mid 1990-s. The same temperature changes were recorded in other areas of the lake. The rate of its increase (0.64-0.60°C/10 years) was higher in the central and northern parts of Lake Baikal than in its southern part (0.25-0.35°C/10 years). The temperature of the warmer 1994-2005 decade exceeded the temperature of the cold 1964-1975 period by 0.9-1.5°C in the southern area and by 1.8-2°C in the central and northern regions of the lake. In some years of this period (e.g., several days in August of 2002), the increase of surface water temperature up to 18-20°C was recorded even in the deeper areas of the lake.

Ice regime. Beginning in the middle of the 20th century, the warming caused "mitigation" of the ice regime at Lake Baikal [Verbolov et al., 1965; Magnusson et al., 2000]. Freezing of the lake started later, whereas ice breaking began earlier. In1868-2010, in Southern Baikal (the settlement of Listvennichnoye) the trend of freezing and ice breaking terms were 10 and 7 days per 100 years, respectively. The duration of ice free period prolonged, whilst the ice cover period shortened by 17 days. According to the 1950-2010 data, the maximal ice thickness decreased on average by 2.4 cm every 10 years. During the phase of significant warming (1970-1995,) the rate of ice process changes sharply increased: freezing started by 10 days later and ice breaking by 15 days earlier; the ice period shortened by 25 days, and the ice thickness decreased on average by 8.8 cm per 10 years. The observation data from shore stations and satellites showed that beginning from the mid 1990-s to the middle of 2010 there was a tendency towards early freezing, late break-up of ice and prolongation of ice period [Kouraev et al., 2007]. These changes are consistent with inter-annual climate periodicity associated with fluctuations of atmospheric circulation in the Northern Hemisphere.

The main meteorological factor, which causes fluctuations of freezing terms (Dfr) is the air temperature in November-December (Ta) affecting the rate of heat losses from the water surface. The correlation between these characteristics in Southern Baikal is described by equation Dfr=4.26Ta+75 ($R2=0.57$, $p<0.001$) for the period of 1896-2010, where Dfr is the number of days from December 1st to the freezing date. Temperature conditions in spring also affect the date of ice breaking. However, the correlation between ice breaking dates and air temperature is not high [Livingston, 1999]. It is attributed to the effect of both thermal and dynamic (wind) factors on the break-up of ice [Kouraev et al., 2007; Shimaraev, 2008], as well as to the influence of ice thickness, which depends on air temperature in winter months.

133. TEMPERATURE OF WATER SURFACE ACCORDING TO SATELLITE DATA



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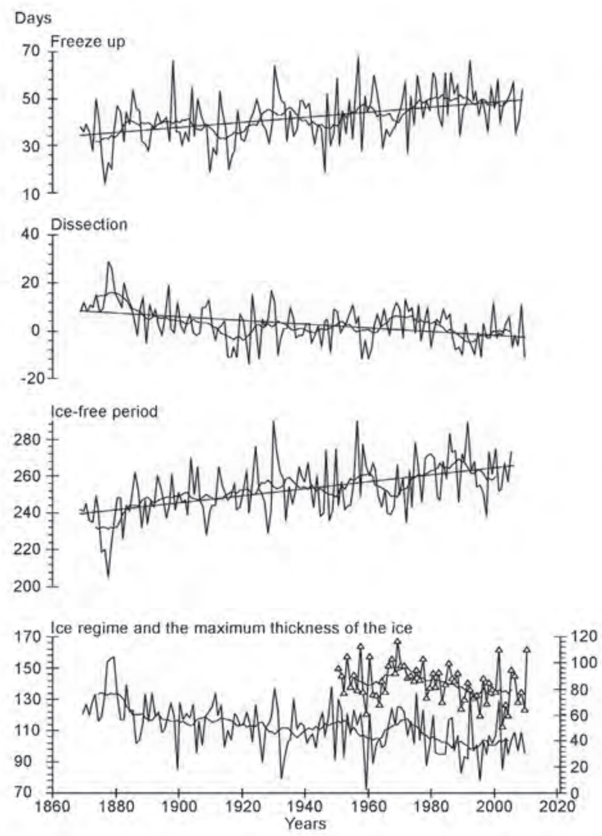
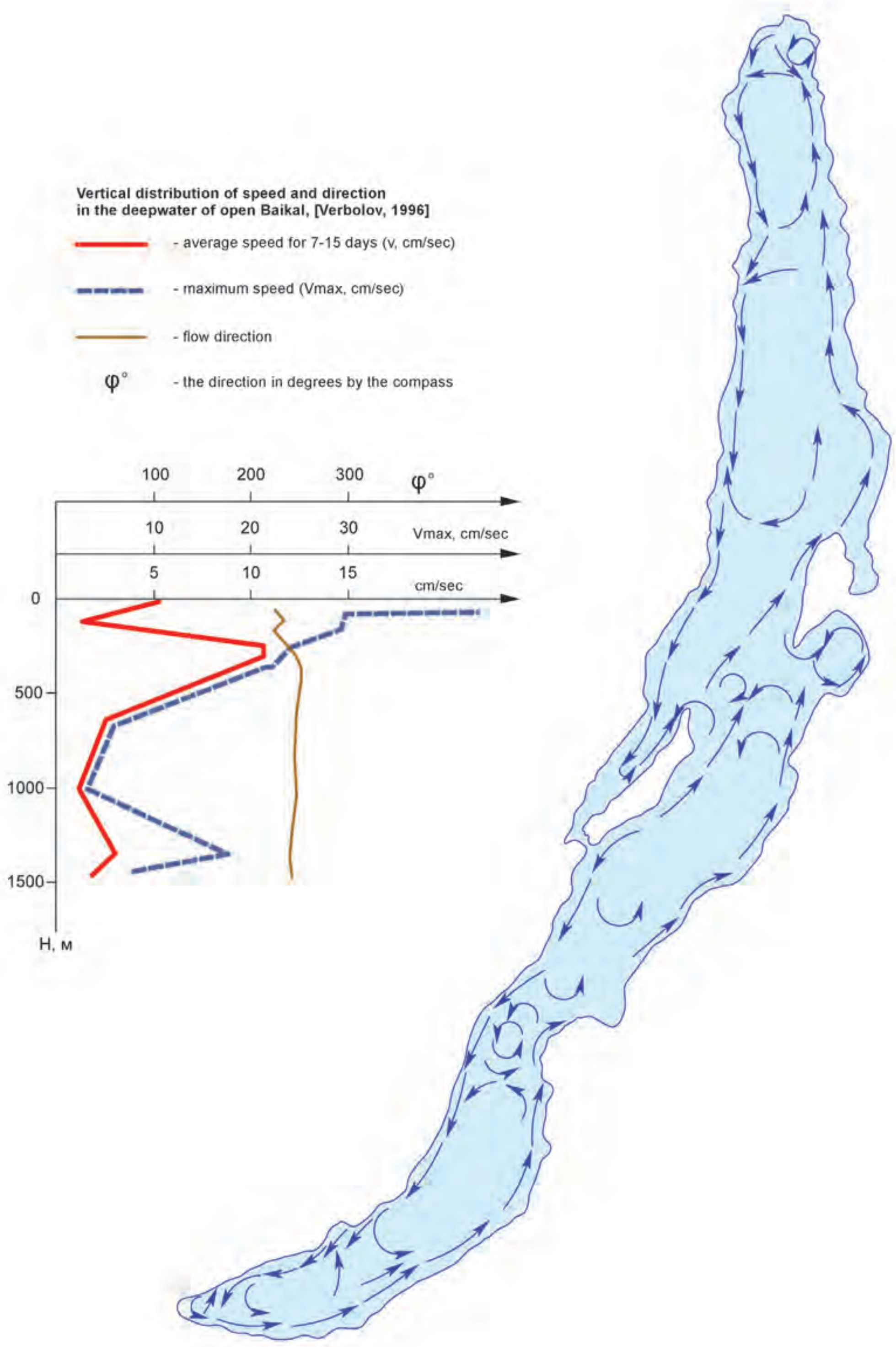
134. ICE REGIME



Freezing time (days from 1 December), and dissection of the ice cover (days from May 1), the duration of the ice-free periods and ice, ice thickness in the Southern Baikal, Listvyanka.

135. CURRENTS



CURRENTS (135)

The main cause of currents during the ice free period is the wind. Depending on changes of the wind velocities, wind (drift) currents intensify in May, subside in June-August and again intensify in autumn reaching its maximum in December. Wind-induced currents take place during strong winds, when the surface waters are transferred, thus causing the water level decrease by 10 cm. In summer and autumn, the negative water setout lasts approximately 40 h, and in winter about 35 h, whereas the wind setup continues 44 and 40 h, respectively. Average negative water setout height (decrease of the level near the windward shore) is 9-11 cm, and that of wind setup (increase of the level near leeward shore) is 7-8 cm. Moreover, geostrophic currents are formed at Lake Baikal, which are stationary currents retaining their main characteristics (location, direction and velocity) for a long period of time. They are induced by the difference in temperature (density) of coastal and lacustrine waters, deflecting force of the Earth's rotation and other factors. These currents covering both the entire Lake Baikal and separate basins are observed throughout the whole year.

Water is transferred counter-clockwise (cyclonic circulation) under the deflecting force of the Earth's rotation (Coriolis force). Secondary cyclonic circulations are observed in separate basins. The water at the interface of neighbouring cyclonic circulations is transferred across the lake (in Listvennichny Bay, the Selenga delta, Academichesky Ridge and Cape Kotelnikovsky). The same direction of water transfer is also observed in deep water layers of the lake.

The highest current velocities are recorded in the upper lake layers – in the epilimnion and sometimes below the thermocline. Their average velocities are up to tens of centimetres per second intensifying from summer to autumn. Maximal velocity registered near the surface can be over 1 m/sec. In winter, when the whole lake is covered with ice, the vertical structure of the velocity field is usually the same, although because of the ice cover the currents attenuate significantly. Their average velocity in the upper layers (up to 40-50 m) can be 2 cm/s and lower during "calm" periods. However, it can increase up to 3-5 cm/s and even to 10 cm/s during atmospheric pressure drop in case of atmospheric fronts. General character of water mass transfer corresponds to cyclonic circulation (Fig. 2.33) in the water column.

In the 1960-s, V. Sokolnikov [1964], working on the lake ice, discovered the effect of current intensification in the near-bottom layer at large depths of the lake, which was later observed in other seasons of the year. The studies of this phenomenon carried out by V. Verbolov [1996] and A. Zhdanov [2006] showed that the velocities in the near-bottom layer are seasonal. In winter, they episodically exceed 10 cm/s and in summer (July-early August) they are 4-8 cm/s during weak winds. In spring (May) and autumn (October-November) they become an order of magnitude at seasonal increase of the wind with the values corresponding to those in the upper 200-m layer (up to tens of centimetres per second). Usually current velocities decrease in the near-bottom layer with the distance from the foot of the underwater slope, their highest values being recorded at the bottom.

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UNINODAL (BIMODAL, TRINODAL AND QUADRINODAL) SEICHE OSCILLATIONS (136)

Seiches are standing waves in an enclosed or partially enclosed water body. Seiche oscillations in Lake Baikal are observed almost continuously throughout the whole year. Some characteristics of these oscillations were obtained from in-situ observations, laboratory experiments on a spatial hydraulic model and from appropriate theoretical calculations. The results of these studies have been published in the works (References). However, available information on Baikal seiches is scarce due to the difficulties of in-situ measurements and rather crude data on bottom topography. Sophisticated instrumental tools and advanced techniques for in-situ measurements were used to perform calculations of seiche oscillations in Lake Baikal based on a spectral difference model using specified bathymetric data obtained by researchers from Limnological Institute SB RAS. All these data are included in this atlas. The main aim of this study was to investigate solutions corresponding to oscillations with the periods of 277, 152, 84, 67, and 59 min, which were identified during in-situ observations.

The spectral difference model is based on the linearized system of equations for shallow water in the spherical coordinate system. Difference approximation is based on irregular triangular spatial mesh. The side length of the calculation mesh is 30 m near the shoreline and about 1 km for the rest of the model area. The numerical model includes solution of the eigenvalues problem. It allows the researchers to get a set of frequencies and corresponding forms of seiche oscillations.

The calculations were obtained taking into consideration the Earth's rotation. Complex solutions were normalised in such a way that imaginary component was minimal, whereas true components of solutions for the rest of the model area were within the range of -10 to 10. The values in the nodes with the depth less than 10 m and in the nodes within the contour of Maloye More (Small Sea) were not taken into account. Spatial distribution of seiche oscillations with the periods of 276.96; 151.58; 84.25; and 67.38 min corresponds to uninodal, binodal, trinodal, and quadrinodal longitudinal seiche modes of Lake Baikal. The level distribution along the centreline is shown for the enumerated modes in Figure. It should be noted that it is necessary to use other approaches for specification of solutions in shallow areas of Lake Baikal, such as Mukhor and Proval Bays and Cherkalovsky and Posolsk Sors, where the bottom friction is likely to play a significant role. The results for the first mode are consistent with the data on distribution of seiche oscillation height along the Baikal length in [Sudolsky, 1991, Fig. 5.2], in which the data on calculations and survey results from the spatial hydraulic model are compared.

Amplitudes of seiche oscillations in Lake Baikal and their seasonal variability were analysed from the data obtained at 3 stations located in the southern basin of the lake. Well-defined maxima for the oscillations with the periods of 277, 152, 84, and 67 min are observed within the range of density spectrum derived from the annual level record. No significant differences were recorded between the amplitudes for a uninodal seiche and amplitudes during the rest of the year when the lake is covered with ice and protected from wind. It was established that a seiche with the period of 67 min is observed in different seasons of the year. At three stations, level changes for the oscillation with the 277 min period differ in significantly. For the 152 min period they have slight differences, and for the 84 and 67 min periods they are similar only at those sites with relatively high amplitudes of oscillations. This is attributed to the effect of wind and atmospheric pressure. Measured and calculated periods for the first four seiche modes are given in Table.

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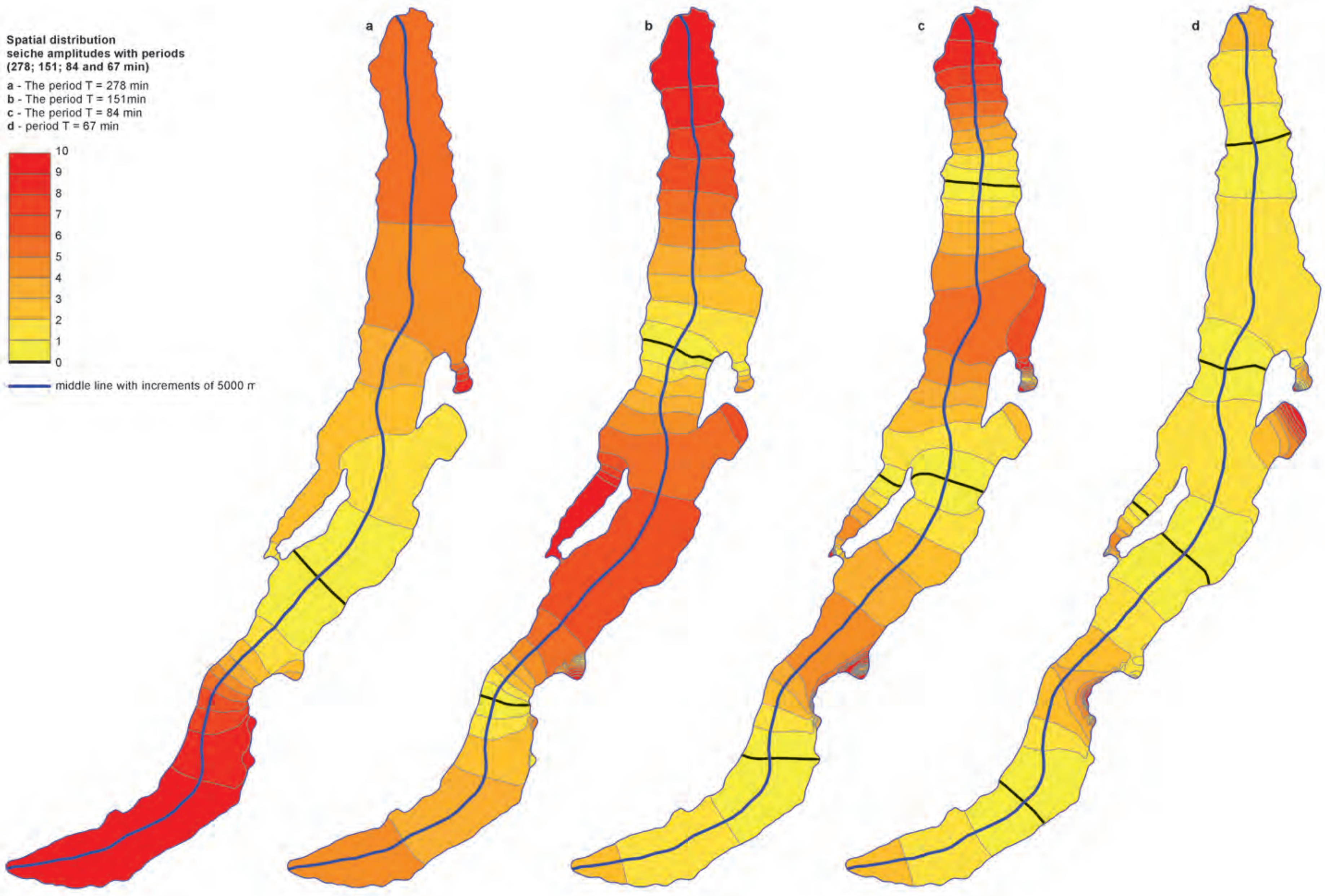
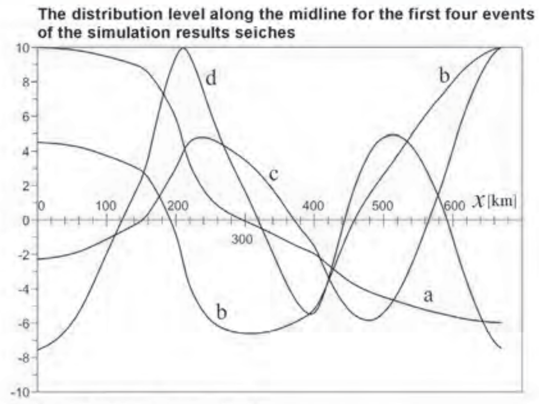
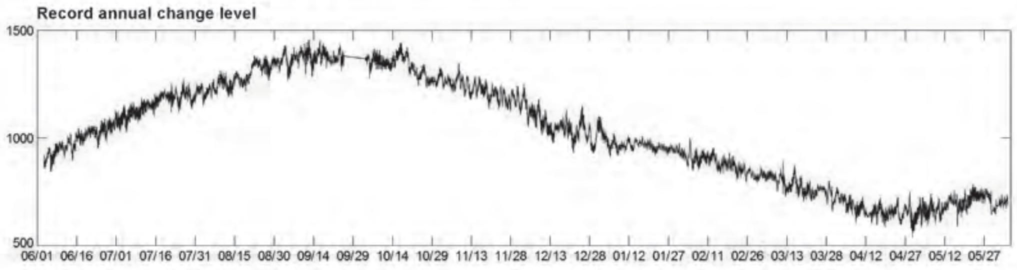
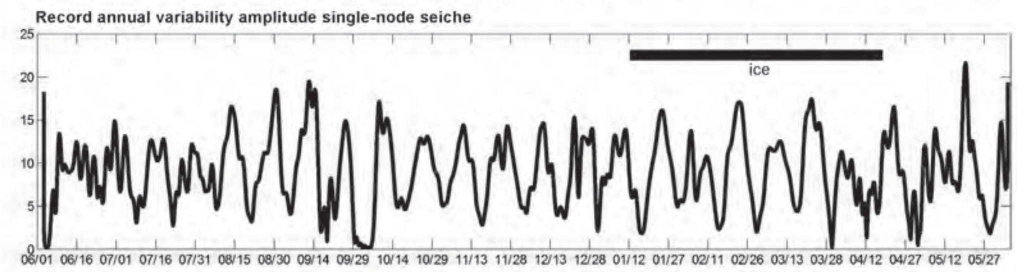
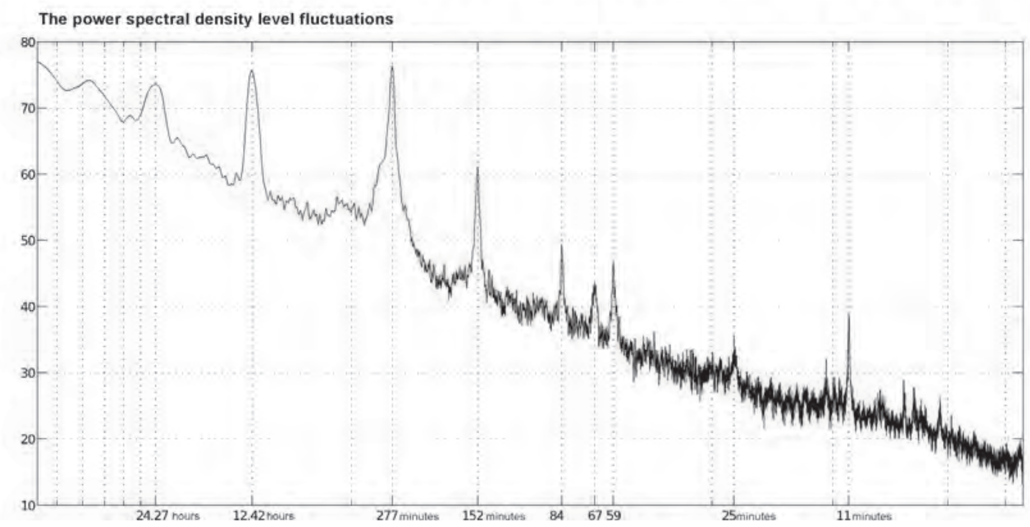
136. UNINODAL (BIMODAL, TRINODAL AND QUADRINODAL) SEICHE OSCILLATIONS











Measured and calculated periods for four seiche modes

Modes	*T1, min*	*T2, min*	*T3, min*	*T4, min*
Measurements	277	152	84	67
Measurements according to [Sudolsky, 1968; Timofeev et al., 2009]	278.4	153	87,7	–
Numerical model	276,96	151,58	84,25	67,38

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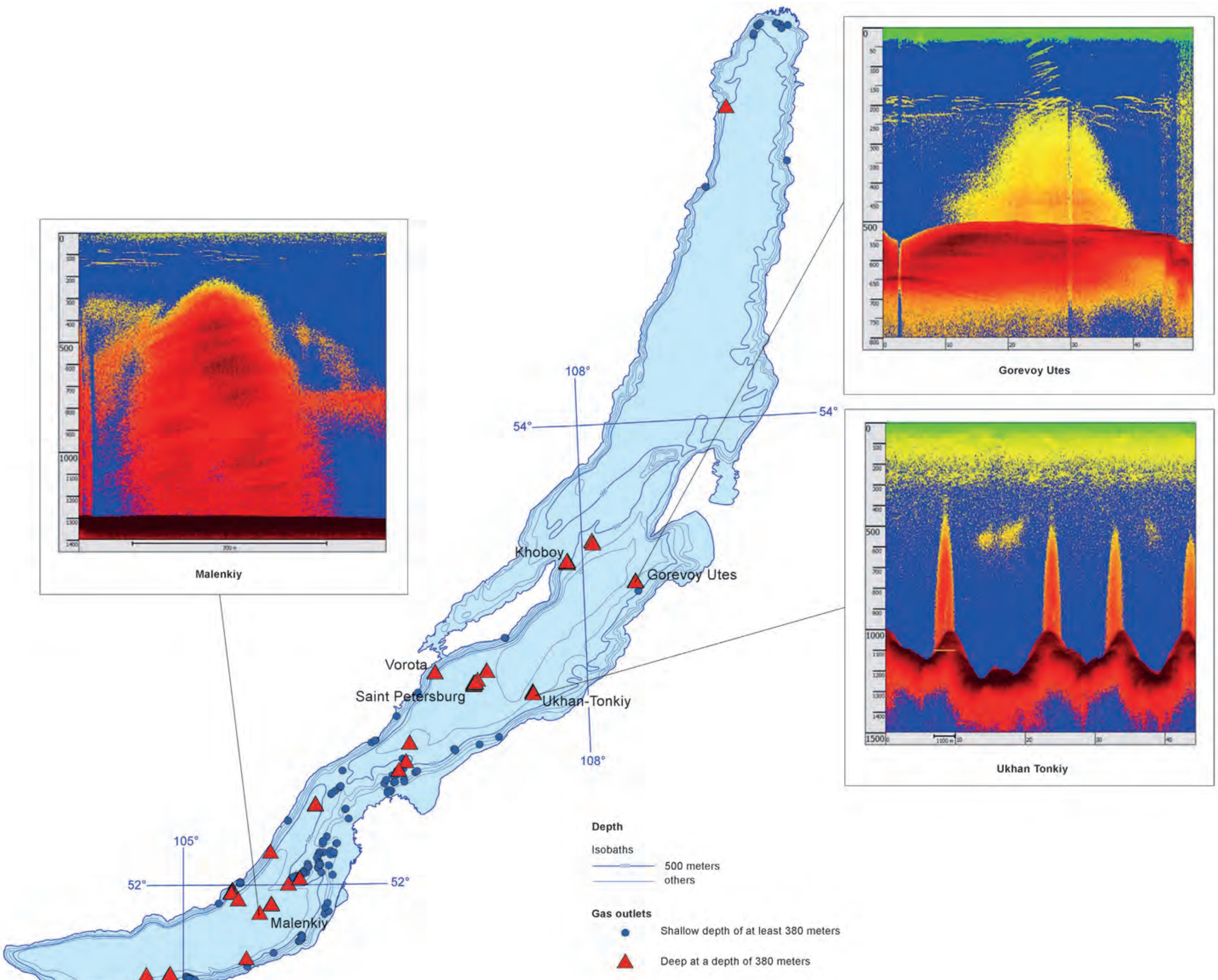

Name vulture	The depth of the place	Height vulture
Kedroviy	589	568
Khoboy	522	413
Gorevoy Utes	870	840
Ukhan-Tonkiy	1054	629
Vorota	1168	700
Malenkiy	1297	1025
Saint Petersburg	1346	954

GAS BUBBLE EMISSIONS FROM BOTTOM SEDIMENTS (137)

Methane emissions from bottom sediments in Lake Baikal have been known for a long time. Even the first travelers, who visited the lake in the 17th century, noticed gas emissions. Later gas emissions in Baikal were explored by the East Siberian Branch of the Russian Imperial Geographical Society. A review of the available materials on gas seeps in Baikal is presented in the publication [Granin and Granina, 2002]. A new stage of research on gas seeps in Baikal started after the discovery of gas hydrates [Kuzmin et al., 1998] and mud volcanoes at the bottom of the lake [Van Rensbergen et al., 2002] at the turn of the 20th century.

Gas seeps are found in oceans, seas and freshwater bodies. To study gas seeps hydroacoustic methods are used, as they enable an extensive search due to the strong backscattering of sound from the bubbles of floating-up gas. To locate and monitor the activity of gas plumes a digital record of acoustic signals of the echo sounders FURUNO, installed on the research vessels "G. Yu. Vereshchagin", "Titov" and "Papanin", was organized.

We subdivide gas seeps into shallow- and deepwater [Granin et al., 2010]. Deepwater gas seeps (red triangles on the map) are the ones that are located at depths greater than the depth of the gas hydrate stability (380 m); gas seeps, located at shallower depths (blue circles), belong to shallow-water gas seeps.

A substantial proportion of the shallow gas seeps are located near the Selenga river delta and on the Posolskaya bank. Multi-year monitoring of the activity of gas seeps made it possible to identify long-term and periodic gas shows. A maximum flare height of more than 1000 m was recorded in the area of the mud volcano Malenky on June 23, 2011 from the RV "Titov". According to the echo sounders data, the rise rates of gas bubbles reach 25 cm/s or more. In the area of plumes there is a near-bottom layer, where the temperature gradient is equal to the adiabatic one. This is indicative of a complete mixing of a significant layer of water as a result of the gas emissions [Granin et al.]

Using the acoustic sounding, a gas flow from bottom sediments was estimated. The estimation of the flow was made for several deepwater plumes. For different plumes the methane flow from the bottom sediments of Lake Baikal ranged from 14 to 216 tons per year. Comparing the result obtained with corresponding estimates for other water bodies, it may be said that the gas flow for the largest bottom gas seeps in Lake Baikal is corresponding to the flows in the Norwegian Sea and the Sea of Okhotsk [Granin et al., 2-12].

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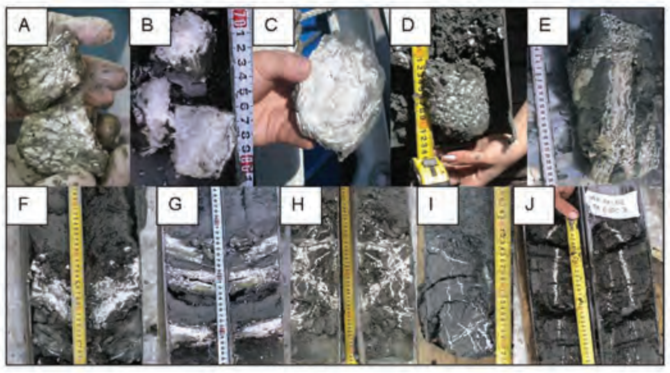
138. BAIKAL GAS HYDRATES

Accumulation of subsurface gas hydrates

- in the area of unloading of gas
- in the area of the mud volcano

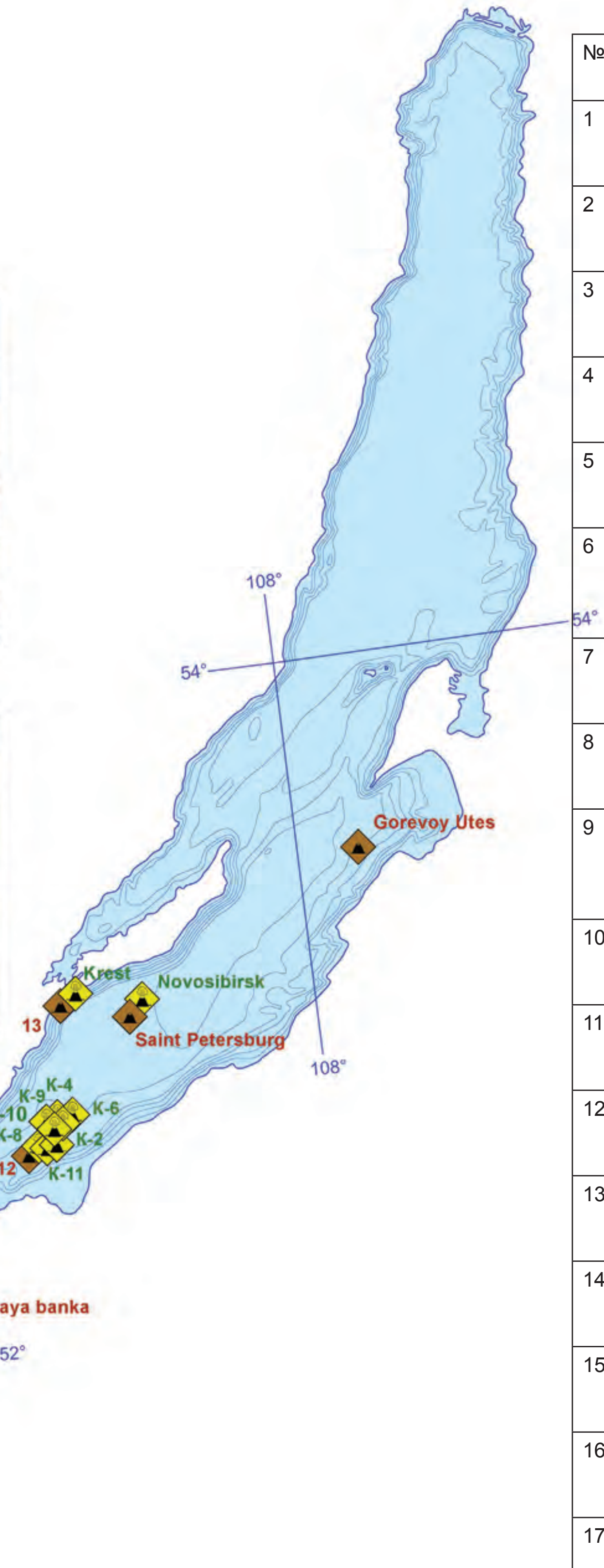
Layout of the surface gas hydrate of Baikal lake

Different forms of gas hydrates (white):
a, b, c - solid;
d, e - the granules;
f, g - layered;
e, h, i, j - differently-veins and veinlets



Горящий гидрат

Гидрат и нефть



Characteristics of gas hydrate Lake Baikal and their location

№	Name	Coordinates and depth, m	Year	Kind hydrates
1	C. Little volcano	51.9274°N 105.6486°E 1280	2000	Porphyritic texture, the layers in the form of cement
2	Big Gr.vulkan	51.8771°N 105.5490°E 1380	2003	The massive, porphyritic texture, veins and veinlets
3	Gr.vulkan K-2	52.5895°N 106.7692°E 900	2005	Granules, vertical layers-core
4	Gr.vulkan K-0	52.5026°N 106.6111°E 415	2006	Veins and veinlets
5	Baby Gr.vulkan	51.9076°N 105.6032°E 1307	2006	The layers, veins and veinlets
6	Gr.vulkan K-6	52.6001°N 106.8149°E 1005	2007	The massive, porphyritic texture, layers, veins and veinlets
7	Gr.vulkan Gerbil 2 (P-2)	52.1737°N 105.8097°E 825	2007	Massive layers, veins and veinlets
8	Sip Goloustnoye (1-3)	51.9762°N 105.3493°E 410	2008 2010	The layers, veins and veinlets
9	Oil vulture cliff Gorevoy	53.3013°N 108.3890°E 875	2006 2008	Massive layers, veins and veinlets, massive bitumen at the bottom
10	Sip St. Petersburg	52.8824°N 107.1675°E 1402	2009	Massive hills on the bottom layers
11	Sip Embassy Bank	52.0360°N 105.8433°E 500	2010	Granules-conductor layers
12	Gr.vulkan K-1	52.5667°N 106.7130°E 675	2010	The layers, veins and veinlets
13	Gr.vulkan K-9	52.5879°N 106.7251°E 741	2010	Massive layers, veins and veinlets,
14	Gr.vulkan K-10	52.5325°N 106.6550E 531	2010	Granules layers, veins and veinlets
15	Gr.vulkan Novosibirsk	52.9348°N 107.2548°E 1396	2010	Massive layers, veins and veinlets
16	Gr.vulkan K-8	52.5195°N 106.6630°E 425	2010	The layers, veins and veinlets
17	Gr.vulkan K-11	52.5171°N 106.6771°E 419	2011	The layers, veins and veinlets
18	Sip K-12	52.5047°N 106.5882°E 489	2011	Layers and veins
19	Gr.vulkan K-4	52.5883°N 106.7498°E 835	2011	Granules layers, veins and veinlets
20	vulture 13	52.9338°N 106.8691°E 1134	2011	Layers and veins
21	Gr.vulkan Cross	52.9601°N 106.9438°E 1280	2011	Massive layers, veins and veinlets

BAIKAL GAS HYDRATES (138)

Lake Baikal is a unique freshwater lake where in the sediments natural gas hydrate accumulations have been found. Both deep (100 m below the lake floor) and subsurface (first meters) gas hydrates occur in Lake Baikal. Subsurface gas hydrates were found for the first time in 2000 [1]. Sidescan sonar, continuous seismic profiling, multibeam sonar data as well as observation from the manned submersibles "MIR" allowed to discover in Lake Baikal before 2012 21 sites where at the depth up to 3 m below the lake floor occur accumulations of gas hydrates with different shape and structure. This map is created on the basis of geological and geophysical methods for gas hydrate survey and identification developed in LIN SB RAS; these methods are based on remote sounding of the floor by hydroacoustics and seismoacoustics. Direct sampling of sediments and gas hydrates was also used. All the gas hydrate found are related to tectonic dislocations where gas saturated fluid or gas are discharged in the form of bubbles, that is in mud volcanoes and seeps. In 15 cases these were mud volcanoes or similar underwater mounds, the remainder were the seeps [2]. All of them are situated at the depth below 380 m (upper boundary of gas hydrate stability zone), in South and Central Baikal (BSR). The marks show at the map their localization areas and discharge structure types. At the present time we continue searching and specifying gas hydrate reserves over the whole Baikal.

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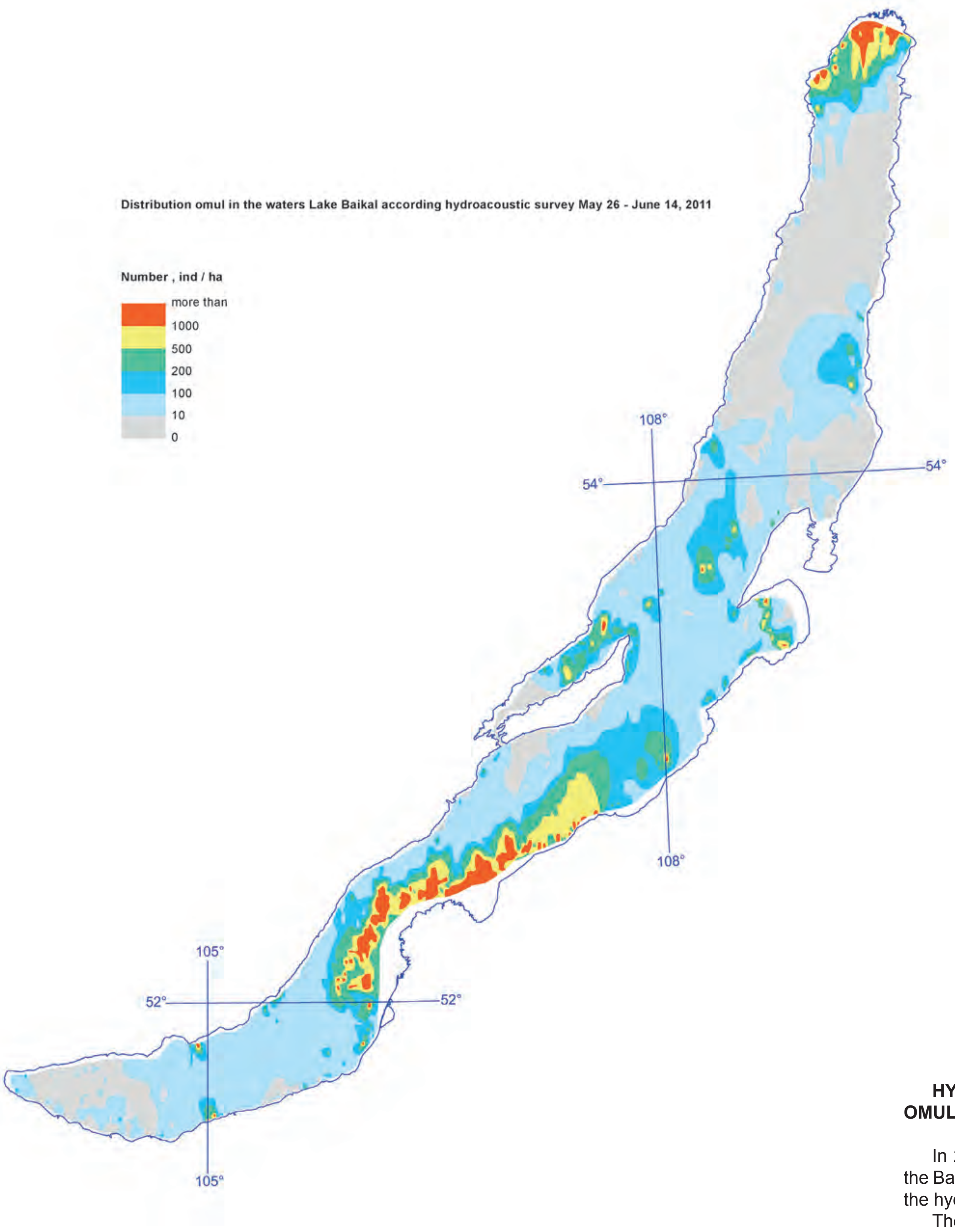

The average length and weight of the Baikal omul based on the trawling catch and hydroacoustic data, May-June, 2011

Area	Acoustic data			Average size according to control catch, cm
	Average power of target signal (TS), dB	Average size, cm	Average weight, 1 g	
Selenga shallow water area	-37.1	21.1	99,8	20.1
Barguzinsky Bay	-37.9	19.2	74.0	21.0
Northern Baikal	-38.3	18.5	65.3	19.4
Small Sea Strait	-37.4	20.5	91.0	23.1
Open lake (Enkhaluk - Cape Goreviy)	-38.0	19.0	71.5	17.9

Results of the hydroacoustic assessment of the number and biomass of the Baikal omul

Area	Area, km^2	Number, thousand	Average density, spec/ha	Biomass, tons	Average density, kg/ha
Total studied water area of Baikal	28696.1	360474.2	126	31588.6	11.0
Selenga shallow water area	2046.3	138108.2	675	13639.5	66.7
Barguzinsky Bay	583.9	7203.5	123	502.0	8.6
Northern Baikal	874.1	54490.7	623	4419.4	50.6
Small Sea Strait	547.5	10476.3	191	889.9	16.2

Notes: Confidence interval for average values ±7.6% at the significance point of 5%.

HYDROACOUSTIC MEASUREMENT OF THE BAIKAL OMUL RESOURCES (139)

In 2011, the assessment of the number and biomass of the Baikal omul Coregonus migratorius was carried out using the hydroacoustic method [1].

The results of the assessment are shown in Tables 1 and 2. The distribution of the number and biomass of the Baikal omul in the water area of Lake Baikal is uneven. Amassments with the density above average take less than a quarter of the examined area. However, they contain almost two thirds of the Baikal omul reserves. A general picture of the spatial distribution of the omul in the lake's water area corresponds with trawling and acoustic measurements. Our work confirmed the necessity of conducting such measurements immediately after ice clearance, but before the start of feeding migrations of the Baikal omul. During this period, the omul forms dense shoals that are easy to register using the hydroacoustic technique, which improves the accuracy of measurements. The derived number and biomass figures of the Baikal omul, especially in the Selenga shallow water area and Northern Baikal, correspond quite well with the forecast of the long-term dynamics based on the peculiarities of the size- and age-related composition of the fish population[2].

We confirmed the findings about the presence of a significant part of the omul population in the deep-water zones of the lake.

The work was performed as part of the integration project of SB RAS №6 «Regularities of behaviour of Baikal omul ...» and the project VI.50.1.4 «Molecular ecology and evolution ...» (№ 0345–2014–0002).

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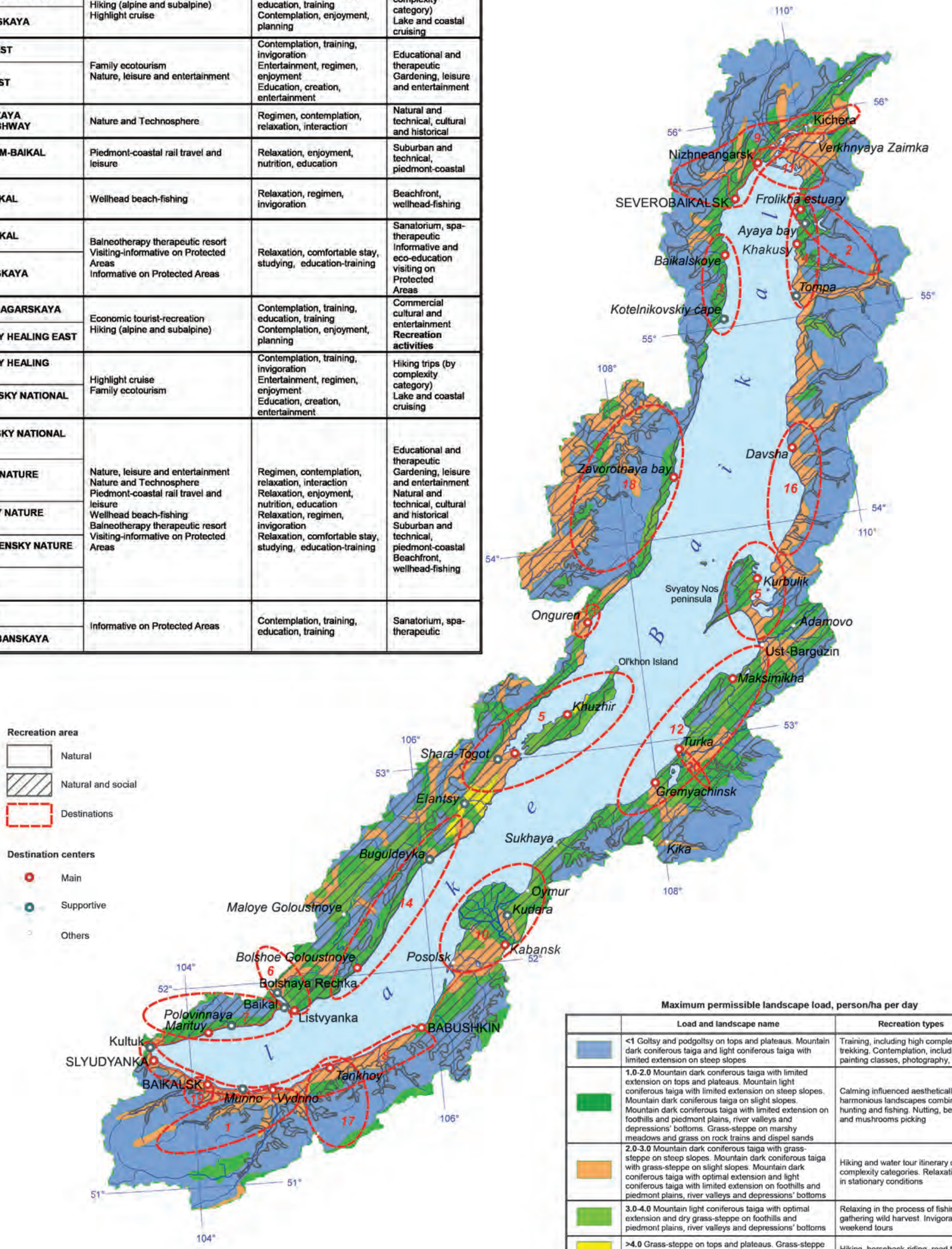
140. RECREATION ON LAKE BAIKAL

Recreation chorology on Lake Baikal shores

№	Destination	Specialization	Recreation forms	Recreation activities
1	HAMARDABANSKAYA	Hiking (alpine and subalpine) Highlight cruise	Contemplation, training, education, training Contemplation, enjoyment, planning	Hiking trips (by complexity category) Lake and coastal cruising
2	BARGUZINSKAYA			
3	CRUISE WEST	Family ecotourism Nature, leisure and entertainment	Contemplation, training, invigoration Entertainment, regimen, enjoyment Education, creation, entertainment	Educational and therapeutic Gardening, leisure and entertainment
4	CRUISE EAST			
5	OLKHONSKAYA BAIKAL HIGHWAY	Nature and Technosphere	Regimen, contemplation, relaxation, interaction	Natural and technical, cultural and historical
6	OLD CIRCUM-BAIKAL RAILWAY	Piedmont-coastal rail travel and leisure	Relaxation, enjoyment, nutrition, education	Suburban and technical, piedmont-coastal
7	SOUTH BAIKAL	Wellhead beach-fishing	Relaxation, regimen, invigoration	Beachfront, wellhead-fishing
8	NORTH BAIKAL	Balneotherapy therapeutic resort Visiting-informative on Protected Areas Informative on Protected Areas	Relaxation, comfortable stay, studying, education-training	Sanatorium, spa-therapeutic Informative and eco-education visiting on Protected Areas
9	SELENGINSKAYA			
10	KICHERO-DAGARSKAYA	Economic tourist-recreation Hiking (alpine and subalpine)	Contemplation, training, education, training Contemplation, enjoyment, planning	Commercial cultural and entertainment **Recreation activities**
11	NATURALLY HEALING EAST			
12	NATURALLY HEALING WEST	Highlight cruise Family ecotourism	Contemplation, training, invigoration Entertainment, regimen, enjoyment Education, creation, entertainment	Hiking trips (by complexity category) Lake and coastal cruising
13	PRIBAIKALSKY NATIONAL PARK			
14	ZABAIKALSKY NATIONAL PARK	Nature, leisure and entertainment Nature and Technosphere Piedmont-coastal rail travel and leisure Wellhead beach-fishing Balneotherapy therapeutic resort Visiting-informative on Protected Areas	Regimen, contemplation, relaxation, interaction Relaxation, enjoyment, nutrition, education Relaxation, regimen, invigoration Relaxation, comfortable stay, studying, education-training	Educational and therapeutic Gardening, leisure and entertainment Natural and technical, cultural and historical Suburban and technical, piedmont-coastal Beachfront, wellhead-fishing
15	BARGUZIN NATURE RESERVE			
16	BAIKALSKY NATURE RESERVE			
17	BAIKALO-LENSKY NATURE RESERVE			
18	IRKUTSK			
19	ULAN-UDE	Informative on Protected Areas	Contemplation, training, education, training	Sanatorium, spa-therapeutic
20	HAMARDABANSKAYA			



Maximum permissible landscape load, person/ha per day

	Load and landscape name	Recreation types
(blue)	**<1** Goltsy and podgoltsy on tops and plateaus. Mountain dark coniferous taiga and light coniferous taiga with limited extension on steep slopes	Training, including high complexity trekking. Contemplation, including painting classes, photography, etc
(dark green)	**1.0-2.0** Mountain dark coniferous taiga with limited extension on tops and plateaus. Mountain light coniferous taiga with limited extension on steep slopes. Mountain dark coniferous taiga on slight slopes. Mountain dark coniferous taiga with limited extension on foothills and piedmont plains, river valleys and depressions' bottoms. Grass-steppe on marshy meadows and grass on rock trains and dispel sands	Calming influenced aesthetically harmonious landscapes combined with hunting and fishing. Nutting, berrying and mushrooms picking
(orange)	**2.0-3.0** Mountain dark coniferous taiga with grass-steppe on steep slopes. Mountain dark coniferous taiga with grass-steppe on slight slopes. Mountain dark coniferous taiga with optimal extension and light coniferous taiga with limited extension on foothills and piedmont plains, river valleys and depressions' bottoms	Hiking and water tour itinerary of low complexity categories. Relaxation stay in stationary conditions
(light green)	**3.0-4.0** Mountain light coniferous taiga with optimal extension and dry grass-steppe on foothills and piedmont plains, river valleys and depressions' bottoms	Relaxing in the process of fishing, gathering wild harvest. Invigoration – weekend tours
(yellow)	**>4.0** Grass-steppe on tops and plateaus. Grass-steppe and steppe meadow on foothills and piedmont plains, river valleys and depressions' bottoms	Hiking, horseback riding, road travels. Aero-heliotherapy, bathing, etc.

RECREATION ON LAKE BAIKAL (140)

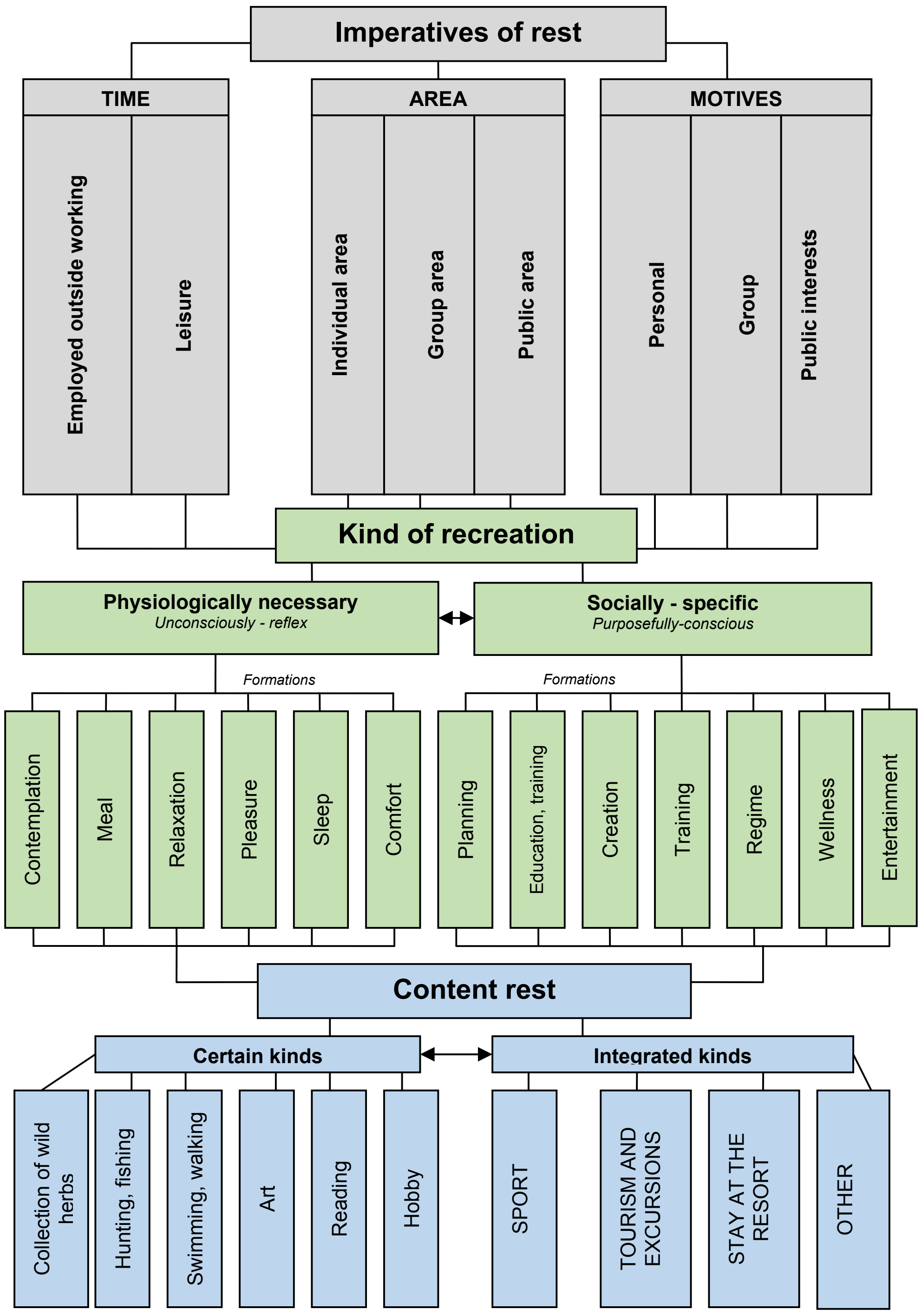
Recreation as an essential type of human activity is mapped as an integral phenomenon. The degree of territorial development of recreational activities is reflected through the use of zoning (natural and natural-social recreation zones). The zones' borders correspond to the isohypse of 1500 m. The contours are defined by a natural and landscape differentiation. Five levels of maximum permissible density (people/ha/day) have been identified.

The main point in the explanatory note is the district and settlement zoning of recreation territories (the main and supplemental recreation centers) with due consideration to the typology of destinations and their specialization by forms and types of recreational activities.

Natural landscapes untouched by human activity directly and comprehensively satisfy the requirements of the physiologically needed recreation (unconscious-reflectory), such as contemplation, solace, relaxation, and so on. These landscapes (groups of landscapes) must be protected. The most accessible part of the Baikal coast demonstrates a certain degree of environmental transformation. Social and specific (purposeful and deliberate) forms of recreation dominate recreation activities on these territories. The accumulation of the problems connected to the anthropogenic impact leads to the digression of landscapes and even to the loss of landscape diversity and total uselessness of the territory in terms of meeting the needs of recreation.

The map shows the types and subtypes of natural landscapes within the Central Ecological Zone of Lake Baikal. It also shows the zones of natural resources management, where integrated targets of the landscape and territorial planning should be achieved (preservation, improvement, development), and the territories that should be protected and recultivated.

View of the natural boundaries of the social and natural areas in Peschanaya bay.



Existence of the rest.

THE AESTHETIC IMAGE OF THE BAIKAL COASTAL AREA (141)

Riviera - an aesthetically holistic coastal territory, where, provided that the specifics of visual perception are duly considered, the integrity, beauty, and picturesqueness of spatial processes of interaction between settlements and the coast is reflected through the development of cultural recreation landscapes.

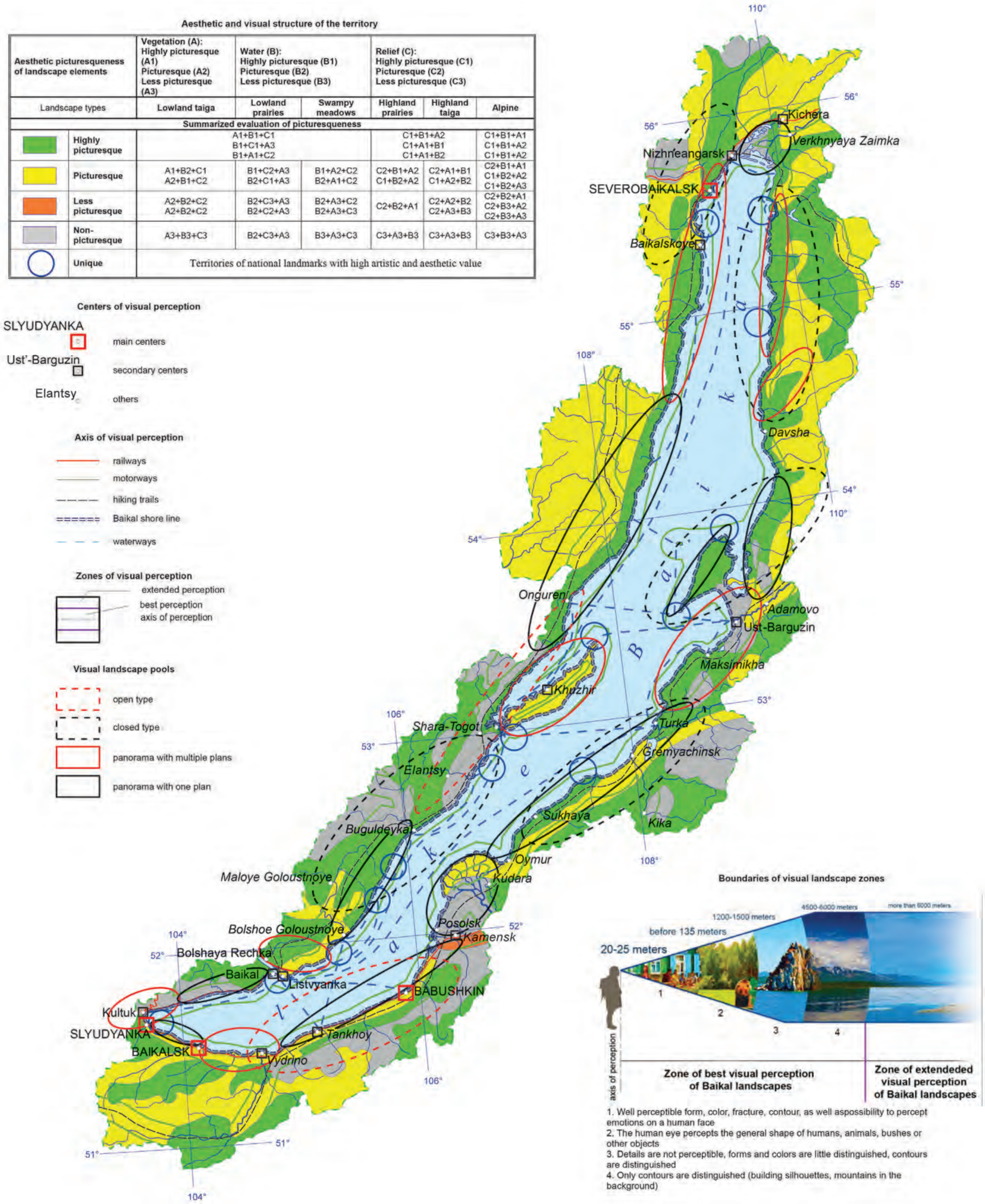
The map of the coastal organization is created as a result of the landscape and architectural assessment that evaluated not only functional and utilitarian requirements reflecting current transportation, communication, and settlement situations, but also aesthetic, architectural, and artistic (scenic) qualities of landscapes and conditions of their development within the belt of the best visual perception.

Structurally, this map represents a system of landscape and architectural centers, axes, zones, and basins. Two zones are identified in the belt of visual perception (approx. 8 km wide): the zone of the best visual perception and the zone for developing visual perception (inset) that include the main types of natural landscapes assessed by their aesthetic value. Segments of the Baikal coastal area are considered as the landscape and architectural basins. Visually, they are relatively homogeneous and located within the open or closed angles of view from recreation centers and settlements and from some segments of highways.

ECOLOGICAL STATE OF THE CENTRAL ECOLOGICAL ZONE OF THE BAIKAL NATURAL TERRITORY (142)

The Central Ecological Zone of the Baikal Natural Territory (CEZ BNT) includes Lake Baikal itself with its islands, the adjacent water protection zone, and specially protected natural areas (SPNA) (Federal Law No. 94-FZ “On Protection of Lake Baikal” dated May 1, 1999). Its boundaries coincide with the boundary of the World Natural Heritage site “Lake Baikal” and follow the outer boundaries of the Baikal-Lena, Barguzinsky, and Baikalsky reserves (zapovedniks), Pribaikalsky, Zabaikalsky, and Tunkinsky national parks, Frolikhinsky, Pribaikalsky, Enkhaluksky, and Snezhinsky nature-sanctuaries (zakazniks), as well as the main watersheds of the Primorsky, Baikalsky, Verkhne-Angarsky, Barguzinsky, Golondinsky, Ulan-Burgasy, Morskoy, and

141. THE AESTHETIC IMAGE OF THE BAIKAL COASTAL AREA



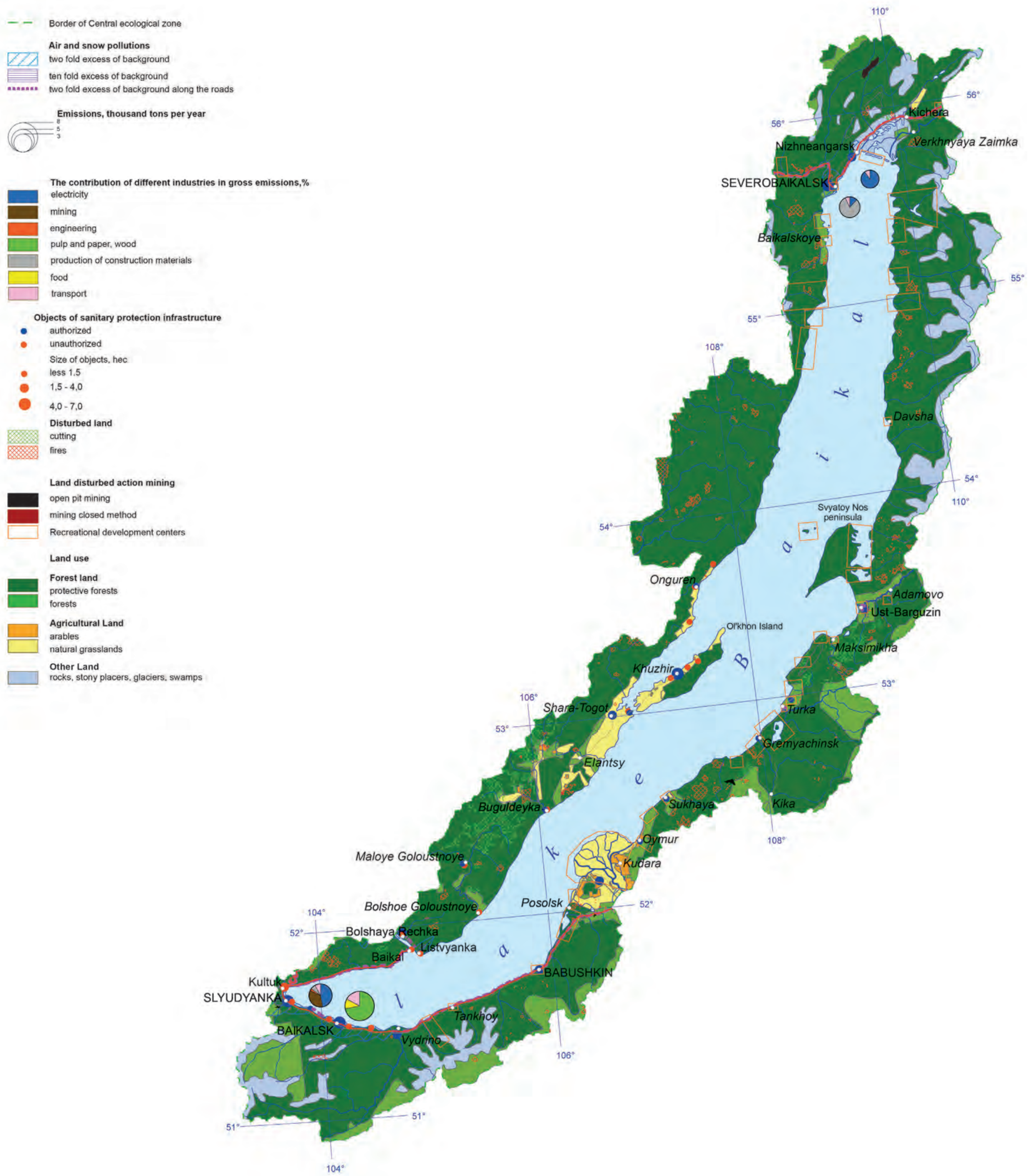
Khamar-Daban ridges. The main function of the central ecological zone is to preserve the unique ecological system of Lake Baikal and to prevent the negative impact of economic and other activity on its state.

The main sources of the atmospheric impact on Lake Baikal are industrial enterprises located in the basin and on the shores of the lake, and sections of the Trans-Siberian Railway and Baikal-Amur Mainline. Air emissions from industrial enterprises and boiler stations of the towns of Baikalsk, Slyudyanka, Severobaikalsk, and Nizhneangarsk and villages located in the Baikal basin have the highest probability of falling into the lake. Air transport products from the Irkutsk-Cheremkhovo agglomeration constitute a much smaller part of the total air pollution over Lake Baikal because of the remoteness and a large number of calms and fogs. Emissions of sulfur dioxide, nitrogen oxides, hydrogen sulphide and hydrocarbon, methyl mercaptan, formaldehyde, and phenol, produced by coastal enterprises have a negative impact on the ecological situation.

On the northern shore of Lake Baikal a single zone of the atmospheric pollution distribution, stretched along Lake Baikal, is formed. Its area for the town of Severobaikalsk amounts to approximately 150 km, and for Nizhneangarsk – to 60 km. Despite the fact that the content of certain impurities tends to decrease, the level of air pollution remains high.

The snow cover, having a high sorption capacity, is the most informative object in identifying the technogenic pollution of the atmosphere. According to the data of the Irkutsk Territorial Administration for Hydrometeorology and Environmental Monitoring, in the CEZ BNT there are several zones of technogenic pollution with the solids concentration in snow ranging from 0.5 to 10 g/kg. Mineralization of snow waters near the sources may exceed the background one by 10 times. The maximum amount of solids in snow reaches 200 g/m^2. Zones with increased concentration of calcium, magnesium, sodium, and potassium were identified. Concerning the cations, which are soluble in snow, the predominance of sodium and potassium was revealed. The maximum values of the insoluble residue of snow associated with the operation of CHP plants, boiler stations, and stove heating, are registered in the vicinity of Kultuk and Sludyanka; as regards the soluble residue, its maximum

142. ECOLOGICAL STATE OF THE CENTRAL ECOLOGICAL ZONE OF THE BAIKAL NATURAL TERRITORY



values are recorded in the area around Baikalsk. The total area of snow pollution with chemical elements extends 60 km from the southeast to the northwest with a width of 10-15 km.

In connection with the spontaneous development of tourism on the shores of Lake Baikal in the CEZ BNT, one of the most pressing issues is the problem of collecting, processing, and recycling of solid household wastes. Most of the garbage goes to disposal sites, both approved and unauthorized.

Within the CEZ BNT, cement and quartz raw materials, facing and ornamental stones, and different kinds of building materials are produced with local environmental disturbances. Significant anthropogenic changes of the natural environment (felled and burnt areas, etc.) are also observed near settlements, roads, and tourist centers and camps.

In order to establish a long-term strategy for the organization of the use of the CEZ BNT, which would ensure a sustainable development and preservation of the unique ecological system of Lake Baikal through reducing the anthropogenic impact and preventing the damage, a technique and scheme of territorial planning of the CEZ BNT was developed [Plyusnin and Vladimirov, 2013].

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