



Soils of the Baikal region: Mapping, use, transformation

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Abstract

The article gives a brief overview of the soil cartographic work carried out in the Baikal region. The paper contains one of the authors' map of agroecological zoning of soils of the Irkutsk region. A fragment of the legend is shown. Suitable and unsuitable districts for their use in agriculture have been identified. Various types of business activities are recommended. Also provided are maps of the use of land of the most developed part of the lands of the Baikal region in 1980 and 2023. In the Irkutsk-Cheremkhov plain with neighboring steppe areas, occupying 11% of the area of the region where the bulk of the farmland is located, relatively good natural and climatic conditions are noted. With the collapse of collective farms and state farms since the 1990s. More than 50% of former agricultural land was abandoned. A positive aspect of the "resetting" of the state system is the emergence of a reserve of agricultural land for use in the form of abandoned land with soils that have restored the level of fertility. The authors proposed a scale of qualitative assessment of the possibility of using land in agriculture, developed an assessment of the state of soil fertility, taking into account their regional characteristics.

Keywords: Conditions, Mapping, Soil, Use.

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Contribution of this paper to the literature

Taking into account the new soil classification soil and agroecological zoning of the Irkutsk region was carried out. We were completed a land use map of the most developed part in agriculture of the Irkutsk region. The authors proposed a scale of qualitative assessment of the possibility of using land.

1. Introduction

Authors group [1-5] carried out ecological zoning of soils in the south of the East European Plain, Russia and the World. There are few materials on the soils of hard-to-reach mountainous regions [6]. An agroecological assessment of the soils of the Irkutsk region and adjacent territories is given in the works of Shpedt, et al. [7]; Ubugunov [8]; Ubugunov, et al. [9]; Lopatina and Belozertseva [10]; Seryshev and Samedun [11]; Atlas [12] and Kalep [13] etc. Published maps: "Soil zoning. Atlas of the Baikal region" [14]; "Soil and geographical zoning. Atlas of the Irkutsk Region" [15]. Any zoning for any purpose reflects the level of knowledge and production of the current time, cannot be unshakable and must be refined and improved as new knowledge of landscape components and conditions for improving production and environmental transformation becomes available. Information on the level of fertility, the ecological state of the soil cover of the region is constantly supplemented by new studies.

2. Results and Discussion

As a result of many years of work, together with colleagues from the Institute of General and Experimental Biology of the SB RAS, the Institute of Geography and Geocology of the Mongolian Academy of Sciences, we were completed a series of soil-ecological maps for atlases and two wall maps (Soils of Lake Baikal Basin [16]) Soils of the Baikal natural territory [17]). Soils are united by natural zones. The most fertile soils are Mollisols (chernozems, umbrisols and other such types of soils) are shown in green and yellow light on the map. This soils are wide spread about 30% of the territory.

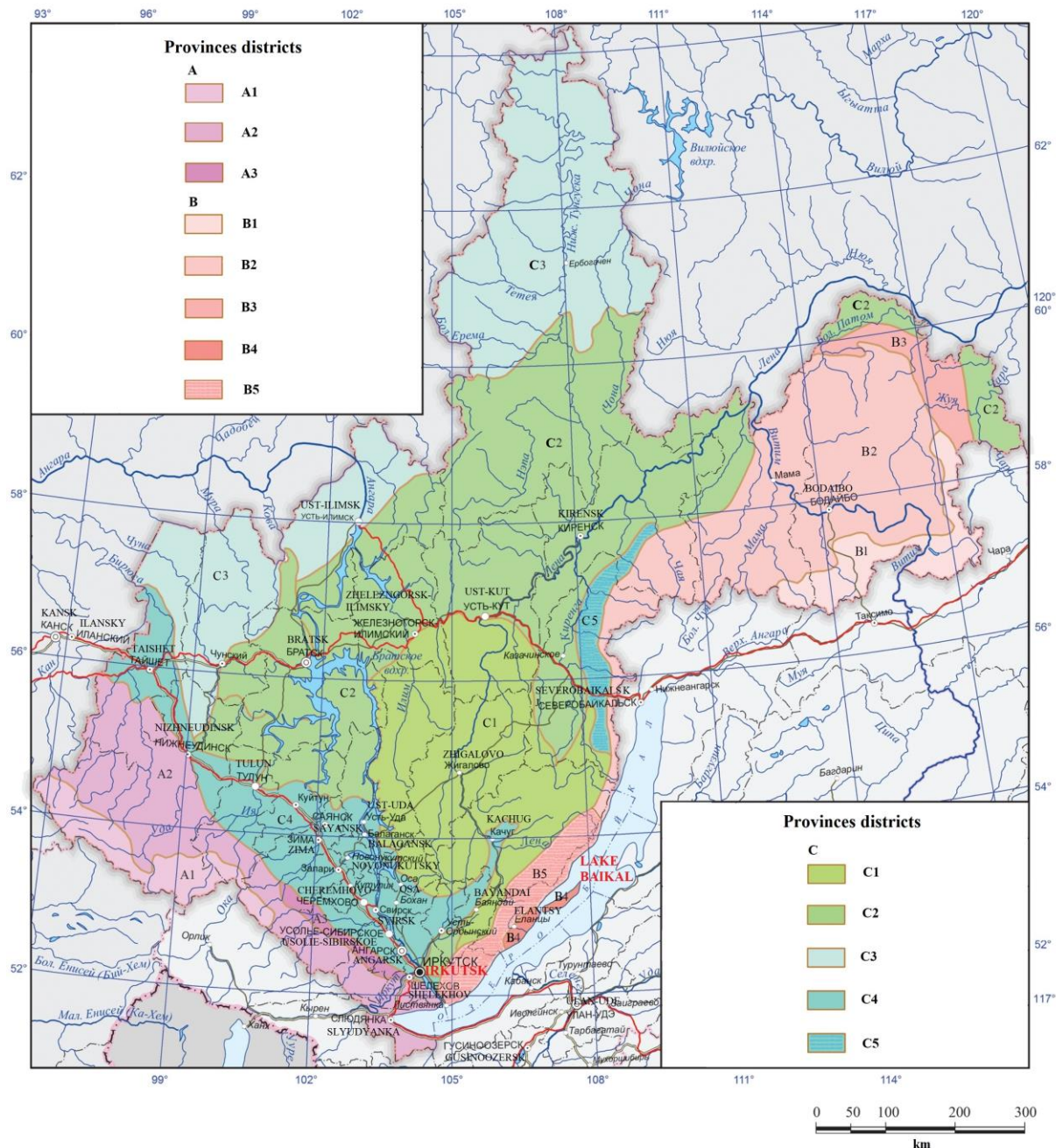


Figure 1. Agroecological zoning of soils of the Irkutsk region.

Note: Provinces: A - East Sayan and Khamar-Daban; B - Pribaikalye and Stanovoy Highlands; C - Irkutsk amphitheater. Districts: A1 - Highland East Sayan, A2 - Middle mountain South-Western Baikal region, A3 - Low mountain and foothill; B1 - Highland Baikal and Delyun-Uransky, B2 - Mid-mountain district of the Stanovoy Highlands, B3 - Patomsky low mountain, B4 - Foothill and low mountain district of the islands of Olkhon and Priolkhonya, B5 - Middle and low mountain Primorsky; C1 - Leno-Angarsk medium-altitude plateaus, C2 - Angarsk and Prilensky medium-altitude plateaus, C3 - Ergobachensky and Biryusinsky low plateaus, C4 - Irkutsk-Cheremkhovsky and Kansko-Rybinsk plain, C5 - Pre-Baikal plain.

Created soil maps for areas of research. For example on the slide: Osinsky district soil map. Heavy Metal and Essential Plant Nutrition Maps for Osinsky district too [18]. Soil maps have also been drawn up for other areas of the Irkutsk region [19]. Various maps of soil pollution in different key areas have been compiled, for example, for such cities as Irkutsk and Ulan-Ude in Russia, Ulan Bator in Mongolia [20].

Maps of soil degradation and pollution were created: Baikal Lake basin, Baikal natural territory [21]. The map shows the natural factors of the potential hazard of soil pollution. Areas of actual soil contamination and industrial sources are marked. The symbols show the lands of the mining industry. The degree of soil degradation of agricultural lands is shown. We were created Soil and ecological zoning of Lake Baikal basin [9].

Soil groups with relatively similar bioclimatic factors (M. Budyko's dryness index, the sum of biologically active temperatures, type and productivity of vegetation) were combined into soil-ecological provinces, which are dominant in soil forming. Soils with the similar lithology and geomorphology features (rocks, relief) were grouped into districts.

We created a map of agroecological zoning of soils of the Irkutsk region (Figure 1).

A fragment of the map legend is shown (Table 1). The legend of the map shows: soils, soil-forming rocks, vegetation and their productivity, height above sea level, dryness index, the number of "active" temperatures, a period with a negative soil temperature, the duration of the warm period, the spread of permafrost, suitability for agricultural use. Suitable and unsuitable districts for their use in agriculture have been identified. Various types of business activities are recommended.

Table 1. Map legend fragment "Agroecological zoning of soils of the Irkutsk region".

Provinces	Districts	№	Soils	Breeds	Vegetation	H*	K*	∑more 10°C*	Months*	Days*	P*	PV*	Suitability*
East Sayan and Khamar-Daban	Highland East Sayan	A1	Regosol, Leptosol, Gleysols, Entic Podzols	Crystalline shales, limestones, dolomites, granitoids, basalts, slag basalts	Moss-lichen and shrub tundra, thickets of cedar dwarf, fragments of larch shrub woodlands and shrubs, rocky placers.	1175-2875	0,5-1,0	600-1000	7-8	50-60	Solidup, to100-300 M	20-40	Unsuitable
Irkutsk amphitheater	Irkutsk-Cheremkhovskiy and Kanskoye-Rybinsky plain	B4	Folic Retisols, Umbrisols, Luvisols, Phaeozems, Chernozem, Histosols	Siltstones, mudstones, carbonate-free sandstones, red-colored carbonate-silicate deposits, limestones	Pine and larch-pine forbs, steppe forests, fragments of islands of meadow-steppe vegetation	400-728	1,5-2,5	1400-1800	5-6	90-104	Areabsent	40-80	Mostlyusable

Note: *– H - height above sea level; K– Dryness index as per [22] sum of air temperature more than 100 (∑t) [23]; Months - period with negative soil temperature; Days - Duration of warm period with air temperature more than 100C; P - Permafrost distribution; PV – Productivity of vegetation by [12].

In most of the vast territory of the region (more than 70%), forestry is recommended under taiga forest vegetation, with the exception of specially protected natural areas, which make up a small area. The most optimal conditions for growing early ripening crops are the Irkutsk-Cheremkhovskiy and Kanskoye-Rybinsky lowland district, which occupies 11% of the region's territory, where productive chernozems, umbrisols, fluvisols have formed under meadow-steppe and steppe forest vegetation, covering 33% of the district's area or 3.7% of the Irkutsk region.

We were completed a land use map of the most developed part in agriculture of the Irkutsk region (Irkutsk-Cheremkhov plain and adjacent territories) (Figure 2), and use maps of certain areas of the Irkutsk region have been compiled.

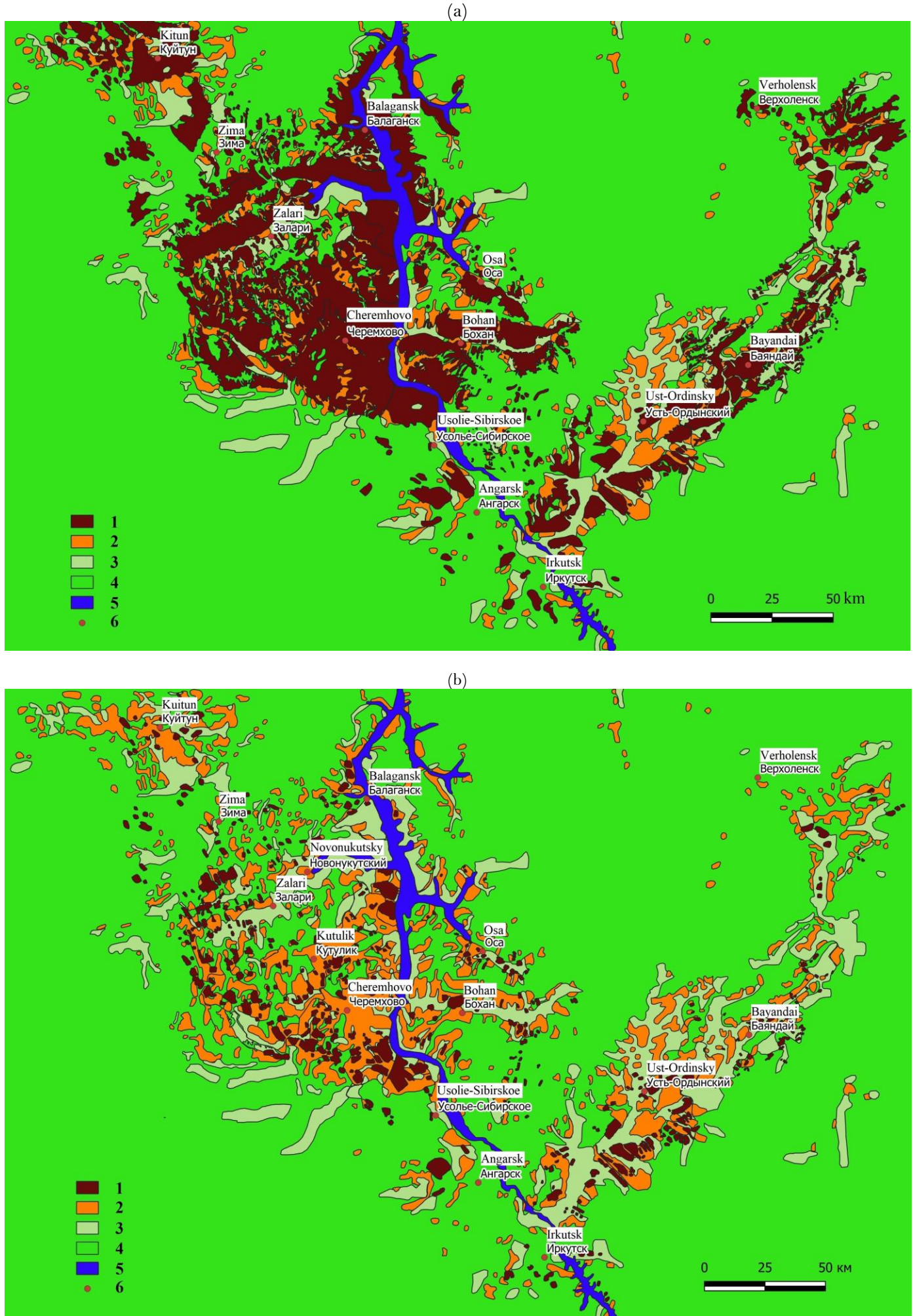


Figure 2. Agricultural land areas of the most developed part of the Irkutsk region in 1988 (a), 2023 (b).

Note: 1 - Arable land, 2 - Deposit, 3 - Pasture, 4 - Forest, 5 - Rivers, 6 - Settlement.

The area of agricultural land in the region is 4% and, in some areas, up to 48%, of which more than half is not used in agriculture, and in remote areas more than 70%, abandoned since the 1990s. After the "restructuring" of the government system. Some of the abandoned land is under pasture.

The authors proposed a scheme for assessing the level of soil fertility (Table 2) [24].

Table 2. Scale for assessing the state of soils by indicators: pH_{H2O}, density, content of physical clay, agronomically valuable aggregates, humus, nitrates, mobile phosphorus and potassium.

pH _{H2O} pH _{KCl}	NL	P ₂ O ₅ , mg/kg	K ₂ O, mg/kg	NO ₃ , mg/kg	Humus, %	S, %	C	PC, %	D g/cm ³	SF	ΣP
<4.5 <4.0	Strong	<25	<100	<4, >130	<1	<20	Verylow	>40	>1.5	Bad1	<16
4.6-5.5 4.1-4.5		26-50	101-200	4-8	2.1-3.0	20-40	Low	<10	1.3-1.5	Unsatisfactor2	16-20
5.1-5.5 4.6-5.0	Average	51-100	201-300	8-15	3.1-5.0	40-60	Average	10-20	1.2-1.3	Satisfactory3	20-24
5.6-6.0 5.1-5.5	Weak	101-150	301-400	15-20	5.1-8.0	60-80	Above the average	20-30	1.2-1.1	Good4	24-30
>6.1 >5.6	Notrequ ired	>150	>400	20-130	>8.0	>80	High	30-40	<1,1	Excellent5	>30

Note: NL - need for liming; S - content of agronomically valuable structure (%); C - content of phosphorus, potassium, nitrates, humus and agronomically valuable aggregates; PC - content of physical clay (particles < 0.01 mm); D - density was assessed on a scale [25-27]; SF - assessment of soil fertility according to the above indicators. P - score; Σ P - sum of points.

The assessment of the soil condition was carried out according to the author's methodology in the form of generalizing data and a system of indices of individual indicators (environmental reaction, density, content of the fraction of "physical clay", humus, nitrates, agronomically valuable aggregates, mobile phosphorus and potassium). Table fragment «Some soil indicators of the main key sites» (Table 3).

It has been established that the soils of arable land and deposits of remote areas (Osinsky, Bokhansky, etc.) have the highest values of positive quantitative characteristics. According to agrochemical and agrophysical indicators, they belong to prosperous, the state of their fertility is assessed as "excellent", "good" and "satisfactory". The worst indicators of fertility are the soils of the Irkutsk region. The soils of the most developed part of the region (Cheremkhovsky, Bayandaevsky and Ekhirit-Bulagatsky districts) are assessed mainly as "good" and "satisfactory" (sometimes "excellent", rarely "non-renewable") according to the main agrophysical and agrochemical indicators. According to such agrophysical indicators as the content of a fraction of physical clay, and sometimes agronomically valuable aggregates and soil density of the most developed areas, they are mainly "unsatisfactory" and "bad" for their use for growing agricultural crops, which is mainly due to natural factors (rocks). The soils of the arable land used near large settlements of almost all regions need the introduction of mineral potash and phosphorus fertilizers, less often nitrogen (mineral or organic). There is a reserve of agricultural land for use in the form of abandoned land, but sometimes they need agrochemical, agrotechnical and other activities.

In colder conditions of low plateaus (Erbogachensky and Biryusinsky okrug, covering about 20% of the region), it is possible to grow early ripening crops of vegetables and greens in greenhouses (closed ground). In the driest and moderately cold conditions (foothill and low-mountain districts of Olkhon Island and Priolkhonya, which make up less than 1% of the area) with rocky soils of low thickness, pasture farming using natural pastures is recommended. About 25% of the land in the high- and mid-mountain areas of the region is not recommended for use either in agriculture or in forestry. Lands on which endemic and relict vegetation species grow must be included in protected areas. In some cases, the territory of protected areas can be expanded, for example, on the southern coast of Lake Baikal.

Table 3. Some soil indicators of the main key sites of the Irkutsk, Chermkhovsky, Bokhansky, Osinsky, Bayandaevsky and Ekhirit-Bulagatsky districts of the Irkutsk region, assessment of their fertility level (Fragment).

Location	Vegetation, use	Soils	Porizon	pH H ₂ O	Humus, %	NH ₄ mg/kg	NO ₃ ⁻ m g/kg	P ₂ O ₅ mg/kg	K ₂ O mg/kg	PC %	D g/cm ³	S %	ΣP	SF
Irkutskregion														
Near the village of Novolisikha	Arable land	Agricultural (Anthrosol)	A	$\frac{5.8}{4}$	$\frac{0.6}{1}$	4.75	$\frac{16.6}{4}$	$\frac{3}{1}$	$\frac{22}{1}$	$\frac{24}{4}$	$\frac{1.35}{2}$	$\frac{24.7}{2}$	19	unsatisfactory
Chermkhovsky region														
1 km north of Kasyanovka village	Background area, grass with sedge steppe meadow	Chernozems	AU	$\frac{6.9}{5}$	$\frac{12.2}{5}$	30.1	$\frac{2.5}{3}$	$\frac{160}{5}$	$\frac{498}{5}$	$\frac{43}{1}$	$\frac{0.61}{5}$	$\frac{68}{2}$	26	excellent
2.5 km northwest of the village of Petrovka	Land under steam, surepka, weedy vegetation	Agricultural umbric	PU	$\frac{6.9}{5}$	$\frac{3.7}{3}$	7.3	$\frac{11.7}{3}$	$\frac{35}{2}$	$\frac{110}{2}$	$\frac{57}{1}$	$\frac{1.56}{1}$	$\frac{60}{3}$	15	unsatisfactory
Bayandaevsky and Ekhirit-Bulagatsky region														
2 km northwest of Ust-Orda village	Arableland, rye	Agricultural chernozems	PU	$\frac{7.2}{5}$	$\frac{5.4}{4}$	5.34	$\frac{1.80}{1}$	$\frac{39}{2}$	$\frac{175}{2}$	$\frac{41}{1}$	$\frac{1.48}{2}$	$\frac{24.4}{2}$	14	unsatisfactory
1.2 km northwest of the village of Pokrovka	Land under steam, oats with weedy vegetation	Agricultural haplic fluvisols	PU	$\frac{8.2}{5}$	$\frac{19.0}{5}$	12.22	$\frac{17.20}{4}$	$\frac{39}{2}$	$\frac{408}{5}$	$\frac{55}{1}$	$\frac{1.21}{3}$	$\frac{43.0}{3}$	23	good
Bokhansky, Osinsky region														
Chernihiv village	Arable land, weedy vegetation	Agricultural chernozems	PU	$\frac{7.9}{5}$	$\frac{5.4}{4}$	11.3	$\frac{8.1}{3}$	$\frac{49}{2}$	$\frac{200}{3}$	$\frac{21}{4}$	$\frac{1.14}{2}$	$\frac{71}{4}$	27	good
Zakharovskaya village	Abandoned land more than 30 years ago, pasture, grass meadow	Agricultural umbric	PU	$\frac{7.2}{5}$	$\frac{7.7}{4}$	13.8	$\frac{8.7}{3}$	$\frac{325}{5}$	$\frac{950}{5}$	$\frac{39}{5}$	$\frac{0.90}{5}$	$\frac{71}{4}$	36	excellent

Note: PC - content of physical clay (Particles < 0.01 mm); D - Density was assessed on a scale; S - Content of agronomically valuable structure (%); Σ P - Sum of points; SF - Assessment of soil fertility according to the above indicators. The numerator shows the values of the indicator, the denominator - points.

3. Conclusion

Taking into account the new soil classification [27] soil and agroecological zoning of the Irkutsk region was carried out. Agroecological zoning of soils took into account the entire set of natural and climatic conditions.

In most of the vast territory of the region (more than 50%), forestry is recommended under taiga forest vegetation, with the exception of protected areas, which make up a small area. The most optimal conditions for growing early ripening crops are the Irkutsk-Cheremkhovskiy and Kanskoye-Rybinsk lowland district, which occupies 11% of the region's territory, where productive chernozems, umbrisols and fluvisols have formed under meadow-steppe and steppe forest vegetation, covering 33% of the district's area or 3.7% of the Irkutsk region. Almost all lands suitable for agriculture in Soviet times were plowed. However, at this time 45% of the agricultural land of the region is abandoned, and in remote areas more than 70%. According to agrochemical indicators, the soils of most of the abandoned lands are in good and satisfactory condition and can be returned to agricultural circulation.

References

- [1] Z. A. Antonova, *Soil and ecological zoning of the Ulyanovsk region: Abstract of the dissertation of the candidate of biological sciences: 02/03/08, 02/03/13*. Ulyanovsk: Ulyanovsk State University, 2011.
- [2] G. V. Dobrovolsky, N. N. Rozov, M. N. Stroganov, and S. Y. Trofimov, *Soil and ecological zoning of the world (M 1:60 million). Atlas "Man and nature"*. Moscow-Vienna: RAS RF, Ch II, 1999, pp. 100-101.
- [3] G. V. G. V. Dobrovolsky *et al.*, *Soil and ecological zoning of the East European plain (M 1:2500000)*. Moscow: GUGK, 1997.
- [4] N. Rozov and M. Stroganov, *Soil cover of the world (soil-bioclimatic regions of the world and their agroecological characteristics)*. Moscow: Publishing House of Moscow State University, 1979.
- [5] I. S. Urusevskaya, I. O. Alyabina, and V. P. Vinyukova, *Soil and ecological zoning map of the Russian Federation* [map]; scientific. ed.: *Academy RAS G.V. Dobrovolsky, I.S. Urusevskaya. Scale: 1: 1:2500.000*. Moscow: Moscow State University, 2013.
- [6] T. Ananko, M. Gerasimova, and D. Konyushkov, "The soils of mountainous territories (in the Russian)," *Dokuchaev Soil Bulletin*, no. 92, pp. 122-146, 2018. <https://doi.org/10.19047/0136-1694-2018-92-122-146>
- [7] A. A. Shpedt *et al.*, "Soil and environmental assessment of agricultural lands of the Krasnoyarsk Territory, Irkutsk Region, Republic of Buryatia," *Farming*, no. 1, pp. 9-13, 2022. <https://doi.org/10.24412/0044-3913-2022-1-9-13>
- [8] L. L. Ubugunov, "Soil resources of the Republic of Buryatia, their agroecological state and rational use," *Bulletin of the Buryat State Agricultural Academy Named after V.R. Filippova*, no. 2, pp. 35-46, 2020. <https://doi.org/10.34655/bgsha.2020.59.2.005>
- [9] L. L. Ubugunov, I. A. Belozertseva, V. I. Ubugunova, A. A. Sorokovoy, C. Dorzhgotov, and M. Dugarzhav, *Soil and ecological zoning of the Lake Basin. Baikal*. Irkutsk: IG SB RAS, 2021.
- [10] D. N. Lopatina and I. A. Belozertseva, "Agricultural lands of the wasp river basin: Use and level of fertility," *Regional Geosystems*, no. 3, pp. 392-405, 2023. <https://doi.org/10.52575/2712-7443-2023-47-3-392-405>
- [11] V. Seryshev and V. Somedun, "Agrolandscape zoning of the Irkutsk region," *Geography and Natural Resources*, no. 2, pp. 86-94, 2009.
- [12] Atlas, *Irkutsk region: Ecological conditions of development. M*. Irkutsk: IG SB RAS, 2004.
- [13] L. L. Kalep, "To the problem of greening the agricultural land use of the Baikal natural territory," *Geography and Natural Resources*, no. 2, pp. 41-44, 2003.
- [14] A. V. Martynov, *Soil cover, in nature management and environmental protection within the baikal drainage Basin, V.V. Vorobyev and A.V. Martynov, Eds*. Novosibirsk: Nauka, 1990.
- [15] V. A. Kuzmin, *Soil and geographical zoning, Atlas of the Irkutsk Region*. Irkutsk-Moscow: IG SB RAS, 2004, p. 41.
- [16] I. A. Belozertseva *et al.*, "Map of the "Soils of the Lake Baikal basin". Scale 1 : 2500 000. Irkutsk: IG SB RAS," Retrieved: https://elibrary.ru/download/elibrary_24268326_12597939.jpg. 2015.
- [17] I. A. Belozertseva *et al.*, "Soils. Ecological atlas of the Baikal region. 2017. Electronic resource of the geoportal: Map No. 57," Retrieved: <http://atlas.isc.irk.ru>. 2017.
- [18] D. Lopatina and I. Belozertseva, "Soil and ecological Zoning of the Osa River Basin territory (The top Angara Region)," *The Bulletin of Irkutsk State University Geoarchaeology, Ethnology, and Anthropology Series No. 22*, 2017.
- [19] I. A. Belozertseva and V. N. Bogdanov, "Soils of the Bokhansky district of the Irkutsk region. Map. Irkutsk: V.B. Sochava Institute of Geography SB RAS, Scale: 1:100000," Retrieved: https://elibrary.ru/download/elibrary_27561954_79426400.pdf. 2008.
- [20] I. Belozertseva, I. Vorobyeva, A. Sorokovoi, and D. Lopatina, "Soil pollution in urbanized centers of Baikal region," *Eurasian Soil Science*, vol. 55, no. 1, pp. 102-114, 2022. <https://doi.org/10.1134/s1064229322010033>
- [21] I. A. Belozertseva, E. G. Nechaeva, and A. A. Sorokovoy, "Soil degradation and pollution of the Baikal natural territory. Map. Irkutsk: V.B. Sochava Institute of Geography SB RAS, Scale: 1:5000000," Retrieved: https://elibrary.ru/download/elibrary_25970923_45780770.pdf. [Accessed 2009.
- [22] M. I. Budyko, "Climate and life, Leningrad, Publishing House: Hydrometeoizdat, English ed. edited by David H. Miller," Retrieved: <https://archive.org/details/climatelife00mibu>. 1974.
- [23] A. A. Sorokovoy, "The sum of temperatures above 100 C. Ecological atlas of the Baikal region. 2017," Geoportal Electronic Resource: Map No. 46, 2017.
- [24] I. A. Belozertseva, D. N. Lopatina, N. A. Zvereva, A. A. Cherkashina, and N. A. Skosyrsky, "Soils of the most fertile lands of the Upper Angara region," *Agrarian Russia*, no. 8, pp. 24-31, 2024. <https://doi.org/10.30906/1999-5636-2024-8-24-31>
- [25] G. A. Vorobyova and N. D. Kiseleva, *Morphoanalytic diagnostics of soils. Simulation training on the interpretation of soil research results*. Irkutsk: IGU, 2023.
- [26] A. Y. Cheremisinov, A. Cheremisinov, and S. Plotnikov, "Compaction of irrigated soils from the impact of agricultural machines," *Forestry Journal*, vol. 4, pp. 156-158, 2013. <https://doi.org/10.12737/2198>
- [27] M. V. Butyrin, *Agrochemical characteristics of agricultural land soils and recommendations for the use of fertilizers in the Ust-Altan municipal district of the Osinsky district of the Irkutsk region*. Irkutsk: FSBI TsAS Irkutsk, 2009, p. 27.