Biological and ecological agrolandscape patterns of the South Eastern Siberia

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Abstract. The article presents the results of agro-landscape and ecological zoning of the East Siberian natural and economic region. Zoning was performed at the Federal Williams Research Center of Forage Production & Agroecology on the basis of the methodology developed by the authors. The East Siberian natural and economic region includes the republics of Buryatia, Tyva, Khakassia, Zabaykalsky and Krasnoyarsk territories, and Irkutsk region. The total area of the territory of Eastern Siberia is 415504.2 thousand hectares. Agricultural land occupies about 6% of the area of the East Siberian natural and economic district, of which 2% is arable land, 4% is hay and pasture. On the territory of Eastern Siberia, which occupies about a quarter of the territory of Russia, there are 10 lowland zones and subzones (Arctic, Arctic Tundra, Tundra and Forest Tundra, North Taiga, Middle Taiga, South Taiga, Larch Forest, Forest-Steppe, Steppe and Dry-Steppe) and Mountain territories. There are 22 lowland and 12 mountain provinces, 49 lowland and 42 mountain districts within the zones. Agro-landscares of Eastern Siberia are formed mainly in the South of the region in Forest-Steppe and Leaf-Forest, Steppe and Dry-Steppe zones, which are developed in agriculture. There are the main areas of agriculture.
tion & Agroecology on the basis of the metodics developed by the authors. The work used materials of agroclimatic zoning, natural-agricultural zoning, landscape-ecological zoning, soil-ecological zoning, biogeochemical zoning. Landscape maps, ecological maps, ecological-geographical maps, soil and geobotanical maps were also used. The state land accounting data, stock materials, statistics of the Ministry of Agriculture of the Russian Federation and Rosstat, electronic resources are also used [7–22].

The East Siberian Natural and Economic Region, whose area is 415504.2 thousand hectares, includes the Republics of Buryatia, Tuva, Khakassia, Trans-Baikal and Krasnoyarsk Territories, Irkutsk Region.

According to data for 01.01.2019, [21] agricultural land occupies about 6% of the area of the East Siberian Natural and Economic Region, of which 2% is arable land, 4% is hayfields and pastures.

On the territory of Eastern Siberia, which occupies about a quarter of the territory of Russia, 10 flat zones and subzones are allocated (Arctic, Arctic Tundra, Tundra and Forest Tundra, North Taiga, Middle Taiga, South Taiga, Leaf Forest, Forest Steppe, Steppe and Dry-Steppe) and Mountain Territories. Within their limits, 22 lowland and 12 mountain provinces, 49 lowland and 42 mountain districts are allocated.

Here there are a wide variety of East Siberian landscapes (Arctic, Arktotundra, Tundra and Forest-Tundra, North Taezhnye, Middle Taezhnye, South Taezhnye, Leaf Forest, Forest-Steppe, Steppe and Dry Steppe, Mountain). The East Siberian North and Mid-West landscapes prevail. Relief – crossed. Rocky, often low-power soils are formed on crushed eluvium of indigenous rocks.

In Eastern Siberia, about half of all forest resources of Russia are concentrated, 70% of the reserves of stone and brown coal, the richest ore deposits with iron, copper-nickel ores, polymetals, and bauxites. A significant amount of Russian oil is produced here, deposits of gold, diamonds and other resources are located [22].

Agrolandscapes of Eastern Siberia are formed mainly in the south of the region in Forest-Steppe and Leaf-Forest, Steppe and Dry-Steppe zones, which are developed in agriculture. The most intensive agricultural activity is carried out in the developed and industrially developed strip along the Trans-Siberian Railway. Here, in the Forest-Steppe and Leaf Forest, Steppe and Dry-Steppe agrolandscapes of the south of Eastern Siberia, there are the main areas of agriculture.

Heat supply and moisture availability in Forest-Steppe and Leaf Forest, Steppe and Dry-Steppe zones of these areas is insufficient for the growth and development of many crops. The duration of the growing period from \( t > 10 \, ^\circ\text{C} \) is 100–120 days, from \( t > 5 \, ^\circ\text{C} \) – 120–170 days. The frost-free period is 100–120 days. The sum of temperatures with \( t > 10 \, ^\circ\text{C} \) is 1450–2300 \( ^\circ\text{C} \), with \( t > 5 \, ^\circ\text{C} \) – 1200–2200 \( ^\circ\text{C} \).

The average rainfall is 340–480 mm, for the period from \( t > 5 \, ^\circ\text{C} \) – 100–300 mm. Humidification coefficient – 0.35–1.0. Probability of dry years 20–30% or more.

In the mountains, the duration of the growing period from \( t > 10 \, ^\circ\text{C} \) is 60–90 days, from \( t > 5 \, ^\circ\text{C} \) – 90–150 days. The sums of temperatures from \( t > 10 \, ^\circ\text{C} \) are 300–2000 \( ^\circ\text{C} \), from \( t > 5 \, ^\circ\text{C} \) – 1200–2200 \( ^\circ\text{C} \). The average rainfall in the mountains is 400–800 mm, for the period from \( t > 5 \, ^\circ\text{C} \) – 100–500 mm. Humidification coefficient – 0.77–1.33.

The predominant types of relief in the agricultural landscapes of the South of Eastern Siberia are flat, undulating and weary plains, foothill plains. The predominant types of soils are gray forest, leached chernozems, common and southern chernozems, dark chestnut and chestnut saltwater. The granulometric composition of soils is mainly loamy. The predominant types of water regime are periodically washing, non-washing, non-washing arid.

The prevailing vegetation types in agrolandscapes of the South of Eastern Siberia are the small-leaved grass forest, bluegrass, wheat-grass, fescue meadows, sheep fescue, bluegrass, stepped meadows, sheep fescue, bluegrass, austrian wormwood forb-grass meadow steppes, sheep fescue, bluegrass, austrian wormwood, sedge steppes, wormwood, forb and puccinellia halophytes meadows, sheep fescue, feather-grass, austrian wormwood, cold wormwood, sedge dry steppes.
The peculiarities of natural conditions determine the selection of crops. In Eastern Siberia, little snow falls, and it is difficult to breed winter crops. Therefore, almost the entire sown area is occupied by spring crops. Up to 70–75% of crops are grain crops, mainly spring wheat. The growing season is short, and the composition of crops is dominated by fast-growing varieties, and closer to the north by those that withstand freezing that occur during the summer months.

Animal husbandry plays a large role north and south of the developed agricultural zone. Animal husbandry is especially developed in Transbaikalia and in the basins of Khakassia and Tuva lying between the mountains. Mainly meat, dairy and meat animal husbandry, tonkorun and semitonkorun sheep breeding are developed, especially in Buryatia and the Trans-Baikal Territory. In Buryatia, along with cattle breeding, herd horse breeding is carried out. The extreme north of Eastern Siberia is a zone of well-developed reindeer herding. In addition, there are separate centers of reindeer husbandry and many to the south - in mountainous areas.

The fodder lands of Eastern Siberia are natural fodder lands (NFL) (16.3 million hectares) and deer pastures (56.6 million hectares). 43% of NFL and 59% of deer pastures are located in flat territories, 57% of NFL and 41% of deer pastures in mountain territories. The area of pastures in flat territories is 3.1, and in mountain areas – 4.3 times more than the area of hayfields (table 1).

| Zone Name Zone area | NFL in total | including hayfields | including pastures | Deer pastures |
|---------------------|-------------|---------------------|--------------------|--------------|
| Tundra and Forest Tundra | 38610 | – | – | 24079 |
| North Taiga | 29219 | – | – | 9541 |
| Middle Taiga | 47603 | 99 | 50 | 49 |
| South Taiga | 41406 | 429 | 259 | 170 |
| Leaf Forest | 5622 | 332 | 164 | 168 |
| Forest Steppe | 8775 | 952 | 293 | 659 |
| Steppe | 10798 | 3732 | 833 | 2899 |
| Dry-Steppe | 4518 | 1946 | 245 | 1701 |
| Total plains | 186551 | 7488 | 1843 | 5645 |

On the plains, the largest areas of NFL are located in Steppe (3.6 million hectares) and in Dry-Steppe (1.9 million hectares) zones. In the mountainous territories, the largest areas of the NFL are in the Forest-Steppe Transbaikal (3.2 million hectares) and Steppe South Sayan (2.2 million hectares) mountain provinces (table 2).

Deer pastures in the lowland territories are located in the Tundra and Forest Tundra zone (24.1 million hectares) and in the North Taiga zone (9.5 million hectares). In the mountainous territories, about 70% of the area of deer pastures are located in the North-Taiga Anabar-Putoranskaya mountain province (15.7 million hectares), 23% are located in the Middle-Taiga Prieniseiskaya (2.7 million hectares).
and in the South-Taiga Baikalskaya (2.8 million hectares) mountain provinces. They are also found in the more southern mountain provinces - the South Taiga East Sayanskaya (144 thousand hectares), the Forest-Steppe Salair-Kuznetsk-Sayanskaya (1.5 million hectares) and in the Steppe South Sayanskaya (77 thousand hectares) mountain provinces.

### Table 2. Area of fodder lands in the mountainous provinces of the East Siberian Natural and Economic Region, thousand hectares.

| Mountain province name          | Mountain province area | NFL in total including hayfields and pastures | Deer pastures |
|--------------------------------|------------------------|---------------------------------------------|--------------|
| North Taiga – Anabar-Putoranskaya | 51052                  | 0 0                                         | 15739        |
| Middle Taiga – Priyeni-seyskaya | 23585                  | 0 0                                         | 2664        |
| South Taiga – Baikalskaya      | 48271                  | 697 201                                     | 2854        |
| South Taiga – East-Sayanskaya   | 17023                  | 632 177                                     | 144        |
| South Taiga – Leno-Angarsky     | 12452                  | 283 91                                      | 0        |
| Forest Steppe – Salairo-Kuznetsk-Sayanskaya | 13489     | 974 197                                     | 1538        |
| Forest Steppe – Altaiskaya      | 469                    | 220 1                                       | 219        |
| Forest Steppe – Trans-baikalskaya | 28353                | 3367 946                                    | 0        |
| Steppe – South-Sayanskaya       | 10391                  | 2320 65                                     | 77        |
| Steppe – South-Altaiskaya       | 453                    | 293 0                                       | 0        |
| **Total mountain provinces**    | **205538**             | **8787 1678**                               | **7109 23016** |
| **Plains + Mountain Provinces** | **392089**             | **16275 3521**                              | **12754 56636** |

The characteristics of the fodder lands of Eastern Siberia include the following indicators: the distribution of the fodder lands according to the administrative and agro-landscape-ecological division of the territory, the structure of the fodder lands, the assessment of the state of the fodder lands according to the following indicators: erodibility, salinity, humidity, swampiness, rockiness, acidity of soils, granulometric composition of soils, assessment of land by grades.

The typological composition of NFL includes 17 classes, including 14 in the flat territories and 16 in the mountain provinces. In Forest Zones, the predominant class of NFL is Plain and prone dry hayfields and pastures, which occupies 81-87% of the area of NFL. In the Forest-Steppe Zone, 62% of NFL belong to the class Flat meadow-steppe, in the Steppe and Dry-Steppe zones 70–81% of NFL belong to the class (Plain steppe and dry-steppe hayfields and pastures. In the mountainous provinces of the southeast of the East Siberian Region, the class of NFL Mountain meadows and meadow-steppe prevails, occupying 76–82% of the NFL area. In the south-western provinces, NFL are represented by classes Mountain steppe and Highland meadows, steppe and tundra.
The typological composition of deer pastures is represented by 11 classes, including 10 classes in the lowland territories, and 4 in the mountain provinces. In the Tundra zone, more than 80% of deer pastures belong to the class Tundra plains, in the North Taiga zone about 40% are occupied by classes Plain and prone deer pastures of the North Taiga zone. In mountain provinces located within Forest zones, 94–100% of deer pastures belong to the classes Mountain tundra and Mountain redwood. In the mountain provinces of the Forest-steppe and Steppe zones, 75–85% of deer pastures belong to the class Forests of the mountain Taiga belt.

Analysis of the state of NFL in Eastern Siberia gives an idea of the uneven development of negative processes. Erosion- and deflation-dangerous pastures are located mainly in the Republic of Tuva (45 and 64%), deflation-dangerous hayfields – in the Republic of Khakassia (36%). Saline soils of hayfields are found mainly in the Republic of Buryatia (30%) and the Republic of Tuva (49%). Overgrown hayfields – 23% each in the Republic of Khakassia and in the Irkutsk region. 26–40% of rocky pastures are located in the Republics of Buryatia, Tuva, Khakassia and in the Trans-Baikal Territory. Acidic soils on hayfields (49%) and pastures (26%) are found mainly in the Krasnoyarsk Territory.

A database on East Siberian Natural and Economic Region fodder lands has been developed, which includes the typological composition of NFL and deer pastures, the structure of NFL and deer pastures for all 136 zoning units of Eastern Siberia allocated. The qualitative state of NFL is assessed by 7 indicators, the most common negative processes are identified. The data obtained make it possible to ensure a targeted approach to the rational use and improvement of the fodder lands of Eastern Siberia.

The database is the necessary information base for environmental management in agriculture, the design of highly productive and sustainable fodder agroecosystems and agrolandscapes.

The topic and results of research are relevant, in demand and are aimed at the priorities of scientific and technological development, established in the Strategy for Scientific and Technological Development of the Russian Federation, obtaining the fundamental knowledge necessary for sustainable development, ensuring rational use and environmental management, environmental and food independence of the country.

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