Geoecological assessment of the state of postagrogenic lands of the Moscow village soviet council of the Republic of Khakassia on the basis of remote sensing data

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Abstract. Currently, the consequences which take place in Khakassia expansion of tree-shrub vegetation on fallow lands have not been properly assessed neither from an ecological nor economic point of view. Based on the analysis of the agricultural map scale 1: 100 000 decoding images Landsat 4-5, 7, 8 and Sentinel 1, and 2, as well as subsatellite ground researches were carried out the identification, the description and assessment of the qualitative state of postagrogenic lands of Khakassia exposed to the processes of overgrowth of tree-shrub vegetation. As an example, this article analyzes the processes of overgrowth of agricultural land on the example of the territory of the Moscow village council of Ust-Abakan district. A geoinformation project of spatial distribution of postagrogenic lands within the Moscow village council of Ust-Abakan district of Khakassia was developed. The results of the research showed that in the studied area in the structure of agricultural land 67204 hectares of land belongs to the fallows located at different stages of recovery of which 77 % exposed to overgrowth processes. The obtained data indicate the need for the formation of management decisions in the field of land use.

Formation and maintenance of optimal land use structure is an urgent problem for many regions of Russia today. The processes of land privatization, which occurred in the 90s of XX century, led to the emergence of «ownerless» land plots that are not used for agriculture. Quite often, the owners of agricultural land do not comply with the requirements of legislation on the rational use of land. Therefore, the regional authorities strengthened the state land supervision, in order to identify idle agricultural land.

Postagrogenic lands are a rather heterogeneous group of lands that differ in floristic composition, species saturation, horizontal and vertical structures, dominant species, productivity, economic value and in soil characteristics (structure, water regime, soil fertility, etc.). Some of these lands with low-power horizon as a result of ill-conceived plowing were exposed to wind erosion. Now they belong to unproductive soils and therefore can't be used as arable land. All this leads to the need to make a decision on the further use of postagrogenic lands in agriculture (for example as pastures and hayfields) or

to exclude their agricultural turnover for other purposes (creation of forest plantations, allocation for industrial and residential areas, etc.). Otherwise, there is a great risk of deterioration of their quality and the development of negative processes. Overgrowth of fallow lands with tree-shrub vegetation is noted as one of the negative factors. From the forestry point of view – this process is natural and corresponds to the succession development.

Quite a lot of works of Russian and foreign researchers are devoted to the study of tree invasion on old arable lands. The study of the space-time evolution of postagrogenic lands and assessment of their overgrowth, were carried out by many authors, but mainly in relation to the forest zone of the European part of Russia, where abandoned agricultural lands are overgrown with quite valuable small-leaved and coniferous tree-shrub species. Geobotanists and foresters described the stages of succession dynamics and the composition and productivity of the emerging forest plantations [1-4]. In the steppe and forest-steppe zones of Siberia, invasions of tree species (*Populus nigra L., P. laurifolia Ldb., Ulmus pumila L., Betula pendula Roth, Larix sibirica Ledeb*) are described on postagrogenic lands. Most stands formed naturally on former agricultural land are characterized by high productivity and practically do not differ from plantations created by artificial means. However, in some regions of Russia, including Khakassia, the fallows are overgrown with low-value tree Elm Siberian (*Ulmus pumila L.)* [5-6]. There are no natural elm community on the territory of Khakassia and South of Krasnoyarsk region. During the renewal of *U. pumila* on postagrogenic lands the source of seeds act as protective forest belts. Elm Siberian has always been considered a promising breed in the creation of protective forest strips. It is drought-resistant, exists on dry soils, withstands significant salinization of soils, well resumed self-seeding [7].

Cause of the best microclimate (shade for grazed animals) and more favorable conditions for the growth of various types of grasses and the emergence of ecological niches, such as habitats of steppe animals, birds and useful entomofauna are formed, a number of authors believe that the agroforestry ecosystems formed in such cases significantly increase the productivity of such lands as pastures. [8-9]. However, if it is an uncontrolled human process, such areas are sources of «biological pollution» and the object of increased fire hazard (lack of care contributes to the accumulation of dead wood). The resulting stand slows down and alters the process of demutation, and also makes it difficult to use the fallow for mowing and grazing cattle [5].

The purpose of our work is to assess the geoecological state of prostagrogenic lands, to identify the share of the total area of agricultural land of the Moscow village council of Ust-Abakan district of the Republic of Khakassia and to determine their stage of overgrowth. To do this, on the basis of ground and satellite data it's necessary to create a GIS project «Geoecological assessment of postagrogenic lands of the Moscow village council» containing a series of maps reflecting the current state of postagrogenic lands.

The characteristic of the processes of overgrowth of agricultural land with tree-shrub vegetation was carried out on the territory of the Moscow village council of Ust-Abakan district of the Republic of Khakassia. The study area with a total area of 54400 hectares is located in the North-Eastern part of Ust-Abakan district and occupies 7,2 % of its total area. From the Eastern part of Moskovsky village council borders with the Krasnoyarsk reservoir, from the North with Bogradsky district, from the South it borders with the urban district of Chernogorsk and Sunny selsoviet, from the Western part it borders with Vershina-Bijinsky selsoviet. On its territory there are 3 settlements with a total population of 1783 people with an administrative center in the village of Moskovskoye (Fig. 1) [10].

The relief of the studied territory is a weakly hilly surface with alternation of low alluvial plains with steep and ridge denudation increases, monoclinal Cuesta ridges with sharply asymmetrical slopes and wide flat hollows between ridges with an absolute height

of 300 to 500 m above sea level. The Duration of the period with an average daily air temperature above 10° is 110-120 days. The sum of the average daily air temperatures above 10° - 1700-1900°. The duration of the frost-free period varies from 105 to 115 days. The amount of precipitation for the year is 310-340 mm. the amount of precipitation for may-July generally does not exceed 170 mm. The dryness Index is more than 1.9 (dry) [11].

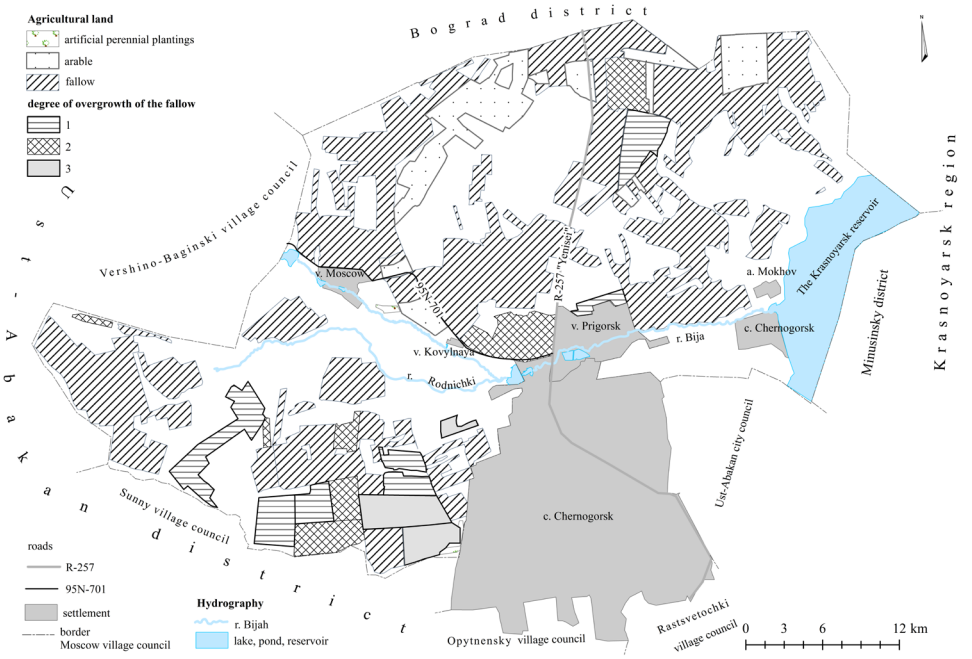

Fig. 1. The map of overgrowth of agricultural land with tree-shrub vegetation on the territory of the Moscow village council of Ust-Abakan district

From West to East, the village council is crossed by the river Bija, which flows into the Krasnoyarsk. It is the left tributary of the reservoir. The river Rodnichki collects water from the North-Western part of the village council and is a right tributary of the river Bija (flows into the river in the area between the settlements Kovylnaya and Prigorsk). A system of ponds for irrigation, watering of pastures, irrigation fields and artificial perennial plantations in the area of the urban-type settlement of Prigorsk was created on the Bijah river. There are also small temporary streams and streams on the logs and also lakes with an area of less than 1 km^2 are usually dry in summer. There are wetlands in the area of farms number 18 and number 11, as well as in the valley of the river Bijah.

Soils are mainly consist of ordinary chernozems and chestnut soils, often saline due to the close occurrence of mineralized groundwater and saline parent rocks. Saline soils in some areas make up even the main background. The main type of vegetation is low-production small-bunchgrass steppes with a high proportion of sagebrushes.

The basic material for the work were the analysis of cartographic materials (agricultural carat Ust-Abakan district, a series of thematic maps for planning of agriculture in the south of the Krasnoyarsk region and others), the results of their ground observations (composition and structure of vegetation postagrogenic lands (floristic composition, projective cover of grass, the ratio of botanical groups, height and age of tree-shrub bushes, etc.), data, public land maps and multi-temporal remote sensing data.

Esri's ArcMap program was used to create a GIS project for the overgrowth of postagrogenic areas. In the GIS project, the contours of agricultural territories were digitized on the basis of the agricultural map of Ust-Abakan district. Esri's World Imagery base layer was used to highlight different types of areas (https://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer). Also, to clarify the areas and the degree of overgrowth were deciphered at different times (since 2010 to 2019) satellite images of Landsat 4-5, 7, 8 and Sentinel 1 and 2 taken from the archives of the United States Geological survey (USGS, https://earthexplorer.usgs.gov). The ArcMap work project settings are as follows: WGS 1984 UTM zone 46N coordinate system, Mercatora / WGS84 projection. According to the results of the analysis of attribute information, calculations of arable land areas and postagrogenic areas with different degrees of overgrowth were made.

The Moscow village council in its structure belongs to the agro-industrial complex. On the Moscow village council's territory the share of agricultural land accounts for 90.7 % of its total area. The economy of the Moscow settlement is mainly based on the conduct of agricultural production of peasant farms and personal subsidiary farms. The most of the land is represented by fallows since the area is in the zone of risky agriculture and the soil with poor low-spent fertility. The main activity of the peasant farm is the breeding of sheep and cattle. Only 2 entrepreneurs are engaged in growing grain and leguminous crops. The total area occupied by arable land is only 7761,6 hectares. These lands are located on the border with the Bograd district where the greatest amount of precipitation falls and soils are more fertile. Most of the agricultural land set aside for arable land and previously used for growing crops is now in various stages of recovery. As a rule, cause of the lack of productive hayfields and pastures (mainly small-bunchgrass steppes with a high proportion of sagebrush), fallows are used for hay harvesting and cattle grazing.

On the lands of the Moscow village council a forest reclamation is partially implemented. Because of the lack of moisture in the territory, *Ulmus pumila L.* was used in conjunction with *Caragana arborescens Lam* to create protective and pasture-protecting forest strips. Forest reclamation was carried out on three sections of the village council: in the southern part of the village council №. 23, in the area of farm; between Kovylnaya and Prigorsk in the central and the Northern parts of the village council on the border with Bogradsky district. Forest belts are mainly 3 rowed of the blown type. The direction of the forest belts from North to South, across the prevailing winds. In total, there are 187 bands with varying degrees of damage (completely lost bands about 35 %).

Existing methods of score assessment of the current state of agricultural land exposed to overgrowth processes can't be used for the territory of Khakassia, as the forming stand of elm Siberian is strikingly different from the forests (coniferous, small-leaved), formed in other regions of Russia. Therefore, in relation to the territory of Khakassia, based on the analysis of long-term field data, a score assessment of the current state of deposits subject to overgrowth processes was developed. The following stages of the processes of overgrowth of agricultural land with tree and shrub vegetation were identified:

1. Zero stage of overgrowth – there are no overgrowth processes.
2. The first stage of overgrowth – there is an undergrowth of tree species commensurate with the grassy tier with a projective cover up to 50-100% especially near the mother plantings (forest belts).
3. The second stage of overgrowth - begins thinning of the undergrowth due to the biological characteristics of elm (a large percentage of freezing plants), the completeness of the stand is reduced to 0,3-0,5.
4. The third stage of overgrowth is further thinning of the stand. The completeness is very low ≤ 0.1. The average height of the elm is at least 2 m (the age of the plantings is usually more than 8 years). Again there is a young sapling.

According to the data obtained, 29,5% of the land from the total area of the Moscow village council is accounted for by a fallow. 77 % of the land (15432 ha) are subject to overgrowth processes, 43 % are in the first stage of overgrowth, 38,3% in the second and 18,7 % in the third. Haymaking and grazing on fallow lands constrain the appearance of woody vegetation, but if they stop *Ulmus pumila L.* for several years actively spreads over abandoned fields.

Protective forest strips play a multi-functional positive role for agricultural fields. However, in the absence of proper care for forest belts and a spontaneous conservation of land between the forest belts, overgrowing of fallow fields with elm tree and shrub vegetation occurs. Geoecological assessment of the features of overgrowth and growth of tree-shrub plantations on postagrogenic lands, remote sensing data and geoinformation technologies will provide not only new knowledge about their space-time evolution organization but will also provide a basis for the formation of a science-based system of measures for rational agriculture.

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