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АГРОЭКОЛОГИЧЕСКАЯ ТИПИЗАЦИЯ ЗЕМЕЛЬ

✉ **Гарафутдинова Л.В.**
Сибирский федеральный научный центр агробиотехнологий Российской академии наук
Новосибирская область, р.п. Краснообск, Россия
✉ e-mail: lv.garafutdinova@mail.ru

Описаны минимально необходимая информация и последовательность выделения агроэкологических типов земель на территории землепользования опытной станции (ОС), расположенной в лесостепи Приобья Новосибирской области. Выделены агроэкологические типы земель: первый тип (плакорные земли) представлен черноземом выщелоченным в сочетании с обыкновенным, оподзоленным и темно-серой лесной почвой, второй тип (слабоэрозионные земли) – черноземом выщелоченным в сочетании с темно-серой лесной почвой. Почвенный покров ОС в обоих типах земель представлен черноземом выщелоченным (Чв-2-2с), доля которого для первого типа составляет 75,26%, для второго – 76,26% от общей площади типов. Для первого агроэкологического типа земель характерно варьирование высот от 134 до 165 м. Рабочие участки относительно угла наклона рельефа расположены на склонах от 0 до 3 град. Вертикальное расчленение рельефа в среднем составляет 1,3 м, горизонтальное расчленение эрозионными формами – 0,8 км/км^2. Второй тип земель характеризуется высотой над уровнем моря от 113 до 137 м, углом наклона рельефа – от 1 до 4 град. Вертикальное расчленение рельефа в среднем составляет 1,7 м, горизонтальное расчленение эрозионными формами – 0,9 км/км^2. Типизация осуществлена с помощью сформированной цифровой модели землепользования (ЦМЗ) ОС на основе анализа географической информации, материалов дистанционного зондирования Земли (ДЗЗ) и кадастровой карты. ЦМЗ состоит их следующих геоинформационных слоев: топография, почвенный покров, цифровая модель рельефа (ЦМР), рабочие участки. ЦМР включает информацию о крутизне и экспозиции склонов, вертикальном и горизонтальном расчленении.

Ключевые слова: агроэкологические типы земель, геоинформационная модель, ДЗЗ, ГИС, базы данных

AGROECOLOGICAL LAND TYPIFICATION

✉ **Garafutdinova L.V.**
Siberian Federal Scientific Centre of AgroBioTechnologies of the Russian Academy of Sciences
Novosibirsk Region, Krasnoobsk, Russia
✉ e-mail: lv.garafutdinova@mail.ru

The minimum required information and the sequence of agroecological land type allocation on the land management territory of the experimental station (ES) located in the forest-steppe of the Priob'ye region of Novosibirsk is described. Two agroecological land types are distinguished: the first type (upland lands) is represented by leached chernozem in combination with common, podzolized and dark-grey forest soils; the second type (slightly erosive lands) is represented by leached chernozem in combination with dark-grey forest soils. Soil cover of ES in both types of lands is represented by leached chernozem (Lch-2-2s), the share of which for the first type is 75.26%, for the

second - 76.26% of the total area of the types. The first agroecological land type is characterized by a range of heights from 134 to 165 m. The working areas are located on the slopes between 0 and 3 degrees in relation to the terrain angle. Vertical dissection of the relief averages 1.3 m, horizontal dissection by erosion forms is 0.8 km/km^2. The second type of land is characterized by an elevation of 113 to 137 meters above sea level and a slope of 1 to 4 degrees. Vertical dissection of the terrain averages 1.7 m, horizontal dissection by erosion forms 0.9 km/km^2. Typification was carried out with the help of a generated Digital Land Use Model (DLM) of the ES based on the analysis of geographical information, remote sensing materials (ERS) and cadastral map. The DLM consists of the following geo-information layers: topography, land cover, digital elevation model (DEM), working areas. The DEM includes information on slope steepness and exposure, vertical and horizontal dissection.

Keywords: agroecological types of lands, geoinformation model, remote sensing, GIS, databases

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INTRODUCTION

The design of adaptive-landscape farming systems is impossible without a comprehensive agro-ecological assessment of lands. Agroecological assessment of lands takes into account the characteristics of the soil cover, geomorphological and agroclimatic features of the land use area, which determines the productivity of agricultural crops [1]. The capabilities of geographic information systems (GIS), which allow you to systematize spatial information and analyze it in accordance with the objectives are used to carry out analytical work [2-4]. Geoinformation solution of such tasks consists in the system of accumulation, storage and processing of the information obtained [5]. There are a number of functions in GIS with the help of which it is possible to carry out the analysis connected with changes of land resources (calculation of the areas, lengths and other parameters), to receive geomorphometric characteristics of the surface of a territory (slope angle, exposition of a slope, vertical and horizontal dissection of a relief), that allows to give an estimation of the land use.

The basis for GIS is geodata. They are information about a real object obtained through observation or measurement, with the data unit having two components: information about the location of the object in space and information about the properties of the object describing its essence, and respectively spatial and attribute characteristics [6]. With the integration of GIS and Earth's remote sensing (ERS) it is possible to obtain information about land resources for their analysis on-line.

The purpose of the study is to carry out agro-ecological typification of land using the created digital model of land use.

MATERIAL AND METHODS

The research was conducted on the territory of the ES "Elitnaya" (54°54'57 "N, 82°57'6 "E) of the Novosibirsk district of the Novosibirsk region, located on the third terrace of the Priob

plateau, which has a slight slope towards the Ob river. According to the scheme of agrolandscape zoning of the Novosibirsk region compiled by the Siberian Research Institute of Soil Management and Chemicalization of Agriculture (SibNIIZiH) of SFSCA RAS, the farm territory belongs to the forest-steppe Priobsky agrolandscape district of the North-Pre-Altai forest-steppe province [7]. The soil cover is mainly represented by different subtypes of chernozem and dark gray forest soil.

Public cadastral and topographic maps were used to clarify information on the boundaries of the objects. The geospatial database (GDB) reflects information about geometry, spatial location of objects and characteristics of the territory. The GDB is developed in SpatiaLite DBMS. GIS geo-information layers were formed with the use of land use project data of M 1: 21 000, topographic map of M 1: 100 000, Landsat-8 satellite images with the resolution of 30õ30 m in one pixel. The satellite images were downloaded from the site of the US Geological Survey (https://earthexplorer.usgs.gov). All electronic layers were created in the unified 3857 WGS-84/Pseudo-Mercator coordinate system using Quantum GIS (QGIS) software with open modular architecture (https://qgis.org/ru/site/) [8]. When preparing the geoinformation layer soil cover, the map of the experimental-production farm "Elitnoe" (1999 M 1: 10 000) was taken as the basis.

The GDB terrain model includes slope angles, horizontal and vertical dissection, and slope exposure. Digital elevation model (DEM) is formed on the basis of topographic map with digitized elevations and isolines, as well as SRTM data (https://earthexplorer.usgs.gov).

To assess the dissection of the relief, the area was divided into squares of 1 × 1 km. Within the resulting squares, the main indicators were calculated using GRASS GIS in the QGIS interface. Horizontal landform dissection was calculated using the algorithm "Fill sinks" → "catchment area" → "channel network" and linked attribute information about the area and the degree of erosion development. The vertical dissection of the relief was calculated based on a map of elementary catchments using the algorithm → "r.watershed". Then, using the tool "Vector <-> raster" - "Raster statistic for polygons", the maxima and minima of heights in each watershed were calculated. Using the field calculator in the attribute information, the value of height difference and the area occupied by a certain height on the terrain were calculated.

RESULTS AND DISCUSSION

The data obtained during the formation of a digital land-use model (DLUM) were formed into geoinformation layers with a GDB. Geoinformation layer topographic map carries information about actual boundaries of land use, working areas, reference points of the geodetic network, settlements, road network, power lines, gas pipelines, heights, horizontals, etc. With the help of the public cadastral map the boundaries of the working areas of land use were specified. When digitizing and clarifying the areas of the working areas with the help of the territorial land management project, remote sensing, raster map substrate (Google Satellite Hybrid) and the data provided from the ES, it turned out that the accounting area is different everywhere. Therefore, it is necessary to specify the acreage of the working sites with the help of contour interpretation of aerial photos.

The formed GDB by working plots includes attributive information: plot number, area, ridge length, configuration of the working sites, distance from the central farmstead, thickness of the humus horizon, crops cultivated over the last 5 years, and their yields (see Fig. 1).

The basis of land management is crop rotations, the placement of which depends on soil and climatic conditions. The geoinformation layer of the crop rotation scheme in the ES "Elitnaya" is shown in Fig. 2. Field and forage crop rotations prevail equally on the territory of the ES "Elitnaya", since the specialization of the agricultural organization is cattle-breeding and plant-growing.

As one of the thematic layers of GIS, a geoinformation layer soil cover was created, which contains the characteristics of the soil cover of the territory, and serves as the basis for agro-ecological land typing [9].

The soil cover of the "Elitnaya" ES territory is represented by different subtypes, the share of which from the total area is the following values: leached chernozem - 83.35%, common - 6.11, podzolized - 3, dark gray forest - 7.54% (see Fig. 3). Soil GDB contains information on soil index, soil name, content of humus and physical clay, pH, mobile phosphorus, and exchangeable potassium. The granulometric composition of soils varies from medium to heavy loamy. The humus content in the soils varies from 2 to 5%, pH from 4.51 to 5.01.

The relief of the earth's surface influences the physical and geographical elements of the landscape, being the main factor of its formation. Microclimatic and geochemical conditions of the territory under study - water flow and soil erosion, which are its main characteristics, depend on the steepness, shape, exposition of the slope and dissection of the territory. The temperature of soil warming, the intensity of erosion and the thickness of the soil profile depend on the steepness and shape of the slopes. Therefore, the obtained spatial data on the morphometric characteristics help to estimate the erosion potential of the territory [10]. For these purposes a DEM was created. A GDB with point and linear geometry was formed for the DEM. The linear layer contains information about heights, which are built with a cross section in 10 m (see Fig. 4).

The calculation and analysis of maps of horizontal and vertical dissection, exposure and steepness of slopes, and conclusions about the exposure of the territory to geomorphological risks depending on the values of morphometric parameters of the relief were made [11].

One of the main characteristics of the relief is the steepness of the slope and its shape, which determine the rate of surface water runoff. Proceeding from the fact that it is the steepness of the slope that affects the manifestation of erosion processes, we calculated the slope indicators of the territory of ES "Elitnaya" on the basis of SRTM.

The territory of the ES "Elitnaya" has land plots of different steepness, the classification

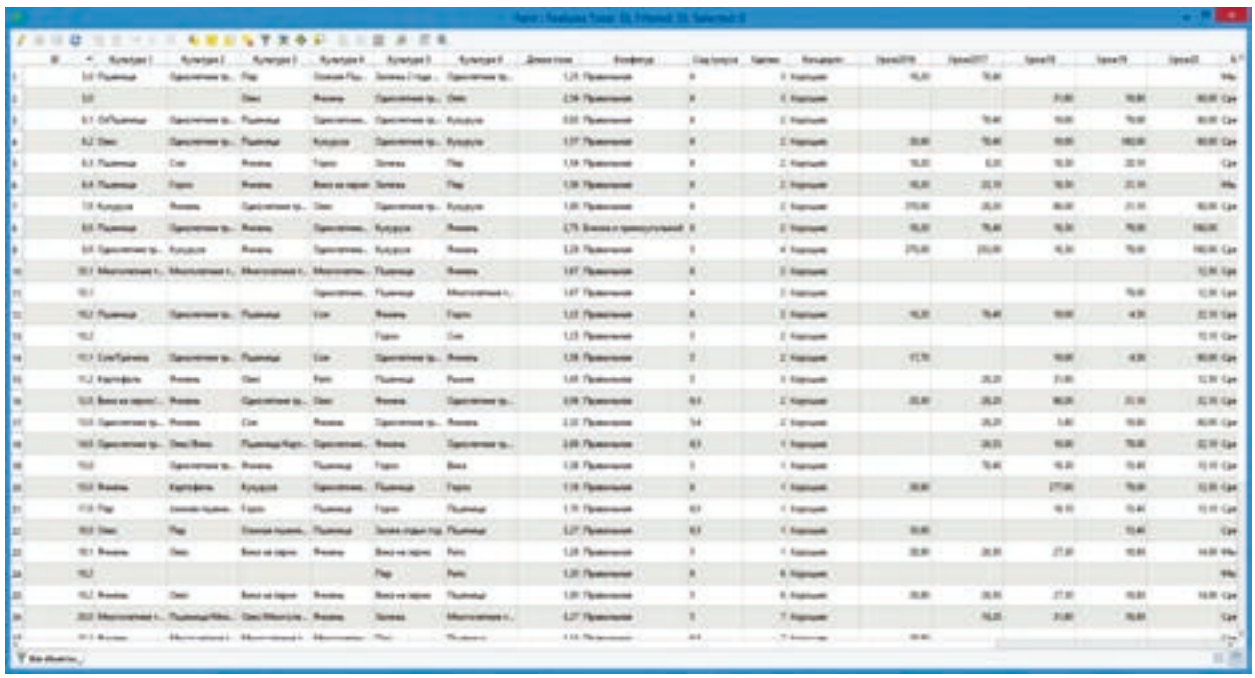

Рис. 1. Фрагмент базы геопространственных данных рабочих участков
Fig. 1. Fragment of the geospatial database of work sites

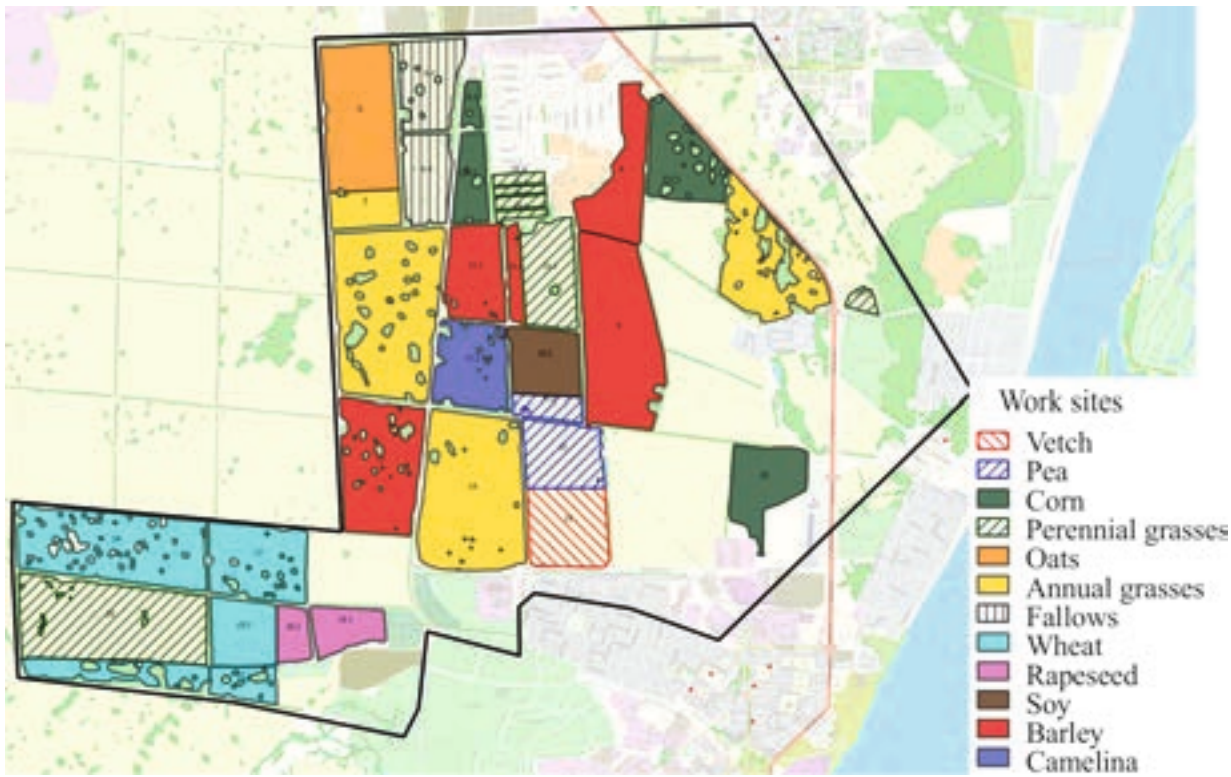

Рис. 2. Геоинформационный слой рабочих участков посевов сельскохозяйственных культур ОС «Элитная» в 2021 г.

Fig. 2. Geographic information layer of working areas of crops of the ES «Elitnaya» in 2021

of which was carried out by the method of M.N. Zaslavsky (see Fig. 5) [12].

The largest part of the ES "Elitnaya" is occupied by 0-1-degree slopes. They cover 57.17% of the area, slopes 1-3 deg. occupy 41.03%, 3-5 deg. - 1.77, 5-7 deg. - 0,03%. This shows that the relief of the slopes varies from very gentle to slightly sloping [1]. Working sites are mostly located on slopes 0-3 degrees, they are less washed away than the location on steeper slopes.

The intensity of sunlight distribution, vegetation and soil cover, microclimate, and snow distribution in winter depend on the exposure of slopes. The most favorable slopes for placing agricultural crops in the forest-steppe are considered the southern ones, they warm up faster, the duration of vegetation period of plants on them is higher, and the most unfavorable - the northern, colder and often overmoistened. On the eastern slopes, the maximum temperature is reached in the morning and in the evening on the western slopes [13]. When forming the electronic layer of slope exposures, a breakdown into eight ranges was adopted: north, northeast, east, southeast, south, southwest, west, and northwest (see Fig. 6).

The analysis showed that the slopes of the northern exposure account for 14.79%, northeastern - 15.86%, eastern - 14.22%, southeastern - 10.57%, southern - 14.42% of the total area on the territory of "Elitnaya" ES. The southwestern exposure slopes are represented by the smallest proportion and account for 8.96%, the western exposure 11.20, and the northwestern exposure 9.99%. The southern exposure of slopes is most significantly expressed in the working sites located in the southwestern part of the ES "Elitnaya", the other sites have equally complex distribution of slope exposures.

The degree of horizontal dissection of the territory under study depends on the development of the erosion network, the classifica-

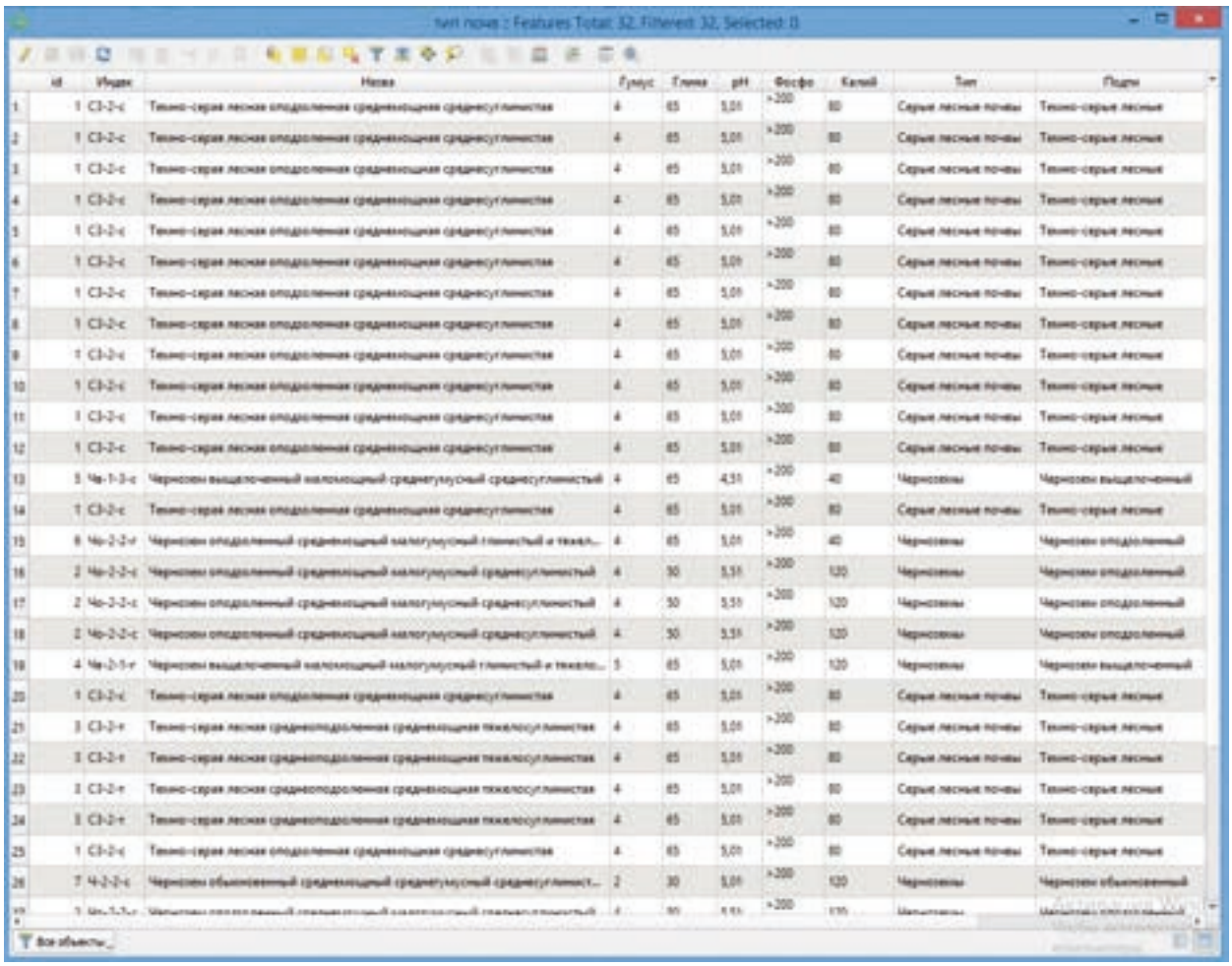

Рис. 3. Фрагмент базы геопространственных данных электронного слоя почвенный покров
Fig. 3. Fragment of the geospatial database of the electronic layer soil cover

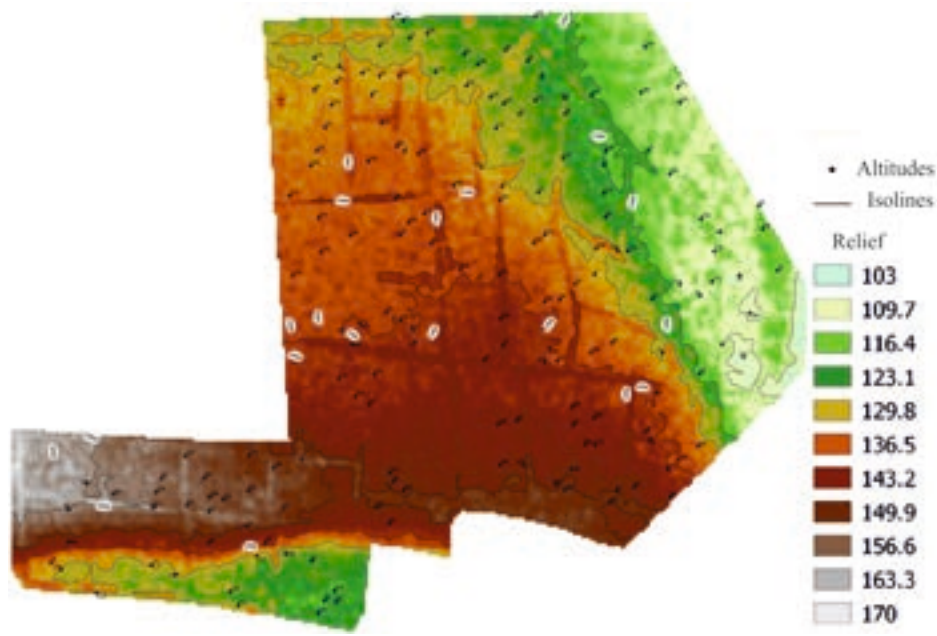

Рис. 4. Цифровая модель рельефа ОС «Элитная», м
Fig. 4. Digital relief model of the ES «Elite», m

Рис. 5. Геоинформационный слой распределения значений крутизны склонов, град.
Fig. 5. Geographic information layer for the distribution of slope steepness values, degrees

tion of which is generally accepted [12]. The formed layer of horizontal dissection of the relief is characterized by the indicator of the territory division into sections on the basis of a regular grid with the area of 1 km^2, with subsequent calculation of the length of the erosion network in each cell. The attributive GDB data contain information about the area, length of permanent and temporary watercourses.

According to the calculations of horizontal dissection of the relief, 64.98% of the territory of ES "Elitnaya" is attributed to slightly dissected plain with little manifestation of erosion processes. Dissection by erosion forms is less than 0.2 km/km^2. Average dissection of the territory is 12.77% of the total area, strong - 12.77% and very strong - 9.57%.

The dissection of the relief by erosive landforms from north to north-east increases from 0.1 to 0.9 km/km^2. In the eastern part, the horizontal dissection coefficient varies from 0.1 to 0.5 km/km^2, in the south-west - from 0.2 to 0.5, in the western part - from 0.1 to 0.3, in the north-west - from 05 to 0.8 km/km^2.

Attributive information of geoinformation layer of vertical dissection of relief contains information about heights, the difference between maximum and minimum heights, the areas occupied by heights on the terrain. The difference between heights varies from 11 to 73 m. In general, the territory of land use of ES "Elitnaya" is characterized by conditionally undivided plain, the share of which from the total area is 96.83%. Shallowly partitioned plain is 0.52% of the total area, moderately partitioned - 0.51, deeply partitioned - 0.63 and heavily partitioned - 3.06%.

Agroecological types of lands are identified by mutual superimposition of map layers [14]. On the basis of the analysis an electronic layer of agroecological types of land was formed. The basis of agroecological land typification is the definition of agroecologically homogeneous territory according to the conditions of crops cultivation.

Agro-ecological land typification was carried out according to the methodology of V.I. Kiryushin [15]. Two types of lands were singled out on the land use territory of ES "Elit-

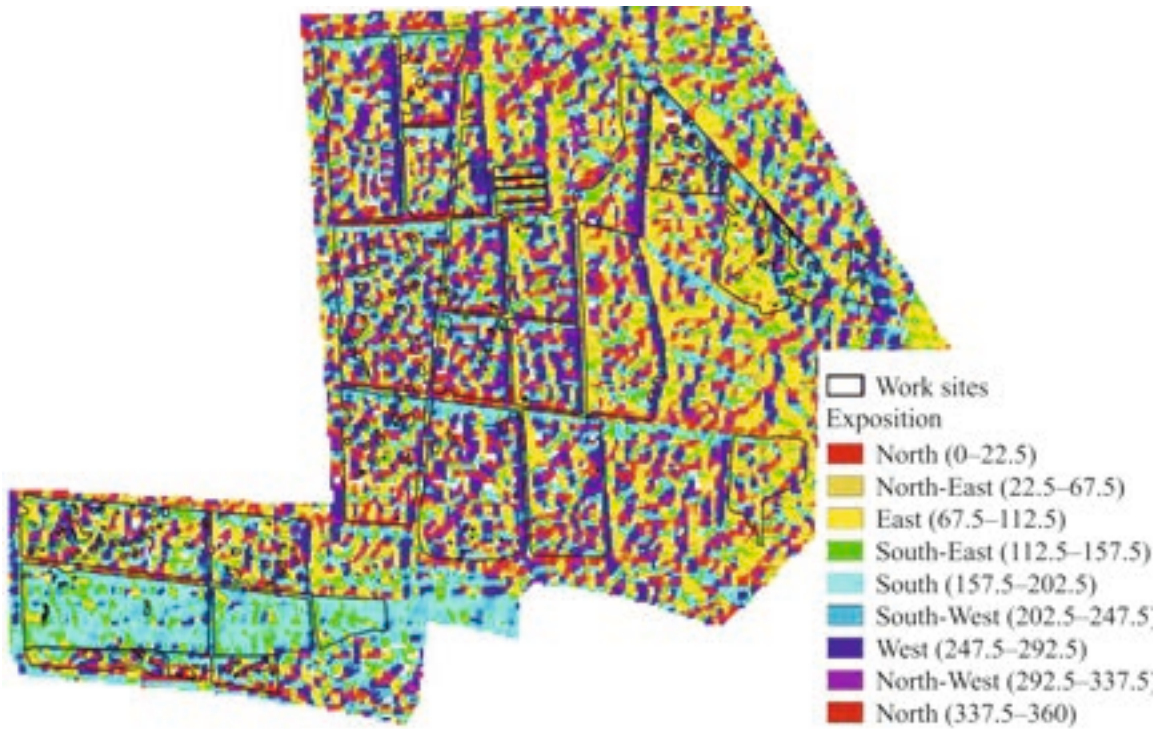

Рис. 6. Геоинформационный слой распределения значений экспозиции склонов, град.
Fig. 6. Geographic information layer of slope exposure values distribution, degrees

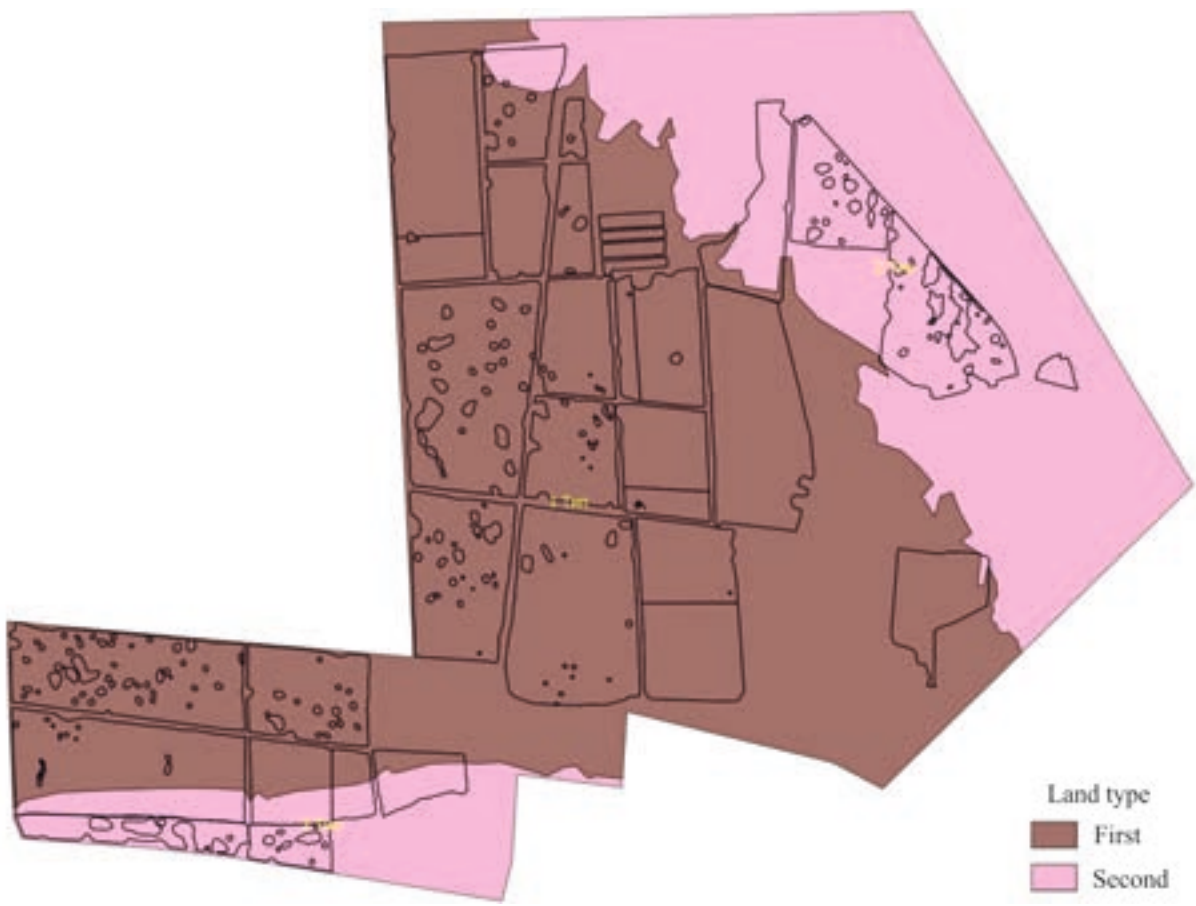

Рис. 7. Геоинформационный слой агроэкологических типов земель
Fig. 7. Geoinformation layer of agroecological land types

naya" (see Fig.7). The first agro-ecological type of lands (upland lands) is represented by leached chernozem in combination with common, podzolized and dark gray forest soils. Elevations above sea level vary from 134 to 165 m. Relief slope angle varies from 0 to 3 degrees. Vertical dissection of the relief averages 1.3 m, horizontal dissection by erosion forms - 0.8 km/km^2. The largest area is occupied by medium-humus medium-loamy leached chernozem (Chv-2-2s), the share of which is 75.26% of the total area of the type.

The second agro-ecological land type is located on slightly erosive lands and includes chernozem, leached in combination with dark gray forest soil. The elevation varies from 113 to 137 m above sea level. Relief slope angle varies from 1 to 4 degrees. Vertical relief dissection averages 1.7 m, horizontal dissection by erosion forms - 0.9 km/km^2. The largest area is occupied by medium-humus medium-loamy leached chernozem (Chv-2-2s), the share of which is 76.26% of the total area of the type.

CONCLUSION

The land use area of ES "Elitnaya" has an upland and a slightly sloping type of terrain, rugged with linear erosion forms. The working sites are mainly located on the predominant slopes of 0-3 degrees. (98,2%). In the soil cover, leached chernozem is predominantly expressed, which accounts for 83.35% of the total ES area. Slopes of the north-eastern exposition prevail; they account for 15.86% of the total area. The ES territory is attributed to the poorly broken relief plain, where the dissection by erosion forms is less than 0.2 km/km^2, and the vertical relief dissection varies from 11 to 73 m.

Agroecological land typing using DEM consists of the following algorithm sequence: coordinate referencing, geoinformation layers formation using RS data processing, DEM formation (horizontal and vertical relief partitioning, slope angle, slope exposition), GDB creation. To form a higher-quality DEM, it is necessary to specify the boundaries of the working sites and the spatial location of geographical objects, as well as to create a soil map (the paper version of the map is lost) with the help of RS data and field soil survey.

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ИНФОРМАЦИЯ ОБ АВТОРЕ

✉ **Гарафутдинова Л.В.,** младший научный сотрудник; **адрес для переписки:** Россия, 630501, Новосибирская область, р.п. Краснообск; СФНЦА РАН, а/я 463; e-mail: lv.garafutdinova@mail.ru

AUTHOR INFORMATION

✉ **Lyudmila V. Garafutdinova,** Junior Researcher; **address:** PO Box 463, SFSCA RAS, Krasnoobsk, Novosibirsk Region, 630501, Russia; e-mail: lv.garafutdinova@mail.ru

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