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GEOINFORMATION ANALYSIS OF THE CURRENT STATE OF THE PROTECTIVE FOREST BELT ON THE TERRITORY OF THE VOLGA UPLAND

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Abstract

The state protective forest belt Penza-Kamensk is an important component of the ecological framework of the territory, where it is included in the system of protective forest plantations and contributes to the transformation of the steppe agricultural landscape into an agroforest landscape. The purpose of the research was an inventory and assessment of the state of forest protective plantations in order to preserve and restore the agroforest reclamation fund. In office conditions, up-to-date cartographic material was created on the basis of satellite images of high and ultra-high resolution, visual interpretation was carried out with the compilation of a vector polygonal layer of the current location of protective forest plantations, the number of decoded objects was determined. Visual interpretation of space images made it possible to identify disturbed areas of forest belts, in which the sparseness (fragmentation) of the forest stand is noted. At present, forest stands of pedunculate oak (62.0% of the forested area) dominate in the plantations of the forest belt in terms of species composition, the second place is occupied by birch (22%), pine, larch and spruce by 12%, willow - 2%, aspen and ash - by 1 %. Artificial plantations in most of the area have an average density of 0.7-0.8, which indicates a qualitative selection of the main forest-forming species in relation to soil conditions, on the one hand, on the other hand, the correct choice of the type of crops and the required planting density, taking into account the survival rate and preservation of plants at all stages of forest growing. Preservation of plantings is high, fluctuating within 75-85%. In general, the state of plantings is satisfactory.

Key words*: inventory, protective forest plantations, planting safety.*

INTRODUCTION

State forest protection belts play an important role in maintaining the natural potential of the region, in maintaining soil fertility and increasing the biological diversity of ecosystems. Protective forest plantations increase the bioclimatic potential of the area, improve the hydrothermal regime of the lands adjacent to the protective forest belts, protect them from droughts and dry winds. In addition to performing the main water protection and protective functions, they play a large social and aesthetic role: together with other types of protective plantations, they form a forest-agricultural landscape new for the region, and are a significant regulator of carbon balance in the surface layer of the atmosphere (Mikhina et al., 2019; Mikhin et al., 2020; Larionov et al., 2021; Lavrov et al., 2021).

The most western of the watershed forest belts laid across the Penza, Saratov, Voronezh, Volgograd and Rostov regions is the Penza-Kamensk state protective forest belt with a total length of more than 700 km. She is aboutone of eight water protection and watershed wide state protective forest belts established by the Decree of the Council of Ministers of the USSR and the Central Committee of the All-Union Communist Party of Bolsheviks of October 20, 1948 (Brain, 2010; Kulik, 2018).

In accordance with the geographical zoning of the Penza region, located on the East European (Russian) plain and occupying the middle and western part of the Volga Upland, the forest belt runs between the Sursky site of the Volga region of the European forest province, located in the east of the region, and the Khopersky site of the Volga-Don region of the Steppe province, located in the west of the region. It is located in the forest-steppe at the junction of the Vorono-Khopersky low-elevated steppe and Kadada-Uzinsky ridge-hilly forest-steppe regions. The forest cover of the area where the

forest belt is located is 8.6%, represented by broad-leaved forests. Within the borders of the Penza region, it runs from the central part to the southern border along the most elevated parts of the relief through the steppe spaces of the Penza, Kolyshleysky and Maloserdobinsky regions. The total area of forest plantations is 1477 hectares, the length of the territory of the region is 80.1 km. It consists of 3 parallel forest belts about 60 meters wide at a distance of 300 meters from each other. Each strip consists of 20 rows of plants. The total width of the route is 780 m, and the area, including inter-lane spaces, is more than 6 thousand hectares.

MATERIALS AND METHODS

The research was carried out in three stages. The first, preparatory stage, was implemented in office conditions. The study and analysis of forest management documentation (taxation descriptions, flatbed materials), forestry regulations of the forestry was carried out. The material for the analysis was an electronic database containing the taxation characteristics of forest stands in the Penza region. Second phase, inventory of protective forest belts using satellite imagery materials using the SAS Planet interactive application (spatial resolution of about 0.5 m), Sentinel Hub satellite sensing materials (spatial resolution of 10 m) and web services that provide access to high-resolution satellite imagery (Bing Maps, Yandex Maps, Google Maps). At the third stage, a vector polygonal layer of the site was created. The raster was transformed according to the absolute coordinates of control points presented in the MSK-58 system, the creation of a vector map was carried out in the GIS Panorama program. The data on the state of the forest belt were updated by the method of visual interpretation of satellite images. When assessing the functional state of protective forest plantations based on satellite imagery visually, based on the criteria of continuity, the horizontal degree of density of the forest stand and the integrity of the forest belt, a rank scale of the state was used: good (forest belts do not require restoration measures), satisfactory (partially lost functionality, require restoration) and oppressed (mostly or completely lost functionality) state. When conducting research, methods of analysis and synthesis, statistical methods for calculating absolute, relative, average values, methods for constructing and studying time series, tabular, photogrammetric, graphic, monographic and method of statistical groupings.

RESULTS AND DISCUSSIONS

Research has established that forest belt plantations created on chernozem soils are characterized by rich forest growing conditions, under the influence of which forest plant communities were formed, which belong to four types of forest. The largest areas belong to the forest type oak forest - mixed herbs - 886.4 ha (61% of the total area) and oak forest - 549.7 ha (38%) in the type of habitat conditions D2 - fresh oak forest. Oak plantations consisting of 3 to 10 oak units occupy 62.0% of the forested area, birch accounts for 22%, pine, larch and spruce - 12%, willow - 2%, aspen and ash - 1% each. In the undergrowth there are hazel, euonymus, honeysuckle.

Plantings of the forest belt differ from each other in the composition of forest stands, the share of participation of the main species, the type of mixing of rows and trees in a row. The stands with the most diverse composition of tree species were formed in oak, ash and larch plantations, which indicates a positive mutual influence of tree species that form these stands. The poorest in terms of biological biodiversity are pine plantations, which prevent the development of trees of other species. In the forest belt, 6 groups of plantations pure in composition, as well as 6 groups of mixed plantations according to the prevailing main tree species, were formed, which in turn are divided into many varieties depending on the composition and proportion of species in it. Pure stands have the following taxation indicators:

- birch plantations in the type of forest oak forest, in the conditions of fresh oak forest, have an average height of 20 m, a diameter of 21.0 cm, a density of 0.7, quality class I, with an average reserve of 162 m^3/ha.
- oak plantations in the type of forest oak forest of snotty-forb in the conditions of fresh oak forest growth have an average height of 14.2 m,

a diameter of 17.8 cm, a density of 0.7, quality class III, with an average reserve of 122 m^3/ha.
- pine plantations in the oak forest type, in the conditions of the fresh oak forest habitat, have an average height of 20.5 m, a diameter of 22.5 cm, a density of 0.8, a grade of 1A, an average stock of 310 m^3/ha.
- spruce plantations of units in the type of forest oak forest-forb in the conditions of fresh oak forest growth have an average height of 8.0 m, a diameter of 10.0 cm, a density of 0.8, quality II, an average stock of 80 m^3/ha.
- plantations of aspen in the type of forest oak forest snotty-forb in the conditions of fresh oak forest habitat have an average height of 19.0 m, a diameter of 26.0 cm, a density of 0.7, quality II, an average stock of 180 m^3/ha.
- willow plantations in the type of forest oak forest snotty-forb in the conditions of fresh oak forest growth have an average height of 11.0 m, a diameter of 14.0 cm, a density of 0.6, a quality class of 3, an average stock per 1 ha is 70 m^3/ha.

Pure plantations of oak, birch, pine, willow, aspen and spruce grow on 40 forest plots with an area of 156 hectares, which is 10.7% of the forested area of the forest belt and are mainly single-story plantations with undergrowth.

Plantations mixed in terms of species composition are mainly single-tier plantations with undergrowth and a second layer.

Oak mixed plantations with a predominance of pedunculate oak from 6 to 9 units in the composition grow in the type of forest oak forest and oak forest - forb in the conditions of growth - fresh oak forest. Oak grows mixed with maple, willow, linden, birch, ash and larch. Average height 15.2 m, diameter 17.2 cm, weight 0.7, quality II, average stock 144 m^3/ha. Oak is most often found in the first tier as a dominant in 15% of cases, as a co-dominant in 12%.

Mixed birch stands with a predominance of warty birch from 5 to 9 units grow in the forest type oak forest in the conditions of fresh oak forest. Birch grows mixed with maple, ash, aspen and oak. Average stand height 20.6 m, diameter 23.0 cm, density 0.73, quality class I, average stock 179 m^3/ha. Mixed pine plantations with a predominance of Scotch pine in the forest type snotty oak forest in the conditions of fresh oak grove. Pine grows mixed with maple, linden, birch, ash, spruce and larch. Average stand height 18.3 m, diameter 20.4 cm, density 0.8, quality class IA, average stock 264 m^3/ha.

Mixed stands of larch with a predominance of larch 8-9 units in the type of forest oak forest in the conditions of fresh oak forest growth. Larch grows mixed with maple, willow, linden, birch, ash and oak. Average stand height 21.0 m, diameter 23.0 cm, density 0.8, class I, average stock 240 m^3/ha.

Mixed plantations of spruce with a predominance of larch 8-9 units in the type of forest oak forest in the conditions of fresh oak grove. Spruce grows mixed with maple, pine and aspen. The average height of stands is 16.0 m, diameter is 18.0 cm, density is 0.9, class II, average stock is 218 m^3/ha.

Ash mixed plantations with a predominance of ash 6-9 units in the type of forest oak forest in the conditions of fresh oak grove. Ash grows mixed with maple, willow, linden, birch and oak. Average stand height 14.2 m, diameter 17.0 cm, density 0.67, quality II, average stock 130 m^3/ha.

Forest stands with the participation of common ash in the forest belt grow in the type of habitat conditions fresh oak forest (D_2) on an area of 640.3 ha (43.3% of the total plantation area). The largest areas of plantations with the participation of ash belong to the type of forest oak forest snytevo - forb in the type of habitat conditions D_2 - fresh oak forest on an area of 365.0 ha, which is 24.7% of the total area of the forest belt and in the forest type oak forest snytevo in the type of habitat conditions D_2 fresh oak forest on the area of 275.3 ha or 18.6%.

Five types of mixed forest stands with the participation of ash were identified, differing among themselves, first of all, in the share of tree and shrub species in the composition of the plantation and the nature of their mixing:
- oak mixed plantations with a predominance of English oak 3 to 9 units in the composition. Oak grows mixed with maple, willow, linden, birch, ash and larch. The average height of stands is 13.8 m, diameter is 16.3 cm, density is 0.7, quality class is III, average stock is 130.0 m^3/ha. Oak is found in the first tier as a dominant in 67% of cases.
- ash mixed stands with a predominance of ash from 2 to 6 units. Ash grows mixed with

maple, willow, linden, birch and oak, pine and larch. The average height of stands is 14.2 m, diameter is 17.0 cm, density is 0.7, quality class is III, average stock is 130.0 m^3/ha.

- birch plantations with a predominance of warty birch from 4 to 9 units. Birch grows mixed with maple, ash, and oak. The average height of stands is 20.5 m, diameter is 22.6 cm, density is 0.7, quality class is I, average stock is 166.0 m3/ha.
- mixed pine stands with a predominance of Scotch pine from 4 to 8 units. Pine grows mixed with maple, birch, ash and larch. The average height of plantations is 20.0 m, diameter is 22.0 cm, density is 0.75, quality index is IA, average stock is 280 m^3/ha.
- mixed stands of larch with a predominance of larch from 3 to 8 units. Larch grows mixed with maple, willow, linden, birch, ash and oak. The average plantation height is 20.8 m, diameter is 21.8 cm, density is 0.8, quality index is IA, average stock is 246 m^3/ha.

In terms of composition, forest stands with the participation of ash have a complex structure, consist of 4-5 tree species, of which oak (35.0%), linden (22%), birch (15%), Norway maple (12%), larch (8%), willow (8%). The share of ash in them varies from 1 to 6 units, most often 1-3 units. The predominance of ash was noted only on an area of 15 hectares out of 640.3 hectares with its participation, which is 2.2%. Ash grows in forest stands from IA to III class of bonitet (on average II), density from 0.7-0.8, age 60 years. A high occurrence of ash (more than 40%) is observed in larch and birch plantations.

Thus, the creation of mixed plantations of the state protective belt helps to increase their resistance to adverse environmental factors and increases the degree of their positive impact on the microclimate of adjacent territories. As an example, the protective forest plantations play important role in the biota and the food chains management within agrocenoses.

It is identified

that the forest belts have smoothing influence on the change in the abundance of insects belonging to the different trophic groups on the developed fields. The peaks in the number of harmful and useful insects coincide in these fields, whereas in treeless agrocenoses the rise in useful components density takes place only after a year of the mass reproduction of pests (Belitskaya, 2015).

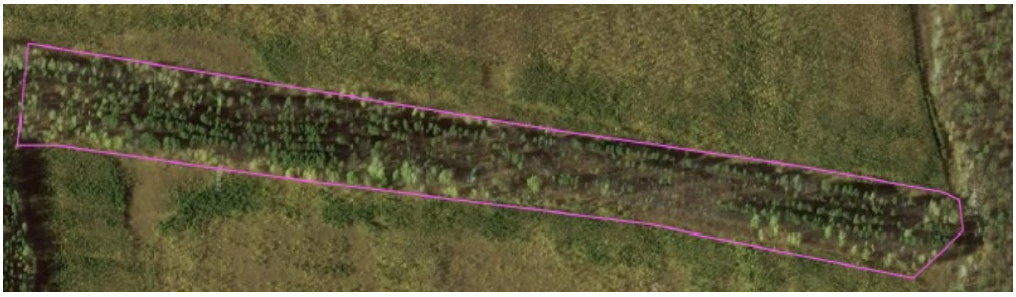
In the areas of the forest belt, environmental conditions were formed that are characteristic of forest ecosystems, with the so-called "edge effect". Trees in the outer rows have a maximum diameter and more powerful crowns. As the distance from both edges goes deeper into the forest belt, the diameter of the trees decreases rapidly and decreases to a minimum in the middle of the belt. In the central rows, there is an increase in the average height compared to the edge trees and a decrease in the average diameter, which is associated with the illumination of the crowns and the growth of tree species. The maximum height - 24.5 m, they reach not in the extreme rows, but fifteen meters from the edge. The least intensive growth in height and thickness is observed in the middle part of the belt.

One of the most advanced, efficient and reliable sources of information for forest inventory in order to determine qualitative and quantitative characteristics is Earth remote sensing data. The main advantages of the remote monitoring system are the speed of obtaining information, objectivity, simultaneity and periodicity, uniformity, visibility and a comprehensive solution to a wide range of applied agricultural problems (Franklin, 2001; Xue et al., 2017).

A visual interpretation of the current satellite images (2019-2020 surveys) was carried out with the compilation of a vector polygonal layer of the current location of the forest belt. From these results, it was found that: good (forest belts do not require restoration measures) condition have 726.7 ha of forest belts; satisfactory (partially lost functionality, require restoration) - 654.3 ha; oppressed (mostly or completely lost functionality) conditions - 96 ha forest belts (Figure 1). In plantations of the forest belt, seed and vegetative renewal of trees and shrubs is observed. The physical properties of soils, in order of decreasing importance for ecosystem services such as crop production, are texture, structure, bulk density, porosity, consistency, temperature, color and resistivity.

With natural overgrowth, the water-physical properties of the soil favorable for the development of woody plants are preserved in the territory of the forest belt.

Good condition



Satisfactory condition

Unsatisfactory condition

Figure 1. Examples of assessing the condition of forest belts according to criteria their continuity, integrity and degree of density of the forest stand

In this regard, the formation of natural plantations of seed and vegetative origin is a very important process for increasing biodiversity and sustainability of the biocenosis as a whole. To ensure the natural regeneration of tree species under the canopy of plantations, it is necessary to create conditions for the mass appearance of self-seeding of woody plants under the canopy of the parent stand by thinning it to fullness up to 0.5-0.6, and arranging gaps and windows. To improve the condition of plantations in the forest belt, it is recommended to carry out selective sanitary felling of moderate intensity,

CONCLUSIONS

The experience of creating a protective forest belt by planting seedlings of trees and shrubs has shown the possibility of forming mixed forest stands with a complex structure of forest stands that are resistant to adverse biotic, abiotic and anthropogenic factors in sparsely forested areas.

Forest belt plantations are unique objects for studying the methods of steppe afforestation in specific soil and climatic conditions, the features of the existence of artificially created forest biogeocenoses, and their spatial

influence. A wealth of experience has been accumulated in the technology of growing broad-band protective forest plantations, the selection and reclamation mixing of species, soil preparation and care for plantings of different ages in the forest-steppe zone of the Middle Volga region. Biogeocenoses have formed in them, consisting of more than three dozen species of trees and shrubs, which regulate the carbon balance in the surface layer of the atmosphere, have a positive effect on soil structure, increase humus content, and improve other water-physical properties of the soil.

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