Features of the formation of the floodplain ecosystem of the black alder cluster in the conditions of the Orenburg Urals

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Abstract. The article provides original information on the peculiarities of the formation of a floodplain ecosystem with the predominant tree species Black Alder, a cluster type in the conditions of the steppe (treeless) Orenburg Urals. The object of study is located in a zone of extremely insufficient and unstable moisture in the floodplain area of the Ilek River during certain periods of the year. A bioecological assessment of the black alder plantation and its phenological features of development in the conditions of the arid steppe are given. Taxation characteristics of the stand allow us to give a qualitative assessment of the black alder cluster. Currently, on the territory of the Orenburg region there is no vector for the reproduction and promotion of natural regeneration of black alder, which is primarily due to the poor knowledge of the formed spatial ecotones. The identification of cluster plantings, which ontogenetically and phylogenetically demonstrate the ability to form stable natural, dynamically developing forest ecosystems, under the influence of anthropogenic load, has important scientific and practical significance.

1 Introduction

The peculiarities of the geographical location of the Orenburg Urals have left a significant imprint on the natural conditions, therefore the territory is characterized by a variety of bioecological conditions [1].

Forest plantations in the form of forests and floodplain forests are clearly expressed in the northern part of the study area, and island forests here cover the hills and hills present in the relief. The central and eastern parts of the Orenburg Urals are mainly represented by steppes with a very low degree of forest cover, not exceeding 5%. The forest cover of the Sol-Iletsk district, the location of the floodplain black alder ecosystem, is about 1.2%, so the territory was classified as treeless.

The object of study is the floodplain ecosystem of the black alder cluster, located geographically in the Sol-Iletsk administrative region, in the southeast of the East European Plain, within the hilly plains of the Orenburg Urals.

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The inland waters of the study area are represented by rivers, lakes and artificial reservoirs, the main source of which is snow, which is about 80% of the flow, but the role of groundwater and rainwater is negligible.

In general, the study area belongs to a low-water area, the characteristic feature of which is its location in a zone of extremely insufficient and unstable moisture in certain periods of the year, therefore watercourses, due to the dry climate, are characterized by sharp instability of water flow over the seasons.

All these rivers belong to the Caspian Sea basin and the river system of the Ural River, and its large tributary the Ilek River.

Within the boundaries of the Sol-Iletsk district, 8 large black alder forests have been identified, having a clear spatial outline. Chernoolshanik located near the village. Abundant is part of these plantings and is of great scientific importance, since in the conditions of the dry steppes of the Orenburg Urals, the study of their natural renewal, stability of state over time, and phytomonitoring is of great environmental and silvicultural significance for the preservation of existing natural plantings.

Having compared the data from the study of the formation of black alder phytocenoses on the territory of the European part of Russia, we concluded that typologically the vegetation is represented by uniformity and is largely similar in the formation of black alder clusters in different regions of the country.

The high degree of agrarian development of the steppe expanses of the study area, the plowed area of which is more than 40%, the low proportion of forest plantations, and natural plantings of black alder or black alder allow us to distinguish them as clusters.

Black alder located along existing watercourses, in steppe regions also performs the most important forest reclamation function, partially participates in the regulation of water flow, and helps strengthen the coastline, which is very important in the conditions of the arid steppe.

Silvicultural research of the last decade has been aimed at identifying tree species that ontogenetically and phylogenetically demonstrate the ability to form stable natural, dynamically developing forest ecosystems under the influence of anthropogenic pressure [2].

Alnus glutinosa (L) *Gaertn* is one of the few tree species that has ecological and physiological plasticity, considering the characteristics of phylogeny, it tolerates prolonged flooding inherent in steppe regions of atmospheric drought, the ability of active vegetative reproduction, with a high proportion of viable young growth, characterized by rapid biological growth [3].

Methodological recommendations on the structure and content of biological diversity conservation programs dated November 25, 2019, N 35-r suggest the creation of a number of reference areas of plant communities in the Orenburg region, including black alder clusters, reflecting the features of their ecology, structure and coenofloristic composition.

Currently, on the territory of the Orenburg region there is no vector for the reproduction and promotion of natural regeneration of black alder, which is primarily due to the poor knowledge of the formed spatial ecotones.

2 Materials and methods

Research on the formation of high-quality black alder plantings was based on simple random selection - the possibility of extracting n objects from the final general population N, with each of the intended samples having an equally probabilistic nature of selection.

The average tree diameter was rounded to the nearest whole cm for average diameter (dm) less than 16 cm and to a whole even cm (18, 20, etc.) for dm greater than 16 cm. The result was rounded to 0.1 m [4].

The average age of the predominant species, black alder, corresponded to the age class.

Depending on the age, origin of the tree stand and the height of the predominant species, the quality class was established according to the tables of Prof. M. M. Orlov. Dead trees were accounted for separately in the corresponding column of the accounting sheet.

The height of the trees was measured with an altimeter.

Litter samples were sorted into fractional components: small or unsorted detritus, leaves, branches and bark, cones, grasses, and other components. Leaf litter samples were sorted into their constituent fractional components: small or unsorted detritus, leaves, branches and bark, cones, grasses, and other components. It was not the total litter of the herbaceous cover that was counted, but parts of the herbs that somehow fell into litter.

Field records and observations were processed by standard generally accepted methods of statistical analysis using MS Excel.

3 Results

The object of the study is the black alder phytocenosis, which we distinguish as a cluster with an area of 36 hectares. Geographically, black alder is located in two landscape subzones: typical steppe and southern steppes of the Orenburg Urals.

The Ilek River acts as a natural separator of these subzones, where the northern side of the valley is represented by a typical steppe, and phylogenetically formed fescue-feather grass vegetation and the soil cover is represented mainly by loam and sandy loam southern chernozems. The southern side of the Ilek River valley is represented by typical southern steppes formed on dark chestnut soils, interspersed with solonets complexes and wormwood-halophytic vegetation.

High-quality black alder forests have special forestry, recreational, bioecological and soil-improving significance, and therefore deserve special attention. Sol-Iletsk black alder forests are a kind of “green” zone along the floodplain of the Ilek River.

Regional forestry specialists specifically promote the inappropriateness of maintenance and annual dendromonitoring, arguing for the low productivity of plantations and the presence of natural death of overmature trees [5].

Comprehensive observation of the development and formation of black alder floodplain phytocenoses is the basis of scientific information, on which the methods and directions of forestry management, the development and implementation of economic measures that stabilize the dynamics of their development and preservation over time directly depend.

The studied black alder grows along the swampy foot of the second floodplain terrace of the Ilek River, composed mainly of sand and sandy soils. Object coordinates 51°02'13.7"N 54°38'13.6"E 51.037130, 54.637110, Buranny district forestry, state government institution Sol-Iletsk forestry, block 35 (Figure 1).

Fig. 1. Gallery black alder forests along the Ilek River.

The annual dynamics of phenological development processes in the plant world has its own patterns, determined, as a rule, by seasonal phenomena in wildlife, changing temperature conditions, which are characterized by zonal and climatic features [6,7].

Phenological observations of black alder in the planting under study showed that only one phenological form grows here. In our opinion, this is an early form; leaf bloom is observed already at the end of April (Table 1).

Table 1. Phenodates of black alder in the Sol-Iletsk district 2022.

Phenological phase / Established onset date											
Beginning of sap flow	Swelling of growth buds	Opening of growth buds	Beginning of foliation	Full foliation	Beginning of yellowing of leaves	Complete yellowing of leaves	Beginning of leaf fall	Complete leaf fall	Beginning of flowering	End of flowering	Fruit ripening
12.03.22	08.03.22	05.04.22	13.04.22	14.05.22	21.08.22	05.10.22	17.09.22	05.11.22	19.03.22	25.03.22	16.08.22

Black alder, unlike many tree species, even in the harsh continental climate of the arid steppe, exhibits high adaptive properties, such as the early onset of the main phenological phases: the beginning of vegetative and generative development, and a long and smooth phenomenological interval to winter period of rest.

The main phenological phases of black alder development in the studied area of the steppe, such as swelling of buds and the beginning of flowering, are tied to the first ten days of April.

The growth processes of trees are recorded already at a sum of positive temperatures of no more than 70 C^0, no ecological differences were identified in the dates of the beginning of phenological phases, it was only noted that with a slight difference, no more than 4-5 days, active sap flow, massive swelling and unwinding of growth buds begin, friendly beginning of leaf blossoming and development.

A biological feature of black alder on the cluster territory is the completion of the generative cycle 10-12 days before the leaves fully bloom.

The entire flowering period of plants is associated with an average daily temperature from +5 to -5 C^0, and the end of flowering usually ends when the average daily temperatures cross the border of +10 C^0.

The beginning of mass leafing occurs during the transition period of the average daily air temperature of +10 C^0, and it is the entire vegetative cycle of black alder that takes place after the establishment of the indicated average daily temperature.

When the sum of positive temperatures reaches 259-270 ^{0}C, leaf buds bloom. The first, as a rule, leaf buds to bloom along the outskirts of the black alder cluster, where the steppe “borders” forest vegetation, it is here that yellowing of the leaves and the formation of future growth buds occurs earlier, this is probably due to the influence of the thermal regime of the steppe vegetation, due to strong heating steppes in summer and the presence of dry winds.

The composition of the cluster under study shows that the predominant stands of black alder are predominantly 50-60 years old, the bonitet is II, the planting is predominantly of the same age (Table 2).

Table 2. Taxation characteristics of black alder planting.

Composition	Average age, years	Rotundity	Bonitet	Average	
				H, m	D, cm
8Olch 2Os unit B	55.9	0.7	II	24.0	22.5

In the black alder forest studied, according to experts, modern peat formation processes are currently taking place, which is the only place in the Orenburg Urals.

Fig. 2. Black alder cluster (Sol-Iletsk district).

The hilly and ridged topography of the study area is spatially cut by the watercourses of the Ilek River, along which gallery forests are formed with the predominant tree species being black alder, where the shrub layer is absent (Figure 2), however, along the outskirts of the cluster there is a single silver birch (*Betula pendula Roth*).

In general, the planting is a homogeneous pure black alder plantation with high quality, which is perhaps why it was designated as a protected object, the status of which has been preserved to this day.

Analysis of black alder undergrowth by size categories of viable undergrowth shows that there is much more of it than non-viable undergrowth, this is evidence that suitable bioecological conditions have formed here for the growth of this species valuable in silviculture, the close location of the groundwater level, despite the fact that that the cluster under study is located in dry steppe conditions and its distribution is strictly limited by the hydrological regime of the permanent watercourse of the Ilek River (Figure 3).

Analysis of the study and observation of juveniles showed that most of the juveniles are in a healthy state, weakened juveniles, of which no more than 30%, are found closer to the edge line of the phytocenosis, which provokes unfavorable conditions for growth, consisting in the contact interaction of “forest” and “steppe”.

Categories of the relative life state of black alder on the territory of a natural forest cluster according to the presented parameters show that all life states are represented here (Figure 3).

The planting of black alder is predominantly of coppice origin, so there is an introduction of the reproductive potential of the existing black alder through the system of their felling.

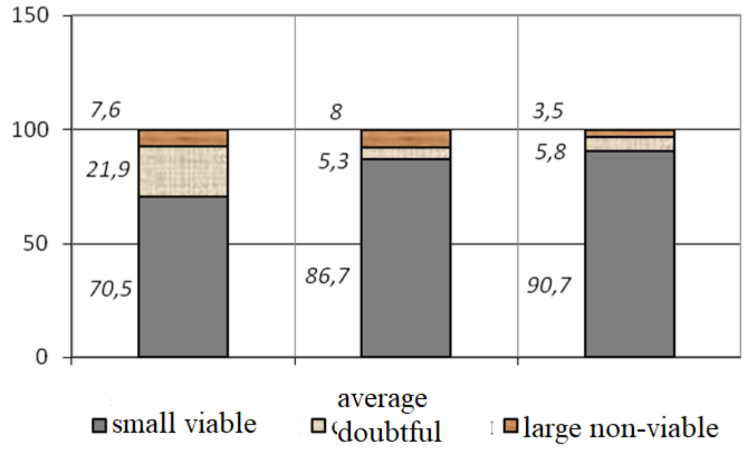

Fig. 3. Size categories and relative vital status of black alder undergrowth.

There are more healthy trees, without signs of disease and pest damage, than visually identified weakened trees, therefore, analyzing the data obtained, we evaluate the planting as healthy.

The blue alder leaf beetle (*Melasoma (Linaeidea) aenea L.*) was recorded once, feeding on alder leaves at almost all stages of its development.

The composition of the soil in the territory of the black alder cluster is characterized as - loose type - the soil crumbles into small lumps, the knife enters the soil horizon without effort. Based on the porosity inside the structural units, the soil is characterized as spongy - pores from 3 to 5 mm, predominantly wet - moisture is felt to the touch, when compressed the soil sticks together, the lump moistens the filter paper, when the lump dries, it becomes lighter.

Forest litter plays an important role as the main component in the formation of forest soils, but its structure, structure, and mass have significant differences even in small areas and are influenced by natural environmental territorial factors.

The obtained data on the state and mass of forest litter characterize many bioecological processes that occur intensively in forest plantations of various types:

- pyrological state of the study area, intensity of the small biological cycle of the represented phytocenosis, black alder reforestation, hydrothermal regime of soils forming the cluster.

The forest litter was conventionally identified as consisting of three layers, which were designated by the generally accepted symbols A_{01}, A_{02}, A_{03} (Table 3).

Table 3. Power and reserve in an absolutely dry state of the forest floor in black alder (average value and error of the average value).

Power, cm			Stock, t/ha		
A_{01}	**A_{02}**	**A_{03}**	**A_{01}**	**A_{02}**	**A_{03}**
3.52±0.03	2.78±0.1	3.04±0.04	2.7±0.01	19.8±0.14	22.5±0.2

In floodplain forests, A_{01} is formed under conditions of diversity of soil-hydrological and floristic factors, the height of A_{01} is 3 cm [8].

The composition of the studied black alder in A_{01} is dominated by fine earth (45%) and rot (25%), in depressions the height of the A_{01} layer reaches 1-2 cm, where an increased content of branches, bark particles, fallen cones and seeds that are clearly distinguishable and have not undergone decay is noted.

The middle layer of litter A_{02} consists of morphologically difficult to define fractions, which are partially cemented among themselves and have already undergone an initial process of decomposition, which is clearly defined. The lowest layer A_{03} consists entirely of indistinguishable parts and is a homogeneous decomposed organic mass mixed with soil components (Figur 3).

Fig. 4. Thickness of forest litter in the black alder forest area.

Thus, the moistened floodplain territory of the black alder phytocenosis, under the influence of warm air masses, contributes to the rapid process of biological decay and stimulation of soil formation processes.

4 Discussion

The special moisture regime of black alder ecological cluster communities determines the environment-forming role of black alder, the peculiarity of which is the symbiotic interaction with nitrogen-fixing microorganisms.

On the territory of the Orenburg Urals, today there are few areas of high quality black alder plantations, well preserved, and the determining factor for their future is the organization of specially protected natural areas with regular phytomonitoring and a certain forest management regime [10].

In conditions of an arid climate and the dominance of steppes, the increased moisture supply of stream ecosystems determines the development within their boundaries of various variants of meadow and forest vegetation.

Low forest cover in conditions of increasingly arid climate determines the increased economic and recreational importance of existing riparian ecosystems in general and forest phytocenoses as their components. However, such forest ecological communities are quite sensitive to the effects of anthropogenic factors; their self-healing is difficult and takes a long time.

The formation of the structure of the black alder cluster and the determination of the direction of the processes of further development of the forest community depends on the dominant tree species - black alder, while in the process of changing age generations the black alder community acts as a dominant.

Within the existing black alder forest ecological communities, it is necessary to establish the gentlest forest management regime, including reforestation measures in existing forest plantations.

The surveyed and studied black alder phytocenosis is in a healthy, stable, dynamically developing state, which does not require drastic measures to introduce protective measures at the existing level of anthropogenic load, but it requires annual phytomonitoring and control over compliance with its protection regime.

The modern floristic richness of black alder forests gives reason to consider them standard systems of high conservation value in the conditions of the Orenburg Urals.

5 Conclusion

Black alder clusters in the Orenburg Urals region, occupying waterlogged floodplain areas that are ecologically inaccessible to other tree species, are valuable reserves of biodiversity and act as fire refugia.

Rational use of forest resources that contribute to the fulfillment of their main environmental and water conservation functions of black alder forests is possible only with the development and implementation of promising management measures.

The restructuring of plantings and the preservation of forest clusters will be facilitated by scientifically based standards for forest care, which in the future will reliably ensure the formation of plantings of optimal age composition.

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