The role of ecological monitoring of the course of the Manchurian ash forest growth as a vital factor of environmental engineering

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Abstract. Ecological monitoring of forests stands is an important issue, because it allows to delve deeper into the issue of the state of forests and consider many problems in the field of forest management and pathology. Forests are an important formative element of terrestrial ecosystems of various ranks. Intensive exploitation, coupled with natural aging processes, inevitably leads to forest weakening and inability to fulfil their ecological functions. This is especially noticeable on the territory of the Priamursko-Primorsky forest region where a large area elongated from the north to the south presents a variety of natural and climatic conditions forming their own biocenosis. In case of loss, due to poor forest pathological or sanitary condition, the forest is unable to perform its functions. The process of forest cutting down will inevitably lead to damage to the ground cover, shrubs and grasses growing in the forest, changes in the microclimate, water balance of the soil. Changing key conditions can lead to a change in the ecological system. Therefore, today the issue of researching and monitoring the ecological state of the forest is relevant, allowing understanding the level of awareness about the state of the forest fund of the Russian Far Eastern region.

1 Introduction

One of the most important factors while monitoring the state of the forest is the completion of tables of the growth of forest stands progress which reflect the dynamics of taxation indicators of forest stands in the process of their growth and development. They contain a system of numerical data arranged in a certain age sequence and characterizing the taxation indicators of forest stands in different periods of their life.

In each forest stand, continuous changes occur during its life. Knowledge of the mechanisms of processes that affect the development of a forest stand is of great scientific and practical importance, allowing it to be managed through economic activity. This explains the interest shown in the study of forest stands. The efficiency of forestry production directly depends on the accuracy of the standards used. In this work, the standards (tables of the

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course of growth, assortment and commodity tables) were compiled according to the data of the state forest inventory, which were not previously used for their development. This is the first time that standards have been drawn up using the method mentioned.

The object of the study is Manchurian ash.

2 Literature review

Models of the dynamics of the main taxation indicators growing stands are an integral part of forest inventory and forest management. For more than a century and a half, history of the existence of the growth progress table in Russia since the moment of its publication by A.R. Vargas de Bedemar in 1844 [1] much has changed in methodological approaches and development techniques tables. Vargas de Bedemar's tables were published in the "Forest Journal" in 1846, and in 1847 they were published as a separate brochure in German. Those tables became classics. They differed from similar works of his predecessors, German foresters, in their completeness and in the presentation of detailed data that served as the basis for their compilation; the author compared the results obtained with the results of German studies. The first professor of taxation and forest management V. T. Sobichevsky [2] and other contemporaries of the scientist called this work "the best decoration of Russian forestry literature".

Monitoring of forest ecosystems plays an important role in the development of forest science and is in focus of attention of national and foreign researchers [3, 4]. The most important factor while monitoring of forest ecosystems, the assessment of the forest breeding, environmental and medium stabilizing functions and the reproduction capacity of the preserved forest ecosystems is considered [5].

It is believed that different tree parts are important for manitoring of forest growth, for instance, information on tree height-growth dynamics seems to be essential for optimizing forest management and wood procurement [6].

The problem grew in breadth – as in a geographical sense, and in terms of the emergence of numerous types of tables of the course of growth. Several types of growth tables have been proposed, some of which focus on normal, modal, optimal, mixed density, and others on uneven-aged and other stands, targeted forest growing programs, etc., compiled by various methods and on different classification bases [7, 8, 9].

Currently, there are many manuals and textbooks on the table of the course of forest growth by such authors as: A.Z. Shvidenko, A.N. Fedosimov, V.V. Strakhov and others [10, 11, 12, 13].

The increment estimation methods of forest management were profoundly described in the works of foreign scholars, for instance, T. Gschwantner, A. Lanz, C. Vidal, M. Bosela etc. [14]. This method seems to be promising for harmonization at the European level.

Today the use of the newest methods and techniques of airborne laser location, high resolution digital photography and the global positioning satellite systems became very popular in the field of forest research [15]. Drone laser scanning data allows for the efficient collection of very dense point clouds, creating new opportunities to measure tree and branch architecture [6].

This technology offers significantly new opportunities for remote sensing monitoring and inventory of forest resources. High efficiency of laser location in combination with centimeter spatial resolution of digital aerial photography, high accuracy for coordinate definition of trees' and tree stands' morphostructural parameters by satellite geopositioning systems, as well as three-dimensional visualization of the remote sensing data at geoinformation systems, allows developing effective algorithms for research of forest resources' structure and dynamics, guaranteeing a real time automatic extraction of forest inventory parameters [15].

Also important are different models for predicting the within-tree and regional variation of tree species

Great contribution to the field of forest management was made by such researchers as S.P. Kulizhskiy, E.V. Kallas, A.V. Rodikova and others [16].

According to the opinion of Q.V. Cao "… it is difficult to fit annual tree survival and diameter growth models to data that were measured, not every year, but at some interval" [17, p. 127]. In this case it is important to determine proper methods for obtaining parameter esteems for such a system from periodic measurements.

3 Methodology

This part of the paper pays special attention to the methods employed. The major method when carrying out the research is the analytical one. Here it is necessary to describe data which will have to be analyzed. Together with that method the random sampling method and regression equation are used.

The forest inventory system is an optimized set of methods for collecting, processing and presenting information about forests and forest resources to users, logically, methodically and technologically linked to the objects and purposes of accounting. The goals and expediency of the functioning of the system are determined by its users, many of which, in relation to the applied to inventory forest system, can be divided into two broad groups. One of them includes the professional forestry sector of the country and the forest management system, the second includes various organizations and institutions outside the forestry sector, various public groups and associations (educational, scientific, environmental, cultural, municipal), as well as individual citizens.

The main task of the research is to compile a table of the growth progress for a particular tree species. In order to calculate the table, it is necessary to determine the most typical forest types for the study region. For each type of forest, several test plots are laid, characterizing stands of different ages. In order for plantations to belong to the same natural series of growth and development, trial plots in old plantations must have taxation indicators that younger plantations will achieve after a certain period. Data from trial plots of one natural series are used to obtain the age dynamics of taxation indicators. In this case, both graphical and analytical constructions can be used.

4 Results and discussion

The study of the growth of Manchurian ash plantations using the method of model trees is due to the low share of its participation in the composition of forest stands, as well as the presence of general patterns in the growth of this tree species. The model tree is part of the plantation. According to the model tree, it is possible to restore (reconstruct) changes with the age of taxation indicators, i.e. to study the course of plantation growth. This issue is discussed below.

In the course of the work, the state of trees in the Priamursko-Primorsky coniferous-broad-leaved forest region was analyzed. 61 test plot passports were processed, on which 122 trees were identified. To compile a table of the growth progress, model ash trees without damage were selected.

Permanent trial plots of the state forest inventory are laid out by forest inventory using a random sampling method, belonging to different strata. Currently, a sample is proposed that characterizes the growth of Manchurian ash plantations from young stands to overmature plantations on an area of about a million hectares.

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In order to find the average height and average diameter per 1.3 m of the analyzed stands, plots of height versus age (Figure 1) and diameter per 1.3 m versus age (Figure 2) were constructed using the regression equations presented in Figure 1 and 2 average height and average diameter were determined at a height of 1.3m.

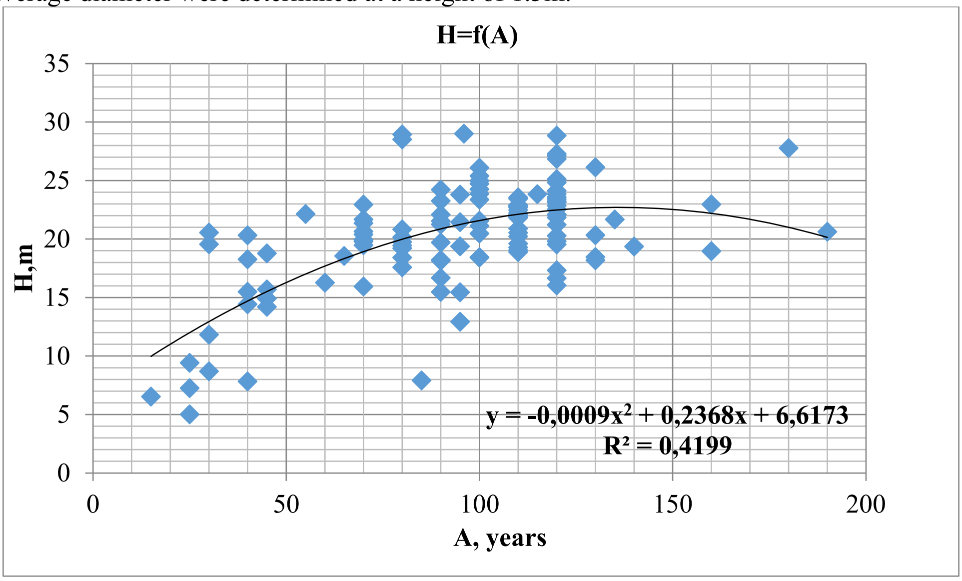

Fig. 1. Graph of height (H) versus age (A) of Manchurian ash.

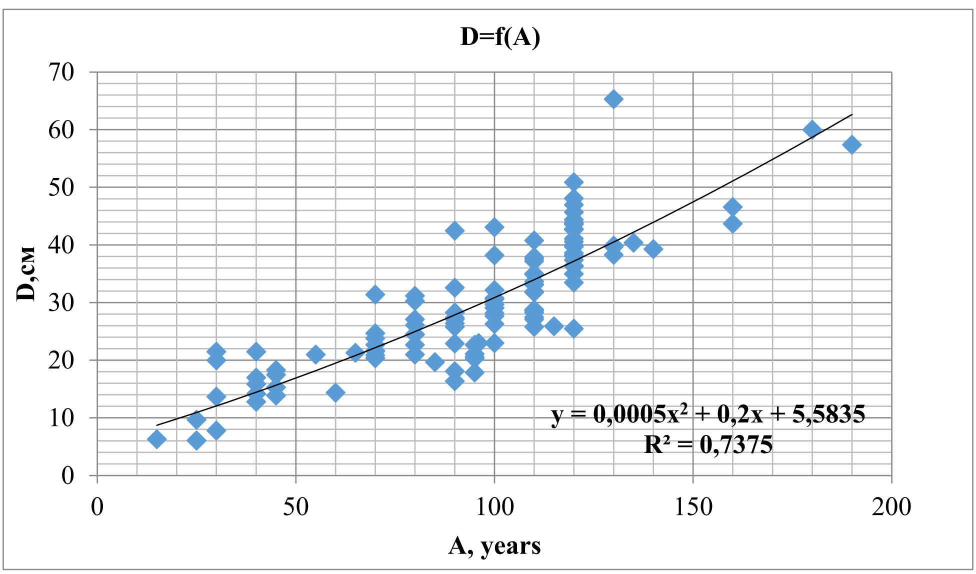

Fig. 2. Graph of diameter (D) versus age (A) of Manchurian ash.

With the help of the obtained regression equations, the calculation of the main taxation indicators was carried out, which are entered in the growth progress table. The table is built on the principle of a digit scale, in which the thickness step is taken as an independent variable, and the remaining indicators are found through regression dependences on diameters. This approach is due to the fact that the diameter most closely correlates with all indicators, including the age of the trees, and in essence, there is not much difference in whether diameter or age is an independent variable. Moreover, the diameter is determined more accurately compared to age. Thus, the average diameter of model trees is taken as an independent variable. Table 1 shows the calculations of heights, species numbers and taxation indicators.

Table 1. Growth table for Manchurian ash growing in the Priamursko-Primorsky coniferous-broad-leaved forest region

A, years	D	H	HF	H/D	N, items	G m³/ha	M, m³/ha	Δ ev, m³/ha	Δ curr, m³/ha	N fall off	G fall off
10	7.9	9.5	5.0	120	3828	19	86	8.56	-	-	-
20	9.9	10.5	5.4	106	2729	21	106	5.29	2.03	1099	5.4
30	11.5	13	6.6	113	2180	23	141	4.71	3.54	549	4.2
40	14.2	14.5	7.4	102	1588	25	175	4.38	3.38	591	6.1
50	16.2	16.5	8.3	102	1304	27	213	4.26	3.77	285	4.5
60	19.5	17	8.6	87	987	29	241	4.01	2.77	316	6.5
70	22	19	9.5	86	824	31	286	4.08	4.50	163	4.9
80	25	20	10	80	680	33	320	4.01	3.49	144	5.5
90	27.5	21	10.5	76	589	35	353	3.92	3.24	91	4.4
100	30.5	22	11	72	505	37	389	3.89	3.64	85	5
110	34	22.2	11	65	429	39	415	3.77	2.55	76	5.5
120	37	22.5	11.2	61	378	41	439	3.65	2.38	51	4.6
130	40.5	22.8	11.3	56	330	42	465	3.58	2.64	48	5.1
140	44	22.7	11.3	52	291	44	483	3.45	1.75	39	5
150	47.7	22.5	11.2	47	258	46	498	3.32	1.55	33	5.1
160	51	22	11	43	233	48	503	3.15	0.55	25	4.4
170	55	21.7	10.8	39	208	50	516	3.03	1.22	25	5.1
180	58.4	21	10.5	36	190	51	514	2.86	-0.14	18	4.3
190	62	20.1	10	32	174	53	507	2.67	-0.71	16	4.4

The final stage is the comparison of the experimental data with the table of stem volumes in the crust by height categories.

5 Conclusion

For the first time, a table of the Manchurian ash growth was developed according to the materials of the state inventory of forests. The table of the progress of growth is built on the principle of a digit scale of volumes and differs from its counterparts in that it is built on model trees, and not on trial plots.

The independent variable is the diameter at a height of 1.3 m. Other indicators are determined by regression dependencies on the diameter.

In the table, calculations are made only for ash, other associated species are assumed, but calculations were not carried out for them.

An analysis of the developed table of the progress of growth allows us to draw several important conclusions:

1) Manchurian ash spent 180 years on the transition from the step of 8 cm to the step of 62 cm.
2) The ratio of height to diameter, which characterizes the proportionality of the growth of linear indicators, indicates that by the age of 60 years, the growth rate in

diameter exceeded the growth rate in height. Ash in the plantation entered the first tier and then only increased the increase in diameter.

The height of the trees from the growth progress table is reduced compared to the ash bit tables. If, with a diameter of 12 cm, the height of an ash tree in the developed table no longer corresponded to the first category, and with a diameter of 20 cm it already belonged to the third category. This pattern of growth of modern ash can be explained by the active growth of deciduous, related species of oak, cedar, linden, maple, and ribbed birch.

This is an occasion to think about improving the existing regulatory framework, because the effectiveness of forestry activities directly depends on the accuracy of existing standards. To do this, it is advisable to use the data of the state forest inventory, as they quite accurately and fully reflect the state of plantations.

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