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# ASSESSMENT METHODOLOGY OF AN OPTIMAL PLAN FOR FOREST FELLING

This article discusses the method of estimating the optimal plan for felling. The paper deals with the following objectives: to study the nature of influence of the productivity of pine tree stands on the felling age (according to the ripeness of economic forests), the calculation of the average increase in the value of wood in accordance with the current forest fees as well as the defining the age at which most cost-effective cutting of stands is achieved. When optimizing the size of the main use it is necessary to distinguish two problems which, because of their relationship and influence on each other, must be addressed comprehensively: the establishment of the optimum cutting age, based on the theory of ripeness of the forest, and the determination of the annual allowable cut, taking into account the age structure of forests. Methods of assessing the losses from the delays in the felling may be used in the calculation of the objective functions based on this value, and to compare different options for the design of the main forest use. The indicators of growth of the pine stands: Baginsky normal stands, Baginsky modal stands, Zagreyev, Miroshnikov, Yurkevich and the tables of growth of economic forests have been taken as the test data.

**Key words:** table of growth, optimality, the main use, cutting age, efficiency, average growth, tree stand.

**Introduction.** Increasing the size of forest management and the size of harvested wood are related to the optimization of the main forest use.

Almost all existing methods of calculating the amount of forest management are based on the theory of normal forest, which is built on the principle of continuous and inexhaustible forest management. According to this theory, the main criteria of are the normal forest: even distribution of plantings according to age classes within the felling rotation, the normal distribution of plantings on the territory of the object, the highest overall average growth of stands, permanent forest income and return on investment.

In general, the main task of optimizing forest exploitation in today's forest management is achieved in two ways:

1) optimization the size of the main use of forests;

2) optimization of forest management planning in the audit period [1].

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At various times, various scientists have developed approaches to optimize the size of the main use. So, S. H. Lyameborshai suggested the approach that the main criterion for optimization is the age of the stand, which is set depending on the required assortment structure of timber.

The model of determining the optimal cutting age of the stand has been designed under the direction of professor A. Z. Shvidenko (A. Z. Shvidenko, S. I. Kashpor et al., 1991). The essence of the proposed model is the simultaneous optimization of management turnover and the size of the main use. A. Z. Shvidenko and S. I. Kashpor took into account the area of plantations of each age class of all business units and areas of cuttings in each management section in the calculation period during the optimization.

V. F. Baginsky points as the main disadvantage of the economic and mathematical models to determine the age and size of the use the application of highly changing indicators: price, prime cost, etc. Their deviation from the accepted values, even at a relatively low value, leads to significantly different results [2].

The aim of the work is to describe the methodology for assessing optimal plan for felling pine stands.

**Main part.** The dynamics of change of taxation parameters is characterized by the age table of plantation growth (TPG). The tables of growth reflect the entire history of the development and growth of plantings of different species and different productivity. Comparing the data in these tables, one can imagine how this or that planting will look in a certain age. The ability to determine the history of the plantings on the TPG is widely used in forestry. These tables are of great importance in the planning of forestry and forest inventory.

The indicators of growth of the pine stands: V. F. Baginsky normal stands (1 variant), V. F. Baginsky modal stands (TPG, 2 variant), V. V. Zagreyev (3 variant), V. S. Miroshnikov (4 variant), I. D. Yurkevich (5 variant) and the tables of growth of economic forests (6 variant) have been taken as the test data.

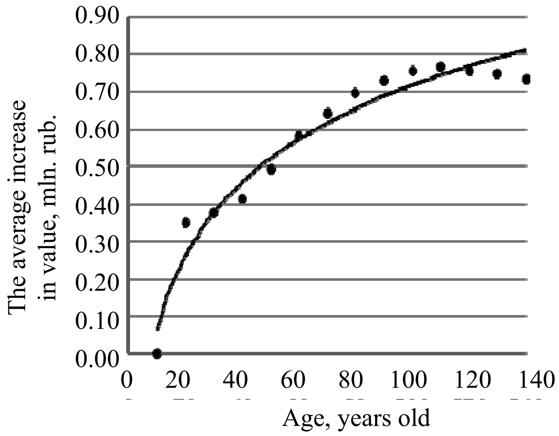
1–4 variants of the TPG are based on the construction of the quality class (yield), and the 5th and 6th versions – according to the forest types.

Using the data from each of the tables of growth, as well as the commodity tables that are used to commoditization of forest fund, the output of large, medium and small-scale commercial timber and firewood has been defined by multiplying the percentage of the output of timber on the growing stock. For the purposes of the experiment, all the data from the commodity tables were taken for the 1st class of marketability.

According to the current forest fees of Belarus the cost of large, medium and small-scale commercial timber and firewood by the age for the 1st category of forest fees (the cost of 1 $m^3$ of large commercial timber of pine is 198,210 rub., the medium commercial – 114,140 rub., small commercial – 50,650 rub., firewood – 1,070 rub.) was calculated. Summing up the cost of large, medium and small-scale commercial timber and firewood, the total cost of wood at a certain age was obtained.

Then, the total increase was received by the average value of pine wood, which is the ratio of the total value of the wood to the age.

In order to visualize the results obtained for each of the TPG, we have made the charts of the dependence of the total increase in the average value upon the age. The Figure below shows an example of the chart obtained according to the TPG of V. F. Baginsky normal stands.




The graph of dependence of the average increase in the cost of wood on the age according to the data of the TPG Baginsky normal stands

For further analysis, a summary table has been made, which includes three values of the total growth in the average value (the lower and upper boundaries of the age of final felling of pine stands of the 2nd group of forests, as well as the maximum increase in the average value), depending on the age and yield class.

**The cost of the average increase, mln. rub.**

| Pine forest stand | | Yield class Ia | I | II | III | IV | V |
|---|---|---|---|---|---|---|---|
| 1 variant | At the age of 80 | 0.94 | 0.70 | 0.510 | 0.37 | 0.24 | 0.150 |
| | At the age of 120 | 0.95 | 0.76 | 0.577 | 0.44 | 0.31 | 0.210 |
| | Maximum cost | 0.98 | 0.77 | 0.578 | 0.45 | 0.32 | 0.221 |
| | Age of achieving the maximum, years old | 100 | 110 | 130 | 130 | 130 | 130 |
| 2 variant | At the age of 80 | 0.70 | 0.54 | 0.38 | 0.27 | 0.18 | – |
| | At the age of 120 | 0.76 | 0.47 | 0.36 | 0.28 | 0.20 | |
| | Maximum cost | 0.77 | 0.54 | 0.39 | 0.29 | 0.20 | |
| | Age of achieving the maximum, years old | 70 | 80 | 100 | 100 | 110 | |
| 3 variant | At the age of 80 | 1.13 | 0.807 | 0.54 | 0.34 | 0.19 | 0.12 |
| | At the age of 120 | 1.00 | 0.790 | 0.57 | 0.39 | 0.24 | 0.13 |
| | Maximum cost | 1.13 | 0.828 | 0.58 | 0.39 | 0.24 | 0.14 |
| | Age of achieving the maximum, years old | 80 | 90 | 100 | 120 | 120 | 140 |
| 4 variant | At the age of 80 | 0.849 | 0.63 | 0.45 | 0.29 | – | – |
| | At the age of 120 | 0.840 | 0.66 | 0.49 | 0.33 | | |
| | Maximum cost | 0.853 | 0.66 | 0.49 | 0.33 | | |
| | Age of achieving the maximum, years old | 90 | 90 | 100 | 100 | | |

| Pine forest stand | | Forest type sour | bill-berry | long moss | fern | heathy | cow-berry | moss | lichen |
|---|---|---|---|---|---|---|---|---|---|
| 5 variant | At the age of 80 | 0.829 | 0.62 | 0.352 | 0.130 | 0.36 | 0.49 | 0.58 | 0.19 |
| | At the age of 120 | 0.740 | 0.56 | 0.320 | 0.090 | 0.31 | 0.41 | 0.50 | 0.17 |
| | Maximum cost | 0.830 | 0.63 | 0.352 | 0.164 | 0.37 | 0.49 | 0.59 | 0.20 |
| | Age of achieving the maximum, years old | 70 | 70 | 80 | 40 | 70 | 80 | 70 | 70 |
| 6 variant | At the age of 80 | 0.53 | 0.40 | 0.272 | 0.110 | – | – | – | – |
| | At the age of 120 | 0.43 | 0.33 | 0.250 | 0.134 | | | | |
| | Maximum cost | 0.54 | 0.40 | 0.273 | 0.135 | | | | |
| | Age of achieving the maximum, years old | 70 | 80 | 90 | 110 | | | | |

Analyzing the data in the table, we can conclude that the increase in the average cost (economic ripeness) depends on the productivity of forest stands: the higher the yield class and better growing conditions, the lower the age of the economic maturity of pine forest stands. With the deterioration of habitat conditions, respectively, the average growth of the total cost of the wood decreases and the age of the economic maturity increases. This trend is observed in all the examples we have considered. The results depend directly on the existing forest fees in our country.

The data of the TPG of Baginsky modal tree stand will be taken into account as further research because they most closely describe the dynamics of data changes.

To evaluate the effectiveness of the cuttings it isnecessary to identify the losses that may be incurred by forestry because of the untimely cutting of forest stands. To do this, we need to take two values: the maximum growth of the average cost $P^{\text{av, max}}$, and the average increase in the value at the age of felling the tree stand $P^{\text{av}, A_P}$ which can be found by the formula

$$P^{\text{av}, A_P} = \frac{P^{A80} + P^{A120}}{2}, \qquad (1)$$

where $P^{A80}$ and $P^{A120}$ – growth in cost in the lower and upper boundary of the cutting age.

Thus, the amount of losses caused by the deviation of the age of felling of the forest stand $A_P$ from the age $A_{\max}$ in which the maximum increase of the average cost reaches the maximum, is calculated by the

$$A_P(P^{\text{av, max}} - P^{\text{av}, A_P}), \qquad (2)$$

where $P^{\text{av, max}}$ – maximum increase of the average cost of the forest stand; $P^{\text{av}, A_P}$ – total increase in the cost of the age of felling forest stand [3].

Thus, based on the above considerations, the algorithm of estimating the losses from the delays in collectingforest stands for felling, can be summarized as follows:

1. Choose regulatory materials (tables of growth, commodity table).
2. Determine the output of timber according to the size categories for all ages, presented in the tables of growth, where possible, and for the age $A_P$ in which it is cut.
3. Calculate the total increase in the average cost for all ages.
4. Find age $A_m$, where the maximum growth of the average cost is the most important from the calculated values.
5. Determine the value of the maximum growth of the average cost $P_i^{\text{av, max}}$.
6. Calculate the amount of losses by the formula (2).

**Conclusion.** The paper describes the method of estimating the optimal plan for felling of pine forest stands. Having studied the character of the productivity effect of the pine forest stands on the age of felling it was possible to calculate the average increase in the value of timber on the basis of existing forest fees in our country. There was also determined the age at which the highest cost-effectiveness of cutting of pine stands is achieved. From the data obtainedit was concluded that the increase in the average cost depends on the productivity of forest stands: the higher the site class and better growing conditions, the lower the age of the economic maturity of pine stands. Accordingly, with the deterioration of habitat conditions there occur a decrease in the average growth of the total value of timber and an increase of the age of the economic maturity.

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