Application of unmanned aircraft vehicles and techniques ground laser scanning for measurement of dimensional and quality indicators of tree stand

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Abstract. Currently, the use of measuring methods and laser scanning tools is one of the most relevant and priority areas for solving the problems of monitoring and evaluation of forest plantations. Such measurement can be performed independently or in combination with aerial video shooting, and can also be carried out by ground-based studies on test areas. According to a number of indicators, laser scanning surpasses others known today, such as aerial photography, earth sounding, etc., remote methods for assessing the qualitative and quantitative characteristics of the forest fund. The use of aerial and ground-based monitoring of forest areas with the use of lasers makes it possible to achieve high accuracy in determining the main forest taxational parameters. It is advisable to use the formed methodological principles and techniques when developing specific methods for determining indicators as separate factors determining the appropriate types of forest accessibility.

1 Introduction

To assess and account for the indicators of the stand, taxation indicators have been developed, which are reflected in a number of tables: sorting and commodity tables (Anuchin), tables of the course of the growth of plantations (Zagreev), a bonus scale (Orlov) [1-3], etc. These indicators determine the distribution of the forest fund by age classes, bonus classes, completeness, types of forest, average diameter of the stand, average height and distribution of reserves by quality classes. Forestry and taxation characteristics of plantings consists of the general characteristics of forests of forestry institutions for which the planned measures are being developed, characteristics and analysis of plantings on trial areas laid down to assess the effectiveness of measures (technologies), their impact on the growth, development and productivity of plantings, etc. The general characteristic

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includes an analysis of species, typological, age, complete structure of the considered part (or all) forests of the forestry and other indicators.

Also, previously developed methods for determining these indicators, methods of taxation, accounting, logging, are regulated by such documents as TCP 622-2018 "Technical requirements for forest management. Allotment and taxation of cutting areas in the forests of the Republic of Belarus", rules for allotment and taxation of cutting areas, sanitary rules, including with the use of information systems and technologies in the ARM "Forest Management" [4-6]. They include tables based on previously conducted experimental studies that allow for the removal and taxation of cutting areas, evaluation of stand indicators, etc. The complex of taxational indicators effectively displays the characteristics of stands and allows planning forestry activities.

Based on the above, it can be concluded that at present there are a sufficient number of different methods for determining the indicators of the stand, which have their own characteristics.

However, in order to organize the planning of logging by machine methods, taking into account the availability of the stand, in addition to the available indicators, it is necessary to have data on the distribution of trees in the stand, as well as more detailed dimensional and qualitative indicators, taking into account the location of trees.

In this regard, the aim of this work is to investigate the applicability of UAVs and NLS for measuring the dimensional and qualitative indicators of a stand.

Table 1. Setting Word's margins.

Margin	mm
Top	24
Bottom	16
Left	20
Right	20

2 Results and discussion

Currently, when assessing the availability of a stand, it is assumed that trees grow according to the law of normal distribution. If this may be enough for planning work on solid cabins, then this is a controversial point in the care of machine complexes and requires a more detailed study [7].

The distribution of stand indicators may depend on various factors, and therefore, in order to establish a more accurate pattern, it is necessary to carry out a large number of measurements (Figure 1).

Based on this, in order to reduce labor costs, these changes are proposed to be carried out using unmanned aerial vehicles (drones) and ground-based laser scanning methods [8].

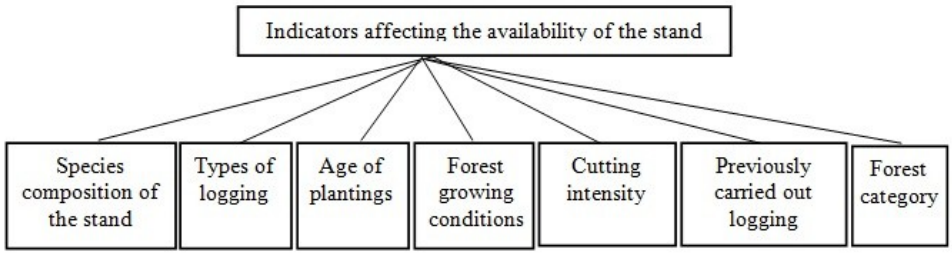

Fig. 1. Indicators affecting the availability of the stand.

Recently, the technology of the radar is increasingly used to solve problems in forestry [9-11]. It is an active filming method that works analogously to aerial laser scanning, but from static positions [12]. The principle of operation of the NLS is to obtain three-dimensional models of the investigated area of the forest fund. The technology is based on radiation-the reception of a laser beam that is deflected by a grain and automatically scans the area, while the laser is reflected from the first object encountered. As a result of shooting with a laser scanner, several point clouds are obtained. In order to measure an object completely and get accurate results, it needs to be scanned from all sides. The main form of presenting the results of ground-based laser scanning is an array (cloud) of points. The result of the work of the NLS is a three-dimensional model of the plantation site, which is described by a set of points with spatial coordinates X, Y, Z. With the help of ground-based laser scanners, the main forest taxational characteristics are determined: the species (species) composition of the forest fund, the diameters of the tree trunk at any height, the height of trees, the main defects of wood, the cross-sectional area, the total sorting and sorting stock of wood [13-17]. Today, NSLS from manufacturers such as RIEGL (Austria), Leica (Sweden), Trimble (USA), etc. are being produced. The principle of operation of ground-based laser scanners is shown in Figure 2.

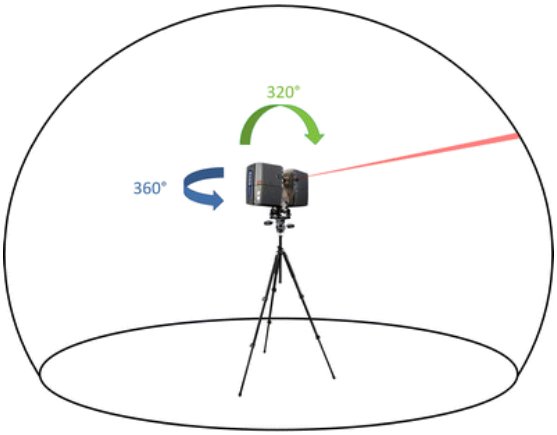

Fig. 2. The principle of operation of a ground-based laser scanner.

Machine-assisted felling requires a qualitative approach to the organization of work, selection and use of machines in order to minimize damage to the stand, while ensuring the necessary removal of the worst trees to ensure accurate and high-quality performance of care felling [18].

A method for measuring the size and quality indicators of a stand based on the use of UAVs and radar is proposed. The work is as follows: a plot (allotment) is allocated on the plot, where temporary test sites (runways) will be laid (the size of the test area depends on the breed, age of the plantings, completeness and growth conditions). After that, ground-based laser scanners are installed according to the diameter of the test area, which evaluate and fix the stand by measuring various geometric parameters (distances, angles, diameters, radii of curvature, etc.). Especially important is the fact that the RADAR systems allow for high-precision measurements of remote objects at a previously unknown speed. The radar allows scanning up to 976,000 points/sec at a distance of up to 153 m with the following angles of field of view: vertical – up to 320°, horizontal – 360°. At the same time, the value of the angular step of scanning can reach 0.01°, with an accuracy of measuring angles of 0.009°. The resolution of the measuring unit is 0.07 mm [19-20]. Next, the drone is launched over the site so that it takes a picture of the test area from above. After that, the

drone's indicators are combined and compared with laser scanners and data is processed in software (software). After the initial processing of the scan data, vector models are constructed (Figure 3). The vector data obtained are transferred to three-dimensional vector graphics programs such as AutoCAD, ArcView and others.

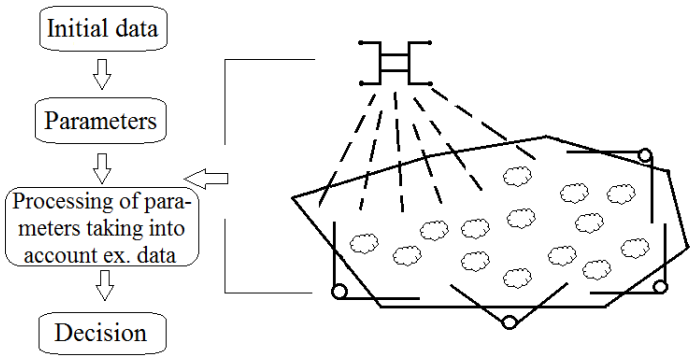

Fig. 3. Method of measuring the size and quality indicators of a stand.

This method will allow you to more accurately and qualitatively obtain dimensional and qualitative indicators of forest plantations, which will affect the availability of the stand. In further studies, it is planned to test this method taking into account the above indicators.

To control the data, individual plots can be checked by standard taxation methods, after which the measured indicators are compared.

3 Conclusion

When establishing the taxation indicators of plantings, it is recommended to apply the method proposed in this article for measuring the dimensional and qualitative indicators of the tree using UAVs and ground-based laser scanning methods. To solve the problems of forest management, the implementation of various types of monitoring, modeling of the dynamics of the forest stand, the most promising method of assessing forest stands is a radar in combination with aerial survey of UAVs integrated into geoinformation systems. The use of methods and means of aerial and aerial forest cover will significantly improve the efficiency and accuracy of determining the main forest taxational indicators of forest plantations in assessing the qualitative and quantitative characteristics of the forest fund.

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