ASSESSMENT ALGORITHM FOR IN THE COPPICE OAK FORESTS OF THE SOUTHWEST CENTRAL RUSSIAN UPLAND

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Article Information

Editor(s):
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Reviewers:
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(2) Erayya, Bihar Agricultural University, India.

Received: 02 June 2020
Accepted: 07 August 2020
Published: 15 August 2020

Original Research Article

ABSTRACT

The object of research was the wood-destroying fungus *Laetiporus sulphureus* (Bull.) Murrill from the community of pathogenic *Polyporaceae* growing on oak *Quercus robur* L. It is known that the immature fruiting bodies of *Laetiporus sulphureus* living on deciduous trees have nutritional and medicinal value. The subject of research is the development of an algorithm for assessing the yield and stock of *Laetiporus sulphureus*. Experimental studies were conducted in 2010−2018 in the coppice oak forests of the southwest of the Central Russian Upland. The studies were conducted in 2010−2018 in the oak forests of the southwest of the Central Russian Upland and a field survey is conducted. As a result of statistical processing of the obtained experimental material, the prevalence models of *Laetiporus sulphureus* on different types of oak substrate are proposed. The models served as the basis for an assessment algorithm for the yield and stock of *Laetiporus sulphureus*. The researchers estimate the area occupied by 100 oak trees in the stand, correlate it with an area of 1 ha to recalculate the number of oak trees and tree units of oak (dead wood, windbreak, stumps) with fruit bodies of *L. sulphureus* (the number of fruit bodies of *L. sulphureus*) per 1 ha in the first half year.

Keywords: Assessment algorithm; yield; *Laetiporus sulphureus;* fruit body; *Quercus robur;* coppice oak forests; Central Russian Upland.

INTRODUCTION

One of the measures the concept of multi-purpose forest management involves is the rational use of fungus resources [1,2,3,4,5,6,7]. Primarily - the resources of traditional symbiotrophic fungi. To assess their productivity (yield) assessment the current methods and models have been developed and optimized [1,2,3,6]. In this case, the yield is assessed on the basis of tabular data or statistical models. The tabular data are systematized long-term average yields of commercial fungus species obtained at experimental sites in different forest growing zones, different forest growing conditions and forest types. Statistical models are statistical (regression) relationships of yield and productivity influencing factors (forest conditions, rainfall during the fruiting period), approximated by some functional relationships.

Tree-destroying fungi associated with a forest-forming species, which often form their fruiting bodies with nutritional and medicinal value, can also be of significant importance as a forest biological resource. The resource value of these fungi, at least in the Russia, in our opinion, is low. This study is intended to arouse interest in assessing the bioresource potential of tree-destructive *Polyporaceae* species confined to pedunculate oak *Quercus robur.* The objective of research was to develop an assessment algorithm for the yield and stock of *Laetiporus sulphureus* in oak stands of oak forests of the southwest of the Central Russian Upland. The tasks were as follows: 1. Identify the statistical patterns of the prevalence of *L. sulphureus*. 2. Develop statistical models of the prevalence of *L. sulphureus* on different types of oak substrate (vegetative trees, dead wood and windbreak, stumps). 3. Develop an assessment algorithm for the yield and stock of *L. sulphureus*.

MATERIALS AND METHOD

The studies were conducted in 2010−2018 in the oak forests of the southwest of the Central Russian Upland. The research area is limited latitudinally by parallels 50°20’ and 50°86'N.; longitudinally by meridians 36°01’ and 38°16'E. The object of the study was the wood-destroying fungus Laetiporus sulphureus (Bull.) and a field survey is conducted. For this purpose, a typical oak stand is chosen in a specific oak forest. The researchers write the date of the survey, the name of the tract, quarter, and plot in the field notebook. They indicate forest conditions and the composition of the forest stand, choose a route and enumerate continuously 180-200 live oak trees in the route strip, considering - separately - oak trees with knotted hollows and damages, with dry fused trunks and with broken trunks, and also - separately - oak trees only with trunk hollows and damaged trunks.

RESULTS AND DISCUSSION

Introductory Remarks

L. sulphureus is a basidiotic wood-destroying fungus from the ecotrophic group of saprotrophic pathogens. It grows both on living (vegetative) trees, and on dry, windbreak and stumps of oak. The yield and stock of this fungus depends on its prevalence (occurrence) on the oak substrate. The prevalence (occurrence) in vegetating trees differs from that in dry, windbreak and stumps; therefore, the prevalence (occurrence) of *L. sulphureus* for different substrate categories should be considered: Separately for the growing part of the forest stand, for dead wood and windbreak, and for oak stumps.

We should note that *L. sulphureus* forms fruits two times a year: in May-June (1st half of the year) and August-September (2nd half of the year). The algorithm presented below, which relates to the assessment of the prevalence, yield, and stock of *L. sulphureus,* was developed according to the results of field studies carried out in August-September. Therefore, one-half-year period of study is analyzed instead of one year.

The prevalence of *L. sulphureus* on living oak trees is found by the following formula [8,9].

$$y = -0.213 + 0.041x_1 + 0.896x_2 \qquad (1.1)$$

where y is the prevalence of *L. sulphureus* by the share of affected oak trees (i.e., y is the share of oak trees with fruit bodies of *L. sulphureus*), %; x_1 - the occurrence (share) of oak trees with butt root hollows and damages, with dry fused trunks and with broken trunks, %; x_2 - the occurrence (share) of oak trees with trunk hollows and damaged trunks, %.

This is a mathematical expression of the obtained determinate probability statistical (regression) prevalence model of *L. sulphureus* on growing oak trees in coppice oak forests of the southwest of the Central Russian Upland. The calculated value of multiple correlation coefficient between y and x_1, x_2: $r = 0.791$ (Student's t-test $t_{exp} = 4.463$, critical value of Student's t-test $t_{st} = 2.179$, number of degrees of freedom $k = 12$; probability of incorrect estimation $p = 0.05$) [8,10].

By substituting the known value of the dependent variables x_1, x_2 into formula (1.1), we calculate the independent variable *y*, i.e., the share of oak trees with *L. sulphureus* fruiting bodies formed with a probability p = 0.05. Multiplying the obtained value by 100, we get the number of oak trees with the fruiting bodies of *L. sulphureus* (or the number of fruiting bodies of *L. sulphureus*) per 100 oak trees in the stand. Estimating the area occupied by 100 oak trees in the stand, we correlate it with an area of 1 ha and recalculate the number of oak trees with fruit bodies of *L. sulphureus* (the number of fruit bodies of *L. sulphureus*) per 1 ha. As a result, the yield of fungi on living oaks is obtained: the number of fruiting bodies (pcs.) per 1 ha in 1 half-year (pcs. × ha-1 × ½ year^{-1}).

In addition, the yield of fungi is assessed on dry forest stand, windbreak and stumps. The assessment is based on the statistical relationships established as a result of field surveys [8]. The essence of these relations is as follows. The stand usually has on average eight times less dry and windbreak oak trees than vegetative trees, and the prevalence of pathogenic *Polyporaceae* on them is 2.8 times higher on average. Stumps are found on average 9.6 times less than vegetative trees, and the prevalence of pathogenic *Polyporaceae* on them is 4.8 times higher on average. Considering that the occurrence of fruiting bodies of *L. sulphureus* among other pathogenic *Polyporaceae* on oak is on average about 26% [8], then the prevalence and yield of *L. sulphureus* on dry and windbreak will be the next share of the prevalence and yield on vegetating trees: (2.8/8.0) ×0.26 = 0.09. The prevalence and yield of *L. sulphureus* on oak stumps will be the following share of the prevalence and yield on vegetative trees: (4.8/9.6) ×0.26 = 0.13.

As a result, the yield is estimated as the sum of the yields on vegetating trees, dry and windbreak, and oak stumps.

The studies did not involve measurement of the average weight of the fruiting bodies of *L. sulphureus*, but the relevant preliminary information is available in open sources, and thus, the yield of *L. sulphureus* can be estimated in kg per 1 ha. More accurate data on the yield of *L. sulphureus* in kg/ha can be obtained empirically by weighing mature fruit bodies discovered during fruiting (August-September) and determining the average weight of the fruiting body.

We should note that the statistical model described by mathematical expression (1.1) is built on the basis of a series of experimental data taken in the studied stands in the seasons 2012–2013, when the amount of precipitation during the fruiting period – July-August – exceeded the average annual rate. Thus, it should be assumed that the model expressed by formula (1.1) is designed to assess the potential (established biological) yield of *L. sulphureus.*

Yield is estimated for different stands in the composition of oak forest. The stock of *L. sulphureus* in this oak grove is defined as the product of average yield and the area occupied by this oak forest.

Assessment Algorithm

A field survey is conducted. For this purpose, a typical oak stand is chosen in a specific oak forest. The researchers write the date of the survey, the name of the tract, quarter, and plot in the field notebook. They indicate forest conditions and the composition of the forest stand, choose a route and enumerate continuously 180-200 live oak trees in the route strip, considering - separately - oak trees with knotted hollows and damages, with dry fused trunks and with broken trunks, and also - separately - oak trees only with trunk hollows and damaged trunks.

Depending on the area of the oak forest massif and the heterogeneity of the oak stands in its composition, such experienced stands differing in the state of the butt of the oak trees and the near-butt zone can be selected from 1 (oak forest outliers) to 10 or more (large oak forests).

According to the data of field surveys, each experimental stand requires to find x_1 - share of oak trees with butt root hollows and damages, with dry fused trunks and with broken trunks, %; x_2 - share of oak trees with trunk hollows and damaged trunks, %.

Using formula (1.1), we calculate *y*, i.e., the share of oak trees, on which *L. sulphureus* fruiting bodies may form. Multiplying the obtained value by 100, we get the number of oak trees with the possible (p=0.05) fruiting bodies of *L. sulphureus* (or the number of fruiting bodies of *L. sulphureus*) per 100 oak trees in the stand, i.e. yield per 100 living oak trees in the stand:

$$U_{(100)1} = 100y \quad (2.1)$$

2.4. Using the previously obtained statistical ratios (paragraph 1. Introductory remarks), we assess yield on dead wood and windbreak, which are found together with 100 vegetative oak trees in the stand:

$$U_{(100)2} = 100 \times 0.09y = 9y \quad (2.2)$$

And on the oak stumps:

$$U_{(100)3} = 100 \times 0.13y = 13y \quad (2.3)$$

Summing up the yield on different substrates, the final yield is obtained (the number of fruiting bodies (pcs.) of *L. sulphureus* per 100 vegetating trees, the accompanying number of dead trees and windbreak trees, the corresponding number of stumps):

$$U_{(100)} = U_{(100)1} + U_{(100)2} + U_{(100)3} = 100y + 9y + 13y = 121y \quad (2.4)$$

The researchers estimate the area occupied by 100 oak trees in the stand, correlate it with an area of 1 ha to recalculate the number of oak trees and tree units of oak (dead wood, windbreak, stumps) with fruit bodies of *L. sulphureus* (the number of fruit bodies of *L. sulphureus*) per 1 ha in the first half year. As a result, the yield of fungi on living oaks is obtained: the number of fruiting bodies (pcs.) per 1 ha in 1 half-year (pcs. × ha-1 × ½ year^{-1}):

$$U_{(1\ ha)} = 121y \times n \quad (2.5)$$

where n is the number of plots with 100 oak trees in the composition of a forest area of 1 ha.

The researchers recalculate the yield of *L. sulphureus* in kg per 1 ha in 1 half year (kg × ha^{-1} × ½ year^{-1}):

$$U_{(1\ ha)} = 121y \times n \times m_{cp} \quad (2.6)$$

where m_{av} is the average weight of the fruiting body (kg).

The researchers assess the stock (resource) based on the average yield (U_{avg}, kg × ha^{-1} × ½ year^{-1}) (considering the occurrence of sites with some yield) and the area of the oak forest mass (S, ha):

$$P = U_{avg} \times S\ (kg \times ha^{-1}\ ½\ year^{-1}) \quad (2.7)$$

Based on the available facts [11] we can state that the yield of *L. sulphureus* is comparable in the first and second half of the year, and assess the yield in terms of 1 year (kg × ha^{-1} × year^{-1}) as follows:

$$2U_{(1\ ha)} = 2 \times 121y \times n \times m_{avg} \quad (2.8)$$

where m_{av} is the average weight of the fruiting body (kg).

And the stock (resource) of *L. sulphureus* based on the average yield ($2U_{avg}$, kg × ha^{-1} × year^{-1}) (considering the occurrence of sites with some yield) and the area of the oak forest mass (S, ha):

$$2P = 2U_{avg} \times S\ (kg \times year^{-1}) \quad (2.9)$$

We should note that the formula (1.1) is obtained on the basis of a series of experimental data taken in the studied stands in the seasons 2012–2013, when the amount of precipitation during the fruiting period – July-August – exceeded the average annual rate. Therefore, it should be assumed that the algorithm based on the relationship (1.1) is designed to assess the potential yield (established biological yield) and, accordingly, the biological stock of *L. sulphureus*. The relationship between the fruiting of *L. sulphureus* and the amount of precipitation has not been studied.

CONCLUSION

Statistical patterns of the prevalence of *Laetiporus sulphureus* have been identified. Statistical models of the prevalence of *L. sulphureus* on different types of oak substrates (vegetative trees, dead trees and windbreaks, stumps) have been developed. An assessment algorithm for the yield and stock of *L. sulphureus* in the overgrown oak forests of the southwest of the Central Russian Upland has been developed.

The research was carried out with the financial support of the Ministry of science and higher education of the Russian Federation (agreement № 075-15-2020-528).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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