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Research Article

Assessment and Forecasting of Phytosanitary Risks in the Forests of the Irkutsk Region

Svetlana S. Timofeeva[1] ✉, **Semen V. Tenchikov**[1,2], **Semen S. Timofeev**[1]
[1] Irkutsk National Research Technical University, Irkutsk, Russian Federation
[2] Department of Phytosanitary Control in the Irkutsk Region of the Federal Service for Veterinary and Phytosanitary Supervision in the Irkutsk Region and the Republic of Buryatia, Irkutsk, Russian Federation
✉ sstimofeeva@mail.ru

EDN: VCFCDM

Abstract

Introduction. Timber export plays a significant role in the budget of the Irkutsk region. To ensure the continued and sustainable use of forest resources, it is essential to implement preventive measures for forest conservation. One such measure is the analysis of phytosanitary risk, which helps to identify potentially harmful insects and determine the likelihood of their introduction and spread, as well as the potential economic consequences. From the perspective of applied riskology, it is necessary to carry out a predictive assessment, calculate the acceptability of risks and develop methods for managing them, combining economic and monitoring approaches. The aim of the presented work was to assess and predict phytosanitary risks in the Irkutsk region and potential damage to forestry and the economy, as well as to develop measures to reduce them.

Materials and Methods. For this analysis, we used the results of forest surveys conducted in the Irkutsk region in 2021–2023 with the participation of the authors of this article. These surveys included the identification and detection of harmful insects, as well as the determination of their distribution areas according to GOST 34 309–2017 and the methodology approved by the phytosanitary control authority. Additionally, data from official statistics from the Federal Customs Service of Russia for 2021–2023 were used.

Results. We found populations of quarantine pests listed in the Unified List of Quarantine Objects of the Eurasian Economic Union in the forests of Ust-Ilimsky district, such as *Monochamus sutor, Monochamus sartor, Monochamus galloprovincialis, Dendrolimus superans*. We calculated the phytosanitary risk and assessed the quarantine phytosanitary zone, taking into account the buffer zone.

Discussion and Conclusion. The results of the analysis suggest an unfavorable phytosanitary situation in the studied areas. The high infestation of the detected harmful insects in the Ust-Ilimsky district compared to the reference areas indicates the potential for quarantine zones and losses for loggers. To manage phytosanitary risks, it is important to select options that are effective in reducing the spread of quarantine organisms and minimizing risks to an acceptable level. Sanitary logging with timely removal of wind-damaged and fire-affected trees, as well as the use of pheromone traps and biological products, are environmentally friendly options for managing phytosanitary risks.

Keywords: coniferous trees, pests, insects, death, forest diseases, lesions, phytosanitary risk, quarantine zone

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Научная статья

Оценка и прогнозирование фитосанитарных рисков в лесах Иркутской области

С.С. Тимофеева[1] ✉, **С.В. Тенчиков**[1, 2], **С.С. Тимофеев**[1]

[1] Иркутский национальный исследовательский технический университет, г. Иркутск, Российская Федерация

[2] Отдел фитосанитарного контроля по Иркутской области Управления Федеральной службы по ветеринарному и фитосанитарному надзору по Иркутской области и Республики Бурятия, г. Иркутск, Российская Федерация

✉ sstimofeeva@mail.ru

Аннотация

Введение. Экспорт древесины вносит существенный вклад в бюджет Иркутской области, что требует обеспечения сохранения и воспроизводства леса. Одним из важнейших направлений профилактической деятельности по сохранению лесов является анализ фитосанитарного риска. С его помощью устанавливают, являются ли бесконтрольно размножающиеся насекомые вредными, какова вероятность их интродукции, распространения, а также величина экономических последствий. С позиции современной прикладной техносферной рискологии необходимо осуществлять прогнозную оценку, просчитывать приемлемость рисков и разрабатывать методы управления ими, сочетающими экономические и мониторинговые подходы. Целью представленной работы явилась оценка и прогнозирование фитосанитарных рисков на территории Иркутской области и потенциального ущерба лесному хозяйству и экономике, а также разработка мероприятий по их снижению.

Материалы и методы. Для анализа использовали результаты обследований лесных массивов Иркутской области, проведенных в 2021–2023 годах, проведенных с участием авторов данной статьи. Они включали в себя выявление и идентификацию вредоносных насекомых, а также определение площади их распространения по ГОСТ 34309–2017 и методике, согласованной органом фитосанитарного контроля. Помимо этого, использованы данные официальной статистики Федеральной таможенной службы России за 2021–2023 г[1].

Результаты исследования. В лесничествах Усть-Илимского района были обнаружены популяции карантинных вредных организмов, включенные в Единый перечень карантинных объектов Евразийского экономического союза, такие как: малый чёрный еловый усач, большой чёрный еловый усач, чёрный сосновый усач, сибирский шелкопряд. Рассчитан фитосанитарный риск и оценена карантинная фитосанитарная зона с учетом буферной зоны.

Обсуждение и заключение. Результаты проведенного анализа свидетельствуют о неблагоприятной фитосанитарной обстановке на изученных территориях. Выраженная зараженность по выявленным вредным насекомым в Усть-Илимском районе, по сравнению с территориями, взятыми для сравнения, позволяет спрогнозировать карантинные зоны и возможные потери лесозаготовителей. Варианты управления фитосанитарными рисками следует выбирать, исходя из их эффективности в уменьшении скорости распространения карантинных организмов и снижении рисков до приемлемого уровня. Наиболее экологически целесообразным вариантом управления фитосанитарными рисками являются санитарные рубки со своевременной уборкой ветровала и поврежденных пожаром деревьев, установка феромонных ловушек, обработка биопрепаратами.

Ключевые слова: хвойные деревья, вредители, насекомые, гибель, болезни леса, очаги поражения, фитосанитарный риск, карантинная зона

Благодарности. Авторы выражают признательность сотрудникам фитосанитарного контроля и таможенной службы за проявленный интерес к обсуждаемой теме и благодарят редакционную коллегию журнала и рецензента за профессиональный анализ и рекомендации для корректировки статьи.

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Introduction. The condition of forest vegetation in the Irkutsk Region is negatively affected by the presence of needle-eating insects and other harmful pests. Their reproduction can lead to the death and desiccation of trees, causing significant economic losses for forest users. These losses depend on various factors, including species composition of forests, physiological state of trees, the area where the pests are reproducing, their species, population density, and weather conditions. Factors that can negatively impact forests include economically dangerous insects, phytopathogenic viruses and fungi, fires, windfall, droughts, floods, industrial emissions, recreational activities, and others [1].

[1] *Customs statistics. Federal Customs Service.* URL: https://customs.gov.ru/statistic (accessed: 20.02.2024). (In Russ.).

Earlier, the authors have analyzed the environmental risks associated with forest fires in the Baikal region and proposed measures to manage them [2, 3]. They have also addressed the risks of flooding in the region [4]. In addition to fires and floods, significant damage to forests in the region is also caused by the emergence, uncontrolled reproduction, and spread of harmful organisms. It is essential to carry out a quantitative assessment of risks and threats to forest health in these areas, as well as develop and implement measures to manage these phytosanitary risks.

The procedure for analyzing phytosanitary risks, in accordance with international and Russian standards, is the process of determining the level of penetration and spread of harmful organisms in the Russian Federation and related possible consequences [5, 6]. The list of quarantined harmful organisms is determined by federal law, specifically the "On Plant Quarantine" law[2], which came into effect on January 1, 2019. (GOST 34 309-2017[3]).

Regulatory legal acts, including sectoral ones[4], regulate the requirements for the procedure and criteria for assessing phytosanitary risks. These risks are based on a point assessment of the probability of penetration, acclimatization, and the introduction of temporary restrictions on the export of forest products. They also consider potential economic damage and establish ways to manage and prevent such risks, as well as protective measures aimed at monitoring and preventing the spread of harmful organisms. The main goal in identifying harmful organisms is to isolate and destroy them. The list of quarantine organisms includes pests [7], plant pathogens [8], and weed plants [9]. It is important to conduct phytosanitary surveillance at the border during import and export of plant products [10]. Phytosanitary zones, territories where quarantine organisms have been found, should be monitored and timely measures taken to isolate and eliminate them. This is extremely important for the main logging areas of Russia, specifically the Irkutsk Region, where coniferous forests are primarily located and pulp and paper mills that require high-quality raw material are operating. Long-term contracts have been concluded for the export of wood.

A comprehensive assessment of the phytosanitary risks and potential economic losses from exports in the Irkutsk region was conducted previously. Therefore, the aim of this study was to assess and forecast the phytosanitary risks in this region, as well as the potential damage to the forestry industry and the economy. Additionally, measures were developed to reduce these risks.

Materials and Methods. The work is based on materials from surveys conducted by the authors between 2020 and 2023 to identify harmful insects in forests in the Irkutsk region. Pest distribution areas were evaluated in accordance with GOST 34 309–2017 and phytosanitary monitoring methods. Initial data for estimating economic losses was obtained from statistical data from the Federal Customs Service of Russia[5] and the administration of the Irkutsk region for 2020–2022[6, 7].

Phytosanitary risk assessment was carried out according to GOST 34 309–2017 and the methodology agreed upon by the phytosanitary control authority according to the algorithm below[8] (Fig. 1).

For the analysis, we used the results of a survey conducted in the Irkutsk region between 2021 and 2023, which was carried out with the participation of the authors. The survey included the identification of harmful insects and the determination of their distribution areas according to GOST 34 309–2017, as well as the methodology agreed upon by the phytosanitary control authorities. In addition, we used data from official statistics from the Federal Customs Service of Russia covering the period 2021 to 2023[9].

[2] *On Plant Quarantine*. Federal Law No. 206–FZ dated 21.07.2014. Consultant plus. URL: https://www.consultant.ru/document/cons_doc_LAW_165795/ (accessed: 08.02.2024). (In Russ.).

[3] GOST R 57 973–2017. *Sanitary Safety in Forests. Terms and Definitions*. Electronic fund of legal and regulatory documents. URL: https://docs.cntd.ru/document/1200157752 (accessed: 08.02.2024). (In Russ.).

[4] *On Approval of the Methodology for the Implementation of Phytosanitary Risk Analysis.* Order of the Ministry of Agriculture of the Russian Federation No. 46 dated 05.02.2018. Electronic fund of legal and regulatory documents. URL: https://docs.cntd.ru/document/542618212 (accessed: 08.02.2024). (In Russ.).

[5] *Russia's Exports of the Most Important Goods. Tables.* Customs statistics. Federal Customs Service. URL: https://customs.gov.ru/statistic/eksport-rossii-vazhnejshix-tovarov (accessed: 20.02.2024). (In Russ.).

[6] *Russian Statistical Yearbook.* Moscow: Federal State Statistics Service; 2022. 691 p. URL: https://rosstat.gov.ru/storage/mediabank/Ejegodnik_2022.pdf (accessed: 20.02.24). (In Russ.).

[7] Department of Information and Statistical Services. The territorial body of the Federal State Statistics Service for the Irkutsk region. URL: https://38.rosstat.gov.ru/inform_uslugi (accessed: 20.02.24). (In Russ.).

[8] GOST R 57 973–2017. *Sanitary Safety in Forests. Terms and Definitions*. Electronic fund of legal and regulatory documents. URL: https://docs.cntd.ru/document/1200157752 (accessed: 08.02.2024). (In Russ.).

[9] *Customs Statistics.* Federal Customs Service. URL: https://customs.gov.ru/statistic (accessed:08.02.24). (In Russ.).

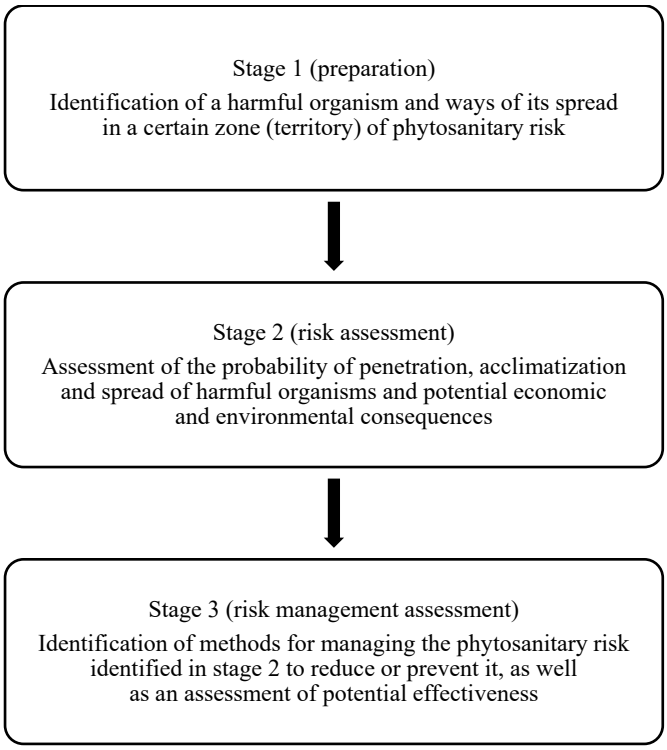


Fig. 1. Algorithm for phytosanitary risk assessment

The objects of research were:

– *Monochamus galloprovicialis Oliv.*, which causes a disease known as “blue timber”. The presence of pests was assessed by the presence of holes and beaten flour in August;

– *Dendrolimus sibiricus*, which is a needle-eating insect and destroys coniferous forests. The appearance of 300 needle-eating 500 insect individuals on one tree was enough for its complete desiccation. The appearance of caterpillars was assessed in late July and early August[10];

– *Polygraphus proximus Blandford*, relates to bark beetles, leading to damage to the bark of coniferous trees, accompanied by redness and shrinkage, is able to survive at low temperatures up to –50°C.

The number of beetles on one infected tree in the foci of invasion could range from several hundred to several thousand individuals[11]. The presence of pests was recorded by the presence of gnawed channels on weakened and shrinking trees [5].

The assessment of potential damage (PD) for a given period of time was determined by the following formula:

$$PD = \frac{VP \cdot VA \cdot PEV}{100};$$

where VP — indicator of the probability of invasion; VA — indicator of the probability of acclimatization; PEV — indicator of potential economic harmfulness [11].

Determination of the density of infestation of timber with harmful insects was performed according to a well-known technique[12]. The number and method of sampling were determined in accordance with GOST 12 430–2019[13].

The results were processed using mathematical methods based on correlation and regression estimation.

Results. When conducting monitoring studies with the authors' participation in the Irkutsk region, several sites were identified where certain harmful insects, such as *Dendrolimus sibiricus, Polygraphus proximus, Monochamus sutor, Monochamus sartor, Monochamus, Monochamus impluviatus* were actively multiplying. The largest area of damage was caused by foci of *Dendrolimus sibiricus* (up to 92%).

[10] All-Russian Plant Quarantine Center STO 2.016–2016. *Dendrolimus Sibiricus Tschetverikov. Rules for Conducting Quarantine Phytosanitary Inspections of Quarantined Facilities and Establishing a Quarantine Phytosanitary Zone and Quarantine Phytosanitary Regime.* URL: https://oi25.vniikr.ru/documents (accessed: 08.02.2024). (In Russ.).

[11] All-Russian Plant Quarantine Center STO 2.054—2017. *Polygraphus Proximus Blandford. Rules for Conducting Quarantine Phytosanitary Inspections of Quarantined Facilities and Establishing a Quarantine Phytosanitary Zone and Quarantine Phytosanitary Regime*. URL: https://oi25.vniikr.ru/documents (accessed: 08.02.2024). (In Russ.).

[12] *On the Approval of Methodological Guidelines for the Implementation of Forest Protection Zoning.* Order of the Federal Forestry Agency No. 179 dated 25.04.2017. Consultant Plus. URL: https://base.garant.ru/71723350/ (accessed: 08.02.2024). (In Russ.).

[13] GOST 12 430–2019. *Plant Quarantine. Sampling Methods and Rates for Regulated Products during Quarantine Phytosanitary Inspection and Laboratory Analysis.* Electronic fund of legal and regulatory documents. URL: https://docs.cntd.ru/document/1200168062 (accessed: 08.02.2024). (In Russ.).

During the surveys, *Abies sibirica* lesions were recorded by *Polygraphus proximus*, an invasive organism in this area. Outbreaks of mass reproduction of this organism can cause serious damage to *Abies sibirica*, which is one of the most important species of coniferous trees and is widely in demand in the international timber market, occupying a small area in the Irkutsk region. During a detailed examination of fir trees and their assessment based on the scale of damage caused by *Polygraphus proximus*, only 20% were found to be healthy, 40% weakened, and 15% severely weakened in the surveyed area. Figure 2 shows the distribution of *Abies sibirica* trees according to categories of condition based on damage caused by *Polygraphus proximus*[14]. The calculation was done using a well-known method[15]. It was established that there was up to 10% of dead wood on the surveyed territory.

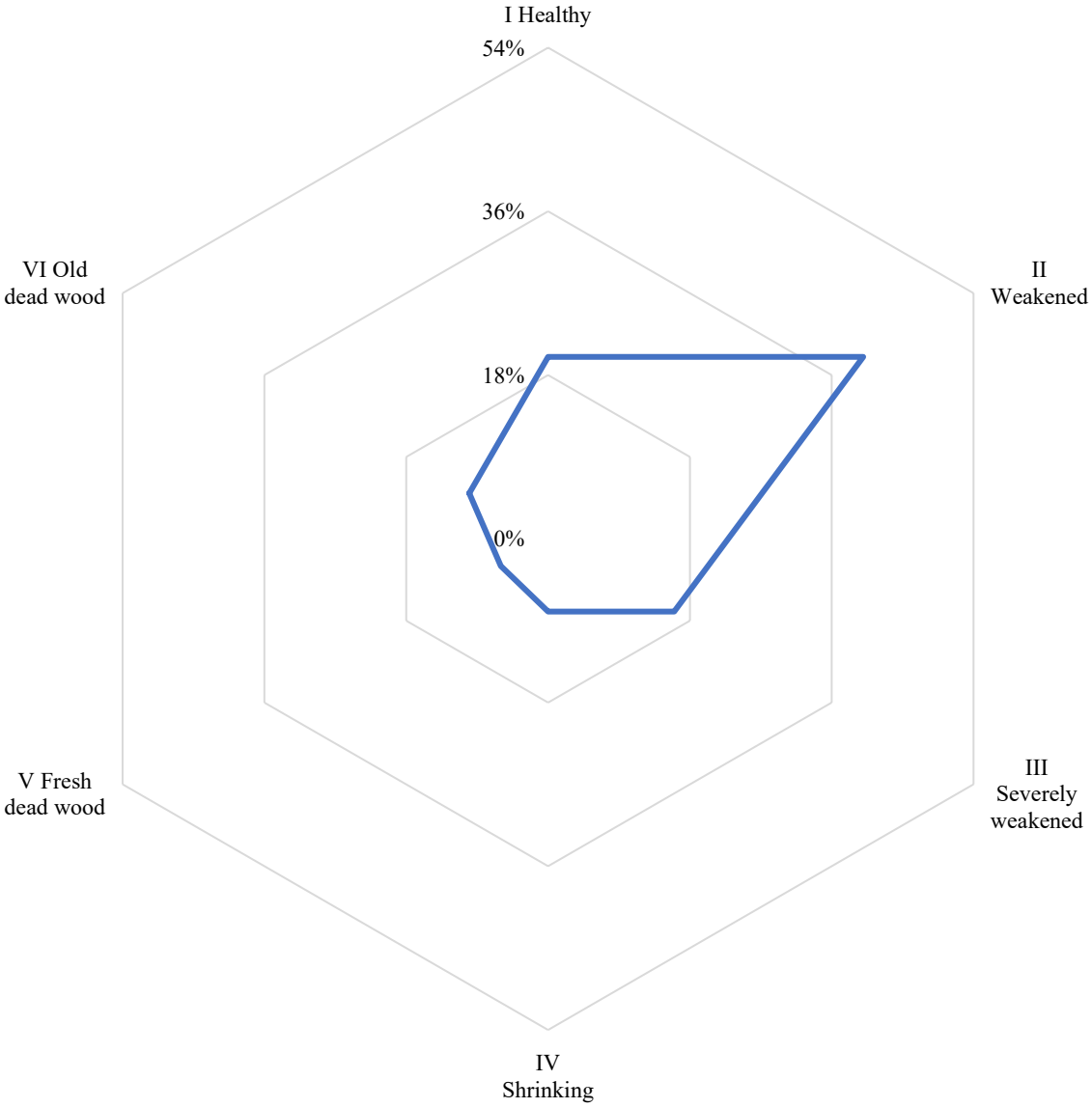


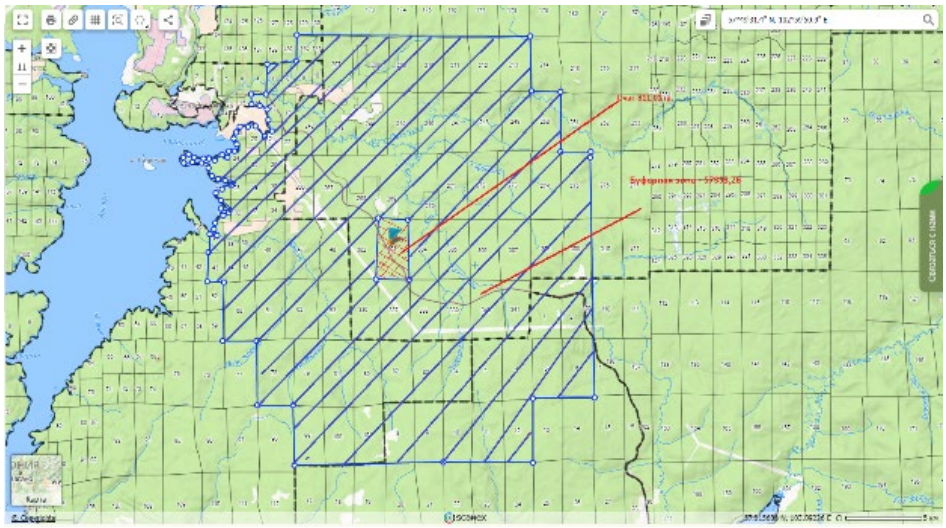
Fig. 2. Categories of condition of *Abies sibirica* trees damaged by *Polygraphus proximus*

During monitoring studies in the summer-autumn period of 2023 in the Ust-Ilimsky district of the Northern forestry region, populations of the quarantine insect pest *Dendrolimus Sibiricus Tschetverikov* were identified in the following locations: Tubinsky district forestry: center area — 758.13 hectares; Sosnovsky district forestry: center area — 811.01 hectares Phytosanitary risk areas have been calculated for each site, as shown in Figure 3 and Table 1.

[14] *The Ussuri Polygraph in the Forests of Siberia (Distribution, Biology, Ecology, Identification and Inspection of Damaged Plantations)*. Methodical manual. Tomsk-Krasnoyarsk: UMIUM; 2015. 48 p. (In Russ.).
[15] Id. P. 3–46.

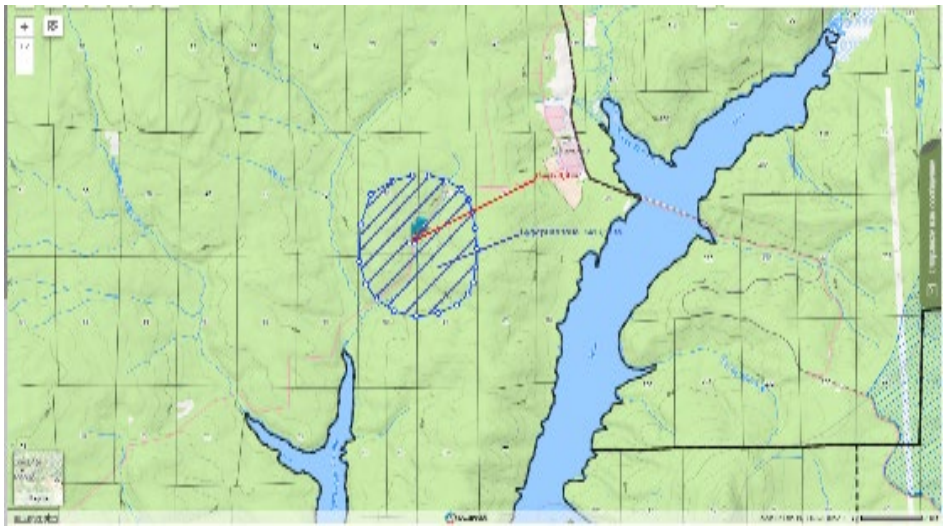
a)

b)



c)

Fig. 3. Phytosanitary risk zone in the forest areas of the Northern forestry on *Dendrolimus Sibiricus Tschetverikov*:
a — Northern forestry, Tubinsky district forestry, Kedrovskaya dacha, 43 quarter-center;
b — Northern forestry, Tubinsky district forestry, Tubinskaya dacha, 116 quarter-center;
c — Northern forestry, Tubinsky district forestry, Kedrovskaya dacha, 303 quarter-center



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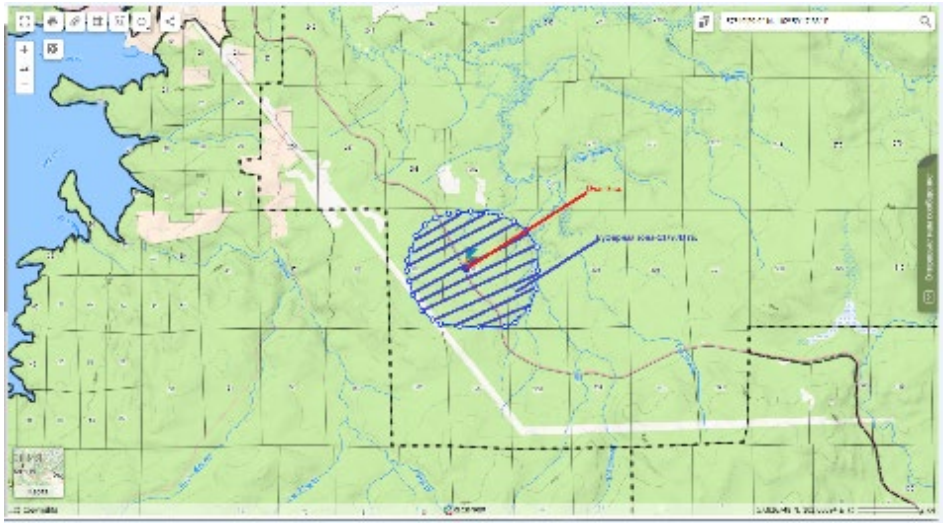

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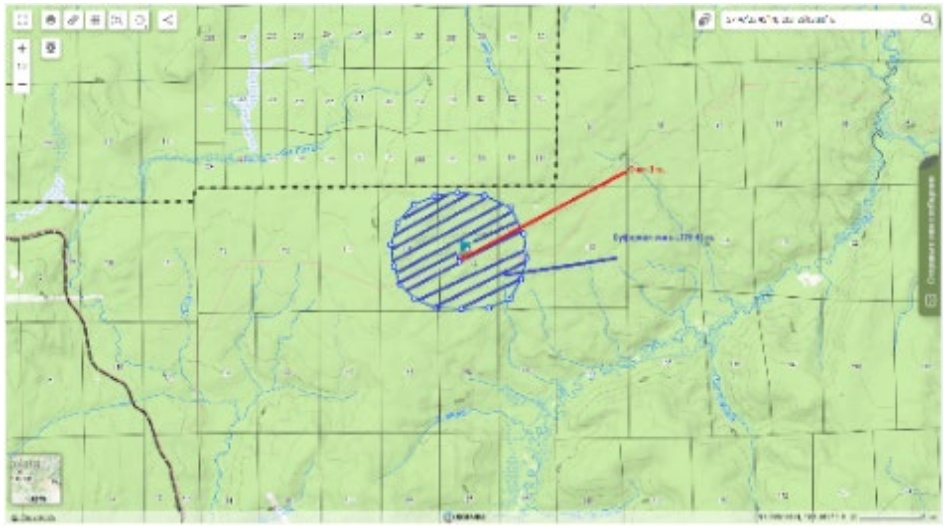

c)

Fig. 4. Phytosanitary risk zone in the forest areas of the Northern forestry on *Monochamus sartor*:
a — Northern forestry, Tubinsky district forestry, Kedrovskaya dacha;
b — Northern forestry, Sosnovsky district forestry, Karapchanskaya dacha;
c — Northern forestry, Tubinsky district forestry, Tubinskaya dacha

Table 1

Phytosanitary risk zones in the Northern forestry of Ust-Ilimsky district on *Dendrolimus Sibiricus*

Risk location	Phytosanitary risk zone, ha
43 quarters of the Northern forestry, Tubinsky district forestry	56,951.66
116 quarters of the Northern forestry, Tubinsky district forestry	57,180.09
303 quarters of the Northern forestry, Tubinsky district forestry	57,353.26

Lesions of *Monochamus urussovi Fisch* and *Monochamus galloprovincialis Oliv.* were found on the territory of the same forestry. Figure 4 and Table 2 provide phytosanitary risk zones for these insects.

Table 2

Phytosanitary risk zones in the Northern forestry of the Ust-Ilimsky district on *Monochamus urussovi Fisch*

Risk location	Phytosanitary risk zone on *Monochamus galloprovincialis Oliv.*, ha	Phytosanitary risk zone on *Monochamus urussovi Fisch*, ha
Northern forestry, Tubinsky district forestry, Kedrovskaya dacha	1,379.43	1,343.18
Northern forestry, Tubinsky district forestry, Tubinsky dacha	1,706.38	1,266.66
Northern forestry, Sosnovsky district forestry, Karapchanskaya dacha	1,821.96	1,263.73

The area of quarantine pest foci that were in the Irkutsk region in 2023 was 76,752.4 hectares. Of this area, foci of *Dendrolimus Sibiricus Tschetverikov* accounted for 92%.

During the customs inspection of wood prepared for export from these forest areas, larvae of *Monochamus galloprovincialis Oliv., Dendrolimus Sibiricus Tschetverikov*, and *Polygraphus proximus Blandford* were found. Calculations have established that the density of distribution of live larvae could reach 540 m^3 of quarantined products, which went beyond the entire volume of production, i.e. the spread of the pest would move to neighboring areas located near logging facilities.

Within the phytosanitary risk zones, the activities of loggers and the export of wood outside the established zone were limited.

Economic losses from the under-supply of wood and the implementation of phytosanitary risks within the studied forestry amounted to 1,276 thousand dollars when exported to China at an average price of 220 dollars per 1 m^3 of coniferous wood.

Discussion and Conclusion. It has been shown that in 2023, on the territory of the Irkutsk region, an unfavorable situation has developed and high phytosanitary risks have been recorded for several pests, including *Dendrolimus sibiricus, Monochamus galloprovicialis Oliv., Monochamus sartor* and *Polygraphus proximus Blandford*.

Ust-Ilimsky district ranked first among the surveyed territories in terms of the total area affected. The largest breeding sites of *Dendrolimus sibiricus* were recorded in the Tubinsky forestry district. The phytosanitary risk areas for *Monochamus galloprovicialis Oliv.* accounted for 2.7% of the total affected area and were mainly concentrated in the Sosnovsky forestry district. The area affected by *Monochamus sartor* reached 2.1% of the total and was recorded in Tubinsky forestry and Kedrovskaya dacha. In Tubinsky forestry, there were foci of an invasive and highly aggressive species — *Polygraphus proximus Blandford* — affecting fir trees over an area of 0.8%. Therefore, special attention must be paid to preventive measures against this pest.

Considering that forestry enterprises in the Ust-Ilimsky district are the suppliers of raw materials for the timber industry and exporters of wood products, the establishment of significant quarantine zones and restrictions on the export of timber causes significant damage to the budget of the Irkutsk region. Pine is the most popular type of wood for export, accounting for an average of 75% of the total volume, followed by Siberian fir at 7%. In this regard, it is essential to monitor fir trees in three categories: operational — for the detection of shrinking trees during forestry rounds; regime — at stationary sites in damaged areas; and local — in areas with the highest incidence of shrinkage. If more than 10% of Category IV trees are identified, sanitary felling should be conducted to prevent the outbreak of pest infestation. Category V and VI trees should be felled for firefighting purposes.

To combat *Dendrolimus sibiricus*, which can be found in coniferous forests, we recommend using a biological preparation called "Lepidocide®", which is based on the *Bacillus thuringiensis var.kurstaki* strain. This preparation contains spores and cells from *Bacillus thuringiensis var. kurstaki* culture producer, as well as delta-endotoxins in the form of protein crystals and inert fillers to ensure the safety and stability of the product. The drug is safe for humans and warm-blooded animals, and the death of insects occurs only after the drug enters their intestines. The recommended dosage of "Lepidocide®" is 3 liters per hectare. It can be applied as a suspension during aerial treatment of forests using low-volume or ultra-low-volume spraying methods, or through aerosol sprayers using adjustable dispersion generators.

The experience of combating *Dendrolimus sibiricus* in the Irkutsk region during 2016–2017 using new insecticides "Clonrin CE" and "Clipper CE" has shown that the processing of timber harvested for export in warehouses, although ensuring its safety, can lead to unpredictable environmental consequences.

Given the unfortunate experience of widespread and careless use in the 1960s and 1970s of DDD — 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane, a persistent organic pesticide that is still present in biota and accumulates in trophic chains, and is found in Antarctic penguin fat tissue, it is important to avoid using "Clonrin CE", despite the recommendations of relevant authorities[16].

For preventive purposes, it is recommended to install pheromone traps to monitor for pests. The traps should be placed at a height of 1.5–2 meters above the ground in the early summer and checked periodically.

The current situation regarding the spread of quarantine insects in the forests of the Irkutsk region is considered unfavorable and requires the compliance with preventive and response measures in the event of an increase in numbers or the emergence of new outbreaks. The most environmentally friendly option for managing these risks is to conduct sanitary logging, which includes timely removal of wind- and fire-damaged trees and the installation of pheromone traps. Additionally, treatment with biological products can help control the spread of pests.

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About the Authors:

Svetlana S. Timofeeva, Dr.Sci. (Eng.), Professor, Head of the Industrial Ecology and Life Safety Department, Irkutsk National Research Technical University (83, Lermontov St., Irkutsk, 664074, RF), SPIN-code: 8427-9622, ORCID, ScopusID, sstimofeeva@mail.ru

Semen V. Tenchikov, Graduate student of the Industrial Ecology and Life Safety Department, Irkutsk National Research Technical University, State Inspector of the Department of Phytosanitary Control in the Irkutsk Region of the Federal Service for Veterinary and Phytosanitary Supervision in the Irkutsk Region and the Republic of Buryatia (Rosselkhoznadzor for the Irkutsk Region) (77, Krasnoyarsk Str., Irkutsk, 664023, RF).

Semen S. Timofeev, Senior Lecturer of the Industrial Ecology and Life Safety Department, Irkutsk National Research Technical University (83, Lermontov St., Irkutsk, 664074, RF), SPIN-code: 2694-7070, sstimofeeva@mail.ru

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SS Timofeeva: formulation of the basic concept, goals and objectives of the study, writing the text, correction of the conclusions, academic advising.

SV Tenchikov: calculations, analysis of the research results, formulation of the conclusions.

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Об авторах:

Светлана Семеновна Тимофеева, доктор технических наук, профессор, заведующая кафедрой промышленной экологии и безопасности жизнедеятельности Иркутского национального исследовательского технического университета (664074, РФ, г. Иркутск, ул. Лермонтова, 83), SPIN-код: 8427-9622, ORCID, ScopusID, sstimofeeva@mail.ru

Семен Вячеславович Тенчиков, магистрант кафедры промышленной экологии и безопасности жизнедеятельности Иркутского национального исследовательского технического университета, государственный инспектор отдела фитосанитарного контроля по Иркутской области Управления Федеральной службы по ветеринарному и фитосанитарному надзору по Иркутской области и Республике Бурятия (Россельхознадзор по Иркутской области) (664023, г. Иркутск, ул. Красноярская, 77).

Семен Сергеевич Тимофеев, старший преподаватель кафедры промышленной экологии и безопасности жизнедеятельности Иркутского национального исследовательского технического университета (664074, РФ, г. Иркутск, ул. Лермонтова, 83), SPIN-код: 2694-7070, sstimofeeva@mail.ru

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С.С. Тимофеева — формирование основной концепции, цели и задачи исследования, написание текста, корректировка выводов, научное руководство.

С.В. Тенчиков — проведение расчетов, анализ результатов исследований, формирование выводов.

С.С. Тимофеев — проведение расчетов потенциального ущерба экономике региона.

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