Problems in the timely improvement of sanitary state of the forests affected by the Siberian silk moth outbreaks

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Abstract. The article discusses topical problems of modern forest management regarding the procedure necessary to prescribe sanitation cuttings in dark coniferous stands damaged by the Siberian silk moth. Nowadays, the inability to timely cut down the defoliated, mature and overmature commercial dark coniferous timber leads to the formation of large areas of damaged stands that will hardly ever recover. There are no subsidies stimulating forest users to cut down forests damaged by the Siberian silk moth and conduct artificial reforestation. The present study suggests steps for adjusting the current legislation in pests control measures prescription in emergencies in forest land leased.

The current system underpinning the forest sector in Russia is based on the principles of sustainable forest management prescribed in the Forest Code of 2007 [1]. It is well known that valuable coniferous forest stands represent the forest resources of Russia. Despite the legislatively promoted sustainable forest development, in recent decades, there has been a tendency towards natural forest area decline as a result of clearcuttings, fires, and insect pests outbreaks. Phytophagous insects are an integral part of forest ecosystems. However, from an economic point of view, they cause colossal damage, leading to growth decline, degradation, and massive drying out of forest stands. Siberian silk moth (Dendrolimus superans sibiricus Tchetv.) is the most economically important forest pest in Siberia and the Russian Far East. Siberian silk moth is capable of forming pandemic outbreaks [2, 3], which cause the most significant damage [4, 5, 6, 7]. Over the past 100 years, more than 13 million hectares of coniferous forests have dried out after outbreaks of the Siberian silk moth in Siberia and the Russian Far East [8].

Unfortunately, the current forest management system dealing with forest pathological monitoring, pest outbreaks, and consequences control leads to significant forest degradation and loss of valuable resources. In most regions of Russia, there is a negative tendency to snap retention caused by insufficient salvage logging and other forestry activities dealing with dead forest stands [9]. The deterioration in boreal forest sanitary conditions is attracting higher research and public interest, especially in the context of the observed climate changes [10, 11, 12, 13].

To reveal the existing problem, we first considered the basic principles of the current forest management system. All Russian forest land is state-owned. A significant part of the powers has been transferred from federal authorities to the federal subjects of Russia. In each federal subject, separate forest management units (FMU) conduct local forest management and perform an administrative function, combined with control over local forest users. The primary economic entity in the forest sector
is leaseholders entering into a rental agreement for 49 years, whose responsibilities include protection, conservation, and reproduction of forests. Nowadays, 21% (about 240 million hectares) of the forest land has been transferred to active and long-term forest use. Forests are mainly used for wood harvesting (since 2013, the volume of harvesting has increased by 10%). The annual allowable cut in the Russian Federation is 704.8 million m3, while forest exploitation is 30.1% [14].

The forest protection system includes detecting harmful organisms, preventing their spread, and controlling outbreaks [1]. Figure 1 shows the total indicators of the Siberian silk moth outbreaks in the Siberian Federal District (SFD) from 2008 to 2019. The peak and the most catastrophic year was 2018, when the area affected by outbreaks exceeded 1 million hectares annually.

![Figure 1](image1.png)

**Figure 1.** The total area of the Siberian silk moth (*Dendrolimus sibiricus*) outbreaks in the Siberian Federal District.

According to the Russian Center for Forest Protection, at the beginning of 2021, outbreaks of the Siberian silk moth affected over 406,143 hectares of the East Siberia taiga forests (figure 2).

![Figure 2](image2.png)

**Figure 2.** The area of Siberian silk moth (*Dendrolimus sibiricus*) outbreaks in the federal subjects of the Russian Federation within the East Siberia [16].
Statistical data show that today minor damage to forest stands dominates in the federal subjects. However, considering climate changes, we should realize that if favorable conditions are created (dry period of 2-3 years), the damaged forest area may increase. Dark coniferous stands are of particular vulnerability to the Siberian silk moth attack [8, 15]. According to the latest state forest pathological monitoring data, the area of forests damaged and destroyed by insect pests is about 2 million hectares. Information for each of the studied federal subjects is presented in Table 1.

**Table 1.** Forests damaged and destroyed by insect pests [14, 16].

| Federal subjects of Russia | ha     | % % of the area of damaged and dead stands | % % of the area of damaged and dead stands |
|----------------------------|--------|------------------------------------------|------------------------------------------|
| Krasnoyarsk Krai           | 1557697| 78.3                                     | 1.0                                      |
| Irkutsk Oblast             | 61441  | 3.1                                      | 0.9                                      |
| Republic of Sakha (Yakutia)| 272109 | 13.7                                     | 0.1                                      |
| Republic of Buryatia       | 983167 | 4.9                                      | 3.7                                      |
| Tuva Republic              | 89     | 0.004                                    | 0.0008                                   |
| Total                      | 1989653| 100                                      | 1.0                                      |

Table 1 proves that in the Krasnoyarsk Krai, damaged forest stands occupy the most significant area. At the same time, only 3.2% (51349.8 hectares) of the total area of damaged and dead forests is recommended to undergo sanitary silvicultural measures in the form of selection cutting and clearcutting. A significant share of such plots, 55.3% (28377.3 hectares), falls on the lease bases of forest users. Low activity on deadwood removal (cutting) creates high risks of catastrophic fires and secondary pest outbreaks.

When analyzing the current situation, the question arises: what are the mistakes of the created forest management system (particularly forest protection), leading to such negative consequences for the sanitary state of forests? In general, the system's imperfection lies in methodological approaches to assessing the state of forests after massive damage by phytophagous insects. These approaches overlap with the bureaucratic system, ensuring the transparency of sanitary measures, particularly selection cutting and clearcutting. Let us consider these procedures in more detail.

Siberian silk moth outbreak area is declared an emergency zone following the Federal Law on Protection of the population and the territories from environmental and technological emergencies [17]. Authorized federal bodies for forest protection conduct activities to eliminate the massive spread of dangerous pests using aerial spraying of chemical or biological agents. As a rule, at the eruption phase of an outbreak, the Siberian silk moth population damages trees most intensively (crown defoliation is 75% or more). Later, to prescribe sanitation cutting, focused on the complete replacement of stands that have lost their biological resistance after massive damage by pests, the forest stand must reach a specific state. According to the current pests control guidelines [17], cutting of forest, where an outbreak occurred, is planned only if stem borers attacked trees from the first to the third condition classes (healthy, weakened, strongly weakened), determined by the Rules for sanitary safety in forests [18]. Thus, the stage of forest stand weakening should reach the mass damage by secondary pests (longhorn beetles, bark beetles, jewel beetles, and others). However, such stands are of no economic interest for forest users.

In the case of mass defoliation, such a methodological approach to the permission of sanitation cutting is economically inexpedient. In this case, it is necessary to consider tree species traits when assessing the prospects for natural reforestation [19]. It is known that all conifers, except for larch and partly pine, cannot survive after complete needle loss [8, 20]. Defoliation reduces resistance to other biotic and abiotic factors in woody plants [21]. Some researchers have proved that low resistance in dark conifers to defoliation is primarily due to sunburns on the butt swell and stem, which occur after an increase in insolation caused by pests-induced needle loss [8, 22, 23]. If it is partially damaged, fir turns out to be the least resistant, followed by spruce, Siberian pine, pine in the order of increased resistance. In case of 100% needle loss, Siberian pine (*Pinus sibirica*) dies regardless of age and growing.
conditions. Fir and Siberian pine wood lose their mechanical properties very quickly. In the fourth year after larvae have fed needles, the mechanical properties of wood are reduced to such an extent that it can only be used as timber assortments or undergo chemical processing. For Siberia, the exploitation of dark-coniferous stands to obtain high-quality industrial wood should be completed within two to three years from the moment of their damage by the Siberian silk moth. At the same time, in forests weakened by needle-eating insects, favorable conditions for stem borers’ establishment are formed. One year after defoliation, xylophagous insects already attempt to penetrate the stems of damaged trees. In the second or third year, the number and species composition of latent stem borers in such forests increase sharply, reaching its maximum for three or four years [2, 8, 15, 24]. Thus, the regulation of the procedure for permitting cutting of damaged and dead forest stands does not contribute to a detailed approach to assessing the prospects for reforestation in case of massive damage by phytophagous insects. Nevertheless, in case of damage to forest stands within a lease base, timely commercial timber harvest became impossible for the forest user.

Current legislation dictates that forest users carry out measures to prevent the spread of harmful organisms (including sanitation cutting in dead and damaged forest stands) in forest land under lease following a forest exploitation project [25]. The basis for the permission of sanitary measures (selection cutting and clearcutting) is the results of forest pathological examination carried out by authorized state authorities.

The lessee must go through a specific procedure to obtain and register permission to conduct sanitation cutting. The time frame of this process can follow two different scenarios, depending on whether cutting will be assigned within the annual allowable cut or exceed it. The Act of forest pathological examination includes this information. How long will the issuing of documents permitting sanitation cutting last significantly depends on whether cutting exceeds the annual allowable cut or not.

Figure 3 schematically shows stages of the permission for conducting forestry practices according to the current rules of sanitary safety in forests [18].

Figure 3. Algorithm for prescribing sanitation forestry practices.
The presented procedure is applied both in the case of local and mass damage to forest stands. This algorithm aims to ensure the open exchange of information on the legal certainty and correctness of prescribed sanitation cuttings for public bodies at all levels and stakeholders (citizens, environmental and regulatory organizations, and others). According to the law, sanitary measures must be implemented within two years after the forest pathological examination [18, 26].

In actual practice, the most successful and quick is the option when the lessee in the current year (at the time of outbreak) has not exceeded an annual allowable cut and can conduct sanitation cutting within the annual amount of timber that can be harvested. However, such cases are just accidental. In such a case, registration takes approximately six months.

In case of need for sanitation cuttings in excess of the annual allowable cut, a more time-consuming registration option includes the following stages. After the legislation of the amendments to the forestry regulations of the FMU (step 9, figure 3), the lessee file a claim in the Commercial Court. The trial takes approximately two or three months. The court renders a judgment regarding the need to cut wood in excess of the annual allowable cut. When the judgment comes into force, the forest user applies to the Deeds Registry to register an Amending Agreement drawn up by the executive authority of the federal subjects of Russia in forest relations. Registration of the Amending Agreement takes approximately five days. Further, changes are made on the forest exploitation project, which takes a different time depending on the forest user since he can do it on his own (if there is a specialist) or engage a third-party contractor. All changes made are subject to a state expert appraisal (30 days), which must end with positive findings only. The final stage is preparing a forest declaration, which is submitted to the FMU five days before the start of cutting. Overall, the entire procedure can take about 9 to 11 months (1 year) in the ideal case. All that time, the forest stand has been losing its original market value and finally reached the state of legally required sanitation cutting. By that time, the forest user has incurred significant economic losses that may hardly be compensated and have no commercial interest in the damaged forest any longer. Besides, additional reforestation obligations explain the lack of motivation for snag management within the lease base [1]. Currently, there are no subsidies stimulating forest users to cut forest stands that have lost their merchantability.

Thus, the existing forest management system requires improvement in terms of improving the post-outbreak sanitary state of forests, taking into account the following points:

- creating a scale for assessing the death risk following significant or complete defoliation based on the tree species biological traits;
- insects outbreaks are natural phenomena and cannot be caused artificially (in contrast to forest fires). Therefore, when declaring an emergency in case of Siberian silk moth outbreak, a special status should be given to damaged stands. Such status should shorten the time needed to prescribe sanitation cutting, ensuring timely harvesting of high-quality timber;
- introduction of a state mechanism to induce forest users to carry out additional reforestation measures after cutting down forest stands damaged by the Siberian silk moth.

What is more, insect outbreaks do not occur annually (unlike fires) and are of certain cyclicality. Thus, it is legitimate to introduce an exclusive integral assessment of sanitary measures prescription in dark coniferous stands damaged by the Siberian silk moth to improve forests condition and prevent commercial timber loss. Besides, global warming combined with forest degradation contributes to change in endemic species distribution. Thereby, invasive species distribution into new areas risk is high. Overall, the following steps are required: to increase forest pathological monitoring efficiency and adopt a system of measures accelerating pest spread prevention.

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