

# The Lessons of Scots pine Forest Decline in Ukraine †

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**Abstract:** The condition of Ukraine's forests has deteriorated sharply since the 2009 drought. The area of Scots pine stands decline has increased 2.3 times. The purpose of the research was an integration of published and own data on Scots pine forest decline with the contribution of bark beetles and pointing the ways for mitigating this process. The reference materials regarding the forest stands characteristics, forest health, weather, as well as the results of own field and laboratory research were the data sources. *Ips acuminatus* (Gyllenhal, 1827): Coleoptera: Curculionidae: Scolytinae was the first bark beetle to infest weakened stands. The predominant development Scots pine decline in Polesie (Forest zone) is associated with a large proportion of pure pine stands of the same age, untimely thinning, and relatively slow drying of felling residues, in which the bark beetle has time to complete its development. The relative density of stocking by itself is a less important risk factor than its sudden decrease. The algorithm for prediction of bark beetles' foci spread was developed. It will help to upgrade the accuracy of prediction, to evaluate the area of survey and control measures against insect pests. Recommendations for improving the forestry regulatory framework have been developed.

Keywords: climate change; tree species composition; forest management; bark beetles; outbreaks development

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## 1. Introduction

In recent years, the health condition of forest tree species has deteriorated [1–4]. Scots pine (*Pinus sylvestris* L.) forests have been particularly affected in Ukraine, where over 10 recent years, their area decline has increased 2.3 times and the foci of pine forest mortality now cover over 10 % of forest area in some regions [5]. The most intensive forest decline was registered in the Forest zone (Polissya): in Kyiv [6], Rivne [7], Sumy [8], Volyn [9], Zhytomyr [10] regions. The purpose of the research was an integration of published and own data on the spatial & temporal dynamics of Scots pine forest decline with the contribution of bark beetles and pointing the ways for mitigating this process. This study is very important because the worsening of Scots pine health condition against the background of climate change and anthropogenic loading will inevitably lead to the loss of this forest tree.

## 2. Materials and Methods

The data sources were the reference materials regarding the forest stands characteristics, forest health, weather, as well as the results of field and laboratory research (forest inspection, laboratory rearing the bark beetles in branches, evaluation of parameters) presented in the references.

## 3. Results and Discussion

The area of Scots pine forests is about 33% of the forested area in Ukraine, and in some regions, it is over 80% [6]. The proportion of natural pine forests is below 20 %. Man-made pure forest

plantations are often planted in the forest site conditions which are favorable for mixed stands [11], which are more resistant to many disturbances, particularly to bark beetles' attacks [8]. The stands of 41–80 years old cover about 62 % of the forest area. In the next 20–60 years, there will be gradual aging of forests, and in certain areas, their weakening [5]. An increase in air temperature and a decrease in precipitation have created unfavorable conditions for pine growth [12]. These changes had a particularly strong effect on the pines of Polissya, where the groundwater was usually located quite high and the root systems of pine were also located close to the surface, and after the drought of 2009, the groundwater level dropped sharply. In such conditions, pine trees became more susceptible to attacks of stem insects.

Multivoltine bark beetles, especially *Ips acuminatus* (Gyllenhal, 1827): (Coleoptera: Curculionidae, Scolytinae) have the advantages in tree colonization because contemporary temperature conditions allow to successfully complete the development of 2-3 main and 2 sister generations of this pest [10, 13]. Relatively slow drying of felling residues in Polissya in comparison with the Forest-Steppe gives the possibility for this species to survive and additionally increase its population number. Injurious of *Ips acuminatus* increases due to its ability to damage healthy trees during supplementary feeding and to vector the pathogens, particularly ophiostomatoid fungi [14] and *Sphaeropsis sapinea* [15], and increases with population density of the pest [16].

Considering the earlier dates of bark beetles' swarming, the removing of trees felled in winter must be completed before the middle of March, and the timber from any type of spring and summer felling as well as wood debris in pine forest must be immediately removed or debarked or protected with insecticides or chopped or placed in a way for rapid drying [13].

It was shown [17], that *Ips acuminatus* prefers to colonize the pure pine stands over 70 years old. The relative density of stocking by itself is a less important risk factor than its sudden decrease by thinning or clear felling of the neighboring stands. An algorithm for predicting the risk of bark beetle spread was developed. It considers forest site conditions, stand characteristics, and the change of land category of neighboring forest plots. Recommendations on priority measures in pine forests damaged by bark beetles [18] were developed. They include issues of bark beetle foci monitoring, prevention of spread, the measures of forest health improvement, felled timber protection, forest renewal etc. However, suggested recommendations cannot be implemented without amending regulatory documents on forest management, particularly "Rules for improving the qualitative forest composition" (2007), "Sanitary rules in the forests of Ukraine" (2016), etc. [19].

#### 4. Conclusions

The main causes of pine forest decline include certain disadvantages of forestry management in the past, global climate change, and increasing anthropogenic loading. It is very difficult to stop climate change but it is possible to improve the practice of forest management, particularly to grow the mixed forest of different ages, to carry out thinning in time and gradually, to remove in time felled trees and wood debris, to monitor bark beetles' foci, and to carry out selective and clear sanitary felling in time to obtain the timber of the highest quality. In connection with earlier vegetation beginning and bark beetles swarming it is necessary to establish the deadline of timber moving out from forest after winter felling to the earlier date (March 15). Timber from any type of summer felling in pine forest must be immediately removed or debarked or protected with insecticides.

Only in time removing of colonized trees can slow down the decline of pine forests. However, the current regulatory framework for forest management does not allow the prompt implementation of the necessary measures. This leads to significant financial losses associated with a sharp decline in the merchantability of timber obtained during sanitary felling.

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