

ЗАХИСТ ЛІСУ

UDC 630.4

O. Y. ANDREIEVA¹, A. F. GOYCHUK^{2*}
SPREAD OF SCOTS PINE STANDS DECLINE
IN KOROSTYSHIV FOREST ENTERPRISE

1. Zhytomyr National Agroecological University
2. National University of Life and Environmental Sciences of Ukraine

The aim of the research was to reveal the features of Scots pine stands decline in Zhytomyr (Central) Polissya using the case of Korostyshiv Forest Enterprise. The investigations included statistical and comparative analysis of the database of forest fund of the State Association “Ukrderzhlisproekt”, the data of forest pathological survey of pine stands in Korostyshiv Forest Enterprise and reports on sanitary felling in 2014–2017. Bark beetles (72.4–95.8 %), fungal diseases (0.4–9.1 %) and weather conditions (3.5–27.5 %) were the main causes of Scots pine decline. A high proportion of pure Scots pine stands and the stands over 50 years old are the main predisposing factors of forest decline. Abnormal increase in air temperature and a decrease in Selyaninov’s Hydro-thermal Coefficient to the level of Steppe zone were inciting factors of forest decline, and bark beetles were a contributing factor to it.

Key words: Scots pine (*Pinus sylvestris* L.), forest decline, Selyaninov’s Hydro-thermal Coefficient, forest composition, age structure, relative density of stocking.

Introduction. Health condition of Scots pine (*Pinus sylvestris* L.) stands worsens in recent decades in many regions, including northern (Siitonen 2014) and southern countries (Lieutier et al. 2016, Pineau et al. 2017), as well as Belarus (Sazonov et al. 2017) and Ukraine (Borodavka et al. 2017, Meshkova and Borysenko 2017).

Stem pests are the most visible cause of pine decline (Siitonen, 2014); however, tree resistance to infestation decreases as a result of climate change (Balabukh et al. 2013; Getmanchuk et al. 2017) and anthropogenic impact (Meshkova and Borysenko 2017, Sazonov et al. 2017).

Pine engraver beetle *Ips acuminatus* (Gyllenhal, 1827) and six-toothed bark beetle *Ips sexdentatus* (Boerner, 1767) (Curculionidae, Scolytinae) have advantages due to monovoltinity (Meshkova et al. 2017). Pine engraver beetle infests the top of stem and branches both in living and felled trees, and six-toothed bark beetle infests stem butts (Meshkova et al. 2015, 2017). Both bark beetles are the vectors of pathogenic fungi (Lieutier et al. 2016, Davydenko et al., 2017).

Investigation of stem insects foci development and spread show its diversity in different regions and stands, owing to climatic features and tree reaction on it (Meshkova and Borysenko 2017).

The aim of our research was to reveal the features of Scots pine decline in Zhytomyr (Central) Polissya on the example of Korostyshiv Forest Enterprise.

Materials and Methods. The investigations included statistical and comparative analysis of forest fund database of the State Association “Ukrderzhlisproekt”, the data of forest pathological survey of pine stands in Korostyshiv Forest Enterprise and reports on sanitary felling in 2014–2017.

Monthly air temperature and precipitation datasets were taken from Zhytomyr meteorological station (50° 15' N 28° 39' E). Selyaninov’s Hydro-thermal Coefficient – HTC (Selyaninov, 1937) was calculated by the formula:

$$HTC = 10 \frac{\sum P}{\sum t}, \quad (1)$$

where $\sum P$ is precipitation for the period with mean month air temperature over 10°C, mm;

$\sum t$ is the sum of daily air temperatures for the same period, °C.

Statistical analysis was carried out with the help of *MS Excel*. A tetrachoric correlation was evaluated to compare pine stands distribution by stand composition, age and stocking density in the

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foci of bark beetles and in other pine stands, and the reliability was assessed by χ^2 criterion (Atramentova & Utevskaia 2008).

Results and Discussion. The area of selective sanitary felling in Korostyshiv Forest Enterprise tended to decrease, and the area of clear sanitary felling tended to increase until 2016 and then to decrease (Fig. 1). The proportion of selective felling was close to 100 % in 2014, decreased to 82.4 % in 2016 and increased to 95.5 % in 2017.

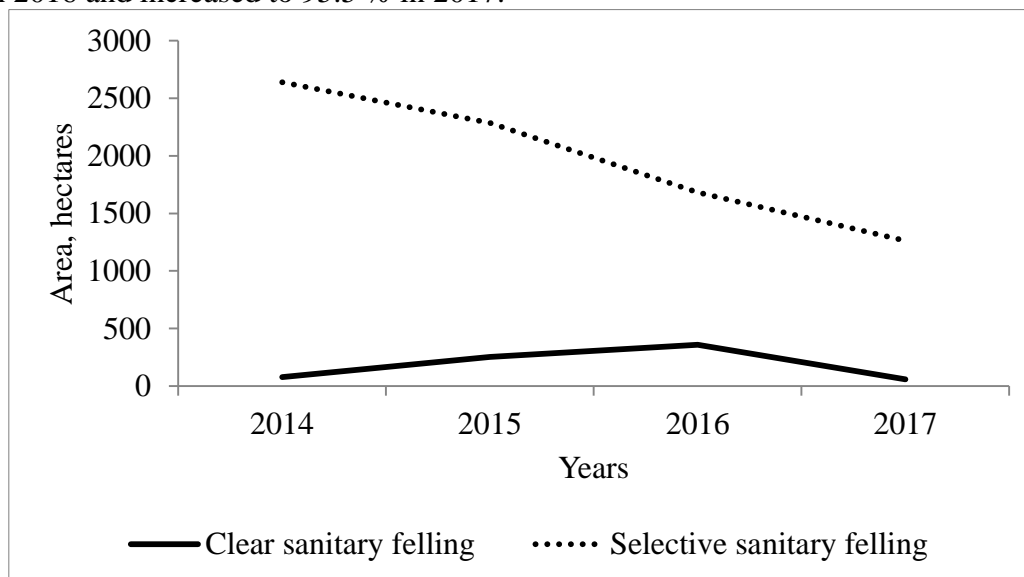


Fig. 1 – Dynamics of clear sanitary felling and selective sanitary felling area in Korostyshiv Forest Enterprise in 2014–2017

Weather conditions, bark beetles and fungal diseases were the main causes of Scots pine decline (Fig. 2).

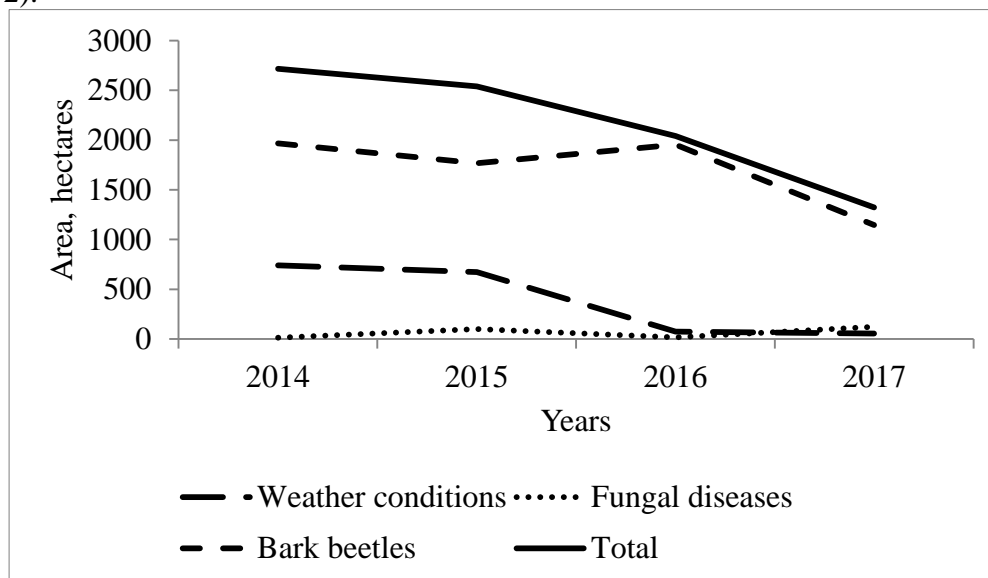


Fig. 2 – Dynamics of Scots pine stands area decline from different causes in Korostyshiv Forest Enterprise in 2014–2017

Area of Scots pine stands decline, as a result of fungal diseases, was the lowest. The average annual area of such decline was 61.7 ha, and it varied from 11.3 to 120.6 ha in different years. The proportion of forest decline from fungal diseases varied from 0.4 % in 2014 to 9.1 % in 2017. Root rot *Heterobasidion annosum* (Fr.) Bref was the main cause of sanitary felling from all fungal diseases. However, ophiostomatoid fungi associated with bark beetles were rather widely represented in bark beetles foci and took an important part in Scots pine decline.

Weather conditions were considered as the cause of Scots pine decline in 384.5 ha on average. The area of forest decline from this reason was the highest in 2014 (738.6 ha) and drastically reduced (over 10 times) in 2016. The proportion of forest decline as a result of adverse weather conditions was 27.5 and 26.5 % from the total decline in 2014 and 2015, and only 3.5 and 4.2 % in 2016 and 2017 respectively.

The area of forest decline as a result of bark beetles infestation was 1,708.4 ha in average for four years. A slight tendency to decrease in this area is registered. However, the proportion of forest decline in result of bark beetles infestation increased from 72.4 % in 2014 to 95.8 % in 2016 and slightly decreased to 86.7 % in 2017 (see Fig. 2).

Analysis of weather conditions for 2005–2017 shows that annual air temperature exceeded the average long-term air temperature in 2007–2008 and 2013–2017 (Fig. 3).

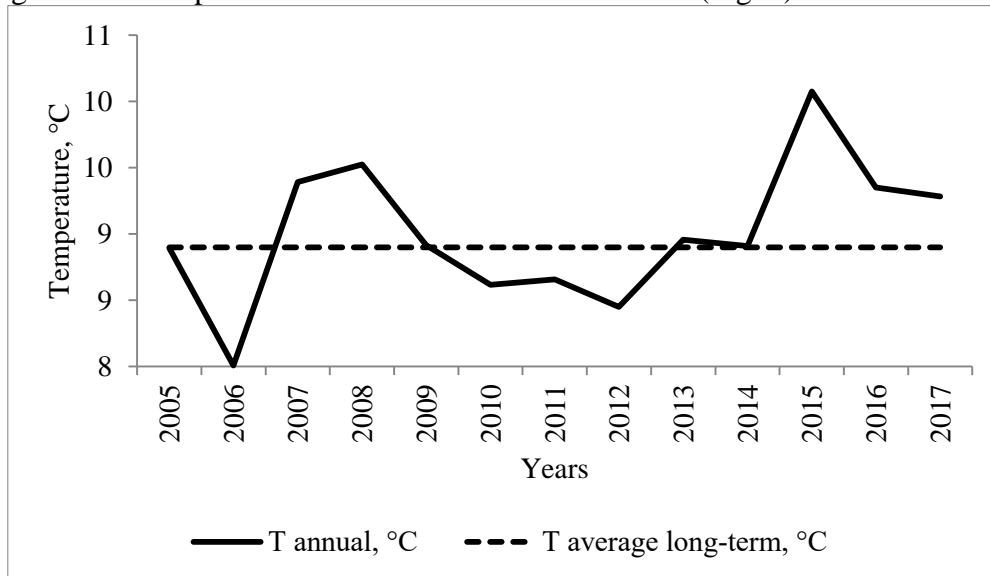


Fig. 3 – Annual and average long-term air temperatures in 2005– 2017 (Zhytomyr meteorological station)

Abnormal increase in the air temperature was favorable for the development of additional generations of bark beetles (Meshkova et al. 2017). At the same time mutual effect of air temperature and precipitation in particular years influenced the Selyaninov’s Hydro-thermal Coefficient, which was 1.2 in average for 2004–2017 that is lower than the range for Polissya zone (1.3–1.6) (Selyaninov 1937). This coefficient fell to 0.91 in 2009, continuously decreased in 2013–2015 to 0.65 and stayed rather low in 2016 and 2017 (0.8 and 0.82 respectively) (Fig. 4).

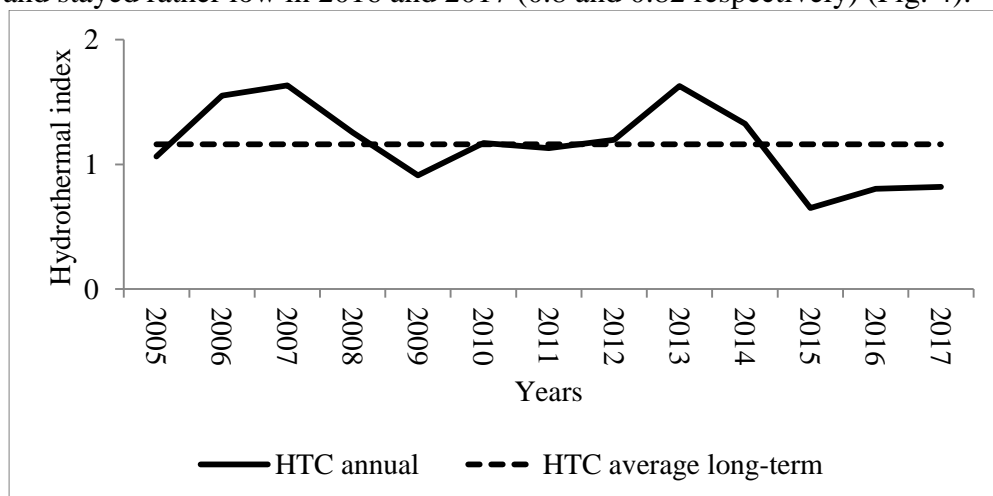


Fig. 4 – Annual and average long-term Hydro-thermal coefficient (HTC) in 2005– 2017 (Zhytomyr meteorological station)

Only three years from analyzed period Hydro-thermal Coefficient calculated by the dataset of Zhytomyr meteorological station was indicative for Polissya zone (1.33 in 2014, 1.55 in 2006, and 1.63 in 2007 and 2013).

The HTC was indicative for forest steppe zone (1–1.3) in 2005, 2008, 2010, 2011, 2012, in some years – for steppe zone (0.7–1.0) – 0.91 in 2009, 0.65, 0.80 and 0.82 in 2015, 2016 and 2017 respectively (see Fig. 4).

Such decrease in HTC in Polissya is very unfavorable for forest trees, which are adapted to the high humidity of air and soil.

Analysis shows (Fig. 5) that proportion of pure Scots pine stands (100 % Scots pine participation) among declining stands is considerably higher, than among all stands ($\chi^2_{\text{fact.}} = 154,7$; $\chi^2_{0.05} = 3,8$).

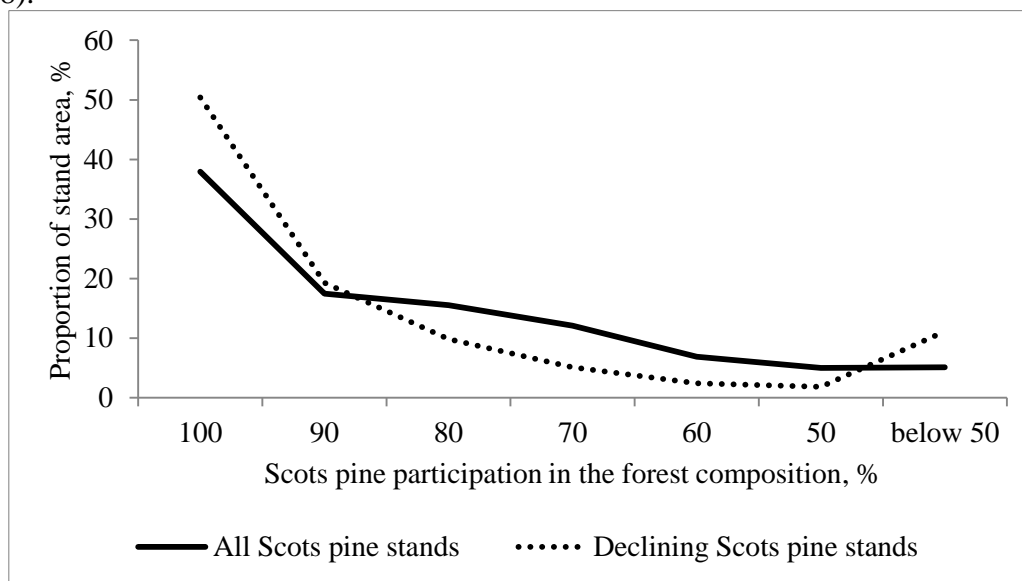


Fig. 5 – Area distribution for stands with different Scots pine participation among all Scots pine stands and declining Scots pine stands (Korostyshiv Forest Enterprise, 2014–2017)

Obtained data are consistent with other publications on the greater resistance of mixed stands to any disturbances, in particular to bark beetles infestation (Sazonov et al. 2017, Meshkova & Borysenko 2017).

Analysis shows (Fig. 6) that the proportion of Scots pine stands older than 50 years old among declining stands is considerably less than among all stands ($\chi^2_{\text{fact.}}=1049.0$; $\chi^2_{0.05}=3.8$).

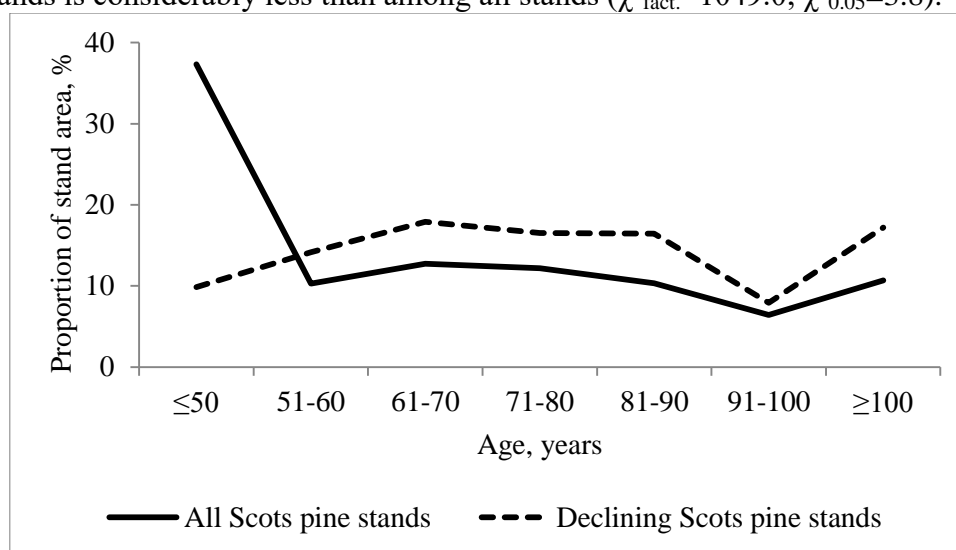


Fig. 6 – Area distribution for all Scots pine stands older than 50 years old and declining Scots pine stands older than 50 years old (Korostyshiv Forest Enterprise, 2014–2017)

In all Scots pine stands and in declining Scots pine stands the area with the relative density of stocking 0.7 is the highest (48.4 and 60.5 % respectively) (Fig. 7).

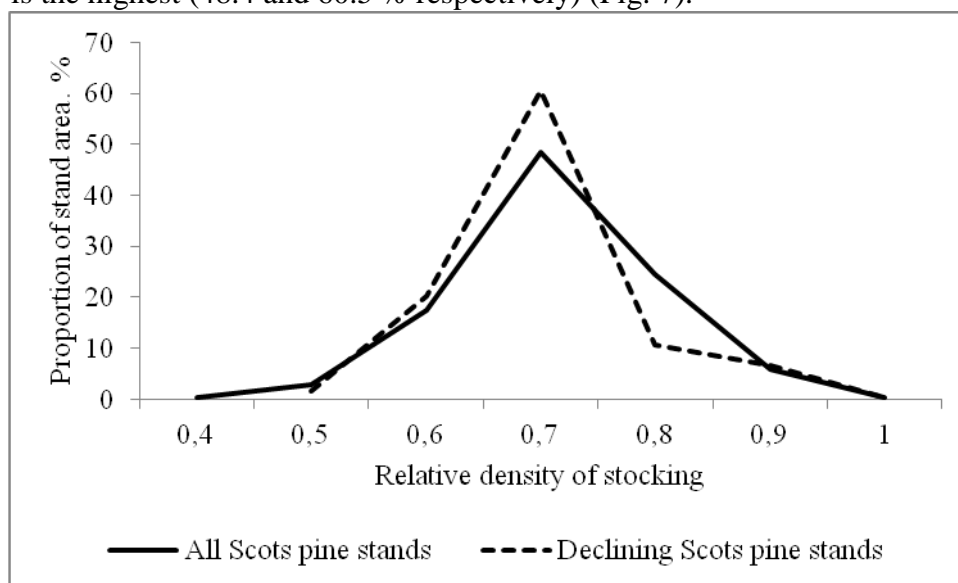


Fig. 7 – Area distribution for stands of different relative density of stocking among all Scots pine stands and declining Scots pine stands (Korostyshiv Forest Enterprise, 2014–2017)

An average weighted relative density of stocking is 0.7 in declining Scots pine stands and 0.71 in other Scots pine stands. The proportion of stands with the relative density of stocking of 0.6 ($\chi^2_{\text{fact}} = 7.38$; $\chi^2_{0.05} = 3.8$) and 0.7 ($\chi^2_{\text{fact}} = 83.5$; $\chi^2_{0.05} = 38$) is reliably higher in declining Scots pine stands than in all stands of this species. The proportion of stands with the relative density of stocking of 0.8 ($\chi^2_{\text{fact}} = 150.7$; $\chi^2_{0.05} = 3.8$) is reliably lower in declining Scots pine stands than in all stands of this species.

Our research supported P. Manion's concepts (Manion 1981) about factors of tree decline. High proportion of pure Scots pine stands and stand age over 50 years old were the main predisposing factors of forest decline. Abnormal increase in the air temperature and a decrease in HTC to the level of Steppe zone were inciting factors of forest decline, and tree susceptibility to bark beetles infestation (contributing factor) increased.

Conclusions. In Korostyshiv Forest Enterprise the proportion of selective felling in Scots pine decline foci was close to 100 % in 2014, and exceeded 80 % in other years.

The main causes of Scots pine decline were bark beetles (72.4–95.8 %), fungal diseases (0.4–9.1 %) and weather conditions (3.5–27.5 %)

Scots pine forest decline developed most often in pure Scots pine stands older than 50 years. Average weighted relative density of stocking was 0.7 and 0.71 in declining and non-declining Scots pine stands. Climatic factors were inciting factor of forest decline, and bark beetles infestation was contributing factor of it.

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Андреева О. Ю.¹, Гойчук А. Ф.²

ПОШИРЕННЯ ВСИХАННЯ НАСАДЖЕНЬ СОСНИ ЗВИЧАЙНОЇ У ДП «КОРОСТИШІВСЬКЕ ЛГ»

1. Житомирський національний агроекологічний університет

2. Національний Університет біоресурсів і природокористування України

Метою досліджень було виявити особливості всихання соснових насаджень у Житомирському (Центральному) Поліссі на прикладі ДП «Коростишівське ЛГ». Дослідження включали порівняльний статистичний аналіз бази даних лісового фонду ВО «Укрдержліспроєкт», даних лісопатологічного обстеження соснових насаджень ДП «Коростишівське ЛГ» та звітів стосовно санітарно-оздоровчих заходів у 2014–2017 рр. Короїди (72,4–95,8 %), грибні хвороби (0,4–9,1 %) та погодні умови (3,5–27,5 %) були основними причинами всихання сосни звичайної. Висока частка чистих насаджень сосни звичайної та насадження віком понад 50 років є основним чинником тривалої дії, що провокує всихання лісу (*predisposing factor*). Надзвичайний ріст температури повітря та зниження гідротермічного коефіцієнта Г. Т. Селянінова до рівня степової зони є короткочасним стимулювальним чинником (*inciting factor*) всихання лісу, а короїди – «супровідним» чинником (*contributing factor*).

Ключові слова: сосна звичайна (*Pinus sylvestris* L.), всихання лісів, гідротермічний коефіцієнт Г. Т. Селянінова, склад насаджень, вікова структура, відносна повнота.

Андреева Е. Ю.¹, Гойчук А. Ф.²

РАСПРОСТРАНЕНИЕ УСЫХАНИЯ НАСАЖДЕНИЙ СОСНЫ ОБЫКНОВЕННОЙ В ГП «КОРОСТЫШЕВСКОЕ ЛХ»

1. Житомирский национальный агроэкологический университет

2. Национальный Университет биоресурсов и природопользования Украины

Целью исследований было выявить особенности усыхания сосновых насаждений в Житомирском (Центральном) Полесье на примере ГП «Коростышевское ЛХ». Исследования включали сравнительный статистический анализ базы данных лесного фонда ПО «Укрлеспроект», данных лесопатологического

обследования сосновых насаждений ГП «Коростышевское ЛХ» и отчетов относительно санитарно-оздоровительных мероприятий в 2014–2017 гг. Короеды (72,4–95,8 %), грибные болезни (0,4–9,1 %) и погодные условия (3,5–27,5 %) были основными причинами усыхания сосны обыкновенной. Высокая доля чистых насаждений сосны обыкновенной и насаждений в возрасте свыше 50 лет являются основными провоцирующими факторами длительного действия (*predisposing factor*) в усыхании леса. Существенный рост температуры воздуха и снижение гидротермического коэффициента Г. Т. Селянинова до уровня степной зоны являются кратковременными стимулирующими факторами (*inciting factor*) усыхания леса, а короеды – «сопутствующим» фактором (*contributing factor*).

Ключевые слова: сосна обыкновенная (*Pinus sylvestris*), усыхание лесов, гидротермический коэффициент Г. Т. Селянинова, состав насаждений, возрастная структура, относительная полнота.

E-mail: andreeva-lena15@ukr.net

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