

Natural disturbances in the forests and bark beetle outbreaks over the period 2015-2024 in the Rhodope Mountains, Bulgaria

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Abstract

Damage caused by abiotic factors (snowfalls, snowbreaks, windfalls and windbreaks) and by bark beetle outbreaks was studied over the period 2015-2024 on the territory of four State Forest Enterprises (SFEs) and two State Hunting Enterprises (SHEs) at the South Central State Enterprise – Smolyan in the Rhodope Mountains, Bulgaria. Three severe natural disturbances were analysed, with different silvicultural approaches to removing damaged wood and preventive measures to reduce bark beetle outbreaks, as follows: *i*) the snowfall on 8 March 2015 affected mainly pine plantations, leaving about 1.5 million m³ of damaged wood in the stands; *ii*) the windfall and windbreak on 18 January 2018 in natural coniferous forests on the territory of the SFE Smolyan, where the affected wood was removed from damaged stands within less than a year, and subsequent infestations by the European spruce bark beetle (*Ips typographus*) were controlled by trap trees; *iii*) the windfall and windbreak on 17 September 2022 on the territory of SFEs Borino, Dospat and Shiroka Polyana, and SHEs Borovo and Izvora – Devin, in which initial settlements of *I. typographus* and of the sharp-dentated bark beetle (*I. acuminatus*) on the felled wood were systematically destroyed with chainsaws equipped with bark peeling modules. In 2015, the large amount of wood left in damaged stands resulted in catastrophic attacks by *I. acuminatus* on Scots pine (*Pinus sylvestris*) and by *I. typographus* on Norway spruce (*Picea abies*) trees in the vicinity of snowbreak areas. In 2018, the damaged trees were removed from the affected stands within less than a year, and the wood was used successfully as trap trees for pest control. In 2022, initial infestations of *I. typographus* and *I. acuminatus* were systematically destroyed on fresh-cut wood, thereby reducing bark beetle attacks in the studied State Forest and Hunting Enterprises.

Keywords

Abiotic factors, coniferous forests, *Ips acuminatus*, *Ips typographus*, calamities, Rhodope Mountains

Introduction

Damage from wind, wet snow and ice in forest ecosystems creates favourable conditions for an increase in the number of bark beetles (Coleoptera: Curculionidae, Scolytinae) and for outbreaks across large areas. In European forests, the most damaging species in Scots pine forests is *Ips acuminatus* Wood & Bright, 1992 (Lieutier et al., 1988; Grégoire, Evans, 2004; Sauvard, 2004, etc.), and in spruce forests – *Ips typographus* (Linnaeus, 1758) (Bright, Skidmore, 2002; Wermelinger, 2004, etc.). Both species are also considered among the most destructive xylophagous pests in Bulgarian conifer forests, causing economic and ecological damage (Rossnev et al., 2005; Georgiev et al., 2006; Mirchev et al., 2016).

Natural disturbances caused by abiotic factors occur periodically in the forest ecosystems of the Rhodope Mountains in Bulgaria. Over the past ten years, three severe natural disasters have been recorded there: one snowstorm and snowbank (2015) and two windstorms and windbreaks (2018 and 2022).

This study aims to present data on damage caused by abiotic natural factors in the forests of the Rhodope Mountains and to assess the effectiveness of preventive silvicultural measures in limiting bark beetle attacks in the region.

Material and Methods

The study was conducted in the Rhodope Mountains, on the territory of four State Forestry Enterprises (SFEs) and two State Hunting Enterprises (SHEs) of the South Central State Enterprise – Smolyan (SCSE).

An analysis of damage from three natural disasters and bark beetle attacks for the period 2015-2024 was conducted, presenting two silvicultural approaches in terms of the removal of damaged wood and preventive measures to reduce the risk of bark beetle outbreaks:

Heavy wet snowfall on 8 March 2015 damaged pine plantations on an area of 73324.6 ha in Bulgaria (Belilov, Georgiev, 2020). In the Rhodope Mountains, four Regional Directorates of Forestry were affected: Kardzhali (31294.9 ha), Smolyan (28538.8 ha), Pazardzhik (5620.2 ha) and Plovdiv (2591.2 ha). About half of the damaged wood (over 3.0 million m³) was not utilised, remaining in the stands, where it facilitated the development and rapid increase in the population density of bark beetles, leading to subsequent calamity attacks in the forests.

Windstorm on 18 January 2018 damaged 117456 m³ of wood in natural coniferous forests on the territory of the SFE Smolyan. The damaged wood was removed from the affected stands within a year. In the bark beetle spots that occurred in 2020, sanitary fellings were carried out, during which about 2000 m³ of wood infested with *I. typographus* was used as trap trees.

Windstorm on 17 September 2022, affecting 106382 m³ of wood in natural coniferous forests on the territory of the SFEs Dospat, Shiroka Polyana, Borino and Selishte, and the SHEs Borovo and Izvora-Devin. The initial settlements of *I. typogra-*

phus and *I. acuminatus* on the felled wood in temporary storage were systematically destroyed using motorised chainsaws equipped with bark-peeling modules.

The area of forests damaged by abiotic factors (snowfalls, snowbreaks, windfalls, windbreaks, icebreaks) and attacks by the most aggressive bark beetle species (*I. acuminatus* on *Pinus sylvestris* L. and *I. typographus* on *Picea abies* (L.) Karst.) in the Rhodope Mountains was examined using data submitted to the Executive Forestry Agency information system (www.system.iag.bg) for the period 2015-2024.

The amount of wood damaged by abiotic and biotic factors is presented, based on data from the South Central State Enterprise in Smolyan.

Results and Discussion

In the SFE Smolyan region, wet snow damage in 2015 mainly affected coniferous plantations covering 1459.9 ha (Table 1), of which 110.5 ha were severely damaged (Belilov et al., 2020). The presence of large amounts of fresh wood in the study area led to a catastrophic increase in the abundance of the most aggressive xylophagous pest of Scots pine, *I. acuminatus*. By the end of 2015, the pest attacked healthy stands on 53.3 ha, and in 2016 the attacks reached 71.6 ha (Fig. 1). In the following years, damage from the pest decreased and did not exceed 10.0 ha per year, including in the years after the 2018 windstorm (Fig. 1).

Table 1. Wind and snow damage (ha) in the forests of the State Forestry Enterprises Smolyan, Borino, Dospat and Shiroka Polyana, and the State Hunting Enterprises Borovo and Izvora – Devin, for the period 2015-2024.

Year	Smolyan		Borino		Dospat		Shiroka Polyana		Borovo		Izvora – Devin	
	Wind	Snow	Wind	Snow	Wind	Snow	Wind	Snow	Wind	Snow	Wind	Snow
2015	424.2	1459.9	179.3	4583.1	0.3	4.9	0	538.0	0	140.7	70.2	30.5
2016	318.3	1209.8	1961.9	1755.1	59.9	2.2	0	260.5	0	0.1	25.3	348.1
2017	1626.2	275.6	797.7	1557.6	3197.8	0	62.6	198.0	7.4	0	0	28.6
2018	363.5	1518.9	593.7	7.3	3732.5	0	62.6	843.1	0	220.6	24.7	71.6
2019	185.4	372.1	23.0	3411.4	1804.8	1206.7	22.7	962.2	0	0	30.1	24.1
2020	257.3	456.6	0.1	1306.6	2106.5	5.6	182.1	564.3	0	124.4	8.2	29.5
2021	446.3	369.2	29.8	2866.1	1339.9	0	206.3	742.9	95.5	0	0	19.0
2022	297.7	1096.6	700.8	1523.6	2744.4	0	1075.2	202.3	499.0	0	208.9	23.4
2023	43.3	152.0	1371.3	21.1	2525.6	0	853.2	70.1	385.8	0	375.6	2.3
2024	108.0	19.1	915.9	465.8	3389.8	0	448.6	5.2	330.3	0	1.55	0

The reason for the low rates of *I. acuminatus* attacks on Scots pine forests in the Smolyan region after the 2018 windstorm is the rapid removal of fresh, damaged wood from the stands.

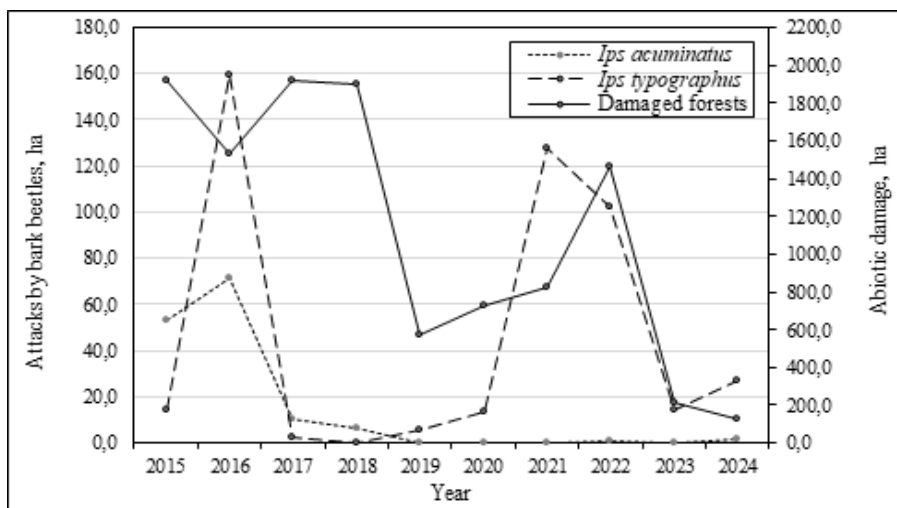


Fig. 1. Damage caused by abiotic factors and bark beetle attacks on the territory of the State Forest Enterprise Smolyan during the period 2015-2024.



Fig. 2. *Ips typographus* attacks in spruce forests near Smolyan (06.08.2020).

In 2015, infestations of spruce bark beetle *I. typographus* were recorded on 14.7 ha within the territory of SFE Smolyan (Fig. 1). In the presence of abundant fresh fallen and broken wood, the pest increased in numbers and, in 2016, attacked 159.7 ha of spruce forests. In 2017, damage decreased sharply to 2.5 ha, but after the windstorm in 2018, it increased again from 0.5 ha to 127.8 ha (2021). During this period, some *I. typographus* infestations occurred in spruce forests near the windstorm (Fig. 2).

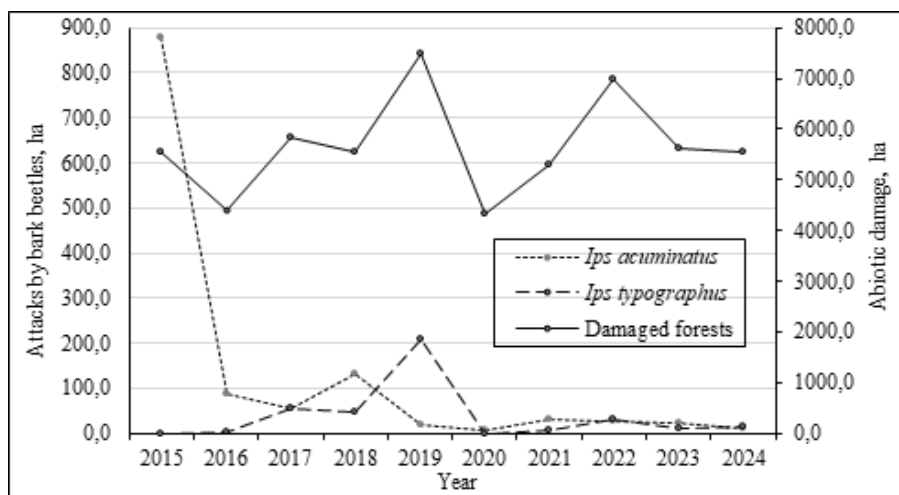


Fig. 3. Damage caused by abiotic factors and bark beetle attacks on the territory of the SFES Borino, Dospat and Shiroka Polyana and SNEs Borovo and Izvora – Devin during the period 2015-2024.

Following sanitary felling in the attacked spruce stands and the removal of infested wood before the emergence of the new generation of the pest, attacks by *I. typographus* sharply decreased from 102.1 ha in 2022 to 14.0-26.7 ha in 2023-2024 (Fig. 1).

Over the last 10 years, snow and wind damage in the SFES Borino, Dospat and Shiroka Polyana, and in the SHES Izvora-Devin, usually fluctuated between 4327.3 ha (2020) and 7485.0 ha (2019) (Table 1, Fig. 3). In the studied areas, damage by *I. acuminatus* in Scots pine forests after the snowstorm in 2015 reached 877.0 ha. Still, the following year, a tenfold decrease was recorded (87.6 ha), which continued in 2017 (55.9 ha) (Fig. 3). In 2018, damage by the pest increased to 130.6 ha, but as the trophic resource depleted, attacks in the following years decreased and fluctuated within the range of 8.5-29.6 ha (2020-2021). It should be emphasised that damage remained at a very low level (26.7 ha) in the year of the windstorm (2022) and later at 21.9 ha (2023) and 11.2 ha (2024) (Fig. 3).

In the spruce forests of the five surveyed Forest and Hunting State Enterprises, damage from *I. typographus* peaked in 2019 at 208.4 ha (Fig. 3). In 2022, damage from the pest was recorded on only 30.2 ha. In the years following the windstorm, damage fell to 9.2 ha (2023) and 16.2 ha (2024) (Fig. 3). In 2022, the windstorm mainly affected SFE Dospat (Fig. 4), where damage was recorded on 2525.6 ha (Table 1). In this area, the initial pest infestations on the felled wood were systematically destroyed.

The lack of attacks by *I. acuminatus* on Scots pine and by *I. typographus* on spruce after the 2022 windstorm is undoubtedly due to preventive measures taken - the systematic destruction of the pests' initial settlements on freshly cut wood in temporary storage, using chainsaws equipped with bark-peeling modules (Fig. 5).



Fig. 4. Windfall in SFE Dospat (17.09.2022, Karadzha Dere loc.).



Fig. 5. Destruction of initial bark beetle infestations: A – peeling the bark of felled wood with a chainsaw attachment: B – peeled spruce wood in temporary storage (14.07.2023, SFE Dospat).

In Bulgaria, trap trees have previously been used to reduce the number of *Ips typographus* following the 2012 fire in spruce stands on Vitosha Mountain (Georgiev et al., 2013). However, the destruction of primary bark beetle colonies on freshly felled wood by peeling the bark in temporary storage areas around windfalls and windbreaks has been implemented in Bulgaria for the first time in the past 40-50 years.

Early infestations of *I. typographus* in spruce stands have been successfully detected through landscape surveys using satellite imagery (Georgiev et al., 2022). Analysis of Normalized Differential Vegetation Index (NDVI) values from maps derived from Sentinel-2 multispectral imagery in the Smolyan region before (2018) and after (2020) the windstorm shows that remote sensing methods are highly suitable for early detection of bark beetle attacks in the so-called 'green phase', with a view to implementing management solutions to reduce populations of aggressive bark beetle species in forests affected by natural disasters.

Conclusions

The damage caused by wet snow on 8 March 2015 in the forests of the Rhodope Mountains affected large areas (63654 ha) and resulted in the loss of over 3.0 million m³ of coniferous wood. About half of the fallen and broken wood remained in the stands, leading to catastrophic attacks by *I. acuminatus* on Scots pine and by *I. typographus* on spruce in the area affected by the snowfall.

The strong wind on 18 January 2018 damaged natural coniferous forests with recreational functions near Smolyan. The affected wood, amounting to 117456 m³, was removed from the stands within one year. *Ips typographus* develops on the remains of felling, increases its number, and in 2020-2021 attacked 14.0-127.8 ha of spruce forests. Sanitary fellings were carried out in bark beetle spots, where infested wood was used as trap trees, thereby reducing pest attacks.

A windfall and a windbreak on 17 September 2022 damaged 106382 m³ of wood in natural coniferous forests on the territory of the State Forest Enterprises Dospat, Shiroka Polyana, Borino and Selishte, and the State Hunting Enterprises Borovo and Izvora – Devin. The initial infestations of *Ips typographus* and *I. acuminatus* on freshly cut wood in temporary storage around the windfall and windbreak were systematically destroyed with chainsaws equipped with bark-peeling modules. The results clearly show that preventive activities can not only limit but also reduce bark beetle attacks.

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