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SNOW DAMAGE IN PLANTATIONS OF AUSTRIAN PINE AND SCOTS PINE IN THE WESTERN PART OF THE REPUBLIC OF SRPSKA

ŠTETE OD SNIJEGA U KULTURAMA CRNOG I BIJELOG BORA U ZAPADNOM DIJELU REPUBLIKE SRPSKE

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Abstract

The paper presents research related to the harmful effects of snowfall in Austrian pine and Scots pine plantations in the western part of the Republic of Srpska. The most common types of tree damage are snow break and snowfall. The harmful effect of snow is more present in Scots pine plantations and at lower altitudes. Also, the harmful effect of snow is reflected in the reduction of the vitality of damaged trees, which become suitable for the attack of other harmful biotic factors, primarily harmful insects and fungi.

Key words: abiotic agents, *Pinus nigra, Pinus sylvestris*, snowfall, snow breaks

1. INTRODUCTION / UVOD

Various abiotic factors, such as light, temperature, wind, snow, rain, etc., have a great influence on forest vegetation. The influence of these factors on normal intensity is very beneficial for forests. However, their extreme action can cause serious damage to both planted forests and natural ecosystems. Snow is considered one of the most unfavorable abiotic factors, which has a great influence on forest stability (Stanivuković, 2013).

In Europe, about 4,000,000 m^3 of wood is damaged by snow on an annual basis, which leads to significant economic losses (Nykänen et al., 1997). The occurrence and effects of snow damage in each forest depend on the climate regime of the local area (Quine, 2000), topographic position, soil properties (Mayer et al., 2005; Ruel et al., 1998) as well as the composition and structure of stands (Dhôthe, 2005; Jactel et al., 2009; Jalkanen & Mattila, 2000; Mason, 2002).

Snow damage occurs when large amounts of snow accumulate on tree tops and trunks. Accumulation and retention of snow in the canopy, among other things, depends on the type of snow (heavy, wet), temperature and wind (Solantie, 1994). The resistance of trees to the harmful effects of snow depends on the tree type, the height and diameter of the tree, the surface and structure of the crown, the depth and type of roots, the implementation of cultivation measures, but also on the combined influence of air, temperature and wind (Nykänen et al., 1997; Quine, 1995; Solantie, 1994; Valinger

et al., 1993). Taller trees often suffer more snow damage compared to shorter and younger trees, because the crowns of taller trees accumulate more snow and are more heavily loaded.

Signs of snow damage are broken trunks at various heights, broken branches and tops of trees, as well as fallen trees. The most common damage caused by snow on trees in forests is fractures, especially in middle-aged and mature pine stands (Perttilä, 1987; Slodicäk, 1995). The threat of stands from the harmful effects of snow is increased by wood rot, various mechanical damage on the trunk and especially by root rot fungi. After being damaged by snow, trees are exposed to the harmful effects of biotic and abiotic factors. Harmful insects and harmful pathogens are the second most important biotic factors. Rotting fungi that use injuries to colonize trees, leading to their destruction, are particularly important. Therefore, damage caused by snow represents the initial link in the chain of damage in attacked stands, often leading to their final decline. Likewise, the accumulated wood waste created after damage in the stand, lacking timely restoration, represents an ideal fuel material for forest fires, significantly increasing the already high degree of danger from forest fires.

According to the Cadastre of Forests and Forest Land (Istraživačko-razvojni i projektni centar-IRPC, 2016), forest plantations in the Republic of Srpska cover an area of approximately 55,264.86 ha. Among this, Austrian pine and Scots pine plantations cover about 28,743.33 ha or about 52.01%.

Due to the high risks posed by snow damage, and to lack of the studies dealing with this problem in the Austrian and Scots pine plantations in our forests, this study aimed to determine i) the most common types of damage to Austrian and Scots pine trees in plantations in the western part of the Republic of Srpska, ii) the most important fungi colonizing damaged trees and iii) the most important insects that are attacking trees weakened after snow damages.

2. MATERIAL AND METHODS / MATERIJAL I METOD RADA

The research presented in this paper was performed in the area of three forest estates (FE): FE "Banja Luka" Banja Luka, FE "Ribnik" Ribnik, and FE "Gorica" Šipovo. At each estate, two sample plots measuring 50×50 m, with an area of 0.25 ha, were selected, one with Austrian pine and the other with Scots pine. Table 1 shows the basic data of the studied locations. A total survey of all trees above the taxation threshold of 5 cm was carried out on

Table 1. Basic information about the studied localities / **Tabela 1.** Osnovni podaci o lokalitetima istraživanja

Locality / Lokalitet	**Wood type** / Vrsta drveta	**Characteristics** / Karakteristike				
		Age / Starost	Bonitet / Bonitet	Exposure / Ekspozicija	Elevation / N.M.V.	Slope / Nagib
FE/ŠG „Banja Luka"	*Pinus nigra*	30	I	E / I	250 m	18°
	Pinus sylvestris	40	I	E / I	300 m	15°
FE/ŠG „Ribnik"	*Pinus nigra*	35	III	S / J	740 m	30°
	Pinus sylvestris	30	IV	SE / JI	720 m	35°
FE/ŠG „Gorica"	*Pinus nigra*	40	III	SE / JI	1050 m	30°
	Pinus sylvestris	30	III	S / J	1010 m	3°

the sample plots. The measured pine trees were classified into two groups:

1. Undamaged trees;
2. Damaged trees.

Damaged trees were classified into two categories:

- Snow break;
- Snowfall.

The experimental plots were classified into three zones by altitude:

- Zone (I) < 500m,
- Zone (II) 501–1000m.
- Zone (III) > 1001m

Species determination was performed in laboratory conditions based on basic diagnostic characteristics and with a comparison with literature data.

3. RESULTS AND DISCUSSION / REZULTATI I DISKUSIJA

According to the results shown in Figure 1, the largest number of trees was recorded in the area of the FE "Ribnik", followed by the area of the FE "Gorica". Also, in the area of both FEs, a higher percentage of Scots pine trees was recorded, while in the area of the FE "Banja Luka" there was a higher percentage of Austrian pine trees.

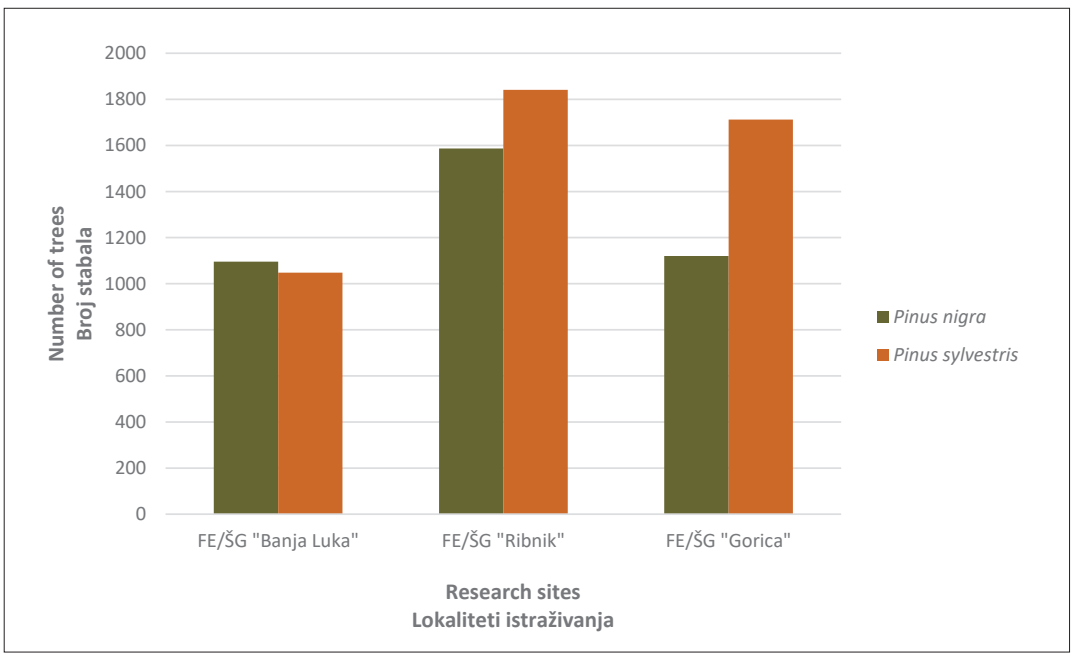

Figure 1. The number of trees per studied locality / **Slika 1.** Broj stabala po lokalitetima istraživanja

Based on the results shown in Figure 2, the largest number of trees of both Scots and Austrian pine in the area of the FE "Banja Luka" was recorded in diameter class of 12.5–22.5 cm. At the other two FEs, in addition to the mentioned diameter class, a larger number of trees in 7.5 cm degree was also recorded.

The results in Figure 3 show the percentage of damaged and undamaged trees concerning the total number of recorded ones. In the area of the FE "Gorica", there were no damaged trees in Austrian pine plantations. The highest percentage of damaged Austrian pine trees out of the total recorded number was in the FE

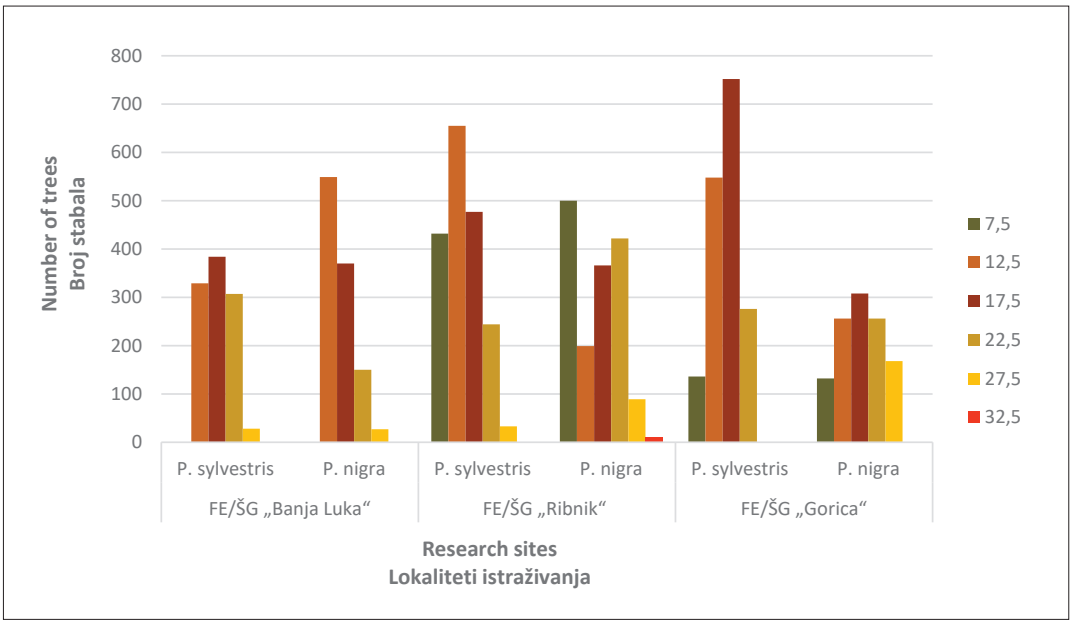

Figure 2. The number of trees by trees diameters at studied localities / **Slika 2.** Broj stabala po debljinskim stepenima na lokalitetima istraživanja

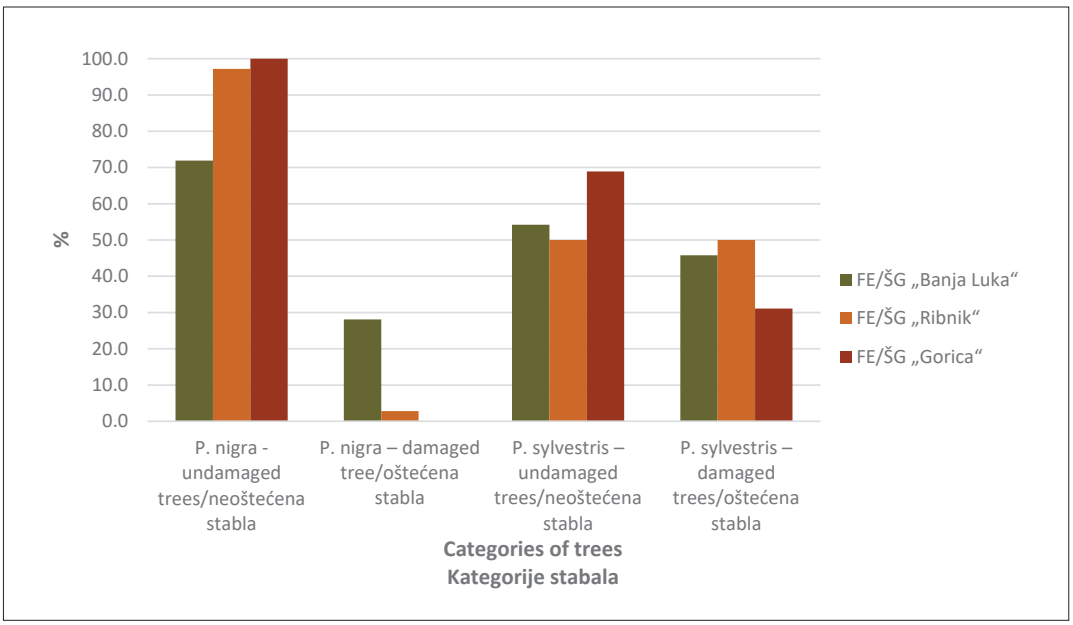

Figure 3. The relative values of trees per damage category / **Slika 3.** Relativne vrijednosti broja stabala po kategorijama oštećenja

“Banja Luka”, while more undamaged Austrian pine trees were recorded in the area of the FE “Ribnik”. In the case of Scots pine, the highest percentage of undamaged trees was recorded in the FE “Gorica”, while the highest percentage of damaged Scots pine trees was recorded in

the FE "Ribnik" (Figure 3). About 40% of the total number of damaged trees was recorded in the FE "Banja Luka", although the share of undamaged trees is slightly higher than the damaged ones. Based on the obtained results, it can be concluded that damage from snow is more present in Scots pine plantations. Also, the damage to pine plantations is most prevalent in the areas of the FE "Banja Luka" and FE "Ribnik", which are located at altitudes of 250–750 m above sea level (a.s.l.). Namely, in this range of altitudes, the probability of snow damage phenomenon is the highest. The amount of wet and heavy snow cover on the tree crown also increases with the increase in altitude, as well as heavy load it causes on the trees, which is considered one of the reasons for damage. Similar results were obtained by Valinger and Lundqvist (1992, 1994), where they stated that in Northern Europe, an altitude of 100 m above sea level is identified as the elevation above which damage increases, and that forest cover and forest land that are 150–200 m a.s.l. are most susceptible to damage from snow. However, Rottmann (1985) stated that snow damage can occur at any altitude, but that in Central Europe the highest incidence of snow damage is at altitudes of 500–900 m a.s.l., whereas damage above 1000 m is unlikely to occur.

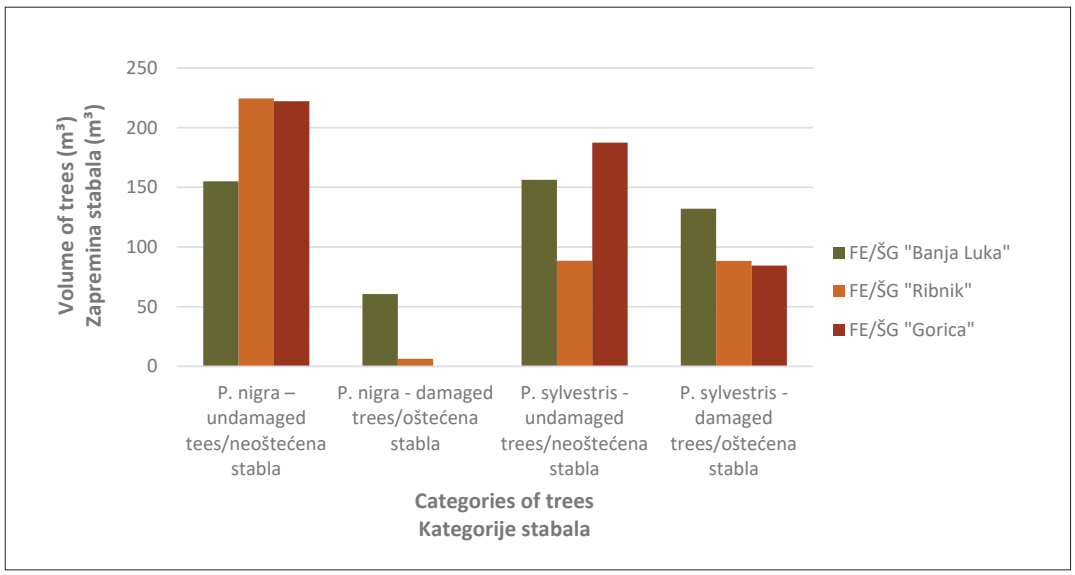

Figure 4. The volume of trees per damage category at studied localities / **Slika 4.** Zapremina stabala po kategorijama na istraživanim lokalitetima

Figure 4 shows volume values by damage category for recorded trees at the studied localities. The highest volume of undamaged Austrian pine trees was recorded in the FE "Ribnik", while the largest volume of damaged trees of this species was recorded in the FE "Banja Luka". The volume of Scots pine trees was recorded in the FE "Gorica", and the highest volume of damaged Scots pine trees was recorded in the FE "Banja Luka", as well as Austrian pine (Figure 4).

During this study, snow break and snowfall were registered as the most common types of damage to Austrian pine and Scots pine trees (Figure 6). The data in Figure 5 show that a greater percentage of snow break was recorded compared to snowfall of Austrian pine trees in the FE "Banja Luka". About 75% of the total number of damaged trees had snow breaks. In the area of FE "Ribnik", all damaged trees (100%) also had snow breaks. In the case of Scots pine, the highest percentage of trees

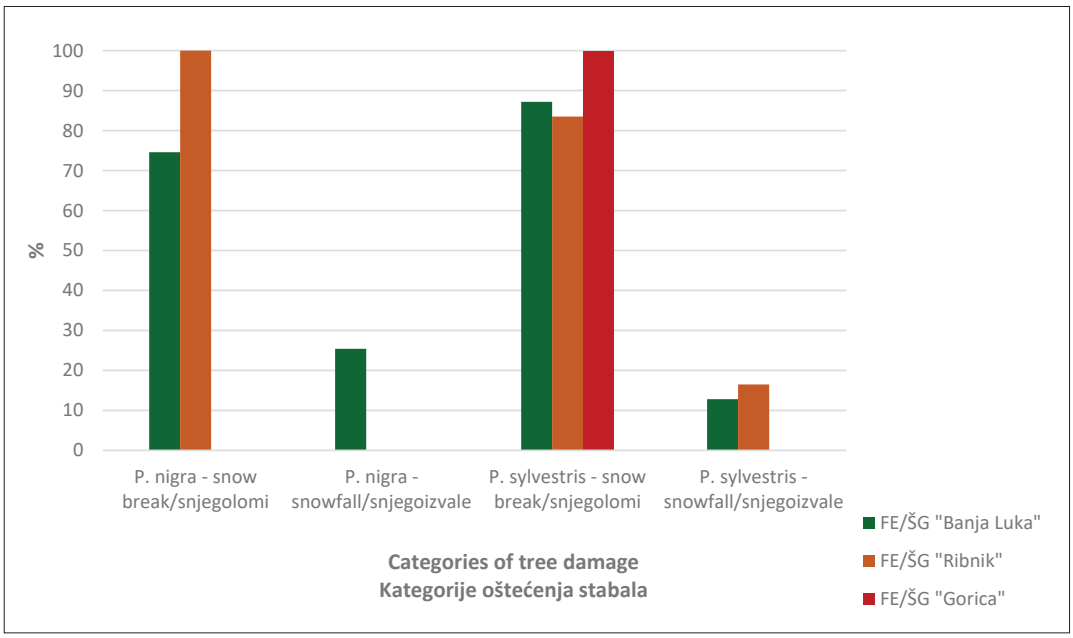

Figure 5. The relative number of trees per category of damage / **Slika 5.** Relativne vrijednosti broja stabala po kategorijama oštećenja

with snow breaks was recorded in the area of FE "Gorica" (100%) (Figure 5). Namely, snow breaks are the most common type of damage in this area. Also, in the area of FE "Banja Luka", a higher percentage (about 87%) of trees with snow breaks was recorded compared to snowfalls (Figure 5). As with the previous two FEs, the same was found in the area of FE "Ribnik" where about 84% of the trees were with snow breaks. The highest percentage of snowfall in Scots pine was recorded in the area of FE "Ribnik", about 16%, while in the area of FE "Banja Luka" the percentage was slightly lower, around 13% (Figure 5). It can be concluded that in the research locations, snow damage is about 24% more extensive in Scots pine plantations and snowfalls are the most common type of tree damage in the plantations of the studied species. Schotte (1922) also stated that snow damage on pine trees was most often manifested in the form of tree breaks just below the crown.

After the damage caused by the snow, there is a decrease in vitality and the deterioration of the health of the trees. The vitality of damaged trees is reduced to varying degrees, depending on the type and extent of the damage. Damaged trees become very sensitive to other harmful factors and then a chain of damage occurs. The availability of large amounts of material suitable for propagation leads to the attack of harmful insects and fungi, which causes great difficulties in the regeneration of pine plantations. Juutinen (1953) stated that trees that have lost more than half of their crown will be attacked and damaged by harmful insects. This can lead to a decrease in the growth and quality of the wood, and insects can also attack the surrounding undamaged trees. Factors that influence the severity of insect attacks include geographic location and ecological characteristics of damaged stands, insect population density, and weather conditions. The types of harmful insects and fungi recorded on the damaged pine trees at the research sites are described below.

Figure 6. Types of tree damage in pine plantations / **Slika 6.** Tipovi oštećenja stabala u kulturama borova (© R. Vasiljević)

Table 2. The most common and significant fungi in *Pinus nigra* and *P. sylvestris* plantations at the following research sites / **Tabela 2.** Najčešće i najznačajnije gljive u kulturama *Pinus nigra* i *P. sylvestris* na lokalitetima istraživanja

Fungi species / Vrsta gljive	**Type of damage**/ Tip oštećenja	**Host** / Domaćin	**Significance** / Značaj
Armillaria spp.	Root Rot, die-back	*Pinus nigra, Pinus sylvestris*	+++
Botrytis cinerea Pers. ex Fr	Needles in the litter	*Pinus nigra, Pinus sylvestris*	+
Cenangium ferruginosum Fr.	Cenangium "die-back" - causes dying of twigs and small branches.	*Pinus nigra, Pinus sylvestris*	+++
Cladosporium herbarum (Pers.) Link.	Needles in the litter	*Pinus nigra*	+
Coleosporium tussilaginis (Pers.) Lev.	Needles from the current vegetation and one year old	*Pinus sylvestris*	++
Cyclaneusma minus (Butin) DiCosmo, Peredo & Minter	Needle necrosis, usually two-year old needles	*Pinus sylvestris*	++ (+)
Cyclaneusma niveum (Persoon ex Fries) DiCosmo, Peredo & Minter	Needle necrosis, usually two-year old needles	*Pinus sylvestris*	++ (+)
Cytospora pinastri Fr.	A parasite of weakness at 2- or 3-year old needles	*Pinus sylvestris*	++
Hendersonia acicola Munch & v. Tub.	Saprophytic on old needles	*Pinus sylvestris*	+
Melampsora pinitorqua Rost.	Rust diseases, pine twisting rust	*Pinus sylvestris*	+
Lophodermium seditiosum Minter, Staley & Millar	Young current-year needles cast	*Pinus nigra, Pinus sylvestris*	+++
Lophodermium pinastri (Schrad.) Chev.	Previous-year needles cast	*Pinus nigra, Pinus sylvestris*	++
Lophodermella sulcigena (Rostrup) Hohnel	Necrosis and current-year needles cast	*Pinus sylvestris*	++ (+)
Mycosphaerella pini Rostrup apud Munk.	Needle blight of pines	*Pinus nigra, Pinus sylvestris*	+++
Phacidium infestans P. Karsten	Necrosis and needles cast on branches covered with snow during winter	*Pinus nigra, Pinus sylvestris*	+++
Penicillium spp.	Saprophyte on old needle in litter	*Pinus nigra, Pinus sylvestris*	+
Rhizosphaera kalkhoffii Bubak	Facultative parasites at old needles	*Pinus nigra*	+ (+)
Schizophyllum commune (Fr.) Fr.	Stem rot	*Pinus nigra*	+
Trichothecium roseum Link.	Saprophyte on old needle and falling cones	*Pinus nigra, Pinus sylvestris*	+
Sphaeropsis sapinea (Fr.) Dyko & Sutton	Sphaeropsis blight, die-back	*Pinus nigra, Pinus sylvestris*	+++
Stereum sanguinolentum (Alb. & Schw. Ex Fr.) Boid.	Stem rot	*Pinus nigra, Pinus sylvestris*	+

Note / Napomena. (+) Fungi occur mostly as saprophytes or seldom as facultative parasites, they have no economic significance; (++) Fungi occur on shoots, bark or two-year-old needles on trees, have less economic significance; (+++) Fungi cause dangerous diseases in pine plantations, can appear in epiphytocia and lead to massive decay of attacked trees / (+) Gljve koje se pojavljuju uglavnom kao saprofiti ili rijetko kao fakultatvni paraziti i nemaju ekonomski značaj; (++) Gljive koje se pojavljuju na žilištima, kori ili dvogodišnjim iglicama a koje imaju manji ekonomski značaj; (+++) Gljive koje uzrokuju opasna oboljenja u kulturalama borova, mogu se pojavljivati u epifitocijama i vode masovnom truljenju napadnutih stabala

A total of 21 fungal species were determined at the research sites (Table 2). In the previous studies in Serbia and the territory of the Republic of Srpska, 59 and 48 species of fungi have been recorded in Austrian pine and Scots pine plantations, respectively (Karadžić & Stanivuković, 2010).

According to their importance, fungi are classified into three groups. There are six species in the first group, which includes parasitic species of fungi that cause infectious diseases that, under favourable conditions, occur in an epidemic form, leading to massive tree declines. Fungi from the genus *Armillaria* spp., which are among the most common and most important lignicolous fungi in deciduous and coniferous forests in Serbia, have the greatest importance in Austrian pine and Scots pine plantations at the studied sites. Five *Armillaria* species are present in Serbia (*A. mellea, A. ostoyae, A. cepistipes, A. gallica* and *A. tabescens*). Among these, two species (*A. mellea* and *A. ostoyae*) most often develop as true parasites or facultative parasites (Radulović et al., 2021).

Armillaria ostoyae represents a particular danger in pine plantations grown in broadleaved species habitats. It causes soft, white root rot, and after some time white wood rot at the base of the tree (Radulović et al., 2021). It is very common in all studied locations, especially on trees that are more severely damaged by the harmful effects of snow (Figure 7).

In addition, the species *Mycosphaerella pini* and *Sphaeropsis sapinea* show a high degree of presence.

Mycosphaerella pini causes red band needle cast and needle shedding, causing the greatest damage to the pines of the northern hemisphere. According to Karadžić & Milijašević (2008), *Pinus nigra* plantations aged 5-25 years are particularly vulnerable in Serbia. This fungus has not been recorded at an altitude higher than 900m in Serbia. *Pinus sylvestris* shows great resistance to this fungus. However, in 1986, a weak infestation of Scots pine was registered in Deliblatska peščara (Deliblato Sands) (Karadžić, 1986; Lang & Karadžić, 1987). It mainly attacks species from the genus *Pinus* but was also recorded on other coniferous hosts worldwide.

Figure 7. *Armillaria ostoyae* (Romang.) Herink. - mycelium of the fungus / **Slika 7.** *Armillaria ostoyae* (Romang.) Herink. - micelija gljive (© R.Vasiljević)

Sphaeropsis sapinea is an important disease agent on coniferous tree species, especially pines. According to Phillips et al. (2006), the correct scientific name for this species is *Diplodia sapinea* (Fr.) Fuckel. This fungus develops on needles, the bark of shoots, branches and trunks, on cones and in the cells of the tree causing staining (Diminić, 1999; Diminić et al. 2004.). Austrian pine shows the greatest sensitivity in cultures and urban areas (Diminić, 1994). The most common predisposing factor for the appearance of this fungus is drought, inappropriate environmental conditions, increased nitrogen deposition, various injuries caused by hail, snow, pruning, insects, etc. (Diminić et al. 2002; Wingfield & Swart, 1994; Zwolinski et al., 1995). The habitat plays a significant role in the predisposition of pines to this fungus, especially in dry periods.

Ecological and economic losses resulting from the activity of this fungus on *Pinus nigra* are attracting the attention of many scientists who are trying to minimize these losses. (Zgrablić et al., 2016).

Out of the other parasitic fungi presented in Table 2, damage of lesser intensity was caused only by the pathogen *Lophodermium seditiosum*. This species showed a lower presence at most of the studied sites.

Table 3. The most common and significant types of harmful insects in *Pinus nigra* and *P. sylvestris* plantations at the studied localities / **Tabela 3.** Najčešće i najznačajnije vrste štetnih insekata u kulturama *Pinus nigra* i *P. sylvestris* na lokalitetima istraživanja

Insect species / Vrsta insekta	**The part of the plant on which it lives** / Dio biljke na kojem živi	**Host** / Domaćin	**Significance** / Značaj
Phaenops cyanea F.	Trunk	*Pinus nigra, Pinus sylvestris*	++
Ergates faber L.	Stumpwood, branch litter	*Pinus nigra, Pinus sylvestris*	+
Criocephalus rusticus L.	Physiologically weak tree, stumpwood, branch litter	*Pinus nigra, Pinus sylvestris*	++
Monochamus galloprovincialis Ol.	Young shoot, stem	*Pinus nigra, Pinus sylvestris*	++
Hylobius abietis L.	Bark of young shoot, bark of stem	*Pinus nigra, Pinus sylvestris*	+++
Pissodes castaneus Deg.	Bark of young shoot, bark of stem	*Pinus nigra, Pinus sylvestris*	++
Blastophagus piniperda L.	Parts of a pine tree with thick bark	*Pinus nigra, Pinus sylvestris*	+++
Blastophagus minor Hart.	Parts of pine trees with thinner bark	*Pinus nigra, Pinus sylvestris*	+++
Hylurgus ligniperda F.	Lower end of the stem, stump with roots	*Pinus nigra, Pinus sylvestris*	+
Hylastes ater Payk.	Stem base, stumpwood, branch litter	*Pinus nigra, Pinus sylvestris*	++
Pityogenes bidentatus Hbst.	Thin branches, tree top.	*Pinus nigra, Pinus sylvestris*	+
Pityogenes bistridentatus Eich.	Thin branches, tree top	*Pinus nigra, Pinus sylvestris*	+
Pitiogenes quadridens Hart.	Thin branches, tree top	*Pinus nigra, Pinus sylvestris*	+
Ips sexdentatus L.	Trees with thick bark	*Pinus nigra, Pinus sylvestris*	+++
Ips acuminatus Gyll.	Parts of pine trees with thinner bark	*Pinus nigra, Pinus sylvestris*	++
Rhyacionia buoliana Schiff.	Young shoot	*Pinus nigra, Pinus sylvestris*	+++
Petrova resinella L.	Young shoot	*Pinus nigra, Pinus sylvestris*	++
Acantholyda hieroglyphica Christ.	Needle of young pines	*Pinus nigra, Pinus sylvestris*	++
Neodiprion sertifer Geoffr.	Pine needles of all ages class	*Pinus nigra, Pinus sylvestris*	+++

Note / Napomena. (+) species that have little economic importance; (++) species that are common and occasionally can cause less damage; (+++) species that are prone to mass occurrence causing great damage / (+) vrste koje imaju mali ekonomski značaj; (++) vrste koje se pojavljuju često i povremeno mogu izazvati manje štete; (+++) vrste koje su sklone masovnoj pojavi uzrokujući velike štete

Out of the total number of recorded species (19), seven species occur on the trunk, ten species on shoots and parts of the tree with thin bark, and two species on stumps and leaves.

Blastophagus piniperda L., *Blastophagus minor* Harth and *Ips sexdentatus* L. represent the greatest danger in the studied sites. In addition to these species, an increasingly frequent presence of *Criocephalus rusticus* L. was found on physiologically weakened trees and stumps. In some localities, the presence of pine needle defoliators (*Acantholyda hieroglyphica* Christ and *Neodiprion sertifer* Geoffr.) was recorded on a smaller scale.

Blastophagus piniperda L. has a one-year generation and swarms early, already in March when the air temperature is around 12 °C. During the summer, females find suitable trees for drilling, freshly cut or physiologically weakened trees. In Europe and North America, they choose the lower parts of the tree with thicker bark, while in China they mainly drill in the upper part of the tree where the bark is smooth (Hui & Xue-Song, 1999). Young imago provides maturation feeding by gnawing the core of young shoots. Ryall & Smith (2000) report that one imago bites up to 6 shoots. After completing the maturation feeding, they gnaw the galleries in the stem base of the older trees where they hibernate. It behaves as a primary and secondary pest. Due to maturation feeding in the core of young pine shoots, as well as the way of hibernating at the base of healthy trees, it is a primary pest. Schroeder & Eidmann (1993) report that *B. piniperda* does not kill healthy trees, but feeding on shoots can result in significant growth reduction. It occurs in overstocking together with *B. minor*, *I. sexdentatus*, and *I. acuminatus.*

The species *Blastophagus minor* Harth is present in all studied sites. This is a monogamous species that has a one-year generation, swarms in April and inhabits the upper parts of the tree with thinner bark, thicker branches and freshly cut and damaged trees. The female builds two-pronged horizontal maternal galleries, with a long entrance hall in the middle (Figure 8). Maternal galleries can be up to 15 cm long.

Figure 8. *Blastophagus minor* Hart.: attacked tree (left), hall system (right) / **Slika 8.** *Blastophagus minor* Hart.: napadnuto stablo (lijevo), hodnični sistem (desno) (© R. Vasiljević)

The most dangerous species of bark beetle on pines that were recorded in the research sites is *Ips sexdentatus* Boern. – six-toothed pine bark beetle (Figure 9). The six-toothed pine bark beetle has a double generation, the first spawning in April and the second in July and August depending on the weather. It is a polygamous species, in which multi-branched maternal galleries of vertical tendency extend from the nuptial chamber. Young imago performs maturation feeding at the place of development, thus spoiling the image of the bite. It hibernates in the imago stage under the bark. This is a secondary pest, which attacks older trees with thicker bark. It also attacks the lower parts of young trees with thicker bark. It is especially dangerous in older plantations that have been damaged by snow, after which it can outbreak.

Figure 9. *Ips sexdentatus* Boern.: hall system / **Slika 9.** *Ips sexdentatus* Boern.: hodnični sistem (© R. Vasiljević)

A less common species, which occurs as a secondary pest on physiologically weakened trees, is *Ips acuminatus* Gyll. – three-toothed pine bark beetle. This is a polygamous species that has a one-year generation, swarming in mid or late May. It most often chooses parts of the tree with thinner bark (tops or thicker branches). After copulation, females build maternal galleries that can be up to 40 cm long. The hall system is star-shaped with a vertical tendency. The larval galleries are shorter and perpendicular to the maternal galleries. The young imago provides maturation feeding at the place of development and also overwinters in the same place. In conditions where there is an outbreak, it becomes the primary pest that attacks healthy trees. In central and southern Europe in recent years, damage to pine trees, caused by the attack of *Ips acuminatus* has increased (Siitonen, 2014). In addition to the mentioned species of bark beetle, the secondary pest *Criocephalus rusticus* L is very common and attacks physiologically weakened trees, especially in plantations. This species from the *Cerambycidae* family has a biennial generation. Imago occurs during June and July. They are most active at dusk and during the night. After copulation, females lay eggs in cracks on the lower parts of the tree, and sometimes under the bark. They usually choose physiologically weakened, freshly felled logs and stumps for egg laying. The hatched larva burrows under the bark, building an irregular gallery. After a while, they burrow deeper into the tree, where they build vertical oval galleries filled with wormholes. It overwinters twice in the larval stage. If the wood in which they are found is of poorer quality, then larval development takes longer (Dominik, 1958). In addition to the listed species of Coleoptera, the presence of harmful species of butterflies from the family *Tortricidae* (*Rhyacionia buoliana* Schiff.) was recorded at all studied sites, but at a low intensity. This is a distinctly primary pest that swarms during June and has a one-year generation. It is especially dangerous if its caterpillars develop in terminal shoots. As a consequence of the harmful activity of this species, the affected trees are deformed up to a height of 3-4 m. A frequently present species on snow-damaged pine material is *Sirex gigas* L. – the large wood wasp. This hymenopter from the *Siricidae* family is a physiological and technical pest that has a multi-year generation.

In the past few decades, the establishment of forest plantations and planted forests on the territory of the Republic of Srpska has been performed in a wide range of habitat conditions.

However, the implementation of intermediate cutting in these plantations, like tending and thinning was in many cases omitted. Due to different habitat conditions, as well as the occurrence of different amounts and types of snow, it is necessary to perform tending and thinning measurements in plantations timely as a preventive measure to reduce damages from snow. It is urgently required to further monitor the occurrence and effects of snow damage in pine plantations, as well as fungal and pest organisms that appear in succession following these damages. All this information should be used in the selection of further habitats for raising and growing pine plantations, to evaluate the risks and predict expected damages, and subsequently to perform preventive measurements accordingly.

4. CONCLUSIONS / ZAKLJUČCI

- The study was performed in the forest plantations of Austrian pine and Scots pine in the areas of FE "Banja Luka", FE "Ribnik", FE "Gorica",
- A greater percentage of Scots pine was recorded in the areas of FE "Ribnik" and FE "Gorica", while a greater percentage of Austrian pine was recorded in the area of FE "Banja Luka",
- The largest number of damaged Scots pine trees (921) was recorded in the area of FE "Ribnik", and the largest number (308) of damaged Austrian pine trees in the area of FE "Banja Luka",
- Snow damage is more present in Scots pine plantations and at altitudes of 250-750 m above sea level,
- The most common types of damage to trees are snow breaks and snowfalls,
- Several harmful insects were recorded on the damaged trees (*Tomicus piniperda, Tomicus minor, Ips sexdentatus, Ips acuminatus, Criocephalus rusticus*, *Rhagium inquisitor*, *Sirex gigas, Rhyacionia buoliana*),
- The most important harmful fungi recorded on damaged pine trees were *Armillaria ostoyae*, *Lophodermium pinastri, Lophodermium seditiosum*, *Mycosphaerella pini*, *Fomitopsis pinicola*, *Cyclaneusma minus*,
- Further studies of the snow damages, harmful insects and fungal pathogens that occur in succession following snow damages are required to determine potential risks for the newly established pine plantations.

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Sažetak

Snijeg, kada se javi u posebnim okolnostima, često nanosi velike štete šumskoj vegetaciji. Te štete predstavljaju veliki problem, naročito u pregustim sastojinama u kojima se nalaze tanka i visoka stabla koja su slabo otporna na pritisak snijega. Prilikom nakupljanja velikih količina snijega na krošnjama i stablima drveća, dolazi do prekomjernog pritiska pod kojim se savijaju i prelamaju grane, vrhovi stabala, pa čak i cijela stabla. Istraživanjem šteta od snijega u kulturama crnog i bijelog bora u zapadnom dijelu Republike Srpske, utvrđeno je da su štete izraženije u kulturama bijelog bora. Takođe, štete su najviše zastupljene u kulturama borova koje su podignute na nadmorskim visinama od 250 do 750m.

Snjegolomi i snjegoizvale su registrovani kao najčešći tipovi oštećenja stabala u kulturama. Velike količine oštećenih stabala predstavljaju materijal pogodan za napad i razmnožavanje štetnih insekata i gljiva. Najčešće i najznačajnije vrste štetnih insekata i gljiva u kulturama crnog i bijelog bora na lokalitetima istraživanja prikazane su u tabelama 2 i 3.

Ključne riječi: abitoički uzročnici, *Pinus nigra, Pinus sylvestris*, sniježne padavine, snjegolomi