11th INTERNATIONAL SCIENTIFIC CONFERENCE
RURAL DEVELOPMENT 2023
BIOECONOMY FOR THE GREEN DEAL
26-28th September, 2023, Vytautas Magnus University Agriculture Academy, Lithuania

VYTAUTAS MAGNUS UNIVERSITY AGRICULTURE ACADEMY

Proceedings of the 11th International Scientific Conference Rural Development 2023

Edited by assoc. prof. dr. Judita Černiauskienė

ISSN 1822-3230 (Print)
ISSN 2345-0916 (Online)

Article DOI: https://doi.org/10.15544/RD.2023.027

DEAD WOOD AMOUNT AND REGENERATION IN SCOTS PINE (*Pinus sylvestris* L.) DIFFERENT AGE STANDS IN THE BURN OF THE "STIKLU PURVI" NATURE RESERVE

Edgars DUBROVSKIS, Institute of Forest Management, Faculty of Forest and Environmental Science, Latvia University of Life Sciences and Technologies, address: 2 Liela Street, Jelgava, Latvia, LV-3001, edgars.dubrovskis@lbtu.lv *(corresponding author)*
Aiva ZINDULE, Faculty of Forest and Environmental Science, Latvia University of Life Sciences and Technologies, 2 , address: Liela street, Jelgava, Latvia, LV-3001, aivazindule@gmail.com
Olga MIEZITE, Institute of Forest Management, Faculty of Forest and Environmental Science, Latvia University of Life Sciences and Technologies, , address: 2 Liela street, Jelgava, Latvia, LV-3001), olga.miezite@lbtu.lv

The forest is affected by various anthropogenic and natural disturbances causing damage to the ecosystem and financial losses. In this research work, emphasis is placed on one of the most important forest disturbances – fire. One of the largest fires in Latvia was in 2018 in the "Stiklu purvi" nature reserve, which affected 1,353 ha of forest territory.
The aim of the study was to evaluate the regeneration process of different age Scots pine (*Pinus sylvestris* L.) in the nature reserve "Stiklu purvi" burn.
The data were obtained in the nature reserve " Stiklu purvi" burn, which is located in Valdgales parish of Talsi district and Usmas and Puze parishes of Ventspils district. The surveyed areas were nine sample plots, which were 2000 m^2 in size each. The calculations were compared with the data obtained in 2019 and conclusions were drawn.
From the results of the study, we conclude that since 2019 in all stands the average diameter of trees has increased by 3.5 cm. The average height in young and middle-aged stands has increased, but in overgrown stands it has decreased, which we can explain by tree mortality. Compared to the results of 2021, in 2022 both the average basal area and the average wood stock have decreased in all stands. Since 2021, the amount and diversity of dead wood and defoliation in all stands has increased. In all stands, the regeneration takes place mostly with deciduous trees.

Keywords: *Scots pine, forest fire, natural disturbance, forest regeneration, deadwood.*

INTRODUCTION

The forest is threatened by various natural and anthropogenic disturbances, and one of the most dangerous disturbances in Latvia and in the world is fire. Fire causes great damage to the forest ecosystem and causes great financial losses. Forest fires are caused by drought, lightning, human influence i.e. careless handling of fire, arson, as well as when performing forest management activities in or near the forest. Forest recovery after a forest fire is difficult and a time-consuming process. The process of reforestation in fires starts with the removal of damaged wood and only then does the soil preparation and planting of new trees begin. In areas where forest operations are limited, such as nature reserves, forest regeneration occurs naturally.

Scots pine (*Pinus sylvestris* L.) is recognized as one of the most important national economic resources in Latvia. The value of pine wood is determined not only by the widely available volume, but also by its quality, which depends both on the external characteristics of the tree - the straightness of the trunk and the thickness, quantity, angle and type of branches, as well as on the physical and mechanical properties of the wood (Baumanis *et al*. 2014).

Nature reserve "Stiklu purvi" is the largest complex of raised bogs in Western Latvia. The reserve is included in the European network of protected areas *Natura 2000* (code LV0518900). The reserve is a site of international importance for birds (PNV) (code LV016). As a large part of the territory of the forest reserve consists of forests on wet mineral soils and wet peat soils, which are characterized by various biodiversity-enhancing elements, e.g. sedges, dry roots, tree trunks, hollow trees, this reserve attracts both invertebrates and birds . The main habitat types are: forest (68%), swamp (28%), grassland (3%) and freshwater (1%). The forest occupies 2/3 of the entire territory of the reserve. A high-risk forest fire broke out in the "Stiklu purvi" nature reserve in 2018, which affected forestland and swamps with an area of 1353 ha.

The main natural disturbances in forests are drought, forest fires, storms, mass breeding of insects, diseases, invasive alien species and increase in average air temperature. The main anthropogenic disturbances are deforestation, forest fragmentation, soil drainage and pollution (Eiropas Komisija, 2018).

Fire is an important natural disturbance in the forest ecosystem, changing its dynamics and increasing carbon emissions (Kitenberga, 2019). Understanding the forest fire regime is an important step towards sustainable forest management (Manton *et al*. 2022). In Latvia, fire most often affects pine forests (Zadiņa *et al*. 2015).

Forecasts indicate that forest fires will become more frequent in the future. The reason is climate change, which leads to an increase in average air temperature and more frequent, longer periods of drought (Spracklen *et al*. 2009). Climate change affects the seasonality, frequency (shorter return interval), intensity, severity (tree mortality) and burned area of fire occurrence (Petrokas *et al*. 2022).

The pine is partially adapted to fires, a moderately fire-resistant tree species, because the pine bark is thick and the crown is high, therefore, part of pine trees survive during a fire (Fernandes *et al*. 2008). Spruce is the opposite; it is a fire resistant species and is often destroyed due to its thin bark and low crown. The fire therefore creates several cohorts of pine stands and destroys the spruce trees (Petrokas *et al*. 2022). Old pines are more likely to survive fires because older pines have thicker trunk bark that prevents fire from reaching the cambium as quickly, and a taller crown compared to young trees (Fernandes *et al*. 2008).

The aim of the study is to evaluate the changes in the dendrometric parameters of pine (*Pinus sylvestris* L.) stands of different ages, to analyse the dynamics of dead wood and to assess the dynamics of stand regeneration after a forest fire.

Large forest fires also kill seed trees, which affects forest regeneration. Burned areas need to be managed with care, as inappropriate management can affect the duration of forest regeneration, species diversity and future resilience to disturbance. Regeneration can be hindered by leaving a dense stand, as well as an excessively large amount of dead wood left behind. (Parro *et al*. 2015). After a forest fire, there is a succession that is influenced by various factors, such as terrain, air temperature, soil moisture, soil fertility, amount of fuel, wind speed during burning, etc. (Latvijas meža tipoloģija, 2014). After fires in the forest, space is freed up - light conditions change. This creates favourable conditions for the development of light loving tree species in the burnt areas (Hart, Chen, 2008).

The depth of fire damage in to the soil (Dzwonko *et al*. 2015) significantly affects forest regeneration dynamics, understory vegetation composition and tree species. In many cases, regeneration does not occur with Scots pine, but with pioneer species if the soil is fertile enough for other species to grow. Regeneration of pine in burnt areas takes place approximately 3-5 years after the fire. However, birch regenerates already in the first years, because birch has a higher germination rate and a larger seed distribution distances (Parro *et al*. 2015). The best pine starts to regenerate 5 years after the fire, but the development of the pine is hindered by competing vegetation (Mallik, 2010).

A study in the Slīteres National Park (Latvia) shows that 25 years after a forest fire, the regeneration is mostly with birch (Freimane *et al*. 2021). Also, a study in the pine forests in the north of Russia shows that the forest stand regenerates with aspen after a fire, and pine is rarely found and makes up a very small proportion - 0.5 - 1% of the forest stand (Ivanova *et al*. 2014).

Whether a forest should be artificially restored after a fire or allowed to regenerate naturally depends on various factors, including the type of fire and the type of forest. A naturally regenerated forest stand after a fire can form a mixed stand that can be more resistant to disturbance compared to a pure stand (Thiel *et. al*. 2012). An intense fire destroys the organic and humus layer of the soil, so the recovery process can be hindered due to changes in the water regime and a decrease in fertility (Buhk *et al*. 2007). In dry pine forests, the preference should be given to the natural forest regeneration, because after a fire, soil fertility and ground water level decrease, thus creating additional unfavourable conditions for the growth of seedlings (Thiel *et al*. 2012). In the poor forest types on dry mineral soils after a fire, the composition of tree species is dominated by pine (Zadiņa *et al*. 2015).

Also, after a forest fire, forestry measures has an impact on the composition and development of understory tree species. Comparing the natural regeneration of pine 23 years after the fire, was Kitenberga (2019) concluded the pine was the dominant tree species (≤ 51%) in poor natural forest types in the areas where sanitary continuous felling was not performed after the fire. In the areas where sanitary continuous felling was performed after burning in the poor forest types on dry and wet mineral soil, the dominant tree species was pine, and on poor wet peat soils - birch. Birch regenerates in greater numbers in areas where the soil has a higher moisture content than in dry and poor soils.

The average height of a pine tree was influenced by several factors – type of forest, type of forest management, number of trees, etc. It was observed that, in all poor forest types, in the natural stands, the average height of pine after sanitary continuous felling was significantly higher than in the areas where sanitary continuous felling was not performed. Birch also increased in average height, but not as much as pine. This means that during sanitary felling, removing dead and damaged trees improves the growth conditions for both pine and birch. (Kitenberga, 2019).

In the poor forest types on wet mineral soils, pine stands taller than other tree species after a fire. In all forest types, except for the poor forest types on wet mineral soils, Scots pine has a higher height in areas where natural regeneration takes place after clear-cutting than in the fire-affected area (Zadiņa *et al*. 2015).

One of the main reasons for the death of pine in fires is direct fire damage to part of the root system. Not all pines affected by the fire die immediately after the fire, several years after the fire the trees continue to die gradually. After two years, pine mortality is almost complete in cases where the horizon of the organic layer is completely burnt. On the other hand, low pine mortality has been observed in areas where the fire affects only the upper part of the horizon of the organic layer (Tybursky *et al*. 2019).

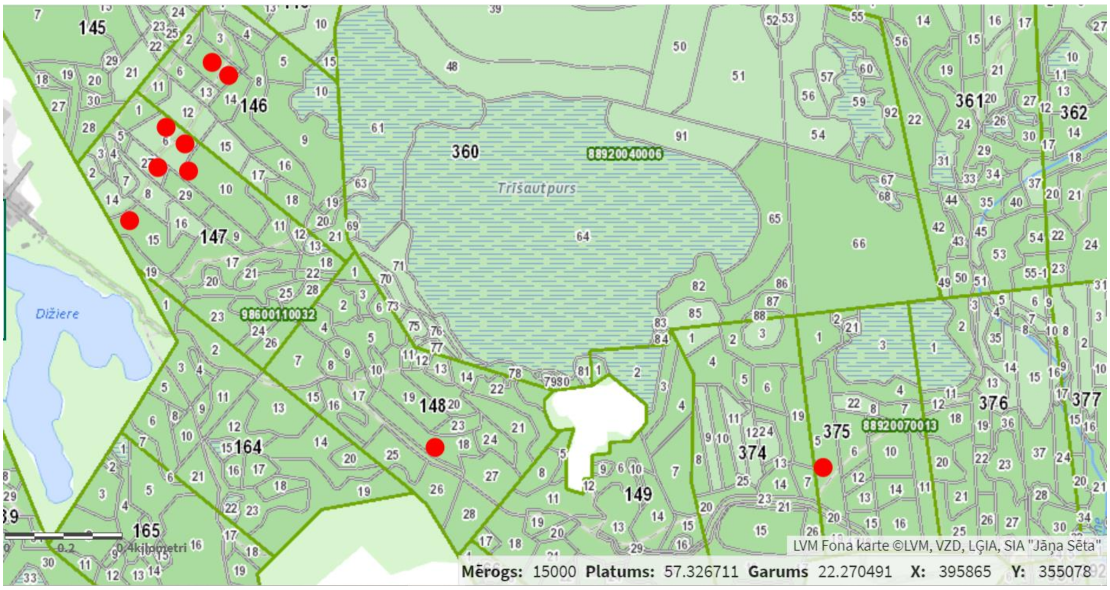
In Finland, it was found that the pine tree was the only tree species that partially survived the fire. Spruce, birch and other tree species almost all died in the fire. Of the trees in the stand, the average diameter of the pines that survived the fire at a height of 1.3 m from the root neck was 15.8 cm; trees of smaller dimensions died (Kolström and Kellomäki, 1993).

The formation of dead wood in the forest is caused by the death of trees caused by mutual competition, aging or natural disturbances - abiotic or biotic factors (Rahman *et al*. 2008). Small-scale disturbances cause the death of individual trees or small groups of trees, while large-scale disturbances affect the entire stand (Merganičová *et al*. 2012). Depending on the size of the disturbance, dead wood consists of standing or fallen trees and their parts. The amount of dead wood depends on the composition of the tree species in the forest, their development and the performed management works.

Dead wood is important for many ecosystem functions. One of the important functions is a source of food for many living organisms (Merganič *et al*. 2022). Some living organisms use dead wood as an environment in which they develop and live, e.g. mushrooms, lichens, beetles (Merganičová *et al*. 2012). Managed forests tend to have less dead wood than unmanaged old growth forests (Merganič *et al*. 2022). The amount of dead wood in deciduous forests is often lower than in coniferous forests, as deciduous forests are generally less damaged by abiotic factors (Juutilainen *et al*. 2011). Decaying trees are important sources of nutrients in forests where the soil is infertile (Kuuluvainen, Rouvinen, 2000). After several years, in a fire-affected area, large standing trees can serve as seed catchers and promote forest regeneration, as well as protect young trees from wind. At the same time, the large trees that survived the fire reduce the availability of light for the remaining smaller trees, dry trees can fall, break and damage the young trees (Parro *et al.* 2015).

RESEARCH METHODS

Research data collection took place from the fall of 2019 to the fall of 2022. During the research, 9 sample plots were established in stands of different ages (Figure 1), with an area of 2000 m^2 and a radius of 25.24 m, in the burnt area of the reserve. Stands were divided in three groups: young stands (up to 65 years old), middle age (66 to 100 years), and overgrown stands(101 to 160 years). Trees in each plot are numbered clockwise from magnetic north of the plot, and the number varies between plots.



Source: lvmgeo.lvm.lv

Figure 1. Location of the sample plots.

Data were collected in the sample plots, and the charactersitics of trees and stands, as well as the proportion and type of dead wood were evaluated. The diameter ($D_{1.3}$, cm), as well as the tree height (H, m) and the height of the first green branch (H_{zz}, m) were measured. The diameter was measured with a forest calliper for all living trees at a height of 1.3 m from the root neck with an accuracy of 1 mm. The height of the first green branch and the height of the tree were measured with a Suunto altimeter. A defoliation class of the growing trees used to assess the condition of the crowns and determine the damage caused to the forest by fire. The state of the crowns was assessed visually in the sample plots with 5% accuracy for those trees with visible signs of life - conifers with needles and deciduous trees with leaves on the branches. Proportion of living crown determined as a percentage. Defoliation classes are divided as follows: light damage (0-25%), medium damage (26-60%), and severe damage (>61%).

In the sample plots, the dead wood is listed, for which two characteristics are determined - condition class and degree of decomposition. Dead trees are assigned a condition class:

- Standing trunks (SA) – a standing, dead tree that still has branches and bark, but no green needles or leaves.
- Stump (ST) – a standing trunk of a dead tree that is branchless or broken.
- Downed logs (K) – fallen or broken lying tree trunk (Donis *et al.* 2010).

Decomposition rates of dead wood were determined according to Hunter (1990) scale:

I. Tree is recently dead, bark and wood colour is original.
II. The trunk is round, the bark has started to peel, the wood is still hard and the colour is original.
III. The bark is less than 50%, the wood has softened and the colour has changed.
IV. The bark is gone, the wood is soft and the wood texture is loose.
V. The wood is soft, parts of the trunk have disappeared and vegetation is already developing on the surface (Liepa *et al.* 2014).

In each of the 2000 m^2 sample plots, there were 9 smaller sample plots with an area of 25 m^2 and a radius of 2.82 m. Eight plots were located in the large plot, two on each side of the cardinal direction (N1; N2; E1; E2; S1; S2; W1; W2) and one in the centre of the plot (C). In the small sample plots, data on the regeneration of the forest stand after the fire have been collected - understory trees are listed, the number of which has been determined by species and the heights have been measured. Coniferous trees with a minimum height of 0.1 m and deciduous trees - 0.2 m were considered. The number of trees in the sample plot was counted, moving clockwise, and the height of at least five trees of each tree species was measured with an accuracy of 1 cm. In the course of the study, the indicators of stand taxation were calculated - the average diameter of the stand; average height of the stand; stand basal area and stand stock. The dynamics of the types and decomposition of dead wood were analysed, as well as the regeneration of forest stands was assessed.

RESEARCH RESULTS AND DISCUSSION

Since 2019, when the sample plots were measured for the first time, the changes of dendrometric indicators differs. Average diameter and height (Figure 2) increased in all stands. In young stands, the average diameter increased by 1.1 cm, reaching 10.8 cm, in middle-aged stands by 3.45 cm, reaching 21.1 cm, and in overgrown stands by 3.37 cm, reaching 24.5 cm. In young stands dominated trees with 8 cm diameter, in overgrown stands with 24 cm, but in middle-aged stands with 20 cm diameter.

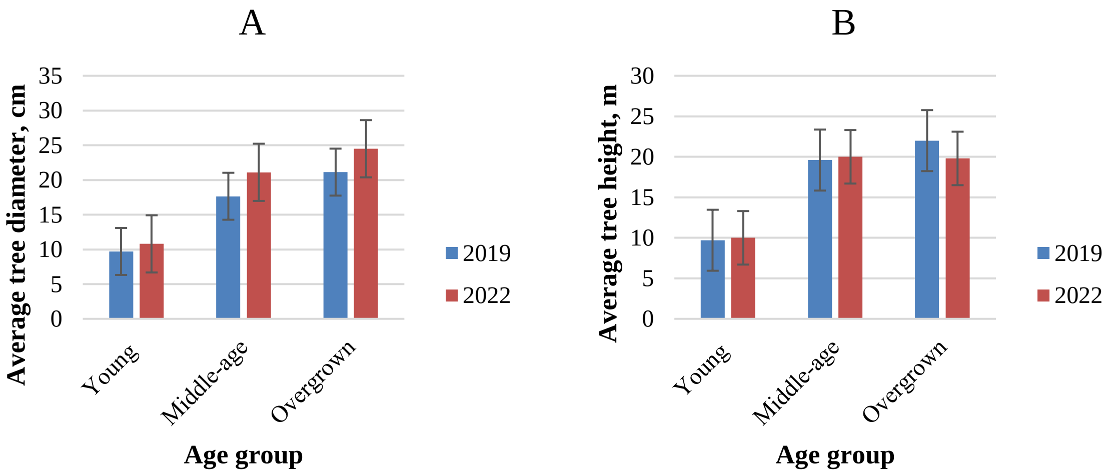


Figure 2. Distribution of the average diameter (A) and height (B) of the stands by age groups in 2019 and 2022 (average±SE)

The young stands had the smallest average height – 10 m. The middle-aged stand was the tallest – 20 m. The average height of an overgrown stand was 19.8 m. Compared to the previous year's data, the average tree height had increased by 0.3 m in the young stand, and by 0.4 m in the middle-age stand. However, the average tree height in the overgrown stand had decreased by 2.2 m. In overgrown stands, the average height is gradually decreasing, as most of largest trees have died since last year.

The smallest basal area of an average tree can be observed in young stands – 0.009 m^2. The average basal area of a middle-aged and overgrown tree is 0.035 m^2. Compared to 2021, in 2022 the basal area of the average tree in young stands has increased by 0.002 m^2, in middle-aged stands by 0.01 m^2, but in overgrown stands the basal area of the average tree has remained unchanged - 0.035 m^2.

After determining the average tree basal area of the stand, the average basal area of the stand was also calculated both by age groups and by sample plots. Figure 3 shows the distribution of the basal area and wood stock of the stand per hectare by age groups. Largest changes are in overgrown stand group, but smallest in middle-aged stand group. In all age groups, basal area is decreasing.

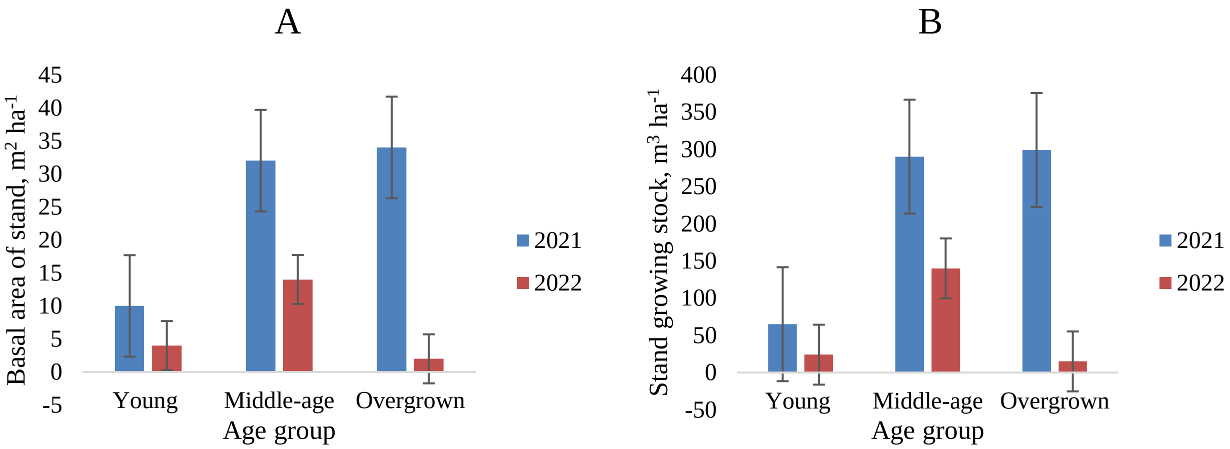
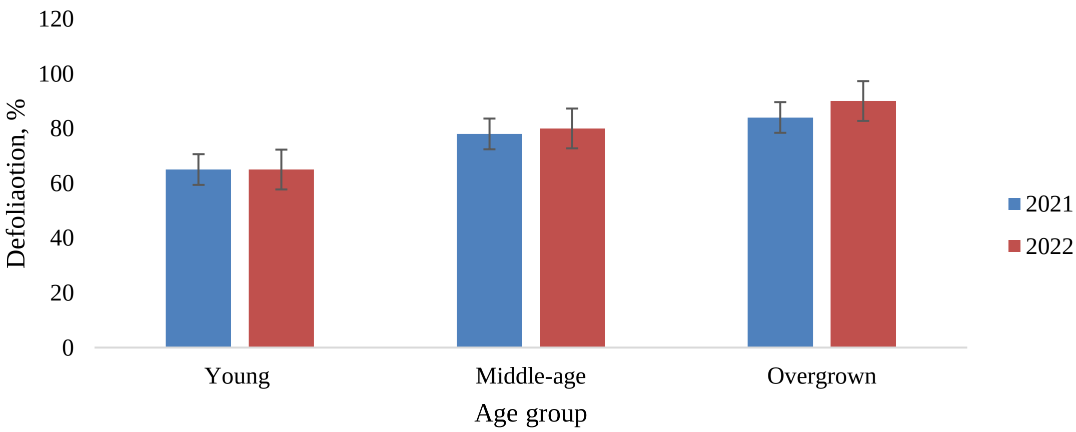


Figure 3. Distribution of the average basal area (A) and stand growing stock (B) per hectare by age groups in 2021 and 2022 (average±SE)

The distribution of wood stocks by age groups is not uniform. The smallest stock of wood per hectare consists of overgrown stands - 9.5 m^3 ha^{-1}, where in 2021 it was still 295.97 m^3 ha^{-1}. The stock has also dropped sharply in middle-aged stands from 290.17 m^3 ha^{-1} to 134.9 m^3 ha^{-1} and in young stands from 65.81 m^3 ha^{-1} to 21.13 m^3 ha^{-1}. The largest stock of wood per hectare is in medium-aged stands.
Defoliation was determined for all living trees to observe changes in crown dimensions. Changes in defoliation in the last two years can be seen in Figure 4.

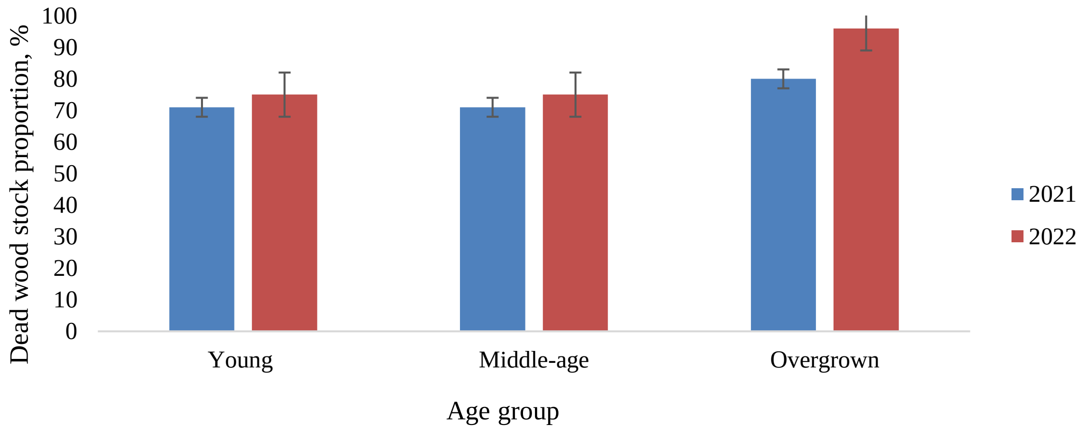


Source: created by the author

Figure 4. Distribution of defoliation by age groups in 2021 and 2022 (average±SE)

The crown deck is most damaged in overgrown stands, where the highest defoliation was observed - 90%. Less damaged crowns are in middle-aged trees - 80%. The least damaged crown deck is in the young stand. Compared to the data of 2021, in 2022 the amount of defoliation in the young stand has not changed. It increased by 2% in middle-aged stands and by 6% in overgrown stands. On average, defoliation has increased by 3% across all plots. In all stands, crown damage is severe, exceeding 61%, therefore, the course of tree growth is also strongly affected.

In the "Stiklu purvi" nature reserve, data on dead wood, its stock, degrees of decomposition and condition class by age group have been collected. The data obtained in the fall of 2022 were compared with the data obtained in 2019 and 2021, and changes in the sanitary condition of forest stands were evaluated. Since 2019, the stock of dead wood per hectare has been mostly formed in overgrown stands. Figure 5 shows the proportion of dead wood stock in the total wood stock in the time period from 2021 to 2022.

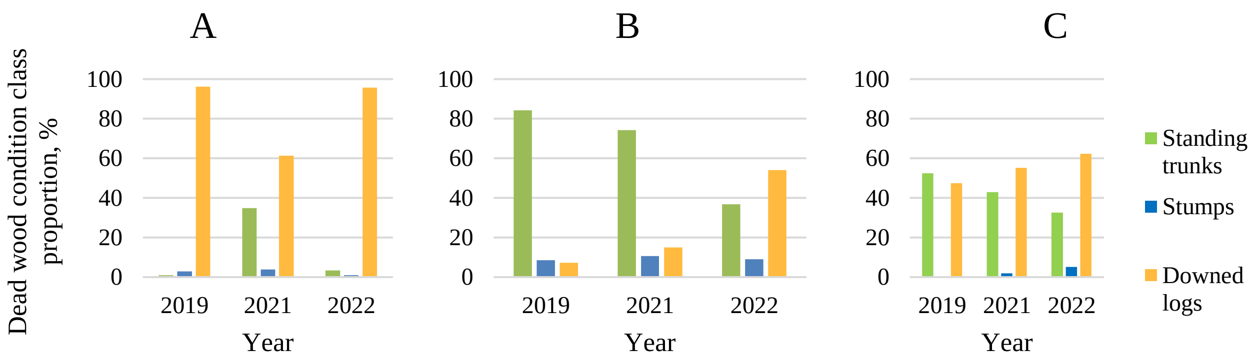


Source: created by the author

Figure 5. The share of the dead wood stock from the total wood stock in 2021 and 2022 (average±SE)

The stock of dead wood gradually increases from the total stock of wood in all stands. In 2022, the proportion of dead wood stock in young stands is 74.9%, in middle-aged stands – 76.3% and in overgrown stands – 97%. Within one year, the proportion of dead wood in young stands has increased by 3.1%, in middle-aged stands by 4.1% and in overgrown stands by 16.9%. The largest proportion of dead wood from the total stock of wood is observed in overgrown stands, where it reaches 97%, which can be explained by the death of overgrown trees.

Comparing the distribution of dead wood by condition classes in stands of different ages (Figure 6), it can be seen that in 2019, standing trunks made up the smallest proportion in the young stand - 1% and stumps - 2.9%, but the largest proportion was downed logs - 96.2%.



Source: created by the author

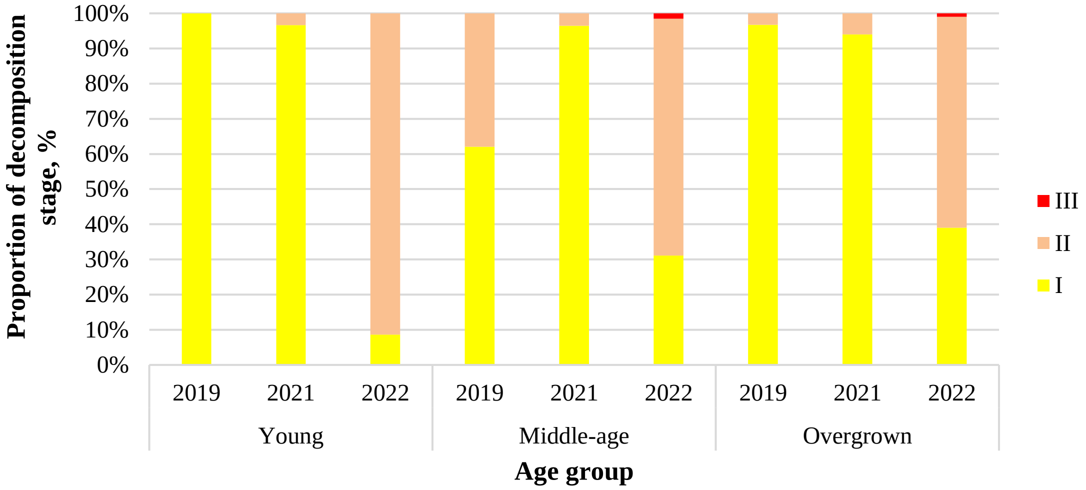
Figure 6. Distribution of dead wood by condition classes in young (a), middle-aged (b) and overgrown (c) stands 2019-2022.

In young stands in 2021, the proportion of standing trunks increased to 34.9% and the proportion of stumps to 3.8%, the proportion of downed logs decreased to 61.2%. In 2022, the proportion of dead standing trunks and stumps decreased in the young stands, but the proportion of downed logs increased to 95.7%.

In middle-age stands in 2019, the proportion of standing trunks was the highest - 84.2%. In 2021, the proportion of standing trunks decreased to 74.3% and in 2022 decreased to 36.8%. The proportion of stumps was the lowest in 2019 – 8.5%, in 2021 it increased to 10.7% and in 2022 it decreased again to 9.1%. The smallest share in 2019 was formed by downed logs. In 2021, the proportion of downed logs increased to 15% and in 2022 it increased to 54.1%.

In overgrown stands, the highest proportion of standing trunks was observed in 2019 - 52.5%, which gradually decreased to 32.6% in 2022. Stumps were not found in 2019, but in 2021 the proportion of stumps was 1.9% and in 2022 it increased to 5.1 %. From 2019 to 2022, the proportion of downed logs is gradually increasing. In 2019, the proportion of downed logs was 47.5%, in 2021 – 55.2% and in 2022 it increased to 62.3%.

Dead wood has degrees of decomposition from I to V. In the investigated objects (Figure 7) degrees of decomposition I to III were present. In 2019, all the dead wood in the young stands was in the I decomposition stage. In 2021, the dead wood of the first stage of decomposition was 96.6%, and the dead wood of the second stage of decomposition also appeared - 3.4%. In 2022, the dead wood of decomposition stage I decreased to 8.6% and decomposition stage II increased to 91.4%.



Source: created by the author

Figure 7. Distribution of dead wood by decomposition stages in young (a), middle-aged (b) and overgrown (c) stands 2019-2022.

In middle-aged stands in 2019, the highest proportion was the first degree of decomposition - 62.1%, and the lowest was the second degree of decomposition - 37.9%. In 2022, the degree of decomposition I decreased to 31.1%, the proportion of degree of decomposition II increased to 67.4%, and dead wood of the degree of decomposition III also appeared - 1.5%.

In overgrown stands in 2019, the proportion of decomposition stage I is high - 93.7% and the proportion of stage II is relatively small - 3.2%. In 2022, the proportion of the I degree of decomposition fell sharply, since 2019 it decreased by 55.1%. In 2022, the proportion of II decomposition degree increased sharply since 2019 by 57.1%. In 2022, 1% dead wood of stage III decomposition also appeared in overgrown stands.

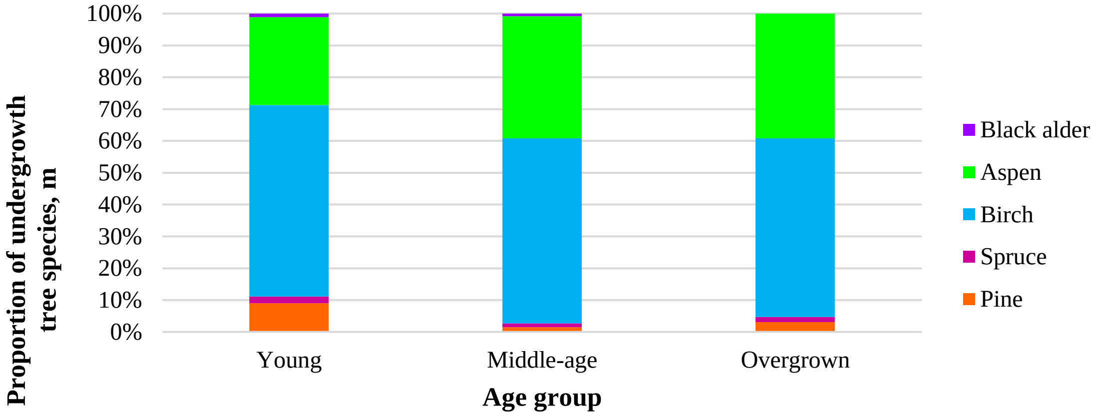
Comparing the data of 2022 on the degrees of decomposition of dead wood with the data of 2019 and 2021, it can be concluded that, both in young stands, in middle-aged stands, and also in overgrown stands, the proportion of the stage of decomposition I decreases and the proportion of the stage of decomposition II increases sharply, as also in 2022, the dead wood of the III degree of decomposition has increased.

The distribution of understory trees by the number of tree species per hectare in stands of different ages can be seen in Figure 8. In the fire of the "Stiklu purvi" nature reserve, regeneration of the undergrowth was assessed 4 years after the forest fire. Based on the measured data – species, number and height of stand trees – the number of stand trees per hectare, average height by tree species is determined. In the young stands, the understory consists mostly of deciduous trees - 89%, and 11% is made up of conifers. The most common tree species in the young stands are birch - 60.2% and aspen - 27.6%. The rarest tree species are black alder - 1.1% and conifers, spruce - 2.1% and pine - 9%. Five tree species are found in middle-aged stands - pine, spruce, birch, aspen and black alder. The most common tree species in the stand in middle-aged stands are birch - 58.1% and aspen - 38.4%. The less common tree species are black alder - 0.8% and conifers, pine - 1.5% and spruce - 1.3%. Deciduous tree species make up 97.2% of the trees in the stand and conifer species the remaining 2.8% per hectare.

As seen in research plots, Parro *et al*. (2015) concluded that birch as a pioneer species dominates the burnt area at the beginning. Birch recovers quickly after a fire and reaches a great height compared to other tree species. After about 15 years, in the burned area dominated by pine and the suitability of conditions for birch to continue to regenerate decreases.

Overgrown stands are regenerated with four tree species - pine, spruce, birch and aspen. The most common tree species in the stand are birch - 56.1% and aspen - 39.2%. Species diversity can be observed in all stands. There is a greater diversity of species in the young and middle-aged stands, where the forest is regenerating with five tree species.

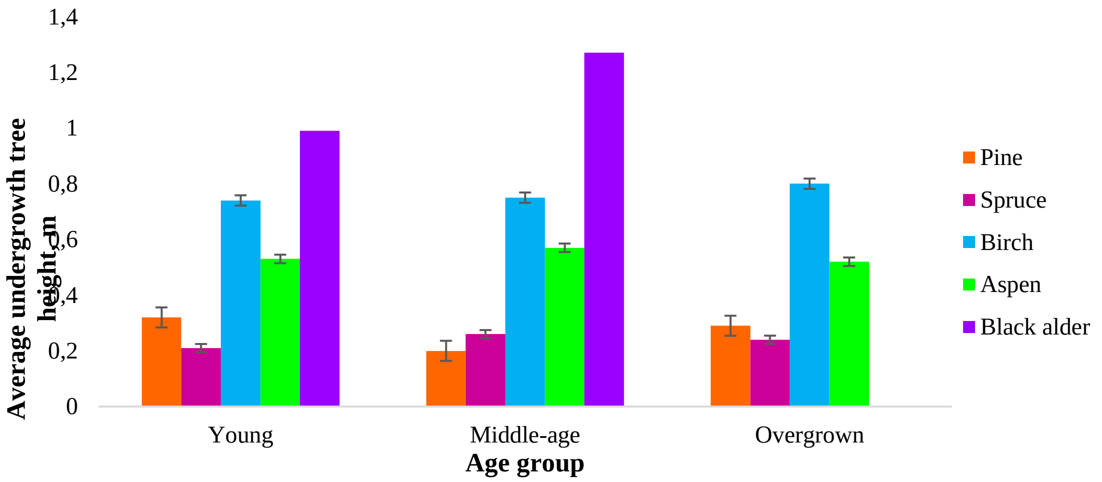
A lower diversity of species was observed in overgrown stands, where the forest stand regenerates with four tree species. Forests regenerate with both deciduous trees and conifers. All stands are more dominated by deciduous trees than conifers. Freimane et al (2021) estimated that in Slītere National Park, 25 years after the forest fire, the regeneration is mostly with birch, as in the results obtained in this study.



Source: created by the author

Figure 8. Proportion of undergrowth tree species per hectare in different age group stands

The distribution of the average heights of young trees by tree species in stands of different ages can be seen in Figure 9. After a forest fire, the young stands regenerates with five tree species – pine, spruce, birch, aspen and black alder. The highest average height in the young stands is black alder - 99 cm, birch - 74 cm, aspen - 53 cm. The smallest average height in young stands is pine - 32 cm and spruce - 21 cm.



Source: created by the author

Figure 9. Average height of undergrowth tree species per hectare in young (a), middle-aged (b) and mature (c) stands.

After a forest fire, middle-aged stands regenerate with pine, spruce, birch, aspen and black alder. The highest average height is black alder - 127 cm, birch - 75 cm and aspen - 57 cm. Conifers have a smaller average height, pine - 20 cm and spruce - 26 cm. In overgrown stands, there are four tree species in the stand - pine, spruce, birch and aspen. Birch reaches the highest average height - 80 cm, aspen also reaches a great height - 52 cm. Conifers have the smallest average height, pine – 29 cm and spruce – 24 cm. Black alder and birch reach the highest average height indicators in stands.

CONCLUSIONS

1. Since 2019, the average diameter has increased in all age group stands as the average height except in overgrown stands where the average height has decreased by 2.2 m, which explained by the death of trees.
2. Basal area and wood stock of the stands decreased in all age groups and the largest decrease was in overgrown stands.
3. Decomposition stages of dead wood gradually pass from I to II and trees of stage III decomposition appear. The largest proportion are trees of the II degree of decomposition - 67%.
4. From 2021 to 2022, the proportion of dead wood stock in the total wood stock has increased from 3% in young stands to 17% in overgrown stands.
5. It has been established that defoliation in forest stands gradually increases after a forest fire. Between 2021 and 2022, defoliation has increased by an average of 3%.
6. Forest stands are regenerated mostly with deciduous trees –89% in young stands, 97.2% in middle-aged stands and 95.3% in overgrown stands from total number of undergrowth trees.

REFERENCES

1. Buhk C., Meyn A., Jentsch A. 2006. The challange of plant regeneration after fire in the Mediterranean Basin: scientific gaps in our knowledge on plant strategies and evolution of trait. *Plant Ecology*, 192, 1 – 19. https://doi.org/10.1007/s11258-006-9224-2
2. Donis J., Bičevskis M., Zdors L., Šņepsts G. 2010 *Meža ugunsgrēka ietekmes uz koka dzīvotspēju novērtēšanas metodikas izstrāde*. Salaspils: Latvijas Valsts mežzinātnes institūts "Silava". 7. – 8. lpp.
3. Dzwonko Z., Loster S., Gawroński S. 2015. Impact of fire severity on soil properties and the development of tree and shrub species in a Scots pine moist forest site in southern Poland. *Forest Ecology and Management*, 342, 56 – 63. https://doi.org/10.1016/j.foreco.2015.01.013
4. Fernandes P. M., Vega J. A., Jiménez E., Rigolot E. 2008. Fire resistance of European pines. *Forest Ecology and Management*, 256, 246 – 255. https://doi.org/10.1016/j.foreco.2008.04.032
5. Freimane L., Čakša L., Kārkliņa A., Elferts D., Bērziņa B. 2021. Post fire ground vegetation development over 25 years. *Forestry and wood processing*, 36, 44 - 50. https://doi.org/10.1890/06-2140.1
6. Hart S. A., Chen H. Y. H. (2008) Fire, logging, and overstory affect understory abundance, diversity, and composition in boreal forest. *Ecological Monographs*. Vol. 78, p. 123 – 140.
7. Ivanova A. A., Kopylova-Guskova E. O., Shipunov A. B., Volkova P. A. 2014. Post-fire succesion in the northern pine forest in Russia. *A case study*, 119 – 128.
8. Juutilainen K., Halme P., Kotiranta H., Mönkkönen M. 2011. Size matters in studies of dead wood and wood-inhibiting fungi. *Fungal Ecology*, 4, 342 – 349. https://doi.org/10.1016/j.funeco.2011.05.004
9. Kitenberga M. 2019. *Hemiboreālo mežu degšanas vēsture un kokaudžu atjaunošanās degumos.* Salaspils, Latvijas Valsts mežzinātnes institūts "Silava", 10. lpp.
10. Kuuluvainen T., Rouvinen S. (2000) Post-fire understorey regeneration in boreal Pinus sylvestris forest sites with different fire histories. *Journal of Vegetation Sciene*, 11, 801 – 812. https://doi.org/10.2307/3236550
11. *Latvijas meža tipoloģija* 2014.: mācību līdzeklis LLU Meža fakultātes studentiem un nozares speciālistiem. I. Liepa, O. Miezīte, S. Luguza, V. Šulcs, I. Straupe, A. Indriksons, A. Dreimanis, A. Saveļjevs, A. Drēska, Z. Sarmulis, D. Dubrovskis, Jelgava: LLU, Meža fakultāte. Studentu biedrība "Šalkone". 76.lpp.
12. Liepa L., Straupe I., Krūmiņš J., Saklaurs M. 2014. Mežaudzes sniegto pakalpojumu novērtējums uz saldūdens ekosistēmām: pētniecības projekts. *Latvijas vides aizsardzības fonda administrācija*. 31. lpp.
13. Mallik A. U. 2010. Conifer Regeneration Problems in Boreal and Temperate Forests with Ericaceous Understory: Role of Disturbance, Seedbed Limitation, and Keystone Species Change. *Critical Reviews in Plant Sciences*, 22, 341 – 366. https://doi.org/10.1080/713610860
14. Manton M., Ruffner C., Kibirkštis G., Brazaitis G., Marozas V., Pukienė R., Makrickiene E., Angelstam P. 2022. Fire Occurrence in Hemi-Boreal Forests: Exploring Natural and Cultural Scots Pine Fire Regimes Using Dendrochronology in Lithuania. *Diversifying Forest Landscape Management Approaches*, 11 (2), 260. https://doi.org/10.3390/land11020260
15. Merganič J., Merganičová K., Vlčková M., Dudáková Z., Ferenčik M., Mokroš M., Juško V., Allman M., Tomčik D. 2022. Deadwood Amount at Disturbance Plots after Sanitary Felling. *Plant Ecology*, Vol. 11 (7), 987. https://doi.org/10.3390/plants11070987
16. Merganičová K., Merganič J., Svoboda M., Bače R., Šebeň V. 2012. Deadwood in Forest Ecosystems: *Forest Ecosystems – More than Just Trees.* p. 81 – 98. https://doi.org/10.5772/31003
17. *Natura 2000 un meži.* 2018. Eiropas Komisija. 11 – 13. lpp.
18. Parro K., Metslaid M., Renel G., Sims A., Stanturf J. A., Jõgiste K., Köster K. 2015. Impact of postfire management on forest regeneration in a managed hemiboreal forest, Estonia. *Canadian Science Publishing*, 45, 1192 – 1197. https://doi.org/10.1139/cjfr-2014-0514
19. Petrokas R., Ibanga D., Manton M. 2022. Deep Ecology, Biodiversity and Assisted Natural Regeneration of European Hemiboreal Forests.___*Structure and Ecosystem Services of Forests*, 14 (10), 892. https://doi.org/10.3390/d14100892
20. Priede. Selekcija, ģenētika un sēklkopība Latvijā 2014. I. Baumanis, Ā. Jansons, U. Neimane, Salaspils, Latvijas Valsts mežzinātnes institūts "Silava", 11.,37.,16. lpp.
21. Rahman M. M., Frank G., Ruprecht H., Vacik H. 2008. Structure of coarse woody debris in Lenge-Leitn Natural Forest Reserve, Austria. *Journal of Forest Science.* Vol. 54, p. 161 – 169. https://doi.org/10.17221/3102-JFS

22. Spracklen D. V., Mickley L. J., Logan J. A., Hudman R. C., Yevich R., Flannigan M. D., Westeling A. L. 2009. Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States. *Journal of geophysical research*, Vol. 114. https://doi.org/10.1029/2008JD010966
23. Kolström, T., Kellomäki. S. 1993. Tree survival in wildfires. *Silva Fennica.* Vol. 27 https://doi.org/10.14214/sf.a15682
24. Thiel D., Nagy L., Beierkuhnlein C., Huber G., Jentsch A., Konnert M., Kreyling J. 2012. Uniform drought and warming responses in Pinus nigra provenances despite specificē overall performances. *Forest Ecology and Management*, 270, 200 – 208. https://doi.org/10.1016/j.foreco.2012.01.034
25. Zadiņa M., Donis J., Jansons A. 2015. Influence of post-fire management on regeneration of Scots pine (*Pinus sylvestris* L.) in north-western Latvia. *Research for rural development,* 2, p. 61 – 67.