Výzkumný ústav lesního hospodářství a myslivosti, v. v. i.

Sachsenforst

2nd Bilateral Workshop of Forest Research Institutions from the Czech Republic and Saxony

Wermsdorf, Saxony, 05.-06.11.2019

Programme

Tuesday 05.11.2019	
09:00 – 10:00	Arrival, registration
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10:35 – 10:50	H. Andreae et al.: Development of climatic indicators at forest meteorology plots in Saxony
10:50 – 11:05	R. Petzold et al.: Mode-based forecasting of site properties – digital soil mapping in practice
11:05 – 11:20	M. Vejpustková: Growth response of Norway spruce to extremely dry period in recent years
11:20 – 11:45	Coffee break
11:45 – 12:00	R. Novotný: The imbalance between nitrogen and other nutrients in forest nutrition in the Czech Republic
12:00 – 12:15	F. Jacob et al.: Conventional or whole-tree harvesting? Results from a biomass inventory on Saxon Level 2 – Plots
12:15 – 12:45	Discussion
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Session II – Pest and Diseases	
13:45 – 14:00	L.-F. Otto: Recent Forest Damages in Saxony
14:00 – 14:15	J. Lubojacký: Actual outbreak of spruce bark beetle (*Ips typographus*) - The greatest outbreak of this pest in the whole history of Czech lands
14:15 – 14:30	S. Sonnemann et al.: The Ipspro Project: Detection and prediction of Ips typographus infestation
14:30 – 14:45	T. Seltmann: FIRIS - Risk assessment in Norway spruce stands: Methods using remote sensing and forest inventory data
14:45 – 15:00	F. Lorenc: Spruce bud blight (*Gemmamyces piceae*) in the Ore Mountains: current situation and research findings
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16:10 – 16:25	J. Novák: Practical recommendation for substitute tree species stands in Natural Forest Area Ore Mts.
16:25 – 16:40	U. Tröber: Genetic characterization of Larch and conclusions for breeding activities in future
16:40 – 16:55	J. Frýdl: Preservation and reproduction of specific forms of the mountain Norway spruce
16:55 – 17:10	H. Wolf et al.: Current projects related to tree breeding for uncertain futures
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17:55 – 18:10	J. Cukor: Estimation of sika deer population density in relation to damage of forest stands
18:10 – 18:25	M. Thomae: Red deer and forest conversion in the Ore Mountains – Project overview and first results
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09:00 – 14:00	Excursion to the Wermsdorfer Forest

List of participants

Name	Institution	Date of participation
Andreae, Henning	SBS	05./06.11.2019
Baumann, Martin	SBS	06.11.2019
Cukor, Jan	VULHM	05./06.11.2019
Eisenhauer, Dirk-Roger	SBS	05./06.11.2019
Frýdl, Josef	VULHM	05./06.11.2019
Hüller, Wolfgang	SBS	06.11.2019
Jacob, Frank	SBS	05./06.11.2019
Kacálek, Dušan	VULHM	05./06.11.2019
Kranz, Katrin	SBS	05./06.11.2019
Lorenc, František	VULHM	05./06.11.2019
Lubojacký, Jan	VULHM	05./06.11.2019
Martens, Sven	SBS	05./06.11.2019
Novák, Jiří	VULHM	05./06.11.2019
Novotný, Radek	VULHM	05./06.11.2019
Otto, Lutz-Florian	SBS	05./06.11.2019
Petzold, Rainer	SBS	05./06.11.2019
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Seltmann, Torsten	SBS	05./06.11.2019
Sonnemann, Sven	SBS	05.11.2019
Šrámek, Vít	VULHM	05./06.11.2019
Thomae, Marcel	SBS	05./06.11.2019
Tröber, Ute	SBS	05./06.11.2019
Vejpustková, Monika	VULHM	05./06.11.2019
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Session I – Site Conditions and Environmental Monitoring

Effects of drought 2015 and 2018 on Czech forests

Vít Šrámek, Kateřina Neudertová Hellebrandová, Věra Fadrhonsová
*Forestry and Game Management Research Institute, Jílovišt**ě**-Strnady, Czech Republic*

While the air pollution influence on forest health was the most discussed topic in the second half of the 20th century, nowadays the Global Change and weather extremes seems to be the driving factors of the forest ecosystem stability. Norway spruce as well as Scotch pine stands are severely threatened by bark beetle calamity which extension was significantly promoted by the drought episodes during years 2015 – 2018 although also other factors play an important role in pest outbreak. In years 2015 and 2018 even direct effect of drought on forest vitality was recorded – decline of individual trees was recorded mostly on sites with decreased water table or in dense stands with high tree competition. Both vegetation season 2015 and 2018 can be characterized as being abnormally hot and dry with only 65% and 72% of precipitation amount in comparison with long term normal condition. The effect on the soil moisture can be evaluated within ICP Forest Intensive Monitoring plots, where we have observed increased interception of Norway spruce stands. The soil moisture significantly decreased during the vegetation seasons 2015 and 2018, with soil water potential (SWP) close to the permanent wilting point (-1.5 MPa) for a substantial part of the monitored period. Differences between stands of different age were observed in terms of the SWP development which does not follow the interception patterns exactly, suggesting that the stand transpiration is a driving factor responsible for the soil water budget. In all stands, with the exception of the oldest one, the SWP of the upper soil horizon was less than 1.5 MPa for more than 80 days. In such extreme conditions the drought would negatively influence any Norway spruce stand regardless of its age or structure. Similar results were obtained on ICP Forests Intensive Monitoring plots with other species – European beech and Scotch pine.

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Gerhardt T., Häberle K.-H., Matyssek, R., Schulz C. Ammer C. (2014): The more, the better? Water relations of Norway spruce stands after progressive thinning. Agricultural and Forest Meteorology 197, 235-243

Keim R.F., Link T.E. (2018): Linked spatial variability of throughfall amount and intensity during rainfall in a coniferous forest. Agricultural and Forest Meteorology 248, 15-21.

Šrámek, V., Fadrhonsová, V., Neudertová Hellebrandová, K., 2019: Interception and soil water relation in Norway spruce stands of different age during the contrasting vegetation seasons of 2017 and 2018. Journal of Forest Science 65, 51-60

Tumajer J., Altman J., Štěpánek P., Treml V., Doležal J., Ciencala E. (2017): Increasing moisture limitation of Norway spruce in Central Europe revealed by forward modelling of tree growth in tree-ring network. Agriculture and Forest Meteorology 247, 56-64.

Acknowledgement

The work was supported by the National Agency of Agriculture Research (project No:QK1810415) and by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0118.

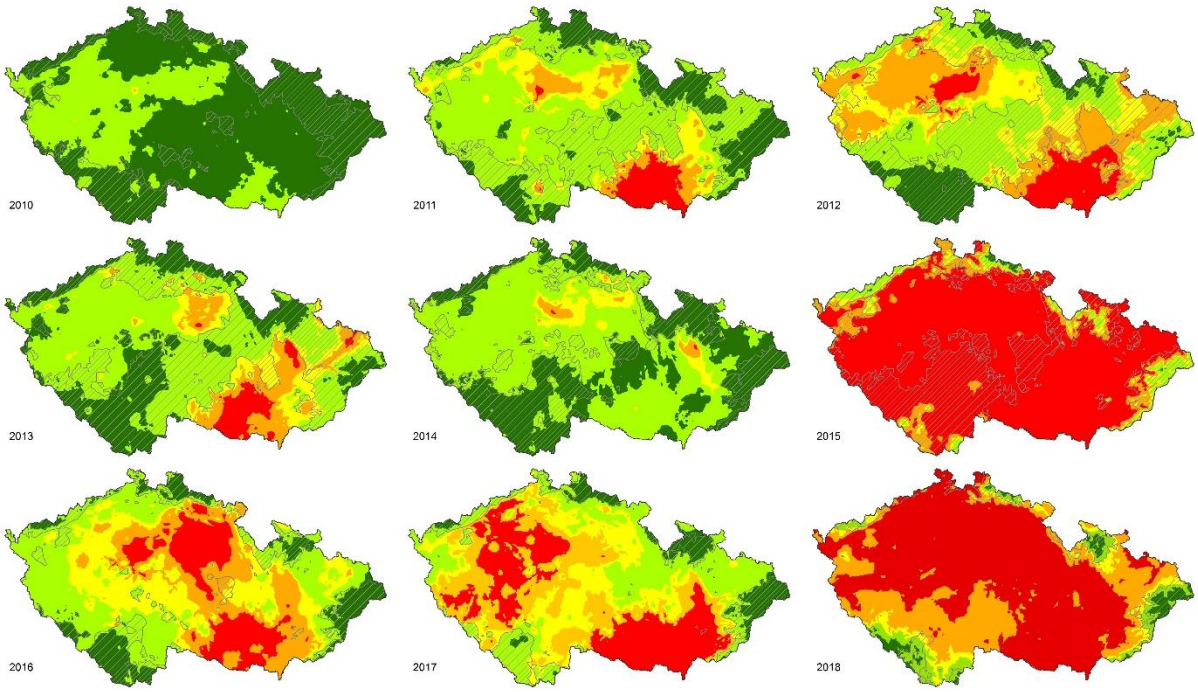

Fig. 1: Modelled drought stress risk for the Norway spruce stands in the Czech Republic in years 2010 - 2018

Development of Climatic Indicators at Forest Meteorology Plots in Saxony

Henning Andreae, J. Franke, Frank Jacob, Sven Martens, Alexander Peters
Public Enterprise Sachsenforst, Competence Centre for Wood and Forestry, Pirna, Germany

Since the mid-1990s, the state enterprise Sachsenforst has been operating forest climate stations in stands and, above all, in the open field. There are currently 21 open field stations in operation, of which 7 are meteorological sub-plots for the Level 2 Programme as part of the Intensive Forest Environmental Monitoring according to ICP Forests or the German ForUmV regulation, respectively. Meteorological data from the TU Dresden are used at one level 2 plot. The open field plots supply verified data to the Climate Network Saxony (KliNeS) and to the Regional Climate Information System (ReKIS) run by the federal states of Saxony, Saxony-Anhalt and Thuringia (https://www.umwelt.sachsen.de/umwelt/klima/26700.htm).
As the German Weather Service (DWD) increasingly withdraws from the area (i.e. closing of the Fichtelberg station in 2017 after 100 years), the supplementing regional measurement networks, run for example by Sachsenforst, gain increased weight for regional climate monitoring and the development of adaptation strategies.
The presented evaluation deals with the development of climate indicators within the period 1997 to 2017. For example, the number of summer and heat days or tropical nights is compared to the occurrence of frost, winter and ice days. The data annual cumulative rainfall amounts give clear indications of the differences between dry and wet years. The calculation of grass reference evaporation or vegetation time lengths (characteristic GTS 200) support the evaluations for the development of the current forest condition.

Model-based forecasting of site properties – digital soil mapping in practice

Rainer Petzold, T. Behrens, A. Wahren
Public Enterprise Sachsenforst, Competence Centre for Wood and Forestry, Pirna, Germany

Besides the classic site survey according to the East German method, methods of digital soil mapping have been used in Saxony for several years. One focus is the continuous processing of old data. After geo-referencing and harmonization they are increasingly made available as part of a document management systems (DMS) based on existing or adapted GIS solutions (ERDAS Apollo) as well as a server database. Based on this data, a variety of model applications are available to objectively qualify or predict site properties. In our talk paper, we will present examples that are directly integrated into practical forestry.

For example, hyperscale relief analyses based on high-resolution terrain models are used to transfer mapped site properties into objective models via machine learning methods. The application of these forecast models serves, for example, the evaluation and disaggregation of the existing site map for detailed silvicultural planning.

Another approach is hydromorphological relief analysis and the assignment of bog ecosystem types for the assessment of the revitalisation capacity and worthiness of bog bodies in FFH areas. Such analyses will in future also be used to update the maps of hydromorphic sites, which are affected by active revitalisation measures, the lack of care of drainage ditches or site changes due to climate alterations. Updating of such hydromorphic site properties is important because changes result in differing technologies for wood harvesting and logging (navigability) in order to ensure soil protection.

Finally, optimized sampling designs (clhs) are applied to achieve sufficiently accurate results for mapping (testing of model forecasts) and soil sampling (state mapping) with as few samples as possible.

Growth response of Norway spruce to extremely dry period in recent years

Monika Vejpustková, Kateřina Hellebrandová, Tomáš Čihák
*Forestry and Game Management Research Institute, Jílovi**š**tě-Strnady, Czech Republic*

In the Czech Republic the average annual temperatures in the last fifty years showed an increase of 0.3°C for every 10 years. The rate of temperature increase is faster in summer (0.4°C) and slower in autumn (0.1°C). Rainfall totals show significant variability over the year (monthly sums), but minimal changes in annual sums (Pretel 2011). The increase in drought episodes was recently recorded mainly at altitudes from 200-600 m a.s.l. (Trnka et al. 2016). The years 2003, 2015 and 2018 are considered to be extremely dry.

The aim of the presentation is to demonstrate how the recent extreme drought has been reflected in the growth of spruce in the Czech Republic. Growth reaction was assessed on intra-annual scale using continuous records of stem size variation measured by electronical dendrometers and on inter-annual scale using ring widths measured on tree increment cores. The analysis of climate – growth relationship was performed for the period 1961 – 2015.

Stem size variation during the growing season is sensitive indicator of drought stress. Spruce reacts to moisture deficit by intensive shrinkage of the stem. At the Želivka monitoring plot (440 m a.s.l.), the year-to-year comparison of spruce diameter growth between 2015 and 2018 showed that although the years 2015 and 2018 were both very dry, the increment was more affected in 2018. The reason is probably the effect of repeated drought causing chronic stress to trees. At the Lazy plot (875 m a.s.l.), the moisture deficit was minimal in 2015, whereas in 2018 the drought was manifested even at this altitude. Throughout the monitored period 2010 - 2018, the curve of cumulative diameter growth increases linearly at the Lazy plot, while at the Želivka plot a flattening of the growth curve is obvious after 2015.

A tree-ring analysis of spruce from the North Moravia, region heavily affected by the dieback of spruce stands, revealed a steady decline of tree-ring widths already since 2003. The analysis of climate – growth relationship showed that spruce is negatively affected by the high temperatures during the peak growing season (June-August) and by high temperatures in September of the previous year. In contrary growth has a positive relationship to the rainfall totals in the months of April-August. Due to ongoing climate change, the growth-climate relationship may be variable. Thus the temporal stability of the climate-growth relationship was studied using moving correlations with window of 25 years. Interesting results were obtained for spruce from Prostějov site (600 m a.s.l.). In the first three time intervals, summer temperatures did not have a significant effect on spruce growth. However, starting from 1968-1992, high summer temperatures became a factor that significantly reduced the growth of spruce at this site. Temporal changes were recorded also in the relationship of spruce increments and summer rainfalls. Since the period of 1968-1992, the values of correlation coefficients had a steady upward trend and, since the period of 1984-2008, they are statistically significant. The results indicate that the risk

of drought stress increased substantially in recent years even for spruce at altitudes above 600 m a.s.l.

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Acknowledgement

The research was supported by project no. QK1820091 “Forest management in areas affected by long term drought“ and by the Ministry of Agriculture of the Czech Republic [MZE-RO0118].

The imbalance between nitrogen and other nutrients in forest nutrition in the Czech Republic

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Forest soils in the Czech Republic developed in most cases on the old rocks, which are poor in nutrient content. Moreover, during the period of high pollution load in the second half of the 20th century, there was still a significant soil acidification and the certain "flattening" of soil properties – an increase of acidity and the loss of basic cations. This also happened on the originally more favorable localities with the brown soil (cambisoil).

According to the Forest Soil Condition Survey BioSoil, which was carried out as part of the ICP Forests program in 2005-2008, soils in the Czech Republic are classified as predominantly strongly acidic (70% of the surface horizon) and acidic. In the deeper soil layers (> 40 cm), 40% of the soils belong to the strongly acidic category. The available contents of the main nutrients are low or very low. More than half of the samples taken down to depths of 80 cm from the soil pits contain calcium in concentrations below 140 $mg.kg^{-1}$. For potassium there is 20% of the lower soil layers and for magnesium 46% of the soil for the lower soil layers below deficit values. In the upper soil layers (0-20 cm) the situation is even worse. Critically low base saturation (<10%) has 40% samples of horizons 0-10 cm and 55% samples of 10-20 cm. On the other hand, nitrogen contents can be characterized as good (0.2-0.3%) to high (> 0.3%), especially in the upper soil horizons.

The state of the forest soils is reflected in the nutrition status of the trees that grow on this soil. Nutritional surveys focuses on those regions that have been significantly affected by air pollution in the past. In young spruce stands (<50 years) there is an apparent increase in nitrogen concentration in both youngest needle classes, while in current needles the concentration is slightly higher compared to one year old needles. The average phosphorus concentration is still slightly decreasing, especially in one year old needles. In addition, phosphorus concentrations are low (<1.2 $g.kg^{-1}$) or even very low (<1.0 $g.kg^{-1}$) in some areas. The combination of an increase in nitrogen concentration and a decrease in phosphorus concentration leads to an imbalance between these important elements, especially in the case of one year old needles (fig. 1).

We also observe a decrease in the concentration of calcium and potassium. Concentration of calcium decreases in current year needles, potassium concentration decreases in one year old needles. Potassium is an important osmotic agent and is very important for ensuring the frost resistance of needles, so its drop below 3 $g.kg^{-1}$ can be taken as a warning of possible problems in the regulation of pores during the growing season and for the ability to withstand severe frosts during winter season. In the case of calcium, a gradual reduction of the concentration is to be seen, especially the values below 2 $g.kg^{-1}$, which were determined on a part of the monitored plots in current year needles, can already be considered as low. The magnesium concentration is stable and in some cases a mild increase has been noted.

The adult stands (> 80 years old), which were assessed on the ICP Forests intensive monitoring plots, also gradually increase the concentration of nitrogen and gradually reduce the phosphorus concentration. The ratio of these important nutrients often rises above the value of 12. The development of the potassium concentration varies, in the mountain areas (> 800 m above sea level) its concentration is lowered in the leaves and needles, in the lower altitudes it fluctuates or slightly increases over time. Decrease of nutrient concentration (P, K, Ca) occurs in both coniferous and deciduous tree species, and it can generally be said that the level of nutrition is slowly changing and tends to be unfavorable.

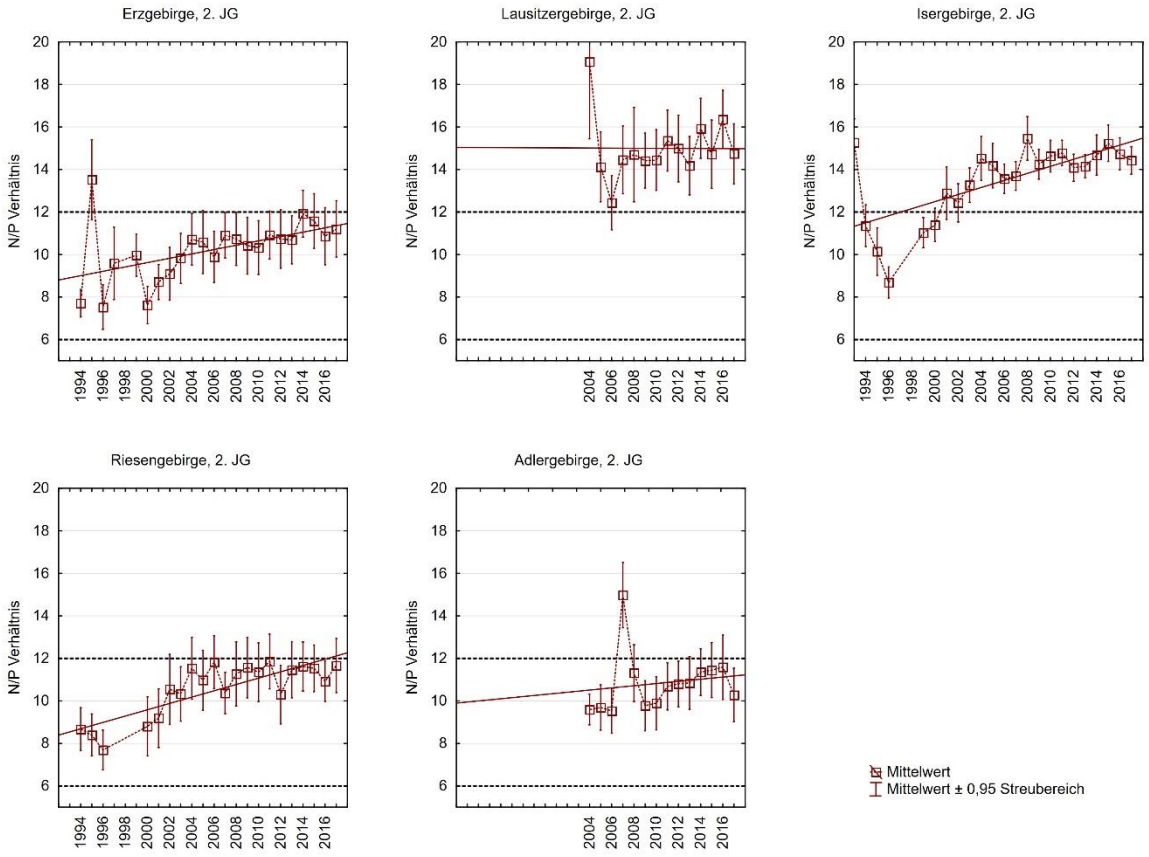

Fig. 1: NP ratio in young Norway spruce stands, one year old needles

Acknowledgement

The work was supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0118; soil survey BioSoil was done within the ICP Forests programme supported by the Ministry of Agriculture.

Conventional or Whole-Tree Harvesting? Results from a biomass inventory on Saxon Level 2 – plots

Frank Jacob, Henning Andreae
Public Enterprise Sachsenforst, Competence Centre for Wood and Forestry, Pirna, Germany

The sustainable use of forest resources is an essential part of sustainable forestry. A healthy forest soil should be the focus of all measures. Precisely because of increased demand and rising prices for forest waste wood as well as the progressive mechanization of wood harvesting technology, attention is necessary for a nutrient-conserving and location-differentiated use of biomass. Older studies on the distribution of nutrients within the dendro mass are already available from NEBE ET AL. (1987) for the area of the Tharandter Forest.
In 2015 necessary thinning measures at the Level II sites of Laußnitz and Altenberg were used to carry out biomass surveys. In addition to determining the actual state of nutrient storage in above-ground biomass, the focus of the studies was set on upgrading long-term flux budgets as well as getting an impression of the aboveground carbon sink.
For the study 6 pines (Laußnitz, 90 years old) and 7 spruce trees (Altenberg, 90 years old) were measured up and sampled using the randomized branch sampling method (RBS) developed by FVA-BW. In order to determine the biomass and nutrient stocks of the compartments of merchantable wood (> 7 cm) and its bark, as well as crown wood (< 7 cm) and needles, the wet and dry weights as well as the nutrient content were analyzed.
As expected, the highest content of nitrogen, magnesium, phosphorus and potassium in the needles has been found in needles. Only in the case of calcium the contents are higher in the bark of merchantable wood are higher than in the other compartments. Overall, significantly higher nutrient contents have been detected in forest residues (needles, crown wood) than in the "mass product" of merchantable wood and its bark.
Due to the hardwood-like crown structure of older pines, the wood biomass within the crown is significantly lower compared to spruce (9% versus 23%). This difference is underpinned with phosphorus stocks. While in the pine stand only 9% more biomass would be removed through whole tree harvesting, the withdrawal of phosphorus is 1.9 times higher than in a conventional harvest. In comparison, the additional gain in biomass with whole tree harvesting at the spruce plot would amount to 13%, but results in 3.6 times higher phosphorus withdrawal. Compared to the yield of biomass, nutrient deprivation of all nutrients, increases disproportionately with an intensification of wood usage.
An extension of the biomass studies for oak and beech to the Level II plots Colditz and National Park respectively, will serve expand the tree species spectrum. With the help of regionalized nutrient stocks from the second soil condition survey and the assessment of the site potential according to KOLB and GÖTTLEIN (2012) based on the forest site map will give hints for practical application in the forestry.

Session II – Pest and Diseases

Recent Forest Damages in Saxony

Lutz-Florian Otto, Franz Matschulla
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Damages in a previously unknown scale caused by bark- and woodbreeding beetles characterize the current situation in the forests of Saxony. A special role is played by bark beetles (*Scolytidae*). The causes of this development are a series of abiotic damages (storm and snow) since 2017 and especially the extremely warm and dry growing seasons 2018 and 2019. Particularly affected spruce stands in the hills and the lower mountains are infested by *Ips typographus*. On these sites, which are unsuitable for the spruce, large-scale disintegration of the spruce stands occurs. A lot of these forests are private forests, one reason, that the large-scale implementation of an integrated bark beetle pest control is very complicated. Over-average damages also occur in spruce stands in the middle and higher elevations. In 2019 also a pheromone trap monitoring for the presence of *Ips duplicatus* was performed.
An outbreak of *Ips cembrae* occurs in larch stands. In the pine-dominated forest areas in northern Saxony, infestations by *Ips acuminatus*, *Ips sexdentatus*, *Phaenops cyanea* and other species cause the dissolution of particularly predisposed pine stands. Particularly in the northeast, damages caused by *Sphaeropsis sapinea* increased in recent years. In deciduous tree stands an increased mortality can be observed alone by drought and partly also in combination with beetles and fungi.

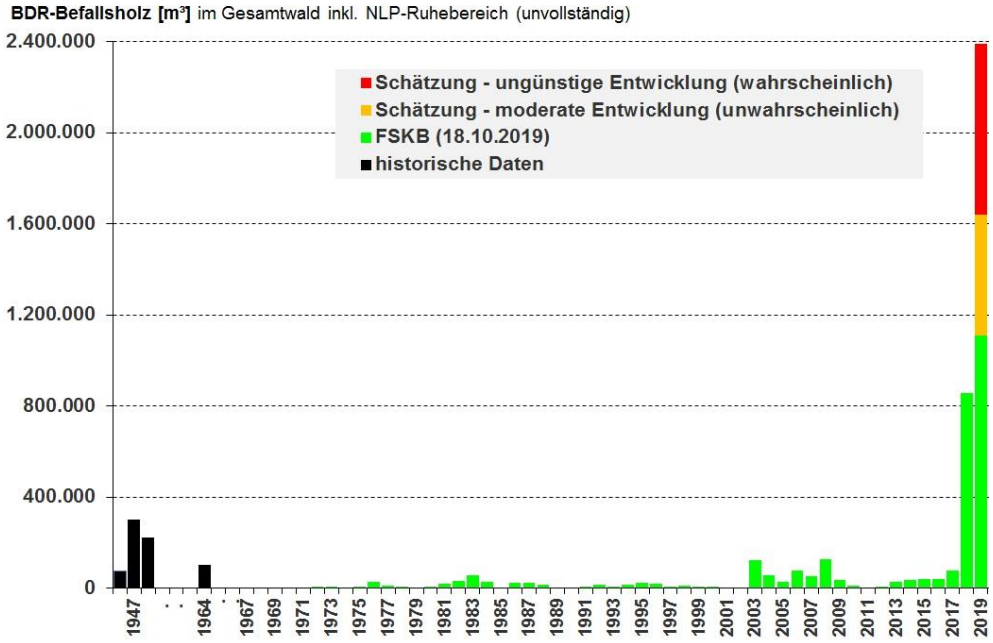

Fig. 1: Long time statistic for volume [m³] of infected spruce by Ips typographus in parts combined witch Pityogenes chalcographus on Saxon territory (source: Forstschutzkontrollbuch (FSKB), state: 30. September 2019; including parts of the National park „Sächsische Schweiz“) 2019 – recorded and estimated volume [created by: Franz Matschulla]

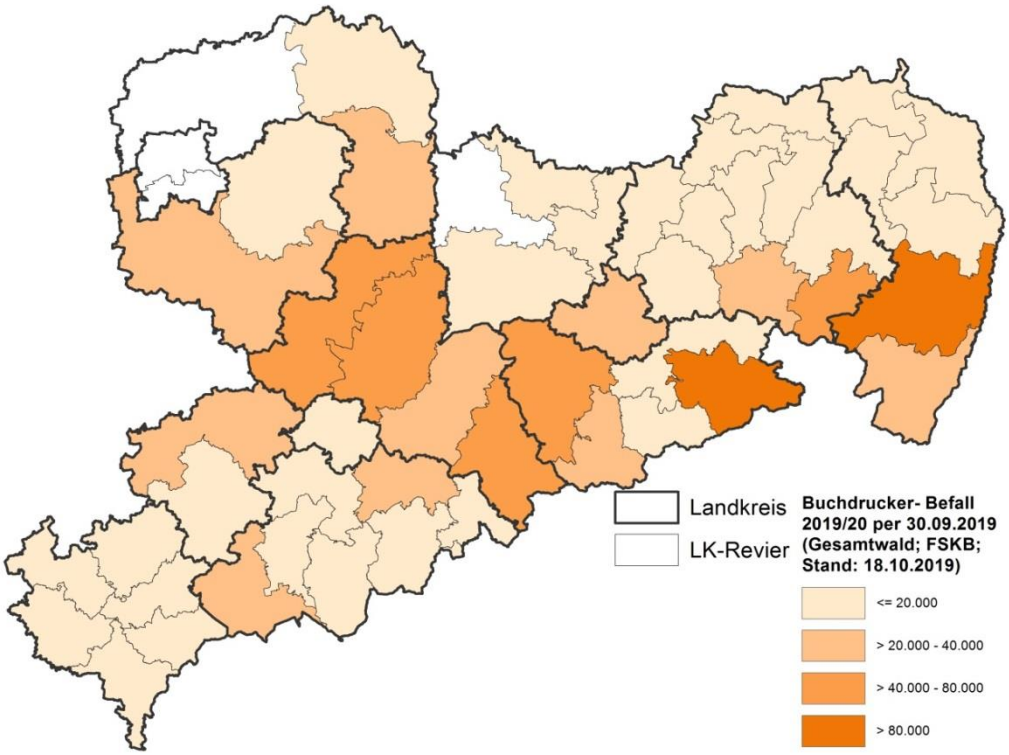

Fig. 2: Recorded volume of spruce wood infested by Ips typographus in 2019 (01.06.19-30.09.19) (source: Forstschutzkontrollbuch (FSKB), state: 30. September 2019; including parts of the National park „Sächsische Schweiz“) [created by: Franz Matschulla]

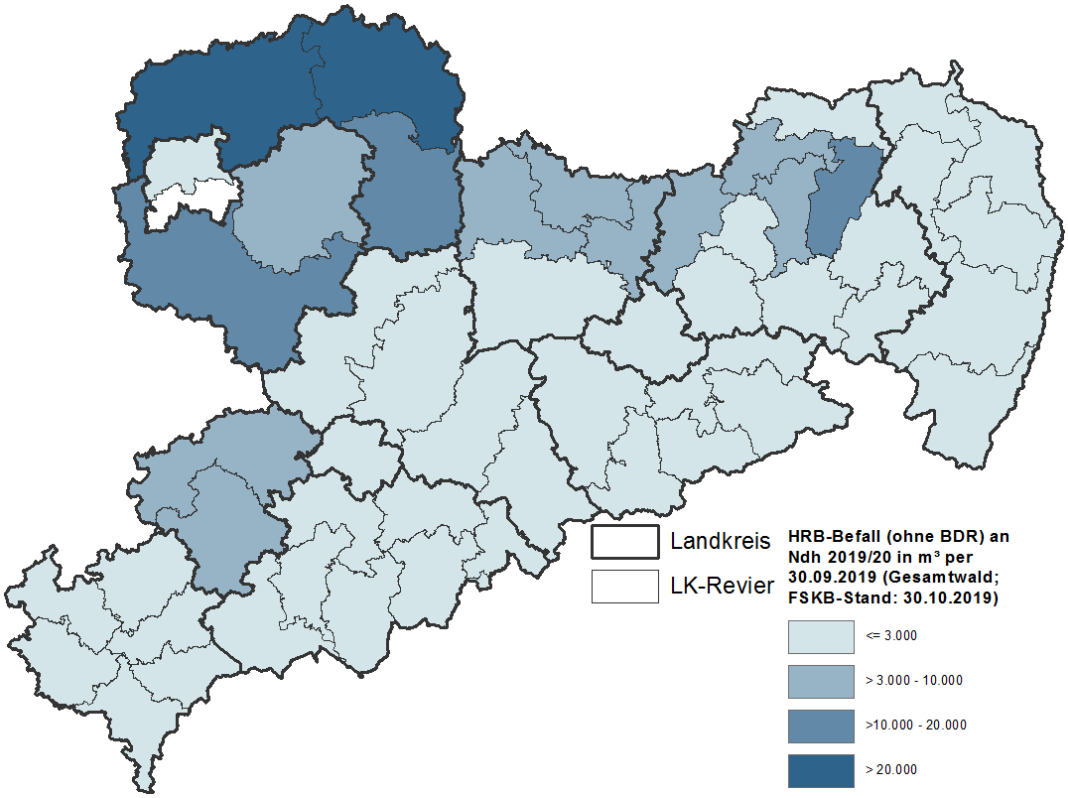

Fig. 3: Recorded volume of pine and larch wood infested by bark und woodbreeding beetles in 2019 (01.06.19-30.09.19) (source: Forstschutzkontrollbuch (FSKB), state: 30. September 2019) [created by: Franz Matschulla]

Actual outbreak of spruce bark beetle (*Ips typographus*) - The greatest outbreak of this pest in the whole history of Czech lands

Jan Lubojacký, Miloš Knížek
Forestry and Game Management Research Institute, Jíloviště-Strnady, Czech Republic

The most prominent group of biotic agents in last years are spruce bark beetles, especially *Ips typographus*. Spruce wood infested by bark boring insects increased again in 2018 and was recorded at a total volume of nearly 8.4 mil. m^3, new highest record in the history. A new record volume will be reached in 2019 (estimated at around 11 million m^3). Mass outbreak stage of bark beetles occurred on nearly all sites of the country. The average volume of bark beetle infested wood per one hectare of spruce stands was alarming ca 8.91 m^3/ha, approximately forty five times more than endemic state (and the actual situation is even worst – bark beetles on wood damaged by drought and *Armillaria*)!
The highest volume of spruce wood infested by bark beetles was recorded in northern Moravia and Silesia, where *Ips duplicatus* is still in epidemic state, but infestation belonged to *Ips typographus* mainly. In the Moravskoslezský and Olomoucký regions together were recorded more than 2.6 mil. m^3 in 2018, which represents ca 30 % of country total amount of spruce wood infested by bark beetles. Extreme deterioration occurred in the Vysočina and Jihočeský regions, where over 2.5 mil. m^3 of bark beetles infested spruce wood was recorded.
Note: The volumes shown above are based on data received from forest managers (by the Forest Protection Service, Forestry and Game Management Research Institute), covering about 70 % of the forest area in Czechia!

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Acknowledgement

Supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0118.

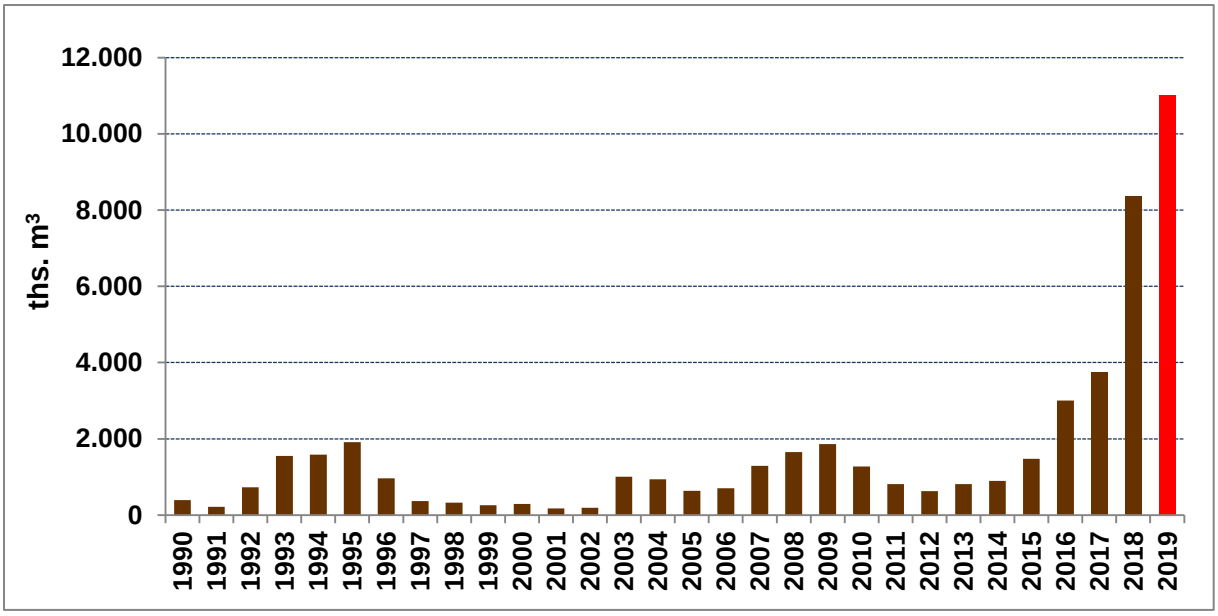

Fig. 1: Recorded volume of felled spruce wood infested by bark beetles since 1990 (2019 – estimated volume) (Modified according to Lubojacký et al. 2019)

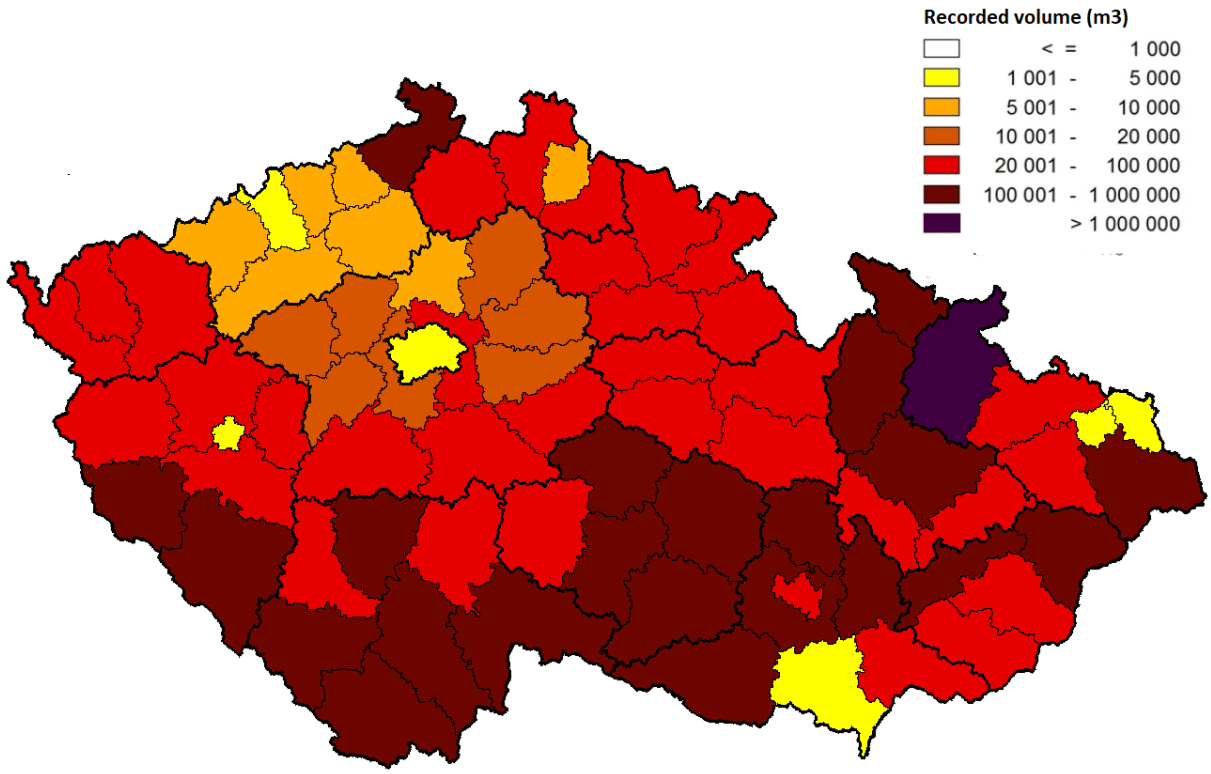

Fig. 2: Recorded volume of felled spruce wood infested by bark beetles in 2018 (Modified according to Lubojacký et al. 2019)

The Ipspro Project: Detection and Prediction of Ips typographus Infestation

Sven Sonnemann, Sebastian Zimmermann
Public Enterprise Sachsenforst, Competence Centre for Wood and Forestry, Pirna, Germany

IpsPro, a collaborated project funded by the Fachagentur für Nachwachsende Rohstoffe e.V. (FNR), aims to improve existing methods for bark beetle risk assessment. Based on previous beetle attacks and stand predisposition, dynamic factors such as the availability of breeding material or beetle pressure are used to estimate the probability of infestation. The resulting information will be published in an online risk prediction tool which will provide its users with a 7 day forecast.
In the framework of the IpsPro project, the Public Enterprise Sachsenforst is responsible for two work packages – “Long-term Data” and “Remote Sensing”. The main focus of the “Long-term Data” work package is the utilization and analysis of historical data from terrestrial bark beetle monitoring. This data is spatially assigned to associated organizational structures and subsequently used to identify predictors of bark beetle attack. In order to support the analysis of previous outbreaks, semi-automatic approaches for the detection of bark beetle infestation from remote sensing data are examined as part of the second work package.
In this regard, a detection method using aerial imagery was developed and successfully checked for practicability. Due to the availability of detailed monitoring data which has been recorded since 1996, the Saxon Switzerland National Park was chosen as test site. Since 2019, the new remote sensing method is used as standard operating procedure for area-wide bark beetle monitoring in the core zones of the national park. Currently, the procedure’s suitability for other study areas is evaluated.
In the final phase of the project, the results of both work packages will be included in the calculation of infestation probability. Thus, they are expected to contribute to the significant improvement of bark beetle risk assessment.

FIRIS - Risk Assessment in Norway Spruce Stands: Methods Using Remote Sensing and Forest Inventory Data

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Spruce (*Picea abies* (L.) Karst.) is the most relevant tree species in the federal states of Saxony and Thuringia, covering 35% and 48 % of the forest area in both states (respectively, data: 2017) from the lower mountain ranges up to the ridges of the Ore Mountains. But the natural habitat of spruce trees is only located at higher elevations (above 600 m sea level), where annual mean temperatures are below + 9 °C and annual precipitation sums (amounts) exceed 800 mm. Owing to that, the potential risk of calamities increases with distance from their ecological optimum. Therefore, FIRIS was initiated to quantify the potential calamity risk of the spruce forests in the mountain ranges of central-east Germany (the federal states of Thuringia and Saxony) and to discuss intervention strategies.

The project FIRIS focusses on three main subjects: (1) characterize the spruce stands from remote sensing products; (2) model spruce growth from inventory and retrospective increment data; and (3) spatially assess biotic and abiotic calamity risks. In order to characterize spruce stands (1), Sentinel-2-satellite and airborne laserscanning (ALS) datasets are analyzed. Random forest algorithms are applied to Sentinel-2 data in order to identify tree species within stands and to detect their changes over time. The information from ALS images are analyzed to quantify the standing stock within stands using relationships of tree allometry. Spruce growth is modeled (2) by GAMs using dendrochronological time series and by boosted regression tree algorithms that are applied on national forest inventory data. The results provide insights on how environmental factors and their interactions influence the growth potential of spruce trees in space and over time (i. e. resistence and resilience). The calamity risk (3) is modeled with the predisposition assessment system (PAS), which has been calibrated for Saxony and Thuringia by the BOKU in Vienna. PAS is a geographic information system locating and quantifying the risk of calamities through barkbeetles, snow and wind-throw.

The main goal of the project is to provide silvicultural strategies for the spruce forests in Saxony and Thuringia with knowledge that is based on up-to-date data and state of the art methods.

Spruce bud blight (*Gemmamyces piceae*) in the Ore Mountains: current situation and research findings

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Spruce bud blight (*Gemmamyces piceae* (Borthw.) Casagr.), ascomycete fungus, infect buds of spruces which lead to their deformation when attempting to growth. Pathogen caused in the Ore Mountains decline of blue spruce (*Picea pungens* Engelm.) stands planted in 70´s and 80´s in deforested areas due to air pollution. Infection of czech autochthonous Norway spruce (*Picea abies* (L.) Karst.) caused by *G. piceae* was recorded between years 2009-2013 on just a few trees and individual buds, but a number of infected trees and trees with a higher proportion of affected buds noticeably increased in the last years.

In current project funded by Lesy ČR, s. p., research placed in Ore Mountains is focused on spreading of *G. piceae* on *P. abies*, ecological factors affecting development of pathogen (stand, climatic, geomorphological etc.) and differences in physiology of infected and non-infected trees. Results from years 2015-2018 showed annual increase in damage caused by pathogen, especially in stands 31-60 years old. Stands with less density and in altitude ca 850 m above sea level were more damaged too. Proximity to *P. pungens* stands (under 1000 m) neither damage caused by cloven-hoofed game had no significant influence on the infection of *P. abies*. Infected trees showed lower photosynthetic rate. Spore production of *G. piceae* was highest from August to September. Potentional solution of problem could be to keep sufficient stand density and remove the most infected trees from the stands before vegetation period.

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Acknowledgement

This work was supported by the project of the Grant agency of Forests of the Czech Republic.

Session III – Silviculture, Forest Genetics and Tree Breeding

Performance of seven spruce species in experimental plantation, the Jizera Mts. (Isergebirge)

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Norway spruce (Pa) forests had been polluted severely by sulphur dioxide load in the Jizera Mountains, the Czech Republic during 1970s – 1980s. The widespread die-off of the Pa forced foresters to raise an issue of maintenance and/or restoration of forest cover. Among the woody species tested to substitute the Pa, five North-American and one South-European spruce species were planted in the Jizerka plot at the beginning of 1990s. The research question was whether exotic spruces show capability of substituting the functions of the declining native Pa.

The research plots consisted of 2 – 6 times replicated one-are square plots with spacing 2 × 1 m, i.e. 50 trees.are^{-1}. Besides Pa, other spruce species were: black spruce (Pm), red spruce (Pr), blue spruce (Pp), Sitka spruce (Ps), white spruce (Pg) and Serbian spruce (Po). Their performance i.e. health, growth and survival were investigated annually. The 2012 survival and 2017 height of 20% of dominant trees are presented in this study.

Native Pa showed lower growth rate compared to all other non-native spruces over the first decade after planting; Pm grew the best (fig. 1). In the early 2000s, Pa overgrew Pp and was keeping up with Pr, Pg and Po; Pm remained the highest one. Until 2010, Pa overgrew Pr, Pg, and Po and also began to keep up with the highest Ps; Pm was excluded from evaluation due to substantial loss of trees after bark beetle attack. After 2010, the height growth of Pa increased as it overgrew also to-date highest Ps. On the other hand, Pp remained the lowest one after 2002. The height ranking of spruce species remained the same after 2011.

As for the survival, the best values were shown in Ps, while the worst ones in Pm (tab. 1). Pp showed the second worst survival. Other spruces were comparable with survivals ranging between 71 and 75%.

Pp performance was affected by spruce bud blight disease (*Gemmamyces piceae*). Pg and Pr suffered from crown breakage and forking (45% and 34% respectively). Pa, Ps and Po showed good health.

Both height and DBH of the highest 20% of trees were significantly highest (10.5 m and 18.9 cm) in 27-year-old Pa in 2017. The slenderness ratio did not differ among the species studied.

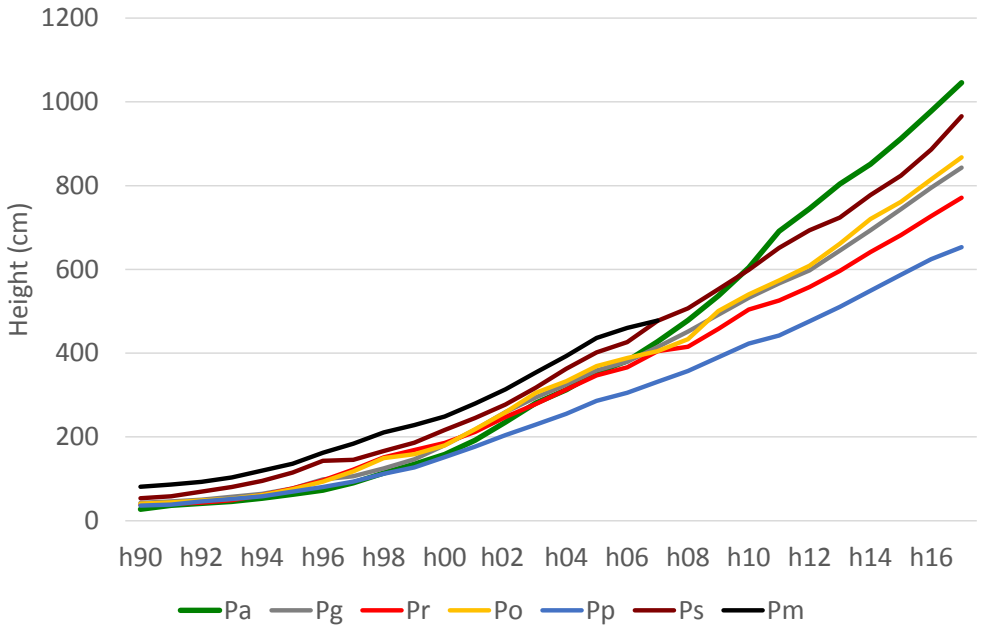

Fig. 1: Heights of dominant trees (20 %) in the spruce treatments

Table 1: Survival of the spruce species in 2012

	% of initial number
Norway spruce (*Picea abies* – Pa)	73
white spruce (*Picea glauca* – Pg)	75
red spruce (*Picea rubens* – Pr)	71
Serbian spruce (*Picea omorika* – Po)	72
blue spruce (*Picea pungens* – Pp)	59
Sitka spruce (*Picea sitchensis* – Ps)	78
Black spruce (*Picea mariana* – Pm)	19

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Practical recommendation for substitute tree species stands in Natural Forest Area Ore Mts.

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Research results should be implemented in practice. In case of silviculture recommendations, transfer by Regional Plans of Forest Development (RPFD) is one of suitable possibilities. RPFD is a methodological tool of state forest policy recommending principles of forest management, especially in the creation and approval of forest management plans and outlines and it is generated by Forest Management Institute (www.uhul.cz) for each natural forest areas (NFA) and the validity of the RPFD is 20 years.

For NFA 1 – the Ore Mts., is typical that forest stands are strongly influenced by anthropogenic activities (mining, air pollution, etc.) and large area (approx. one third) was planted by substitute tree species stands due to destruction of former stands. Silviculture research activities in last decades brought collection of outputs and recommendations, which are processed for transfer to the practice. In 2019, new period of validity of mentioned RPFD for NFA the Ore Mts., started. Therefore we cooperate with Forest Management Institute on update and among others we use Published Forest guides (Certified methodologies) focused on different silvicultural aspects (https://www.vulhm.cz/en/activities/publishing/forestry-guidelines/). For example, guides for conversion (Balcar at el. 2007) or thinning (Slodičák, Novák 2008) of substitute tree species stands were applied, of course, with modification based on updated research knowledge.

Specifically, silvicultural recommendations are implemented into “Framework management directives”, which are the most important output of RPFD. It is a base for preparation of forest management plans (10-year period) for individual owners.

Several main chapters are included into Framework management directives for substitute stands:

- Forest Management Unit – based on growth conditions.
- Target species composition and temporary biomeliorative species composition.
- Basic management recommendations (rotation and regeneration period, silvicultural system, etc.).
- Recommendations and setups of regeneration (incl. site preparation – Fig. 1), thinning, cutting technologies, forest protection setups, amelioration etc.

Fig. 1: Example of site preparation for conversion of substitute blue spruce stands. Standing whole trees are processed by chipper and therefore biomass is equally distributed on area for planting of target species.

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Acknowledgement

This work was supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0118.

Genetic Characterization of Plus Trees in the Genus *Larix*

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In the years 2013 - 2019, the joint project "FitForClim – Procurement of highly productive and suitable forest reproductive material for future forests under climate change", funded by the Waldklimafonds of the German Federal Government, worked on the selection and propagation of plus trees of the species *Pinus sylvestris, Picea abies, Pseudotsuga menziesii, Acer pseudoplatanus, Quercus robur* and *Q. petraea* as well as *Larix decidua* and *L. kaempferi* as basis for new breeding populations. The main responsibility of the Saxon working group in Graupa (SBS) within the project was the conceptional and practical coordination of the efforts with the genus *Larix*. Based on the results available from provenance and progeny trials, seed orchards and in special cases also from larch stands at all partner institutions in the FRG, qualified clones and individuals were selected.
To enable the identification of clones, to characterize the genetic structure of breeding populations and to assist future breeding efforts, the plus tree candidates were analyzed by 12 microsatellite markers (WAGNER *et al.* 2012). The results allow to discriminate species as well as genotypes and to discover hybridization with high confidence. Using information on range-wide genetic variation (WAGNER *et al.* 2015), it was tried to assign plus trees of unknown provenance to certain original regions. The results give also the chance to critically examine risks and sources of errors when dealing with breeding material in long-term trials.

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Acknowledgement
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Czech Republic – The preservation and reproduction of specific forms of the Ore mountains´ Norway spruce

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The breeding programmes were focused on current partial population recovery of Norway spruce, ecotype Ore Mountains; the source material was obtained from rare individuals which – thanks to their relative resistance – survived several periods of heavy imission (sulphur oxides) load in the recent past. The implementation of such rescue programmes requires, among others, the application of proven vegetative propagation technology of Norway spruce, i.e. the maintenance of their *ex situ* conserved clonal variants. In this contribution, we present a brief report about some of the current research activities of the Ore Mountains Norway spruce ecotype preservation and reproduction; these efforts aim at Ore Mountains´ forest restoration with this native spruce ecotype after the above mentioned periods of serious imission damage of this Czech mountain area. Nowadays, the increased efficiency of donor tree vegetative propagation is highly required, so that the material derived from older individuals, growing within spruce subpopulations, could be used successfully. The presented paper deals with our cutting and grafting method development.

Key words
Clonal parent tree gardens, generative progenies, imission load, Norway spruce, Ore Mountains, preservation, repatriation, resistant variants, vegetative variants, vegetative propagation.

Acknowledgement
Supported by the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0118

Current projects related to tree breeding for uncertain futures

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The change of environment due to global warming is leading to more and more uncertain conditions for sustainable forestry as the series of extreme weather events in combination with the mass propagation of bark beetles has shown in the last two years. Since it seems quiet impossible to foresee how the environmental conditions will be in two or more decades in reality, the choice of the right tree species as well as provenance for a given site will be a challenge. On the other hand, several adaptive traits are more or less strictly genetically controlled as has been observed in numerous progeny trials and experiments.
Therefore, SBS started already more than ten years ago the evaluation of phenological, physiological or morphological traits related to stability, resistance and survivability of provenances of various tree species. Additionally, the vegetative propagation of plus trees or of progenies descending from already approved family parents with *in vitro* methods was used to establish clonal material with extraordinary benefits related to yield, quality and stability. Objective of this work is the procurement of forest reproductive material for afforestation and reforestation to create scopes for action for foresters and land users. The presentation will use current projects as examples for the results already achieved and for reproductive material already available.

Acknowledgement
The project DendroMax is funded by the Federal Ministry for Food and Agriculture, the project FitForClim by the Federal Ministry for Food and Agriculture and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety based on a decision of the German Federal Parliament.

In vitro biotechnology and its use in the forest management

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Forests are facing a crisis; in the last decades, the ecological problems caused by climate change, pests, diseases and inappropriate management have manifested themselves in the deteriorating health state of various tree species, and their retreat. Sometimes, it is not possible to restore domestic populations by classic forestry methods for there might be too few exemplars left, because of their old age, or simply due to unfavourable conditions in their native environment.

This is the point where *in vitro* approach may help by producing strong and healthy explants which can be derived from the most valuable trees: These can be found and described by the methods of molecular biology (for example, the DNA analysis help us to determine how closely the trees are related, whereas the RNA analysis help us identify the genes which are responsible for drought resistance etc.)

The number of the tree individuals, obtained by *in vitro* cultivation, can be multiplied within quite short periods of time, and kept in sterile and safe conditions for many years. Once needed, the induction of explant rooting can be performed, the plant is transfered *ex vitro*, and after a short acclimation phase, it can provide the material for an old-new forest area establishment.

Session IV – Game Management and Wild Life

Estimation of sika deer population density with respect to forest damage

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Agricultural landscape has been rapidly changed in the last 150 years, which is mostly related with increasing land use and agricultural intensification (Ramankutty and Foley 1999). Such transformation of cultural landscape generally led to dramatic biodiversity loss. On the other hand, transformed landscape was successfully colonised by the populations of large mammals; population growth is documented throughout most of European countries (Pérez-Espona et al. 2009; Baltzinger et al. 2016). Other reasons of growing numbers of ungulates are the absence of large predators or inappropriate hunting management (Heurich et al. 2015). With the growing numbers of ungulates are generally related increasing damages to forest stands and agricultural crops (Bleier et al. 2012) which are caused by native and also introduced ungulate game species.

In the European context, one of the successfully introduced game species was sika deer (*Cervus nippon nippon*). Sika deer is now one of 10 invasive species with most negative impact on European landscape (Gallardo 2014). The populations of mentioned species are in many cases only on the local basis, sika is expanding the most on British Isles, Germany and in the Czech Republic (Pérez-Espona et al. 2009). In the Czech Republic, there are two separated and well established populations of sika deer: first in Western Bohemia and second in the Bouzovsko area (Eastern Bohemia), however the area of occurrence is still wider and hunted or observed individuals are reported from the localities where sika deer was not present so far (Barančeková et al. 2012). The population growth of sika deer could be well explained by the numbers of hunted individuals. The first available data comes from the 1966 when 276 individuals were hunted. In 2015, it was already 14 541 individuals. The aim of this contribution is to evaluate the numbers of sika deer in the region with one of the highest population densities in Europe (Plaská pahorkatina region; Western Bohemia).

The counting of sika deer individuals was realized between January and March 2019 in ten hunting districts with total acreage about 18,387 ha where the forest covers 7,217 ha (39%), arable landscape covers 8,459 ha (46%), grass covers 1 258 ha (7%) and other areas covers 1 453 ha (8%). The locality of interest is bordered by major road between region cities Plzeň and Karlovy Vary in the northern part and by the Hracholusky dam in the southern part. The centre of the area of interest is around village Líšťany (WGS 84: N 49°49.846'; E 13°10.877').

The counting was done by the simplified “Distance sampling” method where two counters inspect landscape on both sides of vehicle by thermal cameras (Pulsar Quantum, Pulsar Helion). When the hoofed game is detected, the personnel records GPS position (Garmin GPSMAP 64 PRO), distance from the car (Leica Rangemaster

– CRF 2000 B) and the species and its gender if possible. Marked ungulates were sorted into three categories according to habitat: forest, ecotones and open agricultural landscape. Sika deer individuals detected in ecotones and in open agricultural landscape were added into the final numbers directly (no conversion was applied). For the individuals detected in the forest, the average distance from the vehicle was calculated at first. This distance was taken as the distance, at which it was possible to detect the deer in the forest (62 m). The numbers of sika deer detected in the transect was then recalculated to the whole acreage of forest.

The highest number of sika deer individuals was detected in the hunting district Luhov (acreage 905 ha) with population density about 47.2 individuals/100 ha. The lowest population density was found in hunting district Úněšov with 5.9 individuals/100 ha. In the whole area of interest, 3,516 individuals were detected, average population density was about 20.0 individuals/100 ha. The gender was determined for 53% of individuals, mostly when the deer was in smaller groups. Bigger groups of deer were usually in the centre of field blocks, therefore it was only possible to recognise number of individuals but not their gender. Gender ratio in the area of interest was determined as following: 1 male to 3.2 females to 2.5 subadult individuals.

The estimation of sika deer population density brings basic overview on negative impact potential which could be caused by invasive ungulates in the native ecosystems. Detected population density could be acceptable e.g. for intensive breeding in game preserve but not in the open hunting districts. Hunting management in the area of interest should be aimed at the sustainability of the ecosystem, but with the growing population of sika deer are growing not only the risks of damages to agricultural crops and forest stands, but also the risks of hybridization with native red deer (*Cervus elaphus*) (Pérez-Espona et al. 2009; Barančeková et al. 2012). Found numbers of sika deer in the area of interest will be hand over to the local government which should ensure stronger hunting pressure and significant reduction of sika deer population density.

This contribution was funded by Grant Agency of Czech State Forests (project number 75) and also by the Ministry of Agriculture of the Czech Republic (MZE-RO0118).

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Red Deer and Forest Conversion in the Ore Mountains – Project Overview and First Results

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The Ore Mts. are, especially at higher altitudes, sparsely populated, and characterized by large coherent forest areas and extensively managed meadows and pastures. From the 1970's up to the early 1990's, the transboundary low-mountain-range was heavily affected by sulfur emissions. Thus, forest damage and soil degradation have been serious and long-lasting.

Particularly, the flatter expiring Saxon side, which experienced a long history of mining, is characterized by spruce dominated forests. Conversion of forests from spruce plantations to naturally mixed mountain forests with an increasing proportion of other characteristic tree species, such as *A. alba, F. sylvatica, and A. pseudoplatanus*, is an important instrument to improve the diverse functions of the Ore Mts.' forests, and to reduce the risk for biotic and abiotic calamities.

Before 1989, high red deer population densities had been a politically fixed intention. Heavy browsing and bark stripping damages were common consequences. After 1990, forest conversion and ecological forest management gained higher priority. Consequently, game management strategies were significantly changed, now aiming at promoting forest conversion on a large scale. By 2015, changed policies were in use for 25 years. However, the outcomes in Saxony's state forests were diverging : In several regions, the reduction of cervid densities in combination with high forest conversion efforts, led to significant increases in forest structure and plant species diversity. In other, sometimes closely neighboring regions, wildlife damage is still as high that planted trees need to be protected either chemically or by fences. In Saxony's state forests, browsing and bark stripping are monitored every 3rd year by freelance forest consultants. Last inventories were conducted in 2015 and 2018. The results of the 2015 survey showed damage levels higher than during the previous 15 years, and hence forced decision makers at Sachsenforst to initiate a research project in cooperation with the Technical University of Dresden, Chair of Forest Zoology. The project's aim is to study the interconnection between red deer population densities, population structure, space use, landscape structure, and forest damage. The field work was conducted between January 2016 and December 2018 by Sachsenforst, the Technical University of Dresden, and freelance forest consultants. Analyses and statistics are currently performed, and final results are expected in 2020.

Four study areas (∑ = 45.000 hectares) were chosen: Eibenstock (western Ore Mts.; low cervid influence on forest vegetation; high forest conversion efforts and

outcomes), Neudorf (western / middle Ore Mts.; very high cervid influence on forest vegetation; increasing forest conversion efforts), Bärenfels (eastern Ore Mts.; high cervid influence on forest vegetation; high forest conversion efforts), and Neustadt (western Elbe-Sandstone Mts.; low cervid influence on forest vegetation; high forest conversion efforts and outcomes).

The project is divided into three major parts:

1. Red deer population structure and space use:
    a. Different approaches to estimate population densities and structure are used, i.e. Distance Sampling, camera traps, genetics of tissue and faeces.
    b. Habitat use is studied with GPS-telemetry of 39 individuals.
2. Red deer influence on forest vegetation:
    a. Analysis of forest inventory data (bark stripping and browsing)
    b. Annual, “high resolution” (500 x 500 m), stand related bark stripping monitoring
3. Landscape and forest structure:
    a. Land use mapping (CORINE, ATKIS)
    b. forest structure (height, density and tree species composition derived from LIDAR and forest inventory data)
    c. coverage and biomass of the herb and shrub layer (modeled using the results of 160 vegetation survey points)
    d. monitoring of forest management and hunting activities
    e. area and type of agricultural crops

First conclusions:

- Modern methods for population density estimation (i.e. Distance Sampling, camera trap monitoring, faecial genetics) showed clear limitations, especially in forested areas, when population densities were low and individuals were distributed unevenly. Therefore, the results of several methods need to be combined. First results showed significantly different red deer population densities and population structures in the different study areas.
- Space use varied both between and within study areas due to age, sex, and traditive inheritance of individuals.
- Browsing and first-years survival rates of young trees correlated with indirect measures of local red deer population densities for a given vegetation period. Bark stripping damage differed both between study area and recording year.
- Availability and type of agricultural crops (especially rapeseed, meadows and pastures) had a strong influence on space use of red deer.
- Coverage and biomass of the herb and shrub layer differed both between and within study areas. Key drivers were soil conditions, topography, as well as stand height and crown closure of tree layer. Red deer population density did not seem to explain the composition of herb and shrub layer above a detection threshold of 5% coverage. Thus, a browsing induced absence of generally rare plant species could not be measured.

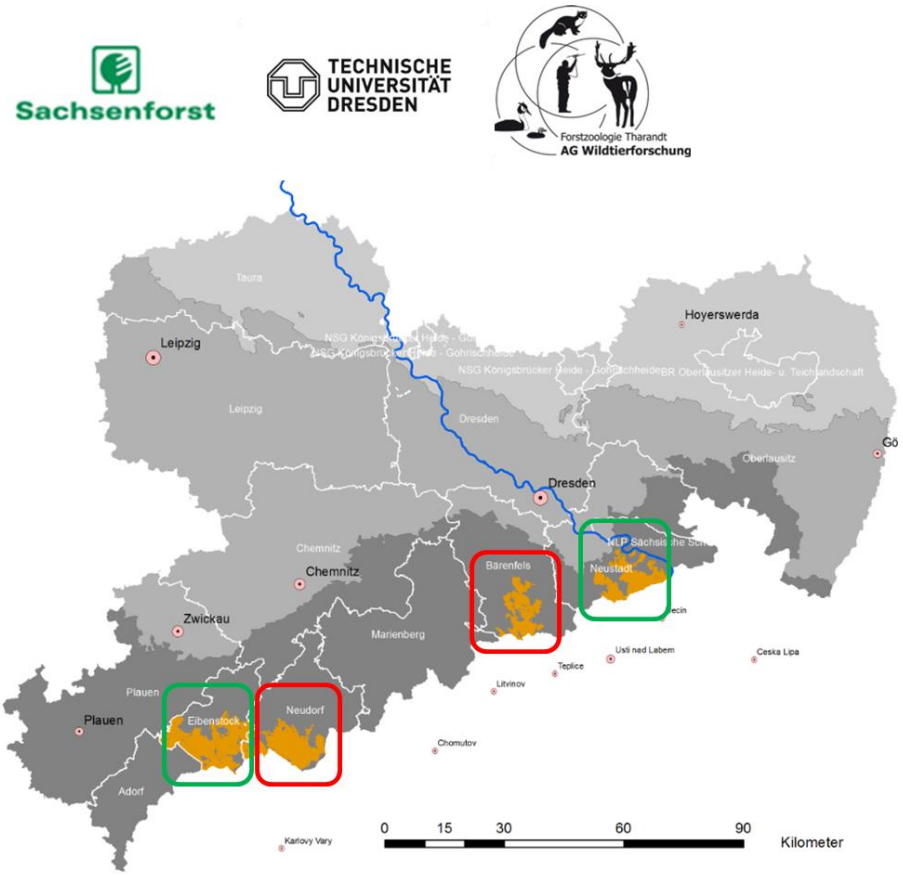

Fig. 1: The study area in overview: Green frames symbolize low cervid impacts, red frames symbolize high cervid impacts by browsing and bark stripping.