KRUŠNÉ HORY – DAS ERZGEBIRGE 2017

A COMMON ISSUE

Bilateral workshop of forest research institutions

from the Czech Republic and Saxony

Most, 26.9. – 27.9. 2017

BOOK OF ABSTRACTS, EXCURISON GUIDE

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

Sachsenforst

In 2017 we commemorate 70 years of the first serious air pollution damages on the Ore mountain forests in 1947. Since than the region on the border between Czech Republic and Saxony has passed through the vast forest deterioration in 1970´s and 1980´s till the forest regeneration and improving vitality in last 20 years. Notwithstanding recent achievements forestry in the region is still vulnerable to many factors including climate change, biotic and abiotic stressors as well as anthropogenic influence. The workshop is aimed on exchange of current experience, planning future cooperation and discussing future challenges in the field of forest research.

Organizing committee

Bohumír Lomský
Dirk Eisenhauer
Vít Šrámek
Henning Andreae
Jana Danysová

Organizing of the meeting is supported by the project of the Ministry of Agriculture of the Czech Republic – Resolution RO0117 (reference number 6779/2017-MZE-14151.)

PROGRAM

Tuesday 26. 9. 2017

9:00 – 10:00 Registration

10:00 - 10:10 Welcome and opening of the workshop

10:10 - 10:25 V. Šrámek: Forestry and Game Management Research Institute – history, current state and visions

10:25 - 10:40 D. R. Eisenhauer: Competence Centre for Wood and Forestry – current state a visions

SESSION I - FOREST HEALTH AND SOIL QUALITY

10:40 - 11:00 R. Novotný: Changes in the health and nutritional status of young spruce stands in the Ore Mts. during the period 1994-2016

11:00 - 11:20 F. Jacob: Assessment of nutrient sustainability and mapping of risk areas for whole tree harvesting 2020-2022

11:20 - 11:40 V. Šrámek: Results of soil survey in the Ore Mts., liming plans for 2020 – 2030, potential problems connected with forest soil quality in other parts of Czech Republic

11:40 - 12:00 R. Petztold: Characterization of humus quality combining easy to handle NIR (near-infrared technique) analysis and digital soil mapping

12:00 - 12:10 Discussion to the Session I

12:10 – 13:30 Lunch

SESSION II - SILVICULTURE AND FOREST GENETICS

13:30 - 13:50 J. Novák: Silviculture experiments in the Ore Mts. – main results

13:50 - 14:10 S. Martens: Actual topics on field research regarding forest conversion, forest risk management and forest inventory

14:10 - 14:30 M. Slodičák: Forestry concept for air polluted area of the Ore Mts. - Proposed variants of forest management (summary)

14:30 - 14:50 R. Petztold: Building Up a Digital Document Management System (DMS) on a Forest GIS Platform (FGIS)

14:50 - 15:10 H. Wolf: Current activities of forest genetic research and forest tree breeding in Saxony - potential points of reference for future cooperation?

15:10 - 15:30 J. Frýdl: Czech Republic – overview and actual topics on provenance research and genetic resources preservation and use in the Ore Mountains

15:30 - 15:40 Discussion to the Session II

15:40 - 16:10 Coffebreak

SESSION III - FOREST PROTECTION, GAME MANAGEMENT

16:10 - 16:30 J. Lubojacký: KŮROVCOVÉ INFO – new service for forest owners

16:30 - 16:50 L. F. Otto: Monitoring systems – important tools for specification actual situations, forecast of insect pests outbreaks with estimating of possible damages, basis for consultation private forest owner und initiation of pest management

16:50 - 17:10 F. Lorenc: Gemmamyces piceae – occurence on Picea abies in the Ore Mountains

17:10 - 17:30 R. Petztold: Updating legacy peat information of the forest site survey in the Ore Mountains (state owned forest)

17:30 - 17:50 J. Cukor: Verification of Red deer population density in the west part of the Ore Mts.

17:50 - 18:00 Discussion to the Session III

19:00 Dinner

Wednesday 27. 9. 2017

9:00 Departure to excursion

Forestry and Game Management Research Institute – history, current state and visions

Bohumír Lomský, Vít Šrámek

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Forestry and Game Management Research Institute (FGMRI) is a public research institution founded by the Ministry of Agriculture of the Czech Republic. It´s history has started in 1921, when the Institute of Forest protection was established. Nowadays the Institute comprise six research departments:

- Department of Forest Biology and Tree Breeding
- Department of Forest Ecology
- Forest Protection Service
- Department of Game Management
- Department of Silviculture – Research station Opočno
- Department of Reproductive Sources – Research station Kunovice

… two “supporting” departments

- Forestry Information Centre
- Department of Testing Laboratories

… and Management department.

All the departments pay attention to current directions in Forest research in the Central European context. Great emphasis is placed on applied research with practical outputs for forest management, forest owners and administrators. Cooperation projects in applied research are also pursued to promote connection between knowledge and practice.

Within the Ore Mts. area FGMRI was considerably active during the air pollution calamity in 1970´s and 1980´s. In last 27 years air pollution decreased significantly, the region, however, is far from stable forest management. FGMRI takes part in the forest health monitoring, soil survey, long term silviculture and forest protection research. Last year FGMRI significantly contributes to the new Program for Revitalization of the Ore Mts which was prepared by the Ministry of Agriculture and accepted by the government of the Czech Republic in November 2017. The topics of reconstruction of “substitutional” forest stands of blue spruce, birch and mountain ash, problems with long – term acidified soil environment, new dynamic of pests activity, deer and rodent damages on newly established forest stands as well as the potential impact of climate change pose a challenge for current and future research activities in this region.

Competence Centre for Wood and Forestry – current state a visions

Dirk-Roger Eisenhauer

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The Competence Centre for Wood and Forestry is a specialist department within the State Enterprise Sachsenforst responsible for developing a basis informed decision-making.

Main working fields are departmental research on forestry, permanent forestry-related environmental monitoring, inventories of soil and forest condition and periodical operational planning for state owned and public forests.

Functional strategies and recommendations for specific site regions are developed in direct cooperation with the State Enterprise´s directorate to ensure that forestry remains sustainable under changing environmental conditions.

Main research activities are:

- Characterise site conditions and its changing for forest management.
- assessment, preservation and economic development of forestry-related genetic resources,
- integrated forest protection, especially controlling of functional risks from biotic and abiotic stressors,
- potentials of site- and functional-based measurement of forest growth,
- management of the red deer population in the Ore mts.,
- Application of remote sensing and GIS in the forest management.

References

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Eisenhauer, D.-R.:, Martens, S., Lehmann, R.: Waldbau, Holzmarkt, Waldarbeit – Strategien und Potenziale. AFZ-DerWald, 21/2016, 22 – 27.

Changes in the health and nutritional status of young spruce stands in the Ore Mts. during the period 1994-2016

Radek Novotný, Bohumír Lomský, Vít Šrámek

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Methods

The nutrition status and the air pollution load have been evaluated at 20 research plots, located in the young Norway spruce stands in the ridge area of the Ore Mountains since 1994. This network was established for monitoring of development and changes of spruce stands growing in heavy polluted region of the Czech Republic.

Research plots were installed in 1994, when samples of assimilation organs were taken in order to evaluate the air pollution load. In 1996 the monitoring system was completed, a transect from Cínovec to Horní Lazy in the Slavkovský les region was created. The plots have an area of 25x25m. The individual trees are numbered and their defoliation and annual increment are assessed on an annual basis.

From 1995 onwards, defoliation of the tree crown was assessed annually at the end of the vegetation season (October-November). The defoliation of minimally 40 numbered trees within a diagonal transect was evaluated, on a 5% scale, in accordance with the ICP Forests methodology, modified for the young Norway spruce stands (Lomský, Uhlířová 1993).

Height increment was measured in a set of 20 trees that are included in crown defoliation assessment. Measuring was originally carried out using a Sokkia measuring pole. As the stands grew, the method had to be changed; since 2006 the Vertex hypsometer has been utilised.

Sampling of the needles to define their nutrient level and air pollution load was undertaken every autumn (October-November), together with the assessment of the crown condition. 10 trees were sampled at individual plots. One branch of the top part of the crown (from the third to the sixth whorl) was taken from each of them. For each plot a pooled sample of the current year needles and a pooled sample of one-year-old needles were created. These foliar samples were prepared in accordance with the ICP Forests methodology.

Soil samples were taken at four-yearly intervals. Individual samples of the upper organic layer and of the mineral soil from a depth of 0-30 cm were taken individually. The sampling was carried out diagonally throughout each plot; the samples from the three sampling spots were pooled prior to their analysis. The preparation of the samples from the upper organic layer and the mineral soil was carried out in accordance with the ICP Forests methodology.

Results

Today, the health status of the spruce stands, expressed in terms of the crown defoliation, has recovered and is comparable to that found in other regions of the Czech Republic. The sulphur and fluorine content of the needles has decreased significantly. The long-term negative effect of acid deposition that contributes significantly to the degradation of forest soils creates a permanent risk for forest ecosystems in the region. In recent years, the nitrogen and the sulphur concentrations in the needles have again increased slightly. A long-term tendency towards a decrease in the phosphorus, calcium and potassium content of the needles was detected.

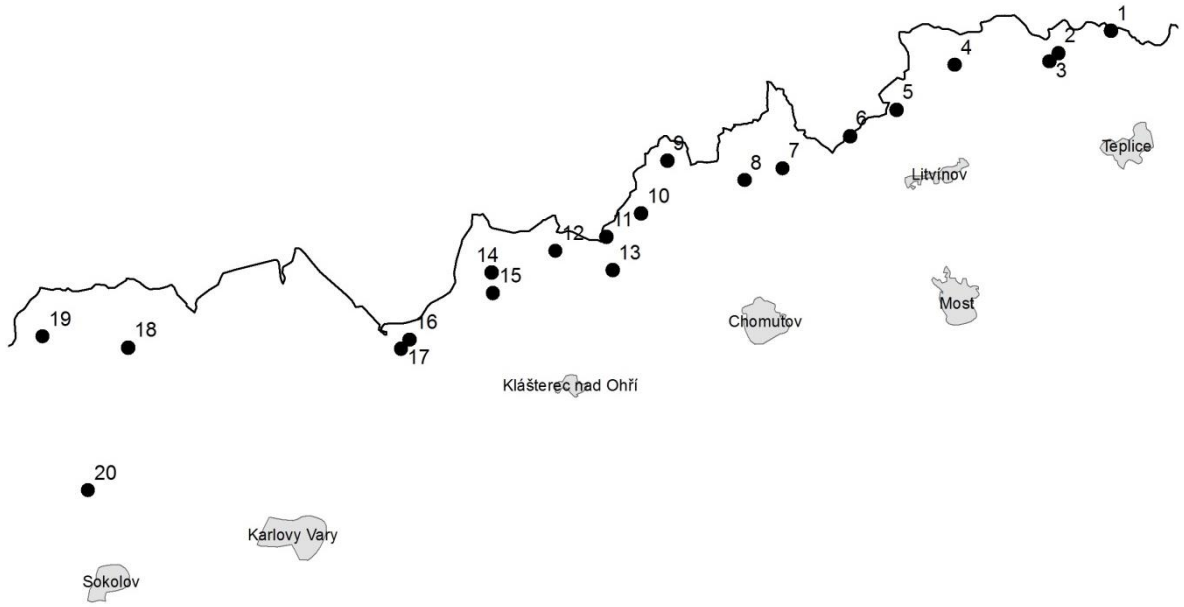

Fig.1: Location of research plots in young Norway spruce stands in Ore Mts.

References

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Assessment of nutrient sustainability and mapping of risk areas for whole tree harvesting 2020-2022

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Fostered by climate change discussions, in the last decade the potential to substitute fossile fuels through energetic use of wood biomass received increasing attention. In order to profoundly discuss the pros and cons of whole tree harvesting under the auspices of nutritional sustainability, experience and data are needed concerning the nutrient content of wooded biomass compartments, the expectable export of nutrients through whole tree harvesting. Moreover on the basis of digital site survey risk maps for whole tree harvesting shall be developed (“traffic light” maps).

In 2015 in co-operation with the FVA Freiburg, tree harvesting at Level II – plots (pine Laußnitz, spruce Altenberg) has been carried out. The aim was to generate experience with effective sampling and analytical techniques. Moreover we collected and analysed wood samples of silvicultural research plots to check or even expand the species data base on wood chemistry published by Jacobsen et al (2003).

For spatial information the site survey and its legacy chemistry data need to be put into use in combination with current soil condition surveys. In co-operation with Prof. Göttlein, TUM, first “traffic light” risk maps for intensive biomass use have been generated.

In the long run we aim at achieving and distributing knowledge and spatial information to all forest owners, to establish a site based decision support system on nutritional sustainability (i.e. DSS Rhineland-Palatinate), develop post-harvest techniques to better distribute harvest debris in the field, assess the pros and cons of wood ash recycling together with routine restaurative forest liming

References

Jacobsen, C.; Rademacher, P.; Meesenburg, H.; Meiwes, K. J. (2003): Gehalte chemischer Elemente in Baumkronenkompartimenten. Literaturstudie und Datensammlung. Göttingen (Ber. Forschungszentr. Waldökosyst./Waldsterben B, 69).

Results of soil survey in the Ore Mts., liming plans for 2020 – 2030, potential problems connected with forest soil quality in other parts of Czech Republic

Vít Šrámek, Bohumír Lomský, Radek Novotný, Věra Fadrhonsová

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The historical air pollution level in the Ore Mts. has strongly decreased during 1990´s and current SO_2, HF or NO_x concentration does not represent any threat to forest stands. On the other hand, the acidic deposition decreased as well but still exceeds the limits of critical loads for mountain forest soils. This situation impedes the regeneration of forest soils which often exhibit critical saturation of base cations especially in ratio to higher amount of nitrogen supplied by atmospheric deposition. In case of reconstruction of forest stands – especially in favour for broadleaves we still need to add base nutrients e.g. in the form of forest liming. For the period 2021 – 2030 more than 34.600 ha was proposed for liming according to soil properties, site quality and with respect to nature protection restriction.

Liming and fertilizing are not the only measures to secure the sustainable quality of forest soils. The important stock of base cations is in bark and foliage of trees. We strongly support leaving of logging residues in the forest stands, optimally in the form of wood chips as an important supply of nutrients for newly established forest. This is, unfortunately, in the opposite with the current tendency of “complex” using of forest biomass and according to our findings can negatively influence the nutrient balance in many areas of the Czech Republic.

References

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Characterization of humus quality combining easy to handle NIR (near-infrared technique) analysis and digital soil mapping

Rainer Petzold [1)], Ulrike Werban [2)]

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[2)] *Helmholtz-Zentrum für Umweltforschung (UFZ) – Department Monitoring- und Erkundungstechnologie,D- Leipzig*

The coming project aims at the development of simple site survey techniques for humus layers (quality and quantity) as a basis for silvicultural decisions by forest district officers in high spatial resolution.

Based on humus and soil samples of known nutrient contents (soil condition survey) we will set up a sprectral library for VIS-NIR-technology. Thus we co-operate with UFZ Leipzig (NIR-technique). Furthermore regionalization algorithms for sampling design and spatial projections shall be developed as well as manuals for both VIS-NIR and regionalization.

References

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WERBAN, U., BEHRENS, T., CASSIANI, G., DIETRICH, P. (2010): iSOIL: an EU project to integrate geophysics, digital soil mapping, and soil science In: Viscarra Rossel, R.A., McBratney, A., Minasny, B., (eds.) Proximal soil sensing Progress in Soil Science 1 Springer, Berlin, Heidelberg, New York, p. 103 - 110

Silviculture experiments in the Ore Mts. – main results

Jiří Novák, Marian Slodičák, David Dušek

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Silviculture experiments created important part of forestry research in the Ore Mts. Main aims of the silvicultural research are focused on growth and development of substitute tree species stands. These stands were planted in order to maintain forests under heavily air-polluted conditions mostly during the period of 1970-1980. Up to now, substitute stands occupied approximately one third of forest area in Natural forest region – the Ore Mts. and they are created by birch (9150 ha), blue spruce (6609 ha), European larch (6370 ha), rowan (2461 ha), alder (1706 ha), dwarf pine and mountain pine (1751 ha), sycamore maple (1161 ha), other introduced pines (167 ha) and aspen (147 ha).

Experiments were established in stands of birch (partly mixed with blue spruce, locality Fláje I), blue spruce (locality Fláje II) and larch (locality Kalek). Research was oriented on determination of optimal techniques for thinning and conversion of substitute stands. Additionally, some parts of ecosystem nutrient cycle (aboveground biomass, litter-fall, forest floor) were investigated in connection with recommended silvicultural measures.

Results from experiments are continually published (see list of references). As an example we can conclude:

- Despite the former and current air-pollution load and (in the case of larch stand) raking of forest floor before planting, the amount of aboveground biomass produced by substitute 20-22-year-old blue spruce, larch and birch stands is comparable with the results observed in similar stands on the other undisturbed sites.
- The removal of biomass for chipping in areas previously degraded by acid deposition may result in the deficiency of Ca and Mg because of their important content in above ground biomass (and consequently in litter-fall) and low content in forest soil.
- First thinning with high intensity resulted in better health condition and higher stability (by h/d ratio) of remained trees in young blue spruce and larch substitute stands. Thus, appropriate conditions for following conversion were achieved by thinning. Unfortunately, in case of blue spruce stands, conversions (by interplanting) were limited because of high attack of pathogen *Gemmamyces piceae* in last decade.
- In case of birch and blue spruce mixtures (Fig. 1), received data showed, that the initial good condition of experimental stands has deteriorated since 1994 in accordance with increased salvage cut to the basal area decrease, which was more significant on variant with thinning from above. Elimination of some dominant trees by thinning from above can result in acceleration of stand disintegration. On the

other hand, planned thinning from below is unnecessary in this stands. The presence of the birch layer on control plot as well as on plots with thinning negatively influenced the basal area of blue spruce 17 years after first thinning (2006). Later spruces were eliminated by mentioned pathogen *Gemmamyces piceae*.

Fig. 1: Conversion of substitute stand (mixture of birch and blue spruce) by underplanting of fir and beech in experiment Fláje (2010).

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Actual topics on field research regarding forest conversion, forest risk management and forest inventory

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In the last two decades a set of 53 thinning and 22 conversion trials was implemented. Up to five periodical measurements build up a dataset on growth and yield for main tree species and forest structures in Saxony. In essence, these are monolayer younger stands of pine, spruce, pedunculate oak, beech and douglas fir and planted understoreys of beech, fir, maple, douglas fir and oak under pine and spruce shelter.

Currently we investigate the conversion trials under pine shelter with view on 1) understorey slenderness and growth, 2) the water use efficiency of the whole forest structure and 3) suitability of the sandy site conditions for the tree species. For the conversion trials under spruce shelter we actual estimate site dependant height growth models for the understorey.

These investigations support the calculations of yield and growing stock in the forest inventory; improve the strategies in thinning and rejuvenation and their education and practice for foresters and private forest owners.

Concerning climate change the management of spruce-stands in the ore mountains become more and more the major topic in silviculture. In the research project FIRIS we use ALS and satellite data for high resolution (0.01 ha) estimations on growing stock, spruce abundance, barkbeetle and storm risks. On this basis we forecast scenarios and derive requirements on the dynamic of forest conversion and cut rate for homogenous mature spruce stands.

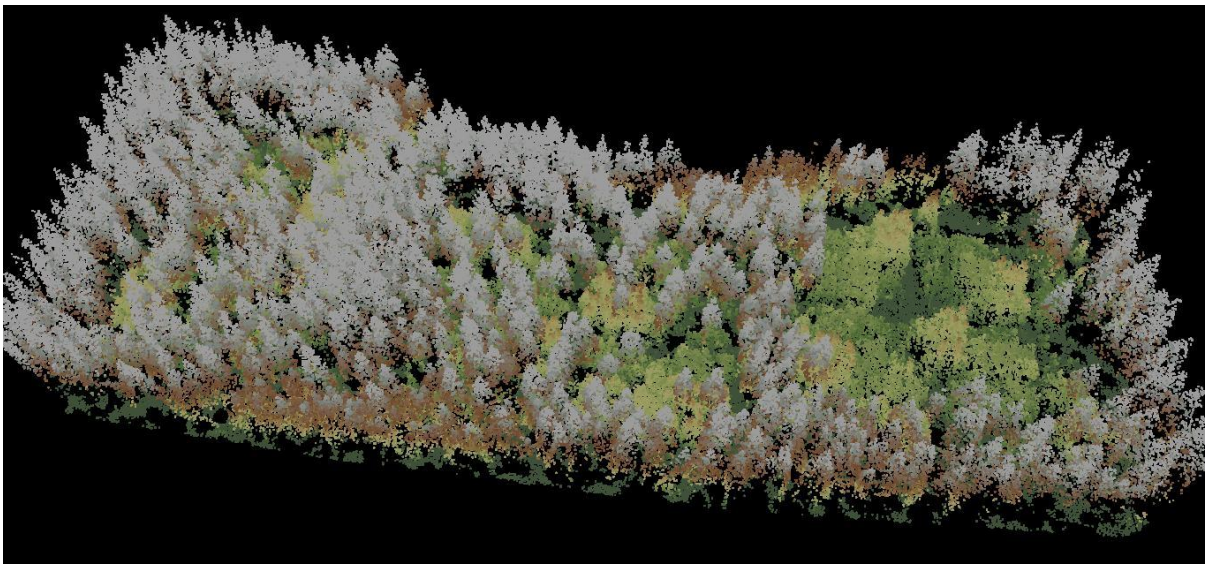

Fig. 1: The conversion trial Olbernhau32 (printed as ALS-point cloud) – an example of the basis for understorey growth modelling

Acknowledgement:
FIRIS (01.12.2016 till 30.11.2019) was supported by the FNR (Fachagentur Nachwachsende Rohstoffe e.V.), reference number 22030614.

Forestry concept for air polluted area of the Ore Mts. - Proposed variants of forest management (Summary)

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In order to convert substitute-tree-species stands in the Krušné hory Mountains, three variants of species composition were proposed in 2008:

- Basic (target) species composition based on contemporary improved environmental conditions leading to target species revitalization and occurrence of natural regeneration.
- Temporary bio-ameliorative species composition based on broadleaves which are able to improve their environment (especially soil); also throughfall acid deposition within broadleaves stands is lower compared to conifers.
- Temporary preparatory species composition as an alternative to both above-mentioned compositions; contrary to the bio-ameliorative one, a lower initial density of planting stock and small-area-fenced spots of selected beech cuttings leads to formation of genetically high quality beech stands with expected earlier masting years occurrence (diversification of stand age structure).

Differentiation of management measures is based on levels of imission load:

- Acid deposition less than double of critical load, i.e. to ca 3.2 kmol H^+ ha^{-1} $year^{-1}$
- Acid deposition exceeding the double of CL, i.e. over 3.2 kmol H^+ ha^{-1} $year^{-1}$.

Investigated area represented 41,060 ha of forest stands, i.e. important part from total forest stand area (115 thousand ha) in the Natural Forest Region – the Ore Mts. The major part of the investigated stands (ca 30 thousand ha) lies in the area with acid deposition lower than the double of critical level. However, over 11 thousand ha of stands are affected by acid deposition higher than 3.2 kmol H^+ ha^{-1} $year^{-1}$, i.e. by more than the double of critical level.

Two variants of silvicultural measures were recommended for the period of following 30 years:

- Variant 1. TSC - (Target species composition on majority of area),
- Variant 2. TBSC – (Temporary biomeliorative species composition on whole area).

Higher costs of conversion and following measures (especially thinning and soil condition treatments) were calculated for Variant 2 – TBSC (during the next 30 years 5 367 Mio CZK, i.e. approx.. 206 Mio EUR) Higher costs are caused especially by higher portion of soil-improving and stabilizing tree species (higher costs of protection despite game management optimization; higher costs of chemical amelioration which

is necessary for some valuable broadleaves, etc.). More intensive thinning of young stands (2nd age degree) is essential as well.

Fig.1: Substitute tree species stands in locality Kalek (photo J. Vondra 2007).

Costs of Variant 1 – TSC are about 19% lower in comparison (4 362 Mio CZK, i.e. approx. 168 Mio EUR). Lower costs are caused by using of TSC, which is characterized by lower portion of soil-improving and stabilizing tree species in comparison with TBSC (lower costs of fencing and chemical amelioration and lower intensity of thinning). Realization of these both variants (BSC and TBSC) is strictly conditioned by optimization of game (especially red deer) management.

Acknowledgement:
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Building Up a Digital Document Management System (DMS) on a Forest GIS Platform (FGIS)

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Legacy data of forest site survey and research plots need to be digitally documented in their spatial context and thus made easy to retrieve for third parties / next generation of users in order to facilitate the design and implementation of coming projects. As the technological platform ERDAS APOLLO will be used, which is already implemented unit 4.5 – Cartography.

The aim is to digitize all relevant analogue point and spatial data sources (maps) as well as plot documentations of the research related units in the competence centre and get these informations geotagged and displayed.

References

ERDAS Apollo: Comprehensive Data Organization, Analysis, and Delivery: https://youtu.be/cvz4YKFBIxI

Current activities of forest genetic research and forest tree breeding in Saxony - potential points of reference for future cooperation?

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The work of the department of forest genetics and tree breeding is based on more than 70 years of research and practical experiences regarding the characterization, protection, improvement and provision of forest genetic resources. During this period, researchers working with similar problems on both sides of the border have met for cooperation at individual topics. In the following, fields of research are presented that could be of common interest and therefore a good reason to renew the cooperation from our point of view.

1) Provenance research with Norway spruce

From 1976 to 1977, the International Norway spruce provenance trial 1972/76-77 was established with about 120 provenances on several trial plots in the ČSSR and the GDR. Several experimental trial plots of this series are still under observation, e.g. in Thuringia and Saxony. Within selected plots, the assessment of height and diameter was done 2005/06 (tree age 34 years) and 2015/16 (tree age 44 years). Additionally, selected provenances were investigated with dendro-chronological methods on two trial plots. It could be of interest to evaluate, if the trial plots established in the Czech Republic still exist and to observe how common provenances from Czech Republic and Saxony developed on the different sites.

2) Conservation and promotion of forest genetic resources across the border

Since the 1980ies, activities for conservation and promotion of forest genetic resources of several endangered forest tree species, e.g. Norway spruce, Silver fir, Noble hardwoods (Elm species), Black poplar or Wild fruit species, have been implemented in Saxony. The measures comprised the identification, characterization and conservation of individuals in clone collections and seed orchards. About 3.500 ha of *in situ* stands with special importance for gene conservation purposes have been identified regarding about 25 species in the forests of Saxony, independently of the ownership, to protect genetic information in the broad sense. It could be of interest to identify common needs and to agree on common activities in Czech Republic and Saxony.

3) Propagation of forest basic material and promotion of forest reproductive material

For several tree species, e. g. Norway maple and large leafed lime, there is an increasing interest with respect to climate change. Due to the impacts of long lasting anthropogenic interference to the forests in Saxony, there is a lack of suitable basic material for their propagation. As both species are cultivated also in Czech Republic, the exchange of knowledge and experiences in generative and vegetative propagation methods, storage of seeds and cultivation of seedlings and plantlets is interesting for us.

4) Tree breeding

Tree breeding methods like plus tree selection and hybridization are applied to several tree species. In Larch- and Fir-species as well as Douglas fir, we develop basic material for somatic embryogenesis by these activities. In general, beside growth traits increasing attention is paid to physiological characteristics as drought and frost tolerance. We would like to cooperate in this field as well as with the establishment of common trial plots for the testing of clones, progenies and provenances of different species.

Czech Republic – overview and actual topics on provenance research and genetic resources preservation and use in the Ore Mountains

Josef Frýdl, Václav Buriánek, Petr Novotný, Jiří Čáp, Jaroslav Dostál

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Introduction:

The Natural Forest Region Nr. 1 Ore Mountains lies predominantly in the 5th (fir-beech) to the 8th (spruce) Forest Vegetation Zone. Forest area is relatively high - 66.9%. Actual tree species composition (according to the Regional Forest Development Plan) is following: The main tree species is Norway spruce (53,3%), then common birch (12%), Scots pine (6 %), European beech, European larch (5% both) and oak and alder (2% both). The presence of exotic species of spruce, especially *Picea pungens*, reaches 8%. There have been 49 research plots established in years 1932 - 2000, which are located in the Ore Mountains or elsewhere with material originated from the Ore Mountains. Most research plots (9) are with larch, with spruce (7) and three plots are with beech. Some experiments are of international character (such as e.g. larch and lodgepole pine /Pinus contorta/).

In the actualized version of case study "Forest Management in the Ore Mountains“ (ŠRÁMEK et al., 2015), there are presented databases of certified forest tree resources of identified, selected and qualified reproductive material in the Ore Mountains, including list of genetic conservation units in this region. Data of growing planting stock for main tree species at the age of 1 year according to forest vegetation zones are presented in that case study, too.

Also, the attention is paid to measures suggested for near and also for future within effort on conservation and using of forest trees genetic resources in the Ore Mountains.

As for state support to the genetic resources preservation and use in the Czech Republic forests, including the Ore Mountains, possible financial support is granted by the state under the approved National Program for the Protection and Reproduction of Forest Tree Genetic Resources for the period 2014 - 2018 with the aim to encourage forest owners and managers to search and manage for additional valuable resources of forest reproductive material.

It is possible to be mentioned, that genetic resources of forest tree species in the Ore Mountains can be considered sufficient for the forest management needs, with exception of silver fir (*Abies alba*) and pubescent birch (*Betula pubescens*). With the exception of silver fir, sufficient number and area of certified seed stands are available for all main tree species.

Some of actual research results:

Results of evaluation of research plots with European larch in the Ore Mountains have certified a level of tolerance of this species against immissions. If larch will survive the first period after planting, its survival characteristics during the following periods are used to confirm satisfactory growth and a satisfactory health state of this species.

Research results also indicated the possibility of using inter-specific hybrids of larch for reforestation disaster areas in the Ore Mountains. Compared to European larch progenies, hybrids of European larch and Japanese larch grow more quickly, avoiding the detrimental effect of ground frosts, competition from weeds, and animal damage.

In the context of provenance research in the Ore Mountains, there have been established several long-term provenance plots with Norway spruce, where provenances from all over Europe are tested, including provenances both from the Czech and German parts of the Ore Mountains.

In the Ore Mountains, there are also tested in long-term research selected species of genus *Picea*. As current results indicate, plantings of black spruce have proved as suitable variants for localities of unfavourable soil and climatic conditions.

Among various discussed ways, how to adapt forest management in response to the challenges of expected environmental (climate) change, there used to be discussed also need to pay a bigger attention to provenance research aimed especially on such forest tree species, which are supposed to be more resistant e.g. to increased average site temperature, changes in site moisture regimes, etc.

In the context of research activities oriented to the preservation and reproduction of forest tree species genetic sources, there also have been realized inventory of mountain elm in the area of Ore Mountains and inventory of vegetative plantings of various forest tree species, including some autochthonous populations of the Ore Mountains origin. In conjunction with these activities, preparation phases of clonal archives establishment (collection of grafts, planting of graftings) have been realized.

In the spring 1999, there was established the seed orchard with mountain elm (*Ulmus glabra* Huds.) of the size 1.27 ha, on the LS LČR Litvínov (formerly LZ Janov, Červený Hrádek), in the locality Telč, southwest of the village Orasín. Reproduction material for this seed orchard was collected at localities of the LS LČR Litvínov (Brandov District, Lom Quarry, Šumný Důl, Načetínský Potok) and LS Klášterec nad Ohří (Jelení hora) from healthy trees of high quality suitable for reproduction, the last healthy remains (residues) of this species populations in the Ore Mountains.

In the Czech Republic, in frame of FGMRI research activities, there has been paid attention in long-term provenance research to testing of various „exotic“ introduced species. E.g. various species of genus *Pinus* have also been tested in the Ore Mountains. In this sense, based on previous research activities with lodgepole pine (IUFRO international experiments) on German side of the Ore Mountains, the experiments established in the 1930s and 1960s proved its resistance to SO_2 (the last

known results are from 1980) and they concentrated the attention to the possibility of this species use also in the immission areas on the Czech side of Ore Mountains.

In frame of research activities aimed to testing of selected species of genus Pinus, there have been established several provenance plots, both of international and national character, in the area of the Ore Mountains. Among these provenance plots, there can be current results of provenance plot „Kovářská“ (Klášterec) evaluation and measurement mentioned, too:

On the provenance plot Kovářská (Klášterec), there is evaluated 27 provenances of three sub-species of lodgepole pine. This plot is part of a triple series of plots established in various site conditions in the Czech Republic.

At the age of 34 years, the height, DBH, stem form, d1.3, truncation of the stem, thickness of branches, type of bark, mortality and defoliation were assessed. As the best one it is the provenance of the subspecies *P. c.* subsp. *latifolia* from the interior of Oregon. When comparing all three plots of the experimental series, a better quality of the trees (stem form truncation of the stem, bark type) was achieved in the mountains. But not in terms of defoliation (vitality) and branch thickness.

The lodgepole pine heights reached in the Ore Mountains are comparable to the results from a geographically close areas abroad. Domestic Scots pine species match in the production only the best provenance of the lodgepole pine. Its use is therefore only considered at specific habitats where domestic species fails.

Other research activities connected with forest tree breeding and improvement in the Ore Mountains:

In this sense, it is possible to mentioned currently realized research programs oriented, among others, also to the selection and grafting of Norway spruce resistant variants in the Ore Mountains have been realized with the aim to preserve those resistant variants in these areas under immission load.

In the period 2008–2011, a specific research project (GS LČR 2008) has been realized, being oriented to evaluate the success and quality of plantings of vegetatively propagated Norway spruce resistant variants from selected localities in the Ore Mountains. This research was designed for verification of genetically conditioned characteristics of vegetative plantings, in comparison with characteristics of generative plantings in the vicinity.

In frame of following research activities, there was approved another research project (NAZV č. QJ1520300) aimed to utilization of resistant local Norway spruce vegetative variants in forest regenaration in the Ore Mountains, for the period 2015–2018. The aim of this research project is to utilize specially selected vegetative variants of resistant (tolerant against emissions) Ore Mountains population of Norway spruce for forest regeneration in forest management in the region. These areas are administrated by a number of participants of the project, including the Municipal Forests (MF)

Chomutov, Forests of the Town Jirkov, Forests Jáchymov and MF Klášterec (the last named organization will participate in the project as user of the project results).

Examples of suggestions and proposals for further (common) research in the Ore Mountains:

Preparation of new research projects (provenance research projects, hybridization, breeding measures oriented to the conservation and utilization of genetic resources of forest trees in the Ore Mountains (*Picea*, *Larix*, *Pinus*, *Abies*, *Fagus*, *Ulmus* etc.);

Other research activities related to forest tree breeding and their genetic resources conservation and reproduction, using modern methods of biotechnology and molecular biology;

Implementation of other measures focused on the use of forest genetic resources in the Ore Mountains as part of sustainable forest management, in order to allow (support) adaptation of forest trees and forest management on an ongoing (climatic) changes in the environment.

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Acknowledgement:

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KŮROVCOVÉ INFO – new service for forest owners

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The project „Kůrovcové info“ is organized as a service for forest owners and managers in Czechia. The main aim of the project is to collect data on flight activity of selected forest insect pests (*Ips typographus* mainly, but also *Ips duplicatus*, *Pityogenes chalcographus* and cockchafers of the genus *Melolontha*). It is also, at the same time, a platform for study of bionomy of forest insects through the monitoring and on-line sharing information about the flight activity in various altitudes on different locations.

Fig. 1: Example of the project “Kůrovcové info” output in on-line web application for selected location.

Field data are collected from voluntary respondents, forest owners and managers, mostly from state forests (VLS ČR, s.p. (the main project partner, Lesy ČR, s.p. (project partner), national parks KRNAP and NPŠ) and many private, ecclesiastic and municipal forests. Each respondent operates one or more monitoring plots. On each monitoring plot is one or more pheromone traps located. Data on number of caught insects are collected weekly (7-10 days period) via on-line application. Results are evaluated monthly and published on www.kurovcoveinfo.cz, enabling observation of actual development in flight activity of selected insects. Resutls are shown on maps and graphs from particular regions and locations.

The project is organized and coordinated in collaboration of Lesnická práce and Forest protection service (FGMRI) since May 2016 under the auspices of minister of agriculture.

Monitoring systems – important tools for specification actual situations, forecast of insect pests outbreaks with estimating of possible damages, basis for consultation private forest owner und initiation of pest management

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The forest protection monitoring system in Saxony consists of two parts. Part one: observe all forests (state, privat, corporate, church) and recording damages (abiotic and biotic), special activities from insects (swarming flight) and diseases; part two: monitor dangerous species (*Lymantria monacha*, *Dendrolimus pini*, *Ips typograhus*, mice and other) in endangered areas with special monitoring methods (pheromon trap, soil search and other).

We collect all data (for example in 2017: 84 spruce stands with pheromone trap systems (3-6 traps) to catch *I. typographus* and *P. chalcographus*, 240 pine and spruce stands with pheromone traps *for L. monacha*, 400 pine stands with soil search to overwintering stages of phytophag insects in pine stands. In state forests we organize on basis of this data necessary activities. In private and corporate forests, this is the task of the Lower authorities for forest in administrative districts.

As a research institute we develop the monitoring and control methods. This include the development of new methods, qualify old methods and their introduction in practice. The monitoring dataset is also a base for develop and validate models. For example: determine risk areas or forecast development steps of insects. In this field we work together with other forest research institutes in Germany.

Together with Forest Research Institute Baden-Württemberg (FVA-BW), and Hamburg University (UHH) we work on the project IpsPro. Aim of the project is the assessment of the acute risk for a spruce bark beetle infestation of potentially vulnerable spruce stands, with a high temporal and spatial resolution. We will analyze historical data and remote sensing. In this summer we carried out an investigation for using UAV (unmanned arial vehicle) detecting hot spots of infested spruce. This was a cooperation with the forest research institute in Thuringia and a Austria company.

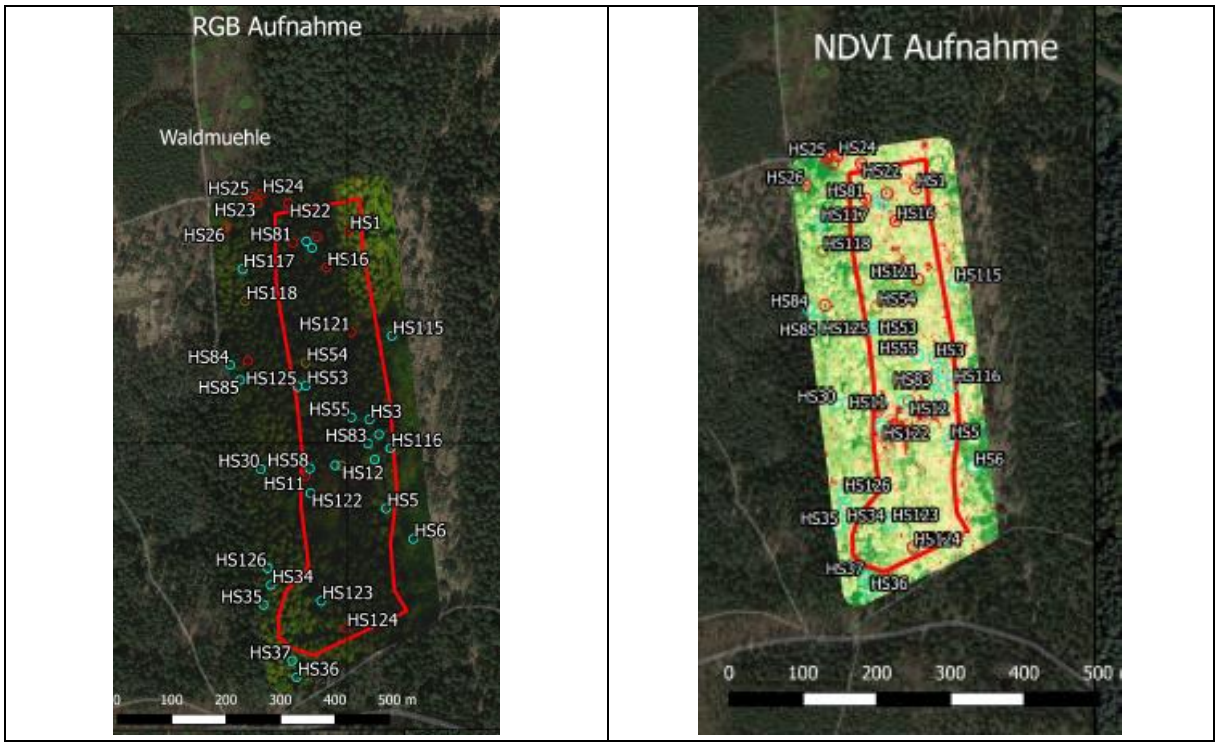

Fig.1: Composition pictures of the same experimental plot with marked trees with the assumed attack

Gemmamyces piceae – occurence on *Picea abies* in the Ore Mountains

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Spruce bud blight (*Gemmamyces piceae* (Borthw.) Casagr.) represents serious fytopathological problem in the Ore Mountains. This ascomycete infects buds, which subsequently die or deform when attempting to growth. When the infection is strong and repeated, assimilation apparatus of trees is no longer recovered. Infection caused by this fungus has been being recorded since 2009 in stands with blue spruce (*Picea pungens* Engelm.), which were planted in 70´s and 80´s in deforested areas due to air pollution. In case of Norway spruce (*Picea abies* (L.) Karst.), *Gemmamyces piceae* was recorded in 2009-2013 only on few trees, where individual buds were affected. However, in 2014-2015 number of trees with a higher proportion of affected buds noticeably increased. Since 2016, research project focused on spreading of *Gemmamyces piceae* on *Picea abies* in the Ore Mountains has been being solved by research team from Czech University of Life Sciences Prague and Forestry and Game Management Research Institute and it is supported by Grant agency of Forests of the Czech Republic. As part of the project, permanent research plots in the whole Ore Mountains are being established for long-term evaluation of *Gemmamyces piceae* on *Picea abies* in this year. Ecological factors (stand, climatic, geomorphological etc.) influencing the fungus development and differences in spruce physiology between infected and non-infected spruces will be determined on the plots.

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Acknowledgement:

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

Updating legacy peat information of the forest site survey in the Ore Mountains (state owned forest)

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25 per cent of Saxon forest sites are hydromorphic. Operational site survey has been done several decades ago. At the same time these sites are more or less heavily influenced by (anthropogenic) environmental change. Silvicultural measures directly on or close to peat sites (on wet mineral sites with thinner organic layers) aim mostly on the amelioration or renovation of protective functions (Saxon Forest Strategy 2050). But the informational background to streamline these management activities often is inadequate

A freelance contractor will carry out hydro-morphological analysis of peat or “mineral wet” sites based on a DTM with 2 meter resolution. The resulting “ecotope projection”, used i. e. for rewetting of peat sites, will be encompassed and validated by actual site survey.

In the long run we aim to generate reliable ecotope projections in order to update and validate of the so-called SIMON-search area for peat sites developed by the Saxon environmental agency.

This project is part of a bundle of projects carried out to improve peat management.

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Verification of Red deer population density in the west part of the Ore Mts.

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The European territory has undergone significant changes in the last decades in forming and use of landscape. The major reasons of this shift are mostly changes in agricultural management. These changes in combination with other factors have caused increase of large ungulate population. The red deer (*Cervus elaphus*) has been one of the species which grew in numbers. Increasing population density of red deer is documented on hunting bags across the states located in Middle Europe, the real population density is probably higher. Changes in population dynamics has significantly negative impact on agricultural, and also on forestry management. The results of increasing red deer numbers are higher damages on young forest stands, especially problematics are damages caused by browsing and bark stripping.

On this changes is supposed to react game management and for responsible management of red deer populations is necessary to establish numbers of that game species in given hunting district.

The aim of this contribution was to estimate red deer density in two selected hunting district Blatenský Vrch (BV – 4449 ha) and Zlatý Kopec (ZK – 1613 ha) which are located in the west side of Ore Mts. For the verification of deer numbers were used two different methods, the method of counting fecal pellets (Mayle et al. 1999) and the backward calculations from the hunted red deer in selected area. Results were then compared with spring counted individuals (JKS), this counts are a basic data for hunting plans in hunting districts. Statistical evaluation of differences of game numbers gathered by pellet group counting method in the years 2015 and 2016 was conducted with the software Statistica, version 12 (StatSoft, Tulsa) using Kruskal-Wallis test. Comparison of game numbers established by fecal pellet group counting with numbers gathered by backward counting method and JKS was processed using Analysis of Variance.

Average number of red deer in the Blatenský Vrch hunting district established by the pellet group counting method were 9.6 indd per 100 ha (± 7.6; min 0; max 31.8) in 2015 and 9.7 indd per 100 ha (± 4.8; min 1.8; max 17.8) in 2016. The average number of red deer in the Zlatý Kopec hunting district were assessed to be 7.8 indd per 100 ha (± 2.9; min 4.4; max 11.4) in 2015 and 6.1 indd per 100 ha (± 5.3; min 2.2; max 15.2) in 2016. Comparison with backward counting and JKS can be found in **Fig. 1.**, figure shows summary average numbers determined in years 2015 and 2016 for whole area of two hunting districts.

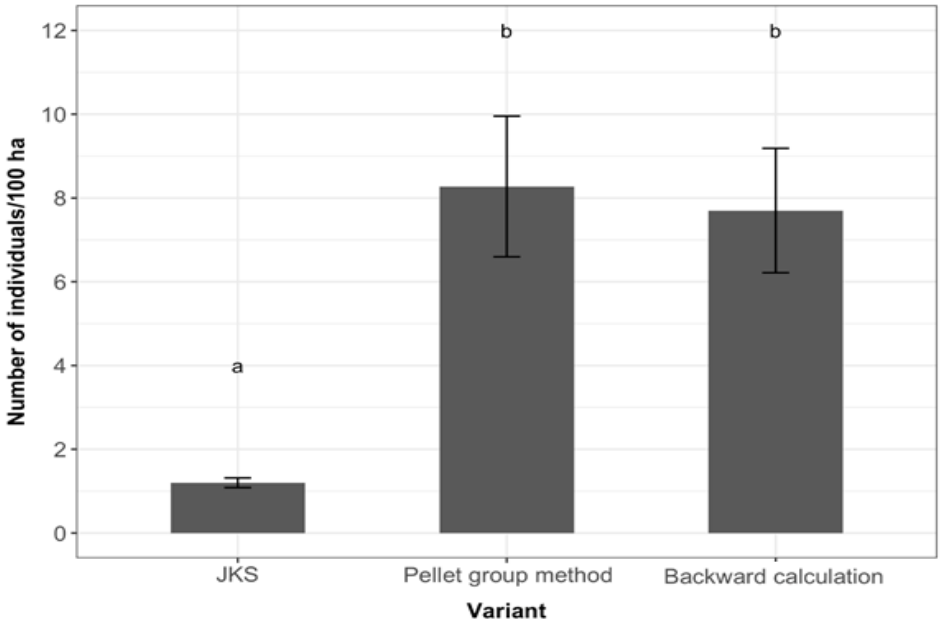

Fig. 1: Average number of red deer individuals determined by different methods in 2015 and 2016.

Similar assessment of deer numbers were conducted in two other places in the Ore Mts., in hunting districts Jelení hora and Černý potok, about 15 km from our area of interest. Comparable method was used to count pellet groups on established transects and the number of red deer in Jelení hora was assessed at 24 ± 23 indd per 100 ha, and 8 ± 5 indd per 100 ha in Černý potok (Vala, Ernst 2011). The resulting numbers in the given area are generally comparable with our results. The risk of significant damage to forests with typical negative effects of red deer is established to be lower with deer density up to 5 indd per hectare (Mayle et al. 1999). Assessed numbers give general idea about real quantity of red deer in the area. This data should be used as a base for planning of hunting management. Even though only two hunting districts (altogether 6062 ha) were monitored, it is important to state that gathered data characterize much larger area based on home range and migration of red deer.

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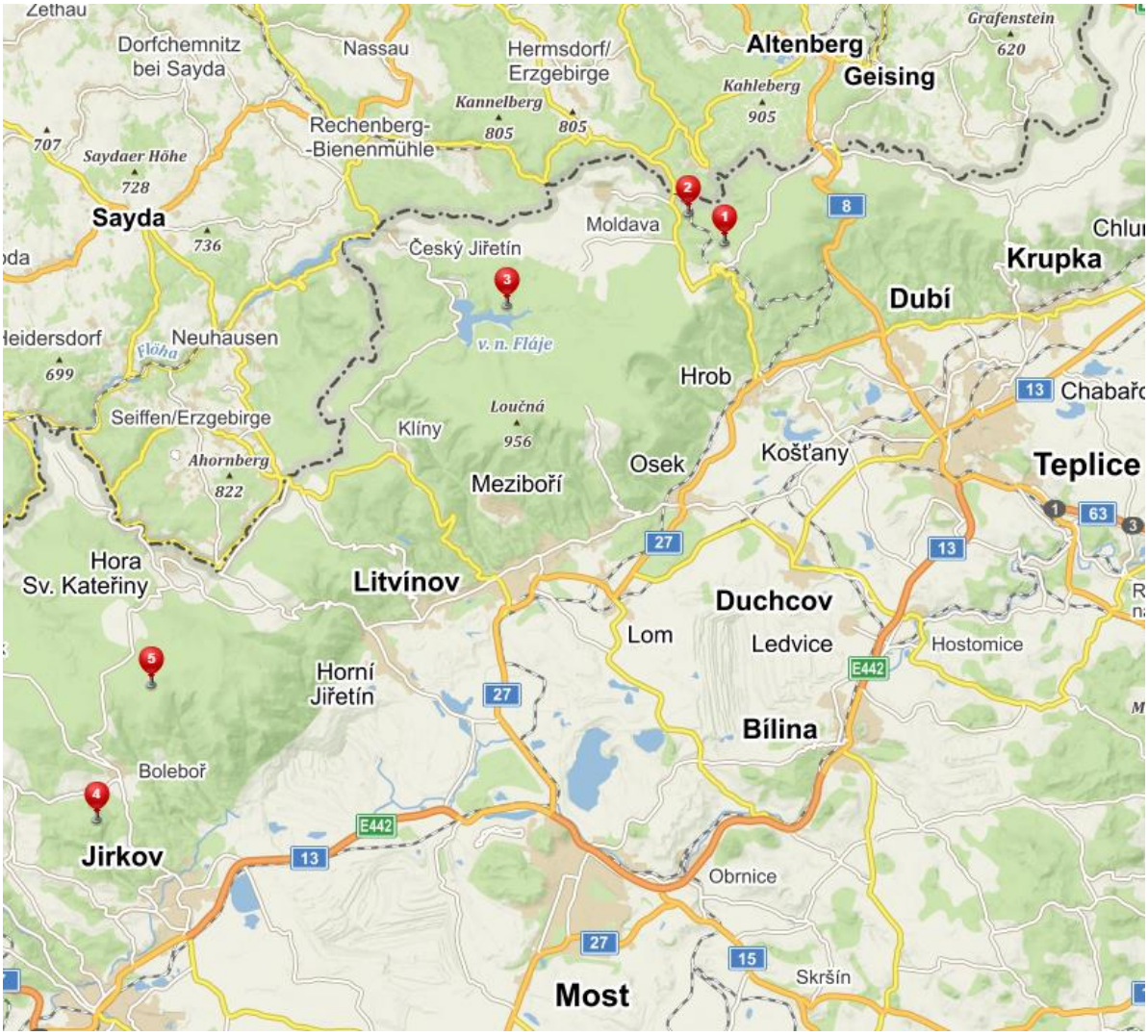
EXCURSION GUIDE



Stops:

1 – *Gemmamyces piceae* on Norway spruce

2 – Long term deposition measurement on Moldava

3 – Conversion of “substitutional” forest stands at Fláje

4 – Mountain elm seed orchard Orasín

5 – Lunch in the Mountain Hotel Lesná

Stop 1: *Gemmamyces piceae* on Norway spruce

Gemmamyces piceae is an important fungal pathogen infecting coniferous trees, especially spruces, less often firs. It mainly occurs in areas with high precipitations and permanent high humidity. Infection of host tree occurs during growing season. The buds of the infected trees looks swollen and they are often spirally twisted and deformed. If the terminal bud dies, growth of the lateral buds is stimulated resulting in a changes in shoot growth. Less infected shoots attempting to growth often show growth deformations. Dead buds are covered with a tough crust (basal stroma), from which grey-brown or black globular fruiting bodies with a diameter up to 1 mm grow.

Fig. 1: Norway spruce (Picea abies) infected by Gemmamyces piceae (author of the photo: Roman Modlinger)

Stop 2: Long term deposition measurement on Moldava

Moldava plot is situated in the Ore Mts., the area of historically high air pollution. Since the second half of the 1970´s deposition is measured in open area (bulk) and in the spruce stand – throughfall. After the stand was felled in 1980, deposition has been measured in the regenerating transitory stand of mountain ash, which is currently reconstructed to the stand with Norway spruce with European beech admixture. Also soil water chemistry and runoff water are monitored. In 1977, 1980, 1988, 1994 and 2003 the chemical properties of the soil and humus horizon were analysed. The results confirm general decrease of deposition in the 1990s, reflected also in gradual increase of the soil pH and soil solution. However, in the transitory stand of mountain ash the amount of available basic cations is still decreasing. In the clearcut the content of available K and Mg increased, Ca content decreased. The difference between deposition and the loss in runoff water show a negative balance of Ca, Mg, but N and SO_4^{2-} as well. Cation content in humus and soil depends, under current litterfall level, on their pool in primary minerals and the speed of their release. Under existing condition mainly soil calcium content seems to be critical for the stand growth in the future.

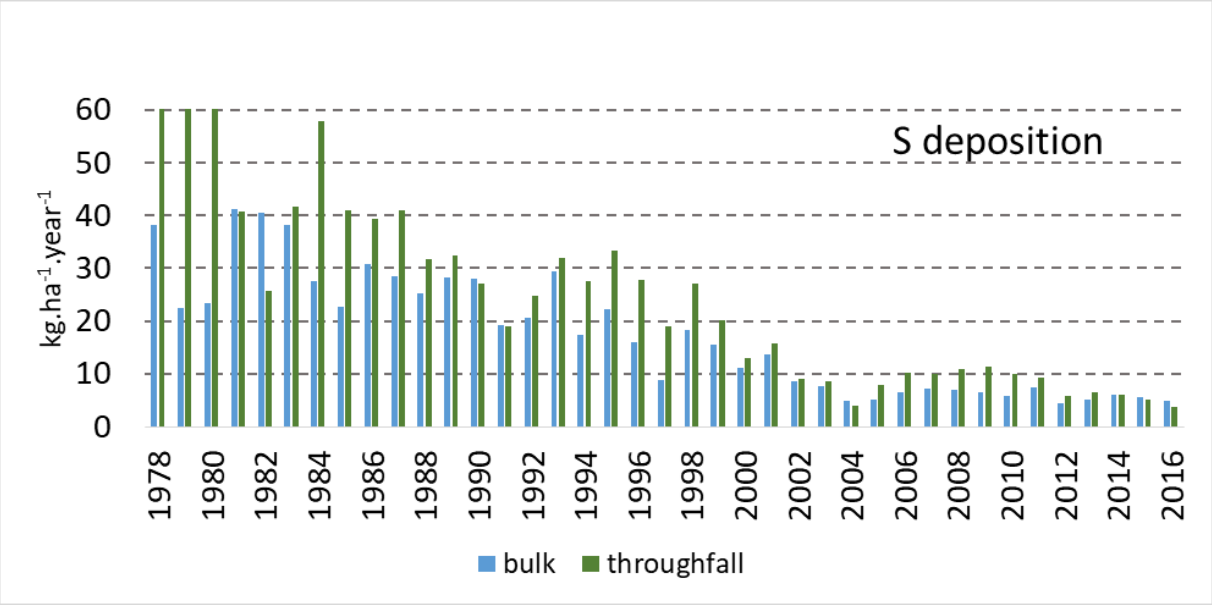


Fig. 1: Sulphur deposition on the plot Moldava. S deposition in the mature Norway spruce stand was following: 1978 – 104 kg.ha^{-1}.year^{-1}; 1979 – 190 kg.ha^{-1}.year^{-1}; 1980 – 101 kg.ha^{-1}.year^{-1}; than the dying forest stand was cut down.

Stop 3: Conversion of “substitutional” forest stands at Fláje

Research plot Fláje located in Ore Mts. is situated on south slope in the altitude of 800 m a.s.l. Site conditions correspond to spruce with beech forest vegetation zone (Fageto-Piceetum acidophilum – Calamagrostis villosa) on cambic ranker. Stand was established by plantation of blue spruce and sowing of birch on immision clearcut in 1981. Admixed rowan regenerated naturally. Stand was fenced in 1989 for thinning experiment (control and thinning plots with various management – NOVÁK, SLODIČÁK 2006), part of the fenced stand was left without management for future stand conversion.

Conversion I

Stand conversion on this plot started by sanitary thinning of the stand and formation of two gaps for plantations (area 100 m2 each) in 1997. Next management in the stand was realised by removing of dead and heavily damaged trees. Twelve homogenous plots (area 100 m2 each) were defined, biometric measurement of trees (diameter, height, crown dimensions) and health status were measured repeatedly in 1997, 2002 and 2007. Removal of nurse stand was realised by application of RoundUp on damaged basal stem part in 2011, most birches and rowans died shortly after application or next year. Dying of blue spruce was slower, some trees survive up to present.

Containerized beech, fir and sycamore were planted under nurse stand and in gaps. Damages by rodents (over 20 %) brought about the necessity of repeated plantations (1998-2000). Biometric measurement and evaluation of plantations damage were done annually.

Main stand on the plot for conversion was formed by mixture of birch, blue spruce and rowan. Birch and partly rowan formed the upper storey, blue spruce dominated in the understorey. High initial number of trees (4410 pcs/ha at the age 16 years) was affected mainly by rowan sprouts. Initial basal area on conversion plot was 12.5 m2/ha, stand density and tree dimensions were comparable with the neighbouring control plot (NOVÁK, SLODIČÁK 2006). Number of trees decreased by thinning on 2633 pcs/ha, basal area was 8.3 m2/ha (tab. 1). Mainly thinning from below removing suppressed birch and rowan in understorey was used. Upper stand height was over 9 m in year 1997, mean height of suppressed blue spruce was only 2.8 m. Mean diameter of birch was 7.3 cm, rowan and blue spruce were thinner (tab. 2).

Tab. 1: Development of basic stand characteristics (mean+Sx in parenthesis)

Year	N (pcs/ha)				BA (m^2/ha)			
	Birch	Blue Spruce	Rowan	Σ	Birch	Blue Spruce	Rowan	Σ
1997	1567 (456)	733 (215)	333 (302)	2633 (431)	6.9 (1.8)	1.1 (0.6)	0.4 (0.3)	8.3 (1.7)
2002	1375 (420)	683 (208)	300 (250)	2358 (378)	8.7 (2.5)	1.7 (0.9)	0.8 (0.6)	11.1 (2.4)
2007	933 (274)	592 (173)	267 (194)	1792 (315)	8.8 (2.7)	3.9 (1.8)	1.1 (0.8)	13.8 (2.6)
2011	573 (218)	362 (147)	160 (154)	1095 (274)	7.7 (2.9)	3.3 (2.1)	1.0 (1.2)	12.1 (2.8)

Tab. 2: Mean diameter (cm) and diameter increment (cm) of species (Sx in parenthesis)

	Mean diameter (cm)			Mean diameter increment (cm/year)			
Year	Birch	Blue spruce	Rowan	Period	Birch	Blue spruce	Rowan
1997	7.3 (1.8)	3.9 (1.9)	3.2 (1.4)	1997-2002	0.24 (0.19)	0.30 (0.15)	0.31 (0.18)
2002	8.7 (2.1)	5.3 (2.1)	4.8 (2.0)	2003-2007	0.34 (0.22)	0.66 (0.16)	0.41 (0.18)
2007	10.6 (2.7)	8.8 (2.4)	7.0 (2.5)	2007-2011	0.45 (0.25)	0.43 (0.18)	0.38 (0.22)
2011	13.1 (2.9)	10.8 (2.7)	9.1 (2.9)				

During next 14 years mortality gradually decreased number of trees on 42%, dead and heavily damaged trees were continuously cut. Slow stand opening improved the growing conditions for originally suppressed trees; mainly blue spruces with good vitality gradually increased their diameter and height growth (at least 20 years growing under the birch stand - tab. 2). Basal area decreased in the last period.

Health development of the stand was negatively affected by climatic conditions and genetic origin of species (birch, blue spruce). Higher mortality of birch started in 1994 and gradually increased. Stand development was also unfavourably affected by icing in winter 1995/1996 (crown breakage), severe temperature changes in spring 1997 and dry year 2003. Most of trees have been damaged by frost at the stem basal part (frost split).Comparable damage and development showed most stands in the whole region (ŠRÁMEK ET AL. 2001).

Plantations were damaged by rodents for first 2-3 years, most individual reduced their height growth after plantation. Mean height of fir was over 160 cm in the year 2007 (9 years after plantation). Fir keeps comparable height growth and health conditions under the stand and in the gap border. Beeches had mean height 230 cm in the year 2007, there were no significant differences in beech height growth in various conditions (gap, border, underplanting). Sycamore in gaps grew better than under the nurse stand (285 cm vs. 175 cm in year 2007). After chemical cutting of nurse stand (2011) differences among variants decreased.

Conversion II

Mixed birch-blue spruce stand was divided into 2 parts and thinned in 2004 (sparse birch part and denser one with birch and blue spruce stand), both plots were underplanted with beech and sycamore. Part of underplantings were protected by plastic belt (green belts with height 1.2 m), part were without protection. Plastic belts should improve microclimatic conditions for plantations and protect against damage (weed, rodents). Plastic belts were removed in 2012.

Birch plot was sparser than plot with blue spruce (N 735 pcs/ha compared with 1050 pcs/ha, BA 7.9/10.1 m2/ha). Next stand development was negatively affected by climatic conditions (crown breakage, frost split), vitality of blue spruce affected long term damage by Gemmamyces piceae. Until the year 2015 number of trees on birch stand decreased (619 pcs/ha) and BA (8.7 m2/ha), similar development was on plot with blue spruce (N 903 pcs/ha, BA 11.2 m2/ha).

Beech underplantings had only minimal height increment first years after plantations, influence of protective belts was minimal. Significant differences in height growth were confirmed 5 years after plantation, beeches growing without protective belts were higher. There were no differences in height growth on both plots (birch and blue spruce nurse stand). Sycamore growing in protective belts had initially better height growth compared to plantations without belts, plantations in belts under blue spruce gradually decreased their height growth (worse light conditions under denser stand?). Occurrence of protective belts on both species accelerates the spring phenology of both species (earlier breaking of bud), differences balanced during development of leaves.

Beech and sycamore growing originally in protective belts have still lower stability compared to variants without belts (4 years after removement), the lowest stability have beeches from belts under blue spruce stand. Utilisation of this kind of protective green belts in denser stand parts was not suitable for this conditions.

The height development of both species does not indicate the need of radical release, most trees gradually grow into crown space of nurse tree species. The risk of beech and sycamore damage by cutting of nurse stand is relatively high, nurse stand should be leaved to natural gradual breakdown.

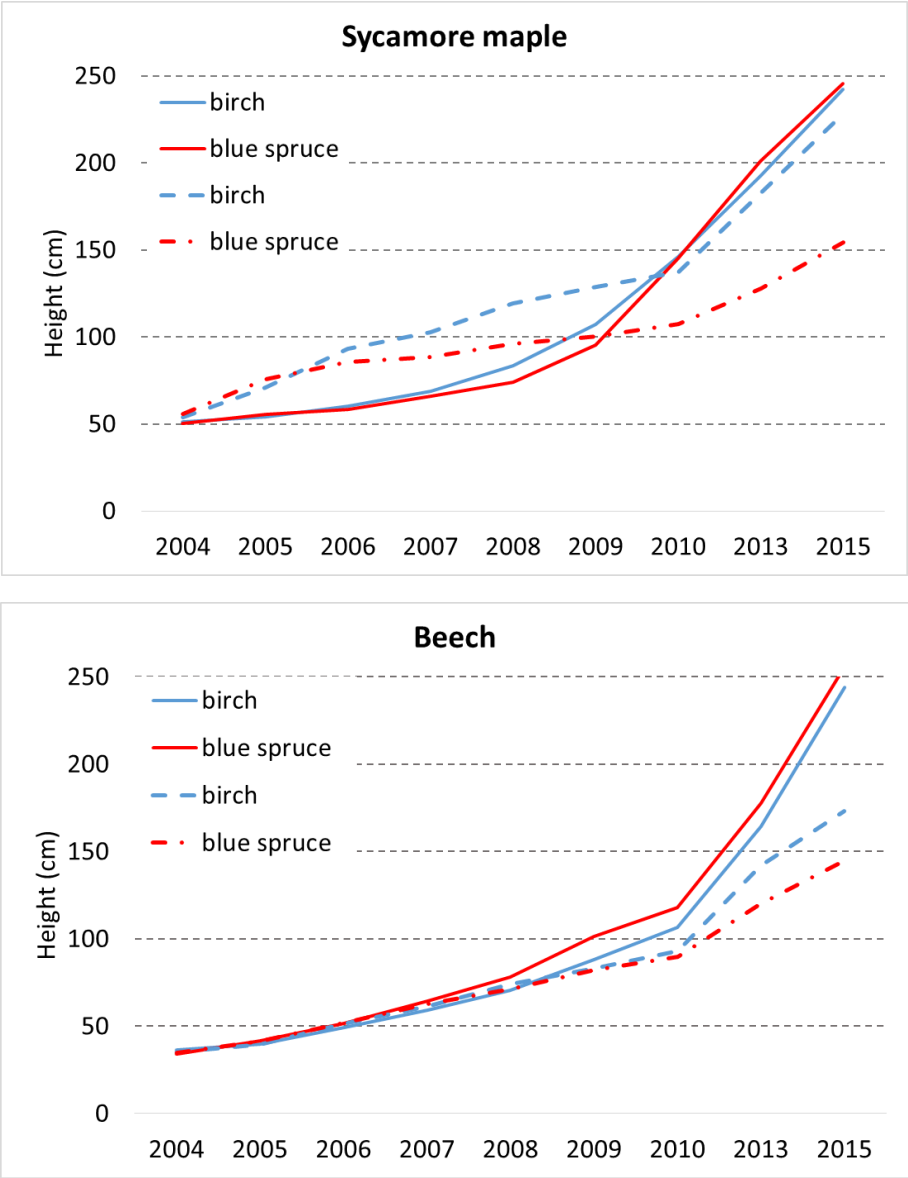


Fig. 1: Height development of beech and sycamore under beech and blue spruce stand (dashed lines illustrate development in protective belts)

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Stop 4: seed orchard for mountain elm (*Ulmus glabra*), FE Litvínov, locality Orasín

The seed orchard for mountain elm (Ulmus glabra) was established in the spring of 1999, on the todays forest enterprise (FE) Litvínov (formerly FE Janov, Červený Hrádek), in the locality Telč southwest of the village Orasín on the area of 1.27 hectare hedgerow seeds. Reproduction material was collected in the ore Mountains within FE Litvínov (district Brandov, Lom district, locality Šumný důl and Načetínský potok) and FE Klášterec nad Ohří (locality Jelení hora) from high quality healthy trees suitable for reproduction. They were last healthy remains of these elm populations in the Ore Mountains surviving in extreme mountain climatic conditions in the 6th to 7th forest vegetation zone, moreover on sites with an earlier high degree of air pollution. Despite the mortality of several individuals in recent years, the trees in seed orchard are in good condition, produce regularly and provide enough seed material for the needs of the all Ore Mountains.

Fig. 1: Seed orchard for mountain elm (Ulmus glabra) in 1999 (Photo: V. Buriánek)

Fig. 2: Seed orchard for mountain elm (Ulmus glabra) in 2017 (Photo: V. Buriánek)