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Summary of the Ph.D. thesis

**Ecology of bog pine (*Pinus rotundata* LINK)
in relation to regeneration of bog pine forests**

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Photo by Petr Horn 2006

supervisor: **Prof. RNDr. Karel Prach, CSc.**

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Introduction

Central European ombrotrophic bogs and poor fens with bog pines are unique ecosystems, having persisted continuously in the same sites and approximately at the same extent since the early Holocene (Neuhäusl 1972, Jankovská 1980, Mikkola & Spitzer 1983, Steiner 1992, Svobodová et al. 2002). Continuity and stability at these timescales is unique among Central European ecosystems. Pine bogs can be considered as long existing habitat islands (Spitzer 1994), offering opportunities for micro-speciation and relictiness, but being vulnerable to external disturbances. Their extrazonal character, occurring outside the main zone of peatlands in north and north-east Europe, makes the Central European peat bogs of interest in a wide biogeographical context (Dierssen 1996, Dierssen & Dierssen 2001).

The Central European pine bogs possess an endemic species, *Pinus rotundata* LINK., and its hybridogenic cline with *P. mugo* TURRA. *Pinus rotundata* occurs in a small geographical range which includes parts of Germany, Austria, Poland and the Czech Republic (Jalas & Suominen 1973) with the centre of distribution in the southwestern part of the Czech Republic. The typical tree-shaped *P. rotundata* occurs in submontaneous bogs only. Towards higher altitudes, it forms introgressive hybrids with *P. mugo* and the shape changes to shrub-like (Skalický 1988, Businský 1998).

P. rotundata dominated peat bogs are nowadays endangered especially by disturbed water regime (drainage) and probably also by atmospheric deposition. There is a clear decline in *P. rotundata* during the last 30 years, in spite of recent protection of its natural stands. The decline usually starts with massive dieback of old trees (Rektoris et al. 1997, Sengbusch & Bogenrieder 2001, Boratyńska et al. 2003, Freléchoux et al. 2004).

Aims of the study

This study was undertaken to find the ecological requirements of *P. rotundata* (especially of seedlings) in comparison to the other co-occurring tree species and recommend changes in the management of protected areas to reinforce *P. rotundata* populations.

Possibilities of regeneration of differently disturbed pine bog vegetation were also studied. Natural disturbances and human-made ones were compared.

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Contents

The thesis is composed of six original studies:

Early development of *Pinus rotundata*, *P. sylvestris* and *Picea abies* - growth responses to abiotic factors in controlled experiments and consequences for bog pine forest restoration

Marek BASTL

FOREST ECOLOGY AND MANAGEMENT, submitted

The aim of the study was to find the ecological requirements of tree seedlings involved in bog pine forest dynamics. Requirements of bog pine (*Pinus rotundata*), in comparison to the co-occurring tree species Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), were studied in relation to groundwater, light and nutrient conditions. The first one-year garden experiment (3 shading, 3 groundwater and 3 nutrient levels) showed the best growth (highest biomass) for *P. rotundata* in the no shading, low water, and high nutrient treatment, followed by *P. sylvestris* and *P. abies*. The second two-year garden experiment (7 water levels) showed the highest biomass for *P. rotundata*, followed by *P. × digenea* (*P. rotundata* × *P. sylvestris*), *P. sylvestris* and *P. abies*. The relative differences in studied species growth show a clear trend of decreasing towards lower water levels. The height growth of *P. rotundata* was the best at all levels of water. But differences between *P. rotundata* and *P. sylvestris* height growth decreased towards lower water levels when high and low water treatments were compared. The experiment showed that a high groundwater table level would probably favour seedlings of *P. rotundata* compared to *P. sylvestris* and *P. abies*. Therefore, a "no action" management plan for *P. rotundata*-dominated peat bogs appears not to be suitable for preserving this species in such habitats in which the water regime has been disturbed (mainly by drainage). Cautious rising of the groundwater table, after damming drainage ditches, may partly suppress *P. abies* establishment and support seedling recruitment of *P. rotundata*.

Vegetation changes following different disturbances in peat bogs with *Pinus rotundata* in the Třeboň Basin, Czech Republic

Marek BASTL, Taňa ŠTECHOVÁ & Karel PRACH

PRESLIA, submitted

Various stages of plant succession were studied in peat bogs in the Třeboň Basin of the Czech Republic, after different disturbances. Two main types of disturbance occurred: (a) natural, represented by windthrow, with subsequent bark beetle attack and fire, and (b) human-made, such as peat digging and industrial peat harvesting. Species composition of successional stages after the above mentioned disturbances were compared to that of undisturbed plots. Regeneration of peat bog vegetation was faster after natural disturbances than after human-made ones. The lowest impact was caused by windthrow, followed by fire.

Regeneration after peat digging was also possible, but it took much longer. Regeneration after industrial peat harvesting was possible only if the groundwater table level remained high.

Central European pine bogs changing along an altitudinal gradient

Marek BASTL, Marek BURIAN, Jan KUČERA, Karel PRACH, Ladislav REKTORIS & Milan ŠTECH

PRESLIA, acceptable after revision, revised and resubmitted

Vegetation analyses (phytosociological relevés) were performed in 20 peat bogs arranged along an altitudinal gradient in the southern part of the Czech Republic, Central Europe, to find relationships between vegetation and environmental gradients. Six of the peat bogs were investigated in detail. The bogs are dominated by *Pinus rotundata*, a species endemic to central Europe, and its hybridogenic populations with *P. mugo* (the hybrid is called *P. × pseudopumilio*), with increasing proportions of the latter towards higher altitudes. Data were processed by the methods of indirect (DCA) and direct (CCA) gradient analyses. Environmental variables (depth to the water table, mean and minimum temperatures, precipitation, pH, conductivity, NH_4 and PO_4 concentrations, total P, but not total N nor NO_3 concentration), as well as biotic characteristics of the sites, such as species composition, and growth form of the dominant pines, were closely correlated with the altitudinal gradient. Woody species, herbs and bryophytes, responded clearly to the altitudinal gradient and the trends were in principal the same. Results also indicate the uniqueness of each particular bog.

Disturbances on a wooded raised bog – how windthrow, bark beetle and fire affect vegetation and soil water quality?

Andrea KUČEROVÁ, Ladislav REKTORIS, Táňa ŠTECHOVÁ & Marek BASTL

FOLIA GEOBOTANICA 43, in press

A *Pinus rotundata*-dominated peatbog (Žofinka Nature Reserve) in the Třeboň Basin, Czech Republic, was affected by 'natural' disturbances: wind damage (in 1984), followed by a bark beetle attack, and fire (1994; 2000). Phytosociological relevés were used to document vegetation. Soil water chemistry was compared in three differently affected stands: (i) an undisturbed *Pinus rotundata* bog forest, (ii) a windthrow–bark beetle affected stand and (iii) a site burned by wildfire in 2000.

The species composition of the windthrow–bark beetle affected sites and the undisturbed *P. rotundata* bog forest differed mainly in the shrub and tree layers. Burned sites were partly colonized by anemochorous species (e.g. *Taraxacum* sp. div.) that disappeared within two or three years after colonization. Bare peat was colonized by bryophytes (e.g. *Marchantia polymorpha* and *Funaria hygrometrica*) typical of the disturbed sites, and by *Polytrichum* sp. div. and *Aulacomnium palustre*. Most plant species characteristic of the *P. rotundata* bog forest occurred at the burned sites eight years after the fire, but in different abundances. The

edificator of the former community – *P. rotundata* – was mostly absent. Compared with windthrow followed by the bark beetle attack, fire promoted rapid expansion of *Molinia caerulea*.

Soil water in both the undisturbed *P. rotundata* bog forest and the windthrow–bark beetle affected sites had a similar composition: very low pH values, high P concentrations, low concentrations of cations (Ca^{2+} , Mg^{2+} and K^+) and inorganic nitrogen. The concentrations of soluble reactive phosphorus (SRP) and NH_4^+ -N were negatively correlated with the groundwater table.

Total P, SRP and NH_4^+ -N concentrations in the soil water at the burned site were by one order of magnitude higher than those in the *P. rotundata* bog forest, while concentrations of K^+ , Mg^{2+} and Ca^{2+} were only about two times higher. High concentrations of P and N in the soil water found three years after the fire indicated a long-term elevated nutrient content in the soil water.

Mire vegetation gradient established by interaction with water reservoir

Petr HORN & Marek BASTL

BOTANY (formerly CANADIAN JOURNAL OF BOTANY), accepted

The peatbog complex Kyselovský les in the Czech Republic was flooded on 85% of its original area by water of the Lipno reservoir in 1958. A new vegetation pattern has spontaneously developed in the newly established shoreline and replaced the original peatbog vegetation dominated by bog pine (*Pinus rotundata* Link) forest. This vegetation pattern consists of zonal strips with relatively sharp borders. This zonation is a mosaic of sedge fens, reed canary grass (*Phalaris arundinacea* L.) beds, tussock cottongrass (*Eriophorum vaginatum* L.) stands and a community dominated by ericaceous shrubs. The study focused on the vegetation development of this zonal vegetation. Measurements of water table level, groundwater pH and conductivity, together with terrain microtopography, were done in order to estimate the ways how the water reservoir influences the mire vegetation. The most important factor is lake water fluctuation, which explained most of the vegetation gradient variability. Lake water fluctuations were represented by lake water levels, which directly flooded a certain part of the gradient from 1990 to 2006 for an exactly known number of days.

Successional changes of vegetation at the "Multerberské rašeliniště" peat bog during the last 50 years, the Šumava Mts.

Petr HORN & Marek BASTL

PŘÍRODA 17: 109-118

Vegetation changes at the "Multerberské rašeliniště" peat bog during the last 50 years were studied using a comparison of two black and white aerial photographs from 1949 and 1996. Massive successional changes leading from the original open peat bog vegetation to dense

Picea abies forest were observed at the site. In the same time influence of a deep drainage to the hydrology of peat bog was studied along a transect. Dam was built in a draining ditch after the monitoring of a groundwater table level during 1996–1997 to study the potential success of amelioration of the site.

Conclusion

Species composition of the peat bogs and the growth form of the dominant pines, i.e. the transition from the tree-shape *P. rotundata* into the shrubby form (*P. × pseudopumilio*) as a result of hybridization, closely reflect the altitudinal gradient. The results also indicate a specificity of even closely located bogs.

The study showed that a high groundwater table would probably favour seedlings of *P. rotundata* compared to *P. sylvestris* and *P. abies*. Therefore, a "no intervention" management plan for *P. rotundata*-dominated peat bogs appears not to be suitable for preserving this species in habitats where the water regime has been disturbed (mainly by drainage). Cautious rising of the groundwater table, after damming the drainage ditches, may partly suppress *P. abies* establishment and support seedling recruitment of *P. rotundata* due to lowered competition by *P. abies* and *P. sylvestris*. Long term inadequate rising or repeated flooding of localities by mineral water could lead to *P. rotundata* extinction and drastic changes of former vegetation.

The results clearly demonstrate that the impact of natural disturbances, i.e. fire, wind and herbivorous insect outbreaks, on pine bog vegetation is only temporary and not very severe in comparison to anthropogenic disturbances. Regeneration of the typical bog pine community is rather fast even after an apparently severe disturbance such as a nearly complete burning.

Curriculum vitae

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Publications:

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