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FOREST DECLINE IN THE SLEZSKE BESKYDY MTS.

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Abstract

The total forest area in the Czech part of the Slezske Beskydy Mts. is 196,894 ha. Forest decline appeared on ca 32 thousand ha of forest land. Climatic studies confirmed the changes of precipitation amounts and its pattern as well as the change of temperature and sunshine in the period 1961–2006 in comparison with long-term average values in 1901–1950 and with calculated standard of 1961–1990. It is apparent that cultivation of Norway spruce in this region in previous extent will be impossible in future. The study brings more detailed information about this ecological catastrophe and the main principles of the new forestry concept in the Slezske Beskydy Mts. which consists in the differentiated change of species composition, adequate thinning regime, more natural continuous cover forestry supporting water management in the forest stands and fertility of forest soils.

Key words: forest decline, Norway spruce, climate change, forest soils, silviculture.

Introduction

The Slezske Beskydy Mts. is the region which lies across the border between Slovakia, Poland and The Czech Republic (Fig. 1). The total forest area in this region is 196,894 ha and there are 76% of coniferous and 24% of broadleaved trees in the frame of the Czech part. Norway spruce stands, which were established in the last century, grew relatively well in the last decades. But forest decline (drying, yellowing) has been observing here several last years on 24% of forest land, i.e. on ca 32 thousand ha. Massive dying is observed now in spruce stands cultivated in oak-beech and beech vegetation zones (elevation 400–600 m, mean temperature 6.0–7.5°C, precipitation 650–800 mm), i.e. in the zones where spruce is not the original species, at least not in monocultures.

The main causation of the Norway spruce decline in the Beskydy Mts. is the fact that spruce was cultivated in Beech and Beech with Fir forest vegetation zones, i.e. on localities naturally dominated by broadleaves.

Spruce stands disintegration is caused by a combination of three main influences: (1) serious nutrient disturbances consisting in nutrient exhaustion of upper soil horizons and minimal base saturation, (2) gradual change of climatic conditions and (3) massive occurrence of fungi (*Armillaria ostoyae*) and bark beetles (*Ips typographus, Ips duplicatus*). It was observed that affected trees change the colour of needles (from yellow to even brown). Only one or two needle year-classes instead of four or five remain. Trees gradually decline and consequently die.

Climatic studies (Bagár 2007) reported the change of precipitation amounts and its pattern as well as the change of temperature and sunshine in the period 1961–2006 in comparison with long-term average values in 1901–1950 and with calculated standard of 1961–1990.

The presented paper summarizes the results of investigation of health conditions and nutrition of forest stands, air pollution in the region and analyzes the biotic harmful factors. On the basis of presented analyses the main silvicultural measures are elaborated as the change of species composition, techniques of stand conversion and thinning.

Health condition, nutrition and air pollution

Health condition of spruce stands continually decreased in the observed period. Rapid change in health condition (up to dying) was found for the stands and individuals with mean defoliation, mainly due to attack by biotic agents (honey fungus and bark beetle). Effect of elevation and forest type on health condition of spruce stands was not observed. On the other hand, younger stands (up to age of 30 years) showed lower defoliation compared to older stands (Fig. 2). But yellowing was detected in the young stands as well.

Despite of the fact that major part of the stands is located on nutrient rich soil category, serious nutrient disturbances were found in some localities. Historical air pollution load is probably main reason of this status. In the spruce and beech stands with mean damage, typical stage of basic nutrients was observed, i.e. higher nutrient exhaustion in

Fig. 1. Location of the Slezske Beskydy Mts.

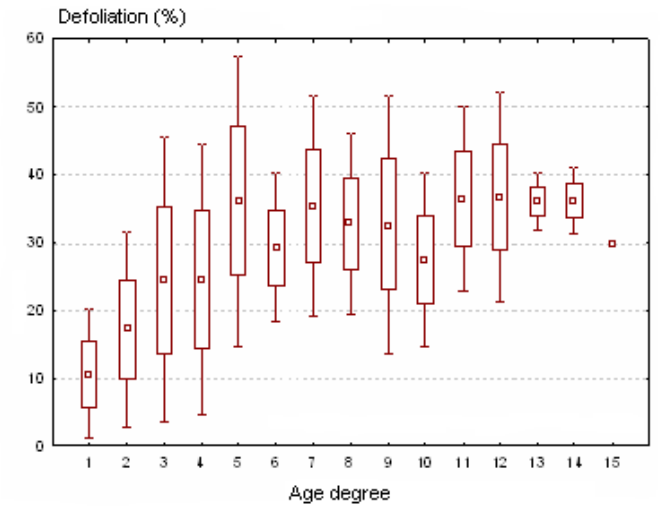

Fig. 2. Defoliation (box plots – mean with standard deviations) by age degrees in the spruce stands (according to Šrámek et al. 2007)

upper soil horizons under spruce stands and in lower soil horizons under beech stands. But in the heavily damaged localities, minimal base saturation was determined in the whole soil profile under both, spruce and beech stands. Principal amount of nutrients remains only in the humus horizons.

Current concentration of SO_2 and NO_x are under limits and these immissions are not risk to health condition of stands. On the other hand, higher concentrations of ozone were detected in the last years, mainly during the summer. But observed values corresponded with results from the other localities in the Czech Republic.

Level of current acid deposition is not critical in the observed area, but this amount is not negligible compared to other localities in the Czech Republic. Additionally, this deposition together with observed status of forest soils can be limiting for spruce stands in the future.

Biotic factors

Main biotic harmful factors (honey fungus and bark beetle) are crucial for current status of spruce stands in the observed area. Chronic course of attack of *Armillaria ostoyae* massively converts into acute phase. It means dying of cambial tissues and quick drying of invaded trees. This trend is supported by repeated dry periods in the last years (see above). Constant increase and spread of bark beetle was observed in spruce stands. Species composition is wider, but main damage is caused by *Ips typographus* and *Ips duplicatus*, partly by *Pityogenes chalcographus* and *Ips amitinus*.

Forestry concept

The main principles of the new forestry concept in the region consist in:

– Differentiated change of species composition.

– More natural continuous cover forestry.

– Adequate thinning regime supporting water management in the forest stands and fertility of forest soils.

The system of silvicultural treatments proposed below is based on information collected in the region by previous stud-

ies. Conclusions can be summarized as follows:

– Mosaic and discontinuous forest decline with relatively low effect of site condition;

– Imbalanced and disrupted nutrition of forest stands (especially low content of Ca and Mg and increased content of Pb and S in humus) and very low values of base saturation;

– Interrelation between health condition and climate, especially adverse effect of drought;

– Low difference in soil conditions in spruce and beech stands;

– Better health status of younger stands.

Species composition

Target tree species composition (TTSC) is composition at the end of rotation optimized from the viewpoint of economy, biology and ability to fulfill all requested forest functions and services with respect of particular natural conditions. For the process of forest conversion, TTSC was proposed in two variants: Basic TTSC and Transient (Ameliorative) TTSC. Basic TTSC proceeds from the present information on spruce decline and increased drought stress on the sites unsuitable for spruce. It can be reached in longer time horizon (1 or 2 rotations). Transient Ameliorative TTSC is based on ability of some mostly broadleaved species to ameliorate the site, to draw the nutrients from deeper horizons and to decrease the acid deposition in throughfall. The main aim of this composition is to ameliorate the site and to prepare it to gradual introduction of Basic TTSC.

In studied area, four unites of forest types prevail. First it is fertile and exposed localities of Beech with Fir forest vegetation zone (FVZ) – *Abieto-Fagetum* with approximately 47 thousand hectares and second it is fertile and exposed localities of Beech FVZ – *Fagetum* together 7.5 thousand hectares. Natural species composition of forest stands on these sites consists of beech, fir, sycamore, elm and in higher elevation with admixture of Norway spruce. The present mostly declining spruce stands must be consequently converted into more stable structured mixed stands (Tab. 1).

The basic strategy for forest conversion is based on following principles:

– To save an admixture of Norway spruce for future natural regeneration in Beech with Fir FVZ.

– To omit Norway spruce in lower Beech FVZ (no chance for its natural regeneration).

– Proportion of beech would not be increased in species composition (it is not the best species from the viewpoint of amelioration and production).

– Proposed species composition should be widened by species as Fir, Wild cherry, Elm, Aspen and Birch and enriched by introduced Douglas fir. These species are efficient from the viewpoint of both amelioration and production.

Techniques of conversion

During the conversion of forest stands it is recommended to utilize the posi-

Table 1. An example of proposed target tree species composition (TTSC) for fertile and exposed sites of Beech with Fir forest vegetation zone (Abieto-Fagetum) in North-Western part of the Beskydy Mts. (digits show the decimal proportion of particular tree species).

Fertile sites of *Abieto-Fagetum*	**Forest tree species composition**													
40,257 ha	NS	EB	SF	La	Li	Ma	O	HB	A	Dg	WCH	Asp	E	BR
Forest plan for spruce dominated sites	6-7	2-1	1-2			0-1				+				
Forest plan for beech dominated sites	0-2	7-5	2-1	+		0-1				+	+	+		+
Natural composition	+	5-7	3-5			+								
Basic TTSC	**1-3**	**2**	**2**	**1-2**	**0-+**	**+-2**			**0-1**	**0-1**	+	+	**0-+**	
Ameliorative TTSC	**0-1**	**1-2**	**2-3**	**0-+**		**1-3**				+	**0-1**	**1**	**0-+**	**0-2**

NS – Norway spruce, EB – European beech, SF – Silver fir, La – Larch, Li – Linden, Ma – Sycamore maple, O – Oak, HB – Hornbeam, A – Ash, Dg – Douglas fir, WCH – Wild cherry, Asp – Aspen, E – Elm, BR – Birch.

tive effect of the present stands, especially ability to soften the climate extremes, to protect the forest soil from erosion, drying out or from increased water table. For this reason, the most common techniques recommended for conversion are interplanting and underplanting.

Interplantig is made in young stands (to the top height ca 4 m) where it is possible to integrate the present stand into the newly created structures. Regeneration elements can have a character of strips or round openings both with shelter or clear cut.

Underplanting is used in older stands and present stand is generally not included into new forest structure. This technique is recommended in open canopy stands. If not, the canopy should be decreased to 40–60%. The optimal area of the regeneration element is c.a. 300–800 m^2 (area not shadowed by crowns). Very important is the planting position. Drip zones of the shelter trees should be avoided.

Thinning

The previous study of the health condition of forest stands in the Beskydy Mts. showed that younger stands (up to age of 40 years) are less defoliated compared to older stands (see Fig. 2). Therefore, the stabilization of these stands by proper treatment is urgent. The main objectives of thinning of young spruce stands in the Beskydy Mts. are following:

Maintaining vitality and stability of dominant trees, i.e. to increase vitality of whole stands before conversion into the stands with more natural species composition.

– Reduction of stand interception for better water management of stands.

– Creation of microclimate favourable to continual decomposition of litter (improvement of soil conditions, prevention of raw humus accumulation).

Thinning models for stands with prevailing Norway spruce are based on one very heavy thinning at the thicket stage; at the top height h_o 5 m. First, heavily damaged trees are to be removed by negative selection both from below and from above. Thereafter, trees with medium damage are removed from below and above, respectively. This first thinning is finished by traditional negative selection from below resulting in recommended density (Fig. 3). During the thinning, support of admixture of shade-tolerant broadleaved species (especially beech) is recommended as well.

First heavy thinning stimulates diameter increment of trees left after thinning as individuals with higher relative stress resistance. Consequently, the resistance of spruce stands to snow and rime damage is increased. Open canopy improves stand microclimate (higher air and soil temperature, higher soil moisture) resulting in continuous litter-fall decomposition (Novák and Slodičák 2004). Annual litter-fall in the spruce thicket exceeds 5 tons of dry-mass per hectare and litter decomposition is important process of nutrient balance maintenance in the spruce stands. From the second thinning (especially for relatively healthy stands), combination of low and high thinning is recommended in case of improvement of health condition.

Recommendations for thinning were prepared as thinning models where number of trees per hectare is proposed across to top height (the mean height of 100 thickest trees per hectare). Models are differentiated according to health condition of the stands (to 25% of

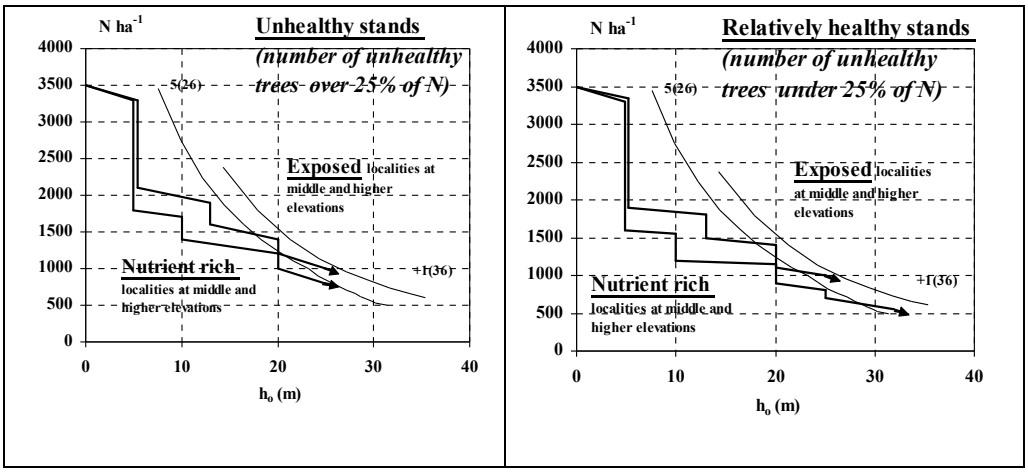

Fig. 3. Thinning programs for spruce stands differentiated according to health condition of the stands and site type compared with growth tables Černý et al. (1996) for site indexes + 1 (36) a 5 (26).

damaged trees and over 25% of damaged trees) and according to site type (exposed sites 41 and 51 and fertile sites 45 and 55). Proposed densities are compared with growth tables Černý et al. (1996).

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