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Health condition of Norway spruce *Picea abies* (L.) Karst. stands in the Beskid Mts

Abstract: The health condition of spruce stands in the Moravian-Silesian Beskids is affected by several predisposition factors, the most important of which is the allochthonous character of spruce grown on improper sites. When exposed to a low supply of nutrients and intensive mechanical damage mainly by game, the trees are susceptible to rot infestations, climatic agents and mechanical destruction by snow, hard rime and wind. At present, air pollution does not show any significant impact on the spruce stands; it rather acts as a less important predisposition factor on mountain peaks. The physiological condition of trees is not impaired to the extent which would facilitate infestation with phytophagous or cambioxylophagous insects.

Additional key words: nutrition, rot, game damage, insects, Moravian-Silesian Beskids

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Introduction

In most of cases we do not know the actual health condition of trees. Foresters are commonly able to detect only conspicuous signs (discolouration, decline, mechanical damage, defoliation) which indicate that health condition has decreased as a result of many predisposition or immediate damaging factors. In this paper I present factors influencing spruce forests in the Beskid Mts in accordance with Manion's theory (modified by Mrkva 1993, Fig. 1) describing the process of plant decline. These factors are marked with bold type in the spiral in Figure 1.

The Beskid Mts are defined as the forest region of the Moravian-Silesian Beskids (Plíva and Žlábek 1986) that is almost identical to the bioregion of the Moravian-Silesian Beskids (Culek 1996). The total forest area of that forest region is 82 432 ha with forest coverage of 75% (Holuša 2000).

Unless mentioned otherwise the data presented below are used according to Holuša (2000).

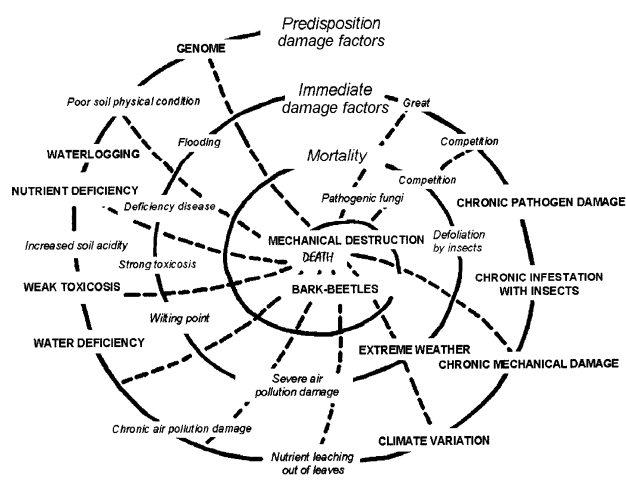


Fig. 1. Manion's spiral of tree decline (modified by Mrkva 1993)

Factors affecting spruce forests

Genome

The major part of the area was originally covered by plant associations of the 4th to 7th altitudinal vegetation zones (Table 1) (according to the system of Plíva 1984). It means that the dominant forests were beech woods and beech-spruce woods. Beech *Fagus sylvatica* L. used to be the most abundant tree species, but recently the dominant tree species has become Norway spruce *Picea abies* (L.) Karst. (Table 2). Seeds of all tree species were used in forest reproduction in the middle of the 19th century.

Table 1. Altitudinal vegetation zones in the Beskids (in %)

Altitudinal vegetation zone						
3rd	4th	5th	6th	7th	8th	total
1.9	8.4	80.8	7.7	1.1	0.1	100

Table 2. Tree species composition in the Beskids (in %)

	Spruce ¹	Fir ²	Pine ³	Larch ⁴	Conifers total	Beech ⁵	Broadleaves total
Natural	4.1	38.0	–	–	42.1	53.3	57.9
Recent	73.6	1.3	0.9	0.6	76.5	19.6	23.5
Target	61.5	10.7	0.5	1.7	74.7	19.0	25.3

¹*Picea abies* (L.) Karst., ²*Abies alba* Mill., ³*Pinus sylvestris* L., ⁴*Larix decidua* Mill., ⁵*Fagus sylvatica* L.

Due to the lack of own seeds in the period of 1870 to 1920, allochthonous seeds from the surroundings of Innsbruck and Steiermark were used. Although from 1920 own seeds have been used, the cones collected from spruce trees planted under 900 m a.s.l. have an “Austrian” origin.

Waterlogging

Only a small area (ca 1100 ha, 1.8%) is influenced by waterlogging. The old net of drains is damaged by logging and serviced only occasionally.

Nutrients and soil acidity

Although Hruška et al. (2002) characterised the Beskid Mts as an area with strongly disturbed soils, they belong in fact to the most productive regions of the Czech Republic. The yield class of spruce varies between 32 and 40 m, which is due to the type of soils (typically cambisols), their depth, favourable humification in the whole area and the total annual rainfall that exceeds 1000 mm. On the other hand, magnesium is often below the spruce requirement level. This is an important consideration because a low nutrient reserve often constitutes a predisposition factor stressing trees (Materna 1994; Kmet' 2001, Podrázský 2001).

In some places, for example in the Podolánky valley (cadastre of the village of Čeladná), a low nutrient reserve (Table 3 and 4) is the cause of the discolouration and defoliation of spruce forests. No biotic damage has been found.

Table 3. Results of foliar analysis in the locality of Podolánky (cadastre of the village of Čeladná, October 2000)

	Nutrient reserve		
	sufficient	sufficient/in-sufficient	insufficient
Declining forest	–	K, Ca, N, P, Zn	Mg
Discoloured forest No 1	K, Ca	N, P, Mg	–
Discoloured forest No 2	K, Ca	–	N, P, Mg, Fe

Table 4. Results of soil analysis in the locality of Podolánky (cadastre of the village of Čeladná, October 2000)

	Declining forest	Discoloured forest No 1	Discoloured forest No 2
Soil acidity	very high	high	high
Available nutrient reserve	low/critical	low/critical	higher
Adsorption capacity	low	low	low

Water deficiency

In the Beskid Mts, water deficiency belongs to the predisposition factors only periodically as was the case with the years 1982–1983 and 1992–1993 when dry periods followed mild winters with a low snow level.

Climate variation and extreme weather

A rapid fall in temperature at the end of 1978 and the beginning of 1979 (combined with an impact of air pollution) resulted in a five-year period of forest dying in the northern part of the Beskids at an altitude of above 700 m. Since that time, a similar situation has not repeated itself.

During the winter of 2001/2002, last year needles were damaged by frost. Damaged trees were observed throughout the mountains, which means that spruces of different ages and from different altitudes and aspects were sporadically damaged.

Even after the dry period of 1992/1993, the forests showed a clear recovery trend. Recently, the area of damaged forests has decreased, as has the area affected by air pollution.

The health condition of spruce forests is still bad on Lysá hora, Kněhyně Mt, Smrk Mt, Travný Mt and Javorový Mt. This is the problem of forests older than 80 years, planted in unsuitable conditions, e.g. at lower altitudes.

Chronic mechanical damage

Root system defects

This syndrome poses a serious problem although no study is available. It results in decreasing mechanical and ecological stability, which can cause trees to fall. Such a situation could have been observed at the end of the 2001/2002 winter as a result of heavy snow.

Game damage

The abundance of deer rapidly increased at the beginning of the 20th century. Substantial damage has been observed since 1920 and is still visible. Another uncontrollable increase occurred during World War II. After 1948, even the official winter stock of game increased. The population of red deer has been considerably reduced since the mid-eighties, but a decrease in damage became visible only after 1990. The red deer population was markedly reduced during the 1990s.

At the beginning of the 90s, the area of browsed young plantations reached 373 ha, i.e. 5.6% of 1- to 10-year-old spruce forests. Older browsed forests covered 5603 ha (timberland) (Table 5) in the total area of 66 183 ha.

Later (until 1986), 7854 ha were at least partly damaged by game. In 1996, this area reached 8875 ha. At the end of the 20th century, the increase in browsing and bark stripping damage approximated 15 ha per year.

Logging damage

About 15% (but very often 25 and even 40%) of trees are damaged in the course of mechanised tending felling when the whole-tree method is used (Simanov 2001). Although no numerical data are known for the Beskids, logging is a very important damaging factor.

Chronic damage by pathogens

More than 20% of timber is infested with fungi in the Czech State Forests (Půlpán 2001). The damage done by pathogens to spruce forests in the Beskids depends on the age of forests and the type of mechanical damage (Table 6 and 7). The effect of underground damage is not known.

Honey fungus (*Armillaria* sp.) in wet places and *Fomes annosus* in former agricultural areas are the most frequent fungi. Spruce trees damaged by game are

Table 6. Total area of forests affected by decay according to the type of mechanical damage

Type of damage	Felling	Game	Snowbreak
Area (ha)	1022	8875	3880

Table 7. Spruce trees damaged by game and consequently infested with fungi during 1973–1987 (in total, 1652 sample trees were surveyed)

Mean age of sample tree (years)	33	43	53	63	73	83	93	103
Total decay (%)	26	42	45	44	42	39	36	36
Soft rot (%)	–	18	22	23	23.5	24	24.5	25
Age of damage (years)	10	20	30	40	50	60	70	80

very often infested with *Fomitopsis pinicola* and *Stereum sanguinolentum*.

In the 1970s and 80s, 10–20% of spruce trees were affected by primary decay and about 30% of trees by secondary decay.

Bark-beetles

The main causes of bark-beetle outbreaks are drought and snowbreak. A higher abundance of bark-beetles was observed in the years 1947–1949, 1954–1955, 1968, 1982–1983 and 1992–1993. Due to the permanent forest protection no major bark-beetle outbreak occurred even in the period of air pollution damage (1979–1985).

The volume of wood infested with bark-beetles was locally higher only during the 1970s; the focuses of the pest were concentrated in the northern part of the Beskids. In the period 1992–1994, the proportion of wood infested with bark-beetles reached almost 40% of the incidental felling.

Ips typographus is the most frequent species in the older spruce forests, while *Pityogenes chalcographus* in the younger ones; *Ips amitinus* occurs more frequently at higher altitudes. Locally, mainly in spring, *Polygraphus polygraphus* infests stressed trees. Recently, beetles of *Ips duplicatus*, which is widespread in the eastern part of the Czech Republic (Holuša et al. 2003), have migrated to higher altitudes, too (Fig. 2). In the case of stressed trees this species could be potentially dangerous to spruce forests.

Table 5. Spruce forests (ha) damaged by bark stripping and browsing in the Beskids

Percentage of trees	Age (years)							total
	1–20	21–40	41–60	61–80	81–100	101–120	older	
5–30	32.7	295.7	356.4	223.0	244.4	76.7	13.1	1242.8
31–70	10.3	423.2	447.7	294.3	231.0	103.2	4.9	1513.0
71–100	6.3	548.0	896.5	694.3	527.5	144.1	20.5	2847.3
Total (ha)	49.3	1266.9	1699.8	1220.7	903.0	324.6	26.3	5603.2

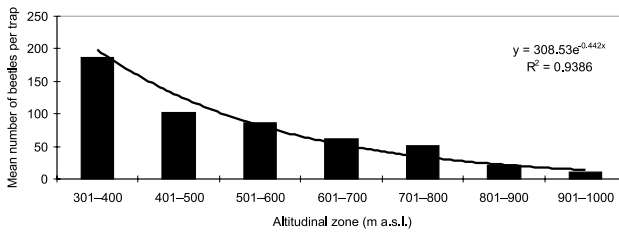


Fig. 2. Occurrence of *Ips duplicatus* in altitudinal zones of Ostrý Mt in April–June 2002 (six pheromon baited traps of Theysohn type were used in each zone)

Phytophagous insects

Spruce tenthrinids

In the northern part of the Beskids, at altitudes of up to 700 m, strong defoliation appeared in 1999 (Fig. 3) and 2000. The increased defoliation was probably due to the warm weather (favourable for insect development) at the end of the 20th century (Holuša and Holuša 2002). Little spruce sawfly *Pristiphora abietina* is the dominant species in young spruce forests in this area (Table 8) (Holuša 2002). The population density of this insect was later reduced as a result of chemical treatment in 2001 (Holuša and Holuša 2002).

Web-spinning sawflies

Several species of web-spinning sawflies live in the Beskids (author's observations) but their population density was not high during the last 10 years. In the period 1979–1981, outbreaks of web-spinning

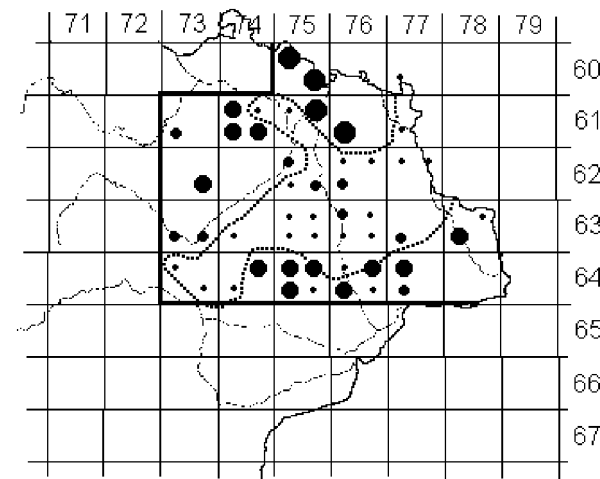


Fig. 3. Infestation caused by tenthrinids to young spruce forests in the eastern part of the Czech Republic in 1999 (point – throughout the stand only single shoots on trees are consumed, little circle – half of trees with one or two top whorls consumed, mid-size circle – more than half of trees with three or more top whorls consumed, circle one-quarter of the size of the map field – stunted trees, dotted line – border of the treated area, bold line – margin of the study area) (Holuša and Švestka 2000, Holuša and Holuša 2002)

sawflies were noted in several localities of the northern part of the Beskids. Recently, in the 1990s, an abundant occurrence of web-spinning sawflies was observed locally on Lysá hora and in the surroundings of the Podolánky valley.

Mechanical destruction

Wind

In the vegetation season, wind damages spruce forests on swampy sites in the months with a higher rainfall (March–April, end of August and beginning of September). Northern, northwestern, western and southwestern winds are the most dangerous.

In winter, wet and heavy snow in combination with wind influence forests at middle and higher altitudes. As a result of intensive thinning the proportion of trees suffering from snowbreak decreased from 35% (1980) to 25% (the 90s).

Snow and rime

Snow is an important factor, but in the Beskids continuous snowbreaks do not occur. The last important snowfalls occurred in 1992 and 1993 causing mainly qualitative damage to spruce forests aged 21–60, damaged by game, at an altitude of 700–900 m. In the period 1990–1999, the reduced area of spruce forests with broken tops of trees was 3880 ha. From 6 to 9% of 31- to 100-year-old forests were damaged.

Table 8. Dominance of spruce tenthrinids in some young spruce forests in the Beskids (using Malaise traps) (Holuša 2002)

Species	Locality		
	Malá Stolová Mt (1000 m a.s.l.)	Noříčí Mt (580 m a.s.l.)	Travný Mt (540 m a.s.l.)
<i>Pikonema montanum</i>	2.9	14.6	7.4
<i>Pikonema pallescens</i>		10.4	4.4
<i>Pikonema scutellatum</i>		25.7	
<i>Pristiphora abietina</i>	53.0	23.6	55.9
<i>Pristiphora decipiens</i>	5.9		1.5
<i>Pristiphora gerula</i>	11.8	0.6	
<i>Pristiphora leucopodia</i>	2.9	13.9	4.4
<i>Pristiphora nigriceps</i>		3.5	
<i>Pristiphora saxesenii</i>	2.9	3.5	2.9
<i>Sharliphora nigella</i>	20.6	4.2	23.5
Number of specimens	34	144	68

Rime damages forests on ridges and tops at altitudes higher than 750 m. The last important rimebreaks occurred in 1996 and 1997. The portion of timber damaged by snow and rime does not exceed 10% of the total incidental felling.

Conclusion

The health condition of spruce forests in the Beskids is influenced by several predisposition factors, among which the planting of allochthonous spruce in inappropriate habitats is the most important. When exposed to low nutrient reserves and intensive mechanical damage mainly by game, such trees are susceptible to decay, extreme weather factors (frost, rapid fall in temperature) or mechanical destruction by snow, rime and wind. Recently, air pollution has not essentially affected spruce forests and has probably acted as a less important predisposition factor on mountain tops. However, the physiological stress is not strong and the forests are able to resist an attack by phytophagous insects as well as by bark-beetles.

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