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Different types of damage in mountain forest stands of the Czech Republic

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ABSTRACT: Forests in the Czech Republic are highly influenced by the antropogenous factors – those are particularly air pollution, pollutant deposition, soil degradation, change of the natural forest ecosystems, and also global climate changes. Significant damages due to air pollution are visible already 50 years (the Ore Mts. region). Since 1989 the sulphur emission has decreased significantly. By the end of 90ies SO_2 emission was reduced in nearly 90%. In the 1990–1995 period, the change of air pollution situation in mountain regions resulted into the spruce stands condition improvement, and good progress of transitory stands (birch, blue spruce, mountain pine, alder etc.). Following development was not that ideal, however. Since 1995, various symptoms of damage have been observed, caused by the complex of factors. During the winter 1995/1996, within the whole region of the Czech Republic, reddening of the last needle year class of spruce was observed in the altitude over 700 m. These symptoms were the most visible in the eastern part of the Ore Mts., where 3–4 needle year classes were affected, or even tree decay observed. An acute damage was caused by direct impact of the high SO_2 concentrations. The average defoliation was over 60% in stands assessed. About 12,578 ha of spruce stands were damaged, 1,300 ha of them has completely died. The rest have regenerated successfully in following period. After following winter, in spring 1997, the damage of transitory birch stands was observed in all the northern mountain regions. In the Ore Mts. ridge birch did not flush at all, the leaf lost was observed in a vast area with variable intensity in altitudes over 800 m above sea level during the springtime. In total 3,400 ha of birch stands was damaged, in 1998 it was nearly 5,428 ha. Birch completely died at about 2,550 ha, in following period the damage development stagnated. Similar damage of smaller extent has been observed also in other parts of the country, in higher elevations, situated above the inversion layer during the spring months. After winter 1999, vast damage of the spruce stands, manifested in yellowing of older needle year classes, and gradual needle drying and fall, affecting the stand of all age categories, was observed in the western part of the Ore Mts. but also in other regions. Yellowing was observed on 2,000 ha in 1999, next year it was 6,500 ha, and in 2001 about 9,000 ha was damaged within the Ore Mts. A new type of damage has been observed in the Orlické hory Mts. ridge caused again by the stressing factors complex after the winter 2001/2002. Nitrogen deposition seems to be one of major problem. The damage presented shows that in spite of significant lowering of air pollution load the forest stands health state in air polluted regions is not stabilized.

Keywords: health status; antropogenous factors; new damage; spruce; mountains

Forests in the Czech Republic (hereinafter CR) are highly influenced by antropogenous factors. Among them are mainly air pollution (SO_2, NO_x etc.), pollutant deposition (S, N), soil degradation, change of the natural forest ecosystems during the history, and also global climate changes. Significant forest damage due to air pollution has been visible for more than 50 years ago. Vast damage has been observed mainly after an extreme temperature break in December 1978. Similar damage has been observed in all the ridge parts in Northern Bohemia (MATERNA 1984). In the middle 90ies, about 60% of the forest stands in CR were damaged. Emission of SO_2, the main pollutant affecting the forest stands, culminated in the eighties, when more than 2 mil. ton was produced per year. At the beginning of 90ies the air pollution situation in CR started to change rapidly. Sulphur emission has decreased significantly thanks to the reduction of industrial production (heavy and chemical industry) and use of de-sulphur devices at the main pollution sources (brown-coal power plants). By the end of 90ies the emission of SO_2 was reduced in nearly 90%. Between 1990–1995, the change in the air pollution situation in mountain regions resulted in the improvement of the health state of spruce stands, and good development of the transitory stands (birch, blue spruce, mountain pine, alder etc.) which were planted mostly in 80ies in the ridge area (especially in the Ore Mts.). Since 1995, various symptoms of damage have been observed, caused by the complex of antropogenous and meteorological factors in different mountain regions of the Czech Republic.

METHODS

The attempt to cope with the problem of forest health status is based on the transects of the research plots,

established since the beginning of nineties in the young spruce stands and transitory stands, in regions of former vast clear cuts. Within the Ore Mts. it is 20 plots in the spruce stands and 12 plots in the transitory birch stands. In the Jizerské hory Mts. it is 18 plots and 10 plots in the Orlické hory Mts. in the young spruce stands. Next follow-up information on the visible symptoms was obtained from the temporary mainly spruce plots established during the survey.

In the spruce stands defoliation, number of the needle year classes, and the height increment are assessed every year. Based on the ICP Forests methodology, also the content of air pollutants and nutrients in the assimilation organs are classified yearly, and the nutrient supply, in the humus layer and mineral soil, are analyzed in a five-year interval (Manual of ICP Forests). The health state in the transitory birch stands is assessed every year. In 1999, the quality and number of roots was also evaluated, and the chemical analysis of the assimilation organs, humus and mineral soil was done. To understand the impact of other stressing factors, also meteorological data and measuring of the air pollution characteristics were used.

RESULTS AND DISCUSSION

Winter 1995/1996 – an acute, direct impact of sulphur emission to the forest stands

During the winter of 1995/1996, in altitudes over 700 m within the whole region of the Czech Republic, reddening of the last needle year class of spruce was observed.

These symptoms were the most visible in the eastern part of the Ore Mts., where 3–4 needle year classes were affected, or even tree decay observed. The symptoms of the damage were the same as in the 40ies and 70ies of the last century. An acute damage was caused by the direct impact of the high SO_2 concentration in the air. The stand damage was connected with a long-lasting inversion situation, going up to 700 m, sharp temperature decrease, hard frost and following forming of the frost deposit. Long-term south-eastern flow lead to pollution cumulating in the ridge part of the Ore Mts., thus the extreme values have been reached even under the condition of comparatively low emission. From November till January the average daily concentrations of SO_2 were many times over 500 µg/m^3 (VANČURA 1999), and the 30 min concentrations have reached even 3,000 µg/m^3 (Fig. 1).

High air pollution load in this part of the Ore Mts. was proved by a high concentration of the stress elements (S, F) in the needle samples. The sulphur content in the first needle year class was 2,755 mg/kg and the fluorine content was 19.03 mg/kg within the most affected regions. Mostly the whole tree crown, or the upper part respective was affected. The average defoliation was over 60% in the stands assessed. In some stands only 10% of vital buds proved that the vitality was decreasing with tree age (LOMSKÝ, ŠRÁMEK 1999). About 12,578 ha of the spruce stands were damaged, 1,300 ha of forests has completely died (Report MA 1997). In the following period the spruce stands have regenerated successfully (Fig. 2).

Spring 1997 – temperature changes and the damage to the birch stands

After the following winter, in spring 1997, the damage to the transitory birch stands was observed in all the northern mountain regions. In some stands of the Ore Mts. birch did not flush at all, during April and May the leaf loss was observed in a vast area. The damage was observed in altitudes over 800 m above sea level, the intensity was variable. Warm temperatures at the end of winter (Fig. 3), followed with sharp frost breaks, were an important factor, causing the damage to the root system when the snow melted. The damage also shows the level of long-term pollution load, soil degradation and genetic qualities of the transitory stands.

In 1997, in total 3,400 ha of the birch stands was damaged, in 1998 it was nearly 5,428 ha. Birch completely

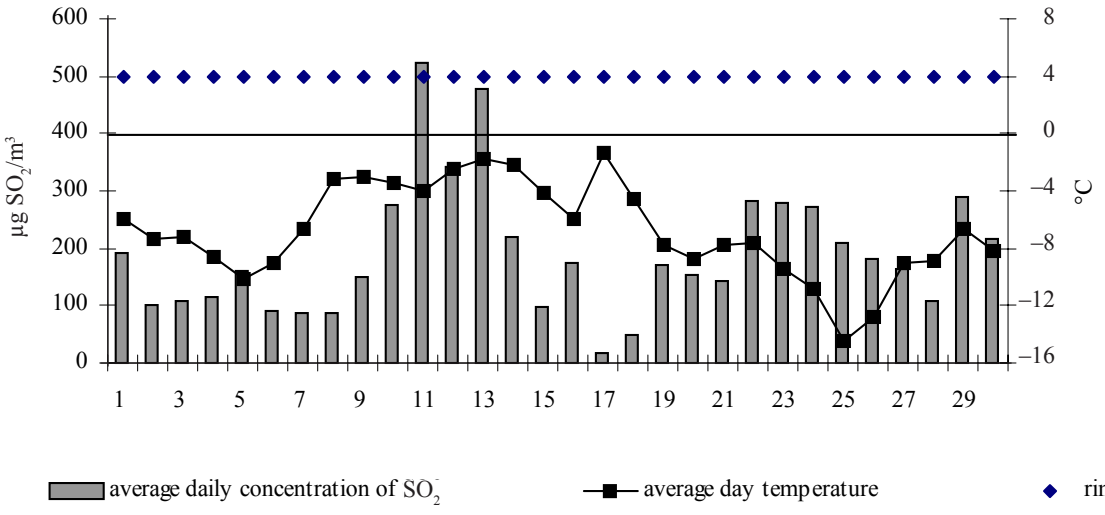
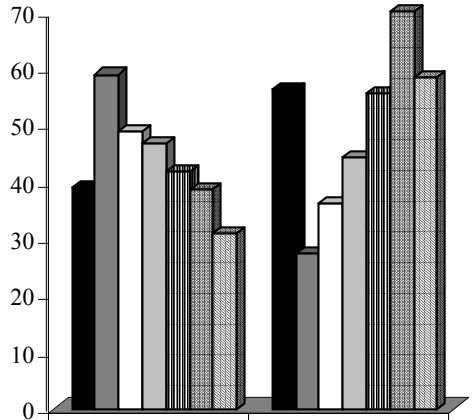


Fig. 1. The impact of stress factors; Medenec – January 1996



	Defoliation	Height increment
1995	38.9	56.3
1996	59	27.4
1997	48.9	36.4
1998	46.8	44.4
1999	41.9	55.8
2000	38.8	70
2001	31	58.3

Fig. 2. Comparison of mean defoliation and height increment of damaged young spruce stands in 1995–2001

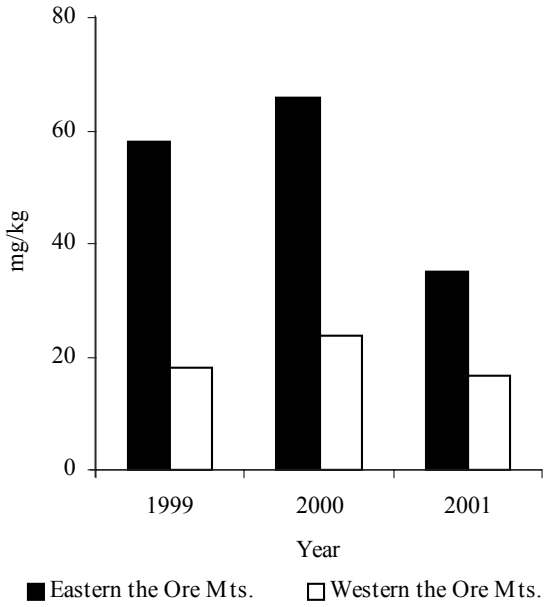


Fig. 4. Comparison of available magnesium content in soil

died at about 2,550 ha (Report MA 2000). In the following period the damage development stagnated.

Similar damage of smaller extent has been observed also in the other parts of the Czech Republic, in higher elevations, situated over the inversion layer during the spring months.

The year 1999 – new forest damage again

After winter 1999, vast damage of the spruce stands, manifested in yellowing of older needle year classes, and gradual needle drying and fall, affecting the stand of all age categories, was observed in the Ore Mts.

The same symptoms were also observed in some localities in the Jizerské hory and Orlické hory Mts. Color changes characterize so called "new type of forest damage", as described in the 80ies in Western Europe (HÜTTL 1998; KAUPENJOHANN et al 1988). They are caused by the long-term effect of comparatively low air pollution concentration and acid deposition on the pure, degrading forest soils. The upper soil layer is acidified, and the basic nutrients, mainly Mg and Ca, eluded from the sorption complex. Significant Mg deficiency in the soil affects the nutrition supply of the spruce stands (Fig. 4). The investigation has proved critical deficiency of the basic nutrients, mainly calcium and magnesium. Their content in the needles was in some cases at physiological minimum level (300 mg/kg)

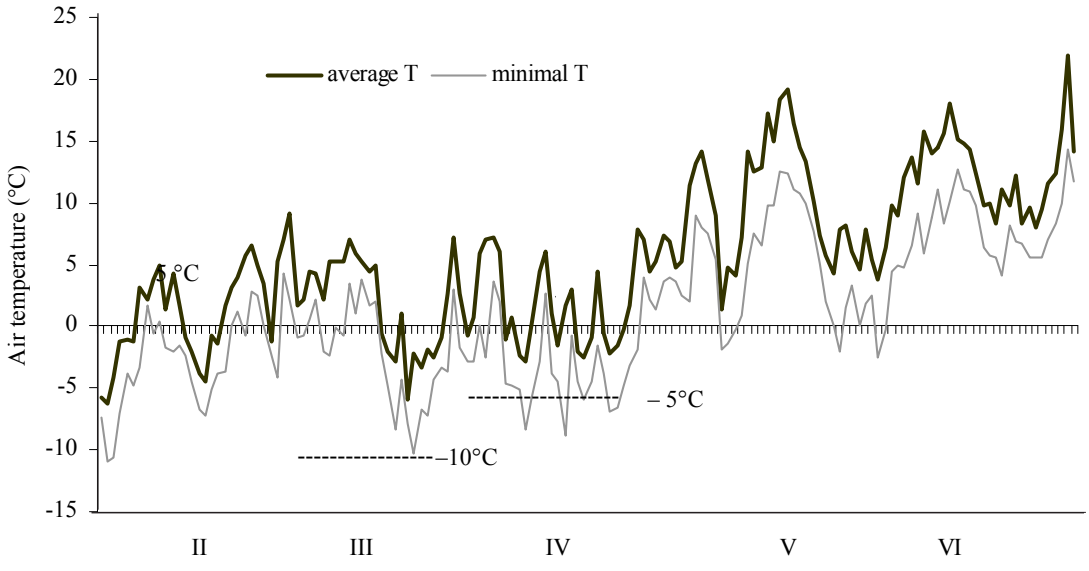


Fig. 3. The course of temperature during winter and spring 1997

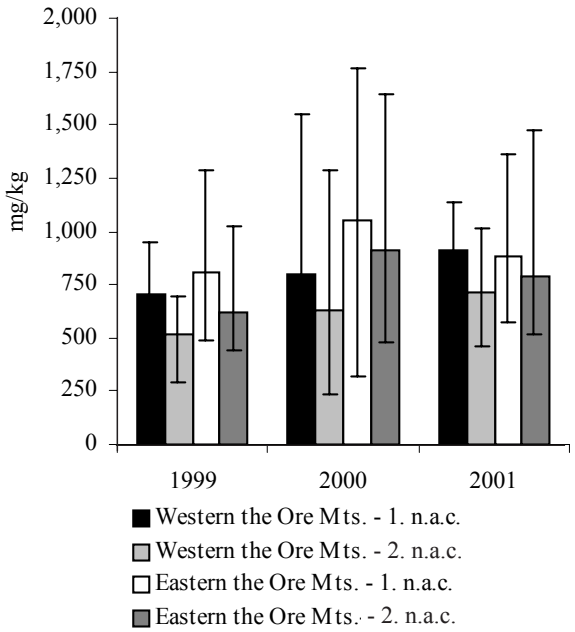


Fig. 5. Comparison of Mg content in spruce needles (n.a.c. – needle age class)

(Fig. 5). In 1999 yellowing was observed in 2,000 ha, in following year it was 6,500 ha, and in 2001 about 9,000 ha was damaged within the Ore Mts., in the Jizerské hory Mts. it was about 1,000 ha. Since 2000 liming and fertilizing has been applied in the damaged stands.

Winter 2001/2002 – nitrogen deposition and damage to the spruce stands

After winter 2001/2002 in the ridge part of the Orlické hory Mts., over 750 m a.s.l., a new type of damage has been observed, caused by complex stressing factors. Nitrogen deposition, oscillating in the range of 30 to 60 kg/ha in the 90ies, was of importance. An increased nitrogen input in higher elevations most probably influences positively the high increment of spruce (1 m), and makes maturing of the shoot slower (Fig. 6). The stands start to be sensitive to damage caused by frost, which is proved by the higher N:K ratio in needles of damaged individuals.

This fact, together with other stressors, such as an inversion, sharp temperature changes, hard frost, and winter transpiration, resulted in significant damage of the upper part of Norway spruce. Damage of a different level was observed at the area of about 980 ha in 2002.

CONCLUSIONS

During the last decade in the mountain regions:

i) change in the pollution spectrum occurred, the importance of once less significant pollutants increased (NO_x, O_3);

ii) significant negative long-term impact of high sulphur deposition is observed, mainly in degrading forest soils;

iii) the impact of sharp changes of meteorological factors – temperature, precipitation – start to be more important;

iv) acid deposition is a permanent risk which will affect the tree growth in the ridge parts.

Every forest region is specific, to find support for the long-term intensive research of the forest ecosystems in mountain regions is of importance.

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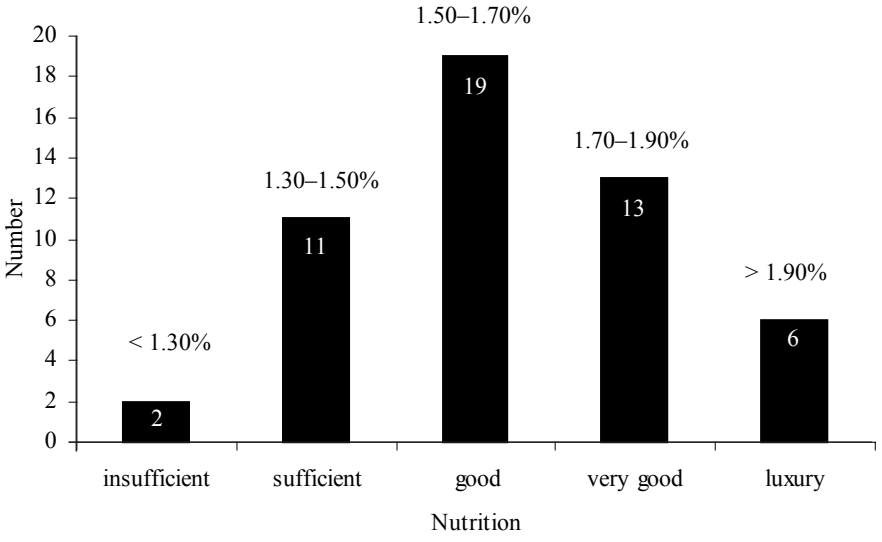

Fig. 6. Nitrogen content in the 1st needle age class

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Různé typy poškození horských porostů České republiky

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ABSTRAKT: Lesy v České republice jsou silně ovlivňovány antropogenními faktory. Nejvýznamnějšími z nich jsou: znečištění ovzduší, imisní depozice, degradace půd, změny přírodních lesních ekosystémů, ale také globální změny klimatu. Viditelné poškození způsobené imisemi je v oblasti Krušných hor pozorovatelné již 50 let. Od roku 1989 prokazatelně klesly emise síry. Od konce devadesátých let došlo ke snížení emisí SO_2 na přibližně 90 %. V období 1990–1995 vedly změny ve stavu imisního zatížení v horských oblastech ke zlepšování porostních podmínek a zdravotního stavu porostů náhradních dřevin (břízy, smrku pichlavého, borovice kleče, olše atd.). Jejich další vývoj však nebyl tak optimistický. Od roku 1995 jsou pozorovány různé způsoby poškození, jejichž příčinou je komplex různých faktorů. V celé České republice v nadmořských výškách nad 700 m se v průběhu zimy 1995/1996 objevilo reznutí posledního ročníku jehličí. Tyto symptomy byly nejvíce patrné ve východní části Krušných hor, kde bylo pozorováno nejen poškození 3–4 ročníků jehličí, ale až dokonce odumírání jednotlivých stromů. Příčinou akutního poškození byl přímý vliv vysokých koncentrací SO_2. Odhadovaná průměrná defoliace porostů dosahovala 60 %. Došlo k poškození okolo 12 578 ha, z nich 1 300 ha odumřelo zcela. Zbytek v následujících letech úspěšně zregeneroval. Po následující zimě, na jaře 1997, bylo ve všech horských oblastech na severu republiky pozorováno poškození náhradních porostů břízy. Hřebenové porosty břízy v Krušných horách vůbec nevyrašily, ve zbytku oblasti nad 800 m n. m. byla v průběhu jara pozorována ztráta olistění. Celkem bylo poškozeno 3 400 ha březových porostů, v roce 1998 to bylo téměř 5 428 ha. Břízy zcela odumřely na 2 550 ha, v následujících letech vývoj poškození stagnoval. Podobné škody menšího rozsahu se v průběhu jarních měsíců vyskytly také v ostatních regionech – ve vyšších nadmořských výškách v lokalitách nad hladinou klimatické inverze. Po zimě roku 1999 nastalo v západní části Krušných hor (ale i v jiných oblastech) rozsáhlé poškození smrkových porostů bez ohledu na věk, které se projevovalo žloutnutím starších ročníků jehličí a jejich postupným vysycháním a opadem. Žloutnutí postihlo 2 000 ha v roce 1999, následující rok to bylo 6 500 ha a v roce 2001 kolem 9 000 ha na území Krušných hor. Na vrcholových partiích Orlických hor se po zimě 2001/2002 objevil nový typ poškození, jehož příčinou je komplex stresogenních faktorů. Zdá se, že nejvýznamnějším z nich je depozice dusíku. Toto poškození ukazuje, že navzdory průkaznému snižování zátěže způsobované znečištěním ovzduší není dosud zdravotní stav imisních oblastí stabilizován.

Klíčová slova: zdravotní stav; antropogenní faktory; nové typy poškození; smrk; hory

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