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COMMENTS ON THE IMMEDIATE HEALTH CONDITION OF BIRCH STANDS IN THE AIR POLLUTED REGION OF THE ORE MTS.

POZNÁMKY K AKTUÁLNÍMU ZDRAVOTNÍMU STAVU POROSTŮ BŘÍZY V IMISNÍ OBLASTI KRUŠNÝCH HOR

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ABSTRACT: In the north-east part of the Ore Mts. (Bohemia) 3400 ha of birch stand (*Betula verrucosa* Ehrh.) situated in higher altitudes (850–1000 m a.s.l.), which did not flush in spring 1997, were inventoried. Biotic (phytophagous insects, fungi), abiotic (low temperature) and anthropogenic (pollution) factors which influence the health condition of birch were characterized. A hypothesis of the absence of flushing in birch was expressed.

birch *Betula verrucosa* Ehrh.; non-flushing; the Ore Mts.; insect pests

ABSTRAKT: V severovýchodním Krušnohoří (Čechy) bylo inventarizováno ve vyšších nadmořských výškách (850–1 000 m) 3 400 ha porostů břízy (*Betula verrucosa* Ehrh.), které v r. 1997 v různém stupni nevyrašily. Charakterizovány jsou biotické (hmyz, houboví patogeni), abiotické (nízké teploty) a antropické (imise) faktory, které ovlivňují zdravotní stav břízy, a byla vyslovena hypotéza možné příčiny nevyrašení.

bříza *Betula verrucosa* Ehrh.; nevyrašení; Krušné hory; hmyzí škůdci

INTRODUCTION

The tree species composition of the Ore Mts. region has completely changed due to the long-term negative impact of anthropogenic air pollution; since 1980 birch (*Betula verrucosa* Ehrh.) has become the dominant species.

The region of the Ore Mts. has been exposed to pollutant load for a long time, SO_2 being dominant. After 1979 when spruce stands declined, a vast territory was reforested with birch with good tolerance to air pollution which reached 90–100 $\mu g.m^{-3}$ after 1985. The territory of the selected transects in the vegetation period did not considerably differ in the average monthly concentrations, while differences in monthly maximal values were substantial. Specific conditions were thus created which affect the vitality of the fertile plant and through this plant a positive or negative reaction of the phytophagous component occurs.

K u b e l k a et al. (1992) reported in detail the air pollutant climatic characteristic of the region of the north-east Ore Mts. and K u l a , H r d l i č k a (1996) described the site conditions of the Děčín sandstone upland.

SITUATION

In 1991–1995 gradual and expressive regeneration of spruce stands was observed and an optimistic prognosis was based on this fact not only in terms of the sanitation of the existing forest stands but also for a successful implementation of a master plan for the regeneration of spruce and beech stands in the entire Ore Mts. The

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winter of 1995/1996, and its severe and long-term rime, caused mechanical damage of large areas of forest stands and extensive dieback of spruce stands in the forest districts Litvínov, Janov and Klášterec and in Saxony.

Abiotic effects

In the winter of 1995/1996 not only spruce stands were severely damaged by rime but also birch stands (Kula, Kawulok, 1998). In spruce stands also physiological disorders appeared followed by dieback of stands, but birch was damaged especially mechanically and the flushing of stands in spring 1996 was normal.

The effect of winter kill of annual shoots and end twigs was observed in connection with autumn clear-eating of the willow leaf beetle (*Lochmaea capreae* L.) (Kula, 1988) as the consequence of insufficient maturing of annual shoots. Living branches of birch stands affected in this way were preserved up to the height of the snow cover.

At the present time 20–50 cm of annual shoots and end twigs on older trees are dying. The cause of the primary impairment and following winter kill of annual shoots could be the premature shedding of leaves due to the effect of fungus pathogens (rust).

The effect of pollutions

The forests of the Ore Mts. have been exposed to SO_2, NO_x, O_3 and fallout for a long time.

In 1996, as in the past, the most important pollutant was SO_2 where concentrations were higher than in 1995 and the entire region was classified as a region where the daily limits were exceeded most frequently. In 1996 the limit of 150 $\mu g.m^{-3}$ was exceeded from January until early April and then in December (Mědĕnec) based on 24-hour average concentrations. In autumn 1996 no station of the imission monitoring network recorded any deviation from the pollutant load (Kolektiv, 1996).

The evaluated transects differ in their average annual concentration of SO_2, the highest load being observed in Litvínov and the lowest in Sněžník; the levels were the same in Janov and Klášterec. In terms of the average daily maximal values differences were observed between Sněžník (low load) and Klášterec (high load), in Janov and Litvínov they were the same. In the height gradient the SO_2 concentration decreased.

In 1996 (VIII) there was an operational breakdown in the chemical factory during the combustion of propylene and ethylene in a field burner; in the course of two days 464 t of ethane and ethylene, 217 t of propane and propylene, 114 t of butane and butylenes, 310 t of methane and 9.7 t of hydrogen burnt and special pollution escaped into the air (Anonymous, 1996). These pollutants were not recorded by the stations of the network of automatized pollutant monitoring. We have no knowledge about their reaction in the atmosphere. After reaction of the released substances and the resulting compounds phytotoxical effects could be expected. The meteorological situation at that time showed good dispersion conditions followed by a passage of the cold front. In November 1996, while extinguishing fire in the chemical factory, motor petrol containing as much as 20% of aromatic hydrocarbons and 5–15% of toxical benzene began to burn. Aromatic hydrocarbons containing toxical benzene, in particular, may damage living organisms. By a warm flow of air these substances were carried into higher heights. In the crucial days there were low clouds above the affected region, a cold front was passing and it was misty (Janeček, 1997). This reduced dispersion.

Leaf waxes

Results determined using the gravimetric method confirmed a considerable total loss of wax in birch leaves in dependence on the height gradient; in late August 1996 in an altitude of 900 m the amount of wax decreased to one third compared with the control non-pollutant region (forest district Litvínov, altitude of 900 m, 32.9 $mg.g^{-1}$, Němčice in the Drahanská Uplands 95.6 $mg.g^{-1}$). The degree of disturbance of the superficial structure lead to an extensive baring of the leaf epidermis and the protective function lost its importance. The amount of epicuticular waxes also decreased in the period between the spring and summer aspect (Bednářová, 1996). In the spring of 1997 the wax content slightly increased (Bednářová, unpublished). The loss of epicuticular waxes is one of the factors of the impairment of the tree species, even though it is not caused by the absence of budbreak of birch it monitors the impact of pollution which was particularly important in the higher altitudes of the Ore Mts. in August 1996 according to the condition of the epicuticular waxes.

In spring 1997 budbreak of birch in higher altitudes of the Ore Mts. occurred in such a low extent that it was considered to be another ecological disaster in this forest region.

The aim of the present study was to evaluate the immediate health condition of birch stands and based on evaluations of factors influencing the health condition of birch to give a hypothesis for the causes of this absence of budbreak.

METHODS

– Inventory of birch stands without budbreak

Inventory of birch stands with poor flushing or where flushing was severely suppressed was carried out in the entire territory of the north-east part of the state-owned, urban and private forests of the Ore Mts. From this point of view two categories were determined: severely damaged stands where restructuring and regeneration will have to be carried out, and the category of extensively damaged and impaired birch. More detailed criteria were not taken into account because the objective was to delimit the area and position of the incidence of this type of damage.

– *Monitoring phytophagous birch pests*

The extent of damage of assimilation organs by insect pests and fungous pathogens has been classified since 1995 using the method of unit branches sampled in June and August from permanent sample trees situated in stands of the Ist–IIIrd age categories in height transects of the forest districts Klášterec, Janov, Litvínov and Sněžník (K u l a, 1997).

RESULTS

INVENTORY OF BIRCH STANDS WITHOUT BUDBREAK

Premature drying up and shedding of leaves affected birch stands in late August and early September 1996. In spring 1997 a disorder in budbreak appeared, i.e. in some stands there was no foliage whatever and no signs of regeneration from the latent buds.

Inventory of these damaged birch stands was carried out in the north-east part of the Ore Mts. and Děčín sandstone upland. Registered were 585 ha of severly damaged birch stands, 1535 ha of stands were classified as damaged and impaired and 1270 ha of impaired stands (Tab. I). Symptoms of this damage were not recorded in the Děčín sandstone upland and neither in the western part of the Ore Mts. The continuous strip of damaged stands of the forest district Litvínov begins near Krupka and stretches eastwards to Moldava where it passes into severely affected stands and reaches the Flájská dam. It then continues along the state border. The second zone of damaged stands lies in the forest district Janov and in the forests of the towns Jirkov, Chomutov and Most, extending from Mikulovice through Rudoltice v Horách and Zákoutí. The third region of damaged stands stretches along the state border from the Hora Sv. Šebastiána to the Přísečnice dam with mainly damaged and impaired stands. Another zone of affected stands lies between Měděnec, Loučná and Vejprty with a strong representation of severely damaged stands (Fig. 1). In general, stands situated in an altitude of 750–1000 m in the tableaus of the Ore Mts. were affected and only to a small extent those on the linking slopes.

PHYTOPHAGOUS BIRCH PESTS

The total average spring losses in assimilation organs caused by phytophagous pests in 1997 were maximally 12% (forest district Litvínov), while this damage was below 10% in the other transects (forest district Janov 8.6%, forest district Klášterec 7.8%, Sněžník 9.4% – Fig. 2). The degree of leaf damage in the category below 10% was balanced, the most marked deviations were recorded in the category of medium leaf damage (11–50% and 51–75% – Fig. 2).

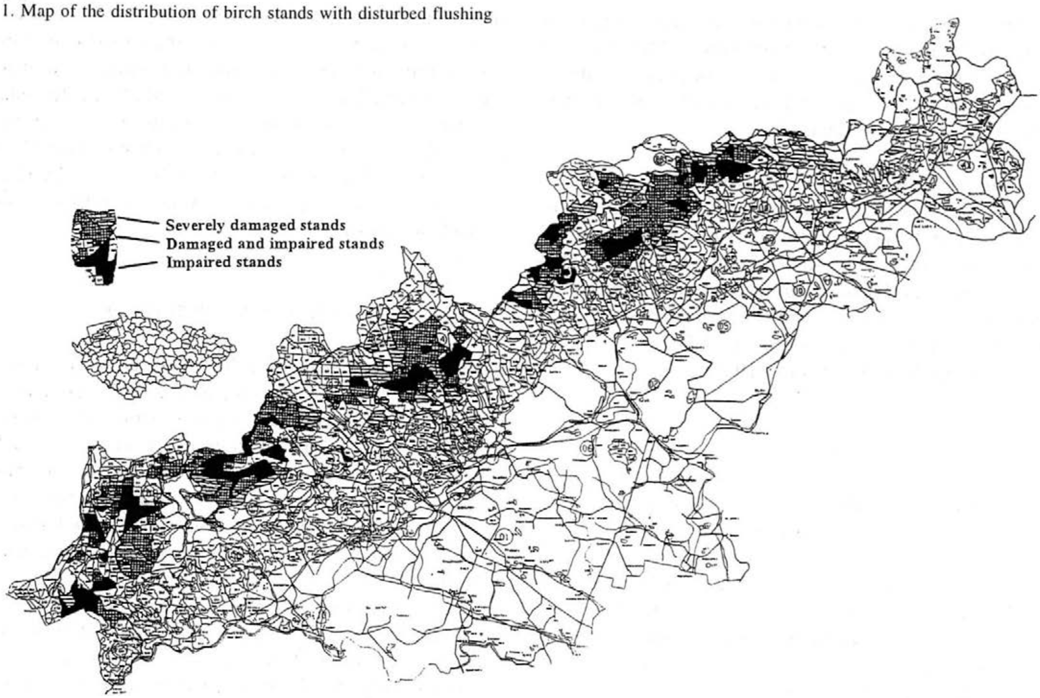
Freely living caterpillars and hymenopterous larvae accounted for the major loss of leaf area in all the studied transects (Fig. 4), followed by miners of the genus *Eriocrania* (Fig. 4) which occurred in the stands of the forest district Litvínov (3.2% share in losses) and accompanied by the casebearer (*Coleophora serratella* L. – 1.2%) (Fig. 4). The share of weevil beetles in leaf damage in all the transects of the studied region was 1–1.5% (Fig. 4).

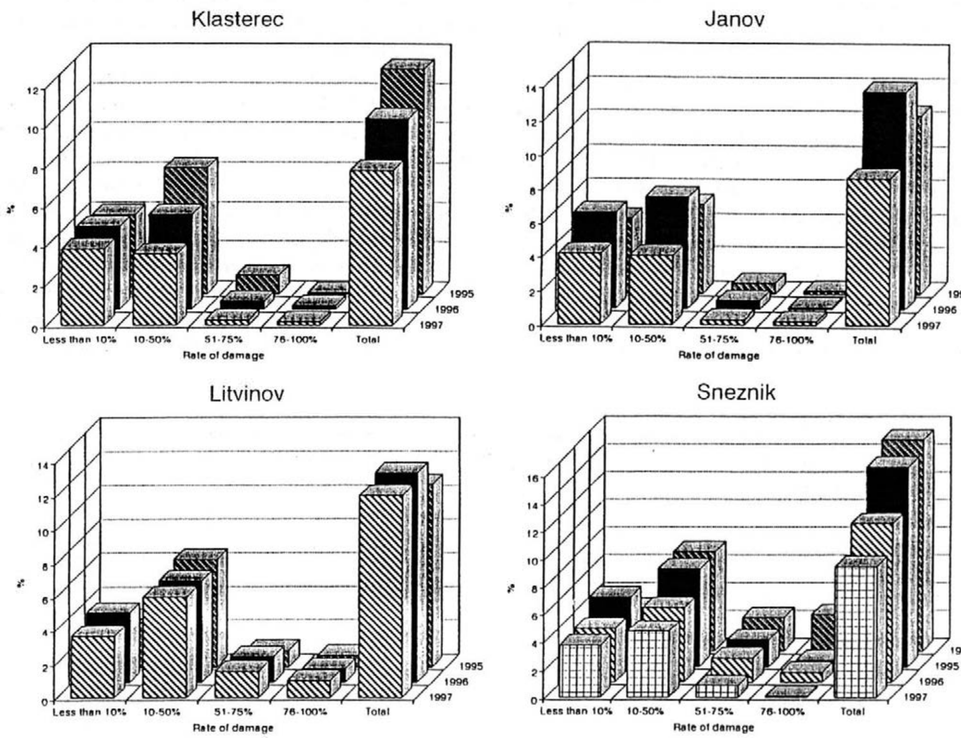
The symptom of damage shown as the breakdown of the edges of the leaves and damage along the primary leaf venation is associated with the direct effect of pollutants. It was recorded particularly in the region of the forest district Litvínov (1.1%) and Janov (1%) in the higher altitudes (Fig. 4). Yellowing of leaves and their premature shedding has been associated with the fungus pathogen *Euryochara betulina* which occurred to a larger extent in the summer aspect of 1997 (0.4–4.4%). Another important leaf pathogen was *Discula betulina* which also caused premature shedding of

I. Extent of unflushed birch stands in the north-east part of the Ore Mts. (ha)

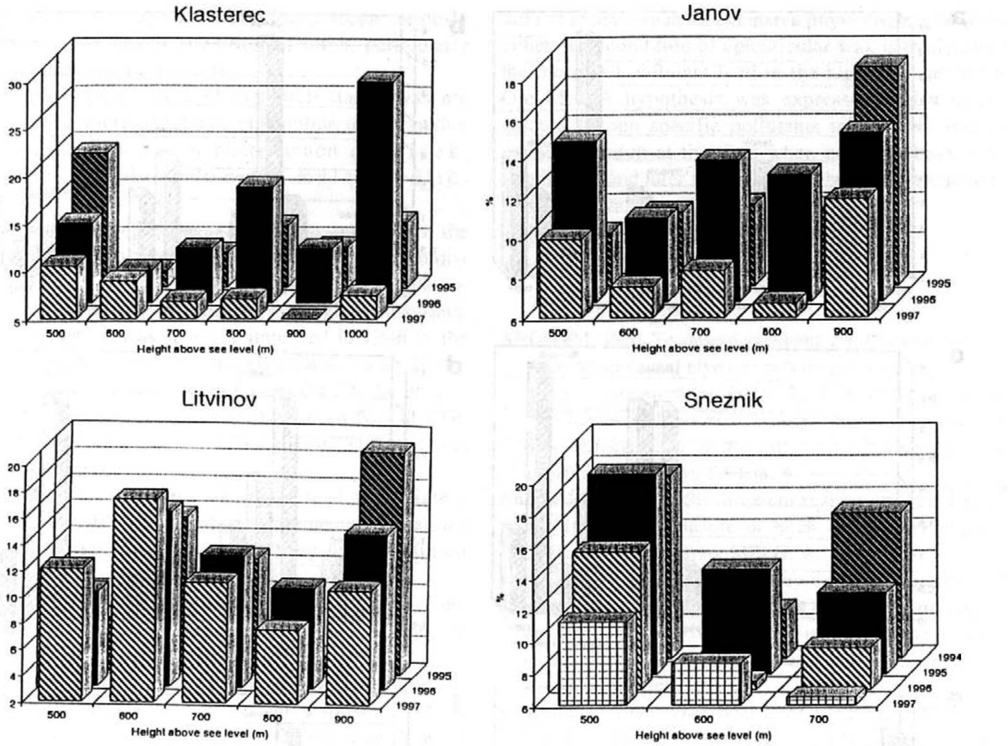
Forest owner-administrator	Severely damaged stands	Damaged and impaired stands	Impaired stands
Forest district Klášterec	100	340	220
Forest district Janov	15	180	140
Forest district Litvínov	150	540	580
Total FCR RSO Teplice	265	1060	940
Forest district H. Blatná	10	60	0
Lobkowic forests	100	50	160
Urban forest – Most	50	160	20
Urban forest – Chomutov	10	50	20
Urban forest – K. Hamry	0	15	0
Urban forest – Jirkov	105	140	130
Total	585	1535	1270

1. Map of the distribution of birch stands with disturbed flushing





2. Overall extent of spring damage to the leaf area of birch according to the individual transects (Klášterec, Janov, Litvínov, Sněžník) in 1995–1997



3. Overall extent of spring damage to the leaf area of birch according to the altitude in the individual transects (Klášterec, Janov, Litvínov, Sněžník) in 1995–1997

leaves and the occurrence of which reached 2.6–5.5% (1996) and 2.9–5.3% (1997 – Fig. 4).

Long-term investigations of the health condition of birch stands in monitoring points of four height transects indicated a positive development expressed in the reduction of total losses of assimilation organs (Fig. 2) with the exception of the forest district Litvínov where an increase was recorded caused by the increased effect of miners of the genus *Eriocrania* and *C. serratella.*

No special regularity was observed in the freely living caterpillars and hymenopterous larvae, but with the miners we recorded not only a change in the extent of damage in the studied three-year period, but also considerable differences between the transects. Members of the genus *Eriocrania* moved westwards in the Sněžník – Litvínov direction and similarly the casebearer which moved from the region of the forest district Sněžník via forest district Litvínov as far as the forest district Janov; in spite of its low share in damages in the forest district Klášterec it was here that we found the local gradation focus (Kula, 1997).

The altitude as a criterion for the evaluation of the average extent of damage of the leaf area of birch does not appear to be suitable. In the complex of the acting harmful factors, some of which prefer certain positions, the regularity of distribution of total losses is out of focus (Fig. 3). Neither phytophagous insects nor fungus pathogens on leaves cause the large-area disorder in birch flushing.

DISCUSSION

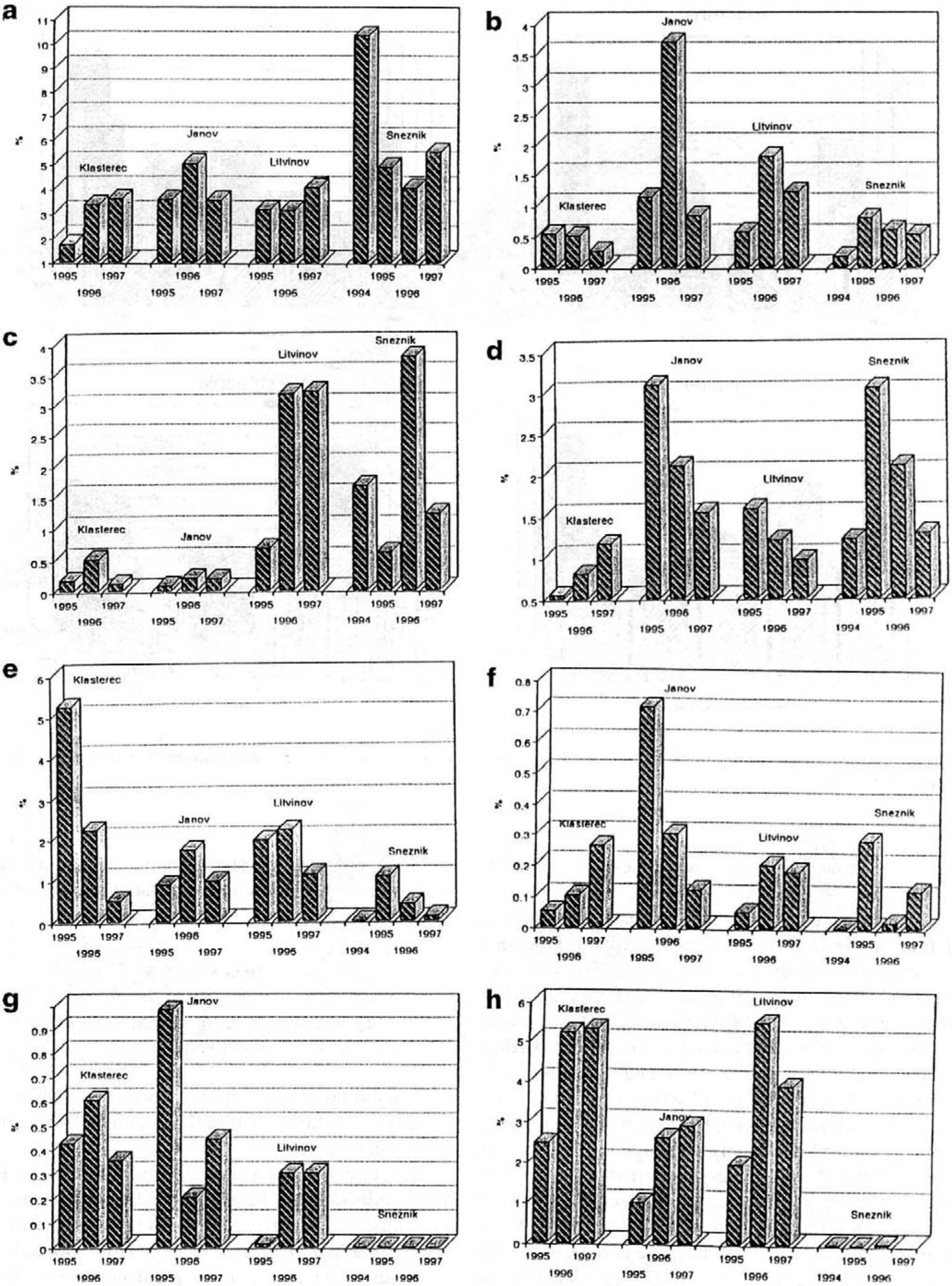
THE HYPOTHESIS OF CAUSES OF BIRCH UNFLUSHING

The mortality of birch buds occurred on large areas, it occurred suddenly and in the great part of this region it affected whole trees.

The direct factor could theoretically be the insect pest feeding on the buds (e.g. *Cydia penkleriana* Den. et Schiff.); its occurrence, however, was not confirmed and such a high degree of damage is not possible.

Among the indirect factors predisposing bud damage in winter we rank premature loss of leaves, the not maturing annual shoots and their winter kill.

We can eliminate the part of insect pests in premature leaf shedding because the development of the most important phytophagous species occurred in spring. The willow leaf beetle is retreating from older stands. The part of freely living caterpillars and hymenopterous larvae in the total losses was 5%. No large-scale gradation of insects was observed in summer.



4. Damage of the area of birch caused by freely living caterpillars and hymenopterous larvae (a), casebearers (b), miners of the genus *Eriocrania* (c), weevils (d), unspecified pollutant load (e), *Euryochara betulina* (f), *Discula betulina* spring (g) and summer (h) aspect in Ore Mts. and Děčín sandstone uplands (1995–1997)

Fungous diseases of leaves (*Discula betulina, Euryochara betulina*) are among the serious factors causing premature leaf shedding. With only a few exceptions, the total average extent of rusts was not high enough to cause large-scale unflushing of buds, even though its occurrence was higher on some control points, especially in the higher altitudes. This biotic factor seriously endangered the health condition of birch, particularly during warm and rainy years.

Disorders in nutrition of the birch stands was not proved. The increased level of sulphur in the higher altitudes is a long-term phenomenon (Vaníček, 1983) which was also confirmed by Kula, Hrdlička (1996).

The reduction of leaf waxes as a consequence of the negative impact of pollution is a serious factor predisposing attacks of birch leaves by insects, fungus pathogens and especially causing physiological disorders. The wax surface was strongly impaired in 1996 in the higher altitudes (700–900 m) (Bednářová, 1996). We still lack any comparisons with 1997 to be able to accept the conclusion that the reduction of wax in 1996 was quite common for the given region or that it was an extreme deviation.

In 1996 the SO_2, NO_x pollutant load was slightly higher than in 1995, but without extreme concentrations in the summer compared with long-term pollutant levels.

The 1995/1996 the physiological impact of rime causing the dieback of spruce stands was not reflected in the deciduous woody species.

From the above given biotic and abiotic injurious agents and their direct or indirect predisposition on the health condition of birch stands it follows that they did not cause the absence of spring flushing.

A potential cause could be the release of another type of pollutant which rose into the high altitudes of the Ore Mts. where its further dispersion was limited by low cloudiness. The high concentration of ethylene released into the atmosphere may have caused not only premature shedding of leaves but it also may have stopped the development of buds. The immature buds either froze in the winter or during winter warming-up they matured before their time and were destroyed by the following frosts or these buds, activated after long-lasting temperatures above the still frozen soil, had "breathed themselves out" and, as a consequence, had lost their energy and dried up. Since other tree species were not damaged it cannot be excluded that this pollution episode occurred in the sensitive period of formation of leaf buds or that in general the birch buds were considerably more sensitive to these pollutants than were other tree species where no damage was recorded in the studied region.

CONCLUSION

No principal reversal in the development of factors affecting the health condition of birch stands (insects, fungus pathogens) which might have been the direct cause or could have predisposed the unflushing of birch was found. Quantitative analysis of nutrient elements did not explain such an extensive physiological disorder either. The condition of epicuticular wax is evidence of the increased pollutant load in the highest areas of the Ore Mts. A hypothesis was expressed that a higher amount of non specific pollutants might have had an impact on birch at the time when new leaf buds were established and later they were maybe more sensitive to frost after warmer winter episode.

References

ANONYM, 1996. Technické vyjádření a. s. Chemopetrol Litvínov ke spalování plynu na polním hořáku olefinové jednotky při provozní poruše 19.–20. 8. 1996 (An expert of the Chemopetrol Litvínov Co. to gas combustion using the field burner of an olefin unit during a breakdown on 19–20 August 1996). Sdělení: 4.

BEDNÁŘOVÁ, E., 1996. Struktura vosků asimilačních orgánů břízy (Wax structure of birch assimilatory organs). [Výroční zpráva.] Brno, MZLU: 9.

JANEČEK, A., 1997. Průběh požáru v České rafinérské a. s. a jeho dopady na životní prostředí (The course of a fire in the Czech Refinery Co. and its impacts to the environment). [Závěrečná zpráva.] Okresní úřad v Mostě, referát životního prostředí: 45.

KOLEKTIV, 1996. Znečištění ovzduší na území České republiky v roce 1996 (Air pollution in the territory of the Czech Republic in 1996). ČHMÚ, úsek ochrany ovzduší, ISBN 80-85813-49-1. Praha, ČHMÚ: 148.

KUBELKA et al., 1992. Obnova lesa v imisemi poškozené oblasti severovýchodního Krušnohoří (Forest regeneration in the pollution-damage region of the NE Ore Mts.). Praha, MZe ČR: 132.

KULA, E., 1988. Hledisko ochrany v náhradních porostech břízy (The forest protection point of view in the substitute birch forest stands). Lesn. Práce, 71: 362–367.

KULA, E., 1997. Březové porosty krušnohorské oblasti a stupeň jejich ohrožení fytofágy (Birch stands in the Krušné hory Mts. area and the level of phytophage risk). Lesnictví-Forestry, 43: 193–200.

KULA, E. – HRDLIČKA, P., 1996. Stav výživy náhradních porostů břízy v imisní oblasti Krušných hor (The state of nutrition of the substitute stands of birch in the pollution-damage region of the Ore Mts.). [Závěrečná zpráva.] Brno, MZLU: 35.

KULA, E. – KAWULOK, T., 1998. Poškození porostů břízy námrazou v oblasti Lesní správy Sněžník (Damage to birch stands caused by rime in the Sněžník Forest Administration area). Lesnictví-Forestry, 44: 506–515.

VANÍČEK, L., 1983. K otázce odolnosti břízy v imisní oblasti Krušných hor (On the problem of birch resistance in the immissions area of the Ore Mts.). Lesn. Práce, 62: 159–162.

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POZNÁMKY K AKTUÁLNÍMU ZDRAVOTNÍMU STAVU POROSTŮ BŘÍZY V IMISNÍ OBLASTI KRUŠNÝCH HOR

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Krušnohorská oblast je dlouhodobě vystavena imisní zátěži s dominantním vlivem SO_2. Po r. 1979, kdy uhynuly porosty smrku, bylo rozsáhlé území zalesněno břízou (*Betula verrucosa* Ehrh.). Na jaře r. 1997 nevyrašila bříza ve vyšších polohách Krušných hor v rozsahu, který je možné považovat za další ekologickou katastrofu v této lesní oblasti.

Cílem příspěvku je posoudit aktuální zdravotní stav porostů břízy a na základě hodnocení faktorů ovlivňujících jejich zdravotní stav vyslovit hypotézu příčiny nevyrašení.

Předčasným usycháním a opadem listů byly postiženy porosty břízy na konci srpna a na začátku září v r. 1996. Na jaře 1997 se projevila porucha v rašení s tím, že v některých porostech nastala úplná absence olistění bez projevu regenerace z latentních pupenů.

Inventarizace takto poškozených porostů břízy byla provedena v severovýchodní části Krušných hor a v Děčínské pískovcové vrchovině. Bylo registrováno 265 ha silně poškozených porostů břízy a 1 640 ha porostů bylo klasifikováno jako poškozené a oslabené (tab. I). Symptomy tohoto poškození nebyly zaznamenány v oblasti Děčínské pískovcové vrchoviny a rovněž nejsou hlášeny ze západní části Krušných hor. Obecně byly postiženy porosty situované v nadmořské výšce 750–1 000 m nacházející se v náhorních plošinách Krušných hor a pouze z malé části na navazujících svazích (obr. 1).

Celkové průměrné jarní ztráty na asimilačních orgánech způsobené v r. 1997 fytofágními škůdci dosahovaly maximálně 12 % (LS Litvínov), zatímco v ostatních transektech pokleslo poškození pod 10 % (LS Janov 8,6 %, LS Klášterec 7,8 %, Sněžník 9,4 % – obr. 2).

Rozhodující podíl na ztrátě listové plochy měly volně žijící housenky a housenice ve všech sledovaných transektech a dále minovači rodu *Eriocrania* (obr. 3), kteří se výrazně vyskytovali v porostech LS Litvínov (3,2% podíl na ztrátách), kde byli doprovázeni pouzdrovníčkem stromovým (*Coleophora serratella* L. – 1,2 % – obr. 3). Nosatcovití se podíleli na poškození listů ve všech transektech sledované oblasti 1,0–1,5 % (obr. 3).

Dlouhodobé sledování zdravotního stavu porostů břízy v monitorovacích bodech čtyř výškových transektů naznačilo pozitivní vývoj vyjádřený poklesem celkových ztrát asimilačních orgánů (obr. 2) s výjimkou LS Litvínov, kde jsme zaznamenali vzestup, který byl způsoben zvýšeným podílem minovačů rodů *Eriocrania* a *C. serratella*.

Jestliže u volně žijících housenek a housenic se neprojevila zvláštní zákonitost, u minovačů jsme zaznamenali nejen změnu v rozsahu škod ve sledovaném tříletém období, ale výrazné rozdíly existují i mezi transekty. Zástupci rodu *Eriocrania* postupují západním směrem a podobně lze hodnotit pouzdrovníčka stromového, který se přesunul z oblasti LS Sněžník přes LS Litvínov až na území LS Janov, ale i přes nízký podíl škod na LS Klášterec zde bylo zaznamenáno lokální gradační ohnisko (Kula, 1997).

Hypotéza příčin velkoplošného nevyrašení porostů břízy

Faktorem s přímým dopadem by teoreticky mohl být hmyzí škůdce vyžírající pupeny, jehož výskyt však nebyl potvrzen.

K nepřímým faktorům predisponujícím poškození pupenů v zimním období řadíme předčasnou ztrátu listů, nevyzrávání letorostů a jejich vymrzání.

Podíl hmyzích škůdců na předčasném opadu listů můžeme vyloučit, neboť nejvýznamnější fytofágní druhy měly jarní vývoj. Bázlivec vrbový ustupuje ze starších porostů. Volně žijící housenky a housenice se na celkových ztrátách podílely 5 %. Žádná velkoplošná gradace hmyzu nebyla v letním období r. 1996 zjištěna.

Podíl houbového onemocnění listů (*Discula betulina*) se řadí k vážným činitelům působícím předčasný opad listů. Až na výjimky nebyl celkový průměrný rozsah výskytu rzí tak vysoký, aby mohl být příčinou velkoplošného nevyrašení břízy, i když na některých kontrolních bodech – zvláště ve vyšších polohách – bylo zvýšené zastoupení.

Úbytek listových vosků jako důsledek negativního dopadu imisí je vážným predispozičním faktorem k napadení listů břízy hmyzem a houbovými patogeny; především vyvolává fyziologické poruchy. Zvláště silné narušení voskového povrchu bylo zjištěno v r. 1996 ve vyšších nadmořských výškách (700–900 m) (Bednářová, 1996).

Imisní zátěž SO_2, NO_x byla v r. 1996 mírně zvýšená proti r. 1995, ale bez výskytu extrémních koncentrací v letním období proti dlouhodobým imisním hladinám.

Fyziologické dopady námrazy 1995/1996 vedoucí k odumření smrkových porostů se neprojevily na opadavých dřevinách.

Z uvedeného výčtu biotických a abiotických škodlivých činitelů a jejich přímé nebo nepřímé predispozice na zdravotní stav porostů břízy vyplývá, že nebyly příčinou jarního nevyrašení.

Jako možná příčina se jeví únik jiného typu polutantu, který vystoupal do vysokých náhorních poloh Krušných hor, kde jeho další rozptýlení bylo omezeno nízkou oblačností. Zvýšená koncentrace etylenu uvolněného do ovzduší mohla způsobit nejen předčasný opad listů, ale zastavit vývoj pupenů. Nevyzrálé pupeny v zimním období buď vymrzly, nebo při únorovém oteplení nastala jejich předčasná aktivace a následnými mrazy byly zničeny, nebo při zimním oteplení a zamrzlé půdě vydýchaly svou energii a uschly. Vzhledem k tomu, že nebyly poškozeny jiné dřeviny, není vyloučeno, že tato imisní epizoda nastala v citlivém období tvorby listových pupenů nebo že pupeny břízy byly obecně výrazněji citlivější k těmto polutantům než pupeny jiných dřevin, u nichž v postižené oblasti nebylo poškození zaznamenáno.

Závěrem můžeme konstatovat, že ve vývoji faktorů ovlivňujících zdravotní stav porostů břízy (hmyz, houboví patogeni) nebyl zjištěn zásadní zvrat, který by byl přímou příčinou nebo by predisponoval nevyrašení břízy. Kvantitativní analýza živinových prvků rovněž nepřinesla zdůvodnění takové rozsáhlé fyziologické poruchy. Stav voskových epikutikulárních povlaků je dokladem zvýšené imisní zátěže v nejvyšších polohách Krušných hor. Byla vyslovena hypotéza, že specifický fytotoxický dopad na břízu mohly mít ve vyšší míře zastoupené polutanty na bázi uhlovodíků v době, kdy se zakládaly nové listové pupeny, nebo v zimním období.

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TREE VIGOR AND BRANCHING PATTERN

ZDRAVOTNÍ STAV DŘEVIN A MORFOLOGIE VĚTVENÍ

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ABSTRACT: In this paper general methodical problems of vitality assessments of deciduous trees are discussed first; existing disparities or contradictions are pointed out if assessments based on "leaf loss" and based on crown structures are compared. The necessity of considering the branching pattern is substantiated and the methods developed to date are presented. With the help of the "shoot base scars", it becomes possible to reconstruct the crown development of the last 10 years, and in some species of decades. In every investigated (broad leaved) tree species there are four growth stages to discriminate: exploration, degeneration, stagnation, and retraction. These stages, which result in fundamental modifications of the branching structure, are due to (statistically significant) decreasing shoot lengths. Especially in the leafless state these different branching structures in the treetop are perceived from a distance (and in aerial photographs, as well). They are the basis of vitality assessment in four vitality classes. These classes were developed for 19 hardwood species. By using this approach which is based on branching structures a long-term chronic decrease of vitality can be recognized. Therefore, it is a practical method to use in detecting forest decline and to discriminate it from short-term influences (e.g. drought damages). Correlations between structural changes of the crown and radial growth as well as root development exist, as do genetic and silvicultural consequences.

branching pattern; shoot base scars; growth phases; vitality classes; crown structure

ABSTRAKT: V článku se diskutují obecné metodické postupy hodnocení vitality listnatých stromů a jsou naznačeny existující nesrovnalosti nebo rozpory v porovnání metod vycházejících ze „ztráty olistění" a metod vycházejících ze struktury koruny. Je zdůrazněn význam hodnocení struktury větvení; jsou prezentovány nově vyvinuté metody. Pomocí jizev na bázi výhonů je možné určit vývoj koruny během posledních 10 let, u některých druhů i za několik desetiletí. U každého zkoumaného listnatého stromu lze rozlišit čtyři růstové fáze: explorace, degenerace, stagnace a retrakce. Tyto fáze korelují (statisticky významně) se zkracováním výmladků, což se projevuje v základních změnách struktury větvení. Zvláště v období bez listů je možné z dálky (i na leteckých snímcích) vidět odlišné struktury koruny, které jsou základem hodnocení vitality ve čtyřech třídách. Tyto třídy byly vytvořeny pro 19 lesnicky významných druhů. Pomocí této metody, založené na struktuře větvení, je možné rozlišit dlouhodobý pokles vitality. Proto je to praktická metoda pro určení odumírání lesů a odlišení od krátkodobých vlivů (např. poškození suchem). Korelace mezi strukturálními změnami koruny, radiálním růstem a vývojem kořenů jsou doprovázené genetickými a pěstebními změnami.

struktura rozvětvení; jizvy na bázi výhonů; růstové fáze; třídy vitality; struktura koruny

INTRODUCTION

It is still very difficult to determine tree vitality and thereby the effects of acid disposition (e.g. in deciduous trees). The reason for this difficulty is due to the fact that until now most inventories considered only parameters such as "percentage leaf loss" and leaf coloring. Therefore, this paper will consider the branching and the crown structure of trees in the assessment of tree vitality. This consideration is also important for the interpretation of aerial photographs.

Among deciduous trees the European beech (*Fagus sylvatica* L.) is of particular interest, for its distribution ranges throughout Central Europe, and in many countries it represents the most important broadleaved tree species. Furthermore, it (naturally) grows on extremely different sites.

DECLINE SYMPTOMS OF TREE CROWNS: "LEAF LOSS" VERSUS CROWN STRUCTURE

The consideration of crown structures in the assessment of tree vitality became increasingly important. That scientists are now aware of the problem of "leaf loss" is shown in many studies (Roloff, 1986, 1989a,b; Flückiger et al., 1986, 1989; Perpet, 1988; Gies et al., 1986; Möhring, 1989; Richter, 1989; Westman, 1989). The number of leaves, and above all the leaf size, is subject to considerable annual fluctuations, for example, as a result of drought and insect damage or flowering and fructification, e.g. Thus crown thinness is inappropriate to the vitality assessment of deciduous trees to some degree. The correlation between "leaf loss" which is crown transparency and fructification has been well demonstrated (Flückiger et al., 1989). On the other hand, the foliage must also be considered. However, the leaf size varies greatly even within the same crown of a deciduous tree. Thus it is difficult to show a statistical significance in values between different trees (Roloff, 1986; Gies et al., 1986).

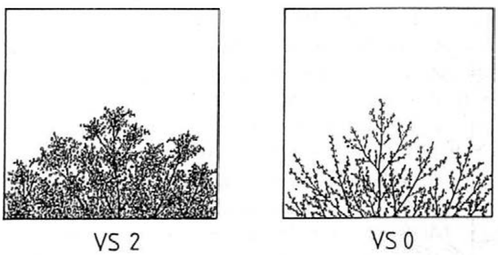
For this reason it is not surprising to find considerable disagreement between so-called "leaf loss" and crown structure (to be discussed later) which occurs when vitality assessments of the same beech trees are compared (Tab. I). Assessments may differ by up to two damage or vitality classes and agreement is only achieved in about 50% of the assessed trees (Hessische Forstliche Versuchsanstalt, 1988; Athari, Kramer, 1989a).

Therefore, it would be advantageous if the term "leaf loss" could be replaced by a different term (e.g. crown transparency) which does not lead to the misconception of shedded leaves. A deciduous tree showing a "leaf loss" of 30% does not mean that 30% of the leaves were shed. These leaves simply never existed at the beginning of the growing season (Roloff, 1986).

In this context there is one more aspect which should be mentioned for it has become particularly apparent in the most recent investigations. There is a great variety of tree species in which the crown, with increasing shoot lengths, becomes more transparent with better growth

I. Disagreements between a vitality assessment of beech trees based on leaf loss (damage classes) and crown structures (vitality classes) (n = 333, after Athari, Kramer, 1989)

Vitality class (crown structure)	Damage class (leaf loss)			Total
	0	1	2	
0	17	17	5	39
1	8	21	14	43
2	1	6	11	18
Total	26	44	30	100



1. Disagreement between a vitality assessment based upon crown transparency and crown structure (VS – vitality stage according to Roloff, 1989a): In many tree species (here: wild cherry) the crown becomes more transparent with better growth

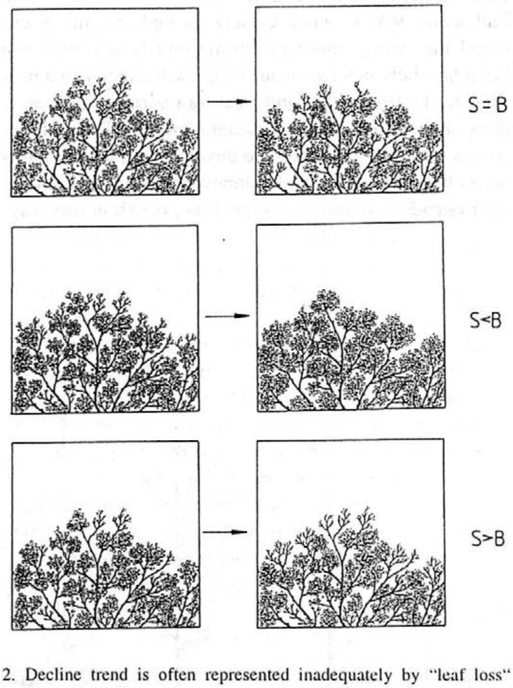
(Fig. 1). In this case a vitality assessment on the basis of crown transparency versus crown structure is bound to produce exactly opposite results (Roloff, 1989a,b).

A problem inherent to present inventories for the determination of decline progress is discussed by Möhring (1989). By using a series of photographs taken over a 5-year period of the same crown parts of beech trees, Möhring could show that due to dying-off and breakage of branches, decline trend is inadequately represented by "leaf loss". Thus, no change of damage class is noticed when the dying-off and shedding of branches happens simultaneously (Fig. 2).

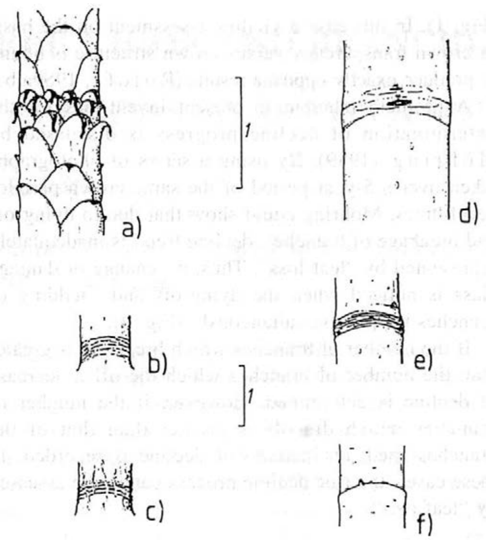
If the number of branches which break off is greater than the number of branches which die off a decrease of decline is determined. However, if the number of branches which die off is greater than that of the branches shed, an increase of decline is recorded. In these cases, the true decline process cannot be assessed by "leaf loss".

CHANGES IN THE CROWN STRUCTURE WITH DECREASING VITALITY

In this paper tree vitality is discussed in terms of growth potential which in trees is expressed in shoot growth. Although various branching structures within one tree crown have been known for long (see e.g. Büsgen, 1927; Thiebaut, 1981, 1988), their significance as a vitality indicator has only recently been discovered (Roloff, 1985).



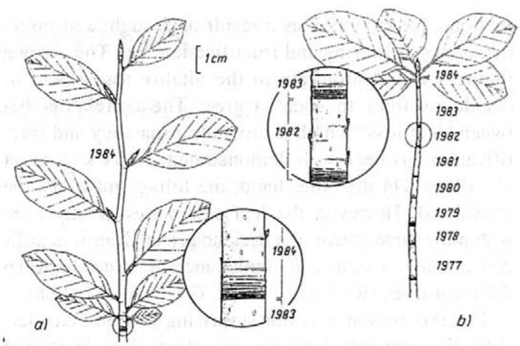
2. Decline trend is often represented inadequately by "leaf loss" because of a different time course of die-off (S) and breakage (B) of branches



3. Shoot base scars of Scotch pine (*a*), Sycamore (*b*), Norway maple (*c*), European ash (*d*), Oak (*e*), and Common willow (*f*) (scales in cm)

SHOOT MORPHOLOGY

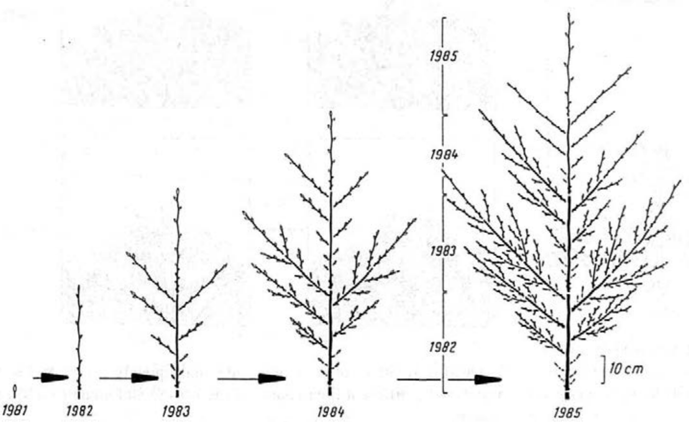
By careful observation of the branching pattern of a hardwood tree closely packed grooves upon the shoot surface can be recognized conspicuously (Fig. 3). The significance of these shoot-base scars has unfortunately been ignored for a long time. They are the scars of the bud scales which, when closely packed, originally encased the young shoot primordia and hence mark the boundary between two years of growth exactly to a millimeter. In beech the rind does not turn to bark as it does in oak but remains rather smooth. Thus, it becomes possible to retrace the development of any hardwood branching pattern for many years (in beech, e.g., over decades) and to reconstruct its growth in this way.



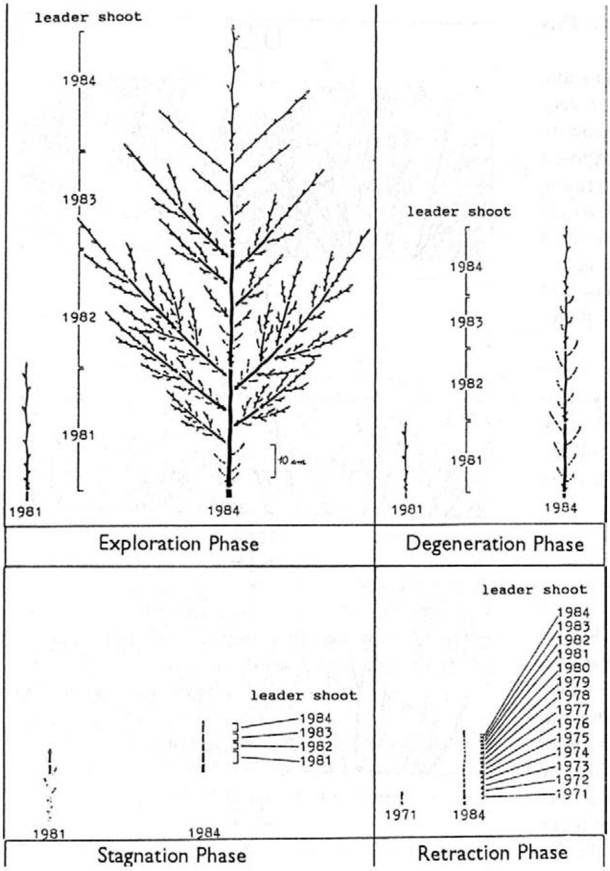
4. Shoot morphology of beech. (*a*) Long-shoot with shoot-base scar (circle), alternate distichous leaves and lateral buds, terminal bud; detail: shoot-base scar, the boundary between the annual shoots of 1983 and 1984. (*b*) A 9-year-old short-shoot chain without ramification and with a terminal cluster of leaves; detail: annual shoot boundaries, clearly marked by the shoot-base scars; dormant lateral buds (reserve buds)

Further investigation of the branching pattern in most tree species can be distinguished two kinds of shoots: short shoots and long shoots (Fig. 4). Short shoots are only a few millimeters or centimeters long, have only 3 to 5 leaves, and do not ramify during the following years because they bear only small dormant lateral buds. The terminal bud of short shoots, however, either produces a short shoot again the following season and short-shoot chains are formed, or else it returns to forming a long shoot. Long shoots are clearly longer, show more leaves, and ramify during the following year.

In any tree species the growth length of the treetop shoots, and therefore the height increment of the tree, decreases after passing a culmination point because of maturity. This finding reflects decreasing vigor in the tree. The lengths of treetop shoots are interpreted as a sign of vitality because the strategy of a forest forming tree species which strives to conquer new airspace



5. Detailed illustration of 4-year-old growth of a typically ramified beech (exploration phase)



6. Growth phases of beech (model): on the left the state of the leader in 1981, on the right its development and ramification after 3 years (1984) (annual boundaries marked by interruptions of the black lines)

must occur at the very top of the tree. On the other hand, the shoot lengths in the inner, lower, and lateral crown areas mainly depend on competition and light conditions, and are therefore unsuitable for the vigor assessment of a whole tree.

MODEL OF GROWTH STAGES

Fig. 5 shows how a typical ramification originates from a leader shoot of a vigorous beech. This ramification is similar in most other hardwoods with only few modifications. This "exploration phase" produces the branching structure that is known best and found most frequently: The terminal and upper lateral buds yearly develop long shoots, the lower lateral buds develop short shoots, and finally the lowest lateral buds do not shoot at all but remain as very small dormant buds for years preserved for unusual events.

On every annual leader shoot the lengths of the younger lateral shoots decrease from top to bottom and the developing branching pattern is turned upwards or forwards. In this way an obviously storied branch system is developed and the annual shoot boundaries (marked by the interruptions of the black lines in Fig. 5) can be distinguished even from a distance by the steps of the branching pattern and by the abrupt change of long lateral shoots to short shoots. This exploration phase is the widespread appearance of the leader shoots in healthy vigorous trees until an old age because this is the only way the treetop can fulfill its main purpose for the tree; i.e. to conquer new airspace steadily, to fill it up with lateral shoots, and to be successful against rival trees.

In the "degeneration phase" (Fig. 6), however, the terminal bud develops shorter long shoots, but from nearly any lateral bud (from the uppermost as well) short shoots arise almost without exception. Thereby an obvious impoverishment of the branching pattern takes place and spears are formed in the periphery of the crowns, which may also be seen from a great distance.

In the course of further decreasing vitality, even the terminal bud changes into developing short shoots. In this "stagnation phase" ramification ceases for short shoots do not ramify. Because of the short annual length of these shoots the length increment of the branch and the height increment, respectively, of the tree stagnates.

If this stagnation phase persists longer than a few years (if it is not only temporary), the branch or (if the treetop shoots are concerned) the treetop dies back. This stage is called the "retraction phase".

As a result of their disadvantageous mechanical-static features (a dense cluster of leaves at the end of very delicate shoots) the short shoot chains cannot grow to any length or any age in the upper crown area exposed to the wind. At this time secondary factors determine the exact time of dieback. At this stage typical claws are formed in the crown periphery because the short shoot chains which are getting longer stretch toward the light.

Now it becomes clear why the different phases of growing are due to decreasing shoot lengths and, therefore, reflect a decreasing vitality.

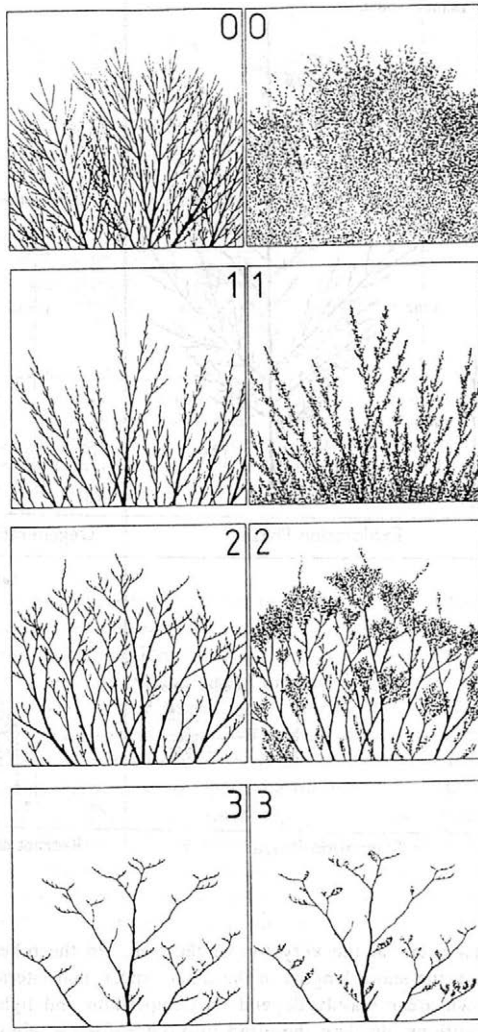
Similar growth phases can be identified in every other investigated broadleaved tree species, with only little species-dependant modifications, e.g. in oak, maple, ash, birch, willow, and others (R o l o f f, 1989a). The following vitality class system is developed basing on these growth phases.

VITALITY CLASSES

Healthy vigorous trees of "vitality class 0" (Fig. 7) show treetop shoots in the exploration phase: Both the main axes and part of the lateral twigs consist of long shoots. For this reason a regular netlike branching pattern is developed, which reaches deep into the interior of the crown. The crowns are equally closed and domed and do not show any greater gap unless a stronger intervention has occurred in the stand because such a gap is closed quickly by the intensive ramification. In this manner the newly conquered airspace is quickly filled by the harmonical branching pattern. In summer a dense foliage arises without any greater gap.

Weakened trees of the "vitality class 1" show treetop shoots in the degeneration phase. Thus, spears are formed rising above the canopy. The leaves on these spears are dense and go all around them (at the top of the lateral short shoots or short-shoot chains). The crowns make a frazzled impression on the outside and have a fastigiate appearance because the airspace between the spears is not completely filled by leaves and twigs, and the crown has a spikey outline. Inside the crown the branching pattern, and there with the foliage, is quite dense. In this vitality class straight percurrent main axes of the treetop branches are still dominant but the crowns no longer look as intact as in class 0 because of the spears shooting out of the canopy.

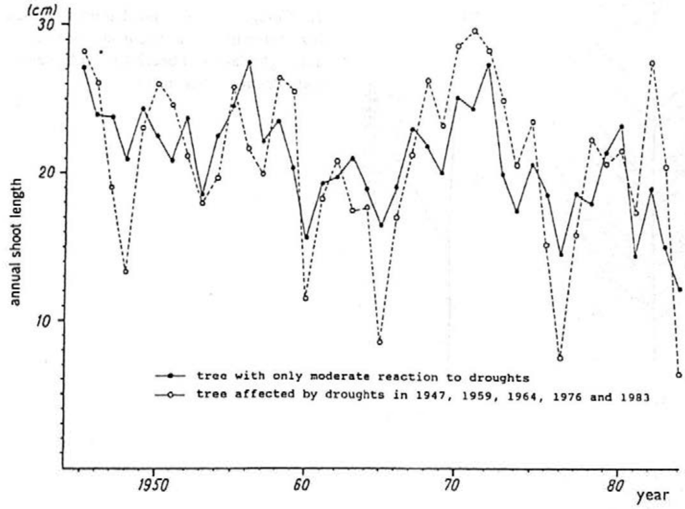
In the obviously declining trees of "vitality class 2" the treetop shoots begin to build short shoots in the stagnation phase. The leafless state could be designated as the claw stage because the short-shoot chains in the outside of the crowns grow longer, are predominant, and stretch clawlike to the light. These short-shoot chains which are growing too long break off in summer in thunderstorms and heavy rains and strew the forest floor in declining beech stands. Under normal circumstances beech as well as other tree species rid them-



7. Vitality classes in beech (view of the upper crown in winter and summer; based on the growth phases of Fig. 6)

selves of parts of their unimportant twigs in the inner and lower crown parts in this way. But if the treetop shoots themselves are declining the self-pruning of twigs progresses into the outskirts of the crown, and the crowns become thin from inside outwards. The cause for this occurrence is not premature leaf fall but broken short-shoot chains, lack of shoots, and dead buds and twigs. The branching pattern shows a bushy and lumpy accumulation in the periphery of the crown. This accumulation causes summer and winter bushy crown structures and greater gaps. The crown periphery still has hardly any straight percurrent branches.

In the considerably damaged or dying trees of "vitality class 3" the crowns finally fall apart by breaking off of larger branches and dieback of whole crown parts.



8. Annual length increment of the leader shoots of two 120-year-old beech trees, one of which clearly shows drought damages (very short shoots formed abruptly in the year following and extremely dry summer and afterwards quick recovery), whereas the other remained nearly unaffected

The tree seems to consist only of more or less surplus subcrowns dispersed randomly in the airspace and forming whiplike structures. The treetop is dying back often or already is dead because the treetop shoots grew in the retraction phase.

DROUGHT DAMAGE AND RELATIONSHIP OF THE PRESENTED VITALITY CRITERIA TO ENVIRONMENTAL FACTORS

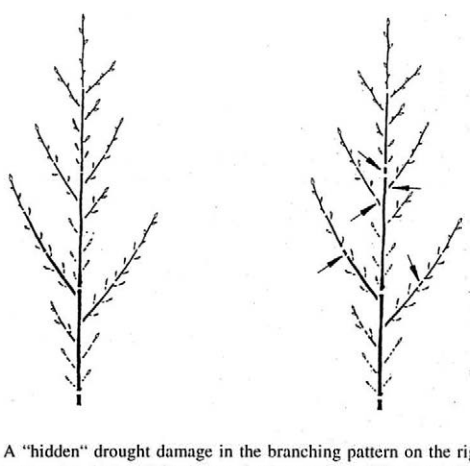
After the previous explanations, it should be self-evident that such a vitality class system based on criteria of the branching structures solely can result from a long-term chronic diminution of vigor.

Drought damage, for example, can influence branching only temporarily and does not lead to a fundamental variation of the branching structure. Drought damage can be indentified even after many years with the help of shoot scars because very short shoots are formed abruptly in the year after a dry summer (in species with determinated growth) and recover their original values quickly again the following season (Fig. 8).

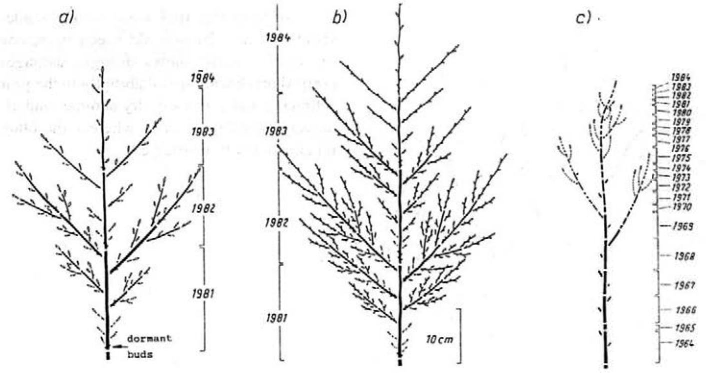
On the other hand, drought damage can cause a fundamental passing thinness of the foliage because of the premature leaf-fall during the current summer and smaller and fewer leaves in the following season. But from a distance it is impossible to recognize the temporary short shoots caused by a past drought (e.g. from ground level in a forest) and they cannot effect a fundamental modification of the branching structure (Fig. 9), whereas a chronic decrease of vitality (connected to a long-term decrease of the shoot lengths in the treetop) can cause a conspicuously different branching structure in hardwoods (Fig. 10). Of course, the best time for an exact assessment of vitality with the help of this method is after leaf-fall, in autumn and winter.

As only long-term influences can effect a fundamental modification of the branching pattern, this method is suitable to identify "forest decline" in hardwoods, because the recent rise in the decline of European and North American forests is supposed to be caused by existing and long lasting influences. Therefore, modifications of the branching structure are not exclusively specific to air pollution but for example are due to such long-term negative factors affecting tree growth such as air pollution. It is similar in almost all other symptoms of forest decline which are known to date: They can be caused by air pollution but may also be a result of other stress factors (Hanisch, Kilz, 1990; Hartmann et al., 1988).

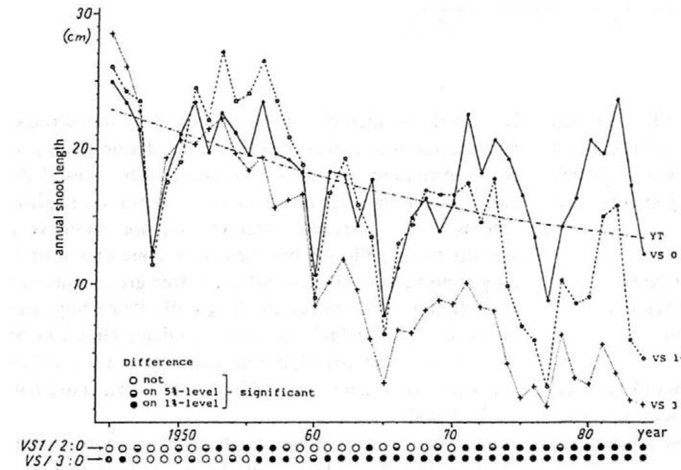
Surprisingly, further investigations of beech trees have clarified how long the decline in this important European hardwood species has been going on (Fig. 11). Only the vigorous, healthy trees of vitality class 0 (vs 0)



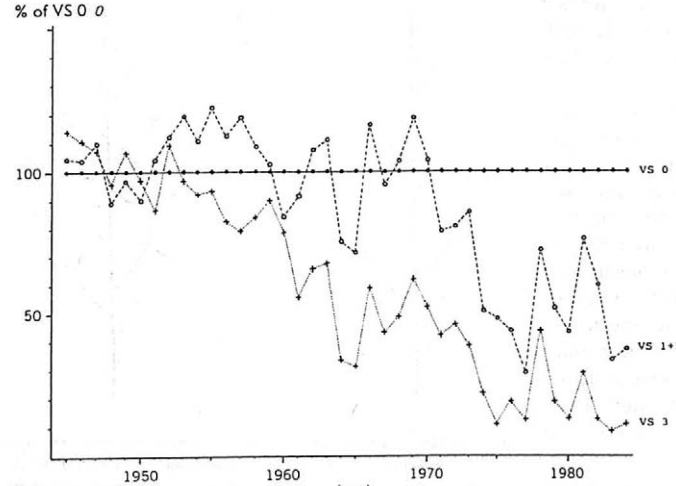
9. A "hidden" drought damage in the branching pattern on the right (see arrows) does not lead to a fundamental modification of the branching structure, but to a "delay" of 1 year compared with the unaffected one on the left



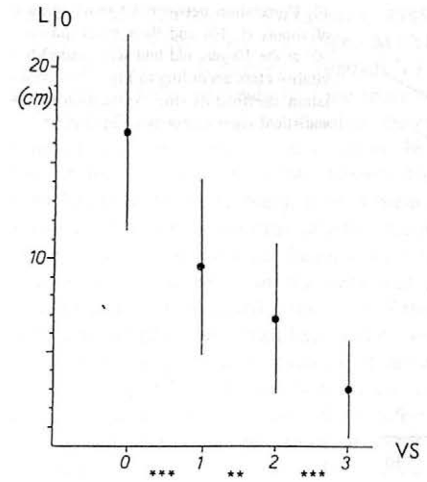
10. Comparison of typical treetop branching patterns of a vigorous beech (*b*), a drought damaged beech (*a*), and a chronically declining beech (*c*)



11. Annual length increment of the leader shoots of 100–160-year-old beech trees during the last 40 years (classified by vitality classes according to Figs. 9, 7: VS – vitality stage, YT – expected trend according to the yield tables, VS 0: n = 140, average age 131 years, VS 1 + 2: n = 279, average age 132 years, VS 3: n = 141, average age 134 years)



12. Annual length increment of the leaders as in Fig. 11, but the vitality classes (VS) 1 + 2 and 3 are in per cent of the annual value of VS 0 (VS 0 in each year as 100%)



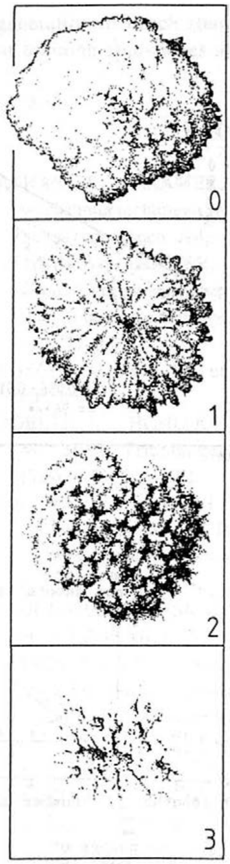
13. Average annual length increment of the leaders of different vitality classes (VS) in the last 10 years (L_{10}) (mean value, standard deviation, and statistical significance of the difference, * significant on 5%-level, ** on 1%-level, *** on 0.1%-level)

follow the age trend of the yield tables, whereas trees of the vs 1–3 decline many years later. Transforming the absolute values of the leader increment into values in per cent of vs 0 (Fig. 12) emphasizes that trees of vs 1 + 2 have in most cases been in decline for about 10–15 years and trees of vs 3 have declined for about 20–25 years. Another way to show the long-term differences between the vigor of trees of different vitality classes is the average annual length increment of the leader shoots during the last 10 years (Fig. 13). This diagram emphasizes the expressiveness of the presented vitality class system again.

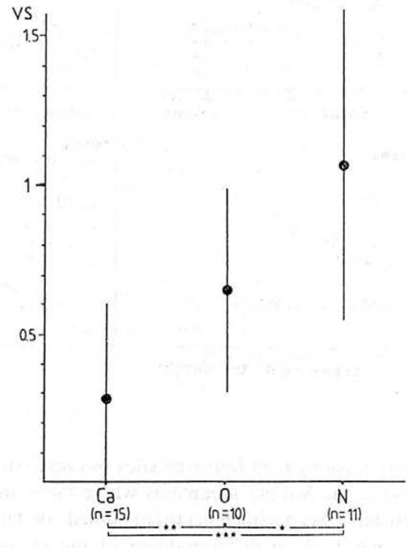
This system which is based on crown structures may also be used successfully in aerial photographs, thus making it possible to cover a larger area in a shorter time (Runkel, Roloff, 1985, see Fig. 14).

Recent research in 18 other hardwoods has shown the possibility of assessing the vitality of other tree species of the northern hemisphere in the same way as reported here for beech trees. In these hard-woods only very few species-dependent modifications must be taken into account. This research was conducted for *Betula pendula, B. pubescens* (Roloff, 1989b; Westman, 1989), *Acer platanoides, A. pseudoplatanus, A. saccharum, Aesculus hippocastanum, Alnus glutinosa, Carpinus betulus, Fraxinus excelsior, Fagus americana, Prunus avium, Q. robur, Robinia pseudoacacia, Salix caprea, Tilia cordata, T. platyphyllos* (Roloff, 1989a).

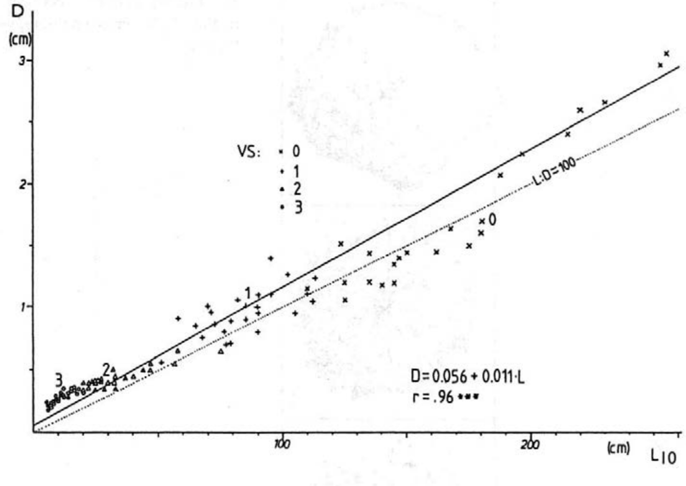
The vitality class key for beech trees was approved and applied in a variety of investigations (Lonsdale, 1986; Lonsdale, Hickman, 1988; Dobler et al., 1988; Hessische Forstliche Versuchsanstalt, 1988; Gies et al., 1986; Stribley, 1993).



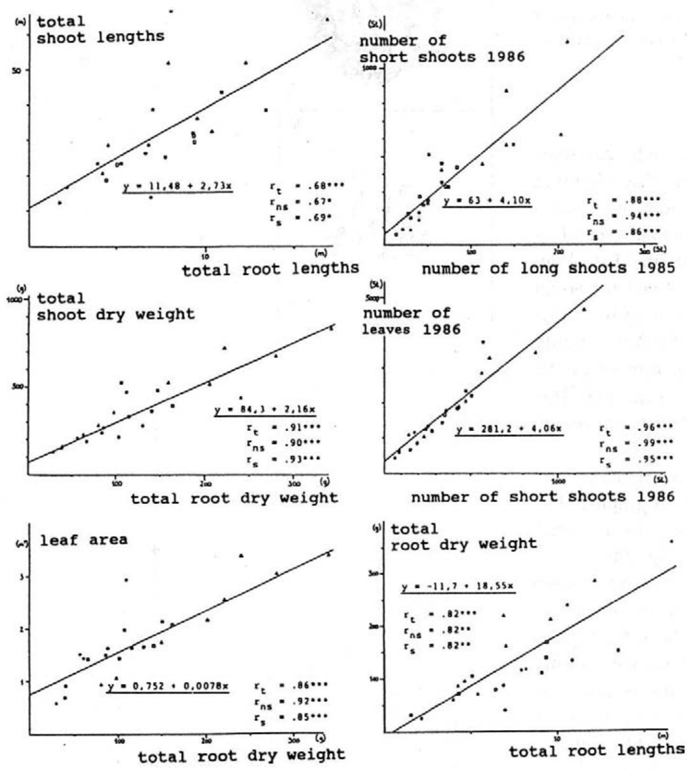
14. Vitality classes (according to Fig. 7) in aerial photographs (beech)



15. Vitality classes (VS) according to Fig. 7 of beech trees on fertilized sites in the Solling mountains in Germany (set up in the early 1980s) with acidified (N), limed (Ca), and untreated (O) plots (for explanation of the statistical significance see Figs. 9, 13)



16. Correlation between 10 year's growth of shoots (L 10) and their basal diameter (*D*) at the 10-year-old bud scale scar (VS – vitality class according to Fig. 7, *r* – correlation coefficient) (for explanation of the statistical significance see Fig. 13)



17. Results and interrelationships of crown and root parameters in excavated 2 m high beech trees [*y*: linear regression, r_t: correlation coefficient total and for sylleptic (r_s) and non-sylleptic trees (r_{ns}), circle: site 1, triangle: site 2, square: site 3; full symbols: sylleptic trees, blank symbols: non-sylleptic trees] (for explanation of the statistical significance see Fig. 13)

Interestingly enough, on fertilized sites (set up in the early 1980s) in the Solling mountains where there are plots which have been either acidified, limed, or left untreated since 1980, a differentiation of the crown structures of beech trees is just beginning to emerge (Fig. 15).

EFFECTS ON RADIAL GROWTH, CORRELATIONS WITH ROOT DEVELOPMENT, AND GENETIC, AS WELL AS SILVICULTURAL, CONSEQUENCES

Although a close correlation between vitality class (on the basis of crown structure) and radial growth of branches of the crown does exist (Fig. 16; R o l o f f, 1989a), it is difficult to correlate with radial growth at breast height (Gärtner, Nassauer, 1985; Wahlmann et al., 1986; Perpet, 1988; Mahler et al., 1988; Athari, Kramer, 1989a,b; Fischer, Rommel, 1988), particularly if the space of the trees investigated is not considered. Possible reasons for this generally unexpected discrepancy will not be discussed here (refer to Roloff, 1986, 1989a). However, it must be pointed out that the growth at breast height as a vitality indicator is not only problematic in the case of beech trees. On the other hand, close relationships were found if the space of the trees was taken into account and if investigated trees were of the same vitality class based on both "leaf loss" and crown structure.

The correlation between changes of the crown and root growth which unfortunately require a considerable amount of research are of particular interest. A legitimate assumption is that the presented modifications of the branching structure are related to similar modifications of the root system because recent research has shown the high correlations between both of these components of the "system tree". By proceeding on the hypothesis that the crown and root development of a tree are related, a tree can be considered as an integrated system of interdependant relationships. On three very different sites 24 beech trees of 2 m height were completely excavated and quantitatively analyzed (Roloff, 1989a; Roloff, Römer, 1989). For these trees (apart from soil data) the following parameters were determined: total leaf number, total leaf area, average leaf size, number of short and long shoots developed in different years, total shoot lengths, total root lengths exceeding a root diameter of 2 mm, total shoot dry weight, total root dry weight exceeding a root diameter of 2 mm, age of plant, and rooting depth.

In almost all cases unexpectedly high significant correlations between all crown and root parameters were found (Fig. 17). This correlation emphasizes the fact that no phenomenon, neither the crown development nor the root-crown interaction, is purely accidental but that the entire tree represents an integrated regulated system in which every change of one parameter immediately induces changes in other parameters of the crown and/or the root system. Neither the age of the tree (9–31 years) nor the site have a considerable influence on the relationships within the crown and between crown and roots of 2 m high beech trees.

Genetic consequences are presented by Müller-Starck, Hattemer (1989). In beech trees they found (on the basis of crown structure) a decreasing genetic variety (heterozygotic grade and genetic diversity, respectively) with a decreasing vitality of the tree, assessed by the method presented. Accordingly, only beech trees of high genetic variety survive stress without suffering obvious damage.

Finally, changes of the crown structure of stressed beech trees may also have silvicultural consequences (Dobler et al., 1988; Hessische Forstliche Versuchsanstalt, 1988). As the canopy becomes more transparent after thinning, it is difficult to regulate natural regeneration of beech stands selectively. A modification of thinning approaches and methods were suggested.

References

ATHARI, S. – KRAMER, H., 1989a. Problematik der Zuwachsuntersuchungen in Buchenbeständen mit neuartigen Schadsymptomen. Allg. Forst- Jagdztg, 160: 1–8.

ATHARI, S. – KRAMER, H., 1989b. Beziehungen zwischen Grundflächenzuwachs und verschiedenen Baumparametern in geschädigten Buchenbeständen. Allg. Forst- Jagdztg, 160: 77–83.

BÜSGEN, M., 1927. Bau und Leben unserer Waldbäume. 3rd ed., Jena.

DOBLER, D. – HOHLOCH, K. – LISBACH, B. – SALIARI, M., 1988. Trieblängen-Messungen an Buchen. Allg. Forstz., 43: 811–812.

FISCHER, H. – ROMMEL, W.-D., 1988. Jahrringbreiten und Höhentrieblängen von Buchen mit unterschiedlicher Belaubungsdichte in Baden-Württemberg. Allg. Forstz., 43: 264–265.

FLÜCKIGER, W. – BRAUN, D. – FLÜCKIGER-KELLER, H. – LEONARDI, S. – ASCHE, N. – BÜHLER, U. – LIER, M., 1986. Untersuchungen über Waldschäden in festen Buchenbeobachtungsflächen der Kantone Basel-Landschaft, Basel-Stadt, Aargau, Solothurn, Bern, Zürich und Zug. Schweiz. Z. Forstwes., 137: 917–1010.

FLÜCKIGER, W. – BRAUN, S. – LEONARDI, S. – FÖRDERER, L. – BÜHLER, U., 1989. Untersuchungen an Buchen in festen Waldbeobachtungsflächen des Kantons Zürich. Schweiz. Z. Forstwes., 140: 536–550.

GÄRTNER, E. J. – NASSAUER, K. G., 1985. Aktuelles zur Waldschadenssituation in Hessen. Allg. Forstz., 40: 1265–1271.

GIES, T. – BRAUN, S. – FLÜCKIGER-KELLER, H. – LEONARDI, S., 1986. Untersuchungen über Waldschäden in festen Buchen- Beobachtungsflächen. Schweiz. Z. Forstwes., 137: 917–1010.

HANISCH, B. – KILZ, E., 1990. Monitoring of forest damage. Stuttgart.

HARTMANN, G. – NIENHAUS, F. – BUTIN, H., 1988. Farbatlas Waldschäden. Stuttgart.

HESSISCHE FORSTLICHE VERSUCHSANSTALT, 1988. Waldschadenserhebung 1988. Hann-Münden.

LONSDALE, D., 1986. Beech Health Study. For Comm. Res. Dev. Pap., 149: 1–15.

LONSDALE, D. – HICKMAN, I. T., 1988. Beech health study. For. Res., 23: 42–44.

MAHLER, G. – KLEBES, J. – HÖWECKE, B., 1988. Holzkundliche Untersuchungen an Buchen mit neuartigen Waldschäden. Allg. Forst- Jagdztg, 159: 121–125.

MÖHRING, K., 1989. Wuchsstörungen und Absterben in den Kronen einiger Buchen im Solling. Allg. Forstz., 44: 113–116.

MÜLLER-STARCK, G. – HATTEMER, H. H., 1989. Genetische Auswirkungen von Umweltstress auf Altbestände und Jungwuchs der Buche. Forstarchiv, 60: 17–22.

PERPET, M., 1988. Zur Differentialdiagnose bei der Waldschadenserhebung auf Buchenbeobachtungsflächen. Allg. Forst- Jagdztg, 159: 108–113.
RICHTER, J., 1989. Stand der Buchenschäden nach den Waldschadenserhebungen in Nordrhein-Westfalen. Allg. Forstz., 44: 760–763.
ROLOFF, A., 1985. Schadstufen bei der Buche. Forst u. Holz, 40: 131–134.
ROLOFF, A., 1986. Morphologie der Kronenentwicklung von *Fagus sylvatica* L. (Rotbuche) unter besonderer Berücksichtigung möglicherweise neuartiger Veränderungen. Ber. Forschungszentr. Waldökosysteme, Göttingen, 18: 1–177.
ROLOFF, A., 1989a. Kronenentwicklung und Vitalitätsbeurteilung ausgewählter Baumarten der gemäßigten Breiten. Frankfurt.
ROLOFF, A., 1989b. Entwicklung und Flexibilität der Baumkrone und ihre Bedeutung als Vitalitätsweiser. Schweiz. Z. Forstwes., 140: 775–789, 943–963.
ROLOFF, A. – RÖMER, H.-P., 1989. Beziehungen zwischen Krone und Wurzel bei der Buche (*Fagus sylvatica* L.). Allg. Forst- Jagdztg, 160: 200–205.
RUNKEL, M. – ROLOFF, A., 1985. Schadstufen bei der Buche im Infra-rot-Farbluftbild. Allg. Forstz., 40: 789–792.
STRIBLEY, G. H., 1993. Studies on the health of beech trees in Surrey, England: Relationship between winter canopy assessment by Roloff's method and twig analysis. Forestry, 66: 1–26.
THIEBAUT, B., 1981. Formation des rameaux. In: TESSIER DU CROS, E. (ed.), Le Hetre. Paris: 169–174.
THIEBAUT, B., 1988. Tree growth, morphology and architecture, the case of beech: *Fagus sylvatica* L. In Comm. Eur. Communities (ed.), Scientific basis of forest decline symptomatology. Brüssel: 49–72.
WAHLMANN, B. – BRAUN, E. – LEWARK, S., 1986. Radial increment in different tree heights in beech stands affected by air pollution. IAWA Bull., 7: 285–288.
WESTMAN, L., 1989. A system for regional inventory of damage to birch. Poster Intern. Kongreß Waldschadensforschung Friedrichshafen/Bodensee 2.–6. 10. 1989.

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CHANGE IN THE CONDITION OF NORWAY SPRUCE FORESTS AFTER THE INSTALLATION OF DESULPHURIZATION DEVICES AT THE ŠOŠTANJ THERMAL POWER PLANT

ZMĚNY VE ZDRAVOTNÍM STAVU SMRKOVÝCH POROSTŮ V BLÍZKOSTI TEPELNÉ ELEKTRÁRNY ŠOŠTANJ PO JEJÍM ODSÍŘENÍ

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ABSTRACT: In a study carried out in 1996, the state of a forest ecosystem was evaluated by analysis of Norway spruce [*Picea abies* (L.) Karst.], the most common, local/Slovenian forest tree species, after desulphurization of exhaust gases from unit 4 of the Šoštanj Thermal Power Plant (ŠTPP). The consequence of reduced SO_2 emissions was a smaller annual mean ambient air concentration of SO_2 and a corresponding lower accumulation of sulphur in spruce needles in 1996. In 1996 increased defensive mechanisms could be observed in spruce, as shown by an increased content of ascorbic acid in needles in comparison with previous years. An increased vitality of spruce was also evident from the increased content of photosynthetic pigments and the ratio of chlorophyll a to chlorophyll b. The improvement can be partly attributed to the reduced emissions from ŠTPP, and partly to more favourable climatic conditions in that year. The results presented show that the ecological improvement programme of the Šoštanj Thermal Power Plant, on which over 180 million DEM has been spent, has been in great measure accomplished. The projects connected with clean-up of stack gases resulted in a lowering of annual SO_2 emission from 90,000 tons to 51,000 tons in 1996. Nitrogen emission were reduced from an average before 1991 of 11,000 tons to an average of 9500 tons in 1996. Fly ash emission was reduced from 5000 tons in 1994 to 1850 tons in 1996. Preparation for construction of a desulphurization plant for unit 5 of the ŠTPP, which also includes reconstruction of the electrofilters, is in full swing and is expected to be in operation by the year 2000. With the introduction of primary measures to reduce concentrations of nitrogen oxides in unit 5 in the year 2000, the ecological sanitation plan for Šoštanj Thermal Power Plant, in which around 360 million DEM will have been invested, should be completed.

Norway spruce; emissions; nitrogen oxides; sulphur dioxide

ABSTRAKT: Při studiu prováděném v r. 1996 byl hodnocen stav lesního ekosystému pomocí analýzy smrku ztepilého [*Picea abies* (L.) Karst.], nejrozšířenější místní (slovinské) lesní dřeviny, po odsíření kouřových plynů z bloku 4 tepelné elektrárny Šoštanj. V důsledku poklesu emisí SO_2 byla v r. 1996 zaznamenána nižší průměrná koncentrace SO_2 v ovzduší a s tím související nižší akumulace síry v jehličí smrku. V r. 1996 bylo u smrku pozorováno posílení obranných mechanismů, indikované zvýšeným obsahem kyseliny askorbové v jehličí ve srovnání s předchozími roky. Vyšší vitalita smrku byla také zřejmá z vyššího obsahu fotosyntetických barviv a z poměru chlorofylu a/b. Zlepšení lze připisovat zčásti sníženému množství emisí z elektrárny a zčásti příznivějším klimatickým podmínkám v daném roce. Předložené výsledky ukazují, že program pro zlepšení životního prostředí, který provádí tepelná elektrárna Šoštanj a na nějž bylo vynaloženo více než 180 milionů DEM, byl do značné míry splněn. Projekty zaměřené na vyčištění kouřových plynů vedly v r. 1996 ke snížení ročního množství emisí z 90 000 tun na 51 000 tun. Emise dusíku klesly z průměrné hodnoty 11 000 tun před r. 1991 na průměrnou hodnotu 9 500 tun v r. 1996. Emise popílku se snížily z 5 000 tun v r. 1994 na 1 850 tun v r. 1996. Přípravy na vybudování odsiřovacího zařízení pro blok 5 této elektrárny, které zahrnuje také rekonstrukci elektrofiltrů, jsou v plném proudu a jeho uvedení do provozu se očekává do r. 2000. Ekologický ozdravný program pro tepelnou elektrárnu Šoštanj, v jehož rámci bude investováno kolem 360 milionů DEM, by měl být dokončen se zavedením základních opatření ke snižování koncentrace oxidů dusíku v bloku 5 v r. 2000.

smrk ztepilý; emise; oxidy dusíku; kysličník siřičitý

INTRODUCTION

The Thermal Power Plant in Šoštanj (ŠTPP) is one of the major sources of air pollution with sulphur dioxide, nitrogen oxides and dust particles in Slovenia (Stropnik et al., 1993). It is located in the valley bottom at an altitude of 300 m in the central northern part of Slovenia. The western slopes of the valley reach 1550 m while the eastern are lower and reach only 900 m. The valley is well ventilated except on the occasion of stable anticyclonic weather when air circulation is low. In such circumstances two temperature inversions are established, one at an altitude of 1000 m and the other at 1200 m. Besides these, a temperature inversion ca. 100 m above the valley bottom is established. The thermal power plant has been active for more than forty years, and air pollution by SO_2, NO_x and dust caused several negative effects in the surrounding forests (Lešnjak et al., 1989; Batič, Kralj, 1989; Druškovič, 1989; Ribarič-Lasnik, Batič, 1990).

The impact of air pollution on forests has been investigated in several studies carried out or coordinated by the Slovenian Forestry Institute and other research organizations, as well as by the local community, the local unit of the Slovenian Forestry Service and by the polluters. Forest damage was assessed using standard methods (Kolar, 1989; Belec, 1992; Batič et al., 1993; Batič, 1994; Batič et al., 1996; Letno. por., 1996), especially after the year 1985, when the effects of air pollution on forests were expressed more drastically after very cold winters preceeded by dry and hot summers. The negative effects of exhaust gases on forest growth was proved by tree ring increment studies (Ferlin, 1990), and negative consequences on the forest ecosystem were determined using several bioindication methods, e.g. epiphytic lichen studies (Batič, Kralj, 1989; Batič et al., 1993), chromosomal damage of Norway spruce root tips (Druškovič, 1989), studies of mycorrhiza (Kraigher, 1994; Al Sayegh-Petkovšek et al., 1992), study of plant hormone relations (Kraigher et al., 1995; Dent, Hanke, 1995), studies of photosynthetic pigments and stress response mechanisms such as increased or decreased content of water soluble thiols and ascorbic acid, activity of peroxidase and total sulphur content of Norway spruce needles (Kalan, 1991; Batič, 1991; Ribarič-Lasnik, 1991; Batič et al., 1995; Ribarič-Lasnik, 1996; Ribarič-Lasnik et al., 1996; Tausz et al., 1996). Analyses of forest soils (Urbančič, 1989, 1996) and the study of mineral nutrition of Norway spruce show that the impact of air pollution is still more pronounced on the aerial part of the ecosystem than in forest soils due to the moderately short duration and low intensity of air pollution, except for some very polluted sites in the near vicinity of the plant (Simončič, 1992, 1996). These investigations showed the commencement of negative effects in forest soils such as the mobilization of soluble cations like Ca^{++}, Mg^{++}, and K^+ in the upper soil horizons, leading to depletion of these elements and to the impoverishment of soils and later to lower productivity of the systems. Upper layers of forest soils also contain more sulphur in sites within the inner emission zone (Veliki vrh, Topolšica, Zavodnje) and less in more distant sites (Osankarica), or in sites which are protected from stack gases (Pirešica) (Urbančič, 1989, 1996; Simončič, 1992, 1996). The input of air pollutants in forest ecosystem was also studied by analyses of rainfall and soil water quality; the results showed an increased content of elements like Al, As, Ba, Br, Fe, Cd, Co, Cu, Sb and Zn in precipitations and accumulation of elements like Cd, Cr, Fe, Mn, NH_4^+, Pb, Rb, Sb, Se and Zn in spring water in more polluted forest sites such as Zavodnje and Veliki vrh (Svetina-Gros, 1994). It was also proved that the input of pollutants was much greater in forests than in grasslands and other open areas, and significantly higher in Norway spruce stands than in stands with prevailing beech (Simončič, 1996). On the basis of all these investigations in our study the most suitable bioindication methods were chosen to monitor the state of forests and other vegetation within the emission zone of ŠTPP.

MATERIAL AND METHODS

Norway spruce [*Picea abies* (L.) Karst.] was chosen as a bioindicator organism (Arndt et al., 1987), and its needles were sampled for several analyses to monitor the impact of air pollution on the forest ecosystem. According to geographical and meteorological circumstances spruce needles were sampled regularly on two profiles laid over the valley with the thermal power plant at the bottom and extending into the outer emission zone. One profile was in the W–E direction, from Smrekovec (1550 m) to Veliki vrh (350 m) and other in the S–N direction (Veliki vrh – Kope 1500 m). Norway spruce needles were sampled in early autumn each year, from five apparently healthy Norway spruce trees (defoliation from 0 to 20%) at each site, from the top of the tree crown (seventh whirl, counting from the top). Sampling of needles and their processing prior to analyses were carried out according to Bermandinger et al. (1990) and described in Batič et al. (1995) and by Ribarič-Lasnik (1996). Photosynthetic pigments and ascorbic acid were determined by HPLC by using the method described by Pfeifhofer (1989) and Bui-Nguyen (1980), water soluble thiols after the method described by Grill, Esterbauer (1973). Total sulphur content was determined conductometrically with a SULMHOMAT 12-ADG instrument (Stefan, 1985). Emissions and ambient levels of pollutants were measured by standard methods by the group from the Thermal Power Plant.

RESULTS

Measurements of the emission of SO_2 from the ŠTPP and the ambient concentrations of SO_2 at chosen sites, the analyses of total sulphur content, the content of chlorophylls and ascorbic acid in Norway spruce needles were made for the period from 1991 to 1996. Desulphurization devices on unit 4 of ŠTPP were installed at the beginning of 1995, and sampling in that year was the first sampling after the beginning of the desulphurization of stack gases.

Emissions of sulphur dioxide from the ŠTPP in the period from 1991 to 1996 are presented in Tab. I.

The data show that emission dropped from 80,757 t $SO_2.year^{-1}$ in 1991 to 51,804 t $SO_2.year^{-1}$ in 1996. The reduction in emission is quite significant. The effect of reduced emissions of SO_2 is also evident in the ambient air concentrations of SO_2 at five sites where such levels were measured. The data are presented in Tab. II. The effect of desulphurization on the ambient levels is not as strong as that for measured emissions but still obvious. The reduced ambient concentration is also manifested by the smaller total sulphur content of current year needles of Norway spruce, especially on sites more distant from the thermal power plant like Kope, Brneško sedlo, Kramarica and Smrekovec, but less in the sites close to the pollution source like Veliki vrh, Zavodnje and Topolšica. These data are presented in Tab. III.

The same trend is also observed when comparing sulphur content classes, computed together for current and one year old needles. The data are presented in Tab. IV.

In this case, very polluted sites like Zavodnje and Veliki vrh do not show any improvement, because common classes of total sulphur content are not so precise measures as separate measurements.

Data for ascorbic acid and total chlorophyll content in current year needles are presented in Figs. 1, 2. There is a trend of increasing ascorbic acid content after desulphurization at all sites, and also an increase of chlorophyll content (Fig. 2) and an increase of chlorophyll a to chlorophyll b (Fig. 3) is also detected.

The pattern of contents of water soluble thiols does not show so clear a tendency (Fig. 4). All these changes in the content of biochemical parameters of Norway spruce vitality are in agreement with the reduction of total sulphur content in current year needles, although the trend of reduction is not very great (Fig. 5).

I. Emissions from the ŠTPP in the period from 1991 to 1996 (Annual ŠTPP Report, 1996)

Year	1991	1992	1993	1994	1995	1996
Tons $SO_2.year^{-1}$	80,757	94,120	86,101	80,516	51,663	51,804

II. Mean annual SO_2 concentration in $\mu g.m^{-3}$ (Annual ŠTPP Report, 1996)

Sites	1991	1992	1993	1994	1995	1996
Šoštanj	40	53	51	41	29	34
Topolšica	40	58	55	34	20	20
Zavodnje	50	55	47	49	26	33
Graška gora	30	42	47	50	27	28
Velenje	20	20	20	13	6	10
Veliki vrh	80	76	58	53	49	57

III. Total sulphur content in current year needles in per cent of dry weight (n = 5) – sampling years

Sampling sites	1991	1992	1993	1994	1995	1996
Smrekovec	0.139	0.145	0.142	0.15	0.111	0.134
Kramarica	0.162	0.188	0.169	–	0.132	0.150
Zavodnje	0.157	0.161	0.169	0.16	0.152	0.166
Topolšica	0.189	0.214	0.181	–	0.160	0.157
Lajše	0.184	0.201	0.199	–	0.151	0.154
Veliki vrh	0.213	0.247	0.151	0.25	0.169	0.161
Laze	0.142	0.139	0.153	–	0.142	0.124
Graška gora	0.145	0.157	0.219	–	–	–
Brneško sedlo	0.133	0.140	0.157	0.13	0.110	0.123
Kope	0.126	0.135	0.140	–	0.095	0.107

IV. Common classes of total sulphur content in current and one year old needles, sampled in the period 1991–1996

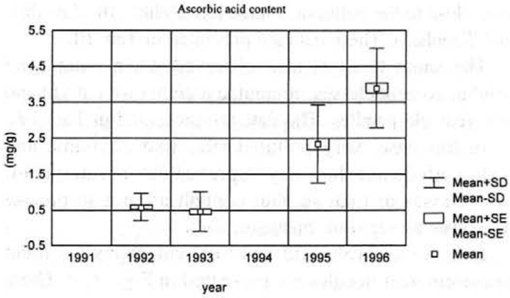
Sampling sites	1991	1992	1993	1995	1996
Smrekovec	3	3	3	2	3
Kramarica	4	4	4	3	3
Zavodnje	4	4	4	4	4
Topolšica	4	4	4	4	3
Lajše	4	4	4	4	4
Veliki vrh	4	4	3	4	4
Laze	3	3	4	2	3
Graška gora	3	3	4	–	–
Brneško sedlo	3	3	3	2	3
Kope	3	3	3	1	3

Legend 1: Adapted marginal levels reguired for ther classification of the sulphur content classes in current year and one year old Norway spruce needles determined by the SULMHOMAT 12-ADG instrument

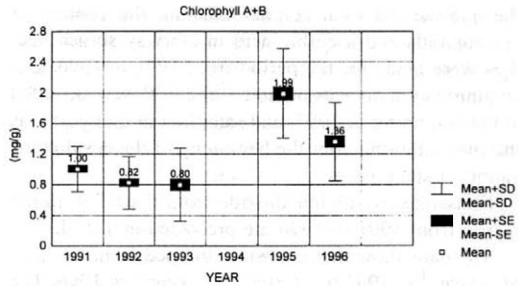
	Sulphur content (mg S) in %	
Sulphur content classes	current year needles	one year old needles
1	≤0.097	≤0.114
2	0.098–0.123	0.115–0.149
3	0.124–0.158	0.150–0.192
4	>0.158	>0.192

Legend 2: Marginal levels for total classes of sulphur content in current and one year old needles

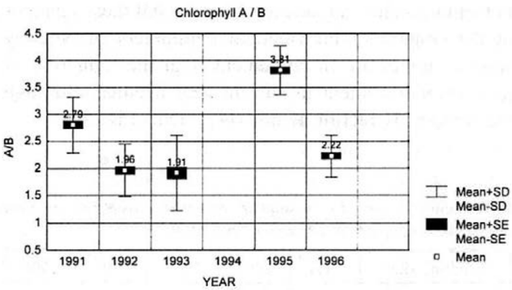
Total sulphur content class	Sum total of classes of S-content in current and one year old needles of Norway spruce
1	2
2	3 and 4
3	5 and 6
4	7 and 8



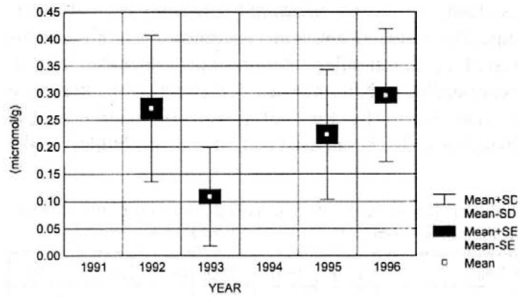
1. Pattern of ascorbic acid in current year needles during the period 1991–1996



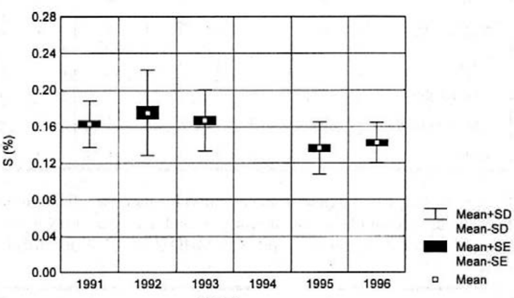
2. Pattern of total chlorophyll content in current year needles in the period 1991–1996



3. Pattern of ratio chlorophyll a/chlorophyll b in the period 1991–1996



4. Pattern of water soluble thiols content in the current year needles in the period 1991–1996



5. Total sulphur content in current year needles

DISCUSSION AND CONCLUSIONS

Desulphurization of exhaust gases from ŠTPP had a significant effect on air quality in the area. Installation of cleaning devices on the stacks of unit 4 of ŠTPP caused a strong reduction of SO_2 emission. A reduction of ambient air levels was also observed, although not so pronounced. The effect was also detectable in decreased total sulphur content and increased content of chlorophyll and ascorbic acid in current year needles. These findings mean better vitality of trees and an improved condition of forest stands (Bermandinger et al., 1990; Batič et al., 1995; Ribarič-Lasnik, 1996; Tausz et al., 1996, etc.). Partly, this can also be explained by more favourable weather conditions in the last two years, but the increased level of favourable vitality parameters is accompanied by the decrease of sulphur content and reduced emissions. From these preliminary results the following conclusions could be drawn:

- The chosen biochemical parameters are a suitable tool for assessing the improvement in the condition of forests after the installation of desulphurization and Norway spruce needles could be suitable accumulative and reactive bioindicator (Arndt et al., 1987; Ribarič-Lasnik, 1996; Tausz et al., 1996).
- Several bioindicators are necessary to get an overview of the overall improvement after the installation of clean-up devices. For the forest ecosystem, the analyses used, combined with measurements of pollutants, could be a solid component of operational monitoring of the environment status around thermal power plants.
- A set of bioindication methods was recommended to the authorities responsible for the environmental regulation as an operational monitoring system.
- Apart from already used bioindication method, some others should also be implemented to detect other stresses and to assess the effect of desulphurization

in other components and levels of forest and other ecosystems.

References

ARNDT, U. – NOBEL, W. – SCHWEIZER, B., 1987. Bioindikatoren. Stuttgart, Ulmer: 388.

AL SAYEGH-PETKOVŠEK, S. – KRAIGHER, H. – BATIČ, F., 1992. Mycorrhizal potential of two forest research plots in the immission area of Thermoenergetic Power Plant Šoštanj (North Slovenia). XI Congress of European Mycologist, Kew, England.

BATIČ, F. – KRALJ, T., 1989. Bioindikacija onesnaženosti zraka z epifitsko lišajsko vegetacijo pri inventurah propadanja gozdov. Zbornik gozd. les., 34: 51–70.

BATIČ, F., 1991. Analyse der photosynthetischen Pigmente. Forschung der Waldökosysteme und der forstlichen Umwelt. Bericht über die Forschungszusammenarbeit Slowenien – Österreich. Ljubljana, Institut für Forst- und Holzwirtschaft: 110–116.

BATIČ, F. – JURC, D. – KOVAČ, M. – KRALJ, T. – MIKULIČ, V. – ŠOLAR, M., 1993. Impact of Pollution Gases from Thermal Power Plant in Šoštanj, Slovenija, on Forest Environment: A Brief Expertise on Cause-consequence Relationship in Forest Decline Studies Carried out at the Slovenian Forestry Institute. Gozdarski inštitut Slovenije, Ljubljana: 36.

BATIČ, F., 1994. Bioindikacija onesnaženosti zraka in njen pomen pri vzpostavitvi integralnega monitoringa. In: Varstvo zraka. Stanje in ukrepi za izboljšanje stanja v Sloveniji. Bled, 28–30. 3. 1994. Zavod za tehnično izobraževanje, Ljubljana: 12/01–12/10.

BATIČ, F. – GRILL, D. – KALAN, P. – RIBARIČ-LASNIK, C., 1995. Impact of emission gases from the thermal power plant in Šoštanj on the biochemical structure of Norway spruce needles [*Picea abies* (L.) Karst.]. Acta Pharm., 45, No. 2, suppl. I: 191–197.

BATIČ, F. – RIBARIČ-LASNIK, C. – KOPUŠAR, N. – VIDERGAR, N. – CIGLAR, R. – ČUHALEV, I. – BIENELLI, A., 1996. Monitoring of the effects of ozone on agricultural plants within the ICP-Crops in Slovenia. Supl. Zb. Biotehniške fak., 23: 4–9.

BERMANDINGER, E. – GUTTENBERGER, H. – GRILL, D., 1990. Physiology of young Norway spruce. Envir. Poll., 68: 319–330.

BELEC, Z., 1992. Vrednotenje metode popisa propadanja gozdov na nekaterih rastiščih mariborskega gozdnogospodarskega območja. Magistrska naloga. Ljubljana, Oddelek za agronomijo, BF, Univerza v Ljubljani: 119.

BUI-NGUYEN, M. H., 1980. Application of high performance liquid chromatography to the separation of ascorbic acid from the isoascorbic acid. J. Chromatogr., 196: 163–165.

DENT, R. – HANKE, D. E., 1995. The effect of pollution on the cytokinin content of Norway spruce needles. In: KRAIGHER, H. et al. (eds.), Proc. of the BIOFOSP, Ljubljana, 22–31 August 1995: 89–93. GIS, Oddelek za agronomijo BF, Ljubljana.

DRUŠKOVIČ, B., 1989. Ocena poškodovanosti rastlinskega genetskega materiala v Šaleški dolini z obrobjem. Raziskovalna naloga. Inštitut za biologijo Univerze v Ljubljani.

FERLIN, F., 1990. Vpliv onesnaževanja ozračja na rastno obnašanje in rastno zmogljivost odraslih smrekovih sestojev. [Magistrsko delo.] Univerza Edvarda Kardelja v Ljubljani, BF, VTOZD za gozdarstvo, Ljubljana.

GRILL, D. – ESTERBAUER, H., 1973. Quantitative Bestimmung wasserloslicher Sulfhydrylverbindungen in gesunden und SO_2-geschädigkten Nadeln von *Picea abies*. Phyton (Austria), 15: 87–101.

KALAN, J., 1991. Einwirkung des Kraftwerkes auf Boden und Vegetation. Forschung der Waldökosysteme und der forstlichen Umwelt. Bericht über die Forschungszusammenarbeit Slowenien – Österreich. Ljubljana, Institut für Forst- und Holzwirtschaft: 70–88.

KOLAR, I., 1989. Umiranje smreke v gozdovih Šaleške doline. [Magistrsko delo.] Univerza v Ljubljani, Biotehniška fakulteta, VTOZD za gozdarstvo, Ljubljana.

KRAIGHER, H., 1994. Citokinini in tipi ektomikorize pri sadikah smreke [*Picea abies* (L.) Karst.] kot kazalci onesnaženosti gozdnih rastišč. [Doktorsko delo.] Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za agronomijo, Ljubljana.

KRAIGHER, H. – BATIČ, F. – AGERER, R., 1995. Types of ectomycorrhizae and mycobioindication of forest site pollution. Phyton, 35 (3): 115–120.

LEŠNJAK, M. – HRČEK, D. – BATIČ, F. – ŠOLAR, M. – KOLAR, I. – FERLIN, F., 1989. Air pollution and damage on vegetation near TE Šoštanj thermal power plant in Slovenia. 8th World Clean Air Congress, den Haag.

LETNO POROČILO TEŠ, 1996. Termoelektrarna Šoštanj.

PFEIFHOFER, H. W., 1989. On the pigment content of Norway spruce needles infected with *Chrysomyxa rhodendendri*, and the carotenoids of the fungus *Aeciospores*. Eur. J. For. Path., 19: 363–369.

RIBARIČ-LASNIK, C. – BATIČ, F., 1990. Air pollution and physiological parameters of Norway spruce *Picea abies* (L.) Karsten in surroundings of the Coal-Fired Plant Šoštanj. 4th International Conference Environmental Contamination. Barcelona, Španija.

RIBARIČ-LASNIK, C., 1991. Ekofiziološke lastnosti smreke [*Picea abies* (L.) Karsten] na vplivnem območju Termoelektrarne Šoštanj. [Magistrska naloga.] Univerza v Ljubljani, Biotehniška fakulteta, VTOZD za biologijo, Ljubljana.

RIBARIČ-LASNIK, C., 1996. Ugotavljanje stresa pri smreki (*Picea abies* L. Karsten) na osnovi biokemijskih analiz iglic na vplivnem območju Termoelektrarne Šoštanj. [Doktorska disertacija.] Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za biologijo, Ljubljana.

RIBARIČ-LASNIK, C. – BATIČ, F. – GRILL, D., 1996. Investigation of Physiological Responses in Norway Spruce Needles to Natural and Anthropogenic Factors. Phyton, 36 (3): 43–46.

SIMONČIČ, P., 1992. Razmere mineralne prehrane za smreko na distričnih rjavih tleh na tonalitu v vplivnem območju TE Šoštanj. [Magistrsko delo.] Biotehniška fakulteta, Oddelek za agronomijo, Ljubljana.

SIMONČIČ, P., 1996. Odziv gozdnega ekosistema na vplive kislih odložin s poudarkom na preučevanju prehranskih razmer za smreko [*Picea abies* (L.) Karsten] in bukev (*Fagus sylvatica* L.) v vplivnem območju TE Šoštanj. [Doktorska disertacija.] Univerza v Ljubljani, Biotehniška fakulteta, Oddelek za gozdarstvo, Ljubljana: 156.
STROPNIK, B. – BYRNE, A. R. – SMODIŠ, B., 1993. Air pollution monitoring by ED XRF in the Šalek valley: part 1. Acta Chim. Slovenica, 40 (4): 301–330.
STEFAN, K., 1985. Bioindikatornetz Kärnten. Ergebnisse der Schwefelanalyse. Forstliche Bundesversuchanstalt, Wien.
SVETINA-GROS, M., 1994. Vpliv padavin na tla in vodne izvire na območju Termoelektrarne Šoštanj. [Magistrsko delo.] Fakulteta za naravoslovje in tehnologijo, Oddelek za montanistiko, Odsek za geologijo, Ljubljana.
TAUSZ, M. – GRILL, D. – GUTTENBERGER, H., 1996. The use of physiological parameters of spruce needles as a bioindication tool. Phyton (Austria), 36 (3): 31–34.
URBANČIČ, M., 1989. Lastnosti gozdnih tal na tonalitu in na andezitnem tufu v imisijskem območju Termoelektrarne Šoštanj. [Ekspertiza.] Inštitut za gozdno in lesno gospodarstvo pri Biotehniški fakulteti v Ljubljani.
URBANČIČ, M., 1996. Proučevanje onesnaženosti gozdnih tal v imisijskem območju šoštanjske termoelektrarne s parno-primerjalnimi raziskovalnimi objekti. Gozd. V., 54 (2): 73–89.

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THE EFFECTS OF ENHANCED UV-B RADIATION ON THE PHOTOSYNTHETIC CHARACTERISTICS OF NORWAY SPRUCE [*PICEA ABIES* (L.) KARST.] TREES GROWING IN FIELD CONDITIONS

VLIV ZVÝŠENÉ INTENZITY UV-B RADIACE NA FOTOSYNTETICKOU CHARAKTERISTIKU SMRKU ZTEPILÉHO [*PICEA ABIES* (L.) KARST.] PĚSTOVANÉHO V POLNÍCH PODMÍNKÁCH

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ABSTRACT: A group of five-year-old cloned Norway spruce [*Picea abies* (L.) Karst.] seedlings were grown in field conditions at the Experimental Research Site, Bílý Kříž, situated in the Beskydy Mts. (Czech Republic, NE Moravia, 49°30' N, 18°32' E, 943 m a.s.l.). Half of them were exposed to elevated levels of UV-B radiation that simulated a 25% decrease of the stratospheric ozone layer. A lamp modulated system was used in this experiment. Photosynthetic characteristics were estimated by examining current shoots after one month and three months of exposure, respectively. Using gas exchange and chlorophyll fluorescence measurements, A/Ci and A/I response curves, and biochemical model parameters, the photorespiration and photochemical efficiency of photosystem II was estimated. Electron transport, Rubisco activity, and enzymes from the Calvin cycle appear to be the most sensitive to UV-B or the synergic influence of the other stresses, especially low temperatures, that affect the CO_2 fixation level.

UV-B radiation; Norway spruce; photosynthesis; biochemical model; fluorescence

ABSTRAKT: Pětileté řízkované sazenice smrku ztepilého [*Picea abies* (L.) Karst.] byly pěstovány na Experimentálním ekologickém pracovišti Bílý Kříž v Beskydech (Česká republika, SV Morava, 49°30' s. š., 18°32' v. d., 943 m n. m.). Za použití systému modulovaných zářivek byla polovina sazenic vystavena zvýšené intenzitě UV-B záření simulující 25% pokles koncentrace stratosférického ozonu. Měření fotosyntetických charakteristik bylo provedeno na jednoletých výhonech po jednom a třech měsících expozice. Gazometrickými metodami byly stanoveny A/Ci a A/I křivky fotosyntézy, parametry biochemického modelu a rychlost fotorespirace. Fotochemická účinnost fotosystému II byla stanovena na základě měření fluorescence chlorofylu. Jako citlivé na UV-B a další synergicky působící stresy, zejména nízkou teplotu, se prokázaly být především transport elektronů, aktivita Rubisca a aktivita enzymů Calvinova cyklu.

UV-B radiace; smrk ztepilý; fotosyntéza; biochemický model; fluorescence

INTRODUCTION

A continuing decline in stratospheric ozone concentrations stimulated interest in the consequences of increased penetration of ultraviolet-B (UV-B, 290–320 nm) radiation on the Earth's surface. Many plants, especially in the seedling stage, are detrimentally affected by solar UV-B. UV-B may be classified as a stress factor or a source of adaptive information for plants (Caldwell, Flint, 1994). Because the concentration of ozone in the atmosphere varies significantly throughout the entire year and there are also seasonal variations when ozone column thickness reaches a maximum in the early spring and a minimum in the late fall, the synergic effects of enhanced UV-B radiation and frost temperatures can be expected in autumn months.

Plant reactions to UV-B are dependent on the amount of absorbed UV-B and the environmental conditions surrounding plant growth. Additionally, considerable differences occur between varying plant species. UV-B radiation reduced plant height, dry weight (Basiouny et al., 1977), net CO_2 uptake (Stewart, Hoddinott, 1993), stomatal density (Naidu et al., 1993), and total chlorophyll content (Basiouny et al., 1977).

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Structural disturbances of the thylakoid membrane (Brandle et al., 1977), reaction centers of photosystem II (Iwanzik et al., 1983), electron transport compounds (Melis et al., 1992), Rubisco enzyme (Jordan, 1993), and nucleic acids (Coohill, 1989) caused by UV-B radiation were previously observed. An increase of UV-absorbing pigments, specifically flavonoids, is typical manifestation for UV-treated plants (Coohill, 1989).

Because of their longevity, forest trees can play an important role in regards to the effectiveness of biointegrators present in all environmental effects. Therefore, it seems to be useful to observe effects of UV-B radiation on the level of forest stands.

MATERIALS AND METHODS

Plant material

A group of five-year-old cloned Norway spruce [*Picea abies* (L.) Karst.] seedlings were grown in plastic pots with natural soil consisting of a sand-clay composition under field conditions at the Experimental Research Site, Bílý Kříž, situated in the Beskydy Mts. (Czech Republic, NE Moravia, 49°30' N, 18°32' E, 943 m a.s.l.) – see Kratochvílová et al. (1989) for detailed information. A control group of 40 seedlings were exposed to an ambient UV-B – control variant (C). A second group (40 seedlings) was exposed to enhanced UV-B radiation which was 25% higher than the actual UV-B – exposed variant (E). The seedlings were exposed to these conditions between 15. 7. and 20. 10. 1995. A lamp modulated system was used for the UV-B treatment (Caldwell et al., 1983).

Gas exchange measurements

Two identical current shoots from five trees were used to calculate measurements during the entire season. The first measurement was taken after one month (C8, E8 variants) and the second one after three months of UV-B exposure (C11, E11 variants).

A closed photosynthetic portable system LI-6200 (LI-COR Inc., USA) was used to measure the relationship between A/Ci, biochemical model parameters, and photorespiration. The light response curves (A/I) were measured by an open gas exchange system CIRAS-1 (PP-System, UK). Standard conditions in the assimilation chamber were kept constant (temperature of needles: 23 ± 3 °C; relative air humidity: 55 ± 5%) – see Marek et al. (1995) for detailed information.

Chlorophyll fluorescence measurement

A fluorometer PAM 101, 102, 103 (H. Walz, Germany) was used for the Fv/Fm ratio measurement. Five to eight needles from two current shoots were removed at 7:30 in the morning. The upper sides of the needles were exposed to a saturating pulse (1s) after dark adaptation (30 min) (Kalina et al., 1994).

Statistical data processing

The A/Ci and A/I curves were calculated using the FOTOS program (Pirochtová, Marek, 1991). Therefore, for each treatment, a set of 10 curves and related parameters were obtained and statistically calculated. The statistical significance of the differences between the C and E variants was based on the *F*-test and *t*-test of mean values. The analysis was conducted using analytical tools from the EXCEL program package.

I. Parameters of net photosynthetic rate – internal CO_2 concentration response (A/Ci)

Variant		A_{sat}	Γ_C	Θ	R_S	τ	LS	LM
C8	mean	a 16.53	d* 97.68	0.86	5.18	f 0.055	i 32.19	l 67.80
	st. dev.	1.62	6.50	0.04	0.46	0.007	2.75	2.75
E8	mean	a, c 12.54	e 122.69	0.91	5.25	g 0.049	j* 37.11	m* 62.89
	st. dev.	1.41	28.02	0.03	1.01	0.009	2.52	2.52
C11	mean	b 13.68	d* 168.23	0.90	5.33	f 0.033	h, i 46.72	k, l 53.27
	st. dev.	1.63	13.72	0.03	0.90	0.007	5.83	5.83
E11	mean	b, c 8.65	e 183.36	0.63	4.37	g 0.025	h, j* 57.28	k, m* 42.73
	st. dev.	1.21	20.56	0.15	0.63	0.004	6.11	6.11

A_{sat} – saturated rate of CO_2 uptake [$\mu mol(CO_2).m^{-2}.s^{-1}$]
Γ_C – compensation CO_2 concentration [$\mu mol(CO_2).mol^{-1}$]
Θ – saturation rate [dimensionless]
R_S – rate of CO_2 evolution in the light at zero Ci [$\mu mol(CO_2).m^{-2}.s^{-1}$]
τ – carboxylation efficiency [$mol.m^{-2}.s^{-1}$]
LS, LM – stomatal and mesophyll limitations of photosynthesis [%]
C8 (C11) – control variants without enhanced UV-B radiation in August (November)
E8 (E11) – exposed variants by +25% of UV-B radiation in August (November). The same letter indicate significant differences (on the level of 95%, $P < 0.05$), asterisks mean high statistical differences (on the level of 99%, $P < 0.01$) ($n = 10$)

II. Input parameters of biochemical model of Rubisco activity

Variant		Γ		R_D^*		R_L	
C8	mean	a	91.76	d, f*	0.65	g*	2.39
	standard deviation		13.89		0.18		0.20
E8	mean	a, c*	62.20	d	1.17	h*	2.34
	standard deviation		11.32		0.37		0.13
C11	mean	b*	73.26	e*, f*	2.21	g*	3.62
	standard deviation		8.42		0.23		0.31
E11	mean	b*, c*	127.18	e*	1.20	h*	3.43
	standard deviation		10.11		0.14		0.21

Γ^* – compensation CO_2 concentration without photorespiration [$\mu mol(CO_2).mol^{-1}$]
R_D^* – rate of non-photorespiratory CO_2 efflux in the light [$\mu mol(CO_2).m^{-2}.s^{-1}$]
R_L – rate of photorespiration [$\mu mol(CO_2).m^{-2}.s^{-1}$]
C8 (C11) – control variants without enhanced UV-B radiation in August (November)
E8 (E11) – exposed variants by +25% of UV-B radiation in August (November). The same letter indicate significant differences (on the level of 95%, $P < 0.05$), asterisks mean high statistical differences (on the level of 99%, $P < 0.01$) ($n = 10$)

RESULTS

A/Ci response curves

Significant changes were observed in some of the A/Ci curve parameters caused by enhanced UV-B radiation and other stresses (Tab. I). There were statistically significant ($P < 0.05$) decreases of A_{sat} values for C8 compared to E8 (24%), C11 compared to E11 (36.8%), and E8 compared to E11 (31%). The difference between the C8 and C11 variants (17%) was statistically insignificant. A high increase of Γ_C was observed between the E8 and E11 (49%) and C8 and C11 variants (71%), as well as a decrease in carboxylation efficiency (τ): 49.4% for the E variants and 39.1% for the C variants, respectively. The saturation rate (Θ) and the light respiration rate (R_S) changed insignificantly. The stomatal limitation (LS) decreased during the season by 45% ($P < 0.05$) for C and by 54.4% ($P < 0.01$) for the E variant. A statistically significant decrease (22.6%) caused by the UV-B treatment was observed in E11 compared to the C11 variant.

Biochemical model

The input parameters of biochemical model, Γ* – compensation CO_2 concentration without the photorespiration and R_D* – rate of non-photorespiratory CO_2 efflux in the light, were significantly changed by enhanced UV-B radiation (Tab. II). The calculated output parameters of the model were decreased in UV-treatment variants compared to control variants in both of the measured time periods of exposure (Tab. III).

Photorespiration

There were no significant differences in the rate of photorespiration in the control variant compared to the exposed one. High statistically significant decreases were observed for C (51%) and E (46.6%) variants in November compared to August (Tab. II).

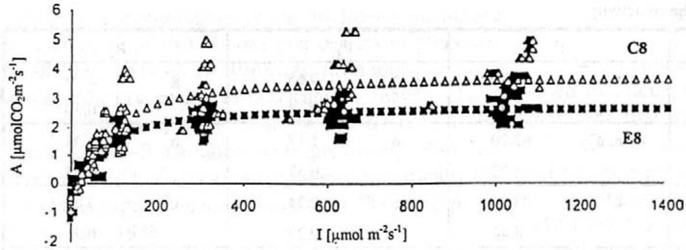
A/I response curves

The parameters of light response curves (Figs. 1, 2), such as the light compensation point Γ_I and dark respiration R_D, were not affected by the UV-B treatment. A high statistically significant decrease was observed in the A_{max} value for the exposed variants E8 (32.3%) and E11 (51.5%) compared to C8 and C11, respectively. A significant decrease (20.5%) was observed in this parameter regarding the E11 variant compared to the E8 variant. Photochemical efficiency (α) was significantly decreased by UV-B radiation in August (5.5%). In November α was higher (10.7%) in the control variant

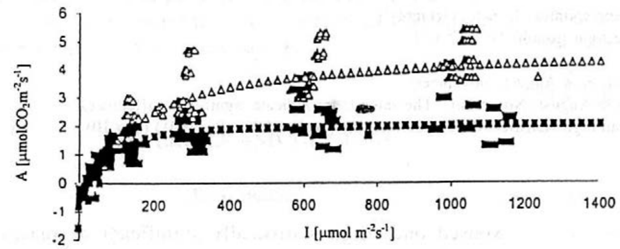
III. Calculated parameters of biochemical model of Rubisco activity. Values were calculated for C_i 350 $\mu mol(CO_2).mol^{-1}$

Variant	V_c	V_o	V_{rubp}	J_a	J_{carb}	$V_o = \%V_c$
C8	14.40	7.55	21.95	81.80	11.280	52.43
E8	8.21	2.92	11.13	50.42	7.920	35.54
C11	6.44	2.69	9.13	48.89	7.300	41.86
E11	3.41	2.48	5.89	28.05	3.370	72.67

V_c – rate of Rubisco carboxylation [$\mu mol(CO_2).m^{-2}.s^{-1}$]
V_o – rate of Rubisco oxygenation [$\mu mol(CO_2).m^{-2}.s^{-1}$]
V_{rubp} – rate of RuBP consumption and formation [$\mu mol(CO_2).m^{-2}.s^{-1}$]
J_a, J_{carb} – rates of actual electron transport rate and electron transport rate of carboxylation [$\mu mol.m^{-2}.s^{-1}$]
C8 (C11) – control variants without enhanced UV-B radiation in August (November)
E8 (E11) – exposed variants by +25% of UV-B radiation in August (November). The same letter indicate significant differences (on the level of 95%, $P < 0.05$), asterisks mean high statistical differences (on the level of 99%, $P < 0.01$) ($n = 10$)



1. Relationship between the rate of CO_2 uptake (A) and photosynthetic active radiation intensity (I) under constant extracelular CO_2 concentration 350 µmol.mol^{-1}. C8 – light response curve of control variant after 1 month of the exposure to ambient UV-B radiation; E8 – light response curve of exposed variant after 1 month of the exposure to enhanced UV-B radiation



2. Relationship between the rate of CO_2 uptake (A) and photosynthetic active radiation intensity (I) under constant extracelular CO_2 concentration 350 µmol.mol^{-1}. C11 – light response curve of control variant after 3 months of the exposure to ambient UV-B radiation; E11 – light response curve of exposed variant after 3 months of the exposure to enhanced UV-B radiation

IV. Parameters of net photosynthetic rate – intensity of photosynthetic active radiation response (A/I)

Variant			A_{max}	Γ_I		Θ	R_D		α
C8	mean	a*	3.79	14.39	e	0.48	0.52	f	27.75
	standard deviation		0.22	1.81		0.12	0.08		2.21
E8	mean	a*, c	2.56	14.91		0.57	0.52	f	25.80
	standard deviation		0.13	2.22		0.08	0.08		3.41
C11	mean	b*	4.20	15.75	d, e	0.31	0.45		34.50
	standard deviation		0.20	2.08		0.09	0.07		4.41
E11	mean	b*, c	2.04	17.00	d	0.56	0.42		38.64
	standard deviation		0.18	2.77		0.11	0.09		7.51

A_{max} – light saturated rate of CO_2 uptake [µmol(CO_2).m^{-2}.s^{-1}]
Γ_I – light compensation point [µmol.m^{-2}.s^{-1}]
Θ – rate of light saturation [dimensionless]
R_D – rate of dark respiration [µmol(CO_2).m^{-2}.s^{-1}]
α – photochemical efficiency of CO_2 uptake [mol.m^{-2}.s^{-1}]
C8 (C11) – control variants without enhanced UV-B radiation in August (November)
E8 (E11) – exposed variants by +25% of UV-B radiation in August (November). The same letter indicate significant differences (on the level of 95%, $P < 0.05$), asterisks mean high statistical differences (on the level of 99%, $P < 0.01$) ($n = 10$)

pared to the exposed one. An increase was observed in the α value during the season: 24% in the control variant and 49.8% in the exposed variant. These differences were not statistically significant (Tab. IV).

Chlorophyll fluorescence

Using the chlorophyll a fluorescence measurement, highly significant differences were observed in the Fv/Fm ratio caused by long term exposure to elevated UV-B and other stresses, respectively. There was no significant difference between the C8 and E8 variant, but a highly significant decrease was observed in the variants: C11–E11 (18.8%), C8–C11 (8.7%), and E8–E11 (27.9%) (Tab. V).

DISCUSSION

Effects of short-term exposure

The first estimation of gas exchange parameters and fluorescence was conducted after 4 weeks of exposure to enhanced UV-B radiation. Decrease of A_{sat} in the A/Ci response (Tab. I) and α in the A/I response (Tab. IV) parameters demonstrated the mean damage effects at the primary CO_2 akceptor ribulose-1,5-bisphosphate

V. Quantum yield efficiency of photosystem II

Variant		C8		E8		C11		E11
Fv/Fm	mean	b*	0.733	c*	0.753	a*, b*	0.669	a*, c* 0.543
	standard deviation		0.010		0.007		0.012	0.030

Fv/Fm – quantum yield of photosystem II
C8 (C11) – control variants without enhanced UV-B radiation in August (November)
E8 (E11) – exposed variants by +25% of UV-B radiation in August (November). The same letter indicate significant differences (on the level of 95%, $P < 0.05$), asterisks mean high statistical differences (on the level of 99%, $P < 0.01$) ($n = 10$)

(RuBP) level while Rubisco activity was unaffected, which can be documented by the significant unchanged value of carboxylation efficiency τ (Brooks, Farquhar, 1985).

The rate of the RuBP regeneration (Tab. III) decreased by 39.3% and demonstrates damage of the compounds involved in the electron transport process. The decrease of the Rubisco oxygenation rate V_o was 61.3%. This may be the result of a protective function of photorespiration. A decrease of Rubisco oxygenation proceeds an increase of Rubisco carboxylation, because they are competitive processes (Leverenz et al., 1990). But this fact was observed only on the Rubisco activity level while the rate of photorespiration R_L was unaffected (Tab. II).

The results of stomatal (LS) and mesophyll limitation (LM) provided evidence supporting slight changes in the effect of the CO_2 transport processes to carboxylation places in short-term UV-B exposure conditions. Statistically insignificant higher values of CO_2 and light compensations points (Γ_C, Γ_I) are consequences of minor stress damage (Peisker, 1978) caused by UV-B radiation.

Effects of long-term exposure

The second estimation of gas exchange parameters and fluorescence was conducted after 14 weeks of exposure to enhanced UV-B. We expected a greater influence of UV-B radiation because the combined effects of irradiance and frost on CO_2 uptake and chlorophyll a fluorescence in Norway spruces were previously studied (Kalina et al., 1994). Low temperatures especially decrease activity in the Calvin cycle enzymes (Gazelius, Hallén, 1980).

A noticable decrease (36.8%) in the saturated rate of CO_2 uptake on the A/Ci response was observed. This result correlates with a decrease in the rate of RuBP regeneration (35.5%) and the actual electron transport (42.6%).

Carboxylation efficiency τ was higher in the control variants (insignificantly). We noticed decrease of the τ parameter for both control and exposed variants, we can presume that decrease in Rubisco activity is caused especially by low temperatures and slightly by UV-B treatment. The rate of Rubisco carboxylation V_c decreased by 47% in the exposed variants compared to the control ones, but the rate of oxygenation V_o decreased by only 7.8%. These results provide the evidence about selective damage in the large Rubisco subunit which is responsible for carboxylation (Jordan, 1993). Additionally other studies have concluded that there is a negative influence on Rubisco carboxylation reactions due to long-term UV-B exposure (Vu et al., 1982).

The rate of Rubisco oxygenation decreased by 64% in the control variants when the November measurements were compared to the August measurements, whereas this difference was only 15% in exposed variants. These results may demonstrate a limitation of the protective possibilities of Rubisco oxygenation.

Higher values of Γ_C and Γ_I were observed in November in the exposed variants, but these differences were statistically insignificant. Low temperatures in November caused an increase of these parameter's values for exposed (49%) and control (72%) variants compared to August. The shift from lower to higher values within these parameters is a typical manifestation of seasonal changes on photosynthetic characteristics (Šesták, 1985).

An outstanding increase of stomatal limitation in November was observed for both exposed and control variants compared to August. Opossit to Naidu et al. (1993) we observed an increase of stomatal limitation in exposed variants compared to control ones which also occured in November. This is in the accordance with Tevini, Teramura (1989). Their findings are consistent with the suggestion that stomatal closure is the primary cause of observed decreases in photosynthetic response due to enhanced UV-B.

Changes in the photorespiration rate R_L were not significant in November. This result documents the possibility of different sensitivity levels during particular steps of the photorespiration cycle in relation to UV-B.

Maximal photochemical efficiency of photosystem II, determined by the Fv/Fm ratio, was significantly decreased by enhanced UV-B. The decrease of this ratio by low temperatures was also observed in Norway spruce stands (Kalina et al., 1994), therefore, it is possible to predict that the outstanding decrease of photochemical efficiency is caused by the combined effect of UV-B treatment and low temperatures especially.

From the finished studies concerning photosynthetic analysis, it is possible to find different sensitivity levels to UV-B radiation on the CO_2 fixation level. Apparently electron transport, activities of Rubisco, and enzymes of Calvin cycle are the most sensitive to UV-B radiation or synergic influence from other stresses, respectively. The synergic effect of low temperatures and UV-B radiation is very important, because the combination of these stresses occurs very often in field conditions.

References

BASIOUNY, F. M. – VAN, T. K. – BIGGS, R. H., 1977. Some morphological and biochemical characteristics of C_3 and C_4 plant irradiated with UV-B. Physiol. Plant., 42: 29–32.

BRANDLE, J. R. – CAMPBELL, W. F. – SISSON, W. B. – CALDWELL, M. M., 1977. Net photosynthesis, electron transport capacity and ultrastructure of *Pisum sativum* L. exposed to ultraviolet-B radiation. Plant Physiol., 60: 165–169.

BROOKS, A. – FARQUHAR, G. D., 1985. Effect of temperature on the CO_2/O_2 specifity of ribuloso-1,5-bisphosphate carboxylase/oxygenase and the rate of respiration in the light. Estimates from gas exchange measurements of spinach. Planta, 165: 397–406.

CALDWELL, M. M. – GOLD, W. G. – HARRIS, G. – ASHURST, W., 1983. Technical note: A modulated lamp system for solar UV-B (280–320 nm). Supplementation studies in field. Photochem. and Photobiol., 37: 479–485.

CALDWELL, M. M. – FLINT, S. D., 1994. Stratospheric ozone reduction, solar UV-B radiation and terrestrial ecosystems. Climatic Change, 28: 375–394.

COOHILL, T. P., 1989. Ultraviolet action spectra (280 to 380 nm) and solar effectiveness spectra for higher plants. Photochem. and Photobiol., 50: 451–457.

GAZELIUS, K. – HALLÉN, M., 1980. Seasonal variation in ribulose-bisphosphate carboxylase activity in *Pinus sylvestris*. Physiol. Plant., 48: 88–89.

IWANZIK, M. – TEVINI, M. – DOHNT, G. – VOSS, M. – WEISS, W. – GRÄBER, O. – RENGER, G., 1983. Action of UV-B radiation on photosynthetic primary reactions in spinach chloroplasts. Physiol. Plant., 58: 401–407.

JORDAN, B. R., 1993. The molecular biology of plants exposed to ultraviolet-B radiation and the interaction with other stresses. In: JACKSON, M. B. – BLACK, C. R. (eds.), Interacting stresses on plants in changing climate. Berlin, Springer-Verlag: 153–170.

KALINA, J. – MAREK, M. V. – ŠPUNDA, V., 1994. Combined effects of irradiance and first autumn frost on CO_2 assimilation and selected parameters of chlorophyll a fluorescence in Norway spruce shoots. Photosynthetica, 30: 233–242.

KRATOCHVÍLOVÁ, I. – JANOUŠ, D. – MAREK, M. V. – BARTÁK, M. – ŘÍHA, L., 1989. Production activity of mountain cultivated Norway spruce stand under the impact of air pollution. I. General description of problems. Ecologia, 4: 407–419.

LEVERENZ, J. – FALK, S. – PILSTROM, M. C. – SAMUELSSON, G., 1990. The effect of photoinhibition on the photosynthetic light-response curve of green plant cells (*Chlamydomonas reinhardtii*). Planta, 182: 161–168.

MAREK, M. V. – KALINA, J. – MATOUŠKOVÁ, M., 1995. Response of photosynthetic carbon assimilation of Norway spruce exposed to long-term elevation of CO_2 concentration. Photosynthetica, 31: 209–220.

MELIS, A. – NEMSON, J. A. – HARRISON, M. A., 1992. Damage to functional components and partial degradation of photosystem II reaction center proteins upon chloroplast exposure to ultraviolet-B radiation. Biochem. Bioph. Acta, 1100: 312–320.

NAIDU, S. L. – SULLIVAN, J. H. – TERAMURA, A. H. – DELUCIA, E. H., 1993. The effects of ultraviolet-B radiation on photosynthesis of different aged needles in field-grown loblolly pine. Tree Physiol., 12: 151–161.

PEISKER, M., 1978. Der Einflus von Somerstoff auf die CO_2-Kompensationskonzentration von C_3- und C_4 Pflanzen und von Intermediärformen. Kulturflanze, 16: 81–89.

PIROCHTOVÁ, M. – MAREK, M. V., 1991. Metoda matematického vyhodnocování fotosyntetické aktivity lesních dřevin (Mathematical processing of photosynthetic activity of forest tree species). Lesnictví, 37: 399–408.

STEWART, J. D. – HODDINOTT, J., 1993. Photosynthetic acclimation to elevated atmospheric carbon dioxide and UV irradiation in *Pinus baksiana*. Physiol. Plant., 88: 493–500.

ŠESTÁK, Z., 1985. Photosynthesis during leaf development. Praha, Academia.

TEVINI, M. – TERAMURA, A. H., 1989. UV-B effects on terrestrial plants. Photochem. Photobiol., 50: 479–487.

VU, C. V. – ALLEN JR., L. H. – GARRARD, L. A., 1982. Effects of supplemental UV-B radiation on primary photosynthetic carboxylating enzymes and soluble proteins in leaves of C_3 and C_4 crop plants. Physiol. Plant., 55: 11–16.

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VLIV ZVÝŠENÉ INTENZITY UV-B RADIACE NA FOTOSYNTETICKOU CHARAKTERISTIKU SMRKU ZTEPILÉHO [*PICEA ABIES* (L.) KARST.] PĚSTOVANÉHO V POLNÍCH PODMÍNKÁCH

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S pokračujícím poklesem koncentrace ozonu ve stratosféře roste zájem biologů o možné vlivy zvýšené intenzity dopadající ultrafialové-B (UV-B; 290–320 nm) radiace na reakce rostlinných společenstev. Výsledná reakce rostlin závisí jednak na množství absorbované UV-B radiace, jednak na synergickém působení dalších vnějších faktorů okolního prostředí a liší se v závislosti na jednotlivých rostlinných druzích. Protože během roku dochází k sezonním změnám šířky ozonové vrstvy, lze v podzimních měsících očekávat zvýšení poměru dopadajícího UV-B a fotosynteticky aktivního záření při současném vlivu nízkých teplot a prvních mrazíků.

Míru efektivity UV-B záření na jednotlivé biologické znaky či reakce označujeme zpravidla jako akční spektrum. UV-B radiace snižuje celkovou biomasu rostlin, snižuje rychlost asimilace CO_2, stomatální vodivost a celkový obsah chlorofylů. Byly pozorovány strukturní změny tylakoidních membrán, reakčních center fotosystému II (PSII), pokles stavu složek elektronového transportního řetězce, aktivity a množství Rubisca. Typickým průvodním jevem při působení zvýšené intenzity UV-B radiace je zvýšená syntéza tzv. UV-stínících pigmentů, např. flavonoidů, ve vakuolách buněk palisádového parenchymu a mohutnější kutikulární vrstva.

Při umělém ozařování sazenic smrku ztepilého bylo využito systému modulovaných zářivek zvyšujících aktuální intenzitu dopadající UV-B radiace o 25 %. Z provedených gazometrických měření a analýz vyplývá, že zvýšená UV-B radiace při krátkodobém působení (dny až týdny) poškozuje zejména primární akceptor CO_2 ribulosa-1,5-bisfosfát (RuBP) a schopnost jeho regenerace. Výrazný pokles rychlosti oxidace Rubisca ukazuje na jistý stupeň protektivní funkce fotorespirace, kdy pokles oxidace Rubisca musí vést k nárůstu rychlosti karboxylace, neboť se jedná o čistě kompetivní procesy.

Dlouhodobé působení (měsíc až sezona) zvýšené intenzity UV-B radiace se projevilo výrazným snížením rychlosti karboxylace, zatímco rychlost oxidace poklesla pouze minimálně. Tento výsledek může svědčit o selektivní destrukci velké podjednotky Rubisca zodpovědné za karboxylaci. Srovnáním hodnot rychlosti asimilace CO_2 u kontrolních a exponovaných sazenic po krátkodobém a dlouhodobém působení zvýšenou intenzitou UV-B radiace pak můžeme říci, že s délkou trvání experimentu docházelo k saturaci ochranných schopností oxidace Rubisca. Vyšší hodnoty kompenzační koncentrace CO_2 a ozářenosti, jakož i nižší stomatální vodivost a maximální fotochemická účinnost PSII svědčí o stresovém vychýlení asimilačního aparátu smrku ztepilého v důsledku působení UV-B radiace. Konečný efekt zvýšené intenzity UV-B radiace byl výrazně zvýšen synergickým působením dalších stresových faktorů – zejména nízkou teplotou, která snižuje aktivitu enzymů Calvinova cyklu.

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PAST, PRESENT AND FUTURE OF THE FORESTRY UNIVERSITY EDUCATION

On the occasion of the 150th anniversary of the beginning of forestry university education in Prague, the Faculty of Forestry of the Czech University of Agriculture in Prague organized an international symposium (November 13–14, 1998) devoted to the history, present situation and future perspectives of forestry university education. Scientists from universities of several European countries participated in the symposium, and presented following contributions.

150TH ANNIVERSARY OF THE UNIVERSITY FORESTRY EDUCATION IN CZECH LANDS

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INTRODUCTION

Forestry education has a long tradition in Czech lands. The necessity of professional education of foresters is given by multiple use of forests. At the beginning of this millenium the importance and administration of forests was closely connected with hunting of forest game. The importance of wood production of forests gradually increased and requirements concerning professional knowledge and education of foresters had also increasing trends. Already in the year 1756 instructions were issued on forestry examinations in Czech lands and required knowledge was determined. Candidates for forest managers had to pass examinations under appointed examinators, and it was ordered to employ only foresters who passed the examinations successfully.

The increasing importance of forests was connected with the increasing number of inhabitants, big wood consumption and fear of wood scarcity, mainly in less forested regions. The necessity of professional knowledge led to the foundation of professional forestry schools. The first one-year forestry school was founded in the year 1773 at Blatno near Chomutov (NW Bohemia) and within short time after that, other forestry professional schools were established also on other places.

HISTORY OF UNIVERSITY FORESTRY EDUCATION

Encyclopedic lectures on forestry were included already in curriculum of lectures for the Chair of Agriculture at the Prague University in the year 1789. In the year 1812 the Chair of Agriculture was affiliated to the Prague Polytechnic University and together with it also encyclopedic lectures on forestry. The first assistant professor of forestry at the Polytechnic University was Christoph Liebich, one of the important foresters of the 19th century. Liebich was born 1783 in Silesia and after he finished studies at the Forestry School at Tharandt he worked since 1812 first as the "king and emperor's engineer" at Lwów and since 1818 in the same position in the administration of state estates at Prague, where he lived till the end of his life in 1874. In the year 1826, after he left the administration of state forests, Liebich started his editing, publishing, and teaching activities. He edited several professional forestry journals and published many professional books. In silviculture, he was founder of the so called Prague school. He stressed not only wood production role of forests, but also non-wood importance of forests (e.g. soil conservation, water management, climatic and health roles). Liebich, as the first assistant professor of forest sciences at Prague Polytechnic University, started lectures November 15, 1848 and offered encyclopedic forestry education to a great number of students during his university activities. In the year 1849 Liebich elaborated a plan for extending forestry studies at Polytechnic University. In his programme forestry studies should last two years. He attached a great importance to practical training. For this purpose he requested the lending of Brandýs forests (closely north of Prague) with the area of more than 6,000 ha for practical training in geodesy, forest inventory and other disciplines. He further required the founding of the independent Chair of Forest Sciences headed by an ordinary professor. But these requests were not accepted and realised. Liebich lectured forest sciences at the Prague Polytechnic University for 18 years and read his last lectures in 1867/1868. After him, readers of forestry encyclopedia were famous personalities like Antonín Bohutínský, Karel Kořistka, Josef Sigmond and Vojtěch Kaisler. Forestry encyclopedia was then lectured in the period 1910 to 1919 at the Czech Technical University in the Department of Agriculture and Geodesy.

Efforts to establish university forestry education with the Czech teaching language were not realised during the period of Austria-Hungary empire. Only after foundation of the independent Czechoslovak Republic October 28, 1918, immediate steps were done to establish university forestry education in Czech language. Already November 6, 1918, professors of Czech Technical University headed by Professor Stoklasa, took out a petition for the founding of School of Forestry within the framework of the Czech Technical University. This proposal was approved by Ministry of Education and the start of lectures was determined for March 16, 1919. The final structure of the university forestry studies was formed in the year 1920. Within the framework of the Czech Technical University, independent university schools were established inclusive the University School of Agriculture and Forestry. At the School of Forestry a study programme was prepared on the basis of experiences of universities which laid the emphasis on the education of technical subjects.

The education at newly founded School of Forestry of the Technical University was provided by experienced teachers. Programmes of studies developed in the course of time, but in principle the same basic curriculum of forestry studies was kept. That was based on combination of biological, technical, and economical subjects. Since the year 1921 to the 1939, in total 674 students graduated at the School of Forestry. After the outbreak of the Second World War, all universities in Czech lands were closed.

The university education was resumed immediately after the end of the war, in June 1945, as a continuation of the summer term of the year 1939. In the period after the war, university staff of the Faculty of Forestry included many prominent teachers as Karel Matyáš, Pravdomil Svoboda, Václav Korf, Václav Douda, Alois Mezera, Antonín Pfeffer and others. Prague Faculty of Forestry existed in the period after the war within the framework of the Czech Technical University up to the year 1959, when it was closed due to the government decision. In the years 1945 to 1959, in total 1,693 students were matriculated at the Faculty of Forestry in Prague. In the year 1964 the Faculty of Forestry was transformed to scientific institution, the Scientific Forestry Institute of the University of Agriculture, with the seat at Kostelec nad Černými lesy. The activities of this institute were focused on fundamental and applied research and on postgraduate and specialized courses. In the year 1990 the activities of the Prague Faculty of Forestry were resumed and lectures started in the year 1991.

FORMS OF EDUCATION

The program of studies at the reopened Faculty of Forestry was prepared with respect to present problems in forestry and requirements of the society. The goal of the Faculty of Forestry remains the education of professionals who will be specialists in biological, technical and economical sciences. The Faculty of Forestry has at present time three main courses of studies, i.e., forestry engineering, landscape engineering with specialization applied ecology, and since the year 1994 also wood technology engineering. Studies in all these study courses last five years and are closed by the second state examination and by the submission of the diploma thesis. Besides these five year engineering studies there exist also three year bachelor studies "Economic and administration service in forestry".

Graduates of forestry engineering are specialists capable of management of forest enterprises and able to solve cardinal problems of modern forestry. Graduates of landscape engineering are specialists in landscape management, soil erosion control, water management, and care of ecological stability of landscape used by agriculture and forestry. Graduates of wood technology engineering are specialists in industrial wood processing, veneer and plywood production, production of furniture and other woody products. Bachelor studies are focused on the economic aspects of forest management and administration, problems of property ownership and finances. Altogether 841 students are studying at the Faculty of Forestry at present time (Tab. I). Since 1991, when the Faculty of Forestry was reopend, 449 students gradued at the Forestry Faculty (Tab. II).

The Faculty of Forestry offers also postgraduate studies, which may be realized after graduation. After passing rigorous examinations, students submit and defend dissertation to obtain scientific degree Doctor of Philosophy (Ph.D.). The Faculty of Forestry in Prague is entitled to offer postgraduate studies in 12 disciplines: Plant Physiology and Anatomy, Dendrology and Forest Tree Improvement, Silviculture, Forest Protection, Game Management, Ecology, Applied and Landscape Ecology, Forest Inventory and Management, Technology and Mechanization in Forestry, Economy and Forest Management, Agricultural and Forestry Hydrology, Soil Protection and Soil Improvement.

I. Number of students of the Faculty of Forestry at the Czech University of Agriculture in Prague (November 1, 1998)

Study year	Forestry engineering	Landscape engineering	Wood technology engineering	Bachelor study	Forestry engineering (distance study)	Altogether
I.	82	98	58	32	62	332
II.	53	59	21	21	10	164
III.	22	73	20	19	8	142
IV.	46	42	22	–	6	116
V.	43	36	8	–	–	87
Altogether	246	308	129	72	86	841

II. Number of graduates of the Faculty of Forestry at the Czech University of Agriculture in Prague since 1991

Year	Forestry engineering	Landscape engineering	Wood technology engineering	Bachelor study	Forestry engineering (distance study)	Altogether
1992	–	37	–	–	–	37
1993	–	39	–	–	–	39
1994	–	29	–	–	–	29
1995	–	48	–	–	–	48
1996	41	42	–	–	–	83
1997	46	47	–	16	1	110
1998	44	42	–	11	6	103
Altogether	131	284	–	27	7	449

FACULTY FACILITIES

Ten departments of the Faculty of Forestry take part in the teaching: Dendrology and Forest Tree Improvement, Silviculture, Forest Protection, Forest Inventory and Management, Logging and Wood Processing, Economics and Forest Management, Ecology, Water Resources, Land Use and Land Improvement, Constructions. The Institute of Applied Ecology is also a part of the Faculty of Forestry. The Arboretum at Kostelec nad Černými lesy with an area of more than 12 ha and with the collection of 156 coniferous and 1,024 broadleaved tree species, is used for dendrology education. In the Arboretum students may appreciate adaptability of various tree species, their growth, and sensitivity to unfavorable abiotic and biotic factors. A very important institution serving for practical education of students is the Training University Forest with the seat at Kostelec nad Černými lesy, which was established and allocated to the University already in the year 1935. The area of managed forests is more than 7,000 ha, and major part of them is of high genetic value, which enables collection of high quality seeds. The production of plants for afforestation exceeds 1 million plants annually. Logging activities apply all basic technologies connected with wood production. The University Forest Establishment includes also a castle, where are situated laboratories and facilities for lodging and boarding of students, taking part in practical training at the University Forest within the education framework.

Large attention at the Faculty of Forestry is devoted to scientific activities done in laboratories and on experimental plots situated in the University Forest or in other regions of Czech Republic. The Forestry Faculty research includes a wide spectrum of projects of both basic and applied research. Funding is provided through a variety grant agencies. Results of scientific projects are published in international journals and monographs.

CHALLENGES TO FOREST EDUCATION IN A CHANGING SOCIAL AND ACADEMIC ENVIRONMENT

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INTRODUCTION

The ties and working relations between Switzerland and Czech Republic in forest education and research have a long tradition and a solid basis. They are quite intensive at present. Several teachers of the staff of Forestry Faculty of the University of Agriculture in Prague visited Forest Sciences Department of the Swiss Federal Institute of Technology, the ETH in Zurich and participated in seminars there. Only a few years ago students and teachers of the ETH in Zurich came on an excursion to the Czech Republic. It is also useful to remember the research co-operation in the 80s when we were all very concerned about the extent and impact of forest decay in different regions of Europe.

UNIVERSITY FOREST EDUCATION IN A CHANGING SOCIAL AND ACADEMIC ENVIRONMENT

150 years of university forest education in the Czech lands is an opportunity to ask ourselves what the changes are that today determine university education in the forest and wood processing sector. I think that the changes come mainly from two directions. There are new demands regarding the forest and regarding forestry. And there are challenges to university education and research co-operation as a whole. The following reflections are based on my personal experience at the ETH.

In 1994 we made a survey with 139 respondents on the employment opportunities of forestry graduates who had left the ETH between 1986 and 1992. Less than one third worked in forest administration, slightly more than one third were employed in research and teaching, and the rest in the private sector. Recently we analysed the current employment of the former assistants in our chair covering a sample of 22 respondents. Most of them graduated between 1982 and 1996. Almost half had a job in the private sector, a quarter were independent and the others were in the public sector. More than 40% described their activity as services oriented and 14% as forest sector related. The others were engaged in a wide spectrum of activities including nature and landscape conservation. Information from studies in neighbouring countries seems to suggest that these figures are indicative.

The findings, even if not representative, demonstrate that university courses in forestry are no longer geared mainly towards students who find employment in the public forest service. Forestry courses are today useful to society and competitive with other educational opportunities as long as they provide a basis in environmental conservation and sustainable land management practices. They have to qualify the graduates for a broad range of jobs. The students need a flexible programme and the liberty to select teaching subjects which correspond to their interest and facilities and which they think useful. After all, why should they not be in a position to identify future employment opportunities and evaluate their chances in a highly competitive labour market?

Society's demands regarding forestry are of a very diversified nature and differ from country to country and region to region. They embrace the production of goods and services of a distributive character. And they refer to interests in the very existence of forests, which have their foundation in the perception and the personal conviction of citizens. It is this global character which makes the forests an important element of our reality. Their potential for satisfying the needs of present and also future generations, and their ability to do so, determine their social relevance. The biodiversity of forest ecosystems and their multi-functional uses are new dimensions in political debates on forests and forestry.

The demands of society towards forests are constantly changing. Their qualitative nature and the intensity with which they are expressed vary with the flux of economic and technological development. The uncertainty inherent in any assessment of future demands should sharpen our eyes for the more long term tendencies that form the underlying pattern of our day to day problems and the solutions which we can offer. They should guide us in judging modestly our predictions of future values and benefits. A far-sighted form of resources management which leaves opportunities and alternatives open to us and to the next generations and which relies on the site specific production potential is probably the best approach in dealing with the uncertainties of the future. In this sense forestry practices close to nature are a modern and appropriate management approach which safeguards the natural diversity and stability of the forests. Silviculture close to nature practiced now determines our future options: those, which we can think of now, and those which we do not yet know of.

It is in this context that one has to consider the present and future role of foresters in society and the perspective from which citizens evaluate their usefulness and competence. Fulfilling the demands for the pertinent professional qualification as managers of land and of forest estates remains an important task. But new challenges have emerged. They refer to the forester's role as a professional expert and advisor to political institutions, interest groups and the general public.

A forest engineer has to be in a position to determine the actual and potential benefits from forests and, at the same time, to define the ecological limits to such uses. He should be able to analyse competing as well as complementary interests, and to explain alternative strategies to forest owners. He should know how to assess not only the value but also the costs of various goods and services, and the financial implications of their availability. These tasks demand economic thinking, knowledge of arbitration processes in order to find a consensus, and understanding of the legal framework in which to act.

In the local, national and international context forest conservation and sustainable management require political decisions. In this respect forest engineers should be able to give advice on the potential of resources, and its contribution to social and economic development. A professional forester has to cope with different demands and to understand their multiple and evolutionary nature. He has to explain and demonstrate the complexity and fragility of different forest ecosystems. He should know how to evaluate the particular characteristics and how to choose the necessary measures of protection and sustainable management.

If the social relevance of professional expertise is constantly changing, so is the academic context for teaching and research. The training of university graduates is moving away from providing specialised knowledge linked to narrow professional activities. What is the point of offering knowledge for a single field if job profiles are in constant change and if research leads to new professions and job opportunities. Continuous academic education with short term courses and master programmes is today part of more flexible and longer lasting academic programmes. Building new curricula combining education in natural sciences and technology with competencies in economics and social behaviour is another way of reacting to new demands.

Academic teaching programmes in environmental sciences, natural resources utilisation and ecosystem management have been established. The variety of new academic studies requires an assessment how far forestry courses may benefit from such programmes. And it is equally important to consider the contribution of forest sciences to environmental education and sustainable land management courses.

One significant element is the increasing importance of university level education offered by "Fachhochschulen" or technical colleges. It complements but also competes with traditional university curricula. Education for the forest and wood-processing sector is such a case. A comparison of the programmes offered by the "Fachhochschulen" today with the university curricula of some 25 years ago reveals this trend. Such a comparison demonstrates that forest faculties must expand their teaching towards broader subjects with more interconnections and towards systems analysis if they want to offer a relevant programme to the students.

The principal conclusion is that the disciplinary balance of existing curricula needs to be critically reviewed. An adaptive academic forest education is one that offers an equilibrium between biological, technical and social disciplines. From my point of view this clearly implies that university education in forestry needs a solid foundation in economics and in the social sciences. This is not an easy undertaking and there is a long way to go. In our own revision we have made some progress, but more efforts are necessary. My rationale is simple. The problems associated with forestry are problems of and among people, of optimising scarce resources and of social equity. They result from the contradictory interests and values that determine resources utilization, and from different perceptions of the rights and opportunities of our generation in view of generations following us. To put it bluntly: it is not forests that have problems. Forests do not have problems. It is society, which creates problems, and it is society, which must solve them.

The educational profile, as a whole needs to be at once specific and interdisciplinary. Specific in that students have to understand the complexity of forest ecosystems and the conditions for managing them in a long term perspective. Interdisciplinary in that forests are one of several renewable resources of the environment. University education can provide a common ground for understanding different interests involved in utilising land and space. It should motivate forestry students to consider their position in relation to other professions with which they will have to collaborate after leaving university.

Academic education, whatever its form, is based on an involvement in research, both of the students and the teaching staff. Research today is highly competitive and internationally linked. Pertinent research in forestry can only be undertaken if it is based on general scientific models and methodology. New research fields such as environmental economics and law, natural resources policy or empirical studies on human perceptions of nature and landscape provide an integrative view. The linkages between different fields of research reinforce the need to assess and measure the relevant contributions of each field and to evaluate its potential. Forestry research has made some efforts to integrate inputs from other fields. It has been much less successful in offering knowledge and findings to other disciplines. And it is still at the beginning of playing a substantial role in multi-disciplinary educational and research networks.

I think that providing an understanding of how to manage a renewable resource in a long-term and multifunctional perspective is the most significant contribution that forestry education and research in the European universities can make. The combination of scientific knowledge with practical experience in sustainable resources management is of value to the other land use activities and to environmental conservation. The challenge of today is to seek for academic networks in which forest education and research contribute to the common goal of sustainable development in a meaningful manner.

Forests are of importance as environment and ecosystems of great biodiversity. Forestry outputs and benefits, whatever their form, are part of rural as well as urban developments. Their multiple role within the broad perspective of sustainable uses calls for fresh syntheses of sectoral and cross-sectoral disciplines which open traditional research communities to new combinations. Protection and management of forests are predominantly local and national issues. But they are also of world-wide concern, both at the international political scene as well as in the public debates of parliaments and citizens. International co-operation helps us to find better solutions to deal with forests in societies that are becoming more and more dependent on each other.

FORESTRY EDUCATION AT THE AGRICULTURAL UNIVERSITY IN KRAKOW HISTORY, PRESENT SITUATION AND PERSPECTIVES

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INTRODUCTION

According to the data recently issued by the Agricultural University in Krakow (1998), the University includes 8 faculties, employs 1,800 persons and a half of this number i.e. 900 persons are members of the academic staff. The number of students amounts to 9,050 and within this number 6,137 students follow the full-time studies and the balance i.e. 2,913 persons are students of the part-time (extramural) studies.

The university examines candidates for degrees during their residency and at the conclusion of their studies; confers degrees; regulates the curricula of the faculties and the system of education; deals with disciplinary problems; and administers facilities, such as library, lecture rooms, and laboratories that are beyond the scope of the faculties or departments.

HISTORY OF FORESTRY STUDIES IN KRAKOW

The history of forestry studies in Krakow may be divided into two different periods. The first covers its history as part of the Jagiellonian University and the second comprises the record of forestry studies within autonomous College of Agriculture, called later the University of Agriculture.

In general, the beginnings of the Faculty of Forestry in Krakow go back to the end of XIX century. In 1889 at the oldest Polish University, the Jagiellonian University founded in 1364, there was brought into existence a division called Study of Agronomy. The Study was formed within the frame of the Faculty of Philosophy. Prof. Aleksander Nowicki gave first lectures in forestry at that Study in 1893. In 1919 based on the Study there was created a Department of Forestry headed by a famous specialist in forestry – Prof. Stanislaw Sokolowski. Later on, Prof. Edward Chodzicki led the Department (since 1937). The Department was a centre of forestry sciences in Krakow and constituted a basis for the foundation in 1946 of the Faculty of Agronomy and Forestry at the Jagiellonian University in Krakow. In 1947 Forestry Section was separated from that Faculty and in 1949 it was transformed into an independent Faculty of Forestry of Jagiellonian University with Prof. Tadeusz Gieruszynski as its first Dean. The Faculty has steadily developed under the great Polish educators in forestry and the basic part of an academic staff consisted of the former Faculty of Forestry professors of Technical University of Lwów. Within this organizational structure it existed until 1954. At that time the enrollment for the first year of study was 110 persons. Admission at the faculty was based on a competitive examination in biology and mathematics. The total number of teaching hours amounted to 4,540 during 4 years of study with an average of 38 teaching hours weekly and 61 teaching subjects. The curriculum offered by the Faculty led to Bachelor of Science in Forestry degree and at the same time, after passing exams in all 61 courses, and successful defence of presented master thesis, to Master in Agricultural-Technical Sciences degree (Zizka, 1992). Unexpectedly, ministerial decision of 1951, based on some nonsense reasons, stopped the enrollment of students and in 1954 the Faculty was definitively closed down.

The Faculty of Forestry was opened again for instruction nine years later i.e. in the academic year 1963/1964 at the College of Agriculture (Wyzsza Szkola Rolnicza) which emerged from the Jagiellonian University and since 1972 it is called the University of Agriculture (Akademia Rolnicza im. Hugona Kollataja) named in honor of a distinguished Polish scholar Hugo Kollataj.

Among many notable professors of the Forestry Faculty one can name the following persons:
Stanislaw Sokolowski, 1865–1942, his scientific interest focused on silviculture, and he was a great supporter of nature conservation;
Dezydery Szymkiewicz, 1885–1948, a very active organizer of forestry studies in Krakow and the precursor of the application of mathematical statistics in plant ecology study, and author of the first Polish manual in this field;
Edward Chodzicki, 1897–1978, the creator of original forest-physiographical division of Poland, the pioneer of forest tree breeding science;
Tadeusz Gieruszynski, 1903–1963, the first dean of the Forestry Faculty, the author of the first Polish manuals of dendrometry (Jurkowska et al., 1965);
Stanislaw Domanski, 1916–1993, the author of unique monographic treaties on raw *Aphyllophorales*, the expert in biotaxonomy of large-fructification fungi;
Stefan Myczkowski, 1923–1977, a prominent investigator of Carpathian forests, very active in the field of nature conservation, awarded the European Goethe Prize;
Boleslaw Rutkowski, 1923–1990, dean of the Faculty for many consecutive terms, the founder of the original Cracowian school of forest management, author of the statistico-mathematical theory of inventory and control of forests and of the Polish way of the development of theory, methods and systems of forest regulation.

ORGANIZATION OF THE FACULTY OF FORESTRY

The Faculty of Forestry in Krakow has the following departments: Forest Botany and Nature Conservation, Forest Ecology, Forest Entomology, Forest Pathology, Silviculture, Forest Management, Forest Mensuration, Philosophy of Nature and Country Culture, Forest Soil Science, Forest Engineering, Forest Climatology, Mechanization of Forest Works, Forest Tree Breeding, Forest Protection, Forest and Wood Utilization, Zoology and Wildlife Management, Forest Tree Physiology.

The executive authorities of the Faculty act through independent decisions supported directly by the opinion of the Scientific Council of the Faculty or by opinions of Council's Commissions approved by the Council. In some matters, such as conferring scientific titles the Council possesses a decisive legal position. So the Faculty Council is authorized to confer Dr. Sc. and Doctor Habilitated (Dr. hab.) degrees in forestry sciences.

FORMS OF EDUCATION

The position of the Faculty in 1994 is illustrated in Tab. I. In 1998, the full-time teaching academic staff of

I. Place of Krakow's Faculty of Forestry among 5 main forest science centres and institutions in Poland according to the state on March 1st 1994

Name of the institution	General number of staff	Number of scientists
Forest Research Institute in Warsaw	297	143
Faculty of Forestry of University of Agriculture in Warsaw	136	94
Faculty of Forestry of University of Agriculture in Krakow	125	80
Faculty of Forestry of University of Agriculture in Poznan	109	73
Institute of Dendrology of Polish Academy of Science in Kornik	113	39

Source: E. Bernadzki, A. Grzywacz, 1995. The Condition of Forest Sciences in Poland. Sylwan, No. 4: 5–13.

the Faculty numbered 88 members, of which 54 persons with Ph.D. (out of this number 24 persons were professors) and 62 persons employed as assisting and administrative personnel. The number of students in 1998 amounted to 960 altogether (Anon., 1998).

The academic year is divided into two terms (semesters) of approximately fifteen weeks each: winter and summer semesters. The total number of teaching hours has recently been significantly reduced from 4,500 to 3,400 hrs. for a full-time graduate program (i.e. 5 years of study) (Kowalski T., 1997). The Faculty offers the following categories of study: full-time (daily) studies, part-time (extramural) studies, postgraduate studies and in addition the Faculty participates in doctoral studies organized by the Agricultural University in Krakow.

Full time studies last 5 years and lead to M.Sc. degree in forestry in two majors ("specialisations"): Forestry and Protection of Forest Resources. The Faculty established an elective, or optional, system for graduates, by which they could choose most of their courses themselves. The Faculty has recently created a possibility of finishing study after completion 4 years of daily studies and presenting and defending a special thesis written on a subject elected by student. This type of studies leads to B.Sc. degree in forestry. At present full-time studies are free of charge.

Part time (extramural) studies last 4 years and lead to B.Sc. degree in forestry; the graduates may continue their studies for 3 semesters more and in this case a Master degree in forestry is conferred on them. The current tuition and fee rates for undergraduate and graduate studies amount to ca. 170 US$ and ca. 230 US$ per semester respectively.

As full-time and part-time studies curricula are intentionally strongly compatible, students may change form of studies depending on personal situation or preferences.

The Faculty also offers postgraduate studies. The types of studies are shown in Tab. II. These studies require paying tuition fees, their rates are subject to changes. The program is completed during two semesters of studies.

With admission criteria ranking among the most selective in Poland the number of students who passed the entrance exams has recently dramatically decreased. As the response to this new situation the policy of Forestry Faculty in Krakow has changed. According to the latest decision of the Faculty Council, 50% of candidates for the first year of study will be admitted on the basis of results of GCSE (General Certificate of Secondary Education) or equivalent and the balance, to the Faculty admission limit, on the basis of written exams with subjects to choose: biology or mathematics. The enrollment rate during the past decade is shown in Tab. III.

THE CO-OPERATION WITH FOREIGN EDUCATIONAL INSTITUTIONS BASED ON BILATERAL AGREEMENTS

Forestry Faculty in Krakow co-operates with Mendel University of Agriculture and Forestry in Brno, Technical University in Zvolen, Technical University in Lvov, Ukraine, Research Institute for Forestry and Urban Ecology, Wageningen, The Netherlands, INRA Ardon (Centre de Recherches d'Orléans), INRA Perroton, Conseil Régionale Provence Alpes Côte d'Azur (students exchange – for practical training in forestry). Besides bilateral agreements between faculties also exist agreements signed at a university level (for example:

II. Postgraduate studies at the Faculty of Forestry of the Agricultural University in Krakow offered in academic year 1998/1999

Legal name of studies	Lectures	Field training	Total	Number of participants
	Number of teaching hours			
Postgraduate study in forest utilization and forest transportation	170	30	200	25
Postgraduate study in nature and environment conservation	85	85	170	50
Postgraduate study in genetics and forest tree breeding	173	14	187	49

Source: The author's investigations based on documents of the Faculty of Forestry of the Agricultural University in Krakow, Poland

III. Enrollment rates at the Faculty of Forestry of the Agricultural University in Krakow, during the past decade 1989/1990 to 1998/1999

	Full-time studies		Part-time studies (Forestry alone)		Postgraduate studies	Total number of students
Academic year	Major: Forestry	Major: Forest Resources Conservation	Undergraduate students	Graduate students		
Number of students						
1989/1990	104	0	39	17	75	235
1990/1991	109	0	35	21	75	240
1991/1992	110	0	63	20	75	268
1992/1993	110	0	78	0	75	263
1993/1994	119	0	0	28	75	222
1994/1995	120	0	78	15	75	288
1995/1996	122	0	91	16	75	304
1996/1997	105	34	90	0	75	304
1997/1998	120	60	56	26	75	337
1998/1999	90	60	44	24	124	342

Source: The author's investigations based on documents of the Faculty of Forestry of the Agricultural University in Krakow, Poland

Agreement on co-operation between agricultural universities in Krakow and Prague). The other projects of bilateral agreements are in the course of preparation (for example University of Göttingen, Germany).

FACILITIES

Students live in residence houses in Krakow at 2 localities. Each house accommodates approximately 580 students. The Faculty provides their students with lodgings for ca. 270 students (1998). They share dormitories with the other faculties students of the University of Agriculture. The Faculty has at its disposal the Forest Experimental Station in Krynica with 6,500 hectares of forest area and residence house, which accommodates 150 students and well-equipped lecturing rooms and a canteen for students. There are 3 field stations located there, namely: Field Station of Genetics and Forest Tree Breeding; Field Station of Meteorology and Climatology and Field Station of Silviculture. The building of Forestry Faculty belongs to one of the best equipped with modern media buildings in Krakow including a newly designed net of Internet access and offers comfortable conditions of work both for scientists and students.

PERSPECTIVES

– In an effort to keep pace with the rapidly changing nature of today's competitive marketplace the Faculty recognizes the following educational priorities: the need to adjust offered curricula to the real needs of students (greater number of electives, constantly revised programs).

– Creating the opportunities for extramural study at the Faculty to serve individual students' interests and academic goals. Making full-time and part-time studies curricula classes even more integrated, so that students could change more easily the form of study.

– Pursuing research and education conducted at the Faculty in connection with a wide range of problems of forest management in mountainous areas and industrial regions of southern Poland.

– Creating the atmosphere more favorable for international education (proposals of lectures in foreign languages).

– Intensification of personal (professors and students) exchanges within the European scientific and educational mobility programs.

– Elaboration of programs of continuing education on the basis of postgraduate or other forms of studies oriented towards the needs of forestry and other related professions practitioners.

– Achievement of higher qualifications by academic staff. By the year 2000 there is expected a total number of 144 faculty members, out of this number 74 with Ph.D. (included 22 professors) (Kowalski S., 1997).

References

ANON., 1998. Jaka jest kondycja Wydziału Leśnego przed rozpoczęciem roku akademickiego 1998/99? Las Polski, No. 19: 22–23.

JURKOWSKA J. et al., 1965. Dzieje studiów rolniczych w Krakowie. Kraków, WSR.

KOWALSKI, S., 1997. Stan obecny i strategia rozwoju Wydziału Leśnego do roku 2000. Maszynopis, Wydział Leśny AR.

KOWALSKI, T., 1997. O transformacjach procesu dydaktycznego na Wydziale Leśnym AR w Krakowie. Las Polski, No. 21: 22–24.

ZIZKA, Z., 1992. Uniwersyteckie studia leśne w Krakowie. Zesz. Nauk. AR w Krakowie. No. 275, Sesja naukowa Z.36: 57–68.

TODAY AND TOMORROW IN POLISH FORESTRY EDUCATION

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FACULTIES OF FORESTRY IN POLAND

Higher forestry education in Poland began in 1816, with the foundation of the Forester's School in Warsaw. The tradition of this school continues in the Faculty of Forestry, one of the first three faculties in the Warsaw Agricultural University. In the same tradition is the Faculty of Forestry of the Agriculture Academy in Krakow, which is celebrating its 50th anniversary this year (a portion of the time under the direction of Jagiellonian University), and the Faculty of Forestry of the Agricultural Academy in Poznan, which is 80 years old.

The Faculty of Forestry SGGW in Warsaw consists of seven chairs and one independent department. The faculty employs 126 workers, of which 89 are academic teachers: 24 professors, 37 adjuncts, and 28 assistants. The Faculty of Forestry in Krakow employs 140 workers, of which 100 are academic teachers (25 professors or higher). The Faculty of Forestry in Poznan employs 119 persons – 15 professors, 27 adjuncts, 35 assistants, and 42 other workers.

The didactic activities of the Faculty of Forestry in Warsaw are full-time studies (755 students, of which 139 are in their first year), part-time (358 persons, of which 76 are newly-accepted), complementary master's studies (19 persons), the post-graduate course "Protection of National Parks" (30 persons) and doctoral studies – full- and part-time (35 persons). The Faculty of Forestry in Krakow educates 960 full- and part-time students. There are 90 first-year students with a forestry speciality, and 60 who have chosen protection of forest resources as a speciality. There are 45 part-time students, and the faculty also provides post-graduate courses. At the Faculty of Forestry in Poznan, in the 1997/1998 academic year, there were 665 registered students, 395 part-time, and 35 studying in other systems. 300 persons were enrolled in doctoral studies, 23 in a postgraduate forestry protection class, and 58 silviculture postgraduate students (O l e n d e r e k et al., 1998).

In the past years a commitment has been made to improve the quality of laboratories, lecture halls and classrooms. At present at the Faculty of Forestry in Warsaw there are new laboratories for botany and physiology, forest zoology and game management, forest protection and phytopathology, silviculture, remote sensing and spatial information systems, and also computer labs (which are equipped with State Forest Information Systems). There are also nature and forestry workshops which contain reading material – to supplement the activities of the main library.

Each Faculty of Forestry has a center for field studies, which is very significant for the scientific and didactic activities. For the Faculty of Forestry in Warsaw, this is an Experimental Forest Station in Rogów. It includes the Nursery Training Center, Arboretum, lumber mill, center for animal husbandry, and the Center for Nature and Forestry Education, opened in 1996 in cooperation with the SGGW and the General Directorate of State Forests. Thanks to a great amount of work on modernization and renovation, the station in Rogów has new up-to-date equipment necessary for forestry and nature education – formal and informal – for students, pupils from forestry schools, State Forest workers, the local community, and different groups interested in forestry. The Faculty of Forestry in Krakow has a new scientific and educational center for 150 students in the Experimental Forest Area in Krynica Górska. The Faculty of Forestry in Poznan has two such areas – Experimental Forest Areas in Siemianice and in Zielonka.

ACTUAL TRENDS IN FORESTRY EDUCATION

According to the present principles of sustainable development (see Forest Principles, 1992; R y k o w s k i, 1994; European Parliament's Resolution, 1997) there is an urgent need to introduce changes into forest management in order to satisfy the various desires of society towards forests. Forestry (people and silviculture) must change. In order for the society to understand the goals of forestry, they must be involved in education at many different levels and in many different forms.

The authors of the document "Polityka Leśna Państwa" 1996 ("State Forest Policy") note the goals of foresters:

- *bringing about transformation of programs in forestry high schools and universities; increase the knowledge of functioning ecosystems in landscapes and forests; protect biological diversity; raise awareness of modern techniques in forest ecological engineering; manage ecological and societal functions of forest; planning, management, and administration of forests; and overseeing forest products and services in new socio-economic conditions, and in new forest management models,*
- *introduce curriculum for primary and secondary schools and university forestry departments to handle problems with the natural environment, provide necessary information about forests as functioning ecosystems and to satisfy a forest's functions for economic and societal development of the nation.*

Following current trends in forestry evolution, a number of changes in the Faculty's forestry study program have been made. Their main goal (O l e n d e r e k, 1994) is to create a new system of forestry study, which will

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conform to current educational standards, adapt higher forestry schools to current practical needs, and follow continuing evolution of multifunctional forest sustainability. An improved form and method of teaching has been developed, with the aim of better adapted programs and plans of study catered toward individual student interests.

The following is a summary of the changes in the plans and programs of study in the Faculty of Forestry in Warsaw in the past years. A change in the number of hours of lectures and exercises from 4,500 to 3,400. Providing new compulsory subjects: nature protection, computer science in forestry, photogrammetry and spatial information systems. Ongoing individual studies in programs, providing around 500 hours of study of subjects chosen by faculty.

Master's specialization is chosen by third-year students. Some examples may be: forest economics, silviculture, forest protection, natural foundation of forestry, forest management and forest geodesy, utilization and engineering of forest management, forest zoology, and game management, nature protection, applications of spatial information systems in forestry.

In the world and in Poland, forestry studies are most often reformed in a continual, evolutionary manner. Systems of study are also changing, in their realization, regulations, and way of evaluating advances in teaching and providing documentation. New programs must allow for changes as they happen in Polish and world forestry, to meet the demands of a great many diverse, often contradictory, functions.

This year a new speciality in forestry studies at the Faculty of Forestry in Warsaw has been developed – nature protection, preparing two postgraduate programs of study: forestry economics and marketing, and the application of remote sensing and spatial information systems in forestry. New subjects are also provided: nature protection, fundamentals of law, fundamentals of photogrammetry and spatial information systems, and forest history.

The academic profile of the Faculty of Forestry in Krakow and the educational trend of its students results from the specific environment in southern Poland. For forestry studies, the direction is towards "protection of forestry resources". The Faculty also conducts postgraduate courses in "Environment and Nature Protection", "Forestry Use and Transport" and "Forest Tree Genetics and Selection".

Responding to current needs, the Faculty of Forestry in Poznan has begun offering postgraduate courses in forestry protection and silviculture.

FORESTRY AND SOCIETY

Besides the evolution of forestry education in higher studies, much importance is attached to the problems increasing the understanding and forestry education of society.

Forestry education is a part of ecological education (G r z y w a c z , 1994), and its contents, forms, and aims are analogous to those of general ecological education. The main goal is to form positive attitudes towards forests and forestry, and to raise awareness of forestry. Similar to ecological education aims, educational activities should provide knowledge and skills relating to forests.

At the Faculty of Forestry in Warsaw, a new specialization is planned in this area of forestry study. Forestry education follows two related paths. First, it conveys knowledge of the various ecosystems in a functioning forest. And second, where it differs from ecological education, it explains the positive and negatives roles of humans in shaping contemporary forestry – explaining why and in what way forest silviculture is conducted; why forests require constant supervision; and why, despite growing threats, we still have forests in Poland the likes of which can not be found anywhere in Western Europe.

The main goals of forestry education are to raise society's awareness of forestry, create understanding and acceptance of the necessity of forest management, and form a positive image of foresters.

Basic forest and ecological education takes place of course at all levels of schooling as a part of formal education. The formal education system complements education outside of the schools, which includes the participation of many different groups: families, environmental non-governmental organizations, religious groups, local governments, mass media, national parks and landscape parks, workplaces, governmental environmental protection agencies, centralized institutions and offices.

A question very often arises in this discussion – Who should be in charge of forestry education – foresters or teachers? By definition of the professions, the answer would seem to be that foresters only look after forests and are separate from teaching. Underlying the question is a clear attempt to define foresters as amateurs and teachers as professionals in this area. Foresters themselves subscribe to the opinion that their job is, above all, to protect forest resources and guarantee safety in the implementation of all forest functions, both concerning raw materials and infrastructure. "Teaching about the forest" is, consequently, the domain of teachers. While some may think that teaching about forests must concentrate on the richness of natural forests, it is forgotten that contemporary forests have been shaped by humans (foresters) and would not otherwise exist. And who is better able to relate this concept of "forest" than foresters? Foresters are professionals. There is arguably no other profession in Poland that requires such a broad range of knowledge.

Strictly separating the duties of foresters and teachers is not possible nor necessary. Each can make an essential contribution to the forestry education process, and serve as support for the other. There are many examples of good cooperation. National forests are often used more and more in the teaching process to establish a lasting ecological education program. Foresters can perfect their educational skills and benefit from the knowledge and experience of teachers. For these purposes, courses have been organized in educational centers located in forest promotional complexes. Additionally, the Center for Nature and Forestry Education in Rogów offers 3-day courses for forest rangers. During these courses, various methods and forms of ecological and forestry education are conveyed in theory and practice. Lecturers and trainers are experienced employees of various educational centers, teachers of methodology, and scientists.

CONCLUSION

We are aware that Poland's entrance into the European Union will not affect the forestry job market. Therefore, students need to be educated in a wide variety of topics. For that reason we offer a large choice of subject programs, which often involve knowledge and skills seemingly far removed from the subject of forestry. We expect to incorporate the following programs: fundamentals of politics, finance, and national and international organizations, change in societal preferences, European Unions laws, methods of societal communication and resolving conflicts and others.

In a majority of countries, like in Poland, each subject has a separate realm. Advocates of such a system maintain the separation between subjects, although in reality they are overlapping. The disciplines come in contact with each other, penetrate their subjects, and inspire the creation of many new disciplines. The majority of work coming in contact with forestry is of a complex form. Too narrow a specialization would make it difficult for foresters globally to understand the complicated management principles involved in forest ecosystems. Increasingly, concepts are being introduced in which students participate in interdisciplinary projects, in which it would be wise to emphasize the connection and use of different methods and technologies. Such work should involve the five existing spheres: nature, technics, economics, organization, and socialization. It would be better if real problems were addressed and solved for actual people, firms and businesses. Work could be realized in small groups, acting as a forum for discussion of scientific and technical problems.

Such preparation in which students participate in practical work may help to break the barrier (which is most of all psychological) between the study and professional work of foresters.

References

GRZYWACZ, A., 1994. Edukacja leśna spoleczeństwa i zmiany w zakresie kształcenia leśników. In: Polska polityka kompleksowej ochrony zasobów leśnych. Wyd. Fundacja Rozwój SGGW: 382–401.

OLENDEREK, H., 1994. Potrzeby i stan reformowania studiów leśnych. Kongres Leśników Polskich. Materiały i Dokumenty, t. II, cz. 2: 279–287.

OLENDEREK, H. – PRZYBYLSKA, K. – RÓZAŃSKI, H., 1998. Jaka jest kondycja Wydziału Leśnego przed rozpoczęciem roku akademickiego 1998/99? Las Polski, 19 (1297): 22.

RYKOWSKI, K., 1994. Sustainable development of forests in Poland. State and perspectives. Warszawa, Wyd. Agencja Reklamowo-Wydawnicza A. Grzegorczyk.

Forest Principles, 1992. United Nations Conference on Environment and Development, Rio de Janeiro, June 3–14, 1992 (gopher://gopher.undp.org/00/unconfs/UNCED/English/forestp.txt).

Polityka Leśna Państwa, 1996. Ministerstwo Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa.

Resolution on the European Union's Forestry Strategy. European Parliament, January 30, 1997 (www.europarl.eu.int/dg1/a4/en/a4-96/a4-0414.htm).

TRAINING OF FOREST ENGINEERS IN NANCY: A NEW CURRICULUM FOR NEW SOCIETY REQUIREMENTS

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INTRODUCTION

Being adapted to new requirements of society is a main challenge for every training of forest engineers. Development of specific pedagogical methods and training for human resources are some assets for forest engineers trained in the ENGREF.

PRESENTATION OF THE ENGREF AND OBJECTIVES OF THE TRAINING OF FORESTRY ENGINNERS (FIF)

ENGREF AND ITS NANCY CENTRE:

ENGREF, Ecole Nationale du Génie Rural des Eaux et des Forêts, the "French Institute of Forestry, Agricultural and Environmental Engineering", is the leading French "Grande Ecole d'Ingénieurs" for forestry, water management and land planning.

ENGREF has five centres: four in continental France (Paris, Nancy, Montpellier and Clermont-Ferrand) and one overseas (Kourou in Guiana).

Nancy is one of the three centres of ENGREF which work on forests. It is the biggest centre and the only one studying and teaching temperate forestry. The Montpellier and Kourou centres work on the forest of hot regions and tropical rainforest.

Since 1990, the school has been responsible for the training of forestry engineers (F.I.F.) (five years) formerly given at the National School of Engineers of Water and Forestry Work (ENITEF). FIF is one of the three courses of studies provided in Nancy.

It admits:

- forest students after a highly selective competitive exam two years after the baccalaureate,
- students with equivalent academic levels and professional experience.

OBJECTIVES OF THE TRAINING OF THE FOREST ENGINEERS: FORMATION DES INGÉNIEURS FORESTIERS (FIF)

The period of training of forestry engineers (F.I.F.) prepares specialists in forestry areas having an educational level of 5 years of higher education after a secondary school diploma.

Qualifications to be achieved

Equipped with a solid scientific background, forestry engineers develop in contact with the forest a particular aptitude for mastering the complexity of interactions of living things and reasoning on the very long term.

They learn to take simultaneously into account the ecological, economic and human components of the problems submitted to them. They are prepared to adapt to an environment in rapid evolution.

Positions aimed at

In the sectors of the forest, forest products, natural spaces and trees outside of the forest (e.g. in urban areas) forestry engineers have a vocation to take care of: production; management; engineering; protection; consulting; teaching, research and development.

They may work in France and abroad (specially in the tropics) in the private, public or public-related sectors: administration (Ministry of Agriculture, Ministry of the Environment); National Office of Forests; territorial bodies; private or public firms and consultant boards; research and development organisations.

The broad axes of the training are:

- a general scientific training, the main part of which concentrates on life sciences and environment, without forgetting the essential area of economic and social sciences,
- the acquisition of the tools of modern analysis, diagnosis and decision-making, indispensable for the engineer,
- the learning of techniques specific to the management and preservation of forests and natural areas,
- the constant concern to develop the capacity for communicating and working in a team.

FIF curriculum has been reformed in 97 to adapt in permanence to new skills required by society. We present below the curriculum and the pedagogical methods.

GRADUAL CURRICULUM

The three years are made up of 24 months of core curriculum, 4 months of electives, and a final 6-months internship.

Two years of compulsory core:

The first year consists more in a general training giving the future engineers a basic knowledge of environment and life sciences, economic and social sciences, and other fundamental tools necessary for an engineer.

The second year is devoted to forest sciences. During this year, the different skills and general knowledge developed during the first year of training are used in the specific forest and forest management context.

Specialisation during the third year and thesis. The third is a year where the students have the opportunity to open up and specialise in fields, which are directly dealing with forest resources management but also with any other fields connected at one point with the forest sector. The third year of training ends up with a final internship lasting 6 months in order to go further into an engineering activity in a firm or an organisation. It gives rise to a paper and an oral defence.

PEDAGOGICAL METHODS

Considering the extent of the knowledge, which would need to be assimilated by the students within their three years of training in the FIF, the general policy chosen was to aim for a fine rather than a full head.

There is of course a general knowledge which is necessary for a good understanding, perception and management of the living environment, but it is believed that the competence of an engineer lies in first place in his capability to find out a problematic, to

I. Contents of training (in hours)

Schedule	1st year	2nd year	3rd year	Total	%
Environment and life sciences	428	108		536	21.3
Engineering sciences	184	113		297	11.8
Silviculture and forest management	80	410		490	19.4
Economic and social sciences	116	112		228	9.1
Human training	74	171	36	281	11.1
Ground visits and practical trainings	82	108		190	7.5
Optional teaching			500	500	19.8
Total teaching	964	1,022	536	2,522	100
Pratical training	1 month	1 month	6 months		

II. Calendar of the "Formation des Ingénieurs Forestiers"

<table>
<tr><td></td><td></td><td colspan="5">Secondary school diploma</td></tr>
<tr><td></td><td></td><td colspan="5">2 years of preparatory classes</td></tr>
<tr><td></td><td></td><td colspan="5">Mathematics – biology – physics – chemistry</td></tr>
<tr><td></td><td></td><td colspan="5">Competitive exam</td></tr>
<tr><td></td><td>+2</td><td colspan="5">1st year FIF</td></tr>
<tr><td>September to June</td><td></td><td colspan="5">COMPULSORY CORE
Lectures – Practical works</td></tr>
<tr><td>Summer</td><td></td><td colspan="5">Practical period in a firm</td></tr>
<tr><td></td><td>+3</td><td colspan="5">2nd year FIF</td></tr>
<tr><td>September to June</td><td></td><td colspan="5">COMPULSORY CORE
Lectures – Practical works</td></tr>
<tr><td>Summer</td><td></td><td colspan="5">Practical period abroad</td></tr>
<tr><td></td><td>+4</td><td colspan="5">3rd year FIF</td></tr>
<tr><td></td><td></td><td colspan="5">ELECTIVE COURSES
To choose among:</td></tr>
<tr><td rowspan="3">September to December</td><td rowspan="3"></td><td>Management of natural areas</td><td>Rural areas planning</td><td>Business administration</td><td rowspan="3">Research
Initiation</td><td rowspan="3">Tropical
forestry</td></tr>
<tr><td colspan="3">then</td></tr>
<tr><td>Avenue and park trees</td><td>Quantitative methods for forest management</td><td>Forest products</td></tr>
<tr><td>January to July</td><td>+5</td><td colspan="5">FINAL INTERNSHIP AND THESIS</td></tr>
</table>

clearly identify it, to find the tools and people to resolve it and to be autonomous, keeping in mind that he will have to work in the framework of an interdisciplinary team.

THREE KEYS TO THE APPRENTICESHIP OF AUTONOMY:

The training thus aims at progressively leading the students to autonomy in work thanks to three key factors of the school's pedagogy:

Fieldwork: where the students are given the opportunity to discover the real issues and to meet the professional actors of the French natural resources management. In addition to the placements and options met during the training in the school, 36% of the apprenticeship consists in fieldwork.

Projects: with an objective of developing the students capacity to analyse and work (on their own or in a team) on the solving of a precise problematic. Projects are especially numerous during the second year of the training. They often consist in team works or interdisciplinary projects, in professional situation.

Choice: in addition to the foundation course, students have the opportunity to specialise themselves throughout the first and second years during their placement (in France or abroad).

The third year of training in the school is even totally devoted to specialisation of the students.

Practical periods

Thus individual training periods, practical fieldworks by teams and study trips take place in the two first years. They have an essential role in the training.

- Two individual training periods:
  - during summer after 1st year: one month discovering professional environment by taking part in a study project,
  - during summer after 2nd year: one month abroad making a recap about one subject linked with forests.
- Practical field-works by teams:
  - during 1st year: one week phytoecology exercise,
  - during 2nd year: one week afforestation exercise, three weeks forest management exercise.
- Study trips: (by bus all over France)
  - during 1st year: one week about silviculture in plain forests, one week in low mountainous areas,
  - during 2nd year: ten days about dry and mountainous areas, one week about intensive forestry and wood industry in Aquitaine country.

TIME GIVEN FOR WORK AND PERSONAL OR GROUP PROJECTS

Not considering the different fieldtrips and placements, the general objective for the first and the second year is basically to provide well-balanced timetables.

III. A typical week at FIF in Nancy

	8 h–12h15		14 h–18 h
Monday	lecture		Tutorial classes
Tuesday	lecture		Tutorial classes
Wednesday		Field	
Thursday	lecture		Sport (optional)
Friday	lecture		Tutorial classes

Aim: each week: 0.75 x 36 h = 27 h

HUMAN RESOURCES SKILLS TRAINING IN FIF

People and companies have very diverse views on how they would like to see forests and natural land used. It is necessary for forest engineers to listen, to express and to discuss their point of view, to work in a team consisting of people with a variety of backgrounds and interests in order to find solutions between different and often conflicting perspectives.

So human resources skills are important to develop in addition to technical and scientific skills.

There are five objectives for human resources development:

- to know how to express one's self written and orally,
- to know how to work effectively in a group as a participant or a leader,
- to acquire knowledge and confidence of one's self, thus allowing:
  - an entrepreneurial spirit and knowing when to take necessary risks,
  - to situate one's self with good rapport with his collegues and negotiators,
- to specify one's professional plan and know the application of technics to find employment,
- to be able to communicate in English written and orally in an international context.

Human resources development is trained by modules requiring students' personal involvement

Pedagogy is based on concrete experiences that students have during their studies:

Oral and written communication skills:

- Training reports and *viva voce* examination: they are used as a base for oral and written communication exercises. Critique of the quality of the *viva voce* examination and of the training report by the other students gives opportunity both to the speakers and the writers to get feed back about their performance, and for listeners and readers to be active.
- Oral expression technics: one module (1/2 week) – with a theatre actor, students learn expression technics in various situations.
- Visual communication tools: one module (1/2 week). Students have to make transparents for their *viva voce* examination and posters with the help of a specialist.

Human resources skills:

- Personality development and team or meeting leading: one module (1/2 week). This module is co-ordinated with of a practical field project: afforestation project that students have to carry out by teams during one week. With a human resources specialist, they analyse their way of working in a team and the possibilities to improve upon it.
- Application technics to find employment: one module (1/2 week). Students think about their professional careers. They learn application technics to find employment: curriculum vitae, hiring interviewing, etc.

Students' human resources are also developed through their personal involvement in school activities, in different student activities and associations, e.g. cultural, sporting, professional, voluntary...

Forest engineers training is in permanent evolution, as is our society and its relationship with forests.

RECENZE

BEJLOMORKY LESNÍCH STROMŮ A KEŘŮ

V. Skuhravý, M. Skuhravá

Vydala Matice lesnická, s. r. o., v Písku ve spolupráci s Ministerstvem zemědělství ČR jako 4. publikaci v edici Dobové spisky v roce 1998. Publikace má 176 stran, z toho 32 tabulí fotografií, kresby, grafy, mapy a tabulky v textu. Doporučená prodejní cena je 147 Kč. Distributorem je Matice lesnická.

Matice lesnická navazuje na tradici *Dobových spisků* a pokračuje v jejich vydávání. V roce 1998 byl vydán čtvrtý svazek nové edice – *Bejlomorky lesních stromů a keřů*. Autoři tohoto svazku, RNDr. Václav Skuhravý, CSc., a RNDr. Marcela Skuhravá, CSc., jsou čtenářům dobře známi a věnují se studiu bejlomorek již 40 let. Značnou pozornost věnovali druhům žijícím na lesních dřevinách – mj. i škodlivým bejlomorkám – v průběhu jejich kalamitního přemnožení. Dobový spisek Matice lesnické navazuje do určité míry na publikaci obou autorů *Bejlomorky* z roku 1960 (ČSAZV v SZN Praha).

Bejlomorky jsou jednou z nejpočetnějších čeledí dvoukřídlého hmyzu. Ve světě je dnes známo celkem asi 5 000 druhů bejlomorek, v Evropě asi 1 500 druhů a v České republice se vyskytuje asi 500 druhů. Studium bejlomorek má v českých zemích dlouholetou tradici a historie studia hálkotvorného hmyzu u nás se datuje již začátkem tohoto století pracemi Bayera (1907), Baudyše (1912) a Černíka (1925).

Převážné většině lesníků jsou jistě známé hálky bejlomorky bukové *Mikiola fagi* ve formě malých červených „citronků" na listech buku a hálky poměrně škodlivé bejlomorky borové *Thecodiplosis brachyntera* na borových jehlicích. V publikaci se však čtenář dozvídá, že na lesních dřevinách se u nás dnes objevuje 80 známých druhů bejlomorek, z nichž řada může působit lesnímu hospodářství větší nebo menší škody svým silnějším a intenzivnějším výskytem zejména na hospodářských dřevinách, jako např. oba zmíněné druhy, některé druhy rodu *Dasineura* aj. Proto autoři dělí bejlomorky z hlediska škodlivosti do čtyř skupin:

- druhy velmi škodlivé, které mohou při silnějším výskytu vést až ke chřadnutí nebo dokonce k odumření hostitelské dřeviny,
- druhy škodlivé, které snižují asimilační plochu dřeviny, a tím snižují její růst,
- druhy slabě škodlivé, jejichž poškození hostitelské dřeviny je málo patrné,
- druhy neškodné, jejichž výskyt se na růstu dřeviny vůbec neprojeví.

Převážná většina u nás se vyskytujících druhů bejlomorek na lesních dřevinách patří do této čtvrté skupiny neškodných druhů.

Vlastní bejlomorky jsou všeobecně velmi málo známé, vypadají jako malí komárci a většina lesníků se s nimi téměř nesetká nebo si jich vůbec nevšimne. Zato však hálky a novotvary jimi působené jsou často velmi nápadné, někdy barevné, a vyskytují se na všech částech rostlin – od zcela nepatrných velikostí několika milimetrů až po hálky, dosahující velikosti několika centimetrů. Specifický a charakteristický tvar, velikost i výskyt hálek umožňuje přesné určení původce. Ovšem schopnost vytvářet hálky se rovněž objevuje nejen u jiných skupin hmyzu, ale i u hlístic, roztočů a u různých druhů hub. Pro informaci o zastoupení a podílu hálkotvorného hmyzu a roztočů uvádíme z publikace jednu tabulku (podle Buhra, 1964–1965):

Skupina	Počet	Skupina		Počet
Vlnovníci (roztoči)	350	Blanokřídlí	– pilatky	75
Třásněnky	25		– žlabatky	170
Ploštice	5		– chalcidky	20
Stejnokřídlí	450	dvoukřídlí	– bejlomorkovití	600
Motýli	75		– vrtulovití	80
Brouci	135			

Nejpočetnější skupinou hálkotvorných živočichů jsou tedy bejlomorky. Pro možnost základního rozlišení původce může být určitým všeobecným vodítkem přítomnost trusu v hálkách, kdy se u bejlomorek trus vůbec nevyskytuje, kdežto u ostatních skupin je přítomnost trusu v hálkách dobře patrná. Řada druhů bejlomorek se vyvíjí na rostlinách, např. v květech, semenech nebo šiškách, ale nevytváří novotvary, hálky. Inkvilinní bejlomorky netvoří hálky, ale vyvíjejí se v hálkách jiných druhů bejlomorek nebo v hálkách jiných druhů hmyzu, např. v hálkách žlabatek. Některé druhy bejlomorek se živí jinými druhy hmyzu, např. mšicemi a červci; tyto dravé druhy mohou být využity i v biologickém boji proti škodlivému hmyzu, např. právě proti mšicím. Třetí trofická skupina se živí houbami – k nim se počítají i druhy, žijící fytosaprofágně v půdě a živící se sáním na rostlinných zbytcích. Nejlépe prozkoumané jsou bejlomorky hálkotvorné a inkvilinní, fytofágní, jejichž podíl je 76 % druhů; dravé, zoofágní bejlomorky tvoří asi 8 % druhů a mykofágní bejlomorky asi 16 % u nás známých druhů.

Publikace je členěna velmi prakticky tak, aby ji bylo možné používat i pro určení bejlomorek podle jimi vytvořených hálek. Lesní dřeviny (stromy i keře) jsou uspořádány abecedně podle českých názvů a u každé dřeviny jsou popsány bejlomorky, které na nich vyvolávají hálky. U každého druhu bejlomorky se uvádí: popis, bionomie, úmrtnost, hostitelské rostliny, vliv na hostitele, paraziti, otázky populační hustoty, možnosti boje, vztahy ke kvalitě ovzduší (prostředí), rozšíření a doprovodné grafy a kresby. Rozsah textu každého oddílu je úměrný významu každého druhu. Z lesnického hlediska jsou právě nejdůležitější údaje o výskytu, rozšíření a hojnosti druhu v České republice i o případné škodlivosti.

Prvních 13 kapitol publikace je velmi stručných, ale přesto výstižných; podávají dobrý přehled o všech dílčích otázkách. Klíč k určení hálek je již poněkud obsažnější a dominantní část celé knihy tvoří kapitola 15 (str. 34–163). Pro informaci uvádíme obsah a členění publikace: 1. Úvod, 2. Krátká historie studia hálek bejlomorek, 3. Systematické zařazení a počet druhů bejlomorek, 4. Morfologie bejlomorek, 5. Hálka (cecidium), 6. Vývoj bejlomorek, 7. Potravní (trofické) vztahy bejlomorek, 8. Geografické rozšíření bejlomorek, 9. Plošné rozšíření (frekvence výskytu), 10. Faunistický výzkum bejlomorek na území ČR, 11. Škodlivost bejlomorek na lesních dřevinách, 12. Paraziti, 13. Sledování hálek bejlomorek v přírodě, 14. Klíč k určení hálek bejlomorek na lesních dřevinách, 15. Bejlomorky lesních dřevin (počínaje bezem a konče zimostrázem).

Závěr publikace tvoří početný soupis literatury, který mj. velmi přesně dokumentuje výsledky obsáhlé a mnohaleté práce obou autorů. Text uzavírá anglický a německý souhrn a podrobný rejstřík českých i latinských názvů bejlomorek a lesních dřevin.

Hálky na lesních dřevinách i morfologii bejlomorek dokumentuje velké množství fotografií na 32 tabulích i četné fotografie, obrázky, perokresby, grafy, mapy rozšíření a přehledné tabulky v textu.

Dlouholetá práce obou autorů byla oceněna i na mezinárodním poli jinými vědeckými pracovníky – např. pojmenováním druhů bejlomorek *Resseliella skuhravyorum* Skrzypczynska (1975) a *Semudobia skuhravae* Roskam (1977).

Vydáním této publikace nasadila Matice lesnická svým *Dobovým spiskům* laťku velmi vysoko. Kniha Marcely a Václava Skuhravých je nejen velmi atraktivní a čtivou prací o bejlomorkách, ale vyplňuje i citelnou mezeru v naší literatuře. Stane se jistě neocenitelnou a neopominutelnou pomůckou nejen pro všechny uživatele, kteří se zajímají speciálně o bejlomorky, ale i pro ty, kteří se rádi dozvídají o tajích přírody, jež v převážné většině zůstávají povrchním pozorovatelům zcela utajeny.

Ing. Vlastislav Jančařík, CSc.

INSTRUCTIONS TO AUTHORS

The journal publishes original results of fundamental and applied research from all fields of forestry related to European forest ecosystems. An article submitted to Journal of Forest Science must contain original work and must not be under consideration for publishing elsewhere. Manuscripts should not exceed 25 double-spaced typed pages (A4 size) including tables, figures, references, abstract and summary. A PC diskette with the paper text and graphical documentation should be provided with the paper manuscript, indicating the used editor program. Papers should be clear, concise and written in Czech, Slovak or English. Each manuscript must contain two or three pages of English summary. Correct English is the responsibility of the author. Manuscripts should be typed on standard paper (A4 size, 60 characters per line, 30 lines per page). They must fully conform to the organization and style of the journal. Two copies of the manuscript should be sent to the executive editor: Mgr. Radka Chlebečková, Institute of Agricultural and Food Information, 120 56 Praha 2, Slezská 7, Czech Republic.

Text

Manuscript should be preceded by a title page comprising the title, the complete name(s) of the author(s), the name and address of the institution where the work was done, and the telephone and fax numbers of the corresponding author, or e-mail. Each paper must begin with an Abstract of no more than 90 words, and key words. The Introduction should be concise and define the scope of the work in relation to other work done in the same field. As a rule, it should not give an exhaustive review of literature. In the chapter Materials and Methods, the description of experimental procedures should be sufficient to allow replication of trials. Plants must be identified by taxonomic and common name. Abbreviations should be used if necessary. Full description of abbreviation should follow the first use of an abbreviation. The International System of Units (SI) and their abbreviations should be used. Results should be presented with clarity and precision. Discussion should interpret the results. It is possible to combine Results and Discussion in one section. Literature citation in the text should be by author(s), and year. If there are more than two authors, only the first one should be named in the text, followed by the phrase „et al.“ They should mainly consist of reviewed periodicals. References should include only publications quoted in the text. They should be listed in alphabetical order under the first author's name, citing all authors.

Tables

Tables should be numbered consecutively and have an explanatory title. Each table, with title, should be on a separate sheet of paper.

Figures

Figures should be referred solely to the material essential for documentation and for the understanding of the text. Duplicated documentation of data in figures and tables is not acceptable. All illustrative material must be of publishing quality. Figures cannot be redrawn by the publisher. Photographs should exhibit high contrast. All figures should be numbered consecutively with arabic figures. Both line drawings and photographs are referred to as figures. If several separate line drawings or photographs are to be incorporated in a single figure, they should be sticked on a white card with a minimum of space left between them. Each figure should contain a concise, descriptive legend.

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