

VĚDECKÝ ČASOPIS



# LESNICTVÍ

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# Vědecký časopis LESNICTVÍ

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## MAN AND FOREST

Science is a power and art is a feeling of people. In idea of the so-called science on science it is considered that the possibility of application of science is given by the level of public revenue. It has, however, its feedback. We are enlightened that the victory over nature is, in fact, a defeat of man, since man is a constitutional part of nature. Science and scientific and production progress associated have brought great success and improved the living standard of people.

Nevertheless, this valuable coin has its negative wrong side, which is represented by destructive war means and dangerous environmental pollution. While military arms can be effective instantaneously and there is the possibility of controlling them, though only to a limited extent, environmental pollution acts somehow unwillingly, without direct intention but with slinking destructiveness.

Mankind searches for means to prevent war destruction and, fortunately, finds them. Therefore, the ways to understanding, which are given by an iron law of sense, have been pointed out and realized. It is evident that a great war of mankind would be their last war, in which only the defeated would occur.

If we recognize that war belongs to the past and it is ranked out of human law, the necessity of solving the other great jeopardy for mankind is opened. It concerns pollution of air, soil and water without which our human genus cannot live. In spite of concluding important international agreements, the desirable changes do not advance quickly enough. Provided that armament is reduced the saved investment can be used for the struggle against starvation. Hunger torments a great part of mankind, including, unfortunately, children, especially in developing countries. Furthermore, considerable means can be given to remove environmental pollution. Nevertheless, removing harmful substances is only a passive part of pollution control. In an active sense, the only right solution is to change processes of manufacture in such a way not to produce harmful substances at all, because they often represent unworked valuable raw material as, for example, sulphur. Consequently, the solution implies not only separating harmful substances, but also preventing their production. Therefore, it is necessary to consider and design all human works in such a way to be in conformity with nature and man. We are often in the role of good workers who do wrong work in spite of making every effort, because the approach to it is incorrect.

Our successful development is conditioned by harmony between us and nature. At this point, the scientific approach itself predominated by reason, is insufficient. Considerable emotional share, which is proper to arts, is desirable as well. It is necessary to associate knowledge and feeling with high creative imagination, particularly in long-range prospects.

To constitute new value standards, the present conditions and planned objectives should be evaluated thoroughly. Artists led by their emotional impulse are speaking about crime against nature. Such a criminality need not always be conscious. Murder and simple killing, however, have the same consequences for the afflicted. It is difficult to recognize, admit and remove a mistake of the individual and even those of the whole society. Nevertheless, it is the only way to prevent the threatening danger.

It concerns also the problem of conservation and management of green vegetation both continuous green areas of forests and parks and those spread in groups throughout the landscape. The United Nations, together with its Food and Agriculture Organization in Rome, has advertised a world-wide task "Everybody will plant one tree at least" which refers to the old wisdom saying that "if you want to sit in the shadow when you are old plant a tree when you are young". The green vegetation withers in all industrial towns of the world which is best exemplified in forests. Forests are rightly called "the lungs of mankind". They are of decisive importance for the environment. Forests are endangered still more, with regard to their continuing mercenary destruction in developing countries, esp. in South America, with consequent destruction of the whole country and annihilation of its

original inhabitants. In these countries, however, considerable people's resistance arises, in spite of the fact that it sometimes results in murdering as has happened recently in the case of the so-called Amazonian Gándhí.

A quite new yet unknown phenomenon is withering and dieback of forests due to industrial pollutants. Some damage has been observed even for a long time, but the consequences which had been initially little apparent have broken out recently like a big fire or explosion and have threatened the industrially well-developed part of mankind. In well-developed industrial countries of Europe, pollutants, released to the atmosphere, amounted to 523 million tons in 1960 and even 792 million tons in 1987. It is apparent most remarkably in the dieback of long-aged forest communities. In 1986, the highest damage to forests was exhibited in Holland (55 per cent), followed by the Federal Republic of Germany (54 per cent) and England (49 per cent).

Analogous situation is in other countries. In addition to local sources, remote transports of pollutants, which are borne even thousands of kilometres from the place of their origin, have very unfavourable effects. The substances get to higher atmospheric layers and are carried to considerable heights and distances by wind flows. In our country, summits and mountain lakes are damaged in the Tatras. Analogously, Scandinavian countries, for example, complain of damage from European sources, e. g. from England.

It is consequently a global problem which must be solved through close international cooperation. Therefore, the effort of our government to enlarge the existing international agreements by further effective measures, especially in Central Europe, is deserving.

It is quite obvious that mankind must change the production method and go on to wasteless technologies, predominantly in natural way which is, however, very difficult and requires long-term efforts. At present, it is necessary to search for all paths to improve the existing undesirable condition.

Active international cooperation demands a comprehensive exchange of information. Small nations have a disadvantage that their mother tongue is not an international language. To secure a valuable communication of knowledge, it is necessary to interpret important data into international languages. This presupposes perfect general knowledge of the language, as well as good experience in special terminology. As early as in 1971 "The Foreign Language Vocabulary of Special Forestry Terms" (in seven languages) was published as a special issue of the scientific journal *Lesnictví* (Forestry). In 1986, it was followed by the "Czech and Slovak Terminological Dictionary — FORESTRY — Selection of basic terms with Russian, German and English Equivalents".

The Editorial Board of the scientific journal *Lesnictví*, in their endeavour to stimulate and deepen international cooperation in forestry, have decided to follow with former experience and tradition of publishing the English version of this journal, including one issue per year. It is evident that this issue cannot represent the whole extensive activities of Czechoslovak scientists and specialists. Nevertheless, it should be a window to our professional life from which our problems and their solutions can be recognized and understood in the context of world-wide development. It will facilitate informing the world professional public about our activities. Up to the present, 213 impressions of the scientific journal *Lesnictví* have been distributed abroad and the papers published are annotated by the leading documentation services, above all those of FAO UNO.

We appeal also to our Czechoslovak readers for supporting our effort which gives them the possibility of publishing their findings in an international language and comparing the text to deepen their knowledge.

We hope that this intention will be of general use and that Czechoslovak and foreign forestry specialists will enrich it with their suggestions.

*Academician Prof. Dr. Ing. Miroslav Vyskot, DrSc.  
Chairman of the Editorial Board  
of the scientific journal LESNICTVÍ (Forestry)*

## ČLOVĚK A LES

Věda je silou a umění citěním lidí. V pojetí takzvané vědy o vědě se soudí, že možnost uplatnění vědy je dána výší národního důchodu, což má ovšem i zpětné vazby. Jsme poučeni o tom, že vítězství nad přírodou je vlastně porážkou člověka, ježto člověk je bytostnou součástí přírody. Věda a na ni navazující vědeckovýrobní pokrok přinesly velké úspěchy a zvýšily životní úroveň lidí.

Tento cenný peníz má však i zápornou, rubovou stranu, kterou představují zkázonosné válečné prostředky a nebezpečné znečištění životního prostředí. Zatímco vojenské zbraně mohou působit okamžitě a lze je, i když omezeně, řídit, znečištění prostředí působí jaksi nechtěně, bez přímého záměru, ale zato s plíživou zkázonosností.

Lidstvo hledá a našťěstí již nalézá cesty, které mouhou zabránit válečné zkáze. Proto se vytyčují a uskutečňují cesty dorozumění, které plynou ze železného zákona rozumu. Je totiž zřejmo, že velká válka lidstva by byla jeho poslední válkou, v níž by byli jenom poraženi.

Uznáme-li tedy, že válka patří do minulosti a je postavena mimo lidský zákon, otevírá se nezbytnost řešení druhého velkého ohrožení lidstva, jímž je znečištění vzduchu, půdy a vody, bez nichž nemůže náš lidský rod žít. I když už byly uzavřeny významné mezinárodní dohody, kýžené změny nepostupují dostatečně rychle. Snížíme-li zbrojení, můžeme ušetřit výklady věnovat na boj proti hladu, který sužuje velkou část lidí, a bohužel i dětí, zvláště v rozvojových zemích. Mohli bychom také věnovat značné prostředky na odstranění nečistot z našeho prostředí. Ovšem odstraňování škodlivin je vlastně trpná část boje proti nim. V čínorodém smyslu je jediné správné řešení změnit výrobní postupy tak, aby při nich žádné škodliviny nevznikaly, protože nezdídka představují nezpracovanou cennou surovinu, jako je tomu u síry. Není tedy cesta jen v odlučování škodlivin, ale v zabránění jejich vzniku vůbec. Proto je nezbytné všechna lidská díla promýšlet a osnovat tak, aby byla v souladu s přírodou a člověkem. Často jsme totiž v úloze dobrých pracovníků, kteří přes veškeré úsilí vytvoří špatné dílo, protože jeho pojetí bylo nesprávné.

Podmínkou našeho zdárného rozvoje je soulad mezi námi a přírodou. Zde nestačí jen vědecký přístup, který vládne především rozumem, ale vyžaduje to i velký citový vklad, který je vlastní umění. Zejména v dlouhodobých výhledech je nezbytné spojovat vědění a citění se značnou dávkou tvůrčí představivosti.

Abychom vytvořili nová hodnotová měřítka, je třeba posoudit velmi odpovědně současný stav a vytyčené cíle. Umělci vedeni svým citovým vznětem již otevřeně hovoří o zločinech na přírodě. Takováto zločinnost nemusí být vždy vědomá. Ovšem pro postiženého má vražda i prosté zabití stejně zhoubný následek. Je obtížné poznat, uznat a odstranit chybu jednotlivce, natož pak chyby celé společnosti. Nicméně je to jediná cesta, jak zabránit hrozícímu nebezpečí.

Je tomu tak i v otázce ochrany a tvorby zeleně, af již souvislé zeleně lesů, sadů anebo skupinovitě roztroušené v krajině. Spojené národy společně se svou Organizací pro výživu a zemědělství v Římě vytyčily celosvětový úkol „každý vysadí alespoň jeden strom“, což navazuje na starou moudrost, pravící, že „chceš-li sedět ve stáří ve stínu, v mládí vysaď strom“. Ve všech průmyslových oblastech světa hyne zeleň, což se nejvíce zračí na příkladu lesů. Lesy se právem označují za plice lidstva a mají rozhodující význam pro životní prostředí. Nebezpečí je o to větší, že v rozvojových zemích, zejména v Jižní Americe, pokračuje zjištěné ničení lesů s následnou zkázou celé krajiny a vyhubením původního obyvatelstva. I zde se však zvedá mocný lidový odpor, i přesto, že končí i vražděním, jak se stalo nedávno v případě takzvaného amazonského Gándhiho.

Zcela novým, dříve neznámým jevem je chřadnutí a hynutí lesů v důsledku průmyslových škodlivin. Některé škody byly pozorovány již dlouho, ale původně málo zjevné důsledky propukly v posledním období doslova jako velký požár nebo výbuch a ohrozily průmyslově vyspělou část lidstva. Zplodiny, které unikaly například v Evropě do ovzduší, činily v průmyslově vyspělých zemích v roce 1960 523 miliónů tun a v roce 1987 již 792 miliónů tun. Nejnázorněji je to patrné právě

na hynutí dlouhověkého společenstva lesů. Největší poškození lesů vykazovalo v roce 1986 Holandsko (55 procent), NSR (54 procenta) a Anglie (49 procent).

Obdobná situace je i v dalších zemích. Mimo místní zdroje působí velmi neblaze dálkové přenosy škodlivin, které pronikají i tisíce kilometrů od místa svého vzniku. Dostávají se do vyšších vrstev ovzduší a větrnými proudy jsou zanášeny do velkých výšek a značných dálek. I u nás jsou poškozeny vrcholové části hor a horská plesa v Tatrách. Obdobně si například skandinávské státy stěžují na poškození z evropských zdrojů, např. z Anglie.

Jde tedy o světový problém, který musí být řešen za úzké mezinárodní spolupráce. Proto je velmi záslužné úsilí naší vlády prohloubit dosavadní mezinárodní dohody o další účinná opatření, zejména ve střední Evropě.

Je zcela zřejmé, že lidstvo musí změnit způsob výroby a přejít na bezodpadové postupy, převážně přírodní cestou, což ovšem je velmi obtížné a vyžádá si dlouhodobé úsilí. V této době je třeba hledat všechny cesty, jak zmírnit současný nežádoucí stav.

Aktivní mezinárodní spolupráce však vyžaduje rozsáhlou výměnu informací. Malé národy mají nevýhodu v tom, že jejich jazyk není jazykem světovým. K zabezpečení kvalitní komunikace poznatků je nezbytné interpretovat důležité údaje do světových jazyků. To vyžaduje dokonalé obecné jazykové znalosti i zvládnutí odborné terminologie. Proto jsme vydali již v roce 1971 „Cizojazyčný slovník odborných lesnických pojmů“ (v sedmi jazycích), který vyšel jako zvláštní číslo vědeckého časopisu Lesnictví. Na něj pak navázal v roce 1986 „Český a slovenský terminologický slovník LESNICTVÍ — výběr základních pojmů s ruskými, německými a anglickými ekvivalenty“.

Redakční rada vědeckého časopisu Lesnictví, ve snaze podnítit a prohloubit mezinárodní spolupráci v lesnictví jako odvětví, se rozhodla navázat na dřívější osvědčenou tradici vydávání anglické verze tohoto časopisu v rozsahu jednoho čísla ročně. Je přirozené, že toto číslo nemůže reprezentovat celou rozsáhlou činnost československých vědců a specialistů. Má být však oknem do našeho odborného života, z něhož lze poznat a pochopit naše problémy i jejich řešení v kontextu s celosvětovým rozvojem. Umožní to lépe informovat světovou odbornou veřejnost o naší práci. Vždyť již nyní je 213 výtisků časopisu Lesnictví zasíláno do zahraničí a anotováno v předních dokumentačních službách, zejména FAO OSN.

Apelujeme také na naše domácí čtenáře, aby podpořili tuto naši snahu, která jim dává možnost publikovat svoje poznatky ve světovém jazyku a srovnáváním textu prohloubit jeho znalost.

Doufáme, že tento záměr bude obecně prospěšný a že jej naši i zahraniční odborníci svými náměty ještě rozhojní.

*Akademik prof. dr. ing. Miroslav Vyskot, DrSc.  
předseda redakční rady  
vědeckého časopisu LESNICTVÍ*

## FOREST AS AN ECOLOGICAL AND ECONOMIC FACTOR

M. Vyskot

VYSKOT, M. (Institute of Systematic and Ecological Biology of the ČSAV, Brno): *Forests as an Ecological and Economic Factor*. *Lesnictví*, 35, 1989 (11) : 949-959.

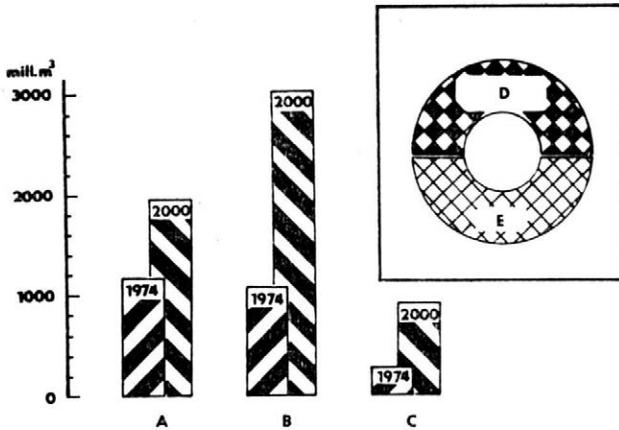
The need of mankind increases faster than disposable sources of raw materials. It is manifested markedly in the case of oil which, as a strategic raw material, becomes a reason for sharp economic and political conflicts. The majority of fossil energy sources is exhaustible and forecasts on the future development in this field are dreary rather than optimistic ones. Therefore, attention is drawn to reversible resources among which the forest treasure is of key importance. Nevertheless, it has been utilized only in part and not economically enough.

forests; biomass; logging; air pollutants

### WORLD FORESTS

The living substance, the so-called biomass of the Earth, is estimated to be 1.8 billion tons in dry weight. The plants represent 97 % of this sum with an 84% majority of forests. Therefore, forests participate in more than 4/5 of the dry biomass of our planet and form 40 % of annual increment of terrestrial organisms. In accordance with the world statistics, forests and fish are the most important living sources of nature. Likewise, their annual biomass increment per 1 ha is rather high. In tropical forests the annual dry biomass increment per 1 ha amounts to 30 t and in the forests of our temperate zone it attains 10 t. For comparison, it can be mentioned that meadows, steppes and savannas reach an average annual dry weight increment of 9 t and fields represent 5 t per 1 ha. Logging is on the third place on a world scale, following the exploitation of oil and coal, and it is higher than iron production.

The world forests cover 37 million km<sup>2</sup>. Two-thirds of these forests are formed by deciduous tree species and one-third by conifers. The world forest resources amount to 238 mld m<sup>3</sup>, of which 114 mld m<sup>3</sup>, i.e. 48 %, fall to coniferous forests. The share of forests on earth lands amounts to 30 %. During the last two centuries the forest areas of the Earth were reduced to a half. In Europe the highest reduction was exhibited in England, where the forest area decreased to 5 %, followed by France, Spain and Greece, where more than 80 % of the original forests decreased. The present reasons for the tremendous decrease of the world forests are associated with excessive logging, forest fires, grazing and fallow lands. In spite of increased world wood processing, there is 50 % of the world volume felled which has still been burned. In developing countries even 80 % of the total volume felled is burned. On the other hand, in advanced industrial countries only 3 % of the

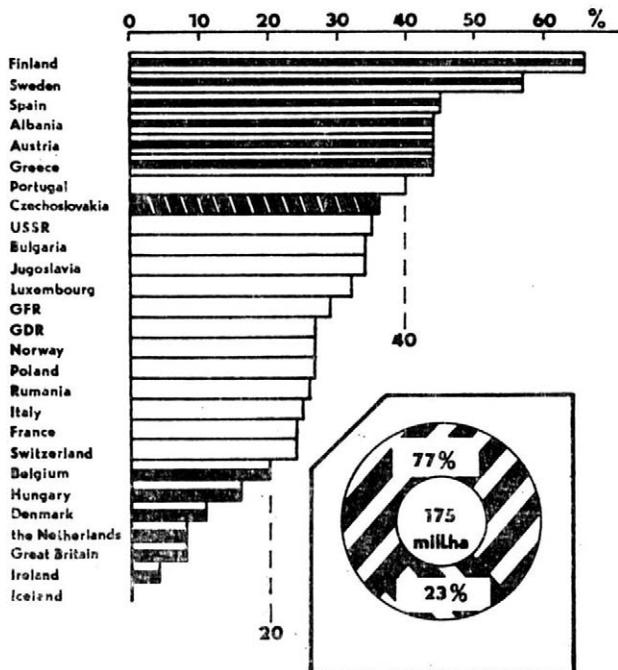


1. World wood consumption: A — fuelwood, B — round wood, sawn timber, flat products, C — paper-making wood. Volume felled in 1974 and its utilization: D — industrial raw material, E — fuelwood

volume felled is burned. Wood as an energy raw material is on the world programme as a result of the energy crisis. By the year 2000 wood is still expected to cover as much as 15 % of energy demand. In this connection, fast growing woody species are especially considered. The amount of 6.25 m<sup>3</sup> of wood is reported as an equivalent of 1 t of oil. For example, according to the Swedish programme it is presumed that wood will cover even one half of the consumption. In tropical and subtropical regions the so-called energy forest plantations are projected at the photosynthetic efficiency of 1 — 2 % to increase the use of solar radiation even to 6 %. The energy function, however, is not the main mission of forests and wood, because the need for wood as an irreplaceable raw material prevails from the economic point of view. The number of wood products is ever increasing. In 1920, 1945 and after 1980 the number of wood products was reported to be 2,500, 5,000 and more than 25,000, resp.

According to the forecasts of UNO and FAO the world is threatened with a lack of wood and, therefore, forests must be regenerated to increase their production in harmony with the landscape management. Forests cannot be considered only „deposits” of raw material. The data of UNESCO report that the non-production functions of forests overreach the production functions in many regions. The forests absorb 90 milliard tons of CO<sub>2</sub> per year. They remove 25 % of dust and 40 % of SO<sub>2</sub> from the atmosphere. In the USSR, the total annual effect of the forest was calculated at 450 — 640 roubles per 1 ha, of which the share of wood was only 7 — 10 %. In economically less developed countries the methods of the so-called agrosilviculture are considered. It is a combination of field and forest management to prevent forest devastation and increase the yield of the fields and forests. Voices of warning against forest exploitation have been heard still more. It concerns especially tropical forests, which cover about 20 mill. km<sup>2</sup>, and the majority of them is threatened with extinction or devastation by the year 2000. It means a destruction not only of the forest, but also of the whole environment. The global climatic balance and other factors, necessary for life, are endangered. The CO<sub>2</sub> content increases and, in result of it, our temperate zone becomes warmer and drier.

2. Forest percentage in European countries. Total afforested area in Europe and its utilization: yielding forests 77%, unused forests 23%

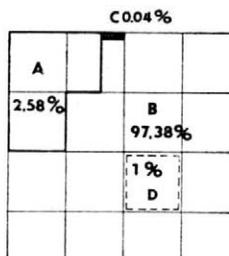
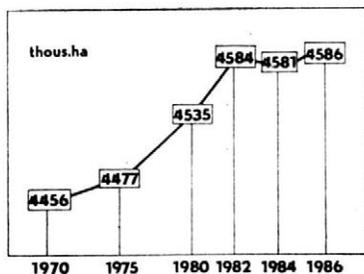


More than 10 000 km<sup>2</sup> of the forest decrease on the Earth per year! In accordance with scientific analyses the forest area should not fall below 30 mill. km<sup>2</sup> on the Earth, not only for economic reasons, but particularly for irreplaceable functions of the forest, which influence oxygen production and atmosphere structure. These facts indicate that forests cannot be a soil reserve for agriculture, because they are ecological complexes, which must be covered with the systems of the forest, water, field, industry and settlement. On the contrary, pastures, natural meadows and wilderness should be considered natural resources of agricultural land.

### CZECHOSLOVAK FORESTS

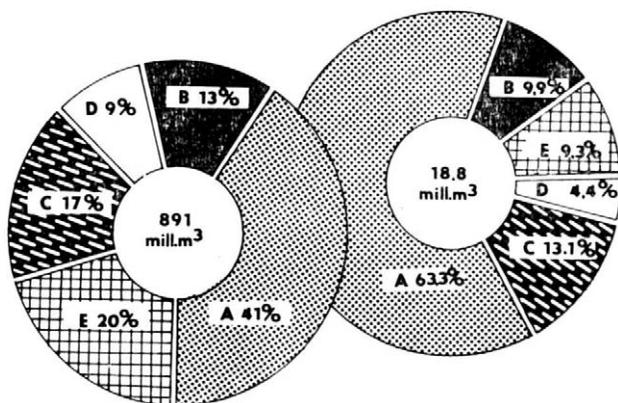
According to the data of the Federal Statistic Office, in 1984 the total forest area of Czechoslovakia covered 4,580,585 ha, of which the CSR and SSR shared 2,626,142 ha and 1,954,442 ha, resp. As a matter of fact, all forest are in socialist ownership. Unified Agricultural Cooperatives manage 125,939 ha and only 2,119 ha is privately owned. In 1983, the number of inhabitants in Czechoslovakia amounted to 15,437,028. This represents consequently, less than 0.30 ha of forest per one inhabitant.

The main species in Czechoslovakia is spruce with 43%, followed by beech, pine and oak with 18%, 14% and 8%, resp. The other species do not attain more than 5% each, and some of them, which had occurred previously on mass, as e.g. fir, die out of our forests. The total growing stock of Czechoslovak forests amounts to 897 mill. m<sup>3</sup>. The volume of wood felled increases all the time. In 1945 it amounted to



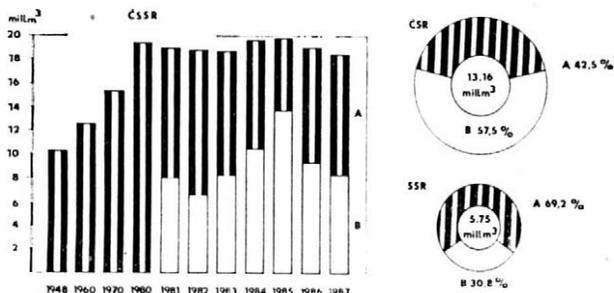
3. Czechoslovak forests. Development of the area of forest land in thousand hectares. Structure of forest area according to sectors (1986): A — cooperative sector, B — state sector, C — private sector, D — 1% forest area

about 8 mill. m<sup>3</sup> inside bark per year, in 1970 14.4 mill. m<sup>3</sup>, in 1975 16.2 and in 1983 18.9 mill. m<sup>3</sup>, to which about 13% of volume is to be added for bark. The production capacity of wood-working industry was enhanced from 100% in 1948 to 1,058% in 1983. The annual volume of wood felled inside bark per one inhabitant of Czechoslovakia amounts to 1.3 m<sup>3</sup>. The same value per 1 ha of forests attains 4.1 m<sup>3</sup>. ha<sup>-1</sup>. The so-called incidental and salvage fellings participate in the volume felled considerably. In 1983 these unplanned and economically uncontrolled fellings represented 41% of the total balance, which is about 8 mill. m<sup>3</sup>. In 1984 and 1985 salvage fellings increased to 50%. Forests, as mentioned above, are significant not only as wood producers, but also as an important component of human life. Czechoslovakia is, for example, dependent only on water precipitation in water balance, because, from the geographical point of view, it forms a certain roof of Europe: most of its waters flow away. In spite of the fact that forests form only 36% of Czechoslovak territory, 51% of total annual precipitation fall on forest soil. The annual forest evaporation attains approximately 30% of the total evaporation in our territory. Forests are important moderators of the bioclimate. They modify extremes, absorb and gradually release water, they are the most effective biological obstacles to water and wind erosions. For a comparison, in Czechoslovakia there are 3 mill. ha of soil which is endangered by water erosion and 1.5 mill. ha by wind erosion. Consequently, the whole third of our territory and a half of agricultural soil are threatened by erosion. Even at the present state of forests, floating debris of the Elbe river near Děčín attains 500,000 t and that in the lower stream of the Morava 350,000 t annually. Forests deliver air from dust and gas pollution. An



4. Proportions of woody species and total growing stock in 1985. Volume felled in 1986. A — spruce, B — pine, C — beech, D — oak, E — other woody species. CSSR — the Czechoslovak Socialist Republic

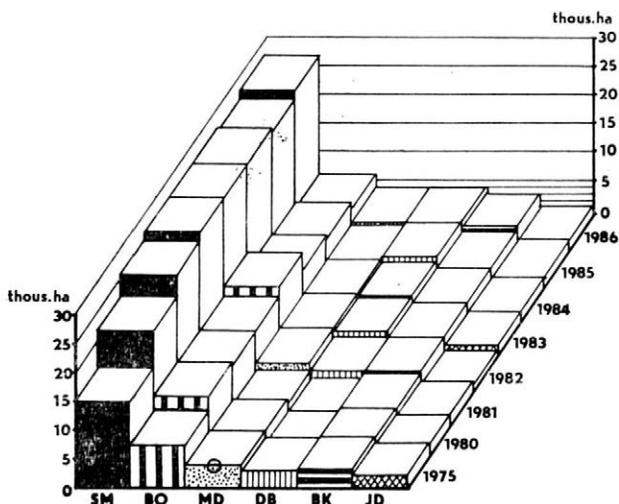
5. Development of wood felling. Volume felled in 1986: A — planned felling, B — incidental felling. CSR — the Czech Socialist Republic, SSR — the Slovak Socialist Republic.



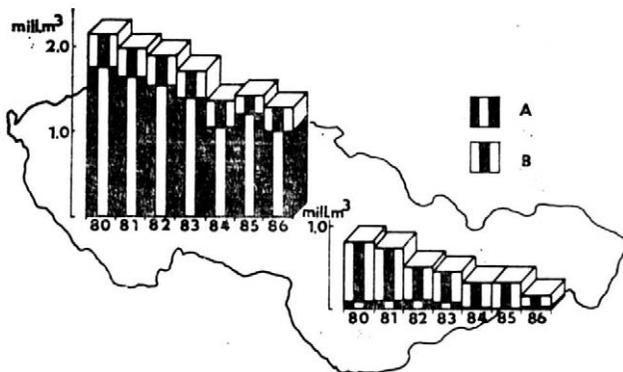
average deciduous tree covers e. g. oxygen consumption for three men. 1 ha of the forest absorbs 39 — 68 t of dust per year. Furthermore, the recreational functions of the forest increase. They are utilized systematically by more than 75 % inhabitants. It was calculated that the so-called non-production functions of the forest surpassed the value of wood felled even five times.

### THREAT TO FORESTS

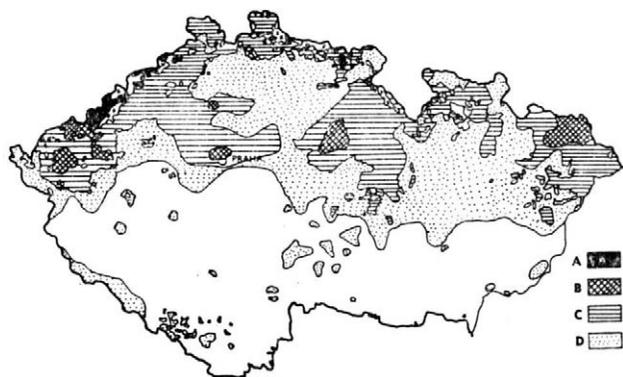
Pollution damage represents considerable losses in wood production. Nevertheless, the damage to the forest functions in water management, soil conservation, climate and in the health effect is much more conspicuous. The western region of our country, especially that of the Ore Mountains, is afflicted catastrophically. Not only the Ore Mountains are endangered. The damage spreads to the Orlické and the Jizerské Mountains, the Giant Mountains and the Beskids, likewise in Slovakia the regions of Žiar n. H., Rožňava and Lučenec are threatened. Even one third of forests dies back, and by the year 2000 a serious threat is forecasted to more than a half of our forest wealth. It is necessary to realize that this irretrievable damage can be prevented only by a change in the technologies of industry and power engineering. Simultaneously, there is the possibility of obtaining important raw materials such as, for



6. Afforestation according to woody species: SM — spruce, BO — pine, MD — larch, DB — oak, BK — beech, JD — fir



7. Development of wood export in 1980—1986: A — soft wood, B — broadleaved wood



8. Threat to forests of the CSR to December 31, 1985. Threatened zones: Vitality of spruce stands from the beginning of damage:

- A — up to 20 years
- B — 21—40 years
- C — 41—60 years
- D — 61—80 years

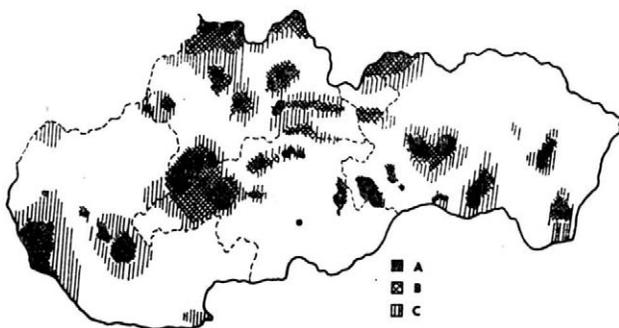
example, sulphur compounds. Forestry can prevent directly only small damage by planting more resistant tree species, particularly broadleaved ones and some introduced conifers, by different amelioration approaches, above all of forest hydrological regime and some fertilization methods.

There is another question of great importance: the harmony between forestry and game management. In the order of damages which endanger forests, pollutions are closely followed by wildlife game, which at insufficient hunting sustenance impairs tremendously our forests. The damage is frequently not too obvious, but it has a long-term effect, as e. g. in the damage to forest stands, especially those of spruce, by deer game peeling. Likewise, fungal pests are responsible for significant damage. It is caused, to a great extent, by impairing the trees in careless extraction of timber from forest stands. As it is apparent, a complex of the problems is in question, which are to be solved consistently respecting all basic conditions of the life and formation of the forest.

#### COMPLEX UTILIZATION OF FOREST TREE BIOMASS

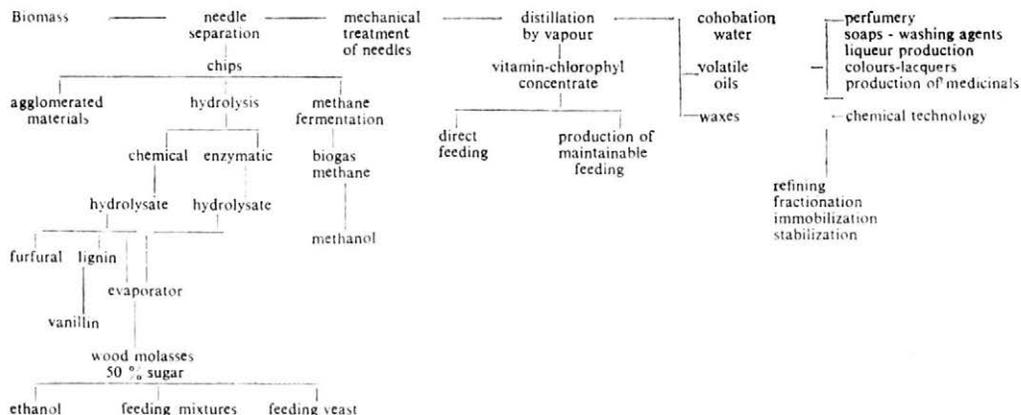
When evaluating the general situation, the problem of complex utilization of forest tree biomass (dendromass) comes out. Up to the present this question has been solved predominantly using methods of mechanical technology and the wood was evaluated mostly according to volume units. If we consider that in Czechoslovakia at the annual

9. Threat to forests of the SSR as of December 31, 1986: A — heavy threat, B — medium threat, C — slight threat

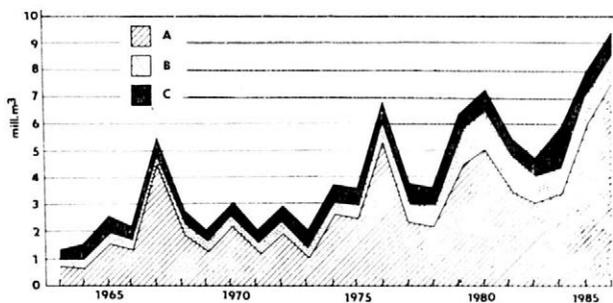


volume of wood felled of 19 mill. m<sup>3</sup>, the forest biomass of about 17 mill. t in fresh weight and more than 9 mill. t when dry can be obtained, it is obvious that there are still considerable reserves. Thin wood and branches remain lying unused and they are often uneconomically burned. This represents approximately 6 mill. m<sup>3</sup> of forest dendromass, which is about 5 mill. in fresh condition and 3 mill. when dry. It is to be emphasized that the forest biomass has been wasted unbearably up to now and it has been mostly destroyed as a troublesome ballast. Mechanisms are developed to rake and remove it and it is burned at many million expenses. Furthermore, an unfavourable fact should be considered that recently forest fires have destroyed and impaired nearly 1,300 ha of the forest and have been responsible for a damage of over 17 mill. Kčs. The greatest share in this damage is represented by undesirable burning of slash.

Therefore, it is necessary to pay heed to exploitation of unutilized sources of forest biomass. In this sphere a wide field of activity is open by complex methods of processing, especially by chemical approaches. It is clearly apparent from the possibility of complex processing of waste in logging of conifers. Green branches can be treated using the method of needle separation, so that brown and green chips are obtained. After mechanical treatment of needles the green chips are distilled by vapour to obtain vitamin-chlorophyll concentrate and volatile



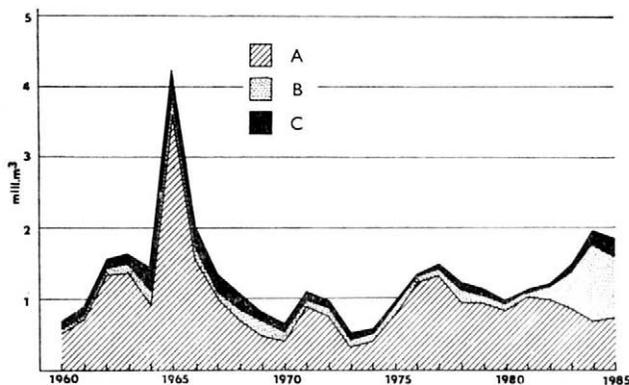
10. Diagram of complex biomass treatment from needle tree species (Vyskot—Uher, 1979)



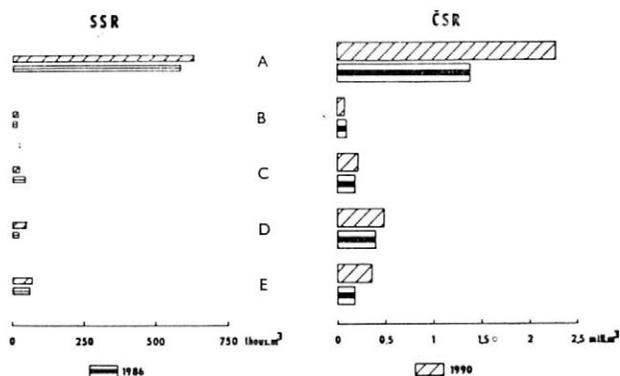
11. Annual volume of incidental felling in the forests of the State Forest Enterprises of the ČSR in the period of 1963—1986. Large timber inside bark in mill. m<sup>3</sup>. A — wind + snow + icing, B — air pollutants, C — biotic factors

oils with waxes. The concentrate can be used for direct feeding or for the production of non-perishable feedstuffs. The volatile oils can be utilized in the production of medicinals, colours, lacquers, liqueurs, soap, washing agents, perfumes, etc. The whole process provides further possibilities in refining, fractionation, immobilization and stabilization of these substances.

Wood chips can be processed for agglomerated materials, or by hydrolysis and methane fermentation. The hydrolysis can be either chemical or enzymatic. Its products are wood molasses, feeding yeast and ethanol or, in other series, furfural, lignin and vanillin. This example demonstrates wide possibilities of chemical wood processing. Wood is one of the principal home-grown raw materials of unique cha-



12. Annual volume of incidental felling in the forests of the State Forest Enterprises of the SSR in the period of 1960—1985. Large timber inside bark in mill. m<sup>3</sup>. A — wind + snow + icing, B — other harmful factors, C — insect pests



13. Losses in wood production by air pollutants in Czechoslovak forests. Losses owing to: A — increment decrease, B — temporary exclusion from production, C — lifetime decrease, D — thinning of stands, E — confusion of woody species

racter, which is given by the fact that under good management the source of wood is inexhaustible and, on the contrary, wood production can increase considerably as a result of forest improvement.

## CONCLUSION

Forests are a great treasure of our planet. They provide not only valuable raw material — wood, but they are important components and factors of the environment. Nevertheless, world statistics show that the forest area decreases rapidly, by which not only wood production but also living conditions of people are threatened. On a world scale wood becomes a shortage article, the utilization of which has been versatile still more. Therefore, it is necessary to care for forests and to regenerate them according to the ethical duty to pass them to future generations in better condition than they had been assumed by us. Provided that forests are to continue being improved, we must prevent damage to them, especially by toxic pollutants.

In Czechoslovakia, there is 41 % of salvage fellings at the annual wood volume felled of 19 mill. m<sup>3</sup> inside bark. This indicates the necessity to increase the forest resistance potential. In addition to the above-mentioned 19 mill. m<sup>3</sup> of the annual volume felled, there is 6 mill. m<sup>3</sup> of wood waste which is unutilized and/or even destroyed. This concerns mostly branches which are a potential source of the production of feeds, vitamins, medicinals and other products. Therefore, the principal trend of complex forest management seems to be the utilization of all disposable sources, in accordance with the development of living conditions and prosperity of society to emphasize the universal social importance of the forest.

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VYSKOT, M. (Ústav systematické a ekologické biologie ČSAV, Brno): *Lesy jako ekologický a ekonomický faktor*. Lesnictví, 35, 1989 (11) : 949-959.

Lesy jsou velkým bohatstvím naší planety. Skýtají nejenom cennou surovinu — dřevo, ale jsou velmi významnými komponenty a činiteli životního prostředí. Světové statistiky však ukazují, že rozloha lesů rapidně klesá, což ohrožuje nejen produkci dřeva, ale zhoršuje i podmínky života lidí. Dřevo se stává ve světovém měřítku nedostatkovou surovinou, jejíž využití je stále všestrannější. Proto je třeba o lesy pečovat a zvelebovat je podle etické povinnosti, odevzdat lesy příští generaci v lepším stavu, než jsme je sami převzali. Mají-li být však dále zvelebovány, musíme čelit poškozování lesů, zejména toxickými imisemi. Při roční těžbě kolem 19 mil. m<sup>3</sup> dřeva bez kůry v ČSSR je 41 % kalamitních těžeb, což signalizuje nutnost zvyšování odolnostního potenciálu lesů. Mimo uvedených 19 mil. m<sup>3</sup> roční těžby zůstává nevyužito anebo je dokonce ničeno 6 mil. m<sup>3</sup> stromového odpadu, zejména větví, které jsou potenciálním zdrojem pro výrobu krmiv, vitamínů, léčiv a dalších produktů. Ukazuje se tedy, že hlavními směry dalšího komplexního hospodaření v lesích je využívání všech disponibilních zdrojů v souladu s rozvojem životních podmínek a prosperity společnosti s hlavním akcentem na celospolečenský význam lesů.

lesy; biomasa; těžba dřeva; imise

ВЫСКОТ, М. (Институт систематической и экологической биологии ЧСАН, Брно): *Леса в качестве экологического и экономического факторов*. Lesnictví, 35, 1989 (11) : 949-959.

Леса — это большое богатство нашей планеты. Они предоставляют ценное сырье — древесину, и являются значительными компонентами и факторами окружающей среды. Всемирные статистики однако показывают, что площадь лесов быстро понижается. Это угрожает не только продукции древесины, но также ухудшает условия существования людей. Древесина становится отсутствующим в мировом масштабе сырьем всестороннего использования. Поэтому нужно заботиться о лесах, возобновлять их и, согласно этической обязанности, передать леса будущему поколению в лучшем состоянии, чем мы их приняли. Но для дальнейшего возобновления лесов надо предотвратить повреждение лесов, происходящее преимущественно под воздействием токсичных загрязняющих веществ. При лесозаготовке около 19 млн. м<sup>3</sup> древесины без коры в год, в ЧССР отмечается 41% рубок после стихийных бедствий, что сигнализирует необходимость повышения потенциала устойчивости лесов. Кроме вышеупомянутых 19 млн. м<sup>3</sup> годовой рубки, не используется, или даже уничтожается 6 млн. м<sup>3</sup> древесных отходов, преимущественно ветвей, которые являются потенциальным источником для производства кормов, витаминов, лекарственных веществ и дальнейших продуктов. Следовательно показывается, что главными направлениями дальнейшего комплексного лесохозяйства является использование всех применимых источников, в согласии с развитием условий существования и благополучием общества, подчеркивая всеобщественное значение лесов.

леса; биомасса; лесозаготовка; загрязняющие вещества

VYSKOT, M. (Institut für systematische und ökologische Biologie der ČSAV, Brno): *Wälder als ökologischer und ökonomischer Faktor*. Lesnictví, 35, 1989 (11) : 949-959.

Die Wälder stellen einen grossen Reichtum unseres Planeten dar. Sie bieten nicht nur einen wertvollen Rohstoff — das Holz — aber gleichzeitig sind sie auch eine bedeutende Komponente der Umwelt. Die internationalen Statistiken zeigen, dass die Waldflächen schnell abnehmen, was nicht nur die Holzproduktion bedroht, sondern auch die Lebensbedingungen der Menschen verschlechtert. Das Holz wird im Weltmassstab zum Mangelrohstoff, dessen Ausnutzung stets allseitiger wird. Deshalb müssen wir für die Wälder sorgen, sie betreuen und veredeln, um entsprechend der ethischen Pflicht sie den nachfolgenden Generationen in einem besseren Zustand als wir sie übernommen haben, zu übergeben. Sollen sie aber weiterveredelt werden, müssen wir ihre Beschädigung mit toxischen Immissionen stoppen. Bei einem jährlichen Einschlag von ungefähr 19 Mio. m<sup>3</sup> Holz ohne Rinde gibt es in der ČSSR 41% Kalamitätennutzung, was die Notwendigkeit der Steigerung des Resistenzpotentials der Wälder signalisiert. Neben den angeführten 19 Mio. m<sup>3</sup> Einschlag/Jahr bleiben unausgenutzt oder werden zerstört ungefähr 6 Mio. m<sup>3</sup> Baumabfall (Äste), die als Potentialquelle für die Produktion von Futtermitteln, Vitaminen, Arzneimitteln und von anderen Produkten anzusehen sind. Es zeigt sich also, dass die wichtigsten Trends der weiteren komplexen Bewirtschaftung der Wälder die Ausnutzung aller zur Verfügung stehenden Quellen entsprechend der Entwicklung der Lebensbedingungen und der Prosperität der Gesellschaft mit besonderem Nachdruck auf gesellschaftliche Bedeutung der Wälder sein muss.

Wälder; Biomasse; Holz einschlag; Immissionen

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## MOTIVATION SYSTEM IN FORESTRY

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The economic reform being introduced in the Czechoslovak forest management the following features become typical: greater autonomy of enterprises, reduction of controlling policies from the centre interfering with the activities of enterprises, promotion of interests in the maximum economic effects and in this connection an emphasis on the responsibility for the condition and development of the entrusted national property, for the management of forest stands. Reasons of the consistent application of the principles of economic control are the more and more complicated enterprise and between-enterprise cooperation, development of interactions between the forest management and the ecological conditions of different territories, orientation to the intensification of forest management. In new state-owned enterprises within the forest management the analogical policies of economic control will be applied like in other branches of the national economy. The differences consist first of all in greater participation of the state funds in financing the works, the results of which are socially important, in the market nonrealized proceeds. In the economic centre, in the Ministry of Forestry, Water Resources and Woodworking Industry specific funds will be created: the fund for forest protection and development and the fund for removal of calamity damage. Substantial changes take place in the sphere of wage control. Besides the volume criteria in effect up to now the claim of adequate formation of enterprise incomes and observation of obligatory wage regulations will be put through. Emphasis is laid on the important role of material stimuli motivating the interest of enterprise collectives in better forest-management practices. This function will be fulfilled by the bonuses paid in five-year intervals. A decisive criterion of granting the bonuses will be the high quality of forest cultures and their tending. The new system of planning brings about a considerable reduction in the number of obligatory indicators set up in the state plan. Besides the obligatory economic prescriptive standards the enterprises in the forest management will be claimed the obligatorily set-up supply of some kinds of rawtimber to the main clients. A characteristic feature of the economic mechanism restructuring in forest enterprises is the greater role of forest legal rules, especially of forest law. From this ensues a greater obligation of the regulations of the important controlling instrument which is at a disposal in the forest management and by means of which the regulations of legal norms are specified in a concrete way for individual enterprises — forest-management practices. The fundametal documents of the forest-management practices — forest-management plans are changing into obligatory projects of the formation and regulation of complex processes of forest reproduction and of intensification of their socially appreciable functions.

economic reform; forest enterprises; forest tending; material stimuli; financing of forest production

The economic reform of Czechoslovak national economy interferes in forestry with non-negligible consequences in many spheres of its activity. One of the most significant consequences is a change in the position of forest enterprises in the system of their direction.

Like in other production branches, there is a considerable increase in the economic independence of forest enterprises, as well as a limitation of directive interventions from the centre in enterprise activity; support is given to efforts for maximization of economic effects and in this connection, emphasis is laid on responsibility for the state and development of the entrusted national property, in this case the responsibility for custody in forest stands.

## **ECONOMIC DIRECTION**

The reasons for wider and more consistent application of economic direction principles in forestry are similar to those in other branches of national economy. Internal and external relations of the forest enterprises are becoming increasingly complicated as a result of progress in production specialization and the ensuing extension of co-operation both between and within the establishments. Management of these processes is unthinkable without due economic link-up and without consistent projection of economic consequences into the economic results of participating subjects. The quantity and variedness of the society's requirements for forestry keep increasing. There are all the time more complicated, more varied and more significant interactions between forestry and ecological conditions in individual territories. The quantitative and qualitative expression of the traditional and newly required benefits from forestry cannot ignore their economic expression and incorporation into the system of enterprise and branch direction as well as complementing the economic system by other effective instruments of motivation and stimulation.

Owing to the limitation of extensive sources of forestry development, especially to the well-known fact that it will obviously be impossible to continue spreading the forest area, it is inevitable to orientate efforts to the mobilization of intensive development factors. Intensification includes both the utilization of the available production potential of forest stands and the multiple-use functions of forests. Under more complicated ecological conditions when the negative factors of civilization are increasing, it is necessary to achieve a maximal volume of the desired effects and benefits from the same area of forest fund. For these reasons, with an acceleration of the scientific and technological development, the direction processes in forestry are becoming substantially exacting and hardly controllable without wider use of economic methods and instruments.

Rational timber utilization cannot be ensured without the application of effective economic instruments and market orientation of procedures and consumers.

## **INTEREST IN PROFIT**

Underestimation of economic interests was characteristic of the used system of forest enterprise direction.

Enterprises' interest was orientated, to a high degree, only towards the achievement of planned profit, without exceeding it. In contrast

to most of other state economic organizations which delivered the profit tax to the state budget at a level fixed by a percentage rate of obtained profit, the profit tax for forest enterprises was determined in absolute value as so-called profit tax of net profit balance. The annual obligation of enterprises to deliver the profit tax was determined by superior ministry in the financial plan. The net profit balance is all the enterprise's profit which was not allocated, according to the valid regulations, to the enterprise or sectorial funds or was not used for other purposes. In the accounting of profit tax on net profit balance, the enterprises adjust it to cover the difference between the planned and actual amount of other deliveries, by the difference between the planned and actual allocations to both stimulation and state funds and by the difference between the planned and actual use of profit for other purposes.

The team of the enterprise has had only a minimal advantage from the surplus profit. Consequently, the interest in higher profitability achieved by the increase of receipts from sales of own production or performed services or by reduction of costs as a result of production process rationalization, was substantially limited.

The situation changes substantially by the application of the general principles of economic direction. Enterprises will return the profit tax assessed by uniform percentage rate of arisen profit. The interest in maximization of profit will considerably increase. The coverage of a great part of enterprises' economic needs, including those for the remuneration of workers, will depend, above all, on the possibility and ability of profit formation.

In the finance system of new state enterprises, subsidies from state budget will still have the significant position under conditions of the application of self-financing principles. It especially involves the subsidies connected with the specified tasks of the state plan, the state programmes for ecology, national defence etc. In forestry the subsidies will be determined particularly for supporting socially important outputs of forest production, for the development of activities not providing an immediate economic effect to enterprises, for meeting the needs not being calculated into timber prices for social and political reasons and the like.

## **PROFIT TAXES AND TAXES**

Enterprise obligations towards the state budget are determined by the system of deliveries and taxes like in other sectors.

For the newly formed system of deliveries, the economic organizations to the state budget, the emphasis on conclusive significance of criterion profit taxes and taxes fixed, in principle, universally for every economic organization, can be considered as characteristic. It also represents the difference owing to prevailing applications of deliveries and taxes of income character, accompanied by a number of exceptions to delivery duties and by undesirable redistribution processes.

The criterion-type deliveries are constructed in order to contribute to the realistic assessment of production factors — funds, labour force, individual environment components. Except the mentioned income tax

(50 per cent of profit), profit taxes of regulative, sanction and similar character, as well as those for environment utilization and/or environment damage, will be delivered. The P. A. Y. E. (pay as you earn) tax is determined at a level of 50 per cent of paid wages and it is refunded from the expenses. The delivery rate is derived from the progress of relation concerning the social expenses for labour force reproduction to the sum of wages and bonuses.

In the delivery system of state enterprises in forestry, some important peculiarities will be applied which are linked up to the used experience in regulation of economy in various considerably differentiated income conditions of individual enterprises and in decisions on unpredicted consequences of natural disaster damage to forest stands. It refers particularly to the finance methods of silviculture and the formation of resources intended for elimination of natural disaster consequences.

At central authority level — the Ministry of Forestry, Water Resources and Woodworking Industry — the specific centralized funds for the fulfilment of its specific functions are administered: the fund of natural disaster and the fund for protection and development of forests.

The principles for the formation and utilization of the fund for natural disaster will have not be changed, in comparison with the used practice. The fund is formed by enterprise deliveries and its means are used for the financing of measures determined for the elimination of consequences of extraordinary natural disasters. The calculation of needs is being presented by enterprises to the Ministry.

The problems with the fund for protection and development of forests are rather more complicated. This fund will partially compensate the used special fund for silviculture whose purpose is the provision of extra-investment means for silviculture performed at enterprises of State forests. The allocations from the fund for protection and development of Forests are largely intended for the financing of silviculture, as well. Nevertheless, the mission of this fund will be wider. For example, it will enable to solve the consequences of rise of differential rent in the State Forest enterprises by redistribution of means among individual enterprises.

Redistribution of means among markedly independent state enterprises is a very delicate matter. Enterprise deliveries into the former fund for silviculture followed from the annual balance of their sources and needs and were included in to the annual financial plans. This practice is not to be repeated. It is recommended to form the new fund for protection and development of forests from enterprise forest taxes determined by objective rates per 1 cubic metre of timber according to the differentiated economic conditions of individual enterprises. Before elaborating the methods of delivery differentiation with respect to the fund, it will stand to reason to start from the long-term calculations and to determine the delivery rate obligatorily for five-year periods.

Moreover, grant from the state budget will be concentrated in the fund for protection and development of forest. Its major and permanent part is formed by a grant for so-called works of universal importance whose mission is to develop some universal, predominantly non-production forest functions in wider national interest. The grant for

ensuring that part of silviculture which could not be included, for social and political reasons, among costs calculation justified by the timber prices level, is also kept. A large share of grant for the formation of the fund for protection and development of forests makes difficult the possibility of determining the fund allocations for acceptable planning periods as the obligatory nature of allocations will be qualified by the obligatory character of grant amount.

The fund for protection and development of forests can be used as an actual instrument for economic stimulation of interest in silviculture development. The evocation of such an interest is enormously important in the conditions of the application of socialist self-government principles. The team of the enterprise will strive above all for profit and therefore, it will be chiefly interested in the development of activities yielding profit.

The outcome of silviculture has not been considered as market production as yet. Expenses of tending of forest stands have had, in principle, the character of long-term returnable investments. Considering silviculture as the fulfilment of social order for tending of forest fund and supposing the refunding of costs for fulfilment of this order from centralized sources of Ministry fund, it is possible to achieve, without methodical and factual difficulties, the formation of adequate profit by silviculture.

The interest in silviculture development can also be supported by means of an additional profit charge to costs paid from the fund for protection and development of forests.

As mentioned above, the measures concerning the exclusive development of some non-production functions of forest stands will be also financed from the same fund. To emphasize their universal importance and owing to the fact that their development is not dependent on the simultaneous development of production function, it will be useful to observe these activities of universal importance separately from silviculture activities of polyfunctional or productive orientation. The means of state budget will keep, henceforth, as the source for financing universal activities. The economic interest in the fulfilment of social order for the development of ecological and social forest functions can be promoted analogously as in the case of silvicultural costs, by additional profit charge to the cost.

A practical application of principles for the formation and use of the fund for protection and development of forests will show soon if it is necessary to limit the sources of its formation only to the deliveries of enterprises and grant from the state budget. The possibility of extending fund resources, for example for some sorts of refunds in relation to damage done to forests, seems to be useful. There are sanctions, above all, for permanent and transient removal of lands from the forest land fund. Their low efficacy has been criticized for longer time because the right of recovery for loss of land is disproportionately lower, in comparison with the right of recovery for deterioration of agriculture land. The advance in the rate of the recovery will result not only in emphasizing its sanction effect but also in significant increase in the production of means necessary for forest improvement.

The concretization of rules for use of the fund for protection and

development of forests indicates possibilities of financing investment activities of universal orientation: construction of forest nurseries, transport network, facilities for amelioration etc.

## **WAGE REGULATION**

The specific procedure of wage regulation has been used in Czechoslovak forestry for more than thirty years. It has been based on the evaluation of each piece of work by the coefficients of so-called planning prices and their summarization into the complex index of production volume.

In various periods this index was called diversely and the procedure of evaluation, so far the construction of planning prices itself, has been changed gradually. The index of production volume in forestry organizations fulfilled the functions which were accomplished by the indices of gross or net production in the respective branches. The means could be used only to an extent adequate to the production expressed by planning prices.

Except this function of wage regulation the index of production has served for the measurement of achieved labour productivity, for the expression of total outcomes of plan fulfilment, for the classification of organizational forestry units in categories according to their demanding character of management and for further purposes.

In conditions of complex restructuring of the economic system, essential deflection from the use of volume category in wage regulation occurs. Therefore, the index of production activity becomes quite unnecessary in this sphere and the conversion of each piece of work to common coefficient by planning prices is unreasonable. The cancellation of the mentioned index is a logical consequence of this procedure.

An expected unfavourable course of timber sales, which form the main income source of forest enterprises, is respected in the assessment of further procedure regarding the formation of means. It is generally well-known that in consequence of serious environmental disturbance by air pollution and other harmful factors, forest stands increment declines as it shows up by the cutting reduction, sometimes also by impairment of assortment composition in supplies, and consequently by a reduction of timber sales.

Nevertheless, forestry cannot expect a fundamental decline in needs for means in the next future. In spite of expansion of progressive technologies, the demanding character of cutting is increased with respect to the urgent need to solve the problems of complex utilization of forest biomass by chipping and processing of logging slash, including timber with volume under 7 cm at smaller end and further, hitherto not sufficiently used assortments and tree species. The extent of intensification silvicultural measures will also be quickly increased within the general conception and the share of silviculture in total production activity will be higher than up to this time. Although the process of mechanization continues satisfactorily, including the chemization of silviculture, laboriousness and following demanding character of wages remain high.

Among important aims of wage policy in forestry, along with the support of workers' interest in profit maximization, the formation of their effective interest in the intensification of custody of entrusted forest resources and in the quality of silviculture is included.

An increase of the range of silvicultural intensification measures be, to a certain extent, encouraged by the means of interest in profit achieved from silviculture. The connection of economic interest of enterprise teams with interest in silviculture quality and in traditional use of means for forest tending with the aid of usual procedures regarding economic interest (e.g. by evaluation of forest stands at different stages of their development according to the price lists) is made substantially difficult because of the excessive burden of paperwork in relation to workers in forest operation.

Bonuses for the improvement of forest state will become a more suitable and more effective instrument to ensure quality and rationalization of silvicultural activity. Their application required replacement of the used, not always well-arranged system of work take-over (for every sort of work, the share which has to be taken-over at individual direction levels is determined to the last detail) and of insufficient evaluation with respect to the quality of established forest culture and forest stands after cleaning and thinning. (A category called established forest culture is defined in the Forest Act. The responsible worker is liable to lay out a new forest culture not later than 2 years after logging of forest stand and to establish this forest culture against harmful factors during next 5 years).

The payment of bonuses for the improvement of forest state which have been paid off up to date according to the outcomes of quality evaluation of propositions assigned in forest management plans, will be conditioned above all be the observance of allowable range of clear-cutting area and good quality of taken-over and established forest cultures, tending measures and other intensification arrangements. The factor of clear-cutting area used for this purposes, will include also the area of forest culture hitherto not achieving the state of establishment along with area not afforested up to this time. The take-over of established forest cultures will be performed in a running way as soon as the forest culture meets both the quantitative and qualitative demands of corresponding directions. The elementary criterion of quality is the observance of forest management provision about the tree species composition of forest culture, the provenance of used seed or seedlings, necessary distance between seedlings, health state of forest culture etc.

In new conditions, the founder of state enterprise, that means the Ministry of Forestry, Water Resources and Woodworking Industry, is authorized to determine the factual conditions for allowance of incentive components in wages. The principles of bonuses paid off for the improvement of forest state and for the achievement of high quality silviculture will be arranged by obligatory instructions. Bonuses for the outcomes of management in forestry will become a counterbalanc to offset the somewhat one-sided effect supporting the interest in profit maximization. With respect to their importance, the amount of bonuses and the group of workers who are to get them will be determined.

A number of managing officers who could be given bonuses

for the improvement of forest state, was very limited in the past. According to the respective instruction, it included only those workers "who had influenced directly the achieved outcomes in comparison with the qualified performing of forest management plan by their control and organizational activity". A section forest officer, district forest officer and his assistant, and a director of forest enterprise are ranked among those workers.

In consequence of continuing progress in specialization and cooperation of enterprises, the group of workers who can influence silviculture quality by their own activity, increases still more. The quality of seeds and seedlings conditioning to the highest degree the quality of newly established forest cultures has not depended only on workers of forest sections and districts for a long time past. Many things depend on the well-organized activity of forest nurseries directed by head office of enterprises. Analogous situation exists in other sections of forestry, as well. Bonuses for the improvement of forest state will be also afforded to other workers contributing to the improvement of silviculture quality.

### **PLANNING, CRITERIA OF EFFECTIVENESS**

A transition from the present direction function of annual plan to the preferential task of the Five-Year Plan is accompanied by changes of starting points for the elaboration of the Five-Year Plan, by a change of effectiveness criteria and change in the procedure of elaboration of the Five-Year Plan and economic plans of organizations.

The elementary starting point for elaboration of state plan for a five-year period is a central instruction approved simultaneously with the long-term prospect. The criteria of effectiveness, economic balance and optimization of proportion will be applied in the instruction above all.

On a wider economic scale, the produced national income is considered to be the total criterion of mass effect, as well as the total criterion of effectiveness is the national income per capita. The relations between the national income (or net production) and the number of workers or productive funds value will serve as particular economic criteria in assessing the influence of productive factors on effectiveness. It does not exclude the use of additional criteria for some specific purposes of evaluation.

At the evaluation of effectiveness of economic organizations, the profit (after returning of criterial profit taxes, income tax and obligatory taxes to the fund) as total criterion of mass effect, and net profit per worker as total criterion of effectiveness, are to be the elementary criteria. The index of net profit per costs, profit per production funds, the level and progress of variation export index will be used as partial criteria. A criterion of contribution of economic organization to the formation of national income will be the net production and its relation per worker and to production funds.

At the evaluation of effectiveness of economic activity in forest enterprises, it will be necessary to adjust these general criteria to the specific features of forest production and to complement them with other

ones, no less important from the point of view of performing the mission of forestry. At a glance at the general criteria of effectiveness we find out they are closely connected with the effects following from rational production which is successfully realized on the market, from the rational practice of services provided for a charge. Nevertheless, the requirements for ecological and labour force balance are emphasized without projecting the value into criteria of commodity and cash balance.

Forestry realizes only part of effects made up on the home or foreign market by its activity. The produced goods whose realization has brought profit to the industry and individual enterprises, is essentially only timber, to a limited degree production of sideline, if need there is a part of seedling production for extra-forestry organizations etc. An extensive and all the time increasing part of effects, arisen in connection with spontaneous or purposeful development of important ecological and social functions in forest stands, is not commercially realized. These services are provided to society, represented as a rule by anonymous users, free of charge and do not influence forestry's participation in national income formation; similarly they do not participate in profit of forestry enterprises.

In consequence of the mentioned long-term nature of forest production, a great deal of expended reproduction costs is not connected with temporary commensurable production realized on the market. The outcomes of measures, for whose performance these costs are expended, are the changes in forest fund state and the changes in production and non-production effects on forest funds. Neither the forest fund, nor its individual components, including the decisive means of production, i. e. the land, have been valuably appraised for the present. In the economic balance of forest enterprise, the changes arisen in consequence of purposeful economic activity of the forester (even in consequence of the effect of other factors) do not show up either positively or negatively.

The changes in the state of forest fund, which are the results of reproduction (mostly intensification) measures of forestry organizations, are significant effect of their economic activity. Volume of this effect, and its comparison with costs expended for purpose of its achievement, represents a non-negligible criterion of economic effectiveness in forest enterprises and in all forestry. In its assessment and inter-enterprise comparison, it is necessary to take into consideration not only the versatility of ecological conditions but also a various degree of harmful factors' effect — air pollution and other consequences of civilization processes on the changes of forest stand condition in individual regions.

It will be necessary to appreciate the effectiveness of tending of forest wealth by an auxiliary technical criterion which is to be available for the taxation of forests before changes in the state of forest fund succeed in projecting the forest fund evaluation and in transforming the changes in value of forest stands into the economic indices of forest enterprises.

The instruction for the Five-Year Plan determines obligatory outputs, on the one hand in relation to the central authorities, on the other hand directly connected with individual economic organizations. (The instruction will be elaborated by the State Planning Commission in colabora-

tion with central authorities and with the Planning Commissions both of the Czech and Slovak republics).

From the formulation of general principles in economic directions it follows that the specified supply of timber assortments for individual tendencies of use will be ranked among obligatory assignments of forest enterprises.

The approach to the determination of obligatory supply tasks has to be appreciated with regard to the forming of adequate scope for the progress in business activity of forest organizations. Forest enterprises will have only little chance to increase the amount of market production in contrast to enterprises of most other branches. The Forest Act defines very factually and explicitly the duty to observe timber cutting volume determined in the documents of forest management plan. Enterprises cannot influence the production structure, either. The location of planned cutting in actual forest stands is also obligatory. The workers of enterprises must not dislocate the logging measures at will under the conditions of increased interest in profit maximization.

High economic independence and following high responsibility of state forest enterprises for achieved economic outcomes (including responsibility of white collar workers to the worker team) requires the constitution of adequate space for spirit of enterprise, for the operational disposal of own production, for factual application of economic interest in complex and maximal use of timber.

This aim cannot be achieved if the distribution of all (or almost all) the production is determined by obligatory balances from the central authorities. Under conditions of timber deficit which will not be easy to overcome by the extending of domestic resources, far less by import, it is necessary to insist on draining only a part of disposable resources formed by allowable cutting for the purpose of obligatory supplies of individual assortments as they are determined to forest enterprises. The placement of remaining assortments will be solved by forest enterprises on the ground of economic profitableness. This is the way how to form contemporaneously adequate economic pressure on the woodworking sector to cover part of its needs from central distributed funds and the remaining part has to be obtained by commercial negotiations with the producer. The fulfilment of supplies of state plan will be the obligatory criterion of economic activity in forest enterprises up to the time when the prerequisites for the complete application of market relations in the economization with timber and wood products are formed.

## **THE ROLE OF FOREST ACT**

An increase of economic pressure can lead, in certain conditions, to the misuse of short-term enterprise or personal interests to the detriment of long-term social interest and to the detriment of forest state. Simultaneously with the progress in economic direction methods characterized by the support of interest in economic outcomes, the role and importance of extra-economic instruments of influence, including

the extra-economic barriers which are to prevent these essentially anti-social processes, are increased. Although it seems to be paradoxical, enhancement of the role of extra-economic active and passive instruments in influencing enterprise manners is an inevitable condition for more consistent progress in economic direction of forestry. The legal regulations, especially provisions of forest legislation, have a decisive place among the instruments of extra-economic influence in forestry.

The contemporary legal regulations of forestry in Czechoslovakia have been valid since January 1, 1978. It is formed, in harmony with the federal state arrangement, by Forest Act No. 61 (1977) and by two National Councils Acts: the Forest Management Act and the Forest Administration Act. The provisions on execution of the law are also integral parts of complex forest legislation issued by the Ministry of Forestry, Water Resources and Woodworking Industry of both the Czech and Slovak republics, as well as the decrees on forest professional conduct and relevant provisions, on forest guard and on proceedings in the forest land protection, the decree on forest category formation and respective management methods, management planning and others.

The Forest Act defines the mission and targets of forestry, defines the concept of forest fund, codifies forest land protection, determines the regime of administration and transfer of forest national property, measures for the formation of integrated forest parts, rights of recovery for non-fulfilment of obligations following from the Forest Act and for forest damage. It delimits forest category formation and the principles of the development of forest functions.

The National Council Acts in relation to forest management and forest administration regulate other points, above all the organization, administration and professional conduct, determine the principles of forest management, silviculture and forest protection, logging and transport of roundwood, rights of recovery assessed by administrative authorities in forestry etc.

Directions and instructions issued by the Ministries of Forestry, Water Resources and Woodworking Industry in both republics have also a statutory character.

In connection with development of economic direction in forestry and with significant increase in forest enterprise independence, adherence to forest legal regulations is appraised and their effectiveness is evaluated. Proposals for the new modification require that the application of the Forest Act regulations and derived principles of management in forests with the aim to obtain short-term economic benefits even for other reasons will be curbed more strictly than till this time. this time.

Enhancement of the obligatory nature of one of the most significant components in economic mechanism of forestry, forest management, is also connected with an enhancement of the obligatory nature of forest law and with an emphasis on inadmissibility of their damage. The used relatively fairly liberal conception of forest management plans is being revised at the present time and their enactment is considered the most obligatory direction for economy in forest. Forest management plans are changing to obligatory projects of formation and regulation in complicated processes of forest reproduction.

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V rámci ekonomické reformy dochází v československém lesnictví k výraznému zvýšení samostatnosti podniků, k omezení zásahů centra do jejich činnosti, k podpoře zájmu na maximalizaci ekonomických efektů a v této souvislosti ke zdůraznění zodpovědnosti za stav a rozvoj svěřeného národního majetku, za péči o lesní porosty. Důvodem pro důslednější uplatnění principů ekonomického řízení je růst složitosti vnitropodnikové a mezipodnikové kooperace, rozvoj interakcí mezi lesnictvím a ekologickými podmínkami jednotlivých teritorií, orientace na intenzifikaci hospodaření v lesích. V nových státních podnicích lesního hospodářství budou uplatněny analogické postupy ekonomického řízení jako v jiných výrobních odvětvích. Rozdíly spočívají především ve vyšší účasti státu na financování prací, jejichž výsledkem jsou společensky významné, tržně nerealizované přínosy. V hospodářském centru, na ministerstvu lesního a vodního hospodářství a dřevozpracujícího průmyslu budou vytvářeny specifické fondy: fond ochrany a rozvoje lesa a fond na odstraňování následků kalamit. K zásadní změně dochází v oblasti regulace mezd. Místo dosavadních objemových kritérií bude uplatněn požadavek přiměřené tvorby podnikových důchodů a dodržení závazných mzdových předpisů. Zdůrazňuje se vý-

znam hmotných stimulů motivujících zájem podnikových kolektivů na zlepšování péče o les. Tuto funkci budou plnit prémie vyplácené v pětiletých intervalech. Rozhodujícím kritériem pro výplatu prémie bude dosažení vysoké kvality lesních kultur a jejich výchovy. Nová soustava plánování přináší výrazné omezení počtu závazných ukazatelů stanovených ve státním plánu. Pro podniky lesního hospodářství bude mimo závazných ekonomických normativů ve státním plánu závazně stanovena dodávka některých sortimentů surového dříví hlavním odběratelům. Charakteristickým rysem přestavby hospodářského mechanismu podniků lesního hospodářství je růst úlohy lesnických právních norem, zejména lesního zákona. S tím souvisí i zvýšení závaznosti ustanovení důležitého řídicího nástroje, kterým lesní hospodářství disponuje a kterým jsou ustanovení právních norem konkretizovány na podmínky pracovišť — hospodářské úpravy lesů. Základní dokumenty hospodářské úpravy — lesní hospodářské plány se mění na závazné projekty tvorby a regulace složitých procesů reprodukce lesů a intenzifikace jejich společensky prospěšných funkcí.

ekonomická reforma; podniky lesního hospodářství; péče o lesy; hmotné stimuly; financování lesní výroby

БЛУДЬОВСКИ, З. (Научно-исследовательский институт лесного хозяйства и охотоведения, Иловиште-Стрнада): **Мотивационная система лесного хозяйства.** Lesnictví, 35, 1989 (11) : 961-974.

В рамках экономической реформы в чехословацком лесном хозяйстве резко повышается самостоятельность предприятий, ограничиваются вмешательства центра в их деятельность, поддерживается заинтересованность в максимизации экономических эффектов и в связи с этим подчеркивается и их ответственность за состояние и развитие доверенного им национального богатства, за уход за лесными насаждениями. Причиной более последовательного внедрения принципов экономического управления является рост сложности внутризаводской и межзаводской кооперации, развитие интеракций между лесным хозяйством и экологическими условиями отдельных территорий, ориентация на интенсификацию ведения хозяйства в лесах. В новых государственных предприятиях лесного хозяйства будут использованы аналогичные методы экономического управления, как и в других производственных отраслях. Разница состоит в том, что прежде всего в более высоком участии госбюджета в финансировании работ, результатом которых являются с общественной точки зрения полезные, на рынке не реализуемые эффекты. В экономическом центре, в министерстве лесного и водного хозяйства и деревообрабатывающей промышленности образуются специфические лесохозяйственные фонды: фонд защиты и развития леса и фонд для устранения последствий стихийных бедствий. Принципиальные изменения происходят в области регулирования заработной платы. В замен объемных критериев вводится требование соответственного образования доходов предприятий и соблюдения обязательных инструкций по заработной плате и по оплате работников. Подчеркивается значение материального стимулирования заинтересованности коллективов предприятий в уходе за лесом. Эту функцию должны выполнять премиальные, предоставляемые в интервалах пяти лет. Решающим критерием для признания премиальных будет достижение высокого качества лесных культур и ухода за ними. Новая система планирования приносит отчетливое сокращение числа обязательных показателей устанавливаемых государственным планом. Для предприятий лесного хозяйства, наряду с обязательными экономическими нормами в госплане в обязательном порядке устанавливается поставка некоторых сортиментов древесного сырья основным потребителям. Характерной чертой перестройки хозяйственного механизма предприятий лесного хозяйства является повышение значения лесных юридических норм, особенно лесного закона. С этим связано и повышение обязательности важного инструмента управления, которым лесное хозяйство располагает и в котором установления лесного закона конкретизируются на условия производственных участков — лесоустройства. Основные документы лесоустройства — лесоустроительные планы становятся обязательными проектами создания и регулирования сложных процессов воспроизводства лесов и интенсификации их общественно-прогрессивных функций.

экономическая реформа; лесохозяйственные предприятия; уход за лесами; материальные стимулы; финансирование лесохозяйственного производства

BLUĐOVSKÝ, Z. (Forschungsanstalt für Forstwirtschaft und Jagdwesen, Jiloviště-Strnady): *Motivierungssystem der Forstwirtschaft*. Lesnictví, 35, 1989 (11): 961-974.

Im Rahmen der ökonomischen Reform kommt es in der tschechislowakischen Forstwirtschaft zu einer wesentlichen Erhöhung der Selbständigkeit der Betriebe (Bezirksbetriebe), zur Einschränkung der Eingriffe des Zentrums in ihre Tätigkeit, zur Unterstützung des Interesses an der Maximierung ökonomischer Effekte und in diesem Zusammenhang zur Betonung der Verantwortung für den Zustand und für die Entwicklung des anvertrauten Volkseigentums, für die Pflege der Waldbestände. Einen Grund für die konsequentere Anwendung der Prinzipien der ökonomischen Leitung stellt das Anwachsen der Kompliziertheit der innerbetrieblichen und der zwischenbetrieblichen Kooperation dar, die Entwicklung der Interaktionen zwischen der Forstwirtschaft und den ökologischen Bedingungen einzelner Territorien, die Orientierung auf die Intensifikation der Waldbewirtschaftung. In den neuen staatlichen Betrieben der Forstwirtschaft werden analoge Verfahren der ökonomischen Leitung geltend gemacht wie in anderen Wirtschaftszweigen. Die Unterschiede beruhen vor allem im höheren Anteil des Staates an der Finanzierung der Arbeiten, deren Ergebnis die gesellschaftlich bedeutsamen, auf dem Markt nicht realisierbaren Beiträge darstellen. Im Wirtschaftszentrum, im Ministerium für Forst- und Wasserwirtschaft und für die Holzverarbeitende Industrie werden spezifische Fonds gebildet: ein Fonds zum Schutz und zur Entwicklung des Waldes und ein Fonds zur Beseitigung der Folgen von Kalamitäten. Zu einer grundsätzlichen Veränderung kommt es auf dem Gebiete der Regulation der Löhne. Anstatt der bisherigen Volumenkriterien wird die Forderung angemessener Bildung von Betriebseinkommen und die Einhaltung verbindlicher Lohnvorschriften geltend gemacht. Es wird die Bedeutung materieller Stimuli betont, die das Interesse der Betriebskollektive an der Verbesserung der Waldpflege motivieren. Diese Funktion werden Prämien erfüllen, die in fünfjährigen Intervallen ausgezahlt werden. Entscheidendes Kriterium für die Auszahlung der Prämien wird die Erreichung hoher Qualität von Waldkulturen und deren Erziehung darstellen. Das neue Planungssystem bringt eine bedeutende Einschränkung der Anzahl verbindlicher, im Staatsplan festgelegter Kennziffern. Für die Forstwirtschaftsbetriebe wird außer den verbindlichen ökonomischen Normativen im Staatsplan die Lieferung einiger Rohholzsortimente an wichtigste Abnehmer verbindlich festgesetzt. Einen charakteristischen Zug des Umbaus des Wirtschaftsmechanismus der Forstwirtschaftsbetriebe stellt der Anstieg der Rolle forstlicher Rechtsnormen dar, besonders der des Waldgesetzes. Damit hängt auch die Erhöhung der Verbindlichkeit der Bestimmungen des wichtigen Leitungsmechanismus zusammen, über den die Forstwirtschaft verfügt und durch den die Bestimmungen der Rechtsnormen auf die Bedingungen der Arbeitsstellen konkretisiert werden — der Forsteinrichtung. Die wichtigsten Dokumente der Forsteinrichtung — die Forstwirtschaftspläne wandeln sich in verbindliche Projekte der Bildung und der Regulierung wichtiger Prozesse der Waldreproduktion und der Intensifikation ihrer gesellschaftlich nützlichen Funktionen um.

ökonomische Reform; Forstwirtschaftsbetriebe; Waldpflege; materielle Stimuli; Finanzierung der Waldproduktion

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## MINERAL NUTRITION OF NORWAY SPRUCE STANDS IN THE WESTERN PART OF CZECHOSLOVAKIA

J. Materna

MATERNA, J. (Forestry and Game Management Research Institute, Jiloviště-Strnady): *Mineral Nutrition of Norway Spruce Stands in the Western Part of Czechoslovakia*, Lesnictví, 35, 1989 (11) : 975-982.

A survey is presented of the state of nutrition of spruce stands situated at higher altitudes in the western part of Czechoslovakia. A leaf analysis has demonstrated that there are great deficiencies in nitrogen and magnesium nutrition. In comparison with the state of nutrition twenty years ago, the nitrogen nutrition of the stands has only little improved (the proportion of samples with nitrogen deficit decreased from 61.5 to 58 %); on the other hand the magnesium nutrition of the stands worsened considerably. The proportion of samples with a low Mg content increased from 13.2 % to 63.4 %. The potassium and calcium nutrition has also deteriorated (the proportion of trees with K and Ca deficiency increased from 0.8 to 7.8 % in K and from 1.7 to 9.3 % in Ca). On the contrary the proportion of samples with insufficient concentrations of phosphorus decreased from 7.6 to 3.4 %. There is also a high proportion of samples with a low content of Zn (9.6 %). Risks in the future consists in a great expansion of the magnesium latent deficit, which can develop into an acute one leading to marked yellowing, decreases in increment, tree decline and higher mortality rates. The liming with dolomitic limestone is not only an amelioration treatment but it can also be considered and practised with respect to the tree nutrition.

Norway spruce; leaf analysis; forest stand nutrition; nitrogen; magnesium; calcium; phosphorus; iron; zinc; manganese

In the forest of Czechoslovakia, sulfur dioxide is the main pollutant causing injury up to the present time; fluorine, chlorine, ammonia are responsible only for local injury in the vicinity of emission sources. The role of ozone is not yet clearly understood, but acute injury caused by high peaks of ozone concentrations have certain importance in the development of forest injury in the sensitive forest tree species under special weather conditions.

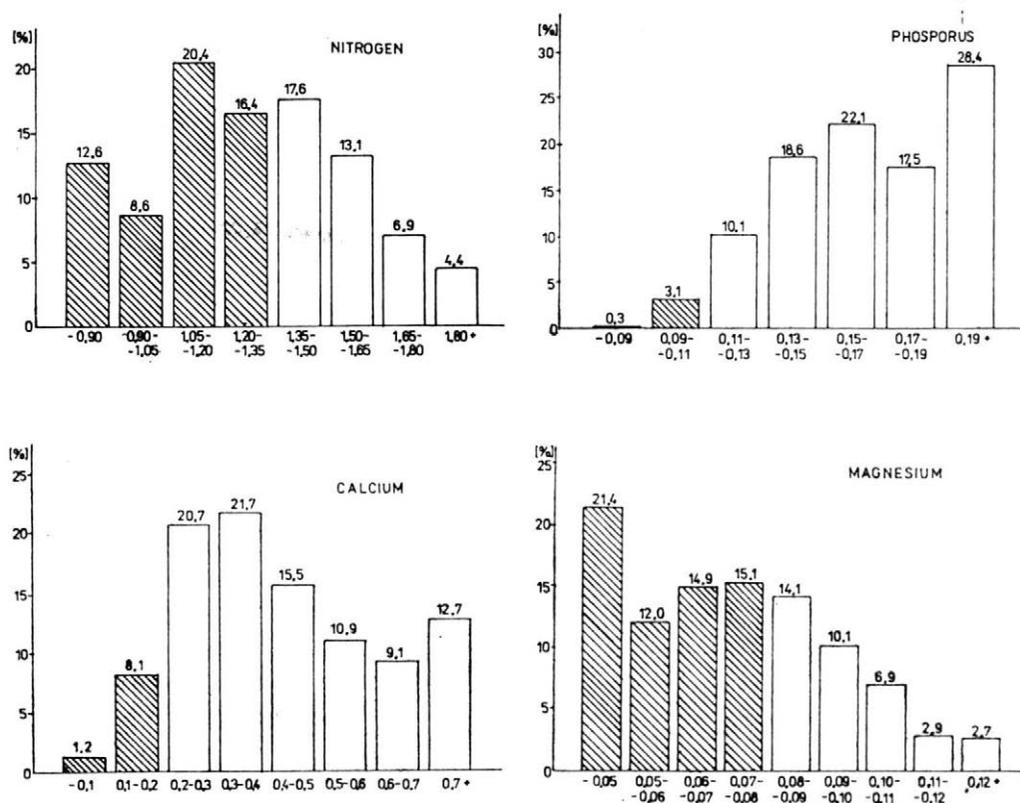
The indirect effect of air pollution on soil conditions and the influence of such changes on the state of forest stands has not such dramatic consequences as the direct effect of long lasting high sulfur dioxide concentrations, but in the future this way of influence can develop to a very important factor. Comparison between the results of chemical analysis of soil samples from the beginning of the 60ties and 80ties is a very intuitive example of such an unfavourable development (Materna and Lochman, 1988). However, the consequences of this development are mostly hidden and only on small places the soil has lost its fertility entirely.

Although other mechanisms are also involved, it is obvious that changes in soil chemistry also lead to changes of mineral nutrition levels. There is much information about the disturbances of mineral

nutrition in stands with distinct symptoms of yellowing. It is mostly the very low concentrations of magnesium, potassium and zinc that are responsible for the occurrence of visible deficiency symptoms (Bosch et al., 1983; Zöttl, 1985; Zech, 1983). Increased deposition of nitrogen compounds can increase the nutrient imbalance (Rehfues, 1983). As such disturbances in mineral nutrition have a very negative influence on vitality of the trees and can result in increased mortality in the stands or of the stands, they are a very important warning, and these phenomena can be considered as a visible consequence of the processes which are going on, to a larger extent, without visible symptoms. Therefore we must be interested in the general situation in mineral nutrition, as such information must be respected in the forecast of further development of injury in the forests and can give an idea about the possible limitations of wood production. From this point of view, further information is presented, concerning the mineral nutrition of Norway spruce stands in the western part of Czechoslovakia.

## MATERIAL AND METHODS

The results are based on the leaf analysis of 1991 samples, collected from Norway spruce stands during 1985—1988. During that time unfavourable changes occurred also in regions with relatively low level of air pollution with SO<sub>2</sub>. The



1.—8. Concentrations of nitrogen, phosphorus, potassium, calcium, magnesium, man-

samples were not collected in stands with visible symptoms of deficiency, and most of the samples had a normal colour. The material has been collected from stands at a higher altitude (above 700 m) in the mountains in the western and northern part of the country. The air pollution with  $\text{SO}_2$  of these regions is very low, ranging between  $10 \mu\text{g} \cdot \text{m}^{-3}$  and  $50 \mu\text{g} \cdot \text{m}^{-3}$  on a long-term average.

The samples were collected from young Norway spruce stands (15–25 years old), from the 4th whorl. This way of collecting material enables us to get more samples from a stand (10–15). The time of sampling is between October and December. One and two years old samples are analysed.

Analysis:

Ca, Mg, K, Mn, Fe, Zn — atomic absorption spectrophotometry

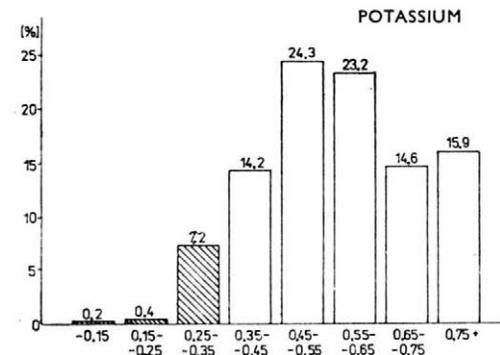
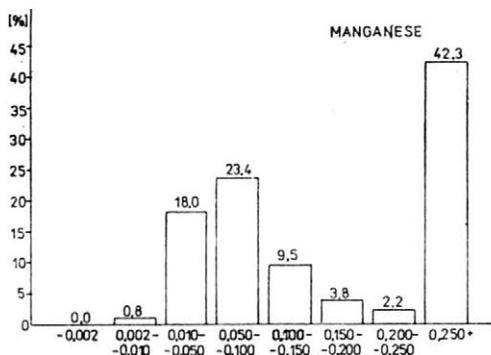
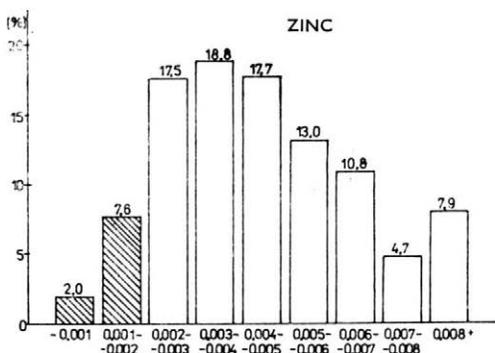
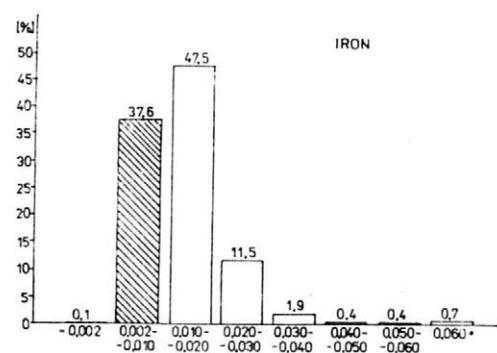
P, N — colorimetry

## RESULTS

The results are presented in the graphs in Fig. 1 — 8. Concentrations about and below the critical concentrations of the nutrients are distinguished in the samples of the first year, as generally accepted for Norway spruce:

nitrogen	1.35 %
phosphorus	0.11 %
potassium	0.35 %
calcium	0.20 %

magnesium	0.08 %
zinc	0.002 %
manganese	0.002 %
iron	0.002 %



gane, iron, zinc in Norway spruce needles. Frequency of concentration classes

If the concentration of the respective nutrient in the needles is higher than this limit, the mineral nutrition is considered as sufficient with the reservation that greater lack of a nutrient does not limit biomass formation to such an extent that the content of other nutrients in the needles increases to a normal level, although in other conditions the soil reserves could not satisfy the nutrient demand.

### Nitrogen

The nitrogen concentrations in more than one half of the samples (58 %) are not high enough to ensure optimal growth of the trees. In more than 10 % of samples the nitrogen content in the needles is extremely low, causing growth disorders and distinct colour changes. No excess nitrogen nutrition was detected.

### Phosphorus

The nutrition with this element can be considered as good according to the results of needle analysis. Only 3.4 % of all samples have not a sufficient level of P. Most of them were collected from stands on soils developed on phyllite. Samples of about 30 % of trees have a very good phosphorus nutrition.

### Potassium

7.8 % of samples have an insufficient nutrition, but only 0.6 % are in the range of extreme deficiency.

### Calcium

The critical level of calcium in the Norway spruce needles, i. e. the level not sufficient for normal physiological processes, is not reliably determined. It can be somewhat lower than the critical concentration used (0.2 %). In any case, concentration below this level is a sign of very low level of nutrition of stands. As many as 9.3 % of the samples lie in this range. The concentration of calcium in the samples of the highest frequency (0.3 — 0.4 %) is also relatively low, and the same applies to the amount of samples with the highest concentration.

### Magnesium

The magnesium nutrition level is very unfavourable. 61.4 % of samples have a Mg concentration lower than 0.08 %, which is probably the critical level. Very low concentrations of Mg in the needles could be detected in more than 20 % of all samples. In some of such samples, typical symptoms of yellowing occur. The occurrence of a satisfactory content of Mg in the needles is also relatively rare.

### Iron

The critical concentrations seems not to be reliably determined, but it seems that there is no deficiency in iron nutrition, as the soluble iron is present in excess in very acid soils.

### Zinc

More than 10 % of samples are below the critical limit.

### Manganese

The range of manganese concentrations in the needles is very wide — between  $10^1$  —  $10^3$  ppm. In no case did the concentration of Mn decrease below the critical level of 20 ppm.

## DISCUSSION

Comparing the results of this broad assessment, based on sampling in Norway spruce stands in higher elevations in the western part of Czechoslovakia, with the results of assessment in the early 60ties (M a t e r n a, 1964), two striking things occur:

- only limited improvement of nitrogen nutrition
- a very drastic deterioration of magnesium nutrition.

At the beginning of the 60ties in 61.5 % of samples the nitrogen concentration was less than 1.35 % and in 19.5 % of samples less than 0.9 %. If we consider that the soils have been influenced by increased deposition of nitrogen compounds for about 20 years at the minimum and the deposition reaches 10 — 15 kg N . ha<sup>-1</sup> more than under natural conditions, it can be derived that the ecosystem has been enriched with more than 200 kg N . ha<sup>-1</sup>. This is not reflected in the nutrition of stands. This is a distinct difference in comparison with some regions in western Europe (the northern part of FRG, Holland), where a deposition of 60 kg N . ha<sup>-1</sup> resulted in a very high nutrition level of forest trees. In GDR's Thüringer Wald at higher altitudes, the nitrogen nutrition level, probably due to long-range transport from western Europe, is also more favourable than in similar conditions in our country (N e b e et al., 1989).

An insufficient reaction of Norway spruce stands to low doses of nitrogen is very well known from the experiments with nitrogen fertilizers. An amount less than 60 kg N . ha<sup>-1</sup> mostly does not influence the growth with the exception of Norway spruce stands stunted as a result of extreme deficiency of the element. Probably the nitrogen requirements of microorganisms in the humus layer must be saturated before there is a surplus which the trees can use. Another possibility is that acid deposition slows down the mineralization of nitrogen compounds in the humus layer and this process limits the positive effect of nitrogen deposition in the stands on the level of N nutrition.

These are the explanations for the fact that the increased nitrogen deposition has not improved nitrogen nutrition until now. Nitrogen as a key nutrient influences nutrition with other elements and the results of the needle analysis. If insufficiency of this element limits the increment and biomass production, it can happen that no deficiency of another element can be detected. This applies especially to potassium.

The greatest shift was recorded in magnesium nutrition. At the beginning of the 60ties there were some magnesium-deficient trees (13.2 %), but the development since then can be characterized as dramatic. An increase to 63.4 % magnesium-deficient samples during 20 years is a serious warning. As to the causes, it must be stressed first that the rocks on which the soils had developed and where the forest stands were sampled, are very poor in this element, esp. the granite and gneiss. Second, soils have been exposed to a relatively high acid deposition for a long time. Last but not least it is necessary to consider the theories according to which magnesium is washed out from the needles by acid deposition after an impact of ozone (R e h f u e s s, 1986).

There is a distinct increase of the proportion of potassium-deficient samples from 0.8 to 7.8 % and calcium from 1.8 to 8.3%. In both cases

the effect of acid deposition is probably the cause. On the other hand, phosphorus nutrition seems to have improved to some extent. At the beginning of the 60ties, in 7.6 % of samples the phosphorus content was low; at the present time this part has decreased to 3.4 %. All these changes are in agreement with development in other regions.

Risks in future development cannot be seen in the deposition of nitrogen in the next 20 — 30 years; probably the stands could be able to utilize the amount of deposited nitrogen. The risk is in the rapid decrease of the level of magnesium nutrition, but also of the nutrition with potassium, calcium and zinc. As to magnesium, the great extent of latent deficiency can develop gradually, and in some areas rapidly, into extreme visible symptoms of deficiency. Further consequences include a decrease in increment, decreased resistance against other stress factors, and increased mortality. The intensity and the extent of nitrogen deficiency are great, but it is not possible to recommend fertilization with this element. First, the area of healthy stands where the fertilization can have adequate effect diminishes; second, it is necessary to protect the quality of surface waters. On the other hand it is not possible to see any risk if in removing the malnutrition of the stand with some other elements, fertilizers containing also nitrogen are used (e.g. liquid fertilizers MgNsol, CaNsol or other fertilizers, where the nitrogen is in relatively small amount).

Liming which has been practiced to a large extent for 10 years, using dolomite, is a long-lasting measure for improvement of calcium and magnesium nutrition. In closed stands, as the movement esp. of calcium through the soil profile is very slow, it is not possible to expect rapid improvement of nutrition with this element. The movement of magnesium in the soil is more rapid than the calcium and therefore its influence on the nutrition can be more rapid. It is necessary to continue dolomite liming in the stands also from the point of view of nutrition disturbances, and this must be considered in deciding about the intensity and extent of liming.

With respect to the extent of nitrogen deficiency in the stand it is not possible to neglect the fact that liming can stimulate the microbial activity and thus decrease the amount of nitrogen compounds available to the trees (Nebe, 1989), with possible consequences for the increment of the stands.

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MATERNA, J. (Výzkumný ústav lesního hospodářství a myslivosti, Jiloviště-Strnady): *Minerální výživa smrkových porostů v západní části Československa*. Lesnictví, 35, 1989 (11) : 975-982.

V předložené práci je podán přehled o stavu výživy smrkových porostů ve vyšších polohách západní části Československa. Pomocí listové analýzy bylo prokázáno značné rozšíření nedostatku výživy dusíkem a hořčíkem. Ve srovnání se stavem před dvaceti lety, se jen velmi málo zlepšila výživa porostů dusíkem (podíl vzorků s nedostatkem dusíku klesl ze 61,5 na 58 %), naproti tomu se výživa porostů hořčíkem velmi podstatně zhoršila. Ze 13,2 % stoupl podíl vzorků s nízkým obsahem Mg na 63,4 %. Také u draslíku a vápníku došlo ke zhoršení (podíl stromů nedostatečně vyživených stoupl z 0,8 % na 7,8 % u K a z 1,7 na 9,3 % u Ca). Naproti tomu klesl podíl vzorků s nedostatečnou koncentrací P ze 7,6 na 3,4 %. Vyskytuje se také značně vysoký podíl vzorků s nízkým obsahem Zn (9,6 %). Rizikem pro budoucnost je hlavně značné rozšíření latentního nedostatku hořčíku, které může přejít do akutního stavu se zřetelným žloutnutím, poklesem přírůstu, chřadnutím a zvýšenou mortalitou. Vápnění dolomitickým vápencem nemůže být považováno jen za meliorační zásah, ale posuzováno a realizováno i s ohledem na výživu.

smrk; listová analýza; výživa porostů; dusík; hořčík; vápník; fosfor; železo; zinek; mangan

MATERNA, J. (Научно-исследовательский институт лесного хозяйства и охотоведения, Йиловиште-Стрнады): *Минеральное питание еловых насаждений в западной части Чехословакии*. Lesnictví, 35, 1989 (11) : 975-982.

V предложенной работе дается обзор по состоянию питания еловых насаждений в повышенной местности западной части Чехословакии. При помощи листового анализа подтвердилось значительное распространение недостатков питания азотом и магнием. В сравнении с состоянием 20 лет тому назад, только не значительно улучшилось питание азотом (доля образцов с недостатком азота понизилась из 61,5 на 58 %), в противоположность этому питание насаждений магнием значительно ухудшилось. Из 13,2 % повысилось процентное содержание образцов с низким содержанием Mg на 63,4 %. Также у кальция и калия обнаружили ухудшение (доля деревьев недостаточно питаемых увеличилась из 0,8 % на 7,8 % у калия и из 1,7 % на 9,3 % у кальция). В противоположность этому понизилась доля образцов с недостаточной концентрацией фосфора из 7,6 на 3,4 %. Распространена также значительно высокая доля образцов с низким содержанием цинка (9,6 %). Риском для будущего в основном значительное распространение скрытого недостатка магния, которое может перейти в фазу острого состояния и значительным пожелтением, понижением прироста, чахлостью и повышенной смертностью. Известкование доломитическим известняком нельзя учитывать только как мелиоративные вмешательства, но его следует учитывать как питательное вмешательство.

ель; листовой анализ; питание насаждений; азот; магний; кальций; фосфор; железо; цинк; марганец

MATERNA, J. (Forschungsanstalt für Forstwirtschaft und Jagdwesen, Jiloviště-Strnady): *Die Mineralstoffernährung der Fichtenbestände in dem westlichen Teil der Tschechoslowakei*. Lesnictví, 35, 1989 (11) : 975-982.

Eine Übersicht über den Zustand der Mineralstoffernährung der Fichte in den höheren Lagen in dem westlichen Teil der Tschechoslowakei. Mit Hilfe der Nadelanalyse wurde ein ausgedehnter Stickstoff- und Magnesiummangel festgestellt. Im Vergleich zur Situation vor 20 Jahren, hat sich die Stickstoffernährung nur un-

wesentlich verbessert (Anteil der Proben mit Stickstoffmangel sank von 61,5 % auf 58 %), dagegen hat sich der Ernährungszustand der Bestände mit Magnesium sehr deutlich verschlechtert. Von 13,2 % hat sich der Anteil von Proben mit niedrigem Mg Gehalt auf 63,4 % erhöht. Auch bei Kalium und Kalzium kam es zu einer Verschlechterung (Anstieg des Anteils der ungenügend versorgten Bäume von 0,8 auf 7,8 % bei K und von 1,7 auf 9,3 % bei Ca). Dagegen sank der Anteil an Proben mit einer ungenügenden P Konzentration von 7,6 auf 3,4 %. Es gibt auch einen hohen Anteil an Proben mit einem niedrigen Zn Gehalt (9,6 %). Risiko für die Zukunft ist hauptsächlich die grosse Ausdehnung von latentem Magnesiummangel der in einen akuten Zustand mit einer deutlichen Vergilbung, Zuwachsrückgang, Vitalitätsverlust und einer erhöhten Mortalität übergehen kann. Die Kalkung mit Dolomitekalkstein muss daher nicht nur vom Gesichtspunkt der Bodenmelioration aber auch vom Gesichtspunkt der Ernährung betrachtet und durchgeführt werden.

Fichte; Blattanalyse; Ernährung der Bestände; Stickstoff; Magnesium; Kalium; Kalzium; Phosphor; Eisen; Zink; Mangan

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# MICROPROPAGATION OF MATURE TREES OF BIRCH (*BETULA PENDULA* ROTH.) AND ASPEN (*POPULUS TREMULA* L.)

## V. Chalupa

CHALUPA, V. (Forestry and Game Management Research Institute, Jíloviště-Strnady): *Micropropagation of Mature Trees of Birch (Betula pendula Roth.) and Aspen (Populus tremula L.)*. Lesnictví, 35, 1989 (11) : 983-993.

Shoot multiplication of selected mature trees of *Betula pendula* and *Populus tremula* was stimulated on WPM and modified MS medium containing cytokinin (BAP, PBA or thidiazuron) and auxin (IBA or NAA). Apical and axillary buds, shoot tips, nodal segments and leaf discs, cultured on WPM or modified MS medium supplemented with BAP or PBA (0.6—2.0 mg.l<sup>-1</sup>) or thidiazuron (0.001—0.05 mg.l<sup>-1</sup>) and IBA (0.05—0.1 mg.l<sup>-1</sup>), produced adventitious and axillary shoots. Shoots excised from proliferating cultures were rooted on GD or WPM, supplemented with low concentration of auxin (IBA, NAA 0.1—0.3 mg.l<sup>-1</sup>), or in non-sterile substrate. High rooting percentages were obtained. The survival of micropropagated trees planted in the field was high and at the end of the fifth growing season the trees attained large dimensions.

*in vitro* propagation; *Betula pendula*; *Populus tremula*; cytokinins; thidiazuron

Air pollution damages on forest stands growing in Czech mountainous regions have reached a great extent. Large areas of Norway spruce stands are destroyed and the regeneration is carried out with the tree species which are more resistant to air pollution. Birch and aspen are used in increasing numbers for afforestation of regions with high air pollution damages. Rapid micropropagation of mature trees of *Betula pendula* and *Populus tremula* is important for production of selected trees suitable for afforestation of regions with high air pollution damages. *In vitro* clonal propagation of mature trees and the effective plant regeneration from leaf discs is an important prerequisite for the application of genetic transformation methods in tree improvement programs of both species.

In past years we have succeeded in micropropagation of mature trees of *Betula pendula* and *Populus tremula* (Chalupa, 1981a, 1983a, b, 1985a, b). Formation of adventitious and axillary shoots was stimulated on explants cultured on nutrient media supplemented with cytokinin, and regenerated trees were planted in the field. The present communication describes results of our experiments with micropropagation of selected mature trees of *Betula pendula* and *Populus tremula* and the field growth of micropropagated trees.

## MATERIAL AND METHODS

Initial explants were taken from selected mature plus trees and hybrids. Trees were selected for their fast growth, good stem form and unusual structure of wood. Totally, 7 mature plus trees (16—24 years old) of *Betula pendula*, and 8 mature plus

trees (22—30 years old) of *Populus tremula* (diploid) and 3 hybrids of *Populus tremula* X *Populus tremuloides* were selected for *in vitro* propagation.

Epicormic sprouts and twigs (taken from low growing branches) were used as the source of initial explants of *Betula pendula* cultures. Axillary and apical buds, shoot tips and nodal segments were used as initial explants. Twigs collected in winter period were forced in water for a few days at the room temperature before axillary and apical buds were excised. Bud scales and outer leaves were removed from buds after sterilization.

Root segments taken from selected mature trees of *Populus tremula* were used as the source of initial explants for aspen cultures. Root segments were placed on moist peat and the root sprouts, which developed from buds, were used for culture establishment. Root sprouts were cut into short nodal segments which were sterilized and used as initial explants. Explants were sterilized in a mercuric chloride solution (0.1 %) for 20—40 minutes. After three successive rinses in sterile distilled water, the explants were placed on agar nutrient medium.

Cultures were grown at 25°C, under 16 hour photoperiod of cool white fluorescent light with an illumination of 4—8 lux. Cultures were grown on modified MS medium (Murashige and Skoog, 1962) or on WPM (Lloyd and McCown, 1981) and on modified GD medium (Gresshoff and Doy, 1972). The composition of the nutrient media used was described earlier (Chalupa, 1981b, 1983a, 1985a, b).

Three cytokinins were used for birch and aspen shoot multiplication: BAP (6-benzylaminopurine), PBA [N-(phenylmethyl)-9-(tetrahydro-2H-pyran-2-yl)-9H-purin-6(1H)-amine] and thidiazuron (N-phenyl-N'-1,2,3-thiadiazole-5-ylurea). BAP and PBA were tested in concentrations 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 3.0 and 5.0 mg.l<sup>-1</sup>, thidiazuron in concentrations 0.001, 0.002, 0.004, 0.006, 0.01, 0.02, 0.05 and 0.1 mg.l<sup>-1</sup>. Auxins NAA (1-naphthaleneacetic acid) and IBA (indole-3-ylbutyric acid) were tested in concentrations 0.1—1.0 mg.l<sup>-1</sup>.

Difco Bacto agar (6 g.l<sup>-1</sup>) was used to solidify nutrient media. Sucrose (20 or 30 g.l<sup>-1</sup>) was used as a carbon source. Media were autoclaved for 20 minutes at 121 °C. Each treatment involved 25—35 explants and was repeated at least twice.

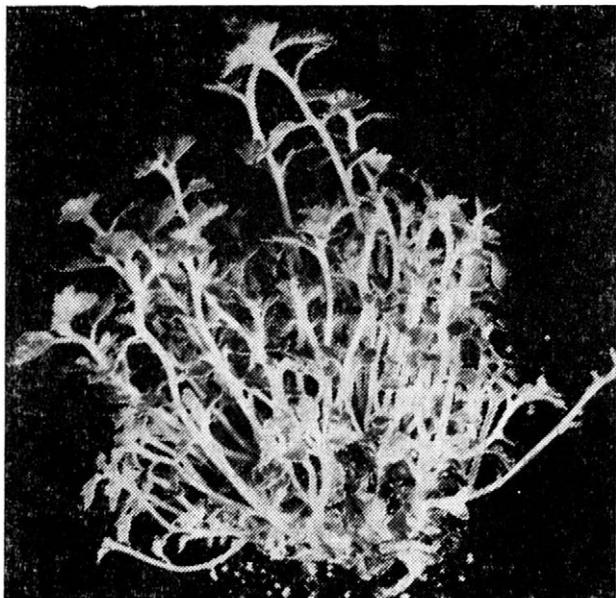
Rooted plantlets were transplanted into Jiffy-pots containing a mixture of peat, soil and perlite (1 : 1 : 1 v/v/v) and were grown under a plastic sheet at a high air humidity (95 %) for 2—3 weeks. After two weeks, humidity was gradually reduced to normal values. After formation of new adapted leaves, the plants were placed outdoors and grown for 1—2 months in partial shade.

## RESULTS

### MICROPROPAGATION OF *BETULA PENDULA* ROTH.

#### Shoot Multiplication

Axillary and apical bud explants and shoot tips laid horizontally on WPM or on modified MS medium supplemented with cytokinin (BAP or PBA 0.6 — 2.0 mg.l<sup>-1</sup>) and auxin (IBA or NAA 0.02 — 0.05 mg.l<sup>-1</sup>) initiated the growth in a few days. Within 2—3 weeks the size of explants enlarged and 2—3 new leaves developed. After 5—6 weeks new tissues with adventitious buds formed at the base of the cultured explants. Induced adventitious buds grew and developed gradually into short shoots. Tissues with adventitious buds were also formed at new developing leaves if the leaves were in contact with the nutrient medium. The parts of leaves which were in contact with the medium swelled and after 3—5 weeks adventitious buds developed. The tissues with induced adventitious buds and shoots were excised and transferred to the fresh medium of the same composition where shoot proliferation continued. Fast growth of induced adventitious shoots was stimulated on WPM containing low cytokinin and auxin concentrations (BAP 0.2 to 0.4 mg.l<sup>-1</sup> and IBA 0.05 mg.l<sup>-1</sup>).



1. Multiple shoots of *Betula pendula* developed from adventitious buds formed at the base of shoot tip, cultured on WPM containing BAP and IBA



2. Multiple shoots of *Betula pendula* produced on a nodal segment cultured on WPM containing thidiazuron and IBA

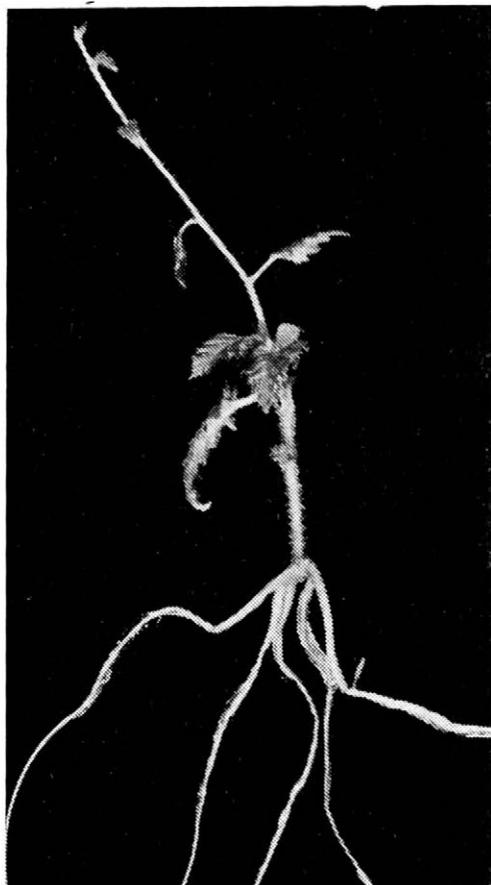
Shoots excised from proliferating cultures were multiplied on WPM. Shoots were cut into short nodal segments and shoot tips, which were cultured on WPM containing cytokinin and auxin. Shoot tips and nodal segments cultured on WPM supplemented with BAP or PBA ( $0.2 - 1.0 \text{ mg.l}^{-1}$ ) and IBA ( $0.05 - 0.1 \text{ mg.l}^{-1}$ ) produced new axillary shoots (2–8 shoots) within 4–5 weeks. The formation of callus tissue was stimulated at the base of shoot tips and nodal segments. After 6–8 weeks adventitious shoots (4–28 shoots) developed from the tissue (Fig. 1). The elongated shoots were separated and used for further multiplication or were rooted.

The formation of new adventitious and axillary shoots was also stimulated on media supplemented with thidiazuron and auxin (IBA  $0.05 \text{ mg.l}^{-1}$ ). Very low concentration of thidiazuron ( $0.001 - 0.004 \text{ mg.l}^{-1}$ ) stimulated growth of axillary shoots and formation of callus tissue at the basal part of shoot tips and nodal segments. After 6–8 weeks adventitious shoots (3–32 shoots) developed at the basal part of segments (Fig. 2). High concentration of thidiazuron inhibited shoot formation. The formation of new axillary and adventitious shoots was also stimulated on WPM supplemented with a low concentration of BAP ( $0.2 \text{ mg.l}^{-1}$ ), thidiazuron ( $0.001 \text{ mg.l}^{-1}$ ) and IBA ( $0.05 \text{ mg.l}^{-1}$ ).

The formation of adventitious shoots was also induced on leaf segments (leaf discs) cultured on media supplemented with cytokinin. Leaves excised from proliferating cultures were cut into segments (each leaf into 4 segments) which were laid horizontally on WPM supplemented with cytokinin (PBA or BAP  $0.6 - 2.0 \text{ mg.l}^{-1}$ ). Within 5–6 weeks new adventitious buds were induced on leaf segments and gradually developed into short shoots. Each leaf segment with induced ad-



3. Adventitious shoots formed on a leaf segment of *Betula pendula* cultured on WPM supplemented with PBA



4. Microshoot of *Betula pendula* rooted on agar WPM containing IBA ( $0.2 \text{ mg} \cdot \text{l}^{-1}$ )

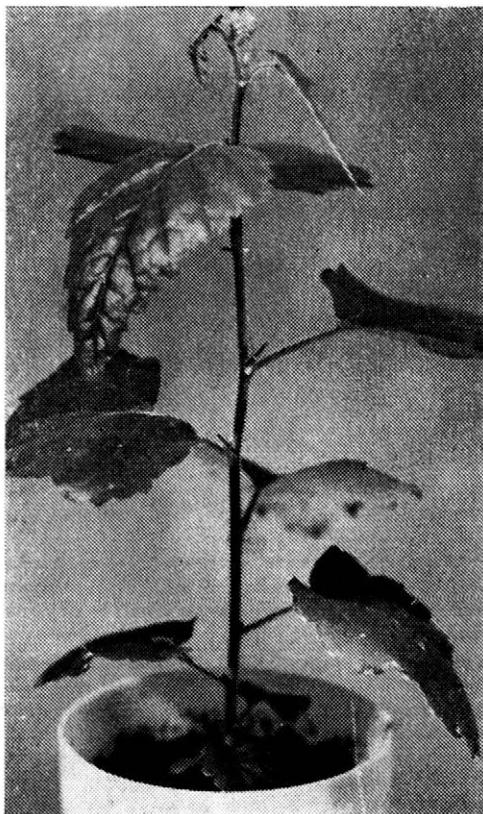
ventitious buds produced 2—11 shoots (Fig. 3), which were separated and multiplied on the fresh medium.

The shoots of selected birch trees were multiplied, using adventitious and axillary shoots induced on cultured explants. Significant differences in shoot proliferation rate between selected trees were observed. The long shoots from proliferating cultures were harvested and used for rooting.

#### Rooting and Acclimation

Microshoots excised from proliferating cultures were rooted on GD or WPM (half strength or full strength) containing low levels of auxin (IBA  $0.1 - 0.3 \text{ mg} \cdot \text{l}^{-1}$ ). Within 2—3 weeks 74—96 % of shoots formed roots (depending on the clone). Each shoot produced 3—8 roots (Fig. 4). Rooted plantlets were removed from agar medium and agar was washed from roots. Plantlets were transplanted into Jiffy-pots and were covered with plastic to maintain a high relative humidity. Plants were grown under high relative humidity for 2—3 weeks, then humidity was gradu-

5. Plant of *Betula pendula* regenerated *in vitro*, growing in potting mixture



ally reduced to normal values. High survival rates (71—92 %) were achieved. After new adapted leaves had formed, the plants were transferred from greenhouse outdoors (Fig. 5) and were grown in partial shade. In May or June they were planted in the field.

#### Field Growth

The survival of *Betula pendula* micropropagated trees planted in the field was high (94—100 %). The height growth of planted trees continued in summer, and at the end of the first growing seasons the trees were 15—25 cm tall. Almost all planted trees survived the first winter without damage. At the end of the fifth growing season, the trees attained a height of 210—360 cm. No abnormalities in the growth and morphology of micropropagated trees were observed. Trees regenerated from the same mother tree exhibited uniformity in the stem form and leaf colour and morphology.

#### MICROPROPAGATION OF *POPULUS TREMULA* L.

##### Shoot Multiplication

Nodal segment and shoot tips placed upright on MS agar medium containing cytokinin (BAP 0.1—0.6 mg.l<sup>-1</sup>) and auxin (IBA 0.1 mg.l<sup>-1</sup>) produced new short shoots from axillary buds within 2—3 weeks.



6. Multiple shoots of *Populus tremula* formed on nodal segment cultured on MS medium, supplemented with BAP and IBA



7. Multiple shoots of *Populus tremula* produced on shoot tip cultured on MS medium, supplemented with thidiazuron and IBA

Within 4–6 weeks shoots elongated and were cut into nodal segments and shoot tips which were subcultured on fresh multiplication medium where proliferation continued and multiple shoots were formed. Shoot multiplication medium consisted of MS medium supplemented with low concentration of cytokinin (BAP, PBA or thidiazuron) and auxin (IBA or NAA). The multiplication rate and shoot growth depended on concentration and ratio of cytokinin and auxin in nutrient medium. MS medium supplemented with low cytokinin concentration (BAP  $0.1 \text{ mg} \cdot \text{l}^{-1}$ ) and a higher auxin concentration (NAA or IBA  $0.2 \text{ mg} \cdot \text{l}^{-1}$ ) stimulated formation of few shoots (3–6 shoots within 4 weeks) which grew rapidly and reached a considerable length. MS media supplemented with higher cytokinin concentration (BAP  $0.2 - 1.0 \text{ mg} \cdot \text{l}^{-1}$ ) and low auxin concentration (NAA or IBA  $0.1 \text{ mg} \cdot \text{l}^{-1}$ ) stimulated formation of numerous axillary and adventitious shoots (Fig. 6). On an average, each shoot segment produced 8–22 shoots within a 4-week culture period. With increasing cytokinin concentration the shoot number increased. Shoot elongation was slower and shoots were shorter on media with a higher cytokinin concentration. The high cytokinin concentration (BAP  $2 - 4 \text{ mg} \cdot \text{l}^{-1}$ ) resulted in the formation of numerous short shoots.

Rapid shoot multiplication was stimulated on MS medium supplemented with low concentration of thidiazuron and auxin (IBA  $0.1 \text{ mg} \cdot \text{l}^{-1}$ ). Low concentration of thidiazuron ( $0.002 - 0.02 \text{ mg} \cdot \text{l}^{-1}$ ) stimulated formation of numerous adventitious shoots (Fig. 7). On an average, each shoot segment produced 16–38 shoots within a 6–8-week culture period. Shoots elongated slowly on media containing thidiazuron. High



8. Formation of adventitious shoots on leaf segment of *Populus tremula* cultured on MS medium, supplemented with thidiazuron and IBA

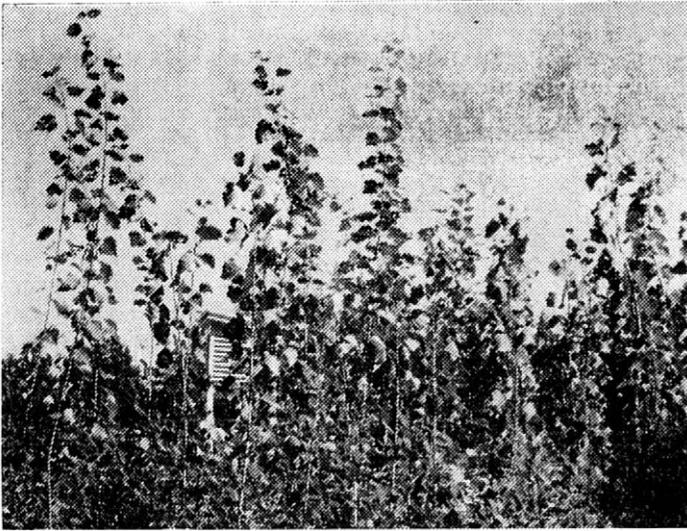


9. Microshoot of *Populus tremula* rooted in non-sterile substrate under high air humidity

concentration of thidiazuron inhibited shoot elongation from induced adventitious buds. The shoot number produced on media containing a low concentration of thidiazuron was significantly higher than on media supplemented with adenine-type cytokinin.

The formation of numerous adventitious buds and shoots was stimulated on leaf segments cultured on medium containing cytokinin. Leaf segments cultured on MS medium supplemented with thidiazuron ( $0.01 - 0.05 \text{ mg} \cdot \text{l}^{-1}$ ) or BAP ( $0.6 - 2.0 \text{ mg} \cdot \text{l}^{-1}$ ) and IBA ( $0.1 \text{ mg} \cdot \text{l}^{-1}$ ) produced numerous adventitious buds within 2–4 weeks. After 6–8 weeks numerous shoots formed on leaf segments. On an average, each leaf segment with induced adventitious buds produced 11–24 shoots (Fig. 8).

For rapid shoot multiplication of selected mature trees of *Populus tremula* we used MS medium supplemented with low cytokinin concentration (BAP  $0.2 - 1.0 \text{ mg} \cdot \text{l}^{-1}$ ) and low auxin concentration (IBA or NAA  $0.1 \text{ mg} \cdot \text{l}^{-1}$ ). The microshoots were subcultured in 4-week intervals. Multiplication rates higher than 6–10 in a 4-week culture period were obtained. A fast shoot multiplication of all selected clones and hybrids was achieved.



10. Micropropagated trees of *Populus tremula* growing in the field

### Rooting and Acclimation

Shoots excised from proliferating cultures were rooted on agar GD or WPM (half strength) containing a low concentration of auxins (NAA  $0.2 - 0.3 \text{ mg} \cdot \text{l}^{-1}$  and IBA  $0.2 - 0.3 \text{ mg} \cdot \text{l}^{-1}$ ). Within 2–3 weeks 81–96 % of shoots formed roots (depending on the clone). High rooting percentages (64–88 %) of aspen microshoots excised from cultures were also obtained when shoots were rooted in non-sterile substrate (a mixture of perlite, peat and sand) under a high air humidity. The shoot bases were first soaked with auxin solution (IBA  $100 \text{ mg} \cdot \text{l}^{-1}$ ) and after the auxin treatment the shoots were placed into solid substrate. The roots formed within 3–4 weeks were well developed (Fig. 9) and the growth of plants rooted in this way was fast.

Plantlets were transplanted into Jiffy-pots and were grown under a high relative humidity for 2–3 weeks, then the humidity was reduced to normal values. Most plants (76–92 %) survived the transfer into potting mixture. After new adapted leaves had formed, the plants were transferred from the greenhouse outside and were grown in partial shade.

### Field Growth

Almost all micropropagated trees planted in the field survived. The planted trees grew fast (Fig. 10) and at the end of the sixth growing season the trees were 720–850 cm tall. No abnormalities in the growth and morphology of micropropagated trees were found.

### DISCUSSION

One of the most serious problem of micropropagation of forest trees is the problem of ageing. The capacity of forest trees to be propagated vegetatively decreases with increasing age. Juvenile explants grow and

proliferate more easily than explants taken from a mature tree. Our approach to overcoming the problem of ageing consists in using juvenile parts of mature forest trees [root sprouts, stump sprouts, epicormic sprouts] for micropropagation [Chalupa, 1983a, 1984]. Some parts of mature hardwood trees, usually the roots and the base of stem, retain juvenile characteristics for a long time. For the micropropagation of *Populus tremula* mature trees we used root segments as a source of explants, and for *Betula pendula* mature trees, the epicormic sprouts and twigs from low growing branches were used as sources of initial explants. Our results indicate that if juvenile parts of mature trees are used, rapid micropropagation of mature trees can be achieved.

Genetic transformation methods have been developed for various plants recently. One of the important prerequisites for the application of recombinant DNA technology to forest tree species is the effective regeneration of trees from transformed cells. Shoot regeneration from leaf segments which were co-cultivated with *Agrobacterium tumefaciens* is an efficient method used for the production of transgenic plants [Horsch et al., 1985; McCormick et al., 1986; Fillati et al., 1987]. In our experiments we have succeeded in tree regeneration from leaf segments of *Betula pendula* and *Populus tremula*, which were cultured on chemically defined medium supplemented with cytokinin. The obtained results indicate that the leaf disc method can be applied for the development of suitable transformation system for *Betula pendula* and *Populus tremula* trees.

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CHALUPA, V. (Výzkumný ústav lesního hospodářství a myslivosti, Jíloviště-Strnady): Vegetativní množení dospělých stromů břízy (*Betula pendula* Roth.) a osiky (*Populus tremula* L.) in vitro. Lesnictví, 35, 1989 (11) : 983-993.

Vybrané dospělé stromy břízy a osiky byly množeny pomocí explantátových kultur pěstovaných na WPM a na modifikovaném MS mediu. Jako zdroj počátečních explantátů byly u břízy použity kmenové výhony a nízko rostoucí větve, u osiky segmenty kořenů, ze kterých byly vypěstovány kořenové výhony. Jako počáteční explantáty byly použity axilární a apikální pupeny, nodální segmenty prýtů, špičky prýtů a listové segmenty. Explantáty byly pěstovány na WPM a MS mediích která obsahovala cytokininy BAP nebo PBA (0,6—2,0 mg.l<sup>-1</sup>) nebo thidiazuron (0,001—0,05 mg.l<sup>-1</sup>) a auxin IBA (0,05—0,1 mg.l<sup>-1</sup>). Na těchto mediích bylo indukováno vytváření adventivních a axilárních prýtů a bylo dosaženo rychlého množení prýtů. Prýty odebrané z množících se kultur byly zakořeněny buď na GD mediu nebo na WPM obsahujících nízké koncentrace auxinu (IBA, NAA 0,1—0,3 mg.l<sup>-1</sup>), nebo byly zakořeněny v nesterilním substrátu za vysoké vzdušné vlhkosti. V obou případech bylo dosaženo vysokého procenta zakořenění. Zakořeněné rostliny byly přesazeny do substrátu a po otužení byly vysazeny na venkovní pokusné plochy. Nebyly pozorovány žádné abnormality v růstu a morfologii stromů vypěstovaných in vitro. Na konci páté vegetační doby stromy vypěstované in vitro dosáhly značných rozměrů.

rozmnožování in vitro; *Betula pendula*; *Populus tremula*; cytokininy; thidiazuron

ХАЛУПА, В. (Научно-исследовательский институт лесного хозяйства и охотоведения, Иловиште-Стрнады): **Вегетативное размножение спелых деревьев березы (*Betula pendula* Roth.) и осины (*Populus tremula* L.) *in vitro***. Lesnictví, 35, 1989 (11): 983-993.

Избранные спелые деревья березы и осины размножались при помощи эксплантатных культур выращиваемых на WPM и на модифицированной MS среде. У березы в качестве первичного источника эксплантатов использовались пневые побеги и низко растущие ветки, у осины сегменты корней, из которых выращивались корневые побеги. В качестве первичных эксплантатов использовались аксилярные и апикальные почки, нодальные сегменты побегов и сегменты листьев. Эксплантаты выращивались на WPM и MS средах, содержащих определенные концентрации БАП или ПБА цитокининов (0,6—2,0 мг. л<sup>-1</sup>) или тидиазурон (0,001—0,05 мг. л<sup>-1</sup>) и ауксин ИБА (0,05—0,1 мг. л<sup>-1</sup>) на приводимых средах индуцировалось образование адвентивных и аксилярных побегов и достигалось очень быстрое размножение побегов. Укоренения побегов из размножаемых культур достиглось или на ГД среде или на WPM содержащем низкую концентрацию ауксина (ИБА, НАА 0,1—0,3 мг. л<sup>-1</sup>), или в нестерильном субстрате при высокой воздушной влажности. У обоих типов получали высокой процент укоренения. Укорененные растения были пересажены в субстрат и после закалки были пересажены на полевые экспериментальные участки. У деревьев выращиваемых *in vitro* не наблюдались никакие абнормальности роста и морфологии. В конце пятого вегетативного периода деревья выращиваемые *in vitro* достигли больших размеров.

размножение *in vitro*; *Betula pendula*; *Populus tremula*; цитокинины; тидиазурон

CHALUPA, V. (Forschungsanstalt für Forstwirtschaft und Jagdwesen, Jiloviště-Strnady): **Autovegetative Vermehrung der adulten Birken (*Betula pendula* Roth.) und Espenbäume (*Populus tremula* L.) *in vitro***. Lesnictví, 35, 1989 (11): 983-993.

Gewebekulturen der adulten Bäume der Birke und Espe wurden auf WPM und modifiziertem Medium MS kultiviert. Als eine Quelle der Anfangsexplantaten wurden bei der Birke Stammsprosse und unten wachsende Äste benützt, bei der Espe die Wurzelsegmente, aus welchen Wurzelausschläge gezüchtet wurden. Als Anfangsexplantate wurden Axilar- und Apikalknospen, nodale Segmente und Blattsegmente benützt. Explantate wurden auf WPM und MS Medien kultiviert, die Cytokininen BAP oder PBA (0,6—2,0 mg.l<sup>-1</sup>) oder thidiazuron (0,001—0,05 mg.l<sup>-1</sup>) und Auxin IBA (0,05—0,1 mg.l<sup>-1</sup>) enthielt. Auf diesen Medien wurde die Bildung von Adventiv- und Axilarsprossen induziert und es wurde eine schnelle Sprossvermehrung erreicht. Die Sprosse, die aus vermehrten Kulturen entnommen wurden, wurden auf GD Medium oder WPM gewurzelt, welche niedrige Konzentrationen von Auxin enthalten (IBA, NAA 0,1—0,3 mg.l<sup>-1</sup>), oder sie wurden in unsterilem Substrat bei hoher Luftfeuchtigkeit gewurzelt. In beiden Fällen wurde ein hohes Bewurzelungsprozent erreicht. Die gewurzelten Pflanzen wurden ins Substrat umgesetzt und nach Erhärtung wurden sie auf die Versuchsflächen ausgesetzt. Es wurde keine Wuchs- und Morphologieabnormalität der *in vitro* gezüchteten Bäume beobachtet. Am Ende der fünften Vegetationsperiode erreichten die *in vitro* gezüchteten Bäume grosse Dimensionen.

Vermehrung *in vitro*; *Betula pendula*; *Populus tremula*; Cytokininen; Thidiazuron

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## THE PLANNED CONTENTS OF THE SCIENTIFIC JOURNAL LESNICTVÍ FOR THE YEAR 1990

The scientific journal LESNICTVÍ is drawn in such a way as to introduce recent advances in forestry and game management research with special regard to the harmony among the decisive triad of biological, technical and economic sciences. It also provides scope to specialists in other fields whose work is associated with the above-mentioned orientation of the journal. Interesting articles which present the latest news are published in the section "Topical Events", an appropriate place is intended for reviews, etc.

The period of the year 1990 is also outlined in this conception. Monothematic and polythematic issues are to be alternated at a ratio of about 5:7. The first monothematic issue will be devoted to the economics and economy of forestry, the next one to ecology, followed by the issues with the topics of vegetative reproduction of tree species, forest machinery and forest ergonomics. No. 11 will be published in English again as a polythematic issue with recent contributions to the principal scientific branches, incl. their practical applications. The following issue will be polythematic again and we shall endeavour at a proper representation of papers in the fields of biology, technology and economy.

The attractiveness of the journal is enhanced by supplements which offer the reader surveys of statistical nature. This applies to the chapters entitled "Forestry in Numbers" and "Game Management in Numbers". Last but not least, the "Mathematical Supplement" is intended for deeper knowledge of mathematico-statistical methods, particularly as related to computerization.

We believe that such contents of the journal will comply with its main mission and satisfy our exacting readers.

*Academician Miroslav Vyskot*

**THE IDENTITY OF *APANTELES DIORYCTRIAE* WILK.  
AND *A. MURINANAE* ČAP. & ZWÖLF. (HYM: BRACONIDAE)**

**M. Čapek**

CAPEK, M. (Forest Research Institute, Zvolen, Research Station, Banská Štiavnica): *The Identity of Apanteles dioryctriae* Wilk. and *A. murinanae* Čap. & Zwölf. (Hym.: Braconidae). *Lesnictví*, 35, 1989 (11) : 995-1001.

Host relations, geographical distribution, and larval taxonomy of four species of the *Braconid* genus *Apanteles* Foerst. (*petrovae* Walley, 1937; *dioryctriae* Wilkinson, 1938; *magnus* Telenga, 1955; *murinanae* Čapek & Zwölfer, 1957) were studied in detail. They are important parasitoids of serious insect pests of forest coniferous trees. All four species were synonymized by Papp (1980) with *A. petrovae* Wall., but the present study has shown that this synonymization is unjustifiable.

*Braconid* parasitoids of insect pests of coniferous trees; application of host relations, geographical distribution and larval taxonomy for judging the identity of *Braconid* species

**INTRODUCTION**

The Hungarian *Braconid* specialist J. Papp published (in several parts) a survey of European species of the *Braconid* genus, *Apanteles* Foerster, 1862, in the form of keys with short taxonomical notes. In its fourth part (Papp, 1980) he synonymized 4 species — important parasitoids of serious insect pests of coniferous forest trees, namely *A. petrovae* Walley, 1937, *dioryctriae* Wilkinson, 1938, *magnus* Telenga, 1955, and *murinanae* Čapek & Zwölfer, 1957. He supported the synonymization by a short footnote only: the types of *dioryctriae* Wilk. and *murinanae* Čap. & Zwölf. were available to him, as well as a pair of *petrovae* Wall., named by W. R. Mason from the Canadian National Collection, Ottawa, and as regards to *magnus* Tel. he accepted the opinion of Nixon (1973) about its intermediate position between *dioryctriae* and *murinanae*.

There are many groups of sibling and morphologically hardly distinguishable species in the huge genus *Apanteles*. The approaches of alpha systematics may be insufficient for solving the problems of their classification on specific level (both synonymization and validation) in such difficult groups of taxa. Therefore the present author is trying to use some non-traditional approaches, namely the characters of gamma systematics, for judging Papp's synonymization.

**MATERIAL AND METHODS**

The synusia of *Lepidopteran* larvae in fir stands and their parasitoids was examined during 15 years of a mass outbreak of *Choristoneura murinana* Hb. in

Slovakia as well as in east France and southwest Germany (Čapek & Zwölfer, 1957). The host range of *Apanteles murinanae* was investigated to great detail not only among the Lepidopteran hosts feeding on fir, but also on other tree species growing in fir stands such as oak, beech, spruce etc. The author found it also in the Braconid materials mentioned by other forest entomologists who bred it from other hosts and tree species, but he cannot warrant the reliability of the mentioned host-parasitoid relations. As regards the host relations of other three *Apanteles* spp., they were taken from the quoted literary sources. The same can be said about the geographical distribution of all four *Apanteles* spp.

The larval taxonomy was studied on cast skins of the last larval instar from bred cocoons. The gift of 4 cocoons of *A. petrovae* from the Canadian National Collection, Ottawa, as well as the loan of 2 cocoons of *A. dioryctriae* from British Museum (N. H.), London, are appreciated with thanks. Further 10 cocoons of *A. murinanae* from the author's collection were examined. No cocoons of *magnus* were available.

#### HOST RANGE

All four *Apanteles* spp. are solitary endoparasitoids of *Microlepidopteran* hosts feeding on economically important forest coniferous tree species.

*A. petrovae* has the broadest range of known hosts of the four *Apanteles* spp. studied. The Tortricid *Petrova albicapitana* Busck., mining in young twigs of various pines, seems to be the principal host for it, but it has been recorded also from other Microlepidopteran hosts on pines, such as Tortricids (defoliator *Choristoneura pinus* Free., shoot borer *Rhyacionia frustrana* Comst.) and Pyralids (e. g. cone feeder *Dioryctria auranticella* Grt.). Zwölfer (1961) considers the defoliators such as *Choristoneura fumiferana* Clem. on firs and spruces or *C. pinus* Free. on pines as accidental hosts for it. Finally, Marsh (1979) lists the following further hosts: *Barbara colfaxiana* Kft. (cone feeder on *Pseudotsuga*, *Larix*, *Abies*, and *Picea*), *Dioryctria reniculella* Grt. (cone and new growth feeder on coniferous trees), *Petrova pallipennis* McD., and *Zeiraphera canadensis* M. & F.

*A. dioryctriae* has only one known host — the Pyralid *Dioryctria peyerimhoffi* de Joann., the cone feeder on *Cedrus atlantica* (Wilkinson, 1938). One specimen was bred from a cone of *Pinus nigra* (Nixon, 1973).

*A. magnus* was bred also from one host only — the Tortricid *Eucosma impropria* Meyrick, the cone feeder on *Larix* (Nixon, 1973).

*A. murinanae* is the principal Braconid parasitoid of Tortricid *Choristoneura murinana* Hb., a serious defoliator of *Abies alba*. During many years of systematic studies of the whole synusia of *Lepidoptera* of fir crowns, only some further additional or occasional host species have been found: defoliators *Zeiraphera rufimitrana* H. S., *Parasyndemis histrionana* Froel., *Archips piceana* L., bud miner *Epinotia nigricana* H. S., and needle miner *E. pusillana* Peyr., all Tortricids. There are further two host records from other tree species, namely the Tortricid *Zeiraphera diniana* Guen., defoliator on spruce (bred by Aeschlimann in Switzerland) and the Gelechid *Exoteleia dodecella* L., needle miner on pine (bred by Sierpiński in Poland), but they are evidently only occasional hosts of this Braconid.

It is interesting to note that each of the four *Braconids* studied prefers the hosts on a specific tree genus, namely *A. petrovae* on pine, *A. dioryctriae* on cedar, *A. magnus* on larch, and *murinanae* on fir. The Lepidopteran host species from other tree genera may be considered as their accidental or occasional hosts only.

#### GEOGRAPHICAL DISTRIBUTION

*A. petrovae* occurs in North America from New Foundland up to California and occupies probably the largest area of the four species studied, while the second species, *A. dioryctriae*, is spread over the smallest area: it is known from Morocco and Turkey. *A. magnus* was described from Mongolia and was found also in northeast Siberia. *A. murinanae* is recorded in Europe from France up to Czechoslovakia and Poland.

All four taxa occur in four continents and their areas taken together (if it is really one species with three synonyms) can be characterized as disjunctive.

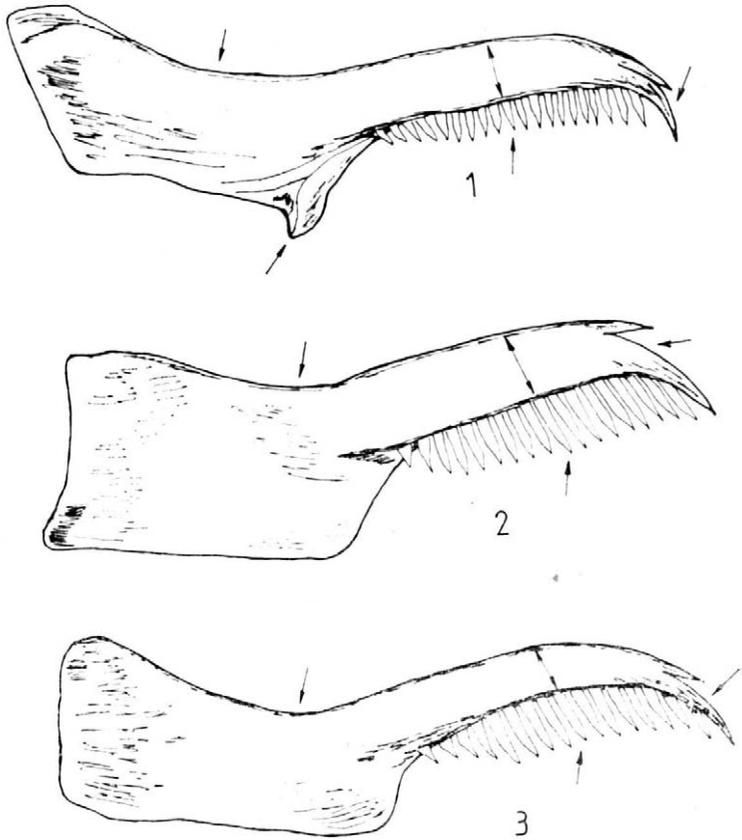
#### THE TAXONOMY OF THE LAST INSTAR LARVAE

The cocoons of only 3 species were available. Differences were found among them, mainly in the colour of cocoons, their contents as well as in the larval morphology.

*A. petrovae* (4 cocoons examined) has whitish, translucent cocoon and its contents are as follows: the droppings are pitch dark, isolated from meconium which is light brown. The base of mandible is nearly rectangular, almost as long as the blade with a little process at the lower edge. The blade is asymmetrically bifurcated — the smaller tip a little shifted to its toothless edge. The toothed edge with 19—20 teeth and the middle tooth half as long as the breadth of blade at the point of this tooth (Fig. 1).

*A. dioryctriae* (2 cocoons examined) has also whitish, translucent cocoon which has the following contents: black droppings are tied together with dark brown meconium and larval cast skin. The base of mandible robust, but a little shorter than the blade without any process. The blade is asymmetrically bifurcated and the smaller tip shifted farther to its toothless edge. The toothed edge with 17—18 teeth and the middle tooth almost as long as the breadth of the blade at the point of this tooth (Fig. 2).

*A. murinanae* (10 cocoons examined) has white, opaque cocoon with the following contents: the droppings greenish brown, isolated, meconium brownish with purple streakiness. The almost rectangular base of mandible longer than the blade without any process. The blade asymmetrically bifurcated, the smaller tip shifted a little to its toothless edge. The toothed edge with 16—17 teeth and the middle tooth as long as the breadth of blade at the point of this tooth (Fig. 3).



1.—3. The left mandible of last instar larva (orig. J. Novotný): 1 — *Apanteles petrovae* Wall.; 2 — *Apanteles dioryctriae* Wilk.; 3 — *Apanteles murinanae* Čap. & Zwölf.

## DISCUSSION AND CONCLUSION

The cephalic structures of the final instar larva with supporting evidence from life history and host relations proved to be a very valuable basis for reviewing the superspecific classification of the *Bracoonidae* (Čapek, 1970). The present paper is a first attempt to use this approach for solving the problems on specific level.

The first described species of the studied Braconids is *Apanteles petrovae* which was found as parasitoid of *Petrova albicapitana* Busck. mining in young twigs of *Pinus banksiana* in Ontario, Canada by Walley (1937). It was recorded as an accidental parasitoid of *Choristoneura fumiferana* Clem. by Miller (1959) and its taxonomy was described in detail by Mason (1974). Its complete host-list is in the Catalog of *Hymenoptera* in America North of Mexico (Marsh, 1979). Zwölfer (1961) compared the parasitoid complexes of European fir budworm, *Choristoneura murinana* Hb. and its very closely related North American spruce budworm, *C. fumiferana* Clem. He stated that the principal parasitoid of *C. murinana*, *A. murinanae*, is strikingly different from the principal parasitoid of *C. fumiferana*, *A. fumiferanae*, but very

similar to its occasional parasitoid, *A. petrovae*. Similarly *A. fumiferanae* is closely related to an occasional parasitoid of *C. murinana*, *A. lineipes* Wesm. — a principal parasitoid of *Zeiraphera rufimitrana* H. S. Finally, Papp (1980) designated *A. petrovae* as senior synonym of further 3 studied species of *Apanteles* spp., which was accepted by later authors, e.g. Tobias (1986). No author has analyzed their host relations, geographical distribution and particularly the larval taxonomy to greater detail from the standpoint of considering the competence of Papp's synonymization. The present application of these approaches proved the unquestioned identity of *A. petrovae* Wall.

The second species, *Apanteles dioryctriae*, was described as the parasitoid of *Dioryctria peyerimhoffi* de Joann. in Morocco by Wilkinson (1938). Its close morphological resemblance to *A. murinanae* was mentioned for the first time by the authors of the latter species (Čapek & Zwölfer, 1957), and later by Nixon (1973) who mentions also one its specimen bred from the cone of *Pinus nigra* from Turkey. The close morphological relation of these two species induced Papp (1980) to synonymize them. However, the present examination of its larval taxonomy as well as the evaluation of its host relations and geographical distribution does not support this synonymization.

The third species, *Apanteles magnus*, was described from Mongolia (Telenga, 1955). Its only one known host species is *Eucosmia impropria* Meyrick, feeding on the cones of larch in northeast Siberia (Nixon, 1973). Papp's synonymization of it with *A. petrovae* is based on Nixon's (1973) opinion on its intermediate position between *A. dioryctriae* and *murinanae*. Unfortunately, no cocoon of this species was available and thus its larval taxonomy could not be examined.

The last species, *Apanteles murinanae*, was described as the principal parasitoid of *Choristoneura murinana* Hb. from Czechoslovakia, southwest Germany and east France (Čapek & Zwölfer, 1957). Its close morphological relationship to *A. dioryctriae* is mentioned already in its original description. Its hosts are listed by Čapek (1961) and Zwölfer (1961). Papp (1980) designated its name as a junior synonym of *A. petrovae*. The detailed examination of immature stages, host relations and geographical distribution has brought new views throwing doubts on the justification of this synonymization.

The results of the present study have brought evidence proving that *Apanteles dioryctriae* Wall. and *A. murinanae* Čap. & Zwölf. are valid species and that their designation as junior synonyms of *A. petrovae* Wall. by Papp (1980) was unjustifiable. As regards the problem of identity of *Apanteles magnus* Tel. which was not available for the study, it could not be solved definitely.

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CAPEK, M. (Výskumná stanica VÚLH, Banská Štiavnica): *Identita lumčika Apanteles dioryctriae* Wilk. a lumčika *A. murinanae* Čap. et Zw. (*Hym.*: *Braconidae*). Lesnictví, 35, 1989 (11) : 995-1001.

Autor prináša výsledky podrobného štúdia štyroch blízko príbuzných („sibling“) druhov rodu *Apanteles* Foerster (*Hymenoptera*, *Braconidae*), a to *petrovae* Walley, 1937, *dioryctriae* Wilkinson, 1938, *magnus* Telenga, 1955 a *murinanae* Čapek et Zwölfer, 1957, ktoré Papp (1980) pokladá za jediný druh — *petrovae*. Prvý, severoamerický *petrovae* bol opísaný ako hlavný parazitoid obaľovača *Petrova albicapitana* Busck., ktorý vŕta v mladých výhonkoch viacerých druhov borovic a príležitostne i ďalších druhov obaľovačovitéch a vijačkovitých predovšetkým z borovic, menej zo smrekov a jedlí. Vyskytuje sa v USA a Kanade od atlantického až po pacifické pobrežie. Stredoziemny *dioryctriae* bol opísaný ako parazoid vijačky *Dioryctria peyrimhoffi* de Joann. zo sušiek cédra atlantického a vyskytuje sa od Maroka až po Turecko, kde bol dochovaný z blízšie neurčeného hostiteľa v šuške čiernej borovice. Tretí, východoázijský *magnus* bol opísaný z Mongolska a v severovýchodnej Sibíri bol zistený ako parazitoid obaľovača *Eucosma impropria* Meyr., ktorý vŕta v šuškách smrekovca. Konečne stredoeurópsky *murinanae* je hlavným parazitoidom obaľovača jedľového, *Choristoneura murinana* Hb. a príležitostne i ďalších obaľovačov z jedle a výnimočne i zo smreka. Vyskytuje sa medzi Vogézami a Karpatami. Každý z uvedených štyroch taxónov má teda svoj okruh hostiteľov na určitej drevine, ďalej svoj ohraničený areál, a keďže aj štúdium morfológie lariev troch druhov (*petrovae*, *dioryctriae* a *murinanae*) dokázalo medzi nimi dobré rozlišovacie znaky, napr. na hryzadlách, synonymizácie Pappa nemôže byť pokladaná za oprávnenú a všetky štyri taxóny tvoria samostatné druhy.

lesnícka entomológia; entomofágne parazitoidy; lumčíkovité rodu *Apanteles*; zemišné rozšírenie; hostiteľské vzťahy; morfológia lariev

ЧАПЕК, М. (Научно-исследовательская станция НИИ лесного хозяйства, Банска Штявница): *Идентита бракониды Apanteles dioryctriae* Wilk. и бракониды *A. murinanae* Čap. et Zw. (*Hym.*: *Braconidae*). Lesnictví, 35, 1989 (11) : 995-1001.

Автор сообщает о результатах подробного изучения 4 очень близкое родственных видов рода *Apanteles* Foerster (*Hym.*: *Braconidae*) а именно *petrovae* Walley, 1937,

*dioryctriae* Wilkinson, 1938, *magnus* Telenga, 1955 и *murinanae* Čapek et Zwölfer, 1957, которых Папп (1980) считает одним видом — *petrovae*. Первый из них североамериканский *petrovae* описан как паразитоид листовертки *Petrova albicapitana* Busck., которая минирует молодые побеги нескольких видов сосен. Тоже определен как случайный паразитоид и других видов листоверток преимущественно из сосен, реже елей или пихт. Встречается в США и в Канаде от атлантического до пацифического побережья. Средиземноморский *dioryctriae* описан как паразитоид огневки *Dioryctria peyerimhoffi* de Joann. из шишек *Cedrus atlantica* и неизвестного хозяина из шишек *Pinus nigra*. Встречается от Мароко до Турции. Третий восточноазиатский *magnus* описан в Монголии и был выведен из листовертки *Eucosma impropria* Meyer., из шишек лиственницы в Северо-восточной Сибири. Последний, средневропейский *murinanae* — является основным паразитоидом пихтовой листовертки *Choristoneura murinana* Hb. и случайно других видов листоверток из пихты и ели. Встречается от Вогез до Карпат. Каждый из приведенных 4 таксонов имеет свой диапазон хозяев и свой отдельный ареал. Изучение морфологии личинок также трех видов определило хорошие различительные признаки между ними (*petrovae*, *dioryctriae* и *murinanae*), например на верхней челюсти, что противоречит обоснованности Паппа синонимизировать эти четыре таксоны, которые являются настоящими самостоятельными видами.

Лесная энтомология; энтомофагные паразитоиды; бракониды рода *Apanteles*; географическое распространение; соотношение хозяин-паразитоид; морфология личинок

ČAPEK, M. (Forschungsstation der Forschungsanstalt für Forstwirtschaft, Banská Štiavnica): *Identität der Apanteles dioryctriae* Wilk. sowie der *A. murinanae* Cap. et Zw. (Hym.: Braconidae). Lesnictví, 35, 1989 (11) : 995-1001.

Der Verfasser bringt Ergebnisse eines gründlichen Studiums von vier eng verwandten („sibling“) Arten der Gattung *Apanteles* Foerster (Hym.: Braconidae), und zwar *A. petrovae* Walley, 1937, *A. dioryctriae* Wilkinson, 1938, *A. magnus* Telenga, 1955 und *A. murinanae* Čapek et Zwölfer, 1957, welche Papp (1980) nur für eine Art — *A. petrovae* Wall.-hält. Die erste von ihnen, die nordamerikanische *A. petrovae* wurde als Hauptparasitoid des Wicklers *Petrova albicapitana* Busck., welcher in jungen Trieben mehrerer Kiefernarten miniert, festgestellt. Gelegentlich kommt er auch in anderen Wickler- bzw. Zünslerarten, vor allem von Kiefern, weniger Fichten oder Tannen, vor. Sie erscheint in USA und Kanada von der atlantischen bis zur pazifischen Küste. Die mediterrane *A. dioryctriae* wurde als Parasitoid des Zünslers *Dioryctria peyerimhoffi* de Joann. aus den Zapfen von *Cedrus atlantica* beschrieben und noch von einem nicht näher bekannten Wirt aus Schwarzkiefernzapfen gezüchtet. Sie kommt von Marokko bis zur Türkei vor. Die dritte, ostasiatische *A. magnus* kennt man von der Mongolei und als Parasitoid des Wicklers *Eucosma impropria* Meyer., der in den Lärchenzapfen in Nordostsibirien lebt. Zuletzt ist es die mitteleuropäische *A. murinanae*, der Hauptparasitoid des schwarzköpfigen Tannentriebwicklers *Choristoneura murinana* Hb. und gelegentlich noch anderer Wicklerarten von der Tanne, ausnahmsweise auch Fichte. Sie kommt von den Vogesen bis in die Karpaten vor. Jedes von den erwähnten vier Taxonen hat also seinen eigenen Wirtskreis an bestimmten Holzarten sowie ein begrenztes Verbreitungsareal. Auch das Studium der Larvenmorphologie von 3 Arten (*petrovae*, *dioryctriae* und *murinanae*) hat gute Differenzierungsunterschiede zwischen ihnen, z. B. an den Mandibeln nachgewiesen, sodass ihre Synonymisierung von Papp als kaum berechtigt angenommen werden kann. Alle vier Taxone soll man deswegen für gute obzwar einander nahe Arten halten.

Forstentomologie; entomophage Parasitoiden; Brackwespen der Gattung *Apanteles*; geographische Verbreitung; Wirtsbeziehungen; Larvenmorphologie.

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# TOPICAL PROBLEMS

## BALANCE OF ESSENTIAL OILS FROM CONIFEROUS TREE BIOMASS

There is a dangerous paradox in today's world. The environment is getting worse rapidly, forests die back but wood consumption increases fast and wood is wasted remarkably. In our country the situation is just like that. We cut about 20 mill. m<sup>2</sup> of rawtimber outside bark per year, in assortments of industrial importance. We do not utilize, however, thinner tree dimensions which fall away in final cutting and during silvicultural treatment. Improvement of this unbearable condition is a task of the management sphere using appropriate effective economic measures. For a right decision objective factography is necessary. Therefore, the problems mentioned were included into the tasks of basic and applied research.

The increasing demand for wood requires acquaintance with the present state and future prospects of biomass (dendromass) balance of principal tree species in volume and weight according to individual components of aboveground and underground tree parts. As early as in 1960 we started with exacting analytical studies resulting in monographs of 200 trees from juvenile stage to adult individuals up to 150 years of age, which were published in Czech and in English (M. Vyskot, 1972—1989).

In our endeavour to accelerate practical application of our research results, we have presented three patents on the use of coniferous slash which were approved and published with descriptions of the invention. In this connection, it is important to know the yield of essential oils from the treated dendromass as well as its composition. For this purpose we established research in 1983 to analyse economically important coniferous tree species. Of the native species it included spruce, fir, pine and larch. Introduced tree species were represented by grand fir and Douglas fir. The yield was investigated for five years. The yield percentage in Norway spruce, silver fir, Scotch pine and European larch ranged from 0.04 to 0.27 %, 0.54 to 0.82 %, 0.19 to 0.43 % and from 0.00 to 0.21 %, respectively. As far as the exotics are concerned, in grand fir and Douglas fir the essential oil yield was from 0.49 to 1.09 % and from 0.33 to 1.15 %, respectively. As apparent, among the native conifers the relatively highest yield was recorded in fir followed by pine and spruce. Nevertheless, spruce and pine are of importance from the point of view of potential biomass quantity. The same is true of the exotics, grand fir and Douglas fir, under study. In both these species the maximum yield of more than 1 % was exhibited. Their mass utilization has not been considered, however, because of their low occurrence.

The quality of essential oil depends on many factors which affect the life of the tree. Nevertheless, the essential oil of each type has its characteristic properties. When using available standards, gas-chromatographic analyses revealed that limonene and  $\beta$ -pinene prevail in the essential oil of spruce, limonene and phellandrene in fir and limonene and  $\alpha$ -pinene in pine, which also applies to larch, as well. The same composition can be found in grand fir while Douglas fir showed the largest representation of  $\beta$ -pinene, followed by  $\alpha$ -pinene and bornylacetate. Essential oils include many other components, of course, which are, not infrequently, of key importance even in small amounts. Therefore, it is necessary to continue developing complex research in the biological, chemical and other scientific disciplines to get thoroughly acquainted with this rich natural treasure and to use it reasonably for the sake of the human society.

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# RESULTS AND PROBLEMS OF AERIAL APPLICATION OF PESTICIDES AND BIOPREPARATIONS IN CZECHOSLOVAK FORESTRY

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ŠVESTKA, Forestry and Game Management Research Institute, Res. Station Horní Česká): *Results and Problems of Aerial Application of Pesticides and Biopreparations in the Czechoslovak Forestry*. Lesnictví, 35, 1989 (11): 1003-1014.

The summary of the results of the aerial treatment of forests against insects and weeds in the CSR, based on the findings of the author, is presented in the study. Regular aerial application of chemicals has been practiced in the Czechoslovak economy since the forties of this century. Most frequently, insecticides and biopreparations are in this way applied against *Zeiraphera diniana*, *Lymantria monacha*, *Cephalcia abietis*, *Pristiphora abietina*, *Operophtera brumata*, *Tortrix viridana* etc. In recent years, the aerial application of herbicides has been used during the formation of forest on large clearings after blow downs. The aerial application of pesticides is restricted only to essential cases when there is a threat to the forests' existence. The penetration of the droplets of insecticide oil solutions in spruce stands was researched and the effect of insecticides on insectivorous birds was studied. The assortment of insecticides was, until the beginning of the seventies, based on preparations containing chlorinated hydrocarbons. After their prohibition in 1974, mainly organophosphorous insecticides were used, together with pyrethroids and ecologically less damaging inhibitors of the chitin synthesis, as well as biopreparations containing the bacterium *Bacillus thuringiensis*. The effectiveness of aerial treatment was evaluated on the basis of the relation between the growth reaction of woody species and the damage caused to assimilation organs by the insecticide. The extent of growth losses was expressed in m<sup>3</sup> of wood per one hectare in a year.

protection of forest; aerial application; insecticides herbicides; biopreparations; entomofauna and birds; economic effectiveness

Forest in Czechoslovakia occupy 4.5 mill. hectares (11.1 mill. acres), i.e. 35.8 % of the area of the country. Coniferous trees occupy 67 % of the area; of that, *Picea* 47 %, *Pinus* 14 %, other conifers 6 %. Broad-leaved tree species are on the area of 33 %, of that *Fagus* 17 %, *Quercus* 7 %, other broad — leaved trees 9 %.

Aerial treatment of forest stands has had a long tradition in our country. The first aerial application of an insecticide was carried out already in the year 1926, i. e. after Canada, U. S. A., U. S. S. R., Switzerland and Germany, as in one of the first countries in the world. Regular aerial chemical control in the Czechoslovak forestry has been practiced since the forties of this century on an area 20 000 to 40 000 ha (50 000 to 10 000 acres) annually. Most frequently, aerial applications have been used in forestry to apply insecticides and biopreparations to control pests, and recently also herbicides to control weeds in forest stands. Fertilizers are also applied from aircraft, mainly limestone intended for soil improvement.

Aerial treatment of forest stands includes the use of airplanes and helicopters and shows in comparison with the terrestrial application a series of advantages. Aerial treatment of forest stands may be done in bad terrain conditions, where the use of terrestrial machines is very difficult or even impossible. Aerial application devices have a considerably higher performance, so the treatment is carried out more rapidly which is very important in the case of the mass outbreak of dangerous pests which may cause large economic losses. Aerial protection of forest stands saves labour and increases work productivity, but it is extremely difficult to control all conditions influencing the quality and security of the treatment. It is necessary to stick accurately to the prescribed technologies. The weather may considerably influence the result of the application of pesticides and biological preparations. This concerns mainly the windspeed and vertical air streams during the work. With respect to actual application methods, maximum values are determined for them. Further important factors are the rain which may cause the washing of the preparations, the temperature which influences the effectiveness of preparations, sun radiation which speeds their decomposition etc.

## AERIAL APPLICATION OF INSECTICIDES

Insect pests were in the past a disaster for forest stands. For instance, *Lymantria monacha* caused in the past in our country six large known calamities with clear eatings and destruction of Norway spruce stands on areas of thousands of hectares. First the development of aerial techniques and the production of insecticides ment the basic change in the control of calamity insect pests. Besides the control of the pests, insecticides also exhibit a more or less pronounced unfavourable effect on other components of the *zoocoenosis*, so their aerial application is limited only to really necessary cases with the mass outbreak of a pest which may cause important losses. The choice of the method, the process of application and the working regime depend on the properties of the insecticide, on the age and area of stands, on zoning and on configuration of the terrain. The treatment time is determined so that the most sensitive stages of the pest are hit and its natural enemies and other components of the *zoocoenosis* are saved. The saving of parasites and predators is important as they are concentrated on the rest of the pest population and cause permanent reduction of its population density. The application of the insecticide is always connected with the control of the number of the pest before the treatment and after it. This control enables the assessment of the effectiveness and economics of aerial application.

In the past decades, insecticides have been applied most frequently from aircraft to control defoliators of spruce. These defoliators were of the order *Lepidoptera* (*Zeiraphera diniana*, *Lymantria monacha*) and of the order *Hymenoptera* (*Cephalcia abietis*, *Cephalcia arvensis*, *Pristiphora abietina*). Further, insecticides have also been applied aerielly to control defoliators of the oak such as those of the order *Lepidoptera* (*Lymantria dispar*, *Operophtera brumata*, *Tortrix viridana*).

## PENETRATION OF SOLUTIONS OF INSECTICIDES INTO FOREST STANDS

Until the early nineteen-seventies, forest protection in our country used for the control of harmful forest insects mainly chlorohydrocarbons (DDT, Lindane), dissolved in oil. In aerial application, the usual dose was  $10 \text{ l. ha}^{-1}$  (0.892 gallon.  $\text{acre}^{-1}$ ) with a content of 10% active substance. The area treated at one flight was as a rule 50 ha (124 acres) of forest stands. This economical application method provided a high work productivity and high effectivity on the larval stages or on imagines of harmful insects. To study the effect of insecticides on other components of the *zoocoenosis*, we investigated the penetration of the drops of the oil

## I. Percentual representation of drops within the range $1 - 75 \mu$

Age class	Vertical crown layer		
	upper	mean	lower
	[%]		
III.	65	96	98
IV.	71	88	92

solution through the space of the treated forest stand and the spray coverage of spruce needles in individual vertical layers of tree crowns.

The measurement itself was based on the catching of drops of the applied insecticide on the prepared slides located in vertical tree crown strata of the 3rd age class (41—60 years) and of the 4th age class (61—80 years) with continued canopy. Afterwards, particle size was measured in the laboratory. Data were evaluated numerically and graphically, followed by the determination of the size composition of the spray spectrum and the mean size of particles of oil solution. Then the number of particles per one sq. cm area was found. The degree of coverage was derived from the density and mean size of particles.

The size of drops in the aerial LV spray of oil solution ranged from  $1 \mu$  to  $360 \mu$ , the most numerous drops were within the range from  $1 \mu$  to  $75 \mu$  (from 65% to 98% of the whole number of drops). The groups of the largest drop size of  $100 \mu$ — $360 \mu$  dominated in volume.

The mean size of drops expressed my means of average volume declined downwards from tops of crowns. The share of drops within the range of  $1\mu$ — $75 \mu$  considerably increased with decreasing height. The number of drops per one sq. cm was reduced pronouncedly in the direction from crown tops downwards to the ground; in the 3rd age class the reduction was more obvious (4115 — 150) than in the 4th age class (3068 — 180) (Tab. I).

The obtained coverage degree declined in the direction from crown tops downwards. The reduction was higher in the 3rd age class (5.5% down to 0.6%) than in the 4th age class (5.0% to 1.0%).

According to the measurements in upper vertical strata, 49—57% and 51—58% of pesticide volume was produced in the determined volume range of average particle size required for LV spray, i. e. 50—250  $\mu$ , and for ULV spray, i. e. 25—125  $\mu$ , respectively. The requirement to produce 80% of pesticide volume in the determined range was not met here. This spray portion was held in lower crown layers where the throughfall of larger drops is difficult.

It was found that the per-hectare application rate of 10 litres of oil solution is optimum in the described stand conditions. The coverage obtained at the above-mentioned aerial spray rate of oil solution applied per one hectare exhibits only small values in lower crown strata and if the dose per hectare is to be reduced, the coverage is obviously insufficient.

It was found that with suitably determined per-hectare dose of insecticide while keeping a certain accuracy of aerial application (depending, besides other factors, mainly on the signaling of air fields, correct function of the application equipment), the flow of the insecticide from the assimilation area of trees under control may not be too large and the undesired cumulation of the insecticide in soil or on other plants may be considerably reduced.

## THE EFFECT OF OIL SOLUTIONS OF INSECTICIDES ON BIRDS

Much attention was also paid to the effects of the application of oil solutions of insecticides on insectivorous birds, which play an important role in the control of insect populations, with the aim of purposefully increasing the numbers and species representation of birds in forest stands. For instance, in investigating 71 boxes (37 were occupied by four species of the genus *Parus*, as found after the application of  $10 \text{ l. ha}^{-1}$  ( $0.892 \text{ gallon. acre}^{-1}$ ) oil solution with a content of 10% active substance DDT, it was found that the insecticide had not killed the young

though the older birds had been out, seeking food in the aerially treated forest stands. In another case after the application 20 l. ha<sup>-1</sup> (1.784 gallon. acre<sup>-1</sup>) of oil solution with a content of 6% phenitrothione, oak forest stands showed mortality of part of their insectivorous birds. This confirms that large area and mainly repeated application of insecticides may be dangerous for birds. Persistent insecticides do not cause acute poisonings at commonly used doses, but may be cumulated in the organism and may be the cause of disease. Some preparations of the group of organophosphates are much more toxic, mainly when applied as aerosol, so that the danger of acute intoxications of birds is increased. But it is without doubt that the generation changes, chronic disturbances and cumulative effects are far more dangerous than a single intoxication: the latter may reduce population density of some bird species in a limited area which, however, may recover soon as a result of migration from neighbouring areas.

## USE OF INSECTICIDES DILUTED IN WATER

At the beginning of the 70ies in Czechoslovak forestry it was forbidden to use air control and (with exceptions) to apply terrestrially chlorohydrocarbons; and because of water management reasons, the use of oil as insecticide carrier was also banned. Insecticides for the control of harmful insects in the forest were based on phosphorus (phenitrothion, pirimiphosmethyl); there were also pyrethroids (permethrin, cypermethrin, deltamethrin, cyhalothrin) and other specific insecticides (thiocyclam, diflubenzuron).

Preparations are generally formulated as emulsion concentrates or as wettable powders which are diluted in water to a volume dose 50–100 l. ha<sup>-1</sup> (4.5–8.9 gallons. acre<sup>-1</sup>). In this way the performance of aerial equipments was considerably lowered; at one flight only an area of 5 ha (12.3 acre) is usually treated. Demands for technical, organizational and economic protection measures for the control of insects pests were also increased. The application equipments for LV and ULV application (for instance, rotation atomisers Micronaire AU — 3000) are used only to a limited extent because of increased demands for the flight technique, necessary use of special formulations of insecticides and certain doubts about the possibility of sufficient cover of leaves and needles of forest stands by preparation drops at the application of very low volumes, usual at UV and ULV applications.

At the choice from the above mentioned spectrum of insecticides more and more stress in aerial application is laid not only on the achievement of reliable effect on the pest, but also on favourable toxicological and hygienic parameters of the preparations. Having given up the use of the comparatively toxic but rapidly decomposing organophosphates, non-specific in relation to insects, foresters later introduced the use of pyrethroids which affect also non specifically the insects but show low toxicity to warm blooded animals. For instance, in a large control campaign against *Zeiraphera diniana* on an area of 46 000 ha (114 000 acres) in mountain conditions at the beginning of the eighties, comparison was made of the effectiveness of aerial application of the pyrethroid permethrin, a mixture of permethrin and the organophosphate pirimiphosmethyl, and pirimiphosmethyl alone. The preparations were applied from helicopters and, consequently, the effectiveness was evaluated according to the obtained reduction of egg abundance and also according to the defoliation of the treated stands. The obtained results are summarized in following table (Tab. II).

## II. The results of the aerial application of insecticides against *Zeiraphera diniana*

Active substance	Dose in g. ha <sup>-1</sup>	Reduction of egg number [%]	Defoliation of forest stands [%]
Pirimiphosmethyl + permethrin	500 37.5	75	10–40
Permethrin	50	72	10–40
Pirimiphosmethyl	500	62	20–50

At the present time attention is more and more turned to specifically acting insecticides, for instance, inhibitors of the synthesis of chitin (diflubenzuron, teflubenzuron etc.) which act selectively only on certain groups of insects, for instance, on larval stages of defoliators.

#### EFFECTS OF AERIAL APPLICATION OF INSECTICIDES ON ENTOMOFAUNA

In large-area aerial application for the control of *Zeiraphera diniana*, investigation was focused on the combined effects on insects living in tree crowns, on insects of the herbaceous layer, on insects flying above ground surface, and on insects of soil surface and in soil, as well as on insects in water streams, and on vertebrates. The effect of aerial treatment was studied by comparing the numbers of species investigated in the treated and untreated areas. The maximal mortality of insects and spiders was found in tree crown space, the target area of the control insecticide. Besides the mortality of 80–87% caterpillars of the pest *Zeiraphera diniana*, investigation in a 1 m<sup>2</sup> plot showed 70 to 230 specimens of non target species of *Arthropoda*. Number of flying insects above the ground surface, mainly representatives of the genus *Diptera*, was reduced during some days to 20–30% in comparison with the control and its number began to be increased again a fortnight after the application. There was no influence on the insects of the soil surface, obviously because the insecticide did not penetrate to the soil through crowns of the treated forest stand and through the herbaceous layer. Likewise, no differences in the representation of individual groups of soil fauna in the treated and control plots were found. A pronounced effect of the treatment was found in the fauna of creeks. The number of affected larvae of water insects transferred by the stream was rapidly increased after the application and reached a 10 to 30 times larger quantity than normal. The spray hit water insects sensitively, but no species was fully destroyed, as later investigation on application localities showed. The influence on vertebrates was minimal. As conclusion it may be stated that single aerial application of an insecticide showed also unfavourable consequences but did not destroy the investigated components of the ecosystems.

#### AERIAL TREATMENT OF WINDFALLS

In recent years after the repeated catastrophic windfalls the danger of the mass outbreak of bark insects has increased. This concerns mainly the bark beetle *Ips typographus* which then attacks also standing spruce stands. To prevent attack on lying windfall and rapid mass outbreak of *Ips typographus* at suitable localities, preventive spraying of windfalls from helicopter was tested just before the swarming or at the beginning of the swarming of the pest. Simultaneously with preventive wood protection, the number of bark beetles was also reduced. This concerns bark beetles which fly onto the lying trees. Pyrethroids were applied [permethrin and cypermethrin at a rate 200 g·ha<sup>-1</sup> (0.178 pounds·acre<sup>-1</sup>)]. Better dispersion and adhesivity of spray drops were achieved with wetting agent at a 1% concentration. During application the helicopter should fly as low as slowly as possible above lying trees to produce a perfect distribution of spray drops on stem surface. When the helicopter flies 10 m above the windfall at a speed of 40 km·h<sup>-1</sup>, the intensity and uniformity of the treatment are satisfactory in a working belt 30 m wide. The destruction effect on imagines of *Ips typographus* persisted for a period of 2 to 4 weeks. This method is designed for the use in special cases, not generally.

#### ECONOMIC EFFECTIVENES OF AERIAL APPLICATION OF INSECTICIDES

Insect pests kill the trees by their feeding; they may cause disturbances in physiological processes which lead to reduced resistance and to a fall of the increment. It is obvious that aerial treatment, performed in time, is to prevent the development of the outbreak of pest and the rise of injuries on neighbouring forest stands. As the insecticides show also effects that are unfavourable and aerial application is expensive, it is useful to carry out the protection treatment only when it is obvious that the mass outbreak cannot be stopped in a natural way, though the height of assumed injuries caused by insects exceeds the costs of aerial treatment. The evaluation of the prevention is to be based on the relation between

the growth reaction of the tree species and the damage to leaves and needles as one of the fundamental questions.

In southern Moravia the mass outbreak of nun moth (*Lymantria monacha* L.) included an area of about 1500 ha. The mass outbreak of temporary type threatened to grow into larger clean feedings and for this reason it was necessary to apply chemical control after shorter time of feeding. We used this locality for the determination of increment losses after defoliation of Norway spruce forests by short time feeding of defoliators. Analysis of 556 borings from sample trees in polluted and control forest stands offered sufficient basis for biometric evaluation of increment changes by a dendroecological method. We investigated mainly increment reaction to defoliation of different intensities in forest stands of various age. The secondary question was, if the different increment reaction in the trees occurs in dependence on their position in the forest stand structure. The evaluation resulted in the following conclusions:

The magnitude of increment losses is directly proportional to the reduction of assimilation mass in tree crowns attacked by feeding. In two years of maximal effect of feeding, at a defoliation of up 1/3 of assimilation mass of crown, these losses represent (in rounded-off values) 30 %, at a defoliation between 1/3 up 2/3 of green mass 50 %, and at a loss of needles larger than 2/3 of crown 70 % of increment of control forest stands not affected by feeding. The increment losses are, of course, spread over a longer period, and even in the third growing season after the chemical treatment, resulting in the destroying of pest population, the recovery in more defoliated forests did not reach the normal increment level of unharmed forests. On an average for the last five-year period, the increment losses depending on feeding degree had a ratio of about 20 % : 30 % : 50 %.

Relative increment losses derived from the development of the diameter increment may — based on the conversion to concrete survey units and size of forests harmed by various degree of feeding — serve for expression of production losses due to feeding of defoliators (in cu.m/ha/year), or for economic evaluation of these injuries in forestry. This method serves mainly in the evaluation of economic parameters and in choosing individual forest protection measures in complex forest protection.

Actual evaluation of increment losses and average price of wood, and their comparison with the costs of aerial treatment of one hectare of spruce stands, resulted in the fact that already at the weakest degree of the clean eating the value of the increment loss exceeded three to four times the expenses of aerial treatment, at a medium eating three to seven times, and at the strongest eating as much as 7 to 11 times. The economic evaluation indicated that aerial treatment performed in time, i. e. at the beginning of mass outbreak, was in this case economically effective.

## AERIAL APPLICATION OF BIOLOGICAL PREPARATIONS

When selecting preparations for aerial control of forest insect pests researchers increasingly take into consideration criteria connected with wildlife protection. In Czechoslovak forestry there are intensifying efforts to limit the non specifically acting preparations and to replace them by preparations which are of selective effect on certain insect groups, are not toxic to vertebrates, preparations to which insects do not develop resistance. The principle is that the treatment should kill only such numbers of pests as necessary for keeping balance in the forest. At the present time biopreparations on the basis of *Bacillus thuringiensis* offer the greatest possibilities for use in the control of caterpillars of butterflies eating in forest stands. They do not possess the destructive effect on caterpillars as chemical insecticides, but have selective effect on caterpillars of butterflies and save other insects, mainly parasites and predators, and are not harmful to other components of the ecosystem. A comparison of the effect of aerial application of the biopreparation of *Bacillus thuringiensis* and chemical insecticides is listed in the following table (Tab. III).

### III. Number of killed insects in the control of *Zeiraphera diniana* (1980)

Group	Number per 1 m <sup>2</sup>		
	<i>Bacillus thuringiensis</i>	Pirimiphos-methyl	Permethrin
<i>Zeiraphera diniana</i>	78	172	462
Diptera	2	16	37
Homoptera	—	33	21
Hymenoptera	—	9	7
Coleoptera	—	1	6
Heteroptera	—	3	—
Arachnoidea	—	1	2
In total	80	235	535

At the present time we use in our country both smaller and larger control measures based on aerial techniques — airplanes and helicopters. Control methods are developed for *Tortrix viridana*, *Operophtera brumata*, *Zeiraphera diniana*, *Lymantria dispar* and we test possible use for the control of other pests, for instance *Orgyia recens* and of gnats.

Use is made of the foreign preparations Dipel, Thuricide HP, Teknar, and of the Czechoslovak preparations Bathurin 82 and Moskitur. Biopreparations are formulated as wettable powders or colloid liquids and are applied diluted in water in spray form, in volume doses 50 to 200 l. . ha<sup>-1</sup> (4.5 to 17.8 gallon . acre<sup>-1</sup>) containing 1 — kg of the biopreparations. The preparing of the spray emulsion in the ease of the powder biopreparation is more laborious, so with aerial application it is necessary to use a special mixing device. The powder biopreparation is to be slowly poured into the mixing container with only one quarter of water which is to be complemented after the mixture is made. With the use of this mixing device, aerial application was not slowed down. As the viscosity of the spray suspension is to be in certain limits because of correct function of air application device, it is necessary to select satisfactory ratio of dilution of the biopreparation in water, and that means relatively high volume of spray suspension which also secures sufficient quality of cover of treated forest stands by the bacterial preparation. Researchers seek the possibility of the effective use of auxiliary substances for better dispersion and adhesion of the bacterial preparation on the assimilation organs of forest trees.

In the spring period when the biological preparations are usually applied, the weather in Central European conditions is unstable, mainly the temperature ranges close to the lower limit unfavourable for the infective development of *Bacillus thuringiensis*. For that reason we seek possibilities, in these conditions, to provide a reliable effect of aerial application of biopreparations. One of the ways is to find and use a synergistic effect with the sublethal dose of suitable chemical insecticide, so that a satisfactory effect on caterpillars of the pest may be

IV. Comparison of the effect of experimental treatments on other insects (1977)

Group	<i>Bacillus thuringiensis</i>	<i>Bacillus thuringiensis</i> + permethrin	Permethrin
<i>Lepidoptera</i>	124	136	123
<i>Hymenoptera</i>	—	8	45
<i>Coleoptera</i>	—	10	90
<i>Diptera</i>	2	30	150
Others	—	2	112

secured and assimilation organs of trees may be protected, and simultaneously, a satisfactory effect on non-target insects may be maintained. The result of the experiment is given in Table IV.

#### AERIAL APPLICATION OF HERBICIDES

The large extent of wind calamities after the year 1984 caused not only extensive calamity felling, but also unusually large extent of clear cut areas. These facts caused extensive soil preparation for afforestation and weed killing in forest plantations. These operations done in time secure successful afforestation of clear cut areas. A serious problem is connected with the protection and care of new forest plantations in regions with concentrated calamity felling where hitherto used technologies, based on mechanical killing of weeds and spot application of herbicides, are not satisfactory. For that reason, aerial application with acceptable hygienico-toxicological parameters was introduced. The target is to provide conditions for successful establishment and growth of the forest stand for a hundred-year period by one application of a minimal necessary dose of herbicide. Hence, reasonable use of chemicals in our forests is considered as an acceptable, economical and necessary measure.

In areas to be afforested, there is a broad spectrum of mostly perennial herbs and shrub, as well as tree weeds. Perennial grasses are frequent. Only helicopters are used for aerial application. In weed killing in plots to be afforested, and directly in the planting, we are to consider not only the mostly negative influence of the weed but also its importance for soil erosion control and as the source of wildlife food. For that reason it is necessary when selecting the herbicide and the rate of its application to respect, beside the economic target, also ecological points of view in regions with different natural conditions and mainly water conservation.

At the present time the most frequently applied preparations for weed killing on forest soil are those on the basis of hexazinone (wettable powder, emulsion concentrate, granulate) and glyphosate (emulsion concentrate) which have a wide non-selective spectrum of effect on herbs of the genera of *Monocotyledonae* and *Dicotyledonae* and on broad-leaved trees and *Larix*; in recommended doses they do not affect the

most common conifers — *Picea*, *Pinus* and *Abies*. They cannot be applied to stands of broad-leaved trees and *Larix*, which are species securing higher stability of future forest stands. The proportions\* of *Quercus*, *Fagus* and *Acer* are also to be increased in the future. What seems promising here is the preparation on the basis of fluazofopbutyl (emulsion concentrate) which may be used without risk of damage on conifers and broad-leaved trees in plots with dominating grasses which are selectively killed.

#### AERIAL APPLICATION OF HERBICIDES DILUTED IN WATER

In aerial application of herbicides in the spray form there is an increasing risk of drift of the herbicide outside the target plot. This drift is influenced mainly by weather conditions and the working regime of application. Of the meteorological factors, the decisive ones are mainly wind and thermal radiation inversion. Unprecise application of herbicides due to unfavourable weather conditions and unsuitable operation regime may be prevented by the determination of limit values of weather conditions and of flight height. Further, it is recommended to use nozzles which produce large drops with mean volume diameter of 300  $\mu$  and larger. To keep the required relation between the size of drops, cover of plants and the biological effectiveness of the herbicide, it is necessary to apply volumes of 100 to 200 l. ha<sup>-1</sup> (8.9 — 17.8 gallon . acre<sup>-1</sup>) from the height of 10 m.

The limit values of weather conditions in the spraying of herbicides:

Hexazinon — permitted windspeed up to 2 m . sec<sup>-1</sup>, air temperature 1 to 25 °C, soil must not be frozen, nor covered by snow, slight rain during application is no obstacle.

Glyphosate — permitted windspeed up to 2 m . sec<sup>-1</sup>, air temperature 10 to 25 °C, relative air humidity minimally 50 %, rain within 6 hours after application reduces effectiveness.

Fluazifop-butyl — permitted windspeed up to 2 m . sec<sup>-1</sup>, air temperature 10 to 25 °C, relative air humidity minimally 50 %, rain in 30 minutes after the application reduces the effectiveness.

Conditions of thermal radiation inversion are fully unsuitable for aerial application of water emulsion of herbicides. The sedimentation of drops is much more difficult and the herbicide may be drifted to large distances. Inversion conditions may be identified, as to orientation, by smoke: it does not rise and remains on the ground without movement.

#### AERIAL APPLICATION OF HERBICIDES IN GRANULATED FORM

As the wind is a major limiting factor in application of herbicides, often making the application impossible or reducing it, researchers sought a method to reduce its effect. For this reason the application of granulated preparation (hexazinon) was tested. The assumption for the application was that granules of a higher specific weight may be more precisely located also at stronger wind than spray drops. As the carrying substrate of herbicide we used siliceous sand with grains 0.6 to 1 mm in size, with a specific weight of 1.45. The 5% active substance hexazinon is bound to sand grains.

For the application of the granules, trials were carried out with an application equipment consisting of two rotating discs carried by the helicopter. Before application, investigation in testing flights was conducted, concerning total width of spread, working width of the strip treated, and uniformity of the spread in an operation zone at a flight height of 10 m and 20 m and at a flight speed of 60 km . h<sup>-1</sup>. The objective was the determination of the most suitable working regime for the application of the necessary dose (30 kg granules . ha<sup>-1</sup>). In the testing flights, the spread granulate was caught into collecting cones and on the basis of weight, quality the actual dose per hectare was determined. The results showed that the uniformity of the spread of granules is better when they are applied from the height of 20 m, the working width being 20 m. On the basis of tests, the following working regimes were determined:

a) For application to unforested clear cut areas: Dose per second 1.03 kg granulated herbicide, flight height minimally 20 m, flight speed 60 km . h<sup>-1</sup>. Dose per hectare under these conditions is 30.8 kg granulated herbicide.

b) For application to unforested clear cut areas: Dose per second 1.03 kg granulated herbicide, flight height minimally 20 m, flight speed 70 km . h<sup>-1</sup>. Dose per hectare under these conditions is 26.5 kg granulated herbicide.

Limit values of weather conditions for aerial application of granulated herbicide.

Hexazinon — permitted windspeed up to 4 m . sec<sup>-1</sup>, air temperature 1 to 25 °C, soil must not be frozen nor covered by snow, slight rain during the application is no obstacle.

The evaluation of results of field application of granulated herbicide with the active substance hexazinon shows that weed was killed in 50 % of the area of treated plots; in 30 % of the area the weed was weakened. The results contributed to the establishment of a new forest in calamity clear cut areas.

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SVESTKA, M. (Výzkumný ústav lesního hospodářství a myslivosti, pracoviště Horní Česká): *Výsledky a problémy letecké aplikace pesticidů a biopreparátů v lesích ČSR*. Lesnictví, 35, 1989 (11) : 1003-1014.

Práce obsahuje souhrnné zpracování výsledků letecké ochrany lesa proti hmyzím škůdcům a buření v ČSR dle poznatků autora. Pravidelná leteckochemická činnost je v československém hospodářství uplatňována od 40. let tohoto století. Nejčastěji jsou letecky aplikovány insekticidy a biopreparáty proti hmyzím škůdcům *Zeiraphera diniana*, *Lymantria monacha*, *Cephalcia abietis*, *Pristiphora abietina*, *Operophtera brumata*, *Tortrix viridana* aj. V posledních letech je uplatňována i letecká aplikace herbicidů při zakládání lesa na velkých holinách po větrných polomech. Letecká aplikace pesticidů se omezuje na nezbytně nutné případy, kdy je ohrožena existence lesa. Výzkumně bylo sledováno pronikání kapiček olejových roztoků insekticidu do smrkových porostů, dále byl sledován vliv insekticidů na hmyzožravé ptactvo. Sortiment insekticidů byl až do počátku 70. let založen na přípravcích obsahujících chlórované uhlovodíky. Po zákazu jejich aplikace v roce 1974 byly používány především organofosforové insekticidy, dále pyrethroidy a ekologicky šetrnější inhibitory syntézy chitinu i biopreparáty s obsahem bakterie *Bacillus thuringiensis*. Hodnocení efektivity leteckých obranných zásahů bylo posuzováno na základě vztahu mezi růstovou reakcí dřeviny a poškozením asimilačních orgánů škůdcem. Velikost přírůstkových ztrát byla vyjádřena v m<sup>3</sup> dřeva na jeden hektar za rok.

ochrana lesa; letecká aplikace; insekticidy; herbicidy; biopreparáty; entomofauna a ptactvo; ekonomická efektivity

ШВЕСТКА, М. (Научно-исследовательский институт лесного хозяйства и охотоведения, Горни Ческа): *Результаты и проблемы самолетной обработки пестицидами и биопрепаратами в лесах ЧСР*. Lesnictví, 35, 1989 (11) : 1003-1014.

Приводятся сводные результаты самолетной лесозащиты от насекомых и сорняков по данным автора за ЧСР. Она регулярно проводится с 40-х годов и включает, главное, инсектициды и биопрепараты против вредных насекомых *Zeiraphera diniana*, *Lymantria monacha*, *Cephalcia abietis*, *Pristiphora abietina*, *Operophtera brumata*, *Tortrix viridana*. В последние годы с самолета опрыскивают леса и гербицидами при лесопосадке на обширных голых участках после поломов, ограничиваясь лишь такими случаями, когда лесу грозит уничтожение. Научные разработки изучали проникание капель масляных растворов инсектицидов в ельники, а также на насекомых пернатых. Вплоть до начала 70-х годов сортимент инсектицидов состоял из препаратов, содержащих хлорированные углеводороды. После их запрещения в 1974 г. использовались, главным образом, органofосфорные инсектициды, пиретроиды и более щадящие экологию ингибиторы синтеза хитина, как и биопрепараты, содержащие бактерии *Bacillus thuringiensis*. Эффективность самолетной лесозащиты оценивали на основе отношения между ростовой реакцией древесной породы и повреждением органов ассимиляции вредителем. Размер приростных потерь выражали в м<sup>3</sup> древесины/га в год.

лесозащита; самолетное опрыскивание; инсектициды; гербициды; биопрепараты; энтомофауна и пернатые; экономическая эффективность

SVESTKA, M. (Forschungsanstalt für Forstwirtschaft und Jagdwesen, Arbeitsstätte Horní Česká): *Ergebnisse und Probleme der Flugapplikation der Pestizide und Biopreparate in böhmischen Wäldern*. Lesnictví, 35, 1989 (11) : 1003-1014.

Die vorliegende Arbeit enthält eine zusammenfassende Bearbeitung der Ergebnisse des mit Hilfe von Agrarflugzeugen durchgeführten Waldschutzes gegen Schädlinge

und Insektenschädlinge als auch gegen Unkräuter in der CSR entsprechend den Erkenntnissen des Verfassers. Die regelmässige flugchemische Tätigkeit wird in der tschechoslowakischen Forstwirtschaft ab der 40er Jahre dieses Jahrhunderts durchgeführt. Am häufigsten werden mit Hilfe von Agrarflugzeugen Insektizide und Biopräparate gegen Insektenschädlinge *Zeiraphera diniana*, *Lymantria monacha*, *Cephalcia abietis*, *Pristiphora abietina*, *Operophtera brumata*, *Tortrix viridiana* u. a. gesprüht. In den jüngsten Jahren werden Flugzeuge für die Anwendung von Herbiziden auch bei der Aufforstung grosser Blößen nach Windbrüchen eingesetzt. Die Flugapplikation von Pestiziden beschränkt sich nur auf solche Notfälle, bei denen die Existenz des Waldes bedroht wird. Es wurde experimental die Durchdringung der Tröpfchen von insektiziden Öllösungen in die Fichtenbestände und der Einfluss der Insektizide auf sog. insektenfressende Vögel untersucht. Das Sortiment von Insektiziden beruhte bis zu Beginn der 70er Jahre auf Präparaten mit chlorierten Kohlenstoffen. Nach Verbot deren Applikation im Jahre 1974 kamen vor allem Organophosphatinsektizide, Pyrethroide und ökologisch schonende Inhibitoren der Synthese von Chitin als auch Biopräparate mit *Bacillus thuringiensis* zum Einsatz. Die Effektivität der Schutzmassnahmen, zu deren Realisierung Agrarflugzeuge eingesetzt werden, wird auf Grund der Beziehung zwischen dem Wachstum der Bäume und der Beschädigung der Assimilationsorgane des Schädlings beurteilt. Die Zuwachsverluste werden in m<sup>3</sup> Holz/ha/Jahr ausgedrückt.

Waldschutz; Flugapplikation; Insektizide; Herbizide; Biopräparate; Entomofauna und Vögel; ökonomische Effektivität

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# TREE FOLIAGE PROCESSING AND ITS UTILIZATION

J. Ilavský

ILAVSKÝ, J. (Forest Research Institute, Zvolen): *Tree Foliage Processing and its Utilization*. Lesnictví, 35, 1989 (11) : 1015-1024.

Technology of tree foliage harvest and its processing into feeding flour is described. The composition of amino acids in spruce needles is analyzed, along with the nutritive value of feed flour produced from the needles. From the viewpoint of nutritive values, the feeding flour from tree foliage is at the same, or higher level, compared with agricultural and forest grasses which are grazed by forest game most frequently. With additional feeding of forest game in winter, using feedstuff with the supplement of flour from tree foliage, damages to forests caused by game are decreasing. It has also favourable effects as an additive into feedstuff for sheep and lambs.

technology of tree foliage harvest; utilization of tree foliage; feed flour from tree foliage; nutritive value of feed flour from tree foliage

## PROBLEMS

Tree foliage has been used in our country only to very small extent up to now. In the past farmers in some regions raked shed leaves and needles from stands and used them as litter for farm animals. Such utilization meant in the majority of cases uncontrolled removal of nutrients from forest soil and deterioration of site conditions, and therefore forest management resisted it.

At present, problems of tree foliage utilization are being solved in connection with the introduction of new mechanized technologies of logging.

The goal of the solution was to design a technology and system of machines for tree foliage harvest, its processing into feed flour and to analyze chemical composition of tree foliage and the produced flour from the viewpoint of its nutritive values.

## MATERIAL AND METHOD

A study was conducted in spruce stands in economic unit-spruce forest of higher altitudes, group of forest types of beech-fir stands, lower degree, at altitudes of 800—900 m where the site class for spruce is 1. During the work on the design of the technologies and system of machines we started from terrain conditions and other factors affecting management of forests under particular conditions of the region for which the technology was designed. For the processing of tree foliage into feeding flour, the machines and equipment to be used for manufacture of feeding components in agriculture were designed to cover the greatest possible range.

Samples from 40, 70, 90 and 120 year old stands were taken for analyses of the chemical composition of tree foliage and the produced flour. In each age class, trees from at least 2 different stands were analyzed. In each stand branches from at least 30 trees, representing by their characteristics the mean trees in stand, were chipped. From the mixture of chips being produced from the chipped branches, crude samples with the amount of approximately 10 kg of chips were taken from different places. These were divided by quartering to have samples with a weight of 0.5—1.0 kg. 34 samples were analyzed on the whole. Analyses were made in three independent laboratories and results from all analyses were evaluated together.

## RESULTS AND DISCUSSION

### LOGGING TECHNOLOGIES AND TREE FOLIAGE UTILIZATION

The utilization of tree foliage started to be interesting after the introduction of mechanized limbing by one-operation limbing machines, or by multioperation processors and harvesters. With regard to the prevailing mountainous character of the terrain in Slovakia, the limbing machines and processors are used mainly at landings. Whole trees are skidded from stand to the landing and are limbed and bucked here. A large amount of branches is consolidated at the landings (Fig. 1). These branches were recently burned without any effect directly at landings. In the case that burning of branches was not possible due to near stands, buildings, or for other reasons, the storage capacity of the landings was reduced for a long period ahead and the heaps of branches became a suitable place for the spreading of forest pests. Therefore it was necessary to consider the processing of this raw material from the viewpoint of its utilization and also from the technological viewpoint.

The utilization of branches had to be consolidated while limbing machines allowed the introduction of chipping technology using mobile chippers. Chipping of the branches provides more homogeneous material, suitable for further transport and handling.

For the harvest of tree foliage the following system of machines was designed:

felling — power saw

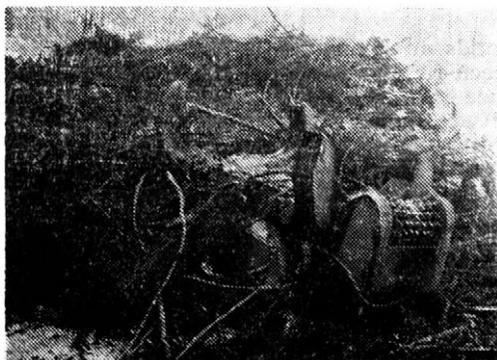
skidding — tractors LKT 81 and LKT 120 with winches

limbing and bucking — processors ŌSA and KP 40, limbing machines OVP and APOS resp.

chipping of branches — chipper SV 6-068, Bruks 800 CT resp.

transport of chips — container set on the chassis TATRA 815.

Next step was to solve the problem of utilization of this raw material. With regard to the known problems of processing in the wood-working and pulp and paper industry we sought a non-traditional method of the utilization. The utilization for feeding and power-energetic purposes was chosen to be further studied, verified and introduced in production.



1. Branches collected at landing near delimiting machine



2. Chipping of branches at landing

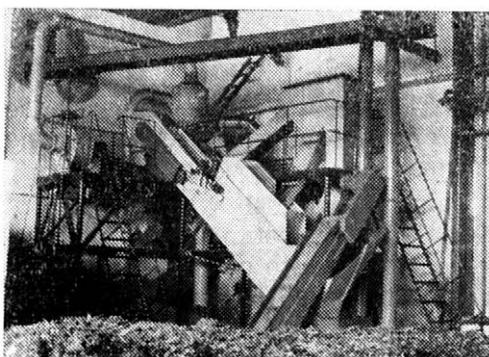
## THE TECHNOLOGY OF TREE FOLIAGE UTILIZATION FOR FEEDING PURPOSES

Branches collected from limbing machines are chipped by the mobile chipper (Fig. 2). Chips are blown out from the chipper directly into containers and then they are transported into the mill for the production of feed flour. This mill was constructed on the basis of agricultural machines and equipment manufactured in series.

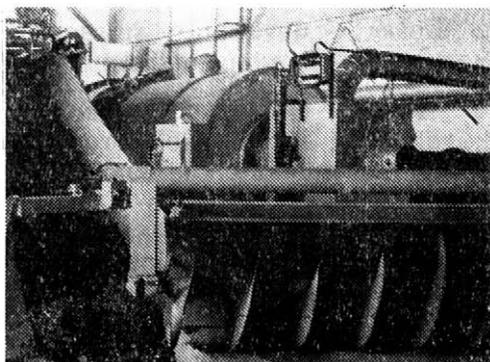
Chips are unloaded in the intake hall and are carried by a system of conveyers into the sorting machine SIKO-2 (Fig. 3). Wood is an undesirable part of feedstuffs since it reduces their digestibility, so it must be sorted out of the chips. The sorting machine SIKO-2 was developed in the Scientific- and Production Association Silava, in Salaspils, Latvian SSR. It is operating on the pneumatic principle. Lighter tree foliage in a vertical pipe is sucked into a bin and heavier wood fractions in the upper part of the pipe fall onto the conveyer. Tree foliage includes not only needles but also all lighter particless of bark, wood, non-woody thin branches and buds.

Sorted tree foliage is transported by a system of conveyers into a drum drier where it is dried to a moisture content of 10—12 % (Fig. 4). Dried tree foliage falls into a grinder where it is ground into feed flour. The flour can be transported by the pneumatic system onto a packing line and dispatched in sacks to consumers, or is transported to bins which are part of the granulating line. On the granulating line, hay, straw, groats, molasses, vitamin-rich components, biofactors and other feeding ingredients are added to the flour and granulated feedstuffs are produced according to recipes for each particular species of animals. Annual capacity of the pilot plant with one shift per work-day is 500 tons of flour and 2500—3000 tons of granulated feedstuffs.

The energy demand for flour drying were one part of this solution. With artificial drying of agricultural products, heating oils or gas are used as a source of energy. With the aim to eliminate the use of these sources, a furnace for the burning of a sorted wood fraction was designed. The combustion gases are conveyed through drier and the



3. Sorting machine SIKO 2



4. Drying of tree foliage in the drier BS 6 E1 with the utilization of the energy from waste wood combustion

whole regime of heating is connected with the automated regulation of drying.

At present, another technological part of tree foliage distillation is added to the pilot plant. According to opinions of specialists in the field of livestock physiology (Gallo et al., 1987), at high doses of the flour the rumen digestion of animals can be affected by the volatile oils from tree foliage. Therefore tree foliage will be distilled before drying and in this way the volatile oils will be removed from it. These oils will be used in the chemical industry.

#### NUTRITIVE VALUE OF FEED FLOUR FROM TREE FOLIAGE

Closer attention has started to be paid to the analysis of tree foliage chemical composition only recently. Tree foliage contains a lot of valuable, biologically active substances. However, not all were quantified and their specific effects with the use of tree foliage as feedstuff were not determined. As we can see from the data in Tab. I tree foliage contains many amino acids.

After the processing of tree foliage into feed flour, laboratory analyses were performed for the presence of substances important for animal nutrition. The results of the analyses are given in Tab. II. From the nutrition standpoint, flour from tree foliage compares with hay.

The effect of flour storage time on its quality was also studied. The analyses were made during 11 months of storage. The results are given in Tab. III.

As we can see from the results of analyses a decrease of nutritive values occurs during flour storage. With some indices, for example nitrogen compounds, nitrogen-free substances of the yield, P, Ca, these alterations are statistically insignificant. However, a high statistical significance is reported for the alteration of moisture and dry matter (correlation coefficient 0.927); this means that the moisture contents of the flour is increasing and therefore the flour must be stored in dry rooms. The content of beta-carotene changed most markedly during the storage. Its content in the flour decreases during storage in a linear way according to the function:

$$y = 48.26 - 3.07 \cdot x$$

where:  $x$  — duration of storage in months

$y$  — content of beta-carotene in  $\text{mg} \cdot \text{kg}^{-1}$

The correlation coefficient is 0.904. The course of the dependence is shown in Fig. 5. The storage has a strong unfavourable effect on the content of this valuable component of flour.

The appearance and smell of the flour did not show any signs of deterioration and even the analyses revealed no substances not admissible from the feeding viewpoint. It is recommended to consume the flour as soon as possible after production to eliminate its quality deterioration.

Feeding trials with farm animals and forest game were made to test the produced flour.

As to farm animals, trials were made with lambs. The control group was fed with traditional feedstuffs and in experimental group 9 % of

## I. Analysis of amino acids composition in spruce tree foliage

Name of amino acid	Unit	$\bar{x}$	$x_{max}$	$x_{min}$	$S_{\bar{x}}$
Asparagine	mg. g <sup>-1</sup>	12.1373	25.3294	5.9290	5.2923
	%	10.9338	14.041	7.432	1.8019
Threonine	mg. g <sup>-1</sup>	5.0191	9.1137	2.6915	1.6935
	%	4.617	5.549	3.530	0.518
Serine	mg. g <sup>-1</sup>	5.2096	9.2551	2.5515	1.8974
	%	4.712	5.313	4.059	0.337
Glutamine	mg. g <sup>-1</sup>	18.8979	41.8682	7.0998	9.0579
	%	16.829	25.988	12.358	4.256
Proline	mg. g <sup>-1</sup>	8.6419	18.2014	3.4342	4.1299
	%	7.655	11.298	5.663	1.712
Glycine	mg. g <sup>-1</sup>	5.8510	10.1189	3.0294	1.8294
	%	5.247	6.343	3.978	0.653
Alanine	mg. g <sup>-1</sup>	6.9845	11.2768	3.978	0.653
	%	6.565	12.574	4.451	1.998
Valine	mg. g <sup>-1</sup>	6.2400	10.5326	3.2635	2.0156
	%	5.736	6.788	4.771	0.524
Methionine	mg. g <sup>-1</sup>	1.297	2.7811	0.7323	0.588
	%	1.201	1.867	0.819	0.383
Isoleucine	mg. g <sup>-1</sup>	5.0666	8.7418	2.6106	1.6952
	%	4.638	5.392	3.939	0.379
Leucine	mg. g <sup>-1</sup>	9.1689	15.4699	4.7423	3.1723
	%	8.356	9.164	7.439	0.654
Tyrosine	mg. g <sup>-1</sup>	4.5876	8.3910	1.8111	1.8686
	%	4.076	4.651	3.421	0.312
Phenylalanine	mg. g <sup>-1</sup>	7.0177	11.2364	3.4617	2.1872
	%	6.462	7.818	5.334	0.690
Histidine	mg. g <sup>-1</sup>	3.4375	5.9586	1.9442	1.3252
	%	3.107	3.672	2.488	0.362
Lysine	mg. g <sup>-1</sup>	5.2508	10.6498	3.0521	2.2344
	%	4.751	6.187	3.645	0.859
Arginine	mg. g <sup>-1</sup>	5.3970	8.6287	2.9506	1.8943
	%	5.115	5.155	3.761	0.600
Altogether	mg. g <sup>-1</sup>	110.2454	180.4020	52.9494	37.9145

flour from tree foliage was added to the diet. During additional feeding with the flour from tree foliage, the mean daily gains increased by 11.5 % and the feed efficiency improved by 7.9 %. During commissional evaluation of cooked meat, cooked liver and meat broth, no negative effects were found to be exerted by the flour from tree foliage.

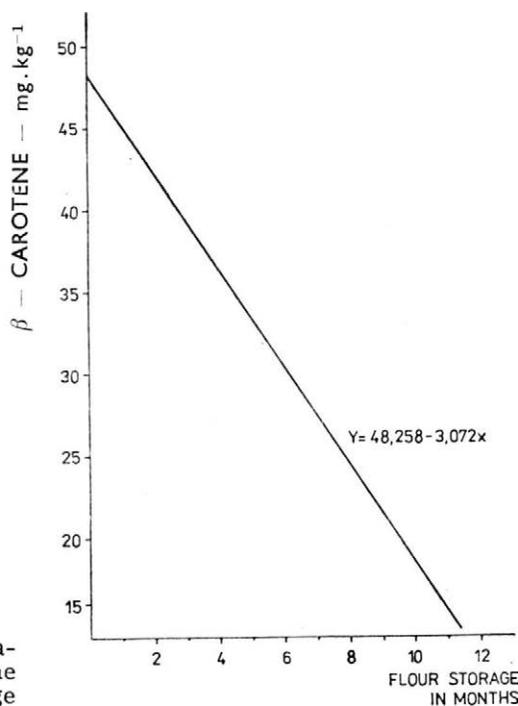
## II. Analyses of the composition of feed flour from tree foliage

	Unit	$\bar{x}$	$x_{\max}$	$x_{\min}$	$S_{\bar{x}}$
Moisture	%	7.95	10.60	3.30	2.05
N - general	%	5.52	9.35	4.18	1.04
N - protein	%	5.52	7.36	4.21	1.25
N - digestible	%	1.74	3.45	0.80	0.66
P	mg.kg <sup>-1</sup>	0.90	2.35	0.10	0.68
K	mg.kg <sup>-1</sup>	3.06	3.85	2.56	0.48
Ca	mg.kg <sup>-1</sup>	5.20	9.18	0.58	3.04
Na	mg.kg <sup>-1</sup>	0.17	0.20	0.12	0.03
S	mg.kg <sup>-1</sup>	1.20	2.26	0.72	0.62
Mg	mg.kg <sup>-1</sup>	2.22	5.04	0.75	1.43
Fe	mg.kg <sup>-1</sup>	0.78	1.37	0.32	0.40
Mn	mg.kg <sup>-1</sup>	0.24	0.33	0.16	0.07
Zn	mg.kg <sup>-1</sup>	0.07	0.11	0.05	0.03
NH <sub>3</sub>	%	0.002	0.002	0.002	—
acetic acid	%	2.02	2.02	2.02	—
butyric acid	%	0	0	0	—
lactic acid	%	0.14	0.14	0.14	—
ash	%	5.82	19.70	1.85	3.67
CO <sub>x</sub>	%	44.23	49.71	39.82	3.55
insoluble rest	%	2.64	7.20	0.78	1.85
starch	%	2.61	3.56	1.87	0.62
crude fibre	%	34.66	43.43	22.84	6.25
pure fibre	%	30.06	30.06	30.06	—
acid of water extr.	mgKOH/100 g	835.20	835.20	835.20	—
PH/KCL		4.14	4.38	3.99	1.57
PH/H <sub>2</sub> O		4.21	4.46	3.98	1.76
dry matter	%	92.90	99.24	89.34	2.71
fat	%	3.88	8.10	1.86	1.56
carbonates	%	0.20	0.30	0.10	0.10
sugar - general	%	2.75	3.88	1.81	0.94
sugar - reduced	%	1.37	1.67	1.17	0.21
sugar - unreduced	%	1.38	2.21	0.64	0.73
β - carotene	mg.kg <sup>-1</sup>	47.68	130.00	8.70	30.64
C - vitamin	mg.kg <sup>-1</sup>	21.45	26.40	15.40	5.01
NO <sub>3</sub>	mg.kg <sup>-1</sup>	1.08	1.44	0.70	0.30
NaCl	%	0.06	0.12	0.015	0.03
substances extracted by ether	%	6.30	7.20	5.80	0.70
nitrogen-free substances of yield	%	41.11	44.60	36.90	2.84

### III. The effect of storage on the quality of flour from tree foliage

Contents of substance	Unit	Period of storage						
		fresh	1 month	3 months	4 months	7 months	9 months	11 months
Moisture	%	5.8	5.6	7.2	9.2	10.2	10.8	10.4
Dry matter	%	94.2	94.4	92.8	90.8	89.8	89.2	89.6
Nitrogenous substances	%	6.4	5.5	7.1	6.0	5.7	5.8	6.7
Fat	%	6.0	6.0	5.4	5.1	5.3	5.2	4.9
Ash	%	10.2	9.4	12.5	11.1	9.5	10.4	10.3
Fibre	%	30.3	33.1	27.5	28.7	31.4	32.8	28.4
Nitr.-free subst. of yield	%	41.3	40.4	40.3	39.3	37.9	35.0	39.4
Rest insoluble in HCl	%	7.3	6.52	9.6	8.1	6.6	7.5	7.2
NaCl	%	0.07	0.04	0.02	0.16	0.1	0.02	—
Ca	%	0.87	0.66	1.00	0.56	0.75	0.64	0.56
P	%	0.11	0.11	0.20	0.11	0.12	0.11	0.11
$\beta$ - carotene	mg.kg <sup>-1</sup>	55.5	35.7	42.0	38.6	21.2	18.3	19.0

Feeding experiments with lactating ewes with lambs were also performed. 4 and 8 % of flour from needles was used as an additive the traditional feed ration. In the experimental group with a 4% supplement, the weight gain of lambs increased by 12.8 % in comparison with the



5. Dependence of decreasing of beta-carotene contents on the duration of the storage of feed flour from tree foliage

IV. Comparison of the contents of main nutrients in agricultural and forest grasses and in flour from needles

Nutrients	Unit	Contents of nutrients in grasses (Katreniak, 1989)		Mean contents of nutrients in flour from needles
		agricultural	forest	
Nitrogenous substances	%	—	1.80 — 4.46	4.18 — 9.35
Fat	%	—	0.14 — 1.16	1.86 — 8.10
Nitrogen-free substances of yield	%	—	5.02 — 39.17	36.90 — 44.60
Digestible nitrogenous substances	%	—	0.36 — 3.40	0.80 — 3.45
Fibre	%	—	1.56 — 7.66	22.84 — 43.43
Ca	mg.kg <sup>-1</sup>	0.60 — 0.70	0.20 — 1.60	0.10 — 2.35
β - carotene	mg.kg <sup>-1</sup>	33.00 — 68.00	20.60 — 164.00	30.00 — 130.00

control group. In the experimental group where 8 % of flour was added, the gain of lambs increased by 16.7 % in comparison with the control group. It is supposed that these differences resulted from the positive effect of the flour on the health state of the ewes, on the production and biological value of milk, and thereby on the good health state of the lambs (Gallo et al., 1987).

Additional feeding of forest game in winter resulted in better health state and decrease of damages in forests caused by game. Damages due to peeling and browsing by red deer dropped to 20 % of former damage extent and intensity (Chudík, 1987).

Katreniak (1989) dealt with problems of red deer nutrition from natural vegetational sources. He gives the contents of nutrients for different kinds of grasses growing on agricultural lands and in forest which are preferably grazed by forest game. These values are compared in Tab. IV with those of the same nutrients in the feed flour from needles. As we can see from the results, the flour from needles has for all given nutrients either the same, or mostly higher, values than in grasses grazed by forest game most frequently. Beta-carotene is important for the formation of vitamin A. Ca and P, and other mineral substances comprised in the flour are very important for red deer as building substances during the formation of skeleton and antlers. In winter, a high content of fat is very important as an energy source. A high content of fibre is also very significant for the nutrition of ruminants. Katreniak (1989), using the data from the work of Schauer, notes that roe-deer need 60 up to 80 % of wood components in food, red deer and chamois at least 30 %; this means they need food with high content of fibre — a fact important not only from the viewpoint of nutrition but also from the viewpoint of forest game digestion improvement. Also Chudík (1987) confirms these data. These results show that feed flour from needles included in granulated feed mixtures can be a highly valuable feedstuff for the additional feeding of forest game and also farm animals.

## CONCLUSION

Tree foliage has been a neglected raw material until recently. Modern logging technologies make it possible to utilize also this material. The results of experiments have shown that the flour produced from tree foliage can be a valuable feed supplement with specific effective substances for additional feeding of farm animals and also forest game.

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ILAVSKÝ, J. (Výskumný ústav lesného hospodárstva, Zvolen): *Spracovanie stromovej zelene na krmivo a jeho nutričná hodnota*. Lesníctví, 35, 1989 (11) : 1015-1024.

Pri stromovej technológii ťažby dreva sa na odvozných miestach pri procesoch odvetvovacích strojoch hromadia veľké množstvá vetiev (obr. 1). Na ich zužitkovanie sa navrhla technológia, pri ktorej sa vetvy sekajú pojazdnými sekačkami a nasekané štiepky sa v kontajneroch dopravujú na ďalšie spracovanie (obr. 2). Získaná surovina sa využíva na energetické a krmné účely. Štiepky sa roztriedia na stromovú zeleň a drevnú frakciu (obr. 3). Stromová zeleň sa suší v bubnovej sušičke a šrotuje na krmnu múčku (obr. 4). Drevná frakcia sa spaľuje v špeciálne upravenom kúrenisku a získaná tepelná energia sa využíva na sušenie zelene. Vyrobenej múčky sa používa ako doplnkový krmný komponent v granulovanej krmnej zmesi hlavne na prikrmovanie lesnej zveri, ale tiež na krmenie oviec. Analyzovali sa nutričné hodnoty ihiľčia aj vyrobenej múčky, v tab. I je skladba aminokyselín v ihiľčí smreka a v tab. II výsledky analýz nutričnej hodnoty vyrobenej múčky. Počas dlhodobého skladovania sa znižuje kvalita múčky (tab. III a obr. 5). Pri krmných skúškach s jahňatami, pri ktorých sa použilo granulované krmivo s prímесou 4 % až 9 % múčky zo stromovej zelene, sa zvýšili prírastky jahniat o 11,5 % až 16,7 % oproti kontrolnej skupine. V tab. IV sa porovnáva nutričná hodnota múčky zo stromovej zelene s poľnohospodárskymi a lesnými trávami, ktoré lesná zver najčastejšie spása. V dôsledku prikrmovania zveri v zimnom období granulovaným krmivom s múčkou z ihiľčia sa znížili škody spôsobované zverou obhryzom a odhryzom na 20 % pôvodného rozsahu a intenzity.

technológia ťažby stromovej zelene; využitie stromovej zelene; krmná múčka zo stromovej zelene; nutričná hodnota múčky zo stromovej zelene

ИЛАВСКИ, Я. (Научно-исследовательский институт лесного хозяйства, Зволена): *Переработка древесной зелени на корма и их питательная ценность*. Lesnictví, 35, 1989 (11) : 1015-1024.

При лесозаготовке методом деревьев с кроной накапливается на местах вывозки при процессорах и сучкорезных машинах большое количество ветвей (рис. 1). Была предложена технология для их утилизации: ветви рубят на самоходной рубительной машине и переработанную щепу перевозят контейнеровозами к месту последующей переработки (рис. 2). Полученное сырье используют для энергетических и кормовых целей. Щепу сортируют на древесную зелень и древесную фракцию (рис. 3). Древесную зелень сушат в барабанной сушилке; далее она проходит процессом грубого помола для получения из нее кормовой муки (рис. 4). Древесную фракцию сжигают в специально приспособленной топке и полученную тепловую энергию используют для сушки зелени. Муку используют как добавочный компонент в гранулированной кормовой смеси главным образом для подкормки лесной дичи, но также для подкормки овец. В табл. I приведен состав аминокислот в хвое ели, в табл. II результаты анализа питательной ценности переработанной муки. При длительном хранении снижается качество муки (табл. III и рис. 5). При подаче муки ягнтятам, когда в опыте подавали гранулированный корм с примесью 4 даже 9% муки из древесной зелени, повысился привес ягнят на 11,5 даже 16,7% в сравнении с контрольной группой. В табл. IV дано сравнение питательной ценности муки из древесной зелени с полевыми культурами и лесными травами, которые дичь чаще всего поедает. В результате подкормки дичи гранулированным кормом в зимний период был сокращен ущерб, причиняемый дичью обкусыванием и откусыванием в 20% от исходного объема и интенсивности.

технология рубки древесной зелени; использование древесной зелени; мука для откорма из древесной зелени; питательная ценность муки из древесной зелени

ILAVSKÝ, J. (Forschungsanstalt für Forstwirtschaft, Zvolena): *Verarbeitung der grünen Baummasse zu Futtermittel und sein Nutritionswert*. Lesnictví, 35, 1989 (11) : 1015-1024.

Wenn bei der Holznutzung die Baumtechnologie angewendet wird, so häufen sich an den Stellen der Abfuhr um die Prozessoren und um die Entastungsmaschinen große Mengen von Ästen an (Fig. 1). Zu ihrer Verwertung wurde eine Technologie entwickelt, nach welcher man die Äste auf mobilen Hackmaschinen zerkleinert und die kleingehackten Holzscheite werden in Containern zur weiterer Verarbeitung abtransportiert (Fig. 2). Der gewonnene Rohstoff wird für energetische und Fütterungs-Zwecke ausgenützt. Die Holzscheite werden unterteilt in Baumgrün und in die Holzfraktion (Fig. 3). Das Baumgrün wird in einer Trommeltrockenkammer getrocknet und zu Futtermehl verschrottet (Fig. 4). Die Holzfraktion wird in einer speziell modifizierten Heizung verbrannt und die gewonnene Wärmeenergie wird zur Trocknung des Baumgrüns ausgenützt. Das erzeugte Mehl wird als ergänzende Futterkomponente im granulierten Futtermisch hauptsächlich zur Fütterung des Wildes, aber auch zur Fütterung der Schafe verwendet. Die nutritiven Werte der Nadeln und des erzeugten Mehls wurden analysiert. Die Zusammensetzung der Aminosäuren aus den Fichtennadeln ist in Tab. I und die Ergebnisse von Analysen des nutritiven Wertes des erzeugten Mehls sind in der Tab. II enthalten. Während einer langfristigen Lagerung sinkt die Qualität des Mehls (tab. III und Fig. 5). Bei Fütterungsversuchen an Lämmern, bei denen ein granuliertes Futter mit einer Beimischung von 4 bis 9% des Baumgrün-Mehls verwendet wurde, haben sich die Zuwächse der Lämmer — im Vergleich mit der Kontroll-Gruppe — um 11,5 bis 16,7% erhöht. In der Tab. IV wird der nutritive Wert des Baumgrünmehls mit dem Werte landwirtschaftlicher Gräser und jener Waldgräser verglichen, die durch das Wild am häufigsten abgeweidet werden. Als Folge der Fütterung des Wildes mit granuliertem, durch Nadelmehl bereichertem Futter in der Winterperiode wurden die Nage- und Fraßschäden durch Wild um 20% des ursprünglichen Umfangs und der ursprünglichen Intensität herabgesetzt.

Technologie der Nutzung der grünen Baummasse; Ausnutzung der grünen Baummasse; Futtermehl aus der grünen Baummasse; Nutritionswert des Mehls aus grüner Baummasse

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# CONTROL OF THE CONVERSION PROCESS TOWARDS THE STOCHASTICALLY DEFINED NORMAL FOREST BY THE LINEAR AND STOCHASTIC PROGRAMMING

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KOUBA, J. (Institute of Applied Ecology and Ecotechnique, Univ. of Agriculture, VŠZ, Kostelec nad Černými lesy): *Control of the Conversion Process towards the Stochastically Defined Normal Forest by the Linear and Stochastic Programming*. *Lesnictví*, 35, 1989 (11): 1025–1040.

In this paper the author's original design of a new theory of normal forest is described; in this theory first of all premature final cuttings (salvage cuttings) are taken into consideration as a result of which premature new forestation will necessarily be to performed. In the introduction there is a formulation of the theory expressing and estimating incidental fellings on the basis of the regeneration theory. The theory of estimate comprises the function of reliability  $R(t)$ , expressing the probability of survival, the probability that the forest will not have to be cut before the period  $t \in (0 \leq t < \infty)$ . Using the functions of Weibull's distribution, the function  $R(t)$  has been written. The function of the intensity of forest destruction in the period  $(t, t + \Delta t)$  can be calculated as follows:

$$L(t) = - \frac{R'(t)}{R(t)}$$

By integration of the function of intensity  $L(t)$  in equidistant time intervals the intensities corresponding to the respective ranges of these intervals will be obtained (age degree/class/ – 10 /or 20/ years). Applying the composition of the last intensities and the proportions of planned final cuttings stated by the law (e. g. in the CSR Edict no. 13/78), a matrix of probabilities of the transition of-homogenous regular Markov chain will be made. From this matrix the stationary distribution of forest in age classes can be calculated, which will provide the basis for a normal forest. The fundamental part of this study is the calculation of the optimum control of cut in individual age classes (they cannot be smaller than expected proportions of salvage cuttings) in the decennia of the so-called adjustment period, i. e. period when the actual, original age structure is to be adjusted to the normal (stationary) age structure. Is it of course necessary to reckon with some planned cuttings of a part of younger stands. The process of conversion is optimized by a simplex method of continuous linear programming. The objective function is the maximum volume of total final cuttings over the conversion period. In conclusion there is assessed a possibility of using other methods, especially stochastic programming, which enables consideration of the variance of task parameters and to solve the problems of finding the optimum control under uncertainty. The illustrative examples presented in this study demonstrate that this method offers better results than a great many methods used until now, e. g. so-called formula methods.

normal forest; conversion to normal forest; random processes; theory of control; linear programming; stochastic programming; adjustment period

In managing the forest production development in practice, effects of harmful factors have been met, which represent an economic risk of forest management. Calamities in forests are their actual manifestation. Calamities causing destruction of forest stands, establishment of a clear-cut area and the duty of reforestation, influence the age structure development at a most significant way. Calamities cannot be predicted quite well in practice, their random character must be presumed. For expressing their influence on production a theory of random processes can be applied. Bases of its application have been presented in a number of my works (Kouba, 1969, 1972, 1973) focused

on forests in which the effect of immission damage (or widely forest sicknesses) can hardly be observed, and on certain bases of sick forests development simulation (Kouba 1986, 1987). This work deals with the theory of calamity development estimations according to the age of stands and with the bases of process optimization of converting a forest into a normal forest, characterized by treating the calamities on the basis of random processes and harvest cut.

## THEORY OF NORMAL FOREST BASED ON RANDOM PROCESSES, CALAMITY PROBABILITIES, AND FOREST PRODUCTION CONTROL

Impossibility of reaching even-age class distribution in practice has been assumed as one the most serious shortcomings of a classic normal forest theory, especially owing to the occurrence of calamities in forests. I have based the new normal forest theory on the principle of involving the probable occurrence of calamities, expressed in age classes on the basis of random processes theory (in particular Markov chains), into the normal forest theory.

The expression of a forest age structure development in terms of a regular Markov chain is given in the form of a transition matrix describing the probability of process transition (a share of forest area) from the status  $i$  to the status  $j$ , the matrix elements being denoted  $(p_{ij})$ ,  $i = 1, 2, \dots, n$ :

$$\mathbf{P} = \begin{pmatrix} p_{11} & p_{12} & 0 & \dots & 0 \\ p_{21} & 0 & p_{23} & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ p_{n-1,1} & 0 & 0 & \dots & p_{n-1,n} \\ 1 & 0 & \dots & \dots & 0 \end{pmatrix} \quad (1)$$

The transition probabilities  $p_{i,j}$  in the first column are the spatial shares of the clear-cut area, caused by salvage cutting and the harvest cut of the mature age stages (including salvage cut) during one step (decennium). The last age stage is harvested totally. The probabilities  $p_{i,i+1}$  above the major diagonal are the spatial shares of  $i$ -th age classes which will transit into the nearest higher stages (process statuses) in the same step — for more detail see (Kouba, 1969, 1973). The elements  $(p_{ij})$  are non-negative, the sum of each line equals 1. The distribution of age stages in the step (decennium)  $t$  is the line probability vector  $\mathbf{p}^{(t)}$  with the elements  $(p_1^{(t)}, p_2^{(t)}, \dots, p_n^{(t)})$ , the sum of which equals 1. The Chapman-Kolmogorov relation is valid:

$$\mathbf{p}^{(t)} = \mathbf{p}^{(0)} \mathbf{P}^t \quad (2)$$

$$\lim_{t \rightarrow \infty} \mathbf{p}^{(0)} \mathbf{P}^t = \mathbf{a} \quad (3)$$

and further

$$\mathbf{a} = \mathbf{aP} \quad (4)$$

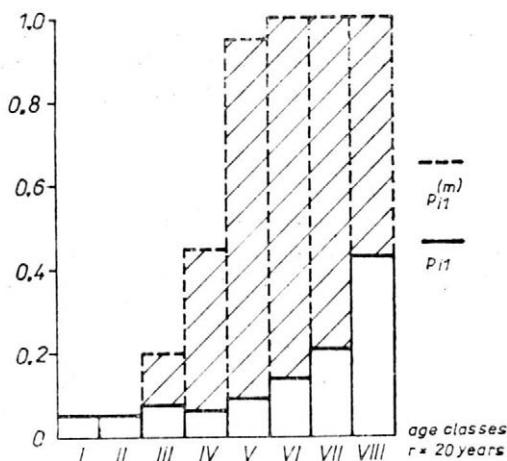
where  $\mathbf{a} = (a_i)$  is the stationary vector not depending on the initial vector  $\mathbf{p}^{(0)}$ . Considering (4), the elements  $\mathbf{a}$  can be computed:

$$a_i = \frac{\prod_{i=1}^{i-1} p_{i,i+1}}{\sum_{k=1}^n \prod_{i=1}^k p_{i,i+1}} \quad (5)$$

$\prod_{i=1}^0 p_{i,i+1}$  the expression is defined to equal 1.

The stationary age structure is the basis of the new normal forest theory — see (Kouba, 1972, 1973, 1983), where theoretical grounds and special literature are presented sufficiently. This theory presents the age structure development, the development of all basic taxation values and their stationary (normal) values for a working circle and their groupings for larger territorial units. The expression according to tree species is possible, the natural succession of forest tree

1. The space of possible decisions (the hatched area) in the boundaries of which the final cut can be chosen in controlling the conversion process of an actual forest to a normal one (based on the random processes theory)



species can be assumed e. t. c. It has not been possible to recognize the salvage cutting probabilities (in age stages) at the appropriately representative and good level. Therefore the share of a final felling quoted by the 1950, 1970, and 1980 Forest Inventories has been used in my works. A similar approach has been chosen by some forest researchers in the G. D. R. That has enabled deeper study of the problem and achieving suitable results in assessing both contemporary and future production of our forests. The forest succession in agreement with this theory approaches, in muffled oscillations, the stationary status- the normal one.

Already since the problem has been studied there has been the question of the optimum control of the forest age structure development and its conversing into target normal status corresponding to a certain composition of salvage and harvest clear-cuts expressed in the form of transition probabilities in age stages (Kouba, 1967, 1969). In Fig. 1., the limits in which the volume of total clear-cut can be selected are demonstrated, described as a space of possible decisions. The acceptable controlled values (shares of total clear-cut harvest) cannot be lower than the calamity shares and cannot exceed the whole clear-cut harvest, the limits of which are stated with consideration of total economy of conversion process which, together with the initial age structure, determines the time of conversion. This idea, I think, makes significant difference between works of Suzuki (1959—1984), see also Kohinora, Amano (1986) and mine, because Suzuki does not take into consideration salvage cuttings at all — he takes the decennial clear-cut harvest rations as the probabilities  $p_{i,j}$ . Suzuki's works became accessible in Europe at the beginning of the 1980's, when I could get them with the kind help of professor Suzuki. Suzuki starts from the theory of reliability (renewal), especially from the probability of harvest clear-cut in a certain age stage — see formula (24). The Japanese name it the "Gentanritu" — Gentan Probability. He considers these probabilities to be stable, or changing in time only a little. Then it can be said that our namely post-war yield regulation, represented at first by working circles and characteristic rotation period and eventually by harvest percentages (in Decree of the Ministry of Forest and Water Management of the C. S. R. No. 13/78) is actually in agreement with Suzuki's concept, though in its construction the Markov chains theory was not used, because that possibility had not been known. The explanation based on the renewal theory is less illustrative than the direct explanation using the Markov chains theory which gives the possibilities to express and analyse a number of time characteristics, as I have pointed out (e. g. Kouba, 1977). On the other hand, the renewal theory enables theoretical grounds of estimation, and forest stand destruction probabilities (which are the natural risk in forest management) to be precised and systematized remarkably.

**BASIC PRINCIPLES OF EXPRESSING AND ESTIMATING THE FOREST STANDS DESTRUCTION PROBABILITIES USING THE THEORY OF RELIABILITY (RENEWAL)**

The theory of renewal deals among others with the likelihood description of successful operation of an element or a whole group of elements and, eventually, systems composed of a number of elements. Important relations between discrete expression of this theory and homogeneous regular Markov chains theory can be demonstrated. When using the reliability theory as a logical ground and theory of, above all, probability of forest stands destruction caused by various, factors we assume the continuous expression of basic terms and functions as an underlying presumption of this theory.

In this work the Weibull (1939) statistical distribution treated in the book by Beyer, Girlich and Zschesche (1982) was applied. To save the space in the further text, definitions and adequate functions of basic terms of the renewal theory are written on the left hand side and their expression with the means of Weibull distribution on the right hand side.

**Definition 1.** The probability  $F(t)$  of failure is the probability that an element fails for the first time before the time  $t \in (0 \leq t \leq \infty)$ :

$$F(t) = P(T < t) = 1 - \exp(-\lambda t^\alpha) \quad (6)$$

$$\lambda > 0, \alpha > 0, t \geq 0$$

$T$  is the period of successful (failureless) work of an element; the density of such a probability is

$$f(t) = F'(t) = \lambda \alpha t^{\alpha-1} \exp(-\lambda t^\alpha) \quad (7)$$

**Definition 2.** The probability that an element does not fail until the time  $t \in (0 \leq t \leq \infty)$  is the probability of survival (the function of reliability):

$$R(t) = 1 - F(t) = P(T \geq t) = \exp(-\lambda t^\alpha) \quad (8)$$

$$R'(t) = -F'(t) \quad - \text{ see (7)}$$

**Definition 3.** The mean time before failure  $T_o$  is

$$T_o = \int_0^\infty t f(t) dt \quad (9)$$

Supposing integral convergence, further equations are obtained by the integration per partes:

$$T_o = \int_0^\infty R(t) dt = \frac{\Gamma\left(\frac{1}{\alpha} + 1\right)}{\lambda^{\frac{1}{\alpha}}} \quad (10)$$

**Definition 4.** Failure rate  $L(t)$  of an element in the interval  $(t, t + \Delta t)$  under the condition it has not failed in the interval  $(0, t)$

$$L(t) = \frac{F'(t)}{1 - F(t)} = -\frac{R'(t)}{R(t)} = \lambda \alpha t^{\alpha-1} \quad (11)$$

The function of reliability  $R(t)$  or  $F(t)$ , respectively, seems to be the most advantageous basis of the estimation theory of a forest stand damage process development.

It seems to be logically possible that by the professional forestry knowledge the proportion of still undamaged forest stands can be estimated in the proximity of the beginning and the end of the given factor's effect. It can be supposed that share of original whole stand destroyed in the aggregate during the period of that factor's effect will be estimated appropriately. It is necessary for expressing the function of reliability  $R(t)$  to estimate their values  $R_1$  and  $R_2$  at two convenient time moments  $t_1$  and  $t_2$ . The parameters of the function  $R(t)$  expressed on the Weibull distribution can be computed from the formulae derived by Kašparová (Kouba, Kašparová, 1988):

$$a = \frac{\ln \left( \frac{\ln R_1}{\ln R_2} \right)}{\ln \left( \frac{t_1}{t_2} \right)} \quad (12)$$

$$\lambda = \frac{-\ln R_2}{t_2^a} \quad (13)$$

A number of harmful factors only occur at certain time intervals of forest life; their influence has been rising since the beginning of any of them and when they reach a certain maximum they decrease gradually until their actual or registerable influence vanishes. Every such a factor, however, destroys by itself only a part of the total forest area. Thus the function  $R(t)$  was improved according to (8) to the form:

$$R(t) = c \exp(-\lambda t^a) + (1 - c) \quad (14)$$

where  $c$  is the constant ( $0 \leq c \leq 1$ ) indicating the total share of initial forest area which is destroyed during its life-span by the given harmful factor. If  $c = 1$  then (14) becomes the original function (8), if  $c = 0$  then  $R(t)$  ever equals 1, which stands for the situation when the factor has no effect.

The function  $R(t)$  in the form of (14) has the same first derivative as the original function (8). Its first derivative is the negative expression (7). When calculating the intensity  $L(t)$  the simple expression (11) cannot be applied but

$$L(t) = \frac{\lambda a t^{a-1} \exp(-\lambda t^a)}{c \exp(-\lambda t^a) + (1 - c)} \quad (15)$$

The appropriate form of the function  $R(t)$ , either (8) or (14), can express or estimate the course of the intensity of typical forest destruction processes.

The course of the sum destruction intensity  $L(t)$  is expressed as a superposition of destruction intensities  $L_i(t)$  corresponding to  $i$ -th harmful factor from the whole set of factors eligible in the given forest area:

$$L(t) = \sum_{i=1}^n L_i(t) \quad (16)$$

The sum function of reliability is:

$$R(t) = \prod_{i=1}^n R_i(t) = \exp \left( - \sum_{i=1}^n \int_0^t L_i(t) dt \right) \quad (17)$$

I. The estimates of reliability function values  $R_i(t)$  and their parameters,  $R_1(t)$  — the destruction of young plantations,  $R_2(t)$  — typical snowbreak damage in coniferous forest of the mean age,  $R_3(t)$  the damage caused by wind and old age,  $R_4(t)$  — undefined random damage

Function	$t_1$	$t_2$	$R_1$	$R_2$	$c$	$\alpha$	$\lambda$
$R_1(t)$	1	2	0.3333	0.1	0.45	1.0675	1.09862
$R_2(t)$	19	90	0.99	0.001	0.1	4.2002	$4.27776 \cdot 10^{-8}$
$R_3(t)$	100	200	0.9	0.2	—	3.9332	$1.43342 \cdot 10^{-9}$
$R_4(t)$	—	—	—	—	—	—	0.0005

and finally:

$$F'(t) = \left( \sum_{i=1}^n L_i(t) \right) \cdot \left( \prod_{i=1}^n R_i(t) \right) \quad (18)$$

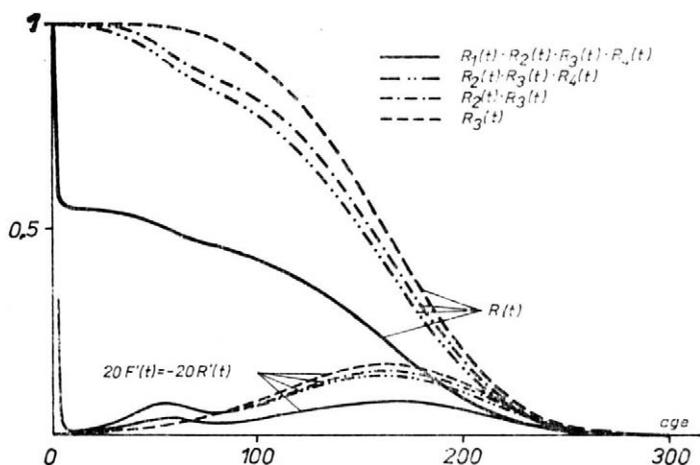
The estimates of the factors which serve as the ground for the process optimization in conversion towards the normal forest are stated in the Tab. I. and the graphs of the functions  $R(t)$ ,  $F'(t)$  and  $L(t)$  are shown in Figs. 2. and 3. Considering the function  $R(t)$  the annual ratio of reforested forest area can be computed

$$p = \frac{1}{\int_0^{\infty} R(t) dt} = \frac{1}{T_0} \quad (19)$$

and the stationary age structure  $a(t)$  in the continuous form as well:

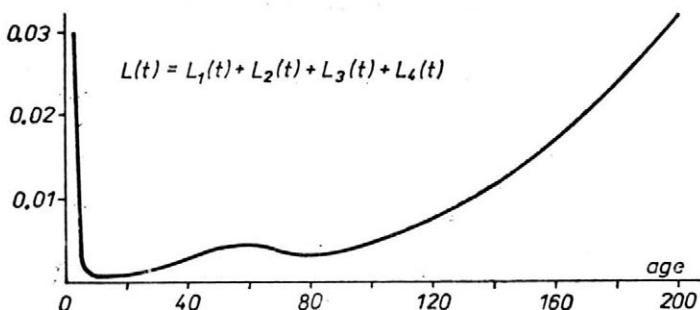
$$a(t) = \frac{R(t)}{T_0} \quad (20)$$

The integral  $R(t)$  in (17) is solved only by numerical methods. As for the reasons of practical use the forest stands are divided into age stages (classes). It is necessary that the expression of the stated functions be connected with their discrete forms or their analogies for equidistant intervals with corresponding span which is denoted  $r$  ( $r = 10$ )

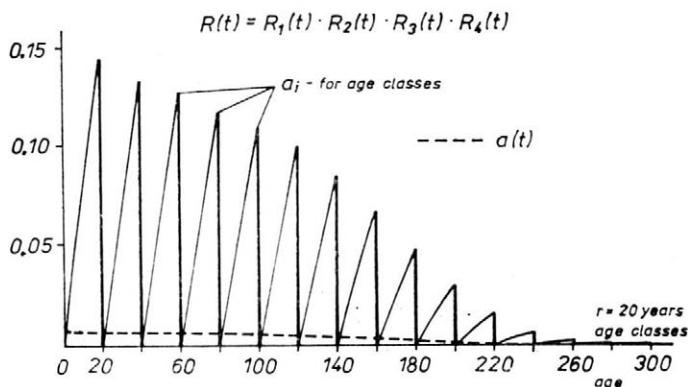


2. The examples of aggregate reliability functions  $R(t)$  according to (17) and  $F'(t) = -R'(t)$  according to (18), derived from  $R_1(t) - R_4(t)$  according to the Tab. I

3. An example of the superposition of the destruction probabilities ( $L(t)$ ) according to (16) derived from the functions  $R_1(t) - R_4(t)$  according to the Tab. I



4. The stationary age structure according to (21) for age classes,  $r = 20$  years, including the demonstration of the step-by-step integration and the stationary age structure according to (20)



or 20 years). On the basis of the stationary age structure described in (20) the stationary vector  $\mathbf{a} = (a_i)$  can be formulated:

$$a_i = \frac{1}{T_0} \int_{(i-1)r}^{ir} R(t) dt, \quad i = 1, 2, \dots, n \quad (21)$$

where  $i$  is the sequence of the age stage (class),  $r$  is ever the span of the age class. The example of the vector  $\mathbf{a}$  for  $r = 20$  with the illustration of step by step integration is shown in the Fig. 4.

The transition probability can be computed from the elements of that vector:

$$p_{i,i+1} = \frac{a_{i+1}}{a_i}, \quad i = 1, 2, \dots, n - 1 \quad (22)$$

and the destruction probabilities:

$$p_{i1} = 1 - p_{i,i+1} \quad (23)$$

which are the discrete analogy of the function  $L(t)$ . The discrete analogy of the derivative  $F'(t)$  is the vector  $\mathbf{q} = (q_i)$  i. e. Suzuki's Gentan probabilities:

$$q_i = F(ir) - F(i-1)r, \quad i = 1, 2, \dots, n \quad (24)$$

The discrete analogy of other functions and their relation to the Markov chains theory see in Kouba (1989) or the theory in Karlin (1968). On the basis of (22) and (23) the matrix  $\mathbf{P}$  can be constructed [see (1)]. The probabilities (23) are then one of the grounds of the optimal conversion towards stochastically defined normal forest.

The basic principle of the control theory is the task to find the optimum trajectory of the controlled system developing towards a designed target status. In this case the target is the conversion of actual age structure to the normal one corresponding with the maximum sustained and continuous forest production under the circumstances given, above all, by the productive ability of a forest but also by the natural risk of their development. The research of the forest age structure and consequently of the forest production has led to the consideration of the possibility to use the methods of the linear and dynamic programming (Kouba, 1967) and further on to the expression of salvage cutting influence by the Markov chains, to the use of the controlled Markov chains or to their control by means of the linear programming (Kouba, 1969). The task of conversion of the actual forest to the normal one without considering the calamities was solved by Nautiyal and Pearse (1967). Our task is based on the ideas from the first part of the article illustrated simply in Fig. 1.

It is beyond dispute that converting an actual initial forest age structure to a given normal one expressed in spatial distribution is only possible by adequately chosen decennial final cut in corresponding age stages and decennia within the conversion period. The problem of the choice can be described by following values:

1.  $p_{i1}$  — the decennial share of calamities in the  $i$ -th age stage according to (25)
2.  $p_{i1}^{(m)}$  — the decennial share of the possible total final cut (which must include also the salvage cutting) in the  $i$ -th age stage
3.  $p_{i1}^{(t)}$  — the decennial share of the total final cut (composed of an optional part of clear-cut and fixed salvage cut) in the  $i$ -th stage and  $t$ -th decennium of the conversion period.

$$p_{i1}^{(t)} = p_{i1}, \quad i = 1, 2, \dots, k \tag{25}$$

$$p_{i1} \leq p_{i1}^{(t)} \leq p_{i1}^{(m)}, \quad p_{i1} \leq p_{i1}^{(m)}, \quad i = k + 1, k + 2, \dots, n \tag{26}$$

4.  $\pi_{i1}$  — decennial share of planned harvest cutting in the  $i$ -th age stage given in the Forest Law of the C. S. R.
5.  $\pi_{i1}^{(n)}$  — the normal decennial cutting shares in the  $i$ -th age stage

$$\pi_{i1}^{(n)} = \begin{cases} p_{i1}, & p_{i1} \geq \pi_{i1}, & i = 1, 2, \dots, 1 \\ \pi_{i1}, & p_{i1} \leq \pi_{i1}, & i = 1 + 1, 1 + 2, \dots, n \end{cases} \tag{27}$$

which will be applied from the moment of conversion on the stand with the normal age structure calculated from (27) according to (5). Theoretically, the normal age structure will be maintained by the application of the cutting shares (27) in the future. The values according to points 1, 2, 4, and 5 for our simple example are presented in Tab. II.

The principle of conversion control is based on the determination of the cutting shares in single decennia at eligible age stages taking into account the relations (25) and restrictions (26) so that on reaching the target (5) based on (27), (22) and (23) the maximum of total harvest volume can be reached during the whole conversion period.

The simplex method of the continuous linear programming is used to solve the task. The standard statement of the task is:

$$\mathbf{Ax} \begin{matrix} \geq \\ \leq \end{matrix} \mathbf{b} \tag{28}$$

$$\mathbf{c}^T \mathbf{x} \longrightarrow \max \tag{29}$$

$$\mathbf{x} \geq 0 \tag{30}$$

II. The basic probabilities of the task solving the conversion to the normal forest, used for the linear programming task in the Tab. III

Age class $r = 40$ years $i$	$p_{il}$	$p_{il}^{(m)}$	$\pi_{il}$	$\pi_{il}^{(m)}$
1	0.2	0	0	0.2
2	0.1	0.5	0.3	0.3
3	0.2	1	1	1
4	0.3	1	—	—

III. The simplex table of the task of the conversion control of an actual forest to the normal forest based on the random processes.  $Z$  is the objective function

Interval	Row	Interval										Variant	
		1			2				3				
		Column										$b_1$	$b_2$
		1	2	3	4	5	6	7	8	9	10		
1	1	1										$= 0.08$	0.04
	2		1									$\geq 0.04$	0.04
	3			1								$\leq 0.2$	0.2
	4				1							$\geq 0.04$	0.08
	5					1						$\leq 0.2$	0.4
2	6	0.2	0.2	0.2	-1							$= 0$	0
	7	1				1						$\geq 0.112$	0.056
	8	1				1						$\leq 0.24$	0.12
	9		1				1					$= 0.4$	0.4
	10			1				1				$= 0.2$	0.4
3	11				0.2	0.2	0.2	0.2	-1			$= 0$	0
	12	0.1	0.1	0.1	-0.1					-1		$\leq 0$	0
	13	0.5	0.5	0.5	-0.5						-1	$\geq 0$	0
	14	1				1					1	$= 0.4$	0.2
	15									1	1	$= 0.4237$	0.4237
	16				1	1	1	1	-1			$= 0.339$	0.339
	17	1	1	1	-1						-1	$= 0.2373$	0.2373
$z$	13	435	706	13	435	706	876	13	435	706	$\rightarrow \max$		

To illustrate the use of the proposed procedure, two simple examples were chosen. For the task statement to be printed, three initial age stages with the span 40 years were chosen and consequently the 40-year interval of computation steps. Table III. contains the task statement in the form of a simplex table. In the area defined by indexes of rows

and columns there is the matrix  $\mathbf{A}$  of coefficients  $a_{ij}$  containing only non-zero elements. In the columns  $b_1-b_2$  there are the values of our required cuttings for the following initial distribution of our 40-year age stages:

Variant	Age stage		
	1	2	3
$b_1$	0.4	0.4	0.2
$b_2$	0.2	0.4	0.4

For both examples the matrix  $\mathbf{A}$  is the same.

The coefficients of the objective function  $\mathbf{c}^T \mathbf{x}$  in the row denoted  $z$ , the value of which is being maximized, is determined from the yield tables, or on the basis of the Forest Inventories (see e. g. Kouba, 1985) or on the basis of those data expressed by the prices of supposed wood assortments.

The list of concrete clear-cut areas in age stages at each decennium (the elements of the vector  $\mathbf{x}(t)$  and the total volume of final cut in cubic meters according to (29) are the results of the task. There are the results of Tab. III. in Tab. IV. The computations were performed with the aid of the MPSX system (IBM software). The

IV. The solution of the simplex task from the Tab. III the felling area  $x_i(t)$  in each 40 year interval of the conversion period, the objective function  $z$  i. e. the maximum of total final cuttings the conversion period (3 intervals,  $r = 40$  years)

Variable No.	Age class $r = 40$	Variant	
		$b_1$	$b_2$
1	1 $x_1(1)$	0.08	0.04
2	2 $x_2(1)$	0.08031	0.10031
3	3 $x_3(1)$	0.2	0.4
1st interval		0.36031	0.54031
5	1 $x_1(2)$	0.07206	0.10806
6	2 $x_2(2)$	0.032	0.016
7	3 $x_3(2)$	0.31969	0.29969
8	4 $x_4(2)$	0	0
2nd interval		0.42375	0.42375
9	1 $x_1(3)$	0.08475	0.08475
10	2 $x_2(3)$	0.05095	0.19495
11	3 $x_3(3)$	0.288	0.144
3rd interval		0.4237	0.4237
$z$ $\text{m}^3 \cdot \text{ha}^{-1}$		644.33	734.07

matrix  $\mathbf{P}(t)$  is determined for each stage being of the same form as in (1) but depending on the step  $t$ . The elements of its first column are

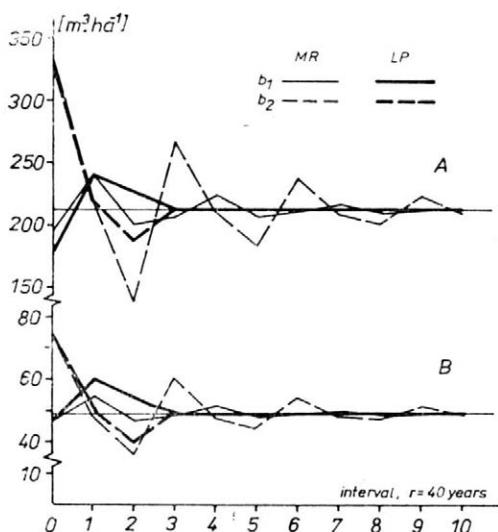
$$p_{11}^{(t)} = \frac{x_1^{(t)}}{p_{11}^{(t-1)}}, \dots, p_{n-1,1}^{(t)} = \frac{x_{n-1}^{(t)}}{p_{n-1}^{(t-1)}}, p_{n,1}^{(t)} = 1 \quad (31)$$

The elements above the diagonal are ever calculated according to (23). If we need that the eligible taxation values be calculated, formulae (15)–(35) are used (in Kouba, 1983). In these formulae, instead of equation (15) given there, here (2) the following expression should be used:

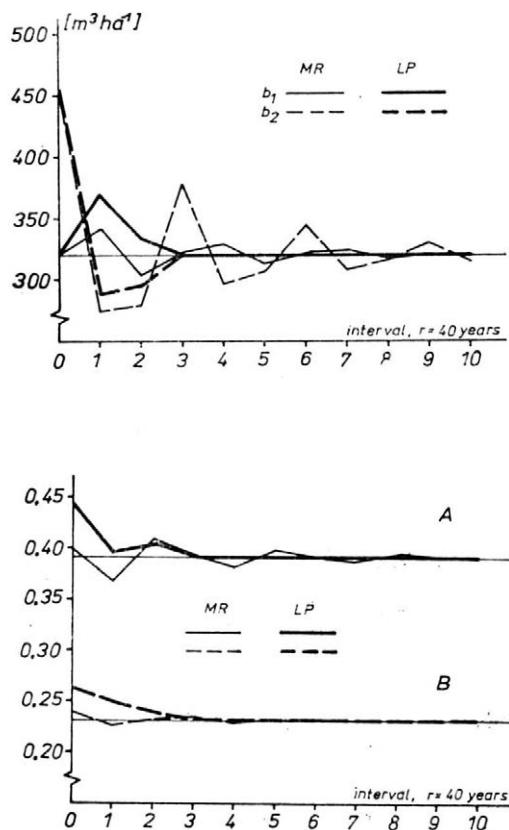
$$\mathbf{p}^{(t)} = \mathbf{p}^{(t-1)} \mathbf{P}(t) \quad (32)$$

and we can obtain the values describing the optimally controlled process of conversion to a normal forest on the basis of random processes which was determined in characterizing the target of the control. The examples of development of the basic taxation values, i. e. growing stock, final cutting, total and final salvage cutting, are presented in Fig. 5. and 6. In Fig. 7. the development of salvage cutting share is demonstrated, in Fig. 8. and in Fig. 9 the development of the rotation period and mean age are presented.

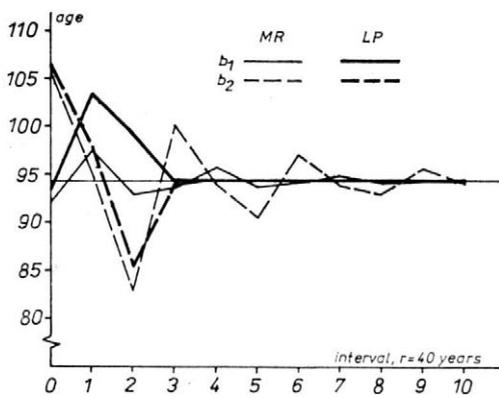
5. The development of the growing stock (in  $\text{m}^3 \cdot \text{ha}^{-1}$ ) derived from the homogeneous regular Markov chain (MR) and the conversion controlled by the linear programming (LP), both converging to the normal (optimum) value of the growing stock



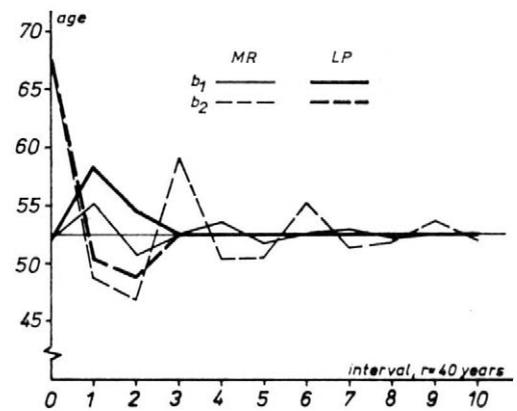
6. The development of total final cutting (A) and salvage one (B) in  $\text{m}^3 \cdot \text{ha}^{-1}$  according to the Markov chain (MR) and the conversion controlled by the linear programming (LP), both converging to the normal (optimum) values



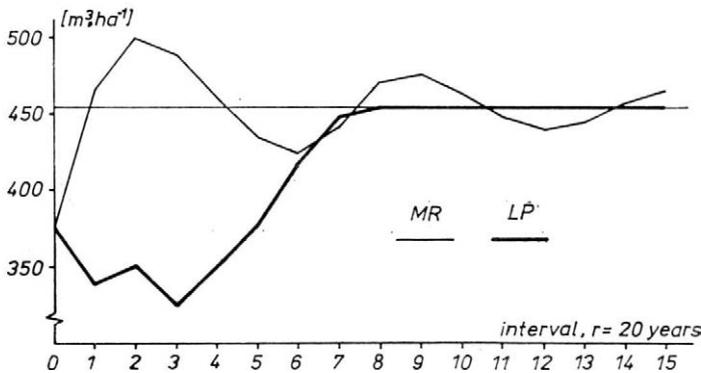
7. The development of the share of salvage cutting of the total final cutting. A — the share of the felling area, B — the share of volume felled. MR — Markov chain, LP — linear programming



8. The development of actual rotation period, MR — Markov chain, LP — linear programming



9. The development of the mean age of the working circle. MR — Markov chain, LP — linear programming



10. The development of the growing stock (in  $m^3 \cdot ha^{-1}$ ) derived from the homogeneous regular Markov chain (MR) and the conversion controlled by the linear programming (LP), both converging to the normal value of the growing stock according to Tab. V

As a comparison there is the development controlled by the homogenous Markov chain with the matrix  $\mathbf{P}$  corresponding to (27) demonstrated in the figure. The normal values of presented quantities are achieved after three steps.

In solving these tasks it is necessary that the maximum of the growth function's first derivative be achieved within the rotation period. In Fig. 10 there is demonstrated the development of the total volume of the task formulated on the estimates in Tab. I. (see also Fig. 1—4). Regarding the requested achievement of the age structure with the rotation period higher than 100 years the process develops so that in the beginning the age stages are reduced to the number of 5, only later the process approaches the required adequate normal distribution. Thus it is necessary to solve the question of the optimum conversion period. The Pontryagin principle of maximum seems to be a pretty chance of solution.

The presented task can be solved using the methods of the stochastic programming. The methods of the stochastic programming, widely the methods of control under uncertainty are the appropriate perspective tool for making our task more precise. A number of variants can be considered. The stochastic programming requires the knowledge of two first statistical moments (i. e. the mean and the variance) and at the same time stochastic character of all or only some parts of the model determined in (28)—(30) can be considered. Estimating the model parameters can stem from the estimation methods as they are commonly used in e. g. solving the net or sequential models when often the  $\beta$  distribution is being used. First two moments of this distribution are obtained

V. The basic probabilities of the linear programming task demonstrated in Fig. 9

Age class $r = 20$ years $i$	$p_{ii}$	$p_{ii}^{(m)}$	$\pi_{ii}$	$\pi_{ii}^{(n)}$	initial vector $\mathbf{p}^{(0)}$	stationary vector $\mathbf{a}$
1	0.053	0	0	0.053	0.23	0.184629
2	0.052	0	0	0.052	0.216	0.174843
3	0.075	0.2	0	0.075	0.199	0.165751
4	0.064	0.5	0	0.064	0.185	0.15332
5	0.09	0.95	0.2	0.2	0.11	0.143508
6	0.14	1	0.5	0.5	0.0525	0.117806
7	0.21	1	0.9	0.9	0.005	0.057403
8	0.43	1	1	1	0.0025	0.00574

from the estimate of optimistic, probable and pesimistic value of a given parameter. At the same time the bases of estimation can be applied, which are presented in the former part of this article.

#### CONCLUSION AND FURTHER PERSPECTIVES OF THE RESEARCH

As the principle result of the work such fact can be assumed that the normal forest theory based on expressing the effect of, above all, salvage cuttings on the development of the spatial forest structure has been theoretically precised further on. Following topics were treated and solved, theoretical bases of expressing and estimating the forested area destruction probability in dependence on the age, both in discrete and continuous form, based on the reliability theory (of renewal). Its application enables to describe mathematically in general the process of forest destruction caused by both harmful factors and, since a certain moment, even their natural decay as a consequence of limited life span of the forest.

Based on such grounds it is possible to make theoretically proved estimates, to analyse them together with further consequence and to support them. And finally, to express them in the mathematical-statistical form on the basis of empirical data. The results of such theoretically well established estimates and expressions are used as most important principles of the optimum forest production control, among which the consideration of both the natural and anthropogenically conditioned risk belongs undoubtedly. The task of optimizing the process of conversion of initial (actual) forest age structure to the normal structure represented by the stationary vector of age stage distribution is one of the basic tasks of the optimum forest production control. The examples presented in the paper illustrate the reality of solving that task by means of the simplex method of the continuous linear programming. The procedures stated here are supposed to facilitate better results achievement than the methods which have been commonly used so far in the harvest regulation and which have been constructed on the variants of so-called formulae methods, as a matter of fact. Solving these tasks requires, of course, further elaboration. The use of the linear programming brings the advantage of considerably simple and easy introduction of further factors (limits) of e. g. economic and technological character. In considering the actual (10-year) age stages the range of processed tasks rises rapidly, which is not, however, an unsolvable task nowadays. Further progress is represented by using the methods of the stochastic programming when also the variance of task parameters may be taken into account.

The methods of the stochastic programming may be connected with other operational research methods. Finally, the theory of controlled Markov chains may be applied. The use of such methods should further bring the methods of forest production control closer to the reality.

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KOUBA, J. (Ústav aplikované ekologie a ekotechniky VŠZ, Kostelec n. Č. lesy). *Řízení procesu vyrovnání k stochasticky definovanému normálnímu lesu lineárním a stochastickým programováním*. Lesnictví, 35, 1989 (11) : 1025-1040.

Práce rozvíjí původní autorův návrh nové teorie normálního lesa, založené především na úvaze předčasných mýtních těžeb (kalamit), které si současně vynucují předčasné nové zalesnění (K o u b a, 1969, 72, 73, 77 etc.). Úvodem je formulována teorie vyjádření a odhadu těchto nahodilých těžeb na základě teorie obnovy. Teorie odhadu je založena na funkci spolehlivosti  $R(t)$ , vyjadřující pravděpodobnosti přežití, pravděpodobnost, že les nebude nutno vytěžít před obdobím  $t \in (0 \leq t \leq \infty)$ . V práci je funkce  $R(t)$  vyjádřena na základě funkcí Weibullova rozdělení. Z této funkce vypočteme funkci intenzity zničení lesa v období  $(t, t + \Delta t)$ :

$$L(t) = - \frac{R'(t)}{R(t)}$$

Integrací funkce intenzity  $L(t)$ , v ekvidistančních časových intervalech, získáme intenzity odpovídající příslušnému rozpětí těchto intervalů [věkový stupeň (třída) — 10 (resp. 20) let]. Na základě kompozice posledních intenzit a podílů úmyslných mýtních těžeb předepsaných zákonem (např. v ČSR Vyh. č. 13/78 Sb.), vytvoříme matici pravděpodobností přechodu homogenního regulárního Markovova řetězce. Z této matice vypočteme stacionární rozdělení lesa ve věkových stupních, na kterém založíme normální les. Stěžejní částí práce je výpočet optimálního řízení — těžebních podílů ve věkových stupních (které nemožno být menší, než předpokládané podíly kalamitních těžeb) v jednotlivých deceniích tzv. doby vyrovnávací, tedy doby, ve které požadujeme vyrovnání konkrétní, výchozí věkové struktury na věkovou strukturu normální (stacionární). Při tom je samozřejmě nutno počítat, že bude třeba někdy úmyslně těžít i část mladších porostů. Proces konverze je optimalizován simplexovou metodou spojitého lineárního programování. Účelovou funkcí je maximum celkových mýtních těžeb za období konverze. Závěrem je posouzena možnost aplikace dalších metod, především stochastického programování, které umožňuje počítat i s rozptylem parametrů úlohy a řešit tak otázky nalezení optimálního řízení v podmínkách neúplné informace. V práci uvedené ilustrativní příklady ukazují, že navržená metoda dává lepší výsledky, než řada doposud užívaných tzv. vzorcových metod.

normální les; konverze k normálnímu lesu; náhodné procesy; teorie řízení; lineární programování; stochastické programování, doba vyrovnávací

КОУБА, Я. (Институт прикладной экологии и экотехники СХИ, Костелец над Черными Лесами): *Управление процессом выравнивания к стохастически определенному нормальному лесу линейным и стохастическим программированием*. Lesnictví, 35, 1989 (11) : 1025-1040.

Работа углубляет познания по прежнему проекту новой теории автора — теории нормального леса, основанной на рассуждении о преждевременных главных рубках (стих. бедствий), которые с равной силой вынуждают преждевременное облеснение. В введении сформулирована теория выражения и оценки этих случайных рубок на основании теории обновления. Теория оценки основана на функции надежности  $R(t)$ , выражающей наверное выживание, вероятность того, что лес не будет нужным вырубить до периода  $t \in (0 \leq t \leq \infty)$ . В работе функция  $R(t)$ , выражена на основании функций распределения Вейбулла. Из данной функции рассчитаем функцию интенсивности уничтожения леса за период  $(t, t + \Delta t)$ :

$$L(t) = - \frac{R'(t)}{R(t)}$$

Интегрируя функцию интенсивности  $L(t)$ , в эквидистанционных интервалах получим интенсивности отвечающие соответствующему размаху данных интервалов (возрастная степень (класс) — 10, (т. с. 20 лет). На основе композиций последних интенсивностей и долей главных рубок пердписанных законом (например в ЧСР Оглашение за № 13/78 Сб.), создадут матрицу вероятностей перехода гомогенной регулярной цепи Маркова. Из данной матрицы рассчитаем стационарное разделение леса в возрастных степенях, на котором заложим нормальный лес. Основой

работы — расчет оптимального управления — рубкостных долей в возрастных группах (они могут быть и меньшими, чем предполагаемые от рубок после стих. бедствия) в отдельных десятилетиях так назыв. периода выравнивания, т. е. до того периода, в котором требуем выравнивани конкретной, исходной возрастной структуры на нормальную возрастную структуру (стационарную). При этом естественно следует рассчитывать, что будут проводить рубку у молодых насаждений. Процесс конверсии оптимизирован симплексным методом линейного программирования. Целевой функцией — максимум общих главных рубок за период конверсии. В заключении оценена возможность применения следующих методов, прежде всего стохастического программирования, позволяющее рассчитывать и на дисперсию параметров задания и тем самым решить вопросы поиска оптимального управления в условиях неполной информации. В работе приведенные, иллюстративные примеры показывают, что предложенный метод дает лучшие результаты, чем ряд использованных так назыв. методов формул.

нормальный лес; конверсия к нормальному лесу; случайные процессы; теория управления; линейное программирование; стохастическое программирование; срок — период выравнивания

KOUBA, J. (Inst. f. applizierte Ökologie u. Ökotechnik d. Landwirt. Hochschule, Kostelec nad Černými lesy): *Steuerung des Ausgleichprozesses zum stochastisch definierten Normalwald durch lineare und stochastische Programmierung*. Lesnictví, 35, 1989 (11) : 1025-1040.

Die Arbeit entwickelt den ursprünglichen Vorschlag des Verfassers der neuen Theorie des Normalwaldes, die vor allem auf der Erwägung vorzeitiger Endnutzungen (Kalamitäten) aufbaut, die gleichzeitig vorzeitige neue Verjüngung des Waldes erzwingen. Einleitend wird die Theorie der Darstellung und der Schätzung dieser Zufallsnutzungen aufgrund der Theorie der Erneuerung formuliert. Die Schätzungstheorie ist auf der Verlässlichkeitsfunktion  $R(t)$  gegründet, die die Wahrscheinlichkeit des Überlebens darstellt, die Wahrscheinlichkeit, daß der Wald nicht abgeholzt werden muß vor dem Zeitraum  $t \in (0 \leq t \leq \infty)$ . In der Arbeit wird die Funktion  $R(t)$  auf der Grundlage der Funktionen der Weibullschen Verteilung ausgedrückt. Aus dieser Funktion berechnen wir die Funktion der Intensität der Waldvernichtung im Zeitraum  $(t, t + \Delta t)$ :

$$L(t) = - \frac{R'(t)}{R(t)}$$

Durch Integration der Intensitätsfunktion  $L(t)$  in äquidistanten Zeitintervallen bekommen wir Intensitäten, die der entsprechenden Spanne dieser Intervalle entsprechen [Altersstufe (Klasse) — 10 (bzw. 20) Jahre]. Aufgrund der Komposition letzter Intensitäten und der Anteile planmäßiger Endnutzungen, die durch das Gesetz vorgeschrieben sind (z. B. in der ČSR Verlautbarung Nr. 13/78) bilden wir die Wahrscheinlichkeitsmatrix des Übergangs der homogenen regulären Markovschen Kette. Aus dieser Matrix berechnen wir die stationäre Einteilung des Waldes in Altersstufen, auf der wir den Normalwald aufbauen. Den wichtigsten Teil der Arbeit bildet die Berechnung der optimalen Leitung — der Nutzungsanteile in Altersstufen (die nicht kleiner sein können, als die vorausgesetzten Anteile der Kalamitätsnutzungen) in einzelnen Dezennien der sogen. Ausgleichzeit, also derjenigen Zeit, in der wir den Ausgleich einer konkreten Ausgangs-Altersstruktur auf die normale (stationäre) Altersstruktur erfordern. Dabei muß selbstverständlich damit gerechnet werden, daß man eventuell irgendwann absichtlich auch einen Teil jüngerer Bestände wird abholzen müssen. Der Konversionsprozeß wird durch die Simplex-Methode der kontinuierlichen linearen Programmierung optimiert. Die Zweckfunktion stellt das Maximum der gesamten Endnutzungen im Konversionszeitraum dar. Zum Schluß wird die Möglichkeit der Applikation weiterer Methoden beurteilt, vor allem der stochastischen Programmierung, die es möglich macht auch mit der Streuung der Parameter der Aufgabe zu rechnen und auf diese Weise auch die Fragen der Ermittlung optimaler Leitung in Bedingungen unvollständiger Information zu lösen. Die in der Arbeit angeführten illustrativen Beispiele zeigen, daß die vorgeschlagene Methode bessere Ergebnisse liefert als eine Reihe der bis jetzt angewandten sogen. Formelmethode.

Normalwald; Konversion zum Normalwald; zufällige Prozesse; Leitungstheorie; Linearprogrammierung; stochastische Programmierung; Ausgleichzeit

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