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REVIEW PAPER

Significant works of forestry research from the second half of 20th century in Slovakia

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Abstract
The contribution is published on the occasion of the 120th anniversary of the establishment of a forestry research organisation in Slovakia and the 100th anniversary of the establishment of the Czechoslovak Republic. We present important forestry research works, which were written by former (no longer alive) workers of the Forest Research Institute (FRI) in Zvolen in the second half of 20th century. The works (30 works in total) were divided into seven scientific areas: biology and silviculture (five works), forest protection (four works), forest management (five works), forestry mechanisation and harvest-production technologies (four works), forestry economics (five works), hunting (three works), natural environment (four works). First, summary information on selected works in a specific area was presented. Then, individual works from the specific scientific areas were characterised in more detail. Their value for the development of science and research as well as for the practical forestry was presented. Moreover, their importance for the present time was addressed. The paper presents only a very limited selection of a great number of works by FRI workers published in the second half of 20th century. The table with the information on the periods, when the individual significant researchers worked at FRI, is presented at the end of the paper.

Key words: forestry science and research; biology; technology; economics; forest environment; Forest Research Institute

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1. Introduction

On January 1st, 2018, 120 years have passed since the establishment of the first forestry research institution in Slovakia, the Central Forestry Research Station in Banská Štiavnica. During that time, great changes occurred in all areas of society, including forestry and its science and research. A number of works dealing with the development have already been published. The achieved results in individual areas were evaluated in the publication entitled "History of forestry science and research in Slovakia" (1978). The work dealt with the period since the establishment of the forestry research up to approximately 1975. From that time we need to highlight three works of two former workers of the Research Institute of the Forestry Sector (RIFS) of Zvolen, which was previously located in Banská Štiavnica, namely Dušan Zachar (a long-term head of the institute) and Katarína Kovácsová (a head of the department of scientific and technical information). The mentioned works were written by Zachar & Kovácsová (1968, 1973, 1979). The last overview publication entitled "Forest Research Institute Zvolen, history and present time" was published on the occasion of 115th anniversary of forestry research in Slovakia (Konôpka et al. 2013). The work focused on the analysis of the research performed at the Forest Research Institute (FRI) Zvolen between the years 1990 and 2012. An electronic DVD medium with an overview of publications of the institute workers is included in the cited work.

In this contribution we applied a different approach to elaborate this issue. From a large number of publications, we selected only those that dealt with the individual topics of forestry science and research in the second half of the 20th century. The selected works brought new knowledge, and significantly contributed to the development of forestry science and research. Preferentially, we selected the works that had not only theoretical outcomes, but also a positive impact on the practical forestry or on the overall development of forestry sector. They are book publications, most of which fulfil the current criteria of scientific

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monographs. We selected only the works of those former workers of RIFS or FRI Zvolen, who are no longer alive. Only a small number of works were prepared in cooperation with professionals from other institutions.

The presented work was prepared on the occasion of 120th anniversary of the establishment of the forestry research in Slovakia to remember our former highly appreciated colleagues and to acknowledge their excellent contribution to the development of forestry science and research. From a large number of existing works, we selected thirty publications. Evidently, such a small selection may not be completely objective, and many high-quality works were not included.

In addition, we publish this work on the occasion of 100th anniversary of the establishment of the first Czechoslovak Republic (1st CSR). It is an extremely important anniversary for both nations. From the point of forestry research, we shall not forget the help from the Czech parts to Slovak parts of CSR to renew the development of science and research after the break-down of the Austrian-Hungarian Empire. The same assistance came after the Second World War, when mutual cooperation was deepened and more coordinated.

During the second half of the 20th century, several outstanding Czech scientists worked at RIFS. In spite of the political isolation from the "western" world and work organisation under the conditions of planned economy, forestry research in both the Czech and Slovak Republics managed to achieve the global level. The results of the research activities corresponded with the needs of the social practice of that period, creativity of the researchers, and equipment quality. Achieved outcomes of forestry oriented basic research, but above all of applied research were accepted and recognised by the European scientific and professional community as well as by the national forestry practice.

2. Description of selected forestry research works

Individual works were divided into seven scientific areas: I) biology and forest silviculture, II) forest protection, III) forest management, IV) forestry mechanisation and harvest-production technologies, V) forestry economics, VI) hunting, VII) natural environment. First, short summary information on the selected works in a specific area is presented. Next, the content of individual works is characterised in more detail. Their input for the development of science and research as well as for the practice, and their importance for the present time is outlined.

2.1. Biology and forest silviculture

In the first forestry scientific area called "Biology and forest silviculture" we present five significant works. The first work "Natural tree species distribution in Slovakia" is a continuation of the works of Fekete & Blattný (1913, 1914) entitled "Distribution of tree and shrub species important for forestry in the Kingdom of Hungary". It is a significant work from the biological and ecological point of view, because the whole concept of close to nature forestry in Slovakia is based on the knowledge on natural tree species distribution. The other two works deal with tree species genetics and breeding. They are entitled "Provenance research of Norway spruce (*Picea abies* Karst.) in the Slovak Republic (SR) and its application" (to reduce the extent of the contribution we selected only one tree species) and "Ways and possibilities of preserving and conserving of a gene pool of forest tree species in Slovakia". These works are significant mainly because apart from the obtained knowledge they represent a basis for solving this topic now and in the future. They can bring substantial changes from the point of ensuring human life needs, especially in the future (new discoveries in genetics, e.g. using gene manipulations).

The second group of important works focuses on forest silviculture. They deal mainly with the possibilities how to affect growth processes of forest stands in such a way that they are able to fulfil the society needs and requirements to the highest extent. The works focus on beech (Štefančík 1974) and poplar stands (Kohán et al. 1981). A number of other publications dealing with silvicultural approaches for other tree species (mainly spruce, oak, and pine) were also published at that time, but due to a limited extent of this work we do not present them.

Natural distribution of tree species in Slovakia (Blattný & Šťastný 1959)

L. Fekete and T. Blattný published a two-volume book on the results of the geographical plant research in the former Kingdom of Hungary in 1913 and 1914. The substantial part of this work contained the data from the area of Slovakia. In the next years, T.Blattný, first in cooperation with L. Fekete and later alone, performed further research in this field. After World War II, T. Blattný in colaboration with T. Šťastný from RIFS in Banská Štiavnica complemented the mentioned work with the new information on tree species distribution. The substantial part of the book comprises the information on the horizontal and vertical distribution of individual tree species in Slovakia. It deals primarily with the commercially important tree species: fir, pine, spruce, larch, and beech. It also contains information on tree species, which have their northern boundary of their European distribution in the area of Slovakia (e.g. *Fraxinus ornus, Quercus cerris, Quercus pubescens, Acer tataricum*). For example, in the case of spruce the work presents the lower boundary of its sporadic and abundant occurrence; the upper boundary is characterised with stands which have closed uniform canopies, open gappy canopies, groups of dwarf trees and individual dwarf trees. The boundaries of tree species distribution are listed in Tables for individual regions (West Slovakia, Central Slovakia, East Slovakia) and aspects,

together with the characteristics of forest communities. The zonal distribution of individual tree species is shown in maps. The last chapter discusses the impact of natural factors on tree species distribution (parent rock, aspect, latitude). At the end, the work deals with the introduced tree species (for example Douglas fir, Persian walnut, black locust, sweet chestnut).

Theoretical as well as practical forestry conclusions can be derived from the results of geographical plant assessment published in this work. Natural tree species distribution represents a basis for the development of forestry science and research in almost all biological and ecological fields. It can be used in basic scientific disciplines, such as zoology including entomology, botany together with plant physiology, phytopatology, meteorology, climatology, etc. Next, it is also useful for applied forestry research disciplines, which synthesise the knowledge from basic scientific disciplines, such as forestry phytocenology and typology, forest silviculture, forest protection, forest management, forestry economics, hunting, etc.

Since the publication examines natural tree species distribution in detail, it allows purposeful forest management following natural laws. Hence, it is an important publication also from the point of practical forestry. The work is of importance also from the point of changing ecological conditions due to the ongoing climate change. It can be used when dealing with the impact of climate change on forest stands, specifically when suggesting adaptation and mitigation measures.

Provenance research of Norway spruce (Picea abies Karst.) in Slovakia and its practical application (Holubčík 1980)

The attempts to determine the provenance differences in the growth and development of tree species occurred long time ago. Provenances represent tree species variability determined by their genetic characteristics and long-term natural conditions. The extensive research of spruce at an international level was performed at the end of 60s in the last century. In the year 1973, the IUFRO working group 2.02.11 that dealt with the provenance research of spruce, discussed and prepared a plan for the future. In Slovakia, this topic was studied at RIFS in Zvolen. In the years 1963 and 1964, spruce seeds from its European distribution area were collected representing 337 provenances including 37 provenances from the SR and six provenances from the Czech Republic. After seedlings from the whole material grew up, the provenances were selected for the establishment of a series of provenance research plots that represented three different natural conditions (at the upper boundary of spruce optimum in the Slovak Beskids, at the lower boundary of spruce optimum in the Low Tatras, and outside the natural distribution in the Javorie Mts.). At each research site, three sets of plots containing 49 provenances were established. In addition, other research plots were also established, particularly to monitor production of Slovak national provenances (High Tatras, Low Tatras, Slovak Ore Mts., Oravská Magura).

Five years after planting of five-year-old seedlings, the evaluation of 83 spruce provenances originating from four provenance regions (Carpathian, Hercynian, Alpine, Dinaric) and growing on five research plots showed that the greatest differences in the survival and mortality between the provenances were found in the warmer and drier conditions outside the natural distribution of spruce. Based on this result an efficient selection can be expected to secure regeneration. Significant differences were revealed between growth characteristics of individual provenances. The highest proportion of well-growing provenances occurred in harsher natural conditions. In general, eastern provenances grew better than western provenances. Well-growing provenances originated from Slovakia, Romania, and Western Ukraine. Height increments were reduced during the first three years after planting in harsher conditions, and for two years in milder conditions. Individual provenances grew best at an elevation of 700 m a.s.l. The order of individual provenances according to their average height was significantly different only between the plots situated in optimum and in harsh conditions.

These results refer to the provenances at young age - ten years old (five-year-old seedlings, five years after their planting). More exact results can be obtained after the order of individual provenances becomes settled, i.e. after the culmination of their height growth. The establishment of such an extensive provenance experiment was a very important step for future research or for solving strategic forestry tasks.

The development of forestry science can benefit from the prepared and verified methodology for the establishment of provenance research plots. Another important outcome is the methodology how to evaluate growth and development of provenances in different natural conditions. The results were practically applied for the classification of parent stands to category II. A. and during the preparation of the proposal of a programme aimed at establishing seed stands.

Ways and possibilities of preserving and conserving a gene pool of forest tree species in Slovakia (Lafférs et al. 1988)

In the 80s of the last century, the highest attention of forestry science and research was paid to the identification of forest stand die-back. It was concluded that this new type of forest damage was caused by a complex of negative factors. Air pollution was the most important factor. Since the elimination of intoxication sources was not expected, forestry science and research focused on making proposals how to protect forest ecosystems against this negative influence. The most important task was: to save, preserve and reproduce the gene pool of forests. The cited work first analyses the possibilities how this

issue can be solved. It was said that the ways towards this goal should include information sources, such as natural regeneration, seeds, vegetative parts (cuttings, grafting), pollen (storage, controlled cross-breeding), and tissues (tissue cultures). Subsequently, they include stands and crops that transfer this information. All at that time existing knowledge was synthesised. The most important part of the work was the proposal of the measures for preserving and conserving the gene pool of forests of SR. The programme was very specific and was prepared until the year 2000 (with five-year time horizons – 1985, 1990, 1995, 2000) at a level of the whole Slovakia as well as according to the organisation structure of forests valid at that time. It was proposed to perform the measures using the following approaches: gene banks, certified stands, plus trees, seed orchards, seed stands, clone archives, plantations from vegetative propagation of material, forest seed banks. The measures were divided as follows: – in situ (preserving the most valuable stands, tree groups or biotopes using natural regeneration), – ex situ (evacuation of populations outside the polluted areas in the form of different reproduction plantations, seed orchards, clone archives, etc.), – a bank of forest seeds (storing most valuable populations).

When preparing the programme for preserving and conserving a gene pool of forest tree species, the knowledge on the gene pool of forest tree species was taken into account together with the outcomes of the research on the impact of pollution on forest tree species (localisation of polluted areas, prognosis of further forest die-back, particularly up to the year 2000). It was a summarising work focusing not only on the actual, but mainly on the future prosperity of FS in SR.

Implementation of the project was prioritised because it is known that Slovakia was and partially still is one of few European countries, where native populations adapted to the specific conditions, which are very valuable from the genetic point of view, have been preserved. Preserving this valuable gene pool was at that time understood as the first and most important pre-condition to return to unrestricted forest management when the intoxication sources are eliminated, and eventually when the inevitable corrective measures are performed in natural environment.

During the programme implementation, a lot of valuable knowledge for the progress of forestry science in specific areas, as well as for the practical actions was acquired. We can say that the programme has its continuation also now, since a lot of attention is still being paid to the issue. For example, since the year 1993 the implementation of the measures in the area of forest reproductive material has been annually evaluated within the scope of the "Reports on FS in SR".

Impact of thinnings on structure, qualitative and quantitative production of pole beech stands (Štefančík 1974)

The publication summarises the results of thinning experiments in pole beech stands. The research was performed in accordance to the agreed distribution of the scientific forestry work in the former CSR (based upon tree species composition of forest stands – in CR high proportion of coniferous tree species, mainly spruce, while in SR high proportion of broadleaved tree species, mainly beech). It was a long-term research on permanent research plots. In 1972, 17 permanent thinning research plots were established in Slovakia. The publication summarises the results of the research performed in pole beech stands after three thinning treatments, or after eight or nine years of tending. The greatest reduction in tree numbers was observed in the case of strong thinning from below – 79%, while following the loose thinning from above the number of trees decreased only by 32 to 60%. The reduction of the total wood biomass following both thinning methods was almost identical. The total production of wood biomass in thinned pole beech stands was similar to the production of unthinned stands. The differences between the stands thinned following different approaches were not unambiguous. The situation in the production of high-quality wood biomass is different. The best approach from this perspective seems to be the "loose thinning from above", which practically affects only the main canopy composed of promising trees. Special attention was paid to the research of thinnings in unhealthy stands, particularly to those affected by bark necrosis. In these stands, health condition of trees was used to select the trees to be thinned. Hence, all infected trees from the understorey were thinned, while from the main canopy only the trees in advanced disease stages were extracted. The thinning from above was found to have a more positive impact on the quality of wood production than the thinning from below also in unhealthy stands.

The theoretical outcome of the work is that it is not possible to significantly affect the total wood production by applying any of the examined thinning methods. No substantial differences were found between thinned and unthinned stands. The situation in the production of high-quality wood biomass is different. From this point of view, best results can be achieved when "loose thinning from above" is applied.

This is a practical outcome if the management goal is to produce high-quality wood biomass. Another important outcome from the economical point of view is the fact that in the case of "loose thinning from above" the interventions can be performed less frequently than thinning from below. A four-year long intervention interval between the second and third thinnings was found to be short and can be prolonged in healthy stands.

Intense approaches to grow poplar in Slovakia (Kohán et al. 1981)

After World War II, FS was obliged to produce large amount of wood for the national economy in a short time. Thus, in 50s of the last century cultivated poplar species were largely introduced and planted not only in forests but also on non-forest land. This led to the need to establish a specialised workplace, which would deal with all basic problems of this task. Hence, in the year 1952 the scope of the Research Station in Gabčíkovo was extended from dealing with windbreak forests to silviculture and cultivation of fast-growing tree species.

It was assumed that poplar would grow in SR at an area of 12,320 ha. The selected sites were located mainly in alluvial forests of Podunajská plain (57%), at Váh downstream (25%), and in Východslovenská plain (18%). The publication thoroughly evaluates performed research works as well as achieved outcomes over a period of almost 30 years. It is a summarising work dealing with intense approaches of growing poplar (lignin crops, intense crops, special crops for pulp production). Silvicultural technologies are described in detail starting with full-area soil preparation (stump extraction, levelling ground, deep soil loosening) to prospective technologies of full-area soil preparation. The methodology of monitoring intense approaches of poplar silviculture (regional and typological distribution of research plots, works on research plots, processing of measurements and observations) is presented separately. The next part evaluates achieved results (poplar growth, growing of agricultural crops, health status and protection of poplars, wood assortment structure and value production, thinning interventions, evaluation of special crops for pulp production). The economic evaluation of intense approaches of poplar growing is presented in a separate chapter. At the end, production methods and their variants applied for intense poplar growing are presented individually for rotation and pre-rotation harvest (assortment, stem and tree methods). For example, the research results determined the rotation age of lignin and intense crops to be 15 – 20 years, and 20 – 25 years, respectively. The production aims for round-wood assortments, particularly the logs of special quality. The rotation age for pulp production was determined to be 10 – 15 years. The average annual wood production was 20 – 25 m^3 per ha. Profitable cultivation of poplars was achieved if the total average increment equalled 10 m^3 per ha.

The important knowledge from the point of scientific progress is that intense poplar cultivation is possible only in several groups of forest types in alluvial forests. The poplar clones ´I–214´ and ´Robusta´ have the highest increments followed by ´Gelrica´ and ´Grandis´.

From the practical point of view, the important information is that positive outcomes can be achieved only under favourable natural conditions for poplar. In addition, technological steps of poplar cultivation need to be strictly followed. Currently, processing of poplar wood is problematic because the wood-processing factory in Štúrovo ceased its production. Another up-to-date problem is that nature protection movements promote a return to native poplar and willow species.

2.2. Forest protection

From the works dealing with forest protection research, we selected four areas, or three tree species, namely fir, oak, and poplar. The proportion of the first two tree species in Slovak forests is much lower than it is desirable. As for fir, its mass die-back (MDF) in the past resulted from a complex of factors, while its proportion in sub-optimal conditions was to a great extent reduced by defoliating insects. Currently, forest ruminants represent the biggest obstacle to increase its proportion. Oak species is in a similar situation. Mass die-back of oak (MDO) occurred in Slovakia in the first half of 80s of the last century. RIFS in Zvolen mobilised large research capacities to solve this problem. It was caused by a fungal disease (tracheomycosis), as well as by the outbreak of bark-beetles that carried this pathogen. Thanks to the thorough implementation of the research results this epidemic could be stopped. A very important lesson can be drawn from this issue, particularly from the approach how the problem was solved. Specifically said, if forests are under the risk of being affected by harmful agents, all available preventive, protective and defensive measures need to be performed as soon as possible. In other words, we should follow the "precautionary principle".

Fir moths in Slovakia (Patočka et al. 1960)

In the 50s of the last century, mass die-back of fir stands (MDF) occurred in Central and Eastern Slovakia. This was caused by large gradation of moths feeding on fir. Hence, RIFS in Banská Štiavnica was chosen to deal with this issue. The results of their investigation were summarised in the publication, the title of which has an amendment "with regard to the fauna of Central Europe" (the research was carried out also in other countries of Europe). The introduction of the work specifies the goal. Next, a large number of co-workers and institutions that cooperated in the research or publication preparation are listed. Then, the methods follow. The research results revealed that 40 different butterfly species occur on fir. The publication presents the number of butterflies by individual tree parts occupied by larvae. Next, systematic classification of these species is presented. From all listed species, three species (from the Tortricidae family) were identified as more severe pests on fir in Central Europe: two of them live in a web shelter spinned around needles (*Choristoneura murinana* (Hb.) and *Zeiraphera rufimitrana* (H. S.)), and one feeds on buds. Three other important pests were mentioned from Yugoslavia (*Epinotia proximana* H. S., *E. subsequana* (Hv.) and *Argyresthia fundella* F. R.). Quite severe damage of

fir seeds is caused by larvae of *Dioryctria abietella* (Den. et Schiff.). The work contains original identification keys of fir moth species, their pupae, larvae, caterpillars, coming out from photoeclectors in winter. All developmental stages are described for each species, as well as their bionomics, distribution, importance for forestry, and a list of parasitic insects. In the case of important pests, the data about their monitoring, prognosis and elimination is presented. In the case of the main pest *Choristoneura murinana* (Hb.), the questions of the past outbreaks, relationship between the outbreaks and the character of infested stands, stand disposition, foliage loss, and regenerative ability of fir are discussed. Economic losses on quantitative and value production caused by its feeding were also evaluated. In the future, occasional reproduction of the listed species was assumed. Chemical control of these pests remained an open question. Similarly, further solutions of stand disposition to damages caused by *Choristoneura murinana* (Hb.), fir regenerative ability, economic evaluation of damages, as well as other problems remained unsolved.

The work is beneficial from the theoretical point of view (for entomology, and forest protection in the case of MDF). Foreign entomologists from Central and Western Europe were highly interested in the results. The situation evolved in such a way that in sub-optimal conditions of Slovakia fir could not be preserved. Currently, fir dieback due to the reasons stated in the publication is not significant. Nevertheless, fir proportion is much lower than it would be desired. The increase in its proportion in optimal growth conditions is limited by game, which severely damages this species.

Natural enemies of fir pests (Čapek 1961)

This work follows the previous publication "Fir moths in Slovakia". It was an experiment aimed at the evaluation of the influence of several factors on the regulation of larvae and pupae of Lepidoptera pests, which were coresponsible for MDF. The attention was mainly paid to parasites. Individual pests are discussed in separate chapters. The work presents a complex of natural enemies of *Choristoneura murinana* Hb. (episites, parasites of larvae and pupae, hyperparasites) and *Epinotia nigricana* H. S. Special attention was paid to the impact of chemicals against *Choristoneura murinana* Hb. on its entomophags and on parasites of *E. nigricana*. The impact of DDT cold aerosol application on parasites in infested stands was examined. At the end it was stated that these chemical actions against *C. murinana* were highly efficient if applied in a suitable period, but had also severe negative influence since the caterpillars and predator larvae of *Dasytes coeruleus* F. beetle were killed. In the next part of the publication, insect parasites of other Lepidoptera on fir, and of moths are presented. The last chapter discusses syn-parasitic relationships of Lepidoptera on fir. It was revealed that the impact of natural factors on the population of a specific pest is very complex, affected by a whole set of different factors, and that it continually changes in time and space. The proportion of parasites and diseases responsible for the pest mortality can be determined relatively precisely if the bionomics of parasites, way of spreading and the course of the disease are known.

Apart from the specific conclusions related to MDF the most important revealed knowledge is that healthy and resistant fir stands can be grown only at sites, which meet ecological demands of this species. The work is important from the theoretical point of view. It is desirable to continue in the research, while the highest attention should be paid to pest diseases, and to suitable and practically applicable approaches to use them as biological control of pests.

Mass die-back of oaks in Slovakia (Čapek et al. 1985)

Oak die-back was first observed at the end of 70s of the last century, and it gradually turned into MDO at the beginning of 80s. The RIFS in Zvolen was obliged to put forward proposals how to deal with this negative situation. At the same time, its task was to manage practical implementation of the measures to save oak stands. A large number of institute workers participated in solving the issue (20 scientific workers). A summary work consists of ten chapters and presents the solution results. The first five chapters define problems, characterise oak species affected by die-back, describe the course and symptoms of the disease, the origin, spread and extent of die-back in Slovakia, the causes of the disease and its mass development, pathogens and associated diseases, insects, the impact of sites, stand structure, weather, and cleanliness in oak stands, and the impact of pollution.

The most important part of the work is devoted to protection and defence. It begins with restoration and maintaining the cleanliness in stands, emphasises its importance, states the risk if this principle is not kept, and finally discusses the responsibilities of the forestry practice. At the same time, the assumptions for restoration and maintenance of cleanliness in stands are presented. The next discussed issue is sanitation of barked oak wood. The following parts are: insecticides and equipment for chemical sanitation of oak wood, prevention of tree damage, treating stumps, silvicultural prevention, increasing the resistance and influencing the pathogens with boric acid, direct chemical control of oak bark beetle and other transporters and pests, biological protection, protection of seeds, and seedlings. The work continues with describing forest management in stands suffering from MDO. It includes the inventory of infested stands, management goals in oak stands suffering from MDO (target tree species composition, stocking, structure, production). Tending and regeneration principles in stands affected by MDO are presented separately (silvicultural technique, natural regeneration, planting, acorn collection, seed storage and preparation). These are followed by harvesting technologies and utilisation of wood from stands suffering from MDO (harvesting technologies in

pre-mature and mature stands, utilisation of merchantable and non-merchantable wood). The last part deals with the impact of MDO on forest economics. In that part, the costs for maintaining clean stands are presented, the costs of sanitation of trees affected by die-back are analysed, and the impact of sale of infested oak wood on its utilisation and on income in the year 1983.

The theoretical outcome of this work is that the pathogens, namely parasitic fungi from the *Ceratocystis* genus that cause oak tracheomycosis (vascular disease), were unambiguously identified. These fungi commonly occur in oak stands, but under normal weather conditions without any extreme events and under proper management they do not threaten healthy and viable individuals. Next, conditions suitable for disease spread are identified. An important outcome is the knowledge that when proper protection and defence measures are suggested and performed, it is possible to stop or at least to prevent the spread of such epidemics. It should be noted that on the base of the presented results and new knowledge an important publication about oak pests and their enemies was published (Patočka et al. 1999). Practical outcomes of the work that were achieved after the implementation of proposed measures can be evaluated exceptionally positively. High values of wood production as well as of ecological and environmental functions of these forest stands were saved.

Poplar protection (Leontovyč et al. 1959)

As we have already mentioned in the previous chapter, extensive introduction of cultivated poplars to SR started in 50s of the last century A serious issue was to protect cultivated poplar plantings against pests, diseases and damages. The presented work first presents the knowledge about the specific requirements of individual poplar clones on site conditions, particularly soil properties, ground water level, and climate. The next part deals with the principles of poplar protection against individual groups of harmful agents: abiotic, animal, and plant ones. The first group (abiotic factors) includes damages caused by frost, heat, drought, excess of moisture, hail, ice, wind, and lack of light. A position of damage on a tree (stem, tree rings, foliage, etc.) as well as the form of negative influence is characterised. Finally, particular protection measures are suggested. Usually, it is prevention, focusing mainly on the selection of suitable sites, silvicultural and protection measures at stand establishment, its tending and regeneration.

The second group (animals) contains mites, louse, and worms; pests of: buds, shoots, aments, foliage, roots, stems, and branches; rodents, and game. Individual pest species are listed together with their type of damage and type of protection (defence). Protection (defence) types are differentiated according to individual pests. In the case of insect pests, they include mainly chemical and mechanical methods. Effective measures against rodents (voles, mice) include keeping forest nurseries and plantings clean, and using suitable agrotechnics. Protection against game includes heavily branched seedlings, fences, bandages, chemical repellents.

The third group (plants) covers higher plants - weeds, and fungal and bacterial diseases. The first sub-group (higher plants) includes specific species bound to site conditions of alluvial forests (e.g. climbing plants). Different types of protection are presented. The second group (fungal and bacterial diseases) comprises pathogens causing falling of seedlings, diseases of: foliage, shoots, stems, roots; rots in stands on loading places. Similarly to the previous cases, types of protection and defence are presented. The second part of publication contains Directives for poplar protection. They specify the approaches against poplar pests, fungal and bacterial diseases, bark canker of poplars caused by *Dotichiza populea* Sacc. et Briard fungus, and brown slime flux of poplars. Directives include the rules for the import of poplar material from abroad with regard to protection.

From the theoretical point of view, the work is valuable because it describes the symptoms of brown slime flux on poplars in Slovakia and compares the symptoms with those of the disease caused by *Micrococcus populi* Delacroix bacteria. It was concluded that the symptoms of both diseases are so different that it is not possible for one organism to cause a disease with such different symptoms. Slime flux is also caused by bacteria, but the species is different and was not known at that time. To evaluate damage intensity, a scale was proposed. Symptoms of the disease were described verbally and were shown in photographs. The identification of cultivated and native poplars with the fastest progress of this disease was the important practical finding. It was revealed that tree position in a stand has a great influence on the infection degree. Emergent trees and trees of the main canopy suffer from slime flux less than trees in the understorey. At best sites, thinnings can reduce the harmfulness of slime flux. However, they need to be performed on time. The usefulness of the work for the present time depends on the fact what concept of using sites with optimal conditions for poplar cultivation is followed (more details in Cifra et al. 1982).

2.3. Forest management

The works that were included in this section can be divided into two groups. The first one covers the research of growth processes of tree species and stands, on the base of which uniform methodological instructions used for the elaboration of forest management (FM) works, mainly forest management plans, were prepared. These include e.g. tables for determination of volume and increments of forest stands – the final output was called "Tables of stand volume and increments" (1963). The most important task of a national character was the elaboration of national growth and yield tables. The work

on the task started in the year 1965. In the years 1965 – 1974, research plots were established and measurements were performed in the whole area of Czechoslovakia. The results were produced in the year 1979. In the following years, the measurements were repeated and the "Yield tables of main tree species of the Czechoslovak Socialistic Republic" (1987) were published and are presented here. On the base of their verification, 3rd edition was prepared, which started to be carried out together with the edition from the year 1987 in FM of SR in 1992. In those years, other significant works were prepared, particularly from the measurements performed on permanent research plots, e.g. thinnings in spruce stands of CSSR (1976), Height growth and stand structure (1978) – these are not presented in more detail here due to the limited extent of the contribution. Within the second group of tasks, the knowledge and results from almost all forestry fields were summarised or transferred for forest management purposes. In the year 1951, a large activity of establishing objects for the research of the selection management system was launched (Smolnická Huta, Biely Váh, Nižný Komárnik). A significant work of that period was "Empirical harvest indicator in the forests of CSSR" (1969). It was a new approach to determine harvests in a shelter-wood forest. With regard to the changed forest age structure, a new proposal of harvest determination has been recently prepared (2016), which should be put into force at latest legislative amendments.

Tables for determination of stand volume and increments (Halaj 1963)

The work is the second edition of "Tables of uniform volume curves" (the first edition was published in the year 1955). The first text part characterises volume tables. It describes uniform volume curves (for even-aged stands). This is followed by tariffs (function, properties, construction for stands, shift of height curves, their use), tariffs for uneven-aged (selection) stands (function, characteristics, construction for stands, shift of height curves, their use). In the second part, the method of tariff differences used to determine the current stand increment is presented. The method is mathematically derived in the work. The following text presents the determination of increments in even-aged and selection stands (using height tariffs, stem analyses, their comparison and use), determination of volume increments of even-aged and selection stands (common properties of derived methods, deriving unit volume increments for the tariffs of even-aged stands, for uniform volume curves, and for tariffs of selection forests, deriving of unit volume increment percent). Afterwards, the work presents the application of derived tables, which can be used to determine increments of even-aged and selection stands: the method of a mean stem to determine the increment of the whole stand (for even-aged stands), determining increments of even-aged and selection stands in diameter classes, and the accuracy of the derived methods. A large chapter is "Instructions for practical determination of volume and increments of even-aged and selection stands". To determine stand volume, mean (classification) diameter needs to be determined, tree heights need to be measured in a stand, and volume is calculated. The instructions how to determine diameter increments are more extensive. They include information about the required number of cores, the procedure of measuring diameter increments in a stand, office processing (determining diameter increment for a mean stem, for diameter classes). Next, the work presents the calculation of stand volume increment, globally for the whole stand – using methods of a mean stem (for even-aged stands), tariffs for even-aged stands, or using unit volume increment percent. The calculation of increments in diameter classes using unit volume increments and tariffs of selection stands, and unit volume increment percent is described. This is followed by tables (numerical data) for individual tree species.

It was a significant work both from the theoretical and practical point of view. It has been used during the preparation of forest management plans to determine growing stocks of individual forest stands.

Yield tables of main tree species of CSSR (Halaj et al. 1987)

They comprise original national tables for five main tree species (spruce, fir, pine, oak, beech) and modified tables taken from other sources for seven more tree species (Douglas fir, hornbeam, birch, coppiced oak, alder, black locust, poplar). The tables were derived within the research programme that was ongoing since the year 1965. An extensive research material from the whole CSR was collected. All scientific institutes, forestry faculties and institutes for FM, as well as forestry practice in the whole CSR participated in their processing. Coordination, inspection, and national united management of works was performed by the "Commission for yield tables", which consisted of the representatives of all participating institutions. The structure of yield tables of main tree species differed from the previous tables. In addition to the previous division into a main stand and a thinned part of the stand, a new main element called a combined stand (prior to thinning) was added to tables. Instead of relative site indices, absolute height site indices were applied. New volume units, such as the most important merchantable wood inside bark instead of the merchantable wood outside bark used before, were introduced. To allow processing of the whole tree volume, tree volume outside bark was also introduced to tables. The yield tables of other tree species were modified accordingly. For all tree species, inevitable figures were added to yield tables, namely height site index curves to determine site index on the base of a mean height of a combined stand (in the case of main tree species also on the base of top height), and graphs of growing stock of a combined stand (merchantable wood inside bark) in relation to age, height, site index (in the case of main tree species

for three volume levels). The publication also contains instructions for their use. Tree species site indices were determined on the base of age and height using height curves. For main tree species, two types of graphs for the determination of site index are available, one on the base of mean height, and the other for top height. Volume levels of tree species were identified on the base of management sets and growth regions. Three volume levels were introduced. Tables contain information for combined, main, and thinned stands, and total production.

The presented work was 2nd edition of yield tables (1st edition was of an experimental and research character). The tables were not implemented into practical FM in the whole CSR due to the objections of participants from CR to the content of the tables. Thus, in the year 1987, research activities were renewed to finalise the research programme. However, uniform country-wise solution was not achieved during these works either. The representatives of SR wanted to use all knowledge and experience acquired during the construction and verification of 2nd edition of yield tables and thus, they prepared 3rd edition of yield tables, which has been implemented in the forestry practice of SR together with 2nd edition since the year 1992. The 3rd edition of yield tables was published in the year 1998 (Halaj & Petráš 1998).

The research performed during the construction of national yield tables brought an extensive amount of new knowledge, which significantly contributed to the progress of forestry science. The outcomes have been used to solve research tasks in almost all areas of forestry science and research. Yield tables have been undoubtedly used in FM, as well as in forestry practice in general.

Empirical cutting indicator in forests of CSSR (Greguš 1969)

Introducing a small-scale shelter-wood system in accordance to Act No. 166/1960 coll. required to perform changes in harvest regulation. The author of the work proposed a new approach of harvest regulation on the base of an empirical cutting indicator. He first characterised harvest regulation in the past and at the time of problem solving. Then he listed the requirements for harvest regulation in a shelter-wood forest – to increase increments and quality of a parent stand, to ensure the establishment and good development of a subsequent stand, and finally to produce wood volume. It is a mutual ratio of components: growing stock – harvest – increment. The next part of the work describes empirical cutting percentage (proportion of prescribed allowable cut in a particular age class). It was revealed that cutting percentage increases with the increasing age, while the values are very similar in the same age class but in different management groups. It was found that the derived empirical cutting percentage can be used to reduce growing stock, which is in accordance with stand regeneration and simultaneous attempt to increase production amount and quality. From the point of the theoretical basics of harvest regulation, the author of the publication dealt with the beginning and end of the regeneration cycle, theoretical distribution of cutting percent, and their justification. The next chapter focuses on the management model of a shelter-wood forest. It presents its arrangement and the use of the model of a shelter-wood forest when dealing with the question of the level of implemented regenerated interventions in stands. Afterwards, the work evaluates the results of the verification of the cutting indicator on empirical material. It was revealed that by applying cutting percentage, the required distribution of age classes in a shelter-wood forest represented by the area ratio of age classes is achieved. At the end, the author suggested directives how to use the cutting indicator in FM practice. In the year 2008, he prepared the proposal of the "Complex harvest regulation in the long-term development of FM in Slovakia", and in the year 2016 the "Proposal of harvest regulation in Slovak forests".

Great attention has always been paid to the allowable cut. From the national perspective, a serious mistake has never been made in Slovakia. Therefore, harvest possibilities are currently much greater than in the past. Nevertheless, the issue needs to be further addressed because FM in Slovakia nowadays occurs in a critical phase due to disturbances.

Outcomes of clear-cut management at Research Base of Biely Váh (Greguš 1980)

The work is based on Act No. 100/1977 coll. and Decree No. 14/1978 coll. It characterises even-aged management system and its three forms (clear cut, shelter-wood, and combined strip clear cut and strip shelter-wood). It analyses past development of forests and FM, as well as natural, social, technical, and economic conditions of even-aged management at the Research Base of Biely Váh. Next, organisation of the research of even-aged management at this research object since the year 1955 is presented. The research outcomes are divided into two periods, 1955 – 1964 and 1965 – 1978. Management and research results from the second period and assessment of advantages and disadvantages of shelter-wood management is presented. The following part shows FM research results of even-aged management. First, it is the forest management concept of even-aged management, particularly shelter-wood management (it is based on a detailed assessment of the current and expected situation in FS, and its specific characteristics). The next part deals with the survey of forest state and of management conditions (spatial arrangement, forest management typology, forest management variables and indicators), determination of management goals (operational objectives, target arrangement of a management group), management planning (basic, framework, detailed), and management inspection (inspection of forest development, of how basic management principles are followed, how the plan of management measures is fulfilled). In addition, other research results originating from this research object (focusing on selection forest

management, Norway spruce provenances, spacings of Norway spruce, planting during the entire growing season, thinning treatments – IUFRO experiment, resistance of spruce stands to abiotic factors, optimal cohabitation of trees and game) are presented.

It is a significant work from the point of decision making about the suitability of management systems or the forms of even-aged management system in mountainous regions of Slovakia. Since the research was ongoing for a long time, it provided relevant results for the theoretical studies, as well as possibilities of their application in practical forestry. A new FM concept that integrates individual partial solutions (forest silviculture, protection, harvest technologies, as well as economic cost analysis) into a complex unit should be highlighted. It provided material for the establishment of integrated FM, which focuses on enhancing non-production forest functions. The principles of a biological value of a forest, and how to enhance ecological stability of a forest biome with regard to decisive harmful agents (mainly wind), the attempts to rationalise management interventions and maximise the use of modern technical equipment, and the principles of economic efficiency, etc. are characterised. From the practical point of view, the work was valuable because it formed basic material for the preparation of the Technical FM Guidebook (Lesoprojekt Zvolen 1984).

Management principles in Slovak forests affected by pollution (Grék et al. 1991)

In 80s of the last century, particularly in the second half of the respective decade, mass die-back of spruce stands started in Slovakia. Due to this, RIFS in Zvolen shifted a substantial part of research capacities to identify the origin of this situation and to search for the possibilities how to change this unfavourable state. The pollution impact on forest stands was identified as the main cause of MDS. The solution results were summarised in the presented work, which was prepared by a large team of RIFS workers. Emission load was presented, and pollution deposition types (acidic, alkaline, and ammoniacal) were characterised. With respect to this, threat zones of Slovak forests and the practical approach of their identification are presented. In acidic and alkaline pollution types, four threat zones were determined (A – heavily polluted areas, B – less exposed and partially protected areas, C – less polluted areas, D – protected areas in valleys with low pollution). Next, a practical approach how to determine threat zones is described. Separate parts of publication include the characterisation of stand stability under pollution load, and the evaluation of the health status of coniferous stands in Slovakia, and its link to pollution load. The next chapter deals with the risk of coniferous stands to be affected by abiotic harmful agents (three risk levels) and the consequence for management principles in polluted regions of Slovakia. It covers threat of mechanical damage of forest stands by wind, snow, and frost. Similarly, threat of damage caused by biotic harmful agents in coniferous stands was elaborated. It was concluded that from biotic pests, coniferous stands are most threatened by bark beetles and wood borers. Spruce bark beetle *Ips typographus* (L.). is the most important pest from the Scolytidae family in spruce stands of Slovakia. The most threatened regions were Orava and Spiš. Plantations of coniferous tree species were more and more threatened by sap beetles from *Hylastes* Er genus, and the large pine weevil – *Hylobius abietis* (L.). An important part of the publication discusses the principles of forest management planning in the stands affected by pollution. They contained basic decisions, operational goals, principles of framework and detailed planning according to pollution types, threat zones and stand types. Last chapters deal with forest establishment, tending, impact of pollution on game, protection and conservation of a gene pool of tree species, and with the principles of stand fertilisation in polluted areas.

This work substantially contributed to solving many problems of FS. The publication was prepared in close cooperation with workers of Lesoprojekt and practical foresters, who applied the mentioned results in practice. Already at the time of solving this issue, on April 20th, 1988, the Východoslovenský regional council in Košice declared an extreme threat of forests at an area of 180 thousand ha, where extensive measures were taken. Thanks to this, MDS was reduced and no outbreaks of other secondary harmful agents, particularly of bark-beetles, which are nowadays frequent, occurred.

2.4. Forest machinery and harvest and production technologies

With regard to production technologies, and the spread of technologies in FS, research in Slovakia focused on harvesting activities, mainly in broadleaved stands (wood felling, skidding, transport, and sorting on wood yards). The research was performed within the scope of FS scientific and research base. The tasks included solving of individual operations (wood felling, skidding, sorting, transport), as well as optimisation of technologies considering mutual relationships in the whole production processes (from felling up to supply to a customer). The research covered also proposals and designs of new machines and equipment for wood production, or adapters on mass-produced machinery and equipment. The producers were mainly engineering companies of state forests (Enginnering Company of State Forests in Slovenská Ľupča, Enterprise of technical development in Olomouc). The cooperation with industrial companies, mainly with Heavy Engineering Factory in Martin, was developed. RIFS in Zvolen specified requirements for the production of machinery and equipment for FS at home and abroad. Apart from that, RIFS closely participated in the development of this machinery or equipment, or organised its testing under specific natural conditions.

Special attention was paid to the research of optimal utilisation of wood, which was solved in cooperation with many non-sectoral institutions and organisations, particularly from wood-processing industry.

Felling, skidding and wood transport (Jančo 1977)

The work dealt with at that time progressive technologies and machines for felling, skidding, and wood transport in CSR and abroad. It consists of six chapters. The first chapter analyses wood production in pre-mature stands. It presents individual technologies, their comparison, advantages and disadvantages. It also includes the overview of technical parameters of machines, which were used for skidding in pre-mature and mature stands. It shows the combinations of technologies based on at that time existing and expected technology for wood production in coniferous stands. Next, the results from the comparison of technologies in broadleaved stands from the point of time consumption and work shift performance, energy consumption, financial costs and stand damage are presented. Summer felling of beech during the growing season is examined. The third part focuses on wood skidding. There was an attempt to replace horse skidding with a special terrain vehicle. In the next part, the authors deal with tractor skidding in flat and hilly terrains. Technologies are represented by machines that were used in our country and abroad. The overview of skidding with cable systems provides us with the information about the use of these machines at that time, as well as with the expected technical development in this area in future. Technical parameters of machines used at that time are listed. The fourth chapter deals with wood transport from the point of technologies, vehicles and their technical features for wood transport. The overview of used trucks, tractor units, semi-trailers, automotive winches, and hydraulic arms is shown in a table. The fifth chapter focuses on the aerial transport of wood using helicopters. Its practical implementation was problematic because of high financial operational costs. The sixth chapter focuses on the use of tree felling and multi-purpose (multi-operational) machines for wood harvesting. It contains a short overview of chain-saws, which are most wide spread mechanical means in FS. Their technical description is presented. It was stated that rapid technical development introduces a number of multi-purpose (multi-operational) machines and their combinations into forestry to increase work-shift performance, reduce labour input, and enhance working conditions of workers. These machines are highly demanding on work organisation, concentration of wood felling sites, corresponding qualification increase of those who operate them and maintain them in an operational state. With regard to the performed operations they are divided into the machines that fell and bunch, skid, de-branch, shorten stems, and sort assortments. A short technical description is presented for each group of machines or for individual types of machines.

The presented technologies, machines and devices were tested under specific conditions, not only with regard to their utilisation possibilities, but also from the point of their implementation efficiency. The works also proposed designs for construction modifications of machines, which were solved in a close cooperation with the engineering production sector, mainly engineering companies of state forests in SR and CR, as well as the companies of engineering industry, above all Heavy Engineering Factory in Martin and Automotive Factory in Kopřivnica.

Cable yarding of wood in mountainous areas (Roško 1970)

The work presents the principles and the peculiarities of accessibility of mountainous forests. It includes the steepness and rockiness of the terrain, which makes road construction difficult. In spite of that, roads are inevitable also in these areas. Road network in steep, so called skyline terrains, can be less dense, since a substantial part of transport is ensured by skyline systems. A large part of the publication deals with the static calculations of cable facilities. In the first place, it is the skyline, which represents a runway for load transport. When calculating the rope with fixed anchored ends, three different calculations are taken into account: static, geometric, and physical. The work contains formulas, as well as tables and nomograms, which can be used to simplify the calculations. The simplest approach is to use nomograms, which have satisfactory accuracy. Next, static calculation of anchors of the skyline is presented. They are dimensioned to maximum axial traction of the skyline, which is practically equal to the rope strength if the safety coefficient is taken into account. The design of the winch performance is based on the requirement of the maximum pulling force the winch has to develop to transport the loads of the suggested weight, and the requirements on the minimum winching speed of the main line needed for the load extraction from the stand with regard to work safety. The second part focuses on the construction and operation of cable systems. The commonly applied route is a straight line. However, in some cases the route cannot be straight. In such cases, jacks are used, which can be of two types: a hung one with a shape of ordinary or reduction jacks, which are adapted to angled routes; a bracket jack consisting of a bracket and a rail, while at the end of the bracket there is a ball pin that moves in a bed, which enables forced movement of the jack caused by the movement of the skyline or by passing the carriages through the support. The third part of the work comprises technological approaches. The working crew consists of a winch operator, a loading operator, a helper, and an unloading operator. Since each of them is at a different place, working operations are performed using signals. From the silvicultural point of view, wood extraction from the stand under the skyline is very important. The simplest harvesting approach is clear-felling. Only small clear cuts can be used for the regeneration of forest stands

in mountainous terrains. Shelter-wood management system is applied that includes opening of stands to promote natural regeneration, or establishing the starting points of natural regeneration in a parent stand, from which felled wood needs to be extracted.

It should be noted that the presented work discusses the issue not only theoretically but also practically. From the theoretical point of view, it comprises the proposals of static calculations of constructed cable systems including proposals for the simplification of these calculations. From the practical point of view, the designs of construction of cable systems as well as the proposals of technological approaches of skyline skidding of wood are important. Implementation of cable yarding reduced gravitation skidding of wood in mountainous terrain, which was ecologically inappropriate. At present, when finer forest management methods are becoming favoured, these technologies are prospective.

Wood transport. Machinery and technology of wood transport (Majkút 1973)

The publication characterises basic types of automotive vehicles: engine vehicles (trucks, tractor units), trailers and semi-trailers, and sets of vehicles (semi-trailers). Next, the operational conditions and principles, which need to be followed when selecting a particular vehicle, are presented. They include volumetric wood mass, its length and diameter, which determines the parameters of a vehicle (fuel wood, logs, poles), as well as the type of transport, if it is a short terrain transport of long-distance transport. Finally, it is noted that when selecting a suitable vehicle emphasis should be placed upon economy (consumption of fuel, lubricants, and tyres, vehicle performance, purchase price, service and maintenance costs, vehicle manipulability, and comfort of operators). Basic equipment for wood transport includes: vehicle facilities (bolsters, stakes, auxiliary control of semi-trailers), loaders (automotive loading reels, hydraulic arms), ancillary equipment (ancillary frames for hydraulic arms, sliding platforms for semi-trailers, transport of semi-trailers on the vehicle). Technologies of wood transport are characterised in detail. They include loading of poles (distribution of a set of vehicles, wood loading method, inspection of vehicle load and of a semi-trailer distance), loading of logs, kinematics of vehicle sets (movement of trailer and semi-trailer sets). Assessment of automotive transport is an important part of the work. This is based on a set of indicators that characterise the efficiency of transport process (ratio of productive and non-productive elements). They are following: vehicle drive time, breaks, loading works, vehicle downtime, average transport distance, load capacity of a vehicle, utilisation coefficients of: time, drive, load capacity. Then it is a vehicle performance, and work productivity. Finally, progress trends in wood transport are presented. At that time new types of vehicles are described: S 430, Škoda 101.10 and 101.60, Tatra 148, Tatra 813. Their technical data are characterised. In addition, the work deals with the development of hydraulic arms in FS, the use of which can reduce time losses when the vehicle stands, reduce work forces, and costs for loading and unloading.

Wood transport was solved at a state level (work division between sectoral research institutes in CR and SR). Production of mentioned motor vehicles was ensured by national companies belonging to the industry sector of CSR. Adaptation of these basic machines for FS, and production of some specific machines for FS was performed by engineering companies of state forests in CR (i.e. Factory of technical development in Olomouc) and in SR (Engineering Company of State Forests in Slovenská Ľupča). The same situation was in the case of machines and equipment for wood transport. The result was that wood transport from forest stands to the centralised expedition and conversion wood yard, from which wood was transported on railways or directly to a customer, was fully mechanised. It was a significant progress in comparison to the past, when animal power or wood floating were used to transport wood.

Technology of harvest and transport process of beech wood with sorting on a wood yard in the premises of customers (Kern et al. 1991)

The intention to reduce work load in the harvest and production process of FS, to increase high-quality assortment proportions, and to use felled dendromass in a more complex way, was put into practice by solving a research task in the eastern Slovakia in the second half of 80s of the last century. The RIFS in Zvolen was a responsible investigator, which solved it in cooperation with other 9 research, design and production organisations. The investigation started with the preparation of the concept of harvest, production and transport process of broadleaves (beech) with sorting on a trial conversion wood yard in the premises of a customer – a state factory of Bukóza, Vranov nad Topľou. This was followed by the analysis of machine structure and the proposal of a technology of wood harvest in a collection area (allowable cut, equipment for wood felling and skidding, the sets and technological methods), assessment of road network (basic transport vehicles were designed, and equipped with the adaptations for wood transport, the consumption of fuel was determined, and the benefits from the implementation of new technologies were presented). Afterwards, technologies and technical equipment for the production of assortments were designed. The model conversion wood yard was built: Two parts – pre-prototype for 30 thousand m^3 of wood per year, – a prototype for 170 thousand m^3 of wood per year. The machines and equipment for wood sorting were automatised. The machines were produced within the country: cranes with a grapple for wood, sorting lines, and splitters. Sorting lines were equipped with a control system, which used information technology to control the sorting process, to measure sorted stems to produce logs and to

determine their amount. The obtained information was transferred to a central computer, where the overview needed for the organisation of the whole wood yard was prepared. Finally, the issues of supply and demand relations in the case of wood supply from the wood yard, the issues of legal relations, the anticipated structure of supplies, the place of supply realisation and the wood prices were discussed.

It was the biggest research task the RIFS in Zvolen has ever solved (100 mill. Sk, i.e. more than 3 mill. Euro). The investigation resulted in the construction and opening of a fully automated turnkey wood yard. Almost all until then performed research solutions dealing with this issue as well as practical experience were summarised. It was a real model solution. The work can be regarded as a message for the present time how to innovate technologies or mutual bonds within the forestry-wood processing sector.

2.5. Forestry economics and politics

The works focusing on the economics of FS can be divided into two groups: The first group includes the analysis of the development of FS economics in CR and SR between the years 1950 and 1970, as well as the assumption of its development until the year 1980 (Hromada 1972). Two other works dealing with cost planning of FS in Slovakia (Pelcner 1972), and with a differential rent in CSR (Václav 1986) can be included in this group, too. These works were solving the problems of the sector in SR as well as in CSR of that time. They covered financial security of silvicultural and harvest activities, sectoral and enterprise economics – understandably in the frame of the directive management of FS at that time. Two other tasks focused on investigating conceptual questions of FS (Papánek 1978; Greguš 1987). The first one brought a new view on forest roles and on FS tasks linked to the future society requirements and needs. The work devoted to this issue was entitled "Theory and practice of functionally integrated FS". Although this work was published 30 years ago, it is still up-to-date. Many of the presented conceptual intentions have been practically applied via FM. The progress to apply the functionally integrated forest management to the economic mechanism of FS has not been achieved, and is an urgent issue to be solved. The second work "Strategy of FS" can also be positively evaluated. The presented conclusion was that further forest development, which is ensured by forest management, needs to be expanded to cover the trajectory of making prognoses about the development of all FS components in such a way that the sector would equal other sectors.

Analysis of the economic development of forestry sector in CR and SR (Hromada 1972)

The work consists of four parts: – State and dynamics of forest land. It examines the development between the years 1950 and 1970, as well as an assumption until the year 1980. Next, there is a frame prognosis until the year 2000. It characterises the development of forest land and its basic trends. It states that the values of individual indicators of FS (forest area, growing stock, harvest possibilities, etc.) increased. – Development and intensification of FS in CSR. It lists the problems during the development (exceeding allowable cut, insufficient wood utilisation, little care for forest land, lagging behind in the mechanisation, lack of workers, low salaries, etc.). Improving cadre and material conditions in forestry science and research is an example of positive changes. – Development of administration system of FS in CSR. Many changes in the organisation of production and technical base, planning, financing, system of personal and enterprise material involvement, etc. are presented. It is stated that the economic administration system of FS was enhanced at all its levels, and the planning system, financing and material involvement in production and economic results of enterprises and internal enterprise units were improved. – Problems of economic development of FS in CSR and SR. Some results from the evaluation of summary economic development in FS are presented. A positive development in spatial relationships and an increase of forest cover at a national level are pointed out. Nevertheless, the share of FS on domestic product and national income continuously decreased. From the point of profitability, SR lagged behind CR. Finally, it is stated that the increasing importance of non-material forest functions does not mean that the material production of FS will lose its significance. Moreover, economic development of society is inconceivable without more efficient utilisation of all natural sources, and hence also of wood and other material products forests provide. Fulfilling of forest functions in both areas cannot be seen in opposition. It is not an unsolvable discrepancy.

In general, it is a significant work that evaluates economic development of FS after World War II up to the year 1970. At the same time, prediction until the year 1980 and a general prognosis until the year 2000 are presented. We need to highlight the statement that forests were and particularly at present are considered an important part of the national wealth not only because they are sources of renewable wood material, but also because they are important positive factors of geographic environment in the life of society.

From the theoretical point of view, the work is valuable because it presents the methodology how the development of FS can be analysed. Next, it also shows how this analysis can be used to elaborate prognoses for future. From the practical point of view, the work is significant because it states not only positive aspects of development, but also problems and shortages that need to be solved.

The important statement for the present time is that from the economic point of view, wood production should not be underestimated. The presented development, mainly numerical data if combined with more recent years can be effectively used for future orientation of FS.

Planning of production costs in forestry sector at forest enterprise and forest district levels (Pelcner 1972)

The introductory part of the publication characterises forest production and its specific features. It is stated that forest production consists of silvicultural production or production of a forest, which can be called as organic production, and of industrial production of wood (mechanical production of wood). The problem is to quantify production costs of total forest production, because the production cycle lasts several decades. The work analyses possibilities to quantify forest production as a correlated variable to production costs (one summary indicator, measuring units of partial works, factors affecting costs). Next, it divides production costs on the base of their types, purposes, and other views, and presents their dynamics as well as principles, methods and stages of their planning. The goal of the work was set to determine the best, i.e. the most precise and the least laborious way of planning production consumption at a level of enterprises and districts of FS. Then, the work methodology, sources of information and approach of their processing, methods of evaluation of suitability of calculation units (one, more) and their system (one calculation unit, one calculation unit after excluding fixed costs, labour costs, material and energy consumption costs, planning of production costs according to cost types, direct costs according to activities, planning of production costs according to performance) are presented. The suitability of calculation units in individual systems presented above was assessed. The evaluation of systems of planning production costs on the base of the standard structure of production followed. It includes inter-enterprise variability of total costs converted to a standard structure of production according to systems, inter-annual variability of total costs converted to a standard structure of production according to systems, and assessment of systems according to moderate differentiation. At the end, the achieved results are summarised.

We agree that planning of production costs in FS is quite difficult because of high diversity of production conditions. In comparison to other sectors, the economic category of production costs is significant because the final effect of economy – the business result or gross product of FS can be enhanced with an intense approach, i.e. by saving of labour and material and energy consumption costs. Extensive improvement by increasing volume production and incomes is very restricted, because maximising of wood cutting depends on increment. Enhancing business outcomes by reducing labour and material and energy consumption costs can be characterised as absolute (social) efficiency, because saved sources remain available to society, unlike the increase of income for production, since in FS social values in an instant economic year are not created by better monetization, but by better manipulation of the existing harvest fund. Exact estimation of production consumption in plans is impossible because forest production occurs in nature at a great number of extremely different workplaces exposed to an infinite number of factors affecting production costs.

At the end we have to note that during the directive management when almost all forests were managed by state organisations, the solution of given problems was up-to-date and was useful from the theoretical as well as from the practical point of view. It is also true that forest functions and FS change as the society develops. Forest management focuses not only on wood production, but more and more also on ecological and environmental functions. The specific feature of FS is that positive results can be achieved only by ensuring long-term forest development, which is valid now and will remain valid also in the future.

Differential rent in forestry sector of CSR (Václav 1986)

The work deals with an important issue – a differential rent in FS, or its impact on the revenues of forest enterprises, and hence, also on their economic position. It contains 7 chapters. It begins with the characterisation of a differential rent from forest soil (conditions of its establishment, impact on revenues of forest enterprises, compensation of adverse impacts). Next, it presents the analysis of FS revenues in the former CSR at federal and national levels and specifies the need for differential compensation of wholesale prices of raw wood – year 1977, 1985, comparison of unit indicators. The returns of the enterprises of state forests in the former CSR were evaluated (years 1974 – 1984, verification of the specific need of differential compensation, trends in development of economic results). Specific attention was paid to the proposed economic indicator "tree species composition". Its establishment, importance, and results of the verification of its information value is presented. The temporal development of the economic indicator in the years 1977 to 1984 was evaluated. The following chapter is called "Preparation and assessment of unit tariffs of differential compensation". It deals with the standardised profit of enterprises of state forests from the production of raw wood, annual normatives of differential compensation of forest state enterprises, annual and unit normatives of differential compensation for forest state enterprises and a tariff book with unit tariffs of differential compensation. The end of the chapter evaluates the creation of unit tariffs of differential compensation in the future. The chapter "Subsidies to wood price" presents the values of subsidies to wood price and the way of their usage and accounting, quantifies the benefits of subsidies, and evaluates their efficiency. At the end, the proposals of the subsidies to income for the next years are presented. The final chapter of the work is "Utilisation of knowledge

about the impacts of differential rent in forest production". It deals with the utilisation of knowledge about the impacts of differential rent from the location and fertility.

It was a significant work from both the theoretical and practical points of view. It was published during the directive management of economy, also in FS. Although CSR was a federal republic after the year 1970 (with relatively independent national ministries of forestry and fishery sectors), economic efficiency was evaluated in the whole state following the same economic indicators. These did not account for the specific conditions of FS in SR and CR. The countries differ in natural conditions, tree species composition, accessibility of forest stands, etc. The impact of the differential rent penalised FS in SR in comparison to CR. Of course, this impact of the differential rent has existed also within specific economic subjects. Hence, there was an attempt to compensate these differences using a suitable approach.

The differential rent in FS was evaluated only on the base of incomes from the sale of products. After the change of the political system the impact of the differential rent on individual subjects managing forests was partially compensated from the "State fund of forest reclamation in SR" (Act No. 131/1991 coll., paragraph 4, letter a). When this fund was cancelled, this compensation also ceased. A positive change can occur only if fulfilling public services will be equal to providing material products (goods) - wood. Hence, the solution is to include public services of FS into an economic mechanism of FS.

Theory and practice of functionally integrated forest management (Papánek 1978)

The cited work contains main outcomes of the research performed in the years 1971 – 1976 dealing with complete regionalisation of forests in CSR according to their functions and the associated valuation of useful forest functions. It is an extensive work focusing on human environment, forest functions, and forest classification, integration of forest functions, their valuation, regionalisation according to prevailing functions and functionally integrated FS. The appendix contains valuations keys. It is a comprehensive work comprising such a great amount of information that it is difficult to summarise all its results. This is confirmed by author´s prologue and epilogue to the wok. Hence, here we present only a torso, i.e. a definition of functionally integrated FS: an optimal solution selected on the base of comparison and evaluation of different possibilities to combine various forest functions into a harmonic system of forest management. The main principles of this management are: universality – all forest functions, which depend on natural conditions and public interests, are considered, equivalence – all functions are quantified and measured in technical units and in monetary indicators used for mutual evaluation, analysis – their economic impact on benefit provision is determined, optimisation – the variant with best results and fewest sacrifices is selected, such a variant combines various forest functions in their optimum proportions, implementation – the variant is implemented in the forest management plan and consequently into practical forestry operations, it is a practical fulfilment of theoretical concept of forest management.

The work is theoretically valuable because it presents new content or mission of FS. Traditionally, FS is viewed as a sector of productive activities used to manage and utilise forests as sources of raw wood material. Although FS has long been restricted by law and has been bound to respect defined rules, all these constraints came from outside. FS as a productive sector has lived from selling its products, from this point of view the production function is the one that earns money, while non-production forest functions are burdens, i.e. they are not functionally equal.

Already this work has noted that there are no essential reasons why material and cultural services, which society requires from forests, could not be valued and hence equalised to wood production. It is also stated that the progress in the theory and practical forest valuation and in the methods of directing and financing of FS will no doubt solve this question.

Although this intention has not been fulfilled yet, the work has had a big influence on the practical forestry, forest development and FS. Forest management has been modified following this work. A proposal of differentiated forest management according to integrated functions was prepared at RIFS in Zvolen (Midriak et al. 1981). Functional types of forests were implemented in forest management. Consequently, prescribed management of forest stands was modified in forest management plans.

The work is nowadays important also from the point of practical forestry. We should go back to the ideas presented in the work because the situation in FS has lately been developing unfavourably. The specific features of this sector are not respected (on one hand FS is under high pressure of liberalism, while on the other hand great damages occur due to extreme nature protection approaches towards forests). The solution is to approve new state forestry politics followed by its thorough implementation in practical forestry. In addition, financing of forestry public service functions should be included into the economic mechanism of this sector.

Strategy of forestry sector in the Slovak Socialistic Republic (Greguš et al. 1987)

The work presented a proposal of a general trend of FS development oriented at basic needs of society at the beginning of the third millennium. In fact, it was a project of intensification of the whole FS, which consisted of six main programmes of relevant importance: 1. To create a forest that is a biologically valuable and stable ecological system satisfying all vital needs of society, 2. To increase increment and wood harvest, 3. To convert forest management to technically developed (mechanised) FS, 4. To equalise social care for FS workers to the level of other national economic sectors, 5. To increase economic efficiency of FS, 6. To enhance directing of FS.

Every main programme contained principal objectives (components): – 1st programme: to increase biological value of forests (a gene pool of tree species, seed management, forest nursery management, regeneration and tending of forest stands), to increase ecological stability of forests (protection against abiotic, biotic, and anthropogenic agents), to increase non-production forest functions (impact on air, water, soil, plants, animals, human environment), – 2nd programme: to increase forest increments (stand reconstruction, intensive stands, other approaches), to increase harvest and yield until the year 2000 (at regeneration and tending, modification of regeneration periods, intensity of wood harvest, complex utilisation of biomass), – 3rd programme: mechanisation of silvicultural activities (seed management, forest nursery management, reforestation, soil preparation, tending and protection of young stands), mechanisation of harvesting activities (techniques and technologies, power engineering, harvesting, wood sorting and transport, development and production of forest machinery, repair service, material and technical supplying and services), – 4th programme: to increase the care in the area of social structure, social conditions of workplaces, transport, nutrition, medical service, accommodation, off-work time, – 5th programme: to improve utilisation of forest production potential, to enhance methods of production measurements and economic stimulation, to rationalise production and organisation structure, – 6th programme: to enhance management organisation, to intensify impact of economic tools, to create an automated management system, to enhance planning and bonds with the complex of national economy.

The theoretical benefit of the work is in the elaboration of the systematics of the whole prognostic activity in FS. It consisted of three connected parts: a strategy that represents a basic trajectory of making prognoses (a general trend - a purpose and a goal, principles the sector should follow in the next decades); a prognosis that respects social, technical and economic conditions in the pre-defined time horizon; and a concept of FS, which is the last part of the work.

A positive effect of the existing strategy for practical forestry was that the state governmental structures supported development of forests and FS. Financial means were set off from the state budget for developmental (mainly public) tasks of this sector. After the change of the political system in the year 1989, state governmental structures declared the importance of forests for society, but this fact as well as other specific features have not been sufficiently accounted for any more. The volume of financial means allocated to the development of forests and FS and to the provision of public services has gradually decreased.

2.6. Hunting

The selected works can be divided into two groups. The first group contains research results dealing with individual game species and their management. The second group comprises materials that were used as a basis for guiding the development of hunting at individual levels of its management, or at individual levels of game management. From the first group we selected only one example focusing on roe deer. The attempt was to investigate the issue in a wider context, and not only some partial problems. Other game species were processed in the same way, but it was not possible to include them in the publication due to its limited extent. From the second group, two works were selected. Clearly, they were also based on the knowledge of individual game species. Nevertheless, main attention was paid to the analyses of the overall development of game in relationship to natural environment, and its carrying capacity. On the base of this, conceptual proposals, which ensure sustainable, rational, and systematic game management and their utilisation as natural wealth and as a part of natural ecosystems, were elaborated. This intention was fulfilled by the proposal of hunting regionalisation and site classification of hunting grounds in Slovakia (1974). The newest study was "Large-scale ecological game management within hunting regions and localities" (2004), which formed a basis for the concept of hunting development approved by the government of SR in the year 2017.

Studies of hunting regionalisation and site classification of hunting grounds in Slovakia (Škultéty et al. 1974)

The work was prepared as a reaction on high population of red deer, which exceeded the carrying capacity of the environment. This was the main reason of the growing damage of forest stands caused by red deer. In addition, negative effects on game quality were also observed. It was concluded that game management needs to be modified. To perform such changes, hunting regionalisation needs to be prepared and implemented. Three basic types of game management regions were created: one for red deer, one for roe deer, and one for small game. Too large regions were divided to sub-regions. In total, 30 regions were defined for red deer, out of which 7 were separate hunting regions, and 23 regions were divided into 50 sub-regions. For roe deer, 23 regions were established, out of which 11 hunting regions were divided into 34 sub-regions. For small game, 14 regions were specified, out of which 1 was separate, and the other 13 were divided into 37 sub-regions. Red deer regions cover 45% of the total hunting area, while the regions of roe deer and small game cover 29% and 26% of the area, respectively. An average area of a separate region or a sub-region for red deer, roe deer, and small game was 38 thousand ha, 30 thousand ha, and 32 thousand ha, respectively. Hunting commissions under regional councils should manage the populations of individual game species in the individual hunting regions. At the same time, the proposal

of directives for the management of hunting regions was presented. Next, protected areas (national parks, protected landscape areas, reserves), game reserves, protected hunting regions, pheasant reserves are characterised. This is followed by site classification of hunting grounds (classification of grounds into quality classes). More specifically, the groups of forest types and groups of agricultural site units are classified into quality classes. At the end, the proposal of Directives for the classification of hunting grounds into quality classes for forest game and field game is presented. In the case of forest game, general regulations specified classification, and specific regulations for individual species of forest game were proposed. Apart from that, regulations for mixed (combined) hunting grounds, game reserves, and small acclimation game reserves were presented. In the case of field game, specific regulations for individual species were listed. It was noted that commissions under district councils need to be created (from the particular subjects of interest) to classify hunting grounds to quality classes.

It was a significant progress in hunting from the theoretical as well as the practical point of view. From the theoretical benefits, we can mention a new approach to site classification of hunting grounds derived from natural conditions on forest and agricultural land. A practical intention was to harmonise actual population sizes with standardised stocks. Specifically, we need to point out at a conceptual approach to game management, which was supposed to be in harmony with the mission of FS and agriculture. As we will see in the description of the last significant hunting work (2004), the principles of large-scale ecological game management were elaborated on the base of forest regions, which formed a basis for the conception of hunting development that was approved by the government of SR in the year 2017.

Achieved results of roe deer research in Slovakia (Hell et al. 1980)

The work summarised all gained knowledge about roe deer in Slovakia. It includes the taxonomy of roe deer with the information about the average weight of a roebuck and a doe, dimensions of a body of roe deer (a length, a shoulder height, a back foot length, an earlobe length), parameters of a skull, teeth, hair, an average height of antlers. It was stated that based on the body size and antler size Slovak populations of roe deer occur in the middle of the range determined for this species. The evaluation of the existence of two types of skulls in roe deer populations in accordance to the Frankenberg hypothesis revealed that all skull measures and indices of Slovak populations are within the natural variability without any extreme deviations from the anticipated normal distribution. Determining the age of roe deer on the base of growth layers in dental cement is objective, but much more difficult than in the case of red deer (growth layers are significantly less visible and frequently branched and entwined together). When determining the age of caught roebucks on the base of pedicles it was concluded that using this approach we determine the number of antlers the caught buck had during its life. Hence, when determining the age in such a way, mistakes of one year more or less are possible. Roe deer antlers culminate in the 7th, 8th or 9th years of the bucks´ life if they are in good health conditions. The obtained results were used for the elaboration of the criteria for the selective cull in Slovakia. The analysis of the relationship of some craniological measurements and trophy quality of roebucks revealed that for the evaluation of the roe deer value in nature not only antlers need to be taken into account, but also the body size together with the age, and health conditions. Roebucks with above standard long and wide skulls in their age class have better preconditions to grow capital trophies than the bucks with below standard skull sizes. Fast increase of the number of caught "golden" roebucks in SR was observed after the year 1960, which was most probably related to the increase of roe deer population size, but also to the establishment of the field eco-form in optimum nutritious conditions, and possibly to the enhanced management of roe deer from the point of caring, selection, and increased interest for trophy hunting. At the same time, the overview of "golden" roe trophies from the SR area is presented there.

Comprehensive elaboration of the issue should be highlighted. From the theoretical point of view, the work is valuable mainly because partial problems logically follow one after another, the level of the current knowledge is characterised, the methodology of investigation is described, and finally new knowledge acquired during the investigation is summarised. From the practical point of view, it is important that the proposals of the measures to enhance caring for roe deer in individual hunting grounds of SR are presented. At present, it is good that future research and practical implementation of measures can built upon this knowledge, which was missing in the hunting literature before.

Large-scale ecological game management in hunting regions and localities (Hell et al. 2004)

Game management specified for individual hunting grounds has caused great problems, particularly in the case of large game species. There are several reasons for this. First, natural areas of these species are large and frequently exceed one hunting ground (they often cover two or more grounds or their parts). Hunting grounds are small. Their borders insufficiently fulfil game management and ecological requirements. Game migrates to find food sources, for trophical reasons, as well as during rut. Due to these reasons, there are problems with game counting and planning of hunting, selection, feeding, etc. It was concluded that these problems could be resolved or at least significantly eliminated by large-scale ecological game management within hunting regions or localities. The presented work comprehensively solves this issue. The boundaries of hunting regions and localities were

newly defined. In each region, the current situation of game management and natural environment was analysed. Specifically, the carrying capacity of hunting grounds in individual hunting regions and localities was evaluated, and on the base of this standardised population sizes were determined, as well as the measures to improve game management. The chapters about game management in individual hunting regions of red deer, roe deer, and small game, as well as in the localities for fallow deer and mouflon (in total there are 64 hunting regions, and 28 hunting localities) are the most important parts of the publication. The greatest problem is that the population sizes of hoofed game in SR highly exceed standardised sizes, and hence they cause great damages on forest stands and agricultural crops. The situation of small game is opposite; the actual population sizes are smaller than the standardised sizes. From rare species, chamois, wild cat, otter, capercaillie, black grouse, hazel grouse, and badger had lower populations sizes. On the contrary, population sizes of bear, wolf, lynx and fox species were higher. The proposal of organisation and management of hunting regions and localities was a very important part of the work. By implementing this proposal, it was planned that the actual population sizes of game would concord to the standardised sizes by the year 2025.

For the development of science and research, the work was valuable because it confirmed that the game should be considered as a natural source and as an important part of natural environment. Next, its utilisation needs to account for the ecological bonds with other components of natural environment. Game management should not disturb dynamic equilibrium in ecosystems. Biodiversity must be retained or promoted in both natural and artificial ecosystems, since it is a pre-condition for sustainable development.

The main practical benefit is the unambiguous definition of measures for game management not only at a level of SR, but also in hunting regions and localities. The work also presents a proposal of organisation and management of hunting regions and localities, which defined competencies and responsibilities of individual levels of state administration in hunting, as well as of hunting organisations and users of hunting grounds. Following the presented work, the concept of hunting development in SR, as well as changes in legislation, precisely in the law on hunting were suggested to be approved.

2.7. Natural environment

The selected works about natural environment focused on negative impacts of a complex of factors on soil. First, the attention is paid to the lands that were in the past degraded, became infertile, or were extensively managed, in order to enhance useful forest functions, to improve protection of natural resources, and to increase the cultural value of the landscape. Forestry research participated in the delimitation of non-forest land, and its reclamation mainly by afforestation. In such a way, forest cover in SR increased, which strengthened the overall potential of landscape. Considering the fact that water erosion caused the greatest soil damages, the greatest attention was paid to this issue. The published works dealing with this issue were of high quality and gained international appreciation. They were valuable not only for FS, but also for agriculture and the whole country. Similarly, the outcomes of avalanche investigations can be positively evaluated. The works identified conditions for their establishment, and presented the proposals of avalanche control measures. It should be highlighted that forestry research also dealt with the importance and usage of greenery for the landscape formation and nature protection. It was a multidisciplinary approach that evaluated vegetation cover as an important component of landscape formation and nature protection in greater or narrower contexts, and its importance for natural environment and usage in urban areas.

Afforestation of non-forest land (Zachar 1965)

With regard to the land arrangement, an extensive action of delimitation of non-forest land and its afforestation was ongoing in CSR (according to the approved proposal, 361 thousand ha of non-forest land were planned to be afforested in the years 1959 – 1980, out of which 262 thousand ha were in SR). The goal of the action was to utilise infertile or extensively managed, somehow degraded soils in the best possible way, to multiply useful forest functions, to improve and protect natural sources, and hence to increase the cultural value of our country. In most cases, the afforested non-forest land was the land that was degraded, unsuitable for agricultural production, with extreme qualities. It is not needed to highlight that the establishment of forest stands at such sites is more difficult, which in the first years of this action led to the failures and losses due to the lack of experience.

In the year 1961, RIFS initiated the investigation of the most suitable afforestation approaches, while in the years 1956 to 1960 the institute worked on the tasks about soil delimitation and erosion. The outcomes of this research are summarised in the publications of several authors, workers of RIFS (e.g. Zachar 1960; Kňazovický 1962; Intribus 1964 etc.). The presented publication contains mainly the outcomes of the research on afforestation of non-forest land in the years 1961 – 1963, although the author used literature sources of national and foreign authors and abundant experience of our forestry practice. The work first explains the term “non-forest land”, the types and the importance of afforestation, and then the attention is paid to the afforestation of non-forest land abroad and in CSR. From the point of classification, non-forest land covers wind-blown sands, saline soils, weedy land, and land covered by various shrubs, abandoned land (in our conditions, the most difficult to afforest are erosion rills, scree flows, gorges), landslides,

waterlogged non-forest land, rocky and scree soils, land degraded by industrial activities, and areas above the upper timber line that need forest protection. General principles of afforestation described in the work include the selection and mixture of tree species, approach and method of afforestation, material for afforestation, soil preparation, establishment of forest stands using agricultural cultures, soil amelioration for afforestation, soil compaction, afforestation techniques, seeding, planting, and protection of established stands.

The second part of the work describes special cases of afforestation, which are based on the biggest personal experience of the author. They include afforestation of not very fertile sandy soils, of saline soils, of abandoned land on dolomite bedrocks, limestone bedrocks, and other bedrocks, as well as afforestation at the upper timber line. For each case, tree species selection, afforestation approaches, avalanche control measures at afforestation, examples of afforestation and management of established stands are discussed. The last part of the work deals with the afforestation of other types of non-forest land. The table of afforestation of non-forest land (clearings) at extreme sites give a valuable overview of the knowledge.

The work comprehensively presents the discussed issue, which is valuable from the theoretical and the practical point of view, and the knowledge can be directly implemented in the forestry sector. In accordance to its conclusions, the first pre-condition for successful afforestation is thorough knowledge of site ecological conditions, as well as the knowledge of ecological demands of individual eco-types of forest tree species. The most important parts of the preparation works are soil preparation (treatment, amelioration, stabilisation, etc.) and the preparation of sufficient amount of high quality afforestation material. As the site becomes more extreme, ecological conditions must be examined more thoroughly and soil must be prepared more carefully. The work is valuable not only for forest silviculture, but mainly for natural environment from the point of fulfilling forest functions (mainly protective functions).

Soil erosion, 2nd edition (Zachar 1970)

Soil erosion has long been a global economic problem. At the beginning, we need to point out that the author laid with his work (together with the 1st edition, but mainly with the extended English version "Soil erosion" (Zachar 1982)) the scientific foundations of erodology (science on soil erosion) not only in Slovakia, but also in Europe. The second edition of the work consisting of seven chapters and 172 sub-chapters first presents the terminology and classification of erosion events according to the factor, form, intensity of material loss (mainly soil), eroded soils, erosion residues, sediments, and classification of eroded soils. Author´s proposals of classification are in many cases original (particularly those devoted to the evaluation of soil erosion intensity), and they were also applied in the works of his successors abroad. According to the human impact and harmfulness, he divides erosion into natural – normal (harmless) and abnormal (harmful), and modified – accelerated and decelerated (both are harmful). The next chapter is devoted to the research methods of soil erosion – here the author specified and described 14 separate methods of erodological research (nivelation, volumetric, deluometric, irrigation, monolitic, pedological, morphometric, hydrological, vegetation, photogrammetric, historical, dephlametric methods, methods for mapping erosion events, and complex methods), and he also applied some of them in his field or laboratory investigations.

The chapter about the results of the soil erosion investigation in SR is quite extensive – covering mainly the area of crystalline rocks in the Low Tatras, carbonate rocks of Kremnické vrchy, Brezovské Karpaty, Slovenský kras, then in the area of the flysch zone north of Prešov, of loess loam east of Sobrance, as well as the research from the cadasdre of Lučatín and Hiadeľ, from the surrounding of Hriňovská dam, and other sites. On the base of the data from 60s of the last century, the work considers that the area threatened by water erosion in SR is equal to 1.2 mill. ha (an underestimated value), which was 44.2% from the total area of the agricultural land, while wind erosion was a potential risk for 241 thousand ha. In the next chapter, the author evaluates the results of the soil erosion research in the Czech Republic, where it was assumed that water erosion threatened 21.5%, and wind erosion 12.2% of the total area of the country (in total 2.12 mill. ha of agricultural land in Czechia, and 3.1 mill. ha including Moravia). The most detrimental erosion was observed on abandoned land, where erosion had a long-term impact. It was again confirmed that pasture as a significant pre-condition of the occurrence of abandoned land reduces inhibitory effect of vegetation cover. At such land, the predominance of soil formation over its loss can be secured only by afforestation. The work presents a complex analysis and a summary of results, while a very valuable (quantitative and qualitative) overview of soil erosion abroad – almost on all continents, is given at 50 pages before the overall conclusion.

The work is more-less theoretical, but due to its quantitative but mainly qualitative analyses of soil erosion it greatly contributes not only to gaining new knowledge in erodology, but it is also a valuable basis for practical measures against erosion, above all afforestation. The work is illustrated with many photographs from the whole world and with a number of graphs.

Avalanches (Kňazovický 1967)

The research of avalanches (driven by several disasters caused by avalanches in Slovakia) led to the publication of this monograph. The work comprehensively presents the knowledge about snow avalanches, about the research methods as well as about practical avalanche control. From the whole publication we mainly point out at the

chapters about snow and its transformations, about the cause and conditions of avalanche occurrence (balance of tensions in snow cover, causes of its breaching, meteorological conditions for avalanche occurrence, impact of terrain morphology on avalanche occurrence, analysis of causes and conditions of avalanche disasters in the Alps in the year 1951), avalanche dynamics (movement speed and destructive dynamic influence of avalanches) and classification of avalanches. The most extensive part deals with meteorological and topographic conditions of avalanche occurrence in the Czechoslovak part of the Carpathians. The author performed a very valuable numerical (in a tabular form) and text hypsometric analysis of slope conditions of individual orographical units, where avalanches frequently occur (Malá Fatra, Veľká Fatra, Nízke Tatry, Západné Tatry a Belianske Tatry), and of the sizes of avalanche areas (their total area was stated to be 12,529 ha), and present topographical characterisation of important avalanche regions (the following work of the author is the Atlas of avalanche routes of SR, 1979). The work also analyses which meteorological conditions are favourable for the occurrence of snow avalanches in SR (on the base of the period 1951 – 1963), and examined the conditions of their occurrence in winters 1955/1956 and 1961/1962.

From the practical point of view, as well as from the point of FS (mainly afforestation in the regions, where the upper timber line was lowered due to human impact), an important part of the work deals with avalanche control. It evaluates the purpose and the classification of avalanche barriers: snow retention structures (supporting walls, snow bridges, snow nets, support barriers); retardation structures (stakes, terracing, earth retardation mounds, rock and concrete retardation barriers); barriers affecting snow distribution (snow fences and wind baffles); barriers that stop and deflect avalanches (snow sheds and nets, avalanche ditches, snow breakers, walls and galleries).

An important part of the work comprises an example of photogrammetric mapping of avalanche areas in Belianske Tatry, and an extensive appendix containing 101 photographs, pen drawings, and graphs, while the most useful supplement is the one consisting of 13 tables of morphological and topographic characteristics of typical avalanche areas, each represented with an aerial photograph of the particular area of the high mountain range and its hypsometric (contour line) assessment. The work laid foundations of scientific analysis of snow avalanches and practical avalanche control, and had its continuators at RIFS, and found its practical application in the Mountain Rescue Service (Centre of Avalanche Prevention Jasná).

Importance and utilisation of greenery in landscape formation (Petrík 1977)

The complexity of relationships in the area of understanding of human environment needs a multidisciplinary approach of its protection and formation. In this publication, the author evaluates landscape and vegetation cover as its important component in wider and closer contexts, its importance for environment, and application in urban areas. The work first analyses the relationships between landscape and urbanisation, defines landscape and its categories (natural landscape – forest and natural agricultural land, technical urban landscape - settlements and technical industrial landscape), as well as planning principles of landscape formation. A relatively extensive chapter is devoted to the importance and utilisation of vegetation in landscape formation. From the vegetation at open landscape, attention is paid to the vegetation of forested areas (from non-production forest functions it focuses on landscape formation functions – soil protection, soil formation, water management, reclamation, sanitation, refugial historic and climatic functions). Next, the work discusses vegetation of agricultural areas (permanent production crops – orchards, vineyards, hop fields; forest stands – mainly protective forest belts, accompanying vegetation of water courses and water areas – riverside stands), and specific parts are devoted to vegetation in protected landscape areas, and to vegetation in recreation and spa areas.

Following the general classification of vegetation, the publication deals with the structure of vegetation in urbanised environment (the relative, functionally linked structure of vegetation areas, the so-called efficient vegetation set, is decisive). The work presents the most frequent types of spatial distribution of vegetation areas – peripheral (circumferential), groupwise (patchy), central, zonal, linear. A separate chapter focuses on the vegetation at housing estates with regard to their types, as well as on the vegetation in industrial urbanised units. The longest chapter of the monograph deals with the hygienic significance of vegetation and its utilisation in the formation of urbanised environment. The work contains 14 sub-chapters, which present the impact of vegetation on micro-climate (on air temperature and humidity - verbal and numerical characteristics are given in a tabular form separately for cold, slightly warm and warm regions; on air movement), and the relationship of vegetation to air cleanness in a town, and the impact of vegetation on noise absorption. The work uses national and international literature sources, and can be recommended as a practical tool for planning and execution of landscape formation using forest and non-forest tree species.

3. Conclusion

The goal of the presented paper was to select the works from a great number of publications prepared by former workers of RIFS in Zvolen that thoroughly (comprehensively) dealt with individual thematic areas, and are valuable for the development of science, research, and practical forestry, and are still up-to-date.

As we have already written, it is only a selection of investigated tasks. Many works could not be included due to the limited length of the paper, particularly biological works, which prevailed (e.g. from genetics and cultivation those that dealt with other tree species, selective trees, seed plantations; from forest silviculture those focusing on forest nursery management, establishment of forest stands, regulating growth processes of other tree species in stands; from forest protection those about seed protection, protection against game damage), and forest construction works. We also significantly reduced the important works from forest machinery and forestry economics. We wanted to point out at a wide range of problems, which need to be solved if permanent sustainable development of forests and FS in Slovakia is to be ensured.

We think that even from the presented torso of investigated problems and achieved results we can conclude that the sectoral scientific base was in the past built to such a level that it significantly positively affected not only the development of forestry science and research, but also of forests and FS in Slovakia. Therefore, our ancestors deserve our great gratitude and respect for the performed work. Young generation should build upon what was achieved in the past, and where it is effective, they should continue in problem investigation. At the same time, the sectoral ministry should secure necessary financial and technical conditions for further development of research in FS.

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Appendix tables

Table A1. List of some selected (no longer living) workers of the Forest Research Institute in Zvolen, who elaborated significant works dealing with forests and forestry sector in Slovakia in the second half of the 20th century.

Personality name	Activity area of a worker	Main focus of a worker	Activity period during 20th century				
			50.	60.	70.	80.	90.
Čapek Miroslav	Forest protection and entomology	Biological control of pests					
Greguš Tibérius	Forest management	Shelter-wood forestry					
Grék Ján	Forest management	Operational goals					
Halaj Ján	Forest management	Growth processes, biometry					
Hell Pavel	Hunting and zoology	Game management					
Holubčík Milan	Biology, genetics, cultivation	Genetic variability of spruce					
Hromada Eligius	Forestry economics	Complex economic analyses					
Jančo Jozef	Forest machinery	Wood felling and skidding					
Kern Jozef	Forest machinery	Wood yards, sorting					
Kňazovický Ladislav	Natural environment	Avalanche occurrence and consequences					
Kohán Štefan	Forest silviculture	Fast-growing tree species					
Laffers Anton	Genetics and cultivation	Eco-types of pine					
Leontovyč Roman	Forest protection	Diseases of fast-growing tree species					
Majkút Štefan	Forest machinery	Wood transport					
Papánek František	Forestry economics	Functionally integrated forestry					
Patočka Jan	Forest protection and entomology	Forest moth pests					
Pelcner Július	Forestry economics	Sector economics					
Petrík Ľudovít	Natural environment	Importance of greenery in landscape formation					
Roško Pavel	Forest machinery	Wood skidding, skylines					
Škultéty Jozef	Hunting and zoology	Biology of wild game					
Šťastný Tibor	Biology, genetics, cultivation	Genetics, cultivation of larch					
Štefančík Ladislav	Forest silviculture	Tending of beech stands					
Václav Vladimír	Forestry economics	Differential rent in FS					
Zachar Dušan	Natural environment	Ameliorations, soil erosion					

Explanatory notes:

A person was active at FRI during the whole decade.

A person was active at FRI during a part the of decade.

A person was not active at FRI in the particular decade.

Table A2. List of abbreviations used in the text.

Abbreviation	Meaning
CR	Czech Republic
CSR	Czechoslovakia – general term (regardless of the period)
1st CSR	First Czechoslovak Republic (period between 1918 and 1938)
CSSR	Czechoslovak Socialist Republic
FM	Forest management
FRI	Forest Research Institute (name of the organisation used since the year 1991)
FS	Forestry sector
IUFRO	International Union of Forest Research Organizations
MDF	Mass dieback of fir
MDO	Mass dieback of oak
MDS	Mass dieback of spruce
RIFS	Research Institute of Forestry Sector (former name of the organisation used till 1990)
SR	Slovak Republic