

Scientific Activities of Forest Faculty

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Abstract. The article presents a systematic evaluation of the research carried out at the Forest Faculty since Latvia regained its independence. The research has been arranged in two groups: the forestry group and wood processing group. The following major directions of research have been reflected: the evaluation of forest and wood raw material resources, forest inventory and management planning, evaluation of volume and quality of the growing trees and harvested round timber, silviculture and forest ecology, complex evaluation of the quality of wood from commercial tree species, the expansion of the diversity of complex utilization of wood, inventory of timber flow and simulation.

Key words: main research fields, timber volume, quality, forest inventory, wood science and processing.

Introduction

The forest sector which is based on local renewable resources is one of the leading sectors here in Latvia with the fastest development, which has recently occurred during the years of independence. That is the reason why the research in the fields of forest science and complex utilization of wood are among the priority support themes.

When evaluating the scientific activities the whole period of Latvia's independence can be divided into three separate periods:

1. From 1990 to 1995 the academic staff were involved in the elaboration of legislation of a new faculty, forest policy, laws and regulations, national standards and the sector's development of a programme (masterplan). In this period fundamental scientific research could not be carried out due to lack of finances and human resources.
2. From 1995 to 1999, positive tendencies started to take shape in the development of scientific research. Under the leadership of professor H. Tuherms, the section "The complex and perspective evaluation of wood as a material" was carried out. The research was carried out in cooperation with the Latvian State Institute of Wood Chemistry and Latvian State Forest Research Institute "Silava". It was devoted to the evaluation of the quality of pine and spruce wood, characterization of physical and mechanical properties and explanation of anatomical and chemical composition. During that period the following questions were also addressed:
 1. Sewage sludge usage in fertilizing tree nurseries and forests (under the leadership of professor I. Mangalis).
 2. Evaluation of the current standing timber (volume) increment (Prof.I.Liepa).
 3. Elaboration of sawnwood drying procedures (associate prof. J.Staprāns).
 4. Forest policy and the role of the state in supporting private forestry (prof.H.Tuherms).
3. The third period started in the year 2000 when the leading enterprise of the woodprocessing sector SC „Latvijas Finieris” started to show interest in financial support of the elaboration of market oriented research programme "Physical mechanical properties of birch wood and birch plywood depending on the growing conditions of trees and plywood manufacturing technology". A further rapid development of science was delineated by the establishment of the Forest Development Fund at the Ministry of Agriculture and SC „Latvijas valsts meži” – "Latvian State Forests" involvement in the financing of scientific research orders. Consequently, the subject-matter of research expanded rapidly.

The scientific subject-matters researched at the Forest faculty can be divided into two groups: the forestry group, which pertains mainly to the Silviculture and Forest utilization department and wood processing field, where the Department Wood Processing

is involved as well as Forest and Wood Products Research and Development Institute (MeKA).

Description of forestry research

The scientific activities of the academic staff of the Forestry and Forest Utilization departments took place in 4 research directions:

1. Evaluation of forest and wood raw material resources.
2. Forest inventory and management planning.
3. Evaluation of growing tree's and prepared round timber's volume and quality.
4. Silviculture and forest ecology.

Evaluation of forest and wood raw material resources

In forecasting the development of the forest sector and evaluation of the carbon cycle, it is important to clarify the wood resources in the forest, the structure and amount of round timber, the types, amount and the directions of the utilization of residues derived from wood processing.

Professor I.Liepa (2008), has calculated and analysed the actual forest growth of pine and spruce using the complicated and differentiated method of growth –increment calculation. That is the difference between the potential growth increment from which the deadwood of the forest growth and the annual amount of the volume felled are deducted.

According to the data of 2005, it was stated that in the coniferous forests of Latvia 11.95mil. m³ of the standing volume of timber is formed annually and 2.06 mil. m³ die, which results in 9.89 mil.m³ of a natural annual increment. Deducting the fellings, the actual annual increment is obtained in all the coniferous forests, which is 4.26 mil.m³. Since the commercial forests of Latvia account for 82% of all the forests, the actual increment of standing volume of timber in these forests is 3 mil.m³, which is considered to be a reserve of balanced use of the standing volume.

The second direction of the research carried under the leadership of professor I.Liepa is connected with the evaluation of carbon attraction in the surface parts of trees and roots (Liepa, Blija, 2008).

The need for clarifying the biomass of the whole stand has become very topical over the last 10 – 15 years, when it was provided by the activities of the Kyoto protocol. The aim of the protocol is to reduce the effect of the emissions of gases causing the greenhouse effect. The countries which have supported the protocol (Latvia ratified it in 2002) have to systematically evaluate the capacity and dynamics of gas emission and accumulation that cause the greenhouse effect.

Forests are the chief attractors of carbon among dry land ecosystems. In the research on the structure of Latvia's spruce forest tree biomass, choosing sample trees in the three most widespread forest types (Oxalidosa, Myrtilloso-sphagnosa and Myrtillosa mel.) transitional coefficients were obtained for calculating the amount of different parts of the tree.

The total amount of Latvia spruce is 117.095 mil. t from which 60.2 % is trunk, but 39.8 % is a non-trunk fraction part. These data characterize the reserve of the commercial use of forest and are the out-going basic data for calculating the amount of the accumulated carbon.

Under the leadership of profesor L. Līpiņš in 2003 and 2004 the research on the structure of the wood raw material sources and the effective use of it was carried out. The necessity of this research was determined by the substantial changes in both – wood treatment and wood processing types and technologies. The diversity of the use as well as the total amount of wood increased. More and more thinner and shorter trees were delivered for processing. Debarking of round timber, manufacturing of pulp chips and granulating and briquetting of wood processing residues was being introduced on a wider scale. The use of wood residues and low value wood for generating heat energy increased.

It has been stated in the research that in the prepared round timber amount 80 % of timber is obtained from the final felling. This proportion does not differ in state owned and private forests.

Regarding the assortment structure, the greatest proportion is made up by the assortments used for sawing – 51.5 %, followed by pulpwood - 31.7 %, firewood – 10.2 % and veneer logs – 6.0 %.

The structure of round timber in the final felling in state and private forests does not differ substantially. The round timber structure differs in state and private forests in intermediate fellings. In state forests the yield of small-sized logs is $9 \div 18$ % higher, while in private forests the yield of deciduous firewood is twice as high as in state forests.

The balance for round timber has been made, taking into consideration the import and export volumes. The total volume of residues after felling and that which is of potential use has been estimated. The balance of wood resources used for generating heat energy has been made (4.66 mil. m³ 2003), where residues from wood processing make up the greatest proportion – 1.57 mil.m³, firewood - 1.3 mil.m³ and felling residues – 0.89 mil.m³.

The output, residue structure, amount and utilization trends of the products obtained from woodcutting, veneer and plywood manufacturing, matches and charcoal production as well as fibreboard manufacturing have been estimated.

It has been calculated that the income from 1 m³ of processed veneer logs for plywood production is 115 LVL (164 EUR), that is twice as much as in wood sawing, but 7 times less than in producing veneer for furniture finishing.

Forest inventory and forest management planning

In 2004 under the leadership of the Dean of the Forest faculty asoc. professor D. Dubrovskis, a research group "Precise Forestry Research Group" was established at the Latvia University of Agriculture in cooperation with the staff of Forest and Information Technology faculties. The necessity of establishing such a group was motivated by the rapid development of information technology worldwide over the last decade. It provides the development of new solutions to forest and wood resources inventory, planning, analysis, and control. The aim of the project group is to carry out research on forest inventory and planning processes, demonstrate innovative solutions and increase the competencies of the employees and students of the forest sector. The research group has the following aims:

- forest inventory which includes the development of measuring instruments and the development of forest inventory and wood resources measurement methods;
- planning of forest management, which includes the development of new methods and new generation software;
- forest logistics, which includes the research into the processes of timber preparation and transportation, simulation and creating an information technology support system.

The research group has carried out the projects ordered by the SC Latvia's State Forests, Ministries of Agriculture, Environment, Education and Science and Metrum Ltd., as a result of which several prototypes of computer software and programmes have been created:

- „Ozolin's algorithm beta version" (virtual measurement) – a programme prototype developed for the evaluation of the felling site fund to forecast SC „Latvia's State Forests" round timber supply;
- „Mežvārte"- the software developed for evaluating the fund of the felling site, which includes the analysis of the virtual measurement analysis of trees, forecasting the round timber output and the calculation of the felling site value. The programme can be used for private forest evaluation and in evaluating the amount of compensation for the protected territories;
- „Meža eksperts" – forest inventory, a forest ownership evaluation and forest management planning software programme, which was developed for planning forest property management, assessing the value of the forest property and for registration and control of economic activities. The programme is used for providing private forest management for both individual forest properties and combined forest properties. Currently, the users of the programme are private forest owners, associations of forest owners, assessors of real estate and providers of forest consulting services;
- „MAPIS"- the use of the forest management planning information system Web for education of private forest owners, forest evaluation and forest management planning. The forest owners can get free access to the programme through the Internet. Through this programme forest owners can become acquainted with the

planning principles of forest property management in a practical way and prepare the forest management plan for their property;

- „Kokmateriālu plūsma beta versija” – the support programme prototype of decision making in optimization of round timber transportation and sales. The prototype of the programme is developed as a simulation model of forest logistics processes. This programme will enable the forest owner or logging enterprise to calculate the optimal round timber structure and determine the optimal delivery enterprises.

Taking into account quite a substantial subjective factor and the influence of accidental errors in forest inventory, solutions are being researched to improve or replace the existing methods with less labour consuming semi-automated and automated methods. Here one should mention the study of the remote sensing method.

Up to now the use of satellite photos in forest inventory and forest management control has been studied. The use of LIDAR (laserscanning technology) in forest inventory and determining the growth parameters as well as the use of unmanned aerial vehicles in forest inventory and management control, the solutions to recognize the photos have been worked out. The programmes of accumulating and processing of the data of forestry measuring tools have been developed.

Evaluation of volume and quality of growing trees and prepared round timber

A group of researchers under the leadership of professor L. Līpiņš, within the framework of national research programmes, has explained the dimensional and qualitative evaluation of pine, spruce, birch, aspen and grey alder trunks. The occurrence of defects in wood, branching characteristics, as well as factors influencing rot and the relationship with the trees dimensional characteristics (the proportion of height and diameter, the length of the green crown part and the size of the branchless part of the trunk, etc.) have been clarified (Līpiņš, Sarmulis, 2002, 2005).

It has been stated that for each tree species the trunk quality and wood value is determined by different factors. The trunks of our major coniferous trees are straight. Since fungal damages to pine, including rot, occur quite seldom, the major factor influencing the evaluation of quality is branching, particularly the length of the branchless part. In the case of spruce, the occurrence of fungal damage is an important defect in wood, and the branching influences wood quality of the trunk to a lesser extent than in the case of pine.

In the case of birch and aspen, the most essential factors are the occurrences of fungal damage, followed by crookedness and branching. The resulting marketable timber and the value of trunk wood in grey alder are determined by the diameter of the trunk and crookedness, but the influence of branching is considerably smaller. A more detailed description of findings can be found in the collections of scientific articles.

In the framework of the market oriented research programme, in the years 2004 and 2005, under the leadership of professors L. Līpiņš and I. Liepa, broad research was carried out on the interdependence of industrial tree species' bark thickness and changes in taper depending on the round timber diameter and length and taking into account the region of tree growth and the location in the trunk.

The necessity of the research was determined by the situation that existed in the manufacturing, when a new national standard „Round timber measuring” was approved in 2003, which complied to the European standards. The new standards provided for different principles of measuring round timber parameters. It was impossible to be applied in Latvia since there were no adequate regulations here.

In the course of research, it was stated that the region of tree growth does not influence the indicators of bark thickness and taper coefficient, therefore the measurements obtained in different regions of Latvia were combined in a common data bank, that enhances the credibility of the data obtained.

The mathematical processing of data proves that the thickness of pine and birch round timber bark is influenced both by the place on the trunk (the assortments prepared from the trunk butt-end, middle and top of the tree) and by the diameter in the place of the measurement. In spruce, aspen and alder the thickness of bark is not influenced by the location in the trunk, because the bark is uniform over the whole length of these tree species.

The paper presents mathematical correlations for evaluation of bark double thickness in mm and %, depending on the diameter in the place of the measurement, as well as the volume in %. Tables have been made up to select the indicators.

Mathematical correlations are used in an automatic measurement processes of round timber.

It has been stated that the timber taper is considerably influenced by the tree species, location in the trunk, diameter and length.

According to the obtained taper indicators, new original round timber volume tables were developed, where the diameter at the smaller end was used for determining the volume. When checking the accuracy of the tables for measuring 30 m³ volume (one truck load), it was found that the volume obtained from coniferous logs was with twice a smaller error, but for birch veneer logs a four times smaller error than determining the volume according to the middle part diameter, which is practiced in most Western European countries.

Mathematical correlations between packing case logs, small diameter logs, match logs pulpwood and stacks of firewood loaded timber of average diameter and capacity coefficient have been found. The option tables of capacity coefficients have been made up where the evaluation of the stacking quality has been included as an additional factor.

A new, simple and inexpensive method for calculating the capacity coefficient has been proved as useful, using digital photos and net graphical design. It can be used for both – timber loaded onto trucks and for big timber stacks. The results of the research are summarized in the book under the title „The measurement of round timber“(2007).

Silviculture and Forest Ecology

At the Department of Silviculture regular repeated research on the growth of introduced tree species, the structure and productivity of stands is carried out at the Forest research station of the Šķēde forest area under the leadership of professor A. Dreimanis

The introduced species extend the variety of tree species and in many areas it provides valuable wood production for practical use. The first plantings of the introduced tree species in the Forest research station of the Šķēde forest area were carried out at the end of the 19th century and a lot of the stands are over 100 years old. In the forest area one can find valuable, biologically significant and productive forest stands of European beech, European white fir, European larch, red oak, Weymouth pine, Douglas fir and other tree species. The results of the research from the last decade have been collected and summarized in several publications (Dreimanis, 2001; 2006, Dreimanis, Šulcs, 2006). In the conditions of Talsi hilly relief, these species have reached high productivity and they have a high resistance to frost, but thicker trees may have a volume of 6-8 m³.

The productivity and structure of grey alder has also been described in the context of growing biomass (Miezīte, Dreimanis 2008).

Grey alder had not been thoroughly researched for almost 50 years in Latvia. It was considered to be a less significant tree species. Due to the limited resources of fossil fuel, it has the capability to produce biomass for obtaining chipped wood for fuel. At the beginning of the 21st century grey alder occupied 4th place among other tree species by the stand area which was 190.6 th.ha (data of 2006). Empirical formulas have been developed during the research process for the determination of leafless growth above the ground biomass of grey alder in freshly cut and absolutely dry conditions in trees with a diameter of up to 26 cm. Mathematical models have been developed for calculating biomass of grey alder stands depending on the average diameter of the stand and basal area. The distribution of the number of trees by diameter stages, the length of the green crown and cumulative frequency values of the number of trees, basal area and growing timber have been studied (Miezīte, Dreimanis, 2008). The average increment of most stands are within the limits of 5 – 10 t ha⁻¹ per year.

In natural biotopes of different tree species the occurrence of lichen species has been studied. (I.Straupe, J.Donis).

The diversity of species and environment quality are characterized by the occurrence of lichen species in natural forest biotopes, where the anthropogenic influence is smaller. Thirteen lichen species have been found in pine natural biotopes. Their exposition on pine and spruce at different heights of the trunk depending on the points and ecological factors (has been clarified (Straupe, Donis, 2006).

In oak natural biotopes 28 lichen species have been found. The variety of these species at the height of 0.5 m is smaller than at the height of 1.5 m. It is connected with the physical differences of the bark at different ages of trees. (Straupe, Donis, 2007).

Overall, in the sites of black alder 6 lichen species belonging to 6 genera have been found. The epiphyte lichen identified in the sites are morphologically divided into: crustose lichen – three species (50 %), foliose lichen – two species (33 %) and fruticose lichen – one species (17 %), *Arthonia spadicea* and *Glyphis scripta*, which in natural forest biotopes indicate suitable conditions for particularly endangered species – special biotope species and testify for high humidity of the air in the stand. In addition, *Arthonia spadicea* is a particularly protected species in Latvia. Black alder forests in Latvia are very significant areas for biological diversity. This is proved by the results of the research: in black alder sites there is a greater variety of epiphyte lichen in comparison to the researched spruce sites, which corresponds to the data described in literature.

Research into wood processing

The Department of Wood Processing together with the Institute MeKA, other departments and institutes directed their research in the following major directions:

1. Complex research programmes on industrially significant tree species in an operational chain: forest – wood- end product – market requirements.
2. Expanding the versatility of the use of wood.
3. Inventory of timber flow and simulation.

Complex research programmes

From 1995 to 1999, under the leadership of professor H. Tuherms a part of the research programme "Complex and Perspective Evaluation of Wood as a Material" was carried out. The research explained the dimensional and qualitative evaluation of the wood from the trunks of pine and spruce which were grown in different conditions, differences in anatomical composition, differences of physical properties (colour, moisture content, density), mechanical properties (ultimate strength and modulus of elasticity at different loading types), the output of sawnwood and distribution according to quality, the possibilities of improving the timber drying process and the protection of construction timber from biodegradation.

The obtained results proved high quality parameters of Latvia's softwoods and its competitiveness in the world markets.

Over the period of 2000 – 2005, a market oriented research project was implemented "Qualitative Indicators of Birch Wood and Birch Plywood Depending on Growing Conditions of Trees and Plywood Production Technology" (head of the project – professor H. Tuherms). This project was suggested and co-financed by SC „Latvijas Finieris“. The research programme was carried out in three stages. For each stage the tasks were clearly specified. As a result of the research, recommendations for growing high quality birch wood, the dimensional and qualitative evaluation of the birch trunk wood veneer logs from the merchandise point of view. Research on imported birch veneer log parameters, birch wood and birch plywood physical-mechanical properties was also carried out (Миончинскис и др., 2004). The methodology for forecasting the mechanical properties of plywood and calculating standard timber constructions with plywood elements, the changes of optical properties of birch veneer and plywood depending on veneer exposure after peeling, seasoning procedures and veneer exposure after drying, complex research has been developed on the use of birch plywood in interior furnishing and producing cargo containers.

Using the results obtained from the research on the physical, mechanical and visual properties of the birch wood growing in Latvia, and also adapting to the requirements of the end users, the stock company „Latvijas Finieris“ 2 substantially new products were created:

- *Riga Ship ply* – plywood which is used in producing insulation panels for liquified gas containers. The strength parameters are two times higher than in the case of standard plywood, enabling this plywood to be used in ship building in Korea, Japan, China and France.
- *Riga Decor* – varnished high quality plywood, the decorative surface of which has been obtained by gluing the base plate with 0.8 mm thick peeled veneer.

The implementation of the third complex research programme began in the year 2005 and finished in 2009. It proceeded with the evaluation of soft hardwood species – aspen, grey alder and hybrid species. Under the leadership of professor H. Tuherms, a subprogramme was implemented at the faculty – „Utilization of Hardwood in the Mechanical Treatment for Obtaining New Products“

As a result of the project for the first time a complex research on the grey alder and aspen wood grown in Latvia had been carried from the point of view of wood science and forest merchandise, using modern research methodology, which enabled the researchers to carry out their research according to the EU standards. Due to this approach, the results are internationally comparable (Tuherm, Ludvigsons-Rudzīte, 2006). For the rational utilization of wood potential in the mechanical treatment, mechanical properties of the wood of these species have been determined, the drying procedures have been worked out and also the possibilities to improve the performance properties, including the surface hardness have been studied. The possibility to improve the performance properties of grey alder and aspen wood through thermal modification has also been proved. The market demand for various types of grey alder and aspen products has been studied (Spulle et al. 2008). The possibilities of using soft hardwoods in construction and wood articles production have been evaluated.

Expanding the versatility of the use of wood

Since wood is most often used in construction, several research projects were carried out to expand the versatility of the use of wood. Under the leadership of the associate professor Andrejs Domkins the following projects were carried out: "Research on the Use of New Products in Construction", "Stating the Conformity of Latvian Pine Wood to the Construction Standards of the USA", "An Innovative Use in Creating New Products", "Wood Plates of Increased Specific Strength", etc.

As a result of the research, the summarizing and evaluation of the regulations and standards has been carried out. Technical instructions have been elaborated for the use of the new construction wood products in Latvia. Recommendations have been prepared for the elimination of the limiting factors of the use of wood.

In cooperation with a certification institution accredited in the USA, the testing of sawn pine timber, produced in Latvia, was carried out and a report prepared for the Standardization Committee of Sawn timber of the USA. Basing on its decision, the Latvian pine wood has been included in the list of accepted foreign species, determining standard strength parameters and assigning a designation for grading Scot.P.(I)LAT, thus opening the ACV construction timber market for the Latvian manufacturers.

An important factor in the use of wood for construction purposes is the improvement of its fire resistance, therefore fire resistance tests of the flooring and other construction elements as well as wood composite materials were performed. The possibilities of increasing fire resistance were analysed (Bukšāns, Morozovs 2007, 2008).

Thorough research was carried out on pallet constructions. The strength of these constructions and the durability of their joints, (Spulle, Pušinskis 2006). The possibilities of gluing wet wood have also been researched as well as a probation of non-damaging quality control methods for different wood materials and gluing types (Iejavs, 2007).

Combining the competencies of scientists, plywood manufacturers, competencies of transport and chemistry, a new kind of plywood to be applied in the field of transport was developed. These are the so called wood plates with an increased specific gravity, which ensures the reduction in the use of wood material and lower use of fuel per one unit of load.

Timber flow inventory and simulation

The research in this field started with the development of classifier of energy and pulp chips as well as code system (head assoc. prof. K. Būmanis). First the evaluation of the classification used in Latvia was performed and the experience of Sweden, Finland, Estonia and Lithuania was summarized. The classifiers of round timber assortments, energy and pulp chips used in Latvia have been made, which include the name of the respective assortment and its description, making use of: tree species, diameter, length, quality and other parameters. It enables the users to create a uniform information system in the sector. The development of the round timber flow model has been carried out. (head prof. P.Rivža). By using this model it is possible to perform the current timber flow evaluation and determine the scenarios for development. As a game variant, this model gives the students an opportunity to get acquainted with the timber market and have a better understanding of its functioning.

As a separate task, the development of theoretical and experimental model of fuel wood flow and evaluation of quality requirements have been completed (assoc. prof. K.Būmanis).

As a result of the project, the fuel wood product specifications and quality descriptions have been performed. The methodology of quality evaluation has been developed and the necessary data have been accumulated and summarized for the development of system model. Contacts have been established and international cooperation started in the field of standardization of fuel wood products and quality evaluation. Internationally acknowledged tests have been carried out for the fuel wood products. A system model has been developed by means of which it is possible to analyze the demand and flow to the industrial or target customer. Auxiliary tools of the system have been developed to optimize the product flow and analyze the future scenarios as well as carry out the economic calculations of the flow.

Conclusion

It has been planned to continue part of the research which pertains to carbon attraction evaluation in the ground surface part and roots of other tree species and, to the factors influencing the structure of timber and also to the use of mass method in determining the volume of round timber and chipped wood.

The "Precise Forestry" research group will turn to forest logistics research in the future. It has been planned to develop the competencies of IT technologies for supporting decision making. In the future research will be carried out on the issues of forest management planning (creating forest landscape, developing land reclamation systems, etc.) Innovative solutions to obtain forest information will be developed (LIDAR, unmanned aerial vehicles, etc.) and it has been planned to create an algorithm library which will be used in forest sector and to use it in the form of data processing prototypes (LEGO principle).

In the field of wood processing it has been envisaged to continue the research on the methods of improvement of wood properties, increasing fire resistance, the use of new composite materials and the use of wood finishing materials.

The existence of research activities is connected with the prioritising and development of state ordered research programmes and establishment of Forest sector competence centre. We are always open to new ideas and ready to cooperate with the enterprises within the sector in the development of different information technologies and innovative solutions.

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