Summary

Forest science as a source of new knowledge for the Latvian forestry

Forest science has now become an inseparable part of the forest sector, involving both the entities concerned with forest ecosystem management and a variety of stakeholders, who use the products, services and benefits provided by forest. In forest science the number of researchers in classical forestry is decreasing, with that of other branches of knowledge increasing. Integrated interdisciplinary research in the field of forestry, which is typical for the modern times, requires also the expertise in molecular biology, microbiology, geography, botany, zoology, environmental sciences, mathematics, chemistry, engineering, and other fields. It is the forest that puts together otherwise dissimilar branches of science for a common goal of generating new knowledge for the forest sector needs.

Within the framework of the national research programmes launched in 2006 the forest scientists decided to take up in-depth research on grey alder (*Alnus incana*), one of the Latvia's six commercially important tree species. During a period of four years the researchers of the Latvian State Forest Research Institute „Silava", the Latvian State Wood Chemistry Institute and the Latvian Agricultural University in a joint effort investigated grey alder, covering such aspects as the prospects for its cultivation and the utilization in wood processing and woodworking industries. In 2010, when attempting to formulate the tasks for a new four-year research programme NATRES, the forest sector's interests and needs were so manifold and varied that it was difficult to identify a

unifying element or a keyword for the related research work. That is why the contribution of the Latvian State Forest Research Institute „Silava" to the above programme was as a separate longer-term (four years) research consortium with an overall goal to develop and offer to the country's forest sector new knowledge and novel technologies. Because of limited funds a number of research directions of the institute remained outside the programme, including also various topics suggested by the forest sector stakeholders.

The title of the given monograph "*Četri mežzinātņu motīvi*" (Four motives of forest science) reflects the above considerations. It refers to four ways of solving the problems essential to the forest science, which for a person unconcerned may seem detached. Still, each problem to be dealt with makes a part and parcel of what we call sustainable and long term management of wood resources. On a global scale the wood resources of Latvia are small – 647 million m^3 only, yet important for the nation. According to the National Forest Monitoring data tree- or shrub-covered lands (woodlands, bogs, scrub, farmlands and abandoned farmlands), including forest infrastructure objects, account for 57% of the country's land area. Four motives of forest science imply not only more accurate methods of wood resources assessment and development forecasts, but also offer unconventional methods for managing birch stands following the natural succession of trees and the emergence of spruce forests in the hemi-boreal forest zone. Research results in forest genetics offer new knowledge and experience in forest tree breeding. It means that we are in a position to establish ever more valuable forests for cultivation over the ensuing rotation cycles. Research in forest phytopathology provides possibilities for reducing the losses caused by root rot in managed forest ecosystems.

Site index is one of the major indices describing the potential productivity of a tree stand. Historically, the site index was determined following the standing volume, the mean increment, and other stand parameters. Today, in the majority of countries where forestry is an important branch of economy, the forest productivity is determined following the height and age of a tree stand. In Latvia, we still use the site index scale for high forest and coppice growth worked out by professor

M. Orlov in 1931. According to this scale, the tree stands following the mean height fall into seven site classes (five basic classes) with additional classes for describing especially productive and also low productivity stands, Ia and Va, respectively. However, soon after developing this system of indexing tree stands it was clear that it disregarded the actual course of stand growth. The forest management activities (thinnings, for instance) affect the tree mean height. Futhermore, the tree growth may differ from region to region. In Latvia the tables for normal stand growth were worked out in 1924 with improvements introduced later on. The site index scale, based on the dendrometric measurement data, was made following the top height for pine, spruce, birch, aspen, and grey alder at a predetermined age; the said index is less affected by management activities. However, when evaluating the methodological principles the site index scale is based on, already at the time of developing the indexing system it was clear that it was anamorphic, i. e. evenly proportional at any age of the tree stand. Actually, the course of tree growth is polymorphic, i. e. for more productive stands (higher site index) the asymptote for top height sets in before that of less productive stands (lower site index), which may result in inaccurate long-term forecasts. That is why one of the tasks of the NATRES programme was to work out new site indexing scales for pine, spruce, birch, and aspen so as to exclude inaccuracies. For this purpose in the woodlands of the Forest Research Station chosen were 35 stands of the species to be studied (pine, birch, spruce, aspen). In each stand at least two circular 500 m^2 sample plots were established (their total number 280) with the sample trees felled down for analyses.

Normally, the cutovers, as well as abandoned farmlands, are naturally taken over by a mix of tree species. When the emerging stand is kept mixed, we usually get birch-dominated stands with spruce in the understory, where its growth is stunted – about 2 m^3 ha^{-1} yr. Similar stands may be regarded as both a manifestation of forest self-preservation and a loss to forest managers because of no timely thinnings.

The total stock volume in mixed composition birch stands with spruce in the understory is usually higher than in pure stands of birch with no spruce. Still, the competition between the tree species may reduce the

productivity of birch by 15-25%, or it may be the opposite – the volume of birch and its current annual increment may reduce the current increment of spruce. In sample plots the competition between the two species is evaluated.

In the eight forest districts of the state joint stock company "*Latvijas valsts meži*" there are about 1,000 compartments of pure stands of birch with spruce in the understory. This brings up the question what to do about it. The previous experience in solving the conflict between two species is related by A. Zviedris in his monographs "*Egle un egļu meži Latvijas PSR*" (Spruce and spruce forests in Latvia, 1960) and „*Kopšanas cirtes Latvijas PSR mežos*" (Thinnings in Latvian forests, 1961). The author points out that it is impossible to convert birch stands with spruce in the understory into pure stands of spruce simply by thinning the birch stand. In such a situation a highly productive pure stand of spruce will develop only after thinning out all birches. The same has been observed by other researchers too, yet in the past decades no substantial research has been done in this respect.

Birch promptly appears in undrained waterlogged forests as soon as the flow of water is activated. In conifer stands the presence of birch, which excellently transpires moisture, is essential for the survival of forest ecosystem as such. That is why in undrained wetland forests there is no point in removing birch from mixed stands, when attempting to convert it into a pure stand of conifers. Ditching waterlogged forest areas activates the flow of water and improves soil aeration, substantially speeding up the growth of conifer species and altering the stand's structure. Most often it manifests itself as a rapid emergence of spruce in the stand composition, with the admixture of birch now hindering the stand growth.

Pure stands of birch with spruce in the understory are normally considered a conflict situation, which cannot be solved by thinnings. Still, forest manager has an option of transforming the mixed stand into a pure stand of spruce by completely removing birch from it. So far inadequately studied is this peculiar stand type with birch as the dominant species and spruce in the understory, which is typical for highly productive site types. Concern of the Latvian birch plywood manufacturers about a possible raw material shortage for this industry (it needs birch logs of the diameter above 16 cm) has been an additional stimulus to investigate this problem.

The research goal is to identify the nature's ways in forming mixed birch-spruce stands with spruce in the understory and work out the theoretical basis for the related management methods, which would allow obtaining also birch assortments while converting a mixed birch-spruce stand into a highly productive pure stand of spruce. The research task was to work out a mathematical model for predicting, with the perspective of 20 years, the stock volume of the pure stand of spruce after removing birch. The compartment descriptions found in the State Register of Forests for the mixed birch-spruce stands of the DBH above 16cm were used for analysing the interdependence between stand parameters. The data were summed up for four regions, corresponding to the Ziemeļlatgale, Dienvidkurzeme, Rietumvidzeme, and Vidusdaugava forest districts of the state joint stock company "*Latvijas valsts meži*", including the respective regions of scientific research forests of the Forest Research Station. The field data collected in 60 permanent sample sites were used for working out the forecasting model.

Conventional practices in forest tree breeding and phenotypic evaluation of results is a time consuming process. By using DNA markers it is possible to speed up this process and make it more accurate. Tree seed orchard genotyping is necessary for identifying and confirming clonal identity and for seed orchard certification so as to ensure that the genetic diversity within breeding programmes is not significantly reduced compared to that of natural self-seeding stands. Seed orchard clone and ramet identification is essential for designing controlled pollinations. The analyses of genetic resources by DNA markers may be used for clarifying the origin and genetic structure of natural stands and identifying interspecies hybrids. By this method it is possible to ascertain whether the genetic diversity of the stands and trees designated as genetic resources is representative of regular stands throughout the country.

The goal of the above research effort was to analyse and describe, by using DNA markers, the forest genetic resources of Latvia and the material included in breeding programmes. This would help to confirm clonal identity within established seed orchards and to compare genetic diversity within forest genetic resources to the overall genetic diversity of Latvian forests. For the needs of current and future research, the data of

tree genetic analyses will be available in a unified database. That is why it was envisaged to analyse, by using DNA markers, the seed orchard clones and other forest genetic resources so as to obtain the reference information needed for identifying highly valuable genetic material. DNA markers have also been utilised for analysing the genetic structure of progeny families in order to identify their genetic value, as well as to create a database of Latvian forest tree genetic resources.

About 22% of trees in mature spruce stands of Latvia are infected by root and butt rot, caused mainly by the polypore *Heterobasidion annosum* s.l. The rot may rise up to 10 m in spruce stem. Economical losses caused by root rot of spruce to Latvian forestry are estimated at EUR 800 – 4,790 ha^{-1} during rotation time.

H. annosum spreads by spores which infect fresh conifer stumps, and by fungal mycelium that grows through root contacts from infected roots to neighbouring healthy trees. To limit the spread of *H. annosum* on heavily infected sites it is advisable to remove spruce stumps after cutting, or regenerate the site with broadleaved trees. In Latvia, no *H. annosum* has so far been found on grey and common alder and rarely on pure stands of other broadleaved trees. Stump removal not only decreases the infection rate but also yields an additional amount of energy wood.

In infection-free stands, an efficient way of controlling *Heterobasidion* root rot is the treatment of fresh conifer stumps by biological preparations containing spores of the fungus *Phlebiopsis gigantea*. The result of a successful stump treatment is that *P. gigantea* quickly colonizes upper parts of the stump, restricting the spore infection by *H. annosum*. Since 2008, the biological control agent Rotstop, made in Finland, is used in Latvia for stump treatment in thinnings of spruce and pine. Rotstop contains spores of only one *P. gigantea* genotype. However, long term use of one *P. gigantea* genotype in stump treatment may affect the local populations of this fungus, as well as the biodiversity of other fungi.

Since 2005, the Latvian State Forest Research Institute „Silava" has been investigating the possibility of finding *P. gigantea* isolates of Latvian origin, to use them for stump treatment in conifer stands. The main task

in this project was to obtain *P. gigantea* isolates from spruce and pine wood, to evaluate their spore production in laboratory conditions, and to analyse their growth rates in spruce wood. These properties were compared with those of the Rotstop isolate. The isolates which showed best qualities *in vitro* were subjected to field tests where their efficiency against stump infection by *H. annosum* was analyzed. In addition, the efficiency of isolate mixtures of *P. gigantea* was tested and compared with the efficiency of single component isolates.

The given monograph includes original papers on four-year research results, prepared by the leaders of four research topics, which were included in the NATRES national research programme. We hope that every specialist working in the field of forestry will find this monograph useful for raising the level of knowledge and strengthening the vocational self-esteem of forestry professionals. The authors feel indebted to the Ministry of Education and Science and the Ministry of Agriculture for a possibility to work on this long-term research programme. Special thanks to the managers and employees of the Forest Research Station and the state joint stock company "*Latvijas valsts meži*" for personal contribution in finding and establishing the objects needed for this research.

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