Genetic resources of conifers and their conservation in Lithuania

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Forest land in Lithuania comprises 30.1%. Coniferous forests make up 61.6%, pine 37.4%, spruce - 24.2% of the total area. Natural pine and spruce stands comprise more than 2/3 of their total area. Premature and mature stands are divided into 3 selection groups. The best (the 1st selection group) pine stands make up 28.0%, spruce 21.7%. Genetic resources of pine and spruce stands are preserved *in situ* and *ex situ*. A permanent inventory and assessment of genetic objects is being carried out. Studies of phenotypic and genotypic structure of populations and provenances, peculiarities of progenies growth, inheritance of traits are also being carried out, as the adaptivity of provenances and families, the effect of stability and selection, changeability of traits, peculiarities of reproductive biology and hybridization are ascertained. Standards for preservation and utilization of genetic resources are being worked out.

Keywords: genetic resources, population, Scots pine, Norway spruce.

Introduction

Lithuania belongs to mixed forests within temperate climate forest zone. Lithuania is crossed by the northern boundary of *Carpinus betulus* L. distribution area. Forests in Lithuania have great economic and ecological significance, while dispersion of small woodlots is favourable for climate improvement and recreation.

Almost all mature stands in Lithuania are natural, productive and of good quality. Autochtonous stands have formed up under certain ecological conditions under which

they are most stable. These stands comprise a valuable genofund in Lithuania, and its studies and selection as well as conservation are immensely important seeking to preserve the natural genetic diversity of its components necessary for the regeneration of local stands. Due to intensive exploitation of forests in the past Lithuania has very few mature stands (9.6%). Premature stands comprise 17.9%, middle-aged – 44.7% and young stands - 527.8%. Undisturbed and natural forests are left only, in reserves. In the country prevail semi-natural forests.

At present about 8 thou. ha of forests are felled annually. Artificial regeneration is used on 6.5 thou. ha, the rest area regenerates naturally. 5% of forests are regenerated with genetically improved seeds, while since 2000 it is planned to use such seeds for the of establishment of all new forests. A strict control system for reproductive material in accordance to OECD requirements is being introduced.

All forests in Lithuania according to their purpose are divided into 4 groups: 1-st group - reserve forests (2.0%0; 2-nd special forests (5.8%); 3-rd - protective forests (14.9%); 4-th - economic forests (77.3%). They differ by management purposes and economic activity restrictions. The purpose of management in forest reserves - to leave the forests for natural development. Management aim in special forests - to preserve forest ecosystems, to arrange and use them for restricted. A valuable genofund is selected and singled out in forests of all groups.

Due to climatic anomalies, atmospheric pollution and damage by ungulates Lithuanian forests undergo severe losses, while some species fail to regenerate naturally. Total defoliation in Lithuanian forests in 1994 comprised 28% (Ozolinčius 1994). In the place of dead valuable species or genotypes regenerate for less valuable ones which leads to the degradation or total destruction of the valuable genofund. Besides, the diversity of the genofund decreases with increasing area of forest plantations, for the establishment of forests is conducted by using not the best genotypes or very few of them. therefore today conservation of genetic resources is of utmost importance.

Material and methods

The aim of studies - to ascertain the genofund of pine and spruce stands, to define its selective value, and to apply corresponding forms its selection, conservation and utilization.

According to Lithuanian regulations all premature and mature stands of the main tree species from the selection view point are divided into 3 groups. Selection group of stands is ascertained according to stand productivity and bonitet, stem form, branchiness, resistance to unfavourable conditions and the quantity and quality of timber (Ramanauskas 1979).

To the first selection group there belong stands of the highest quality, the most productive, economically valuable, of highest bonitet, undamaged by feelings, wind breaks, resistant to diseases and pests, having formed under optimal for the species growth conditions. Stands of this group should contain not many trees with thick or dry branches, as well as trees damaged by pests and diseases. Being very productive but having at least one of these negative signs stands cannot be attributed to the first selection group.

Some part of the best from selection point of view stands of the first group are singled out as plus stands (I^A group).

To the second selection group belong all stands of average productivity and quality, growing on corresponding sites wick due to men growth rates small stocking level or other reasons cannot be attributed to the first group.

Stands of low quality, small productivity, thin, branchy, of low bonitets (mostly IV-V) belong to the third group.

Studies and selection of valuable genofund are carried out in stands of I^A and I selection groups.

Stand quality is first of all defined according to mean stand height, crown length and width, thickness of branches, number of productive and plus trees.

Studies on stands have shown that the greatest part of these indices, especially stand height, branchiness of trees, crown length and width, bark, bud opening time are peculiar to individual populations and provenances.

Studies on pine and spruce stands relied on tables and standards from "Вспомогательные таксационные нормативы для лесохозяйственного и лесоустроительного проектирования, 1981", Kenstavičius (1989), Kenstavičius, Brukas (1993), Baliuckas et al., 1994, "Lithuanian forest resources, 1994".

The condition of genetic resources in pine and spruce stands, ways to conserve them, to study and the need to improve the studies were ascertained.

Earlier and present investigations on the basis of assessment, conservation and utilization of genetic resources are divided into fundamental and applied.

Results and discussion

Forests in Lithuania cover an area of 1920 thou. ha. Woodedness of the country - 30.1%. (Forest resources of Lithuania, 1994). Pine stands cover 659.3 thou. ha (37.4%), Spruce stands - 450.2 thou. ha (24.2%) (Table 1).

Over the last 20 years the area of pine stands decreased, while that of spruce stands due to intensive afforestation increased (Fig. 1), therefore their young stands (up to 40 years) comprised 39% from the whole area. From all stands growing in Lithuania pine stands (278m³/ha) and spruce stands (285 m³/ha) when mature are the most productive. Productivity of pine

Table 1. Resources of Lithuanian woods

Species	1962		1993						
	100 ha	%	100 ha	%	Distribution by age classes (%)				Volume of mature stands (m^3/ha)
					Young	Middle-aged	Premature	Mature	
Pinus sylvestris	642.4	41.2	695.3	37.4	37.0	47.7	11.7	3.6	278
Picea abies	308.6	19.9	450.2	24.2	39.0	26.3	26.2	8.5	285
Other coniferous	2.7	0.2	0.8	0.04	-	-	-	-	-
Quercus robur	23.6	1.5	32.4	1.7	17.3	58.0	8.7	16.0	246
Fraxinus excelsior	16.1	1.0	49.3	2.7	48.9	44.4	4.9	1.8	244
Betula verucosa and B.pubescens	276.6	17.7	363.4	19.5	7.2	65.9	15.5	11.4	235
Populus tremula	93.8	6.0	50.4	2.7	6.9	12.7	25.0	55.4	261
Alnus glutinosa	97.8	6.3	104.0	5.6	14.4	56.4	15.7	13.4	270
Other broadleaves	97.5	6.2	114.5	6.2	-	-	-	-	-
Total	1559.1	100	1860.3	100	27.8	44.7	17.9	9.6	244

and spruce stands growing in various forest types is presented in Table 2.

In Lithuania 6 (4) forest natural regions (Karazija 1988) are singled out, where different populations of

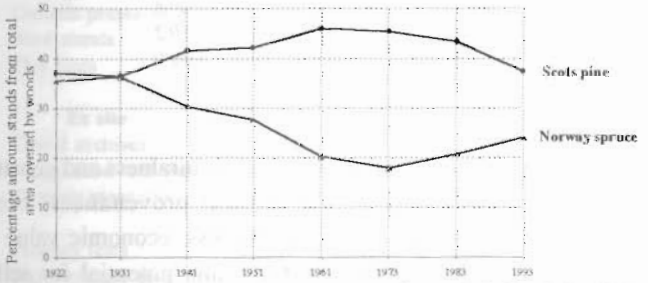

Fig. 1. Dynamics of Scots pine and Norway spruce stands areas in Lithuania by years

separate tree species have formed. The main object of forest tree selection are natural populations, as far as populations the initial stage of genetic information. In stands of natural regeneration due to interbreeding of separate individuals and natural selection under corresponding environmental conditions valuable and best used to local conditions genotypes as well as their accumulations are formed.

To ascertain boundaries between populations is a long and complex process, but the most distant ones due to climatic differences and specific structural traits may be singled out and assessed as separate populations. Due to the absence of deeper genetic studies, except three (Labanoras, Kapčiamiestis and Darbėnai) populations of Scots pine, where varying gene frequency distribution was ascertained, while assessing population boundaries geographically closer stands in various localities are called provenances. Provenances also have peculiar phenotypic structure.

The largest forest tract is Dainavos forest covering 150 thou. ha. Forests of Kazlų Rūda, Labanoras and Karšuva occupy at 44 - 58 thou. ha. Still 7 forest tracts take up from 20 to 30 thou. ha. The rest forests are less in size. Pine stands comprise the largest forest tracts. They are situated in the eastern and southern parts of the country. There are no large spruce forests. Spruce stands grow in the western, central and northern parts of the republic. Larger stands are left in four places and make up the following spruce clusters z south-western Žemaitija, north - eastern Žemaitija, Biržai forest and forests of central south-eastern part. But these spruce stands are also full of cutting areas and are damaged by windbreaks. A number of spruce stands are found also in other places of Lithuania, but they fail to make up larger tracts. They are mostly found within the tracts of other species (Gabrilavičius 1993, Danusevičius 1995).

Table 2. Productivity of various Scots pine and Norway spruce stands at 100 years of age and 0.7 of stocking level

Type of forest	Mean		
	height (m)	diameter (cm)	volume (m^3/ha)
Scots pine			
Pinetum cladoniosum	22.2	29.2	253
Pinetum vacciniosum	24.7	31.1	294
Pinetum vaccinioso-myrtillosum	25.6	32.0	309
Pinetum myrtillosum	24.3	30.8	286
Pinetum myrtillosa-oxalidosum	26.9	33.8	330
Pinetum sphagnosum	16.4	20.8	169
Norway spruce			
Piceetum myrtillosum	24.1	27.5	313
Piceetum myrtilloso-oxalidosum	25.7	29.0	333
Piceetum oxalidosum	24.4	28.8	317
Piceetum caricosum	20.8	23.6	269

Table 3. Distributions of Scots pine and Norway spruce stands according to the selection (genetic) groups in Lithuania

Age classes	Stands		Distribution by selection (genetic) groups			
			I	II	III	Total
Premature	Scots pine	ha	27863	45245	18089	91197
		%	30.6	49.6	19.8	100.0
	Norway spruce	ha	17736	48237	9233	75205
		%	23.6	64.1	12.3	100.0
Mature	Scots pine	ha	5878	13093	10483	29454
		%	20.0	44.4	35.6	100.0
	Norway spruce	ha	2507	10382	5002	17891
		%	14.0	58.0	28.0	100.0
Total	Scots pine	ha	33741	58338	28572	120651
		%	28.0	48.3	23.7	100.0
	Norway spruce	ha	20243	58618	14235	93096
		%	21.7	63.0	15.3	100.0

Table 4. The amount of first selection group stands of Scots pine and Norway spruce by forest natural regions in Lithuania

No	Forest natural region	Scots pine		Norway spruce	
		Area,		Area,	
		ha	%	ha	%
I	Highland of Žemaitija	5819	17.2	4094	20.2
IIA	Central lowland	1009	3.0	1939	9.6
IIB	Highland of Aukštaitija	1872	5.6	858	4.3
III	Littoral lowland	10538	31.2	3019	14.9
IVA	Sūduva and Lower Nemunas lowlands	10688	31.7	8262	40.8
IVB	Dzūkija and Sūduva highlands	3815	11.3	2071	10.2
	Total	33741	100.0	20243	100.0

At present the best Scots pine (Labanoras, Juodkrantė, Viešvilė - Smalininkai, Veisiejai, Kazlų Rūda, Šimonys, Vainagiai, Druskininkai) and Norway spruce (Močiškiai, Punia, Trakai, Rokiškis, Survilai, Ignalina, Šakiai, Kazlų Rūda) populations and provenances studied have reliable differences in their structural traits.

In Lithuania premature and mature pine and spruce stands are of good selection value (Tables 3 and 4). Pine stands of the Ist selection group make up 33.7 thou. ha (28%), while spruce stands - 20.2 thou. ha (21.7%) (Kenstavičius 1993).

Frequent storms (1967, 1982, 1993) have destroyed many of Lithuania s spruce stands. Drought in 1994 had physiologically weakened stands which led to mass infestations by pests (*Ips typographus*) and damages on vast areas. At present there are over 40% of middle - aged and older spruce stands damaged by pests. A part of them is already clear-cut and the work proceeds. In the last five - year period outbreaks of *Diprion pini* and *Ocneria Lymantria* were observed. They have damaged 45000 ha of pine stands. Much attention is paid to preserve and regenerate the remaining genofund of pine and spruce stands.

The genofund of forest trees is comprised on the level of species, populations, provenances, ecotypes and individuals according to their value and necessity.

To the criteria of value are ascribed: naturalness and genetic diversity, autochthonicity - for natural provenances, eco-geographic and ecotypic representativeness, economic value - productivity, quality, demand, viability and potential for self-regeneration, ecological-protective value, rareness (uniqueness) and distribution (abundance), selection value of reproductive material, bordery populations within distribution area.

Recessity criteria include: parts of valuable genofund under extinction or liable to damage, vanishing species and their components, populations under selection, ecotypes and individuals, developed species (hybrids).

Under the current situation of intensive changes in environmental conditions adaptivity criterion goes in the first place.

In order to preserve evolutionary adaptivity of populations and provenances in the changing environment it is necessary to conserve and enlarge genetic diversity.

The main altitude towards preservation of genetic resources is as follows: to preserve representative populations of all forest natural regions, to preserve border populations, to protect populations and provenances which are on the verge of destruction, to conserve both assessed and unassessed genetic diversity for the higher, selection stage, to ensure sufficient diversity if reproductive material for forest re-

generation, to preserve standard populations for future studies.

Ways to preserve valuable genofund are the following:

1. *In situ* (in the original place):
   a) forest genetic reserves,
   b) genetic preserves,
   c) seed stands,
   d) separate genotypes (plus and unique trees).
2. Ex situ (transferred):
   a) clonal archives,
   b) seed orchards,
   c) experimental plantations,
   d) gene banks.

Ways of preserving of pine and spruce genetic resources and extent are presented in Table 5.

Table 5. The conserved Scots pine and Norway spruce genetic resources in Lithuania

No	Way of preservation	Number of objects		Area (ha)	
		Scots pine	Norway spruce	Scots pine	Norway spruce
	In situ				
1.	Strict genetic reserves	2	1	5273.0	429.0
2.	Genetic preserves	112	19	2382.0	337.0
3.	Seed stands	28	21	307.0	150.0
4.	Plus trees	475	589	-	-
	Ex situ				
5.	Clonal archives	3	5	8.5	15.5
6.	Clonal seed orchards	19	25	309.6	350.1
7.	Progeny plantations	52	21	108.6	51.2
	Progeny tests	36	13	48.4	22.0
	Provevenance tests	16	8	60.2	29.2

Assessment, selection, preservation and usage of forest genetic diversity and resources is a peculiar sphere of genetic studies, covering also the analysis not only of high productivity, but also adaptivity and stability of stands under the changing ecological situation. Genetic variation of populations significantly greater than the observed morphological variation.

Extensive genetic variation is proved by artificial selection experiments. In such experiments for further propagation and usage are selected those populations and genotypes which manifest selection trait to the highest degree (Gabrilavičius 1993, Pliūra 1994).

Previous and current studies may be divided into two groups: fundamental and applied (Table 6).

The success of genetic resources preservation depends on the quality of descriptive information on protected plants and compiling of corresponding catalogues. Forest inventory and scientific research haven not yet formed a uniform system and do not cover all genetic - selection objects in the country. Forest regeneration processes are studied only in separate stands. More detailed studies were carried out analysing phenotypic and genotypic structure of populations, selection efficiency of provenances and families *in situ* and *ex situ*, including adaptivity and stability indices, investigations on genotype x environment correlation and geographical variation, peculiarities of reproductive biology in seed orchards as well as interspecific hybridization (Danusevičius, 1993; Gabrilavičius, 1992, 1994).

In the sphere of applied sciences recommendations and standards for selection assessment of stands, plus trees, forest genetic reserves and preserves, for the establishment of seed orchards and clonal archives as well as for improving seed productivity were worked out. From the practical point of view a somewhat better trait in the first generation should be assessed as a stimulus to continue the selection work, but not as final evaluation that the awaited result has been achieved.

Taking into account the level of studies on genetic resources it is necessary to prepare not only detailed methods and ways to select, preserve and utilize valuable genofund, but also to apply a unified system of documentation and information on selected and protected genetic objects, which could be detailed, clear, informative and in compliance with information systems of other countries.

Table 6. Investigations on genetic resources assessment, preservation and utilization

No	Basic research	No	Applied research
1.	Analysis of the phenotypical and genotypical structure of populations and provenances.	1.	Criteria for the selection of plus trees, stands and selection groups.
2.	Methods for the selection of plus trees and stands.	2.	Selection of genotypes for the higher generation seed orchards; methods and technologies for the establishment of seed orchards.
3.	Efficiency of selection of families and provenances grown in situ and ex situ.	3.	Selection of genetic reserves and seed reserves.
4.	Limits of provenance transfer.	4.	Establishment of clonal archives.
5.	Methods of the early prediction and evolution of genotypes.	5.	Means to increase forest seed production.
6.	Bioecological peculiarities of flowering and bearing in seed orchards.		
7.	Creation of new hybrids.		

Conclusions

1. Forest land in Lithuania makes up 30.1%. Coniferous forests comprise 61.6% pine stands - 37.4%, Spruce stands - 24.2% from the total area.

2. From all mature stands in Lithuania the most productive are spruce (285 m^3/ha) and pine (278 m^3/ha) stands.

3. Almost all mature stands in Lithuania are natural, productive and of good quality. Autochthonous stands have formed under concrete ecological conditions under which they are the most stable. They comprise a valuable Lithuanian genofund, the studies, selection and preservation of which are very important to preserve natural genetic diversity of its components, necessary for the regeneration of local stands.

4. The main object of tree selection are natural populations, for populations is the initial stage of genetic information.

5. In Lithuania premature and mature pine and spruce stands are of good selection value. Pine stands of the first selection group make up 28.0%, spruce stands 21.7% from all premature and mature stands.

6. Valuable genofund of forest trees is comprised on the level of species, populations, provenances and individuals according to value and necessity criteria.

7. Valuable forest genofund is preserved *in situ* (in the original place) and *ex situ* (transferred).

8. Assessment, selection, preservation and utilization of forest genetic diversity and resources is a peculiar sphere of studies, covering the analysis not only of high productivity, but also stand adaptivity and stability under changing ecological situation.

9. It is necessary to apply not only detailed valuable forest genofund selection, preservation and utilization methods and ways but also to work out and adapt a unified system of documentation and information on selected and preserved genetic objects in compliance with information systems of other countries.

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Генетические ресурсы хвойных и их сохранение в Литве

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Резюме

Лесистость Литвы 30.1%. Хвойные леса составляют 61.6%, в т.ч. сосняки - 37.4%, ельники -24.2% от всей площади лесов. Более чем 2/3 лесов этих пород являются натурального происхождения. Приспевающие и спелые леса разделены на 3 селекционные группы. Наилучших (I селекционной группы) сосняков выделено 28.0%, ельников - 21.7%. Генетические ресурсы сосняков и ельников сохраняются способом *in situ* (генетические резерваты, заказники, генотипы и их потомство) и *ex situ* (клоновые архивы, лесосеменные плантации, семейственные и популяционные культуры, различные коллекции и семена). Осуществляется постоянная инвентаризация и

атестация генетических объектов. Изучается фенотипическая и генотипическая структура популяций и провененций, исследуется особенности роста потомства, наследование признаков, степень адаптивности популяций и семей, их стабильность, а также селекционный эффект отбора, вариабельность признаков, биологические и экологические особенности репродуктивности, межвидовая и внутривидовая гибридизация. Подготовляются рекомендации и нормативные документы для сохранения и использования генетическим ресурсов.

Ключевые слова: сосна обыкновенная, ель обыкновенная, генетические ресурсы, популяции.