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INTEGRATION OF SILVICULTURE IN REGIONAL DEVELOPMENT: SOME EXPERIENCE OF LITHUANIA, USSR

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Foreword

With increasing population and development pressures in many countries, it is essential that more attention be given to the management of the world's forest. Academician Leonardas Kairiukstis has had long experience as a forester in Lithuania, and in this paper, he provides an intersting and very useful overview of forest management practices in that country. The system is based on the application of ecologically sound principles, and thus the forests of Lithuania should be sustainable for the multiple users involved.

Professor R.E. Munn
Leader
Environment Program

Abstract

This paper describes an integrative approach and the practical means employed in regional (national) land use planning concerning the utilization of renewable resources and specialized forest growth in sustainable regional development in the Lithuanian SSR. The approach is based on systems analysis, modeling and optimization of regional development. The function of a forest in a region is determined by the optimal use of natural processes that govern the region's ecosystem. Forest growth is regulated conforming to ecologically sound standards; examples of standards of growing highly productive industrial-exploitative forest are presented; the final yield is based on the principle of continuity.

CONTENTS

INTEGRATION OF SILVICULTURE IN REGIONAL DEVELOPMENT: SOME EXPERIENCE OF LITHUANIA, USSR*

*Leonardas Kairiukstis***

INTRODUCTION

The acceleration of industrial and agricultural development usually leads to negative consequences in nature, such as destruction of forests, increase in soil erosion, water and atmospheric pollution, etc. One such example is the Great Lakes Region of the USA and Canada (Regier and Baskerville, 1985). The authors, using the general approach suggested by C.S. Holling "Think Global, Act Local" (Holling, 1984) have described the historical exploitation of forest resources and fisheries which lead to serious degradation. In determining the reasons for such negative effects, the authors came to the conclusion that there has been much talk about management in the past, and indeed a certain amount of planning, but little of this came to grips with the fact that to make it happen where it really counts, it is necessary to specify where the local events will take place in order to achieve a specified regional effect.

The other example of land mismanagement is the Himalayan region which has resulted in the degradation of much of the forest which led to increased erosion of the mountains and to an isolation and flooding of waterways and prime agricultural land during the summer monsoons (Nautiyal and Babor, 1985). In this case, it seems to be most difficult to avert ecological collapse, while meeting the requirements of a still-growing population.

The third example shows the European history of forest resources depletion during the last centuries. Lessons learned in Europe show that the sustainability of forest resources is simultaneously a precondition and a consequence of the sustainability and continuity of the use of forest resources and at the same time it is vital for the sustainability of regional development altogether. Government laws, the use of strong regulating forces and programs for afforestation have been adopted in many countries. As seen from experience gained in the Lithuanian SSR, a decrease of forest areas during the last eight centuries was stopped in the middle of this century† and presently the forested area is continually increasing (see Figure 1). The monitoring of forest dynamics was improved; modern techniques for forest inventory, repeated every 10 years were initiated; for the final yield regulation, an area method based on rotation and the age-class

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†Historical data was collected by Prof. P. Matulionis at the beginning of this century and was processed by Prof. M. Jankauskas.

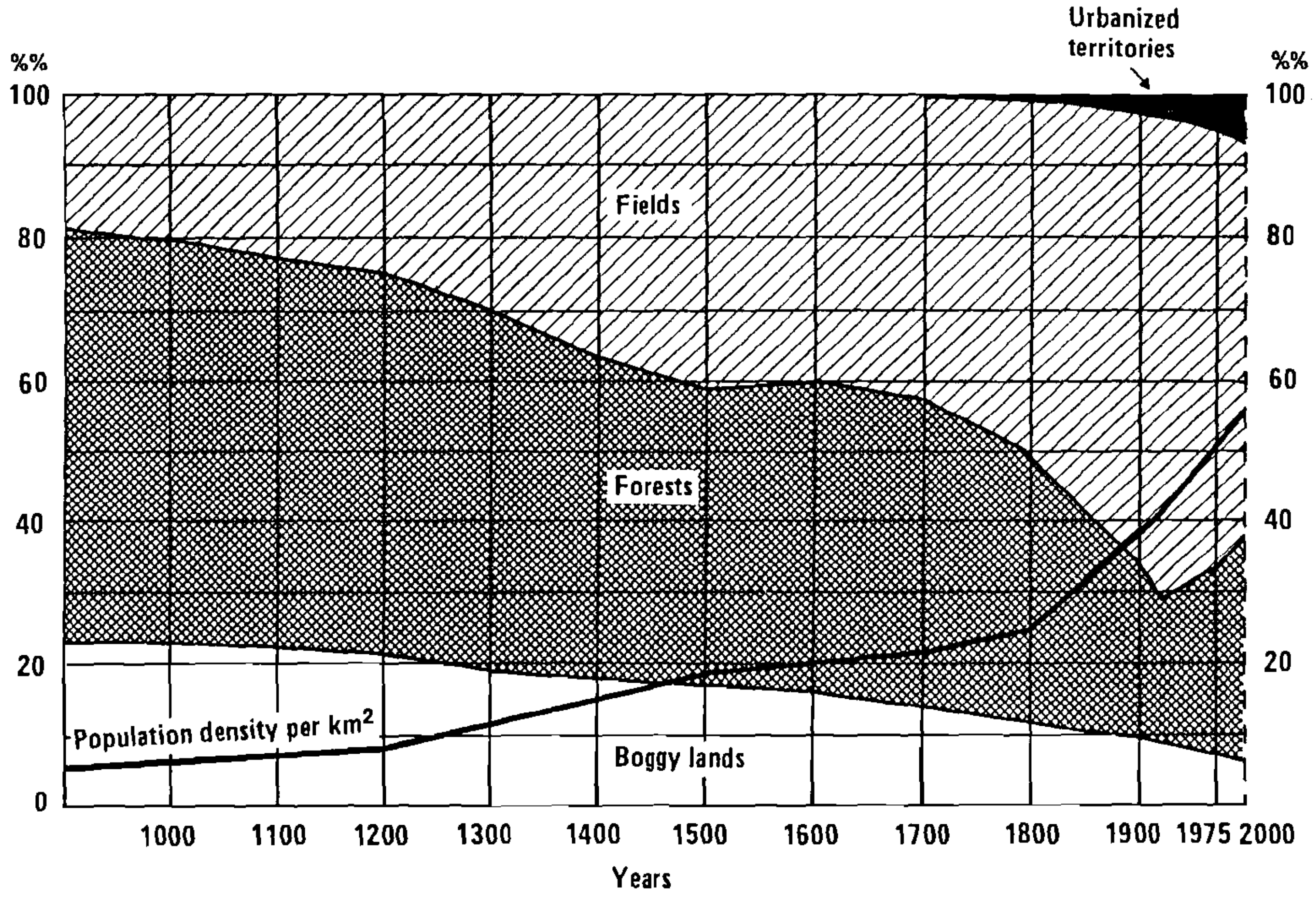

Figure 1. Landscape transformations in Lithuania according to various sources of historical data with additions up to the year 2000 (by Prof. P. Matulionis and Prof. M. Jankauskas).

distribution into management classes was adopted (Deltuvas, 1982; Kenstavicius and Brukas, 1984).

Despite great differences in the above–mentioned examples, they all have in common the fact that the landscape transformation process was, still is, and will be in the future, an inevitable precondition and consequence of the further development of society. It gives an opportunity to create productive industrial agriculture, to develop industry, and to create a sound economic basis for higher material, cultural and social welfare of the population. This process greatly influences the forest system on the territorial scale. It is important that the changes are well–balanced in regional and national development and do not brake the ecosystem, particular forest ecosystem balance on a large scale.

To meet the challenge outlined above, traditional approaches to forest management must be replaced by adaptive policy responses, capable of

- opposing and preventing the spontaneous destruction of forest systems;
- integrating silviculture in national land use and regional development.

INTEGRATION OF SILVICULTURE IN REGIONAL (NATIONAL) LAND USE

Following the 6th World Forest Congress (Madrid, 1966), the socio-economic value of forests was reappraised. Society needs new kinds of forest utilization (different kinds of businesses, recreation, conservation, etc.). Therefore, optimizing forest growth, for different purposes on a specific territory have appeared during the last decades to be important problems in regional development and physical planning.

To solve the problem of growing of forests ceased to be the object only of foresters engaged in growing and exploiting of forests. A professional forester in the traditional sense of the word, guided by silvicultural fundamentals, is capable of implementing optimization of forest growth only on the areas allotted for this purpose, and especially on the areas with a previously determined particular purpose.

The elucidation of the role and place of forests in the whole land use system and the determination of the predominating functions of forests on a specific territory are presently feasible only for a whole complex of scientific and projecting organizations engaged in geographical, ecological, forest, economic, demographic, social, genetic and other investigations as well as planning on the given territory. For example, in the Soviet Union and other countries where land is state owned, the allocation of functional landscapes among the main branches of the national economy (agriculture, forestry, urban development, etc.) is mainly solved with the help of regional physical planning. Moreover, when optimizing land use of separate regions, rather intricate problems arise in achieving an adequate improvement of living conditions of the local human population and development of separate industrial branches. Difficulties in the elaboration of coordinated decisions by regional and branch interests are caused not only by some shortcomings in management; managers and planners lack a reliable set of tools for situation analyses and the selection of variants for optimum decisions. To achieve a more or less optimal decision in regional development a set of models should be used.

Land Use Optimization and Functional Landscape Allocation

In an effort to attain integrated decisions in regional development, and to improve physical planning, as for example in the Lithuanian SSR, many institutions and specialists of many branches were united under the UNESCO program "Man and the Biosphere". In cooperation with the International Institute for Applied Systems Analysis (IIASA), a pattern of Sustainable Regional Environmental Balanced Development Strategies is being worked out. The main goal of this effort is to find an integrated solution for land use and resources management which secures the ecological and socio-economic sustainability of regional system; in other words, the sustainability of soil fertility, productivity of agriculture, forests, water basins, wildlife, etc.

In pursuance of the above-mentioned tasks, a system of models simulating and predicting the development of "Lithuania" as a regional ecosystem, was carried out. For this analysis, economic, ecological and social factors were taken into account. The modeling goal affords opportunities for the planners and managers to evaluate the state of forestry, agriculture and other branches of the economy as well as the state of the environment and well-being of people at different regional development strategies. The cycle modeled is the following: industrial-agricultural development changes in the environment (air pollution, decrease in woodiness, forest and agriculture productivity, increased soil erosion, etc.); due to environmental changes an impact is noted on the factors of production and on those of the non-productive sphere, including an impact on human health. The consequences of this change influence the regional economy and social development of the local human population.

Taking into account the agricultural, forestry, industrial and environmental development of a region as a complex economic-ecological system, simultaneously two kinds of optimization problems are being solved: in other words, regional or interbranch optimization and branch optimization.

Interbranch Land Use Optimization in Regional Development

The system of models used for interbranch optimization embraces the branches of the regional (national) economy and territorial land use. The basis of numerical calculations of the simulation and forecasting of regional (national) development is the model of analysis and prediction of a reproduction process of gross national product. The model was constructed at the Institute of Economics of the Academy of Sciences of the Lithuanian SSR (Rutkauskas, 1980). In the model, the multibranch economic system is described by balance equations. For the gross output prediction of branches, the productive functions are applied. The growth rate of net output was chosen as a criterion of the optimum.

The forest sector as a branch of regional (national) economy is united into a complex which includes forestry, timber supply, wood processing and the cellulose-paper industry. In order to disaggregate the forest sector and to single out the branches of logging and timber sorting, the following data is used: coefficients of direct expenditures; production function of the gross output; branch structure of capital investments; lag of capital investments; the main production funds at the end of the pre-plan period. The coefficients of direct expenditures are determined according to the data of inter-branch production balance and output distribution in the regional (national) economy. The model of reproduction of gross national product can work with the productive functions of the gross output and with linear functions.

To analyze the ecological factors in the interbranch model of reproduction of gross national product, additional indices are introduced (Mizaras, 1979). They characterize reproduction, the use of natural resources and constraints imposed by scarce resources. The principal task of the interbranch modeling of regional (national) economy is to assist decisionmakers to establish the basic proportion of land use in regional development and to preserve stable ecological systems over a long period of time. The data obtained are disaggregated in the models of individual branches and subregions.

Optimization at the Branch Level

At the branch level, we consider the optimization of the development of individual branches and of their whole complex is modeled. The production volumes, ascertained in the model of the national economy must be in agreement with the possibility of a branch (resources, investments, etc.) and the environment. These tasks are being solved at the branch level. For example, the forest sector is modeled in the following way: forest resources are compared with demand. In case of shortage, the impact on the resource block is noted due to changes of factors determining the availability of forest resources.

The fundamental problems being tackled by a system of models of the forest sector are the following: determination of demand for forest resources, singling out of specialized wood growing sectors, forecasting and optimization of reproduction of forest resources, establishment of the volume of forest use, forecasting and optimization of logging and timber sorting development, and forecasting and optimization of wood processing.

The demand for products of the branches of wood processing as a whole is ascertained in a balance interbranch model. It is further detailed in the block of demand determination for production of wood processing; the demand for timber resources is calculated through the model of the development of wood processing. The requirements for non-wood forest resources (berries, wildlife, hunting fauna, etc.) and also for the resources that form the environment are established from the dynamics of population growth and other indices predicted in the models of the national economy.

Integrative Approach to Optimization

The combination of regional and branch optimization enables one to obtain the optimum development of any territory taken as an ecological system. At the same time, it also makes it possible to foresee and eliminate undesirable contradicting consequences between economic branches and to direct the development of any territory, including forest growth on behalf of the whole regional human population.

For instance, a preliminary analysis of the territorial transformation trends in Lithuania conditioned by production output, ecological and social consequences of this production enabled an optimal distribution of the territory according to its function to be approximately established (Kairiukstis, 1982). This was done simultaneously in two ways. *First*: There are five main landscape functions (categories) in the Lithuanian SSR: agricultural, exploitative forest, recreational, urbanized, reservation. In each of these there are similar management particularities within the whole functional zone. The Republican Commission of Scientific-Technical Progress (an expert group, and government body) analyzed the historical trens of the territorial transformation and economic development. They found an optimal distribution of the territory according to its function for preplanned period, at least 15–20 years ahead. *Second*: scientific organizations, using the regional models of socio-economic and ecological reproduction (Rutkauskas, 1980) performed a balance of land use and singled out the specialized sectors of the regional economy. The essential group of factors subjected to analysis while singling out the specialized sectors is as follows:

- initial structure of land use;
- demand for production of land use branches;
- restrictions imposed on the use of natural resources for environmental protection;
- suitability of territories for different functions;
- expenditures and losses of transforming one territory function into another.

Accordingly, agricultural territories must occupy 55–58% (including 17% of meadows and pastures) – forest areas 30–33%, water and boggy territories – 5–6%, and 5–7% industrial-urban areas (see Figure 2).

The forest and agricultural territories, apart from their own forest and agricultural areas, occupy territories of other functions (recreation, conservation, etc.). Due to the contiguity limits and mutual scale of overlap of these territories, buffer zones between the territories devoted to the main economic branches were established. In optimal regional development, these buffer zones perform the function of contiguity peculiar to the chief adjacent economic sectors. The forestry sector, for example, under the pressure of agricultural, recreational, industrial-urban, etc., sectors on a specific territory becomes greatly specialized. Under the pressure of contiguous economic branches, other sectors are required to conform (agriculture, water, etc.), which means that adverse impacts of the competing uses (production, recreation, conservation areas) can be avoided.

The forest sector of a national economy, guided by a given purposeful function of territorial units and forestry science foundations as well as by economic branch possibilities, can determine an optimal purposeful distribution of forests and specializes in forest growth.

At the same time, the forest sector, beyond fulfilling the main landscape function, is primarily responsible for total wood supply and other forest products and utility functions to the national economy. This means that in the whole forest sector system, the following questions have to be settled:

1) to afforest the region up to the relative optimum using all land resources (useless for agriculture and urban districts) so that forests would rationally meet the balanced requirements of the national economy for wood, and might be applied for recreation and could possibly exert a more positive influence on agriculture and the environment;
2) to meet utilitarian requirements of the economy and population for secondary forest products (resin, berries, mushrooms, herb and other technical raw material, abundance of hunting fauna, recreation facilities, etc.);
3) to secure a genetic pool of flora and fauna, as well as natural complexes which are significant from the scientific and historical point of view.

Foresters seek to optimize forest growth and productivity. According to the pattern of the territorial ecosystem "Lithuania" forest growth (see Table 1) is optimized as follows:

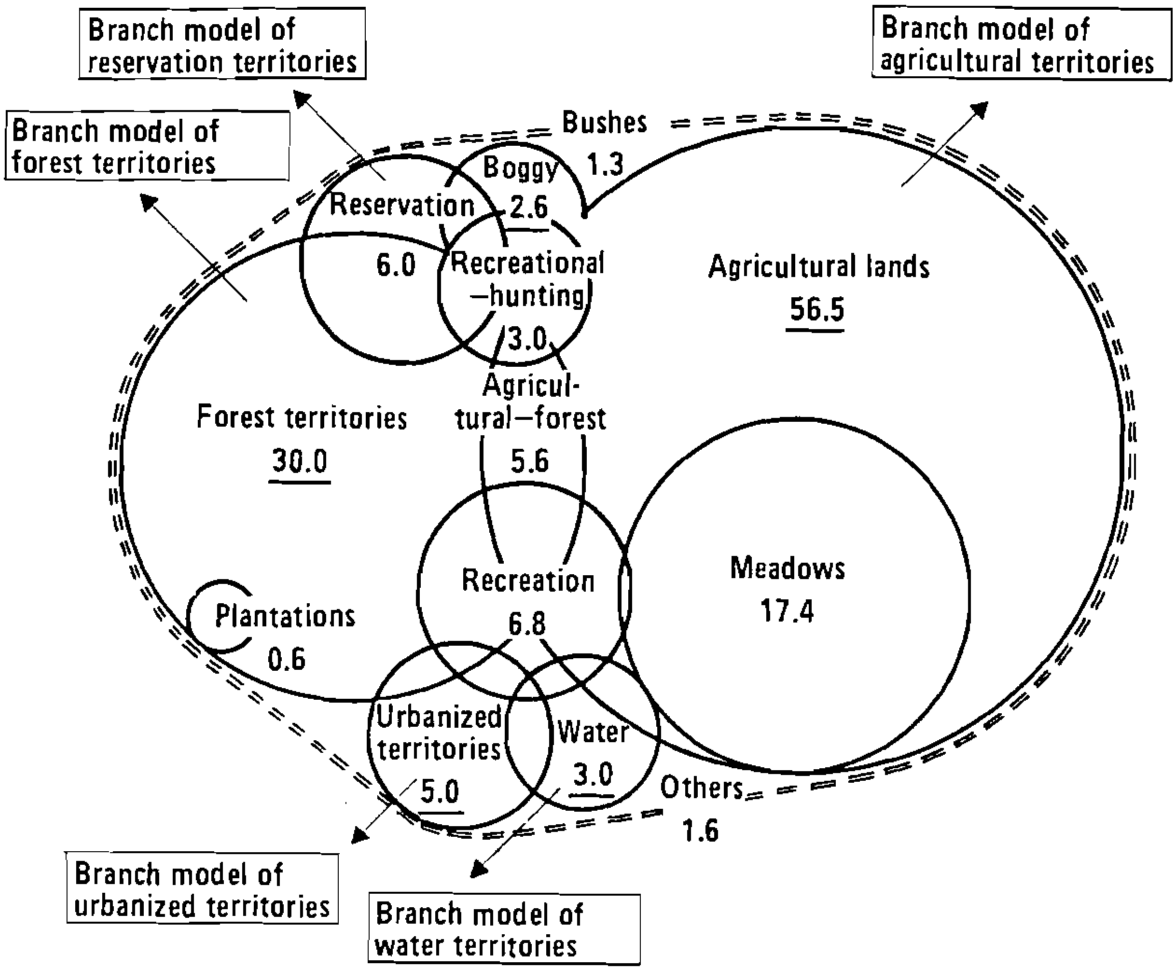

Figure 2. Conditional optimal distribution of the territory of Lithuanian SSR according to functional destination.

Table 1. Characteristics of the Lithuanian SSR forest resources in actual fact and optimally.

Forest Fund Holders	Forest distribution according to species (thousand ha/%)											
	Pine Stands	Spruce Stands	Larch Stands	Oak Stands	Ash Trees	Aspen Stands	Birch Stands	Black Alder Stands	Grey Alder Stands	Other	Total ha (mill.)m^3	Forest Resources
Ministry of Forest Management & Timber Industry	531,2	224,8	0,4	14,7	19,1	61,9	258,8	65,1	33,5	2,8	1212,3	178,7
	43,9	18,5	0,0	1,2	1,6	5,1	21,3	5,4	2,8	0,2	100,0	77,4
Ministry of Agri-culture & others	139,9	108,5	0,1	10,5	6,6	25,4	155,7	38,4	101,3	5,5	591,9	52,1
	23,6	18,3	0,1	1,7	1,1	4,3	26,3	6,5	17,1	1,0	100,0	22,6
TOTAL												
In reality (thousand ha)	671,1	333,3	0,5	25,2	25,7	87,3	414,5	103,5	134,8	8,3	1804,2	230,8
%	37,2	18,5	0,0	1,4	1,4	4,8	23,0	5,7	7,5	0,5	100,0	100,0
Optimally (thousand ha)	848,0	415,0	54,1	90,2	108,2	36,1	144,3	108,2	-	-	1804,2	316,2
%	47,0	23,0	3,0	5,0	6,0	2,0	8,0	6,0	-	-	100,0	137,0

1) industrial–exploitative forests, including plantation forests = 52,7%;
2) agricultural–protective forests = 18,5%;
3) recreational forests = 11,2%;
4) conservation forests = 10,6%;
5) sport (recreational) hunting forests = 7,0%.

GROWING SPECIALIZED FOREST STANDS

Forest distribution into specialized subsectors is an essential condition for regional land use optimization and forest resources reproduction. A specialized subsector comprises a complex of stands territorially isolated and united by the major objective of wood growing and similar management. For example in the Lithuanian SSR, standards for forest growth were carried out for each subsector and measures for installation of standards are being prepared (see Figure 3).

Standards for Industrial-Exploitative Forests (including plantations) of Maximum Productivity

Standards of a maximally productive forest have been created at the Lithuanian Forest Research Institute (Kairiukstis et al., 1980). Such standardss are formed on the basis of mapping forest soils (Vaicys, 1975) from species which under given soil and ecological conditions can give maximum production of industrial wood during the shortest period of time (Kenstavicius and Vaicys, 1968).

The optimal growth of a maximally productive stand is based on maximum stand productivity of a definite species on certain soils and is feasible under the following conditions:

a) maximum energy is absorbed and utilized by the stand (reduced albedo) through selective thinning (Kairiukstis, 1967);
b) stand density is regulated in such a way that negative consequences of tree growth depression should be minimal (Kairiukstis and Juodvalkis, 1975);
c) forest cover is formed from maximally productive trees of class A, uniformly distributed over an area; the distance between trees is optimal (Kairiukstis, 1973; 1981); and,
d) crown density and homoestatic stand sustainability are maximal.

According to the above conditions, the optimal sunlight requirements of different species and development classes, the stories structure at which the albedo index is at its smallest point, is determined. Within the specific class of trees, those with the most economical use of solar energy for the formation of stem timber increment, have been found and density regulation procedures have been carried out (Patent Certificate Nr. 409677). Finally, based on the above-mentioned, the standards of maximally productive stands for pure stands and main groups of species' composition and site conditions have been elaborated. These standards provide optimal stands in different periods of their growth. The standards reflect optimum stand density and structure at any age.

In the process of the formation of a forest of maximum productivity, the assessed indices of the forming stand in nature are compared with the corresponding indices presented at a certain height in the program (Table 2). In the planning of intermediate cuttings, the volume or stand basal area in the forest is compared with the corresponding data presented in the program.

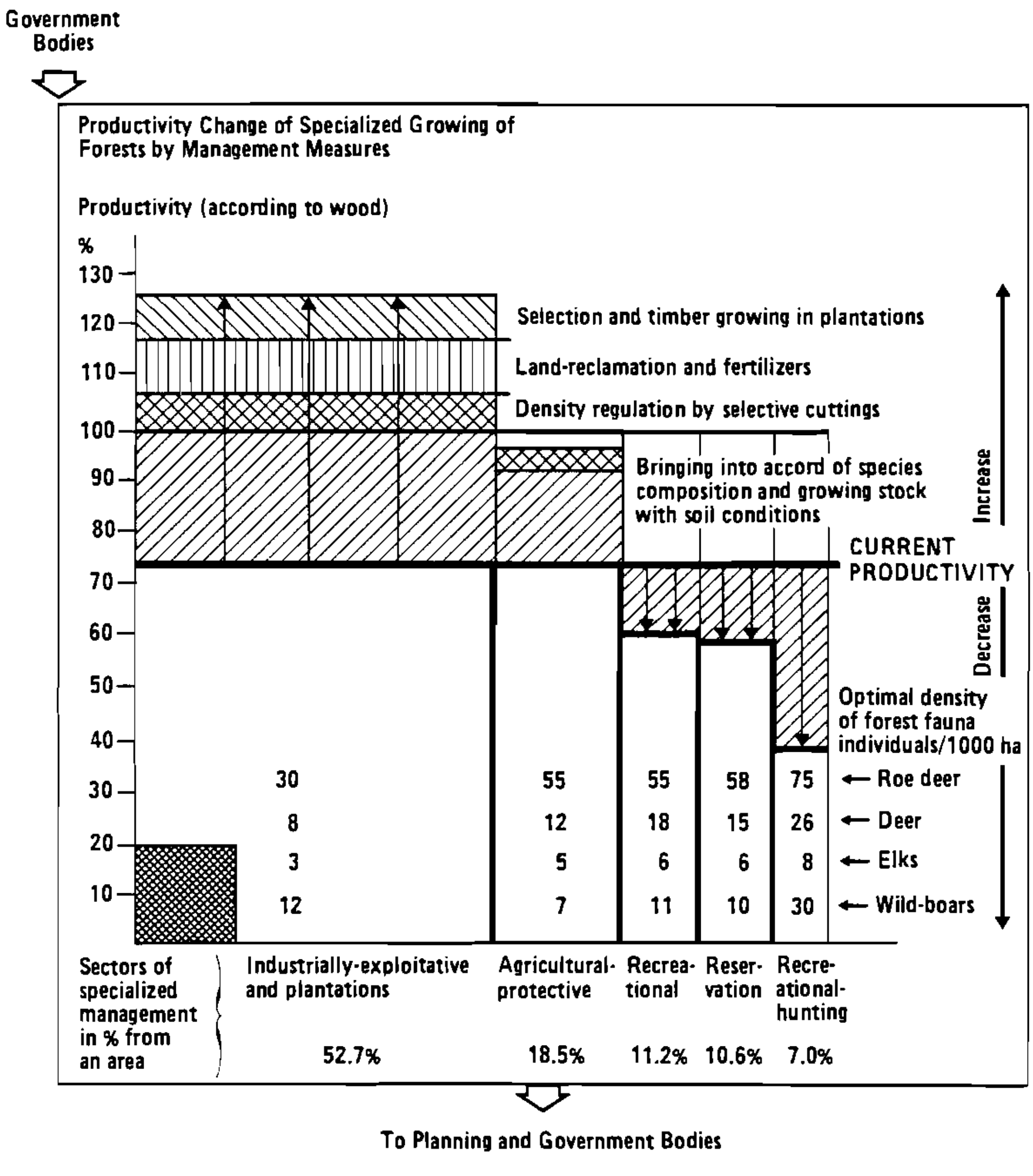

Figure 3. Branch model of forest territories.

Table 2. Program of maximally productive spruce stand formation under the conditions that opening the crown cover and clearing occur every five years, while thinning and intermediate cutting occur every ten years.

Mean height of well-developed trees, m	Assessment indices of trees left after thinning in different forest types					
	Myrtillosum, aegopodiosum mixtoherbosum			Myrtillosum oxalidosum		
	N* trees/ha	G** m^2/ha	V*** m^3/ha	N* trees/ha	G** m^2/ha	V*** m^3/ha
2	2320	0,3	3	2410	0,2	2
3	2310	0,9	5	2400	0,7	3
4	2290	2,0	6	2390	1,5	4
5	2250	3,2	9	2370	2,6	7
6	2200	4,8	15	2320	4,1	14
7	2140	6,6	25	2270	5,9	24
8	2080	8,8	40	2210	7,9	35
9	2000	11,4	59	2140	10,0	51
10	1920	13,9	78	2070	12,4	68
11	1830	16,5	101	1980	14,6	89
12	1740	19,2	128	1890	17,1	112
13	1640	22,1	158	1800	20.0	139
14	1540	24,9	188	1700	22,6	165
15	1430	27,7	222	1590	25,1	196
16	1330	30,0	225	1490	27,2	228
17	1220	32,4	287	1380	29,5	256
18	1120	34,5	321	1280	31,3	289
19	1020	36,3	352	1180	33.5	320
20	920	37,9	384	1080	34,7	352
21	830	3,92	415	980	35,9	380
22	740	40,3	443	890	37,4	410
23	650	41,1	470	800	38,3	435
24	580	42,0	493	720	39,3	458
25	510	42,8	517	650	40,2	485
26	450	43,6	540	590	41,0	510
27				540	41,7	534
28				490	42,1	554
29				470	42,6	576
30				450	43,1	595

*N - number of trees; **G - stand basal area; *** - volume of wood

In the sector of industrial-exploitative forests, all silvicultural operations contributing to more simple, inexpensive and rapid wood growth for consumption are being implemented. In purely industrial- exploitative forests, clear cutting prevails. In mixed forests, shelterwood cutting is provided. In these forests, the elk and deer population is decreased to that level which causes little damage to the forest, while the number of boars is close to the limit of ecological density.

Experience has revealed that due to specialized growing of industrial-exploitative forests according to the program mentioned above, industrial wood increment is increased by 20–25%, its utilization from an area unit is significantly augmented and its cutting cycle is much shorter.

Standards for Agricultural Protective Forests

Standards for agro-protective forests are being established in conformity with the forest which maximally prevents erosive processes and creates better micro-climatic conditions for the adjoining agricultural fields. The forest management goal in these stands is the preservation and increase in their protective capabilities. Dense, many-storied, natural regeneration and undergrowth standard forests serve this purpose.

Under the conditions of Lithuania, such stands exert a favorable influence on the microclimate of fields at a distance of 500–600 meters from the forest. Thus, precipitation is distributed more equally, surface run-off decreases up to 65%, soil erosion reduces greatly, crops lie flat (due to wind, storms) to a lesser extent and yield increases by 10%. Such forests are of paramount importance in hilly regions where woodland is scarce.

A selected cutting system prevails in the management of agricultural protective forests. Shelterwood cutting is an exception. Intensive intermediate cutting is directed towards the reduction of spruce (in view of its low resistance to wind and poor protective qualities) in stand composition, in the restoration of deciduous species and pine as well as towards a continuous maintenance of protective features of these forests. While the quantity of deer is greater, in agro-protective forests the boar population density is regulated on the basis of damage which it inflicts on agriculture.

Standards for Recreational Forests

The standards of recreational forests were set up in conformity with the highest sanitary, hygienic and aesthetic levels. The forests were formed, with great patchings in stand density and species composition. Approximately 70% of the whole recreational territory is to be forested. Scotch pine (Pinus silvestris L.), European white birch (Betula verrucosa Ehr.), oak (Quercus robur L.), maple (Acer platanoides L.), with underwood of common juniper (Juniperus communis), and ash-tree (Fraxinus excelsior L.) predominating in the composition of pure of mixed stands.

A systematic selection of individual trees, cutting favoring the formation of the best landscape view and forest stability, as well as intensive sanitary fellings are applied in the management of recreational forests. Forest road construction, parking areas, foot-paths, etc., are of great significance. The great density of hunting fauna, intensive sport hunting and its management are typical of recreational forests.

Standards for Conservational Forests

The standards established meet the goals of the most valuable stands from a scientific and nature protection point of view. Such forests are composed of game preserves, reservations and national parks. They are preserving the gene pool of the main species, primeval environment, the vanishing vegetation, animals and their cenoses. Management activities in these forests are entirely forbidden or strictly limited. Statutes and protection measures for each object are worked out by scientific organizations and approved by state departments. In conservational forests a great number of fauna is kept; it may reach an optimum ecological level.

Standards for Sport Hunting (Recreational) Forests

The standards for sport hunting (recreational) forests exclusively answer the aims for intensive hunting management. Silvicultural operations applied in these forests contribute to the increase of forage and protective measures for game. Depending upon fauna type, these forests are reconstructed for roe deer, red deer and elk rearing. Only one of these animal species prevails, while the rest are minor. Hare and wild boar distribution occurs in all forests.

Significant attention is focused on the percentage of the territory which is covered by wood, the average size of forest areas, the predominant soil types, stand composition, and the recurrence of forested and non-wooded areas. The ecological density limit of all the main game species is determined as a function of fertility of the prevailing soil types, deciduous species in stand composition, percentage of territory covered by wood and the scale of forest areas.

Cutting is directed towards increasing the in light level in the stand and towards reproduction and development of forage plants and securing hiding places for game. The creation of plantations containing oak (Quercus robur L.), horse chestnut (Aesculus hypocastanum L.), wild apple (Malus silvestris L. Mill.), pear (Pyrus L.), mountain ash (Sobus hybrida L.) and goat-willow (Salix caprea L.) is of great importance.

CONCLUSION

In recent decades, the universal process of man's intrusion into nature and the spontaneous destruction of ecological systems has been growing rapidly. There exist many examples where industrial and agricultural development have impacted negatively. In the Lithuanian SSR, this process was met by a Sustainable Regional Environmental Balanced Development Strategy alternative, based on an integrative approach to national land use planning, renewable resource utilization, and specialized forest growth strategies. The dynamic optimum correlation among the sectors of the regional economy (agriculture, forest, water, industrial-urban, etc.) and the correlation between the main territories and buffer zones were ascertained.

The forestry sector as a branch of the regional (national) economy and as the key factor of the ecological system of a region in a specific territory under pressure of adjacent sectors has become specialized to the greatest possible extent. The function of a forest within a region is determined by the optimal use of ecologically sound principles. Forest growth is implemented in conformity with five designated forest standards: (i) industrial-exploitative (including plantation forests): 52,7%; (ii) agro-protective: 18,5%; (iii) recreational: 11.2%; (iv) sport (recreational) hunting: 7%; and (v) conservation forests: 10,6%.

The optimization of forest growth based on a purposeful function affects forest productivity and forest sector capacity in meeting wood requirements. In the Lithuanian SSR, for instance, measures taken to bring the composition of species in the forest into accord with ecological soil conditions can increase the productivity up to 25–30%. Also, specialized industrial-exploitative forest growth, undertaken in accordance with the standards set, have already resulted in a productivity increase of up to 37%. This occurs due to the application of scientifically sound and effective measures including water drainage, fertilization, stand density regulation by selective cuttings, forest species selection, etc. It will then be possible to meet the wood requirements in the Republic and to fulfill all the auxiliary forest goals for environment protection.

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