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13. Basic Premises and Methods in Landscape Ecological Planning and Optimization

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Several key scientific disciplines participate in the research of landscape ecology. Yet within the framework of comprehensive landscape research, the need for new theoretical and methodological approaches in each of these disciplines is ever more urgent.

All planning activity aimed at utilization, protection and development of a territory, its environment and its natural resources, should be based on knowledge of the ecological essence of a landscape. Until now efforts have focused on learning the preconditions for the ecologically optimum uses of a territory. Planning methods differ depending on the complexity and heterogeneity of a landscape as a study object as well as on the goal, such as land use optimization.

The objective of this chapter is to present a landscape ecology planning and optimization approach (LANDEP) that we and our colleagues have used successfully over the past two decades. We begin by delineating the landscape ecology research and approaches, including biotic components, most critical in landscape ecology planning. We then consider the nature of landscape ecology planning, followed by a description of the main steps of LANDEP, a scientific system of research methods directed towards landscape optimization. We conclude with some results of using LANDEP, and also consider future research developments and applications.

Foundations in Landscape Ecology

Overall landscape ecology is a spatial (chorological) expression of site specific (topological) ecological properties across a landscape. At present we distinguish three main theoretical and methodological trends in landscape ecology:

1. *Landscape ecological research on ecosystems and their spatial relationships.* Includes primary and secondary landscape structure (Appendices A and B), processes and relationships among ecosystems, and energy flow in areas and along lines.
2. *Development of new methods.* Includes computer programming, mathematical and systems approaches, remote sensing and digitization analyses, and synthesis and interpretation of landscape ecological data.
3. *Theoretical basis for landscape ecology modelling and planning.* Based on the systematic classification of landscape ecology complexes (units) and regions.

These trends indicate a robust, developing discipline. The content of landscape ecology and planning, in turn, can be divided into five areas:

1. *Theory and methods of comprehensive ecological research and landscape ecology planning (modelling).* Includes the: (a) theory of generalizing ecological information in regard to its spatial expression; (b) methods for interpreting ecological factors in landscape ecology synthesis; (c) principles for a systems approach in comprehensive landscape ecology research and planning; and (d) methods of using landscape ecology knowledge in management, planning and production.
2. *Landscape ecology data bases, data analysis, interpretation, and partial syntheses.* Includes (Appendices A, B and C) the: (a) primary landscape structure, landscape components, elements, factors and processes; (b) secondary landscape structure, landscape components, elements, factors and processes; and (c) socioeconomic landscape structure, phenomena and processes.
3. *Synthesis and evaluation of landscape ecology data.* Includes the: (a) classification of the landscape ecological types (LETs), that is, the ecologically homogeneous spatial units in the landscape; (b) determination of limits for ecological functions for each land use; (c) determination of the suitability of a LET for a particular land use function; and (d) the combinations of LETs into whole landscapes or regions.
4. *Proposed ecologically optimum land use.* Includes the: (a) proposed ecological data for a land use based on ecologically functional limits; (b) alternative land use proposals based on the order of land use suitability for ecological functions; (c) ecologically optimum proposals for land use, that is, a theoretically ideal proposal; and (d) proposal that relates the economic and social (governmental, etc.) requirements for a land use with ecological conditions.

5. *Protection and shaping of the landscape*. Includes the: (a) steps in land use planning resulting from the landscape ecology models of LANDEP (described below) and other simplified methods; (b) spatial analysis, synthesis and classification of environmental problems in the landscape; (c) interests in landscape protection, nature conservation, and natural resource protection; and (d) steps for relating the development interests of society with landscape ecological conditions.

Biotic Components in Landscape Ecology Research

The biotic components are the basic parts of a landscape that reflect, and to a certain degree are indexes of, the ecological properties and processes taking place in the landscape. Applied and simplified methods of botanical and zoological research are needed to permit rapid understanding of the spatial expression of vegetation and animal communities. This would also aid our understanding of these organisms as functioning components of ecosystems and landscapes.

The significance of the question of spatial position and roles of biotic components in a landscape system emanates from the worldwide, but especially European, interest in ecologically optimizing the use of nature and its resources. Two basic natural vegetation formations, forests and perennial grasslands, are of special interest. For example, within these formations the roles of swamps and scattered landscape greenery or natural vegetation patches is being studied. Cultural vegetation, such as agroecosystems, is also of special interest in the study of landscape structure and function. Indeed, cultural vegetation is a key integrated component in the ecological evaluation and use of landscape components.

Ecosystem science has focused on the production functions of the vegetation formations under the aegis of varied projects and programs (e.g., UNESCO-MAB, UNEP, and IUCN). Increasingly scientific studies are considering the quality, spatial distribution, and share of natural elements in a vegetation formation or specific territory. These aspects are especially critical to understanding landscape ecology stability, landscape-creative dimensions of biotic elements and components, carrying capacity, and ecological corridors and barriers in the landscape. However, these aspects at present are poorly understood.

General Landscape Ecology Planning Considerations

Driven by society's needs for development and by increasing problems associated with society-nature interactions, landscape ecology planning has become one of the most significant directions of landscape ecology research (Figure 1).

We now see that national economies, the world economy, and civilization itself are not immune from global environmental change. In addressing this problem, scientific and technical cooperation in the socialist countries (of the

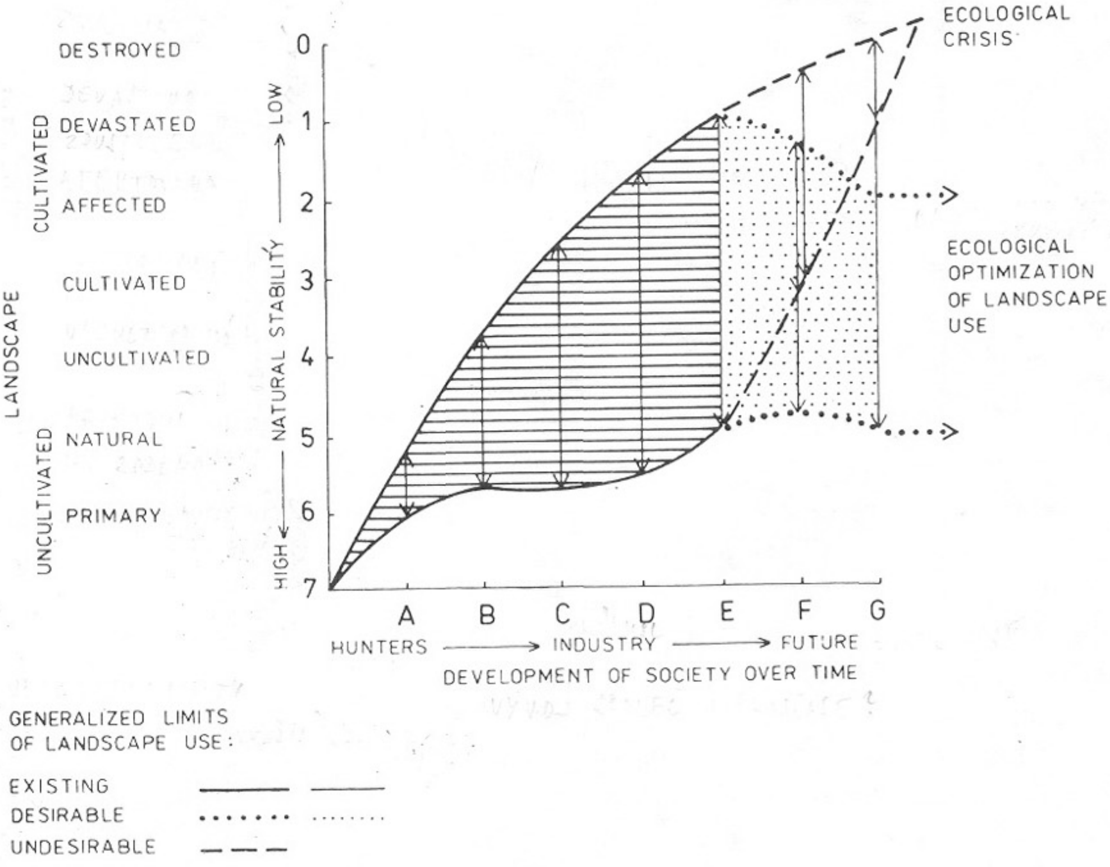


Figure 1. Change in overall landscape stability with the development of society, and with landscape-ecological planning. Vertical arrows indicate the range of widespread land uses present. Two future scenarios beginning at point E (the present) are indicated on the right. Without landscape-ecological planning the expected range of land uses narrows and natural stability decreases, ending with an ecological crisis. With landscape-ecological planning the expected results differ markedly.

CMEA) is coordinated through the Council for Protection and Improvement of the Environment. Among the 14 activities of the Council is "Protection of Ecosystems and the Landscape" dealing with landscape ecology problems. Also landscape ecology planning is included here within the framework of a special theme.

The following five landscape ecology problems deserve particular attention:

1 rational utilization of natural resources;
2 creation of ecologically optimum landscape structure and ecological data for territorial planning (landscape management);
3 creation of favorable living conditions for the inhabitants of towns and settlements, and harmonization of the urbanization process with ecological conditions;
4 transformation of nature consistent with the development needs of different branches of the national economy that affect ecological conditions;
5 nature conservation, including maintaining the natural gene pool of living organisms.

International research and cooperation in this area are developing within the framework of international, nongovernmental and governmental programs. For example, programs of the United Nations (UNEP and UNESCO-MAB) and the International Union for the Conservation of Nature (IUCN) involve the environment, nature and culture. The International Association for Landscape Ecology (IALE), established in 1982 in the CSSR (Czechoslovakia) at the 6th International Symposium on the Problems of Ecological Research of Landscapes, specifically deals with problems of ecological planning.

The LANDEP System for Landscape Optimization

LANDEP is a complex system of applied scientific activities, which includes biological, ecological, geographical, agricultural, silvicultural and other research methods. These methods are united by an integrated modelling process directed towards landscape optimization (Ruzicka and Miklos, 1981).

The LANDEP system sequentially includes a comprehensive landscape ecological analysis, a synthesis component, a landscape ecological evaluation of the territory, and a proposal for optimum land uses. Individual aspects of such a method appear in all planning approaches, but with the possible exception of the McHarg (1969) approach (cf. Junea 1974), LANDEP appears to be the only comprehensive landscape ecology planning system yet available.

The theory and methods of LANDEP have been worked out and tested in Czechoslovakia over the past two decades. The results obtained so far (Ruzicka 1970; 1973a; 1973b; 1976; 1979; 1982; 1985; Ruzicka et al., 1988) permit an unusually broad range of ecological perspectives in a process that leads to landscape management, regional planning, and projecting. The results also open possibilities for a new branch of basic research. In principle, LANDEP permits planning the optimal use of ecological properties of the landscape, as well as creating conditions for a harmony between humanity and the landscape. In territorial planning practice, LANDEP has a simplified form for the ecological proposal of territory (Figure 2).

The LANDEP concept stresses the need for evaluation of the landscape as a territory in which human and societal activities develop on the basis of natural phenomena and processes. LANDEP contains two basic parts (Ruzicka and Miklos, 1979; 1981; 1982a; 1982b) (Figure 3):

1. *Landscape ecology data*. The core of this part is as follows: inventories and assessment of the abiotic and biotic components, the contemporary landscape structure, ecological phenomena and processes, and effects and consequences of human activities upon the landscape (Figure 4). Analysis, interpretation and synthesis (typification and regionalization) complete this part.
2. *Ecological optimization of landscape use*. This part relies on the landscape ecology data, particularly for the ecologically homogeneous spatial units. Thus, the spatial units are compared with the requirements and development

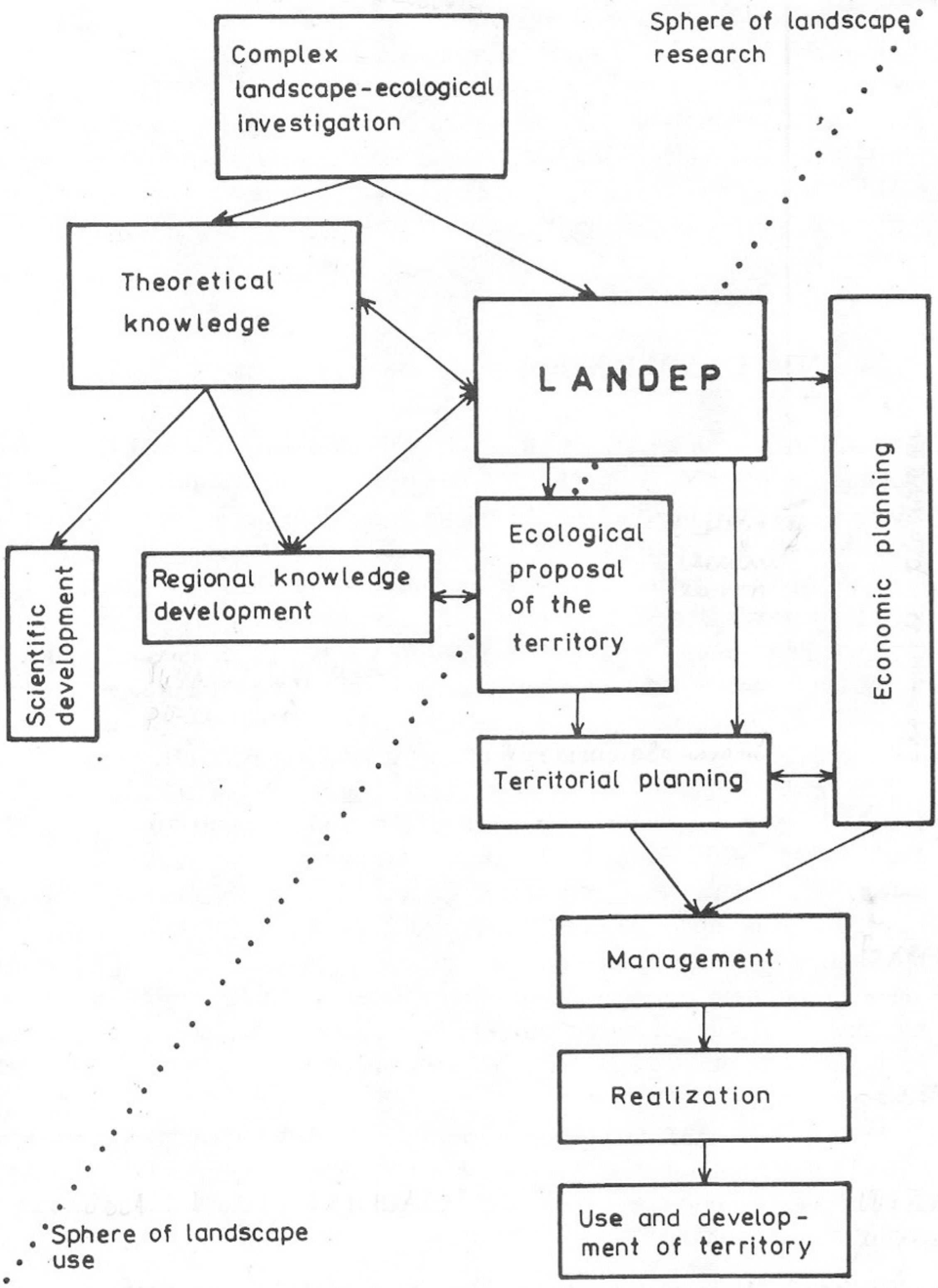


Figure 2. The position of LANDEP, a comprehensive set of methods for landscape planning and optimization, in science and practice.

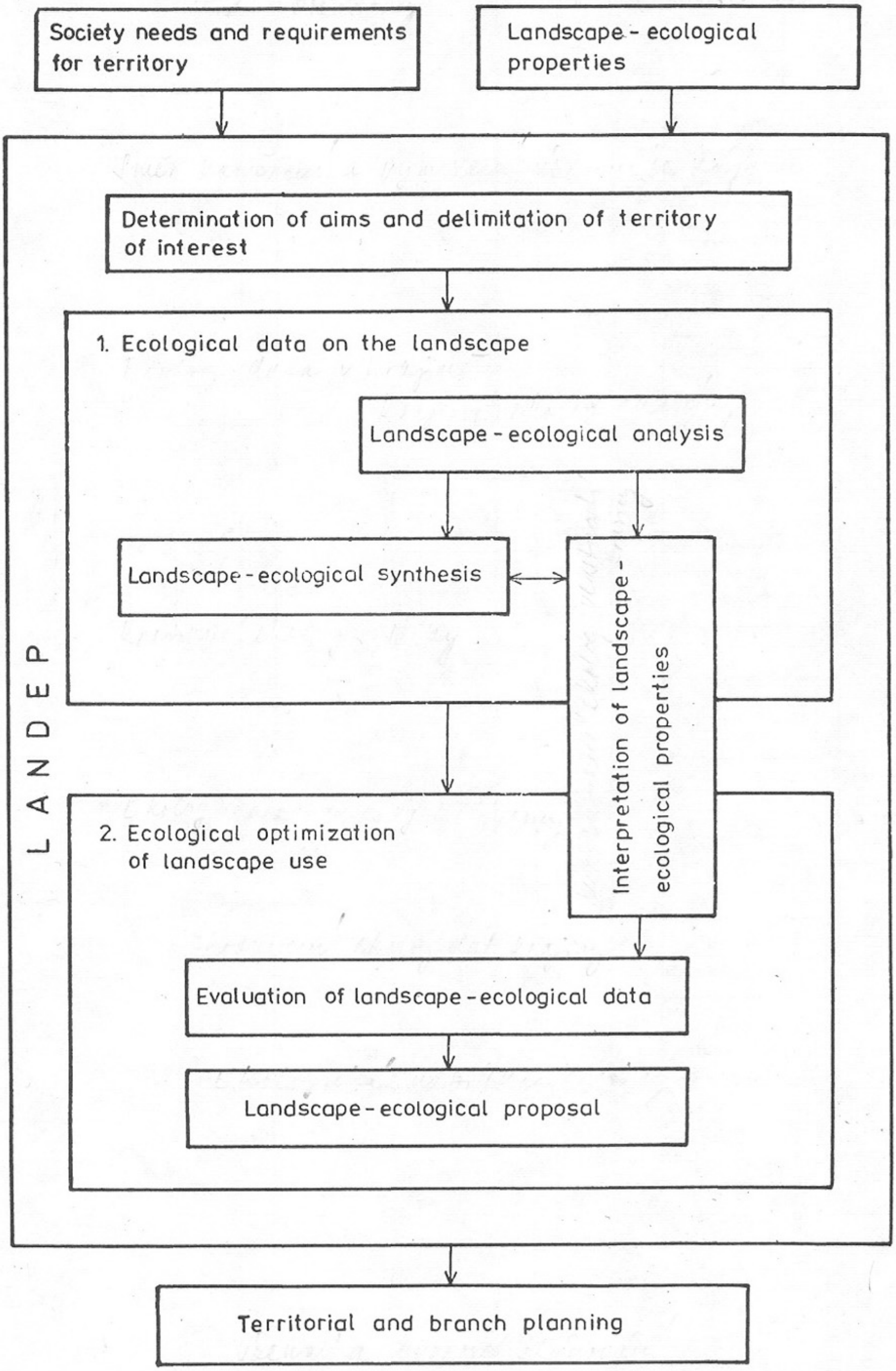


Figure 3. The systems approach and content of LANDEP.

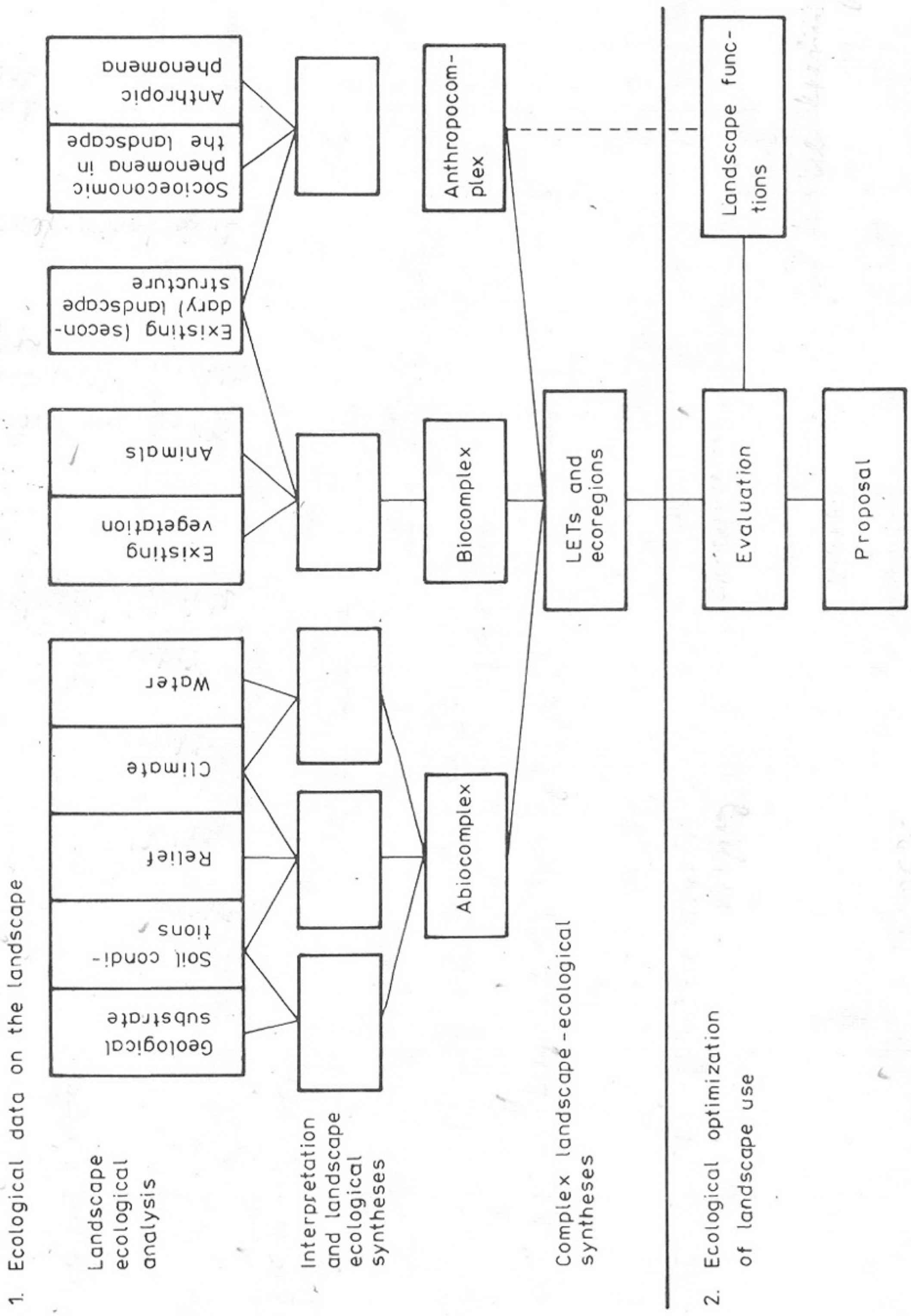


Figure 4. The main steps of LANDEP.

needs of society for a particular territory. Following evaluation of the degree of appropriateness of each spatial unit for a particular human activity or land use, a proposal is made on the most suitable location of the activity in the landscape based on landscape ecology criteria (Figure 4).

Optimization in LANDEP may result in proposing the most suitable location of a planned land use (landscape utilization type) in the landscape based on landscape ecology criteria. However, because landscape optimization should preferably not retard economic development too much, optimization here means choosing the site causing the least evil. That is, a location is determined where a given human activity will be in least conflict with natural conditions. This goal is attained by the complex processes of LANDEP (Ruzicka and Miklos, 1981; 1982a; 1982b).

The LANDEP method is based on confronting land use requirements with the ecological ability of a given territory to support the projected use. In this process three essential questions are answered (Ruzicka and Miklos, 1982a):

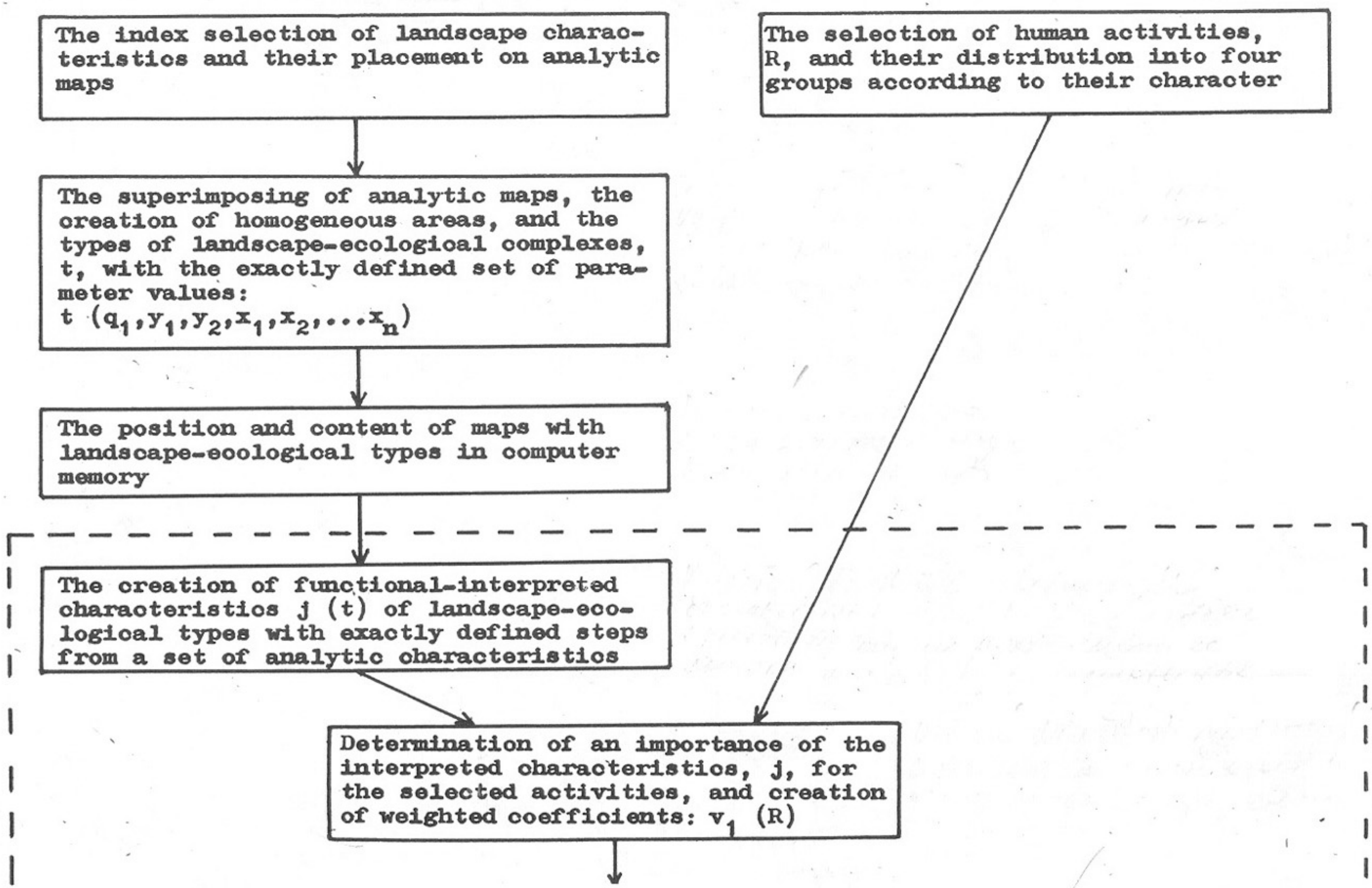
1. How is a given set of ecological properties of the landscape adapted to the functional demands of land uses, that is, to what extent can some activity be developed in a given area?
2. What effects have locating a particular activity had on the ecological characteristics of a given area in the past?
3. What is the present state of natural and human conditioned processes and properties of the landscape (e.g., stability, balance, and resistance)?

By the gradual reevaluation and combination of these partial evaluations, we may find: (a) what activity has the best functional potential to be performed in a given area; (b) what activity is most suitable from a combined ecological and economic perspective; and (c) what danger a particular activity poses to the landscape, as well as the most suitable measures available to mediate the threat.

The optimization process in LANDEP is wholly systematized and partly automated. It simulates the management process occurring in the human mind, aimed at the best planning of space. We have tried to keep this process objective on two important points: (a) consistency during the whole decision-making process according to predetermined accurate principles, and (b) consistency over the whole area of concern.

We must, therefore, divide this process into analytical phases that logically arrange the results and state the underlying systematic procedure. We have also tried to automate this system to the greatest extent with computer techniques (Figure 5).

The systematic LANDEP process permits many ways to simplify, without loss of the main logical principles of the methods. During simplification, the ecological analysis is narrowed to the most important ecological properties of the landscape. It is then checked mostly by reevaluation of already worked up data, supplemented by informational investigation in the field.


The index selection of landscape characteristics and their placement on analytic maps
The selection of human activities, R, and their distribution into four groups according to their character
The superimposing of analytic maps, the creation of homogeneous areas, and the types of landscape-ecological complexes, t, with the exactly defined set of parameter values: $t\ (q_1, y_1, y_2, x_1, x_2, \ldots x_n)$
The position and content of maps with landscape-ecological types in computer memory
The creation of functional-interpreted characteristics j (t) of landscape-ecological types with exactly defined steps from a set of analytic characteristics
Determination of an importance of the interpreted characteristics, j, for the selected activities, and creation of weighted coefficients: v_1 (R)

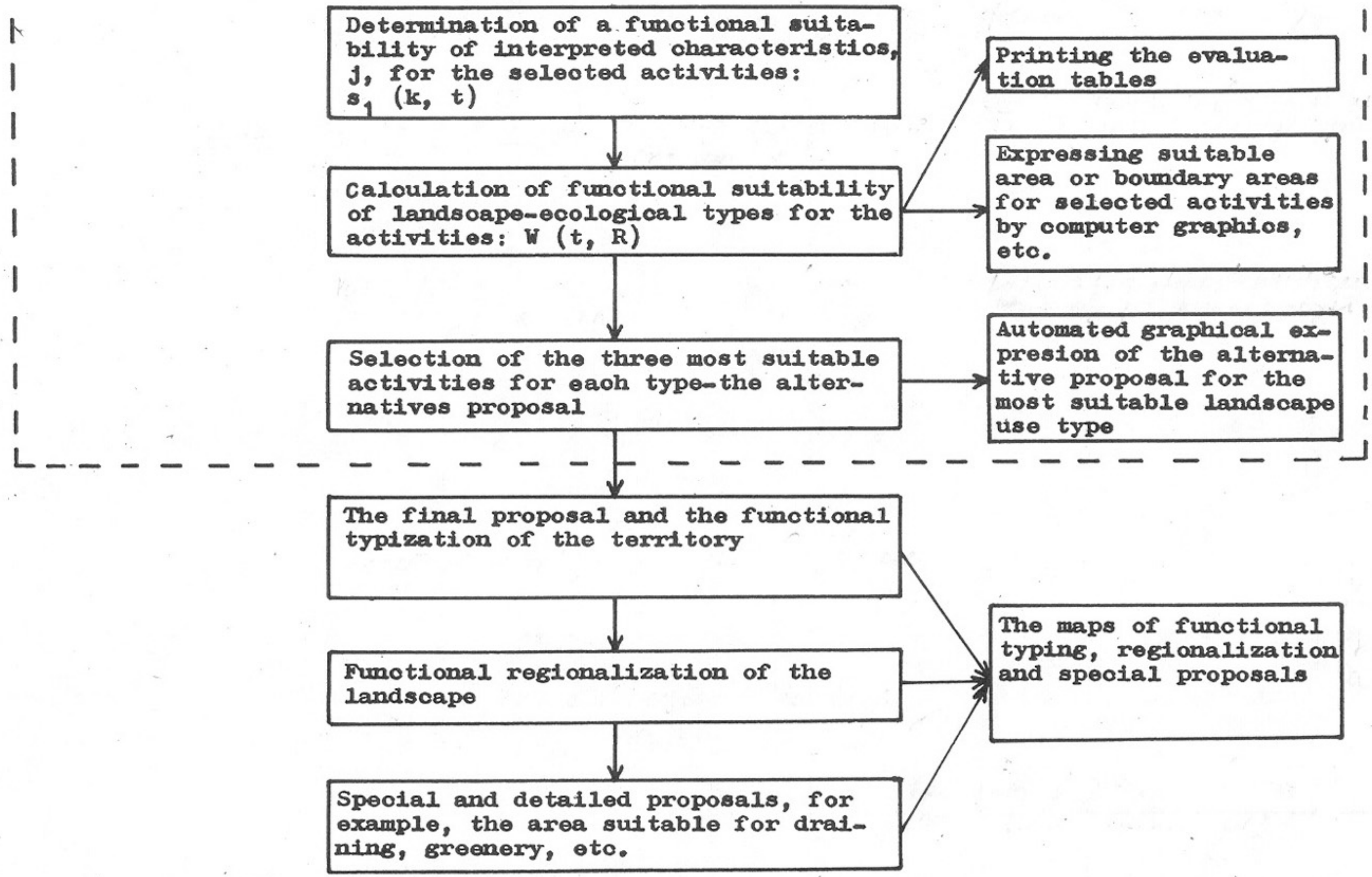


Figure 5. The systematization and automation scheme of the LANDEP method. Steps within the dashed line are accomplished by computer.

The Main Steps of LANDEP

Landscape Ecological and Socioeconomic Data on the Territory

Analytical Portion

The most frequently used analyses are (Figure 4 and Appendices A, B and C):

1. *Delimitation of the territory of interest,* where both administrative boundaries and natural boundaries are recognized (Figure 3).
2. *Geological basis,* from the standpoint of its resistance, carrying capacity and tectonics (from engineering, geology and hydrology).
3. *Soil-forming substrate, soils and ground water,* on the basis of Quaternary sediments and of soil-ecological properties (from soil and stand reconnaissance).
4. *Morphometry of relief,* mainly the inclination, orientation, curvature, and forms (from evaluation of topographic maps).
5. *Hydrography,* the size and shape of a partial catchment area.
6. *Climatic conditions,* based on climatic regions and wind conditions (from atlases), and interpretation of topographic relief forms for insolation and shading.
7. *Potential and actual vegetation,* evaluated on the basis of physiognomic-ecological formations.
8. *Animal biotopes,* analysis and interpretation.
9. *Contemporary landscape structures,* resulting from human economic activity and natural factors (Fig. 6 and Appendix B). Mapping is based on classification with six groups of elements (forests and scattered natural greenery, grasslands, arable lands, denuded substrate, water areas and flows, and built structures and settlements), and its application to individually determined spatial units.
10. *Socioeconomic phenomena,* connected with: (a) industrialization, urbanization and traffic; (b) agriculture (related to soil use intensity, chemical fertilization, amelioration, etc.); (c) recreation and housing; and (d) natural resources and nature protection (Appendix C).

Synthetic Portion

The aim of synthesis (Figures 3 and 4) is to create ecologically homogeneous areal units that in turn are of vital importance in the LANDEP process. These units are of different order and content. They form landscape-ecological types (LETs) differing in landscape properties both vertically and horizontally. LETs have clearly defined content (represented by codes), and can be arranged into a logical and tabular form. The areas of homogeneous LETs form the elements of synthetic maps (Figure 7).

A second aim of synthesis is to provide a clear statement or representation of spatial structure, using analytical indexes for LETs and for regions.

Synthetic maps are the deliberate databases for the subsequent LANDEP process. The contents of LETs put into the computer memory are: (a) all

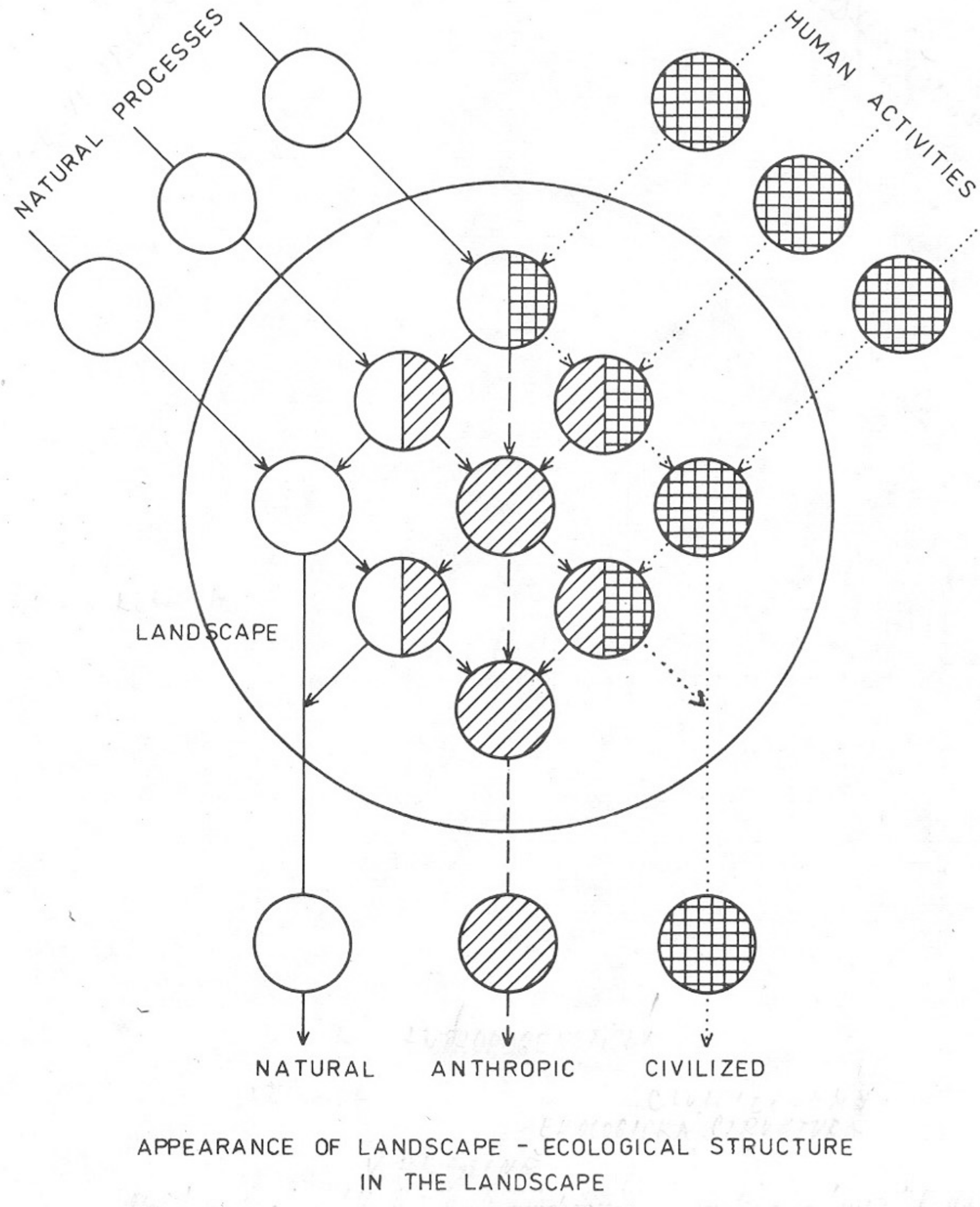
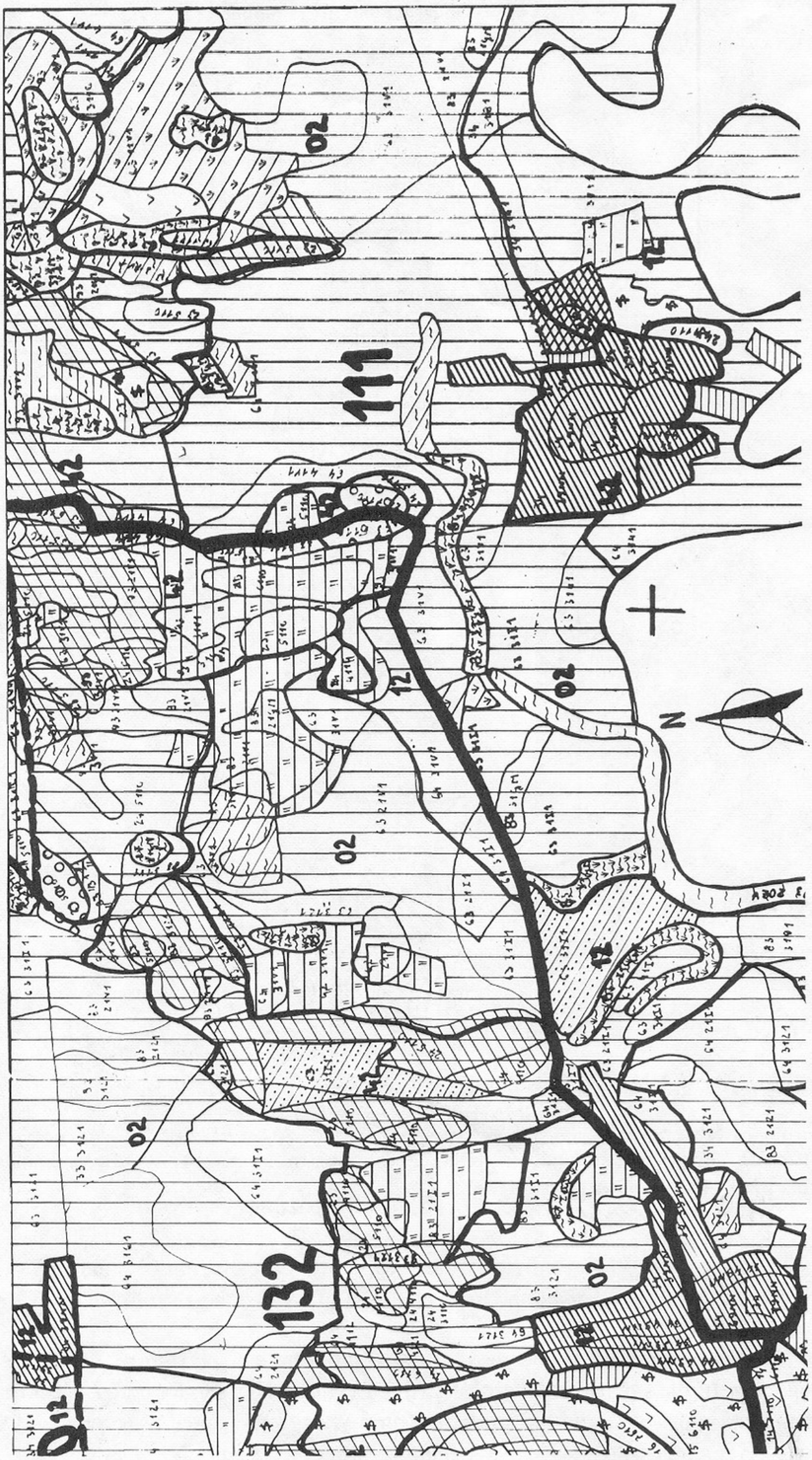


Figure 6. Components of landscape structure resulting from interactions between human economic activity and natural forces.

necessary values for the individual landscape properties or indices; and (b) the areal coördinates for the boundaries of LETs. This is a key synthesis step for LANDEP.

The "overlay" map is the most used methodological portion of the spatial synthesis. In the subsequent steps of LANDEP, the LETs serve as a basis for the optimization process, and the landscape properties, represented as a code set for each LET, enter into the decision-making process.

Clusters of LETs are then recognized in a regionalization process that spatial-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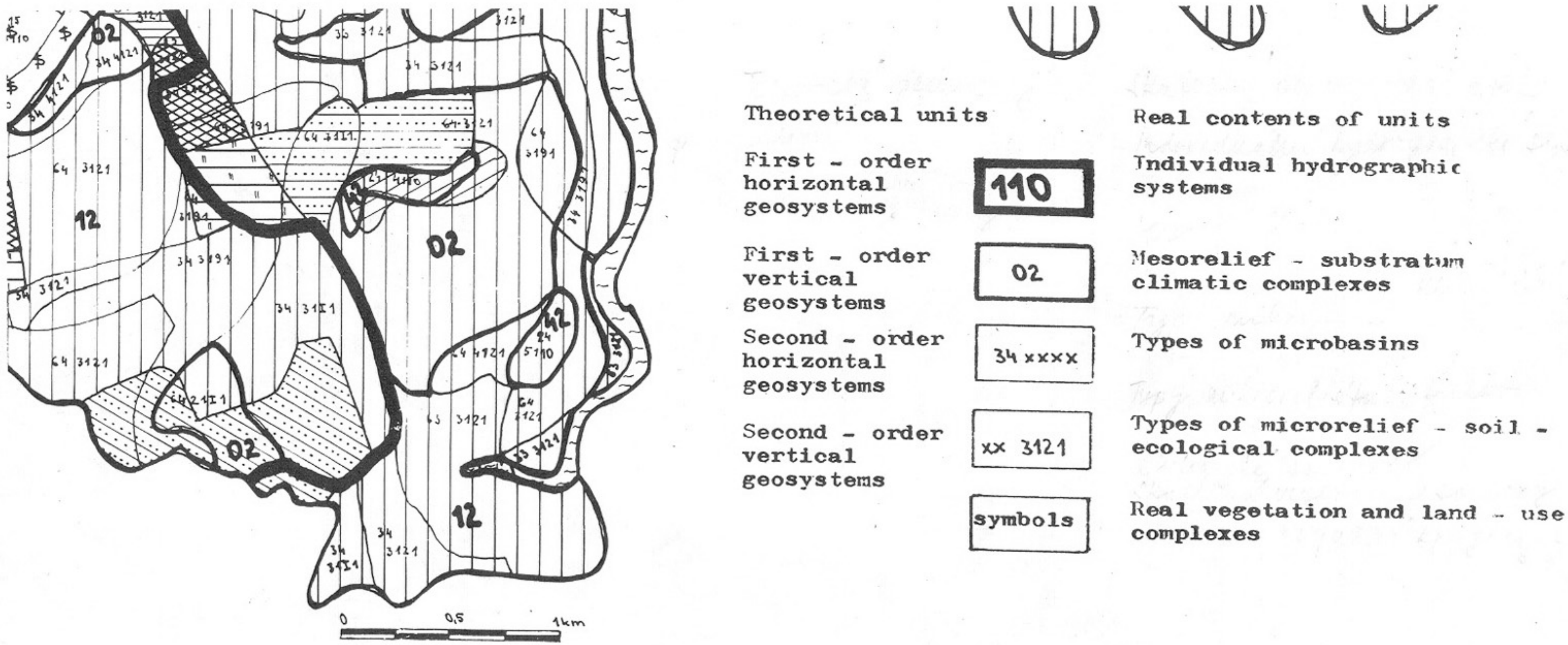


Figure 7. Example of a synthetic map with integrated landscape-ecological types (LETs) in the East Slovakian Lowland.

ly differentiates larger territorial units of the landscape, that is, regions. These regions serve for an overall description of the territory, as well as the basis for separating functional units.

Interpretation of Landscape-Ecological Data

The primary purpose of "interpretation" (Figure 3) is to provide indications of ecological uniquenesses in the landscape that are often not otherwise revealed in the field. Interpretation, as defined here, is a process of transforming basic landscape ecological indices into a form amenable to the process of optimization.

Interpretation of the basic landscape ecology properties makes it possible to obtain from analytic methods a range of functional characteristics, j, that we call interpreted properties. These include availability, arability, waterlogging, soil trophism (physical), carrying capacity of the substrate, insolation from relief, material transport dynamics, anthropogenic vegetation change, degree of "synantropization" of the landscape, suitability for housing, etc. Detailed individual methods are used for determining each of these. The essence of these methods is to state what the combination of analytic indexes (based on LETs) is, and how it influences the interpreted properties, j, of landscapes.

Landscape Ecology Optimization

Optimization is the core of LANDEP methodology. Here, the landscape indexes are compared with selected human activities according to the following steps.

Evaluation

The objective of the evaluation process (Figure 3) is to state (a) the suitability of geosystems (mainly LETs) for human activities, and (b) the limits of landscape properties for a human activity. Again the process is systematized and automated, with two primary inputs: (1) the interpreted functional properties, j, which depend on the original analytic data set (of LETs); and (2) the selected human activities, R. Four human activity groups are of key importance in the decision-making process: (1) "ecological" (forests, natural greenery, reservoirs, etc.); (2) agricultural (arable land, pasture, etc.); (3) permanent culture and recreation (orchard, garden, vinyard, cotagering, etc.); and (4) investment (varied building activities).

The distribution of human activities into classes reflects similarity in the way a function is accomplished. It also reflects similarity in the requirements for a function, "physical" stability in the landscape (that is, if the activities can be changed frequently or not), and importance for the protection and creation of the natural landscape (hence, their "ecological importance").

The three step process of evaluation involves: (1) the determination of weighting coefficients, (2) functional suitability of interpreted properties, and (3) total suitability of LETs for human activities.

Weighting Coefficients

Naturally the different interpreted properties do not influence our decision about the suitability for a given activity in the same way. On the contrary, a property has different importance for different activities. For example, trophism has a different importance for forage cultivation than for building houses. This circumstance is solved by forming weighted coefficients of the interpreted properties for each human activity evaluated, V_j^R.

Functional Suitability of Interpreted Properties

In this step the *functional suitability* of each class of interpreted property, j, for each activity, R, is stated (Figure 5) as $-S_j^{R,LET}$. The limit values of the interpreted properties for each R ($S_j^{R,LET}$ = limit), and the limit sizes in particular, are determined. These values are initially excluded from the proposal for a given activity, based on predetermined principles that limit realization of the activity. Then the zero values ($S_j^{R,LET} = 0$) are determined (the values making a given activity impossible).

Naturally, we are unable to express the individual functions in precise mathematical terms. Therefore, the values $S_j^{R,LET}$ are determined in the order of suitability of each value, j, for an activity, R, on a relative scale.

A team of "experts" decides upon the functional suitability, $S_j^{R,LET}$, for a selected activity. The basic groups of evaluation criteria are: (a) the technical feasibility for realizing a given activity, that is, the practical suitability of a given property for R; (b) the prognosis of a localized influence of the given activity on a locality (we should emphasize the roles and inclusion of landscape-ecology prognosis in this step of the LANDEP process); (c) the influence of the localized activity on specific landscape ecology properties, such as the biological balance or ecological stability; and (d) the expectation that a given localized activity can be realized, based on economic and geographic criteria such as distance and position.

Total Suitability

We assume that the degree of suitability of a particular LET for a particular human activity, is determined by the cumulative effect of its properties, R, being evaluated by their theoretically interpreted properties, j. Thus the total suitability, W (R,LET), is the sum of these partial suitabilities, expressed as a percent of the maximum possible suitability of a given LET and a given activity:

$$W(R, LET) = \sum_{j=1}^{n} S_j^{R,LET} \cdot V_j^R$$

Proposals

Proposals (Figure 3) are aimed at harmonizing the ecological properties of the landscape with its development use for humans and society. The proposal process is divided into four steps.

Initial Selection of Alternative Proposals

The foregoing procedure results in a decision concerning the suitability of a given LET for a given human activity. In the following procedure, in contrast, a decision about the best activity for a given type is made. This phase of the management process results in three or more alternative proposals for the most suitable activity for each LET (Figure 5). The following characteristics are considered in selecting the activities in this alternative proposal:

1. The suitability of the existing land use, that is, how appropriate is the present activity on a given site.
2. The character of the present land use and the distribution (with or without priority) of the land uses into classes and into human activities.
3. The suitability of other human activities for a given type, that is, other evaluation values expressed in percent.
4. The possibility, need and intention of looking for various alternatives.
5. The physical stability of the existing land use as a limiting factor in the selection of alternatives. This determines whether a change from the present use is possible, and if so, how it is technically possible.

The algorithms in this overall alternative selection process determine whether to maintain or change the land use, and in the latter case, what land use should replace the existing one. In essence, for each LET, a selection is made based on simultaneous calculations that determine the human activity with the highest suitability, and the activity group with the highest priority (Miklos et al. 1986). In this process, the present land use is maintained if it falls into the high priority activity group, performs a stabilizing function, or can be changed only with difficulty.

Final Proposal Selection

The next step (Figure 5) of the decision-making process selects from among the alternative proposals. The ecologically most suitable activities are first graphically portrayed on maps (e.g., by color). In this manner, the most suitable human activity or *function* is illustrated for every LET. This *functional typing of territory,* whereby the original LETs are spatially replaced by new functional types, is the basic result of ecological optimization.

The management principles underlying the final selection of the most suitable human activity result primarily from space conditions. Most important are the size of a homogeneous area, properties of adjacent areas, similarity of proposals for adjacent areas, and spatial configuration of surrounding areas.

In larger territories certain groupings of the same or similar functional types can be recognized and correlated with overall natural conditions. This phase of the optimization process is effectively a regionalization of the territory, whereby *functional regions,* that is, characteristic groups of functional types, are delineated (Figure 5).

Functional typing and regionalization serve as the basis for management, decision making and planning in territory development.

Protection and Management of the Environment

This step represents a further stage of the proposal process, in which the proposed ecologically optimal landscape use is compared or confronted with any existing or valid documents of territorial planning. This emanates from the fact that all human activities required for social and economic development must be located somewhere in this or another landscape.

Graphic Expression of the Management Process

The basic results of the evaluation and initial selection of alternative proposals are presented in tabular form. The results are also expressed on hand-made or computer-drawn maps (Figure 8).

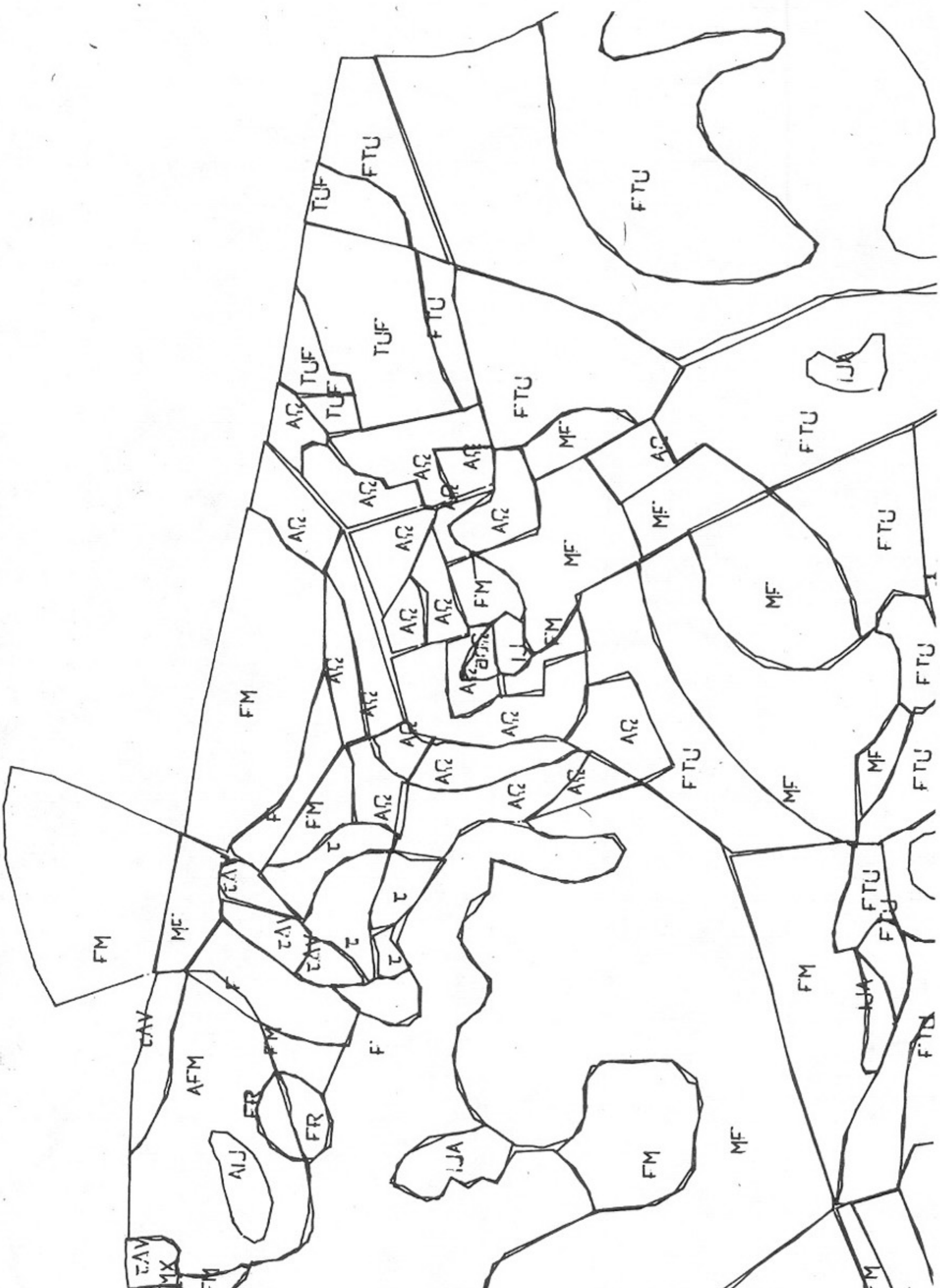
Besides presenting basic results the automatization process allows a graphic expression of the (a) boundaries appropriate for selected human activities, (b) areas of minimum values for selected activities, (c) areas of critical values based on individual ecological indexes, and (d) optimum locations for selected human activities, etc.

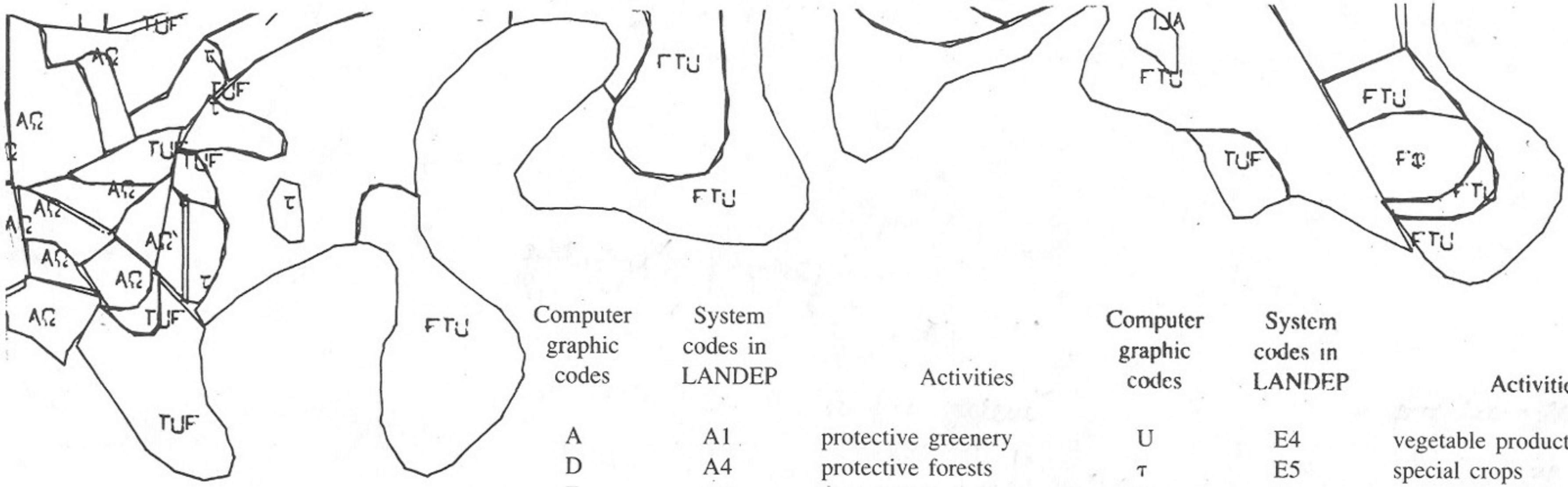
Results and Use of LANDEP

LANDEP as part of a landscape ecology research program can only be developed on a team basis, with composition of the team reflecting the LANDEP content. Each member of the team must also be skillful in obtaining all necessary published and unpublished data, and in elaborating his or her topic inventively for its use in the LANDEP program. The amount and quality of landscape data used in LANDEP must be modified according to their significance and usage for final theoretical and practical objectives.

To verify and modify the LANDEP methods in practice, approximately 100 projects of small to large territories (scales from 1 : 500 through 1 : 500,000) have been done in collaboration with other institutes. Close collaboration with regional planners and practitioners made it possible to develop simplified methods of LANDEP that cooperating institutions could use. To work out and use these simplified methods, additional ecological teams were included in the collaborating institutes. These teams were involved in regional planning and in planning for development of agricultural production.

In Czechoslovakia, LANDEP is in the process of being incorporated into





Computer graphic codes	System codes in LANDEP	Activities	Computer graphic codes	System codes in LANDEP	Activities
A	A1	protective greenery	U	E4	vegetable production
D	A4	protective forests	τ	E5	special crops
E	A5	park forests	V	F1	vineyards
F	B1	timber-trade forests	W	F2	fruit growing
H	B3	deer-parks and pheasantries	X	F3	allotment gardens
I	C1	ponds	Δ	G3	camping
J	C2	water reservoirs	Φ	H1	sport stadiums
M	D1	extensive pastures	Λ	H3	cotagering
N	D2	intensive pastures	Ω	J1	housing
Q	D3	medium intensive meadows	a	K1	industrial areas
P	D4	intensive meadows	d	K4	agri-technical structures
R	E1	forage crops	n	L2	farmhouse areas
T	E3	arable land with staples			

Figure 8. Initial proposal map showing the highest priority optimal land uses for each homogeneous unit of the landscape (1 : 25,000 scale). Produced by computer graphics. Note that this area overlaps the easternmost portion of Figure 7.

methods of regional planning. Landscape ecology data are becoming a part of routine projects where there is little time available for long-term planning.

LANDEP results in a specific proposal, including a map, for the optimal localization of human activities in the landscape. Several important aspects of LANDEP recommend use of the method in practice:

1. The choice, extent and mode of elaborating often detailed data on natural conditions is not left to good will, professional knowledge or the sense of an urban planner, but rather is incorporated into an integrated spatially-organized proposal. The proposal is developed from ecological data and contains clear cut criteria and procedures as to the what, where and why of the ecological proposal.
2. In principle, LANDEP is not in disagreement with economic development of the territory, because it respects all categories of landscape use required by society. The role of LANDEP is to provide the optimum ecological arrangement of such requirements in a given territory, and to pinpoint ecological problems for society caused by poor spatial arrangements.
3. Though LANDEP is applied to socioeconomic categories of territorial development, natural indexes play a crucial role in deciding the localization of these categories. This concern is motivated by an effort to preserve the "life" of the landscape in a harmony between economy and ecology.

These aspects also guarantee a close collaboration among urbanists and ecologists during further stages of territorial planning, because: (a) the urban planner or decision maker becomes aware of conflicts, especially of ecological losses when the ecological proposal is not taken into account; (b) the kind and significance of the conflicts in a given territory can be directly compared on maps based on ecological versus traditional urban planning approaches; and (c) the character of the conflicts forces urbanists and ecologists to decide jointly on a final proposal for territorial development, and on a mode for minimizing associated negative consequences.

These aspects are missing in many other methods that have the same goals as the LANDEP program. A few brief examples might be mentioned. A high degree of comprehensiveness and systematization is achieved by applied landscape ecology methods based on so called *potential concepts* (e.g., Haase, 1978; Nieman, 1977; Jager and Hrabowski, 1976; Junea, 1974; Mannsfeld, 1979; McHarg, 1969). This is also the case for the methods for determining agroecopotential in Hungary (Goczan 1980). However, these concepts are missing the explicitly expressed proposal level as described above. This is illustrated in the methods of landscape planning in the Federal Republic of Germany (Olschowy 1975) and in Holland (van der Maarel and Vellema, 1975) which are based on modelling systems. Systematization of the contents of individual steps of these models is at a different level. Of course, many theoretical models of this type exist. Most often practically oriented models use a hierarchical branching type of evaluation of the landscape. These are particularly evident in evaluations for recreation, nature conservation, human effects on the landscape, etc. (e.g., Lebedeva, 1983; FAO, 1976; Zee, 1984; Hrabowski, 1980; Preobrazenskij et al., 1974; Aleksandrova et al., 1985).

Comparison of the systematized LANDEP method with other methods is complex. Applied methods are highly dependent on local landscape conditions and on particularities of the objectives given (Miklos, 1982).

Further Research Development and Objectives

When addressing questions of ecological evaluation and use of biotic components of the landscape, simplified and applied research methods for vegetation and animals should be developed. Such methods should be aimed at a step by step understanding of their ecological structure and spatial expression. In essense, biotic phenomena and processes should be investigated as part of a landscape complex, as well as indicators of ecological landscape characteristics and use.

The principles and methods of working up landscape-ecology plans should focus on harmonizing land uses with ecological conditions (Fig. 6), and on pinpointing the conflicting land use interests of society. The process should also create prerequisites for conservation of natural resources and for rational ecologically optimum use of the landscape, focused on long-term societal interests and development of humankind.

The systems approach should be applied to understanding the landscape with a major focus on spatial configuration. Further development of the methods of using remotely sensed data, mathematical methods of evaluating spatial relationships, and computer systems, such as geographic information systems, are needed.

The development of specific principles for determining ecologically optimum land uses, landscape conservation, and the creation of new landscape structure would be particularly valuable. Basic research on the structure of models that link general plans to detailed solutions should be enhanced. Finally, for regional and economic planning, we need to develop a simplified method of ecologically evaluating a territory and apply this evaluation in practice.

Application for Society

Knowledge of the ecological properties and biotic components of a landscape can be applied in practice through landscape ecology planning (Fig. 1). Direct application is possible when solving the problems of conservation and rational soil use, optimization of agricultural production, landscape protection against erosion, and increase in ecological stability of the landscape.

The practical focus of landscape ecology planning and the systems approach enable us to play socially important roles. At present there is considerable pressure to satisfy the social order to solve important tasks connected with the national economy, development of individual regions, and society at large. The applicability and progressive character of the results achieved to date have stimulated a number of institutions into collaboration or other forms of using the results.

The widest application potential has been within regional planning where clear linkages among ecological data, analytic procedures, and presentation of territorial plans are especially critical. The second major use of this landscape ecology planning and optimization is in branch planning. Here the search is for ecologically optimum solutions on how to use land for agriculture, water systems, dislocation of industry, power engineering, transportation development, and recreation.

The ecological dimensions of using nature and natural resources should become government policy, as well as a prerequisite in the further development of society.

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Appendix A. Landscape components and primary landscape structure

Components	Ecological analysis and interpretation	Landscape-ecological synthesis	Landscape-ecological planning
1 Geological substrate		Interpretation of geological substrate for LE synthesis	Regional aspects of geological substrate interpretation for LANDEP expressed on a map
2 Soil and soil-forming bedrock	Soil biology, soil and vegetation	Analysis and interpretation of soil-ecological units in terms of physical and chemical properties	Regional aspects of analysis and interpretation of soil-ecological units for LANDEP expressed on a map
3 Relief		Evaluation of relief forms, morphometry and spatial relationships	Regional characteristics of relief forms, morphometry and spatial relationships
4 Water	Water and vegetation	Microbasins and hydrological systems, water flux in a landscape	Regional hydrological systems and microbasins
5 Climate	Phenological aspects of microclimate and local climate	Meso- and macroclimate, insolation	Meso- and macroclimate
6 Vegetation	Potential reconstructed vegetation, real vegetation, forests and scattered vegetation	Potential and real vegetation	Vegetation map
7 Animals	Selected animal groups with regard to their bond to the environment		Map of distribution of selected animal groups
8 Anthropogenic phenomena and processes	Synanthropization of vegetation and animals	Evaluation of anthropogenic relief forms and technogenic phenomena and processes	Regional characteristics of anthropogenic phenomena and processes

Appendix B. Landscape element types and secondary landscape structure

	Ecological analysis and interpretation								Landscape-ecological synthesis		L E P*
Type of elements	Study Subject	Purpose of study									
		Quality and quantity		Spatial structure		Function		Interpretation of purpose			
1 Forest and scattered vegetation	Physiognomic-ecological formation, communities, forest types	Mapping units and their hierarchy	Homogeneity, diversity, vertical structure	Point, line, area	Size, shape, arrangement of the area, edges	Biological, ecological, socioeconomic	In a landscape: corridors, barriers, borders, etc.	Indicator properties of vegetation and animals	Precision and detailing of mapping units of secondary landscape structure, and their use in partial syntheses and in landscape-ecological complex typing. Landscape dynamics in terms of human-land relationships.		Use of mapping units of secondary landscape structure in the elaboration of landscape ecological designs
2 Grassland and permanent grassland	Ecological formation and types of meadows and pastures, communities, cultivated grassland										
3 Crops	Weedy vegetation, permanent crops, character and types of crop rotations										
4 Water flows and basins	Aquatic vegetation and animals									Microbasins and hydrologic systems	
5 Rocks	Colonization and succession of vegetation and animals									Natural and anthropogen. elements	
6 Technical objects and built-up areas	Character and types of technical areas, ruderal vegetation and animals									Economic-geographical characteristics and zoning	

*Landscape-ecological planning

Appendix C. Socioeconomic phenomena and processes

	Ecological analysis and interpretation	Landscape-ecological synthesis	Landscape-ecological planning
1 Nature protection	Interests of nature protection		Synthesis of interests of nature and natural resource protection on regional scale
2 Natural resource protection	Protection of soil and recreation resources	Protection of soil, water resources and mineral resources	
3 Anthropogenic elements and technical phenomena		Interests of urbanization, industrialization and recreation	
4 Anthropogenic elements and phenomena with seminatural character	Interests of agriculture, water and forest management		
5 Overlap of interests in a landscape		Synthesis and evaluation of interests of particular economic branches and of landscape protection	Regional projection of interests in a landscape