3 CONTRIBUTION OF PHYSICAL GEOGRAPHY TO THE DEVELOPMENT OF LANDSAPE ECOLOGY IN SLOVAKIA

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Beginnings

Integrated (holistic) thinking is the typical feature of geography. Its most conspicuous manifestation is regional geography (Matej Bel is the geographer and historian who laid foundations of the Slovak regional geography in the 18th century). Regional geography developed above all by Prof. Hromádka (1943) has significantly influenced thinking of Slovak geographers, particularly interpretation of the landscape and approach to its exploration as a holistic entity in the sense of A. von Humboldt (1862).

The first studies concerning the landscape were written shortly after the establishment of the CSR in 1918 and inspired by the need of administrative division of the new State. Knowledge about landscape as a whole consisting of natural physico-geographical units was to be used as the source material for delimitation of new administrative units (for instance Dědina, 1922), to produce a synthesised view of the Carpathian landscape (Král, 1930) and its use (Kubijovyč, 1932) or the regional-geographical context (Moschelesová, 1935).

An important stimule for the interest in the landscape in the Slovak geography was the politically determined orientation to the Soviet geography after the Second World War. The traditional component of the Soviet geography was the landscape science. The first particular result was the study of Prof. Lukniš (1963), who mediated the used Russian approach to the landscape study. Drdoš (1965) summarized theoretical and methodological knowledge and landscape research questions leaning not only on the Russian (*nauka o landšafte, landšaftovedenije*), but also on German (*Landschaftsgeographie, Landschaftskunde*, even *Landschaftsökologie*) and other geographies. Studies of the Russian geographer Prof. A. G. Isachenko (1963) provided the triggering impulse for the interest in the landscape as research subject under physical geography. The study of Haase et al. (1964), who considered landscape ecology a physico-geographical discipline, also responded to this classification.

Troll's (1950) idea about joining geographic approach (geographical landscape-scientific, to which the author attributed spatial horizontal aspects) and ecological approach (relationships among natural elements – vertical aspects) to landscape research has met with hesitation. The aim was to delimit the smallest though homogeneous landscape unit in content and space. However, such unit, was already known (for instance Polynov, 1925, Hettner, 1927, in ecology Tansley, 1935). This also caused that the term landscape ecology in its interdisciplinary sense and its working methods were introduced only later.

As the holistic study of the landscape is hardly viable by the current methods (see for instance Leser, 1997, and others – see in detail Drdoš, 2004c) and it was rejected in the human geography already in the mid-20th century, the landscape became almost exclusively the subject of physical geography. However, Lukniš (1977) and later Košťálik

(1984) made an attempt and characterized the landscape by means of physical and human geographical analysis. It was connected with interpretation of the landscape as the dynamic spatial system of natural and socio-economic phenomena linked to the Earth surface (Mazúr et al., 1980).

Comprehensive physical geography, geoecology

Not only spatial but also synthesising aspects concentrated upon functional and integrated research of relationships between the studied phenomenon and its causal factors are immanent to geography (Paulov, 1969, Hampl 1971). It is a generally applied approach in all branches of geography. As the landscape research was the domain of physical geography above all, by the end of the 1960s attempts in denoting the integrating landscape research as comprehensive physical geography appeared (see Mazúr et al., 1971, Drdoš, 1972a, 1973, 1974, 1977, Mičian, 1971, 1977, 1980, 1995a, Mičian, Zatkalík, 1984).

As Drdoš asserts (1972a), its subject was the natural complex (or the natural landscape complex - Drdoš, 1977 or geocomplex – Drdoš, 1978c). This author characterized it by two basic attributes: "1. it explores the natural complexes through mutual relationships and conditioning of their components, 2. it explores spatial structures of natural complexes. The natural complex is defined and integrated 4D material dynamic system of elements, which represent different forms of matter controlled by laws of inorganic and organic nature. Natural complex represented by a typical vertical profile (note: at the geographic point) is characterized in its space by those properties of physical elements that were measured or identified by some other ways. Natural complexes established by analysis of their structure, i.e. nature of links between their components in particular profiles of epigeosphere (note: landscape sphere where all Earth spheres crosscut) are considered homogeneous. They serve as the basis for further analysis of spatial structure of natural complexes and building of physical taxonomic systems. In this way, the chorological dimension of the complex physical geography grows up from the topological one".

However, the term *comprehensive physical geography* did not take root in international geography. After 20 years an effort to introduce it again, this time through identification with landscape ecology (Mičian, 1995) or geoecology (Mičian, 1996, 1999, Minár et al., 2001), emerged again. Michal (1997) wrote the textbook of comprehensive physical geography.

In the second half of the 1970s, also the term geoecology (introduced by Troll, 1970 and in our country by Mazúr et al., 1980) appeared – see also Mazúr, Drdoš (1981), Drdoš (2000a, 2003, 2004c), Mičian (1996, 1999), Čech (2004b). This is how in present both terms: the landscape ecology (Drdoš, 2004c considers geoecology its indivisible part) and comprehensive physical geography (Mičian, 1996, 1999, Michal, 1997) are used. Minár et al. (2001) identify comprehensive physical geography with geoecology. Nevertheless, they possess common typical features – exploration of the landscape after Troll (1950) – in its functional-topical sense (topical dimension – research into relationships between the landscape elements in geographical point – vertical profile in the landscape sphere) and spatial approach (choric dimension – research into relationships among the landscape areas based on research of the topical dimension).

Regionalizing trend in landscape research

Regional geographical thinking introduced by Hromádka (1933, 1934, 1935, 1943) and later developed by Lukniš (1946, 1963, 1977) enjoys a strong tradition in the Slovak geography. The natural culmination of regional research is the delimitation of synthesised spatial units, regional taxons (rather holistic landscape units after A. von Humboldt). The requests of the social practice determined by changes of administrative division, environmental problems and the like have compelled geographers to synthesise the knowledge concerning the landscape. The logical synthesis of the knowledge in this sphere is its spatial classification. It manifests in the regionalizing approach to the researched subject (the landscape and its components), which relies on individual, typological and mixed regionalization (sorting individual units, typological units and their presentation most often following the hierarchic principle and alternation of hierarchic levels of individual and typological units). This approach has been used since the beginning (see Drdoš, 1965, Mazúr et al., 1971) in classification of landscape-ecological (and geoecological) units (Michaeli, 1976, 2004, Oťaheľ, 1978, Čech, 2003, 2004a, Pešáková, 2004 and others).

Studies accomplished in the area of Slovenský kras (Drdoš, 1967, Mazúr et al., 1971), the lowland of Záhorie (Plesník, 1971, Mičian, Plesník, 1981), the South Slovakian basin (Bašovský et al., 1987), the basin of Turčianska kotlina (Minár, Tremboš, 1994a), Žitný ostrov (Minár et al., 2001), the Devínska Kobyla Mt (Minár et al., 2001), and other, are examples of regionally focused landscape research. Research results were often presented on examples of selected profiles at local and regional scales (for instance Kandová, 1973, Kolény, 1980, Lauko, 1995 and others). Research and pedagogical results found reflection in text books on the landscape (Mičian, Zatkalík, 1984).

Landscape notion, research approaches, landscape structure, natural and cultural landscape

Landscape is a phenomenon interpretable in multiple ways. Several definitions of the landscape can be found, which reflect the professional interests of selected authors in the relevant Slovak literature, e. g. Krcho (1974), Mazúr et al. (1980), Mičian, Zatkalík (1984), Miklós, Izakovičová (1997), Žigrai (1997a, 1998c), etc. As example can be cited the definition by Oťaheľ (1994): "Landscape is a system of material elements, which interact in synergy through their properties in spatial and temporal dimension. Its material structure possesses its outer manifestation, image of which is differentiated in time and space by its visual structure".

Survey of notions concerning the landscape

In accord with the quoted definitions and landscape characteristics by selected authors the following notions concerning the landscape are used:

According to the content (comprehensiveness) of the concept landscape:

1. Landscape as a material (real) entity.

   1.1. Natural (physico-geographical or biophysical) entity: natural landscape (natural, physical or biophysical content of real landscape which, however, is used and more or less changed by humans).

1.2. Cultural material entity: cultural landscape (anthropic content of the land scape).

1.3. Total material entity: geographic landscape. Landscape as a total reality is subject of interdisciplinary research.

2. Landscape as perception (perceived landscape, landscape as set of images).
3. Landscape as emotional experience (landscape identity).
4. Landscape as environmental entity (as integrated entity of physical and aesthetic state – living space with material equipment and outer appearance and emotional perception)

According to research (approach) subject:

1. Landscape as ecological system (landscape ecosystem) – applies ecosystem approach; the central research element is biota and its relationship to environs.
2. Landscape as a geographical system (geosystem) uses above all geosystem approach (all elements and their mutual relationships are examined equally). System approach also makes possible structured research, i.e. research of autonomous, hierarchically lower systems (abiotic, physico-geographical, cultural, total – integrated system) while it can also apply the ecosystem or geoecosystem approach.
3. Landscape as perceived system (landscape as perception, visual quality, set of images and also identity) – uses above all visual, aesthetic, and emotional research approaches.
4. Landscape as environmental system (landscape as home or living space of humans) applies ecosystem, geosystem and visual approaches.

In terms of modern landscape ecology i.e. in interdisciplinary sense and environmental conception, landscape as a material entity should be interpreted as a real landscape used by humans – living space of humans (see the draft of the Act on landscape planning 2005) or the territory with the natural content (physico-geographical content and complex composed of natural, physico-geographical or biophysical components) and anthropogenic content or the complex represented by the set of land use forms and objects created by humans (Oťahel' et al., 1997), with natural and anthropogenic layer while the landscape content and space form a single indivisible whole (if dissected, it is only for the methodological purposes determined by research aims). From the anthropocentric point of view, it is the natural environment more or less changed by humans. In other words, landscape is represented by the characteristic spatial set of land use forms linked to spatial, physico-geographical (or primary) structure of territory (spatial set of geosystems or ecosystems with various levels of alterations done by human).

In accord with the overall development of landscape ecology, at the beginning the attention focused on issues of what is referred to as the basic landscape units, their clustering into series according to geoecological similarity, identification of types (Drdoš 1967, Mazúr et al. 1971) and regional landscape units (Oťahel', 1978) at different hierarchic levels with the aim to get familiarized with the spatial landscape structure. Natural attention was devoted to research of physiotopes (Drdoš, 1975). The methodical model of physiotope research of authors Miklós, Oťahel' (1978) was adopted at the international

level as the example of analysis of abiotic complex (elements, relationships and properties) and cognition of its regime and behaviour for different kinds of social use. Minár, Tremboš (1994a, 1997), Tremboš, Minár (1995), Tremboš (1994, 1998, 2003) contributed by several studies to research of abiocomplexes.

Research and division of the landscape have been verified in varying landscape-ecological dimensions at the topical level in the methodical form (Drdoš, 1972b), empirically (Drdoš, 1977, Michaeli 1997, 1998, 2001, 2005, Čech, Krokusová, 2005), in choric dimension (Michaeli, 1976, 1989, Drdoš, 1979, Lehotský, 1981, 1991, Poláčik, Oťaheľ, 1983), and in regional dimension (Mazúr et al., 1980).

The crucial form of landscape cognition involves analysis of its natural structure. It represents the hypothesis about the state of the landscape which functions free from social impact and regulation. It is in fact reconstruction of the original landscape how it was before human intervention and under the present climatic conditions. Structure of the natural landscape is identified according to abiotic conditions along with mapping of potential natural vegetation (Drdoš, 1977, Oťaheľ, 1978, Feranec, 1978, Drdoš et al., 1980, Oťaheľ, Poláčik, 1987, Oťaheľ et al., 2000, 2004). The basic landscape unit is characterized by relatively homogeneous physical basis and the corresponding unit of potential vegetation. The classification system of landscape units did not copy the model of German landscape ecology with individual names of units in different dimensions. In contrast it dwells in the conventional hierarchic decimal classification.

System and environmental paradigm simultaneously brought an emphasis on landscape structure research. The structured set of landscape objects and properties works as a common whole based on recognizable mutual relationships.

Landscape research, above all in geography, leans on the diagnosis of natural and anthropogenic (cultural) structure (cf. Krcho, 1968), forming decisive subsystems in terms of landscape functioning as the living environment. It is appropriate to know the physical state of the cultural landscape represented by land cover and simultaneously the hierarchy of its social and economic functions. Drdoš (2004c) distinguished the topic (vertical or functional) landscape structure and spatial (choric or horizontal) landscape structure. Both approaches to landscape structure research (according to originality or anthropic modification and according to research dimensions) are proper to the basic landscape research. Differentiated analysis of landscape structure above all in terms environmental assessment and an efficient result interpretation (see Oťaheľ, 1999a, Oťaheľ et al., 2004) was applied both in basic and applied research. In this sense, the landscape structure is analysed and assessed according to three substructures: natural (reconstructed) referred to as the primary or original landscape structure by Miklós, Izakovičová (1997), substructure of material land use elements (land cover) referred to as the secondary landscape structure and substructure of selected socio-economic elements and phenomena (landscape functions) referred to as the tertiary landscape structure.

Spatial structure of the real landscape (defined by spatial structure of land use) does not always copy the spatial structure of the natural landscape. An adequate way of delimiting the units of real landscape, above all for purposeful use (in landscape planning, ecological network programmes, etc.) is delimiting of natural (reconstructed) landscape units with variants of their real use (anthropogenic variants of natural landscape units,

see Drdoš, 1977). Under this concept, the natural landscape is linked to the cultural (see Žigrai, 1995a). However, the authors also use the separated delimitation of types corresponding to the potential natural landscape and types of cultural landscape (see Oťaheľ, Poláčik, 1987, Drdoš, 1988a, Lehotský, 1991).

The type and intensity of surface modelling processes is also used as the criterion for landscape division, above all for purposeful use (for instance Drdoš, 1979). Criterion of type and rate of surface modelling processes talks about consequences in form of accelerated processes following the destruction of the landscape that can be expected after inadequate land use. Spatial landscape structure analysis was carried out by Michaeli (1989) and others.

Special attention was also given to classifications of cultural landscape. Drdoš (1965) summarized them and Žigrai (1971, 1972, 1997a, 1995a, 1997b, 2002a), Chrastina (2005a, 2005c) along with others elaborated its problems in theoretical, methodological and empirical terms. The basis for delimitation of cultural landscape units is the system of land use categories. Nevertheless, in typology of the cultural landscape, first of all implications were sought with the natural landscape by use of which it origins (Drdoš 1988a). Žigrai (1982, 1995) elaborated this approach in detail and classified the land use categories. Additional criteria such as the level of destruction of natural landscape structure by use (Drdoš, 1980), detailed characteristics of human activities, particularly the type of farming production and its size (Žigrai, 1981, Lehotský, 1981) were also introduced in the division of the cultural landscape.

Landscape research by application of remote sensing data

Remote sensing data, above all aerial photographs and satellite images have enormously contributed to cognition of real cultural landscape. Application of these data in landscape research is also important from the point of view of synthesis of material (substance-energetic) and visual signs of the landscape. Substance-energetic composition (content) of the landscape, materialized in individual parts (objects) of the landscape displays its physiognomic face. Physiognomic signs serve to visual differentiation and identification precisely by remote sensing data. Land cover identification or in other words identification of objects with biophysical substance of the present landscape (Oťaheľ, 1996a, 1999c, Feranec, Oťaheľ, 2001, Oťaheľ et al., 2000, 2004, Falťan, 2000a, 2000b) is considered one of the salient points for integration of the quoted landscape signs.

Cultural landscape research should be followed by differentiation of the subsystem and its function of land cover as the material or physical state of the landscape (Oťaheľ, 1999). Cognition of relevant socio-economic landscape functions is especially important for establishment of hierarchy of their geoecological significance, hence the landscape stability. These functions represent an important regulative mechanism above all in terms of preventive social responsibility for a harmonious development of the landscape (Oťaheľ et al., 2004).

Spatially and temporally correct remote sensing data brought another stimulus for the research of landscape and land use changes (Feranec et al., 1997, Boltižiar, 2004, Cebecauerová, Cebecauer, 2004, Oťaheľ et al., 2000, 2004, Petrovič, 2005).

Geosystem approach to landscape research

The level of correctness of landscape research has been significantly influenced by system approach. The general system theory based in holistic axiom which asserts that the whole is something more than a sum of its parts also determined formulation of the methodology applied to landscape research (Krcho, 1968). System definition of the landscape where geosystem is defined as a set of landscape sphere elements and their relationships and interactions has been adopted (Krcho, 1968, 1974 and others). Landscape as the fragment of Earth surface is the material manifestation of the landscape sphere. System approach particularizes the set of elements and their properties of state quantities and mutual relationships in the landscape (Krcho, 1968, 1974). Landscape is the spatial system with concrete position within the immaterial georelief formed by interacting elements like substrate, water, soil, plants and animals as well as the human-made or modified objects (Zonnenveld, 1988).

Structure, inner building characterized by the unity of stable mutual links among its elements is the attribute of the landscape as the geosystem (Oťaheľ et al., 2004). Knowing these interactions means to possess the key to the cognition of self-regulating and self-regenerating capacities of the landscape and the mechanism of their functioning. System approach also makes it possible to define the landscape research concept through its relevant subsystems. Research has traditionally departed from the diagnosis of the natural and anthropogenic (cultural) landscape subsystems. The concept of landscape synthesis (Drdoš et al., 1980, Mazúr et al., 1983) also builds on this principle. In research of land use i.e. the subsystem of cultural landscape it is appropriate to differentiate the subsystem (substructure) of the material land use elements (land cover) (Oťaheľ 1999) from the subsystem (substructure) of their functions. Miklós, Izakovičová (1997) differentiate substructures the landscape structure for the purposes of applied research: natural landscape as the primary (original) landscape structure, substructure of material land use elements (land cover) as the secondary landscape structure and the third substructure of selected immaterial socio-economic elements and phenomena (landscape functions) is the tertiary landscape structure.

Using the systemic approach, the landscape can be either polycentrically analysed as a set of elements without discerning the importance of elements and relationship or monocentrically with preference to one decisive element. The natural centre in the landscape structure is the vegetation or plant associations to which the animal realm i.e. the landscape biota is linked. This research is generally known as ecological and in and landscape ecology it is referred to ecosystem. Polycentric-geosystem emphasis offers a greater possibility of completeness and coherence of cognition, which the monocentric-ecosystem approach searches for key interacting properties and is efficient in result interpretation. Application of both analytical aspects is recommended in geographical, as well as in landscape-ecological research.

Landscape synthesis

The book of Hagget (1972) *Geography a Modern Synthesis* meant an impulse for the development of landscape research in Slovakia. Hagget asserts that the mission of geography is to produce a comprehensive idea about the world that surrounds us and about the relationship of human to the environment. Humans and their activities in space are emphasized. Application of landscape research to the solution of the above-mentioned relationship was the response (see also Leser, 1997).

In 1979, Slovak geography initiated international symposium about the state and perspectives of landscape research which led to formation of the Landscape Research Working Group in the IGU. The Working Group started to work in 1980 and its program *Landscape Synthesis – Geoecological Foundations of the Complex Landscape Management* expressed the effort in methodological elaboration of the geoecological information system which should contain data relevant for the rational land use and management. In 1988, it finished its activities in accord with the statutes of the IGU. Symposium about the landscape synthesis was held in 1991 in Bratislava. It focused on further activities and possible orientation of research work. The programme then continued within the framework of the International Association of Landscape Ecology (IALE) led by Professors Moss and Richling.

Elaboration of landscape synthesis (synthesis of geoecological information for the purpose of land use management) concentrated on the methodological model of landscape assessment above all for landscape planning applying the environmental concept, which is close to the sustainability concept. The programme included subjects like landscape structure (natural, anthropogenic), landscape carrying capacity, landscape vulnerability (sensitivity), environmental impact assessment and other. Numerous foreign and Slovak studies (see Drdoš et al., 2005), of theoretical and methodological (for instance Drdoš, 1983a, Drdoš, ed., 1983b, Drdoš et al., 1980, Mazúr, Drdoš, 1981, Mazúr et al., 1983) and empirical nature (Mazúr et al., 1984, Oťaheľ, Poláčik, 1987, Lehotský, 1991) were the results.

The new research programme also offered several tasks. First of all it was necessary to change the traditional approach to the landscape. In time of global environmental crisis, the landscape could not bet treated as a neutral object. Landscape became the object of crucial importance for humans, hence its research called for utmost engagement. The relationship existing between the human and the landscape is complex. On the one side, the human is part of the landscape because of its existential bonds (physiological implications), on the other side landscape is home to the human. The human is a reasonable being and uses the landscape as a resource and object of work. Existential aspect is the most important of all, as the landscape is irreplaceable for the human – it is his/her only home (Gould, 1991). Further landscape research promoted this relationship to the decisive one in the study of the landscape and use of its resources by humans (see Drdoš, 1982, Huba, 1982).

The reason was that the previous attitude to the landscape as an unlimited source led to the global environmental crisis and the possible collapse of the planet Earth with subsequent dying out of life on it. This approach suggests the concept of sustainable development but at that time only in the sphere of science (sustainable development covers all

spheres of life starting by cognition, over application, decision-making sphere and ending by policies at local, regional, and global levels).

However, what really is the home of humans – the landscape? It is an extra complex phenomenon. Mazúr, Urbánek (1984) and Urbánek (1992) report the following: landscape is the time-spatial form – region with certain spatial composition and temporal rhythm. Time and space at the global level are continuous and the composition principle is the existential bond of humans to natural processes. Time and space in local dimension are discontinuous and the composition principle is the relationship of epigenesis – i.e. loosened existential dependence. Modern technologies can radically change the locality i.e. a locality can be more of a result of human work.

Landscape potential

Landscape potential became a much treated subjects of landscape research in the 1970s. Development of this branch was spurred by the study of Neef (1966) and above all the 3rd theme of the then existing COMECON International Programme for the Protection of Ecosystems (Geobiocenoses) and the Landscape coordinated by the Institute of Geography SAS. The concept of landscape potential interpreted the landscape in the sense of landscape synthesis (see above), and environmental concept (see Drdoš et al., 1980, Mazúr et al., 1980, 1983, Urbánek et al., 1980, Drdoš, 1983a, Mazúr, Urbánek, 1984) and also Mazúr, Drdoš (1984). They argumented with the increasing environmental crisis which was abruptly altering the landscape structure. Our research and the landscape potential assessment instead of taking into account only the properties of the natural environment (for instance Haase 1978) studied the landscape as a whole (in total not only physical sense). As the primary motif of potential assessment is the rational land use based on exploitation of resources as a social category which changes in time, not only the natural category, the potential was identified both in terms of natural and socio-economic aspects. It is because the landscape potential only exists in relationship of the human/landscape, the human realizes this relationship while the manner of realization also depends on the human (professional interests, level of education, technology available, environmental awareness, etc.).

Its conception is based on the following (Mazúr, Drdoš, 1984):

1. The unity of the landscape potential and the socio-economic development of the society, i.e. the harmony between the environmental and socio-economic approach (i.e. conception of three dimensions of sustainability).
2. The aspect of social efficiency preferred to other local, sectoral or individual interests.
3. The aspect of protected future reproductive capacity of the landscape.

The quoted aspect expresses the approach to the landscape as a home to humans, which in other formulation expresses the concept of sustainability.

Mazúr, Drdoš (1984) defined the potential as the prerequisite of the landscape of its use by humans where the long-term self-reproductive capacity of the landscape is not damaged while the criterion for the assessment of the threshold value of the potential use rate is the

carrying capacity of the landscape. Synthesis of partial potentials (for individual ways of land use) represents what is referred to as preferential potentials denoted by Mazúr (1980) the functional landscape delimitation. Oťaheľ, Poláčik (1987) elaborated it in its empirical form by means of component analysis.

The first studies that started to verify the idea of potential in different territories above all in its choric dimension appeared by the end of the 1970s and the beginning of the 1980s (Drdoš, 1978a, Huba, 1980, 1986, Lehotský, 1981, Hanušin, Huba, 1982, Poláčik, Oťaheľ, 1983, Mazúr et al., 1984, Zelenský, 1984, Oťaheľ, Poláčik, 1987). At present time for instance Michaeli, Ivanová (2005), Škrabuľáková-Ivanová (2005), Škrabuľáková, Valek (2005), Ivanová, Valek (2005), Valek, Ivanová (2006) are involved with the subject of landscape potential.

Application of the environmentally formulated concept of landscape potential is especially topical now when the basic criterion for the governance of the society is the issue of sustainability (the unity of environmental, social and economic dimensions of the development). It also is one of the imperatives contained in the *National Strategy of Sustainable Development of the SR* and its *Action Plan.*

Materialization of the idea inherent to the landscape potential required assessment of additional landscape characteristics given by the relationship between humans and the landscape, such as stability (Drdoš et al., 1980, Huba, 1984), carrying capacity and vulnerability (sensitivity). Huba (1982) referred to them as purpose characteristics because they are recognized in the landscape for some human purpose. They were considered utilizable only in connection with the potential as they determine its rate.

The issue of the landscape potential and accompanying properties is indispensable for the solution of rational and sustainable land use i.e. for landscape planning. It was Drdoš (1978b) who pointed to the relevance of this subject. Huba (1981, 1982, 1986) elaborated the methodology of landscape planning in a modern way and Mazúr et al. (1984), Michaeli, Kandráčová (1985), Oťaheľ (1986), Lehotský et al. (1991) applied it to individual regions. Landscape planning called for assessment of the landscape scenery (Oťaheľ, 1980). Drdoš (2005a), Drdoš et al., (1995) now dedicate more attention to landscape planning also in the context of environmental planning (Drdoš, 2005a, 2005c, 2005d, Drdoš, Michaeli, ed., 2001, Drdoš et al., 2005). Žigrai (1999a) identifies its limits.

The present developments

The new social situation after 1990 introduced new themes in landscape research. The direct stimulus consisted of requests posed by social practice and above all the rapidly developing environmental practice. Here belong numerous subjects at a different level of elaboration such as the problem of the landscape scenerywhich was originally processed by Oťaheľ (1980) according to the theory of photographic principles as part of the programme involved with the landscape synthesis (landscape assessment for the purpose of landscape plan) of the area of Tatranská Lomnica. However, the proper question of visual landscape quality (perceived landscape) assessment was only developed after 1990, both in the theoretical and empirical forms (Oťaheľ, 1994, 1996b, 1999b, Drdoš, 1995a, 1998a, 1998b, 2004c).

Slovak research laid emphasis on visible signs of the perceived object, outer conditions of visual perception above all, search of places with attractive views, range of visibility in the landscape and the like. Several authors made use of photographs, aerial photographs and satellite images, topographic and cartographic sources or they processed them in the computer environment by means of visualisation and 3D models (see Oťaheľ, 1980, 1999b).

Drdoš, (1992a) pointed to the natural risks and hazards what has aroused interest of numerous authors, for instance. Huba, ed. (1993), Drgoňa et al. (1992), Minár, Tremboš (1994b), Minár (2003), Trizna, Minár (1996), because it is especially relevant for the varied environmental projects.

The issue of landscape carrying capacity also developed dramatically although its theoretical and empirical aspects (several projects of landscape carrying capacity concerning the National Parks of the SR) were elaborated already in the 1980s (for instance Drdoš, 1981, but also Drdoš, Hrnčiarová, 2005). After 1990, the theme was part of environmental projects as studied by Drdoš (1990, 1992b), Drdoš, Kozová (1995), Drdoš, Hrnčiarová (2005) and others. The last quoted authors discerned the landscape carrying capacity in the anthropic and biological approaches and pointed to the fact that an objective (result of measuring) and subjective (perception by population concerned) critical thresholds of the landscape carrying capacity exist. Subjective threshold is important for environmental planning as it is mostly done for humans. The specific feature of Slovakia is the elaboration of the cultural carrying capacity. Limits of the landscape carrying capacity were also elaborated. The authors discern eight limits: 1. spatial limits derived of the landscape space and its parameters (size, vertical and horizontal dissection, shape and the like) which determine the land use; 2. geocomponent (abiotic above all) limits derived of the properties of individual landscape components (substrate, relief, soil, groundwater and surface water and climate). 3. geodynamic limits derived of processes going on in the landscape such as avalanches, slope sliding, erosion, floods, windstorms, frost, earthquakes, etc. These are processes that can potentially damage anthropic objects (buildings) infrastructure (roads, electric conduits) various categories of land use (gardens, forests or arable land) or impair further use or even exclude use in planning. Real and potential natural processes are assessed (i.e. susceptibility of territory to extreme natural processes; 4. ecological limits derived of natural importance of vegetation and animal biotopes or landscape areas such as wetlands, moors, pit bogs, meadows, natural forest, rock steppe, etc.; 5. eco-zoological limits are established by legislative nature protection, for instance protected species, protected areas and landscapes and by protection of natural resources, for instance protected areas with water resources and the best quality soil and by other standards such as elements of the territorial system of ecological stability (core territories, biocorridors, interacting elements which can overlap with protected areas). 6. cultural-historical limits established by legislative protection of cultural monuments (for instance National Cultural Monuments, Monument Reserves, Monument Zones, etc.), but also historic and landscape structures of extra high value (preserved traditional forms of farming, typical character of the landscape and other). 7. Hygienic limits established by hygienic standards which define the acceptable content of pollutants in individual landscape components, for instance sulphur oxide in air, noise, phenols in water (surface waters, for instance, are classified into 5 classes of purity), etc.; 8 safety limits established by legislative standards which

define protective zones of various anthropic objects which produce emissions such as dumping sites, animal farms, produce conduits, transport structures of different types (roads, railways) and other.

As obvious from the nature of limits which determine the critical threshold of the landscape carrying capacity, character of the methodology is exclusively a planning one.

Questions of landscape stability (Izakovičová et al., 1997, Tremboš, 1998, Drgoňa, 2004, Oťaheľ et al., 2004, Cebecauerová, 2006) were elaborated in the context of environmental planning as well.

Methodology of environmental impact assessment was also elaborated under landscape ecology (for instance Kozová, Drdoš, 1995, Kozová, Drdoš et al., 1995), and it was applied in numerous projects and recommended by the Act on environmental impact assessment. Likewise, environmental planning (part of which is the environmental impact assessment) was elaborated at the theoretical, methodological and empirical levels by many authors (for instance Lehotský et al., 1990, Oťaheľ, 1994, 1996a, Oťaheľ et al., 1997, Oťaheľ, Feranec, 1998, Drdoš, 2003, 2004b, 2005b, Drdoš et al., 2005, Žigrai, Drgoňa, 1995) and so was the issue of sustainability (for instance Drdoš, 1995b, Izakovičová et al., 1997, Huba, 2001, Žigrai, Huba, 2004), which constitutes the conceptual basis of such planning.

Special attention is given to the theoretical and methodological questions of landscape ecology (geoecology) for instance Drdoš (1988b, 2000b), also in relation to the environmental planning (Drdoš, 2001, 2003), Miklós (1996), Žigrai (1998b), and Oťaheľ (1999) and to comprehensive physical geography (Michal, 1997, Minár et al., 2001). Drdoš (1999, 2004c) emphasized the importance of landscape ecology for the solution of environmental projects. Its extra mission in this context was also confirmed by the environmental practice after 1989. Mičian (1996, 1999) elaborated metascientific questions of geography and physical geography also including issues of ecology and geoecology. However, the first author to present the meta-landscape ecology at the international level was Žigrai (2001a,b, 2003a,b). Development of the landscape since the first settlement in our territory has been studied by Chrastina (2005b, 2006). Žigrai, Chrastina (2002) elaborated the landscape archaeology (reconstruction of prehistoric landscape at archaeological sites.

The problem of holistic approach to the landscape (Drdoš, 2004a), use of geographical paradigms and geographical thinking in general in landscape ecology and environmental planning (Žigrai, 2002b, Drdoš, 2004b, 2005b) and philosophical basis of landscape ecology as the science that studies the relationship of human to the environment have been also dealt with (Drdoš, 2002). Drdoš (2005b) discerns the following paradigms: 1. Paradigm of geographical space and time; 2. Paradigm of continuity and discontinuity of the geosphere connected with 3. Paradigm of spatial differentiation of geographical phenomena; 4. Paradigm of mutual synergic and choric linkage of geographical phenomena connected with 5. Geosystem paradigm; 6. Paradigm of structured geographical phenomena; 7. Paradigm of geographical dimensions; 8. Paradigm of the human and the environment.

Landscape ecology is greatly influenced by the geographic thinking analysed by (Drdoš, 2005b), as determined by capacities of geography and its principles, paradigms and properties of geography. Among them above all:

1. Capacity to develop and update paradigms, use of which is irreplaceable in solution of scientific problems. 2. Capacity to develop theoretical, notional and methodical tools

irreplaceable in acquisition of information about the landscape, its components and the environment. 3. Capacity to obtain relevant exact information about problems solved by proper methods. 4. Capacity to recognize relevance of information obtained by analyses of varied geoscientific, biological, environmental and other disciplines for the solution of research problems. 5. Capacity to synthesise analytical information into wholes with higher statement value about the essence of the investigated problems and its solutions. 6. Capacity to interpret obtained information from the point of view of time and space and to bring relevant statements about geoecological and environmental quality of the living space of the human and tendencies of their development. 7. Capacity to produce information system about the landscape according to criteria of: 7.1. Geosynergic (mutual relationships); 7.2. Geochoric (variability and development in space); 7.3. Geotemporal (variability and development in time); 7.4. Environmental (the human and development); 7.5. Geodynamic (dynamics of processes in the landscape); 7.6. Geoecological (natural significance of landscape phenomena and areas and their geoecological functions); 7.7. Geosozoological (landscape diversity, value and uniqueness of landscape phenomena and areas); 7.8. Geodiagnostic (hemerobia of the landscape, offers of the landscape in terms of human needs - natural resources, natural potentials, land use and its risks – potential and real natural and anthropogenic hazards, vulnerability (sensitivity) of the landscape to destruction, load and the carrying capacity of the landscape for human activities); 8. Capacity to establish the most appropriate ways of land use and its spatial organization (prognosis of land use development and its impact on natural i.e. primary landscape structure based on physico-geographical and human-geographical analysis and assessment (point 7) 9. Capacity to solve research problems in terms of sustainability (equal assessment of social, economic and ecological aspects of the problem).

The quoted paradigms, capacities and methodological parts of geography contribute essentially to the basic framework of landscape ecological theory and its conceptual basis, and together with paradigms, approaches and knowledge of ecology and other sciences constitute in final integration the landscape-ecological theory and methodology.

Cartographic presentation of results is important in integrated landscape research and interpretation. Maps constitute an efficient expressing and communicating means. Simultaneously they are indispensable spatial source materials for further scientific analysis but also solutions for practical life. Hence they were the natural components of the majority of regional analysis and synthesis and often represented a decisive output of geographic studies (for instance, Oťahel' et al., 2000, 2004). Cartographic works authored by Slovak geographers and landscape ecologists deserve a special distinction (Atlas SSR, 1980, Atlas krajiny SR, 2002).

This (although not complete) spectre of studies represent the contribution of the Slovak geography to the development of landscape ecology and strengthening of its position in the system of sciences in Slovakia. The capacity of geography to participate efficiently in interdisciplinary landscape-ecological research programmes has been also strengthened (see also Oťahel', 2004, 2005) and so was the environmental mission of landscape ecology and synthesis in sciences. Gould (1991) wrote that the contemporary science needs synthesis more than ever before. Gore (1992) reports that the paradigm of science in the 3rd millennium must be a holistic one because the solution of environmental crises is only

possible applying the principle of wholeness. It is an advantage that landscape ecology was developed on the basis of modern holism and approach to the landscape as home to humans because these are the foundations the concept of sustainability leans on.