METHODOLOGY OF LANDSCAPE RESEARCH
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ECOLOGICAL ANALYSIS OF LANDSCAPES

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INTRODUCTION

The development of a number of approaches, such as Landscape Ecology, Geoecology, Ecogeography (Ecological Geography), Ecological Geomorphology, Ecological Studies of Landscapes and others results from long-term relations between Geography and Ecology dating back to the origin of Ecology as a science (Tansley, 1935).

Landscape Ecology developed in German Geography due to the activity of K. Troll (1939), J. Schmithussen (1942), E. Neef (1961), G. Haase (1964) a. o. Simultaneously, analogous investigations developed in Russia as part of Biogeocenology (Sukachev, 1944) and Geosystems Studies (Sochava, 1978).

If Ecological Studies of Landscapes developed within the framework of Geography in the 1950s-1970s, mostly in German and Russian, in the 1980s they spread in many countries of Europe, America and Asia. This was connected with the advancement of their anthropological paradigm due to the work of the Dutch scientist A. Vink (1981). The publication of a number of textbooks and monographs (Leser, 1978; Naweh, Lieberman, 1984; Finke, 1986; Forman, Gordon, 1986; Grodzynskyi, 1993; Richling, Solon, 1996; Dierke-Worterbuch, 1997; Vinogradov, 1998) indicates an intensive development of Ecological Studies of Landscapes. Nowadays, Landscape Ecology is considered both as an independent field, placed between Ecology and Landscape Studies (Grodzynskyi, 1993), and as a professional sphere, which involves Geography, Regional Planning, Environmental Protection, etc. (Dierke-Worterbuch, 1997).

Despite the broad content and numerous tasks, Landscape Ecology and its conceptual foundations, formulated by K. Troll (1970), have not changed nowadays. This field is targeted at the study of interrelations in the landscapes of the Earth through the prism of an ecological approach. Its specific features are connected not

so much with the object of investigation, but rather with the approach to it (Grodzynskyi, 1993).

Regretfully, the content of Geoecology is not consistently treated. Geoecology as a scientific approach has not yet outlined its theoretical principles, and today its content, object and research themes are differently regarded (Pozdeev, 1998; Timashev, 2000; Maruszczak, 2001; Kruglov, 2003, 2004; Melnyk, 2004a).

In German science, Geoecology is treated as part of Landscape Ecology, which focuses on abiotic environment, that is, geosystems, which, along with bioecosystems and anthropoecosystems, form Landscape Ecosystems (Dierke-Worterbuch 1997). In East Slavic geography, Geoecology is mostly regarded as part of Geography, which deals with any questions of society and nature interaction (Topchiyev 1996, Pozdeev, 1998).

Some researchers identify Geoecology with complex physical geography (Richling, 1992; Huggett, 1995; Blumenstein et al, 2000), which is hard to accept, since it is not logical from both terminological and content viewpoints. Complex physical geography (Richling, 1992) or landscape studies (Isachenko, 1991) have more than half-of-a-century history with its own research objects – territorial or landscape complexes, or geocomplexes, geosystems of different levels. Both of these names are adequate, and there is no need to replace them by geoecology.

From our perspective, it is also not appropriate to treat geoecology as an "interdisciplinary natural and social science targeted at geoecosystems (Bachynskyi, 1989), oriented at the optimization of the interaction of society with its geographic environment" (Kruglov, 2003). These tasks have already been successfully solved by ecogeography (Paffen, 1959; Issachenko, 1995).

Ecogeography as a field which studies systematic interaction of humans with environment was developed mostly in German geography (Dierke-Worterbuch 1997), where it originated in the end of the 50s under the name "physical anthropogeography" ((Paffen, 1959). Today it is considered as one of the three main parts of complex physical geography (Dierke-Worterbuch, 1997).

Ecological geography (ecogeography) has been treated somewhat broader in Russian (Issachenko, 1995, 2003) and Ukrainian geography (Baranovskyi, Shyshchenko, 2004).

As has been convincingly shown by A. G. Issachenko (1994), the roots of ecogeography date back to the lifetime of Herodotus, since the first concepts related to the interaction of humans and nature, characteristic of Geography throughout its history, originated at that time.

Ecological geography, according to A. G. Isachenko, is "part of geography …which studies geographical environment from an ecological (more precisely, humanitarian-

ecological) perspective with a purpose of solving ecological problems of humankind" (Issachenko, 1995). Accordingly, "ecological geographical investigations remain geographical as to their essence and themes; being ecological according to their ultimate goals, they rely on conceptual basis and methods of geography" (Issachenko, 1995). Ecological geography is theoretically framed by the concept of landscape studies, and its objects are natural geosystems or landscape complexes of regional and local levels (Issachenko, 1991, 1995, 2003).

Ecological Geography can be considered as a trend of Geoecology treated as a field of Geography busying itself with any issues of the interaction of society and nature with no single research object at that (Topchiyev, 1996; Pozdeev, 1998). On the other hand, Ecological Geography which develops, on the basis of its contact with Geography, all of its major divisions, with Ecology of Humans, consists of a number of already formed or *in statu nascendi* disciplines: Natural – Ecological Geomorphology, Ecological Hydrology etc., and Social – Ecological Social Geography, Ecological Industrial Geography, etc. Ecological study of landscapes is an independent field, too (Melnyk, 2004a). It applies the approach of Landscape Studies (Preobrazhenskiy et al., 1988) to solving ecological problems of humans, improving the quality of environment on the whole. Its main task is to elaborate theoretical foundations of the protection of reproducible environmental functions of landscape complexes.

Ecological studies of landscapes as a discipline relies on a logical theoretical concept which includes an object and themes of investigation, system of specialized terms and notions, possesses a clear goal and concrete tasks. The ecological analysis of landscapes, which is a variant of landscape analysis (Preobrazhenskiy et al., 1988), oriented at solving the problems of human environment (Melnyk, 1997, 1999, 2004 b), can be viewed as such a concept.

Finalizing our consideration of relations between Geography and Ecology, we may conclude that two directions in the interaction of these disciplines developed historically. The first one, connected with the development of Landscape Ecology, consists in the application of theoretical foundations and methods of Ecology to the study of geographical objects, landscape studies in particular – landscape complexes, their components and interactions between them. The second direction consists in the application of theoretical foundations and methods of geography, its separate and complex parts, to solving the problems of Human Ecology, questions of the interaction of people and nature, issues of optimization of the environment of human life activities. This served as a basis for such disciplines as Geoecology, Ecological geography (Ecogeography), Ecological Studies of Landscapes, Ecological Geomorphology and others.

THEORETICAL FOUNDATIONS OF THE ECOLOGIC ANALYSIS OF LANDSCAPES

The ecological analysis of landscapes is a methodological concept of investigating the state of human environment, its ecological conditions and problems with the aim of preservation, reproduction and improvement of landscape-complex ecological properties. It is based on theoretical principles of Landscape Studies (Neef 1967; Preobrazhensky et al., 1988; Isachenko, 1982, 1991) and use of scientific princeples of Landscape Ecology (Leser, 1991; Naveh Lieberman, 1993; Hrodzynskyi, 1993), Geosystems Theory (Sochava, 1978), Ecological Geography (Isachenko, 1995, 2003), Geoecology (Topchiyev, 1996) and other fields. Its object is landscape complexes of various levels, its subject –humans with their ecological problems, its subject-matters being states of landscape complexes, in particular, their aspects such as eco-states formed as a result of activities of natural and anthropogenic factors. The ecological analysis of landscapes is aimed at the evaluation of the present-day state of landscape complexes from a viewpoint of ecological human needs, i.e. their role for human life and activities, and justification of the ways to improve the quality of environment.

The contents of the ecological analysis of landscapes is consistently elucidated through notions such as natural or geographical environment, natural and ecological potential of landscape complexes, landscape ecological conditions (eco-conditions), ecological factors (eco-factors), ecological situations (eco-situations), ecological problems (eco-problems), ecological state (eco-state) of landscape complexes etc., which characterize the state of natural environment of human activities.

Natural environment is treated as natural surroundings of people, natural bodies and natural conditions, under which they live and act (Okhrana, 1982). Natural environment consists of landscape complexes of different levels, which are capable of self-organization and self-development.

The natural and ecologic potential of the landscape complex is "its ability to satisfy the needs of man in all necessary basic means of existence – air, light, heat, drinking water, sources of food-stuffs, as well as natural conditions of work, recreation, spiritual development" (Isachenko, 1995).

Natural conditions, which influence life, health, work and other activities of people, are called eco-conditions (Hrynevetskyi, Schevchenko, 1991). **Landscape eco-conditions** are natural and anthropogenically determined properties of landscape complexes, upon which life activities of people depend. Specific features of landscape systems, which are of ecological significance, are **landscape eco-factors**. They can be characterized by **landscape eco-parameters**. Eco-parameters can be classified according to different criteria: according to their genesis, they may be divided into

natural and anthropogenic; according to their relations with natural components – into hydro-logic, climatic, etc.; according to the character and interaction mechanisms in a land-scape complex – into geophysical, geochemical, biological; according to the type of influence upon people – into direct and indirect ones.

Ecological consequences (eco-consequences), either positive or negative for people, are connected with landscape eco-factors. The consequences of the influence of eco-factors on certain territories can either coincide or not coincide with borders of landscape complexes. In the latter case, certain habitats, fields and zones with a specific eco-situation called **ecological anomalies** (eco-anomalies) are formed (Isachenko, 1995). They may be natural, for example, connected with floods, hurricanes, earthquakes etc., as well as anthropogenic – zones of technological pollution and others.

The emergence of **landscape eco-problems** is connected with a change of landscape eco-conditions under the influence of economic activities and of catastrophic rhythms of natural and geographical processes. They are negative changes of nature, accom-panied by the damage of structure and functioning of landscape complexes, which lead, as a result, to negative ecological, social, economic and other consequences.

Eco-conditions and eco-problems, which remain stable during a certain period of time, form **landscape eco-situations**.

Landscape eco-conditions, eco-problems and eco-situations reflect the **eco-state** of **landscape complexes**, i.e. the state of environment on the whole.

The eco-state of a landscape complex is its state interpreted from the viewpoint of ecological needs of humans. It is one of the aspects of the general state of a landscape system and is characterized by eco-parameters of its structure and functioning, which are maintained during a certain period of time (a year and more).

Landscape complexes' eco-states change under the influence of natural and anthropogenic factors causing the necessity of their evaluation. Accordingly, the evaluation of eco-states of landscape complexes that is **landscape eco-evaluation** (Isachenko, 1995) allows us to determine the level of suitability of the environment for life activities of people.

The question of optimization, improvement of eco-states of landscape complexes, i.e. their ecological optimization (Isachenko, 1996), is an important issue. Here it is important to justify **ecological norms** (eco-norms), differentiated according to landscape complexes of various levels. **Landscape eco-normalization** is a normalization of anthropogenic loads upon landscapes (Isachenko, 1995).

The model of the landscape complex, – which is the human environment considered within the system of interrelations and interactions between all components of

the landscape system, – is a basis of the theoretical model of the ecological analysis of landscapes (fig. 1).

The model reflects the essence of the ecological analysis of landscapes, which is part landscape studies as to its content and methods, and part of ecology as to its direction and ultimate goals.

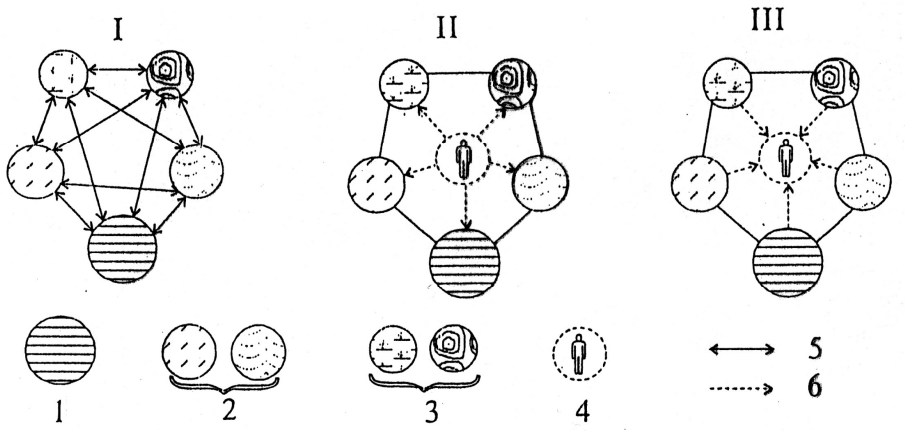

Fig. 1. Conceptual scheme of the ecological analysis of landscapes.
Stages of ecological and landscape research: I – investigation of the properties of landscape complexes, II – study of the human influence on landscape complexes, III – analysis and evaluation of anthropogenic variations of landscape complexes, landscape eco-conditions and echo-states. Interacting components-factors: 1 – geological and geomorphological, 2 – hydroclimatic, 3–biotic; 4 – anthropogenic; relations: 5 – landscape-forming, 6 – ecosystem-forming.

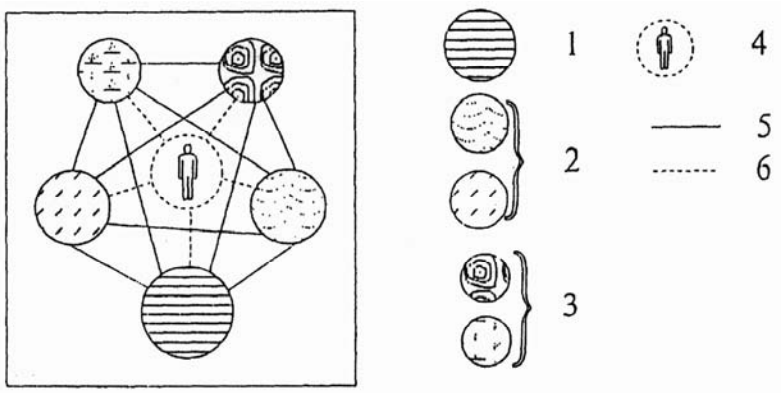

Fig. 2. Schematic theoretical model of the ecological analysis of landscapes.
Interacting components-factors: 1– geological and geomorphological, 2 – hydroclimatic, 3 – biotic; 4 – anthropogenic; relations: 5 – landscape-forming, 6 – ecosystem-forming.

The ecological analysis of landscapes is methodologically framed by dialectic materialism, which reflects a general tendency towards dialecticization of landscape studies (Pashchenko, 1984), and by such general scientific approaches as genetic, systemic, ecological, synergetic and others.

The concepts of Landscape Studies are theoretical foundations for the ecological analysis of landscapes. They include deductively established geographical axioms and postulates of landscape studies (Herenchuk, 1977), sufficiently elaborated notions and terminology (Isachenko, 1988, 1991), a number of empirically found theoretical principles and regularities (Armand, 1975; Isachenko, 1991; Solntsev, 2001), concepts related to knowledge on natural potential, sustainability, and anthropogenic modifications of landscape complexes, cultural complexes, landscape variety, landscape prognostication a.o. (Isachenko, 1991; Solntsev, 2001), as well as landscape-forming principles of optimization of environment and nature use (Isachenko, 1980).

The ecologic and landscape analysis is implemented on the basis of a program envisaging a consistent solution to the following principal tasks: 1) investigating the landscape organization of the territory under research; 2) studying the influence of anthropogenic factors on landscape complexes; 3) analysis and evaluation of anthropogenic variations of landscape complexes, landscape eco-conditions and echo-states; 4) substantiating the ways of improving eco-states of landscape complexes and prognosticating the tendencies of their variations. Analytical models of various sciences are used to solve these tasks – Landscape Studies, Ecology and Landscape Ecology (fig. 2).

The stage of revealing the regularities of the landscape organization of territories is obligatory for any applied research. Its main tasks are as follows: 1) revealing, syste-matization and mapping of landscape complexes; 2) study of their genesis and regularities of the development of landscape systems; 3) research of the properties of the current structure of landscape complexes, the processes of their dynamics and other features; 4) elaboration of the landscape cadastre; 5) investigation of the natural eco-potential of landscape complexes. The inventory of landscape systems by field landscape mapping, their classification, compiling landscape and landscape-inventory maps, zoning maps, and landscape cadastres, study of natural landscape eco-properties and natural eco-potential of landscape systems is conducted at this stage.

During the first stage, special attention is paid to the study of natural potential of landscape complexes, which is an important factor of the formation of eco-situations, and to the analysis of natural eco-properties connected with all natural components. The methods of solving these tasks for mountainous and sub-mountainous territories

have their peculiarities and are reflected in appropriate recommendations (Miller, 1972, 1974; Melnyk, Miller 1993).

The stage of investigating anthropogenic loads on landscape complexes envisages a thorough registration and analysis of various anthropogenic influences. Three groups of tasks related to the study of different types of loads are solved here, viz. 1) investtigation of the level of population of the territory and revealing the degree of demographic load on landscape complexes; 2) study of the anthropogenic influences of plane character, such as forestry, agriculture, etc.; 3) investigation of local anthropogenic loads, connected with permanent separated and linear sources of influence (industrial objects, settlements, roads, etc.).

The analysis of anthropogenic loads is accompanied by calculations and use of various quantitative indicators of social and geographical character, such as density of population, plowing up of a territory, level of air pollution etc., which causes a wide use of statistical methods. Here mapping of social and economic phenomena upon landscape territorial units is especially effective (Isachenko, 1995). The analysis of current economic influences, their dynamism in the course of history is of importance, too.

The major results of this stage of investigation are masses of quantitative information in the form of tables and computer databases that characterize these or those influences in absolute values, and a series of analytical maps, maps and diagrams reflecting the territorial differentiation of anthropogenic influences in a systematized evaluative form.

The stage of the analysis and evaluation of anthropogenic changes, eco-conditions and eco-states of landscape complexes includes the following: 1) analysis and evaluation of structural, functional and dynamic changes of landscape systems determined by the influence of an anthropogenic factor; 2) evaluation of eco-conditions and eco-states of landscape complexes and prognostication of the tendencies of their changes; 3) ecological and landscape mapping and zoning.

Ecologically important consequences of anthropogenic loads on landscape systems are reflected, firstly, in the change and modification of their vertical structure, secondly, in the activation of negative natural phenomena, thirdly, in the pollution of functional chains of landscape complexes and their separate natural components by poisonous substances, and in the formation of technological geochemical eco-anomalies. All these eco-consequences can be fixed in details on appropriate ecological and landscape maps. That is why the cartographical method of analysis and modeling of ecological consequences of anthropogenic loads is one of the main methods.

The final stage of the ecological analysis of landscapes is that *of justifying the ways of improving the eco-situations in landscape complexes* on the basis of their rational use

and protection, prognostication of variation tendencies of landscape eco-conditions. The main tasks of this stage are as follows: 1) organization of ecological and landscape monitoring; 2) elaboration of measures targeted at restoration and melioration; 3) normalization of anthropogenic loads on landscape complexes; 4) justification of the network of nature protected territories; 5) elaboration of measures to prevent negative natural and geographical processes; 6) justification of the stable development of territories; 7) prognostication of variation tendencies of landscape eco-conditions.

The important research instrument and presentation form of results on the stage of the elaboration of the ways of landscape complexes optimization are landscape recommendation as well as ecological and landscape maps. They can be partial (for example, maps of recommendations on combating these or those negative processes or on forestry, etc.) and complex landscape-planning maps which include the system of measures on the formation of cultural landscapes (Isachenko, 1980).

ECOLOGICAL CONDITION OF LANDSCAPE COMPLEXES IN THE UKRAINIAN CARPATHIANS

The study and estimation of eco-conditions of landscape complexes envisages an account of a whole number of landscape eco-parameters, which characterize, firstly, the genesis and structure of the landscape systems and their natural eco-properties, secondly, anthropogenic changes of their vertical and horizontal structure; thirdly, specificity othe dissemination of modern negative naturally geographical phenomena and processes; fourthly, levels of technogenic contamination of landscape complexes.

The most effective method of ecological estimation of landscape complexes is their ecological classification (Isachenko, 1991б). An elaboration of the integral ecologic and landscape classification, which would take due account of all ecological factors, most heterogeneous by their very nature, is rather problematic. Therefore, it is more expedient to utilize evaluatory classifications of landscape complexes in relation to the separate groups of ecological factors, and then compare them among themselves. In this case there is no necessity to analyse in detail all of ecological properties, but it is sufficient to choose, within the limits of that or other group, the principal ones taken as a basis for classification.

In the process of ecological and landscape analysis of the Ukrainian Carpathians' landscapes three ecological classifications of landscape complexes were implemented: 1) according to potential favourability of their natural conditions for human life, i.e. according to their natural ecological potential; 2) according to the degree of anthropogenic changeover of the landscape systems, which is expressed by the aggre-

gate of heterotemporal anthropogenic states — anthropogenic modifications, each of which is characterized by the specific spectrums of negative naturally geographical processes; 3) according to the level of technogenic contamination of landscape complexes. The integral estimation took into account all the three classifications, the basic among which was the one that characterizes the degree of anthropogenic transformation of the landscape systems.

The Ukrainian Carpathians are a part of the Carpathian Mountainous System within the state border of Ukraine. It stretches from the north-west to the south-east with a band of ca.100 km wide and ca.380 km long. These are middle-altitude mountain ranges, the highest peak being Hoverla (2,061 meters above sea-level) composed of primarily flysch (layers of sandstones, arguilites and aleurolites) as well as volcanic (volcanic range) and crystallic (Rakhiv-Chyvchytsia or Maramoreş Massif), and pre-mountain highlands (up to 500 m) and lowlands (up to 300 m) made up of alluvial layers.

First and foremost, on the basis of generalizing the experience of the landscape mapping of the region (Voropay, Kunytsia 1966; Nature, 1968; Miller, Fedirko, 1990), as well as following the materials of the long-term self-conducted field research in its different parts we have made a landscape map of the Ukrainian Carpathians showing the landscape complexes at the level of high localities (fig. 3). The highland terrain is, according to H.P.Miller (1974), a landscape complex formed on the basis of mesoform relief complexes under the leading influence of one of the morphogenesis factors. It provided the basis for a subsequent analysis and estimation of landscape natural eco-properties.

The estimation of natural landscape eco-conditions characterizing the natural eco-potential boiled down to the ecological classification of height localities on the basis of descriptions laid in the legend to the landscape map. As a result, the landscape complexes were incorporated, on the strength of the favourability of the natural eco-potential, into several ecological groups: very favourable, favourable, little favourable and unfavorable. Very favourable are the localities of low (19) and middle terraces (18) in pre-mountain part of the Tisza basin; favourable are those of even, waterlogged surfaces of low terraces (19) and middle terraces (18) in the pre-mountain part of the Dniester and Prut basins, surfaces of pediments (10), high wavy territories between rivers (11), widely mountainous territories between rivers (14), weakly wavy surfaces (17), gibbously mountainous erosive- movable territories between rivers (12) and Gibbously depressive erosive movable territories between rivers (13, *a*lluvium-sandry plains (15), *e*ven waterlogged bottoms of old river valleys (16) terrace bottoms of river valleys (fluxes and lower terraces) (9), gently sloping erosive-denudational woody and secondary-meadow low-altitude mountains (6),

steeply sloping erosive-denudational woody and secondary-meadow low-altitude mountains (5), gently sloping woody old glacier middle-altitude mountains (3), steeply sloping erosive-denudational woody middle-altitude mountains (4), convex peneplained Alpine-subAlpine highlands (1), sharply concave old glacier erosive subAlpine (2) highlands, as well as fluxes and river-beds (21).

The present-day eco-state of landscape complexes mainly depends on their anthropogenic transformatedness, whose depth and duration depend on which of the natural components have undergone changes. The transformation of biotic components, as a rule, predetermines weak, often reverse, changes, whereas violation of the lithogenic basis – mountain rocks – causes radical, mainly irreversible changes in landscape complexes.

On the basis of analyzing the anthropogenic loadings of the plain character, which are fixed in the modern structure of the lands, we have revealed in the Ukrainian Carpathians anthropogenic modifications of landscape complexes such as stages of anthropogenic degression, viz. conditionally radical, secondary forest, secondary meadow, field (field-crop), selitab and industrial (Melnyk, 1999). Prevailing of certain types of anthropogenic modifications within the limits of those or other landscape complexes was the foundation for an evaluatory classification of them according to the degree of anthropogenic variability with the selection of ecological groups such as 1) poorly changed (moderately favourable eco-conditions); 2) middle-changed (satisfactory eco-conditions); 2) largely changed (worsened eco-conditions); 4) very much changed (unsatisfactory eco-conditions).

An analysis of the dissemination of the stationary sources of contamination and volumes of the throw-out of polluting substances into the atmosphere on landscape localities gives grounds to delineate in the Ukrainian Carpathians, following the level of the territory contamination, ecological groups of landscape complexes such as: conditionally clean, moderately polluted, polluted, very polluted and extra-polluted (Melnyk, 1999). Conditionally clean in the region can be considered middle- and low-mountainous landscape wood-covered localities with no permanent settlements. To the moderately polluted belong low-altitude mountain highlands with secondary meadows and rural settlements of dispersible type, as well as pre-mountain landscape complexes covered with predominantly large forest massifs. Polluted are localities of the benched bottoms of river valleys, covered with settlements and roads, and all pre-mountain landscape complexes, used for land-ploughing and housing construction. Very polluted as well as extraordinarily polluted landscape complexes are localized round the considerable sources of throwing-out harmful substances into atmosphere and in the places of large-scale mountain developments

Fig. 3

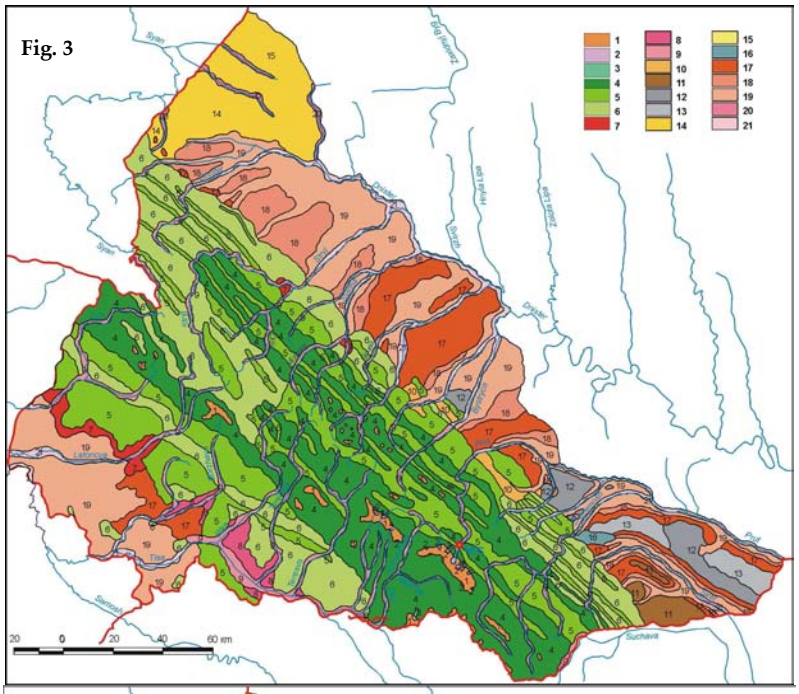
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Fig. 4

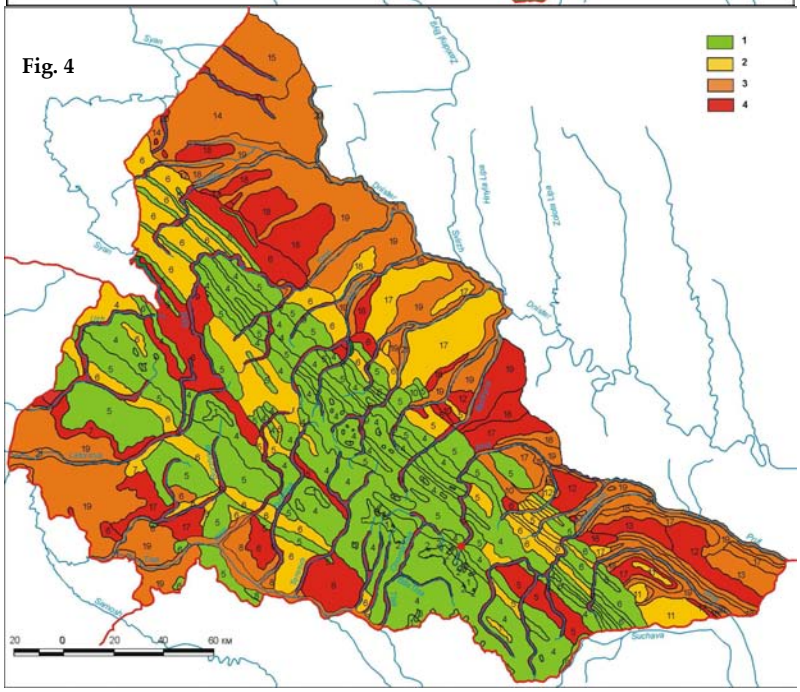
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Fig. 3. Landscape map of the Ukrainian Carpathians.

High-altitude areas: **1 – *Convex peneplained Alpine-subAlpine highlands,*** made of massive sandstones, conglomerates and coarsely rhythmic flysch with mountain meadows, crooked Alpine pine-trees and green alder-trees on mountain-meadow-brown and mountain-peat-brown soils; **2 – *Sharply concave old glacier erosive subAlpine highlands,*** made of massive sandstones, conglomerates and coarsely rhythmic flysch with crooked Alpine pine-trees, green alder-trees and meadows on mountain-peat-brown and mountain-meadow-brown soils; **3 – *Gently sloping woody old glacier middle-altitude mountains,*** made of loamy-boulder moraine with fir-tree forests on brown mountain-forest averagely strong, averagely skeletal soils formed by loamy-boulder carbonateless morain; **4 – *Steeply sloping erosive-denudational woody middle-altitude mountains,*** made of massive sandstones and sandstone flysch with fir-tree, beech-fir-tree, fir-tree-beech and beech forests on brown mountain-forest weakly strong, strongly skeletal soils; **5 – *Steeply sloping erosive-denudational woody and secondary-meadow low-altitude mountains,*** made of clayey-sandstone flysch, mudstones and aleurolits with layers of sandstones and basalts, andesits and tuffs within the boundaries of the Volcanic Carpathians with oak, beech, oak-beech, fir-tree-beech and beech-fir-tree forests on brown mountain-forest averagely strong, averagely skeletal soils; **6 – *Gently sloping erosive-denudational woody and secondary-meadow low-altitude mountains,*** made of sandstone-clayey flysch, mudstones and aleurolits with layers of sandstones with beech-fir-tree, fir-tree-beech, beech, oak-beech, oak and hornbeam-oak forests on brown mountain-forest strong, weakly skeletal soils; 7 - ***Gently falling surfaces of high terraces,*** made of pebble clayey-alluvium with beech and oak-beech forests on brown-podzol soils; **8 – *Gently falling surfaces of middle terraces,*** made of clay sand-clayey pebble alluvium with beech, beech-oak and hornbeam-oak forests on brown-podzol soils; 9 – ***Terrace bottoms of river valleys (fluxes and lower terraces),*** made of clay sand and sand pebble alluvium with fir-tree-beech-alder-tree forests and meadow vegetation on turf and meadow soils; **10 –** Falling ***surfaces of pediments,*** made of elluvium-delluvium loamy sand with fir-tree-beech forests on turf-podzol and brown mountain-forest soils (mostly plowed); 11 – ***High wavy territories between rivers,*** made of elluvium-delluvium loams with fir-tree-beech forests on turf-podzol skin-deep gley soils (occupied by cultivated lands and forests); **12 – *Gibbously mountainous erosive-movable territories between rivers,*** made of elluvium-delluvium loamy sands with fir-tree-oak-beech forests on turf-podzol skin-deep gley soils (occupied by gardens, meadows and cultivated lands); **13 – *Gibbously depressive erosive movable territories between rivers,*** made of elluvium-delluvium loams with fir-tree-oak-beech forests on turf-podzol skin-deep gley soils (occupied by gardens, meadows and cultivated lands); **14 – *Widely mountainous territories between rivers,*** made of forest loams with beech, oak-beech and hornbeam-beech forests on grey podzol soils and podzol chernozems (occupied mostly by cultivated lands); **15 - *Alluvium-sandry plains,*** made of sands with pine-tree-oak and pine-tree forests on turf-podzol soils (mostly occupied by cultivated lands); **16 – *Even waterlogged bottoms of old river valleys,*** made of alluvium pebbles, loams and clays with swampy ameliorated meadows on turf-podzol strongly gley soils; **17 – *Weekly wavy surfaces of high (sixth, seventh) terraces,*** made of pebble alluvium covered by loams with beech-oak forests on turf-podzol gley and brown-podzol soils (mostly plowed); **18 – *Weekly falling surfaces of middle (fourth, fifth) terraces,*** made of pebble alluvium covered by loams with beech-oak forests on turf-podzol gley pounds (mostly occupied by cultivated lands); **19 - *Even, here and there waterlogged surfaces of low (first-third) terraces,*** made of pebble-clay sand-loamy alluvium and loams with oak-beech and hornbeam-oak forests and meadows on turf-podzol gley, turf, meadow and marsh soils (mostly occupied by cultivated lands); **20 – *Even terraced (flux, first-third terraces) bottoms of river valleys,*** made of pebbles, clay sands and loams with meadow-marsh vegetation on meadow and marsh soils (meliorated, mostly occupied by pastures and hayfields); **21 – *Fluxes and river-beds,*** made of pebbles, sands and clay sands with meadow vegetation and bushes on turf non-developed soils.

Fig. 4. Ecological and landscape map of the Ukrainian Carpathians.

The eco-state of the landscape complexes: 1 – moderately favourable, 2 – satisfactory, 3 – worsened, 4 – unsatisfactory.

(extraction of oil, gas, sulphur, salts etc.). Very polluted can be considered highlands of gently-sloping low-altitude mountains in the area where oil is extracted. Extraordinarily polluted are landscape complexes with technogenic geochemical eco-anomalies having formed around large industrial centers in which the throw-outs of harmful matters into atmosphere exceed 1,000 tonnes per year. Such eco-anomalies have formed round the towns of Kalush, Drohobych, Komarno, Bohorodchany, Dolyna, Ivano-Frankivs'k, Zhydachiv, Nadvirna, Chernivtsi in the Precarpathia, Volovets and Svaliava in the mountains and Uzhhorod in Transcarpathia.

The comparative analysis of the above-provided ecologic evaluation classifications has made it possible to estimate the eco-states of landscape complexes in the Ukrainian Carpathians and to single out several ecologic groups of the landscape systems, viz. with moderately favourable, satisfactory, worsened and unsatisfactory ecological states (fig. 4).

Moderately favourable can be considered the eco-state of landscape localities that are little-changed and in which the secondary-forest modification prevails as to the area criterion. These are forest-covered middle- and low-forest highlands. The former are characterized by mudstone phenomena, the latter – by mountain torrents, avalanche, forest-pathologic and blow-out processes. The landscape complexes of this ecological group are conditionally clean and moderately polluted (mainly in the local sources of atmospheric throw-out zones along transport highways and round the industrial objects).

It is expedient to divide the landscape complexes with a satisfactory eco-state as to the scecificity of anthropogenic changes into mountain and pre-mountain subgroups. The mountain landscape systems with a satisfactory eco-state are characterized by the domination of the secondary-meadow modifications with dispersible settling. Their peculiarity is a considerable distribution of such negative naturally geographical phenomena as linear erosion and avalanche (in localities of gently-sloping low-altitude mountains) and erosion with mountain torrents (in localities with middle-altitude and low-altitude mountains). The pre-mountain landscape complexes with a satisfactory eco-state are characterized by a middle anthropogenic changing, high share (over 50%) of forest territories next to arable lands and populated territories. The forest-covered localities are accompanied by wind blow-out and stormy phenomena, whereas the plough-land areas – by active erosive processes. Landscape complexes with a satisfactory eco-state are in the main moderately polluted, and in the places of field-crop cultivation and round the local sources of influence – polluted.

Landscape complexes with worsened eco-conditions are in the main strongly changed. They are also divisible into mountain and pre-mountain sub-groups.

Accordingly, the mountain subgroup covers less strongly changed, and pre-mountain – more strongly changed ones. Mountain landscape complexes with worsened eco-conditions are distinguished by the – according-to-area predominance of the secondary -meadow modification, – considerable settling and intensive development of the erosive, avalanche and flood phenomena. To them were referred the landscape localities of gently-sloping low-altitude mountains, as well as localities of middle terraces and benched bottoms of river valleys. The river-valley localities are characterized by a considerable pollution along main transport highways and round the powerful sources of throw-outs into atmosphere (in the vicinity of the towns Svaliava, Volovets', Rakhiv, Putyla, Verkhovyna and some others). Peculiar to the pre-mountain landscape complexes with worsened eco-conditions are identical shares of forest, on the one hand, and arable and built-up lands – on the other (50% each). These are mainly localities of high and middle terraces. The arable lands have an increased linear erosion here, and in forest localities blow-out and stormy phenomena occur. To this ecological group also belong localities of hilly-range and hilly-hollow territories between rivers, in which, alongside with the above-mentioned ones, widespread on a mass scale are also avalanche phenomena. The level of pollution in the pre-mountain landscape complexes with worsened eco-states differs – from a moderate to an extraordinary one (the latter occurs in the vicinity of the towns Drohobych, Nadvirna, Chernivtsi et al.).

The unsatisfactory eco-state is characteristic of the pre-mountain localities only. With field-crop cultivation prevailing in them, there is a dense network of habitated points and roads, and these localities periodically suffer from floods, waterside erosion. To this ecological group belong low-terraces localities, alluvium-sander plains, widely-mountainous territories between rivers, middle and high terraces. The last-mentioned three localities are especially characterized by an active linear erosion, as they are mainly arable. Considerable pollution of soils occurs as a result of application of pesticides and mineral fertilizers. On the whole, pollution levels vary from considerable to extraordinary, especially in the areas of technogenic geochemical eco-anomalies.

Summarizing the analysis of the ecological state of landscape complexes of the Ukrainian Carpathians, one can trace a reverse dependence between the natural ecological potential and the present-day eco-state. The present-day unsatisfactory eco-state is characteristic of the landscape systems with the most favourable natural eco-potential, particularly in the localities of low terraces. Farther on, the eco-state is somewhat improved in the localities of terraced bottoms of river valleys, middle and high terraces, hilly-range territories between rivers. Still better is it in low-altitude mountain localities, and the best – in middle-altitude mountains and alpine land-

scape complexes. Thus, one can trace an improvement of eco-states with a height above sea level. This general regularity is violated in some places due to the character of land-tenure and local influences related to the settlements, development of minerals, laying of tracks etc.

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SUMMARY

Based on the analysis of interrelations between Geography and Ecology, a conclusion is made about the existence of two trends in the interaction of these sciences. The first one consists in the use of theoretical tenets and methods of Ecology to the study of Geography objects, particularly Landscape Studies, viz. landscape complexes, their components and interactions, and which is related to the development of Landscape Ecology. The second trend lies in the use of theoretical tenets and methods of Geography, its branch and complex chapters to the solution of Human Ecology issues. In this connection, scientific trends such as Geoecology, Ecologic Geography (Ecogeography), Ecologic Landscape Studies, Ecologic Geomorphology a.o.

Theoretical foundations of Ecologic Landscape Studies, a new applied trend in Landscape Studies, are laid out, whose conceptual basis is an ecologic and landscape analysis. A theoretical model of this analysis, its principal algorithm and basic notions, have been substantiated; the task and contents of the major stages of landscape studies, viz. 1) investigating the landscape organization of the territory under research; 2) studying the influence of anthropogenic factors on landscape complexes; 3) analysis and evaluation of anthropogenic variations of landscape complexes, landscape eco-conditions and echo-states; 4) substantiating the ways of improving eco-states of landscape complexes and prognosticating the tendencies of their variations. have been elucidated.

Major points of methodology are covered and the most important results of ecologic and landscape research of the Ukrainian Carpathians have been elucidated. On the strength of the study of the eco-potential of the landscape complexes, degree of their anthropogenic change, level of technogenic pollution, as well as negative natural and geographic processes, the ecologic state of the area's landscape systems has been estimated and their ecologic classification made, with the distinguishing of four ecologic groups of landscape complexes, viz. with moderate-favourable, satisfactory, worsened and unsatisfactory eco-states.