Chapter 3
Landscape Ecology Culture and Some Principles of Sustainable Nature Use

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Abstract Economic activity, as a rule, is accompanied by negative changes to landscapes and ecological conditions, and by a depletion of natural resources. The main causes of these processes are analyzed. Two possible aspects of sustainable nature management are highlighted: ideas from the natural sciences about the formation of a culture of nature management, and the emergence of natural and human-made landscapes, cultural landscapes included. These ideas are based on the paradigm of evolutionary synergy. This serves as a methodological basis for developing principles and approaches to sustainable nature management. An important component of this paradigm is the concept of a culture of nature management. This concept roughly describes ecological culture, its components and the reasons why it lags behind the material and production culture of nature management, as well as describing landscapes and their resiliency. Definitions of basic concepts are a subject of theoretical and applied research. The consideration and development of various aspects of an ecological culture, including a culture of landscape ecology and nature management, is a key element of sustainable nature management. The principles underlying the landscape ecology planning of economic activity and the ecological and technological culture of production are mutually complementary. They make it possible to create a natural-economic system of cultural landscapes and sustainable nature management. Some mutually complementary approaches are presented. These can be used to optimize nature management in terms of landscape ecology, to preserve the most important elements of landscape diversity, and to create favorable environmental conditions.

Keywords Ecological culture of nature management · Ethics of nature management · Material and industrial culture · Landscape · Cultural landscapes · Natural and economic systems · Resiliency · Landscape ecology planning · Universal evolutionism · Ecological imperative

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3.1 Introduction

The population of the earth is growing rapidly. Accordingly, economic activity has intensified, and more and more natural resources and territories are required. Based on material and technological forms of nature management, economic activity and consumer ideology have led to a rapid depletion of natural resources and to negative changes in landscapes and the ecological state of the environment (Millennium Ecosystem Assessment 2005). All this, accompanied by resource emergencies and environmental crises, is beginning to slow down the further development of mankind. Therefore, in the 1970–1990s, scientists and progressive public figures began to pay more attention to the creation of various models of sustainable development and the development of principles for sustainable nature management. At the same time, considerable attention is now paid to the generation of ideas about an ecological culture. It has become a fundamental theoretical and practical category, which is intended to underlie the paradigm of the "sustainable development" of a gradually ecologized technocratic, anthropocentric civilization.

Sustainable nature management. Two aspects of sustainable nature management can be considered:

(i) sustainable nature management without development: relatively efficient management without increasing damage to the ecological state of the environment, including the natural environment,
(ii) sustainable nature management with development: the development of economic activity and an increase in the efficiency of production, without increasing environmental damage to landscapes and the state of the environment.

The first aspect, nature management without development, is realizable only if renewable natural resources are used. In the field of peasant economics, it is of limited use only for small farms or closed communities living according to the traditions of subsistence farming in remote areas, such as the "Old Believers" in Siberia.

The second aspect, nature management with development, is an element of the sustainable development of mankind while maintaining a favorable ecological situation, natural landscapes and biodiversity. This aspect of sustainable nature management includes the optimization of nature management and economic activities in general in terms of technology, resources and environmental, economic and landscape planning, based on the accelerated development of an ***ecological culture of nature management*** (ECNM). In an ECNM, in turn, a difference is made between its natural science and socioeconomic components.

Natural science aspects of sustainable nature management. The natural science fundamentals of nature management are based on modern ideas about the landscape envelope and its evolution under the influence of humanity into the anthroposphere and the noosphere. According to the concept of V.I. Vernadsky and P. Teilhard de

Chardin, the anthroposphere is increasingly moving into the noospheric stage of its development (Vernadsky 1967, 1988, 1994). Accordingly, the development of new scientific directions, patterns and concepts connected with this is accelerating. In particular, it has become obvious that the ecological culture of nature management lags far behind the material and industrial culture, which is focused on meeting people's exaggerated, growing needs. Because of this, as N. N. Moiseyev stated, the noosphere cannot arise by itself: it must be created by ecologizing thinking and developing an ecological culture of nature management (Moiseyev 1995; Kazakov 2003a, 2012; Kazakov and Chizhova 2001).

3.2 The Lagging Ecological Culture of the Use of Nature

Historical aspects. What are the reasons for the lag in ecological culture and when did it start? In the Paleolithic, humans were almost completely dependent on nature and in order to survive they had to know it well and adapt to it. In the Neolithic period, when a type of economic activity was born (the "Neolithic revolution") and technological mechanisms and methods (material and production culture) of nature management were actively developed, human dependence on various natural phenomena decreased. With the transition to a productive type of vital activity, in accordance with the landscape features of the territories in which they lived, there was a change in ethnic groups' adaptive instincts, mechanisms and skills. The culture of farming (cultivation of the land) and animal husbandry was born, the tools and technology of cultivation were improved, and irrigated agriculture was created. In other words, humans had learned to use nature to gain more material life benefits. As a result, the adaptive instinct began to become dulled, and the customs, collective consciousness, world view and behavior of people in ethnic communities changed. Humans began to stand apart and be alienated from nature. This is reflected in the Judean and Christian anthropocentric elements of cultures. In these creeds, humans appear as the highest divine creation and rule over all the living and inanimate nature on earth. As a result, the development of the environmental and humanitarian aspects of the cultural and environmental ethics of nature management began to lag significantly. As a result, an anthropocentric, material and pragmatic, production-based culture of nature management was formed. In it, all nature is viewed as an inexhaustible material and production resource, the value of which is determined by its usefulness to humans. That is, the pragmatic imperative was made the basis of the collective ideological culture of nature management—everything is right that is useful to humans, and natural resources are inexhaustible. The hypertrophied development of one of the components of culture, namely the technological culture of nature management, which is oriented toward meeting humans' increasing material demands and needs—often at the expense of nature—is leading to the degradation of nature and the depletion of its resources. Under the influence of the technological culture of nature management, a second, "humanized nature" was formed. Karl Marx wrote in 1868 that "… culture, if it develops spontaneously, and is not directed consciously … leaves a desert behind it …" (Marx 1964).

Some meanings of culture. Culture as a complex, fundamental concept has many definitions. From the point of view of the natural sciences, it can be defined as follows:

1. Culture is a way of life and the fruits of labor of a particular society, based on its collective mind and captured in anthropogenic-natural landscapes. In the broader philosophical understanding, culture is any superstructure of nature associated with human activity.

Other meanings are

2. The formation factor of a second, humanized nature.
3. The form or method of organizing the vital activity of mankind and its results in nature and society, focused on the best way of humans' adaptation to the environment.
4. The set of means and forms of a person's social adaptation to their environment: the techniques, technologies and rules for a person's purposeful material, industrial and spiritual life, aimed at optimizing their relationship with the environment.

The aggravation of environmental problems of nature management and the study of their causes determined the relevance of the accelerated development of an ***ecological culture of nature management***, or environmental management as a special theoretical and applied direction. When the anthroposphere enters the noospheric stage of development, an ecological culture based on science, education, high technologies and the ethics of nature management and life activity in general begins to play a leading role. According to V. I. Vernadsky, scientists, including geo-ecologists, are faced with the tasks of consciously organizing natural-anthropogenic landscapes through the co-adaptation of economic activity and nature. They cannot move away from this, as they are guided by the spontaneous growth of scientific knowledge, and are still being pushed today by growing environmental and economic situations (Vernadsky 1988).

3.3 Basics and Components of the Ecological Culture of Nature Management

Ecological culture is one of the theoretical and practical aspects of the concept of "culture." It underlies the paradigm of escaping the systemic ecological crisis and creating sustainable nature management within the development of a modern technocratic, anthropocentric civilization.

In the ecosystem model of the anthroposphere, the culture of nature management proceeds from the understanding that nature is a habitat, an arena for the economic activity of mankind and a source of the resources people need. In turn, humanity, with its economic activity, in evolving has already become a habitat for nature. That is, in this natural and economic ecosystem, nature and humans are fully fledged subjects of coexistence and interaction. The most active, reasoning factor in their joint long-term development, co-adaptation and co-evolution is humanity, with its collective mind and environmental ethics. In order to survive, it is obliged and compelled to maintain the auspicious conditions of the coexistence of nature and society. To do this, when cultural landscapes are designed as elements of the noosphere, natural ecosystems should become analog models for the ecologized technological culture of nature management. An important component of ecological culture is its humanitarian, spiritual part, represented by the ethics of nature management. It is based on education, traditions and a way of thinking that form an ecological outlook (Moiseyev 1995; Kazakov and Chizhova 2001; Kazakov 2013).

Nature management ethics can be defined as the voluntary restriction of freedom of action in order to preserve the material, spiritual and environmental benefits of nature for a long time. These restrictions are imposed by natural science concepts, education and the environmental imperative formed in the public consciousness.

The evolutionary synergetic concepts and paradigms of V. I. Vernadsky, P. Teilhard de Chardin, I. R. Prigogine, G. Hagen developed and concretized in the works of other scientists, including N. N. Moiseyev, serve as the natural science basis for the development of an ECNM (Kazakov and Chizhova 2001). They are the basis of methodological developments connecting universal evolutionism and the self-organization of nature. According to the synergistic paradigm which is of enormous ideological significance, the processes of the creation, development and evolution of open systems, regardless of their nature, are subject to a single algorithm and are characterized by an increase in the complexity and orderliness of their organizational structure. This paradigm has been tested in relation to explanatory models of the evolutionary transition of the biosphere into the noosphere, as well as the transformation of natural landscapes into natural-anthropogenic and cultural landscapes. They are special cases of the synergetic model of development (Vernadsky 1967, 1994, 1988; Kazakov 1999, 2008; Kazakov and Chizhova 2001). Table 3.1 shows the main components of ecological culture which define the principles of sustainable nature management that have to some extent developed in theoretical, methodical and practical plans.

For geography and landscape studies, aspects and areas of environmental culture are of great and direct importance, such as the creation of general schemes for introducing different types of environmental management in large regions, as well as planning schemes at the regional level and at the level of construction projects. The choice of the types of environmental management to be introduced in large

Table 3.1 Components of the culture of nature management

Ecological culture of nature management (ECNM)				
Material and production culture		World view (ways of thinking and understanding)		
Technological		Natural science	Ideological (humanitarian)	
Technologies production, ecological and technological features of the resources used, protective structures, filters, circulating systems, closure of technological systems, emission standards in the operating system, etc.	Accommodation, planning and construction aspects of ecological culture	Natural science models of the universe, the laws of organization and evolutionary development, universal evolutionism, synergy and self-development, landscape, landscape ecology and ecological/geographical concept of nature management, ideas about the sustainability of landscapes	Beliefs, religions, cults, customs, traditions, ideological ecological flows and associations (alarmism, biocentrism, environmentalism, universal ethics, extending the scope of human ethics to include nature)	Philosophical, political, economic theorized constructions, models, legislative systems, to substantiate the interests of countries, peoples, ethnic groups, communities and their leaders in resources, the environment, power and other issues
Ecotechnologies of nature management, conservation and melioration of nature		Ethics of nature management, environmental imperatives (e.g., something is correct and allowed if it does not violate natural laws and the ecological balance)		

regions determines the environmentally safest and most cost-effective way to develop certain types of production, recreation or settlement in each natural area or regional landscape, and which landscapes should be left as specially protected or reserves. This is the level of the master plan for the development of production and settlement in a country or a large region thereof. The planning aspect suggests whether it is environmentally safer to place certain types of environmental management in the selected region or industrial zone, or in the agricultural or natural landscape. At this level, landscape planning is determined by the structure of a territory's landscape and ecological framework. Construction aspects determine the environmental safety of production or settlement, as well as their design within industrial zones and individual settlements and parts thereof. It is important to create or maintain all the elements in a territory's landscape-ecological framework, including sanitary protection zones and strips.

The natural science foundations of the ecological culture of nature management are the basis for its technological and humanitarian (ideological) components.

3.4 Landscape Ecology Approaches and Principles of Sustainable Nature Management

Scientific approaches, principles and methods behind sustainable, inexhaustible environmental management, especially of landscape-based farming, have been actively developed since the end of the 19th century and the early twentieth century.

Definitions of terms and basic concepts. Landscape. The term "landscape" (German *Landschaft*, Russian *Ландша́фт*, French *paysage*)—a type of terrain, a limited relatively homogeneous stretch of a terrain, region or country) is entrenched in geography and soil science and has acquired a deep scientific meaning in Russia. The concept of landscape is now widely used both in natural science and in the humanitarian sphere. In natural history, landscape has become a fundamental concept.

The definition of concepts is an important component of any science. In geography, landscape is a complex, multifaceted scientific concept. Therefore, it can have many definitions reflecting its different aspects. One thing they share in common is the idea of an interconnected set of landscape components (natural and other unity) and their binding to a certain territory. The following definitions of the scientific concept of "landscape" are the result of generalizations of many definitions available in Russian-language reference books, dictionaries, encyclopedias, textbooks and manuals on physical geography, landscape ecology and nature protection. In addition, the definitions take into account the views of the author and other scientists working in the field of theoretical and applied landscape science, engineering geography and geo-ecology (Berg 1947, 1958; Milkov 1970, 1973, 1986; Nikolaev 2000; Solntsev 2001; Sochava 1978; Kazakov and Chizhova 2001; Kazakov 2004, 2005, 2008, 2013).

1. As a natural territorial complex (NTC), a landscape is a morphologically (structurally) and functionally expressed part of the earth's mantle, formed in a narrow contact zone of the abiotic and biotic environments. Examples include the landscape of the earth, a continent or its parts.
2. L. S. Berg (one of the first disciples of V. V. Dokuchaev) defined a landscape as an area in which the nature of the elevation, climate, vegetation and soil cover, wildlife, population and human culture "merge into a single harmonious whole, typically repeated throughout the known zone of the Earth."
3. A natural geographical landscape is a natural territorial complex of any dimension. It stands out morphologically from its surroundings and is a genetically relatively homogeneous area of the earth's surface where a geographically stable set of naturally related and interacting natural components, functioning as a whole, producing a specific new substance, energy and information. The landscape is characterized by natural combinations of properties of surface sediments, mesoforms, climates, soils, hygrotopes, vegetation and animal populations. Under economic development, the landscape performs the functions of natural ecological and technological conditions of human

activity and also provides the basic resources for production, turning into a natural-anthropogenic landscape (NAL). Some synonyms of the term “natural geographical landscape” are “natural landscape,” “landscape geosystem,” “landscape complex” or “natural territorial complex” (NTC).

4. A natural geographical landscape is a NTC of a certain rank—the lowest regional level of the landscape hierarchy, relatively homogeneous in origin, with zonal and azonal features, forming on a genetically individual lithogenic morphostructure on the macro-level and characterized by naturally repeated interrelated combinations of natural complexes of local levels (facies, tracts and localities), known as its morphological parts, as well as its local climate. It acts as a link between local and regional landscape geosystems. The horizontal dimension is n 10–n 100 km^2.
5. As a natural territorial complex (NTC), a landscape is a relatively small, specifically homogeneous section of the earth’s surface, delimited by natural boundaries, within which natural components are closely interconnected and mutually depend upon one another and human beings (with elements of their culture) and are historically adapted to one other.
6. As a typological or generic concept, the term “landscape” is used with an adjective denoting a species or other generalizing classification, reflecting its specificity and relative genetic and other homogeneity in terms of a certain attribute. Examples include taiga, steppe, marsh or mountain landscape(s), cultural, domestic or marginal landscape(s), natural or natural-anthropogenic landscape(s), ecotone, geochemical, eluvial or elemental landscape(s), industrial or agricultural landscape(s), spiritual and ideological landscape(s): political, ethno-cultural, folklore, sacral or criminal landscape(s).
7. The natural-anthropogenic landscape is a landscape transformed to some extent by economic activity (positive or negative), often saturated with various elements of material culture.
8. A cultural landscape (from Latin *cultura*—cultivation, processing) is purposefully transformed and regularly used by man for the sustainable production of environmental, material and spiritual benefits, a landscape complex that includes interrelated elements of culture and nature, functioning as a whole.
9. A geographical landscape is an environment-forming and resource-replicating geo-ecosystem that serves as a habitat and arena for the economic activities of socio-ethnic groups and communities. This interpretation of the term “landscape,” supplementing its former classical definitions, offers a broader picture of its modern use.
10. A landscape can also be a visually limited part of the earth, its external appearance, perceived through the senses, the appearance, image and generally visible part of the terrain. In French literature, landscape architecture and landscape design, the terms “landscape” and “paysage” are often used as synonyms. Examples of a landscape include forest, forest-field, steppe, mountain, field, rural, urban, open, visually shielded, deep, multi-composition, etc.

Other definitions of the landscape, with their humanitarian interpretations, are also presented in textbooks, manuals and articles by the author. The concept that a landscape is fundamental is now applied in different spheres of human activity and fields of knowledge. The main feature of the extended concept of a landscape is that it is linked to a certain territory, terrain or surface, and that interrelated, interdependent elements perform certain functions in the natural, natural-anthropogenic or anthropogenic environment.

Examples of landscape modifications in the twentieth century. In the second half of the nineteenth and the early twentieth century in Russia, the questions and principles of optimizing nature management and inexhaustible, sustainable farming on a landscape basis were actively developed by Dokuchaev (Dokuchaev 1994), his students and followers. The practical implementation of these developments in the Soviet Union (Russia) was reflected in the State Plan for the electrification of the country (1920–1930) and, especially, in the State Plan for the transformation of nature (1948–1954). On the scientific basis of that time, the implementation of this plan allowed a system of interconnected forest belts of various ranks (state, district, kolkhoz, etc.) to be created in the steppe, forest-steppe and treeless southern regions of the non-black-earth zone of the European territory of the Soviet Union. Most of them were tied to river valleys and other erosional forms, following the thalwegs. Therefore, the forest belts fulfilled a complex role in anti-erosion, water protection, snow retention, anti-deflationary and other amelioration, with a favorable effect on crop yields and the local climate. However, in the years 1960–1990, funding for forest reclamation and fire prevention in the system of state and collective forest belts was gradually reduced, and in 1993, it stopped. Therefore, by 2015, many forest belts were degraded, or had been destroyed by fires and excessive economic activity.

In the countries of Western and Central Europe, such theoretical and practical developments in landscape ecology at the end of the twentieth century can be associated with attempts to create ecological networks to preserve the most valuable elements of the landscape and biodiversity.

Geo-ecological studies in developed regions have shown that the negative consequences of economic activity there are usually associated with a poorly developed culture of ecological technology and landscape planning. The negative effects, as well as economic losses, can be eliminated or reduced by using the landscape ecology approach to designing business activities. An important part of such an approach to optimizing nature management is the concept of landscape resiliency.

3.5 Landscape Resiliency

Resiliency (stability, resistance) is one of the most important properties of any natural, natural-economic and economic system. It determines the existence of landscapes and other geo-ecosystems, their development, efficiency and the favorableness of their economic use. Resiliency often determines the choice of the type and intensity of landscape use in economic activity and nature conservation. The natural resiliency of landscapes is one of the main prerequisites for efficient production. At the same time, the persistency of the negative properties of landscapes (waterlogging, salinization, etc.) complicates their amelioration, increases costs and reduces production efficiency.

In Russia, ideas about the resiliency of landscapes began to actively develop in the 1980–1990s. Research has established that landscape stability is a complex phenomenon, and therefore, it has many definitions (Moiseyev 1987, Kazakov 1999, 2008).

In a generalized form, the stability of landscape geosystems is their ability to remain relatively unchanged or vary within a structural and functional range, or return to it during the period of their life cycle or the cycle of external influence. Like any complex phenomenon, stability has many aspects. It is possible to assess the stability of landscape geosystems or NTCs in terms of the amplitude of natural fluctuations of their parameters within the invariant range or deviations from it, or the deviations of these parameters under anthropogenic loads. When the stability of geosystems is measured and evaluated, it acts simultaneously as a relative value and as a very specific concept. For example, a clear definition is needed of the type of resistance that is being tested (to mechanical, chemical effects, etc.), and a point of reference is required when measuring and evaluating—an invariant of a specific NTC or changes in similar parameters in adjacent geocomplexes of other types. The indicator used also needs to be specified. Even relying on the concept of an invariant, one should take into account the phase characteristics of geosystems changing in the course of their functioning or development, since many parameters of geosystems change the speeds and directions of their "drift" and how informative the data is in different phases of functioning and development. For example, in winter, the photosynthetic activity of plants and the erosion activity of sloping NTCs in Russia are significantly lower than in the spring and summer periods.

Examples of different kinds of landscape resiliency. The differences in the natural stability of landscape geosystems and their resistance to anthropogenic influences can be shown by the following examples. Thus, natural zonal tundra and forest-steppe landscapes, mudflow or avalanche geocomplexes in the mountains and valley geosystems on the plains, in modern environmental conditions, are very stable both in space and in time. However, they differ greatly in the dynamics (variability) of their states. It has been established that there are landscape geo-ecosystems with strongly and weakly fluctuating organizational structures. For example, geocomplexes of floodplains and gentle watersheds differ sharply in the dynamics of their structure and state. In NTC watersheds, fluctuations of their parameters relative to the mean are less than in floodplain geosystems. However, these are their stable norms or invariants under natural environmental conditions. That is, floodplain NTCs are stable in terms of their increased natural variability or dynamism. At the same time, their resistance to various specific anthropogenic influences varies. In particular, naturally occurring tundra and north-taiga geo-ecosystems react very unstably to acid pollution, and forest-steppe and dry-steppe landscapes react to this type of impact very poorly. Moreover, even the reaction to acid pollution in different landscapes can take different directions. In taiga landscapes—especially those composed of outwash sand, with poor plant nutrients in podzolic soils—zonal coniferous forests and moss-lichen communities are actively dying out under the influence of acid emissions. In the steppe zone, acid emissions are easily neutralized by chestnut and chernozem soils with a saturated base-absorbing complex. At the same time, geosystems with wormwood plant communities can even occur on alkaline soil varieties. That is, under the influence of the same pollutant in taiga and tundra landscapes, the effect of one of the factors limiting the biodiversity of geosystems, lack of nutrition, is increased. The effect of ash emissions on the ecological situation in the same geosystems will have the opposite effect: a positive one in the taiga and a negative one in the dry steppe.

The resistance of sloped and flat geosystems to mechanical loads caused by recreational use, motor vehicles and grazing varies significantly. For example, for dry whitewood bogs on poor, highly podzolic sandy soils, the permissible recreational load which does not lead to the development of landscape ecology crises, is 1–2 persons/ha. For natural territorial complexes (NTCs) with fresh grass birch forests on weakly podzolic light loamy soils, it increases to 15–20 people/ha. In the examples given, different properties of landscape NTCs are shown: the factors that influence landscapes' passive or static (buffer) stability to various types of anthropogenic loads (Kazakov 1999, 2008).

Factors, mechanisms and types of landscape resiliency. The factors and mechanisms behind the stability of landscape geosystems are divided into passive/static and dynamic. Passive/static factors are usually determined by the mass, capacity, stiffness or strength characteristics of a substance, or the power of the energy flow. The passive (static) stability of landscape complexes is manifested in their invariance with respect to their structural and organizational invariant within the "characteristic time cycle" of their development. In contrast, dynamic factors are related to the plasticity of landscape geosystems—their adaptive capabilities, and elasticity—and the ability of landscapes to quickly return to a state of relative dynamic equilibrium after the load is removed (IGAN USSR 1989). A common property or factor combining the passive and dynamic stability of landscapes is their hierarchical organization.

Studies in areas of anthropogenic influence show that the properties of the natural components of different landscapes have very different effects on their stability. Therefore, hard scales for assessing the resiliency of landscapes can produce errors when used in large areas with different landscapes. However, studies have revealed some patterns to how the stability of landscape geosystems depends on the properties of their individual components (lithogenic basis, moisture, climate, biota, soils).

Landscape components and their resiliency. Other things being equal, the following relationships were revealed between the properties of natural components and landscapes' stability when exposed to anthropogenic loads (Kazakov 1999, 2008).

(1) The gravitational or denudation potential of a territory—the larger it is, the less geo-resistant it is to denudation, erosion, mechanical stress and even to toxicants,
(2) The slope of the surface—the greater it is, the lower the stability, but with slopes less than 10° stability may fall due to possible waterlogging and low self-purification from pollutants,
(3) The length of the slope—the longer it is, the lower the stability,
(4) The mechanical composition of the soil is usually more resistant to stress when the NTC is composed of light loam and sandy loam, but the maximum can be shifted somewhat depending on the type of impact (when exposed to acid precipitation, the NTC's stability distribution graph is sharply asymmetric),
(5) Soil thickness—if loamy soils have a thickness of less than 1.0–1.2 m, then as it decreases, the stability of the NTC decreases,
(6) Hygrotopes (or moisture)—maximum resistance to stress in geo-ecosystems of fresh habitats, dry and wet, stability decreases,
(7) Climatic characteristics—NTCs with the optimum ratio of heat and moisture have the highest resistance (hydrothermal coefficient and coefficient of moistening are close to 1), while NTCs with pronounced limiting factors for heat and moistening and a wide range of oscillations have the lowest resistance and moderate winds of 2.5–4 m/s also contribute to the stability of landscapes,
(8) Soils—the greater the thickness of the humus horizon, the humus content, capacity and saturation with the bases of the absorbing complex of the soil, the more resistant the NTC,
(9) Biota—the more capacious and intensive biogeochemical circulation (BIC), the denser the projective surface coverage, the higher the stability of the NTC, conifers and forests are on average less resistant to impacts than hardwood, meadow-steppe grass species are more resistant than forest ones, and roadside grasses and other synanthropes have the most resistance, species with a deep and dense root system are more resistant than those with a superficial and loose one, modified plant communities in the middle of a highly productive stage are the most resistant to anthropogenic impacts (e.g., forests at 50–70 years of age)
(10) The following landscape geo-ecosystems are potentially more resilient: (a) those with increased diversity and repeatability (duplication) of structures, (b) those in the central range of typicality for their zone and region, (c) trans-accumulative landscapes are more stable compared to trans-eluvial ones, (d) those which are more ambitious in size and substance, higher hierarchical ranks (landscape zone > landscape > tract > facies).

The stability of dissipative landscapes of hills, which mainly dissipate matter and energy in the environment, is lowered. It is also reduced in the NTCs of the extreme accumulative units of landscape catenas characterized by maximum entropy.

In the Soviet Union (Russia), several maps have been published to assess the potential passive stability of landscapes of the territory of the USSR/Russia and its individual regions with regard to various types of pollution and erosion hazard. Examples of these include maps with an analysis of the geochemical prerequisites of landscape resistance to pollutants (Glazovskaya 1988), or a map of landscape resistance to acid emissions from thermal power plants (Kazakov 1999).

Due to the different stability of natural complexes, the same processes or environmental factors can, with varying likelihood, cause environmental crises in some geosystems and hardly affect others. Thus, in the areas of influence of acid emissions from thermal power plants and steel mills, damage and shrinkage of coniferous taiga forests in eluvial habitats are common. In the trans-accumulative units of the same landscape catenas, as well as in landscapes of deciduous forests and forest-steppe, there is less visible damage to vegetation in zones of influence of acid emissions is less. This is explained by the different stability or buffering of NTC data with respect to acid emissions. They can differ in their stability levels by as much as 50–200 times.

Hierarchical level of landscape geosystems and their resiliency. An important factor determining landscape geosystems' passive stability and other types of stability in natural and anthropogenic conditions is their hierarchical organization (Kazakov 2003b). The increased stability of geosystems at higher hierarchical levels is primarily based on their greater mass and area, and therefore on inertia. The stability of large regional geosystems, which include significant masses of matter and energy, can only be disturbed by the impact of a more powerful natural or anthropogenic factor than those required to change the state of small local geosystems. This is most clearly manifested differences in the passive stability of geosystems of different ranks. A similar pattern occurs in ecology as applied to living organisms: The individual is less stable than the population or species. Accordingly, landscape dominants are usually more stable with respect to sub-dominants, etc.

However, as natural geo-ecosystems evolved, other mechanisms were developed in addition to passive stability: dynamic mechanisms for overcoming crises, aimed at stabilizing environmental protection systems in the environment and their further development. The key mechanism is the various types of adaptive variability found in the structures and functions of geo-ecosystems that are in crisis situations. This mechanism determines the adaptive type of landscape resiliency.

Often, adverse factors that cause crises and even disasters in some organisms and landscape geo-ecosystems are favorable factors for the development and prosperity of others. As a result, the latter begin to flourish, functionally replacing the former and stabilizing the changed landscape as a whole during the environmental changes (ECs). It is not without reason that the image of the concept of "crisis" in Chinese consists of two hieroglyphs denoting "danger" and "opportunity." For example, river valleys or mudflow-avalanche complexes, though generally stable in natural environmental conditions, can easily change some elements of their planned structure. In floodplain landscapes, depending on the nature of the floods, some old landscape elements disappear, but new ones appear, new channels appear and the river banks are formed and disappear. Accordingly, the vegetation and soil are rebuilt. That is, depending on the specific states of the environmental parameters, landscape geosystems can change their structure somewhat and even sacrifice part of the NTC on smaller, local levels.

Adaptive capabilities of landscape geosystems (elasticity and plasticity). The greater stability of the landscapes at the highest hierarchical levels is determined not only by their greater inertia in terms of mass and size but also by their great adaptive capabilities. More complex geosystems of higher ranks are more diverse in their constituent structural elements than geosystems of lower ranks. Due to their greater diversity, the range of possible and permissible adaptive changes in the states of complex geosystems is wider, without any loss to their stability. Different landscape complexes included in complex geosystems react differently to interannual or even seasonal changes in weather conditions. In some, biological productivity increases, while in others, it decreases with the same changes to the hydrothermal environmental factors. As a result, the bioproductivity of the landscapes that contain plant associations, on average, changes less than the bioproductivity of each of the separate associations. A similar picture is observed in the landscapes of large river systems with diverse watersheds. There, too, the average changes in the water level in the main river artery change to a lesser extent as compared with the river geosystems, which have smaller and simpler catchments in the landscape plan.

A moderate agricultural development of the moraine-glacial plain geosystem as a whole will not lead to a loss of stability and complete degradation. At the same time, the same moderate loads on its slope elements or subsystems can lead to a loss of stability and a radical restructuring of some local landscape geosystems of lower rank when erosion is activated. As a result of such local adjustments to the landscape of the plain, it will retain its stability in general.

In the cases considered, the stability of geosystems is supported on the one hand by the ability of more diverse geosystems to better absorb external impacts, variously mediating them, and on the other hand, by the fact that geosystems which are more complex and diverse in structure are easier to rearrange in accordance with environmental changes (ECs). Such properties and mechanisms for maintaining the stability of geosystems can be called adaptive plasticity or elasticity.

Studies have shown that NTCs of the following types have greater adaptive stability due to the plasticity of geosystems: ecotone landscapes, due to the greater species diversity of elements and their ability to easily replace each other, NTCs with highly fluctuating modes of operation and structures, NTCs with a high variety of elements, actively developing NTCs at the secondary bioproductive stages of succession. Geosystems with pronounced limiting factors, with reduced diversity, have low plasticity and adaptive stability.

Ability of landscape geosystems to self-repair. Another of the mechanisms that support the stability of geosystems is their ability to self-repair after disruption. This ability is described as a landscape's elastic stability.

Examples include the rapid recovery of destroyed vegetation or intensive self-cleaning of pollutants. The stability of geosystems can therefore be evaluated by the speed of their self-healing. Thus, tundra landscapes are less stable measured by the criterion of self-restoration in comparison with floodplain geosystems, which can restore not only disturbed meadow-shrub vegetation, but even the lithogenic basis in 2–6 years. Landscapes of tropical rainforests, characterized by high-capacity, intensive biogeochemical circulation (IBC), also have a great restorative ability. However, this mechanism for maintaining the stability of landscapes works mainly with periodic and occasional impacts. If the disturbed geo-ecosystem is restored during the time between impacts, it is assessed as resistant to them. Comparing the stability of different NTCs, elastic stability is assessed by the speed of their self-healing, and passive resistance by the degree of degradation or alteration.

Analysis of landscape geosystems shows that the mechanism of sustaining stability due to self-healing works better in geosystems with powerful real energy flows. An example of this is the landscape geosystems of river valleys, with such a powerful system-forming factor as a water flow, possessing high-capacity and intensive IBC. Other examples are delta-type landscape geo-ecosystems with a powerful stream of nutrient and biophilic nutrient elements and landscapes of humid subtropical, tropical and equatorial forests. These geosystems are characterized by a powerful stream of solar radiation and a significant amount of precipitation supporting active and high-capacity IBC.

An analysis of the general mechanisms and processes that generally determine the stability of geosystems shows that the geosystems least resistant to anthropogenic influences are the following:

- relict and young geosystems whose structure and functioning are not fully consistent with the modern conditions of their natural environment,
- geosystems with increased or, conversely, reduced reserves of potential dissipation energy (dissipation), but with increased concentration potential of a substance (mountains, hills or lowlands),
- geosystems with pronounced limiting hydrothermal factors (tundra—lack of heat, desert—lack of moisture, swamps—excessive moisture) or trophic factors (geosystems on well-washed fluvioglacial or alluvial sands),
- stability decreases with a decrease in the hierarchical rank or level of geosystems, as well as geosystems decreasing from dominants to subdominants and rare NTCs.

The most stable landscape geosystems are those which are located at the penultimate, long-term, highly productive stages of restorative successions. They are characterized by relatively high passive stability, including natural fluctuations of the environment, high potential for directional development, enhanced bioproductivity and a variety of structures. These properties also determine the wide possibilities of their adaptive variability, which helps to preserve the stability of the geosystem as a whole. That is, a small artificial rejuvenation of climax geo-ecosystems and their maintenance at highly productive stages of successions is one of the important geo-ecological directions for maintaining geo-ecosystems in a steady state, even under conditions of increasing anthropogenic influence and development.

Economic activity destabilizes and violates the stability of landscapes in the environment both by itself and through the intensification of destructive natural processes. As a result, natural-economic systems (NESs) function less efficiently and dangerous crisis situations develop in nature and society. Therefore, one of the ways to optimize NESs and nature management is to stabilize them in the natural environment, by creating sustainable cultural landscapes and preserving natural diversity.

In landscape science and geo-ecology, ideas about the elements of ecological culture of nature management have been developed: cultural landscapes as natural-economic systems, ecological and landscape ecology frameworks of territories, ecological planning and design of economic activities (Vernadsky 1988; Dokuchaev 1994; Kazakov 1999, 2008, 2013).

3.6 Landscape Ecology Principles and Approaches to the Optimization of Nature Management and Natural-Economic Systems

Landscape ecology principles. The landscape ecology culture of nature management and environmental technology allows us to gently overcome multi-scale environmental crises by mutually adjusting and adapting natural landscapes and technologies of economic activity. This is the essence of co-adaptation and the joint, sustainable evolutionary development of nature and society.

Important components of the ecological culture of nature management include the rationalizing of life, tied to the landscape, the development of environmentally friendly high technologies, focused on minimizing the consumption of natural resources and waste products discharged to the environmental.

The types of nature management, specialization and technical levels of production (agriculture, mining or processing industries, recreation) form a different organizational structure of cultural and marginal landscapes. Studies in industrial regions with localized powerful pollutant emissions have allowed us to identify patterns in the formation of unfavorable environmental conditions and combat the degradation of landscapes (Kazakov and Chizhova 2001; Kazakov 2008).

The environmental problem of the degradation of nature can to some extent be solved, and crisis situations mitigated, with the help of technological methods and technical means, for example, the integrated use of extracted raw materials and circulating water supply systems. In analog ecosystem models and natural-economic systems implemented in practice with cultural landscapes, the waste of some industries is partly used in others and partly incorporated into natural processes, assimilating elements of nature. This allows the economic subsystems to function more efficiently, preserving the valuable properties and elements of natural complexes, biodiversity and a favorable environmental situation. However, with poorly organized, diffuse emissions and impacts on the landscapes of the regions, it is not possible to solve the problem of environmental degradation by technical methods alone.

A greater effect is achieved if, to solve this problem, a location is planned in terms of landscape ecology and the territorial structure of economic activity is organized. To prevent the development of acute environmental crises in industrialized regions, it is necessary to use all available scientific and methodological, administrative and educational principles and techniques, including those developed in the culture of landscape ecology and nature management.

Approaches to the optimization of natural-economic systems. Studying the interaction of different economic systems with landscapes shows that the following complementary approaches can be used to optimize nature management in terms of landscape ecology.

1. An ecological and geographical territorial approach associated with the planning and design of economic activities in terms of landscape ecology. For example, in large areas of Russia, from the points of view of ecology, economics, landscape ecology and hygiene, it is more expedient to design and place thermal power plants (TPPs) operating on solid fuel in the landscapes of the forest zone. TPPs using fuel oil are ecologically safer and more effective in steppe landscapes. If it is necessary to locate them in the forest zone, it is better to choose landscapes formed on carbonate rocks or cover loams for this purpose. The stability and productivity of landscapes composed of sandy soils with coniferous and mixed forests in the areas of influence of thermal power plants operating on fuel oil can be greatly reduced (Kazakov 1999, 2008).

A well-known example is the optimization planning of agricultural activities depending on the slope and slope exposure. Slopes with a gradient of less than 2–4° are optimal for arable farming. As the gradient increases, the intensity of erosion processes sharply increases and the stability and efficiency of the functioning of agro-landscapes of this type decreases.

2. Another approach to the geo-ecological optimization of natural-economic systems is an adaptational one. This is associated with adaptive adjustments of small, less stable natural complexes and their components to new environmental conditions. Examples of such adjustments are the application of fertilizers or neutralizing agents to contaminated geosystems, the creation of new geosystem elements or the replacement of the least stable ones (replacement of coniferous trees with other trees that are more resistant to pollutants). When agro-landscaping NESs, such new or specially conserved elements include a variety of anti-erosion flux-scattering and windbreak forest belts and grass strips on the slopes near the top of ravines and on convex watersheds.

Another example of adaptive adjustments of recreational areas to improve the resiliency of landscapes is phytomelioration and various technical measures.

Phytomelioration can be carried out by grafting and planting species of trees, shrubs and herbaceous plants which are resistant to trampling, or creating artificial multi-species lawns. Technical means of improving the resiliency of recreational landscapes include the creation of an artificial road and footpath network, small architectural forms, etc. These activities increase a landscape's ability to withstand excessive loads, while maintaining a high level of biodiversity and attractiveness. The stability of NTCs increases, and hence, the maximum permissible recreational loads on them can significantly increase, sometimes tenfold. Standards have been developed for the density of the road and path network, depending on the recreational loads in parks and forest parks.

An important geo-ecological trend in maintaining landscapes in a steady state under the conditions of various anthropogenic impacts is the artificial rejuvenation of climax communities and their maintenance at highly productive stages of succession. These activities and new elements of the natural-economic landscape dramatically increase its stability and efficient functioning.

3. The third approach is technological. It is associated with the geo-ecological optimization of the technology used in economic activity (production) and environmental protection measures. In particular, coal-fired thermal power plants located in arid and sub-arid landscapes, in order to comply with EC hygienic standards, must keep all their equipment running well in the long term, and adjacent geosystems in a steady state require more efficient ash-collecting filters and more powerful and efficient cooling systems.

Using these principles of co-adaptation and techniques aimed at ecological modifications of low-level landscape geosystems, in accordance with new environmental conditions, allows us to prevent environmental crises of nature management, or shift them to micro-levels, reducing possible damage. As a result, restructuring in nature comes with less negative consequences for both the landscape and humankind.

The landscape ecology planning of cultural landscapes and technologies of economic activity is one means of actively promoting the co-adaptation of human beings and their economic activity in the natural environment. At the same time, an important role in the conservation of nature and biodiversity is played by the idea of the territories' landscape ecology complexes (LECs), which determines the favorableness of the ecological situation. LECs are an important element of landscape ecology planning and environmental stability (Kazakov 2008).

3.7 Conclusions

1. The lagging ecological culture from the material and production culture of nature management and consumer ideology are the main causes of environmental and resource crises, hampering the development of humanity.

2. The ecologization of the technological culture of nature management, the development of landscape ecology regulation and the planning of economic activities, as well as environmental ethics, are the basis of sustainable nature management.
3. The further development of natural science and other fundamentals of the ecological culture of nature management and the definition of its basic concepts should contribute to the formation of a new ecological world view in the society.
4. The use of landscape ecology principles and approaches to optimize nature management in practice will allow many environmental problems of nature sustainability to be solved or mitigated.

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