Methodology of large-scale research in landscape history

V A Nizovtsev
Lomonosov Moscow State University, Geographical faculty, Department of Physical Geography and Landscape Science, 1, Leninskie gory, Moscow, 119991, Russia
E-mail: nizov2118@geogr.msu.ru

Abstract. The purpose of this article is to present an original methodology that has been prepared for large-scale landscape-historical research. The most important methods of landscape-historical research are the systematic comparative-geographical and landscape-historical-archaeological approaches; and the main subjects of this research are not only natural territorial or natural-anthropogenic complexes, but also landscape-economic systems and landscape-historical complexes that reflect economic or spiritual human activities in specific landscape conditions during certain historical periods. A key component of landscape-historical research, complex both in subjects and in methods used, is the compilation of multi-scale maps of several hierarchical levels (from regional to local) using GIS technologies, and compiling a series of multi-temporal maps for the model areas. The combination of field and desk field methods (landscape, historical, archaeological, paleogeographic, paleopedological, historical and geobotanical, various types of mapping and other natural scientific methods) with desk methods (the analysis of cartographic, collection materials) and remote-sensing methods (the analysis of aerial photographs and satellite images) allows researcher to track spontaneous and anthropogenic changes in specific landscapes, to reconstruct nature management systems and landscape living conditions of settlers, to identify the specifics of the formation of a settlement structure for the main historical chronosections, to determine the features of the interaction of man and landscape at different stages of its economic development.

1. Introduction
Integrated interdisciplinary landscape historical research is based on the landscape historical version of the comparative systemic and structural-genetic approaches, including the original combination of landscape, historical archaeological and paleogeographic research methods using computer and GIS technologies. During this landscape-historical research of the territory, involving a combined study of the landscape and time, landscape and economic activity in it, man-modified landscapes from different periods are compared with indigenous or natural landscapes, as a result of which, according to the "theory of actualism", retrospective reconstructions of landscapes are created [1]. The natural and anthropogenic components of the evolution of landscapes and socio-ecological history [2] are considered in single specific space and time, and the research is carried out at the local level, taking into account the specifics of landscape-zonal conditions.

Landscape-historical research is divided into two interconnected blocks: the studies of the modern landscape structure and the basic properties of landscape complexes, and the studies of the evolution of landscapes under the influence of the anthropogenic factor [3]. The main objects of such studies are not only natural territorial or natural-anthropogenic complexes, but also landscape-economic systems
(LES) and landscape-historical complexes reflecting the economic or spiritual activities of man in specific landscape conditions during specific historical periods [1, 3]. The anthropogenic factor in the development of landscapes directly depends on the historical demographic and socio-economic factors of development. The direction of anthropogenic impacts, their evolution, can be ascertained from the development of the production method (the economic factor). Retrospective landscape studies ultimately serve to establish the mechanism and development trends for modern natural-territorial complexes (NTC) and to project their further changes.

2. Methods
The main methods of landscape historical research are the systematic comparative-geographical and landscape historical and archaeological methods, which are used when choosing standards and "keys" for the field study of the territory, the classification of historical sources, and for emphasizing (among many) the most typical and characteristic objects for these given territories. Historical genetic and diachronic methods developed by V.S. Zhekulin [4] make it possible to draw up a detailed scheme of the periodization of nature management processes and the anthropogenic evolution of landscapes.

The use of a wide range of field methods together with desk methods allows us to trace spontaneous and anthropogenic changes in specific landscapes and their morphological parts in their reciprocal linkages. A similar combination of approaches and methods was used in numerous model territories in different landscape-zonal conditions of Russia. In these areas, large-scale field studies were carried out, involving a compilation of a series of maps and cartographic models on a scale of 1: 100000 (1: 50 000) and on a scale of 1: 10 000 (1: 25 000) for the key areas. Landscape mapping and landscape profiling of the key areas was carried out according to the methodological of the Moscow landscape school [5]. Particular attention was paid to the development of criteria and diagnostic features of anthropogenically altered landscapes with the determination of their morphological and temporal structure.

3. Results and Discussion
Landscape mapping and landscape profiling of the key areas allows, firstly, to study the modern landscape structure of the territory; and secondly, to identify anthropogenic changes in the NTC and to evaluate the modern anthropogenic load; and the landscape maps themselves serve as the basis for subsequent retrospective reconstructions of the landscape structure and nature management for certain time stages [1, 3]. The methodology of integrated landscape-historical mapping is based on the concepts of natural-anthropogenic landscapes [6], natural-economic systems [7], social-natural systems [8], landscape-economic systems [3], landscape systems [9] and the factors of their transformation [10].

The selection of landscape complexes and landscape-economic systems and the drawing of their boundaries is based on the principle of genetic uniformity and the principle of subordination developed by N.A. Solntsev [11]. Since, according to these principles, the decisive role in the division and differentiation of landscapes into morphological parts (i.e., sites with different hydrothermal conditions, vegetation, soil formation processes) belongs to the lithogenic base, then, first of all, the morpholithogenic framework (morpholithogenetic complexes) and its geological and geomorphological boundaries are determined.

When conducting landscape surveys, the use of the landscape-geobotanical indicator method through indicator plants allows the edaphic properties of the NTC to be determined to a certain extent, which provides a reliable foundation for retrospective landscape reconstructions. To identify the internal relationships in the landscape, a study of the soil cover is carried out, the study of the so-called "soil memory". In the field, internal (intercomponent) and external (i.e., relations with the neighboring NTC) facies bonds are studied. Ecological and edaphic conditions and features of the resource potential of the NTC are identified. Particular attention is paid to the study of the impact of human activities on landscape complexes, modern anthropogenic loads and the characteristics of the
anthropogenic transformation of the NTC. The methodology for this work was tested on the example of the Moscow region [12].

The most important part of the research is the use of the landscape-edaphic approach when reconstructing the landscape structure of territories within specific chronosections, and compiling maps of conditionally restored (indigenous) NTCs [3]. The main condition for compiling such maps is the complete "removal" of the anthropogenic factor. Particular attention is paid to the analysis of anthropogenic changes in the relief (artificial terracing, planation, "anthropogenic" erosion forms, etc.), the power of accumulation and distribution of the cultural layer, and the change in the hydrological regime in this territory. The most important factors are selected from the great number of those natural factors on which the growth of phytocenoses depends: the topography and location, substrate fertility, the nature of moisture and the level of moisture.

Knowing the natural properties of the NTC, it is possible to establish its basic edaphic properties (its specific edaphotope) and, accordingly, the base type of forest or steppe vegetation, most fully corresponding to these properties, and to predict successional changes of modern phytocenoses. Each specific type of NTC also has its definite specific series of successions of plant communities. According to the ecology of phytocenoses and indicator plants, conjugate series of forest or steppe phytocenoses and habitats are compiled. The selection of the main tree species and species of the shrub layer, as well as the main groupings of the ground layer for each proposed specific type of forest or species composition of steppe communities is carried out according to the method of A.A. Vidina [5], L.I. Milkina [13], V.A. Nizovtsev [3], and numerous literary sources characterizing the ecological requirements of forest and steppe plants and their indicator properties.

The climatic context is restored for the chronological section under research, and the anthropogenic changes in the relief, the power of accumulation and distribution of the cultural layer are analyzed. The established regularities of the confinedness of modern plant communities and soil phases to certain topographical forms and the lithology of parent rocks, according to the “principle of actualism”, can be extrapolated to certain chronosections, with adjustments for climatic changes [1]. The reconstructed landscape structure is revisioned, and in some areas, it is modeled on the basis of the obtained detailed paleoecological (spore-pollen and carpological) data. Therefore, the NTC data are highlighted on the map with a certain degree of conditionality.

An important research method is landscape-historical mapping, involving the compilation of a series of maps of different periods for the key sites, reflecting the economic activity there at a certain historical stage in the specific natural conditions in which this activity took place [3].

The retrospective analysis of nature management and the formation of landscape-economic systems is carried out on the basis of the original method of comparing textual and various graphic materials. The basis for this analysis is the reconstruction (based on archaeological and historical data) of the types and methods of farming and land management by the settlers, as well as the paleoreconstruction of their original living environment [3]. Based on the historical and genetic method, the main periods of economic development, nature management and anthropogenic dynamics of landscapes are identified. Overlaying maps of the distribution of material cultures on the physical-geographical and landscape maps reflecting the natural features of the territory makes it possible to assess the role of the landscape factors in the formation of a spatial settlement structure, to identify limiting and favorable factors for the economic and land development. Determining the dates of events that took place in the life of settlers and landscapes is based on the archaeological analysis of artifacts, palynological and radiocarbon methods.

The most important part of the research is the study of the resource potential of landscape complexes, including the determination of their main "production" characteristics. The production unit is the most active part of the system, which includes all types of economic impact on the NTC and allows to manage the development and restructuring of the entire system as a whole. The reconstruction of farmland, reflecting the nature management at a specific historical time, is an important part of the research.
The development of various types of environmental management in certain NTCs, over time, led to the formation of certain landscape-economic systems (natural-economic systems, according to G.I. Schwebs [7]). Landscape-economic systems (LES) are the result of specific economic activities in specific landscape conditions [3, 12].

The landscape-economic systems are characterized by the appearance of new stable elements in the natural component, as well as the formation of various types of natural-anthropogenic circulation of matter and energy flows, based on the use of the natural potential of the landscape by man. The strongest correlation of LES with the local landscape structure is observed at the local level, most often with landscape complexes of lower hierarchical levels - the rank of a sub-tract. This is due to the historically developed adaptability of human economic activity.

This approach is important because the differences in the relationship between nature and society in each region are reflected in the change of certain landscape-economic systems. It is well known that the anthropogenic variability of landscapes depends on both the properties of the landscapes themselves and the methods and intensity of their use and management by man, that is, the anthropogenic load. Therefore, when defining the types and methods of farming in specific landscape conditions in certain historical sections, we determine the corresponding anthropogenic loads on the landscape. Subsequently, it is possible to distinguish the types, degree, and depth of anthropogenic changes in the landscapes of that time. Two main groups of impacts on landscapes can be distinguished: local and areal; linear and mosaic are also quite common. Time-wise, this impact can be short-term (not extending beyond one or several years and at the same time recurrent and not recurrent), long-term (tens and hundreds of years), and permanent [1, 3].

Through LES, it is possible to isolate, separate disturbances to landscapes, and establish at what specific time this or that transformation of landscapes or their components took place. That is, this approach makes it possible to localize the anthropogenic impact both in space and in time. At the same time, the development phases and anthropogenic changes in landscapes are quite reliably dated.

The landscape-archaeological method of field research allows you to determine right in the field the boundaries of ancient settlements and farmland, and their confinedness to specific landscape conditions. The determination of the dates of events that took place in the life of settlers and landscapes is also based on the archaeological analysis of artifacts and on radiocarbon and palynological methods.

Paleo-soil (paleo-pedological) studies are included in the block of landscape and archaeological work as a component and a very important part. This research is a necessary link in the reconstruction of landscape conditions, and indispensable in identifying the indicators of anthropogenic landscape disturbances in the distant past. In contrast to the usual paleo-soil studies, which in the absolute majority of cases are point-like, local, we take into account the landscape situation and the placement of the studied objects in space. The methodology for this research is well known [14, 15]. The foundation is the methods for diagnosing anthropogenic changes in landscapes through buried anthropogenic-transformed soils. Analytical soil-geochemical studies make it possible to trace changes in the soil cover associated with various types of economic activity, and to load the edaphic (trophic) properties of specific habitats with quantitative attributes. The analysis of soil samples for phosphorus is carried out taking into account the landscape situation in order to mark the boundaries of ancient settlements according to this indicator. For paleo-landscape and retrospective reconstructions, a morphological (morphogenetic) analysis of the soil profile is used. The analysis is based on the method of "the archeology of ecosystems" proposed by E.V. Ponomarenko [16] and M.V. Bobrovsky [17]. Very promising are the conjugate paleo-landscape and paleoecological reconstructions, and the compilation of paleo-landscape maps based on landscape edaphic interpretations of spore-pollen spectra and data from paleopedological studies at the local level.

Landscape-historical mapping makes it possible to trace the features of the relationship between man and the landscape in certain chronosections of specific territories at several hierarchical levels, and makes it possible to analyze and reconstruct the dynamics of the nature management, environmental situations and anthropogenic evolution of landscapes. An important method of research is the compilation of a series of multi-temporal maps for the key areas that reflect the economic
activity at a certain historical stage in the specific natural conditions in which this activity took place. At the same time, all maps are compiled on a single scale, which makes it possible to perform not only a qualitative assessment, but also a quantitative analysis of the processes taking place. When processing and analyzing historical materials, a new type of GIS is created: the landscape-historical geographic information systems, which allow to get a clear picture of the functioning of territories in different historical periods on the basis of landscape-historical analysis of the territory, including an associated study of the dynamics of the landscape and economic activity in it, together with the compilation of a series of maps for various chronosections. GIS technologies allow faster and more efficient paired analysis of multi-temporal and multi-scale historical maps, allow to overlay maps of one type on another, to determine the area of contours and quantitatively describe the land use dynamics of specific NTCs (of various taxonomic ranks, up to types of natural tracts and sub-tracts) in certain historical time intervals [3].

4. Conclusion
The combination of field and desk field methods in large-scale landscape-historical studies makes it possible to trace the spontaneous and anthropogenic changes in specific landscapes and their morphological parts in their interconnection. It also allows researcher to reconstruct nature management systems, to identify the specifics of the formation of a settlement structure for the main historical chronosections, to determine the characteristics of the interaction of man and landscapes at different stages of their economic development. The variety and complexity of the methods used in landscape-historical research significantly increases the quality of the research results and allows us to identify not only long-term, but also short-period changes in the nature management and landscape structure of the studied territories.

Acknowledgments
The reported study was funded by RFBR according to the research project № 19-05-00233.

References
[1] Nizovtsev V A 2010 To the theory of anthropogenic landscape genesis Geogr. and natural resources 2 5–10
[2] Kulpin E S 1996 Bifurcation West-East. Introduction to Socio-Natural History, lecture course (Moscow: Moscow Lyceum)
[3] Nizovtsev V A 1999 Anthropogenic landscape genesis: subject and objectives of the study Moscow Univer. Geogr. Bull. Ser. 5 Geogr. 1 26–30
[4] Zhekulin V S 1972 Historical geography of landscapes (Novgorod: Novgorod Pedag. Instit.)
[5] Vidina A A 1977 Practical studies in landscape science (Moscow: MSU Publ. house)
[6] Nikolaev V A 1992 Fundamentals of the doctrine of agro-landscapes, in: Agro-landscape research (Moscow: MSU Publ. house) p 56
[7] Schwebs G I 1987 The concept of natural economic territorial systems and issues of rational nature management Geogr. and natural resources 3-4 30–8
[8] Verburg P H, Erb K H, Mertz O and Espindola G 2013 Land System Science: between global challenges and local realities Current Opinion in Environmental Sustainability 5(5) 433–7
[9] Aspinall R and Staiano M 2017 A Conceptual Model for Land System Dynamics as a Coupled Human – Environment System Land 6(31)
[10] Lambin E F, Turner B L, Geist Helmut J, Agbola Samuel B et al 2001 The causes of land-use and land-cover change: moving beyond the myths Global Environmental Change 11 261–9
[11] Solntsev N A 1949 On the morphology of the natural geographical landscape Questions of geography (Moscow: Geografiz State Publ. House of Geogr. Lit.) vol 16, pp 61–86
[12] Annenskaya G N, Zhuchkova V K, Kalinina V R, Mamai I I, Nizovtsev V A, Khrustaleva M A and Tseselchuk Yu N 1997 Landscapes of the Moscow region and their current state (Smolensk: Publ. House of SHU)
[13] Milkina L I 1984 *The technique of large-scale reconstructive geobotanical mapping* (Kiev: Naukova Dumka)
[14] Alexandrovsky A L 1983 *Soil evolution of the East European Plain during the Holocene* (Moscow: Nauka)
[15] Dergacheva M I 1997 *Archaeological soil science* (Novosibirsk: Publ. House of the Siber. Branch of the RAS)
[16] Ponomarenko E V 1999 Methodological approaches to the analysis of succession processes in the soil cover *Succession processes in Russian reserves, and problems of conservation of biological diversity* (St. Petersburg: Russ. Botanical Society) pp 34–57
[17] Bobrovsky M V 2010 *Forest soils of European Russia: biotic and anthropogenic factors of formation* (Moscow: KMK Sci. Press Ltd)