



GEOSPATIAL MODEL OF REGIONAL NATURAL RESOURCES AS A BASIS FOR SUSTAINABLE ENVIRONMENTAL MANAGEMENT



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ABSTRACT

The role of geospatial modeling as a basis for the effective management of sustainable development is examined in the paper. The timeliness of geospatial modeling for planning regional natural resource management is stated. A new term is proposed: a natural resource geospatial model (NRGM). The purposes and main structural elements of the model are described. Relevance and reliability criteria of NRGM data are given. The significance of natural resource geospatial models as a tool for integrating heterogeneous data (e. g., Earth remote sensing data, state cadastral data, government statistics) are emphasized. The main tasks associated with optimizing natural resource management by using NRGM are listed. A case study of forest resources modeling in the Novosibirsk Region (Russia) is described.

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Contribution/ Originality

The study contributes to the theory and methodology of 3D geospatial modeling and analysis for the rational management of natural resources. The paper introduces a new term and approach to the 3D-modelling of heterogeneous natural resources data.

1. INTRODUCTION

Efficient use of the natural resources of a region is essential to –its competitiveness. Sustainable economic activity requires administrative and economic entities to have detailed and comprehensive data on the region's natural resources and convenient means for using these data to determine the development strategies of current and future natural resource exploration and processing industries.

An efficient tool for implementing the above mentioned objectives is geospatial modelling. It allows taking into account a wide range of natural factors when analyzing various economic activities, e.g. evaluation of local conditions for different practical uses [1-4] environmental monitoring and control [5, 6] emergency management [7, 8] etc. The resulting product of geospatial modelling is a geospatial model, that is the basis for further decision making and planned activities that require the use of large sets of current initial data and analysis of all possible impacts of planned actions. When planning environmental management activities in specific regions, a natural

resource geospatial model (NRGM) of the region (digital representation of an ordered set of spatially distributed data on the region's natural resources obtained from various sources) may become the most efficient tool. The list of these data should be sufficient to cover all needs aimed at sustainable management of natural resources in the region at present and in the future.

The key structural elements of a regional NRGM are presented in Fig. 1.

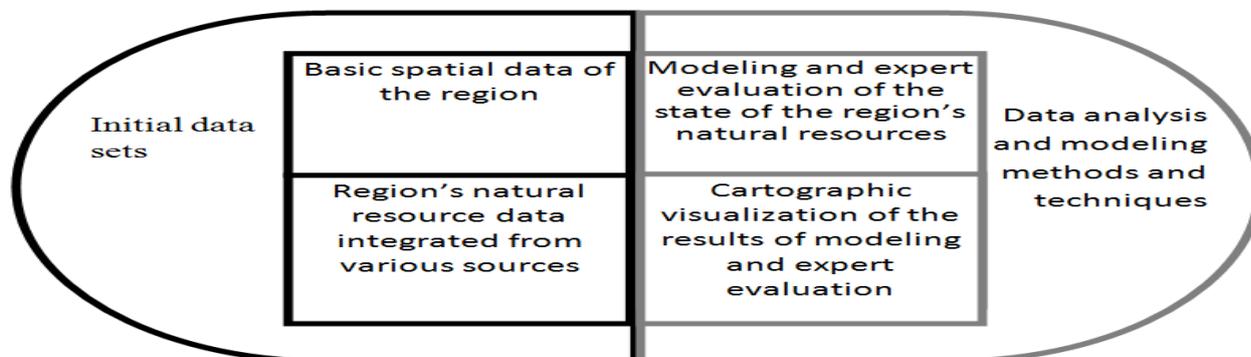


Fig-1. Main structural elements of the NRGM of a region.

Source: Nikolaeva [9]

As seen in Fig. 1, a regional NRGM comprises the following structural elements:

- 1) Initial data sets (basic spatial data of the region and sets of natural resource data containing thematic information).
- 2) Data analysis and modeling methods and techniques, used to transform the data included in the natural resource data sets. They provide the following operations using a regional NRGM:
 - a) cartographic visualization of the natural resource data sets in correlation with the basic spatial data;
 - b) modeling and expert evaluation of the derived characteristics of the amount and condition of natural resources in the region.
 - c) cartographic visualization of the modeling results and expert evaluation in the form of thematic digital maps and three-dimensional models.

The information elements of the initial data sets of a regional NRGM are units of natural resource information which are stored, collected, and processed for cartographic modeling of the current and future state of the region's natural resources. From the viewpoint of spatial localization, each specific information element can be assigned to only one of the classes of graphic primitives: a point, a line or an area (a portion or the whole area of the region).

2. EXPERIMENTAL STUDIES

The above mentioned methodological foundations of geospatial modeling of regional natural resources have been tested for the Novosibirsk region as an example. Due to the structural complexity and the huge information content of the developed model, below we consider in detail only the biological resource modeling subsystem. It includes models of floral and faunal resources that reflect different aspects of their state and use (see Fig. 2).

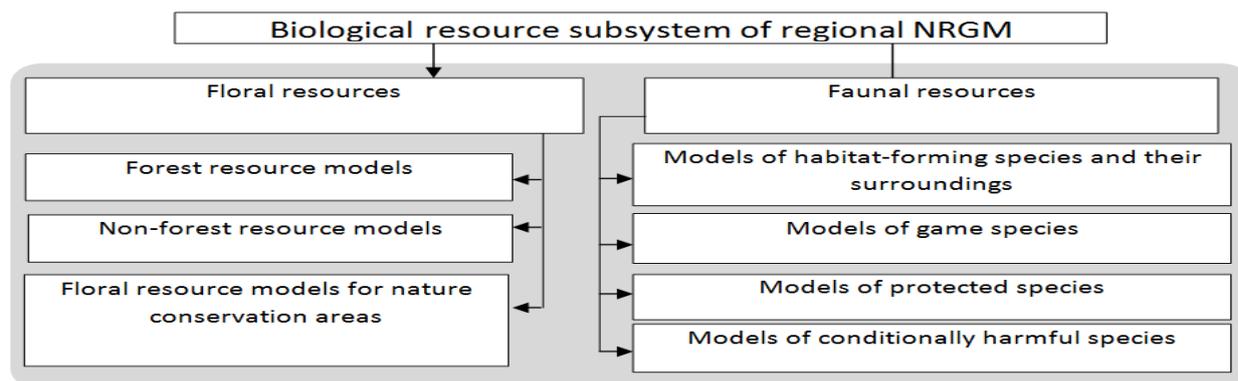


Fig-2. Structure of the biological resource subsystem of the regional NRGM

Source: Nikolaeva [9]

Experimental work on the development of the thematic content of the biological resource subsystem a regional NRGM has focused on modeling the characteristics of forest resources because it is this type of biological resources that makes the greatest contribution to the economy of the region.

Geospatial models of forest resources have two levels of spatial coverage:

- Regional geospatial models developed for the entire area of the region (1:1 000 000 – 1:3 000 000 scale). The purpose of these models is to reflect the main indicators of the state, use, and restoration of forests to identify the main trends of change in the forest resource and plan its possible future usage. Mapping units are forest areas.
- topical geospatial models developed for a particular forest area (1:200 000 - 1:1 000 000 scale). These models provide a detailed description of forest resources for planning forest use, updating forestry plans, and taking into account environmental factors (first of all, topography) in forest management. Mapping units are the technical sites of the mapped forest area.

The indicators of regional geospatial models of forest resources are divided into three thematic groups: Forest Stand Condition, Forest Resource Use, and Forest Protection and Restoration. The thematic content of topical geospatial model contains more detailed characteristics of forest resources divided into four thematic groups: General Characteristics of the Forest Area, Characteristics of the Species Composition of Forest Stands, Use of Timber and Non-Timber Resources, and Forest Fire Fighting, Reforestation, and Forest Pathology Research. The basic spatial data used to localize thematic data include hydrographic and transportation facilities, topography, soils, the boundaries of the administrative and cadastral units of the area, and the boundaries of nature reserves.

Geospatial models of forest resources are designed to ensure the sustainable development and management of forest resources in the Novosibirsk region. They are responsible for the integration, processing, and visualization of reliable and timely data on the forest resources of the region and providing them to public authorities to improve the forest management system and optimize the use, protection, and reproduction of forests.

Geospatial models of forest resources can reflect particular indicators of forest resources (age categories, the presence of damaged forest areas, growing stock increment, the volume of cutting for various purposes, etc.) or establish spatial correlations between mapped features. For example, Fig. 3 shows different forest zoning options based on three criteria: stand species, stand age, and slope steepness. The zoning identified forest sites recommended for final felling (i.e., mature and overmature forests) growing on gently sloping areas (less than 6°) and characterized by a lower risk of soil erosion.

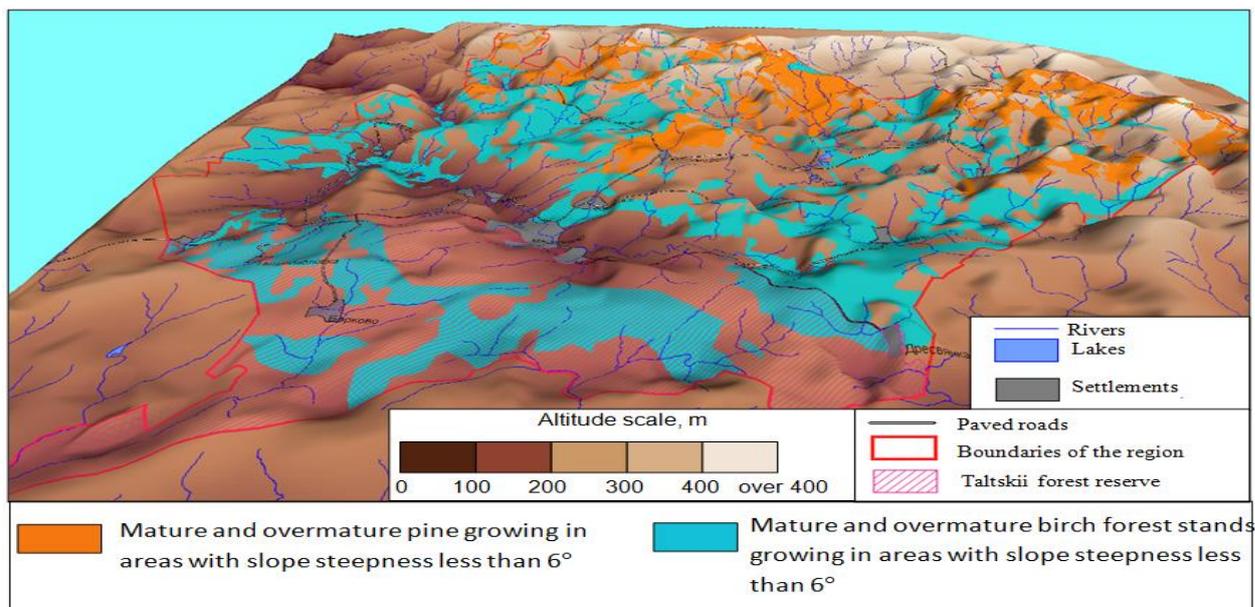


Fig-3. Geospatial modeling of tree species characteristics, stand age, and slope steepness

Source: Nikolaeva [10]

3. CONCLUSIONS

A regional NRGM provides an integrated visualization of basis spatial data and diverse natural resource data of the region and allows the use of spatial analysis methods to model the current and future state of the natural-resource potential of the region. The modeling results are represented as digital cartographic products in two-dimensional or three-dimensional form. A regional NRGM lays an information foundation for the solution of the following problems of natural resource management in the region [9]:

- Analysis and evaluation of the current state of a natural resource (cartographic visualization of currently identified qualitative and quantitative characteristics of the resource);
- Predicting the potential use of a natural resource under various scenarios of economic development of the region and predicting the resource state changes due to anthropogenic use (cartographic modeling of spatial, quantitative, and qualitative changes in the resource by means of spatial analysis and GIS analysis);
- Making recommendations on the use, protection or restoration of a natural resource (cartographic support of activities for designing new industrial facilities or reclamation activities).

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