Forestry system improvement by arranging and storing soil data

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Abstract. The article describes the application of information technologies results in the field of forestry relating to processing soil survey and creation of a single database. Basing is carried out by inventory and formalization of representative profiles soil data having a full set of indicators of the profile morphological structure, physical-chemical properties and their inclusion in the soil attribute database. Using the practices of digital soil cartography in the soil data exchange system, simplified thematic maps were obtained for the convenience of perceiving a significant amount of information.

1. Introduction

Modern forestry is characterized by a multi-purpose orientation, including the forest resources management. In order to make a rational managerial decision, it is necessary to master modern approaches and methods of applying the innovative tools such as computer technology and automated systems. “The application of technical means, as well as mathematical methods and control systems, relieve a person partially or completely from direct participation in the process of obtaining, converting, transmitting and using energy, materials and information” [1].

There appears a necessity to increase the knowledge standard of forestry specialists in the field of forest management and the skills of applying modern information technologies due to the development of information technologies.

Lately a special attention in the field of forestry has been given to the introduction of geographical information technologies necessary for the immediate solution of tasks in the forest complex [2].

Due to the intensive utilization of forests, reduction of mature and accessible for forestry equipment forest areas, the topic of reforestation is relevant. At present it is fairly evident that the soils are the most important factor affecting the process of creation and growth of forestry crops. In this regard, in order to increase the efficiency of forest planting formation, it is appropriate to conduct soil surveys on the territory of the planned reforestation. The creation of an automated information system (AIS) will significantly improve the efficiency of work by providing visualized access to soil surveys united in a single database.

Primary data is quite heterogeneous in their scale, chronology of receiving and source of information. The most important aspect preceding the use of the system is the preparation of information for machine processing namely vectorization and structuring of the semantic component of maps.

Vectorization of cartographic materials is possible by using various geographic information systems (ArcGIS, MapInfo, QGIS) and original software (SoilContour). The principle of highlighting soil
contours and the specifics of introducing attribute information is fundamentally important but not the use of a particular software product.

The research is aimed at digitalizing soil surveys and visualizing the collected data using GIS products. The following tasks are formulated:

- Collection and verification of archival and field data of the study area,
- Digitization of the received data,
- Systematization of the received data using the local Soil-DB ver.1 module for inputting primary data of soil indicators,
- Construction of GIS for the territory of the studied object.

2. Methods and Materials
The research began with a study of archival materials of soil surveys, which were presented in different volumes and formats, as shown in figure 1.

![Figure 1](image-url)  
**Figure 1.** Scheme of represented archived data.

Archival data was presented with heterogeneous information content. In one case, it was possible to find only the soil full name and the label part by location in the net of rides. In other cases, rarely came across information about the full amount of information as shown in figure 1 block III.

In addition to the collection and processing of archival materials, a field soil survey was conducted on the studied silvicultural areas. At the same time, archival data was being updated. During the field study, a significant amount of soil information was collected. In total, soil research materials totaled about 150 pit profiles; the most peculiar ones were deepened to sections.

The soil research method was carried out by creating a series of pits (in the amount of 115 pcs.) and sections (in the amount of 35 pcs.) evenly covering the study area, the percentage of coverage was 1% of the total area, to determine the morphological parameters and the subsequent soil types specification according to the classifications developed at the Department of Forest Cultures, Breeding and Dendrology at the Mytishchi branch of Bauman Moscow State Technical University. Then, in accordance with the methodology developed at the Faculty of Soil Science at the Lomonosov Moscow State University soil samples were taken to identify chemical indicators in a laboratory.
Systematization of the obtained data was carried out by entering information into the Soil-DB ver.1 local data entry program a Javascript and a MS ACCESS database. It has a hierarchical system of reference tables. The result of this program is a structured description of one or more soil profiles by horizon. The data of one selected or all profiles can be uploaded to an XML standard hypertext file.

The local input program with an empty database is placed in the form of a freely downloadable archive on the main web page. The developers of this module are the V V Dokuchaev Soil Science Society, employees of the V V Dokuchaev Soil Institute and staff of the Faculty of Soil Science from the Lomonosov Moscow State University [3, 4].

Data input is carried out by inventory and formalization of representative profiles soil data, provided with a comprehensive set of indicators of the morphological structure, physical-chemical properties of the profile, as well as their inclusion in the soil attribute database.

3. Results and Discussion

The main object of the Soil-DB ver.1 local data entry program is a specific soil pit with its inherent set of horizons characterized by a specific set of attribute data. Systematization of data on the structure of selected profiles involves a single form of the presented data, highlighting a set of attributes necessary for a comprehensive description of the soil type. Since soils are described by a whole set of features, a unified system of presenting all soil data is necessary. For this purpose, classifiers (systematic lists of indicators) of soil properties have been developed on the basis of existing concepts of soil morphology and basic scales underlying the descriptions of soil profiles. At the moment, the Soil-DB ver.1 local data entry program contains more than two hundred classifications of soil indicators.

In order describe chemical properties of soils, numerous data on chemical analysis of soils over the entire history of the domestic soil science development have been summarized, the modern standards for conducting chemical analyzes of soils have been taken into account.

At each level, a description a systematic list of indicators positions characterizing the morphological structure of soils, a description of the external conditions of the section, physical-chemical characteristics are given, it also has several points for detailing the characteristic.

Having been previously mentioned, the data of one selected or all profiles can be uploaded to a hypertext file of the XML standard. XLM files are connected with one or more file types and can be viewed using Microsoft Excel, developed by Microsoft Corporation. Then, using some simple techniques, we transform the XML file into Excel format and then import this file into the geographic information system.

Thus, all the collected information during the stage of the field survey in the process of cameral work is processed and entered into a single database.

Experimental data processing consisted of two stages:

• Primary processing, systematization and digitization of field survey data and archival materials.
• Combining all the information collected in the GIS.

To visualize a large amount of information, it was decided to build thematic maps applying GIS technologies.

The results of field studies, as well as the collected archival information, served as the basis for the creation of a geoinformation system of soils and vegetation of the study object.

To fill in the geographic information system with the collected information, it is necessary to create its structure. When developing the GIS structure, information layers were created that contain isolated data. Organized data can be represented as a diagram (figure 2).
Thus, while working with the GIS program several layers were created in which various information components are grouped [5].

The attribute table is a relational database associated with layer features in a GIS. One object on the map corresponds to a certain line in the table, which reflects its attributes and contains soil information about the point. Objects in the table can be searched, selected, moved and edited, as well as a complex of mathematical, statistical and logical operations.

Each object on the map is connected with a line (record) in this table. This connection is bidirectional, when you select an object on the map, you select its entry in the table and vice versa. Attribute tables contain information on objects entered manually (name, type of object, etc.) or calculated automatically (perimeter and area, length, position point).

The created information component can reflect the complexity of the attributes of the data used, including information about the conditions of soil formation, as well as the photofixation of the trial area or profile of a particular section.

Based on the results of data digitization, an electronic soil map of the study area was built. A fragment of this map is shown in figure 3.
Figure 3. Fragment of the study area soil map.

The obtained and systematized data are applicable to simplify the reforestation process. It is a known fact that when creating forest crops, soils are one of the most important factors for reforestation. Having data on the percentage ratio of the areas with different soils, the degree of drainage and the silvicultural category of cuttings are determined (table 1). At the same time, it is considered that deforestation refers to:

- Category I (drained cuttings) if more than 75% of its area has fresh and dry soils;
- Category II (temporarily excessively moistened cuttings) if more than 25% of its area has wet soils and less than 25% has soggy and nasty soils;
- Category III (swampy cuttings) if more than 25% of its area has soggy and nasty soils.

For each forest silvicultural cutting category the creation of the following elements is specified:

- furrows with a depth of up to 15 cm, mineralization of skidding tracks and logging sites of Category I and drained soils;
- rows with a height of 20 ... 30 cm on category II cuttings and moist soils;
- ridges with a height of 30 ... 40 cm on cuttings of category III and damped soils.
In accordance with the generally accepted in 1977 classification of forest soils and the above data, all soil differences identified in the study area were grouped into three categories by the degree of natural drainage.

Table 1. Characteristics of cuttings drainage categories.

| Drainage category     | Soil name                                                                 |
|-----------------------|---------------------------------------------------------------------------|
| I Fresh and dry       | Sod-strongly podzolic, sod-medium-podzolic, sod-weakly podzolic, sod-     |
|                       | strongly podzolic gleyed, sod-medium podzolic gleyed and sod-slightly      |
|                       | podzolic gleyed                                                          |
| III Moistened         | Surface-gleyed: peaty-podzolic, sod-podzolic, humus-podzolic; Ground-    |
|                       | gleyed: peaty-podzolic, sod-podzolic, humus-podzolic                      |
| III Soggy and nasty   | Swamp surface: peat-gley and peat. Lowland swamp (typical): depleted     |
|                       | peat-gley, peat-gley, depleted peat, peat                                |

Guided by this classification, a thematic map was designed by using GIS tools, a fragment of which is shown in figure 4.

![Figure 4. Thematic map of silvicultural assessment of the study area.](image)

The thematic map shows the category of cutting appropriate for reforestation.

3.1. Discussion
At the moment, the collection, processing, systematization and digitalization of the research data is going on. The database can be updated and added for an unregulated number of times. The presented approach to data systematization allows organizing soil data collected during the study, it uses the digital soil cartography in the data exchange system of the main soil indicators, and simplifies the perception of a large amount of information.
The topic of soil inventory was more closely discussed in the works of Shoba S A and Golozubov O M. The purpose of the works was “to conduct an inventory, harmonization and semantic analysis of heterogeneous information about the soil resources in Rostov region to do the tasks of agro-ecological monitoring using digital soil cartography and modeling methods”. They also found that “the collection of heterogeneous soil data is possible only by applying software oriented to the specifics of data collection in regional data centers for the purpose of agro-ecological monitoring” [6-8].

Systematization of soil data into a single database is relevant at the world level. The working group on the creation of an international soil classification system was founded in 1980 and was approved by the Council of the international society of soil scientists (ISSS Council) in 1998 As a result of this group's activities, the first World Reference Base for Soil Resources (WRB) was published in 1998 and the second in 2006.

The development of the WRB system was based on the verification of the world soil map and the available achievements of international correlation of soil nomenclature [9].

The research in this direction is carried out by other foreign countries. Since 2007, under the auspices of the working group, a geographical information system for natural phenomena has been developed. In 2007, the work began on the INSPIRE project and was completed in 2019. The project aims to create a spatial data infrastructure, which will provide an opportunity to organize public access to environmental information in the EU territory [10].

In 2008, the Global Soil Map project was created by a global consortium. The aim of the project is “the creation of a new world digital soil map applying the most modern and latest technologies for a high resolution soil mapping and predicting the soil properties.

4. Summary
This new global soil map is of scientific and practical interest to the world community, it will be complemented by interpretation options and functional opportunities aimed at facilitating more effective solutions to a variety of global issues, such as food production, the eradication of hunger, climate change and environmental deterioration [11].

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