31

Soil Geographic Database of Russia

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31.1 Introduction

Russia, the largest country in the world, encompasses nearly 30% of the world area of permafrost-affected soils, more than 60% of the world area of soils of the Boreal zone, and about 40% of the world area of Chernozems. More than a century since the shaping of modern pedology by V.V. Dokuchaev, Russian soil scientists have gained a vast amount of information about the soils of Russia. Some of the data are integrated in thematic information systems and databases, although a larger portion of it is preserved in paper form and cannot be readily applied in modern information technologies.

In the last decade, specialists from several organizations have digitized a great number of various thematic maps. In particular, the digital Soil Map of the Russian Federation on a scale of 1:2.5 M (1988) was developed, as well as a new digital map of the soil-ecological zoning (SEZ) of Russia on the same scale.

One of the major challenges facing Russian soil scientists is the creation of the national Soil Geographic Database (SGDB). The SGDB of Russia is considered a crucial element of soil inventory at the federal level. The SGDB should facilitate the regulation of land management and soil conservation policies in the country. The SGDB should be applied toward the development of legislative acts for soil protection and federal standards of soil quality for the purposes of soil-ecological monitoring. It should also serve as the basis for cadaster assessments of land resources.

Work on the SGDB project was initiated by the Dokuchaev Soil Science Society in 2008 at the All-Russia Conference in Rostov-on-Don. Since then, the concept and ideology of the project have been developed rigorously, and several major principles and goals of the SGDB have been formulated. The SGDB has been discussed in several papers and reports. The V.V. Dokuchaev Soil Science Society has presented soil scientists throughout the country with a request to contribute their time and research to the development of the SGDB. Special software aimed to aid in the completion of the SGDB has been developed; work on filling out informational fields in the SGDB is still in progress.

31.2 Soil and Land Resources of Russia

31.2.1 Soil Resources

The total area of Russia is 17,098,242 km^2, extending nearly 3,000 km from north to south and nearly 7,000 km from west to east. These large dimensions allow for a diversity of environmental conditions throughout the country and many differences in land management practices. The environmental differences manifest themselves in different ways: from gradual geographic transitions to sharply pronounced contrasting changes.

The diversity of climatic and biotic conditions in Russia is the first group of factors determining the diversity of soils and soilscapes throughout the country. The second group of differentiating factors is related to the geological history of particular territories and their lithological composition; the chemical, mineralogical, and physical properties of surface deposits serving as parent materials; the hydrogeological conditions; and the modern dynamic processes shaping the surface topography. The superposition of bioclimatic, litho-geomorphic, and historical–geological factors is responsible for the diversity and complexity of the soil cover in Russia.

General regularities of the soil cover of Russia and its regional differentiation are reflected in the most explicit form on the maps of SEZ.

The digital *Map of Soil-Ecological Zoning of Russia* (Figure 31.1, Table 31.1) was developed at the Faculty of Soil Science of Moscow State University on the basis of the *Soil Map of the Russian Federation* developed by the V.V. Dokuchaev Soil Science Institute under the supervision of V.M. Fridland (1988). SEZ is based on the taxonomic system with several hierarchical levels: (1) geographic belts and (2) soil-bioclimatic areas. These levels are further subdivided into mountainous and plain areas. Plain areas comprise (1) plain soil zones (subzones), (2) plain soil provinces, (3) plain soil regions, and (4) plain soil districts; and mountainous areas comprise (1) mountain soil provinces, (2) mountain soil regions, and (3) mountain soil subregions or mountain soil districts (not obligatory level).

The types of Russian soils are numerous, and extend from Arctic soils located on islands in the Arctic Ocean to Brown Semidesert soils of the Caspian Lowland, as well as Subtropical Yellow Ferrallitic soils from the foothills of the Caucasus in the south. Soils of the taiga zone occupy more than 50% of Russia, including Podzols and Gleyed Podzols (10.2%),

FIGURE 31.1 Scheme of the SEZ of Russia.

TABLE 31.1 SEZ of Russia

Plain Soil Zones (Subzones)	Mountain Soil Provinces
I—Polar Geographic Belt	
I—Eurasian Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
A—Arctic soils of Arctic zone	a1—Arctic islands
B—Arctic-tundra soils of subarctic subzone	a2—Polar–Urals
C—Gley tundra soils and podburs of subarctic subzone	a3—Byrranga
	a4—East-Siberian
	a5—Chukotka
	a6—Koryak–Taigonos
II—Boreal Geographic Belt	
II—European–West-Siberian Taiga-Forest Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
D—Gley podzolic soil, gleyzems, and podzols of northern-taiga	b1—Khibiny
E—Podzolic soils of middle taiga	b2—North-Ural
F—Soddy-podzolic soils of southern taiga	b3—Central Ural
III—East-Siberian Permafrost Taiga Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
G—Peaty-muck cryogenic taiga gleyzems of northern taiga	c1—Anabar–Putoran
H—High-humus peaty-muck nongleyed and pale cryogenic taiga soils of middle taiga	c2—Verkhoyansk
	c3—Kolyma
	c4—Yenisei
	c5—Cisbaikal
	c6—Aldan
	c7—East-Sayan
	c8—Lena–Angara
	c9—Transbaikal
IV—Far-Eastern Taiga-Forest Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
I—Forest volcanic soils	d1—Kamchatka
K—Raw-humus burozems and podzols	d2—Okhotsk
	d3—Sikhote-Alin–Sakhalin
	d4—Bureya
III—Subboreal Geographic Belt	
V—Western Forest Soil-Bioclimatic Area of Brown Forest Soils	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
—	e1—North-Caucasian
VI—Central Broadleaved-Forest, Forest-Steppe, and Steppe Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
L—Gray forest soils of deciduous forests	f1—South-Ural
M—Podzolized, leached, and typical chernozems and gray forest soils of forest-steppe	f2—Salair–Kuznetsk–Sayan
N—Ordinary and southern chernozems of steppe	f3—Altai
O—Dark chestnut and chestnut soils of dry steppe	f4—South-Sayan
	f5—South-Altai

TABLE 31.1 (continued) SEZ of Russia

Plain Soil Zones (Subzones)	Mountain Soil Provinces
VII—Eastern Forest Soil-Bioclimatic Area of Brown Forest Soils	
P—Burozems and podzolic-burozemic soils of coniferous-broadleaved and broadleaved forests	g1—South-Sikhote-Alin
VIII—Semidesert Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
Q—Light chestnut and brown soils of semidesert	h1—East-Caucasian
IV—Subtropical Geographic Belt	
IX—Subtropical Humid-Forest Soil-Bioclimatic Area	
Plain Soil Zones (Subzones)	Mountain Soil Provinces
—	i1—West-Caucasian

Source: Dobrovol'skii, G.V., and I.S. Urusevskaya (eds.). 2007. The map of soil-ecological zoning of Russia (digital version), scale 1:2.5 M. Moscow State University, Moscow, Russia [in Russian].

permafrost-affected Taiga and Gleyed Taiga soils (9%), Podburs (6.9%), Brown Taiga soils (2.8%), permafrost-affected Pale (Palevye) soils (3.1%), Gley-Podzolic and Podzolic soils (2.2%), Soddy-Podzolic soils (7.9%), and Bog-Podzolic and Peat Bog soils (11.8%). Smaller areas are occupied by Gray Forest soils (3%), Brown Forest soils (Burozems) (1.4%), Chernozems and Meadow-Chernozemic soils (7%), Chestnut (Kastanozemic), and Brown Semidesert Soils and their complexes with Solonetzes (3%). Mountain soil provinces occupy about one-third of the territory of Russia.

31.2.2 Land Resources

Land resources of Russia are classified with respect to land categories and land use types.

According to Article 7 of the Land Code of the Russian Federation (2001), seven land categories are specified in regard to land designation:

1. Agricultural lands
2. Settlement lands
3. Lands of industry, power generation, transport, communications, radio broadcasting, television, and information media; lands for ensuring spacecraft launches; lands of defense and security, and lands of other special designation
4. Lands of specially protected territories
5. Forest lands
6. Water-protection lands
7. Reserved lands

Data on the areas of different land categories in Russia for 2007 (Rosnedvizhimost', 2008) are given in Table 31.2. A majority of the country (about 65%) is classified as forest land. Agricultural

TABLE 31.2 Distribution of Russian Lands by Land Use Categories (as of January 1, 2008)

Land Category	Thousand Hectares	Percentage of the Total Area
Agricultural lands	403177.0	23.58
Settlement lands	19258.5	1.13
Lands of industry, electric power, transport, communications, radio broadcasting, television, and information and lands for ensuring outer space activity, lands of defense and security, and lands of other special designation	16687.4	0.98
Lands of specially protected territories and objects	34393.8	2.01
Forest lands	1104975.9	64.62
Water-protective lands	27942.3	1.63
Reserved lands	103389.3	6.05
Total	1709824.2	100

Source: Data from Rosnedvizhimost'. 2008. National report on the state and use of land in the Russian Federation in 2007. Federal Cadaster Center, Moscow, Russia [in Russian].

lands occupy more than 23% of Russia's territory, while specially protected territories occupy 2% of the area of Russia.

Land use type is defined as an area regularly used for specific economic purposes and having specific natural, historical, and other properties. In accordance with current economic use, all the lands are subdivided into two major groups: (1) agricultural lands, that is, lands actually or potentially used for agricultural production, and (2) nonagricultural lands, that is, other lands not used in agriculture.

Agricultural lands include the following land use types:

1. Plowland
2. Idle land (fallow, temporarily abandoned land)
3. Perennial plantation
4. Hayfield
5. Rangeland (pasture)

Nonagricultural lands are subdivided into the following land use types:

1. Land subjected to reclamation measures
2. Land under forest
3. Land under woody-shrub vegetation
4. Land under water bodies
5. Land under bogs
6. Land under construction
7. Land under roads
8. Disturbed land
9. Other lands

Data on land use in Russia (as on January 1, 2008) are given in Table 31.3.

Only about 13% of the country is actually used for agriculture (land use types 1–5). More than 50% is considered forest land. Other lands not used for agricultural purposes compose one-fifth of the total land reserve. These are mainly glaciers; lands occupied by landslides, slumps, and ravines; tundras; windblown sands; landfills; and dumps.

TABLE 31.3 Distribution of Russian Lands by Land Use Types (as of January 1, 2008)

Land Type	Thousand Hectares	Percentage of the Total Area
Agricultural lands, including	220567.9	12.90
Plowlands	121573.5	
Fallow	5105.7	
Perennial plantations	1794.2	
Hayfields	24004.1	
Pastures	68090.4	
Forest lands	870761.2	50.93
Forests beyond the category of forest lands	26594.5	1.56
Lands under water	72049.8	4.21
Lands under construction	5604.9	0.33
Lands under roads	7937.8	0.46
Bogs	152936.9	8.94
Disturbed lands	1107.5	0.07
Other lands	352263.7	20.60
Total	1709824.2	100

Source: Data from Rosnedvizhimost'. 2008. National report on the state and use of land in the Russian Federation in 2007. Federal Cadaster Center, Moscow, Russia [in Russian].

TABLE 31.4 Soil Cover of Agricultural Lands in the Russian Federation

Soil Types	Percentage in the Total Area of	
	Agricultural Land	Plowland
Podzolic and soddy-podzolic soils	12.3	14.7
Soddy and soddy-calcareous soils	2.4	1.4
Gray and brown forest soils	11.8	14.9
Chernozems, including	42.9	52.6
Leached chernozems	10.5	14.7
Ordinary chernozems	11.4	15.1
Chestnut soils	12.8	10.6
Solonetzes, solonchaks, solods	7.0	3.4
Floodplain soils (alluvial)	4.9	0.6
Other soil types	5.9	1.8
Total	100	100

Source: Romanenko, G.A., N.V. Komov, and A.I. Tyutyunnikov. 1996. Land resources of Russia and the efficiency of their use. Rossel'khozakademiya, Moscow, Russia [in Russian].

Table 31.4 contains data on the percentage of major soil types in the total agricultural, as well as the plow land of Russia.

Nearly 75% of Russia lies in the cold zone and in the mountainous regions with an insufficient heat supply. Only focal crop farming is possible in these areas. Rangelands are also limited in these regions.

A combination of sufficient heat supply (with the accumulated mean daily temperatures above 10°C of more than 2500 degree days) and sufficient moistening (with the precipitation to the potential evapotranspiration ratio of more than 0.75) is only observed on about 1% of Russian land.

Territories with optimum combinations of high heat supply and sufficient moisture are virtually absent in Russia.

31.3 History of Collection of Soil Information in Russia

31.3.1 History of Soil Mapping

Soil mapping in Russia has a long history. The first estimates of soil resources were based on the written descriptions of real estate prepared by local officials in the time of Ivan the Terrible in the sixteenth century. The first soil map of European Russia on a scale of 1:8 400,000 was compiled and edited by academician N.S. Veselovsky on the basis of information sent by local land committees; it was published in the *Economic-Statistical Atlas of European Russia* in 1851. Despite the schematic character of this map, its publication was a noteworthy milestone in the study of soil resources of the country.

In 1879, a new soil map of European Russia on a scale of 1:2,520,000 was published. This map was developed by a statistician V.I. Chaslavsky on the basis of completed questionnaires received from local land committees. After the death of Chaslavsky, V.V. Dokuchaev was entrusted with the preparation of explanatory notes to this map. They were published in 1879 under the title *The Cartography of Russian Soils*. In this work, the basic principles of pedology and soil cartography were outlined by Dokuchaev for the first time. Field studies on land assessment for a "better justified taxation" were performed by Dokuchaev and his team in the 1880s and 1890s. With other special soil survey works, they served as the basis for the first soil map of European Russia based on factual results of soil surveys and compiled on a scale of 1:2,520,000 by N.M. Sibirtsev, G.I. Tanfil'ev, and A.R. Ferkhmin under the supervision of V.V. Dokuchaev in 1900.

A new period in the study of soil resources began in the 1920s. Large-scale soil surveys of agricultural territories were organized with the aim of providing the cartographic basis for rational land use planning, crop rotation, agrochemical service, and soil reclamation.

The scales of Russian soil maps are subdivided into detailed (1:5000 and larger), large-scale (1:10,000–1:50,000), medium-scale (1:100,000–1:300,000), small-scale (1:500,000–1:1,000,000), and general (smaller than 1:1 M) maps.

Detailed soil maps have been developed for experimental fields and strain-testing stations. Large-scale soil maps are compiled for land use planning and land reclamation purposes at the level of particular farms, while medium-scale (sometimes, large-scale) soil maps are used for agricultural and forestry planning at the levels of administrative districts, oblasts, and regions. Small-scale and general soil maps are used for strategic economic planning at the federal level as well as for educational purposes. Soil maps of different scales are used to assess soil resources and land quality, and to perform soil zoning for various applied and scientific purposes.

Since the 1960s, the data provided by aerial surveys and satellite imagery have been applied to large-scale soil mapping. Their application has made it possible to improve the accuracy and objectivity of mapping large areas of soil. Large-scale soil maps, developed by local research institutes for land surveys and land management, have been supplied with explanatory notes containing the descriptions of representative soil pits, analytical data on the soil properties, and recommendations on the optimum use of soil resources. By the 1990s, three to four rounds of large-scale soil surveys were performed for agricultural lands of Russia.

In the 1970s and 1980s, zonal institutes for land management and land planning initiated the work of compiling medium-scale soil maps for the administrative regions and oblasts of Russia. These maps were developed based on large-scale soil maps. In some cases, new remotely sensed data were used for their compilation. The legends to these maps are rather detailed (normally about 150 mapping units are shown on them). Inset maps show the agricultural zoning of the territory as well as soil erosion and other hazardous processes. In general, the degree of detail on such maps is much higher than that on medium-scale soil maps developed in the first half of the twentieth century. Recently, a new methodology for compiling medium-scale soil maps with the use of GIS technologies has been prepared by the V.V. Dokuchaev Soil Science Institute (Simakova, 2008). Regional soil maps on the scales of 1:50,000–1:100,000 have also been developed by various research institutes for about a half of the administrative regions of Russia (Simakova and Andronikov, 1999). Unfortunately, most of them have not been published and are stored in various archives.

The accumulated data have also been generalized in a series of general soil maps. These maps include the Soil Map of the Soviet Union (1:4 M) developed by N.N. Rozov and E.V. Lobova with I.P. Gerasimov as editor in 1954, soil maps included in the Physico-Geographic Atlas of the World (Ed. I.P. Gerasimov, 1964), Soil Map of the World (1:15 M) developed by Glazovskaya and Fridland (1982), and others.

In the 1930s, L.I. Prasolov initiated the development of the State Soil Map of the Soviet Union on a scale of 1:1 M. This work was resumed in 1949. Presently, this is the most detailed soil map for the entire territory occupied by Russia and the FSU countries, as well as the main reference for assessing soil resources at the federal level. This map developed by the V.V. Dokuchaev Soil Science Institute synthesizes knowledge on the genesis and geography of soils gained by Russian pedologists in the second half of the twentieth century.

In the past 60 years, 111 separate pages of this map have been published. They encompass the territory of all the republics of the former Soviet Union. For Russia, 83 pages of this map have been published, mainly for the agricultural regions. The total list of soils and soil complexes shown on separate map pages exceeds 1000 mapping units. The work on unification of the legend to the map and harmonization of separate pages is in progress.

In 1988, the Soil Map of the Russian Soviet Federal Socialist Republic (*Soil Map of the Russian Federation*) on a scale of 1:2.5 M,

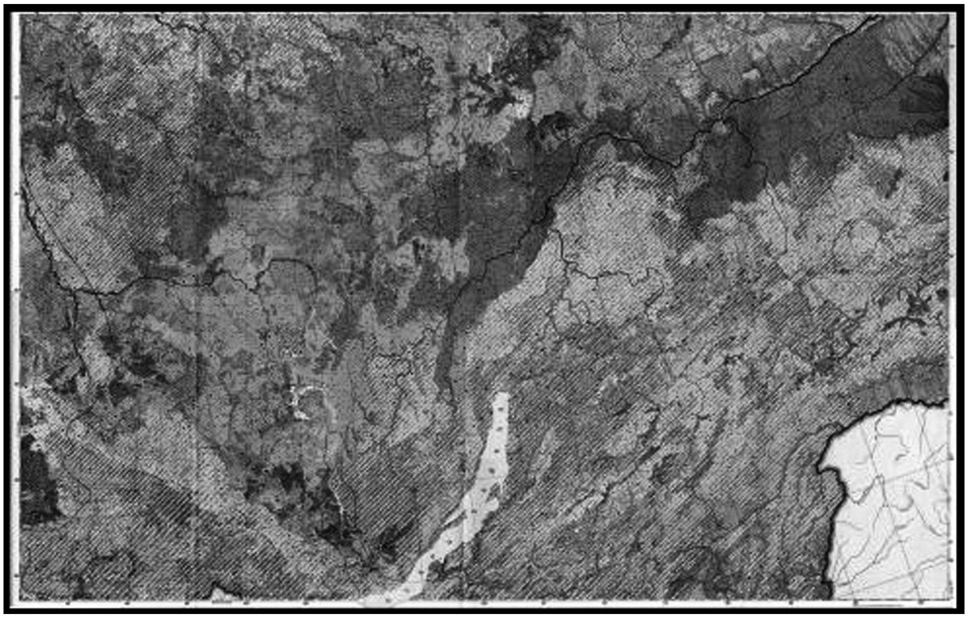


FIGURE 31.2 (See color insert.) Soil map of the Russian Federation.

was published. This map was created in the V.V. Dokuchaev Soil Science Institute on the basis of data provided by a large team of scientists from various research and educational institutes in Russia. This project was carried out under the supervision of V.M. Fridland. It consists of 16 pages (Figure 31.2) and presents the most detailed information on the soil cover of the entire Russia in published form.

In the 1960s and 1970s, important work on the generalization of soil maps and the development of soil geographic and soil-agrochemical zoning maps was performed. The *Soil Geographic Zoning of the Soviet Union* (1962), *Soil-Agricultural Zoning of the Soviet Union* (1975), the *Soil-Agrochemical Zoning of the Soviet Union* (1976), the *Map of Soil Geographic Zoning of the Soviet Union* (1983), and the recently developed digital *Map of Soil-Ecological Zoning of Russia* (edited by Dobrovol'skii and Urusevskaya (2007)) are the major accomplishments of this effort.

31.3.2 History of Soil Information Science and the Development of Digital Soil Mapping in Russia

The application of modern informational tools to soil studies began in the 1970s, with the appearance of the first data banks and their structural and functional components (databases) (Rozhkov, 2002). By that time, mathematical methods had actively been applied by soil scientists and agrochemists. Data archives on notched cards became prototypes of data banks (Fridland and Il'ina, 1972). The first steps in the development of information technology in soil science (or soil informatics as referred to by B.G. Rozanov) were made at the V.V. Dokuchaev Soil Science Institute.

In 1980, a complete system of soil classification and coding (SCC) was created. The final description contained five volumes and included all known soil characteristics and methods of their determination, a classification table, and the forms of data input. Being a formalized language of soil description, this system was designed for the development of a national bank of soil data with the application of a commercial system of database management INES for ES-1020 computers. This language was used in the creation of the Automated Information Search System (AISS) SOIL.

In order to improve the classification system, its basic principles with abbreviated forms for soil description and with a system of data coding were published (Rozhkov et al., 1982). Later on, the concept of the information base of soil classification was suggested (Shishov et al., 1985), and a special *Guide to Soil Description in the Soil Classification Database System* was published (Shishov, 1986). In accordance with the suggested descriptive structure, the information system MERON with formalized descriptions of individual soil types was created (Rozhkov and Stolbovoi, 1988).

By the early 1990s, several information systems and separate databases were developed by the V.V. Dokuchaev Soil Science Institute. With these as a base, the bank of soil fertility models was created (Frid, 1999).

In the 1990s, work on applying geographic information systems to soil science was initiated by the V.V. Dokuchaev Soil Science Institute using EPPL7 (U.S.) software. An original GIS envelope called LESSA was developed by V.B. Vagner. Based on LESSA, and with the support of the Russian Foundation for Basic Research, the first bank of maps and their related attribute databases was shaped. In 4 years, an ecological soil atlas was developed in the GIS environment.

In 1995, the Dokuchaev Soil Science Institute purchased the world-standard program ARC/INFO and the Digital Chart of the World (DCW) (1:1 M) showing relief, hydrographic network,

TABLE 31.5 Digital Cartographic Materials on the Territory of Russia

Maps and Schematic Maps
Administrative division of Russia
Soil map
Soil-geographic zoning
Accumulated daily air temperatures above 10°
Number of days with the mean daily air temperature above 10°
Duration of frostless period
Climatic continentality
Accumulated daily soil temperatures above 10° at the depth of 20 cm
Annual amplitude of soil temperatures at the depth of 20 cm
Mean annual precipitation
Precipitation during the warm period (April–October)
Annual potential evaporation from the soil surface
Annual difference between precipitation and potential evaporation
Bulk moistening of the territory
Soil-forming potential of the climate (as estimated for reference zonal soils)
Soil-forming potential of the climate for humus accumulation and mineral transformation
Vegetation
Forests of the Soviet Union
Net phytomass production for actual and restored (natural) phytocenoses
Phytomass reserves for actual and restored (natural) vegetation
Dead organic mass (mortmass) of ecosystems
Capacity of the biological turnover of ash elements in natural phytocenoses
Ecological functions of the vegetation cover of Russia
Geomorphologic zoning
Age, genesis, and composition of surface deposits
Texture of surface deposits
Bulk calcium content in surface deposits
Parent materials
Texture and petrographic-mineralogical and chemical compositions of soils
Age of soils and types of soil rejuvenation
Soil-geological countries
Soil cover patterns
Geochemical landscapes
Pedodiversity
Soil temperature regimes
Pools of organic matter in terrestrial ecosystems
Types of humus in soil humus horizons
Contents of organic carbon in soil humus horizons
Soil quality estimates for soil regions
Pools of organic carbon in the 1-m-deep soil layer
CO_2 emission from soils
Sustainability of soil functioning
Soil capacity for self-purification from technogenic substances
Soil capacity for oxidation
Soil sorption capacity
Budget of organic carbon in biomes
Budget of organic compounds of nitrogen in biomes
Soil erosion
Erosion control measures
Zoning of the territory with respect to the types of soil cover changes upon oil extraction and transportation
Natural-agricultural zoning of Russia
Boundaries of specially protected natural territories of the federal level
Soils of specially protected natural territories
Major soil types in the reserves and national parks of Russia

and infrastructures. The Soil Map of the Russian Federation and the Landscape Map of the Soviet Union (1:2.5 M scale) were some of the first to be digitized. Thus, the first serious soil GIS at the federal level appeared. The attribute databases of these maps are being updated constantly. The cartographic base of the Dokuchaev Soil Science Institute was registered in the international network GRID UNEP. Information on some of the maps developed by the institute can be found on the Web site http://agro.geonet.ru.

Representatives of the V.V. Dokuchaev Soil Science Institute (V.S. Stolbovoi and E.N. Rudneva) participated in the international project on the Global Assessment of Human-Induced Soil Degradation (GLASOD). This work was continued from 1997 to 2000 within the framework of the Soil and Terrain Vulnerability in Central and East Europe (SOVEUR) project aimed at the creation of GIS for the assessment and prognostic modeling of different types of soil degradation in this vast region.

An important issue was the integration of the Russian soil classification system into the soil database of the European Community (Stolbovoi et al., 2001). This step was intended to facilitate the creation of a unified policy regarding land use and soil monitoring. Russian classification was linked to the World Reference Base on Soil Resources. The soil map of Russia was also interpreted in terms of the FAO legend to the Soil Map of the World. The Dokuchaev Soil Science Institute suggested that the World Reference Database for Soil Resources should be organized as an information system in 1990.

Active work on the creation of new digital maps, as well as the use of cartographic and statistical databases for the assessment of soil resources, is being performed by the Faculty of Soil Science and by the Institute of Ecological Soil Science of Moscow State University. Soil maps of Russia on the scales of 1:25 M, 1:22 M, and 1:15 M and a digital version of the Map of Soil Ecological Zoning of Russia on a scale of 1:2.5 M have been developed.

The geographic information system has been created using the MapInfo format; it includes differently scaled maps for the entire territory as well as for separate regions of Russia. Some of the initial sources of cartographic information used in this work were published materials, unpublished original materials, and specially purchased digitized maps. Some of the digitized cartographic materials available on different scales for the entire territory of Russia are listed in Table 31.5.

In recent years, geographic information systems have been extensively applied in Russian agriculture. Since 2006, the Computing Center of the Ministry of Agriculture has been involved in the development of a remote-sensing system for the monitoring of agricultural lands. This system's objective is to integrate previously accumulated archive data and recently obtained data to refine the inventory of agricultural lands, to evaluate the efficiency of their use, and to predict crop yields. This system includes the federal and regional geographic information systems arranged according to the hierarchical principle: from the federal level to the level of local farms (specially selected representative farms) and fields. This process is based on digitized cartographic data in the ArcGIS format and satellite imagery subjected to continuous renewal (http://www.gisa.ru/pd_1_09.html).

31.4 Soil Geographic Database of Russia

The development of the SGDB of Russia is aimed at providing the scientific basis for the federal strategy of sustainable land use, soil monitoring, and soil conservation (Shoba et al., 2008).

Thus, the major objectives of the SGDB are as follows:

- The inventory and formalization of data on Russian soils. Most information on soil profiles is presently kept as hard copies—published articles, monographs, collections of papers, dissertations, and field records. These data should be unified and prepared for collective use.
- Information support of research projects and educational programs.
- The integration of Russia into a unified soil-information space of the European Community and the world and in various global and regional soil programs.

The main principles of SGDB development and functioning are as follows:

- The integration of soil information is based on digital maps using modern GIS technologies.
- The base map scale is 1:2.5 M. This scale is selected because this is the largest scale of digitized soil map for the entire country developed on the basis of a unified legend and common methodological principles.
- Openness of the database and the possibility for its further augmentation.
- Availability of the database.
- Involvement of a wide range of specialists in soil science and related disciplines possessing original information on the morphological and physicochemical properties of representative georeferenced soil profiles to be included in the SGDB.
- Online data transfer via the Internet.
- Offline administration and edition of input materials (for ensuring data security and quality).
- Involvement of experts in the work with input materials from separate contributors.

The main blocks of the SGDB are the Geographic Database and the Specialized Attribute Database. A relational database management system is used for data storage and processing.

31.4.1 Cartographic Block: Digital Maps

The cartographic base of the SGDB—the Geographic Information Soil Database—consists of two digitized maps in the MapInfo format. COVERAGE 1 is a digital map uniting the Soil Map of the Russian Federation on a scale of 1:2.5 M edited by V.M. Fridland (1988) (corrected digital version, 2007) and the Map of Soil-Ecological Zoning of Russia on the same scale edited by Dobrovol'skii and Urusevskaya (2007). COVERAGE 2 is the digital map of the administrative division of Russia on a scale of 1:1 M (2007).

31.4.1.1 Soil Map of the Russian Federation, 1:2.5 M Scale

The digital version of this map consists of 25,711 polygons (soil delineations). Each polygon contains information on the soil cover (color) and parent materials (hatching). The legend to the digitized map includes 200 names of individual soil units, 70 names of different soil complexes, 5 names for nonsoil formations, and 30 legend units for textural classes and petrographic composition (for hard rocks) of soil parent materials. Correlation of the Legend to the Soil Map of the Russian Federation with international and foreign soil classification systems can be found in Fridland (1982), Shishov et al. (1985), Rozhkov et al. (1990), Stolbovoi and Sheremet (1995), Stolbovoi (2000), Stolbovoi and Sheremet (2000), and CD-ROM Land Resources of Russia (2002).

A given polygon may include up to four soil units (or soil complexes). The main soil (soil complex) unit occupies 100% of the polygon area in the absence of accompanying soils (complexes), 75% in the presence of one accompanying soil (complex), 65% in the presence of two accompanying soils (complexes), and 55% in the presence of three accompanying soils (complexes). The accompanying soils are considered to occupy equal areas. In soil complexes, the percentages of component soils are not calculated. Parent materials in soil polygons may be represented by one (major) or two (major and accompanying) units.

31.4.1.2 Digital Map of Soil-Ecological Zoning of Russia, 1:2.5 M Scale

In the digital map of SEZ, 1377 polygons are separated (Figure 31.3).

The digital version of this map contains information about soil cover and the factors of its differentiation at different levels. Thus, at the soil district level, information about soils and their texture is given; at the soil region level, information about the genetic types of relief, parent materials, land use pattern, and soil quality classes is provided. For larger typological units—soil provinces—parameters of atmospheric and soil regimes are given for plain territories and the patterns of the vertical soil zonality are indicated for mountainous territories.

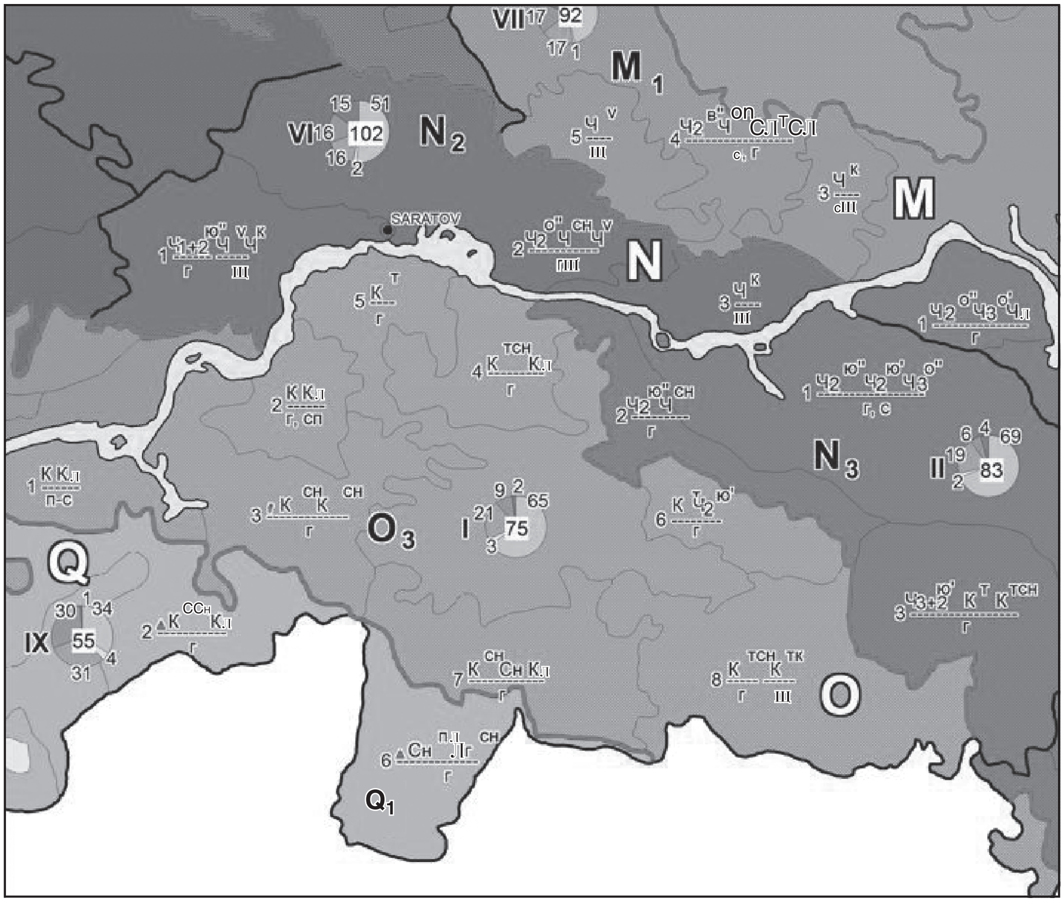


FIGURE 31.3 Fragment of the map of SEZ of Russia.

31.4.1.3 Soil Map Combined with the Map of Soil-Ecological Zoning of Russia, 1:2.5 M Scale: COVERAGE 1

Digitized versions of the soil map and the map of SEZ on a scale of 1:2.5 M are combined into COVERAGE 1. The number of polygons on this integral map reaches 32,605. Each polygon contains information from both maps (Table 31.6).

31.4.1.4 Digital Scheme of the Administrative Division of the Russian Federation, 1:1 M Scale: COVERAGE 2

At present, there are 83 subjects of the Russian Federation, including oblasts, krais (regions), republics, autonomous areas, autonomous oblast, and two cities. They are combined into eight federal okrugs: Tsentral'nyi (Central), Severo-zapadnyi (Northwestern), Yuzhnyi (Southern), Severo-Kavkazskii (North Caucasian), Privolzhskii (Volga), Ural'skii (Ural), Sibirskii (Siberian), and Dal'nevostochnyi (Far Eastern) (Figure 31.4).

COVERAGE 2 includes 2394 polygons representing the administrative division of Russia. It contains data of the Federal Statistical Survey of land resources performed by the Federal Agency for Realty Cadaster for January 1, 2006 (Table 31.7).

31.4.1.5 Additional Digital Cartographic Materials

Currently, work on inclusion of additional materials in the geographic database is being performed. In particular, these are characteristics of relief and parameters of soil temperature regimes.

Digital elevation model (DEM) with a horizontal grid spacing of 30 as (approximately 1 km) is taken from the Land Resources of Russia CD-ROM (2002).

Long-term soil temperature data (Table 31.8) recorded at 370 weather stations in 1960–2000 were provided for the database by D.A. Gilichinskii (the Laboratory of Cryogenic Soils, Institute of Physicochemical and Biological Problems of Soil Science, Russian Academy of Sciences, Pushchino).

The large volume of information concerning soils, their properties, functions, soil factors of soil formation, soil cover patterns, and land use is also available from digitized maps on different scales included in the GIS of Russia (Table 31.5).

TABLE 31.6 Information Structure of the SGDB. COVERAGE 1

No.	Information Description	Source of Information	Level of Information
1	Identification field	COVERAGE 1	COVERAGE 1 polygons
2	Major soil (soil complex)	Soil map	Soil map polygons
3	First accompanying soil (soil complex)	Soil map	Soil map polygons
4	Second accompanying soil (soil complex)	Soil map	Soil map polygons
5	Third accompanying soil (soil complex)	Soil map	Soil map polygons
6	Soil-forming rocks	Soil map	Soil map polygons
7	Soil-forming rocks	Soil map	Soil map polygons
8	Soil cover pattern	SEZ map	SEZ map polygons
9	Soil-forming rocks	SEZ map	SEZ map polygons
10	Genetic relief types	SEZ map	Districts
11	Litho-geomorphic characteristics	SEZ map	Districts
12	Land use pattern	SEZ map	Districts
13	Soil cover quality class	SEZ map	Districts
14	Vertical zonality pattern	SEZ map	Mountain provinces
15	Average July temperature (°C)	SEZ map	Plain provinces
16	Accumulated daily air temperatures >10°C		
17	Duration of period with temperatures >10°C (days)		
18	Duration of frostless period (days)		
19	Mean January temperature (°C)		
20	Mean annual precipitation (mm)		
21	Annual humidity factor (Vysotskii–Ivanov)		
22	Accumulated daily soil temperatures >10°C at the depth of 20 cm		
23	Penetration depth of temperatures >10°C into the soil (cm)		
24	Period with soil temperatures >10°C at the depth of 20 cm (months)		
25	Accumulated daily soil temperatures <0°C at the depth of 20 cm		
26	Penetration depth of temperatures <0°C into the soil (cm)		
27	Predominant water regime		

31.4.2 Attribute Block: Soil Profile Database

31.4.2.1 Contents and Structure of Soil Profile Database

The database of representative soil profiles is an attribute part of the SGDB. Representative soil profiles should be provided with information on their geographical location and with a complete set of data on soil morphology and analytic properties to be included in the database.

The main component of the SGDB database is a soil profile with a set of soil horizons characterized by attribute data. Necessary information on the properties and composition of soils is obtained via selecting of representative soil profiles characterizing the main soil types shown on the Soil Map of the Russian Federation (1:2.5 M scale). A series of representative soil profiles for a given soil type makes it possible to calculate averaged characteristics for this soil type. Information on the regional features of soil cover patterns, vegetation and relief conditions, soil-forming rocks, and climatic parameters is taken from the Geographical Database.

The systematization of data on the selected reference soil profiles implies a unified form of data presentation. For this purpose, classifiers (systematized lists of parameters) were developed based on existing concepts of soil morphology and basic scales used in the current descriptions of soil profiles. The form and format of data presentation are described in detail in the attachment to the database. The necessity for including both the results of recent studies and the vast archival materials into the database is taken into consideration. Most soil attributes are ranked using specially developed scales (the database envisages the description of each attribute and its range). The developed systematized list of parameters includes two large sections:

1. Parameters characterizing the location of soil profiles and the morphological characteristics of soils
2. Parameters characterizing the physical, chemical, physicochemical, and other soil properties

The database has a hierarchical structure ensuring soil description at several levels: SOIL–PIT–PROFILE–HORIZON–SAMPLE (Table 31.9).

FIGURE 31.4 Scheme of the administrative division of Russia.

TABLE 31.7 Information Structure of the SGDB. COVERAGE 2

No.	Information Description
1	Identification field
2	Total area
3	Total agricultural land
4	Including plowlands
5	Including fallow
6	Including perennial plantations
7	Including hayfields
8	Including pastures
9	Land of reclamation construction and fertility restoration
10	Total forest lands
11	Including forest lands
12	Including forest-free lands
13	Tree–shrub vegetation beyond forest lands
14	Including shelterbelts
15	Land under water
16	Total land under construction
17	Including lands under industrial structures
18	Total lands under roads
19	Including lands under ground roads
20	Bogs
21	Disturbed lands
22	Total other lands
23	Including landfills and dumps
24	Including sands
25	Including ravines
26	Including lands with tundra vegetation not entered in other lands
27	Including other lands
28	Reindeer pastures in all lands

TABLE 31.8 Meteorological Archive Data

No.	Information Description
1	Penetration depth of 0°C into the soil for months and years (thawing)
2	Penetration depth of 0°C into the soil for months and years (freezing)
3	Soil freezing depth for months and years
4	The number of days per month with soil temperature ≤0°C for standard depths
5	The number of days per month with soil temperature ≤0°C for non-standard depths
6	Dates of the first and last soil frosts for standard depths
7	Dates of the first and last soil frosts for nonstandard depths
8	Dates of the first and last soil surface frosts
9	Average maximum temperatures of soil surface for months and year
10	Average minimum temperatures of soil surface for months and year
11	Average monthly and annual soil surface temperatures
12	Average monthly soil temperature for standard depths (bent thermometers)
13	Average monthly soil temperature for nonstandard depths (bent thermometers)
14	Average monthly soil temperature for standard depths (drawing thermometers)
15	Average monthly soil temperature for nonstandard depths (drawing thermometers)
16	Average annual soil temperature for standard depths
17	Average annual soil temperature for nonstandard depths

TABLE 31.9 Hierarchical Model of Soil Description

Soil	Classification Position	
PIT	Environmental conditions	Date
	Relief	Information source
	Vegetation	Georeference
	Groundwater table	Coordinates
	Soil-forming rocks	Height above sea level
		Economic use
		Erosion signs
Profile	Profile type	
	Disturbance	
	Number of horizons	
Horizon	Horizon description	
	Index	
	Small additional index	
	Water content	
	Color	
	Texture	
	Structure	
	Density	
	Consistence	
	Effervescence with HCl	
	Boundaries and transition, thickness	
	Description of soil morphological elements	
	Roots	
	Mycelium	
	Alga film	
	Plant residues	
	Zoogenic elements	
	Pedons	
	Hard rock fragments	
	Inclusions	
	Neoformations (pedofeatures)	
	Pores	
Sample	Chemical properties	
	Physical properties	

The set of semantic soil data is given in Table 31.10.

At the SOIL level, the classification position of the soil is given. For the purposes of correlation between the existing classifications, the most complete descriptions of soils are given within the frameworks of current national and world soil classification systems.

The description of a pit includes the characterization of the pit site, the main factors of soil formation (including relief, parent materials, and vegetation), and the source of information. The number of genetic horizons, the degree of disturbance of the profile, and its genetic type are also indicated. The HORIZON level includes a description of the most common morphological properties of the horizons, as well as the description of soil morphological elements at the next hierarchical level.

At the SAMPLE level, data on the physicochemical properties of soils are systematized. In this section, the values of the

TABLE 31.10 Structure of Soil Attribute Database

Soil—Pit	
Description of environmental conditions	
Relief	Macrorelief
	Mesorelief
	Microrelief
	Slope aspect
	Slope gradient (degrees) of the pit site
	Slope shape
Vegetation	Association name
	Stratification and species composition, projective cover
Groundwater	Groundwater level
	Groundwater salinity
Soil-forming rocks	Genetic type of rocks
	Weathering level of soil-forming rocks
	Hard rock outcrops
General information	Date
	Information source, author
	Administrative-territorial location
	Coordinates
	Height above sea level
Economic use	
Erosion signs	Erosion type
	Erosion intensity
Profile—Horizon	
Profile description	
Profile disturbance	Disturbance source
	Disturbance degree
Profile type	
Total number of genetic horizons	
Description of genetic horizons	
Horizon index	
Small additional index	
Water content	
Color	
Texture	Additional characterization of texture
	Stone content
Mineral matrix composition	
Structure	
Density	
Consistence	
Effervescence with HC1	Effervescence depth
	Effervescence intensity
Boundaries and thickness	Boundary shapes
	Transition type
	Horizon and sampling depths
	Horizon thickness
Description of soil morphological elements	
Roots	
Mycelium	
Alga film on soil surface	

TABLE 31.10 (continued) Structure of Soil Attribute Database

Plant residues	
Zoogenic elements	
Pedons	
Hard rock fragments	
Inclusions	
Neoformations	
Pores	
Sample—Chemical Properties	
Chemical composition of soils	
Elemental composition of mineral soil component (bulk composition)	Ignition loss
	Silicon
	Sesquioxides
	Aluminum
	Iron
	Calcium
	Magnesium
	Titanium
	Manganese
	Phosphorus
	Sulfur
	Potassium
	Sodium
Elemental composition of organic soil component	Organic carbon
	Humus
	Nitrogen (total)
	C:N ratio
Material soil composition	Alkaline earth carbonates
	Gypsum
	Ion composition of readily soluble salts soil salinization parameters
Group (fractional) composition of chemical element compounds in soils	Group composition of iron compounds
	Group composition of aluminum compounds
	Group composition of phosphorus compounds
	Group composition of potassium compounds
	Group composition of microelement and heavy metal compounds
	Group and fractional humus composition
Mobility of chemical elements in soils	
Mobility of phosphorus compounds (intensity factor)	Degree of phosphate mobility
	Reserve of mobile phosphorus compounds (capacity factor)
Mobile compounds of chemical elements	Mobile phosphorus compounds
	Mobile potassium compounds
	Mobile nitrogen compounds
	Mobile compounds of microelements and heavy metals

TABLE 31.10 (continued) Structure of Soil Attribute Database

Cation exchange capacity of soils	
Cation exchange capacity	
Total exchangeable bases	
Composition (content) of exchangeable bases	
Degree of base saturation	
Acid–base properties of soils	
Acidity	Actual acidity (pH_{water})
	Actual acidity (pH_{KCl})
	Exchangeable acidity
	Total acidity
Alkalinity	Water suspension pH
	Water-saturated paste pH
	Total alkalinity (Alk_{tot})
	Carbonate alkalinity
	Organic alkalinity
	Borate alkalinity
	Difference between the total alkalinity and the sum of calcium and magnesium (water extraction method)
Sample—Physical Properties	
Particle-size composition	
Aggregate composition	
Microaggregate composition	
Specific surface area	
Soil density	
Solid phase density	
Density of pedons and aggregates	
Porosity	
Soil-hydrological constants	Hygroscopic moisture (HM)
	Maximum hygroscopic moisture (MHM)
	Field capacity (FC)
	Wilting point (WP)
	Total moisture capacity (TMC)
	Water permeability

attributes measured, the methods of their determination, and the measurement units (with due account for the currently and formerly used units) are presented.

Each position in the systematized list of parameters characterizing soil morphology, environmental conditions, and soil physicochemical characteristics have several levels of parameter detailing.

31.4.2.2 Soil-DB: Software for Filling in the Attribute Database on Soil Profiles

A special software, Soil-DB (version 1.0) has been developed for database management (Alyabina et al., 2009). This software is intended for the input of initial soil information by contributors to the SGDB and transmission to the central server of the system, where the collective SGDB is being created. Information on the SGDB, User's manual, and the Soil-DB software are available from the Web site http://db.soil.msu.ru.

Development of the system includes several stages. The first stage is registration of potential contributors. Registered contributors may fill in the cards of soil description using the suggested software tools and send these cards to the central server of the system via the internet. At the next stage, moderators of the system verify information received from the particular contributors and decide (with the help of experts) on the feasibility of its inclusion in the SGDB. The contributors are informed of this decision. In certain cases, not all the fields of the card concerning the classification position of the soil and its exact geographic coordinates are filled in by the contributor. These fields may be filled in by experts who link information about soil profiles to the geographic database.

The Soil-DB program, together with tens of built-in information lists, is rather compact and occupies less than 500 Kb of disc space. The files created with the use of this program are also small (2–3 Kb). This allows one to keep and launch the program from a flash card.

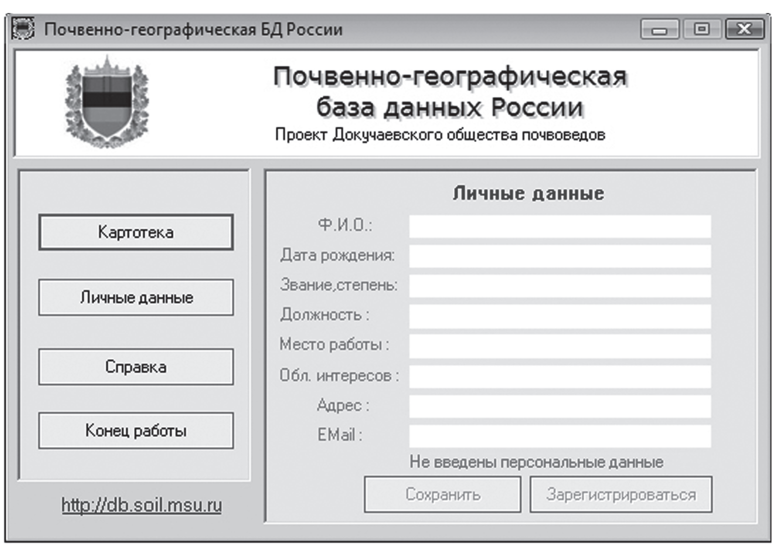
Filling in of Personal Data and Registration in the System

To register in the system, the registration form should be filled in (Figure 31.5a). Three fields of this form are obligatory for registration: (1) personal data (name/family name), (2) address, and (3) email. This information is necessary for contact between moderators of the database and the registered contributors, and is confidential. Registered persons acquire the status of official participants to the project and may contribute to the collective database. A participant may fill in the cards for soil description and send them to the central server of the system to supplement the database.

Information Units

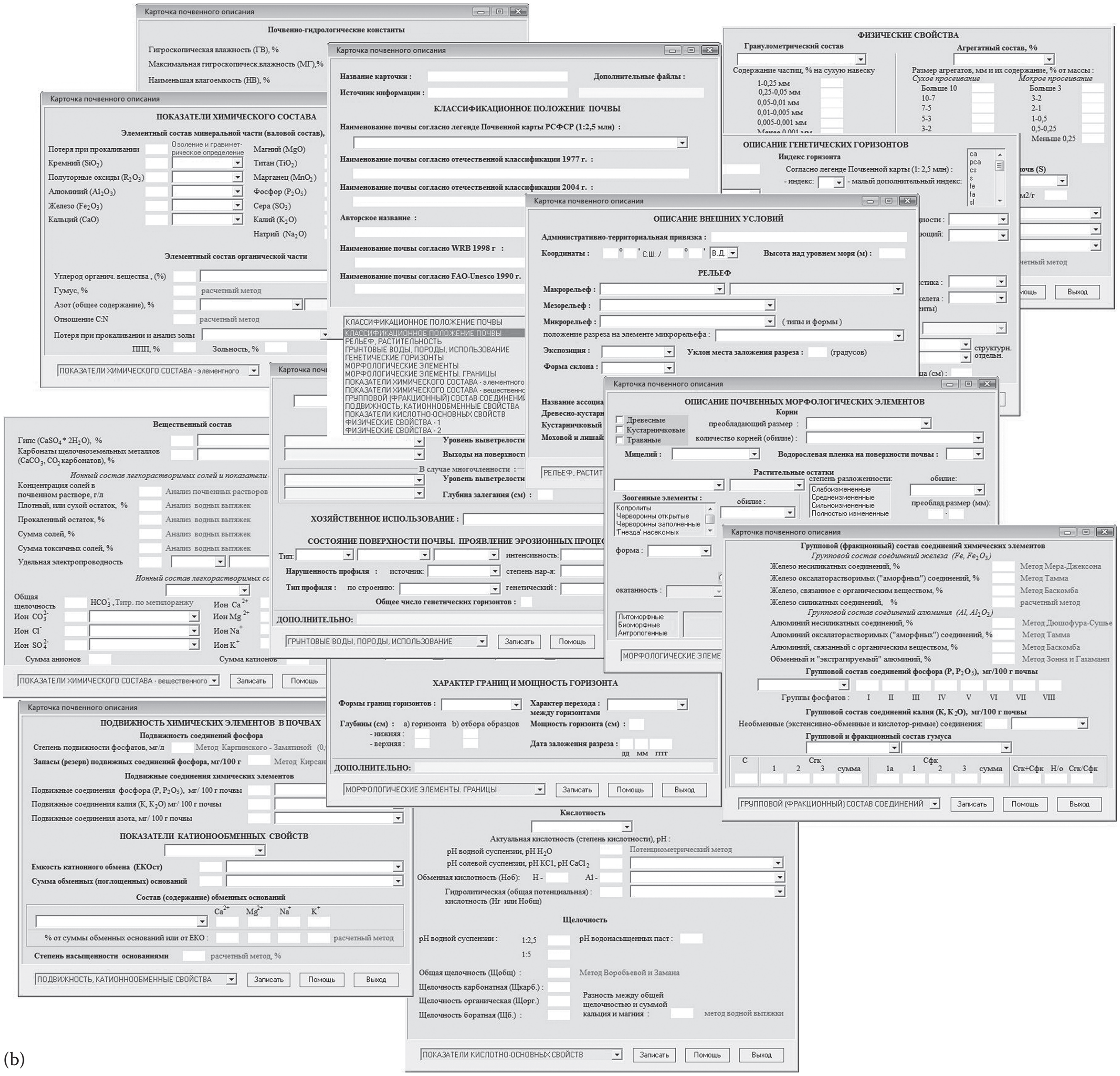
The major information unit of the Soil-DB program is a card with the description of a given soil horizon (sample). Numerous separate cards can be organized by a user of the system into a card file. Any card can be supplemented and/or edited at any time by saving the results on the system. Because a considerable volume of information is in separate cards, it is subdivided into separate pages (thematic fragments) on the monitor. A transition from any given card to another card is accomplished with the help of a menu bar, from which necessary page names can be selected. Each page contains several rubricated fields represented either by a menu from which necessary items can be selected, or a window, in which necessary textual or numerical information can be filled in. Many ways of completing the fields are available in the program: keyboard typing, copy–paste procedure, choice from the list of variants (including multistep lists), and the input of nonformalized data that do not fit the developed data structure.

Pull-down menus are the main means of data input; these menus contain necessary lists of classifiers of soil properties, so that a user can select required information from the menu window without typing it. This approach makes the completion of the cards more efficient and allows one to avoid typing errors. There are simple and complex (hierarchical) pull-down menus. In a simple menu, only one window for the choice of appropriate information is opened. In a complex menu, two or three windows with hierarchically organized information lists are opened. Complex menus differ from simple menus in the font color and background color. The left panel (red font) is used to select the appropriate term for a general description of the macrorelief (e.g., plain territories), and the right panel (white font against blue background color) is used to specify the description (alluvial and ancient alluvial plains).



(a)

FIGURE 31.5 (a) Registration form



(b)

FIGURE 31.5 (continued) (b) Pages of the card file.

In some cases, several entries from the menu can be selected. For this purpose, multiple-selection menus are suggested. They consist of three–four visible information lines against the pink-colored background. Most of these menus have scroll bars allowing the selection of appropriate information.

In a blank (new) card, all the pull-down menus are initially empty (nothing is selected). If the required information for a given menu is absent, its window should be left empty. Upon the submission of the completed card to the central database, such empty windows are considered as a lack of data (no data). Upon the secondary opening of the earlier filled card, previously selected information is shown in all the menu fields. It can be changed at any time, and the last choice will be saved on the disk and opened during the next opening of the card.

Textual Fields

Some of the windows opened on card pages are designed for the entry of textual information (names, descriptions, etc.). Where necessary, the maximum length of the text is limited, though such limits are absent in most cases.

Numerical Fields

The windows designed for the entry of *integers* have certain limits for the number of digits. These limits are set up in order to avoid unfortunate misprints and errors because of the inadvertency of the users. With the same aim, only digits can be inserted into such windows; letters and symbols are not allowed. The windows designed for the entry of *fractional numbers* (e.g., for the values of some physical and chemical soil properties) do not have special limitations for the number of digits and for their format. However, only digits and the decimal sign (period) can be inserted into such windows.

Card Maintenance and Transmitting to the Server

After the launch of the program, a panel of the most frequently used (default) regime of card filling is opened. To begin the work, the blank card has to be created and saved as a file. Each card is a separate file stored in the same directory as the Soil-DB program.

The program ensures the following options for the work with the cards:

Card editing (menu bar "Edit"). After pressing this bar, a panel for data entry and editing of information is opened.

Card copying (menu bar "Copy"). A copy of the selected card is saved under another name. This option is useful upon the availability of analytical results in several duplicate cards, for the description of different horizons in the same soil profile, or for the description of several soil profiles within the same area, (for which a larger part of the information is identical, and only several information fields are different). In such cases, a copy of the first card is made, and then information in necessary fields is changed.

Menu bar "Delete" is used to delete unnecessary cards.

Menu bar "Send to the Database" is used for sending the card to the central server and to the moderator of this work. After the card is verified by the moderator, its information becomes available from the collective database.

Each soil profile's geographic location should be indicated. Coordinates of the pit (longitude and latitude) are given, and the radius of uncertainty (in meters or kilometers) should also be indicated. In case such information is unavailable (for archive data, literature sources, dissertations, etc.), approximate location in relation to a nearby settlement or other notable geographic feature is acceptable (e.g., 2 km to the northwest from Peskovka railway station).

The multipage format of the card assumes that not all the fields are obligatory. Some fields may remain empty in the case of missing corresponding information. Overall, the card consists of 13 pages (Figure 31.5b). The first six pages are designed for the description of the classification position of a soil, the environmental conditions in the area of described soil profile, and the soil morphology.

Pages 7–13 are designed for the description of soil chemical and physicochemical properties. For each characteristic, special fields for the numerical values of particular properties, measurement units, and the methods of their determination (to be selected from the pull-down menu) are provided.

The program also suggests fields for the input of nonformalized data. Thus, the "Additional Files" field on the first page of the soil profile description is used to indicate the names of files sent to the moderator of the system with the descriptions of soil attributes that are not included in the standard list. Also, each page of the standard soil descriptions ends with the line "Additional Information" against the yellow background color. This line should be filled in with any relevant information about the particular soil and not included in standard menus.

31.4.2.3 Development of the Attribute Database on Soil Profiles

The development of an attribute database on soil profiles was initiated by specialists from the Dokuchaev Soil Science Institute. Appropriate data are derived from published and archived sources, including the archive of dissertations at the Higher Attestation Commission of the Russian Federation. Representative soil profiles characterizing the soil cover of Russia are typically selected. An obligatory requirement to the data sources is the exact knowledge of the geographic position of a given soil profile, or its allocation to a given delineation on the Soil Map of the Russian Federation (1:2.5 M scale). The selected profile should also have a full morphological description and be supplied with analytical data on the main physical, physicochemical, and chemical properties. The quality and completeness of these data are assessed by the experts.

Currently, the National Soil-Geographic Database of Russia includes data on 584 representative soil profiles with nearly 3000 samples from the genetic soil horizons.

Additionally, data on 688 representative soil profiles on the European part of Russia have been selected. At present, an expert evaluation of these data is performed, and the classification position of corresponding soils is verified. After completion of this work, this data will also be included in the Soil-Geographic Database. The search of representative soil profiles for the Asian part of Russia is still in progress.

31.4.3 Software Support of the SGDB

Work on filling in the SGDB is performed using cartographic data presented in the MapInfo format (MapInfo Professional, version 9.5 and earlier versions) and with attribute soil data in the Microsoft Office 2007 format; the database management on the server is ensured by the PHP, MySQL, and MapServer software (Windows platform).

The SGDB management will be ensured by several programs.

- Software for the local input of soil data (Soil-DB)
- Modulus of information input–output on the server
- Relational database management system on the server
- Program for administrating, editing, and conversion of the input information (TXT-format) into the format designed for storage and transfer of structured data (XML-format)
- Modulus of remote database query (search for necessary data from metadata) and data output via internet

At present, the first two software tools are ready. The third and fourth software tools are being developed. The work on database query software is at the stage of selection of the particular indices to be displayed on key fields.

Technical documentation to the program with a detailed description of the work of the system and with an instruction for filling in soil description cards can be obtained from the website devoted to the SGDB of Russia (http://db.soil.msu.ru).

31.5 Conclusions

At present, one of the challenges for Russian soil scientists is to ensure the legal status of soil as a natural resource via the preparation of the corresponding legislative act for its adoption by federal authorities. In this context, the inventory of soils of the country and the creation of the All-Russia SGDB as the scientific and information basis for the policy of sustainable land management are necessary. A computer-based inventory of extensive soil information linked with digitized soil maps and the use of modern GIS technologies will make it possible to create this database and to apply it for soil monitoring purposes and for the development of a unified system of soil management, certification, and conservation.

The development of the collective SGDB as an available information center for collecting, storage, and processing of soil information is in progress. This work is performed by specialists in soil science and related sciences. The SGDB of Russia should be compatible with the European Soil Database and the World Reference Base for Soil Resources. This will make it possible for Russian soil scientists to be integrated into the common European soil information system and to participate in the development of global soil programs.

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