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The IIASA-LUC Project Georeferenced Database of the Former U.S.S.R. Volume 5: Land Categories.

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Abstract

The IIASA/LUC georeferenced database for the former U.S.S.R. was created within the framework of the project "Modeling Land-Use and Land Cover Changes in Europe and Northern Asia" (LUC). For Russia, essential information on relief, soil, vegetation, land cover and use, etc. for routine environmental analysis was lacking when the LUC project started developing the database. In addition, the environmental data on the former U.S.S.R. which was available occurred in formats (papers, tables, etc.) that in general could not be used with modern information technology, and in particular in model building. In creating the LUC project database, we have achieved three objectives: 1) to obtain relevant information for the LUC project modeling exercises; 2) to develop data which are usable with modern information technology; 3) to contribute a series of digital databases which could be applied for various other analyses by the national and international scientific community. In defining the tasks it was agreed to create a set of digital databases which could be handled by geographic information systems (GIS). The full set of georeferenced digital databases was combined into the LUC project's GIS, using ARC/INFO. However, each individual item (physiography, soil, vegetation, etc.) was created as a unique specific digital database, allowing each item to be used separately, depending on users' needs.

The complete series of these unique georeferenced digital databases for the territory of the former U.S.S.R. is described in the IIASA/LUC volumes:

Volume 1: Physiography (landforms, slope conditions, elevations).

Volume 2: Soil.

Volume 3: Soil degradation status (Russia).

Volume 4: Vegetation.

Volume 5: Land categories.

Volume 6: Agricultural regionalization.

Acknowledgments

The georeferenced database presented in this paper could not have been compiled without the publication of the Map of Land Categories of the U.S.S.R. We express our gratitude to L.F. Yanvareva (editor-in chief), K.N. Martynyuk and N.M. Kiseleva who took on the tremendous task of compiling the land categories map.

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Introduction

According to internationally recognized concepts (FAO, 1976), land is defined as "an area of the earth's solid surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above or below this area, including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity." This definition embraces a wide range of biogeophysical and socioeconomic aspects and their interrelations. Traditionally, land related human activity has been termed land use. However, land use is a complex phenomenon and can be described by a number of external and internal characteristics. For instance, a key characteristic of human activities is their purpose, i.e., we ask what the land is being used for, e.g., cropping, grazing, or forest harvesting. Externally, the purpose of a land use is manifested by corresponding land categories. In our broad example, cropping will correspond to cropland, grazing to pasture, forest cutting to forest harvesting, etc. Thus, land categories reflect external features of land use, and as such they are closely related to the land-cover concept[1]. Therefore, the creation of a georeferenced land categories database has been a high priority task in the project *Modeling land use and land cover changes in Europe and Northern Asia* (LUC).

Traditionally, information on land categories has been collected in the form of various descriptions, tables, paper maps, etc. Of course, such kind of data organization is inadequate for current computerized methods of data analysis. The urgent demand for a digital database on land categories was also necessitated by the research objective to assess land-use/cover interrelations.

The Map of Land Categories of the U.S.S.R. (Yanvareva et al., 1989), a recent observational map, was adopted for digitizing to create the georeferenced land categories database. Unfortunately, the publication of the map was not accompanied by detailed explanatory text. Thus, additional information on attributes had to be derived from a number of reference books and scientific publications. To facilitate better manipulation with attributes the original structure of the legend was developed as well.

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[1] "*Land cover is the biogeophysical state of the Earth's surface shaped by and relevant to various kinds of land use and other human activities.*" (Fischer et al., 1995).

This report presents a manual for users of the georeferenced database of land categories. It includes a brief introduction of the sources used for compilation of the map as well as the map legend. The report describes projection parameters of the base map, lists the definition of attributes, and explains the database structure. The information should guide the users to handle the database in the most effective and appropriate way.

A. Projection parameters and methodology

The parameters of a cartographic projection are essential pieces of information for transferring paper maps into a Geographic Information System (GIS). As in any other country, the former U.S.S.R. (FSU) had its own traditions and preferences in using cartographic projections. Officially, all issues dealing with cartography in the FSU were guided by the State Administration of Geodesy and Cartography (GUGK).

Since 1958, a normal equi-distant projection of sphere has been used for mapping in the U.S.S.R. This projection (K.A. Salischev, 1995) is known as "the projection of the map of the U.S.S.R. at 1:2.5M scale." This map is also known as the map of the U.S.S.R. at scale 1:2.5M in the GUGK projection. The base map compiled in this projection was published several times: in 1958, 1976, and 1984. The projection was used for map compilation intended for public use: general geography, administrative and thematic maps of the U.S.S.R. The best known maps include the following:

- series of political-administrative and administrative maps of the republics, autonomous republics, krays and oblasts of the U.S.S.R. (wall versions) at scales from 1:400000 to 1:2.5M;
- series of political-administrative and administrative maps of the republics, autonomous republics, krays and oblasts of the U.S.S.R. (foldable versions) at scales from 1:400000 to 1:4M;
- series of reference general geography maps of the U.S.S.R. and autonomous republics (foldable versions) at scales from 1:400000 to 1:4M;
- a number of tourist maps (observational and route) at middle and small scales;
- educational regional physical and thematic maps of the series *Your Home Oblast*;
- regional reference general geography and thematic maps of administrative units, natural and economic regions;
- different regional maps for atlases (scientific-reference, reference, educational).

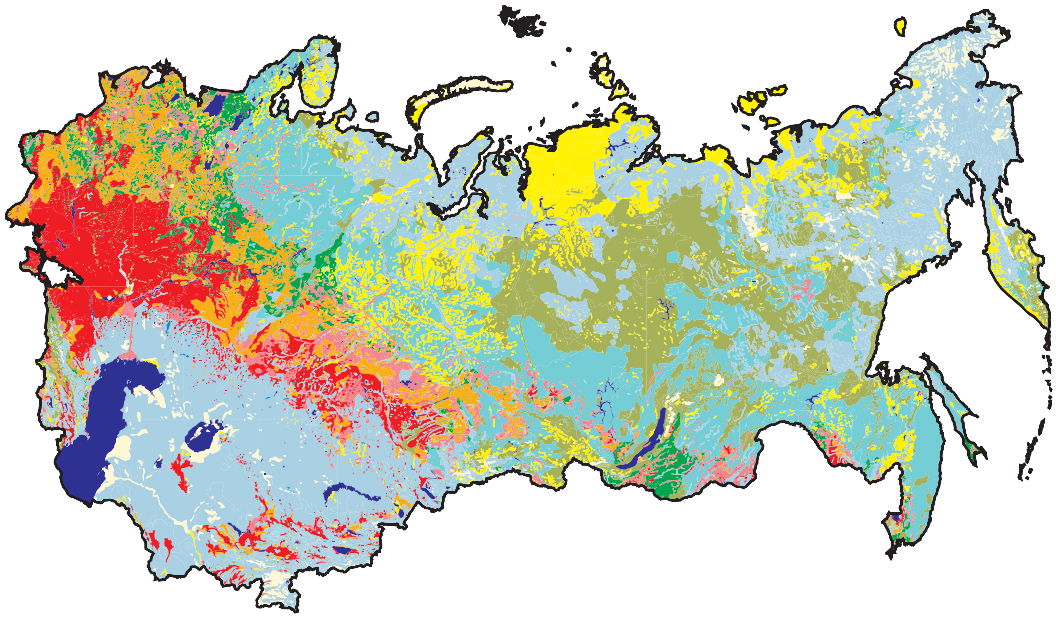
The GUGK projection is characterized by two standard parallels:

$$\varphi_n = 67°48' \text{ and } \varphi_s = 49°24'$$

The digitizing of the map was carried out by scanning. After entering into the GIS, further processing was necessary such as changes of projection and correction of geometry. The digitized polygons were corrected according to information on coastal lines, water bodies and rivers obtained from the Digital Chart of the World at scale 1:1M (ESRI, 1993). Mapping unit codes were entered in a database and linked to the corresponding polygon labels in the GIS.

Detailed information on the legend of the Map of the Land Categories is given in Appendix 1. A generalized version of the map is shown in Figure 1.

LAND CATEGORIES of the former USSR



CULTIVATED LAND
- Cropland (> 80 %)
- Cropland (>50 %)
- Cropland (<50 %)

PERENNIALS
- Gardens, orchards, vineyards, etc.

FORAGE/GRAZING LAND
- Fodder land
- Natural grazing/hay land

FOREST
- Industrial harvest
- Protective with limited ndustrial harvesting

- Reserved (unused)
- NATURAL VEGETATION

OTHER LANDS
- Built-up areas
- Water bodies
- Bare lands (rock outcrop, sands, solonchaks, etc.)

Generalized from
Land Categories map of the USSR.
Scale 1:4M. 1991. Edited by L.F.Yanvareva.

LUC IIASA

B. General information on the Land Categories Map of the U.S.S.R.

The information used for the compilation of the Land Categories Map of the U.S.S.R. was derived from different sources. The basic set of data was obtained from the land cadastre of the country. This comprises the main source of data on land inventorization. In the process of compiling the land cadastre, various descriptions of land categories and paper maps have been produced at local and regional scales in the FSU. High resolution remote sensing images at scales of 1:200 000, 1:500 000 and 1:1 000 000 were used as a basis for land categories mapping in southern steppe, forest-steppe and broad-leaved and other forest zones. They also helped to outline more precisely land categories under irrigation, and to specify areas of bare sands caused by human-induced degradation, for example, overgrazing of pastures in Kalmykia. A lot of useful information on land categories for the forest zone was derived from high-resolution spectro-zonal images at scale 1:200 000. Existing maps of reindeer farms were used for identification of natural tundra and forest-tundra pastures. Topographic maps at middle scale were applied to delineate patterns of land categories of territories where other documented land-use information did not exist. A large amount of statistical data was contributed by the Ministries of Agriculture and Forestry.

The basic concept underlying the Map of Land Categories of the U.S.S.R. was to stratify land according to natural landscape conditions. The first level of land stratification was defined through physiography and relief of landscapes. Three main classes were distinguished – plains, mountains, and river valley complexes.

Land categories were differentiated according to landscape zones on the plains. Six zones were distinguished for the territory of the FSU. They were grouped into two major climatic belts. The temperate belt includes five zones: forest, forest-steppe, steppe, semi-deserts and deserts. The subtropical belt includes forest and dry steppe. For mountains and river-valley complexes no further stratification of the natural landscape conditions was done.

Spatial accuracy for mapping varied for different land categories. Priority was given to cropland. The size of the mapping units for selected cropland varied from about 6–8 mm^2, while the mapping units of land categories were larger with a size of 10–15 mm^2. According to the principles adopted for mapping, “pure” cropland was shown for regions, where it occupied more than 80% of the mapping unit area. In the case of mixed land categories – for instance, combinations of cropland, grassland and/or forest – the cropland occupied more than 50% in mapping units with two components, and over 40% in combinations of three components.

Orchards were shown for regions where they occupied areas large enough to be mapped at the given scale. Small orchards, which were dispersed both in the European and Siberian parts, were not shown.

The most widespread areas of natural haylands were identified for West Siberia. Natural features such as wetness, a large number of lakes, soil salinity, etc., have not allowed to use this territory in any other way. Haylands and pastures were also shown along rivers with large extents of seasonal flooding. In regions with intensively developed

agriculture, haylands were mainly confined to narrows and ravines and did not play an important role in agriculture. In these regions haylands were ignored.

Sands and solonchaks were identified on the basis of topographic maps or aerial images.

Natural territories represented by parks and reserves were shown as separate land categories. They were identified according to information obtained from the Central Government Organisation on Geodesy and Cartography (GUGK).

C. Definition and composition of attributes

Attribute definition

Since the original map publication was not accompanied by an explanatory text, the definitions of land categories were taken from different official manuals and reference books.

1. Cropland – an agricultural area, permanently ploughed and used under crops, including abandoned land, perennial grass and bare fallow (State land cadastre, 1986).
2. Irrigated cropland – an agricultural area, permanently ploughed and used under crops, including abandoned land, perennial grass and bare fallow, covered by a regular irrigation network.
3. Multi-year plantations – agricultural area, used as artificially created lands for wood, shrub or grass vegetation to obtain yields of fruit-berry, technical or medicinal plants (orchards, vineyards, berry plants, fruit gardens, plantations).
4. Irrigated multi-year plantations – agricultural area, used as artificially created land for wood, shrub or grass vegetation to obtain yields of fruit-berry, technical or medicinal plants (orchards, vineyards, berry plants, fruit gardens, plantations), covered by a regular irrigation network.
5. Fodder land – agricultural area used as improved pastures and haylands.
6. Natural grasslands – agricultural area used as unimproved (natural) pastures and haylands.
7. Pasture – agricultural area, systematically used for grazing.
8. Haylands – agricultural area, used for grass cutting.
9. Natural elfin woodlands – native haylands and pastures under prostrate dwarf trees and shrubs, sometimes almost impassable.
10. Haylands and pastures in valley floors of semi-desert and desert zones, including not only wood, but also shrub and grass vegetation in floodplains and sometimes overlaying terraces (Kireev, 1984).
11. Fodder land – haylands and pastures, in which a new grass cover is created by removing of grassy turf and subsequent regrassing (apart from river floodplains and slopes of high erosion danger).
12. Parklands – grasslands under park-like forests and shrubs.

12.1. Park-like forest – sparse forest of natural or artificial origin.

12.2. Shrub – a form of perennial woody vegetation 0.8-6.0 m high, which has no clearly expressed smooth trunk, is branched from the ground, and includes an independent plant community, or is found to be included into the undergrowth composition.

13. Grasslands in sparse and open forest - area covered by grassland in sparse and open forests; tree canopy is less than 40%.

    13.1. Open woodland – area, covered by woody vegetation. The density of the tree canopy is not less than 40%, the diameter of tree trunk exceeds 7 cm.

14. Meadow grasslands – area covered by dense grass vegetation comprising such mesophile species as monocotyledonous (grasses) and dicotyledonous (herbs) plants in floodplains and areas between rivers.

15. Forest – area covered by wood and shrub vegetation: density of canopy is more than 40%, the diameter of trunks is over 7 cm, relative density of stocking is 0.1-0.3 (Recommendations..., 1987, 52 p.).

    15.1. Relative density of stocking – a ratio between absolute density (area in ha/ha covered by trees with trunk section at breast height) and the optimum density for the given height of the respective timber stand.

16. Protective forest – forest of group I, designed for conservation purposes (water and soil protection, forest stripes, etc.). Forest stripes of 250 m along highways, rivers, around lakes and other water reservoirs, forest stripes of 500 m along railways, etc.

17. Forest of limited industrial harvest – forest of group II of limited industrial harvest as well as water conservation value. Forest cutting within the range not exceeding annual calculation of felling area (Kozlovsky, 1959).

18. Exploited forest – forest of group III being subject to industrial harvest. All types of cutting are permitted as established by Government plan.

19. Reserve forest – forest of group III designated as a reserve (unused) forest fund.

20. Mire – wetland, excessively moist by surface and groundwater with decomposed or semi-decomposed plant residues in the form of peat.

21. Tugai – natural bottomland complexes with forest, bushes and meadows in river valleys of semi-desert and desert zones. They are especially widespread in Central Asia and represent a dense, almost impassable forest comprising poplar, willow stand, tamarisk, etc., with a large number of lianas and high reeds (Kireev, 1984).

Attribute composition

Mapping units with “pure” land categories are shown for the territories where population density is low and/or both natural features and land-use practices are relatively homogeneous. However, for most cultivated areas the diversity of land use is considerable. In such cases, the mapping units show combinations of land categories. The composition of the components in complex mapping units has been expressed as the proportion (in percent) of the mapping unit.

As mentioned above, on the land categories map priority was given to cropland. Therefore, the composition of patterns involving cropland was recorded more precisely. In these cases the percentage of each component in the mapping unit was shown. For other combinations only the share of the first component was explicitly given. The common rule is that any component included in a combination should occupy at least 20% of the mapping unit extent. The composition of the components in the land category combinations is shown in Table 1.

Table 1. Land categories composition in complex polygons (in percent).

Mapping unit composition	N		From	To	Remarks
1. Mapping units with only one land category	1		80	100	
2. Mapping units including two components	1		50	80	
3. Mapping units including three components	1		40	50	The sum of the second and the third components varies in the range from 50 to 60 %
	2		30	40	
	3		20	30	
4. Mapping units including three components, the first of which is cropland.	1	Cropland	50	80	The sum of the second and the third components varies in the range from 20 to 50 %
	2		20	30	
	3		0	20	
5. Mapping units including two components, the second off which is cropland.	1		80	100	
	2	Cropland	0	20	
6. Mapping units including three components, the third of which is cropland.	1		50	80	The sum of the second and the third components varies in the range from 20 to 50 %.
	2		20	50	
	3	Cropland	0	20	Sometimes the range for cropland in the legend varies from 0 to 30 %.
7. Mapping units including four components and the main is cropland.	1	Cropland	50	80	The sum of the second, the third and the fourth components varies in the range from 50 to 60 %.
	2		20	30	
	3		0	20	
	4		0	20	
8. Mapping units including four components and one of them is cropland.	1		40	50	The sum of the second and the third components varies in the range from 50 to 60 %.
	2		30	40	
	3		20	30	Sometimes the range for cropland in the legend varies from 0 to 30 %.
	4	Cropland	0	20	

D. Database structure

Each polygon on the map (PAT.POLYGON) has been defined by land category (PAT.LU_TYPE) as well as natural zone position (PAT.ZONE). In addition, all polygons are characterized by presence (or absence) of stony soil (PAT.STONES), shown on the map by special symbols.

All land categories are kept in the file LU_DESC and characterized by:

1) relief (field RELIEF, the list of relief conditions is kept in the file RELIEF)

2) primary land categories (the field LU_PRIM, the list of the primary land categories is kept in the file PRIMARY);

3) complete name of land category (the field LU_NAME), which fully correspond to the name in the map legend.

Each land category is labeled to indicate the presence (T) or absence (F) of the following characteristics:

- irrigation (the field IRRIGATION)
- cropland (the field ARABLE)
- multi-year plantations (the field GARDENS)
- forage/grazing land (the field PASTURES)
- forest (the field FORESTS)

Furthermore, each land category is characterized by indicating the share (in percent) of cropland (the field ARABLE_FROM, ARABLE_TO).

The complete name of a land category includes the primary land category (listed first in the description) and associated land categories. The list of primary land categories is stored in file LU_DESC.

Each primary land category (the field ID, with the full list of existing names in the field LU_UNIT) is described by several database fields:

- irrigation (the field LU1_IRG, with the meaning T - irrigated, F – non-irrigated);
- share (in percent) of primary land category in the polygon (the field LU1_FROM, LU1_TO).

A given land category can be associated with several other land categories. The associated land categories are kept in the file COMB.DBF. Each of the associated land categories (the field ID, with the complete list in the file LU_UNIT) is described by:

- irrigation (the field COMB_IRG, with the meaning T - irrigated, F - non irrigated).
- share (in percent) of land categories in the polygon (the field COMB_FROM, COMB_TO).

When the additional fields are not defined this has to be interpreted as the legend not containing this information.

The complete file structure is shown in Table 2.

Table 2. The file structure of the georeferenced land category database of the former U.S.S.R.

Field, number	Field Name	Description
PAT – polygon attribute table with marked thematic fields		
1	AREA	Standard fields in Polygon Attribute Table
2	PERIMETER	
3	LANDUSE_	
4	LANDUSE_ID	
5	POLYGON	Unique polygon number
6	LU_TYPE	Land category (integer code). Description is given in file LU_DESC.
7	ZONE_ID	Natural zone code. Description in ZONE.
8	STONES	Boolean field, indicating presence of stony soils.
ZONE – the list of climatic and natural zones		
1	ZONE_ID	Zone code, the same as in PAT
2	BELT	Climatic belt
3	ZONE_NAME	Natural zone name
RELIEF – the list of relief types		
1	RELIEF_ID	Relief code
2	RELIEF	Relief name
PRIMARY – the list of primary land categories		
1	LU_PRIM_ID	Primary land category code
2	LU_PRIM	Primary land category name
LU_UNIT – the list of land category units		
1	1 ID	Land unit code
2	2 NAME	Land unit name
LU_DESC - land categories description		
1	LU_TYPE	Land category code (the same as in PAT)
2	RELIEF_ID	Relief code (the same as in RELIEF)
3	LU_PRIM_ID	Primary land category code (the same as in PRIMARY)
4	LU_NAME	Land category name (according to map legend)
5	IRRIGATION	Presence of irrigation ("T " - yes, "N" - no)
6	CROPLAND	Presence of cropland ("T " - yes, "N" - no)
7	GARDENS	Presence of multi-year plantation ("T " - yes, "N" – no)
8	PASTURES	Presence of forage land ("T " - yes, "N" - no)

9	FORESTS	Presence of forest ("T " - yes, "N" - no)
10	CROP_FROM	Minimum extent of cropland, %
11	CROP_TO	Maximum extent of cropland, %
12	ID	Primary land category code (the same as in LU_UNIT) (It is first in LU_NAME)
13	LU1_IRG	Presence of irrigation in primary land category ("T " - yes, "N" – no, Absent - not defined in the legend)
14	LU1_FROM	Minimum extent of primary land category, %
15	LU1_TO	Maximum extent of primary land category, %

COMB – associated land categories

1	LU_TYPE	Land category code (the same as in PAT)
2	LU_PRIM_ID	Primary land category code (the same as in PRIMARY)
3	ID	Associated land category – code (the same as in LU_UNIT)
4	COMB_IRG	Presence of irrigation in associated land category ("T " - yes, "N" – no, Absent - not defined in the legend)
5	COMB_FROM	Minimum extent of associated land category, %
6	COMB_TO	Maximum extent of associated land category, %

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Appendix 1: Map of Land Categories of the U.S.S.R.

Map of *Land Categories of the U.S.S.R.* 1991, Scale 1:4 M. Compiled by Yanvareva L. F., et al. Published by GUGK, Moscow.

Natural zones

Polar belt
- tundra
- forest-tundra

Temporal belt
- forest
- forest-steppe
- steppe
- semi-desert and desert

Subtropical belt
- forest
- desert-steppe

Description of the Legend

PLAINS

Cropland

1 - cropland
2 - cropland (more than 50%) combined with natural forage land
3 - cropland (more than 50%) combined with natural and improved forage land
4 - cropland (more than 50%) combined with natural forage land and forest
5 - cropland (more than 50%) combined with natural forage land
6 - cropland (more than 50%) combined with forest
7 - cropland (more than 50%) combined with multi-year plantations
8 - irrigated cropland
9 - irrigated cropland (more than 50%) combined with rainfed ones
10 - irrigated cropland (more than 50%) combined with multi-year plantations

Multi-year plantations

11 - multi-year plantations
12 - multi-year plantations (more than 50%) combined with cropland
13 - irrigated multi-year plantations
14 - irrigated multi-year plantations (more than 50%) combined with irrigated cropland

Forage land

15 - tundra
16 - tundra combined with bogs
17 - sparse forest and open woodlands
18 - forest
19 - park forests and bushes
20 - park forests and bushes combined with cropland (up to 20%)
21 - park forests and bushes combined with cropland (up to 20%) and bogs
22 - meadow and meadow-steppe combined with cropland (up to 30%) and forest
23 - meadow and meadow-steppe combined with forest and bogs

24 - meadow and meadow-steppe combined with cropland (up to 30%), forest and bogs
25 - meadow and meadow-steppe combined with cropland (up to 30%), forest and solonchaks
26 - irrigated meadows
27 - meadows combined with improved meadows, forest and cropland (up to 30%)
28 - steppe
29 - steppe combined with cropland (up to 20%)
30 - desert and semi-desert
31 - desert and semi-desert combined with cropland (up to 20%)

Forest and sparse forest

32 - protective forest and sparse forests (group I)
33 - forest with limited industrial harvest (group II)
34 - exploited forest (group III)
35 - reserved (unused) forest and sparse forest (group III)
36 - forest combined with natural forage land and cropland (up to 20%)
37 - forest and sparse forest combined with natural forage land and bushes

MOUNTAINS

Cropland

38 - cropland
39 - cropland (more than 50%) combined with natural forage land
40 - irrigated cropland

Multi-year plantations

41 - multi-year plantation
42 - multi-year plantation (more than 50%) combined with cropland

Natural forage lands

43 - tundra
44 - tundra combined with thin forest
45 - elfin woodland
46 - elfin woodland combined with sparse forest and tundra
47 - sparse forest and open woodland combined with elfin woodland
48 - sparse forest and open woodland
49 - sparse forest and open woodland combined with cropland (up to 20%)
50 - forest
51 - bushes and open woodland combined with steppe
52 - bushes and open woodland combined with steppe forage land and cropland (up to 30%)
53 - bushes and sparse forest combined with meadow grassland
54 - bushes and sparse forest combined with meadows and cropland (up to 30%)
55 - meadow
56 - steppe
57 - steppe combined with cropland (up to 20%)
58 - desert and semi-desert
59 - desert and semi-desert combined with cropland (up to 20%)

Forest and sparse forest

60 - protective forest and sparse forest (group I)
61 - forest with limited industrial harvest (group II)
62 - exploited forest (group III)
63 - reserved forest and sparse forest (group III)

64 - forest combined with natural forage land and cropland (up to 20%)
65 - forest and sparse forest combined with fragments of elfin woodland and tundra
66 - forest and sparse forest combined with fragments of tundra
67 - elfin woodland
68 - elfin woodland combined with forest fragments

LAND COMPLEXES IN VALLEYS

69 - cropland
70 - irrigated cropland
71 - cropland (more than 50%) combined with natural forage land
72 - cropland (more than 50%) combined with improved forage land, forest and bushes
73 - multi-year plantations
74 - multi-year plantations (more than 50%) combined with cropland
75 - natural meadow forage land combined with cropland (more than 20%) and forest
76 - improved forage land combined with cropland (up to 20%)
77 - natural forest forage land combined with cropland (more than 20%)
78 - natural meadow forage land combined with forest
79 - natural meadow forage land combined with bushes
80 - natural meadow forage land
81 - natural meadow-tugai forage land
82 - natural forage land among forest and sparse forest
83 - forest combined with cropland (up to 20%) and natural meadow forage land
84 - forest combined with natural meadow forage land

The other lands in land complexes

85 - bogs combined with natural forage land
86 - bogs combined with natural forage land and forest
87 - bogs combined with tundra pastures

OTHER LANDS

Plain

88 - bogs
89 - solonchaks
90 - tugai
91 - barren sand areas
92 - tundra
93 - tundra in complex with sparse forest
94 - polar deserts

Mountain

95 - tundra in complex with elfin woodland and sparse forest
96 - tundra
97 - placers
98 - glaciers

Lands in valleys

99 - bogs
100 - bushes