Working Paper

THE LUC APPROACH TO CREATING A CONTINENTAL-SCALE LAND-COVER DATABASE FOR RUSSIA

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Contents

1. Introduction

Land cover is an essential surface characteristic of the Earth. Yet - this may come as a surprise - there is no generally accepted, complete and universal land-cover product for Russia, as is the problem in many other parts of the world. A review of global land-cover databases (Bradley *et al.* 1994) concluded that one of the most pressing problems in global climate and ecosystem studies is a lack of adequate land-cover data. This may explain why land-cover mapping often leads to debate over classification schemes, use of class descriptors and labels, and product specifications.

Land-use and land-cover information is required in various forms and at different scales. A variety of techniques are in current use to collect the necessary data, ranging from census studies, ground observations, to remotely sensed data. The methodological plurality has also resulted in a widely diverse number of methods to store and present these data. In view of this unsatisfactory situation, FAO[1] and UNEP[2], with the support of UNESCO[3] and a number of other organizations, have launched an initiative on harmonizing and standardizing land-use and land-cover classification systems.

Another major effort has been launched by the International Geosphere-Biosphere Programme (IGBP), to serve the needs of the global environmental change research community. The IGBP-DIS Global 1 km Land-cover Project is currently underway. The project is primarily relying on NOAA AVHRR[4] data and aims to develop and distribute a global data-set representing land-cover in terms of seventeen broad classes.

Being aware of these efforts, and aiming to be consistent with and useful to the international research community, the Land-Use Change (LUC) project at IIASA decided at an early stage to be in active contact with the research groups charged with harmonizing land-use and land-cover classifications, to use their methods and standards as they would emerge. Consequently, as regards land-cover database development, the main task of the LUC project was defined as: (i) producing a complete list of land-cover categories in Europe and Northern Asia based on available national-level data sources, and (ii) which

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[1] Food and Agriculture Organization of the United Nations.
[2] United Nations Environment Programme.
[3] United Nations Educational, Scientific and Cultural Organization.
[4] National Oceanic and Atmospheric Administration Advanced Very High Resolution Radiometer.

would correspond to the diversity of land-use and land-cover of this huge territory. Charged with this task, it was necessary to develop a framework allowing to concentrate the project's efforts on these problems.

The objective of this paper is to present an outline and rationale of the methodology for elaborating the project's land-cover database. Comprising the major portion of the study region, the approach has been developed on the basis of Russian experience.

2. State of the art

Summarizing our conclusions from a thorough literature review of existing internationally recognized land-cover products (Anderson *et al.* 1976; Bradley *et al.* 1994; CEC 1992; ESRI 1993; Fuller *et al.* 1993; Loveland *et al.* 1991; Remmelzwaal 1990; Wilson *et al.* 1985; Wyatt *et al.* 1994; Wyatt *et al.* 1995, Young 1994; etc.) we state the following observations:

- Land cover, in general terms, denotes very broadly defined phenomena which refer to common external features of geographical objects present on the Earth's surface, such as, for instance, forests, grass, soil, settled areas, etc. More specific land-cover classes arise only when the purpose of land-cover analysis is well defined. In this case, concrete land-cover objects and their quantitative attributes can be established. In the LUC project, the aim is to relate land cover to anthropogenic influences. Therefore, broad land-cover categories (forests, soils, etc.) should be further differentiated into classes which correspond to different types of land use. Consequently, the objective is to formally establish a relationship between land uses and land-cover patterns;
- Most land-cover classification schemes were designed for specific purposes and applications. In order to analyze anthropogenic influences on land cover, i.e., to capture the consequences of practicing different types of land use , it is necessary to produce a classification of land-cover appropriate for this purpose.
- Conversely, no single land-cover classification scheme is likely to satisfy all, or even most, applications. A spatial land-cover framework, even when it is readily available and widely applied, may not necessarily be a good choice if it is used for purposes other than those for which it was developed or intended;

- The same kind of land cover may be classified very differently in different classification schemes because of differences in the declared aims and tasks. This makes it usually difficult, or even impossible, to combine distinct land-cover classification systems. For instance in Russia, it is not easy to reconcile land-cover designations for a given area that were established by different institutions for agricultural, forestry or infrastructure purposes.

These observations correspond to the conclusions of the IGBP on this topic. After year-long discussions on appropriate land-cover products for global change applications, it was concluded that the varied requirements of the IGBP core projects cannot be satisfied by a single map or one set of attributes (IGBP 1990). Thus, it has even been questioned whether it makes scientific sense to develop a common land-cover scheme.

Another relevant consideration is that scientists typically must select a land-cover framework based on availability of data rather than derived from purely theoretical considerations. Accordingly, the elaboration of a digital land-cover database appropriate for the LUC project is guided by three principles:

1. The land-cover database should serve the main tasks of the project.
2. Land-cover categories should be created in accordance with availability and suitability of existing data.
3. While keeping existing schemes in mind, the project has to be flexible in developing a land-cover product that focuses on relating land use and land cover.

3. Definitions of land cover

As was mentioned above, there have been many land-cover classifications, definitions, etc., proposed by various authors and organizations. Obviously, there is not much benefit in producing yet another definition in the frame of the LUC project. Nevertheless, charged with *Modeling Land-Use and Land-Cover Changes*, the LUC project must clearly define its study objects as well as establish quantitative land-cover attributes for modeling. The easiest way would be to apply an existing suitable definition. Below are some of the internationally recognized definitions of land cover.[5]

[5] Based on de Leeuw *et al.* 1995.

'*Land-cover refers to the make-up of the land surface - whether it comprises arable crops, trees or buildings and so forth.*' (Fuller *et al.* 1990)

'*The term land cover refers to the attributes of a part of the Earth's land surface and immediate subsurface, including biota, soil, topography, surface and ground water, and human structures. Land cover can be classified according to numerous criteria, depending on the scientific purposes for which the classification is being developed. Examples of some broad categories of land covers include boreal forest, tropical savanna, temperate grasslands, croplands, wetlands, and settlements.*' (IGBP 1993).

'*Land cover is defined as the vegetation (natural or planted) or human constructions (buildings etc.) that cover the Earth's surface.*' (Young 1994).

'*Land cover is defined as the collection of objects present at or above the Earth's surface, including vegetation, built-up features, water, rock and soil.*' (de Leeuw & de Bie 1995).

'*Land cover is the result of land use at a certain moment in time.*' (Mucher *et al.* 1993).

We believe that none of these definitions can be directly applied in the LUC project since none of them captures the specific tasks of the study. There are several reasons for this statement. First, a major disadvantage is that most of the definitions cited above are too far from the project's aims. They do not establish a clear relationship with land use as the purpose of the land-cover analysis. Only the above definition, proposed by Mucher *et al.* (1993) is suitable in that respect, because it explicitly refers to land use. However, the authors' view of land cover seems too narrow, as land cover is seen as deriving only from land use. Hence, some very important natural components of land cover are not clearly and sufficiently taken into consideration. Secondly, the definition suggests that land cover is a direct and immediate consequence of land use. However, it is well known that under certain conditions land cover results from indirect human impacts, for instance, degraded forests due to transboundary pollution. Finally, land cover, as proposed by Mucher *et al.*, is defined with reference to a '*certain moment in time*', leaving aside all the temporal aspects of land-cover. Thus, historical analyses of its formation and transformation are not included.

Another characteristic of the land-cover definitions listed above is that they are fairly abstract. As we have already pointed out, this makes it difficult to specify concrete land-

cover objects, a prerequisite for compiling relevant quantitative land-cover attribute parameters.

Ambiguities arise when the authors attempt to define land cover by enumerating the objects which comprise land cover (de Leeuw & de Bie 1995). Even a brief look at the list of proposed objects shows that such attempts are far from producing an unambiguous and complete set. For instance, terms like '*immediate subsurface*' are too vague for quantitative assessments. (Does this mean soils, or does it refer to the level of the groundwater table, or does it denote the thickness of loose deposits, etc.?).

In summary, this brief analysis of various internationally known land-cover definitions leads us to state that none of them can be directly applied within the LUC project. Thus, it is urgent need to develop land-cover definition related to the purposes of the LUC project. We propose the following definition:

'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.'

This captures the key elements of importance to the LUC project, namely:

- The definition is of immediate relevance to the project's tasks. It clearly outlines the field of investigations declaring that the LUC project defines land cover as the outcome of land use as well as of other human activities, i.e., both direct and indirect anthropogenic impacts.
- The definition states that the entire surface of the Earth is taken into consideration;
- The definition gives a basic idea of how to construct a land-cover database.

The principal scheme underlying this definition and the construction of the LUC land-cover database is shown in Figure 3.1. It indicates that land cover results from the interaction between natural ecosystems and human activity. A range of different land-use types constitutes the basic elements of these activities. Theoretically, land-use impacts on the environment, i.e., the degree and severity of human intervention in ecosystem development, can be defined on a continuous scale from 0% (purely natural objects) to 100% (fully artificial objects). Thus, land cover consists of natural ('unused'), artificial (man-made) and mixed (complexes of natural and anthropogenically transformed) objects.

Figure 3.1: Principal scheme for constructing the LUC land-cover database.

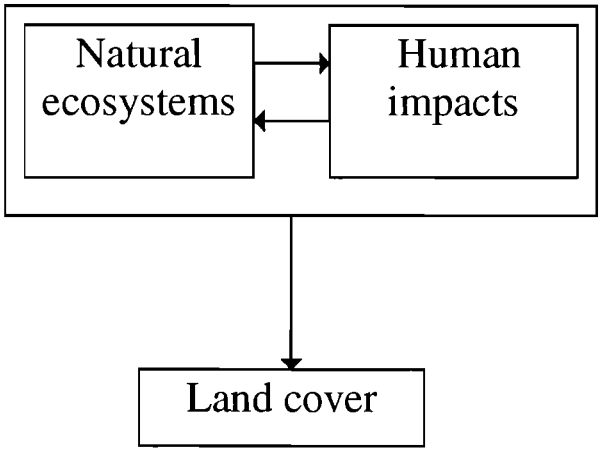
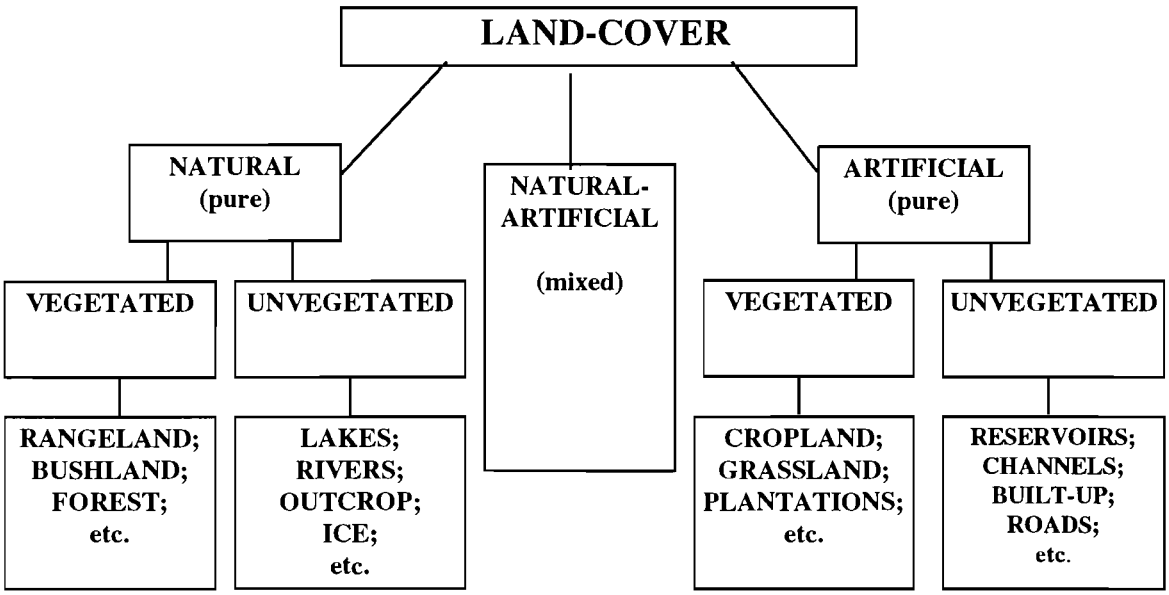


Figure 3.2 Conceptual scheme of land-cover database.



A more detailed scheme of the land-cover database structure is presented in Figure 3.2. In this scheme, the human activity is presumed as the main driving force which is shaped the Earth. Accordingly, land-cover at the highest level has been separated in natural, natural-artificial and artificial groups. Each of them is subdivided into vegetated or non-vegetated sub-groups. Furthermore, each of these patterns can be described by finer land-cover elements. The number and level of detail of the finest elements are

determined by the scale and characteristics of the data sources that have been used for constructing the land-cover database[6]. Thus, the class elements which result from the legends of the source maps play the role of 'building blocks' for constructing a land-cover database. These 'building blocks' are, by definition, the finest land-cover units that can be distinguished. By appropriate grouping of the basic units, specific land-cover categories can be produced, for instance, for the purpose of modeling vegetation and the terrestrial carbon stock.

4. Elaboration of land-cover categories.

As discussed above, land-cover denotes the biogeophysical state of the Earth's surface as composed by different objects, e.g., forest, soil, water bodies, rock outcrops, etc. A critical question is whether land-cover is only the reflection of the external features of these known objects and should be described by some of their attributes, or whether land-cover should be considered an original phenomenon in its own right.

In the frame of the LUC project, we have defined a land-cover category as denoting a homogeneous or a regularly heterogeneous pattern of objects at the Earth's surface which reflects its biogeophysical state, shaped by and relevant to particular human activities. Homogeneity or regular heterogeneity are used in the sense that a given pattern of the Earth's surface is characterized by a common kind of human activities, but may include various geographical objects (types of forests, grasses, soils, settled areas etc.). Thus, in practice, some of the existing surface objects will be combined into one land-cover category due to a common type of land-use characteristics, or will be subdivided because of a different degree of human impacts (if such information on spatial characteristics of human impacts is available). Therefore, for the purpose of modeling in the LUC project, a land-cover category is not only a reflection of the external features of known objects but should be considered as a specific phenomenon. It follows that land-cover categories cannot fully be characterized by parameters of the external objects, for instance, tree species, density of stands, etc. Instead, being a specific phenomenon, a land-cover category must have its own original characteristics which emerge when substantial land-cover analysis is being undertaken. Some of these land-cover category attributes can be grouped as follows:

[6] At least, this is the case for the mapped data sources.

1. Components (i.e., land-cover units derived from source maps);
2. Composition (percentage of each land-cover unit in a land-cover mapping polygon);
3. Structure of composition:
   uniformly distributed;
   irregularly distributed;
4. Type of human intervention i.e., major land use)
   agricultural;
   forestry;
   settlement and industry;
   nature protection;
   not used.
5. Degree of human intervention: level of agriculture intensity, intensity of forest exploitation, etc.
6. Among the attributes which describe each land-cover category albedo has been included as it is frequently used in global change models.

5. Sources of information.

5.1. Map of Land Categories of the USSR.

The compilation of the land-cover database of the LUC project is based on several sources. First, the map of land categories *Map of Land Categories of the USSR.* is used (Yanvaryova, 1989). This map was created by the Laboratory of Applied Complex Cartography, Faculty of Geography, Moscow State University. Its intended use is for scientific and educational purposes. On this map, land is stratified according to both natural and human factors.

The following basic materials were used for the compilation of the *Map of Land Categories of the USSR*:

- Data from the Ministry of Agriculture of the USSR; Forest Ministries of the Russian Federation and other Republics of the USSR; Institute of Geography, Siberian Division of Russian Academy of Science; Yakut State University; Complex East Expedition; and Department of Biogeography, Faculty of Geography, Moscow State University.
- Landscape Map;

- Vegetation Map;
- Nature Protection Map.

The concept underlying this map is to stratify land based on natural landscape conditions and most valuable land-use types devoted to these conditions. The first level of land stratification on the *Map of Land Categories of the USSR* is defined through physiography and relief of landscapes. Three main classes are distinguished - plains, mountains, and river valley complexes.

Next, land categories on plains are determined according to landscape zones. Six zones are distinguished for the territory of the former Soviet Union. They are grouped into two major climatic belts. The temperate belt includes the following zones: (3) forest, (4) forest-steppe, (5) steppe, and (6) semi-deserts and deserts. The subtropical belt includes (7) forest, and (8) deserted steppe. There is no further stratification of natural landscape conditions for mountains and river valley complexes. More detailed information on the legend of the *Map of Land Categories of the USSR* can be found in Appendix 1.

5.2. Map of Vegetation of the USSR.

The second data source used in the land-cover database construction is the map of *Vegetation of the USSR* (Isachenko *et al.* 1990). A lot of ground and remote sensing data was analyzed for map compilation. The map shows present vegetation. In locations delineated as agricultural areas, potential vegetation is shown as reconstructed on the basis of soil distribution and landscape analysis.

In the map legend, vegetation is described in terms of plant architecture. There is also information on dominant species. This information is organized in accordance with both climatic (belts and zones) and main physiographic features (plains, sloped lands and mountains). It is also possible to extract some information as to anthropogenic influences on vegetation. The full legend of the map of *Vegetation of the USSR* can be found in Appendix 2.

5.3. The Digital Chart of the World (DCW).

A third block of information is extracted from the Digital Chart of the World (ESRI, 1993). This data product contains geographic, attributive, and text data from a 1:1 million scale vector base-map of the world. The primary source of the database is the Defense

Mapping Agency (DMA) Operational Navigation Chart (ONC) series. The main digitized polygon layers contain features that had a circumference of more than 0.12 inches (perimeter measure) on the ONC source lithographs. Features smaller than that were captured as points and included in separate coverages. There are seventeen separate layers of information in the DCW: Political boundaries and Oceans; Populated places; Railroads; Roads; Utilities; Drainage; Drainage supplemental; Hypsography; Hypsography supplemental; Land cover; Ocean features; Physiography; Aeronautical; Cultural landmarks; Transportation structure; Vegetation; Data quality.

Further details on the applicability of various DCW layers to the construction of the LUC land-cover database is given in Appendix 3. DCW data layers can be used in two ways: (i) for the creation of land-cover units and categories, and (ii) for the compilation of specific attributes of the land-cover database. Some polygons from the DCW form separate land-cover units (for example, built-up area units, i.e., polygons of urbanized areas from DCW with a size exceeding some critical thresholds). In other cases, land-cover categories will be delineated by using values computed from DCW data. (For example, the density of infrastructure and of urban settlements will be used as criteria for subdividing land-cover categories such as 'croplands' into 'croplands with high density of infrastructure and settlements' and 'croplands with low density of infrastructure and settlements'). In both cases appropriate threshold levels are under discussion now.

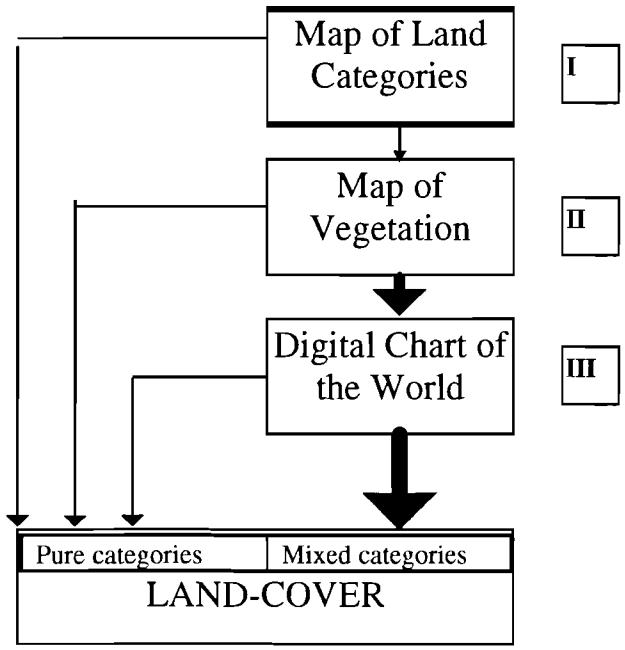
6. Algorithm for creating the LUC project land-cover database.

The procedure to construct the LUC project land-cover database of Russia are based on the data sources and follow the logic mentioned above. The procedure involves three main steps (Fig. 6.1).

At first, step (i), the *Map of Land Categories* is analyzed. The polygons of the map are grouped into two broad sets: used and unused lands. Used lands are overlaid with selected original or derived (i.e., containing calculated attributes) features from the DCW. Thus, land-cover units with pure land categories and land-cover units with mixed land categories (the polygons from the *Map of Land Categories* + DCW) are delineated. Then, polygons of unused land categories are combined with DCW polygons forming similar pure and mixed land-cover units.

Secondly, step (ii), unused land polygons are analyzed with respect to information shown on the vegetation map. As far as mixed vegetation-DCW land-cover categories were produced during the first step, pure vegetation land-cover units are delineated.

Figure 6.1. Flow-chart for creating the LUC land cover database.



Finally, step (iii), DCW is analyzed and pure DCW land-cover units are established. Thereafter, the land-cover database is completed by combining pure and mixed land-cover units which were generated during all three steps. Once a specific task is defined such a grouping of land cover units is a standard operation in GIS.

7. Attributes of land-cover categories.

Modeling requires quantified information. Therefore land-cover categories will be described in terms of several quantitative attributes. The previous discussion on the compilation of the LUC land-cover database for Russia leads to the description of land-cover units by two sets of attributes:

1. attributes derived from the basic sources, and
2. attributes generated for characterization of land-cover categories.

7.1 Attributes derived from the basic mapped sources.

The first set of attributes can be derived directly from the legends and explanatory texts of the basic mapped sources, i.e., *Map of Land Categories, Map of Vegetation* and DCW. These parameters will be linked with the respective land-cover units. Examples of such kind of attributes, mainly derived from the vegetation map, are presented below[7]:

- formation level (trees, shrubs, succulents, forbs/ferns, graminoids, mosses/lichens).
- leaf type (broad-leaf, needle-leaf, small leafed, leafless);
- leaf phenology (deciduous, semi-deciduous, evergreen);
- dominant floristics (genus level);
- origin (primary, secondary, regenerated);
- duration (permanent/perennial, episodic);
- age (juvenile, mature);
- height of the vegetation (well-grown, stunted/dwarfed);
- vertical structure of vegetation (description of the top layer and undergrowth);
- stem attributes;
- root attributes;
- percentage of tree cover.

These attributes will be derived from the legend of the vegetation map and various other publications.

7.2 Attributes for characterization of land-cover categories.

In addition to attributes derived from the features of the basic source maps, land-cover categories are characterized by some additional attributes: components (i.e., reference to basic building blocks land-cover unit), composition, geometric pattern, type and degree of human intervention, and albedo. As outlined in Section 6, land-cover categories are constructed by manipulation of basic 'building blocks', of the land-cover units. Due to the algorithm for constructing the land-cover database, pure land-cover categories can be presented by single land-cover units. By definition, that pure land-cover categories (see Table 7.1) should contain less than 10% of inclusions in a mapping unit area.

[7] Some of the attributes are taken from Wyatt *et al.* 1995.

Mixed land-cover categories are described as combinations of pure land-cover units and appear, for instance, due to scale generalization. Such generalization is required when the extent of a given land-cover unit cannot be shown separately. Substantial grouping will be done, when several land-cover units should be combined due to common land-use practice, etc. The number of pure land-cover units in a mixed land-cover category may vary from 2 to 8, as shown in Table 7.1.

Table 7.1 Composition of mixed land-cover categories (% of polygon)[8]

Dominant land-cover unit	Associated land-cover unit*	Included land-cover unit**
100	0	0
90	0	10
80	0	10+10
70	0	10+10+10
70	30	0
60	30	10
60	20+20	0
50	20+20	10
50	30	10+10
50	30	5+5+5+5
40	20+20	5+5+5+5
40	30	10+10+10
40	20+20	10+10
30	20+20+20	10
30	20+20	10+10+10
30	20+20+20	5+5
25	20+20+20	5+5+5
24	20+20+20	4+4+4+4

* Associated land-cover unit occupies more than 20% of a polygon
** Included land-cover unit occupies less than 20% of a polygon

Accordingly, mixed land-cover categories are characterized by the composition of land-cover units. As shown in Table. 7.1, categories may have a wide range of associated and included land-cover units. By construction, mixed land-cover categories will partly come from the original source maps, i.e., represent mixed classes in the original maps, for instance, patterns of cropland and forest on the *Map of Land Categories*. Additional mixed land-cover categories may result from overlaying the source maps with geographic features from the DCW.

[8] The example shows the complex classes used in the FAO-UNESCO Soil Map of the World. 1974.

Mixed land-cover categories will also be characterized by the geometry of the patterns of land-cover units. At continental level, it will suffice to apply two categories: (i) regularly distributed, when land-cover units form regularly dispersed patterns, and (ii) irregularly distributed, when component land-cover units cluster or form irregular patterns.

Furthermore, land-cover categories will also be described by type and intensity of human land-use intervention. These attributes reflect the prevailing human impact and therefore indicate the main driving forces shaping land-cover. The following classes for definition of land-use intervention are proposed:

- agriculture;
- forestry;
- settlement
- settlement and industry;
- industry
- mining
- nature protection;
- other.

Some of the land-use intervention types will be further detailed by degree of intervention. For agricultural land-use types this will be done by indicating the general level of management and inputs. For forestry, the degree of intervention will be indicated as types of activity, from collection of herbs to commercial logging. The principal scheme of compilation as well as the general coding system for attributes of land-cover categories are presented in Table 7.2.

Table 7.2 General coding scheme for attributes of land-cover categories.

ID	Dominant land-cover unit	Associated land-cover unit	Included land-cover unit	Geometry	Type of intervention	Degree of intervention
1	A.* Thematic character-istics; albedo.	B.* Thematic character-istics; albedo	C.* Thematic character-istics; albedo	regularly distributed; irregularly distributed;	Type of LU intervention: - agriculture; - forestry; - settlement, industry; - nature protection; - not used.	Degree of LU intervention: classes of LU intervention

* A,B,C - land-cover units from the basic source maps

8. Summary

In this paper, a methodology for the compilation of a continental-scale land-cover database for Russia has been outlined. Land cover is defined as '*the biogeophysical state of the Earth's surface shaped by and relevant to various kinds of land-use and other human activities.*' This clearly specifies the focus and spatial dimension of the LUC project investigations and establishes human intervention as the main organizing principle to construct a land-cover database.

In this approach, land-cover categories appear as specific patterns of Earth surface objects, characterized by components, composition, geometry of patterns, type, degree of land-use intervention, and albedo.

The basic building blocks for the construction of the land-cover database, termed land-cover units, are derived from the legends of the source maps used in the compilation. Land cover is described by single land-cover units (pure categories) or by combinations of land-cover units (mixed categories).

The concept that has been developed leads to a flexible structure of the land-cover database. The principal idea is that the number and substantial content of the land-cover units is solely determined by the scale and accuracy of the sources that have been used for compiling the land-cover database. Beyond that, the number of land-cover categories as well as the rules for combining land-cover units are flexible depending on the specific requirements of a particular land-cover application.

Two sets of land-cover attributes are distinguished. The first type of attributes is derived from the original mapped data sources and characterizes individual land-cover units. The second type is generated to specifically describe land-cover categories.

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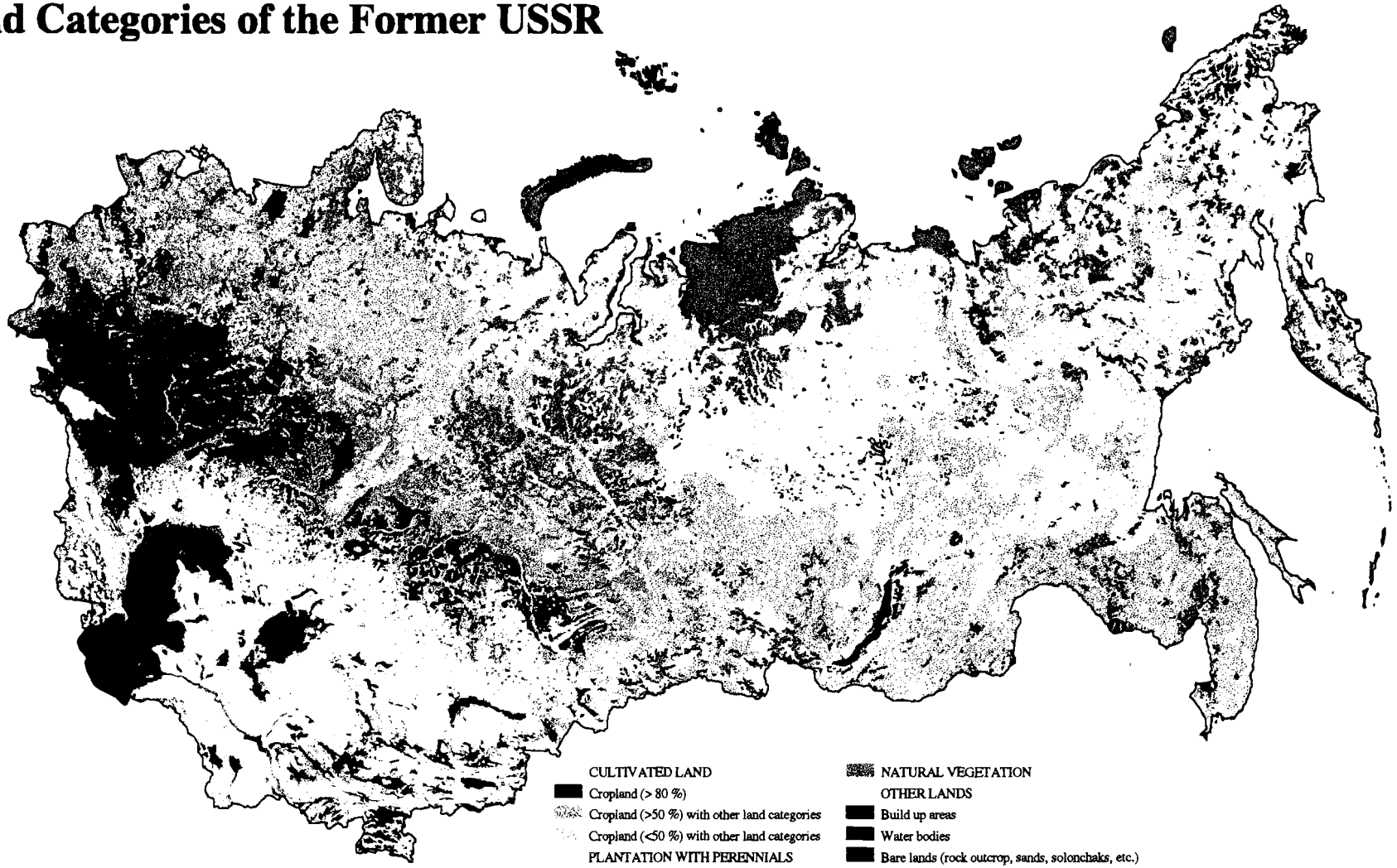
Land Categories of the Former USSR



CULTIVATED LAND
Cropland (> 80 %)
Cropland (>50 %) with other land categories
Cropland (<50 %) with other land categories
PLANTATION WITH PERENNIALS
Gardens, orchards, vineyards, etc.
FORAGE/GRAZING LAND
Fodder land
Natural grazing/hay land
FOREST
Industrial harvest
Protective with limited industrial harvesting
Reserved (unused)

NATURAL VEGETATION
OTHER LANDS
Build up areas
Water bodies
Bare lands (rock outcrop, sands, solonchaks, etc.)

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

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APPENDIX 1

LAND CATEGORIES OF THE USSR.
Edited by L.F. Yanvaryova. Scale 1:4 M., 1989.

I. Crop lands

Plains:
1. Crop lands
2-7. Combinations of crop lands and types from other classes (where crop lands occupy more than 50% of the territory)
8. Irrigated crop lands
9-10. Combinations of irrigated crop lands with types from other classes (where irrigated arable lands occupy more than 50% of the territory).

38-40. Crop lands in mountain areas.

69-72. Crop lands in river valley complexes.

II. Multi-year plantations

Plains:
11. Multi-year plantations.
12. Multi-year plantations (>50% of the territory) with arable lands.
13. Irrigated multi-year plantations.
14. Irrigated multi-year plantations (>50% of the territory) with irrigated crop lands.

41-42. Multi-year plantations in mountain areas.

73-74. Multi-year plantations in river valley complexes.

III. Meadowlands

Meadowlands are stratified according to landscape zone belonging, because use of meadows is mainly conducted by their natural conditions.

Plains:
15-16. Tundra meadowlands and combinations.
17-21. Meadowlands of forests and sparse growth of trees areas.
22-29. Natural meadowlands in steppe and combinations.
30-31. Desert and semi-desert meadowlands and combinations.

43-59. Meadowlands in mountain areas.

75-82. Meadowlands in river valley complexes.

IV. Forests and sparse growth of trees

Plains:
32. Restricted forests (Group #1).
33. Limited usage forests (Group #2).
34. Operational forests (Group #3).
35. Reserved forests (Group #3).
36-37. Combinations of forests with meadow lands and arable lands.

60-68. Forests and sparse growth of trees in mountain areas.

83-84. Forests and sparse growth of trees in river valley complexes.

V. Complexes of unused and used lands

85-87. Combinations of wetlands with types from other classes.

VI. Other unused lands

88-94. Unused lands on plains (wetlands, solonchaks, sand unvegetated massives, tundra and polar deserts).

95-100 Unused lands in mountain areas (tundra, rocks, glaciers, wetlands and bushes).

Thus lands are divided into 100 types according to land utilization and 12 classes according to their landscape belonging.

Other layers of information on the map include swamped and rocky lands, inland water bodies (natural and artificial) and drainage system, major cities and administrative division.

APPENDIX 2

VEGETATION OF THE USSR.
Edited by M. Gugk. Scale 1:4 M., 1990.

Compiled by: c.g.s. A.V. Belov (Inst. geography SO AN SSSR), c.g.s. I.I. Buks (Inst. applied geophisics named by E.K. Fedorova Goskomgidromet USSR), c.biol.s. S.A. Gribova, c.g.s. T.I. Isachenko, et al. Edition by: c.g.s.T.I.Isachenko,c.biol.s. Z.V. Karamysheva, c.biol.s. G.M. Ladygina, c.biol.s. I.N. Safronova, et al.

POLAR DESERTS

1. Open (unclosed) primitive aggregations of lichen, moss and arctic species of flowering plants

TUNDRA

Plain tundra
Arctic tundra
2. Grass-moss and low bush-grass-moss
Northern tundra
3. Grass-moss and low bush-moss
4. Low bush-moss
5. Small willow stand
6. Small willow stand
Southern tundra
7. Shrubbery grass-low bush-moss
8. Low bush-cotton grass-moss
Alpine tundra
9. Open (unclosed) aggregations of crustaceous and foliose lichen, moss, arctic-alpine species of flowering plants
10. Low bush-moss, grass-low bush-moss and lichen
11. Low bush-lichebn and low bush-moss in combination with shrubs and sparse vegetation in placers

HIGH MOUNTAIN VEGETATION

(carpet-like meadows, umbelliferous plants, cushion plant formation, elfin and open woodlands)

12. Sparse communities of subnival plants, scree and rock vegetation
13. Herb (alpine) and carpet-like meadows in combination with communities of shrubs and sparse scree and rock vegetation
14. Herb (short grass) meadows in combination with communities of mountain cryoxerophytes
15. Elfin and open woodlands (subalpine)
16. Herb (middle grass) meadows and umbelliferous plants
17. Sedge, Cobresia apline, herb (short grass) meadows
18. Cushion plant formation of herbs, semi-shrubs and shrubs

DARK AND LIGHT CONIFEROUS, BROAD-LEAVED FORESTS, OPEN WOODLANDS

Plain forests
Boreal forests and open woodlands
Pretundra open woodlands
19. Birch forest with short grass-low bush cover
20. Spruce forest with mosaic low-shrub-grass cover
21. Larch forest with low-bush-lichen-grass cover

North-taiga forests
22. Spruce thin forest with Betula nana in low bush-lichen-grass undergrowth
23. Larch-spruce-cedar thin forest with low bush-lichen cover
24. Pine thin forest with low bush-grass-lichen cover
25. Larch thin forest with low bush-moss and low bush-lichen cover

Middle-taiga forests
26. Spruce and fir-spruce forest with low bushes and short grasses
27. Spruce-cedar and cedar-spruce forest with grass and low bush cover
28. Pine forest with low bushes, grasses and lichens
29. Larch forest

South-taiga forests
30. Spruce, fir-spruce and spruce-fir forest with mosaic grass-low bush and grass cover
31. Cedar-spruce-fir forest with mosaic short grass cover
32. Pine and larch-pine forest with grasses and low bush-lichens
33. Larch and pine-larch forest with shrubs and grasses

Subtaiga forests
34. Dark coniferous forest with admixture of broad-leaved one (undergrowth and cover of nemorose species), broad leaved-dark coniferous forest
35. Pine forest with grass cover, frequently forest with pine and meadow-steppe species (southern bor)
36. Larch forest with Quercut mongolica, Betula davurica and other grass species
37. Aspen-birch forest with grass cover, Tilia cordata,predominated in Pre-Ural region; birch-aspen forest with nemorose species in the region of Kuznetsk Alatau

Steppe forests
38. Pine forest with steppe grass cover
39. Aspen-birch and birch-aspen forest with steppe grass cover

Mountain forests
Boreal forests and open woodlands
Subgoltsy (tundra belt above the timberline) open woodlands
40. Dark coniferous forest with low bush-moss-lichen cover
41. Larch forest with low-bush-moss-lichen cover
42. Communities with Pinus putila in combination with larch open woodland and tundra

Mountain taiga forests
43. Cedar-spruce and fir-spruce forest
44. Spruce-fir and cedar-fir forest with grass-low bush cover
45. Cedar and fir-cedarr forest with low bush-short grass cover
46. Spruce-fir, cedar-fir, fir-spruce forest with nemorose species
47. Pine forest

48. Larch forest
49. Birch forest with high grass cover

Dark coniferous forests outside boreal belt

50. Spruce, fir and beech-fir forest
51. Spruce-fir forest often with Fagus orientalis
52. Spruce, fir-spruce, aspen-spruce forest in combination with meadows and steppes
53. Pine forest

Broad-leaved forests

Plain forests

54. Beech forest frequently with Quercus petraea, Carpinus betulus, Acer pseudoplatanus
55. Oak-hornbeam, hornmeam forest with Acer pseudoplatanus, Cerasus aviumm
56. Oak forest
57. Pine-broad-leaved forest with boreal types in the cover
58. Lime-tree and oak forest
59. Cedar and broad-leaved forest with ferns and high grasses

Piedmont and mountain forests

60. Beech forest
61. Oak and hornbeam-oak forest
62. Broad-leaved and oak forest
63. Polydominant moist broad-leaved forest
64. Cedar-broad leaved forest
65. Walnut and apple-tree forest

STEPPES AND SECONDARY COMMUNITIES

Plain steppes

Meadow steppes and steppe meadows

66. Herb-grass and grass-herb meadow steppe and steppe meadows in combination with forests (forest steppe)
67. Herb (xeromesophytic herbs) and bunchgrass steppe
68. Herb (mesoxerophytic herbs), bunchgrass and bunchgrass herbs
69. Northern dry bunchgrass and rootstock (rhizome) grasses
70. Southern dry xerophytic herbs and bunchgrasses

Desertificated steppes

71. Northern semishrub and bunchgrass steppe
72. Southern semishrub and bunchgrass steppe

Piedmont and mountain steppes

73. Meadow and herb-bunchgrass steppe
74. Shrub communities in combination with meadow steppes
75. Herb-bunchgrass and bunchgrasses in combination with shrubs
76. Shrubs and bunchgrasses in combination with petrophytes
77. Short bunchgrasses
78. Halfshrub-bunchgrass desert steppe
79. Ephemeroid-bunchgrasses

High mountain steppes

80. Mountain xerophytic-bunchgrasses

81. Cryophytic herbs and bunchgrasses, in some places with ad-mixture of dwarf-pine wood
82. Pillow-like brunchgrass steppe

DESERTS

Plain desert
Northern deserts
83. Sagebrush (Artemisia) among grasses in complex with sage-brush and saltwort (Salsola rhutenica)
84. Saltwort in complex with halophytic sagebrush
85. Meadow grass - sandy-sagebrush, meadow-psammophytic shrub

Central deserts
86. Saltwort in complex with sagebrush
87. Sagobrush with Haloxylon aphyllum
88. Sandy sagebrush-psammophytic shrub with Haloxylon

Southern deserts
89. Saltwort in complex with sand sagebrush
90. Sagebrush
91. Haloxylon aphyllum woodland
92. Sedge-psammophytic shrubs and Haloxylon
93. Sedge-sandy sagebrush and psammophytic shrubs

Piedmont and mountain deserts
94. Young and thalloid plants
95. Ephemeroid-sagebrush
96. Ephemeroid-saltwort
97. Ephemeroid-fether grass-sagebrush
98. Ephemeroid-psammophytic shrub and Haloxylon
99. Ephemeroid-psammophytic shrub
100. Dwarf halfshrubs in some places together with grasses

High mountain deserts
101. Dwarf halfshrub and grass-dwarf semishrub

COMMUNITIES WITH EPHEMERE-EPHEMEROIDAL COVER (SAVANNOIDES)

Piedmont and mountain
102. Mesophytic open woodlands and dwarf shrubs with tall-grass cover
103. Xeromesophytic open woodlands and dwarf shrubs with tall-grass cover
104. Xerophytic open woodlands, dwarf shrubs and dwarf semishrubs with short grass cover, in some places high grasses
105. Short grasses and dwarf semishrub-short grasses

OPEN WOODLANDS AND MOUNTAIN XEROPHYTIC STEPPE VEGETATION (PHRYGANOIDES)

Mountain

106. Jumper open woodland with meadow-steppe cover, admixture of mountain xerophytes in combination with steppes and shrub communities
107. Jumper open woodland with mountain xerophytic steppe cover
108. Jumper open woodland with ephemeroid-mountain xerophytic steppe cover
109. Mountain xerophytic steppe communities

Mires

110. Grass and hypnum grass bog
111. Grass-subshrub-lichen-moss complex polygonal bog
112. Grass-subshrub-lichen-moss palsa bog
113. Grass-hypnum-sphagnum aapa with ridges and pools
114. Hepatic-lichen-sphagnum high bog with ridges and pools
115. Sphagnum raised bog with ridges and pools
116. Grass-sphagnum and subshrub-grass-sphagnum transitional
117. Wooded swampy fen

Shrubbery vegetation

118. Shrub communities

Halophyticc vegetation

119. Herb and grass halophytic meadows
120. Ecological rows of perennial and annual saltworts, halo-phytic grasses, halophytic subshrubs, halophytic shrubs in combination with bare solonchaks

ECOLOGO-DYNAMIC SEQUENCES OF ALLUVIAL COMMUNITIES, SECONDARY (ANTHROPOGENIC) MEADOWS AND AGRICULTURAL AREAS

121. Meadow-bog-shrub sequence with an admixture of willow stand and yernik (dwarf shrub formation with Betula nana) tugai (bottomland complex with forests, bushes and meadows in river valleys)
122. Sor-meadow-small leaved-coniferous sequence
123. Shrub-coniferous sequence
124. Shrub-small leaved-coniferous sequence
125. Shrub-broad leaved-coniferous sequence
126. Shrub-broad leaved forest sequence
127. Shrub-broad leaved forest sequence
128. Halophytic meadow-tugai sequence
129. Shrub-small leaved-coniferous sequence
130. Meadow sequence
131. Reed brakes in plavni (long time flooded areas with Phragmites in river deltas and bottomlands) and lake kettle depressions
132. Reed brakes and halophytic grass meadows in combination with halophytic communities on solonetzes andf solonchaks

APPENDIX 3.

DIGITAL CHART OF THE WORLD DATA AVAILABILITY FOR OBTAINING LAND-COVER INFORMATION.

coverage name	code for definitions	application for Land Cover unit creation	decision rule for Land Cover unit creation (for discussion)	application for Land Cover database construction	form of information for Land Cover data base (for discussion)
PPPOLY	1-urbanised area	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
PPPOLY	2-kampong	no	-	yes	percent of land cover unit
UTLINE	1-power transmission line	no	-	yes	density per Land Cover unit
UTLINE	2-telephone or telegraph line	no	-	yes	density per Land Cover unit
UTLINE	3-above ground pipeline	no	-	yes	density per Land Cover unit
DNNET (polygon)	1-perennial inland water	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
DNNET (polygon)	2-nonperennial inland water	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
DNNET (polygon)	4-snowfield, glacier, ice field	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
DSPOINT	1-small lake, inland water body	no	-	yes	percent of land cover unit
LCPOLY	1-rice field	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit

coverage name	code for definitions	application for Land Cover unit creation	decision rule for Land Cover unit creation (for discussion)	application for Land Cover database construction	form of information for Land Cover data base (for discussion)
LCPOLY	3-cultivated area, garden	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	4-peat cuttings	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	5-salt pan	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	7-quarry, strip mine,mine dump, and blasting area	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	10-lava flow	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	11-distorted surface area	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	12-unconsolidated material	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
LCPOLY	14-inundated area	yes	size of poligon more than 0.6 inch on Charts	yes	percent of land cover unit
TSLINE	1-road structure	yes	critical percent of land cover unit or of density per land cover unit	yes	percent of land cover unit or of density per land cover unit
TSLINE	2-railroad structure	yes	critical percent of land cover unit or of density per land cover unit	yes	percent of land cover unit or of density per land cover unit

APPENDIX 4.

GLOSSARY OF VEGETATION DEFINITIONS (AFTER UNESCO, 1973).

Closed forest-formed by trees at least 5 m tall with their crowns interlocking;

Woodland-composed of trees at least 5 m tall with crowns not usually touching but with a coverage at least 40%;

Scrub-mainly composed of woody plants 0.5 to 5 m tall. Subdivisions:
shrubland-most of the individual shrubs not touching each other, often grass undergrowth;

thicket-individual shrubs interlocked;

dwarf-shrub thicket-branches interlocked, rarely exeeding 50cm in height

Dwarf-shrubland-individual dwarf-shrubs rarely exeeding 50 cm in height and more or less isolated or in clumps;

Tall graminoid vegetation-dominant graminoids over 2 m tall. Forb coverage less than 50%;

Medium tall grassland-the dominant graminoid growth forms are 50 cm to 2 m tall.Forbs cover less than 50%;

Short grassland-the dominant graminoid growth forms are less than 50 cm tall. Forbs cover less than 50%;

Tall forb communities-dominant forb growth forms are more than 1 m tall;

Low forb communities-dominant forb growth forms are less than 1 m tall;

Canopy description classes:

<10%
10-40%
>40%

APPENDIX 5.

LAND COVER CATEGORIES FOR RUSSIA.

VEGETATED

Natural

LAND COVER CATEGORIES	MAP OF VEGETATION (1990). No. of mapping units	MAP OF LAND CATEGORIES. No. of mapping units	DCW
Dwarf-shrubland	5. Small willow stand; 6. Small willow stand; 11. Low bush-lichebn and low bush-moss in combination with shrubs and sparse vegetation on placers; 2. Grass-moss and low bush-grass-moss; 3. Grass-moss and low bush-moss; 4. Low bush-moss; 7. Shrubbery grass-low bush-moss; 8. Low bush-cotton grass-moss;		
Dwarf-shrubland-rangeland	1. Open (unclosed) primitive aggregations of lichen, moss and arctic species of flowering plants; 9. Open (unclosed) aggregations of crustaceous and foliose lichen, moss, arctic-alpine species of flowering plants; 10. Low bush-moss, grass-low bush-moss and lichen; 12. Sparse communities of subnival plants, scree and rock vegetation		
Bushland	118. Shrub communities		

Bushland in combination with rangeland	74. Shrub communities in combination with meadow steppes; 75. Herb-bunchgrass and bunchgrasses in combination with shrubs; 76. Shrubs and bunchgrasses in combination with petrophytes;		
Forest	19. Birch forest with short grass-low bush cover; 26. Spruce and fir-spruce forest with low bushes and short grasses; 27. Spruce-cedar and cedar-spruce forest with grass and low bush cover; 28. Pine forest with low bushes, grasses and lichens; 29. Larch forest; 30. Spruce, fir-spruce and spruce-fir forest with mosaic grass-low bush and grass cover; 31. Cedar-spruce-fir forest with mosaic short grass cover; 32. Pine and larch-pine forest with grasses and low bush-lichens; 34. Dark coniferous forest with admixture of broad-leaved one (undergrowth and cover of nemorose species), broad leaved-dark coniferous forest; 35. Pine forest with grass cover, frequently forest with pine and meadow-steppe species (southern bor); 36. Larch forest with Quercut mongolica, Betula davurica and other grass species; 43. Cedar-spruce and fir-spruce forest; 44. Spruce-fir and cedar-fir forest with grass-low bush cover; 45. Cedar and fir-cedar forest with low bush-short grass cover; 46. Spruce-fir, cedar-fir, fir-spruce forest with nemorose species; 47. Pine forest; 48. Larch forest; 50. Spruce, fir and beech-fir forest; 51. Spruce-fir forest often with Fagus orientalis; 53. Pine forest; 57. Pine-broad-leaved forest with boreal types in the cover; 59. Cedar and broad-leaved forest with ferns and high grasses; 64. Cedar-broad leaved forest		

Woodland	21. Larch forest with low-bush-lichen-grass cover; 33. Larch and pine-larch forest with shrubs and grasses; 37. Aspen-birch forest with grass cover, Tilia cordata, predominated in Pre-Ural region; birch-aspen forest with nemorose species in the region of Kuznetsk Alatau; 38. Pine forest with steppe grass cover; 49. Birch forest with high grass cover; 52. Spruce, fir-spruce, aspen-spruce forest in combination with meadows and steppes; 54. Beech forest frequently with Quercus petraea, Carpinus betulus, Acer pseudoplatanus; 58. Lime-tree and oak forest; 60. Beech forest; 61. Oak and hornbeam-oak forest; 62. Broad-leaved and oak forest; 63. Polydominant moist broad-leaved forest; 65. Walnut and apple-tree forest		

Wooded rangeland	15. Elfin and open woodlands (subalpine); 20. Spruce forest with mosaic low-shrub-grass cover; 22. Spruce thin forest with Betula nana in low bush-lichen-grass undergrowth; 23. Larch-spruce-cedar thin forest with low bush-lichen cover; 24. Pine thin forest with low bush-grass-lichen cover; 25. Larch thin forest with low bush-moss and low bush-lichen cover; 39. Aspen-birch and birch-aspen forest with steppe grass cover; 55. Oak-hornbeam, hornmeam forest with Acer pseudoplatanus, Cerasus aviumm; 56. Oak forest; 66. Herb-grass and grass-herb meadow steppe and steppe meadows in combination with forests (forest steppe); 40. Dark coniferous forest with low bush-moss-lichen cover; 41. Larch forest with low-bush-moss-lichen cover; 102. Mesophytic open woodlands and dwarf shrubs with tall-grass cover; 103. Xeromesophytic open woodlands and dwarf shrubs with tall-grass cover; 104. Xerophytic open woodlands, dwarf shrubs and dwarf semishrubs with short grass cover, in some places high grasses; 106. Jumper open woodland with meadow-steppe cover, admixture of mountain xerophytes in combination with steppes and shrub communities; 107. Jumper open woodland with mountain xerophytic steppe cover; 108. Jumper open woodland with ephemeroid-mountain xerophytic		

Rangeland	13. Herb (alpine) and carpet-like meadows in combination with communities of shrubs and sparse scree and rock vegetation; 14. Herb (short grass) meadows in combination with communities of mountain cryoxerophytes; 16. Herb (middle grass) meadows and umbelliferous plants; 17. Sedge, Cobresia apline, herb (short grass) meadows; 18. Cushion plant formation of herbs, semi-shrubs and shrubs; 42. Communities with Pinus putila in combination with larch open woodland and tundra; 67. Herb (xeromesophytic herbs) and bunchgrass steppe; 68. Herb (mesoxerophytic herbs), bunchgrass and bunchgrass herbs; 69. Northern dry bunchgrass and rootstock (rhizome) grasses; 70. Southern dry xerophytic herbs and bunchgrasses; 71. Northern semishrub and bunchgrass steppe; 72. Southern semishrub and bunchgrass steppe; 73. Meadow and herb-bunchgrass steppe; 77. Short bunchgrasses; 78. Halfshrub-bunchgrass desert steppe; 79. Ephemeroid-bunchgrasses; 80. Mountain xerophytic-bunchgrasses; 81. Cryophytic herbs and bunchgrasses, in some places with ad-mixture of dwarf-pine wood; 82. Pillow-like brunchgrass steppe; 83. Sagebrush (Artemisia) among grasses in complex with sage-brush and saltwort (Salsola rhutenica); 84. Saltwort in complex with halophytic sagebrush; 85. Meadow grass-sandy-sagebrush, meadow-psammophytic shrub;		

Rangeland (cont.)	86. Saltwort in complex with sagebrush; 87. Sagobrush with Haloxylon aphyllum; 88. Sandy sagebrush-psammophytic shrub with Haloxylon; 89. Saltwort in complex with sand sagebrush; 90. Sagebrush; 91. Haloxylon aphyllum woodland; 92. Sedge-psammophytic shrubs and Haloxylon; 93. Sedge-sandy sagebrush and psammophytic shrubs; 94. Young and thalloid plants; 95. Ephemeroid-sagebrush; 96. Ephemeroid-saltwort; 97. Ephemeroid-fether grass-sagebrush; 98. Ephemeroid-psammophytic shrub and Haloxylon; 99. Ephemeroid-psammophytic shrub; 100. Dwarf halfshrubs in some places together with grasses; 101. Dwarf halfshrub and grass-dwarf semishrub; 109. Mountain xerophytic steppe communities; 110. Grass and hypnum grass bog; 111. Grass-subshrub-lichen-moss complex polygonal bog; 112. Grass-subshrub-lichen-moss palsa bog; 119. Herb and grass halophytic meadows; 120. Ecological rows of perennial and annual saltworts, halophytic grasses, halophytic subshrubs, halophytic shrubs in combination with bare solonchaks		
Wooded swamp	117. Wooded swampy fen		
Swamp	113. Grass-hypnum-sphagnum aapa with ridges and pools; 114. Hepatic-lichen-sphagnum high bog with ridges and pools; 115. Sphagnum raised bog with ridges and pools; 116. Grass-sphagnum and subshrub-grass-sphagnum transitional		

Cultivated

Cropland		13, 14, 15, 16, 380, 690	
Plantations		113, 114, 115, 116, 410,	
Irrigated cropland		83, 84, 85, 86, 400, 700	
Irrigated grassland		263, 264, 265, 266	
Irrigated plantations		135,	

UNVEGETATED

Natural

Sands			
Ice			
Rock outcrops			

Man-made

Excavations			
Build up			
Transportal and infrastructural			

INLAND WATER

Natural

Rivers			
Freshwater lakes			
Salinewater lakes			

Man-made

Chanals			
Reservoirs			

MIXED VEGETATED

Patterns of cropland (20%) within rangeland and forest		750,	
Patterns of cropland (20%) within woodland		363, 364, 365, 640,	
Patterns of cropland (20%) within wooded rangeland		203, 213, 490	
Patterns of cropland (20%) within rangeland		770, 830, 293, 294, 295, 296, 316, 590, 570,	
Patterns of cropland (20%) within grassland		760,	
Patterns of cropland (30%) within rangeland and forest		223, 224, 225,	
Patterns of cropland (30%) within grassland and forest		273,	
Patterns of cropland (30%) within wooded rangeland		540, 520	
Patterns of cropland (30%) within rangeland, forest and swamp		243, 244,	
Patterns of cropland (30%) within rangeland, forest and solonchaks		254, 255,	
Patterns of cropland (more than 50%) within forests		63, 64, 65	
Patterns of cropland (more than 50%) within rangeland and forests		44	
Patterns of cropland (more than 50%) within grassland and forests		720	

Patterns of cropland (more than 50%) within rangeland		23, 24, 25, 26, 43, 390, 710	
Patterns of cropland (more than 50%) within grassland		33, 53	
Patterns of cropland (more than 50%) within plantations		123, 125, 126, 420, 73, 75, 76	
Patterns of irrigated cropland (more than 50%) within nonirrigated cropland		93, 95, 96	
Patterns of irrigated cropland (more than 50%) within plantations		106,	
Patterns of irrigated cropland within irrigated plantations more than 50 %)		145, 146	

Primarely Nonvegetated (some examples)

build up areas with roads and infrastructure			
Excavations with water reservoirs			

Complex (some examples)

Croplands with build up areas, roads and infrastructure			
Forest with swamps and lakes			