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International Institute for Applied Systems Analysis • A-2361 Laxenburg • Austria
Tel: +43 2236 807 • Fax: +43 2236 71313 • E-mail: info@iiasa.ac.at • Web: www.iiasa.ac.at

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of Soil Degradation in Russia

Vladimir Stolbovoi (stolbov@iiasa.ac.at)

Günther Fischer (fisher@iiasa.ac.at)

Approved by

Gordon J. MacDonald (macdon@iiasa.ac.at)
Director, IIASA

Table of Contents

Summary

Information on human-induced soil degradation in Russia has now been compiled in a new digital georeferenced database. It comprises the latest data on the status of soil degradation in Russia, including soil deterioration in non-agricultural regions. The information has been linked to a digital soil database, which has recently been prepared for the FAO by the Dokuchaev Soil Institute. Soil degradation attributes were derived from unpublished maps compiled for the State Committee on Land Resources and Land-Use Planning of Russia.

The analysis shows that more than 14.5% (243 million ha) of the Russian territory is affected by soil degradation caused by a variety of reasons, including socio-economic changes, and improper management and technology. The assessment reveals that the rate of soil degradation and loss of soil productivity in Russia has been fairly rapid.

Keywords: soil degradation, land use, soil database, GLASOD

1.   Introduction

Expanding populations and economic development have generated a growing demand for various land-based products, leading to increasing pressure on soils, water resources, and plants. In developing and developed countries, this pressure can exceed critical thresholds and requires land managers to face problems of deteriorating land resources, declining productivity and consequently reduced income. Maintenance of the productive potential of land resources, and checking of land degradation, is a fundamental element of sustainable land use (Pieri, et al., 1995).

The first attempt to combine soil degradation data collected by different ministries and institutes of Russia was undertaken by Dokuchaev Soil Institute in 1988-89 in the frame of the project on Global Assessment of Soil Degradation (GLASOD) (Oldeman, et al., 1991) Since then[1] numerous publications concerning negative human impacts on soil have appeared in scientific and public journals describing types of degradation, their nature, severity, rate of change, extent, consequences, etc. The basic data were collected and published in Government (national) reports on the status and use of land in Russia (Government Report, 1993).

The GLASOD assessment for the Russian territory was based on data of varying quality, ranging from well-documented sources (i.e., on soil erosion) to assessments based on expert opinion (i.e., acidification). Also, the project was limited to degradation of agricultural lands. Thus, several other widespread forms of soil deterioration taking place in Russian forests and permafrost areas were not considered. Another disadvantage resulted from the fact that GLASOD aimed to compile a degradation map "manually". This led to many cartographic restrictions, generalization and loss of collected information presented in tabular and paper formats. There was an enormous discrepancy between the amount of soil degradation data collected and their acceptability and practical application.

The project *Modeling Land-Use and Land-Cover Changes in Europe and Northern Asia (LUC)*, established by IIASA in 1995, recognizes the importance of soil degradation as one of the driving factors in land resources alteration. The present georeferenced database on soil degradation for Russia is the result of collaborative efforts by the LUC project, the Dokuchaev Soil Institute, and the State Committee of Russian Federation on Land Resources and Land-Use Planning.

2.   Objectives

The objectives of this paper are twofold:

- to introduce a new georeferenced database on soil degradation in Russia;
- to overview the soil degradation status in Russia.

2.1   The georeferenced database on soil degradation in Russia

In the georeferenced database on soil degradation in Russia, the spatial information is represented by the mapping units of the updated FAO soil map of Russia (Stolbovoi et al., 1995). The updating was contracted by the FAO and the map was compiled by the Dokuchaev Soil Institute in Moscow on the basis of the latest *Soil Map of the Russian Soviet Federative Socialist Republic* at scale 1:2.5 M (Soil Map, 1988). In total, 1295 mapping units were created.

The attribute database consists of two parts (Fig. 1). The first set of attributes contains general soil information derived from the soil database and included soils, soil phase, slope

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[1] soil degradation was not widely discussed before, as officially at that time the Former USSR did not have widespread ecological problems.

and texture classes, according to FAO's Revised Legend of the Soil Map of the World (FAO-Unesco, 1988).

The second set of attributes relates to soil degradation. It was created by coding information from several unpublished paper maps into digital format (Fig. 2). These maps had been contracted by the State Committee of Russian Federation on Land Resources and Land-Use Planning, and compiled by different authoritative organizations for the Government (national) report on the *Status and Use of Land in the Russian Federation* (Government Report, 1993). The following source maps were used:

- *Map of Soil Water and Wind Erosion in Russia*, at a scale of 1:4 M, compiled by the Dokuchaev Soil Institute, 1992;

- *Map of Recent Land Status of Forest Fund of Russia*, at a scale of 1:4 M, compiled by the All Russian Research Institute of Forest Resources, 1993;

- *Map of Natural Grassland Degradation in Russia*, at a scale of 1:4 M, compiled by the All Russian Research Institute of Fodder, 1992;

- *Map of Soil Salinization in Russia,* at a scale of 1:4 M, compiled by the Dokuchaev Soil Institute, 1992.

Soil degradation attributes were compiled following the *Guidelines for the assessment of the status of human-induced soil degradation in South and Southeast Asia (ASSOD)* (Lynden, (ed.), 1995). The georeferencing of degradation attributes was accomplished by overlaying the polygons from the soil map with each of the maps listed above.

The database contains soil degradation attributes describing type and extent of degradation, and indicating the severity of impacts on productivity, rate of change, causative factor, and rehabilitation or protection measures. Degradation types include water and wind erosion, secondary salinization, desertification, underfloods and compaction. For forest areas, two additional types of soil degradation were distinguished: disturbances of organic horizons caused by industrial cutting, and disturbances caused by fires. To account for the specific forms of degradation in permafrost areas, the distribution of thermokarst and surface corrosion were shown. These two types of soil degradation are mainly caused by overgrazing of deer pastures and by industrial activities such as oil drilling.

2.2   Soil degradation in Russia

When starting with the analysis of soil degradation of a region it is important to take into account the general features of land use (Table 1). This gives an idea of the variety of human impacts on soils, and can help identify and understand the main causative factors.

The cultivated areas are located in the densely populated west European region of Russia and the southern part of the west Siberian plain. Forest land is located both in the European (30% of total forest area) and Asian (70%) parts of Russia.

The total extent of land in Russia affected by soil degradation is estimated at 243 million ha, i.e., 14.4% of the area covered by soil (Table 2). Most soils stable under natural conditions (Table 2) have been formed under undisturbed vegetation (1266 million ha), primarily forests, forest-tundra and tundra. There are some stable soils (30.6 million ha) that have developed under poor vegetation in desert areas, high mountain zones, etc. The third group includes soils that are stable due to human influence (141.8 million ha). The latter comprises soils that are stable due to regulating human influence (reserves, protected areas).

Cultivated land in Russia occupies some 130.7 million ha (Table 1). Almost half of it (63.3 million ha) is affected by various degradation processes caused by cultivation. Soil compaction is the most widespread type of soil degradation influencing agricultural land. Compaction refers to soil conditions with increased bulk density exceeding undisturbed levels by more than 1.2 times. It has been assessed to occur on more than one fourth of the cultivated land (33.2 million ha), mainly in the European part of Russia (Fig. 3). For the first time soil compaction has been widely identified in the northern tundra deer pastures (Fig. 3), caused by overgrazing.

Water and wind erosion are the second most wide-spread types of soil degradation occurring on cultivated land. The total extent suffering from erosion is estimated at 25.8 million ha (Table 2), i.e., approximately one fifth of cultivated land. It occurs in the agricultural regions of both the European and Asian parts of Russia (Fig. 4). The geographical distribution of different types of soil erosion varies with climate aridity. The database indicates (Table 3) that protection measures, comprising land and plant management practices, have been implemented on practically the entire area affected by erosion. However, the effectiveness of these measures appears to be rather low, as can be concluded from the considerable rate of erosion.

Irrigated soils are often influenced by secondary salinization. This type of soil degradation refers to salt accumulation in the upper part of the soil profile resulting from evaporation of irrigation groundwater in the capillary fringe. The estimated extent of secondary saline soils is 3.5 million ha. Protection and rehabilitation measures are used on 3.2 million ha, i.e., some 0.3 million ha of soil affected by secondary salinization are not covered by any protection or rehabilitation activity.

Desertification is the main type of soil degradation affecting moisture deficit zones in steppe, dry steppe, and semi-desert regions. This refers to expansion of desert areas as a result of natural and anthropogenic factors. Desertification extends over 35.7 million ha. It includes a mixture of degradation processes such as compaction, deflation, loss of soil structure, decline of soil water holding capacity, etc. The primary human causative factor of desertification is overgrazing. The rate of desertification has been mostly slow and moderate. One fifth of the area is adjudged a rapid rate, caused by a high degree of human intervention and fragile natural conditions (soil texture and moisture, wind speed, etc.).

Overgrazing is also the main cause of other types of rangeland degradation. In tundra areas it can trigger processes of surface corrosion and thermokarst in gelic soils (solifluction, landslides, etc.). These two types of soil degradation are found (Fig. 5) in the north of the European and West-Siberian parts of Russia as well as in East Siberia and the northern Far East. The total area covered by permafrost is estimated to be more than 1100 million ha (about 65% of the entire Russian territory). Surface corrosion was recorded to occur on 60.2 million ha and thermokarst on 31.2 million ha (Table 2).

The forested area in Russia is 784.7 million ha (Table 1). In these areas, disturbances of the soil organic horizon caused by fires and industrial wood cutting are the main degradation types identified in the database, indicating insufficient forest management and application of inadequate technology.

The extent of disturbances of the soil organic horizon caused by fires during a 10-year period is estimated at 15.4 million ha, or about 2% of the total forested area. The primary cause of forest fires (90%) is human carelessness (see: Land of Russia, 1995). Fires occur mainly in the Asian part of the country, where 40% of the forest is not protected against fire.

Disturbances of the soil organic horizon caused by industrial wood cutting result from the application of heavy machinery, mechanized skidding, etc. It refers to loss of organic and mineral topsoil. The total extent of such disturbances in Russia is estimated at 10 million ha (1.3% of total forested area), widely spread in the European part of Russia (Fig. 6), where clear-cutting is practiced over the whole year.

3.　Conclusions

1. A georeferenced soil degradation database covering the entire territory of Russia now allows one to assess the status of human-induced soil degradation country-wide. The database is available for application to scientific analyses, practical recommendations, and decision- and policy-making. One application is the analysis of actual productivity

and management of soils. It contributes to the understanding of the spatial distribution, causes, and rates of soil degradation, and thus provides information relevant for optimizing the use of soil resources and for sustaining agricultural production.

2. The total extent of soil degradation in Russia is estimated at 243 million ha, or 14.5% of the country. Almost 48% of the cultivated land is affected by various degradation processes. This means that soil degradation is widely spread in Russia.

3. The rate of soil degradation processes over the past 5-10 years has been rather rapid. Apparently the effectiveness of soil protection measures has been low. Thus, it can be expected that the recent trend towards further soil degradation and loss of soil productivity in Russia may continue. This undesirable development calls for proper policy-making.

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APPENDIX

Table 1. The structure of land use in Russia, (from Land of Russia, 1995)

Land categories	Land use by owners (million ha)								
	Agricultural enterprises	Forest enterprises	Urban	Industrial	Land of water fund	Protected areas	Reserves	Total	% of total
Cultivated	122.9	0.2	5.9	0.2	-	-	1.5	130.7	7.6
Other agricultural	63.7	3.6	18.5	1.0	0.0	0.4	3.9	91.1	5.3
Forest and shrubs	134.4	620.5	5.0	3.8	0.1	13.0	7.9	784.7	45.9
Deer & horse rangeland	253.3	60.1	0.0	0.1	-	1.7	12.8	328.0	19.2
Infrastructure	3.6	1.7	5.0	3.0	0.0	0.1	0.0	13.4	0.8
Other land	54.4	62.5	1.7	8.3	0.4	9.1	45.5	181.9	10.6
Swamps	15.8	77.1	1.6	0.4	0.7	1.6	11.0	108.2	6.3
Water bodies	19.6	12.9	0.9	0.8	18.2	1.4	18.0	71.8	4.2
Total	667.7	838.6	38.6	17.6	19.4	27.3	100.6	1709.8	
% of total	39.1	49.0	2.3	1.0	1.1	1.6	5.9		100.0

Table 2. Extent and causes of soil degradation and stable soils in Russia

Degradation type	Extent[2]		Causative factors (million ha)					
	million ha	% of soil area	Cultivation	Over-grazing	Cultivation & over-grazing	Defores-tation	Conflag-ration	Industrial activities
Water erosion	12.8	0.76	12.8					
Water & wind erosion	8.4	0.50	8.4					
Wind erosion	4.6	0.27	4.6					
Terrain deformation	1.7	0.10		1.7				
Compaction	58.3	3.50	33.8	19.3	5.2			
Underfloods	0.9	0.05						0.9
Secondary salinisation	3.5	0.21	3.5					
Desertification	35.7	2.14	0.2	35.4				0.2
Disturbances of soil organic horizon due to cuttings	10.0	0.60				10.0		
Disturbances of soil organic horizon due to fires	15.4	0.92					15.4	
Surface corrosion[3]	60.2	3.61		60.2				
Thermokarst	31.2	1.87						31.2
Total area affected by degradation	242.7	14.44	63.3	116.6	5.2	10.0	15.4	32.3
Stable soil								
Stable due to human influence	141.8	8.43						
Naturally stable by vegetation	1265.5	75.30						
Naturally stable without vegetation	30.6	1.82						
Total stable	1437.9	85.56						

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[2] the discrepancy in total extents of land between Table 1 and Table 2 is mainly due to some differences between the statistics and extents of mapped inland water bodies
[3] natural and human-induced degradation are combined

Table 3. Protection measures, productivity decrease and rate of soil degradation in Russia (million ha)

Degradation type	Protection measures				Productivity decrease			Rate of degradation change			
	Land manage-ment	Plant & land manage-ment	Plant management	Others	Small	Moderate	Large	No change	Slow	Moderate	Rapid
Water erosion	12.8				0.1	12.7			2.8	8.5	1.5
Water & wind erosion		7.9			0.6	7.8			0.8	7.5	0.1
Wind erosion		4.6			0.2	1.9	2.4		0.2	1.7	2.8
Terrain deformation							1.7				1.7
Compaction					43.0	15.3			10.8	25.0	22.6
Under floods						0.9			0.9		
Secondary salinisation				3.2	2.9	0.6		1.0	1.6	0.4	0.4
Desertification					23.6	12.2		1.0	13.4	14.1	7.2
Disturbances of soil organic horizon due to cuttings					10.0					10.0	
Disturbances of soil organic horizon due to fires					n.a.	n.a.	n.a.				15.4
Surface corrosion	0.5	0.6	2.3				60.2[4]			60.2	
Thermokarst							31.3				31.2
Stable due to human influence	2.2		139.5								
Total	15.5	13.1	141.8	3.2	80.4	51.4	95.6	2.0	30.5	127.4	82.9

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[4] natural and artificial degradation are combined

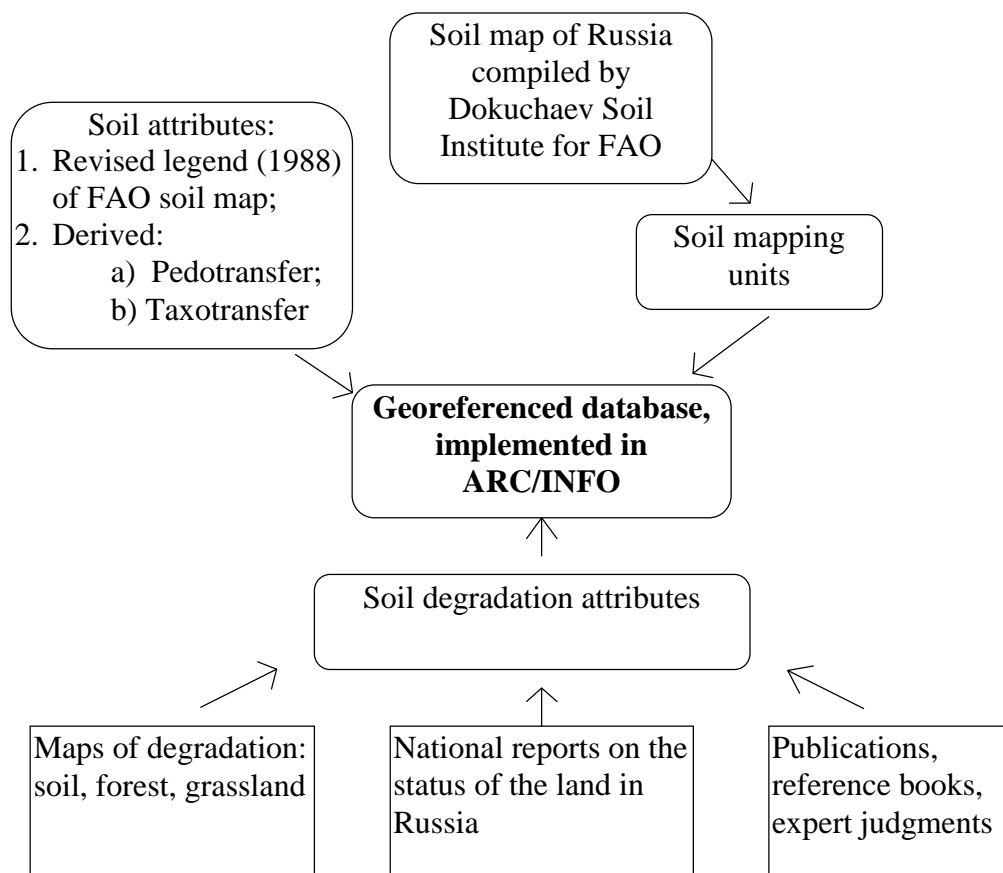**Figure 1. Principal elements and basic sources of the database**
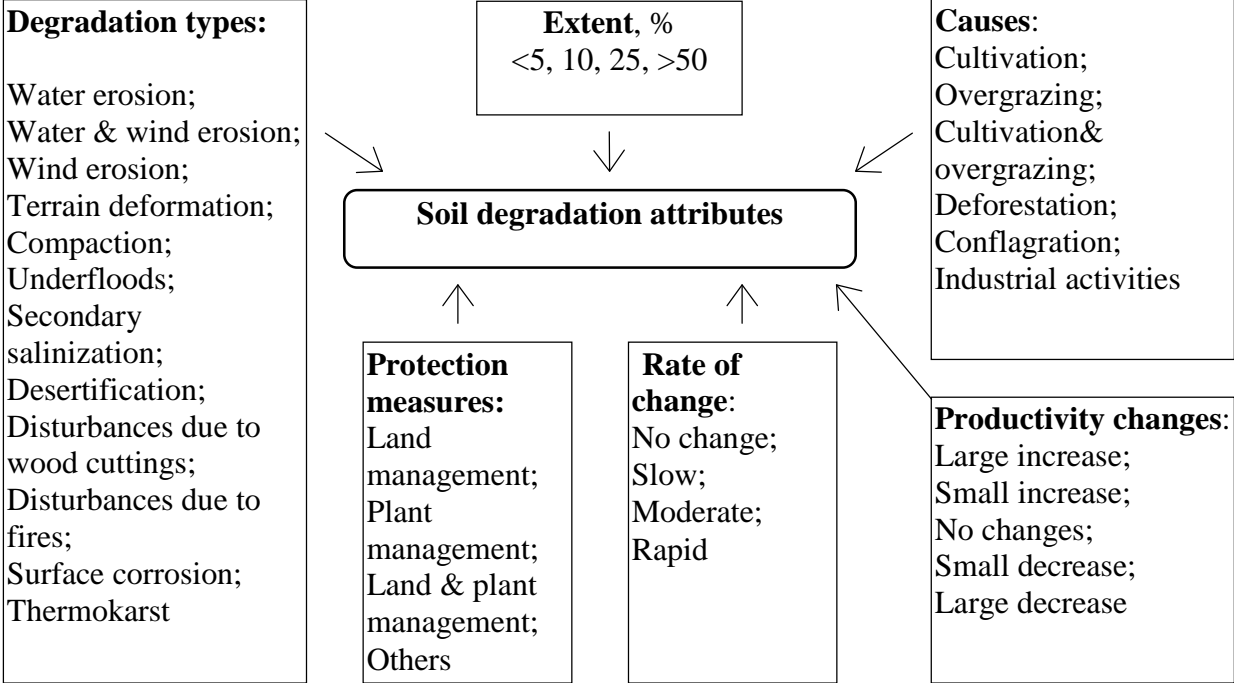
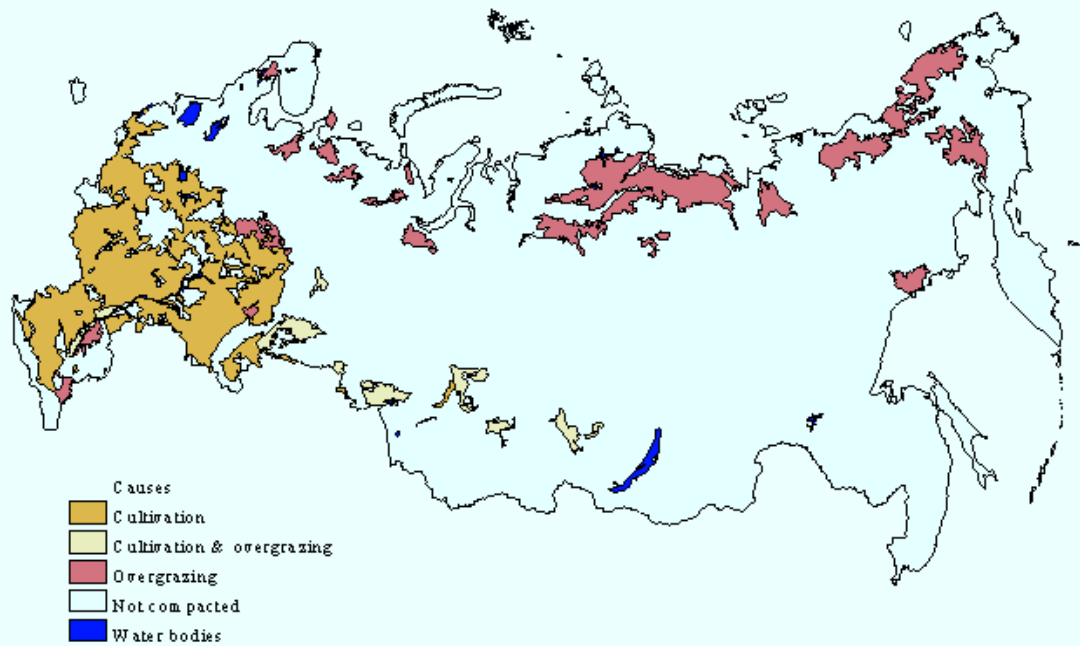**Figure 2. Composition of soil degradation attributes.**

Degradation types:

Water erosion;
Water & wind erosion;
Wind erosion;
Terrain deformation;
Compaction;
Underfloods;
Secondary salinization;
Desertification;
Disturbances due to wood cuttings;
Disturbances due to fires;
Surface corrosion;
Thermokarst

Extent, %
<5, 10, 25, >50

Soil degradation attributes

Causes:
Cultivation;
Overgrazing;
Cultivation& overgrazing;
Deforestation;
Conflagration;
Industrial activities

Protection measures:
Land management;
Plant management;
Land & plant management;
Others

Rate of change:
No change;
Slow;
Moderate;
Rapid

Productivity changes:
Large increase;
Small increase;
No changes;
Small decrease;
Large decrease

12

Figure 3. Soil compaction

Causes
- Cultivation
- Cultivation & overgrazing
- Overgrazing
- Not compacted
- Water bodies

Figure 4. Soil erosion

Types of erosion
- Water
- Water & wind
- Wind
- Terrain deformation
- None
- Water bodies
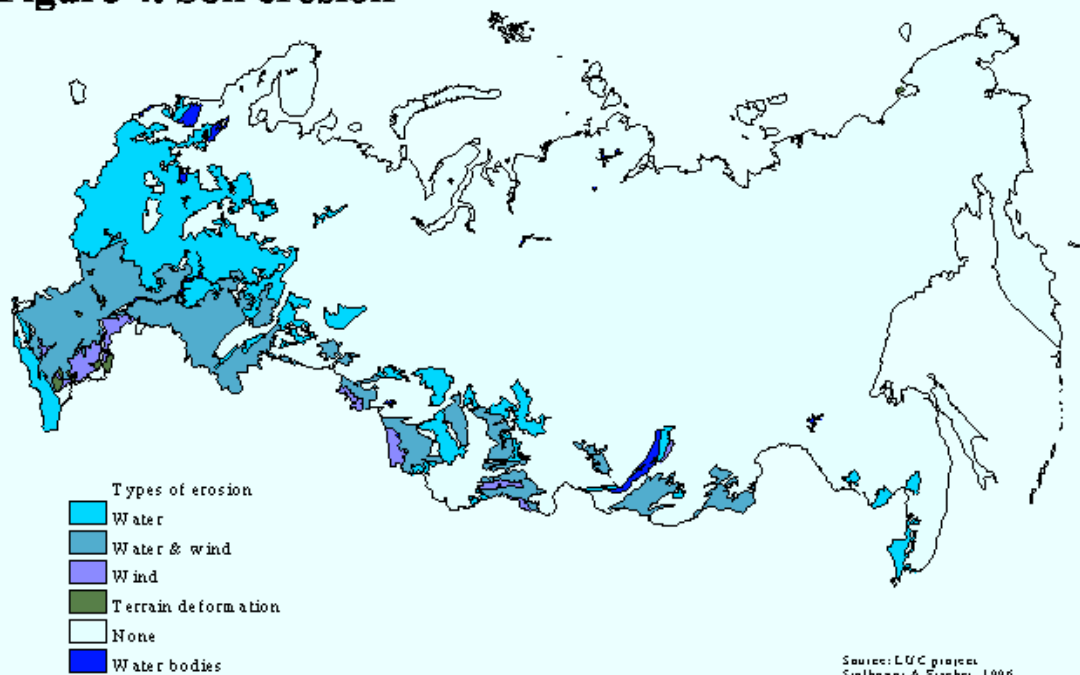
Source: LUC project
Stolbovoi & Fischer, 1996

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Figure 5. Degradation of gelic soils

TYPES
- Surface corrosion
- Thermokarst
- None
- Water bodies
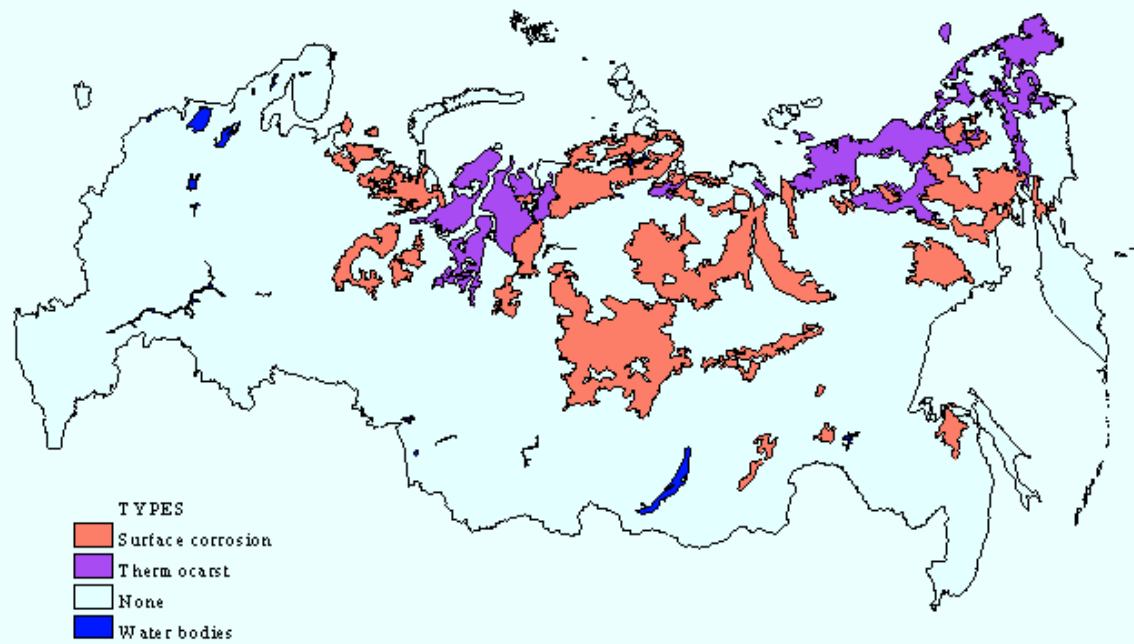
Figure 6. Disturbances of organic horizons of forest soil

CAUSES
- Conflagration
- Conflagration & industrial cutting
- Industrial cutting
- Without disturbances
- Water bodies

Source: LUC project
Svidovoi & Fischer, 1996

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