Chapter 5
Soils of the Central and Western Steppes of the Altai Krai

A. Mizgirev, M. Zierdt, P. Illiger, A. E. Kudryavtsev, A. A. Bondarovich, E. Stephan and G. Schmidt

Abstract The World Reference Base for Soil Resources (WRB) was chosen as the soil classification system for the pedological work of the KULUNDA project. The in-depth analysis and evaluation of anthropogenic soil changes required the use of historical information based on the Russian soil classification system. The soil map of Altai Krai (KGKRF in Soil map of the Altai Territory and the Altai Republic 1986, scale 1:500,000. Novosibirsk, 1992; Kovda and Rozanov in soil science—types of soils, their geography, and use. Moscow, 1988) and the results of a soil science expedition to the Altai Krai in 1954 and 1955 published as "The Soils of Altai Krai" in 1959 (Akademiya Nauk SSSR 1959) worked as reference database. This historical soil information had to be converted to the WRB system to make it comparable to current soil information. An unequivocal conversion and transformation were not always possible resulting in loss of information and data uncertainty. Especially, the information regarding spatial distribution and area percentage of soil groups was affected by having an impact on the analysis of soil changes over time. The article describes the challenges of converting soil information and possible ways of handling them.

Keywords WRB · Agriculture · Landuse change · Soil degradation · Soil mapping

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M. Frühauf et al. (eds.), *KULUNDA: Climate Smart Agriculture*, Innovations in Landscape Research, https://doi.org/10.1007/978-3-030-15927-6_5

5.1 Introduction

The dominant soil groups of the research region are the result of a soil development under high continental climate along a vegetation gradient from forest steppe to typical steppe to dry steppe. Late Pleistocene deposits like loess and loess derivatives are the parent material of the pedogenesis. The short vegetation period and large annual temperature amplitude are the important preconditions for the pedogenesis in the region (Rosanov and Karmanov 1959; Kovda and Rozanov 1988). They vary along a northeast–southwest gradient. While the annual precipitation amounts between 500 and 600 mm/a in the northeast, it is much lower in the southwest with values between 250 and 300 mm/a. With the reduced water supply, the biomass production of the vegetation decreases. Less organic matter means reduced humus horizons and decreased humus content in the soils. Therefore, Chernozems and Kastanozems of different varieties are typical for this climate and vegetation gradient. Because of their good water and nutrient storage capacities, these soils are the foundation for the region's intensive agriculture. Solonetz and Solonchaks are common too, depending on geological and morphological characteristics in the region. Their percentage is less than 25% in the region and they are usually not used for agriculture.

Systematic soil mapping of the region was already started at the end of the nineteenth century and reached its peak with the soil surveys of the Virgin Lands Campaign. In 1959, the summary of the soil surveys of the 1950s was published with the title "The Soils of the Altai Krai" by the Academy of Sciences of the Soviet Union. Based on this work and the results of further soil surveys during the following years, the Committee of Geodesy and Cartography of the Russian Federation published the soil map of the Altai Krai at 1:500,000 scale. Both publications are an essential foundation for the soil degradation research of the KULUNDA project.

Comparing analyses of soil characteristics and soil states are an important approach to evaluate the effects of land use on soils. Historically, different countries developed different soil classification systems and methods which are now problematic for research regarding land use effects on soil quality. Not only the classification but also the field and analytical methods used for soil characterization differ, which makes it difficult—sometimes even impossible—to compare historic data with current soil information. The following material offers not only a description of the soils of the western Altai Krai but also a discussion of problems of converting information from soil maps and of comparing laboratory methods to determine soil characteristics. Exemplified approaches will be presented.

5.2 Converting Soil Information from the Russian Soil Classification System to the WRB Standard

The necessity to transform soil information from the Russian Soil Classification System and pedological field and laboratory research arose from the agreement to use the “World Reference Base for Soil Resources” (FAO 2014) as a reference system for the work of the KULUNDA project. First steps were taken to compile Russia’s soil information and make it useable for an international context as early as in the 1980s. This was done for the project GLASOD—Global Assessment of Soil Degradation (Oldeman et al. 1991) which had the global evaluation of soil degradation as its goal (Stolbovoi and Fischer 1997). Stolbovoi provided an updated version of the Russian soil information for the FAO World Soil Map in 2000. The conversion was based on Russia’s Soil Map at 1:2,500,000 scale.

Unfortunately, for the KULUNDA project, this scale is too small for a sufficiently differentiated depiction of the varying soil groups and soil characteristics in the western Altai Krai. The conversion of soil information with a higher resolution was required. The soil map of the Altai Krai at 1:500,000 scale seemed suitable (Kovda 1973; Kovda and Rozanov 1988). It was published by the Committee of Geodesy and Cartography of the Russian Federation (Komitet po geodezii i kartografii Rossiiskoi Federatsii (KGKRF)) in 1992.

5.2.1 Depiction of Different Classifications

The usage of the higher-resolution soil map of the Altai Krai required a new and differentiated conversion of the soil groups into the WRB format. The comparison of both soil maps for the Altai Krai revealed some differences regarding the soil groups based on the Russian Soil Classification System. The map at 1:2,500,000 scale did not depict ten soil subgroups which are contained in the legend of the map at 1: 500,000 scale (see Table 5.1). This kind of generalization loss was corrected for the soils of the chosen research regions. In this process, overall 40 soil groups and soil subgroups were identified and translated into the WRB in the research regions.

The comparison of soil profile descriptions in both map legends showed some differences, too (see Table 5.1 and Chap. 2). The reason for the differences was that the profile descriptions of the soil map at 1:500,000 scale from Kovda (1973) were based on the soil classification system for the legend of the FAO World Soil Map but the Stolbovoi (2000) used the since 1974 developed WRB soil classification (see Table 5.1). The use of these data sets results at least in the different allocation of qualifiers for some soil groups. But it might even result in a different spatial allocation of soil groups which would lead to a completely different depiction of the soil distribution. The further usage of such soil maps holds quite some uncertainty for a comparing analysis and evaluation of soil degradation phenomena.

Table 5.1 Comparison and conversion of soil information of the research region with different scale references (Mizgirev 2013)

Name Russian	Name Transliterated	Name Englisch	Type_Profile (Kovda 1973; Kovda and Rozanov 1988)	Type_Profile (Stolbovoy 2000)
Черноземы оподзоленные	Chernozemy opodzolennye	Chernozems podzolized	Ah/AB/Bt,f,al/Bca/Cca	A1-A1B-Bt-Bca-Bcca-Cca
Черноземы выщелоченные	Chernozemy vyshelochennye	Chernozems leached	Ah/AB/Bt/Bca/Cca	A1-A1B-Bt-Bca-Bcca-Cca
Черноземы типичные	Chernozemy tipichnye	Chernozems typical	Ah/AB/Bca/BCca/Cca	A1-A1Bca-Bca-BCca-Cca
Черноземы обыкновенные	Chernozemy obyknovennye	Chernozems ordinary	Ah(Aca)/ABca/Bnca/BCcs	A1-A1Bca-Bca-BCca-Cca-Cs
Черноземы обыкновенные карбонатные	Chernozemy obyknovennye karbonatnye	Chernozems ordinary calcareous		A1ca,z-A1Bca,z-BCca,z-Cca
Черноземы обыкновенные солонцеватые	Chernozemy obyknovennye solontsevatye	Chernozems ordinary solonetzic		A1-A1Bslca-Bsl,ca-Cca
Черноземы южные	Chernozemy yuzhnye	Chernozems southern	Ah(Aca)/AB(ABca)/Bca/BCca/Cca/Ccs/Cca	A1ca-A1Bca,sl-BCs-Cs
Черноземы южные солонцеватые	Chernozemy yuzhnye solontsevatye	Chernozems southern solonetzic		A1-A1Bslca-Bsl,ca-Cca
Лугово-черноземные	Lugovo-chernozemnye	Meadow-chernozemics	Ad/AB/Bca/Cg	A1-A1B-B-Bca-Cca(Cca,g)
Лугово-черноземные солонцеватые	Lugovo-chernozemnye solontsevatye	Meadow-chernozemics solonetzic	Ad/AB/Bca/Bna/Cg	A1-A1Bsl,ca-Bsl,ca-Cca(g)
Лугово-черноземные засоленные	Lugovo-chernozemnye zasolennye	Meadow-chernozemics saline	Ad/AB/Bca/Bsa/Cg	A1-A1Bsl,ca-Bsl,ca-Cca(g)
Темнокаштановые	Temnokashtanovye	Chestnuts dark	A/AB1/AB2/Bca/Bcs/C	A1-A1B-Bca-Bca,cs-Ccs
Каштановые	Kashtanovye	Chestnuts	A/AB/Bt/Bca/Bcs/C	A1-B-Bca,cs-BCcs-Ccs
Светлокаштановые	Svetlokashtanovye	Chestnuts light	A/E/Bt/Bca/Bcs/C	A1-B-Bca-Bcs-Ccs

(continued)

Table 5.1 (continued)

Name Russian	Name Transliterated	Name Englisch	Type_Profile (Kovda 1973; Kovda and Rozanov 1988)	Type_Profile (Stolbovoy 2000)
Каштановые солонцеватые	Kashtanovye solontsevatye	Chestnuts solonetzic	A/AB/Bt/Bca/Bcs/Bna/C	
Светлокаштановые солонцеватые	Svetlokashtanovye solontsevatye	Chestnuts light solonetzic	A/E/Bt/Bca/Bcs/Bna/C	
Луговато-каштановые	Lugovato-kashtanovye	Meadow-chestnuts	Ad/AB/Bca/Bcs/Cg	A1-B-Bca-Cca(Cca,g)
Луговато-каштановые солонцеватые	Lugovato-kashtanovye solontsevatye	Meadow-chestnuts solonetzic	Ad/AB/Bca/Bcs/Bna/Cg	A1-A1Bsl-Bca-BCca(cs)-Ccs(g)
Луговато-каштановые засоленные	Lugovato-kashtanovye zasolennye	Meadow-chestnuts saline	Ad/AB/Bca/Bcs/Bsa/Cg	
Болотные низинные торфянисто- и торфяно-глеевые	Bolotnye nizinnye torfyanisto- i torfyano-gleevye	Peats low moor gleyic and peats boggy gleyic	T1/(T2/)G	
Лугово-болотные	Lugovo-bolotnye	Meadow-boggy	Ad(T)/G	(O)-Av-A1g-Bg-G
Лугово-болотные засоленные	Lugovo-bolotnye zasolennye	Meadow-boggy saline	Ad,na(Tna)/G	A1(sl)-A1B(sl)-Bca,(cs),(s),(g)-Cg,ca,(cs),(s)
Луговые	Lugovye	Meadows	Ad/A/AC/Cg	A1-A1B-Bg,ca-Cg,ca
Луговые засоленные	Lugovye zasolennye	Meadows saline	Ad/A/ACna/Cg	A1(sl)-A1B(sl)-Bca,(cs),(s),(g)-Cg,ca,(cs),(s)
Солоди луговые	Solodi lugovye	Meadows differentiated and solodic	Ad(T)/Eg/Bt,g/Bca,g/Bcs,g/Bsa,g/Cg(G)	A1-A2(A1A2)-Bt,(g)-Bca,(g)-Cg
Солонцы лугово-черноземные	Solontsy lugovo-chernozemnye	Meadow-chernozemics solonetzic	Ad/(Ah/)E/Bna/Bca/Bcs/Bsa/C	

(continued)

Table 5.1 (continued)

Name Russian	Name Transliterated	Name Englisch	Type_Profile (Kovda 1973; Kovda and Rozanov 1988)	Type_Profile (Stolbovoy 2000)
Солонцы лугово-черноземные засоленные	Solontsy lugovo-chernozemnye zasolennye	Meadow-chernozemics solonetzic and saline		
Солонцы лугово-каштановые	Solontsy lugovo-kashtanovye	Meadow-chestnuts solonetzic	Ad/(Ah/)E/Bna/Bca/Bcs/Bsa/C	
Солонцы лугово-каштановые засоленные	Solontsy lugovo-kashtanovye zasolennye	Meadow-chestnuts solonetzic and saline		
Солончаки типичные	Solonchaki tipichnye	Solonchaks typical	Asa/ACsa/Csa	
Солончаки луговые	Solonchaki lugovye	Solonchaks meadow	Ad,sa/ACsa/Csa	
Аллювиальные луговые насыщенные	Allyuvial'nye lugovye nasyshennye	Alluvials meadow saturated	Ad/A/AC/Cg	A1-B-Bg-CDg
Аллювиальные луговые насыщенные засоленные	Allyuvial'nye lugovye nasyshennye zasolennye	Alluvials meadow saturated saline	Ad/A/ACna/Cg	
Аллювиальные лугово-болотные	Allyuvial'nye lugovo-bolotnye	Alluvials swamp meadow	Ad(T)/G	

(continued)

Table 5.1 (continued)

Name Russian	Name Transliterated	Name Englisch	Group_WRB (FAO/IIASA/ISRIC/ISSCAS/JRC 2012)	Qualifier WRB	Code_wrb
Черноземы оподзоленные	Chernozemy opodzolennye	Chernozems podzolized	Phaeozem	Luvic	PHlv
Черноземы выщелоченные	Chernozemy vyshelochennye	Chernozems leached	Chernozem	Luvic	CHlv
Черноземы типичные	Chernozemy tipichnye	Chernozems typical	Chernozem	Haplic	CHha
Черноземы обыкновенные	Chernozemy obyknovennye	Chernozems ordinary	Chernozem	Haplic	CHha
Черноземы обыкновенные карбонатные	Chernozemy obyknovennye karbonatnye	Chernozems ordinary calcareous	Chernozem	Haplic	CHca
Черноземы обыкновенные солонцеватые	Chernozemy obyknovennye solontsevatye	Chernozems ordinary solonetzic	Chernozem	Luvic	CHlv
Черноземы южные	Chernozemy Yushnye	Chernozems southern	Chernozem	Calcic	CHca
Черноземы южные солонцеватые	Chernozemy Yushnye solontsevatye	Chernozems southern solonetzic	Chernozem	Calcic, Luvic	CHcalv
Лугово-черноземные	Lugovo-chernozemnye	Meadow-chernozemics	Phaeozem	Haplic	PHha
Лугово-черноземные солонцеватые	Lugovo-chernozemnye solontsevatye	Meadow-chernozemics solonetzic	Phaeozem	Luvic	PHlv
Лугово-черноземные засоленные	Lugovo-chernozemnye zasolennye	Meadow-chernozemics saline	Phaeozem	Luvic	PHlv

(continued)

Table 5.1 (continued)

Name Russian	Name Transliterated	Name Englisch	Group_WRB (FAO/IIASA/ISRIC/ISSCAS/JRC 2012)	Qualifier WRB	Code_wrb
Темнокаштановые	Temnokashtanovye	Chestnuts dark	Kastanozem	Haplic	KSha
Каштановые	Kashtanovye	Chestnuts	Kastanozem	Haplic	KSha
Светлокаштановые	Svetlokashtanovye	Chestnuts light	Kastanozem	Haplic	KSha
Каштановые солонцеватые	Kashtanovye solontsevatye	Chestnuts solonetzic	Kastanozem	Luvic	KSlv
Светлокаштановые солонцеватые	Svetlokashtanovye solontsevatye	Chestnuts light solonetzic	Kastanozem	Luvic	KSlv
Луговато-каштановые	Lugovato-kashtanovye	Meadow-chestnuts	Phaeozem	Haplic	PHha
Луговато-каштановые солонцеватые	Lugovato-kashtanovye solontsevatye	Meadow-chestnuts solonetzic	Phaeozem	Luvic	PHlv
Луговато-каштановые засоленные	Lugovato-kashtanovye zasolennye	Meadow-chestnuts saline	Phaeozem	Luvic	PHlv
Болотные низинные торфянисто- и торфяно-глеевые	Bolotnye nizinnye torfyanisto- i toryano-gleevye	Peats low moor gleyic and peats boggy gleyic	Histosol	Terric	HStr
Лугово-болотные	Lugovo-bolotnye	Meadow-boggy	Gleysol	Mollic	GLmo
Лугово-болотные засоленные	Lugovo-bolotnye zasolennye	Meadow-boggy saline	Gleysol	Mollic	GLmo
Луговые	Lugovye	Meadows	Gleysol	Umbric	GLum

(continued)

Table 5.1 (continued)

Name Russian	Name Transliterated	Name Englisch	Group_WRB (FAO/IIASA/ISRIC/ISSCAS/JRC 2012)	Qualifier WRB	Code_wrb
Луговые засоленные	Lugovye zasolennye	Meadows saline	Gleysol	Umbric	Glum
Солоди луговые	Solodi lugovye	Meadows differentiated and solodic	Planosol	Mollic	PLmo
Солонцы лугово-черноземные	Solontsy lugovo-chernozemnye	Meadow-chernozemics solonetzic	Solonetz	Gleyic	SNgl
Солонцы лугово-черноземные засоленные	Solontsy lugovo-chernozemnye zasolennye	Meadow-chernozemics solonetzic and saline	Solonetz	Gleyic	SNgl
Солонцы лугово-каштановые	Solontsy lugovo-kashtanovye	Meadow-chestnuts solonetzic	Solonetz	Gleyic	SNgl
Солонцы лугово-каштановые засоленные	Solontsy lugovo-kashtanovye zasolennye	Meadow-chestnuts solonetzic and saline	Solonetz	Gleyic	SNgl
Солончаки типичные	Solonchaki tipichnye	Solonchaks typical	Solonchak	Haplic	SCha
Солончаки луговые	Solonchaki lugovye	Solonchaks meadow	Solonchak	Gleyic	SCgl
Аллювиальные луговые насыщенные	Allyuvial'nye lugovye nasyshennye	Alluvials meadow saturated	Fluvisol	Umbric	FLum
Аллювиальные луговые насыщенные засоленные	Allyuvial'nye lugovye nasyshennye zasolennye	Alluvials meadow saturated saline	Fluvisol	Thionic	FLti
Аллювиальные лугово-болотные	Allyuvial'nye lugovo-bolotnye	Alluvials swamp meadow	Fluvisol	Umbric	FLum

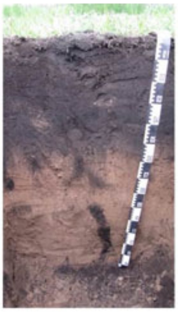
5.2.2 *Exemplified New Examination and Description of Soil Horizons of Selected Soil Profiles*

Additional to the analysis of existing maps, soil profiles were examined in the field and described based on the WRB soil classification system. A soil profile database was built for the research regions which is accessible here: http://www.sibessc.uni-jena.de/. Samples were taken from the described profiles. The samples were analyzed to determine soil characteristics like organic matter, texture, aggregate stability, carbonate content, bulk density, pH value, etc. The analyses were conducted in the laboratories of the Altai State University, the Agrarian State University of the Altai Krai as well as the Institute of Water and Ecological Problems of the Siberian Department of the Russian Academy of Sciences.

The purpose of the examinations was the comparison of current results with data of earlier soil surveys and the evaluation of type and intensity of agricultural land use effects on the soils. The pedological analyses produced a multitude of new data about the soil characteristics of the examined profiles. Figure 5.1 presents profile examples of the widespread soil groups Haplic Chernozem and Haplic Kastanozem.

Profile - Datasheet

Name/No.	202
Date	28-05-2014
Editor	Illiger/Stephan/Mizgiriev
Position	81,637673 - 52,900049
Altitude	247 m
Inclination/ Exposition	< 1°
Usage	Extensive Pasture, Hay Meadow
Notice	West of Perwomayskij, no tilling since 1960s
Soil Type	Haplic Chernozem



Horizon Symbol	Ah	AC	C		
Lower edge (cm)	45	60	60+		
Grain Size	Ut2	Ut2	Ut3		
Soil Colour	10YR 2/1	mix	10YR 5/4		
Moisture (FDR)	31,4%	26,2%	27,0%		

Laboratory Results

Hori-zon	Depth (cm)	Bulk Density (g/cm³)	SOM (%)	pH H_2O	Elec. conduc. (μS/cm)	$CaCO_3$ (%)	SOC (%)	C/N
Ah	15	1,09	5,85	6,8	251	0,09	3,33	10,6
Ah	30	1,14	4,79	7,3	246	0,28	2,72	10,5
C	60	1,34	2,3	7,7	592	0,18	1,31	13,0

Profile - Datasheet

Name/No.	73
Date	17.09.2012
Editor	Illiger/Stephan/ Schmidt/Holzweißig
Position	N5769406.13E424631.51
Altitude	137m
Slope/ Exposition	>1
Usage	Field/ Pea
Notice	Amazone test field; Poluyamkij/ Condor
Soil Type	Haplic Kastanozem

Horizon Symbol	Ah	AC	Ckc	C
Lower edge	30	45	90	120+
Soil Moisture	dry	dry	dry	dry
Grain Size Fraction	SLSi (Uls)	SLSi (Uls)	SL (Ls2)	LS (Sl4)

Laboratory Results

Horizon	Depth (cm)	Bulk density (cm³)	organic Matter (%)	pH H2O	Conduc-tance (μS/cm)	CaCO3 (%)	TC (%)	C/N
Ah	15	1,17	4,68	8,56	398,7	0,43	1,75	12,4
AC	30	1,27	4,27	7,32	127,5	0,23	1,45	9,6
Ckc	60	1,31	3,55	7,9	355,7	11,66	3,1	25,4
C	120	1,46	1,86	8,17	268,0	5,43	1,15	10,4

Fig. 5.1 Examples of standard profile datasheets of the KULUNDA project's soil survey (left Haplic Chernozem, right Haplic Kastanozem)

5.3 Comparability of Analytical Methods Used for Soil Characterization

The intended comparison presumes that the laboratory analyses were conducted using the same methods and the evaluation of the results was based on the same classification system. But the analytical methods for numerous soil characteristics have changed repeatedly in the past and are now more advanced. This presents one of the biggest challenges for converting soil information from the Russian soil classification system into the WRB classification system and using the data of earlier soil surveys for comparisons.

Soil characteristics texture and soil organic matter are especially problematic. The Russian particle-size classification system uses different classification limits and the determination of the humus content uses a completely different analytical method. Comprehensive comparative analyses were required. For instance, soil organic matter analyses have been performed with different methods. They showed mismatching and not comparable results, which is based on the differences in the analytical method. Using this data to analyze changes over time would result in misinterpretations.

5.3.1 Texture

Texture is a fundamental physical soil characteristic which influences the hydraulic properties and erodibility of soils. Figure 5.2 compares the Russian and international particle-size classification. The limits of the particle-size classes are lower in the Russian system than in the international classification.

The usage of texture data derived from different classification methods might result in erroneous evaluations of soil erodibility or water storage capacity. As an example, the infiltration capacity of sandy soil is underestimated if the Russian particle-size classification system is used because the maximal size of its sand class is 1 mm. Depending on the number of particles between 1 and 2 mm in the soil, pore space and pore diameter might be less than thought.

The differences between the classification systems are even greater regarding the definition of textural classes based on the particle-size distribution. While the definition for clay is almost identical, the particle-size distribution of silts and loams

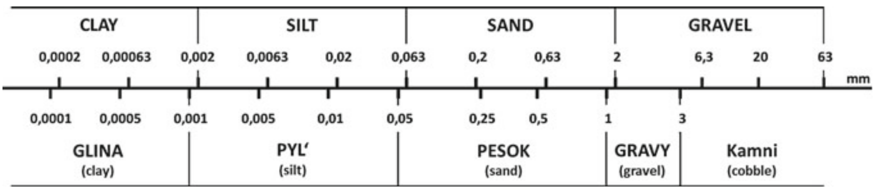


Fig. 5.2 Comparison of the Russian and the international particle-size classes. *Source* FAO (2014), Kovda and Rozanov (1988), Mizgirev et al. (2015) and Scheffer and Schachtschabel (2000)

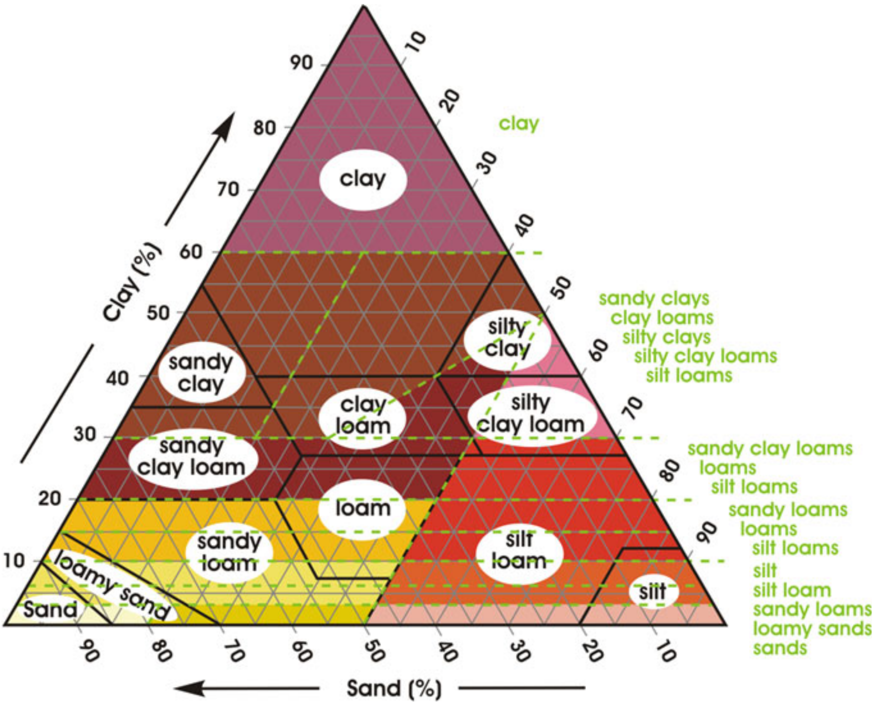


Fig. 5.3 Combined display of textural classes based on the Russian and international texture classification system (underlying color—international classification, green Russian system). *Source* FAO (2014), Kovda and Rozanov (1988) and Mizgirev et al. (2015)

differs widely between the two systems (see Fig. 5.3). The comparability of soil information depends on textural classes, which make it almost impossible to convert data from one system to the other. For this reason, the standardized evaluation of the erosion susceptibility of locations based on older and current data and the evaluation of land use effects is affected by high uncertainty (Mizgirev 2013; Mizgirev et al. 2015).

5.3.2 Soil Organic Matter, Humus, Organic Carbon

The organic substances in soils that are left after decomposition of organic matter are called humic substances. That is why in literature, the term "humus" is often used synonymously with "organic substance." The amount of organic substance or humus besides texture is an important soil characteristic for classifying them into soil groups. As well the direct comparison of soil organic matter data with different time references allows an assessment of soil degradation under different land use types.

Traditionally, the determination of all organic carbon compounds is done in the Slavic speaking region by the wet-combustion method according to Tyurin. Dry-combustion in a muffle oven (also called loss by combustion) and elemental analysis are the common methods in the USA and Western Europe. Higher or lower results due to the usage of different analytical methods might result in the different classification of soils. These analytical differences limit the comparability of data. This is a problem because the data collected in the project cannot be easily compared with data from Russian soil surveys.

For this reason, new determinations of soil organic matter were made in connection with the exemplified new examination and description of soil horizons of selected soil profiles in the project (see Chap. 19). The method of chrono-sequences was then used to assess soil degradation by land use.

5.4 Soil Map of the Altai Krai Based on the WRB Soil Classification System

Due to its location in the high continental region of southern Siberia, the Altai Krai has the typical soil pattern of steppe regions. Along a climatic northwest–southeast gradient, the landscape changes by the transition from the forest steppe with typical Chernozems in the east of the Altai Krai to the light Kastanozems of the dry steppe in the southwest. About 71% of the Altai Krai's soils are Chernozems and Kastanozems (see Fig. 5.4). Solonetz, Gleysols, Fluvisols, and Histosols are taking up smaller areas.

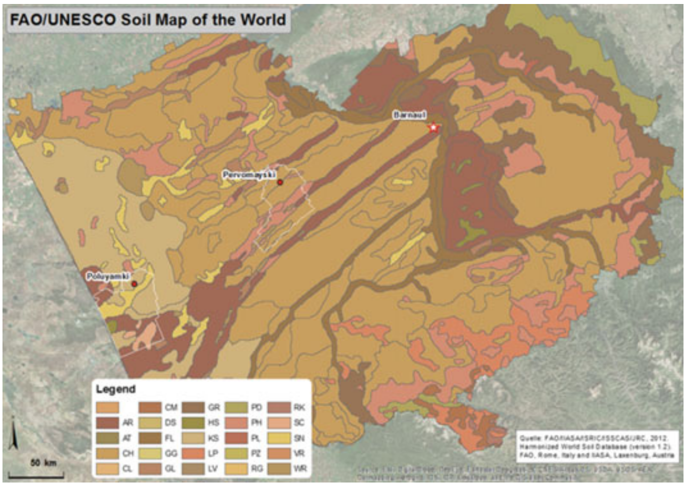


Fig. 5.4 Soil map of the Altai Krai based on the WRB soil classification map at 1:5 million scale. *Source* FAO (2007, 2014)

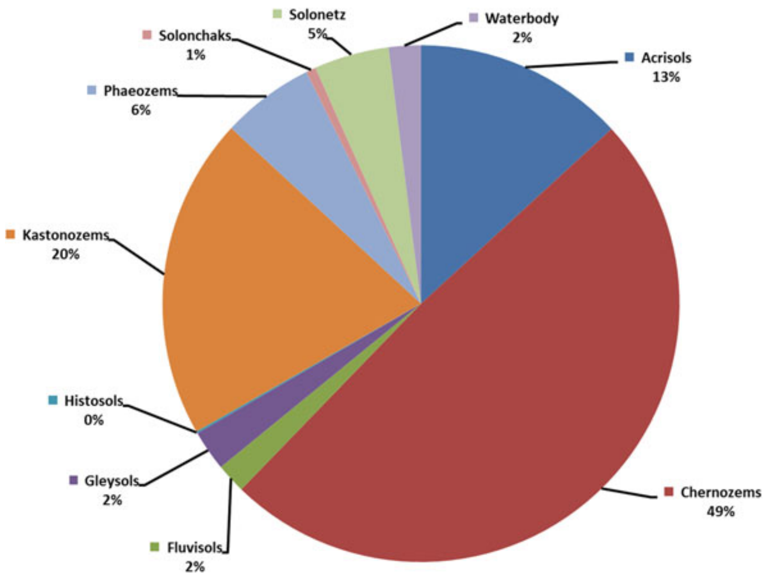


Fig. 5.5 Percentage of the soil groups of the research region. *Source* FAO/IIASA/ISRIC/ISSCAS/JRC (2012)

Work of the KULUNDA project was concentrated on the area to the west of the Ob River and north of the Aley River. It borders at the Novosibirsk region in the north and Kazakhstan in the west. The total of the research region is 77,427 km^2. 69% of the region's soils are Chernozems (49%) and Kastanozems (20%) (see Fig. 5.5) which is very similar to the soil distribution of whole Altai Krai. Acrisols (13%), Phaeozems (6%), and Solonetzes (5%) are other soils of this area.

The soil patterns of the districts, where the test areas are located, are different depending on the local conditions. Figure 5.6 displays the integration of the soil maps of the Rayons Mamontovskiy and Mikhaylovskiy at 1:500,000 scale into the FAO World Soil Map at 1:5,000,000 scale. The much more detailed soil patterns due to the different scaling are clearly visible.

The soil pattern of the Mikhaylovskiy Rayon at 1:500,000 scale shows not only a large variety but also a different percentage of soils in comparison with the research region (see Fig. 5.7). Here, only 26% of the soils are Chernozems but the portion of Solonetzes is with 20% almost four times higher than in the research region. The displayed percentage of Podzoluvisols is about 14% and the Kastanozem portion is the same in the Mikhaylovskiy Rayon as in the whole research region.

The soil map at 1:500,000 scale was converted into the WRB classification system for the districts of the test areas. The comparison with the FAO World Soil Map at 1:5,000,000 scale exemplified by the Mikhaylovskiy Rayon shows clearly a less detailed soil pattern for the small-scale map (six soil groups are displayed). The large-scale map displays the soil pattern much more detailed with eleven soil groups

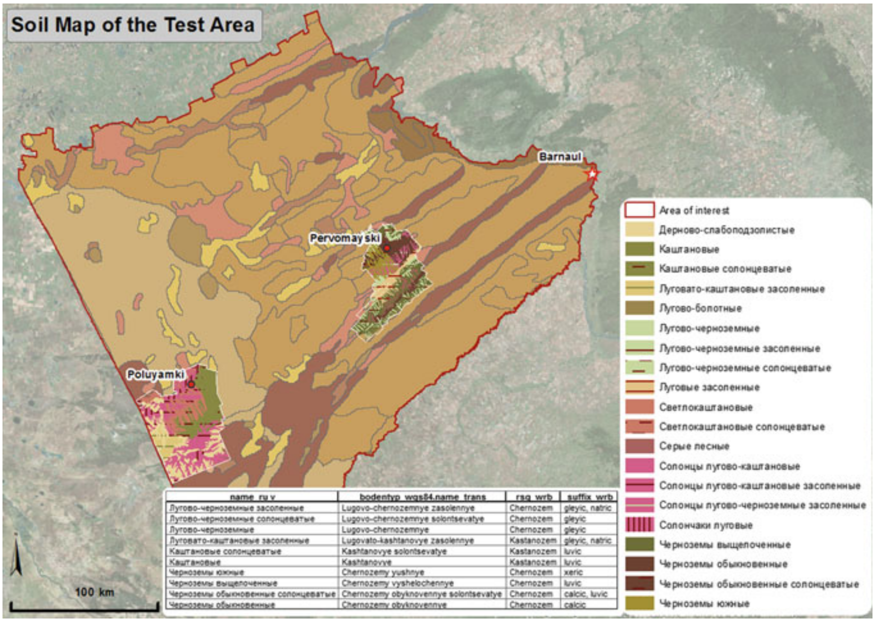


Fig. 5.6 Integration of the soil map at 1:500,000 scale into the FAO World Soil Map of the research area (Mizgirev 2013)

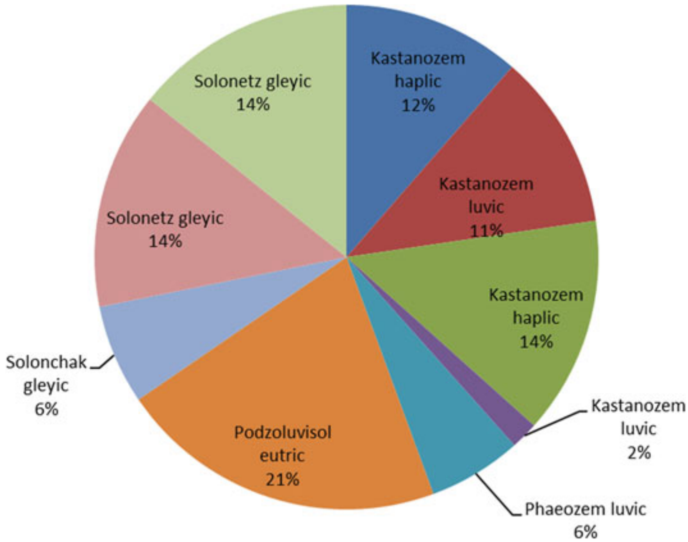


Fig. 5.7 Percentage of the different soil units in the Mikhaylovskiy Rayon. *Source* Kovda and Rozanov (1988); KGKRF (1992)

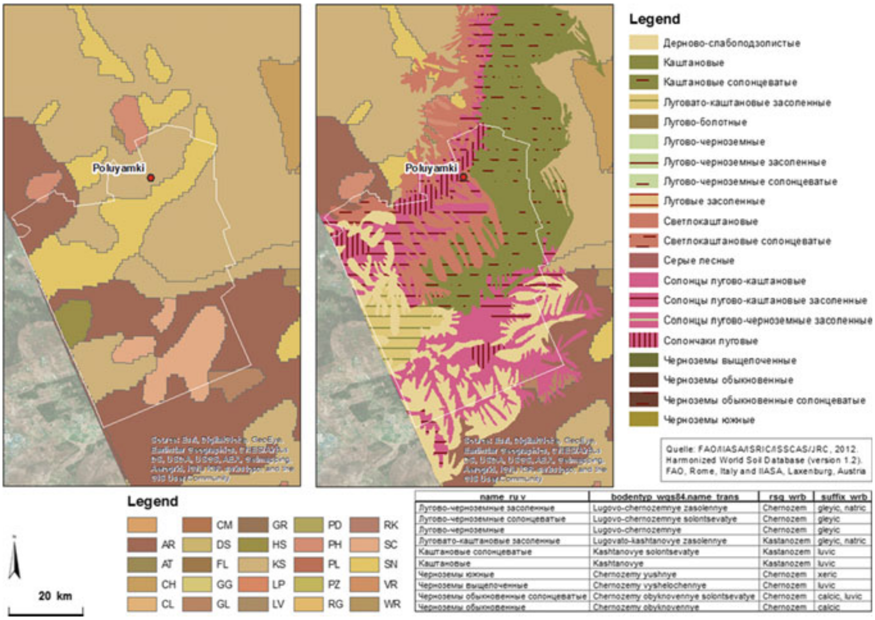


Fig. 5.8 Segments of the FAO World Soil Map (FAO/IIASA/ISRIC/ISSCAS/JRC 2012) and the soil map of the Altai Krai (KGKRF 1992) exemplified by the Mikhaylovskiy Rayon (Mizgirev 2013)

(which are 18 soil groups according to the Russian soil classification system) (see Fig. 5.8). This map reveals that besides Solonetzes a multitude of subgroups of Kastanozems and Chernozems with different saline properties exist which is not shown in the generalized world soil map.

The comparison of both differently scaled maps of the Mikhaylovskiy Rayon does not only reveal the higher degree of differentiation by the map at 1:500,000 scale, it also shows that each map displays soil groups which cannot be found in the other map. The reason is probably not the different map scaling (see Table 5.2), but rather a different interpretation of the soil data for the different soil profiles. The most significant result of the comparison of both soil maps is the absence of Chernozems in the FAO soil map at 1:5,000,000 scale. Here, 24% of the soils are classified as Acrisols.

5.5 Conclusions

The research of the soil pattern and soil characteristics in the Altai region posed a challenge for all parties involved because the comparative analyses of the soil state were based on pedological data of historic Russian soil surveys and new, current

Table 5.2 Comparison of the area of the soil groups in the Mikhaylovskiy Rayon in the soil maps at 1:500,000 scale (KGKRF 1992) and 1:5,000,000 scale (FAO 2012)

Soil (Kovda and Rozanov 1988, KGKRF 1992)	KGKRF_translated to FAO (1:500,000)	Area [%]	FAO WRB (1:5 Mill)	Area [%]
Chernozems leached	Chernozem Luvic	12.8	**Chernozems**	**0.0**
Chernozems ordinary	Chernozem Haplic	7.2		
Chernozems ordinary Solonetzic	Chernozem Luvic	1.9		
Chernozems southern	Chernozem Calcic	5.5		
	Chernozems	**27.4**		**0.0**
Meadow-boggy	Gleysol Mollic	0.2	**Gleysols**	**0.4**
Meadows saline	Gleysol Umbric	4.1		
	Gleysols	**4.3**		**0.4**
Chestnuts	Kastanozem Haplic	7.0	**Kastanozems**	**41.0**
Chestnuts solonetzic	Kastanozem Luvic	4.3		
Chestnuts light	Kastanozem Haplic	8.6		
Chestnuts light Solonetzic	Kastanozem Luvic	1.1		
	Kastanozems	**21.0**		**41.0**
Meadow-chestnuts saline	Phaeozem Luvic	3.7	**Phaeozems**	**0.4**
Meadow-Chernozemics saline	Phaeozem Luvic	2.2		
Meadow-Chernozemics solonetzic	Phaeozem Luvic	3.6		
	Phaeozems	**9.4**		**0.4**
Sod-podzolics	**Podzoluvisol Eutric**	**14.0**	**Podzoluvisosl**	**0.0**
Solonchaks meadow	**Solonchak Gleyic**	**3.9**	**Solonchaks**	**12.5**
Meadow-chestnuts solonetzic	Solonetz Gleyic	8.6	**Solonetzs**	**18.0**
Meadow-chestnuts Solonetzic and saline	Solonetz Gleyic	8.8		
Meadow-Chernozemics solonetzic and saline	Solonetz Gleyic	2.6		
	Solonetzs	**19.9**		**18.0**
	Acrisols		**Acrisols**	**24.8**
	Histosols		**Histosols**	**3.0**

pedological data. The different soil classification systems and analytical methods were especially problematic. A multitude of Russian soil data going back to the 1950s was available for the researchers. But to use these data for comparative analyses, the data had to be converted which always results in loss of information and is not possible for each soil characteristic (analytic). By remapping, soil information can be collected and used for corrections. But due to the size of the research area and given time constraints, only very localized soil surveys and corrections were possible.

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