Eurasian J. For. Res. 10-1: 85-88 , 2007

Ecological Stability of Brown Raw-humus Taiga Soils in Relation to Anthropogenic Influences in Northern Part of Amur Region

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Abstract

The northern part of the Amur region has experienced some disturbances from the logging industry, railway activity and the construction of an oil pipeline. The ecosystem is very sensitive to anthropogenic loading. The brown raw-humus taiga soil is the most widespread type of soil in this area. The thickness of this soil is around 50 cm and most of the nutrients and other elements accumulate in the organic horizon. Forest fires frequently break out in this area. This type of soil has similar stability, a stability that does not depend on the soil physico-chemical characteristics.

Key words: brown raw-humus taiga soil, Amur region, carbon, nitrogen, organic horizon

Introduction

There are many natural resources in the northern Amur region. Therefore, this region has been highly developed by extractive industries. The northern railway was built during the 70s. An oil pipeline is currently being constructed, the biggest portion of which will run through this region. The number of temporary and fixed buildings and roads has increased with the construction of the pipeline. The construction and exploitation associated with this has greatly affected ecosystems and soils alike. In addition, the frequent forest fires in this region have also caused significant damage to the ecosystems.

Mountains comprise 74% of the Amur region and are situated in the northernmost part of the region. There are mountain ridges of about 1500 m in height and there are plains between mountains. The mountains are replaced by hills in the centre and to the south of the region. The soils that are distributed in the area are derived from the weathering of magma rock; therefore, most of the soil in this area is acidic brown taiga soil (Ivanov 1976, Perelman 1979). The Amur region represents the westernmost border of this type of soil in the Far East. After this area, it is replaced by other types of soil derived mainly via the podzolic process of soil formation (Targuliyan 1971).

Brown raw-humus taiga soil develops on the tops and declivities of mountains. The thickness of this type of soil is limited to about 50 cm due to the presence of rock or permafrost. There are many stones in the horizon of the soil generated in declivitous mountain areas. Stones are only distributed in some declivitous areas (Photo 1) where the soil is too young to have well-developed genetic horizons (photo 2) (Ivlev *et al.* 1979). Generally, brown raw-humus taiga soils have a thick O horizon on the forest floor. The humic A horizon, which is about 6 cm deep, lies under the O horizon, which in turn shows raw-humus characteristics and is dark brown in color. There is a mineral B horizon below the humic A horizon of about 20 cm and this is clear brown in color. The mineral B horizon gradually gives way to the C horizon which is a clear yellowish color. The amount of stones increases with depth and there is parent rock at a depth of 40-60 cm (Kreyda 1970). Brown raw-humus taiga soil has low levels of nutrients and other elements with the highest concentrations being found in the top layers.

The information about this type of soil is still limited. Specifically, soil stability is not well known. The purpose of this study is to investigate the structures and properties of the different subtypes of brown taiga soils and their stability with regards to human activity.

Materials and methods

In the summer of 2005, an expedition to conduct a soil study was organized in Verchnezeyskaya province located in the northern part of the Amur region, Far Eat Russia. The expedition was organized under the control of a conservancy. Characteristics of soil horizons and soil location with regards to topography were studied. In addition, parent materials were determined. Soil profiles were made on all topographic elements and the samples were taken from the soil horizons. The following properties were studied: soil acidity, contents of exchangeable cations (Ca^{2+}, Mg^{2+}), mechanical structure of soil, contents of total carbon, nitrogen and phosphorus, mobile forms of potassium and phosphorus and saturation rate of cations of alkaline-earth metals.

Climate

Winter in this area is very harsh. The weather is sunny and clear with limited snowfall under the high atmospheric pressure. The mountains in the northwest are high and helicopters cannot access the plains. Precipitation falls mostly in the mountains. During winter, frigid winds blow across the plains. The absolute minimum temperature in January is – 60°C (Zimovec 1966). Spring comes in May, but even well into June, the temperatures at night continue to be low. The area is without frost for approximately 65 days out

(Received; Feb. 5, 2007: Accepted; March 15, 2007)

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of the year. The diurnal oscillation of temperature in summer is about 20 degrees. The absolute maximum temperature in June is +38°C. The total yearly precipitation is 650 mm with most of it falling during the summer.

Results

The organic horizon (AO or O) was about 8 cm thick in all soils except for soil profile 14 in which the thickness of the O horizon was 2 cm (Table 1). The thickness of the organic horizon depends on forest productivity and the frequency of forest fires.

Humic A horizon with a thickness of up to 13 cm was found below the organic horizon. An A1A2 horizon with white or clear grey spots was found in brown raw-humus taiga podzolized soils. The mineral B horizon, with a thickness of about 30 cm, was found below the A horizon. From a depth of 30 cm, the quantities of stone increased gradually and the mineral B horizon was substituted by horizon C. There was parent rock under the C horizon (Photo 3).

Soil texture varied widely from sandy to clayey. It did not characterize the soil type. Depletion of clay participles in eluvial A2 horizon of podzolized soils was not obvious. All soils were acidic, regardless of the soil type, with pH ranging from 4.5 to 5.9. Cations of Ca^{2+} and Mg^{2+} were concentrated in organic horizons. Ca^{2+} was predominant with up to 33.5 mg-equivalent/100 g. The saturation rate of cations of alkaline-earth metals was high in all soils and highest in the organic horizons (about 90%).

The content of total carbon in the organic horizon was anywhere from 11.37 to 23.3% (Table 2). The content of C was higher in the organic horizon of podzolized soils because the O horizon was thicker and these soils were located on a flat area.

The content of total carbon decreased to 1.5-0.5% in the mineral horizons. High carbon content was found in the horizons with high clay particle content. The transfer of carbon into deeper horizons was found in all the soils studied. Carbon content was about 5.4% even at a depth of 40 cm except for the soil in profile 8.

Nitrogen was concentrated in the top layers and in the organic horizons which, for the most part, measured up to 1.13%. It decreased sharply in mineral horizons, regardless of the soil type. There was biogenic accumulation of phosphorus in the organic horizons of all types of soils (0.18-0.42%). Parent rock was rich in various elements in soil profiles 6 and 8. In profile 8, the content of total phosphorus increased up to 0.4% and the content of mobile form phosphorus increased up to 1742 mg/kg even at a depth of 30-50 cm. In other soils, the content of total phosphorus decreased with increased depth, with the contents of mobile forms of

Table 1. Physicochemical properties of the brown raw-humus taiga soil.

№ of profile	Horizons	Depth (cm)	pH	Absorbed cations (mg-equivalent・$100g^{-1}$)*			Saturation rate of cations of alkaline-earth metals (%)
			H_2O	Ca^{2+}	Mg^{2+}	$H^{+}+Al^{3+}$	
Brown raw-humus taiga typical soil							
16	AO	0-5	5.6	20.4	12.5	12.0	73
	A1	5-12	5.3	6.8	3.6	5.6	67
	Bh	12-26	5.1	8.5	7.1	7.3	65
	Ch	26-30	5.2	8.4	7.6	8.1	66
Brown raw-humus taiga clayey soil							
8	O	0-5	5.9	14.9	9.0	5.6	81
	A1	5-16	4.8	5.5	3.4	5.8	61
	Bg	16-29	5.5	14.8	4.0	1.9	91
	C	29-40	5.6	13.9	3.9	1.6	92
14	O	0-2	4.9	19.8	5.6	16.3	61
	A1	2-5	4.5	12.8	6.3	9.6	66
	B1h	5-20	4.9	9.5	4.6	5.3	73
	B2g,h	20-40	5.5	4.6	2.5	3.2	69
Brown raw-humus taiga podzolized soil							
6	O	0-8	5.9	33.2	6.9	2.4	94
	A1A2	8-21	5.1	3.8	2.0	2.2	72
	Bh	21-30	5.1	1.2	4.3	3.4	61
		30-40	5.2	2.2	1.8	3.6	53
		40-50	5.1	2.1	1.4	3.3	52
15	O	0-6	5.1	33.5	11.6	10.7	81
	A1A2	6-14	4.6	5.4	4.9	6.0	63
	B	14-20	5.0	4.9	3.3	5.3	61
	BC	20-40	5.2	4.2	2.2	4.4	60

*: equil to the unit of [cmol[+]/kg].

potassium and phosphorus being higher in the top layers.

Discussion

This area has a mountainous topography and high surface slope. Hence, there is the danger of erosion in the area. Most of the soils contained bulk stones and permafrost. The majority of nutrients and other elements were contained in the top horizons. Most of this territory has suffered some disturbances from both the logging industry and railway activities. As the construction of an oil pipeline continues, so will the destruction of forests and, consequently, the taiga ecosystem will be disturbed. Given that the activities of construction machinery are concentrated on the soil, permafrost and soil horizons cannot help but be disturbed. As the digging of a trench for the pipeline disturbs the organic layers of soils, the self-restorability of plants may be slow. Mechanical disturbances of the soil may increase the process of sol fluxion and cryoturbation. The incidence of forest fires may also increase during construction resulting in the forest floor being destroyed.

Conclusion

Soils in northern part of Amur region may be sensitive to human activities. Any interference may have strong repercussions on its ecosystems. Furthermore, the process of regeneration of its vegetation and soils may be slowed considerably due to the severe weather conditions in this region.

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Table 2. Composition of the brown raw-humus taiga soil

№ of profile	Horizons	Depth, (cm)	Total forms (% from dry soil)					Mobile forms, (mg・kg^{-1})	
			Participles <0.01mm	C	N	C / N	P_2O_5	P_2O_5	K_2O
Brown raw-humus taiga typical soil									
16	AO	0-5	46	11.82	0.73	16.2	0.25	64	420
	A1	5-12	58	2.82	0.15	19.2	0.095	5	111
	Bh	12-26	66	2.31	0.13	17.8	0.082	6	117
	Ch	26-30	70	1.79	0.11	16.3	0.064	8	100
Brown raw-humus taiga clayey soil									
8	O	0-5	26	11.37	0.81	14.0	0.18	514	457
	A1	5-16	13	1.35	0.13	10.6	0.18	616	85
	Bg	16-29	11	0.56	0.06	10.1	0.39	1482	56
	C	29-40	10	0.49	0.04	11.7	0.40	1742	66
14	O	0-2	-	16.11	0.90	15.2	0.24	111	432
	A1	2-5	52	13.62	0.80	17.1	0.18	34	215
	B1h	5-20	55	4.03	0.24	16.6	0.12	10	127
	B2g.h	20-40	39	5.39	0.23	23.6	0.04	3	67
Brown raw-humus taiga podzolized soil									
6	O	0-8	-	18.57	1.13	16.4	0.42	1390	641
	A1A2	8-21	24	0.32	0.04	8.8	0.20	282	120
	Bh	21-30	24	1.49	0.08	19.6	0.23	149	100
		30-40	19	1.46	0.07	20.2	0.16	188	75
		40-50	20	0.79	0.06	12.6	0.19	156	71
15	O	0-6	-	23.13	1.07	21.6	0.23	323	1269
	A1A2	6-14	43	4.65	0.24	19.1	0.11	45	110
	B	14-20	51	1.89	0.15	12.5	0.08	11	112
	BC	20-40	51	1.34	0.13	10.1	0.06	6	125

Photo 1. Stones on some declivities.

Photo 2. Brown raw-humus taiga soil.

Photo 3. Brown raw-humus taiga soil and stones in it.