ISSN 1064-2293, Eurasian Soil Science, 2023, Vol. 56, Suppl. 1, pp. S1–S4. © Pleiades Publishing, Ltd., 2023.

SOIL SUCCESSIONS IN THE BOREAL FORESTS OF THE KOMI REPUBLIC

Soil Successions in the Boreal Forests of the Komi Republic

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Received January 19, 2023; revised February 6, 2023; accepted February 8, 2023

Abstrac—This issue of the journal presents the translation of the monograph by A.A. Dymov *Suktsesii pochv v boreal'nykh lesakh Respubliki Komi* (Soil Successions in the Boreal Forests of the Komi Republic) (Moscow: GEOS, 2020), describing the current changes in the forest soils for the case study of the Komi Republic. The material is given as eight research papers according to the eight chapters of the monograph. Chapter 1 is a review of the relevant literature; chapters 2–6 dwell on the research objects, used methods, current state of the reference (undisturbed) forest soils, and changes in forest soils caused by cuttings, wildfires, and their withdrawal from active agricultural use. Chapter 7 considers general patterns of soil successions and the rates of changes in particular soil properties. The chapters comprehensively describe and analyze the changes in morphological and physicochemical properties of forest soils, as well as the specific features of the changes in total carbon stock and in individual organic matter fractions isolated by physical and chemical methods.

Keywords: forest soils, fire, cutting, soil organic matter

DOI: 10.1134/S1064229323600239

INTRODUCTION

Boreal forests are the most important type of the biome in the Russian Federation. They play a key ecological role in the climate control over the globe [13, 26]. The soils under boreal forests contain approximately 30% of the global stock of soil carbon [40]. The soils of forest landscapes regulate the chemical composition of surface and ground waters [2, 19, 27, 33, 41]. In the era of anthropogenesis, forest ecosystems are affected by manifold factors and their impact is ever increasing. The current changes in taiga soils are associated with forest harvesting, wildfires, involvement of forest soils in agricultural use, and restoration after these impacts. As of today, over half of the forests in the European Russian North is at different stages of the postanthropogenic restoration [4, 20].

The forest harvesting activities are among the major factors that change the forest soils [6, 17] and transform them from naturally developing soils to anthropogenically transformed soils [14, 39]. According to the estimates by Il'chukov [18], approximately 36% of the forest-covered area in the Komi Republic were affected by forest harvesting in the 20th century. The soils under forests after logging differ in the degree of anthropogenic load. As has been shown, the cutting areas are nonuniform in the degree of soil disturbance. The soils of cutting strips are free of mechanical disturbance, whereas they may be considerably damaged in the skidding trails (or technological corridors of logging machines) and loading areas [24]. The plant restoration in the disturbed areas can be delayed by several years as compared with the cutting strips [30]. Although the amount of organic matter in the soils of boreal landscapes is high enough, representative data on the content and composition of organic matter and on the morphological and physicochemical properties of soils during natural reforestation in cutting sites are virtually absent.

Wildfires play a considerable role in the current dynamics of the taiga ecosystems in the northern hemisphere [8, 9, 12, 21]. Depending on the fire type and intensity, the density and productivity of tree stands changes [15], as well as the dominants in the upper and subordinate vegetation layers [25]. Pyrogenesis is one of the natural or anthropogenic factors that change soil properties [31, 32]. The pyrogenic impact alters the environmental response and morphological soil properties [29, 36]. In some cases, an increase in the bulk density and water capacity of the upper mineral horizons is observed. A considerable part of boreal forest soils is at the stage of postpyrogenic restoration; however, the studies on the postpyrogenic dynamics of the soil properties in the European Russian North are absent.

The forest soils in the middle and northern taiga are involved in the agricultural use mainly near villages. Starting from the end of the 20th century, many farmlands have been abandoned. Natural reforestation is observed over considerable areas. It has been shown that agricultural soils can provide for a large-scale carbon sequestration from the atmosphere [37]. The changes in the carbon content in soils during the reforestation of postagrogenic landscapes may be directed towards both an increase and a decrease in the soil carbon stock. An increase in the total carbon content is observed in the upper mineral horizons of the fallow soils in the southern taiga landscapes [34]. At the same time, a decrease in the content of humus during the first succession stages has been reported for the soils of abandoned hayfields in Kostroma oblast (Russia) [11]. The carbon content increases in the abandoned arable soils [28, 35]. Studies into the changes in vegetation and soils during postagrogenic successions in the middle taiga of the Komi Republic are solitary and descriptive [16]. In the European north of Russia, the best studied postagrogenic soils are the residual-calcareous soils in Arkhangelsk oblast [23]. Poeplau and Don [38] have shown that the contents of soil organic matter and its individual fractions are sensitive indicators of the land use.

In our view, the restoration of soils after the impacts of disturbing factors (cuttings, wildfires, agricultural use, mechanical disturbance) logically blends in with the concept of soil successions. The term "successions" is applied to soils to a considerably lesser degree as compared with plant communities [1, 22]. In Russian soil science, Vasenev [10] considered the soil successions in detail. He gave the insight into the soil successions in the overall dynamism of soil properties and proposed the initial variants for classification of the soil successions in the forest-steppe zone. According to Vasenev, the term "soil successions" means the development of soils in an elementary area of the soil cover with continuous successive changes in soil taxa over decades and first centuries of pedogenesis. Considering soil changes in terms of soil succession, it is possible to assess the transformation and restoration patterns of ecosystems. Available studies that describe soil objects at different stages of soil successions still leave the gaps in our understanding of the current changes in the soils of the taiga zone.

The goal of this work is to elucidate and analyze the patterns of changes in the soils of forest ecosystems in the European northeast of Russia during post-cutting, postpyrogenic, and postagrogenic successions. Based on the published data and original materials, the author considers the relevant issues of the current state and succession changes in forest soils, including their morphological and physicochemical characteristics; specific features of the soil organic matter in reference (undisturbed) and secondary forest ecosystems; patterns of the changes in the pools and fractions of organic matter and in the physicochemical properties of the soils during successions; and systematization of soil successions in the secondary forest ecosystems.

ACKNOWLEDGMENTS

The author is deeply grateful to Lev O. Karpachevskii, Evgenii Yu. Milanovskii, and Elena M. Lapteva, who were the main advisers for this work at its different stages, for their constant assistance, support, and friendly spirit, as well as for the possibility of in-depth discussion of the research plans and results, valuable advice, and criticism. The author sincerely appreciates the helpful and constructive comments of K.S. Bobkova and B.M. Kogut.

The author is grateful to colleagues and friends S.V. Degteva, S.V. Goryachkin, G.A. Simonov, G.M. Vtyurin, T.A. Sokolova, E.G. Kuznetaova, L.G. Bogatyrev, V.G. Kazakov, V.A. Kholodov, Z.N. Tyugai, E.V. Zhangurov, Yu.A. Pautov, D.N. Gabov, A.N. Panyukov, Yu.A. Dubrovskii, and V.V. Startsev for their assistance, support, consultations, and useful advice during the research and discussion of the results; to leading engineers T.V. Zonova, N.A. Vasil'eva, Yu.I. Bobrova, and O.M. Zueva and to postgraduate students N.M. Gorbach, D.A. Severgina, I.V. Payusva, and E.N. Mikhailova for their assistance in field work, sample preparation, and chemical assays.

ABBREVIATIONS AND DESIGNATIONS

κ (kappa)	electrical conductivity
AL	content of aliphatic structures
AR	content of aromatic structures
CP-MAS	cross polarization magic angle spinning;
C_{wsin}	carbon of water-soluble inorganic compounds
C_{wso}	carbon of water-soluble organic compounds
C_{ws}	total water-soluble carbon
C_{ha}/C_{fa}	carbon of humic acids-to-carbon of fulvic acids ratio
D_h	degree of hydrophilicity (for HILC)
f_a	degree of aromaticity
Ac_{tot}	total (hydrolytic) acidity
N	total nitrogen content
N_{ws}	nitrogen of water-soluble compounds
$oPOM_{<1.6}$	occluded particulate organic matter
V	base saturation
WRB	World Reference Base for Soil Resources
WS	water-soluble substances
HS	humic substances
ETR	European territory of Russia
HILC	hydrophobic interaction liquid chromatography
CWD	coarse woody debris
CDRS	classification and diagnostics of Russian soils

ppm	part per million
PAH	polycyclic aromatic hydrocarbons
SOM	soil organic matter
SP	sampling plot
SS	soil succession
KR	Komi Republic
C	total carbon content in soil
$fPOM_{<1.6}$	free particulate organic matter
C_{alk}	carbon of alkali-soluble (0.1 N NaOH) compounds
$MaOM_{>1.6}$	mineral-associated organic matter, density >1.6 g/cm^3
$MaOM_{>2.2}$	mineral-associated organic matter, density >2.2 g/cm^3
$MaOM_{1.6–2.2}$	mineral-associated organic matter, density 1.6–2.2 g/cm^3
PAR	photosynthetically active radiation
JAC	joint-access center
ESP	elementary soil-forming processes
NMR	nuclear magnetic resonance

FUNDING

The research data described in this publication are the results of implementation of the planned basic research of the Institute of Biology, Komi Science, Ural Branch of the Russian Academy of Sciences, namely, "Soil Genesis and Functions in the Organization and Stability of Ecosystems in the European Northeast of Russia" (grant no. 01.2.00.107250) in 2003–2005; "Mechanisms of Formation and Functioning of the Virgin and Anthropogenically Disturbed Soils in the Taiga and Tundra Landscapes of the European Northeast" (project no. 0120.0603502) in 2006–2008; "Organization, Functioning, and Evolution of Soils in the Cryolithozone of the European Northeast of Russia" (project no. 0120.0853980) in 2009–2011; "Biogeographical and Landscape Patterns in the Formation of Soils as the Components of Subarctic Terrestrial Ecosystems in the European Northeast of Russia" (project no. 0120.1250267) in 2012–2014; "Spatial and Temporal Patterns in the Formation of Peat Soils in the European Northeast of Russia and Their Transformation under Conditions of Changing Climate and Anthropogenic Impact" (project no. 115020910065) in 2015–2017; and "Cryogenesis as a Factor of Soil Formation and Evolution in Arctic and Boreal Ecosystems in the European Northeast under Conditions of Current Anthropogenic Impacts and Global and Regional Climatic Trends" (project no. 122040600023-8) in 2022–2024; as well as the Ural Branch of the Russian Academy of Sciences (projects nos. 13-4-NP-246 and 14-4-IP-21); Russian Foundation of Basic Research (projects nos. 08-04-90718-mob_st, 11-04-00885a, 12-04-90700 mob_st, 12-04-10072-k, 13-04-00570a, and 19-29-05111mk); Ministry of Education of the Russian Federation (grants of the President of the Russian Federation for support of young candidates of science nos. MK-1027.2013.4 and MK-2905.2015.4); International OMRISK project; UN/GEF program "Carbon Component"; and contract-based research of the Institute of Biology, Komi Scientific Center, Ural Branch, Russian Academy of Sciences (hereinafter, Institute) in 2003–2022. The variant of this material in Russian was published as a monograph titled *Soil Successions in the Boreal Forests of the Komi Republic* by A.A. Dymov (Moscow: GEOS, 2020) under publishing project of the Russian Foundation for Basic Research (no. 20-14-00002).

CONFLICT OF INTEREST

The author declares that he has no conflicts of interest.

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Translated by G. Chirikova