

Plant and soil diversity in boreal and temperate Eastern European old-growth forests with high level of soil fertility and ecosystem productivity

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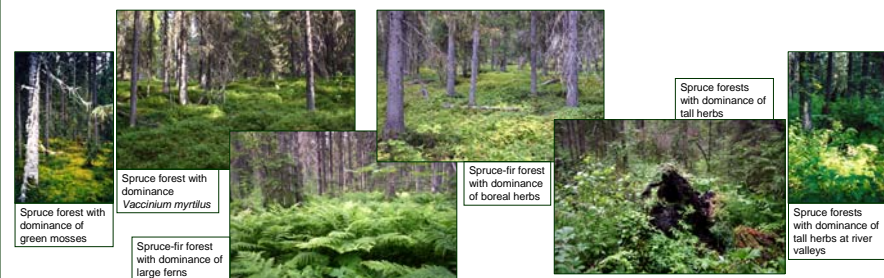
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We have studied old-growth semi-natural boreal and temperate forests in European Russia under Prof. Olga Smirnova leadership (Center for Forest Ecology and Productivity of RAS). Vegetation and soil have been investigated in more than 30 local areas (see a map). Gap mosaics and tree fall mosaics were detailed observed. Database on 15000 vegetation relevés and more than 1000 macromorphological descriptions of soil profiles have been developed.

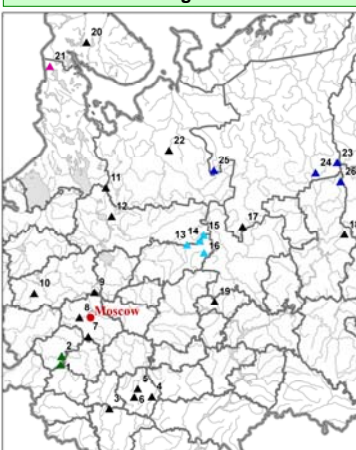
Results of analysis of 520 vegetation relevés for boreal forest and 500 vegetation relevés for temperate forest are presented here. Age of trees in the overstorey was the following: av. 150-200 years old with maximum of 380 years old in boreal forest and av. 100-150 years old with maximum of 300 years old for temperate forest.

Forest types

	Boreal forest	Temperate forest
GM	Spruce-fir forest with dominance of Green Mosses	PinGM Pine forest with dominance of Green Mosses
Vm	Spruce-fir forest with dominance of dwarf shrubs (<i>Vaccinium myrtillus</i>)	PinMd Pine forest with dominance of Meadow herbs and grasses
B	Spruce-fir forest with dominance of Boreal herbs	PinN Pine forest with dominance of Nemoral herbs
F	Spruce-fir forest with dominance of large Ferns	BetMd Birch forest with dominance of Meadow herbs and grasses
NB	Spruce-fir forest with dominance of Boreal (and Nemoral) herbs	BetN Birch forest with dominance of Nemoral herbs
BN	Spruce-fir forest with dominance of Nemoral (and Boreal) herbs	PopN Aspen forest with dominance of Nemoral herbs
TH	Spruce-fir forests with dominance of Tall Herbs	QrN Oak forest with dominance of Nemoral herbs
THm	Mountain spruce-fir forests with dominance of Tall Herbs	
THr	Spruce-fir forests with dominance of Tall Herbs at river valleys	



Locations of vegetation-soil investigations



N	Region	Forestry	Vegetation
Temperate forest			
1	Kaluga	Reserve 'Kaluzhskie zaseki'	Old-growth broad-leaved (hardwood) forests, softwood and coniferous forests
3	Voronezh	National Park 'Ugra'	
4	Tambov	Reserve 'Voronezhskij'	Oak, aspen, birch, and pine forests
5		Reserve 'Voronskiy'	Oak and black alder forests
6		Perkinsky Forestry	Oak and pine forests
		Zninsky Forest	Oak, ash and elm plantations, hardwood forests
Boreal forest, South taiga			
7	Moscow	'Russkiy Les' Forestry	Pine, birch, aspen, spruce, and oak forests
8		Lomonosov University Biological Station	Spruce and spruce-lime forests
9		Taldomsky Forestry	Pine, spruce and aspen forests
10	Tver	Central Forest Reserve	Spruce forests
11	Vologda	Andomsky Forestry, Atleka Reserve	Old-growth spruce forests
12		National Park 'Russkiy Sever'	Pine and spruce forests
13-16	Kostroma	Mezhevskoy, Pavinsky, Vokhomy'sk Forestries	Old-growth spruce-fir forest; pine, spruce and aspen forests
17	Komi Republic	Prihuzsky, Letsky, Koyzordsky Forestries	Old-growth spruce-fir forests; pine, birch and aspen forests
18	Sverdlovsk	'Bazegi' Reserve	Old-growth spruce-fir forests
19	Mari-El Republic	'Bol'schaya Kokschaga' Reserve	Pine and oak forests
Boreal forest, Middle and Northern taiga			
20	Murmansk	Khibiny Mountains	Old-growth spruce forests; birch
21	Karelia Republic	Pyaozersky Forestry	Old-growth spruce forests
22	Arkhangel'sk	Bereznikovskiy Forestry	Old-growth spruce forests; pine forests
23	Komi Republic	'Pechoro-Ilychskiy' Reserve	Old-growth spruce-fir forests; birch and aspen forests, pine forests
24	Republic	Mezdurechensky Forestry	Old-growth spruce forests; pine forests
25			
26	Perm'	'Vyscherskiy' Reserve	Old-growth spruce-fir forests

Plant habitats in semi-natural boreal forest (proposed by Prof. O. Smirnova)

Microsites in semi-natural forest	Dominating functional species group	Species samples
1. Woody debris (deadwood)		
a) initial stage of decay	dwarf shrubs, green mosses	<i>Vaccinium vitis-idea</i> , <i>V. myrtillus</i> , <i>Pleurozium shreberi</i> , <i>Hylocomium splendens</i>
b) improved stage of decay	small boreal herbs	<i>Gymnocarpium dryopteris</i> , <i>Trientalis europaea</i> , <i>Maianthemum bifolium</i>
2. Mound after tree fall with uprooting		
bare soil	pioneer nitrophilous tall herbs	<i>Chamaenerion angustifolium</i> , <i>Rubus idaeus</i>
	seedlings of pioneer boreal trees and shrubs	<i>Betula sp.</i> , <i>Salix sp.</i> , <i>Populus tremula</i> , <i>Sambucus racemosa</i>
3. Pit after tree fall with uprooting		
a) open water	water-swamp herbs	<i>Caltha palustris</i> , <i>Comarum palustre</i> , <i>Equisetum palustre</i>
b) stagnant water	species of <i>Sphagnum</i> bogs	<i>Carex globularis</i> , <i>Rubus chamaemorus</i> , <i>Vaccinium uliginosum</i> , <i>Sphagnum sp.</i>
4. Plain areas between tree crowns		
a) sites of good drainage	mesophilous tall herbs	<i>Diplazium sibiricum</i> , <i>Dryopteris assimilis</i> , <i>Crepis sibirica</i> , <i>Senecio nemorosus</i> , <i>Delphinium elatum</i>
b) overmoistured sites	nitrophilous tall herbs	<i>Athyrium filix-femina</i> , <i>Filipendula ulmaria</i> , <i>Cirsium heterophyllum</i>
5. Areas under tree crowns		
a) of mature coniferous trees	small and medium boreal herbs	<i>Calamagrostis arundinacea</i> , <i>Lerchenfeldia flexuosa</i> , <i>Mclampyrum pratense</i>
b) of mature deciduous trees	herbs of forest edges	<i>Crepis paludosa</i> , <i>Geranium sylvaticum</i> , <i>Solidago virgaurea</i>

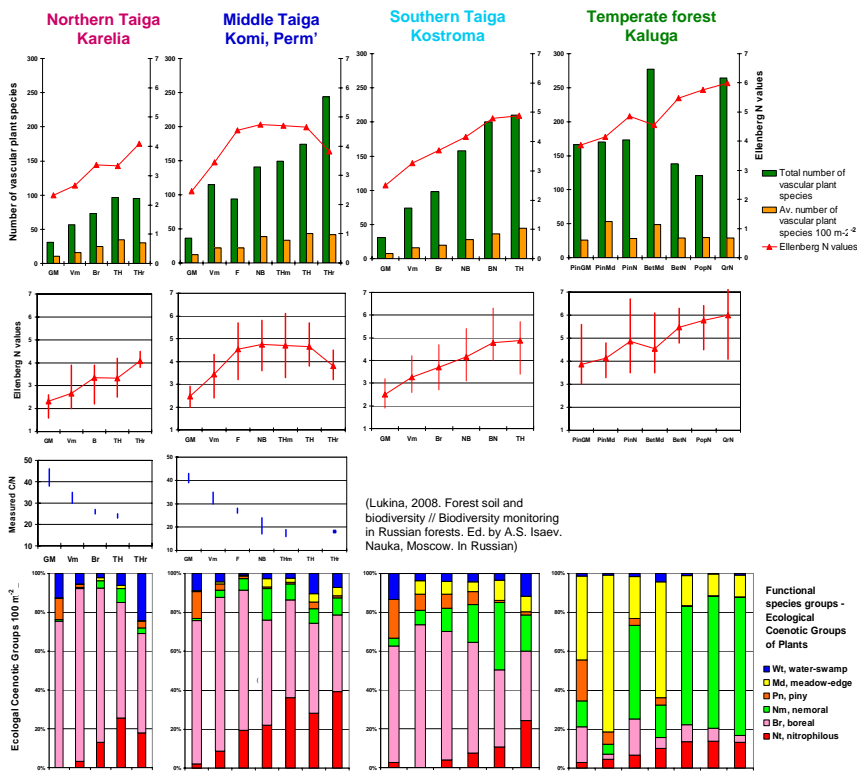


Conclusion

- A high level of available nitrogen in old-growth semi-natural boreal and temperate forests has been observed together with a high level of biodiversity. We have concluded that structural diversity of forest ecosystem together with a seed availability is a crucial point for diversity of plants and soil fauna. Deadwood of different decay stages, tree falls with tree uprooting define the main plant habitat mosaics.
- Nitrophilous species dominated in investigated plant communities; however they did not hamper the growth of other plants. This was due to a great diversity of microsites occupied by species of different ecology. Relationships of facilitation and saturation between species prevailed instead of relationships of competition.
- In boreal and temperate forests with a high level of structural diversity we have observed the formation of soil with a high level of available nitrogen, with moder-mull or mull humus type and low C/N.
- For boreal forests, the highest plant biomass and the richest soil correlated directly with the highest plant diversity. The soil was richer in temperate forests in comparison to boreal forests, but the plant diversity and the share of nitrophilous species were lower there. We propose the main reason for this is a greater degree of anthropogenic impacts in the temperate forests and the absence of a well developed structural diversity there.



Plant diversity and nitrogen estimations in different forest types in European Russia



Soil characteristics in studied forest types

Soil characteristics	Forest types															
	Boreal forest								Temperate forest							
	GM	Vc	B	F	NB	BN	THm	TH	THr	PinGM	PinMd	PinN	BetMd	BetN	PopN	QrN
Humus type	moor	moor, moder	moder-mull, moder-mull	moder-mull, moder-mull	moder-mull, moder-mull	moder-mull, moder-mull	moder-mull, moder-mull	moder-mull, moder-mull	moder-mull, moder-mull	moor, moder	moder-mull, moder-mull	moder-mull, moder-mull	mull	mull	mull	mull
A and/or H horizon thickness	-	-	5-15 sm	5-10 sm	5-10 sm	10-25 sm	10-60 sm	10-60 sm	10-50 sm	-	5-15 sm	5-15 sm	5-15 sm	5-15 sm	10-40 cm	10-120 cm
E or EL horizon thickness	5-20 sm	5-25 sm	to 25 sm	5-10 sm	5-25 sm	5-25 sm	0-10 sm	0-10 sm	-	5-30 sm	5-10 sm	5-25 sm	5-10 sm	5-20 sm	0-20 sm	0-20 sm
Traces of fire (charcoals in soil)	++++	++++	+++	+++	+++	++	+	+	+	+++	+++	++	+	+	+	+
Traces of tillage			+		+	++				++	+++	+++	+++	+++	+++	++

