On methods of regional and local soil organic matter pools evaluation and modelling for soil monitoring in the forests of European Russia

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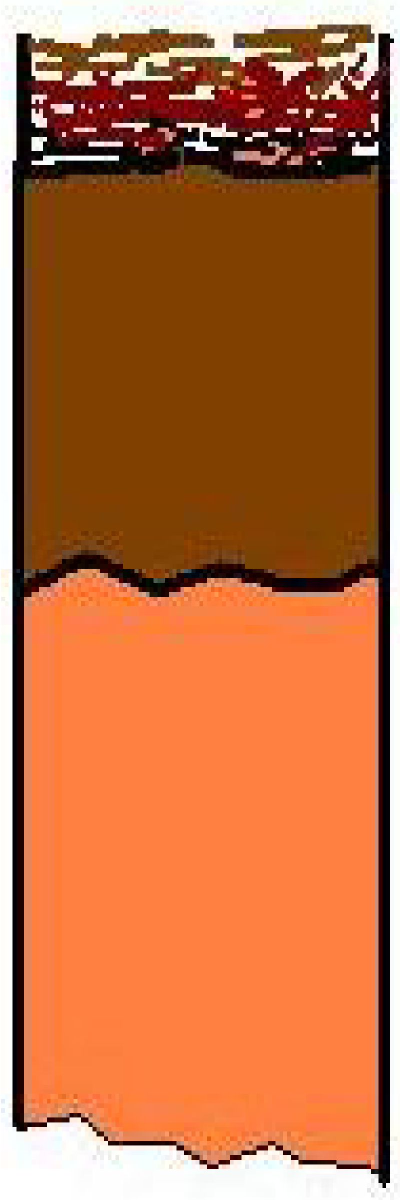
Introduction

A quantitative evaluation of soil organic matter (SOM) pools and their dynamics in forest soils is crucial for the assessment of the role of forests and silviculture in carbon balance at national level

This is an important task in a frame of Kyoto Protocol



State-of-the-art in Russia

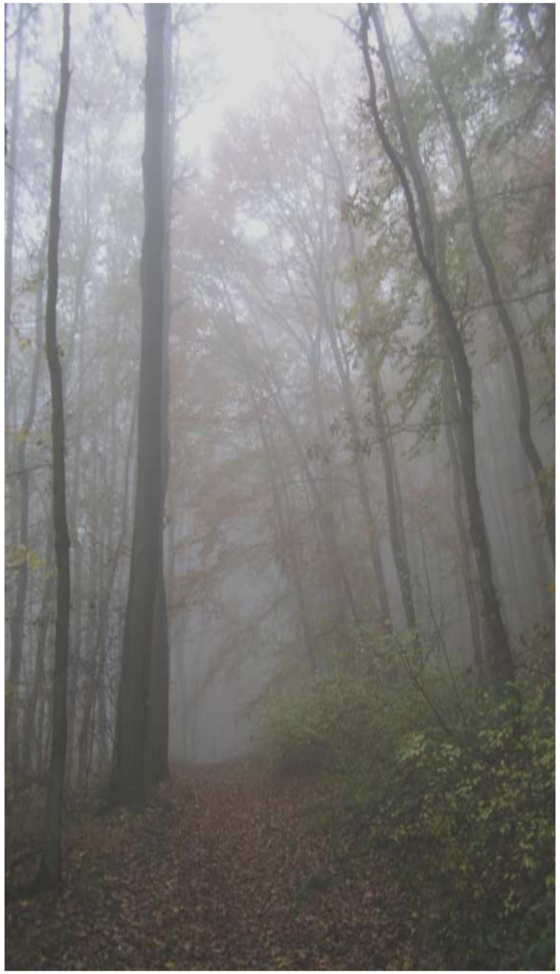
Russia has a very rich pool of forest soil data

Great number of publications with soil information from national to local level allowing for a comparative analysis of soil changes (i.e. sulphur in soil)

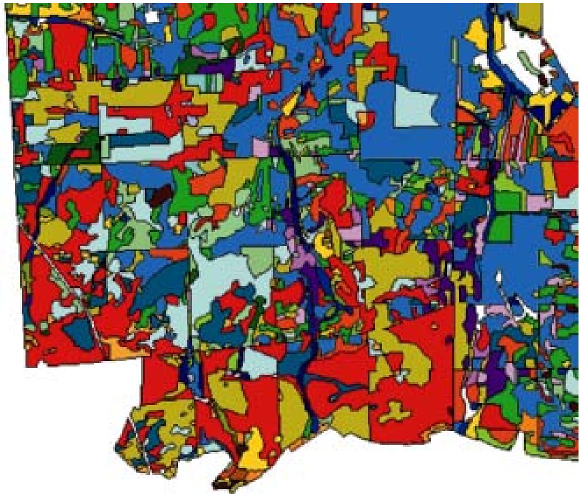
Lot of manuscripts with soil data

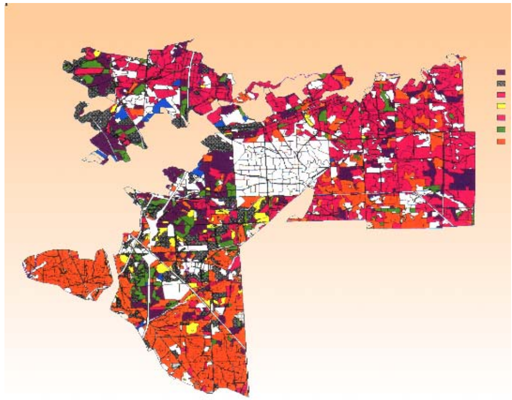
...but :

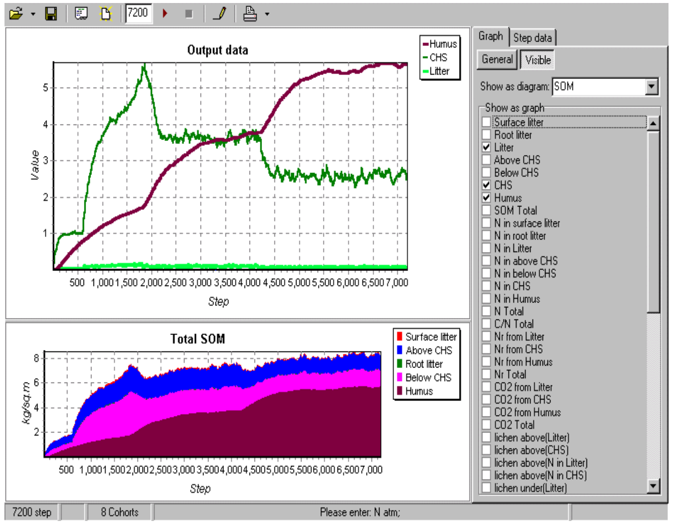
- **National and regional soil databases are still in process of compilation.**
  There is one large-scale forest soil database for European Russia (Centre on Forest Ecology and Productivity RAS) and some regional soil databases
- **Different time of soil research**
- **Variation of methodology in dependence on goals of the work and time of research**
- **Lack of forest soil survey and maps**



For practical solution of soil C pools evaluation in the forests at different spatial levels we propose an integration of soil data with forest inventory statistics and maps and then with models of SOM dynamics for carbon balance assessment in Russian forests







Methods of soil C pools evaluation

First phase

Collection of all published, current and archive ***soil data*** for the region under consideration

↓

Ordination of soil data by units of forest sites/types classification used in national forest inventory

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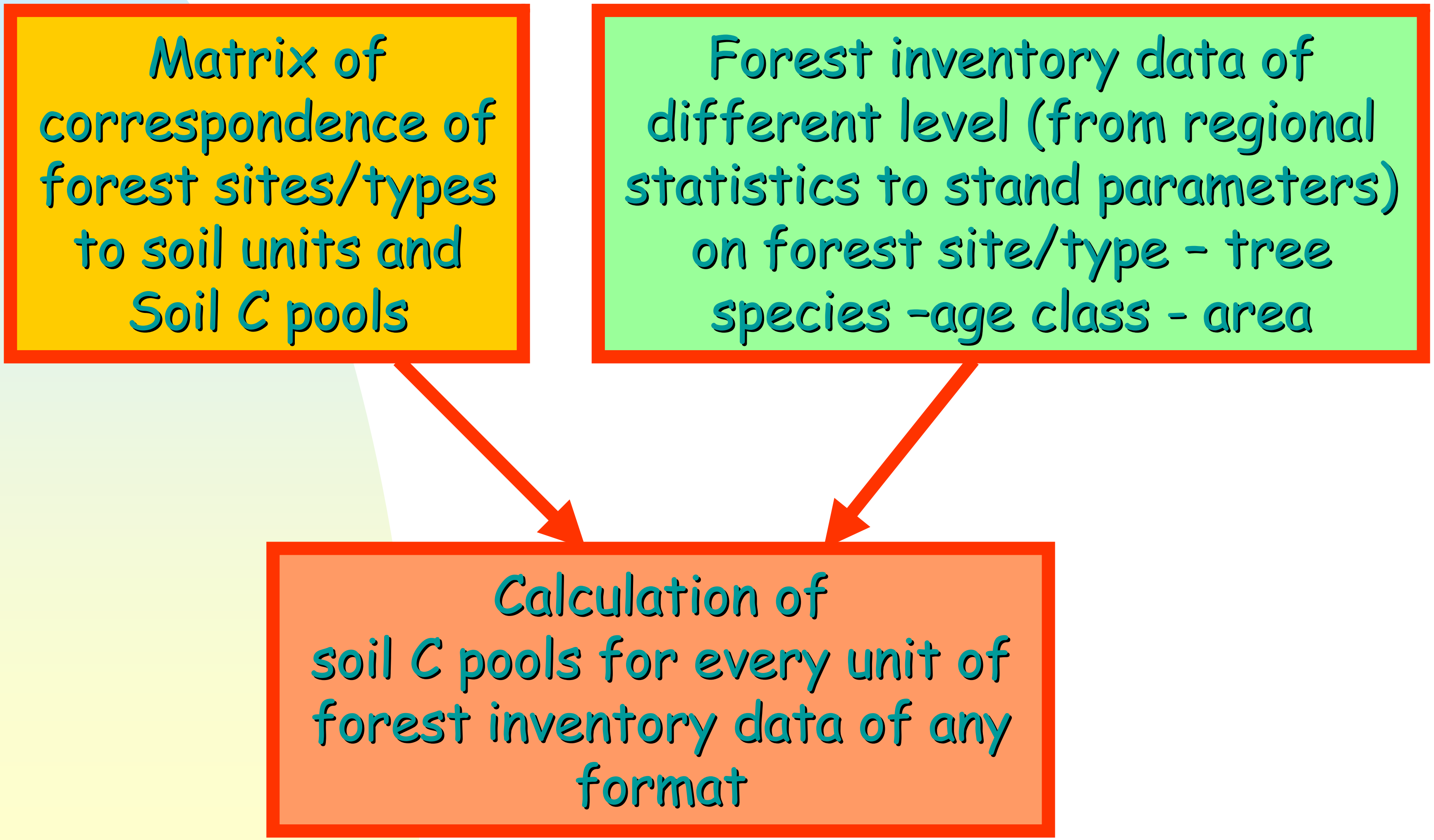
Compilation of a matrix:
"forest site/type – tree species – age class – Soil units - Soil C (t ha^{-1} or kg m^{-2})"

Methods of soil C pools evaluation

Second phase



Integration of soil C data with SOM modelling for monitoring soil C changes

There are two options for using simulation models for the monitoring of soil C dynamics under change of climate and forest management regimes:

1. Direct use the SOM dynamics model that needs a compilation of a special scenario of litter fall.
2. Use the SOM dynamics model as a component of forest ecosystem model with a feedback “tree-soil” where litter fall is generating by the stand growth module

Our experience shows that the second option is preferable because it allows

a) to have additional parameters (of stand growth) for the control of SOM and whole ecosystem model behavior and fitness,

b) to avoid the litter fall scenario compilation that can be additional source of uncertainty

Modelling SOM dynamics for soil monitoring

Compilation of a set of soil climate and bioclimatic scenarios for simulation SOM dynamics and tree growth if given model has no heat transfer and hydrological sub models

Use calculated data on SOM pools as initial values in the simulations

Carrying out a set of test simulations to control SOM changes and tree growth at a long-term time interval

Use Bayesian correction of initial SOM data in a case of strong deviation of modelled data from observed ones for given forest type and soil unit

Use the model for the regular simulation according to the aim of work

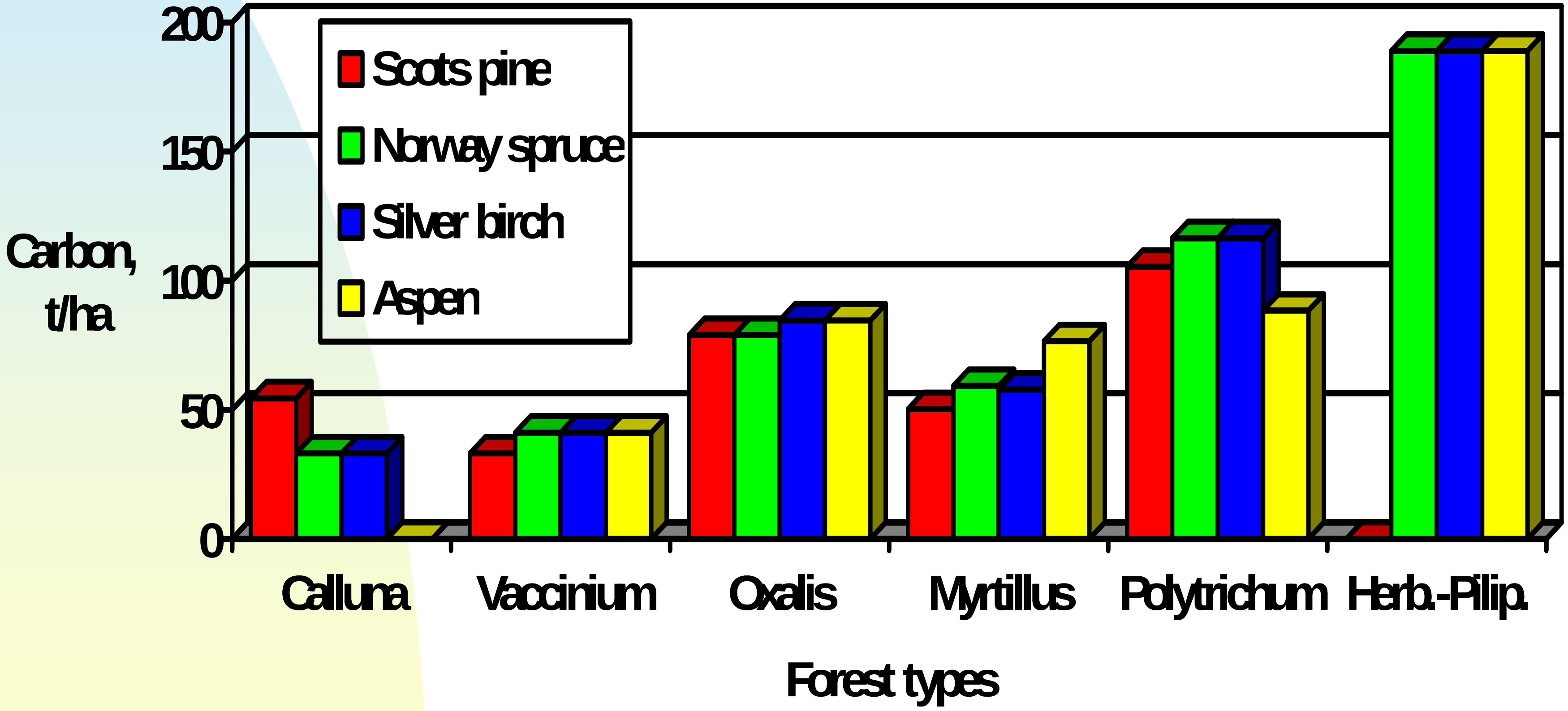
CASE STUDY 1:
Soil carbon in forests of Leningrad administrative area

- The aim was to evaluate regional SOM pools in mineral forest soils of the area (3.8 mln ha)
- Soil database: Published data on forest soils of this area:
  - O.G. Chertov. 1981. Ecology of Forest Lands. Leningrad, Nauka. Consistent soil carbon data with evaluation of pools of organic layers for all forest soils of the area
- Forest database: Generalized statistics of forest inventory in Leningrad region for
  - forest types
  - dominating tree species
  - age classes
  - area of these units

RESULTS: SOC pool (Mg C ha^{-1}), expressed as mean value (s.e.), for soils, arranged by tree species and forest types, in St. Petersburg region

Forest type	Soil groups	Tree species: Scots pine	Norway spruce	Silver birch	Aspen
Calluna	Sandy podzols	7.0 (n.d.)	10.3 (n.d.)	10.4 (n.d.)	Not found
	and rankers	47.5 (n.d.)	16.5 (n.d.)	22.8 (n.d.)	
Vaccinium	Sandy podzols	10.4 (0.97)	14.8 (2.05)	14.0 (n.d.)	14.0 (n.d.)
		22.8 (3.04)	26.7 (2.48)	26.4 (n.d.)	26.4 (n.d.)
Oxalis	Loamy podzolic with	10.1 (1.98)	10.8 (1.63)	8.1 (0.92)	8.9 (n.d.)
	moder humus	68.9 (14.26)	70.9 (12.81)	76.6 (8.45)	75.2 (n.d.)
Myrtillus	Sandy and loamy	18.2 (2.07)	16.4 (2.11)	17.9 (7.49)	19.8 (7.29)
	podzolic with raw humus	32.1 (4.68)	41.8 (3.20)	40.0 (4.66)	56.8 (12.01)
Polytrichum	Peaty gley-podzolic	29.4 (6.55)	38.7 (14.20)	38.7 (n.d.)	58.8 (n.d.)
		76.0 (71.87)	77.8 (80.77)	77.8 (n.d.)	29.6 (n.d.)
Philipendula	Gley with hydromull	Not found	66.1 (61.10)	119.0 (n.d.)	119.0 (n.d.)
	(Anmoor)		122.9 (61.41)	99.4 (n.d.)	99.4 (n.d.)

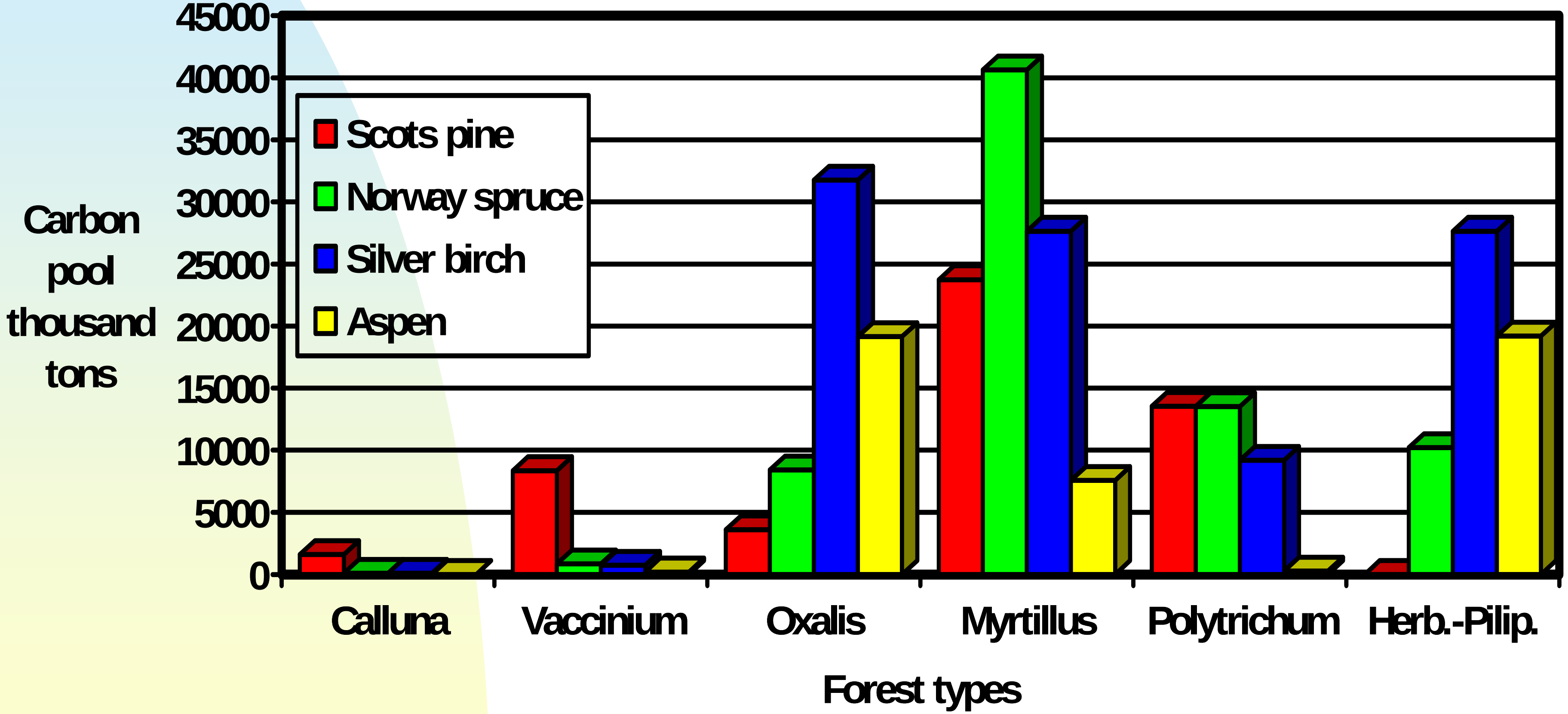
RESULTS:
carbon pools, ton ha^{-1}



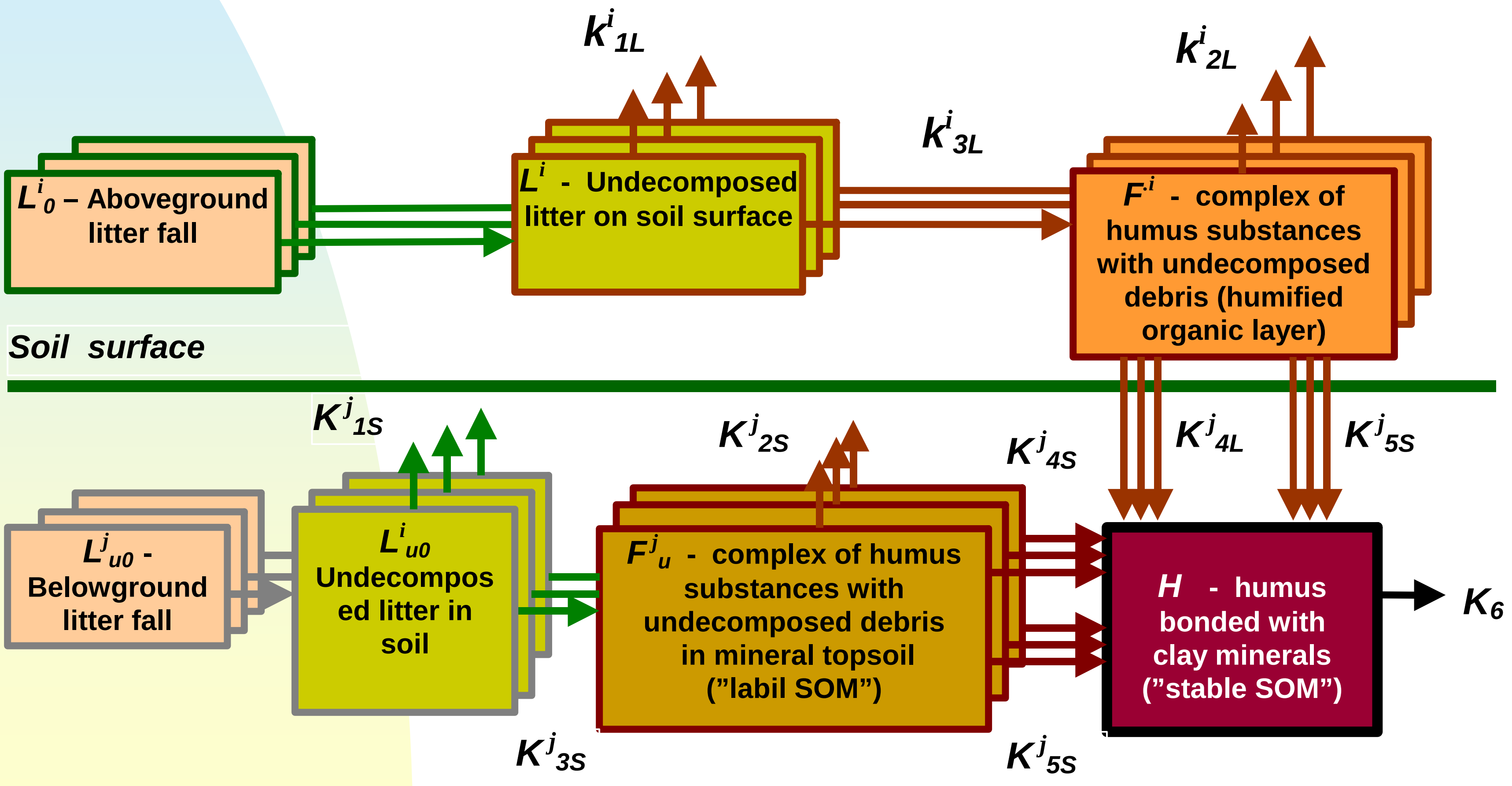
Total amount of soil carbon in mineral forest sols of Leningrad region, thousand tons

Forest types	Young stands	Total
Calluna	476.7	1,787.3
Vaccinium	2,286.8	10,119.9
Oxalis	5,458.3	62,907.4
Myrtillus	16,978.7	99,579.7
Polytrihum	8,050.3	36,796.3
Herbo-Philipendula	8,428.0	57,040.6
TOTAL	41,678.9	268,231.2

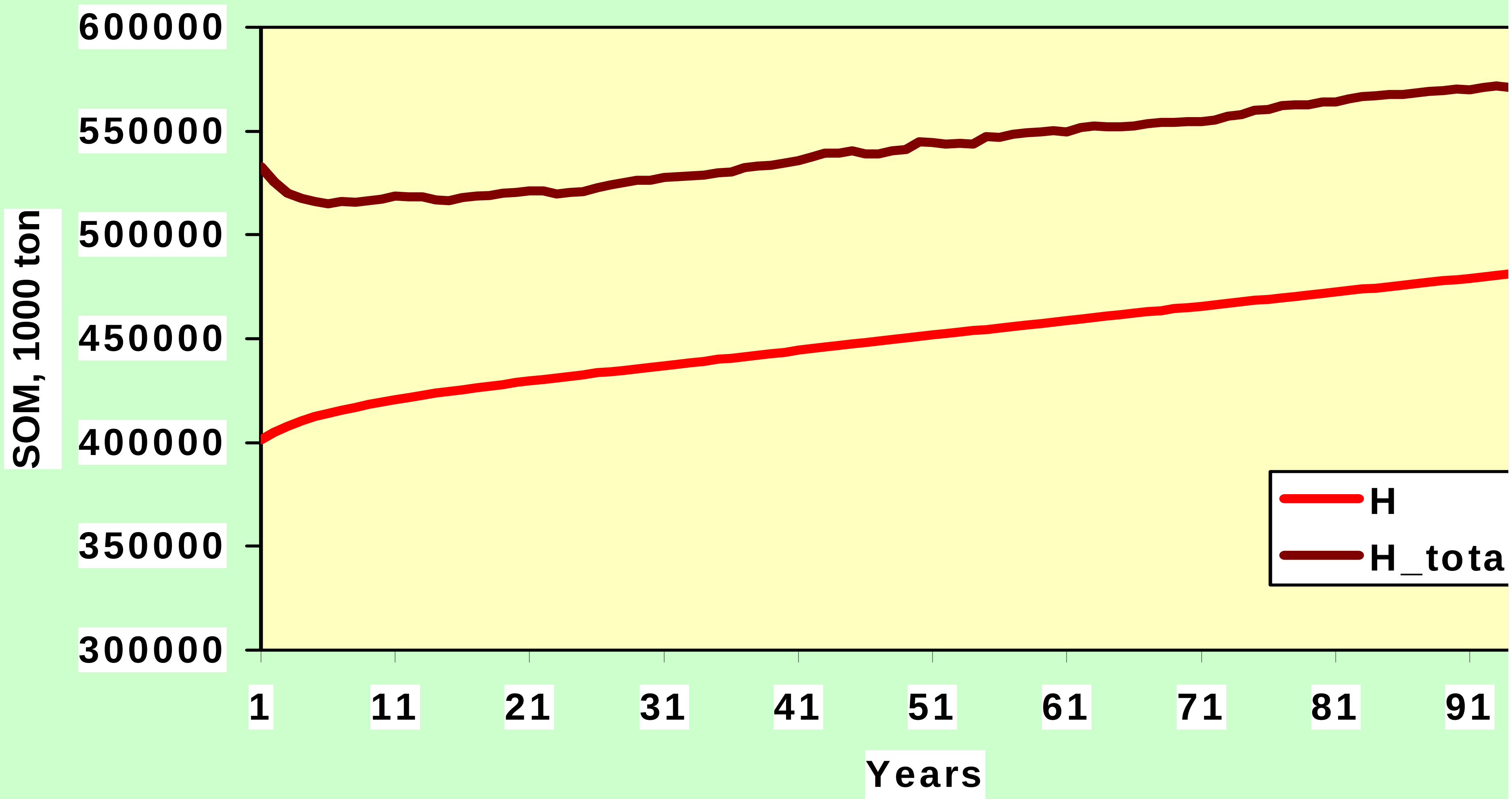
Total amount of soil carbon in different forest types/soil groups



Early version of simulation model of SOM dynamics ROMUL was applied



Total SOM dynamics in forest soils of Leningrad region



Carbon balance in forest soils of Leningrad area

- **Carbon sink (litter input)**
  8.3±1.25 10^6 ton annually
- **Carbon source (SOM mineralization)**
  8.1±2.10 10^6 ton annually
- **It is total increasing 0.08% of annual carbon pool in forest soils of the region**

CASE STUDY 2:

Long-term dynamics of forest stands and soils at different silvicultural regimes

- The aim was to evaluate biomass and SOM pools dynamics under different silvicultural regimes
- Soil database: All available published data on forest soils of this area linked with site classification
- Forest database: Forest inventory data on 300-ha forest lot for every stand:
  - forest types
  - tree species cohorts
  - age classes, H, DBH, growing stock, stand density
  - area of every stand compartment

Standard Pogrebniak's site classification to compile "Soil Carbon Table"

Site classes	A poor	B medium	C medium	D rich
0 very dry	A0	B0	C0	D0
1 dry	A1	B1	C1	D1
2 fresh	A2	B2	C2	D2
3 wet	A3	B3	C3	D3
4 moist	A4	B4	C4	D4
5 very m.	A5	B5	C5	D5

Every site type has evaluated on soil carbon in organic horizon and 100-cm soil (mean and S.D.) using all available published data for the area

Use the table for soil carbon evaluation on the level of forestry enterprise or its part

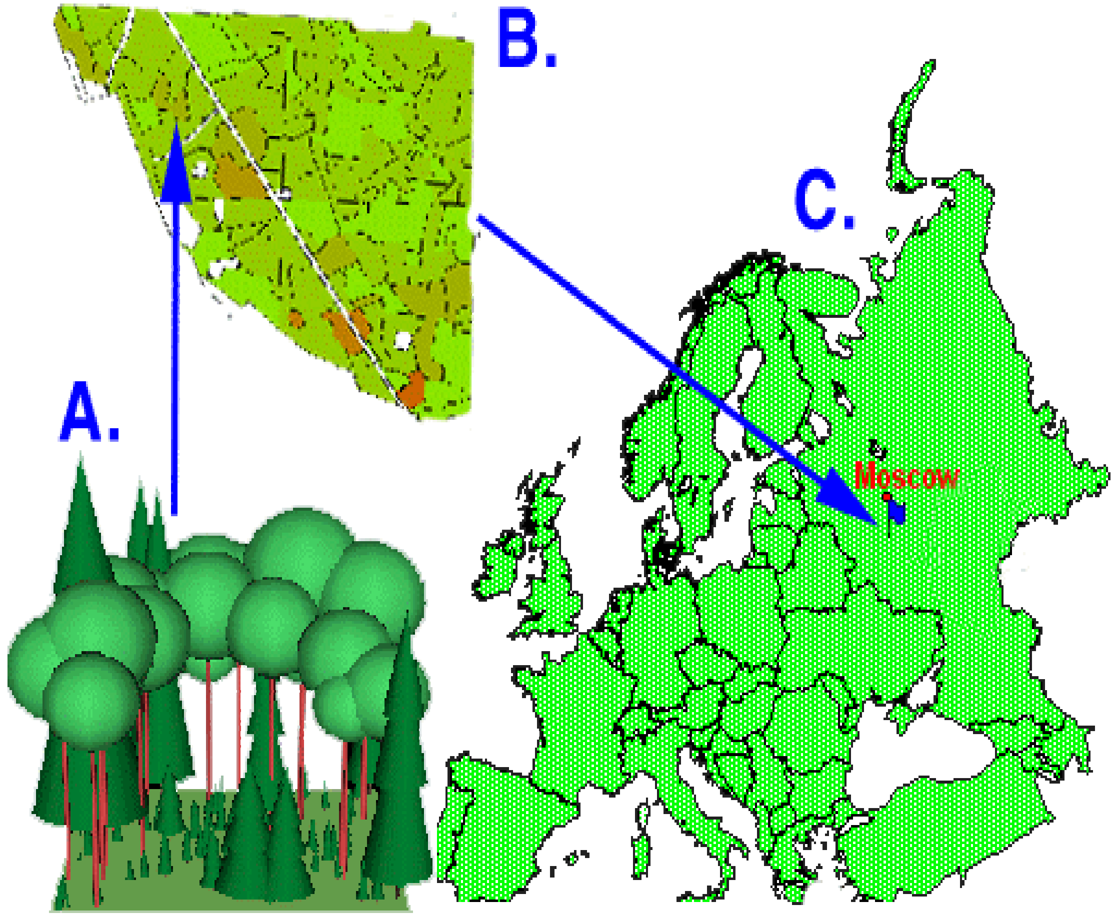
Kg/sq.m		A						B		
		SOM			Nitrogen			SOM		
		x	s	N	x	s	N	X	s	N
0	Organic	0.2		1	0.003		1	0.20		
	Mineral	1.2		1	0.050		1	11.10		
1	Organic	0.8	0.2	3	0.010	0.0	3			
	Mineral	3.9	1.9	3	0.173	0.038				
2	Organic	2.1	0.6	10	0.034	0.0				
	Mineral	6.4	2.0	10	0.28					
3	Organic	6.6	1.0	7						
	Mineral	7.8	1.6							
4	Organic	39.9	?							
	Mineral	11.0								
5	Organic									
	Min									

Fragment of soil carbon and nitrogen table arranged by the Pogrebniak's site classification classes

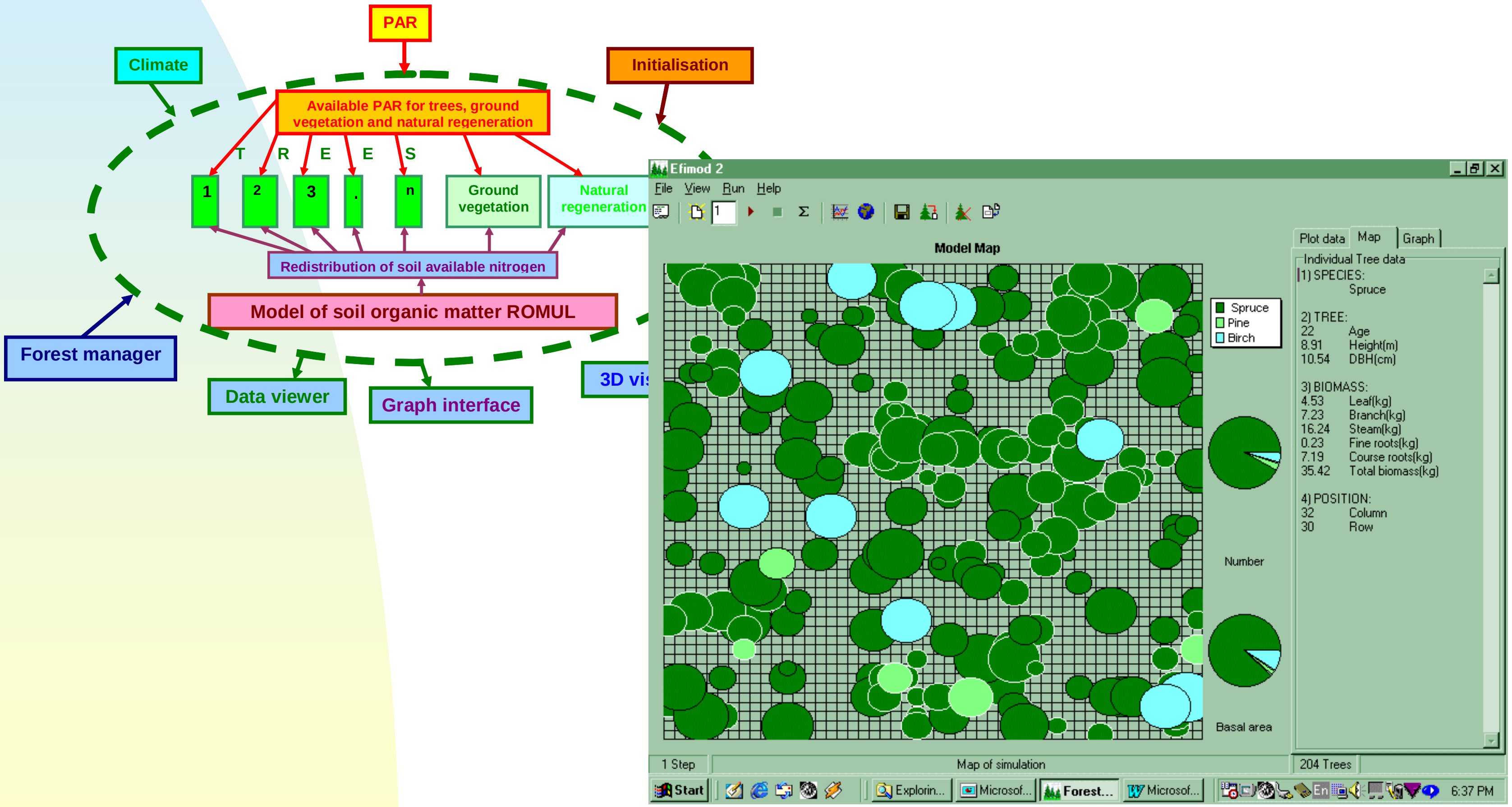
Forest

A part of forest enterprise "Russky Les" south of Moscow

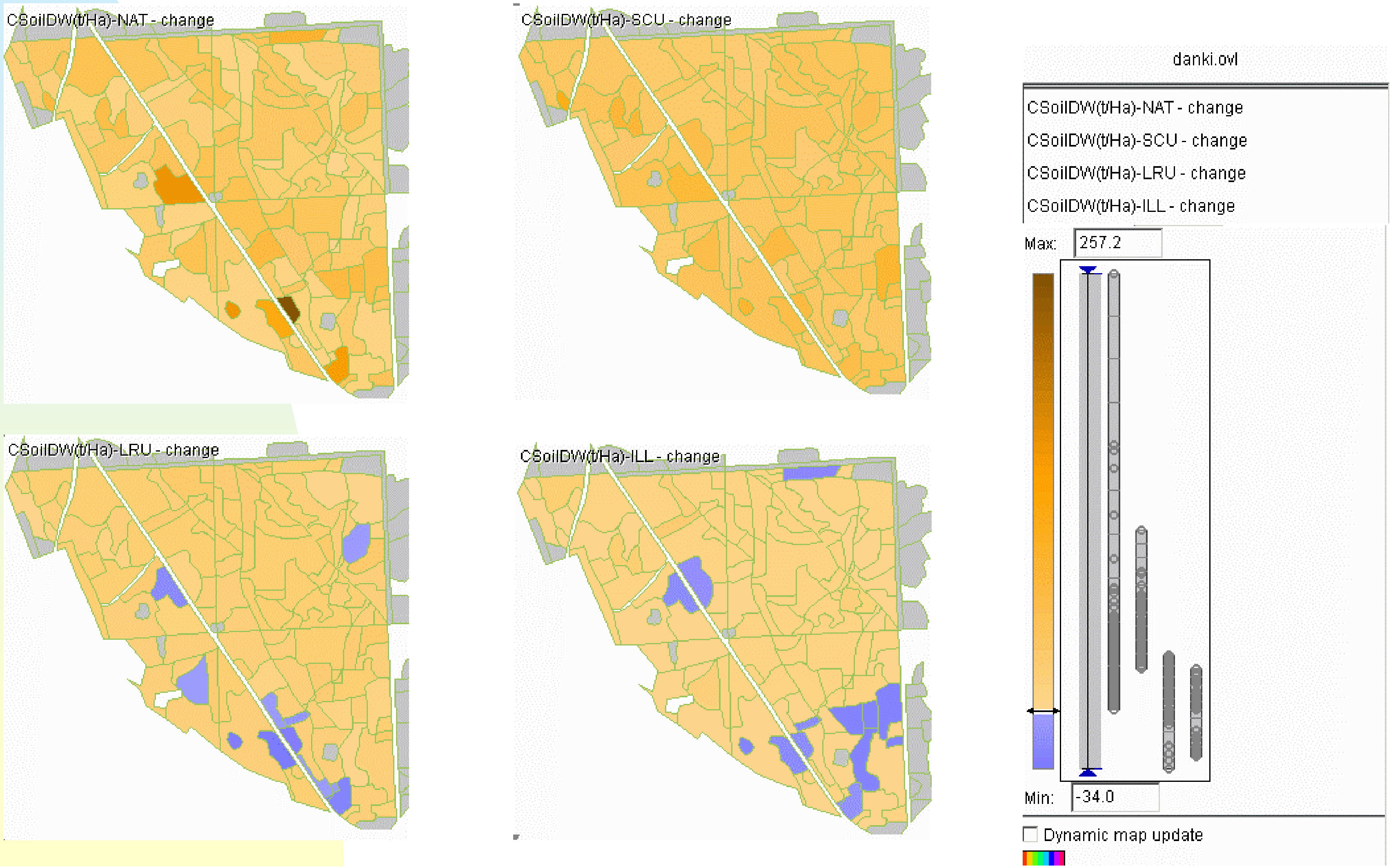
See presentation of Mikhailov et al. here



Spatially explicit individual-based model of tree-soil system EFIMOD



Difference of Soil C pools at the beginning and the end of 200-years simulation at different silvicultural regimes (Chertov et al., 2005)



CONCLUSION

- This methodological approach allows for soil carbon assessment in forest ecosystems of European Russia with a lack of soil mapping and regular soil monitoring of forest lands
- The results of soil carbon evaluation show promising prospects for assessment of soil C dynamics by the integration this assessment with simulation models of SOM dynamics or process/combined models of forest ecosystems
- The approach can be combined both with data of land inventory and remote sensing for mapping soil carbon

Acknowledgements

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Podzol

THANK YOU !