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Regional assessment of forest carbon budget (ROBUL): open source tool for analysis of Russian State Forest Registry databases

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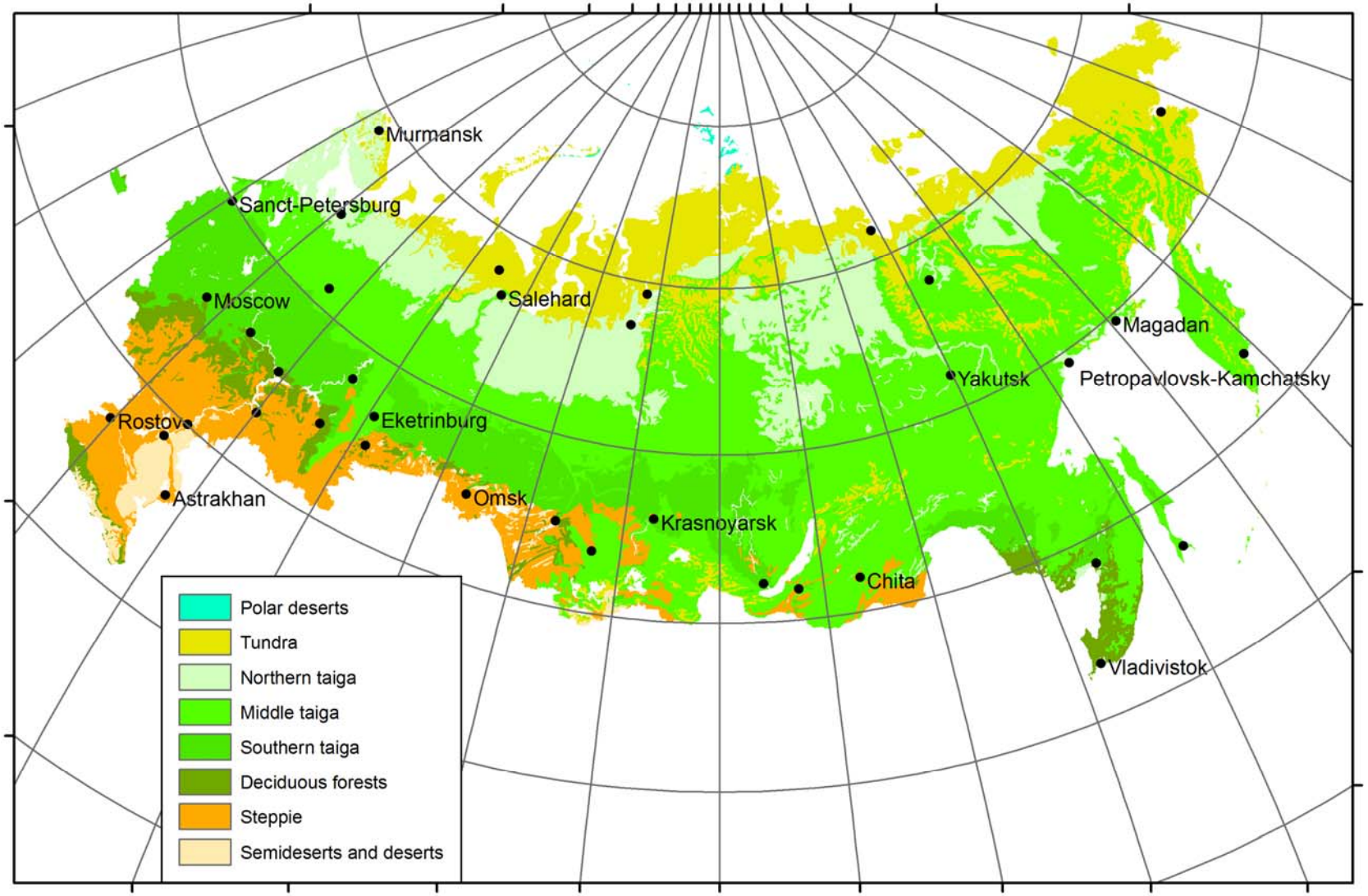
Forested area of Russia is 787 Mha (46.3 % of national area)



Approach to Russian forest GHG inventory

- Traditional forest inventory produces whole-country survey «State Forest Registry» (before 2006 «State Forest Account»)
- SFR databases are used as sources of initial information for GHG accounting.
- The system of calculations has name «ROBUL» (regional estimation of forest carbon budget).

State forest registry

- presents compilations of ground forest inventory (accessible forest, 61% of total area) and remote inventory (low accessible forest, 39% of total area) data.
- contains information about area and growing stock of forests in differentiation by dominant tree species, age group, type of forest use.
- contains information about temporary non-forested lands: clear cuts, burnt areas, dead stands etc.
- exists as databases for 1988, 1993, 1998-2008 (as State Forest Account) and 2009-2014.

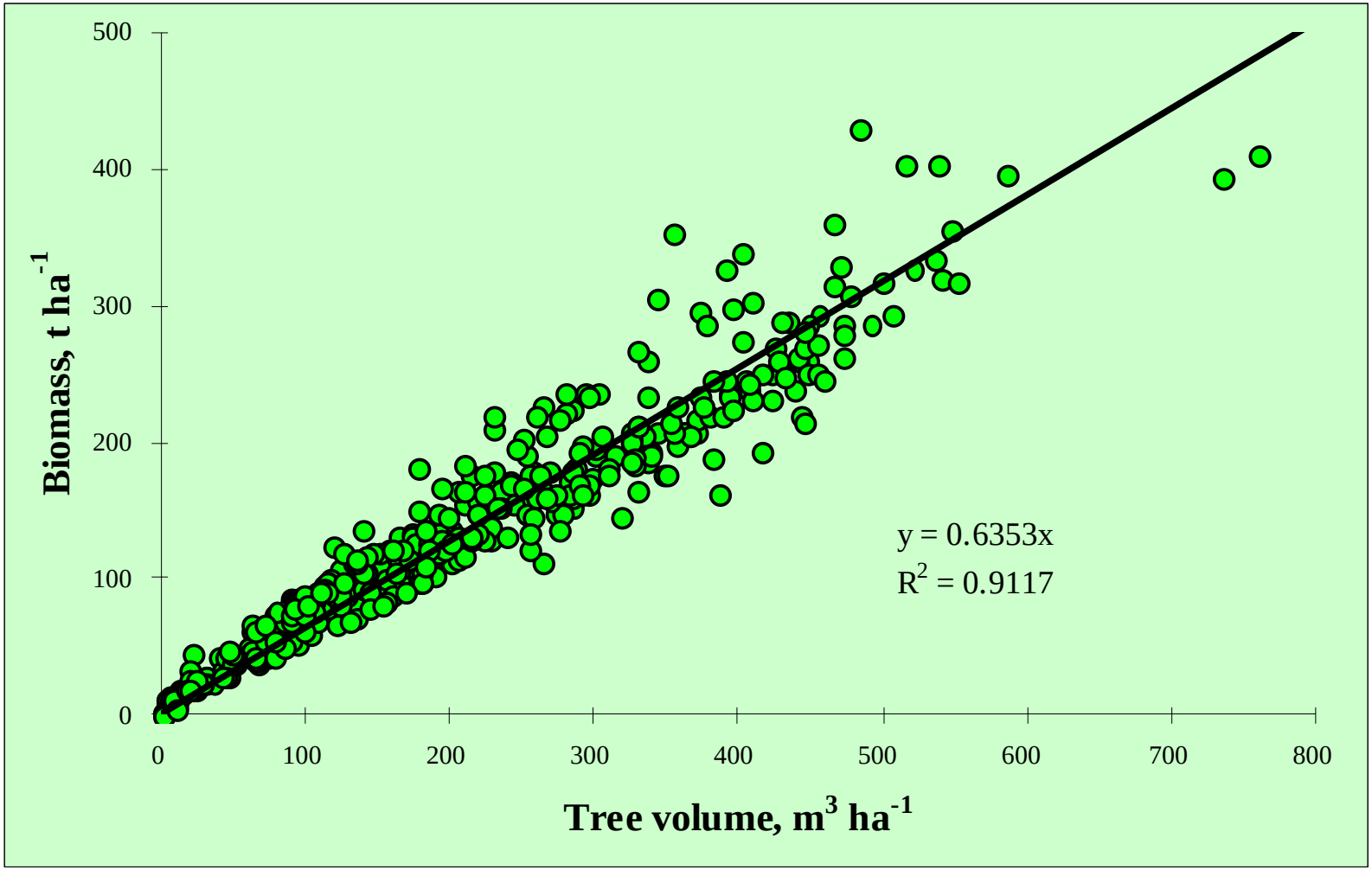
Base for developing of ROBUL

- IPCC Good Practice Guidance for LULUCF, 2003.
- Recommendations of UNFCC experts during in-country reviews in 2009 and 2010.

Main features of ROBUL system

- Estimation of carbon pools is performed for biomass, dead wood, litter and soil pools.
- Estimation of carbon in biomass and dead wood is performed using country-specific conversion factors.
- Estimation of carbon pools in litter and soil is performed using mean values per unit of area.
- Estimation of sequestration is performed on the base of carbon pool dynamics in consequent age groups.
- Estimation of carbon losses (felling, fires, insects, extreme weather events) is performed using information of clear cut, burnt and dead stand areas.

Biomass in relation with growing stock for pine stands



Conversion factors by tree species and age groups

Table 2. Factors of conversion of the volumetric growing stock into forest phytomass carbon (t C m^{-3}) according to the age groups of the prevalent tree species in Russia [according to 10]

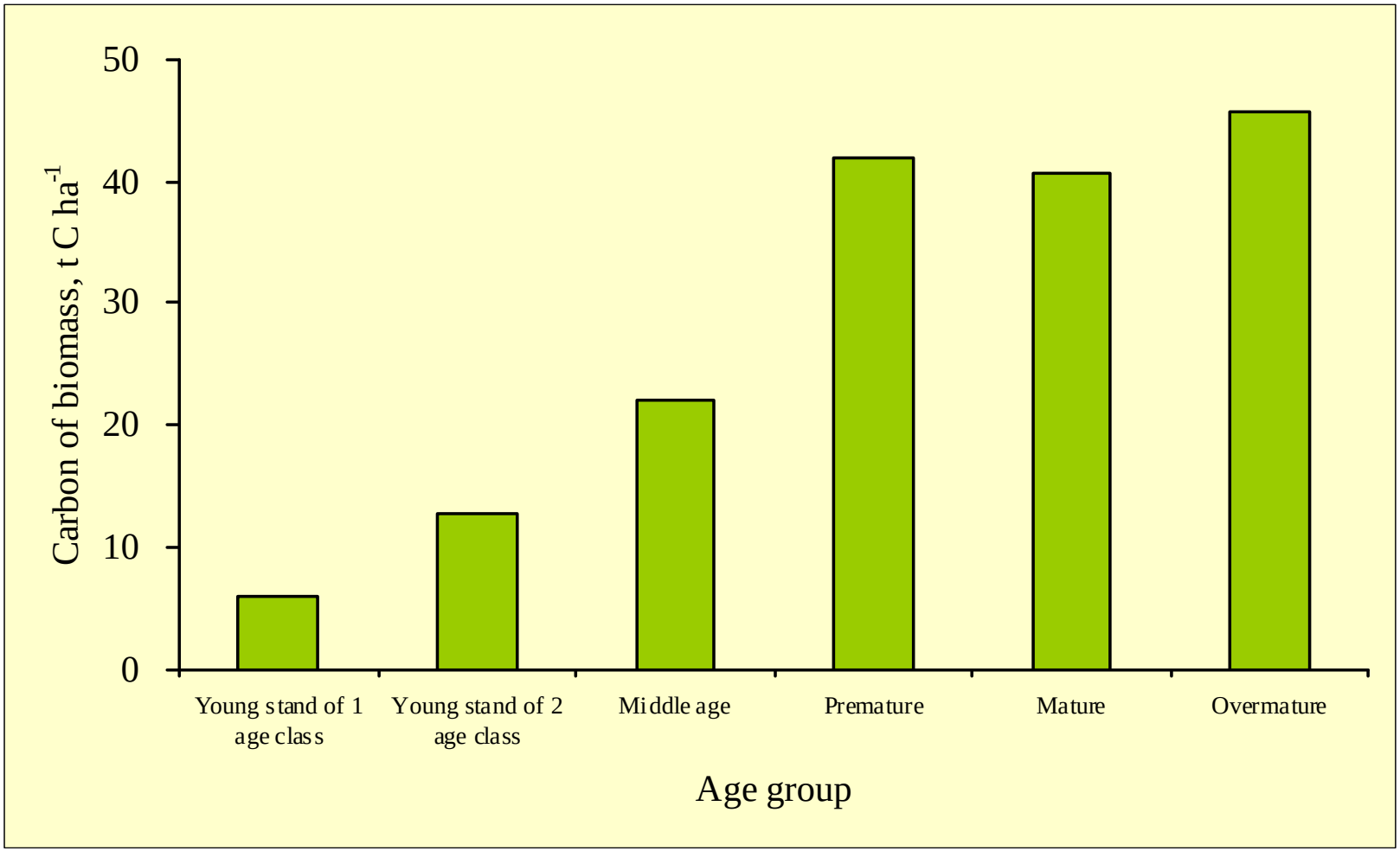
Prevalent species	Band	Age group			
		young forests of the first and second age classes	medium-age forests	ripening forests	ripened and over-ripened forests
Pine	1	0.469 ± 0.059	0.347 ± 0.012	0.369 ± 0.023	0.331 ± 0.012
	2	0.397 ± 0.039	0.323 ± 0.009	0.358 ± 0.026	0.323 ± 0.014
	3	0.434 ± 0.023	0.352 ± 0.013	0.329 ± 0.011	0.356 ± 0.012
Fir	1	0.468 ± 0.034	0.387 ± 0.019	0.381 ± 0.019	0.375 ± 0.020
	2	0.468 ± 0.034	0.370 ± 0.019	0.343 ± 0.013	0.341 ± 0.015
	3	0.614 ± 0.118	0.368 ± 0.037	0.351 ± 0.019	0.364 ± 0.013
Silver fir	1–3	0.420 ± 0.056	0.308 ± 0.020	0.283 ± 0.017	0.269 ± 0.018
Larch	1	0.523 ± 0.083	0.423 ± 0.023	0.450 ± 0.023	0.478 ± 0.022
	2	0.405 ± 0.083	0.418 ± 0.037	0.434 ± 0.056	0.403 ± 0.029
	3	0.392 ± 0.043	0.371 ± 0.056	0.398 ± 0.050	0.398 ± 0.050
Cedar	1–3	0.391 ± 0.037	0.341 ± 0.029	0.318 ± 0.027	0.450 ± 0.027
High-trunked oak	1–3	0.616 ± 0.069	0.490 ± 0.030	0.418 ± 0.040	0.478 ± 0.060
Low-trunked oak	1–3	0.795 ± 0.052	0.541 ± 0.066	0.563 ± 0.154	0.636 ± 0.178
Stone birch	1–3	0.795 ± 0.052	0.541 ± 0.066	0.563 ± 0.154	0.636 ± 0.178
Other hardwood deciduous species	1–3	0.624 ± 0.100	0.477 ± 0.029	0.388 ± 0.039	0.436 ± 0.030
Birch	1	0.461 ± 0.080	0.409 ± 0.060	0.408 ± 0.052	0.422 ± 0.044
	2	0.461 ± 0.080	0.437 ± 0.038	0.382 ± 0.027	0.369 ± 0.022
	3	0.437 ± 0.023	0.396 ± 0.012	0.367 ± 0.017	0.367 ± 0.023
Aspen, poplar	1–3	0.356 ± 0.055	0.363 ± 0.044	0.334 ± 0.059	0.365 ± 0.060
Other softwood deciduous species	1–3	0.381 ± 0.038	0.336 ± 0.023	0.334 ± 0.026	0.337 ± 0.016
Cedar elfin wood	1–3	0.699 ± 0.149	0.766 ± 0.161	0.832 ± 0.173	0.999 ± 0.203

Tables 2–5 give the following designations of bands: (1) the northern band (northern sparse forests and northern taiga), (2) the medium band (medium taiga), and (3) the southern band (southern taiga and more southern geographical zones).

Zamolodchikov et al., Contemporary problems of ecology, 2013

Example of age dynamics of growing stocks (spruce stands of Komi Republic)

Example of age dynamics of biomass carbon (spruce stands of Komi Republic)



Approach 1 to estimate losses

- Initial information:

  (1) SFR data on clear cuts, burnt and dead stands areas;

  (2) Reforestation periods for these areas (mainly from 3 to 15 years) .
- Mean disturbance rates is calculated as (1)/(2).
- Carbon losses are estimated using mean disturbance rates and mean carbon pools in forests of the region

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Approach 2 to estimate losses

- Initial information:

  (1) Officially reported data or remote estimations of annual destructive forest fire rates;

  (2) Officially reported data of annual clear cuts rates .

- Carbon losses are estimated using annual disturbance rates and mean carbon pools in forests of the region

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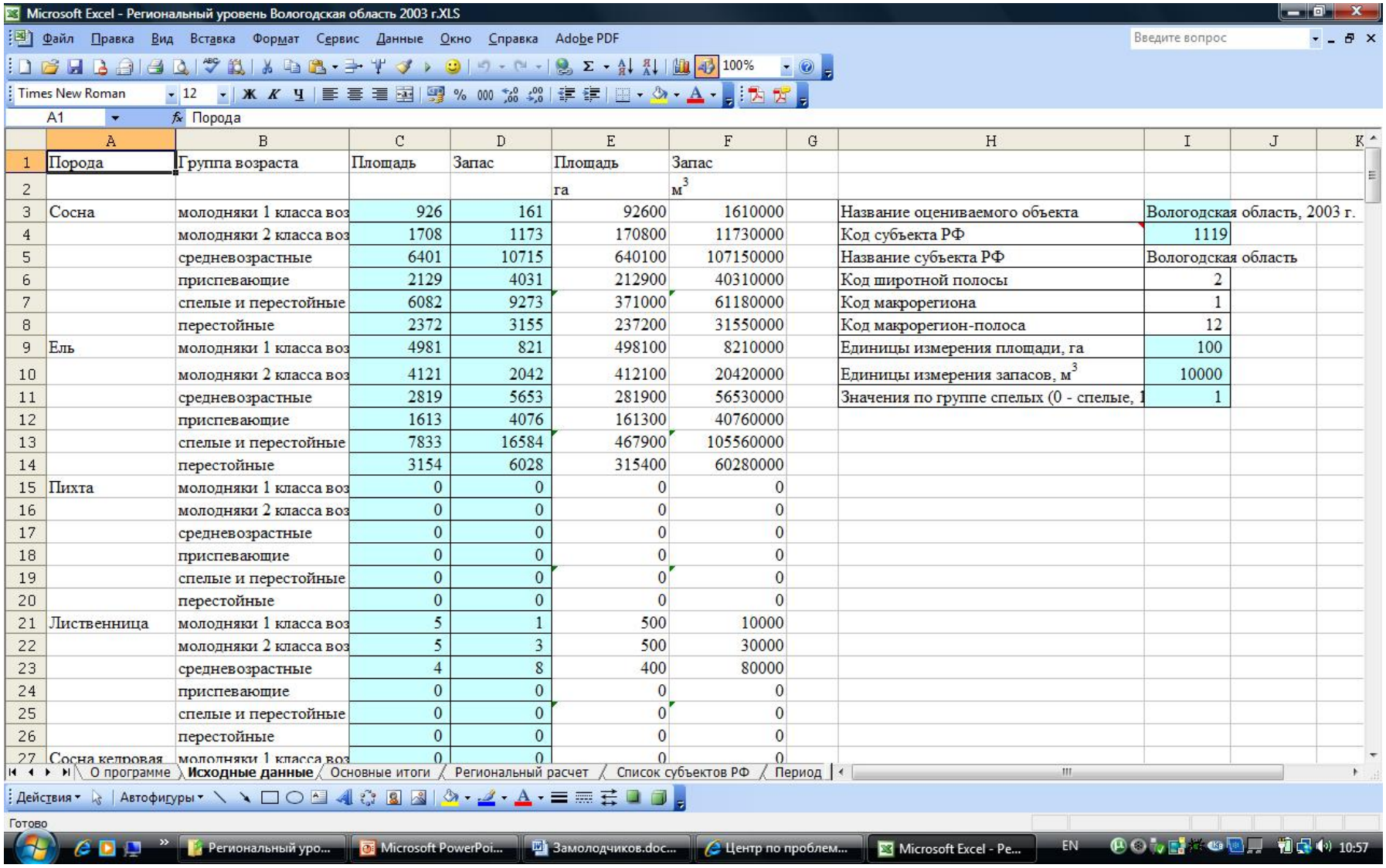
Approach to estimate uncertainties

- Base for estimation – standard errors (68% confident intervals) of parameters (conversion factors and mean values).
- In ROBUL equations parameters are replaced by uncertainties of parameters.
- In ROBUL equations differences are replaced by sums follow rules of uncertainties transformations.
- Uncertainties of area and growing stock values are suggested to be equal 0.

ROBUL open software: sheet of input data



Microsoft Excel - Региональный уровень Вологодская область 2003 г.XLS

	A	B	C	D	E	F	G	H	I	J	K
1	Порода	Группа возраста	Площадь	Запас	Площадь	Запас					
2					га	м^3					
3	Сосна	молодняки 1 класса воз	926	161	92600	1610000		Название оцениваемого объекта	Вологодская область, 2003 г.		
4		молодняки 2 класса воз	1708	1173	170800	11730000		Код субъекта РФ	1119		
5		средневозрастные	6401	10715	640100	107150000		Название субъекта РФ	Вологодская область		
6		приспевающие	2129	4031	212900	40310000		Код широтной полосы	2		
7		спелые и перестойные	6082	9273	371000	61180000		Код макрорегиона	1		
8		перестойные	2372	3155	237200	31550000		Код макрорегион-полоса	12		
9	Ель	молодняки 1 класса воз	4981	821	498100	8210000		Единицы измерения площади, га	100		
10		молодняки 2 класса воз	4121	2042	412100	20420000		Единицы измерения запасов, м^3	10000		
11		средневозрастные	2819	5653	281900	56530000		Значения по группе спелых (0 - спелые, 1	1		
12		приспевающие	1613	4076	161300	40760000					
13		спелые и перестойные	7833	16584	467900	105560000					
14		перестойные	3154	6028	315400	60280000					
15	Пихта	молодняки 1 класса воз	0	0	0	0					
16		молодняки 2 класса воз	0	0	0	0					
17		средневозрастные	0	0	0	0					
18		приспевающие	0	0	0	0					
19		спелые и перестойные	0	0	0	0					
20		перестойные	0	0	0	0					
21	Лиственница	молодняки 1 класса воз	5	1	500	10000					
22		молодняки 2 класса воз	5	3	500	30000					
23		средневозрастные	4	8	400	80000					
24		приспевающие	0	0	0	0					
25		спелые и перестойные	0	0	0	0					
26		перестойные	0	0	0	0					
27	Сосна кедровая	молодняки 1 класса воз	0	0	0	0					

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Готово

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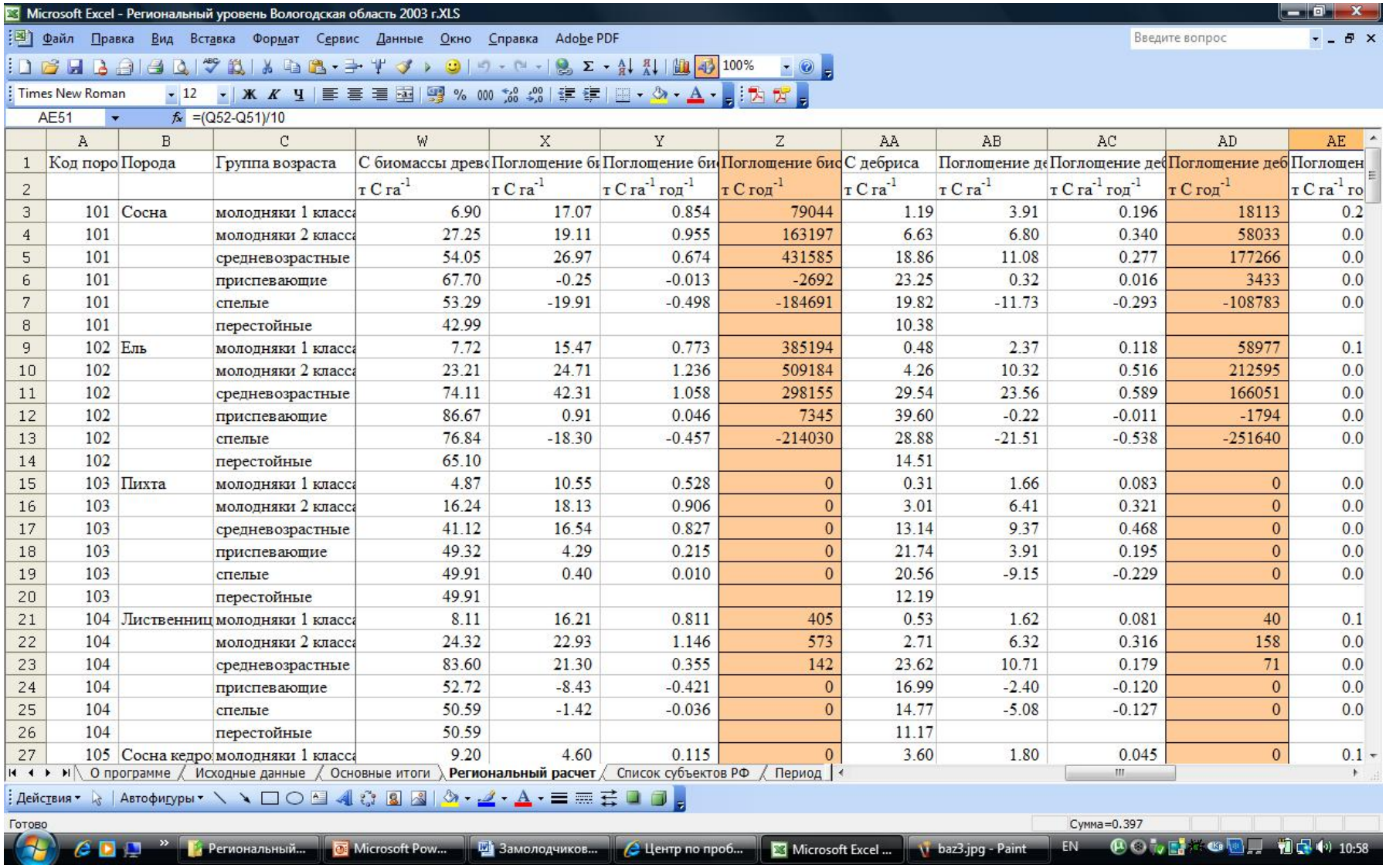
ROBUL open software: detailed results sheet



Microsoft Excel - Региональный уровень Вологодская область 2003 г.XLS

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Введите вопрос

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AE51 =(Q52-Q51)/10

	A	B	C	W	X	Y	Z	AA	AB	AC	AD	AE
1	Код поро	Порода	Группа возраста	С биомассы древ	Поглощение би	Поглощение би	Поглощение био	С дебриса	Поглощение де	Поглощение деб	Поглощение деб	Поглощен
2				т С га$^{-1}$	т С га$^{-1}$	т С га$^{-1}$ год$^{-1}$	т С год$^{-1}$	т С га$^{-1}$	т С га$^{-1}$	т С га$^{-1}$ год$^{-1}$	т С год$^{-1}$	т С га$^{-1}$ го
3	101	Сосна	молодняки 1 класса	6.90	17.07	0.854	79044	1.19	3.91	0.196	18113	0.2
4	101		молодняки 2 класса	27.25	19.11	0.955	163197	6.63	6.80	0.340	58033	0.0
5	101		средневозрастные	54.05	26.97	0.674	431585	18.86	11.08	0.277	177266	0.0
6	101		приспевающие	67.70	-0.25	-0.013	-2692	23.25	0.32	0.016	3433	0.0
7	101		спелые	53.29	-19.91	-0.498	-184691	19.82	-11.73	-0.293	-108783	0.0
8	101		перестойные	42.99				10.38				
9	102	Ель	молодняки 1 класса	7.72	15.47	0.773	385194	0.48	2.37	0.118	58977	0.1
10	102		молодняки 2 класса	23.21	24.71	1.236	509184	4.26	10.32	0.516	212595	0.0
11	102		средневозрастные	74.11	42.31	1.058	298155	29.54	23.56	0.589	166051	0.0
12	102		приспевающие	86.67	0.91	0.046	7345	39.60	-0.22	-0.011	-1794	0.0
13	102		спелые	76.84	-18.30	-0.457	-214030	28.88	-21.51	-0.538	-251640	0.0
14	102		перестойные	65.10				14.51				
15	103	Пихта	молодняки 1 класса	4.87	10.55	0.528	0	0.31	1.66	0.083	0	0.0
16	103		молодняки 2 класса	16.24	18.13	0.906	0	3.01	6.41	0.321	0	0.0
17	103		средневозрастные	41.12	16.54	0.827	0	13.14	9.37	0.468	0	0.0
18	103		приспевающие	49.32	4.29	0.215	0	21.74	3.91	0.195	0	0.0
19	103		спелые	49.91	0.40	0.010	0	20.56	-9.15	-0.229	0	0.0
20	103		перестойные	49.91				12.19				
21	104	Лиственниц	молодняки 1 класса	8.11	16.21	0.811	405	0.53	1.62	0.081	40	0.1
22	104		молодняки 2 класса	24.32	22.93	1.146	573	2.71	6.32	0.316	158	0.0
23	104		средневозрастные	83.60	21.30	0.355	142	23.62	10.71	0.179	71	0.0
24	104		приспевающие	52.72	-8.43	-0.421	0	16.99	-2.40	-0.120	0	0.0
25	104		спелые	50.59	-1.42	-0.036	0	14.77	-5.08	-0.127	0	0.0
26	104		перестойные	50.59				11.17				
27	105	Сосна кедро	молодняки 1 класса	9.20	4.60	0.115	0	3.60	1.80	0.045	0	0.1

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Действия Автофигуры

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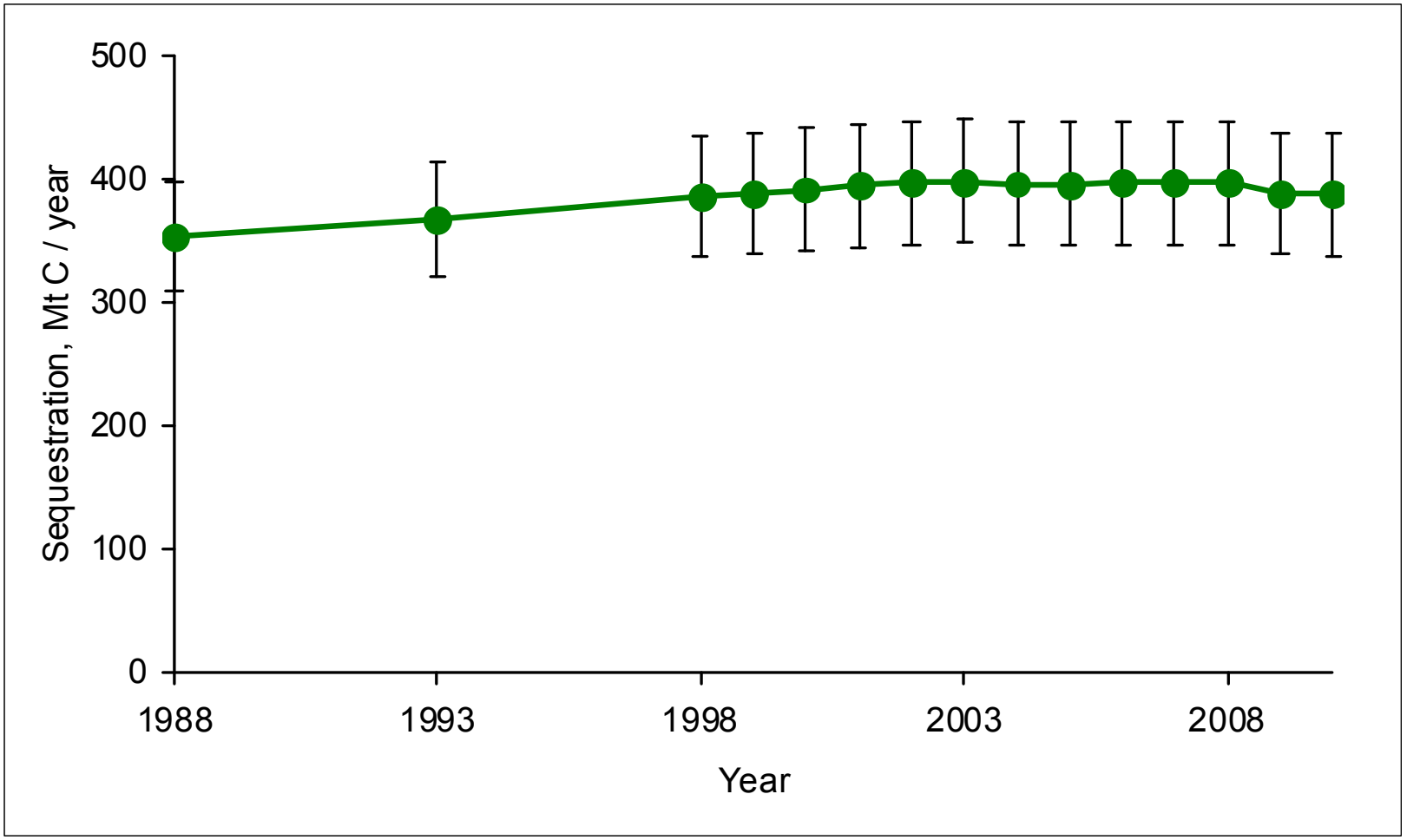
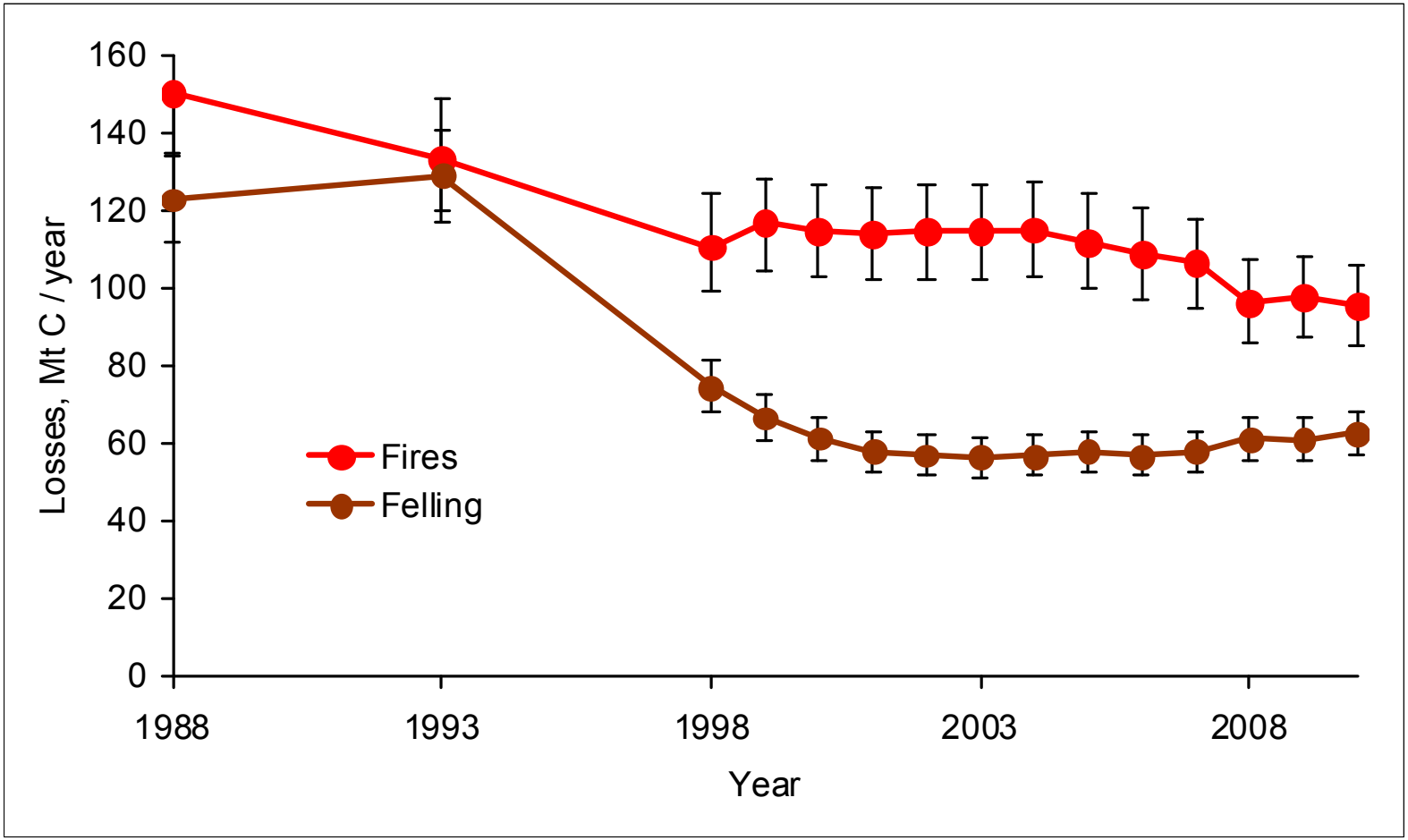
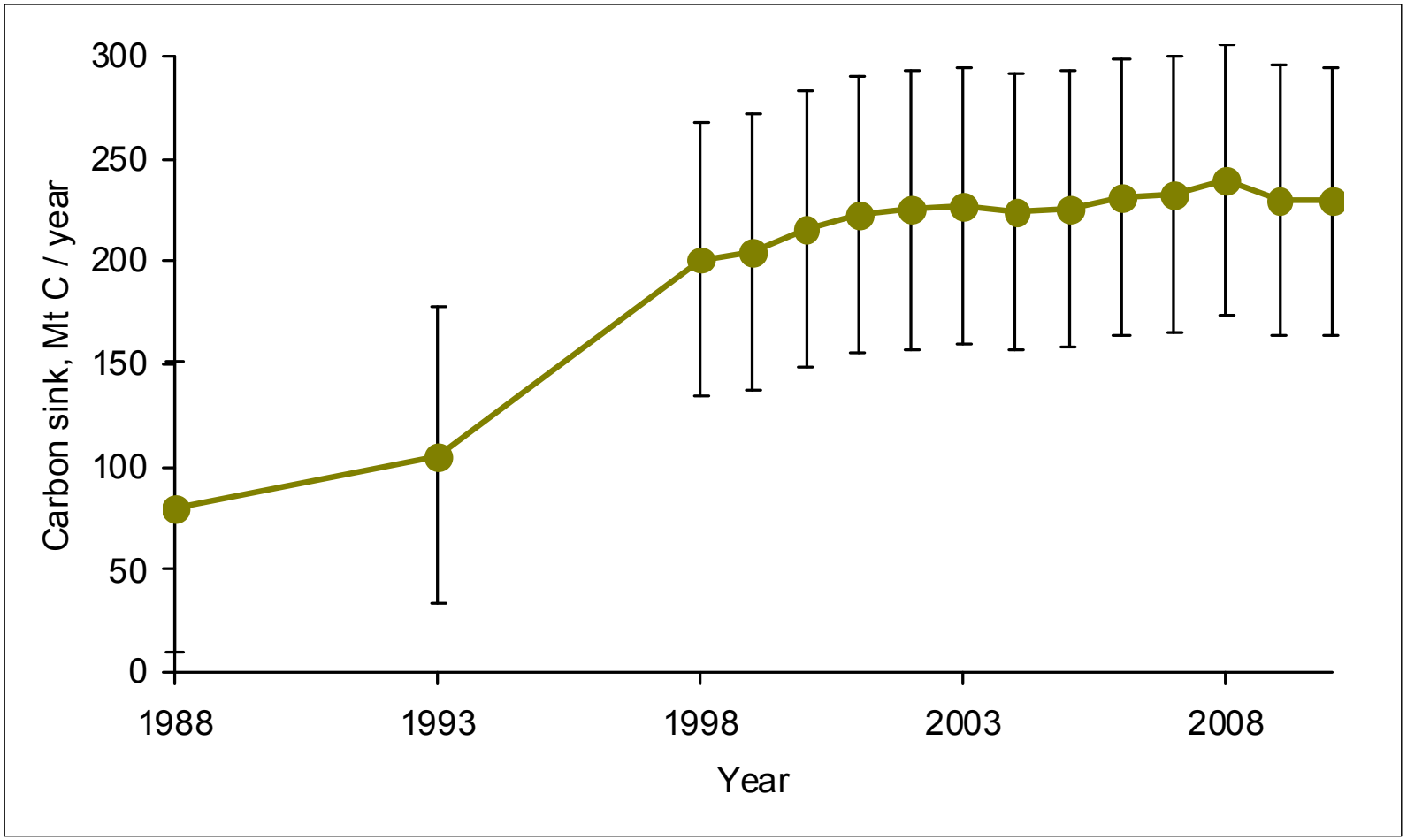
Carbon sequestration in Russian forests



Carbon losses in Russian forests (approach 1)

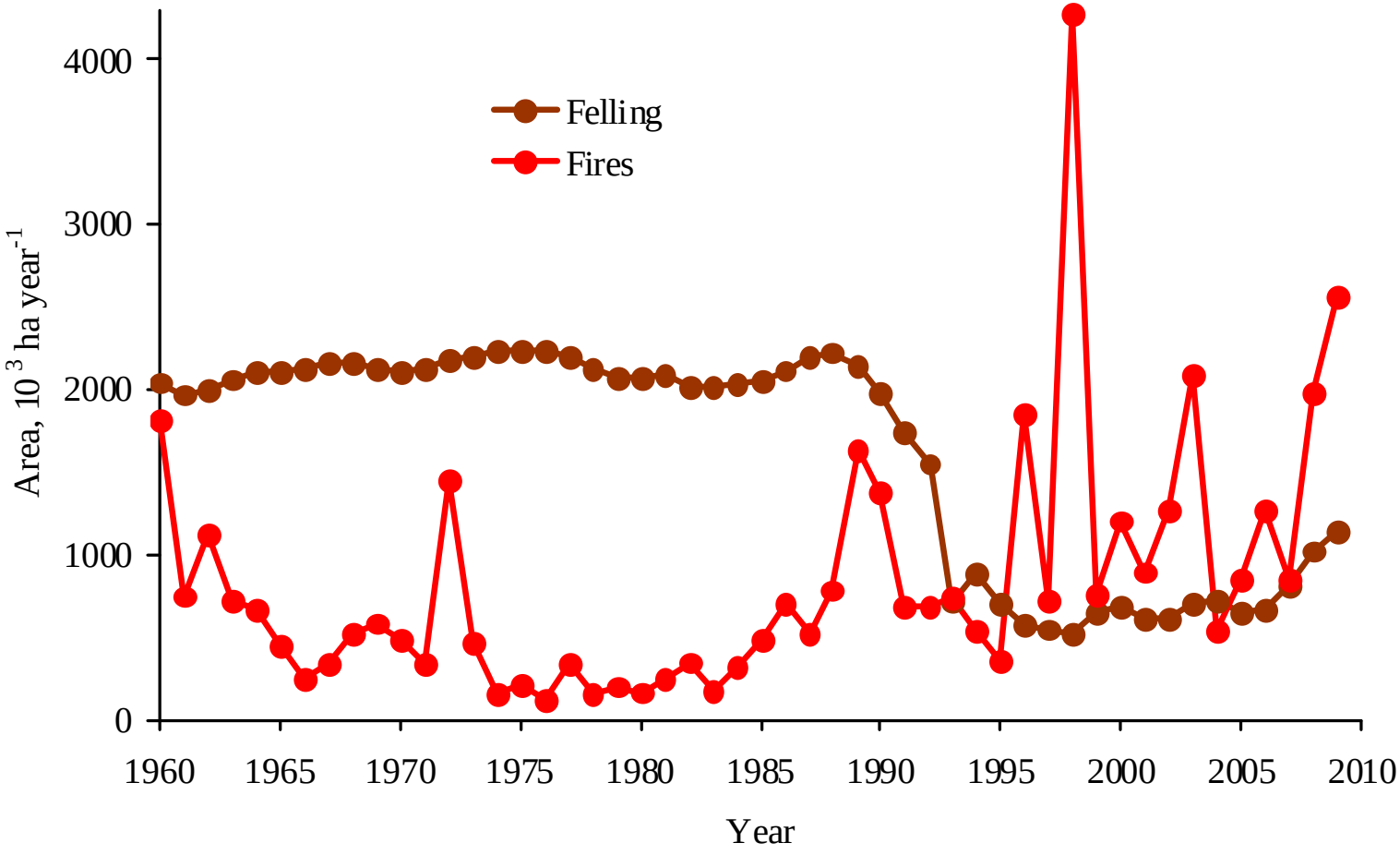


Carbon balance of Russian forests (approach 1)



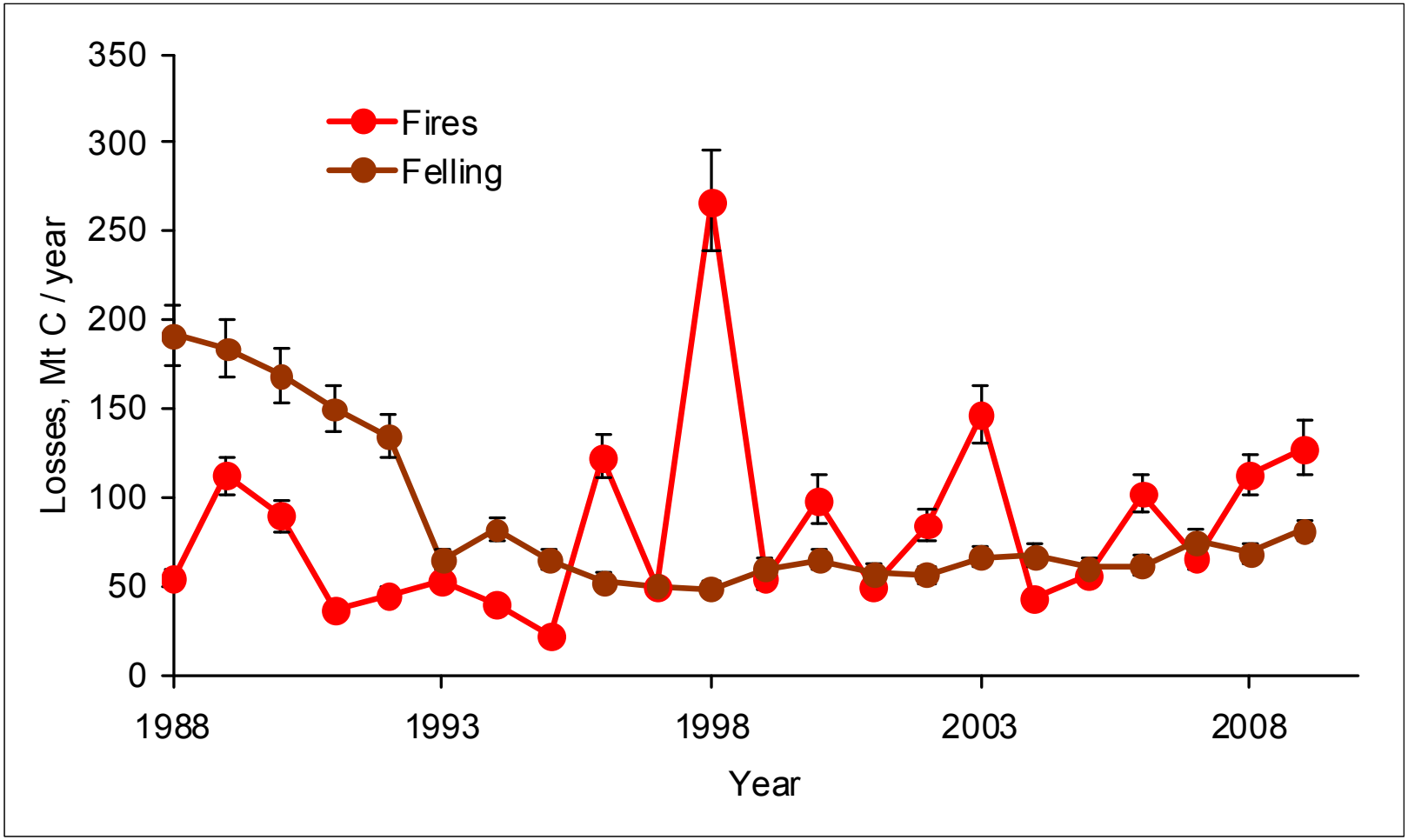
Zamolodchikov et al., Contemporary problems of ecology, 2013

Annual rates of felling and forest fires in Russia from 1960

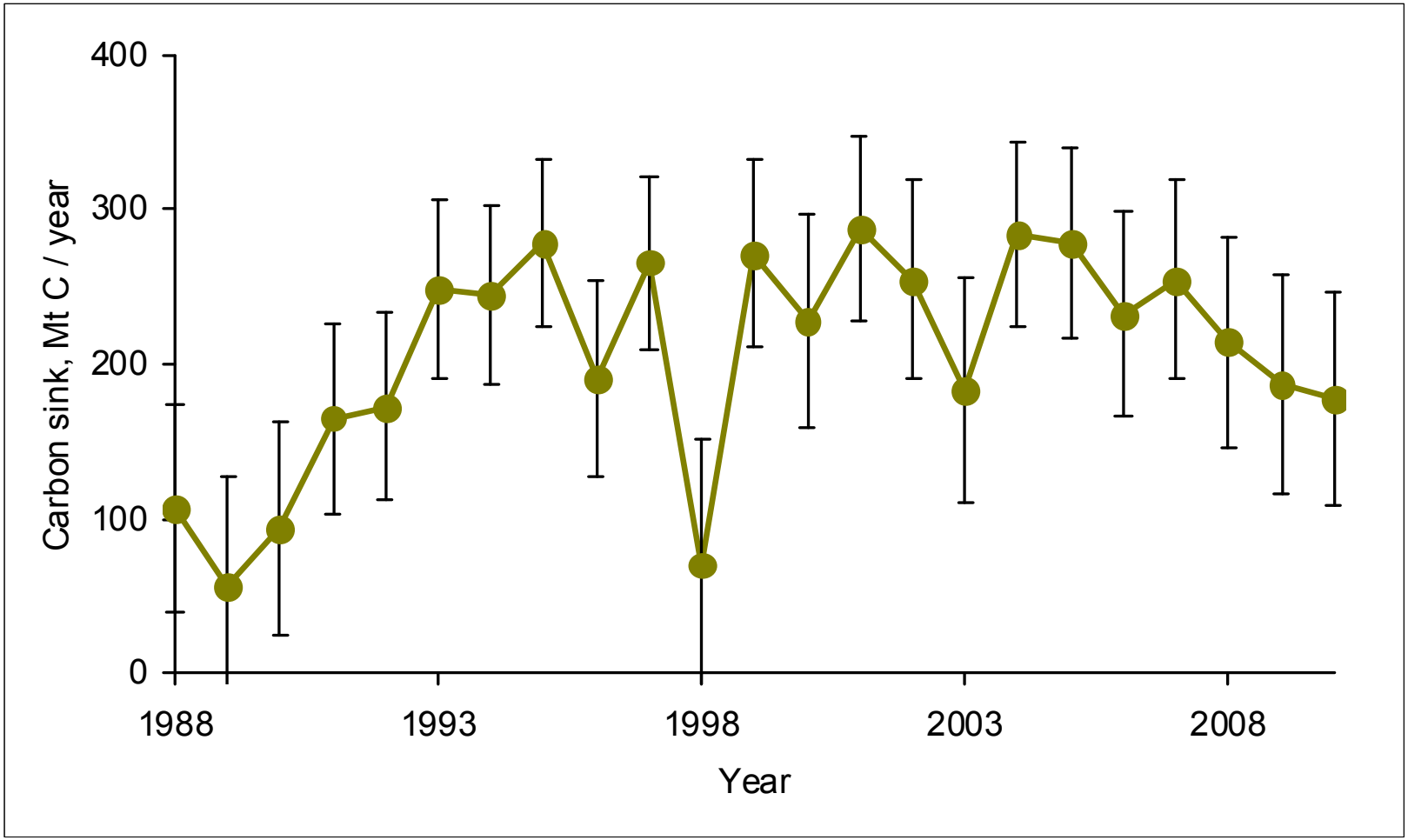


Zamolodchikov et al., Russian hydrology and meteorology, 2013

Carbon losses in Russian forests (approach 1)

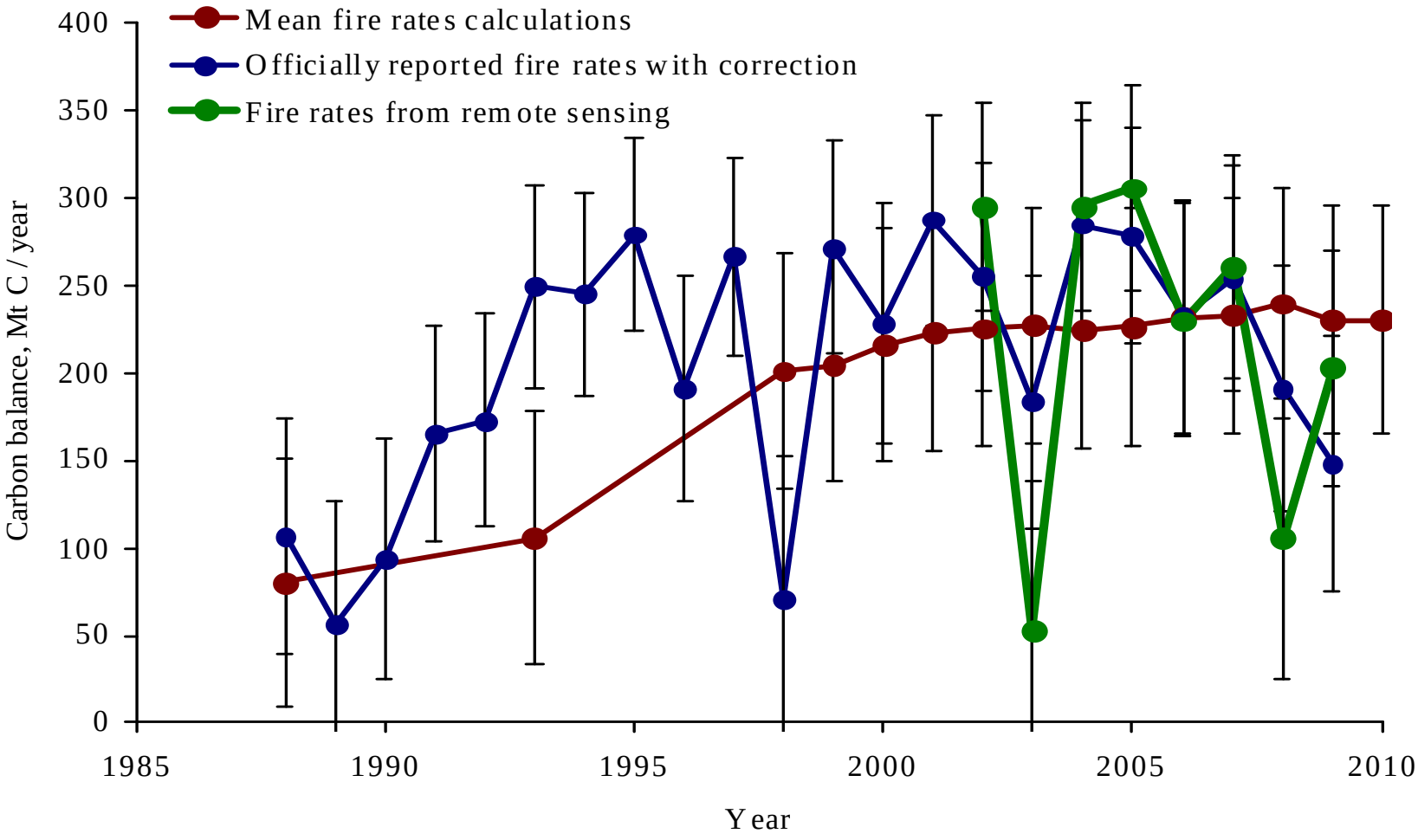


Carbon balance of Russian forests (approach 1)



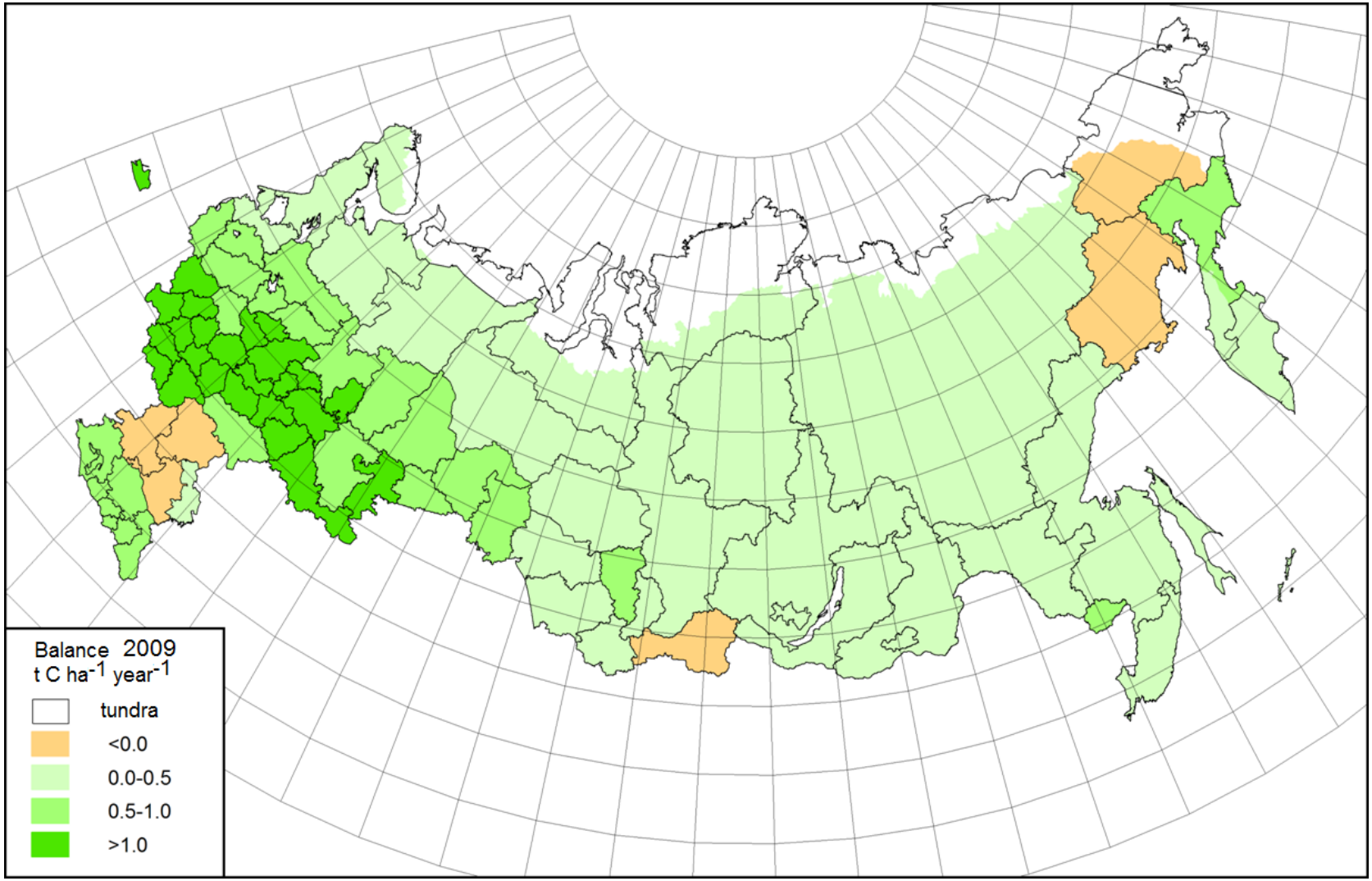
Zamolodchikov et al., Contemporary problems of ecology, 2013

Comparison of ROBUL estimates with different procedures of losses calculations

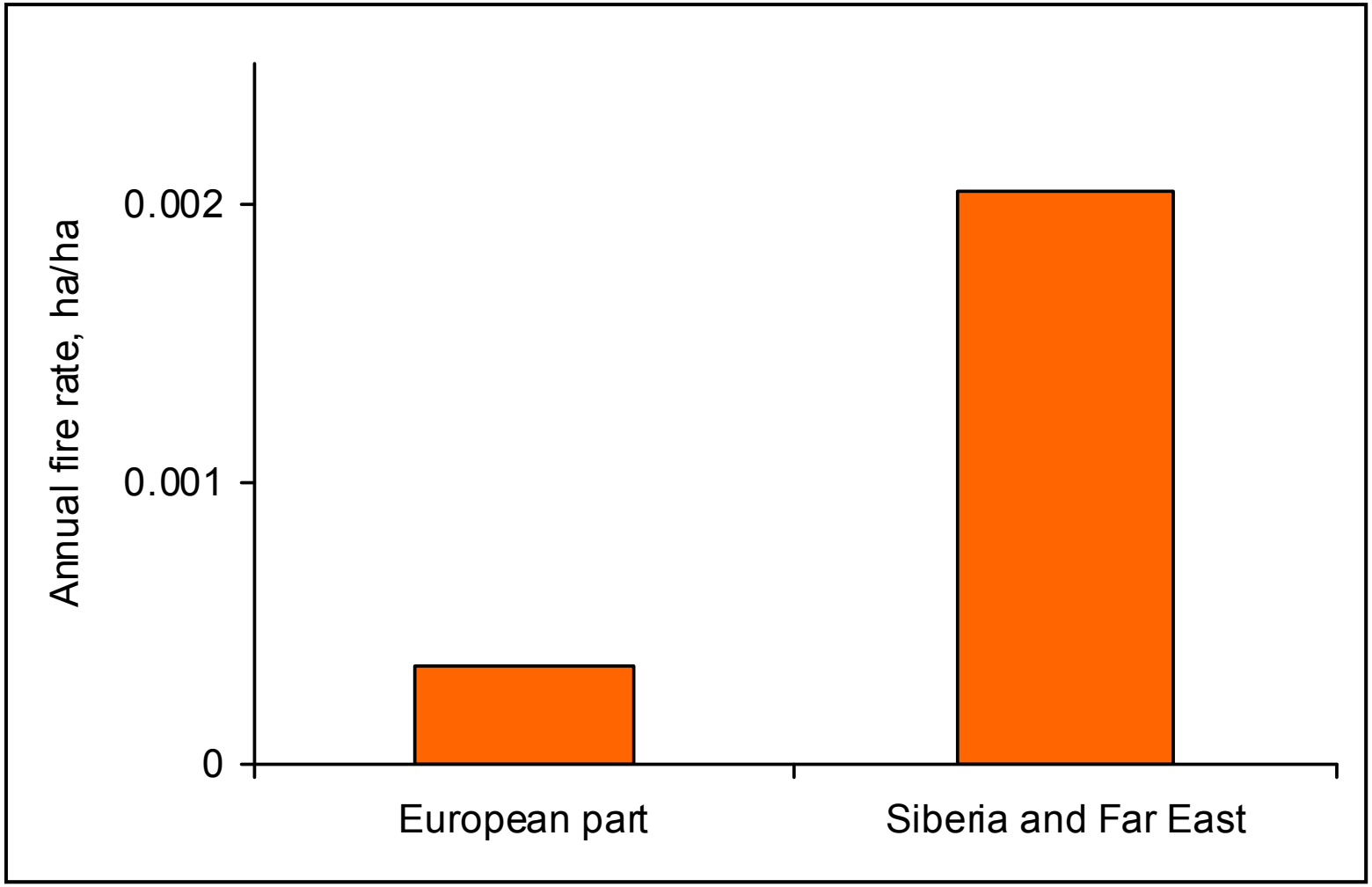


Zamolodchikov et al., Sustainable forestry (in Russian), 2014

Spatial distribution of forest carbon budget in 2009 (approach 1)



Annual forest fires rates (ha per ha of forest area) in European and Asian parts of Russia in 1988-2009



Some estimations of carbon sink to Russian forests

Carbon sink, Mt C / year	Tool of assessment	Источник
234±66	ROBUL system	Zamolodchikov et al., 2011, 2013
280	Estimation using remote sensing NDVI time series	Myneni et al., 2001, Dong et al., 2003
210	Geo-information system IIASA FOR	Nillson et al., 2000, Shvidenko, Nilsson, 2002
560±117 (±600)	Integral land information system (ILIS) IIASA	Shvidenko, Schepaschenko, 2014, Dolman et al., 2013 (Uncertainty from Gusti, Jonas, 2010)

Conclusions

- Russian forests were carbon sink from the atmosphere with annual rate 80 Mt C in late 1980th and 230 Mt C in 2000th.
- The increase of carbon sink to Russian forests is explained by strong decrease of forest felling in early 1990th and has anthropogenic causes.


Thank you very much!
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