CARBON BUDGET OF CIRCUMPOLAR BOREAL FORESTS: AN ATTEMPT OF SYNTHESIS

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Current global change science considers terrestrial ecosystems carbon account for large regions (countries, continents) as a fuzzy system (full complexity problem). In order to reliably estimate uncertainties of the accounting systems this requires integration of results received by different methods of carbon account (landscape-ecosystem approach (LEA); eddy covariance; process-based models, e.g. DGVMs; and inverse modeling). An approach to estimate uncertainties taking into account a fuzzy character of the problem is suggested in [3].

Estimates of the role of boreal forests in the global carbon cycle at a national level differ substantially dependently upon definition and accounted for extent of forests, completeness and system boundaries of the account, reliability of initial data, spatial and temporal coverage, and methodology used. During the last decade, two aggregated assessments of carbon budget of boreal forests were reported using the pool-based method based on forest inventory data [1, 2]. The recent publication estimated boreal forests (for the area of 1135 Mha, without Alaska and unproductive forests of Canada) as a persistent net carbon sink at 493±76 Tg C yr^{-1} on average during 1990-1997 and at 499±83 Tg C yr^{-1} during 2000-2007. This represents 20 and 22% of the global carbon sink, respectively. However, the contribution of boreal countries is substantially different: Russia provided 81% of this value in 1990-1997 and 93% in 2000-2007; Canadian forests were nearly neutral; and European boreal countries served as a small sink (65 and 27 Tg C yr^{-1} in 1990-1999 and 2000-2007, respectively). Small sink in Canada is basically explained by intensified wildfires and insect outbreaks. This assessment used the FAO definition of forests (i.e. 10% threshold of stocking was used and temporarily treeless forest land was accounted as forest).

The flux-based method presents more information for analysis. The latest estimate by the LEA for 2009 considered Russian forests as a net sink of ~0.69 Pg C yr^{-1} [4] (91% of the total sink provided by vegetation ecosystems of the country). The Russian definition of forest was used, and all forests (assessed by combination of remote sensing and ground data) were included. In spite of the high carbon sink provided by Russian land, significant areas, particularly in disturbed forests, open woodlands and grass and shrubs on permafrost are estimated as relatively small source that could be explained by increasing heterotrophic respiration due to the warming of last decades and accelerated wildfires. The results received by ensembles of DGVMs and inverse models showed very close results: during the last decade Russian forests served as a net sink of ~0.7 Pg C yr^{-1}. Additionally, it has been shown that the biosphere in Russian territories is a net source of methane at 16.2 Tg C-CH_4. Of this

amount, 1.5 Tg C-CH_4 yr^{-1} is provided by agriculture, 10.5 – by wetlands, 1.1 – by vegetation fire, and 3.1 Tg C-CH_4 – by inner water reservoirs [4].

Table. Carbon fluxes (Tg C yr^{-1}) associated with biosphere by sources and land classes. Sign “-“ means an efflux to the atmosphere [4]

Land class and processes	***Area, mln ha***	***Carbon flux, Tg C-CO_2 yr^{-1} by source***					
		NPP	HR	Dec	Fire	Insect	Balance
Forest	820.9	2,610.2	1,637.0	175.0*	55.5	50.8	691.9
Arable	77.8	409.1	330.4		0.4		78.3
Hayfield	24.0	109.1	79.5		1.1		28.5
Pasture	68.0	330.8	212.0		1.7		117.1
Fallow	19.0	21.2	16.7		0.3		4.2
Abandoned arable	29.9	151.6	104.5		1.0		46.1
Wetland	144.6	395.2	317.5	3.3	21.0		53.4
Open woodland	85.1	84.2	116.0	2.8	5.7		-40.3
Burnt area	23.7	32.9	38.9	13.4	1.4		-20.8
Grass & shrubland	315.7	618.8	611.4	13.2	9.2		-15.0
Water	44.0						-11.8
Consumption of plant products							-170.4**
Biosphere total	1652.7***	4,763.2	3,463.8	201.4	97.2	50.8	761.3

* including site effect of forest logging (6.3 Tg C-CO_2 yr^{-1})

** including wood products (28.4 Tg C-CO_2 yr^{-1})

*** not includes water and unproductive areas

The presentation considers major components of carbon cycling in boreal forests – Net Primary Production, Heterotrophic Respiration, fluxes due to disturbances, lateral fluxes (to the hydrosphere and lithosphere, trade) etc., their variability and uncertainties of assessments. Likely future trajectories of carbon cycling over the 21st century are briefly discussed.

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