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ASSESSMENT OF PATTERNS IN CARBON BALANCE OF PEATLANDS AT SOUTHERN TAIGA OF WESTERN SIBERIA

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SUMMARY

The regional assessment of carbon balance for peatland ecosystems at the South Taiga of Western Siberia is discussed. The key area located between Iksa and Bakchar rivers (56°58`N 82°36`E) at the Bakcharskoe bog in the Tomsk region, Russia. The basic types of oligotrophic and eutrophic ecosystems were studied. Carbon balance calculated from the emission of CO_2 and CH_4 from peat soils, net primary production (NPP), and carbon leaching with runoff. The analysis of results has shown that the carbon balance is positive in summer months. The analysis of space images and ground data were used for vegetation classification. Vegetation mapping allows estimating carbon balance for the whole key area and construct maps of NPP, CO_2 emission and carbon balance.

KEY WORDS: carbon balance, peatlands, regional assessment

INTRODUCTION

Peatland ecosystems play an important role in the biosphere. They are sources and sinks of greenhouses gases, and keepers of the biological diversity. Peatlands occupy only about 3-5% of the terrestrial surface, but the global peat resources are estimated at 120 - 455 PgC (Gorham 1991; Vomperskii 1994). The peat carbon pool of Russia is estimated at 215 PgC (Botch et al., 1995). The area of peatlands in Western Siberia is about 42% of the area of Russian peatlands. Western Siberia peatlands contain about 36% of all soil carbon of Russia (Vomperskii 1994; Efremov 1994). Carbon content in Western Siberia peatlands varies from 55 Pg (Efremov 2007) to 70 Pg (Sheng 2004). Although the size of the carbon reservoir is considerable, the role of peatlands in the global carbon budget is not studied\investigated deep enough. The carbon budget of a peatland ecosystem is the net result of the balance of net primary production (NPP) by photosynthetic fixation of CO_2, total ecosystem respiration by autotrophic and heterotrophic CO_2 emission from soil, together with methane emission by microbiologic peat decomposition and export of dissolved organic matter by runoff.

The aim of this study was to develop an overall carbon budget of oligotrophic and eutrophic wetlands in the South Taiga and to assess the regional carbon balance of peatland ecosystems in the Western Siberia. The results of long-term (1999–2010) instrumental observations at the northern margin of the Great Vasyugan Mires, the largest peatland system in the world (area 53 000 km^2) are discussed below.

MATERIAL AND METHODS

The region chosen for the observations is located between the Iksa and Bakchar rivers (56°58`N 82°36`E) at the Bakcharskoe bog (area 1400 km^2) (Fig. 1). The studied area includes pine– shrub–sphagnum (PSS) community, a similar community with stunted (low) pine trees (LPSS), and sedge–sphagnum fen (SSF). A detailed description of the vegetation at the studied plant communities is presented in (Golovatskaya, 2009). The peat deposit is 1–3 m thick and 3–5 ka old. The biological productivity at eutrophic fen (EF) “Samara” was studied too. The peatland has square 400 ha and located at low left terrace of Bakchar river. Maximum depth of peat is 4 m.

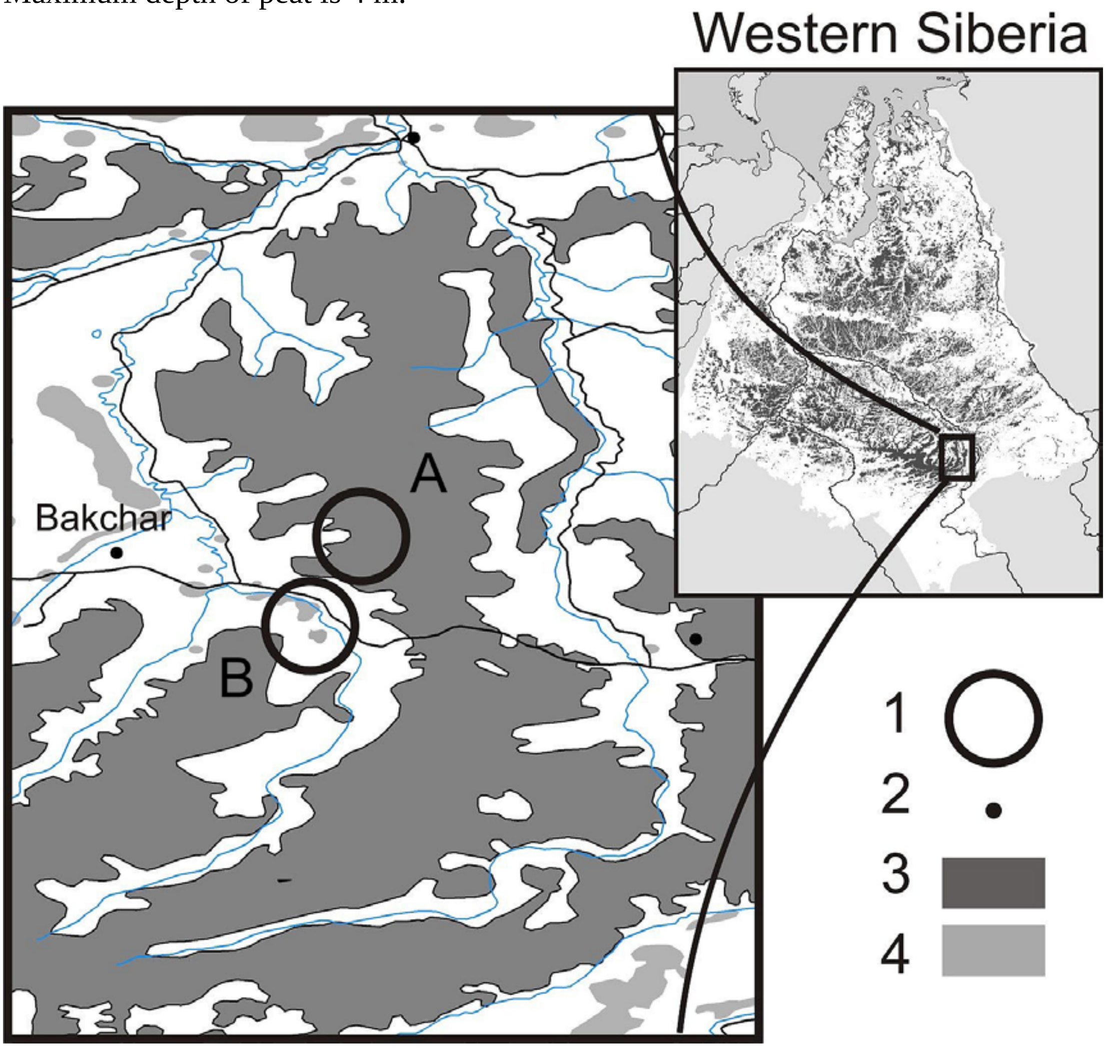

Fig.1. The study area. 1 – Observation points, 2 – settlements, 3 – the Great Vasyugan Mires, 4 – peatlands, A – oligotrophic observation sites. B – eutrophic observation sites.

Net primary productivity was measured by clipping method. Above-ground production (ANP) was calculated as a sum of production of herbs, shrubs and mosses. Below-ground production (BNP) was calculated as a difference between seasonal maximum and minimum of live roots of shrubs and herbs. The net primary production (NPP) was calculated as a sum of values above-ground and below-ground production (Golovatskaya, Dukarev, 2009). Carbon dioxide emission was measured using an infrared gas analyzer OPTOGAS 500.4 (OPTEC Corp., St.-Petersburg, Russia) attached to a static opaque plastic chamber (volume 16.6 L, basal area 590 cm^2)(Golovatskaya, Dukarev, 2009). Carbon dioxide emission was estimated by the rise of

CO_2 concentration in the chamber. The exposition time was 30 minutes. Methane emission was determined by the chamber method, exposure time 15 minutes. Air sampling was conducted at the beginning and at the end of exposure. Then the samples were analyzed in the laboratory on gas chromatography Shimadzu GC-14B. CH_4 emission was estimated by the rise of CH_4 concentration in the chamber. Additional carbon losses, such as, winter CO_2 and CH_4 emissions and carbon export by river runoff, were estimated on the basis of the reference data (Panikov and Dedysh, 2000, Nykanen et al., 2003; Heikkinen et al., 2002; Vomperskii, 1994) obtained for peatlands in climatic conditions similar to those in Western Siberia. The annual carbon budget for the studied ecosystems was calculated as the difference between carbon fluxes (CO_2 and CH_4 emission, export by river runoff) and vegetation net primary production.

Mapping of vegetation types for mire massif Bakcharsky was done basing on the analysis of Landsat space images and field study of the key area (Dyukarev et al., 2008). Area of the key site was divided into watershed, terrace areas and uplands. Classification with training was used for classes recognition. 24 classes of vegetation cover were found at the studied area.

RESULTS

The net primary production (NPP) is the accumulation of carbon in the form of vegetation matter. The results of the study have shown that, despite of essential differences in composition of the vegetation, the average values are similar at oligotrophic bogs. NPP for PSS, LPSS and SSF are equal to 558, 587, 571 g/m^2 per year. NPP at EF is 1.4 times higher in comparison to oligotrophic bogs (Fig.2). The main contribution to production at studied oligotrophic and eutrophic ecosystems gives roots of herbs and shrubs (47-57%) and *Sphagnum* mosses (17-30%).

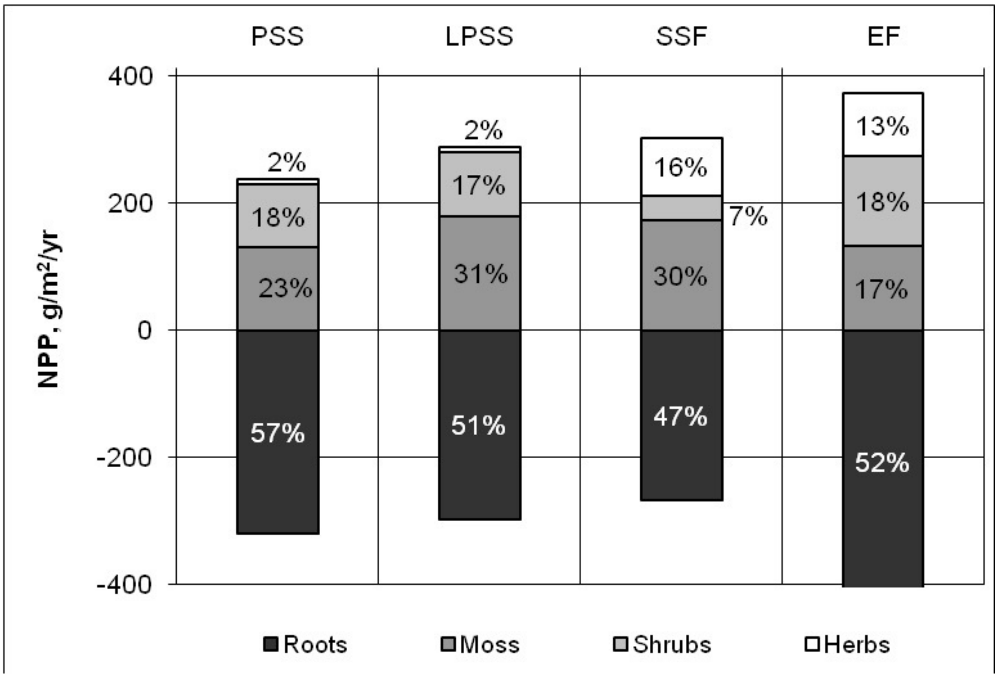

Fig. 2 Net primary production at the studied ecosystems.

CO_2 fluxes recorded during 1999 – 2010 represent a distinct seasonal pattern. CO_2 emission starts at the onset of spring snowmelt. In summer, CO_2 emission intensity rise up to the middle of summer (July), and then goes falls. CO_2 emission rates ranged from 20 - 60 $mgCO_2/m^2/h^1$ in spring (mid-May) and autumn (late-September) to 400-600 $mgCO_2/m^2/h$ in mid-summer (July), depending on the ecosystem.

Observation of methane fluxes has shown that maximal emission is typical for water saturated ecosystems. It varies from 8.22 to 68.78 $mgCH_4/m^2/h$ for sedge-sphagnum fens and hollows. Methane emission at LPSS and PSS is much lower (from 0.32 to 1.93 $mgCH_4/m^2/h$). The average CH_4 emission at eutrophic mire is 70 $mgCH_4/m^2/h$.

Total annual carbon emission at each measurement site were calculated on the basis of the obtained data on CO_2 and CH_4 emission from the surface, winter CO_2 and CH_4 emissions, and carbon movements with runoff , obtained for mires in climatic conditions similar to those in Western Siberia. We assume that wintertime CO_2 fluxes accounted for 20 % of the summer fluxes. The average stream water carbon losses for the studied peatland were estimated equal to 8 $gC/m^2/yr$. Table 2 shows the mean annual carbon fluxes at each studied ecosystem in 1999-2010.

Table 1. Structure of averaged (1999-2010) carbon balance (mean ± standard deviation). All data in gC m^{-2} yr^{-1}

Ecosystem	**PSS**	**LPSS**	**SSF**	**EF**
CO_2 emission (snow-free period)	196.9 ± 6.9	125.0 ± 4.3	130.8 ± 4.6	225.6±5.3
CO_2 emission (snow-cover period) *	35.5 ± 2.1	25.6 ± 0.9	17.0 ± 0.6	45.1±2.2
CH_4 emission (snow-free period)	3.5 ± 0.2	5.2 ± 0.3	10.4 ± 0.5	33.8 ±1.2
CH_4 emission (snow-cover period)*	0.31 ± 0.02	0.47 ± 0.03	0.93 ± 0.06	3.0±0.05
Carbon looses with river discharge*	8.0	8.0	8.0	12.7
Total carbon emission	244.1 ± 5.8	164.2 ± 5.4	167.1 ± 5.5	321.2±6.2
NPP	286.1 ± 45.7	270.0 ± 60.7	252.4 ± 79.3	383.4±84.3
Balance = NPP – Total emission	20.9 ± 45.3	111.8 ± 59.5	102.3 ± 79.1	62±21.2

* - reference data, see text for comments.

Carbon balance estimated for different ecosystems in combination with vegetation classification has allowed to make map of spatial patterns of carbon balance, net primary production and CO_2 emission over the key area and to calculate the total carbon accumulation in peatlands. Studied ecosystems of “Bakcahrskoe” bog accumulates 1.01* 10^5 ton of C annually. The key area occypies only 0.04 % from the world peatlands area and 0.001% from the Earth land surface.

CONCLUSION

The analysis of space images and ground data were used for vegetation classification and an estimation of the areas occupied by different ecosystems. Vegetation mapping allows estimating carbon balance for the key site and constructing maps of NPP, CO_2 emission and carbon balance for studied peatlands. The area of peatlands in South-Taiga zone of Western Siberia makes 3.4% from the area of mires of the world. Carbon accumulation in studied area is 11.3% from carbon accumulation by peatlands of the world and 0.27% from carbon accumulation by terrestrial ecosystems. The rate of carbon accumulation in studied peatlands is 3-4 times higher than with global estimations of peatland carbon accumulation.

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