Map-based inventory of wetland biomass and net primary production in western Siberia

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Abstract

Wetland biomass and NPP inventory for west Siberian wetlands was created using available field survey and literature data. We developed the multi-scale approach based on a regional wetland typology map (2.5M scale), further refined by satellite image classifications (LANDSAT, SPOT, 200K scale). The aerial imagery (25K scale) were used to evaluate the areal fraction of microsites composing the patterned wetlands in a boreal region, where the point observations were conducted.

As a result of scaling up the ground survey data corresponding to wetland type on the regional scale map, the average and total biomass and NPP were estimated by ecosystem type, the number of vegetation layers, and climatic gradient.

The NPP to live biomass ratio gradually increased southward from 0.27 in the tundra to 0.65 in the steppe region. Live biomass of wetlands amounted to only 10-30% of the average biomass of upland forests in the same climatic conditions, although wetland NPP was found to be equal or even higher then that of upland forests (particularly, in grass-dominated wetlands).

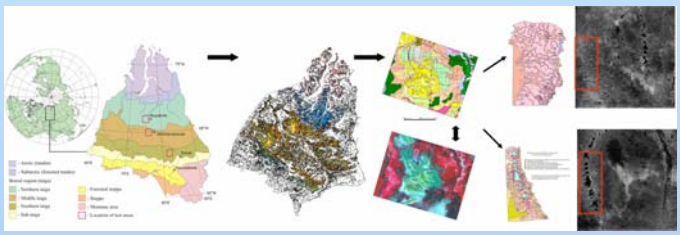
Keywords : **biomass and NPP inventory, wetlands, western Siberia**

Introduction and research methods

Additional studies that include both aboveground and belowground NPP and biomass are needed to build a foundation that can be used to determine the overall carbon storage capacity and carbon fluxes in Siberian wetlands.

Earlier studies (e.g. by *Campbell et al.,* 2000) have described the distribution of biomass/NPP within northern wetlands, primarily above ground. However, there have been relatively few measurements of belowground components. We have developed our own method for direct measurement of root and *Sphagnum* moss production (*Peregon et al.,* 2008).

Spatial differences in microsite characteristics (hydrologic and thermal regimes, nutrient availability, etc.) affect the plant species distribution and productivity. Thus, we decided to use a scale-up approach to combine the GIS and point observation data.



Geographical division of western Siberia and location of test areas. | *Wetland typology map, 2.5K scale, 20 wetland classes and complexes* | *Satellite image classification, 30 classes of landscapes* | *(1) Ridge-hollow,(2) Ridge-hollow-pool patterned wetlands*

Test areas for field observations were selected along a wide south-north latitudinal gradient of WS (in southern, middle, and northern boreal regions) and represent different topography.

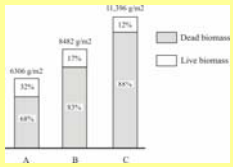
In addition to our own data, we used 91 biomass and NPP estimations derived from the published results of previous studies.

Then, the ground survey data were scaled up corresponding to wetland type on the regional scale map.

Results and discussion

Pool of the wetland biomass

Ecosystems	Live biomass: Green, phytomass: M+L	Green, phytomass: grass	Green, phytomass: shrubs	Below-ground	Live biomass (total)	Dead biomass	Total biomass	n*
				Northern taiga				
Extr. swamp[2]	371±30	40	52	873±85	1339	9971±962	11,310±1430	9
Palsa[1]	555±24	11	106	788±164	1460	13,606±8687	15,066±8962	9
Ridge[1]	410±88	9	296	1349±176	2064	6658±203	8722±239	12
Mesotr. hollow[2]	200±20	74	14	986±77	1274	8365±870	10,139±1524	12
Oligotr. hollow[2]	351±50	19	2	397±83	769	10,973±1930	11,742±1889	18
				Middle taiga				
Ryam[1]	308±33	5	283	931±72	1524	8419±301	9943±820	5
Ridge[1]	345±36	7	184	830±20	1386	11,203±384	12,596±579	5
Mesotr. hollow[2]	539±45	79	163	967±183	1748	4612±206	5860±201	3
Oligotr. hollow[2]	436±50	40	26	468±57	970	4666±241	5636±220	5
				Southern taiga				
Ryam[1]	572±51	53	383	1284±130	2292	5506±1050	7798±920	28
Ridge[1]	317±70	66	139	952±122	1474	4450±1024	5924±1429	6
Extr. swamp[1]	415±53	117	182	2590±154	3304	3079±255	8383±100	9
Mesotr. hollow[2]	332±49	46	121	1594±48	2093	3468±398	5561±394	25
Oligotr. hollow[2]	420±25	27	61	375±48	883	2983±87	3866±88	21



Total biomass (mean values, g/m^2) and its fractions (%). Regions: A – southern taiga; B – middle taiga, C – northern taiga.

Units are in g/m^2.

Vegetation communities: 1- pine-dwarf shrub-*Sphagnum*, ryam; 2 - sedge-*Sphagnum*, 3 - shrub-lichen-*Sphagnum*, 4 – sedge-*Eriophorum*-*Sphagnum*. M+L = mosses and lichens correspond to land-surface biomass (LS), grasses and shrubs correspond to above-ground biomass (AG); n* - number of test plots.

- The total biomass decreses in two-fold from north to the south, in boreal region of WS.
- Dead biomass dominates over the live biomass in all regions. Large amount of dead biomass is stored in peatlands located in northern boreal region.
- The live biomass appears variable without apparent latitudinal gradient. It varies more dramatically among the different ecosystems of one climatic region.
- The majority (60%) of live biomass is formed by belowground parts of vascular plants, the contribution of mosses and lichens is 30%, and only 10% of LB is linked to its aboveground component.

Net primary production (NPP)

Ecosystems	Biomass: grass	Biomass: shrubs	Annual shoots	Mosses and lichens (land-surface)	Below-ground parts of vegetation	Total
			Northern taiga			
Eutrophic swamp[2]	65±5	16±9	8±1	236±20	634±65	959±91
Palsa[1]	12±4	46±8	12±2	198±47	293±40	561±111
Ridge[1]	7±2	94±9	35±3	270±10	239±120	653±163
Mesotrophic hollow[2]	73±17	0.3	0.3	217±37	405±63	696±94
Oligotrophic hollow[2]	15±2	-	-	196±24	143±41	354±51
			Middle taiga			
Ridge[1]	8±1	56±8	18±1	268±10	207±93	557±90
Ryam[1]	7±2	80±3	23±2	310±28	217±80	637±146
Mesotrophic hollow[2]	59±3	87±3	38±2	346±47	357±43	887±190
Oligotrophic hollow[2]	25±4	5±1	4±1	268±17	198±45	500±170
			Southern taiga			
Ridge[1]	12±1	44±3	12±2	297±40	303±42	768±42
Ryam[1]	5±1	86±8	20±2	273±33	532±152	934±205
Eutrophic swamp[2]	160±7	208±40	101±5	190±44	1310±1	1969±131
Mesotrophic hollow[2]	78±12	50±12	14±2	283±11	879±55	1306±121
Oligotrophic hollow[2]	56±5	12±2	10±1	230±9	199±55	527±57

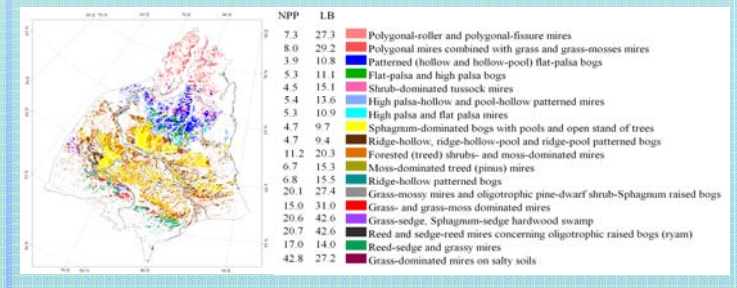
Units are in g/m^2/yr

- Overall, our study revealed the high NPP values in West Siberian wetlands.
- NPP increases from north to south, in the boreal region. The increase of belowground NPP and the reduction of moss- contribution have been identified in the same direction.
- Mosses and the belowground fraction of grasses form the major contribution to NPP.
- The ratio between the above- and below-ground NPP was found to be 1:0.6 at oligotrophic wetland sites (ridges, hollows, and ryams), and 1:2 at eutrophic and mesotrophic grass- and shrub-dominated wetlands.

Range of NPP by ecosystem, and its average distribution by vegetation layer

Latitudinal division	NPP, g/m^2/yr	Distribution of NPP by vegetation layer: Above-ground, %	Land-surface (mosses), %	Below-ground, %
Northern taiga	354-958	11	38	51
Middle taiga	500-887	13	40	47
Southern taiga	527-1970	10	28	62

Mapping of NPP and Live biomass

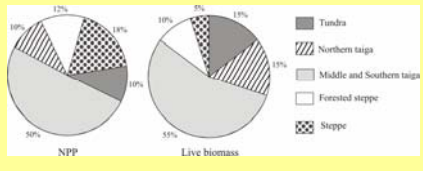


- Total area of West Siberia region is 2 602×10^9 m^2.
- The peatland area is 685×10^9 m^2 (about 27 % of the total).

(!) There were somewhat higher live biomass and NPP values found to the north of the boreal region, that could be caused by:

- differences in observation methods

- the presence of grass-dominated fens in arctic tundra region, which produce high NPP due to a large contribution from the belowground fraction, as compared to moss-dominated wetlands in boreal region.



Spatial distribution of NPP and live biomass created by wetlands in various climatic conditions.

The annual NPP and biomass pool of wetlands vary depending on their geographical locations.

Conclusions **:**

- Wetlands contain much less biomass as compared with upland forests. On the other hand, wetland NPP was found similar or even higher than that of upland forests, regardless the climatic conditions.

- The average live biomass and NPP in wetlands were estimated to be 1600 g/m^2 and 790 g/m^2/yr, respectively.

- The total NPP of WS wetlands was estimated to be 530 Tg (of dry matter)/yr. The live biomass accounts for 1070 Tg.

References

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