Productivity of mire complexes of Western Siberian cryolithozone

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Abstract. New quantitative characteristics of ecosystem productivity in mire complexes of the Western Siberian cryolithozone are obtained. Standing crop of living above-ground and below-ground phytomass (up to 30-sm depth) in palsa complexes varied from 130 to 230 $t \cdot ha^{-1}$. Mortmass stock contributes 70% of the total plant mass. Primary production of palsa complexes in the region is about 5 $t \cdot ha^{-1} \cdot year^{-1}$, that is two times lower in comparison with the production of ombrothrophic bogs in the middle taiga sobzone of Western Siberia.

1. Introduction
The study of the biological productivity of palza ecosystems in the permafrost zone of Western Siberia allows to estimate the amount of carbon sink and its accumulation in peat. The basis for studying the biotic cycle in mire ecosystems and their transformations was the conceptual model of the biological cycle [1]. Similar studies were carried out on the territory of mire complexes in zones of southern and middle taiga in Western Siberia [2, 3]. The aim of this study is to estimate productivity of plant communities in mire ecosystems in the permafrost zone in connection with plant composition and microlief. The obtained data allow to calculate the net primary production (NPP) of plant communities in palza complexes and to predict the dynamics of plant matter stocks for the subsequent evaluating of the biotic cycle parameters.

2. Materials and methods
The study site was a watershed flat palza near the Puritei-Malto lake in the Nadym-Pur interfluve within the northern taiga subzone. According to the regionalization of Western Siberian mires, the study site belongs to the Upper Nadym-Pur subregion of high palsas in combination with flat palsas [4]. The experimental sites were set on flat palsas on hummocks and hollows between, and in oligotrophic and mesotrophic pools that are in complex with palsas and are formed on the place of descended lakes (called as “hasyrey”) (Table 1).

The climate of the region is sharply continental. The average duration of the cold period was 262.6±4.96 days, the warm period - 101±5.46 days. Nearly half of the precipitation falls during a short warm period. In cold period of the year (October-May), 297 mm of precipitation (50.9%) falls, with the maximum value in October - 62 mm (10.7%) [5].

Dwarf shrub-Sphagnum-lichen flat palsas are of about 40 cm higher of the surface of pools, palsas are zigzaggedly bent. The depth of the melting layer in the summer varies from 30 to 50 cm below
mosses and lichens surface. The shape of pools that are in complex with flat palsas repeats the curved elongated form of palsas, reaching 50 m in length and 15-20 m in width. The water table depth varies from 0 to 10 cm below moss surface both within the same pool as well as in different pools within the complex.

The description of plant communities was carried out according to generally accepted methods in the most typical areas of the palsa, taking into account microrelief. The plant matter was collected according to the methods developed in the laboratory of biogeocenology of the ISSA SB RAS [6].

Table 1. Botanical characteristics of the palsa ecosystems

| №  | Ecosystem            | Plant community                                      | Coordinates       |
|----|----------------------|------------------------------------------------------|-------------------|
| 1  | Mesotrophic pool     | Horsetail-sedge-cotton grass-Sphagnum                | N 65°50'39" E 75°22'59" |
| 2  | Flat palsa 1         | Dwarf shrub-moss-lichen                              | N 65°52'22" E 74°57'48" |
| 3  | Oligotrophic pool    | Horsetail-cotton grass-sedge-Sphagnum                | N 65°52'20" E 74°57'44" |
| 4  | Flat palsa 2         | Dwarf shrub-lichen                                   | N 65°49'52" E 75°21'22" |

To estimate standing crop of plant matter and primary production the sampling was carried out in the following way: at sites of 10x10 meters, five plots with an area of 0.25 m² were laid, where dwarf shrubs and grasses were cutted, litter was collected, and then samples of below-ground plant matter were taken by 10-sm layers using 100-sm³ core up from moss surface to a depth of 30 cm. In the laboratory, samples were divided into the following fractions: photosynthetic parts of grasses, shrubs, mosses (capitulas and stems), annual, perennial shrub shoots, living and dead underground organs of grasses and shrubs, buried trunks, living and dead parts of lichens. NPP was calculate as summ of stocks of aboveground production of grasses, shrubs, production of below-ground organs (BNP) and production of surface plant layer (ANP of mosses and lichens). The above-ground production of grasses was formed by fraction of the photosynthetic phytomass. The above-ground production of shrubs represents an increase in the branches of the current year with leaves growing on them [7]. Belowground production of sedges, cotton grass, grasses and shrubs was determined by the growth of the current year of roots, rhizomes and nodes of tillering [8]. The production of lichens is defined as the average value of green phytomass formed over the last 5-8 years, where the number of years is counted according to the number of branching in podecias [9]. The production of sphagnum mosses is a function of the density of the moss cover and the weight of the linear increment of 1 stalk. The linear annual increase in sphagnum mosses was determined by the method of “individual labels” [10].

3. Results

Mortmass (dead vegetable matter) is an organic matter contained in all dead organs of plants, whole plants and products of the primary transformation of dead phytomass and includes dead standing parts of plants, litter, and peat. Maximum reserves of mortmass are recorded in between hummocks hollows on the palsa with the average stock of 210 t · ha⁻¹, decreasing on hummocks up to 140 t · ha⁻¹, and ranging in pools from 90 to 160 t · ha⁻¹ (Figure 1). In contrasting, but stable systems, tops of hummocks and pools, there are fewer fluctuations in the reserves than in hollows, where the cold wind does not penetrate and where microclimatic oases that cause point deep thawing of the permafrost are formed.
The living plant matter or phytomass is the most important fraction, since it determines the amount of carbon to be fixed. The minimum reserves are formed in the ecosystems of oligotrophic sedge-sphagnum pools and are 8.9 t · ha⁻¹. On palsas the stocks of phytomass reach a maximum value at the tops - 24.2 t · ha⁻¹ due to lichens, whose stock is 2 times higher than in hollows. Evergreen dwarf shrubs occupying the upper parts of hummocks, create a wind shadow inside the bush which favors the growth of lichens.

Most of the belowground living standing crop (60-80%) on elevated relief elements is formed by large and small roots of dwarf shrubs and their buried stems. The stocks of photosynthetic parts of mosses and lichens reach a considerable value and range from 3.8 to 4.0 t · ha⁻¹, which is about 25% of the total phytomass stock (Figure 2).

The net primary production of the flat palsa ecosystems ranges from 2.9 to 8.7 t · ha⁻¹ · year⁻¹, depending on the species composition of the plant community with an average value of 5.0 t · ha⁻¹ · year⁻¹ and an average phytomass stock of 16 tonnes · ha⁻¹. Moreover, the maximum production is observed in hasyrey - 8.7 t · ha⁻¹ · year⁻¹ with phytomass stocks of 18.5 t · ha⁻¹. The greatest contribution to NPP is made by belowground organs. The contribution of the grass roots is 1.0 t · ha⁻¹ · year⁻¹ in oligotrophic pools, 6.2 t · ha⁻¹ · year⁻¹ in hasyreys, and 0.8-0.9 t · ha⁻¹ · year⁻¹ on hummocks. The contribution of dwarf shrub roots on hummocks varies from 0.7 to 2.0 t · ha⁻¹ · year⁻¹, in oligotrophic pools - 0.06 t · ha⁻¹ · year⁻¹. The contribution of mosses and lichens to ecosystem production varies between 1.0 and 2.0 t · ha⁻¹ · year⁻¹. The photosynthesizing parts of grasses and shrubs (0.2 - 1.0 t · ha⁻¹ · year⁻¹) make a minimum contribution to the total production on raised and lowered relief elements. On flat palsas, the ratio of the above-ground production to the belowground
one for dwarf shrubs and grasses is 1:4 with dominating of shrub roots, in pools it is 1:6 due to the roots of sedges and cotton grasses.

4. Conclusions
Analysis of the material shows that the dominant role of mosses in ecosystem NPP is retained only in oligotrophic pools. On hummocks the production of roots exceeds the growth of photosynthetic parts of grasses and shrubs. In hasyreys, the maximum production is created by roots of the dominant herbs. On palsas the ratio of aboveground production to belowground is 1:4, in hasyreys and oligotrophic pools it is 1:6. During the growing season the average production of all the ecosystems in the palsa complex was 4.0 t·ha⁻¹·year⁻¹, which is two times lower than on the ridges of mire complexes in the middle taiga zone.

Acknowledgments
The study was funded by RFBR according to the research project No. 14-05-00775, 16-05-00797, 16-34-50008.

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