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## Productivity of some shrub, dwarf shrub and herbaceous communities of forest-tundra

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This paper is based on data obtained at the permanent station Harp (Aurora borealis) of the Institute of Plant and Animal Ecology of the Ural Scientific Centre of the USSR Academy of Sciences. This station is situated in the Yamal-Nenets district of the Tumen region, 35 km NW of Salekhard.

The position of the station on the northern margin of the forest-tundra zone determines the general features of its vegetation: the larch (Larix sibirica) light forests and various types of tundra, swamps and meadows predominate in this area.

Two types of tundra community (moss shrub hummock tundra, dwarf shrub moss spotty tundra) and one type of meadow community (Calamagrostis langsdorffii and Carex stans-dominated swampy meadow) were selected as the main objects of study (Table 1).

In order to estimate the standing crop of above-ground biomass in the communities of hypoarctic shrubs and dwarf shrubs with a standard error not higher than 15 per cent, 7-14 plots of 0.25, 0.5 or 1 m<sup>2</sup> each were taken (number and size of plots vary according to the distribution of dominant species and size of their above-ground parts). For the estimation of below-ground biomass, the same number of plots 0.25 x 0.25 m was taken.

The annual production of above-ground biomass of shrubs and dwarf shrubs was estimated 1) on the basis of the biomass registered on the identical plots at the beginning and at the end of a certain growing season; 2) approximately, on the basis of the biomass of shoots of the current year registered at the end of a growing season.

For the estimation of the annual leaf fall of evergreen dwarf shrubs, three methods were used: a) calculation and comparison of structural elements of leaf biomass on the identical plots during several years; b) calculation and comparison of number of leaves present on the marked parts of shoots during several years; c) determination of ratio of number of live leaves to number of leaf scars in different zones of the annual growth of shoots.

The rate of decomposition of dead parts of plants (K) was determined on the basis of calculations as well as experimentally (litter bag method). The formula

$$K = \frac{L}{L + A} \quad (\text{JENNY, GESSEL \& BINGHAM 1949})$$

was used, where L = mass of leaves fallen during one year, and A = mass of leaves in litter.

Table 1 Brief characteristics of main objects of study

| Plant association   | Layers (projective coverage, average height, dominant species)  |   |   |
|---|---|---|---|
|   | Shrubs  | Dwarf shrubs and herbaceous plants  | Mosses and lichens  |
| Moss shrub hummock tundra   | 30-40 %, h = 30 cm; cop. <sub>2</sub> - <i>Betula nana</i> , sp. - <i>Salix glauca</i> , <i>S. phylicifolia</i> , <i>Ledum palustre</i> var. <i>decumbens</i> | 30 %, h = 20 cm; cop. <sub>1</sub> - <i>Vaccinium uliginosum</i> , <i>V. vitis-idaea</i> , sp. - <i>Carex hyperborea</i>  | 50-80 %, h = 5 cm; cop. <sub>2</sub> - <i>Aulacomnium turgidum</i> , <i>Polytrichum commune</i> , sp. - <i>Hylocomium splendens</i> , <i>Cladonia amaurocraea</i>   |
| Dwarf shrub moss spotty tundra  | 10-15 %, h = 30 cm; sp. - cop. <sub>1</sub> - <i>Betula nana</i> , <i>Ledum palustre</i> var. <i>decumbens</i>  | 60-70 %, h = 15 cm; cop. <sub>2</sub> - <i>Vaccinium vitis-idaea</i> , <i>V. uliginosum</i> , cop. <sub>1</sub> - <i>Empetrum hermaphroditum</i> , sp. - <i>Diapensia lapponica</i> , <i>Arctous alpina</i> , <i>Loiseleuria procumbens</i> , <i>Carex hyperborea</i> | 70 %, h = 5-6 cm; cop. <sub>2</sub> - <i>Aulacomnium turgidum</i> , <i>Dicranum congestum</i> , cop. <sub>1</sub> - <i>Dicranum elongatum</i> , <i>Polytrichum strictum</i> , sp. - <i>Dactylina arctica</i> , <i>Cetraria nivalis</i> , <i>Cladonia uncialis</i> |
| <i>Calamagrostis langsdorffii</i> and <i>Carex stans</i> -dominated swampy meadow | -   | 80 %, h = 65-70 cm; cop. <sub>3</sub> - <i>Calamagrostis langsdorffii</i> , sp. - <i>Carex stans</i> , <i>Arctagrostis latifolia</i> , <i>Poa arctica</i>   | 2-3 %, h = 1 cm; sol. - <i>Calliergon giganteum</i> , <i>Mnium pseudopunctatum</i>  |

As a result of this study it was established (Table 2) that the standing crops of phytomass in moss shrub tundra (3621 g/m<sup>2</sup>), dwarf shrub moss tundra (2860 g/m<sup>2</sup> and in *Calamagrostis langsdorffii* - *Carex stans*-dominated meadow (3349 g/m<sup>2</sup>) are rather similar. But the standing crop of above-ground biomass is almost twice as high in tundra communities (correspondingly 671-613 g/m<sup>2</sup>) as in the meadow community (356 g/m<sup>2</sup>). The shoot-root ratio is 1:4 in tundra communities and 1:6 in the meadow community.

Leaves form about 90 per cent of the annually regenerated part of shoots of shrubs and dwarf shrubs. The annual growth of current year's stems of these plants is extremely small: about 1 per cent in *Betula nana*, 7 per cent in *Vaccinium myrtillus*, 3 per cent in *Ledum palustre* var. *decumbens*, in relation to the mass of shoots of previous years.

Table 2 Standing crop of selected plant communities of forest-tundra

| Plant association  | Phytomass *  |              |                     |              |                 |                           |   | Shoot-root ratio |            |       |       |
|--|--------------|--------------|---------------------|--------------|-----------------|---------------------------|---|------------------|------------|-------|-------|
|  | Above-ground |              |                     | Below-ground |                 |                           | All plant mass incl. mos- ses and lichens |                  |            |       |       |
|  | Shrubs       | Dwarf shrubs | Herba- ceous plants | Total        | Vascular plants | Mosses (brown dead parts) |   |                  | Total      |       |       |
| Moss shrub hummock tundra  | 160(27)      | 68 (4)       | 12 (5)              | 431          | 671 (36)        | 1140(208)                 | 1810                                      | 2950(2018)       | 3621(2054) | 1:4.4 | 1:4.8 |
| Dwarf shrub moss spotty tundra                                     | 137(14)      | 134(22)      | 4 (2)               | 338          | 613 (38)        | 893(107)                  | 1354                                      | 2247(1461)       | 2860(1499) | 1:3.7 | 1:3.3 |
| Calamagrostis langsdorffii and Carex stans-dominated swampy meadow | -            | -            | 505(149)            | 4            | 509(149)        | 2840                      | -   | 2840             | 3349       | 1:5.6 | 1:5.6 |

\* Dead and alive, attached. In the cases when dead mass was estimated separately, its value is shown in brackets.

The annual production of above-ground biomass is 35-40 g/m<sup>2</sup> in tundra communities, 356 g/m<sup>2</sup> in the meadow community; the annual litter fall is 31-39 g/m<sup>2</sup> in tundras and 356 g/m<sup>2</sup> in the meadow (Table 3) respectively. The rate of decomposition of dead parts of plants is higher (34 per cent) in the meadow than in tundras (10-27 per cent). A certain correlation between the characteristics of annual production, annual fall and the rate of decomposition of dead parts of plants shows that the various links of the biological turnover cycle are well balanced in the communities studied. This peculiar feature determines the relative stability of tundra as well as of meadow communities in the forest-tundra zone.

Table 3 Annual production, fall and rate of decomposition of dead above-ground parts of plants

| Plant association  | Annual production of above-ground biomass (gr/m <sup>2</sup> ) | Annual fall of above-ground biomass (gr/m <sup>2</sup> ) | Annual rate of decomposition of dead above-ground parts of plants (% of original weight) |   |
|--|--|--|--|---|
|  |  |  | in litter bags   | on the basis of Jenny, Gessel & Bingham formula |
| Moss shrub hummock tundra  | 35   | 31   | 13-27  | 25  |
| Dwarf shrub moss spotty tundra                                     | 40   | 39   | 10-18  | -   |
| Calamagrostis langsdorffii and Carex stans-dominated swampy meadow | 356  | 356  | -  | 34  |