

# NET PRIMARY PRODUCTION OF DRY STEPPES OF TYVA REPUBLIC

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Grassland resources are important on a world-wide basis. Intensified grazing is one of the main causes of ecological change of meadows and steppes. Almost all steppes are grazed and represent different stages of succession. Heavy grazing impact generally initiates a retrogressive succession (degradation) including a decrease in above-ground net primary production and phytomass as well as a change in species composition, especially in dominant structure. Removal of grazing pressure leads to a progressive succession with an increase in phytomass and production and replacement of degraded pasture community by the original plant association. Stocking rate is one of the most important factors affected a stage of pasture succession. At the

steppes, *C. leucophloea* – mainly in semidesert and desert steppes. Peculiar feature of Central Asia plant cover is the abundance of herb-bunch steppes dominated by *Filifolium sibiricum* and rhizome-grass steppes dominated by *Leymus chinensis*.

In Tuva winter pastures were supplied with pump-houses to provide a livestock with water. After collective farm disruption these pump-houses were demolished and pastures were left without water. Many winter pastures were abandoned and herdsman have driven their flocks into river valleys. Many summer pastures transformed into full year ones with heavy grazing impact. Change of stocking rate leads to degradational or restorational succession which can be observed and investigated then and there [6].

## Materials and methods of research

The study was carried in geographical region of Central Asia – in the Uvsu-Nur depression of Tuva, that located in the southern part of Tuva on the boundary with Mongolia. In Tuva were investigated dry steppes with different grazing impact (Table 1).

Table 1

Description of the site investigated

Region	Coordinates	Altitude, m	Ecosystem type	Ann. prec (mm)	Ann. temp. (°C)
Tuva	49°40'N 95°03'E	1100	Dry steppes	150–170	–4,5

same time stocking rate is a powerful management tool allowing to regulate the amount of herbage available to animals [1, 2, 3].

In this study we were particularly interested in comparing some phytomass properties and species composition of the plant communities at different intensities of grazing impact of Tuva dry steppe vegetation.

Tuva (Russia) steppes belong to Central Asia (C.A.) subregion of steppe region of Eurasia [4]. In C.A. steppe communities feather-grasses from section *Leiostipa* (*S. krylovii*, *S. baicalensis*, *S. grandis*) dominate and on the West of the subregion *S. capillata* and *S. sareptana* prevail. Desert steppes are dominated by lowfeather-grasses from section Smirnova (*S. gobica*, *S. glareosa*, *S. klemenzii*). Among small-bunch grasses in true and dry steppes dominate *Cleistogenes squarrosa*, *C. songorica*, *Agropyron cristatum*, *Koeleria cristata*, *K. macrantha*, *K. altaica*, *Poa attenuata*, *P. botryoides*. Species of *Festuca* (*F. lenensis*, *F. kryloviana*, *F. valesiaca*) are found only in the mountain steppes.

Semishrubs from section *Artemisia* (*A. frigida*, *A. xerophytica*, *A. caespitosa*) are common to a wide variety of steppes. Under grazing impact *A. frigida* abundance usually increases. Steppe shrubs from genus *Caragana* (*C. microphylla*, *C. pygmaea*, *C. stenophylla*) occur in true and dry

Annual precipitation in Tuva steppes varies from 150 to 170 mm. The seasonal distribution of precipitation is rather constant: 70–80 % of the annual total falls during the warm half of the year. The yearly mean temperature at Erzin is –4,5 °C. The coldest month is January with a mean temperature of –33 °C. July is the warmest month with 22,0 °C. The growing season, i.e. the period over which the daily mean temperature remains above + 10 °C, lasts 130–140 days and the period with temperature above 0 °C – 180–190 days. The potential evapotranspiration for the growing season is about four – five times higher than the annual precipitation due to the high wind speed and a lot of very hot days with  $t^{\circ}$  above 30 °C. The steppes of Uvsu-Nur depression belong to the ultracontinental grassland type [6].

## Results of research and their discussion

The following variables of the plant biomass structure are used [7]. *G* = above-ground green biomass; *D* = standing dead plant biomass (attached dead); *L* = litter; *R* = living roots; *Rh* = living rhizomes; *B* = *R* + *Rh* living below-ground organs; *V* = dead below-ground plant biomass; *B* + *V* = total below-ground plant biomass; *NPP* = net primary production; *ANP* = above-ground net primary production; *BNP* = below-ground net primary production.

### Field methods

In Tuva at each site an area of 100×50 m was marked, within which the species composition was recorded in July in each of ten 10×10 m quadrates. For other measurements a series of ten 50×50 cm quadrates was located at random for each sampling occasion. The vegetation was clipped at the soil surface and the litter was collected. The above-ground plants biomass was sorted into green biomass per species and total standing dead biomass. Litter and lichens, if present, were washed on a sieve to remove soil particles.

Soil monoliths with a surface area of 100 cm<sup>2</sup> and a depth of 10 cm were collected in each quadrate to a depth of 20 cm. The monoliths were washed and the plant material collected on a 0,25 mm sieve. All above-ground and below-ground plant biomass was dried for 24 h at 80°C and weighed. Below-ground plant material was sieved to separate the fraction with the length > 2 cm. From this fraction stem basis, rhizomes and long roots were selected [5].

From each sample certain portions of long roots (> 2 cm) and short roots (< 2 cm) were taken to divide plant material of both fractions into living roots and dead mass. The large fraction was divided according to the appearance of roots. Living roots are far more resilient than dead ones and are not so easily broken if twisted.

Net primary production (NPP) was calculated as the sum of the above-ground production (ANP) and below-ground production (BNP). ANP and BNP were estimated using balance equations.

For above-ground plant biomass we have:

$$\Delta G_n = G_{n+1} - G_n + \Delta D_n; \quad (1)$$

$$\Delta D_n = D_{n+1} - D_n + \Delta L_n; \quad (2)$$

$$\Delta L_n = L_{n+1} - L_n + \Delta M_n. \quad (3)$$

For below-ground plant biomass we have:

$$\Delta B_n = B_{n+1} - B_n + \Delta V_n; \quad (4)$$

$$\Delta V_n = V_{n+1} - V_n + \Delta W_n, \quad (5)$$

where  $G_n$ ,  $D_n$ ,  $L_n$ ,  $B_n$  and  $V_n$  are green biomass, standing dead, litter, living below-ground organs, and below-ground dead mass of the sample at occasion  $n$  respectively, and  $G_{n+1}$  etc. are the same variables at sampling occasion  $n + 1$ ;  $\Delta G_n$  is the green biomass production,  $\Delta D_n$  the standing dead production,  $\Delta L_n$  the litter production,  $\Delta M_n$  the litter mineralization;  $\Delta B_n$  and  $\Delta V_n$  are the below-ground living and dead mass production respectively, and  $\Delta W_n$  the below-ground deadmass mineralization, all for the period between sampling occasions  $n$  and  $n + 1$ . Further we have:

$$ANP = \sum_{n=1}^N \Delta G_n; \quad (6)$$

$$BNP = \sum_{n=1}^N \Delta B_n, \quad (7)$$

where  $ANP$  and  $BNP$  are the annual above-ground and below-ground production calculated over  $N$  sampling occasions during a year.

For each period one of the increments  $\Delta G_n$ ,  $\Delta D_n$ ,  $\Delta L_n$ ,  $\Delta M_n$  and one of the increments  $\Delta B_n$ ,  $\Delta V_n$ ,  $\Delta W_n$  must be taken as zero, according to the rule following from the «minimal production estimation» method [7].

### Net primary production

Net primary production was calculated for three years in moderately grazed steppe and for one season in overgrazed and recovering steppes (Table 2).

**Table 2**

Net primary production in steppes, g/m<sup>2</sup> dw.  
Below-ground production for 0–20 cm soil layer.

OG – overgrazed, MG – moderately grazed,

LG-1 = lightly grazed for 1 year,

LG-4 = lightly grazed for 4 years

Production	OG	MG				LG-1	LG-4
	2010	2012	2013	2014	2013	2014	
Above-ground	78	85	284	215	75	107	
Below-ground	627	497	1419	1935	348	2025	
Total	705	582	1703	2150	423	2132	

The NPP of moderately grazed steppe varies during three years from 284 to 1419 g/m<sup>2</sup> per year in dependent on weather conditions. The growing seasons in 2012 and 2014 were normally warm and dry while summer in 2012 was very hot and dry. The NPP value in 2013 and 2014 was very high (1703–2150 g/m<sup>2</sup>). In this very dry season production process was not influenced by the grazing regime. Plants in overgrazed, moderately grazed and recovering for one year pastures produced modest quantity of biomass, moreover NPP is highest in overgrazed steppe. By the end of the fourth year of recovery a burst in the development of the community occurred. Shoots, rhizomes and roots of all species represented in the community had increased. An enormous flow of assimilates was going out of the above-ground into the below-ground phytomass. With a rapid root growth there was an increased death of roots and the standing crop of below-ground dead mass was high compared with dead mass of another pastures.

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