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Structure and Productivity of *Haloxylon ammodendron* Communities in the Mongolian Gobi

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Abstract

Communities of *Haloxylon ammodendron* are widespread in the Mongolian Gobi where they play a significant role in biodiversity preservation. They occupy several main types of habitats, showing differences in density, projective cover, and productivity. *Haloxylon ammodendron* plays a similar, if not even more important role in the arid zone of Mongolia as the principal forest-making trees in the Northern part of the country. The complex set of quantitative parameters of *Haloxylon ammodendron* stands studied here in respect to temporal dynamics can serve as an indicator of both the vitality of desert ecosystems, and of environmental change.

Key words: *Haloxylon ammodendron* communities; structure, productivity, ecotope, soil, morphometric parameters, growth form

Introduction

Saxaul formations are among the most widespread plant communities of the Gobi desert in Mongolia, where they occupy about 2 Mio. hectares (DORJSUREN 2009). *Haloxylon ammodendron* (Saxaul) is a plant species with a broad ecological range. Communities of this species mainly inhabit the following habitats: 1) stony deserts, or hamadas, 2) dried beds of temporary rivers (sairs), 3) sandy deserts, 4) depressions, or takyrs.

Fig 1: *Haloxylon ammodendron*, the main community-forming species, and the basic forage resource for camel pasturing (photo: E. Ariunbold).

The soils of these habitats can be salt-free as well as significantly salinized, gypsiferous, automorphic (i.e. soils receiving water exclusively as atmospheric precipitation), semihydromorphic and (rarely) hydromorphic (EVSTIFEEV & RACHKOVSKAYA 1976). On sand dunes, *H. ammodendron* usually grows as a shrub or a tree being 3 to 5.5 m in height, while in flat lands it is a stunted shrub of only 0.3 to 1.5 m height.

In deserts, *H. ammodendron* is the main coenosis-forming species, being indispensable for pasture grazing of camels throughout the year (fig. 1). Its fallen shoots are readily consumed by sheep and goats in winter and autumn. In Mongolia, Saxaul is highly appreciated as a first-class fuel wood, and is used also to corral cattle (YUNATOV 1946). At present, the area occupied by Saxaul communities decreases as a result of aridization of the climate in Central Asia and due to anthropogenic pressures (utilization for fuel and excessive pasturing). Where Saxaul ecosystems become badly damaged, desertification occurs. It should be taken into account that the reestablishment of the *H. ammodendron* vegetation in Mongolia is a cyclic process with a period of 40 to 50 years (JALBAA & ENKSAIKHAN 1991, SLEMNEV et al. 1994, 1997; GUNIN et al. 2003).

Results and discussion

In Galbyn Gobi, we studied the *Haloxylon-Iris-Nitraria (Haloxylon ammodendron* + *Iris bungei* + *Nitraria sibirica*) community (GG-1, table 1) located in a takyr-like depression. This community included 15 species and consisted of three strata with a total projective cover of 38 %. It has a maximum aboveground phytomass including wood of 17 ton/ha (fig. 2). Most species were either perennial or annual herbs (40 % and 33 % of the total number of species, respectively; table 2). Among the perennial herbs, Iris bungei showed the highest projective cover at 4 %, plants produced numerous fruits with seemingly intact seeds. The dominant species *H. ammodendron* contributed 21 % of the projective crown cover. The values of morphometric parameters of Saxaul in this community are relatively large compared to similar communities analyzed (table 3, SLEMNEV et al. 1997).

Fig. 2: In takyr depressions, *Haloxylon ammodendron* forms rich three-layered stands of high productivity (photo: E. Ariunbold).

Table 1: Physical-geographical properties of selected Saxaul communities in the Gobi desert (abbreviation: *HA.* = *Haloxylon ammodendron*)

eco-regions of the Gobi	**Galbyn**	**Alashan**			**Altai**			**Shargyn**
geographical coordinates	N 42°30' E 106°52'	N 43°28' E 101°20'	N 43°28' E 101°20'	N 43°24' E 101°36'	N 43°15' E 99°00'	N 43°10' E 98°55'	N 44°30' E 96°17'	N 46°12' E 95°42'
altitude (m asl.)	940	1320	1320	1370	1000	1100	1480	1180
community	*HA.+ Iris bungei + Nitraria sibirica*	*HA.*	*HA.*	*HA.*	*HA.*	*HA. + Ephedra przewalskii*	*HA. + Calligonum mongolicum*	*HA: + Carex stenophylloides*
code	**GG-1**	**AG-2**	**AG-5**	**AG-3**	**A-3**	**A-6c**	**A-7c**	**SG-1**
location	75 km south-east of Bayan-Ovoo somon	30 km north-east of Gurvantes somon		4 km east of the Davst village	1 km south of Ekhiin-gol village	12 km south of the Ekhiin-gol oasis	outskirts of Maikhan-bulak	92 km north-east of Tugreg somon
landscape	eastern Gobi depression	Sands Jarangiin-Els in the depression between Gobi Altai (mountain chains Nemegg and Sevrey) and Gobi Tian Shan (mountain chains Tost and Noen)			sands	northern bel, mountain chain Tsagaan Bogdo	southern bel, mountain chain Maikhan-uul	delta of a Sair
ecotope	loamy takyr	flood basin	closed sand depression	sandy plains	top of a sand ridge	sair	sair	sair
soil	takyr-like, loamy	brown desert	fine-grain sandy	grey-brown automorphic	sandy automorphic	sair-like brown extremely arid	sair-like brown	sair-like brown

In the Alashan Gobi, the studies were carried out in a true desert located in a wide intermountain valley between Gobi Altai and Gobi Tian Shan. Monodominant Saxaul communities (AG-2) are widespread in sandy plains there. The AG-2 community showed a left-skewed size class distribution, with a high share of senescent plants. Moreover, these communities contained a significant number of dead individuals which were weakly decomposed and well preserved including their roots.

Fig. 3**:** Monodominant Saxaul community in a stony plain of the Alashan Gobi (photo: E. Ariunbold).

In the same plain, low-productive monodominant Saxaul communities develop on stony, less sandy soils (AG-3; fig. 3). Here, about 80 % of the soil surface was covered with a deflation pavement. This area was inhabited by stunted Saxauls in thinned stands with a projective cover below 1 %. These stands had only one stratum; middle-aged individuals dominate whereas juvenile plants and pre-reproductive individuals were absent.

The ratio of diameter to height (the growth form coefficient) for shrubs was usually greater than 1, though it was 0.87 in the studied community. Plants appeared tree-like because their lateral shoots had been bitten off by camels which are grazing there throughout the year (KAZANTSEVA et al. 2003). In the Saxaul communities of these plains, no other species apart from *H. ammodendron* were encountered. Annual herbs occurred only sporadically during unusually wet seasons.

Table 2: Main growth forms of species in *Haloxylon ammodendron* communities from various habitats

growth form	takyrs		plains		sands		sairs	
	number of species	%	number of species	%	number of species	%	number of species	%
tree	1	7	-	-	1	10	-	-
shrub	1	7	2	12	4	40	4	10
dwarf semishrub	2	13	2	12	1	10	4	10
polycarpic herb	6	40	3	17	-	-	16	40
monocarpic herb	5	33	10	59	4	40	16	40
total	**15**	**100**	**17**	**100**	**10**	**100**	**40**	**100**

Table 3: Morphometric parameters of *Haloxylon ammodendron* in various communities in the Gobi

community code*	**GG-1**	**AG-2**	**AG-5**	**AG-3**	**A-3**	**A-6c**	**A-7c**	**SG-1**
density (individuals/ha)	192	900	640	320	312	244	266	640
mean size								
height (m)	2.77	0.82	2.6	0.70	2.02	0.92	1.17	0.91
diameter (m)	3.72	0.94	2.38	0.61	2.76	1.13	1.42	1.26
volume (m^3)	38.2	1.06	13.02	0.31	19.07	1.26	2.02	1.47
D: H ratio	1.34	1.14	0.92	0.87	1.37	1.22	1.21	1.38
mean dry mass of aboveground tissues (kg)	89.3	3.15	38.68	0.921	59.05	6.09	6.00	5.4
max phytomass (t/ha)	17.1	2.84	24.76	0.294	18.42	1.48	1.60	3.5
mean dry mass of annual shoots (kg)	3.5	0.348	3.0	0.28	3.30	0.189	0.21	0.4
max phytomass kg/ha	669	313	1920	91	1029	46	56	245
projective cover (%)	38	8.1	30.8	0.9	23.5	2.8	3	23.5

* - indicated in table 1

In the Transaltai Gobi, Saxaul communities predominate in the vegetation cover. Of the 14 types of Saxaul associations defined by RACHKOVSKAYA (1986), eight could be found in this region. Here, stunted and thinned communities of Saxaul were found in watersheds of sairs, which represent 65 % of the total area covered by Saxaul stands. Almost all Saxaul communities are characterized by low species diversity and a mono-layered structure (KAZANTSEVA 2009).

In the zone of true deserts of the Transaltai Gobi, *H. ammodendron* communities were studied at gently sloping flats within arid denudation plains (A-5). Soils of the watersheds were grey-brown, saline, slightly loamy and sandy. On a comprehensively surveyed plot of 1 ha in size, only three species were found: *Haloxylon ammodendron* and the two annuals *Micropeplis arachnoidea* and *Tribulus terrestris.* The height of Saxauls plants varied from 0.4 to 1.6 m. The projective cover of Saxaul was less than 0.57 %, and altogether 76 individuals grew in the 1 ha study area. The biomass of annual shoots averaged to 331 g per Saxaul plant (calculated from data obtained during seven years of observations), summing up to 25 kg/ha. Numbers fluctuated between 17 to 48 kg/ha, depending on the conditions in the given year. At present, due to excessive pasturing

and collection of Saxaul for fuel, these ecosystems are increasingly losing their vegetation cover (KAZANTSEVA 1986).

In another region of the true desert zone, the southern bel of the Maikhan-uul mountain chain (A-7), the density of Saxauls in inter-sair watersheds amounted to 86 plants per hectare, with their projective cover reaching 0.63 %. The annual increase of biomass (dried) was 26 kg/ha. Juvenile and young generative plants were absent from this community which was built by senescing generative individuals and senescent plants, indicating that this community was undergoing degradation (KAZANTSEVA et al. 2003). However, in the abnormally humid year 1993, a mass seed reestablishment of *H. ammodendron* took place (SLEMNEV et al. 1994). Thus, the Saxaul communities of inter-sair watersheds in the zone of true deserts of the Transaltai Gobi are characterized by low species diversity, mono-layered structure and overall homogenous phytocoenotical features. Total aboveground biomass of these communities is low (75 to 100 kg/ha) as compared to other Saxaul communities of the plains of the Gobi desert (KAZANTSEVA et al. 2003).

Fig. 4: *Ephedra*-Saxaul community growing in a hamada. Ditches at the front of the image were experimentally made with a plough in 1977. Germination of Saxaul was observed only after the abnormally rainy spring in 1993, when germination also took place on intact hamadas without ploughing as can bee seen in the background (photo: Erdenegerel Ariunbold).

In the Transaltai Gobi RACHKOVSKAYA (1977) defined hyper-arid deserts as large areas of inter-sair watersheds (hamadas) devoid of any higher plant vegetation. In these regions, plant communities with 3 to 4 dominant shrub species and few species of perennial herbs are confined to sair depressions. On the northern bel of the Tsagan Bogdo mountain chain (A-6), *Ephedra*-Saxaul stands dominate the extremely arid desert, while synusia of the annual Chenopodiaceae

Micropeplis arachnoidea and *Bassia dasyphylla* develop successfully only in humid years. Their biomass varies from 25 to 85 kg/ha. The cycle of the mass reestablishment of annual species in these deserts takes 5 to 9 years.

On hamadas, no vegetation has been observed during the whole observation since 1946, with the exception of single annual plants appearing in wet years. However, in 1993, a mass seed reestablishment of the dominant species *Anabasis brevifolia*, *Stipa gobica*, *S. glareosa* was observed in the Mongolian deserts, and also *H. ammodendron* reproduced abundantly in the *Ephedra*-Saxaul desert (SLEMNEV et al. 1994). It was caused by abnormally high atmospheric precipitation in March, 1993. Since then, the status and integrity of Saxaul young growth has continuously been monitored, and only 21 % of young Saxaul plants have remained by 2010 (GUNIN et al. 2003, SLEMNEV et al. 1997, 2010). In its foreground, fig. 4 shows ditches which were made with a plough in 1977 in the course of an experiment designed to see whether ploughing would help plants to inhabit hamadas. Since 1977 the ditches were accumulating seeds but no germination

Fig. 5: Sair in the deserts of Mongolia (photo: Erdenegerel Ariunbold).

occurred until the abnormally rainy spring in 1993; however, similar seed germination simultaneously took place also on intact hamadas without ploughing (image background).

The desert zone of Mongolia is separated by sairs of various sizes (fig. 5). Their soils receive additional moisture due to inflow of surface water from mountains and adjacent watersheds as well as groundwater. In these depressions, Saxaul communities with relatively high species diversity and three-layered structures are widespread (table 2). The dynamics of development and productivity of sair Saxaul communities in the Transaltai Gobi desert have been studied over many decades (A-5c, A-6c; table 1, 3) leading to a number of publications (KANZANTSEVA 1986, 2009).

The composition and structure of a rare (in Mongolia) sedge-Saxaul (*Haloxylon ammodendron* + *Carex stenophylloides*) community is of special interest (SG-1; table 1, 3). This community inhabited the delta of sairs in the depression Shargyn-Bulak. It was constituted by ten plant species including the shrub *Calligonum mongolicum*, the dwarf semishrubs *Eurotia ceratoides* and *Oxytropis aciphylla,* the rhizome sedge *Carex stenophylloides* and five species of monocarpic herbs, among them three species of *Artemisi*a. The total vegetation cover varied from 19 to 28 %. The share of *Carex stenophylloides* in the productivity of this community is especially high. This community produces 350 kg/ha of aboveground biomass (dried) per year (KAZANTSEVA 2009). The annual increase in dry green biomass of Saxaul alone is 245 kg/ha.

Fig. 6: Tall, highly productive Saxaul community on a sandy ridge (photo: E. Ariunbold).

Tall and highly productive Saxaul communities (AG-5, A-3) can be found on sand dunes and sand ridges (fig. 6), where plants had a tree growth form. Their total cover is high at up to 31 %. These *H. ammodendron* communities host ten species (table 2), including the shrubs *Reaumuria songarica*, *Nitraria sibirica*, *Calligonum mongolicum* and *C. gobicum*. The density of mature *H. ammodendron* individuals varies from 126 to 640 plants per hectare (SLEMNEV et al. 1999), depending on the habitat (slope, top of a sand dune, depression etc). Perennial herbs are absent, and annual herbs develop only in humid years. The Saxaul communities on sands produce the highest biomass at 8 to 25 ton/ha. In these communities, Saxaul young growth develops quite well (SLEMNEV et al. 1977a, 1997, 1999).

Conclusion

In the Mongolian desert zone, *Haloxylon ammodendron* fulfils a similar, if not even more important role as the forest-forming trees in the North of Mongolia. Considering its unavoidable but often unreasonably wasteful utilization, we must attract attention to the importance of this unique species for the biosphere. Large-scale investigations of natural Saxaul stands can help to elucidate this role, would allow defining thresholds for land use intensity, and could facilitate monitoring of environmental changes in desert habitats.

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