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VEGETATION ON MARMOT MOUNDS IN THE STEPPES OF CENTRAL MONGOLIA

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The authors aim to show the influence of Mongolian marmot (Marmota sibirica)'s activity on surrounding vegetation. Observed plant structure on marmot mounds and the process of succession is considered in this paper.

Key words: Mongolian marmot, mound, vegetation, succession.

Introduction

The impact of mammalian burrowing activity on the ecosystems of different landscapes has long attracted the attention of researchers. Rodents and hares have considerable impact on biogeocenosis in arid zones (Formozov, 1929; Bannikov, 1954; Kojemyakin, 1978; Sokolov,& Orlov, 1980; Allen, 1938, 1940; Stubbe,& Chotolchu, 1968; Dmitriev & Guricheva, 1978; Avirmed, 1989; Dmitriev, 1991). Among the rodents of steppe landscapes with a strong influence on biogeocenosis, marmots are especially prominent as generations of marmots will live for decades or even centuries in the same colony in the same place(Bibikov, 1967, 1989; Dinesman, 1968; Dmitriev, 2006). They actively participate in the formation of the microrelief, the soil-forming process, and they influence the growth and diversity of vegetation in the area around the colony (Krupennikov, Stepanitskay, 1943; Zubkova, 1967; Zimina, Zlotin, 1980; Dinesman, Kisileva, Knyazev, 1989; and others).

We characterized the vegetation on the burrow mounds of Mongolian marmots (*Marmota sibirica* Radde, 1862) in the *Stipa spp.* steppe of Central Mongolia. Prior to our research, the vegetation of the marmot burrows in Mongolia has only been studied in the East Khangai (Guricheva & Dmitriev, 1997).

Materials and methods

Study area. The study was conducted at Hustai National Park, located 100 km west of Ulaanbaatar, Mongolia (47˚50´N, 106˚00´E). Hustai National Park is situated in the forest steppe region of Mongolia and occupies 50600 ha at elevations ranging from 1190 to 1800 m above sea level. About 88% the area is covered by grassland and shrubland steppe and 5% is covered by birch dominated forest. In the park, there are 44 species of mammals (Todgerel, 2002) including Przewalski's horse *(Equus ferus przewalskii)*, red deer *(Cervus elaphus)*, roe deer *(Capreolus capreolus)*, wild boar *(Sus scrofa)*, argali sheep *(Ovis ammon)*, Mongolian gazelle *(Otocolobus manul)*, grey wolf *(Canis lupus)*, manul *(Otocolobus manul)*, Eurasian lynx *(Lynx lynx)*, and Mongolian marmot. The Mongolian marmot's range covers 12873 ha (25.7%) of the park (Todgerel, 1999).Marmot density in the park was 1.16 marmots per ha in areas were they occurred. In the central and best protected area of the park the density was higher, withwith 3.85 marmots per ha.

Material. In May, June, and July in 1999, 2000 and 2001, all present plant species and vegetation cover types were recorded for the mounds of 696 summer and shelter burrows and also 305 $1m^2$ plots located near the marmot mounds in the feather grass-pea shrub community *(Caragana microphylla + Caragana pygmaea + Stipa Krylovii + Koeleria macrantha + Agropyron cristatum + Cliestogenes squarrosa + Artemisia frigida)*. Geobotanical descriptions were developed following Shennikov (1964) and Martin and Coker (1992).

Statistical analyses. TWINSPAN ("Two Way INdicator SPecies ANalysis" /TWINSPAN/ [Jongman, Ter Braak, Van Tongeren, 1995]) was used to classify vegetation community types and stages of succession on the marmot mounds. For the classification of community types, the program constructed an ordered two-way table displaying site-by-species. Community classifications were defined by 4 indicator species, 3 division levels, and default cut levels of 0, 5, 10, 20, and 40. Each species cover percentage was replaced by a 1-5 score. 1=0-4%, 2=5-9%, 3=10-19%, 4=20-39%, and 5=40-49%. For the construction of species-by-sites tables, two additional features were necessary. First, the dichotomies were ordered, and second, the species were classified. The order of the site groups was determined by comparison of the two site groups formed at any level with site groups at two higher hierarchical levels.

Differences were considered significant at $p<0.05$ with the statistical package SPSS 11 for Windows.

Results

Species composition on the mounds. A total of 61 species from 46 genera in 24 families were documented on the marmot mounds. The most numerous families were *Poaceae* (8 species), *Asteraceae* (7), *Rosaceae* (7), *Fabaceae* (6), *Chenopodiaceae* (5), *Scrophulariaceae* (4), *Brassicaceae* (3), *Ranunculaceae* (2), *Liliaceae* (2), *Cyperaceae* (2), and *Apiaceae* (2). Families with one species represented were: *Caryophyllaceae, Crassulaceae, Lamaiaceae, Polygonaceae, Polemoniaceae, Convolvulaceae, Ephedraceae, Iridaceae, Plumbaginaceae, Rutaceae, Thymelaeaceae, Urticaceae.* Of the species observed, 42 were perennial grasses, 11 were annual grasses, 5 were semi shrubs, and 3 were shrubs. Vegetation on the mound included 15 caespitose species, 18 rhizomatous species and 33 stoloniferous species.

Vegetation community types on the mounds. Vegetation on the marmot mounds was divided into two main communities: *Stipa krylovii +Agropyron cristatum;* and *Artemisia adamsii+Leymus chinensis.* Each community was further divided into four sub-community types.

Community of *Artemisia adamsii +Leymus chinensis.* A total of 54 species were documented in this community, which occurred on 46% (n=319) of marmot mounds (Table 1). This community was dominated by the rhizomatous species *Artemisia adamsii, Leymus chinensis,* and *Carex duriuscula* and the salt annual *Salsola collina*. These species are present mostly in salt soil and degraded pasture. *Artemisia adamsii* and *Leymus chinensis* frequency was 35-40% more and cover was 27% more than the same species in the *Stipa krylovii+Agropyron cristatum* community. The caespitose species *Stipa krylovii* was present on all mounds, but its cover percentage was less in the *Artemisia adamsii+Leymus chinensis* community than in the *Stipa krylovii+Agropyron cristatum* community and

Stipa klemenzii was not present in the former. Other caespitose species such as *Koeleria macrantha, Cleistogenes squarrosa,* and *Poa attenuata* occurred but were not abundant.

Of the shrubs, *Caragana pygmaea* was documented in 13% and *C.microphylla* in 3% of this community.

Of the semishrubs, the frequency of *Artemisia frigida* was 50% lower in the *Artemisia adamsii+Leymus chinensis* community than in the *Stipa krylovii+Agropyron cristatum* community.

Some herbs such as *Potentilla bifurca, Heteropappus hispidus,* and *Potentilla acaulis* and some annuals such as *Cheneopodium album, Ch.aristatum, Ch.acuminatum* were abundant.

The classification identified four sub-community types.

Type 1. *Salsola collina+Artemisia Adamsii+Leymus chinensis* community type.

A total of 22 species were documented on ten mounds. One species had 100% frequency of occurrence, two species had 80% frequency of occurrence, one had 50% occurrence, four had 40% occurrence, two had 30%, two had 20%, and ten had 10% frequency of occurrence. This type dominated by *Salsola collina* with co-dominant *Artemisia adamsii, Carex duriuscula, Leymus chinensis* and *Ptilotrichum canescens. Potentilla acaulis, Chenopodium aristatum* and *Ptilotrichum canescens* were also abundant .

Type 2. *Artemisia adamsii + Leymus chinenisis +Salsola collina* community type.

A total of 52 species were documented on 203 mounds. 41 species had frequencies of 0-20% and 11 species had frequencies of 21-90%. This type dominated by the rhizomatous species *Artemisia adamsii,* which had a frequency of 90% and was dominant on 62% of all mounds with 10-60% cover. Co-dominant *Leymus chinensis* was dominant on 19% of all mounds with 10-35% cover. Some species, such as the caespitose species *Stipa krylovii, Cleistogenes squarrosa,* and *Agropyron cristatum,* the shrub *Potentilla bifurca* and the annual species *Chenopodium album* and *Salsola collina* were dominant on a few mounds.

Type 3. *Carex duriuscula + Leymus chinensis +Artemisia Adamsii* community type.

A total of 29 species were documented on 40 mounds. 25 species had frequencies of 0-20% and 4 species had frequencies of 71-100%. This type was dominated by *Carex duriuscula, Artemisia adamsii,* and *Leymus chinensis. Carex duriuscula* was present on all mounds (92.5%) and dominant on 67% of mounds of this type with 10-50% cover. *Artemisia adamsii* was dominant on 15% of this type with 10-20% cover. *Leymus chinensis* was dominant with 5-30% cover on 40% of all mounds in this type. Besides the dominant species mentioned above, *Potentilla bifurca, P.acaulis* and *Stipa krylovii* were also dominant on a few mounds.

Type 4. *Leymus chinensis+Artemisia Adamsii+Carex duriuscula + Cymbaria dahurica +Artemisia frigida* community type.

A total of 40 species were documented on 66 mounds. 31 species had frequencies of 0-20% and nine species had frequencies of 21-100%. This type was dominated by the rhizomatous grass *Leymus chinensis,* which was present on all mounds (100%) of this type and which dominated with 5-40% cover on 95% of all mounds. *Artemisia adamsii* (48%)

and *Carex duriuscula* (36%) were abundantly present but they were not recorded as dominant (Table 1). Some species such as *Ephedra sinica, Cymbaria dahurica,* and *Artemisia dracanculus* were dominant on one or two mounds. The frequency and cover of *Artemisia adamsii* was lower than in the other three community types.

Table 1. *Synoptic table of Artemisia adamsii+Leymus chinensis community classification*

Community types	1		2		3		4	
Number of mounds	10		203		40		66	
Percent of mounds	1,43%		29,17%		5,7%		9,48%	
Species number in one mound	7±3		7±3		5±2		6±2	
Cover (%)	39,44±8,31		32±14,18		36,31±15,54		29,54±14,35	
Species number in the type	22		52		29		40	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
Grasses								
Koeleria macrantha			1,10	4,93	1,50	20,00	1,00	21,21
Poa attenuata			1,00		3,00	2,50	1,25	6,06
Stipa lrylovii	1,12	80,00	1,39	77,83	1,96	72,50	1,11	78,79
Agropyron cristatum	1,00	20,00	1,28	18,72	1,67	7,50	1,00	19,70
Stipa sibirica			1,00	0,49				
Cleistogenes squarrosa	1,00	30,00	1,18	26,60	1,00	5,00	1,00	7,58
Leymus chinensis	1,50	40,00	1,61	76,85	2,26	85,00	3,30	100,00
Herbs								
Allium bidentatum			1,00	5,91			1,00	1,52
Iris tigrida			1,00	0,99			1,00	1,52
Amblinotus rupestris			1,12	3,94	1,00	5,00		
Convolvulus ammani							1,00	1,52
Orostachys spinosa			1,00	0,99				
Astragalus brevifolius			1,00	1,00			1,00	6,06
Sibbaldianthe adpressa							1,00	3,03
Bupleurum scorzonerifolium			1,00	0,49				
Cymbaria dahurica			1,04	23,15	1,33	7,50	1,12	36,36
Pulsatilla bungeana			1,00	0,99			1,00	1,52
Veronica incana			1,00	1,48				
Potentilla acaulis	1,00	40,00	1,17	11,33	1,75	10,00	1,00	6,06
Stellera chamaejasme			1,50	2,96	1,00	5,00	1,00	1,52
Dontostemon integrifolius	1,00	10,00	1,00	13,30	1,00	2,50	1,08	18,18
Thalictrum foetidum			1,00	0,49				
Lepidium densiflorum	1,00	10,00	1,52	8,37			1,00	4,55
Allium odorum			1,00	0,99	1,00	5,00		
Hedysarum collinum			1,00	0,99				
Goniolimon speciosum			1,00	1,97	1,50	5,00	1,28	10,61
Potentilla tanansitifolia			1,00	10,84	1,00	7,50	1,00	15,15
Saussurea salicifolia	1,00	10,00	1,00	8,37	1,00	12,50	1,17	9,09
Taraxacum collinum	1,00	10,00	1,00	0,49	1,00	2,50		
Potentilla bifurca	1,00	20,00	1,36	32,51	1,40	25,00	1,14	33,33
Potentilla strigosa	1,00	10,00					1,00	1,52
Asteraecea sp			1,00	3,45	1,00	10,00	1,00	10,61

Artemisia drancanculus					1,00	2,50	1,67	4,55
Phlomis tuberose			1,50	0,99	1,00	2,50	1,50	3,03
Artemisia scoparia			1,00	1,48			1,00	1,52
Rheum undulatum			1,00	0,99			1,00	4,55
Chenopodium album	1,00	10,00	1,46	31,03	1,43	17,50	1,09	16,67
Chenopodiacea sp			1,00	1,48			1,00	1,52
Salsola collina	3,70	100,00	1,13	28,57	1,00	2,50	1,00	10,61
Kochia prostrate			1,00	5,42				
Heteropappus hispidus	1,00	10,00	1,13	22,66	1,50	5,00	1,00	6,06
Urtica cannabiana			1,00	0,54				
Chenopodium aristatum	1,00	10,00	1,10	4,93				
Alliacea sp			1,00	0,49				
Lappula myosotis			1,00	0,49				
Chenopodium acuminatum			1,86	7,39			1,00	3,03
Potentlla conferta			1,00	1,48				
Sedge								
Carex duriuscula	1,00	40,00	1,30	44,83	3,19	92,50	1,37	36,36
Shrubs								
Caragana microphylla			1,50	2,96	1,00	2,50	1,00	4,55
Caragana pygmaea			1,21	18,72	1,00	7,50	1,00	16,67
Semishrubs								
Haplophyllum dahuricum			1,00	1,00				
Artemisia frigida	1,00	40,00	1,13	25,62	1,33	7,50	1,09	46,97
Ptilotrichum canescens	1,40	50,00	1,24	18,72	1,00	5,00	1,00	4,55
Ephedra sinica			1,00	1,48			1,80	15,15
Artemisia Adamsii	1,75	80,00	3,25	90,64	1,80	75,00	1,28	48,48
Forbs								
Thermopsis dahurica	1,00	30,00	1,04	10,34	1,50	5,00	1,07	21,21

Community of *Stipa krylovii+Agropyron cristatum.* A total of 59 species were documented in this community, which occurred on 54% (n=377) of all marmot mounds (Table 2). This community was dominated by *Stipa krylovii. Agropyron cristatum, Koeleria macrantha, Poa attenuata* and *Cleistigenes squarrosa* also occurred in this community. *Leymus chinensis* had lower cover and frequency values in this community.

Of the shrubs, *Caragana pygmaea'*s frequency was 63% and *Caragana microphylla'*s frequency was 10%. Some semi-shrubs such as *Ptilotrichum canescens* and *Artemisia frigida* were abundant, while the occurrence of *Artemisia adamsii* was low.

Carex duriuscula's frequency of occurrence was similar to that observed in the degraded pasture community type *(Artemisia adamsii +Leymus chinensis)* but the percent coverage was lower.

Type 5. *Stipa krylovii + Leymus chinensis + Agropyron cristatum + Potentilla bifurca* community type.

A total of 50 species were documented on 112 mounds. 35 species had frequencies of 0-20% and 15 species had frequencies of 21-100%. The frequency of the dominant species, *Stipa krylovii* was 5-50% on half of all mounds. The rhizomatous grass *Leymus*

chinensis was dominant with 10-30% cover on 24% of Type 5 mounds. Some species such as *Thermopsis dahurica, Poa attenuata, Agropyron cristatum, Potentilla acaulis, Carex duriuscula, Koeleria macrantha, Cymbaria dahurica, Cleistogenes squarrosa* and *Potentilla tanansitifolia* were dominant on a few mounds.

Type 6. *Stipa krylovii + Agropyron cristatum + Potentilla bifurca + Dontostemon integrifolius* community type.

A total of 46 species were documented on 128 mounds. 33 species had frequencies of 0-20% and 13 species had frequencies of 21-100%. This sub-community type was dominated by the caespitose grasses *Stipa krylovii* and *Agropyron cristatum*. *Cymbaria dahurica* (47%), *Dontostemon integrifolius* (56%) and *Carex duriuscula* (60%) were often abundant and were dominant on a few mounds. *Potentilla bifurca* (52%) was present on about half of all mounds and was dominant on 8% of all mounds with cover values of 5 to40%.

Type 7. *Caragana pygmaea<Stipa krylovii+Agropyron cristatum+Artemisia adamsii* community type.

A total of 41 species were documented on 57 mounds. 29 species had frequencies of 0-20% and 12 species had frequencies of 21-100%. This sub-community type was dominated by *Stipa krylovii*, which had 5 to50% cover on 12 to 40% of mounds, more than the other three community types. Species such as *Lepidium densiflorum, Agropyron cristatum* and *Potentilla tanansitifolia* were dominant on one or two mounds.

Type 8. *Caragana pygmaea<Stipa krylovii+Agropyron cristatum* community type.

A total of 44 species were documented on 80 mounds. 31 species had frequencies of 0-20% and 13 species had frequencies of 21-100%. The caespitose grass *Stipa krylovii* was present on all mounds in all four subcommunity types. The species' cover value was 10-40% and it was the most dominant species in this sub-community type Besides *Stipa krylovii, Poa attenuata, Ptilotrichum canescens, Cymbaria dahurica, Artemisia frigida,* and *Caragana microphylla* were all dominant on a few mounds. *Agropyron cristatum* and *Koeleria macrantha* occurred in 57.5-70% of all mounds of this type. *Poa attenuata* and *Cleistogenes squarrosa* occurred in 25-34% of all mounds. The frequency of the herb *Allium bidentatum* was higher than in the other three community types and the cover value (1.00) was similar to types 7 and 6. *Amblinotus rupestris, Cymbaria dahurica* and *Saussurea salicifolia* were all abundant. In contrast, *Potentilla acualis* (6.25%), *Artemisia drancanculus* (3.75%) and *Potentilla bifurca* (3.75%) were rare and their cover was 20-30% more than other herb species. Indicator species of pasture degradation such as *Carex duriuscula* (18.75%), *Artemisia adamsii* (7.5%), and *Leymus chinensis* (13.75%) occurred on a few mounds. The frequency of *Caragana pygmaea* (61%) was greater than that of *C.microphylla* in this sub-community.

Table 2. *Synoptic table of the Stipa krylovii+Agropyron cristatum community's classification*

Community types	5		6		7		8	
Number of mounds	112		128		57		80	
Percent of mounds	16,09%		18,39%		8,18%		11,49%	
Species number in one mound	9±3		8±3		8±3		9±3	
Cover (%)	37,7±13		25±15		42,5±16,8		33±14,3	
Species number in the type	50		46		41		44	
	Cover	Frequency	Cover	Frequency	Cover	Frequency	Cover	Frequency
Grasses								
Koeleria macrantha	1,23	34,82	1,12	32,81	1,13	26,32	1,28	57,50
Poa attenuate	1,46	25,00	1,11	7,03	1,07	24,56	1,48	33,75
Stipa klimenzii	2,60	2,68	1,00	2,34	1,67	10,53	1,10	23,75
Stipa krylovii	2,60	94,64	2,10	92,97	3,50	98,25	3,19	97,50
Agropyron cristatum	1,26	60,71	1,17	53,91	1,19	63,16	1,23	70,00
Stipa sibirica			3,00	1,56			1,00	1,25
Cleistogenes squarrosa	1,14	37,50	1,00	21,88	1,22	15,79	1,10	25,00
Leymus chinensis	1,99	73,21	1,04	39,84	1,11	15,79	1,81	13,75
Herbs								
Allium bidentatum	1,22	8,04	1,00	5,47	1,00	12,28	1,00	46,25
Iris tigrida	1,00	2,68	1,00	3,13	1,00	8,77	1,00	18,75
Amblinotus rupestris	1,00	13,39	1,00	7,81	1,00	10,53	1,09	42,50
Convolvulus ammani	1,00	1,79	1,00	0,78	1,00	3,51	1,33	3,75
Orostachys spinosa	1,50	1,79	1,00	5,47	1,00	15,79	1,00	15,00
Linaria acutiloba					1,00	1,75		
Astragalus brevifolius	1,00	4,46	1,33	7,03	1,00	8,77	1,00	17,50
Sibbaldianthe adpressa	1,00	4,46	1,00	3,13	1,00	7,02	1,27	13,75
Bupleurum scorzonerifolium					1,00	3,51	1,00	3,75
Arenaria capillaries							1,00	3,75
Cymbaria dahurica	1,28	57,14	1,13	46,88	1,02	59,65	1,24	67,50
Chamaerhodos erecta	1,00	0,89						
Pulsatilla bungeana	1,07	12,50	1,00	3,13	1,00	5,26	1,00	3,75
Veronica incana	1,17	5,36						
Potentilla acaulis	1,30	41,07	1,23	17,19	1,00	5,26	1,80	6,25
Stellera chamaejasme	1,05	17,86	1,00	0,78	1,40	8,77	1,12	10,00
Pedicularis flava	1,00	0,89						
Dontostemon integrifolius	1,13	13,39	1,17	56,25	1,05	35,09	1,00	10,00
Thalictrum foetidum	1,50	5,36	1,00	1,56				
Bupleurum bicaule			1,00	0,78				
Lepidium densiflorum	1,00	4,46	1,25	3,13	1,65	29,82	1,17	15,00
Allium odorum					1,00	3,51	1,00	5,00
Hedysarum collinum	1,00	1,79					1,00	3,75
Goniolimon speciosum	1,12	14,29	1,00	1,56	1,00	1,75	1,00	1,25
Potentilla tanansitifolia	1,20	26,79	1,00	21,09	1,22	15,79	1,00	12,50
Saussurea salicifolia	1,06	28,57	1,00	7,03	1,00	19,30	1,00	28,75
Taraxacum collinum	1,00	3,57	1,00	1,56				

Potentilla bifurca	1,25	42,86	1,37	52,34	1,00	8,77	1,67	3,75
Potentilla strigosa			1,00	3,91				
Asteraecea spp	1,00	3,57	1,35	13,28	1,50	7,02		
Artemisia drancanculus	1,00	2,68	1,00	3,91	1,00	1,75	1,67	3,75
Artemisia scoparia	1,00	0,89						
Rheum undulatum	1,00	1,79						
Chenopodium album	1,08	11,61	1,11	20,31	1,00	8,77	1,00	3,75
Chenopodiacea sp	1,00	0,89						
Salsola collina	1,08	10,71	1,00	5,47	1,00	1,75	1,00	2,50
Kochia prostrata			1,00	1,56	1,00	7,02		
Heteropappus hispidus	1,09	9,82	1,00	1,56	1,00	3,51	1,00	5,00
Chenopodium aristatum	1,00	0,89					1,00	2,50
Lappula myosotis							1,00	1,25
Chenopodium acuminatum			1,00	0,78	1,00	5,26	1,12	10,00
Potentlla conferta			1,00	1,56				
Sedge								
Carex pediformis	1,00	1,79	1,00	0,78	1,00	1,75		
Carex duriuscula	1,83	43,75	1,62	60,16	1,00	42,11	1,00	18,75
Shrubs								
Caragana microphylla	1,00	3,57	1,10	7,81	1,55	15,79	1,36	13,75
Caragana pygmaea	1,00	9,82	1,02	35,94	1,02	66,67	1,04	61,25
Semishrubs								
Haplophyllum dahuricum	2,00	0,89	1,00	0,78			1,00	16,25
Artemisia frigida	1,37	71,43	1,08	50,78	1,17	40,35	1,41	78,75
Ptilotrichum canescens	1,06	28,57	1,25	9,38	1,05	33,33	1,59	40,00
Ephedra sinica	1,00	2,68						
Artemisia adamsii	1,35	17,86	1,44	70,31	2,14	100,00	1,50	7,50
Forbs								
Medicago falcata	1,00	2,68						
Thermopsis dahurica	1,56	22,32	1,00	2,34			1,00	1,25

Succession of vegetation on the mounds. Fig 1 shows the succession of vegetation on the marmot mounds, which is represented by eight stages. Each stage corresponds to a certain community type, which has its own characteristics (Tables 1,2). Of the eight stages of succession of vegetation on the mounds, the second stage was most often encountered. This suggests that the mounds often revert to the beginning stage of succession because the marmots do not allow vegetation to develop normally.

On summer burrows, where the mounds are larger in size, the vegetation develops more or less evenly. Nevertheless, depending on marmot's level of activityand their number, as well as the location of the burrows and the structure of the soil cover, etc. on different burrow mounds, succession proceeds differently.

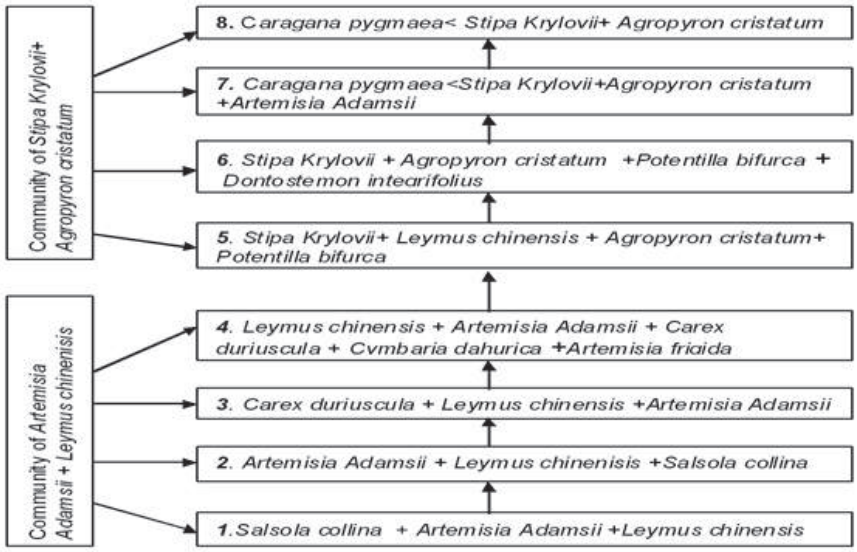

Fig 1. *Vegetation community types at different stages of succession on marmot mounds (Numbers 1-8 indicate the vegetation community types by stage of succession)*

28% of mounds had 1-5 plant species present, 58% had 6-10 species, 12% had 11-15 species, and 2% had 16-20 species present, including eight community types. Over progressive stages of succession, the average number of species gradually increased. At the final stages, where *S. krylovii* dominated, the number of species reached 16-20 (Table 3).

Table 3. *Classification of species number on the mounds of community types*

Community type	1*	2*	3*	4*	5*	6*	7*	8*
Number of mounds	n=10	n=203	n=40	n=66	n=112	n=128	n=57	n=80
Mounds with 1-5 species	n=3 30%	n= 80 39%	n=26 64%	n=23 35%	n=15 13%	n=17 13%	8/ 15%	9/ 11%
Mounds with 6-10 species	n=6 60%	n=105 52%	n=14 36%	n=41 62%	n=68 61%	n=91 71%	n=38 66%	n=43 54%
Mounds with 11-15 species	n=1 10%	n=16 8%	0	n=2 3%	n=27 24%	n=19 15%	n=8 15%	n=19 24%
Mounds with 16-20 species	0	n=2 1%	0	0	n=2 2%	n=1 1%	n=2 4%	n=9 11%

* – number of community type table 1, 2 and fig 1.

As succession at a mound progressed, changes in the structure of the vegetation occurred. At a certain stage of succession, the vegetation shifted from an *Artemisia adamsii+Leymus chinensis* community to a *Stipa krylovii+Agropyron cristatum* community.

Frequency and cover of the caespitose grasses and shrubs increased and frequencies and cover of rhizomatous species *(Artemisia Aaamsii, Leymus chinensis, Carex duriuscula)* decreased during the shift from a degraded pasture community *(Artemisia Adamsii+-Leymus chinensis)* to a steppe community *(Stipa Krylovii+Agropyron cristatum)* (Figs 2, 3).

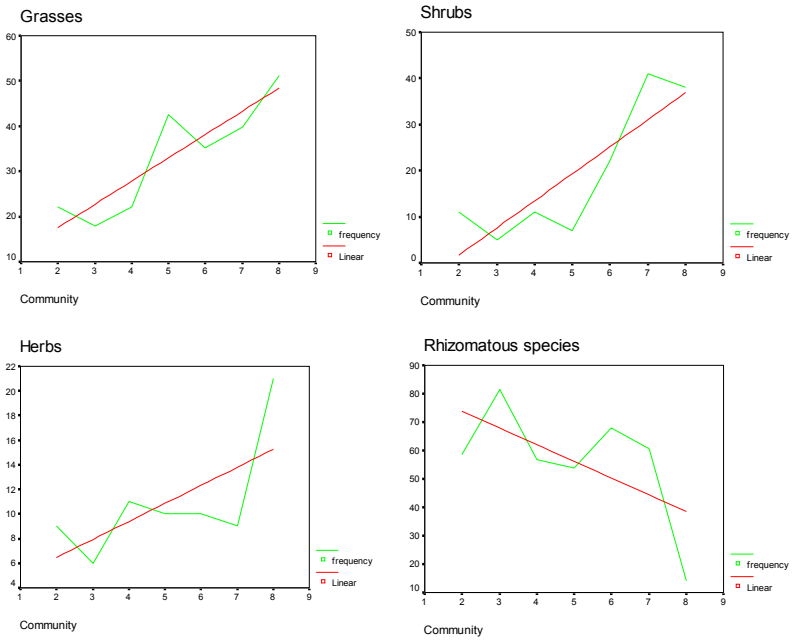

Fig 2. *Frequencies of grasses, shrubs, herbs and rhizomatous species of the community types on the mounds*

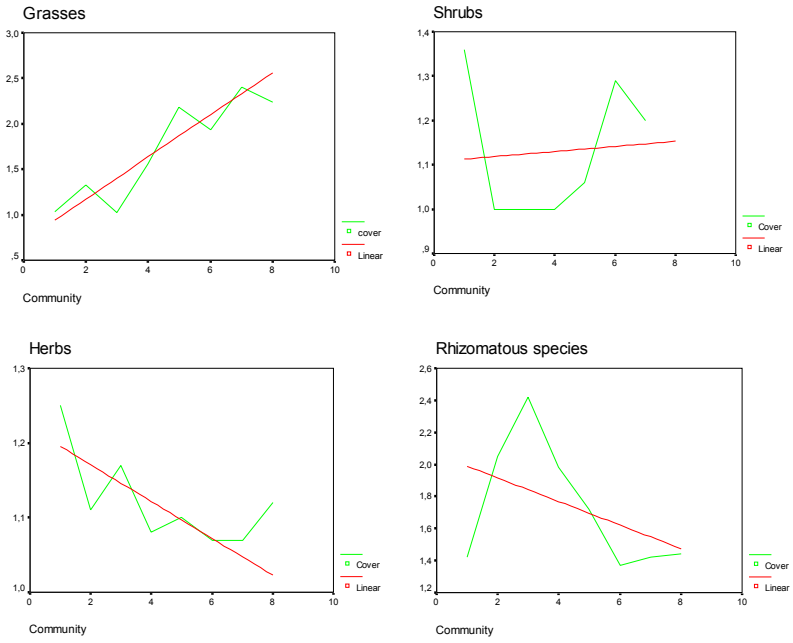

Fig 3. *Cover of grasses, shrubs, herbs, and rhizomatous species of the community types on the mounds*

Although the frequency and cover values for *Leymus chinensis* decreased as succession progressed, the species still had greater frequency and cover than other caespitose grasses This is may be because the mounds were still in use by marmots.

All grasses, herbs, and shrubs did not have significant differences in occurrence by subcommunity type. Only rhizomatous species had significant differences in frequency ($p=0.04$, $p<0.05$) and then only between community types 2 and 8.

The higher cover value of *Stipa krylovii* in all community types compared to other grasses, including *Agropyron cristatum, Cleistogenes squarrosa, Koeleria macrantha, Leymus chinensis,* and *Poa attenuata* was statistically significant.

The frequency of three species and the cover of 13 species were significantly different between the marmot mounds and the plots without mounds. The higher frequency and cover of the rhizomatous species *Artemisia adamsii* on marmot mounds compared to plots without marmot mounds was significant ($p=0.013$) (Table 4, 5).

Table 4. *Means of species frequency on mounds and plots without mounds*

Species name	Means		Statistical significance (P<0.05)
	Mounds	Plots without mounds	
Artemisia adamsii	59.7	30.78	0.013
Artemisia frigida	50.12	83.99	0.003
Allium bidentatum	11.32	54.54	0.024

Table 5. *Means of species cover on mounds and plots without mounds*

Species name	Means		Statistical significance (P<0.05)
	Mounds	Plots without mound	
Artemisia adamsii	6,09	1,71	0,000
Leymus chinensis	5,78	2,79	0,000
Agropyron cristatum	2,33	1,39	0,02
Potentilla bifurca	2,09	0,8	0,000
Chenopodium album	1,69	0,23	0,000
Potentilla acualis	1,42	0,61	0,003
Dontostemon integrifolius	1,27	0,66	0,000
Caragana pygmaea	0,85	0,29	0,000
Potentilla tanansitifolia	0,99	0,65	0,034
Stipa krylovii	9,51	14,03	0,000
Artemisia frigida	1,82	3,34	0,000
Cleistogenes squarrosa	0,84	1,26	0,036
Allium bidentatum	0,53	1,19	0,000

Discussion and conclusions

Avirmed (1989) studied the effects of Brandt's vole *(Lasiopodomus brandtii)* on changes in vegetation cover and defined succession by species composition, abundance, cover, and sequences of change in dominant species. Successive communities were: 1). *Artemisia frigid + Carex duriuscula,* 2). *Chenopodium album + Salsola collina,* 3). *Artemisia adamsii,* and 4). grasses and herbs present in recovering empty colonies.

Chognii (1971) studied the effects of Brandt's voles on communities of *Koeleria macrantha -Agropyron cristatum* and defined four community types: 1). *Leymus chinensis + Salsola collina,* 2). *Salsola collina,* 3). *Artemisia adamsii,* and 4). *Leymus chinensis*

The marmot mounds were dominated by the ceaspitose species *Stipa krylovii, Agropyron cristatum,* rhizomatous species such as *Leymus chinensis, Artemisia adamsii,* and *Carex duriuscula;* and annual species including *Dontostemon integrifolius* and *Salsola collina*. The rhizomatous species were not dominant in the steppe zone (Davaajamts, 1980). Under light or moderate grazing the caespitose species *Stipa krylovii* is the dominant grass species. When grazing pressure increases rhizomatous species become dominant (Bayasgalan, 2002; Chognii, 2002, Avirmed, 1989). In this way the four sub-community types of the *Artemisia adamsiii + Leymus chinensis* community identified by TWINSPAN analysis were similar to the vegetation in areas with a heavy Brandt's vole presence or areas overgrazed by livestock. The stage of vegetation succession on marmot mounds was different than the vegetative community of the surrounding area. When a mound is created by burrowing marmots, it is initially covered by bare soil. This can be easily colonized by *Artemisia adamsii*, a common perennial steppe forb. It produces many, easily dispersed seeds, that establish well on degraded vegetation, bare soil, and around burrows. *Leymus chinensis* shows a fast lateral spread by forming rhizomes. *Stipa spp.,* however, are caespitose grass species much slower lateral spread.

Mongolian marmots, living in the same places for many years, can have a significant impact on the structure of local vegetation. The vegetation of the mounds is unique and is determined by the peculiarity of the structure and use of burrows, as well as the burrowing activity of the marmots. The vegetation of the mounds differs from nearby communities in the ratio and composition of species present.

A comparative analysis of vegetation on mounds and surrounding areas has shown that relatively independent patterns of succession occur on burrows in association of the temporal dynamics of burrow usage.

At the end of succession, there is no similarity between mound vegetation and the surrounding biocenoses. Thus, the burrowing activity of the marmots causes significant and irreversible changes to the environmental conditions around the mounds. Marmots, together with other species of mammals, are clearly actively involved in the formation and development of vegetative communities in the arid territories of Mongolia.

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