JOURNAL OF
ECOLOGY AND ENVIRONMENT
http://www.jecoenv.org

Note
J. Ecol. Environ. 39(1): 119-125, 2016

Changes in plant community structure in relation to climate change and restoration plot areas in Mongolia

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Abstract
Mongolia has one of the strongest climate warming signals on Earth, and over 40% of the human population depends directly or indirectly on pastoral livestock production for their livelihoods. Thus, climate-driven changes in rangeland production will likely have a major effect on pastoral livelihoods (Fernandez-Gimenez et al. 2015). The loss of species dependent mostly on rainfall has resulted in adverse changes in the botanical composition of the steppes (Gunin et al. 1999). Summer season in 2015 was completely dry until middle of July and, had not enough vegetation cover as last 15 years. The purpose of this study is to check plant community dynamics in Mongolia in relation to climate change in 2014 and 2015. The study sites were selected in mountain-steppe habitat in central Mongolia. In the 2014, there have been registered 81 plant species of 56 genera of 25 families on the investigated sites and, occurred 57 plant species of 44 genera of 21 families in the 2015. It is concluded that the abundance and richness of plants are directly connected to heavily affect by the climatic factor, i.e. amount of precipitation during growing season. As a same like result of climate change, in Mongolian land is going become desertification, and each spring, soil particles from Mongolia are swept up by a cold air mass into the atmosphere and blasts into south east China, Korea and Japan. The Koreans call this phenomenon the "Fifth season" or "Yellow sand", and the Chinese call it "Yellow dragon".

Key words: climate change, distribution, Mongolia, plant community structure

INTRODUCTION

Nomadic herding of agricultural is been most important for the people's living in Mongolia. Almost all of grasslands of Mongolia have been lost past century, because of nomadic herding and therefore dominant anthropogenic factor affected steppe vegetation. Herders in Mongolia are directly affected by climate change impact more than urban residents (Suvdantsetseg et al. 2015). The herders' livelihood is dependent on seasonal climate difference, weather conditions and landscape resources of vegetation, water, natural zones, and soil productivity. Climate change in recent year has one more reason for weather which is if summer season has rainfall not enough, winter season will be harsh and cold. Wells grasslands are usually accompanied with increased traffic by humans and livestock (Amartuvshin et al. 2015). Mongolia is now becoming widespread dramatically reduced vegetation changes, and rainfall in recent year. Last 15 years in Mongolia, summer season was not like no rainfall until middle of July in

http://dx.doi.org/10.5141/ecoenv.2016.013

Received 26 November 2015, **Accepted** 26 November 2015

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pISSN: 2287-8327 eISSN: 2288-1220

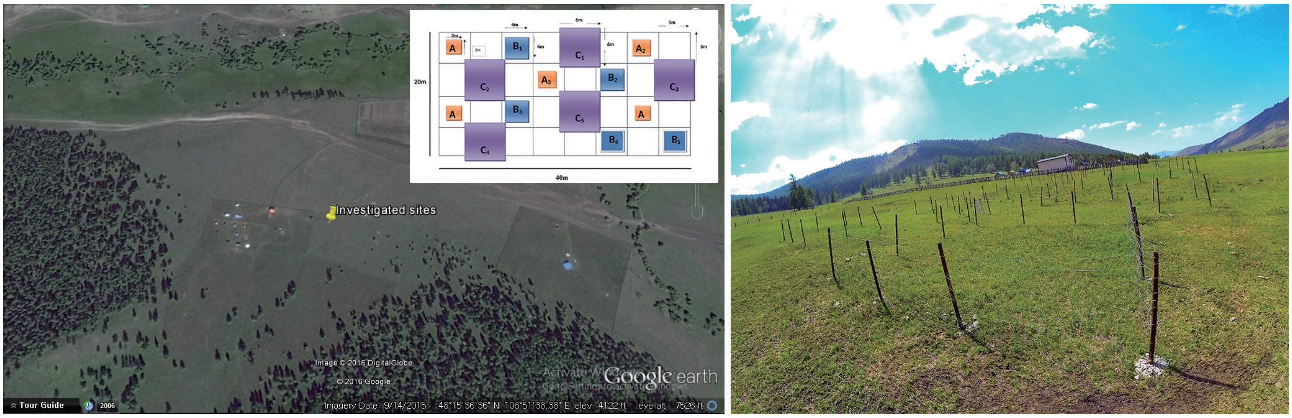

Fig. 1. Study sites in Forest Research Training-Center in Udleg, Tuv province, Mongolia. On the left panel, a small square box shows the study sites, and the numbers of bottom indicate the replicates: A, 2 m x 2 m squares; B, 4 m x 4 m squares; C, 6 m x 6 m squares. The right panel shows the image of the study sites.

2015 and, had not enough vegetation cover. The purpose of this study is to check plant community dynamics in Mongolia in relation to climate change in 2014 and 2015 and to how to determine that increased vegetation cover in recent years.

MATEREIALS AND METHODS

Study area

The study area is located in central Mongolia. It is centered on Tuv province and includes the capital city of Ulaanbaatar. The area of Tuv province is considered as part of the Khentii-Khangai Mountain Range and eastern Mongolian plains. Most of the territory of Tuv province is elevated at 1200 to 1500 m above sea level. The most important body of water is the Tuul River, which crosses Ulaanbaatar and later joins the Orkhon River. The investigated sites were situated in the Forest Research Training-Center (FRTC) of National University of Mongolia, Udleg, Batsumber, Tuv province Mongolia. Total 1360 ha of forested area is managed as the private region of National University of Mongolia and the land use permission is processed under resolution of the Batsumber soum Council.

The observation sites were examined in three different fences (2 m^2, 4 m^2 and 6 m^2) and 5 replications by experimental plot design in grazed land with similar soil conditions and moisture near the FRTC in 2014 (Fig. 1). The experimental plot design has created in 20-40 m squares.

Vegetation

The land surface is composed of three broad vegetation types: forest steppe, steppe, and desert-steppe. The forest steppe zone stretches from the lower slopes of the Khentii Mountains to the steppe zone with an elevation of 850-1400 m above sea level. Average annual precipitation is 300-400 mm; spring and autumn periods are dry. The frost-free season lasts 112-125 days. Carbonated and non-carbonated fine black-brown soil is widespread in this zone. Primary tree species include the Siberian Larch (*Larix sibirica*), Siberian Pine (*Pinus sibirica*), birch (*Betula* spp.) and poplar (*Populus laurifolia*), (Tsolmon 2013).

Field survey

This research study had continued for 2 years. Field survey has been run from August 15th to June 15th every year. For the study, we checked and collected once time a week in each sites and, it has repeated 8 times. In this year, the field work has finished according to time table, and was following next schedule (Fig. 1):

- To check for A sites every Monday
- To check for B sites every Wednesday
- To check for C sites every Friday

A field survey was undertaken from 20th June to 16th August in 2014 and from 20th June to 14th August in 2015. The vegetation covers were photographed to observe how increased the vegetation covers were in each fence site per week.

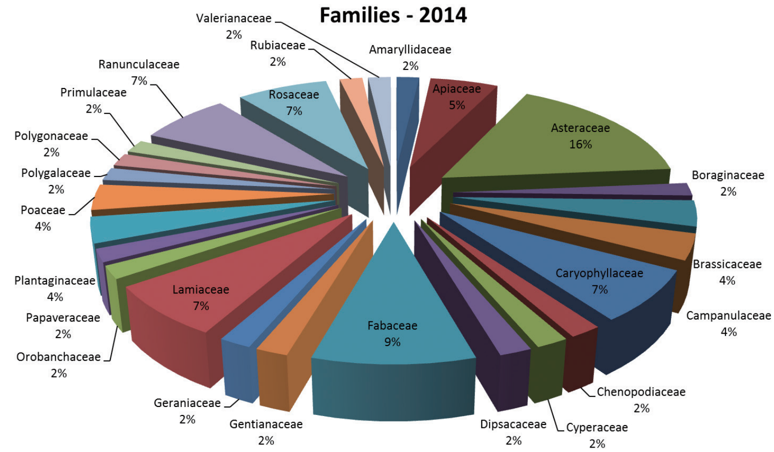

Fig. 2. Comparison between families of determined plant in 2014.

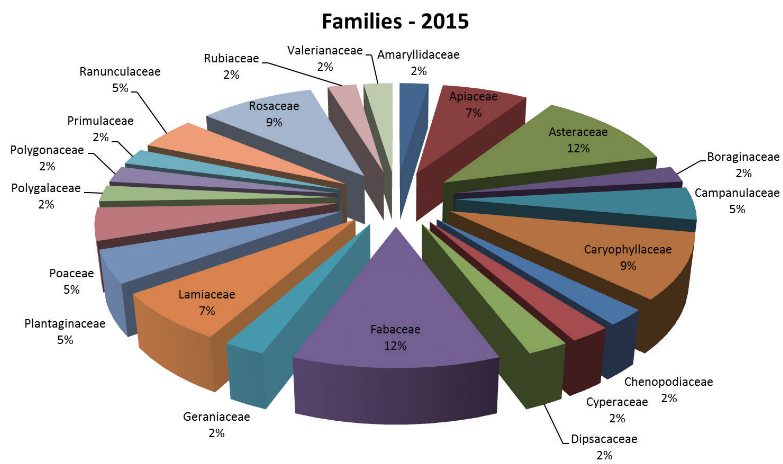

Fig. 3. Comparison between families of determined plant in 2015.

RESULTS

In the 2014, there have been registered 81 plant species of 56 genera of 25 families on the investigated sites (Table. 1). Following below figure 2, among the determined plants collected in FRTC, Udleg, Tuv province, Mongolia, Asteraceae family is dominated 12 species of 9 genera and, Rosaceae family also dominated 10 species of 4 genera. The other genera such as Caryophyllaceae, Fabaceae, Lamiaceae, Poaceae, Ranunculaceae were relatively lower than Asteraceae and Rosaceae genera and species. In the 2015, there have been occurred 57 plant species of 44 genera of 21 families (Table. 1). Therefore family of Caryophyllaceae dominated 7 species 5 genera and, next following family of Asteraceae dominated 6 species of 5 genera. 55 species of total 81 species have identified completely, 26 species are processing to identify.

Dominances of *Bupleurum bicaule, Myosotis sylvatica, Stellaria dichotoma, Achillea asiatica, Galium verum* was appeared on the all investigated sites in June, *Dianthus versicolor, Geranium pretense, Trifolium lupinaster, Phlomis tuberosa, Sangusorby officinalis* appeared in July, and *Leontopodium leontopodium, Chrysanthemum zawadskii* appeared in August, 2014. But temporary season of some dominance plant species were delayed in 2015. *B. bicaule, A. asiatica, G. verum* and *Aster alpinus* were appeared in July. Therefore *Dianthus versicolor* was delayed to dominate in August from July. *M. sylvatica, S. dichotoma, T. lupinaster, P. tuberosa, S. officinalis* were decreased drastically in 2015. *L. leontopodium, C. zawadskii* were delayed to flowering time. Because the climate was very dry and rainfall season was started lately in 2015.

Following next two figures are showing how it is changed proportion between families of determined plants in 2014 and 2015 (Fig. 2 and 3). Asteraceae, Caryophyllaceae, Fabaceae and Rosaceae are showing relatively

Table 1. Family, genera and species list in 2014 and 2015

FAMILY	Genus	Species (2014)	Species (2015)
AMARYLLIDACEAE	Allium	*Allium* sp1	*Allium* sp1
		Alluim sp2	-
		Allium senescens	*Allium senescens*
APICIACEAE	Aegopodium	*Aegopodium* sp	*Aegopodium* sp
	Bupleurum	*Bupleurum bicaule*	*Bupleurum bicaule*
	Peucedanum	*Peucedanum* sp	*Peucedanum* sp
ASTERACEAE	Achillea	*Achillea asiatica*	*Achillea asiatica*
	Artemisia	*Artemisia* sp1	*Artemisia* sp1
		Artemisia sp2	*Artemisia* sp2
		Artemisia palustris	-
	Aster	*Aster alpinus*	*Aster alpinus*
		Aster sp4	-
	Chrysanthemum	*Chrysanthemum zawadskii*	*Chrysanthemum zawadskii*
	Kalimeris	*Kalimeris tatarica - Heteropappus biennis*	-
	Hieracium	*Hieracium umbellatum*	-
	Leontopodium	*Leontopodium leontopodium*	*Leontopodium leontopodium*
	Tephroseris	*Tephroseris integrifolia - Senecio campestris*	-
	Taraxacum	*Taraxacum officinale*	-
BORAGINACEAE	Myosotis	*Myosotis sylvatica*	*Myosotis sylvatica*
BRASSICACEAE	Draba	*Draba nemorosa*	-
	Arabis	*Arabis hirsuta*	-
CAMPANULACEAE	Adenophora	*Adenophora stenanthina*	*Adenophora stenanthina*
	Campanula	*Campanula glomerata*	*Campanula glomerata*
CARYOPHYLLACEAE	Cerastium	*Cerastium arvense*	*Cerastium arvense*
	Dianthus	*Dianthus versicolor*	*Dianthus versicolor*
	Lychnis	*Lychnis sibirica*	*Lychnis sibirica*
	Silene	*Silene repens*	*Silene repens*
	Stellaria	*Stellaria dichotoma*	*Stellaria dichotoma*
		Stellaria dahurica	*Stellaria dahurica*
		Stellaria chamaejasme	*Stellera chamaejasme*
CHENOPODIACEAE	Chenopodium	*Chenopodium* sp1	*Chenopodium* sp1
		Chenopodium sp2	*Chenopodium* sp2
CYPERACEAE	Carex	*Carex* sp1	*Carex* sp1
		Carex sp2	*Carex* sp2
DIPSACACEAE	Scabiosa	*Scabiosa comosa*	*Scabiosa comosa*
FABACEAE	Caragana	*Caragana* sp	*Caragana* sp
	Lathyrus	*Lathyrus pratensis*	*Lathyrus pratensis*
	Oxytropis	*Oxytropis* sp	*Oxytropis* sp
	Trifolium	*Trifolium lupinaster*	*Trifolium lupinaster*
	Vicia	*Vicia Cracca*	*Vicia Cracca*
GENTIANACEAE	Gentiana	*Gentiana barbata*	-
		Gentiana decumbens	-
		Gentiana pseudoaquatica	-
GERANIACEAE	Geranium	*Geranium pratense*	*Geranium pratense*
		Geranium sp	*Geranium* sp

Table 1. Continued

FAMILY	Genus	Species (2014)	Species (2015)
LAMIACEAE	**Phlomis**	*Phlomis tuberosa*	*Phlomis tuberosa*
	Schizonepeta	*Schizonepeta multifida*	*Schizonepeta multifida*
		Schizonepeta sp	*Schizonepeta* sp
	Scutellaria	*Scutellaria scordifolia*	*Scutellaria cordifolia*
	Dracocephalum	*Dracocephalum ruyschiana*	-
OROBANCHACEAE	**Euphrasia**	*Euphrasia tatarica*	-
PAPAVERACEAE	**Papaver**	*Papaver* sp1	-
PLANTAGINACEAE	**Linaria**	*Linaria acutiloba*	*Linaria acutiloba*
	Plantago	*Plantago* sp	*Plantago* sp
POACEAE	**Agropyron**	*Agropyron* sp1	*Agropyron* sp1
		Agropyron sp2	*Agropyron* sp2
	Poa	*Poa* sp1	*Poa* sp1
		Poa sp2	*Poa* sp2
		Poa sp3	*Poa* sp3
POLYGALACEAE	**Polygala**	*Polygala hybrida*	*Polygala hybrida*
POLYGONACEAE	**Bistorta**	*Polygonum viviparum - Bistorta vivipara*	*Polygonum viviparum - Bistorta vivipara*
PRIMULACEAE	**Androsace**	*Androsace septentrionalis*	*Androsace septentrionalis*
RANUNCULACEAE	**Aconitum**	*Aconitum barbatum*	*Aconitum barbatum*
	Delphinium	*Delphinium* sp	-
	Ranunculus	*Ranunculus japonicus*	*Ranunculus japonicus*
		Ranunculus sp1	-
	Thalictrum	*Thalictrum foetidium*	-
		Thalictrum petalodium	-
ROSACEAE	**Dasiphora**	*Dasiphora fruticosa*	*Dasiphora fruticosa*
	Potentilla	*Potentilla* sp4	-
		Potentilla anserina	-
		Potentilla bifurca	*Potentilla bifurca*
		Potentilla fragaria	-
		Potentilla grey	-
		Potentilla sercia	*Potentilla sercia*
		Potentilla sp1	-
	Rosa	*Rosa acicularis*	*Rosa acicularis*
	Sanguisorba	*Sanguisorba officinalis*	*Sanguisorba officinalis*
RUBIACEAE	**Galium**	*Galium boreale*	*Galium boreale*
		Galium verum	*Galium verium*
VALERIANACEAE	**Valeriana**	*Valeriana officinalis*	*Valeriana officinalis*

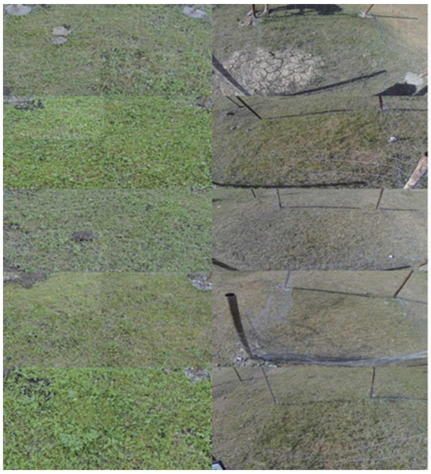

Fig. 4. Vegetation covers on June (the left panel is showing in 2014, the right panel showing in 2015).

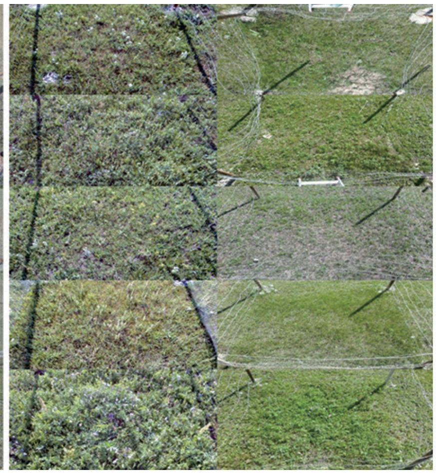

Fig. 5. Vegetation covers on July (the left panel is showing in 2014, the right panel showing in 2015).

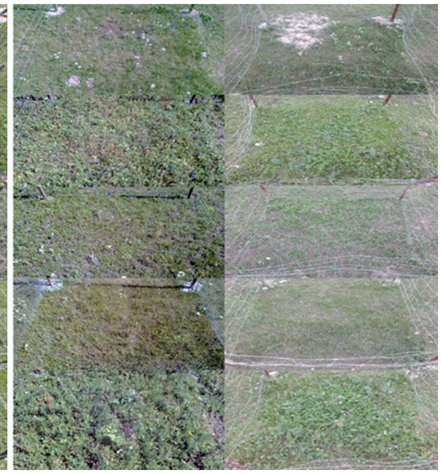

Fig. 6. Vegetation covers on August (the left panel is showing in 2014, the right panel showing in 2015).

higher percent than other families in 2014 and 2015. Therefore, these families are suggested to be strong tolerance groups. As shown in Fig 2, each proportion of Amaryllidaceae, Valerianaceae, Ranunculaceae, Primulaceae, Polyganaceae, Polygalaceae, Papaveraceae, Orobanchaceae, Geraniaceae, Gentianaceae, Dipsacaceae, Cyperaceae, Chenopodiaceae, and Boraginaceae is just 2 percent of the determined plant familes. As shown in Table 1, Papaveraceae, Orobanchaceae, Gentianaceae, and Brassicaceae are disappeared at the investigated sites in 2015. From this result, these families are not strong tolerance groups.

Vegetation cover is a good indicator for evaluating terrestrial environment (Sun 2010). There is a significant correlation between vegetation cover and precipitation and thus, the change in precipitation is an important factor for vegetation variation . Vegetation cover photos are showing three different temporal conditions in 2014 and 2015 (Fig. 4-6). In meaning of this section, vegetation cover is related to precipitation and others climate conditions. In 2014, Mongolia got sufficient rainfall and was good contidion to grow vegetation. But in 2015, it not sufficient rainfall and was drastically dry, and was bad condition to grow vegetation.

CONCLUSION

In 2015, abundance of plants and insects were decreased 5 times and, richness of plants were decreased 0.5 times. The climate was very dry because of no rainfall during the beginning and middle months of summer season, and hence vegetation was very scarce with low biomass and flowering compared to the previous year. Therefore, plant abundance as well as richness were decreased dramatically in the year of 2015. In this conclusion, the abundance and richness of plants are immediately related to heavily affect by climate changes, especially amount of precipitation during growing season. As a mentioned in abstract, Mongolian land is becoming desertification, less vegetation, and spreading strong sand storm each spring (Fifth season, Yellow sand, Chinese dragon) into south east China, Korea, and Japan.

ACKNOWLEDGEMENTS

We thank to all members of The Mongolia-Korea Biodiversity Research Field Station and Forestry Research-Training Center (FRTC) for our field site, and all members of the Entomological Observation Laboratory in Kyungpook National University. This is in part carried out as a Ph.D research for Khureltsetseg Lkhavgadorj. This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR No. 2015-04-203).

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