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UNU Land Restoration Training Programme
Árleynir 22, 112 Reykjavik, Iceland

Final project 2015

TESTING THE ECOLOGICAL SITE GROUP CLASSIFICATION IN MONGOLIAN RANGELANDS: CASE STUDY IN FOREST STEPPE ZONE

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ABSTRACT

The rangeland is the core of the natural and economic resources of Mongolia. The number of livestock has increased by 29.4 million head since 1970, resulting in rapid rangeland degradation with negative consequences for the national economy. The aim of the study presented here was to evaluate rangeland Ecological Site group classification within the forest steppe natural region. Soil water is the main limiting factor for the growth of vegetation in the Mongolian rangelands. Our Ecological Site group classification approach was based on soil physical properties, especially clay and rock fragment content as is reflected in the three main groups that are identified: loamy sites, sandy sites and gravelly sites. Soil texture influences how much water is available for the plant, and loamy sites having a greater water holding capacity than sandy and gravelly sites. Rangeland Ecological Site classification is one of the first steps in sustainable land management when it comes to grazing animals.

This paper should be cited as:

Ulambayar B (2015) Testing the ecological site group classification in Mongolian rangelands: case study in forest steppe zone. United Nations University Land Restoration Training Programme [final project] http://www.unulrt.is/static/fellows/document/Ulambayar2015.pdf

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1. INTRODUCTION

1.1 Mongolian rangelands

Mongolia is a landlocked country between Russia and China, situated in the transition zone between the east Siberian permafrost taiga and the Central Asian arid deserts (Nandintsetseg et al. 2007). It can be seen as a vast watershed between the basins of the Arctic and Pacific oceans with diverse landscape features (Gunin et al. 1999; Dorjgotov 2003). About half of the world's terrestrial rangelands are found in Mongolia (Havstad et al. 2008). There are six different natural ecological zones defined in Mongolia: alpine, mountain taiga, forest steppe, steppe, desert steppe and desert (Yunatov 1976).

Agricultural land, including rangelands, covers 1,153,613 sq. km or 74 percent of the total territory, and the rangelands cover 1,110,261 sq. km or 96 percent of the available agricultural land (Administrative Land Affairs Geodesy and Cartography 2014). Mongolia has 245 thousand herder households and 51.9 million domestic animals (National Statistical Office 2014) . About 800,000 of the 2.5 million people of Mongolia depend directly on animal husbandry and thus on the rangelands (Damdinsuren et al. 2008). Rangeland livestock production is the main source of income of the Mongolian economy, accounting for approximately 20 percent of the gross domestic production. The rangelands of Mongolia are in a critical state of transition today (Johnson et al. 2006). The number of animals has increased by 29.4 million head since 1970 (National Statistical Office 2014), resulting in rapid rangeland degradation in recent years with negative consequences for the national (Green Gold 2015) economy.

Of the six ecological zones of Mongolia, the forest steppe zone covers about 238,108 km^2 or 15.2 percent of Mongolia (Fig. 1), and is also one of the most densely populated areas (Dash et al. 2003). The forest steppe is intensively used for animal husbandry and is thus the most important rangeland resource of Mongolia (Figs. 1 and 2). (Jigjidsuren & Johnson 2003). This intensive land use has resulted in a rapid change in land conditions. The Mongolian rangelands were considered to be in a relatively healthy state 60 years ago (Yunatov 1959), but since the 1960s studies have shown deterioration due to improper land use (Chognii 2001).

The study presented here is based on already available data obtained from the forest steppe zone on Rangeland Ecological Site classification (Green Gold 2015) provided by the Green Gold project. The Ecological Site classification approach is a relatively new concept in land potential classification.

> An Ecological Site is a conceptual division of the landscape that is defined as a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances. (Caudle 2013, p. 12)

Interactions between plants and soil, climate, and landscape features are factors affecting development of Ecological Sites and are the basis for their classification (Moseley et al. 2010). In Mongolia the most fertile soils and the highest number of animals are found within the ecological zones of the forest steppes (Fig. 1).

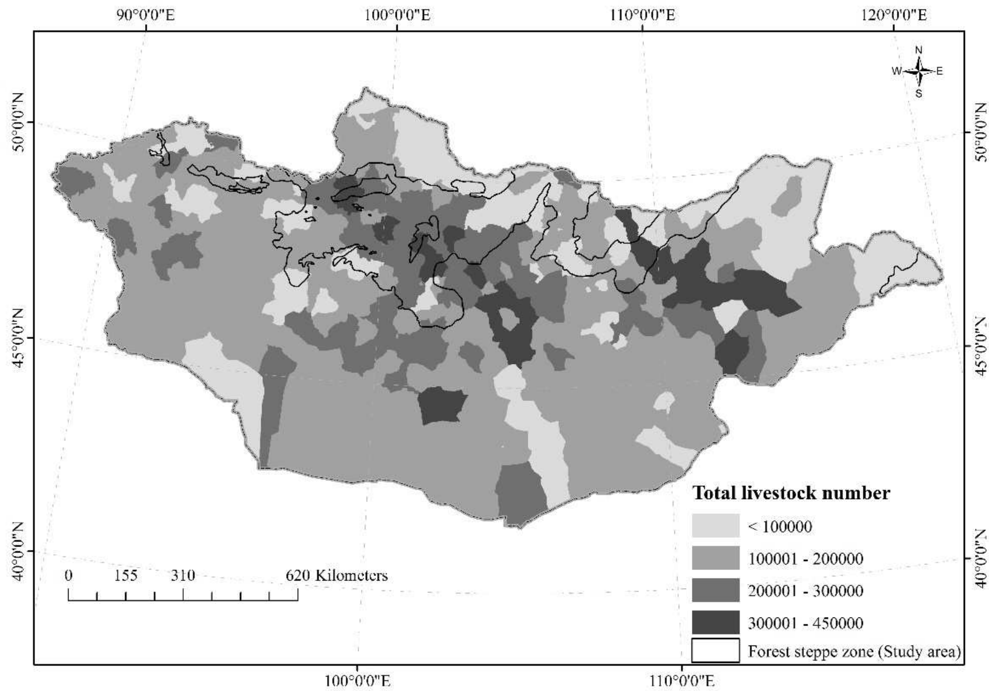

Figure 1. Total distribution of livestock numbers in 2014 and the forest steppe zone (delineated areas). The lightest colour stands for less than one hundred thousand livestock, the darkest for more than three hundred thousand livestock. Approximately 38 percent of all Mongolian livestock are found within the forest steppe zone. (Based on unpublished data from the Ministry of Food and Agriculture of Mongolia, 2014).

The forest steppe zone overall has similar climate conditions but includes different landforms, soil types and vegetation communities and is therefore ideal for testing the suitability of Ecological Site classification.

1.2 Project importance for rangeland management

The Office of Administrative Land Affairs, Geodesy and Cartography, (ALAGaC) develops land management planning methodology at the local administration levels in Mongolia. The current land management plans do not reflect the land potential of various landscape units. The Ecological Site approach does depend on land potential and may therefore improve the ALAGaC methodology and help move land management towards sustainability in the future. To make progress towards sustainable rangeland management requires meaningful technical assistance herders and local land managers that are specific to land areas that vary in ecological potential, productivity and recovery needs (Green Gold 2015).

Ecological Site Descriptions provide base information for Rangeland Health and translating the interpretation into management decisions (Bestelmeyer et al. 2009). Ecological Site classifications supply a consistent framework for describing rangelands and their soil, vegetation, and abiotic features, thereby delineating units that share similar capabilities to respond to grazing management activities or degradation processes. These features are important and can improve the level of rangeland management and also reduce the outcome of limitations. Ecological Site classification and descriptions provide local land managers and rangeland specialists the information needed for evaluating the suitability of the land for various land-use activities (Herrick et al. 2006; Bestelmeyer et al. 2009).

Developing Ecological Site descriptions and an associated inventory and monitoring program will be a valuable tool to communicate the characteristics of a degraded state to local herders and may help in developing recommendations for appropriate carrying capacity guidelines for different Ecological Sites.

1.3 Overall goal

The aim of the study was to assess Ecological Site group classification within an individual natural region with similar climate (Forest Steppe zone of Mongolia) using data on selected soil physical properties, and to

- identify the relationship between selected soil properties and elevation
- determine the relevance of vegetation cover compared to soil properties in Ecological Site classification

2. METHODS

2.1 Study area description

The study area is located within the forest steppe zone (Fig. 2). The data used in this study were collected in the (Green Gold 2015) Green Gold project conducted in 2010 - 2014.

2.2 Climate features

The dissected forest steppe has a mainland climate. About 70% of the annual precipitation occurs during the growing season from May through August. Annual mean temperatures range from -7.2°C to 1.3°C. Winters are generally very cold, but spring is windy and dry (Tables 1, 2 and Fig. 3).

Precipitation is extremely variable from month to month. The highest amount of precipitation falls in June, July and August. The coldest month is January (average -24.8°C), the hottest is July (average 15.8°C). The annual mean air temperature is -2.9°C (Fig. 3).

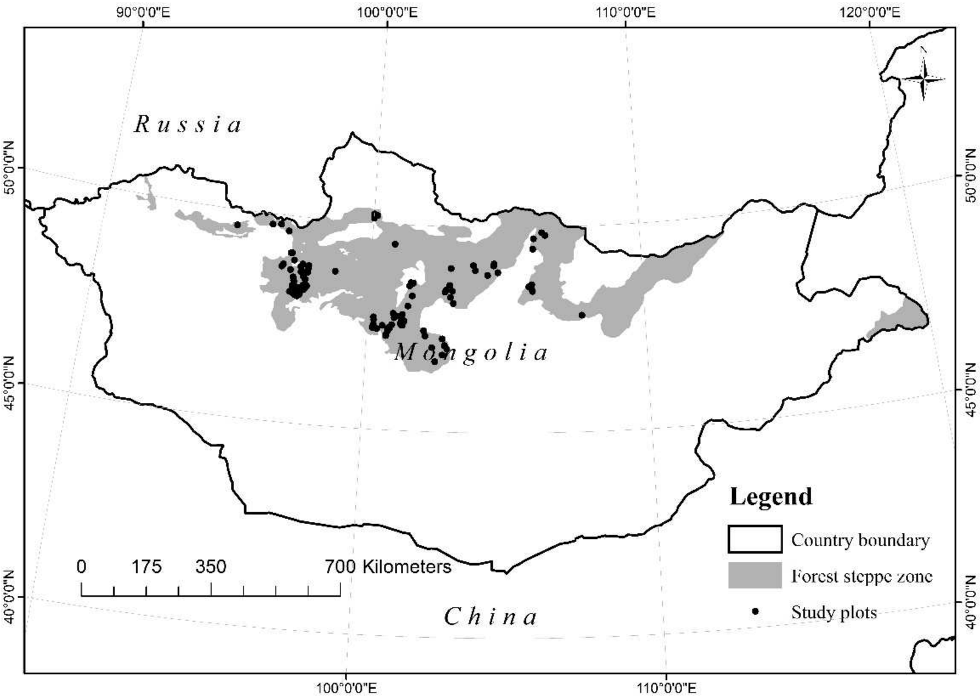

Figure 2. Map showing location of forest steppe natural ecological zone (shaded grey) and the location of study plots used in this study.

Table 1. Monthly mean annual precipitation (mm) and maximum, minimum air temperature (°C) of forest steppe zone of Mongolia. (Data from the Mongolian Institute of Meteorology and Hydrology).

Months	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Avg	2.2	1.8	3.4	8.6	18.6	52.1	82.5	68.8	28.7	9.7	4.5	3.2
Temp Max	-18.2	-14.7	-6.6	3.8	11.5	17.2	19.5	17.3	10.2	1.1	-9	-15.8
Temp Min	-31.5	-27.7	-17.5	-2.5	4.9	10.1	12.2	10.5	4.5	-3.7	-17.7	-27.7

Table 2. A comparison of proportions of Ecological Site groups classified between the field classification and cluster analysis.

Cluster results	Total number of plots and percent	Field classification		
		Gravelly	Loamy	Sandy
Cluster I	26	16	2	8
	100%	61.5%	8%	31%
Cluster II	23	3	18	2
	100%	13.0%	78%	9%
Cluster III	99	0	51	48
	100%	0.0%	52%	49%

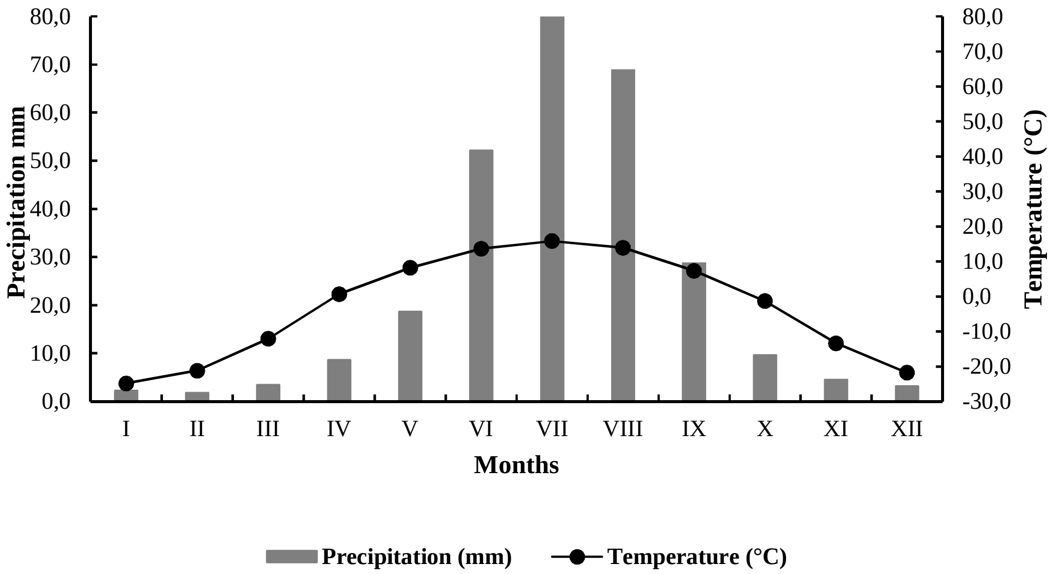

Figure 3. Monthly Precipitation and monthly mean temperature of the forest steppe zone of Mongolia (Data from the Mongolian Institute of Meteorology and Hydrology of Mongolia).

2.3 Data collection

Ecological Site description data were collected, using medium intensity sampling methods (Moseley et al. 2010). A total of 148 study sites were selected from different landforms using Google Earth. The coordinates were recorded and relocated in the field using handheld GPS with 2 – 4 m accuracy. Ecological Sites were classified in the field based on soil texture. A total of three Ecological Site types were identified, gravelly, loamy, and sandy sites (see Fig.4). The general transect layout at each study site is shown in Figure 5.

Vegetation and soil surface cover was measured using the line-point intercept and gap intercept method. At each site, data were collected along two parallel 50-m transects that were installed 25 m apart (Fig. 5). Starting and ending point coordinates of each transect were marked by GPS. These two transects are represented as within-site replicates. For the line-point intercept, foliar, basal, litter cover, bare ground (Table 4) was recorded every 0.25 m along each transect, for a total of 200 points per transect and 400 points per site. A metal rod (1 mm in diameter and 0.7 m in length) was dropped into the vegetation surface, and all plant species that came in contact with the pin were recorded. This method is a quick, accurate way to quantify surface cover, vegetation, litter, rock fragments and biotic crusts (Herrick et al. 2005).

Soil properties were determined in the middle of the transects (Fig. 4). Classification of soil particles were determined according to Schoenberger (2002) United States Department of Agricultural (USDA) system. Together, soil texture and structure are good indicators of the nutrient supplying ability of soil solids, the ability of the soil water holding capacity, and the air necessary for plant root system growth (Brady & Weil 1999).

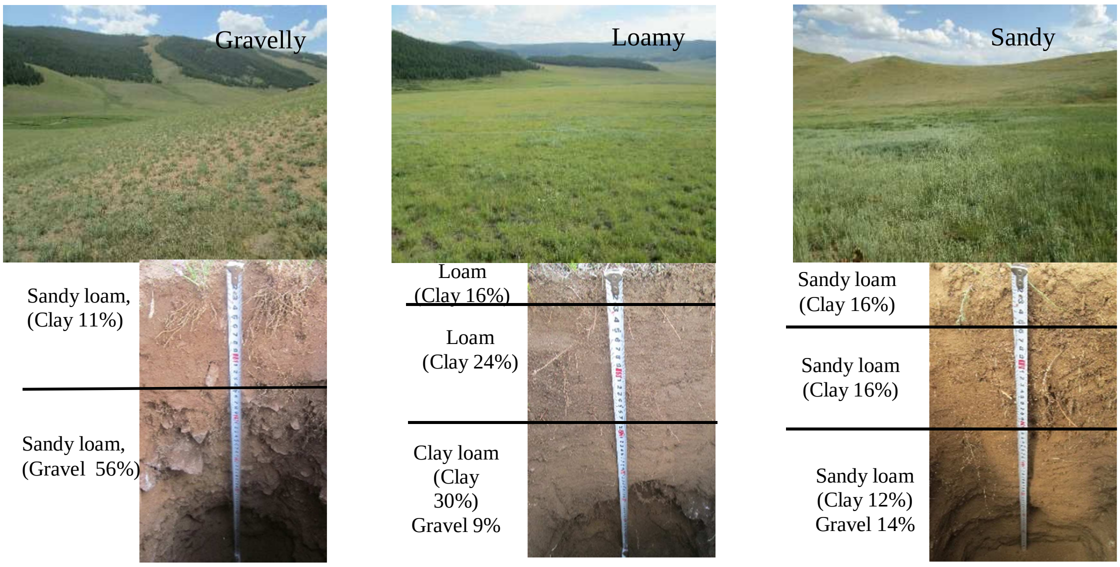

Figure 4. Landscape overview images and typical soil profiles at the three identified Ecological Site types: gravelly, loamy, and sandy (Photos: B. Ulambayar, G. Naym-Ochir July 2014)

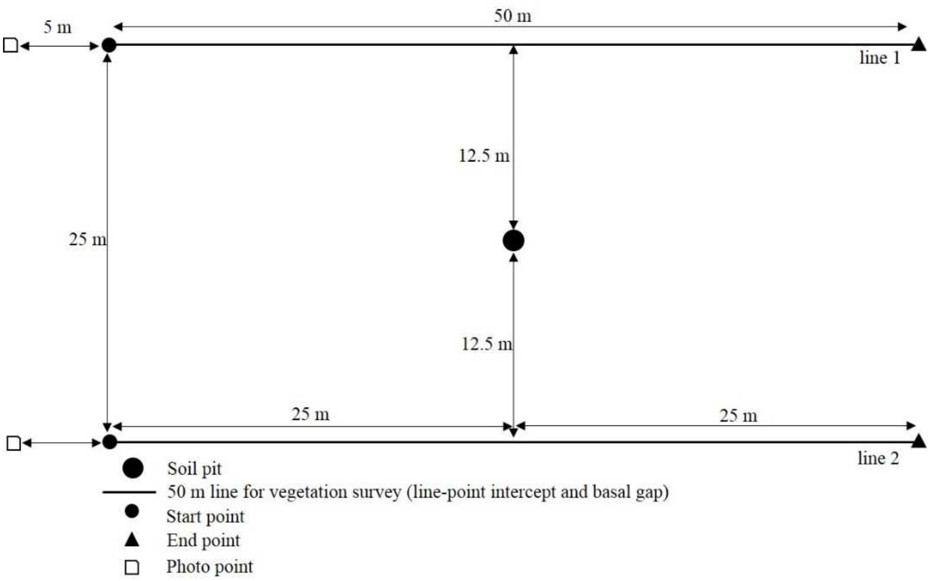

Figure 5. Sampling scheme for each plot. At the centre is a soil pit, and two parallel 50 m transects are located 12.5 m north and south of the soil pit.

Soil cooler is considered to indicate to some extent soil organic matter content and soil fertility (Brown & O'Neal 1923). Soil colour was determined for each horizon using the standard Munsell soil colour charts (Munsell Color, X-Rite Inc.) (Munsell 2000).

A common characteristic of many developed soils in low rainfall areas is the accumulation of calcium carbonate ($CaCO_3$) in the soil profile. The high carbonate concentration in these calcareous horizons inhibits the root growth of some species (Brady & Weil 1999). Carbonates affect available soil water, soil fertility and nutrient transfer to plants. Calcareous layers were determined according to field carbonate detection and effervescence class assessment (Schoeneberger 2002). Figure 6 shows some field methods used in this study.

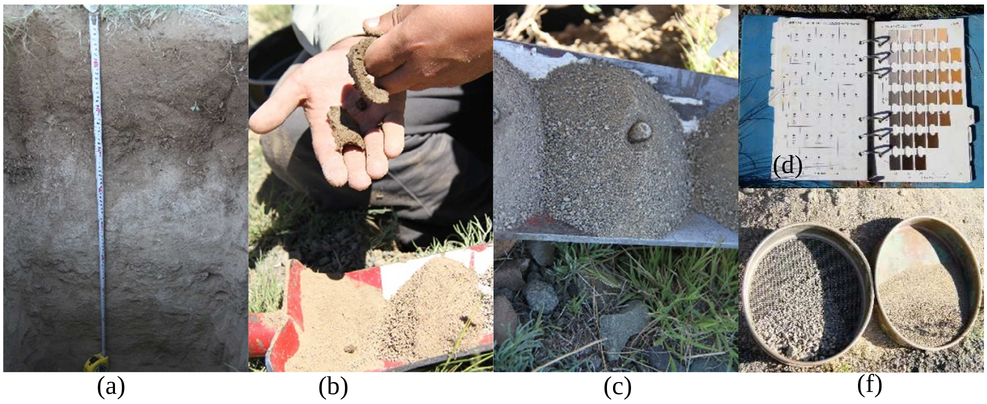

Figure 6. Demonstration of soil field methods. (a) Soil profile, about 0.7 meter deep calcareous loamy soils. (b) The "feel" method for estimating soil texture class. (c) Calcium carbonate ($CaCO_3$) content estimating with a field effervescence test. (d) Determining soil colour using the Munsell soil colour chart. (f) Samples are field sieved to 2 mm (standard particle size cut-off between soil and rock) (Photos: B. Ulambayar, G. Naym-Ochir, August 2013).

2.4 Data preparation

Topography, soil properties and plant community data were collected to use for Ecological Site group classification. These quantitative data relationships were concordant with what was described in the initial concept for Ecological Site description and classification (Moseley et al. 2010). The next step involved entering and storing the data. The Database Inventory Monitoring and Assessment (DIMA) database program (Jornada Experimental Range 2014) was used. DIMA is a configurable software tool for data collection, management and reporting. (Courtright & Van Zee 2011). Vegetation, soil, topography and climate data were arranged in the Microsoft Excel software program (Microsoft Excel 2013) for statistical analysis programs.

Statistical analyses were performed using SAS statistical software (SAS Institute 2013). Statistical analysis involved multiple cluster analyses and average linkage cluster analysis tests. All studied plots were divided into three basic groups using cluster analysis. We used one-way analysis of variance (ANOVA) to detect the differences between means of soil, topography and vegetation parameters examined in the four groups. The least significant difference was performed to determine the significance of groups means at $p<0.05$. Cluster analyses to identify the main Ecological Site groups were performed with PC-ORD multivariate analysis software (McCune & Mefford 2011). A Euclidean distance measure was used and Ward's method for group linkage.

3. RESULTS

3.1 Soil physical properties of the Ecological Site groups

Little correlation was observed between the measured variables, especially soil and vegetation variables (Fig. 7). The results of cluster analysis of soil properties and environmental variable data showed clear separation of three groups: gravelly (cluster I), loamy (cluster II), and sandy (cluster III), illustrating distinct differences between each study site see (Appendices I and II). The Ecological Sites classified in the field were compared with cluster analysis, and results showed similarity as follows: gravelly site 61.5%, loamy 78.3%, sandy 48.5% from same Ecological Site groups (Table 2).

The variables used in the analysis were as follows: value: soil colour value according to the Munsell colour system; texture: soil texture as assessed by hand method in the field, % rock 0-5: proportion of rock fragments in the 0 - 5 cm soil sample; % clay 0-5: proportion of 0 – 5 cm clay in the soil; elevant: elevation above sea level, slope;_d: observations down the slope by clinometer; % canopy: percent plant canopy cover; % bare: percent bare ground; % basal: percent plant basal cover; % grndcov: percent ground cover (including basal cover, litter and rock cover); % littcov: percent litter cover, all of the above vegetation and ground cover percent measured the line–point intercept method (see method section). PREC_SUM: annual sum precipitation, TMEAN: annual mean air temperature.

A total of 148 plots were studied: 26 gravelly, 23 loamy, and 99 sandy (Table 3). The loamy site had a significantly ($p<0.05$) higher clay content than the sandy and gravelly sites. The sandy site had a significantly ($p<0.05$) lower clay content than other sites (Fig. 8). The gravelly sites contained the significantly highest (40.4 ± 0.99) amount of rock fragments compared to other sites. Sandy sites contained the lowest amount (9.5 ± 0.72) of rock fragments (Fig. 9).

Table 3. Main Ecological Site groups that were identified by cluster analysis in this study (refer also to the cluster diagrams in Appendix II) and their corresponding soil clay and soil rock fragment content.

Cluster	Ecological Site groups	n	Clay % (0 – 20cm)			Rock fragment % (0 – 68 cm)		
			Mean	Std Error	Range	Mean	Std Error	Range
I	Gravelly	26	20.1	1.42	10 – 37	40.4	0.99	31 - 50
II	Loamy	23	25.6	0.82	18 – 33	23.9	0.98	17 - 33
III	Sandy	99	20.3	0.68	7 - 38	9.5	0.72	0 – 30

The clay content between the Ecological Site groups differed based on soil depth (Table 4). The loamy site was significantly higher in clay content ($p<0.05$) in surface horizons (0 – 5 cm) than the sandy site but not significantly higher than the gravelly site. The loamy sites had significantly higher clay content ($p<0.05$) in the 5 - 20 cm horizon than the other sites. Loamy and sandy sites did not have significantly ($p>0.05$) different clay content at a 20 - 70 cm soil depth. Loamy and gravelly sites had significantly ($p>0.05$) different clay content at a soil depth of 20 - 70 cm (Table 4).

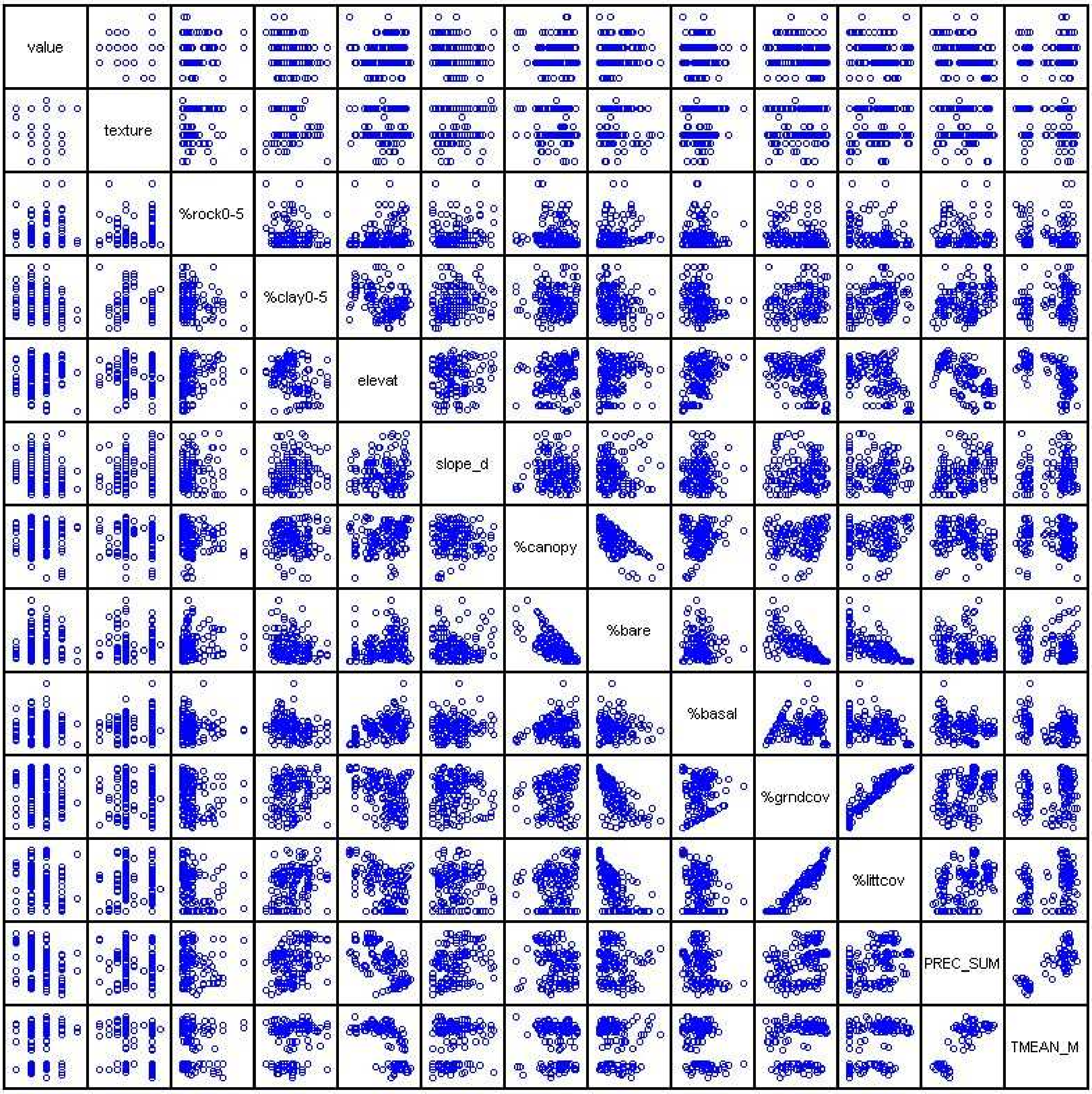

Figure 7. Scatter plot matrix of measured variables showing all correlation combinations. The variables measured in the analysis were as follows: Value: soil colour value according to the Munsell colour system; texture: soil texture as assessed by hand method in the field, ;%rock0-5: proportion of rock fragments in the 0 - 5 cm soil sample; %clay0-5: proportion of 0 – 5 cm clay in the soil; elevant: elevation above sea level; slope_d: observations down the slope by clinometer; %canopy: percent plant canopy cover; %bare: percent bare ground; %basal: percent plant basal cover; %grndcov: percent ground cover (including basal cover, litter and rock cover); %littcov: percent litter cover, all of the above vegetation and ground cover percent measured the line–point intercept method (see method section). PREC_SUM: annual sum precipitation, TMEAN: annual mean air temperature.

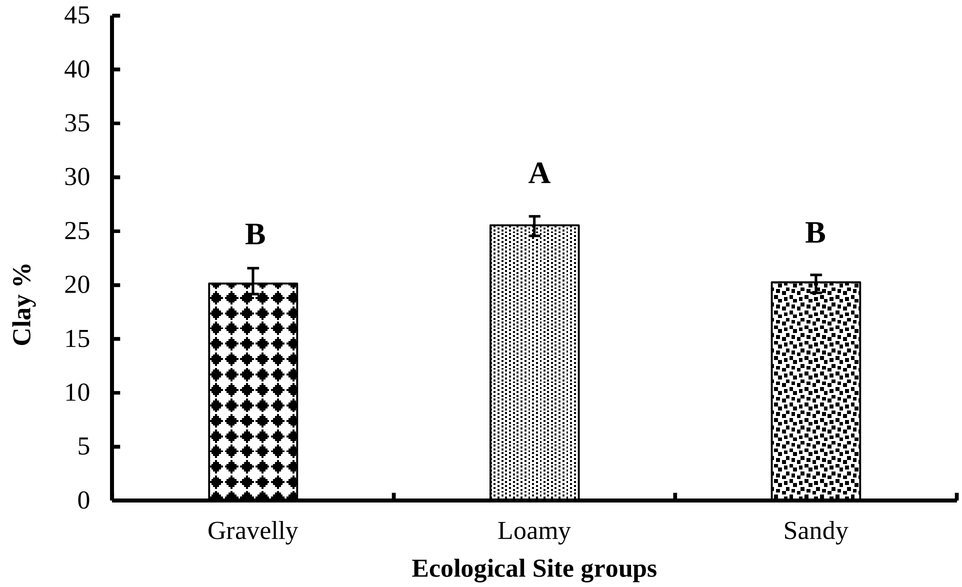

Figure 8. The average (±SE) soil clay content (0 – 20 cm soil depth) of the three Ecological Site groups. Different letters indicate differences in statistical significance at the 95% confidence level ($p<0.05$).

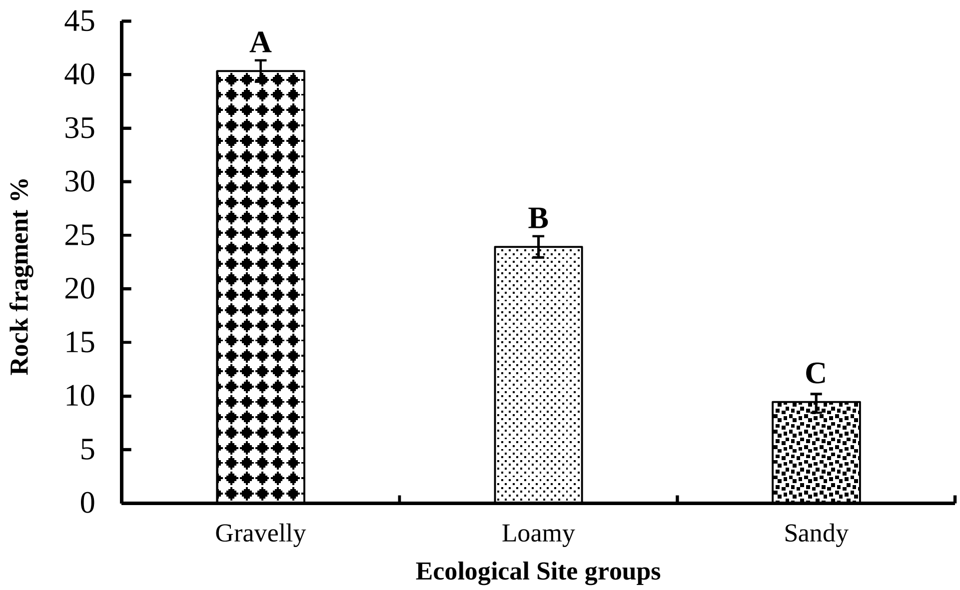

Figure 9. Average (±SE) soil rock fragment content of soil (0 – 68 cm soil depth) of the three Ecological Site groups. Different letters indicate difference in statistical significance at the 95% confidence level ($p<0.05$).

Table 4. ANOVA results showing the mean, standard error, range and presence/absence of significant differences in soil clay content and soil rock fragments between the three identified Ecological Site groups. Different superscripts indicate significant differences ($p<0.05$), ns = not significant at the 95% confidence level.

Ecological Site groups	**n**	**Soil depth cm**	**Clay %**			**Rock fragment %**		
			Mean	**Std Error**	**Range**	**Mean**	**Std Error**	**Range**
Gravelly	26	0 - 5	15.1^{ns}	1.06	8 - 29	4.6^{ns}	1.04	0 - 20
		5 - 20	20.5^{b}	1.46	10 - 38	11.2^{c}	1.93	1 - 45
		20 - 70	22.0^{b}	2.66	4.1 - 46	53.7^{bc}	1.86	40 - 77
Loamy	23	0 - 5	17.4^{c}	0.99	9 - 29	5.6^{ns}	1.41	0 - 30
		5 - 20	26.9^{ac}	1.02	17 - 35	8.7^{ns}	1.34	0 - 25
		20 - 70	30.7^{a}	1.9	6 - 45	32.0^{ac}	1.68	19 - 52
Sandy	99	0 - 5	14.4^{b}	0.51	5 - 29	3.5_{ns}	0.46	0 - 20
		5 - 20	22.0^{b}	0.77	7 - 39	5.6^{a}	0.7	0 - 48
		20 - 70	24.5^{ns}	1.24	4 - 51	11.8^{ab}	1.03	0 - 56

The rock fragment content between the Ecological Site groups differed also based on soil depth, as was observed with clay. All of the three Ecological Site groups contained fewer rock fragments in the surface horizon (0 - 5 cm) (Table 4). Gravelly sites had significantly ($p<0.05$) higher rock fragment content in the 5 – 20 cm depth than did the sandy site. Rather, the depth of 20 - 70 cm of a gravelly site was significantly different from all other sites.

The statistical analysis by horizons indicated that the soils are not uniform in clay and rock fragments (Table 4, Fig. 10). All Ecological Site groups had increased clay and rock fragment content with soil depth. A strong argillic (clay) horizon was detected for the loamy group. The amount of rock fragments deep in the soil increased dramatically for the gravelly group. The lowest rock fragment content was found at the sandy sites (Fig. 10).

Figure 10. Variation in soil clay (left) and soil rock fragment content (right) as a function of soil depth for the three different Ecological Site groups.

The elevation above sea level of the forest steppe zone ranges from 652 - 2282 meters over the total studied plot. Gravelly sites were located at higher elevations ($p<0.05$) than the sandy and loamy sites. Loamy and sandy sites were located at similar elevations (Table 5).

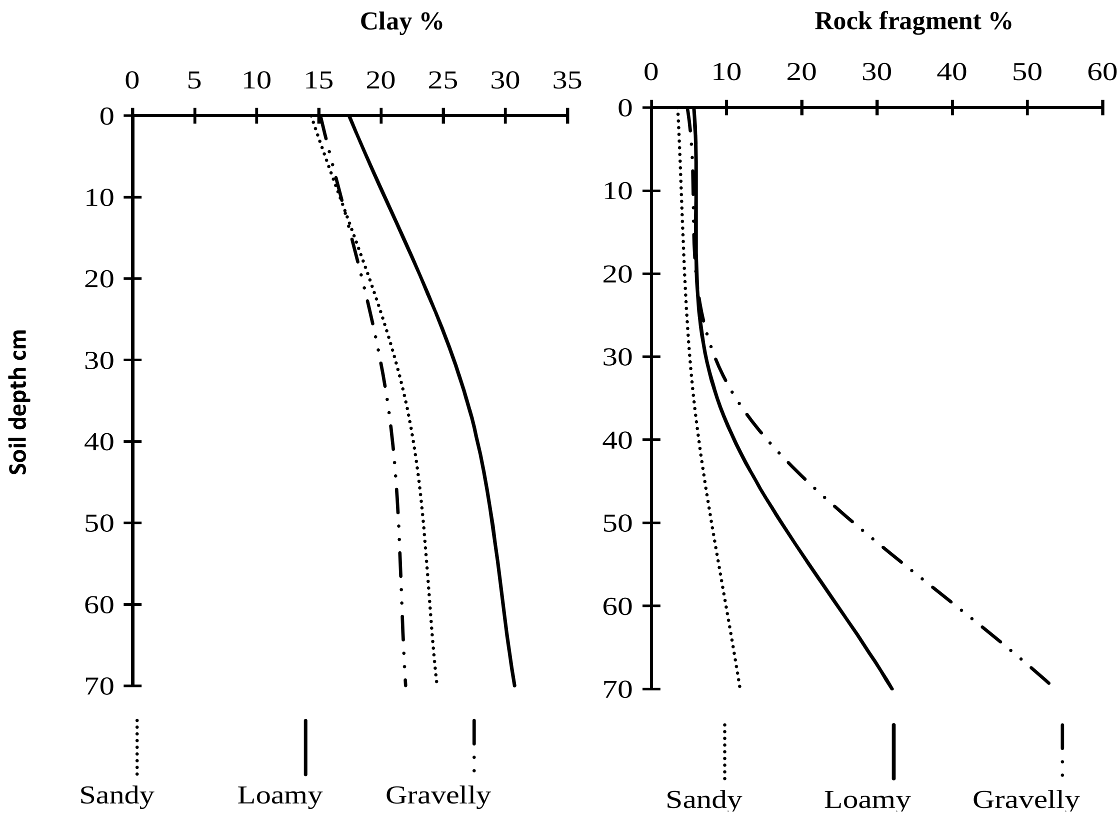

Figure 11. Variation in soil clay (left) and soil rock fragment content (right) as a function of soil depth for the three different Ecological Site groups.

Table 5. ANOVA results showing the mean, standard error, range and presence/absence of significant differences in elevation between the three Ecological Site groups. Different superscripts indicate significant difference ($p<0.05$), ns = not significant at the 95% confidence level.

Cluster	Ecological Site	n	Elevation m		
			Mean	**Std Error**	**Range**
I	Gravelly	26	1810^{bc}	56.9	1172 - 2205
II	Loamy	23	1581^{ns}	80.5	829 - 2151
III	Sandy	99	1522^{nc}	44.8	652 - 2282

3.2 Vegetation and ground cover attributes of the Ecological Site groups

Measured vegetation cover and ground cover indicators showed little variation between the three Ecological Site groups (Fig. 11). The gravelly sites had the highest foliar cover (75.6 cm ± 2.48) but were not significantly different from the Ecological Site groups. Total basal cover (16.1 cm ± 1.24) was greatest for gravelly sites and smallest in the sandy sites. Overall, vegetation and ground cover attributes were not significantly different between all the Ecological Site groups (Table 6).

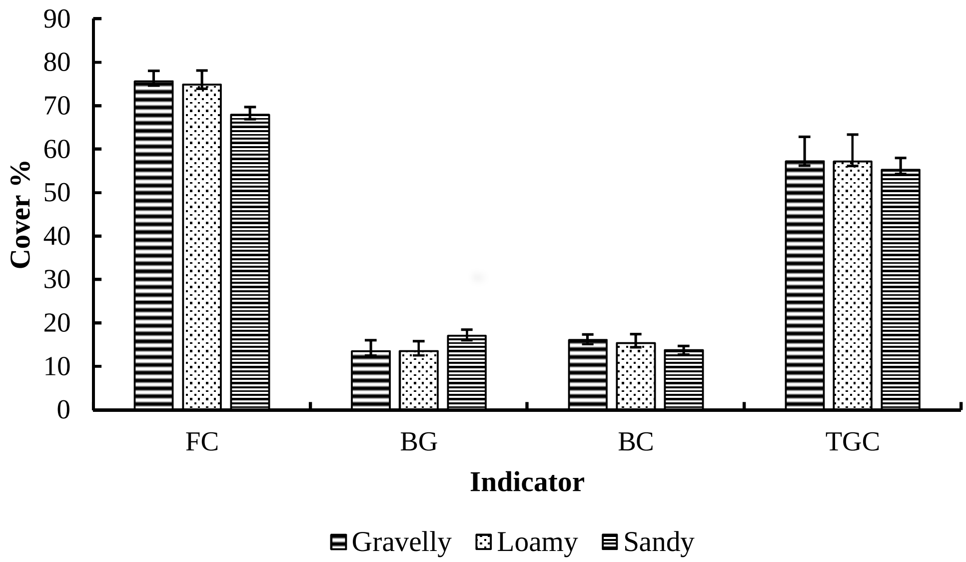

Figure 12. Summary of vegetation and ground cover characteristics of the three Ecological Site groups. Ground cover characteristics include: foliar cover (FC, of plant canopies), bare ground (BG) plant basal cover (BC) and total ground cover (TGC, including basal cover, litter and rock cover). No statistical difference was found between ground cover characteristics. Each bar represents mean ± standard error.

Table 6. ANOVA results showing the mean, standard error in vegetation and ground cover between the three Ecological Site groups.

Indicator	Gravelly		Loamy		Sandy	
	Mean	**Std Error**	**Mean**	**Std Error**	**Mean**	**Std Error**
Foliar cover	75.6	2.48	74.9	3.20	67.9	1.8
Bare ground	13.5	2.47	13.5	2.30	17.0	1.4
Plant basal cover	16.1	1.24	15.4	1.97	13.8	0.9
Total ground cover	57.2	5.57	57.1	6.21	55.3	2.7

4. DISCUSSION

Soil properties could be used to define Ecological Sites within an individual natural region with similar climate (forest steppe region), but there was a difference between texture classes. The cluster analysis resulted in three main Ecological Site groups (Table 2, Appendices I and II). The soil properties classified in the field compared with cluster analysis results showed similarity as follows: gravelly site 61.5%, loamy 78.3%, sandy 48.5% of the sites were found in the respective field determined Ecological Site group and the corresponding cluster defined group (Table 2). Soil and topography features are the main factors of the Ecological Site description and classification (Bestelmeyer & Brown 2010; Moseley et al. 2010; Caudle 2013). The soil physical characteristics of texture, structure and depth are key variables used to determine the capacity of the land (Herrick et al. 2013). These are also properties that affect soil water availability and thus the soil available water capacity is an integral part of the Ecological Sites description. Soil water is the main limiting factor for the growth of vegetation in the Mongolian rangelands (Jugjidsuren 2005). Soil surface and subsurface textures and rock fragment content most influenced permeability and evaporation. For example, a sandy site typically allows more rapid permeability than a loamy site, and a gravelly site has a slower permeability rate than a loamy site (United State Development of Agriculture 2003; Duniway et al. 2010).

The area studied is located in a forest steppe zone and we have observed the typical grazing area. The sandy Ecological Sites constitute 67 percent of the total studied plots. Sandy soil is most common in the steppe and the forest steppe zone of the Mongolian grazing area (Dorjgotov 2003; Avaadorj 2014). The definition of the Ecological Sites has previously been tested using vegetation data (Sainnemekh 2014). The results here, based on soil properties, are consistent with the approach where vegetation was used as the basis for the classification. However, vegetation should not be the main criterion for the Ecological Site group classification, as the vegetation community can be easily changed by natural and human caused disturbance (United State Development of Agriculture 2003; Moseley et al. 2010).

CONCLUSION

The aim of the study was to determine Ecological Site group classification within a natural region with a similar climate. The cluster analysis on soil data suggested three different groups of Ecological Sites. These sites differed in soil texture and clay and rock fragment content. Significant differences among Ecological Site groups were found for most soil properties. The clay content was highest and the content of rock fragments the lowest in the loamy Ecological Site group. The clay content was significantly higher in the loamy Ecological Site group than sites characterized as having sandy and gravelly textures. The content of rock fragments was significantly higher in the gravelly Ecological Site group than in the others. The sandy Ecological Site group contained less clay than the other groups. As a result, cluster analysis showed a clear separation of the Ecological Site groups, illustrating distinct differences driven by the clay and rock fragment content of the soils.

ACKNOWLEDGMENTS

I would like to express my deepest appreciation to all those who provided me the possibility to complete this report.

First of all, I am thankful to the UNU-LRT programme and especially to Programme Director Hafdis Hanna Ægisdóttir, Deputy Programme Director Berglind Orradóttir, Office Manager Halldóra Traustadóttir and the logistical support and for providing necessary guidance concerning project implementation.

My special and deepest thanks go to my supervisors, Dr Johann Thorsson and Dr Olafur Arnalds for their very dedicated support and guidance during my project preparation and writing period, which made it possible for me to complete this report. I am also grateful to all of the lecturers and people who shared their knowledge and experiences and helped me during this programme.

I would like to thank the Green Gold project team, the especially wonderful crew of applied researchers. I also want to thank the international consultants, Dr Brandon Bestelmeyer, Dr Patrick Shaver and Justin Van Zee for their valuable advice.

Many thanks to my LRT fellows and my friends for the mutual support we had during the last six months when we were together and developed an unforgettable friendship.

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APPENDICES

Appendix I. Studied sites' characteristics. Sites are summarized in Table 2.

Cluster	ID	Elev	Value _0-5	%clay 0-20	%rock 0-70	%bare	%basal	%grndcov	PREC_ SUM	TMEAN_M
II	1	2033	4	24.2	24.5	17.5	5.3	35.3	284	-1.6
II	40	1267	4	22.2	27.1	24.0	14.8	43.0	335	0.1
II	17	1634	3	26.2	29.9	31.3	17.9	32.1	318	0.2
II	59	1382	2	25.0	30.3	4.8	12.3	81.8	351	0.2
II	107	1794	4	25.3	30.6	18.0	15.8	30.3	282	-0.5
II	92	1225	4	25.9	27.7	0.0	5.8	93.3	262	-0.2
II	135	1981	3	27.7	27.0	24.5	23.0	23.0	225	-4.8
II	27	2151	3	30.4	30.9	27.0	13.0	13.0	303	-1.9
II	68	1273	3	32.4	32.9	11.5	11.3	72.3	360	0.1
II	6	2059	4	25.4	16.7	24.0	4.0	4.0	246	-1.8
II	69	1288	3	27.0	17.1	12.0	12.0	78.0	371	0.1
II	106	1707	5	26.1	20.7	7.8	15.8	37.5	271	-0.4
II	128	2130	4	25.8	20.9	2.0	39.5	80.0	226	-4.7
II	136	1929	3	25.5	20.2	40.5	3.3	9.8	231	-5.1
II	38	1400	3	31.1	20.6	6.0	20.5	78.3	359	0.0
II	66	1186	3	29.4	22.2	17.8	14.3	70.5	360	0.1
II	54	843	3	33.1	24.9	0.0	0.0	98.3	315	-0.7
II	9	1656	3	18.2	20.1	8.3	17.3	75.5	320	-0.6
II	41	1428	4	20.6	19.3	6.3	15.3	67.0	359	0.0
II	28	1614	5	22.6	22.2	1.0	19.8	92.0	316	0.2
II	81	829	4	22.4	20.4	14.5	12.3	72.8	353	-0.2
II	32	1695	4	20.8	22.8	2.0	27.8	91.0	316	0.2
II	143	1879	4	20.5	21.8	11.0	34.0	36.0	218	-4.4
III	3	2059	2	13.9	13.0	12.0	3.0	3.0	247	-1.8
III	8	1659	3	15.2	14.5	8.5	22.3	84.0	322	-0.3
III	15	1855	.	15.5	13.8	28.3	5.3	45.8	291	-1.0
III	52	1460	3	14.4	14.8	15.3	15.0	65.8	308	-0.7
III	48	1384	3	11.7	14.0	11.0	13.5	64.3	296	-0.4
III	5	2141	3	14.9	11.3	19.0	11.5	28.0	287	-2.9
III	23	1933	5	15.5	11.1	44.0	14.0	16.0	291	-1.0
III	99	1592	2	16.0	11.7	12.3	4.3	20.3	268	0.1
III	24	1883	4	19.8	17.5	47.0	16.0	16.0	291	-1.0
III	72	1124	3	19.3	15.9	19.3	14.3	60.5	346	0.4
III	104	1813	5	20.6	15.6	5.3	21.3	57.5	282	-0.5
III	142	1847	5	21.3	16.7	24.0	7.5	70.3	242	-5.8
III	33	1729	3	18.0	12.9	5.0	17.0	65.3	342	-0.3
III	120	2106	4	18.4	13.2	12.0	15.0	33.5	233	-4.5

III	133	1845	3	18.7	13.7	25.0	27.0	27.0	236	-5.6
III	118	2282	3	18.4	14.6	3.5	16.0	89.5	247	-4.9
III	122	2159	5	17.7	13.9	13.0	13.0	46.0	233	-4.5
III	125	2106	4	17.8	13.7	13.0	52.0	67.0	234	-4.4
III	11	1825	3	12.7	25.2	15.0	14.6	57.9	306	-0.7
III	57	1895	3	14.6	27.2	31.0	16.0	16.0	249	-5.3
III	124	2075	4	14.7	26.4	8.0	11.0	45.0	233	-4.5
III	21	1768	3	12.4	29.6	53.0	17.0	17.0	318	0.2
III	19	1660	4	17.5	24.7	17.0	0.0	0.0	315	0.6
III	105	1866	5	17.5	24.5	26.3	18.5	23.5	271	-0.4
III	22	1782	3	16.3	24.1	36.0	10.0	19.0	315	0.6
III	13	1856	.	10.0	17.7	15.0	5.0	61.0	306	-0.7
III	16	1892	.	14.0	18.9	16.0	10.8	41.3	291	-1.0
III	34	1653	5	15.4	19.1	13.3	18.5	31.3	311	0.8
III	144	2063	4	13.8	21.2	25.0	7.3	53.8	240	-5.0
III	145	2062	4	13.8	21.3	36.0	24.0	27.0	240	-5.0
III	14	1714	.	19.1	1.3	26.3	7.5	57.5	315	0.6
III	53	711	3	19.9	0.0	30.8	2.1	15.8	309	0.1
III	88	711	4	20.5	2.0	0.0	1.5	98.0	324	-0.1
III	45	1228	2	21.1	0.0	3.5	20.3	91.0	371	0.1
III	100	1542	4	22.0	0.1	17.0	11.5	47.5	275	-0.3
III	86	694	4	17.2	0.0	0.3	0.0	95.5	324	-0.1
III	60	1308	2	24.4	0.3	14.3	7.5	69.8	355	0.3
III	97	1109	3	24.7	0.3	3.0	17.0	17.0	282	-0.5
III	61	1316	2	25.6	0.0	7.5	10.8	81.8	347	0.3
III	82	862	3	26.1	0.0	4.8	9.0	81.5	357	-0.2
III	74	1237	3	25.7	1.0	7.3	10.0	82.5	371	0.1
III	20	1761	3	17.4	3.9	65.0	12.0	12.0	329	-1.0
III	111	1381	5	18.4	5.4	25.5	12.8	30.8	202	-4.8
III	30	1574	4	22.3	7.4	7.5	19.5	65.0	290	0.5
III	84	848	4	21.5	8.4	11.0	9.8	81.8	353	-0.2
III	78	817	4	21.3	6.3	12.3	6.3	67.5	303	-0.4
III	132	1838	3	21.1	6.3	20.3	36.3	60.0	236	-5.6
III	103	1792	5	18.9	8.7	1.5	24.3	81.3	278	-0.3
III	31	1822	2	26.3	4.7	3.8	16.8	76.3	309	-0.5
III	114	2189	3	26.2	4.8	2.0	27.5	83.0	240	-5.2
III	131	2008	3	27.0	5.2	14.5	28.3	53.5	236	-5.1
III	110	1450	5	25.8	4.0	21.8	16.3	38.8	214	-5.5
III	112	1540	4	24.9	6.2	18.8	23.5	49.5	213	-5.2
III	71	1235	3	27.1	7.9	16.5	16.0	59.3	360	0.1
III	83	820	4	26.6	6.6	24.3	12.8	52.3	370	-0.2
III	90	823	4	28.2	5.8	39.8	4.0	51.3	296	1.2
III	29	1623	4	22.7	13.5	7.3	21.0	67.8	316	0.2

III	117	2240	3	22.7	13.0	8.5	23.0	83.5	251	-5.5
III	80	812	4	24.5	12.6	14.8	9.8	68.8	370	-0.2
III	75	1164	3	22.8	9.9	17.5	15.5	67.0	360	0.1
III	147	1882	3	22.7	10.1	14.5	12.0	40.8	225	-4.8
III	89	819	4	23.4	10.3	56.0	4.8	30.8	296	1.2
III	101	1695	4	23.0	11.4	25.8	15.5	34.5	268	-0.2
III	134	1943	3	22.3	11.4	18.5	24.5	53.5	224	-4.6
III	39	1467	2	28.1	11.3	3.3	9.3	88.3	357	-0.5
III	55	870	3	26.7	10.3	0.0	1.5	96.0	315	-0.8
III	73	1264	3	27.0	10.8	14.8	10.0	72.5	360	0.1
III	76	820	4	24.8	9.9	15.8	2.0	63.0	303	-0.4
III	102	1688	6	25.3	10.3	12.0	17.8	39.5	268	-0.2
III	44	1145	2	34.9	0.0	9.3	13.8	47.0	371	0.1
III	65	1237	3	34.2	0.7	24.8	9.5	48.3	347	0.2
III	63	1380	3	30.7	4.1	5.8	12.3	86.5	351	0.2
III	64	1253	3	28.8	0.0	12.3	10.3	71.8	317	0.8
III	95	990	3	28.2	0.3	4.3	2.5	72.3	276	0.0
III	79	814	3	30.5	0.0	7.8	14.8	79.8	357	-0.2
III	96	1084	3	31.4	0.0	0.3	23.0	94.5	282	-0.5
III	46	1577	3	37.8	9.3	6.0	4.0	4.0	302	-1.2
III	58	1312	3	32.0	8.4	1.3	12.3	93.3	315	0.7
III	70	1195	3	29.7	9.6	13.0	13.8	79.0	360	0.1
III	77	840	4	29.7	7.6	8.3	7.0	67.3	288	-0.4
III	62	1275	3	31.7	13.3	5.0	14.8	88.0	315	0.7
III	91	1130	4	29.4	14.6	0.0	0.3	93.3	262	-0.2
III	18	1649	3	12.7	3.8	52.0	13.0	13.0	315	0.6
III	47	1403	2.5	12.7	3.3	4.5	17.0	81.5	281	-0.5
III	85	665	4	11.2	3.9	0.0	0.5	99.3	319	-0.6
III	146	1880	5	14.1	4.3	36.0	8.0	57.5	221	-4.8
III	138	1793	5	13.8	1.6	31.8	2.3	60.8	220	-4.8
III	87	652	6	9.4	2.3	0.0	0.5	93.8	319	-0.6
III	130	2041	2	9.9	2.0	21.0	31.0	32.0	236	-5.1
III	109	2074	4	11.1	0.1	6.5	18.3	78.8	296	-0.4
III	35	1615	4	13.8	8.6	9.8	21.8	52.3	311	0.8
III	98	1059	3	14.5	9.2	10.3	18.5	75.3	283	0.0
III	139	1866	4	12.9	9.2	45.0	23.0	24.0	220	-4.8
III	140	1864	3	12.8	8.7	25.0	35.0	35.0	220	-4.8
III	121	2079	5	15.6	7.9	12.0	12.0	52.5	233	-4.5
III	126	1950	3	11.7	5.8	5.0	24.0	70.0	227	-4.7
III	141	1860	4	12.6	7.2	25.0	9.5	43.3	218	-4.4
III	51	1365	3	7.0	8.1	52.0	4.0	4.0	300	-0.4
III	148	1711	5	6.8	10.4	36.0	17.0	17.0	215	-4.4
I	2	2000	3	25.3	49.7	9.0	10.0	14.0	246	-1.8

I	25	1954	3	23.4	48.8	58.0	8.0	8.0	309	-0.8
I	129	2145	3	25.1	44.8	7.5	19.5	71.5	228	-4.4
I	56	1343	4	30.7	43.8	23.0	16.0	16.0	291	-0.9
I	115	2041	3	32.1	43.8	8.0	19.0	78.5	240	-5.2
I	119	2071	3	32.1	45.2	13.0	19.0	64.5	234	-4.4
I	93	1687	3	37.1	39.6	8.5	3.0	61.8	299	-2.3
I	4	2147	4	16.2	36.6	23.0	7.0	7.0	261	-2.6
I	26	1946	4	18.9	39.5	26.0	25.0	25.0	291	-1.0
I	67	1172	3	18.7	39.6	15.3	14.8	68.3	346	0.4
I	42	1457	2	18.2	39.2	8.3	9.3	82.5	357	-0.5
I	127	2003	3	16.8	39.4	3.0	17.5	82.5	218	-4.6
I	37	1649	4	16.5	42.1	5.5	21.0	79.5	302	0.6
I	43	1270	3	18.5	42.3	9.5	18.5	56.8	335	0.1
I	50	1479	4	13.8	43.3	5.8	25.5	86.5	278	-0.4
I	7	2082	3	21.5	38.7	27.8	12.5	31.0	246	-1.8
I	116	2205	3	23.3	40.8	0.0	19.5	90.0	240	-5.2
I	94	1764	3	26.7	38.2	2.5	2.0	68.8	311	-2.5
I	12	1844	3	9.8	47.0	17.9	17.5	67.1	306	-0.7
I	113	1951	4	12.0	45.5	8.0	21.6	65.4	234	-4.4
I	10	1793	3	10.4	34.3	5.8	14.6	80.8	296	-0.4
I	49	1547	3	9.5	36.5	16.0	18.0	18.0	278	-0.4
I	36	1685	3	16.9	32.8	4.3	23.5	84.3	311	0.8
I	137	1780	4	16.8	32.6	34.0	21.0	23.0	248	-6.1
I	123	1941	4	17.0	34.4	10.5	20.5	70.0	227	-4.7
I	108	2121	4	16.5	30.9	2.0	14.8	87.5	317	-0.9

Appendix II. Result of cluster analysis. Name of observation or cluster (vertical axis), average distance between clusters (horizontal axis).