Title: 20-year vegetation change data in three ecological zones in Mongolia

Abstract: Mongolian rangelands have experienced warming temperatures and increasing livestock densities over the past 20 years. Remote sensing studies report widespread degradation, but there are no long-term field studies of vegetation responses to shifts in climate and stocking densities. In 2013, we resampled plots originally sampled in 1994-1995 in the desert-steppe, steppe and mountain-steppe, and analyzed changes in vegetation in relation to changes in climate, stocking densities and forage use. Summer temperatures significantly increased and stocking densities fluctuated in response to droughts followed by harsh winters. Total herbaceous biomass in 2013 was similar to (desert-steppe and steppe) or greater than (mountain-steppe) in 1995, and total foliar and herbaceous cover were unchanged since 1995 in all zones. In the mountain-steppe, functional type and species cover shifts were consistent with warming temperatures and increasing grazing pressure. All species richness and diversity indicators declined significantly in the mountain-steppe since 1995 as did richness in the steppe. Some Mongolian rangelands may be losing resilience due to interacting climate and grazing pressures, but our data suggest degradation observed at our study sites is reversible. Mountain-steppe systems appear more vulnerable to grazing- and climate-induced vegetation change than steppe and desert-steppe.

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Associated publications:

J. Khishigbayar, María E. Fernandez-Gimenez, Jay P. Angerer, R.S. Reid, J. Chantsallkham, Ya Baasandorj, D. Zumberelmaa. 2015. Mongolian rangelands at a tipping point? Biomass and cover are stable but composition shifts and richness declines after 20 years of grazing and increasing temperatures. Journal of Arid Environments 115:100-112. https://doi.org/10.1016/j.jaridenv.2015.01.007

Jamiyansharav, K., M. E. Fernandez-Gimenez, J. P. Angerer, B. Yadamsuren, and Z. Dash. 2018. Plant community change in three Mongolian steppe ecosystems 1994–2013: Applications to state-and-transition models. Ecosphere 9(3):e02145. 10.1002/ecs2.2145

Format of data files – .csv

Location where data were collected – Desert-steppe, steppe and mountain-steppe in Bayankhongor Aimag (District) of Mongolia

Time period during which data were collected – Vegetation data were collected in 1994, 1995 and 2013 (3 sampling dates over a 20-year period). Climate data from 1984-2013 were used to assess climate trends over time.

File Information:

This dataset includes 13 data files and 2 documentation files (README.pdf and Codebook.csv):

- DS_Spp_RM.csv – Desert Steppe Species csv file collected in 1994,1995 and 2013
- DS_MeanAnnTemp.csv – Desert Steppe Mean Annual Temperature csv file (1984-2013)
- DS_MonthlyPrecip.csv – Desert Steppe Monthly Precipitation Data csv file (1984-2013)
- DS_MonthlyTemp_CV_STDEV.csv – Desert Steppe Monthly Temperature, coefficient of variation and standard deviation (1984-2013)
- MS_Spp_RM.csv – Mountain Steppe Species csv file collected in 1994,1995 and 2013
- MS_MeanAnnTemp.csv – Mountain Steppe Mean Annual Temperature csv file (1984-2013)
- MS_MonthlyPrecip.csv – Mountain Steppe Monthly Precipitation Data csv file (1984-2013)
- MS_MonthlyTemp_CV_STDEV.csv – Mountain Steppe Monthly Temperature, coefficient of variation and standard deviation (1984-2013)
- ST_MeanAnnTemp.csv – Mountain Steppe Mean Annual Temperature csv file (1984-2013)

- ST_MonthlyPrecip.csv – Steppe Monthly Precipitation Data csv file (1984-2013)
- ST_MonthlyTemp_CV_STDEV.csv – Steppe Monthly Temperature, coefficient of variation and standard deviation (1984-2013)
- ST_Spp_RM.csv – Steppe Species csv file collected in 1994,1995 and 2013
- Cover_BM_SPR_SW_GINI.csv – Species cover, biomass, species richness, Shannon-Wiener and Gini Index csv file for 1994, 1995 and 2013
- README.pdf (this file)
- Codebook.csv – explains all species codes and data values

Definitions of acronyms, site abbreviations, or other project-specific designations used in the data file names or documentation files:

- DS – Desert Steppe
- MS – Mountain Steppe
- ST – Steppe

Environmental or experimental conditions:
We sampled the same site after 19 years with different teams, therefore plant ID knowledge bias could exist between different teams. In addition, plots were not permanently monumented. Plots were identified using GPS coordinates and individual transects were not located in the identical locations in each year, but they were within the same plot area.

Method(s):

Sampling design followed Fernandez-Gimenez and Allen-Diaz (1999), with slight modifications. In 1994-1995, we sampled 27 plots in the desert-steppe and 15 each in the steppe and mountain steppe. In 2013 we sampled 15 plots in each ecological zone. Five 50 m transects were systematically placed at equal intervals along a 50m baseline. Plant species cover was recorded every half meter along each transect using the line point intercept (LPI) method (500 points per plot; (Herrick et al. 2005)). Nomenclature follows Grubov (1982). When individual species cover was insufficient for analysis or consistency in species identification was in doubt, we lumped species by genus. Species were classified into 5 plant functional types based on life history and growth form: grasses, sedges, annual forbs, perennial forbs, and shrubs. Standing biomass was clipped separately for grasses, sedges, forbs and shrubs, in 5, 1 x 1 m quadrats in each desert-steppe plot and five 0.50 x 0.50 m quadrats in the steppe and mountain-steppe. For consistency with the 1994-1995 sample, shrub biomass was not included in this analysis and grass and sedge biomass were combined. Biomass samples were oven-dried at 60 ºC for 48 h and weighed. Because cages were not used, standing biomass estimates reflect biomass under grazed conditions.

We sampled soils at each plot center in 2013. In order not to disturb the transect vegetation cover, we dug a soil pit at least one meter distant from the nearest transect mid-point. Each soil pit was excavated at least to the C horizon, or approximately 75 cm deep. We described each soil horizon's depth, texture (coded 1–24: 1—finest and 24—coarsest soil particle size), value (coded 0–10: 0—absolute black soil and 10—absolute white soil), rock fragments (%), clay content (%), effervescence (coded 1–5: 1—non-effervescent and 5—violently effervescent), according to USDA NRCS protocol (Schoeneberger et al. 2012). We recorded site characteristics including aspect, slope, landform, slope position, and elevation at each plot. Aspect measured in azimuth degrees was transformed into numerical values according to Beers et al. (1966). Climate variables include the standardized precipitation evapotranspiration index (SPEI), annual temperature, and annual precipitation. For each of our sample plot locations, we extracted the SPEI data from the Global SPEI database (http://sac.csic.es/spei/database.html; Vicente-Serrano et al. 2010a, b, 2013, Beguerıa and Vicente-Serrano 2014), and precipitation and temperature from the CPC Unified precipitation dataset (Chen et al. 2008) and the Global Historical Climate Network temperature dataset (Lawrimore et al. 2011). Because our focus was on the influence of longer term trends in climate rather than inter-annual variation, we used the five-year running average prior to and including the sampling year for annual average temperature, total annual precipitation, and SPEI. The SPEI index incorporates the role of precipitation and evapotranspiration, thus can identify climate change processes related to alterations in precipitation and/or temperature (Vicente-Serrano et al. 2010a, b).

Data sources:

- The Global SBEI database, SBEIbase v2.4 (http://spei.csic.es/database.html; Vicente-Serrano et al. 2010; Beguerıa et al., 2010, 2014) was made available under the Open Database License (ODbL 1.0 license; http://opendatacommons.org/licenses/odbl/1.0/).

  Vicente-Serrano, S. M., S. Beguería, J. I. López-Moreno, M. Angulo, and A. El Kenawy, 2010: A New Global 0.5° Gridded Dataset (1901–2006) of a Multiscalar Drought Index: Comparison with Current Drought Index Datasets Based on the Palmer Drought Severity Index. *J. Hydrometeor.*, **11**, 1033–1043, https://doi.org/10.1175/2010JHM1224.1.

  Beguería S, Vicente-Serrano SM, Angulo M. A Multiscalar Global Drought Dataset: The SPEIbase: A New Gridded Product for the Analysis of Drought Variability and Impacts. Bulletin of the American Meteorological Society 91 (10): 1351–1356 (2010) http://dx.doi.org/10.1175/2010BAMS2988.1

  Beguería S, Vicente-Serrano SM, Reig F, Latorre B. Standardized precipitation evapotranspiration index (SPEI) revisited: parameter fitting, evapotranspiration models, tools, datasets and drought monitoring. International Journal of Climatology 34 (10): 3001-3023 (2014) http://dx.doi.org/10.1002/joc.3887
- CPC Global Unified Precipitation data provided by the NOAA/OAR/ESRL PSL, Boulder, Colorado, USA, from their Web site at https://psl.noaa.gov/

- Jay H. Lawrimore, Matthew J. Menne, Byron E. Gleason, Claude N. Williams, David B. Wuertz, Russell S. Vose, and Jared Rennie (2011): Global Historical Climatology Network - Monthly (GHCN-M), Version 3. Mongolia Subset. NOAA National Centers for Environmental Information. doi:10.7289/V5X34VDR [Accessed on 02/04/2014].

Standards or calibrations that were used:

We used logarithmic and Square root transformations to do statistical analysis.

Software:

Jamiyansharav et al. 2015:
MAKESENS 1.0 software (Salmi et al., 2002); SPSS statistics 22 (IBM Corp, 2013); ArcGIS 10.1 (ESRI, 2011).

Jamiyansharav et al. 2018:
PC-Ord version 6; SPSS statistics 24; IBM SPSS Modeler 18, R software version 3.3.2 and State and Transition Model (STM).

Quality assurance and quality control that have been applied:

We checked the whole data thoroughly for outliers and inconsistent species names.

Additional References:

Fernandez-Gimenez, M. E., and B. Allen-Diaz. 1999. Testing a non-equilibrium model of rangeland vegetation dynamics in Mongolia. Journal of Applied Ecology 36:871–885. https://doi.org/10.1046/j.1365-2664.1999.00447.x

Fernandez-Gimenez, M. E., and B. Allen-Diaz. 2001.Vegetation change along gradients from water sources in three grazed Mongolian ecosystems. Plant Ecology 157:101–118. https://doi.org./10.1023/A:1014519206041