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A Dataset for Spatial Variation of Species Diversity and Biomass of Subalpine Grasslands in Shanxi Province, China

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Abstract: Subalpine grasslands provide grazing for wildlife and grazing animals, so protecting their integrity is important. From July to August in 2016, experimental plots were established in the east of the Loess Plateau of China in high mountains with subalpine grasslands. A total of nine mountains were selected from the north to the south in the eastern part of the Plateau. For each mountain, a typical subalpine grassland was selected and surveys of species diversity and biomass were conducted at the plant community level. Six 1 m^2 quadrats were designed in each plot for measuring the height, abundance, coverage, and frequency of each plant species, and then α-diversity indices were calculated. Next, in order to calculate β- and γ-diversity indices, latitude and longitude were divided into five intervals using intervals of 0.5° and 0.45°, respectively. Elevation was divided into six intervals of 100 m. Lastly, five of the six quadrats in each grassland were chosen and used to survey plant biomass. At the middle of biomass quadrats, 0.2 m × 0.2 m sub-quadrats were designed for measuring aboveground biomass by clipping aboveground plant parts and digging for belowground biomass. The resulting dataset includes subalpine grassland data for Shanxi province as follows: (1) the name of mountains and the geographical location of the experimental plots; (2) the indices of α-diversity; (3) the division of geographical intervals and the indices of β-diversity; (4) the indices of γ-diversity; (5) the indices of biomass; and (6) the correlations between α-diversity and biomass in these grasslands. The data formats are .shp and .xlsx files with a data size of 33.6 KB for a compressed file.

Keywords: subalpine grassland; species diversity; biomass; geographical gradient

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The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2022.05.03.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2022.05.03.V1.

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1 Introduction

Plants serve vital roles in terrestrial ecosystems and provide humans with many ecological services including regulating climate, improving soil fertility, protecting biodiversity, and promoting productivity[1,2]. Studies of plant species diversity and biomass have become important research topics related to ecology and geography, focusing on the spatial distribution of species diversity and biomass together with the correlation between species diversity and biomass along geographical gradients. Species diversity reveals the organizational levels of a community and induces changes in the functional characteristics of a biotic community; it can even alter a shortage of critical species in a community or the use patterns of environmental resources by species, thus leading to modifications in ecosystem structure and function[3]. Measurements of species diversity are primarily conducted at three spatial scales[4]. The first scale is within-habitat diversity, that is, α-diversity, which mainly focuses on the number of species in local homogeneous habitat; the second scale is between-habitat diversity, that is, β-diversity, which indicates differences of species composition among different habitats and communities; the last scale is regional diversity, that is, γ-diversity, which describes the number of species at regional or continental scales[4].

Similar to species diversity, biomass is also a primary quantitative characteristic of ecosystems and reflects plants productivity[5]. Biomass allocation among various organs mirrors the growth strategy a plant uses to adapt to an environment and plays a crucial role in the growth of plant individuals, species coexistence, and vegetation recovery after disturbance[6]. Strategies of biomass allocation among leaves, stems, and roots, together with allometric relationships between plant organs provide a foundation in the study of species evolution, maintenance of diversity, and carbon cycling in ecosystems, and also are important to our understanding of the distribution of carbon in ecosystems and the function of carbon sinks[7]. Biomass allocation, especially the models of allocation under the effects of different geographical gradients, is important in studies of biomass.

Subalpine grasslands are mainly distributed in high-elevation mountains where species diversity and biomass are obviously affected by the mountainous terrain. Latitude, longitude, and elevation are dominant terrain indicators of mountainous subalpine grasslands; they directly affect the spatial distribution of solar radiation and rainfall, and thus they result in an uneven distribution of soil moisture and temperature[8,9]. Large areas of subalpine grasslands on the eastern part of the Loess Plateau have an abundance of species. These grasslands not only provide excellent natural pastures but also serve as famous eco-attractions,for example, Heyeping has been honored as the “plateau jade”, Shunwangping as the “Jiuzhaigou of north China”, and Wutai Mountain as “the roof of north China”[10–12]. With a rapid development of tourism and pasture husbandry, subalpine grasslands have experienced extensive and severe degradation caused by humans in the mountain systems of Liuleng, Wutai, Lvliang, and Zhongtiao, where their environments are sensitive and fragile, grasslands degradation had been increasing, and biodiversity has been seriously threatened[13,14]. Given this, nine typical subalpine grasslands were selected as research objects on the eastern part of the Loess Plateau. From the plant community level, we obtained a dataset of three types of subalpine grasslands in different mountains: (1) species diversity data (α, β, and γ diversity); (2) biomass data; (3) correlations between species diversity and biomass.

2 Metadata of the Dataset

The metadata of the *In situ* dataset of species diversity and biomass of subalpine meadows in Shanxi province of China[15] are summarized in Table 1. This metadata include the full and short dataset names, authors, publication year of the dataset, temporal and spatial resolutions, as well as dataset format, size, file types, publisher, and data sharing policy, and so on.

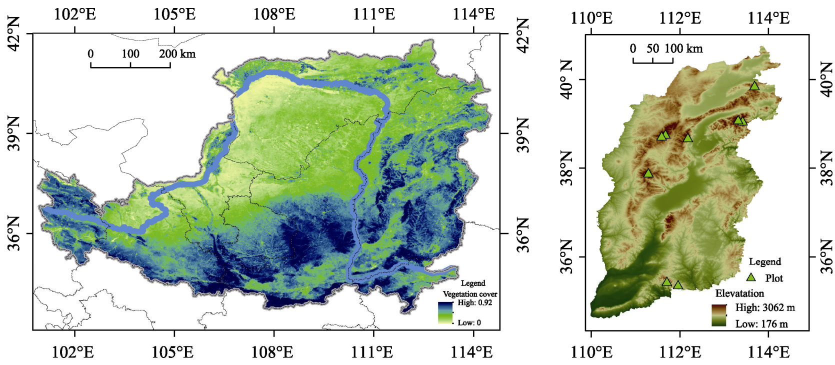
Table 1 Metadata summary of the *In situ* dataset of species diversity and biomass of subalpine meadows in Shanxi province of China

Items	Description
Dataset full name	*In situ* dataset of species diversity and biomass of subalpine meadows in Shanxi province of China
Dataset short name	BiomassSubalpineMeadowsShanxi
Authors	Xu, M. H. F-8170-2017, Taiyuan Normal University, xumh@tynu.edu.cn Zhao, Z. T., Taiyuan Normal University, zhaozit610@163.com
Geographical region	Dianding Mountain in the Liuleng Mountain system, Beitai and Dongtai mountains in Wutai Mountain system, Malun, Heyeping, Yunzhong and Yunding mountains in the Lvliang Mountain system, and Shunwangping and Shengwangping mountains in the Zhongtiao Mountain system in Shanxi province (34°34′N–40°43′N, 110°14′E–114°33′E), China
Year	2016
Data format	.shp, .xlsx
Data size	41.2 KB (33.6 KB for a compressed file)
Data files	(1) The name of mountains and the geographical location of experimental plots; (2) the indices of α-diversity; (3) the division of geographical gradient belts and the indices of β-diversity; (4) the indices of γ-diversity; (5) the indices of biomass ; (6) the data for correlations between α-diversity and biomass
Foundations	Fundamental Research Program of Shanxi Province (202103021224301); Scientific and Technological Innovation Programs of Higher Education Institutions in Shanxi (2021L431); College Students' Innovative Entrepreneurial Training Plan Program of Taiyuan Normal University (CXCY2203)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[16]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

3 Methods

3.1 Experimental Design

By comparing a vegetation-cover map of the Loess Plateau (Figure 1a) and a topographic map of Shanxi province (Figure 1b), experimental plots were selected in typical grasslands of subalpine belts at relatively high elevations (from 1,720 m to 3,045 m) in mountains along the eastern part of the Loess Plateau[4]. These were investigated from July to August in 2016. In this region, nine subalpine grasslands (one subalpine grassland in each mountain) were successively surveyed in different mountain ranges moving from north to south. In total, nine mountains belonging to four mountain systems were surveyed. The names of these mountains were Dianding (DD) Mountain in the Liuleng Mountain system, Beitai (BT) and Dongtai (DT) mountains in Wutai Mountain system, Malun (ML), Heyeping (HY), Yunzhong (YZ), and Yunding (YD) mountains in the Lvliang Mountain system, and Shunwangping (SU) and Shengwangping (SE) mountains in the Zhongtiao Mountain system (Figure 1b).



(a) Vegetation cover of the Loess Plateau (b) Topography of Shanxi province

Figure 1 Map of study area and plot distribution

(Notes: The study area covers the region with extensive vegetation cover on the eastern part of the Loess Plateau. Nine mountains with high elevations were selected as for placement of experimental plots from the north to the south in Shanxi province)

3.2 Measurement of Plant Diversity

On each of these nine mountains, six plots in 1m×1m were installed randomly in subalpine communities to survey plant diversity at a community scale or a total of 54 plots on all mountains. Each 1 m × 1 m quadrat frame was used as a measurement tool, and was divided into 100 uniform grids (0.1 m × 0.1 m) (Figure 2). In each grid, we measured plant height, abundance, coverage, and frequency of each species; the data were used to calculate species diversity indices in the plots. Meanwhile, we recorded the latitude, longitude, and elevation of each plot (Table 2).

Figure 2 Survey method for surveying plant community species diversity using quadrat frames

Table 2 Plot location with LLE

Site Number	Name	Abbreviation	Plot location		
			Latitude/°	Longitude/°	Elevation/m
1	Dianding	DD	39.849	113.939	2,265
2	Dongtai	DT	39.052	113.669	2,565
3	Beitai	BT	39.077	113.570	3,045
4	Yunzhong	YZ	38.677	112.432	2,260
5	Malun	ML	38.752	111.928	2,710
6	Heyeping	HY	38.714	111.841	2,745
7	Yunding	YD	37.882	111.541	2,690
8	Shunwangping	SU	35.423	111.959	2,250
9	Shengwangping	SE	35.344	112.212	1,720

3.3 Measurement of Plant Biomass

At each of nine mountain sites, we randomly located five plots for measuring plant diversity, with 45 plots in total. A 0.2 m × 0.2 m quadrat was placed in the center of each plot with its plants being evenly distributed, so that 45 quadrats were also acquired in total. We used quadrats to survey plant biomass at the community scale using the following method[4]. In each quadrat, aboveground plant parts were clipped near the ground surface (Figure 3), and belowground plant parts were then excavated in the entire 0.2 m × 0.2 m quadrat to a depth of 0.2 m because most plants were very shallow rooted (Figure 4). Samples of aboveground plant parts and soil blocks with volumes of 0.2 m × 0.2 m × 0.2 m were sealed and brought to laboratory for post-sample processing. In this process, for aboveground plant parts, only live plants were retained. Samples of belowground plant parts were first sieved by a standard soil sieve with a bore diameter of 0.42 mm to eliminate stones and coarse debris from the soil. Then, the soil samples were sieved using a standard soil sieve with a bore diameter of 0.18 mm to eliminate fine roots with diameters no smaller than 0.18 mm. Next, live roots and treated stems and leaves were placed into an oven and dried for 48 h to constant weight at a temperature of 80 °C. In the last step, dry samples were weighed to calculate below- and above-ground plant biomass.

Figure 3 Clipping and gathering of aboveground plant parts

Figure 4 Digging and gathering of belowground plant roots

3.4 Data Analysis

(1) Calculations on *α*-, *β*-, and *γ*-diversity of plant communities

First, we calculated the importance values of plant species based on the relative height, abundance, coverage, and frequency of each species; then *α*-diversity indices were obtained, including the Patrick, Simpson, Shannon, and Pielou indices[13]. Second, using the horizontal directions of latitude and longitude, the nine plots were divided into five latitudinal and five longitudinal intervals with 0.5° and 0.45° intervals arranged from south to north and from west to east, respectively; the nine plots were divided into six elevational intervals from low to high elevation with an interval of 100 m[4]. Species in different plots were merged in each geographical interval. Unlike *α*-diversity, measurements of *β*-diversity could be separated into two methods: binary attribute data and quantitative data. Hence, we used two indices, the Cody and Sørenson indices, in the analysis of *β*-diversity based on binary attribute data; in addition, we used the Bray–Curtis Index based on quantitative data[4]. Lastly, the total number of species present (i.e., total species richness) in each geographic interval (five latitudinal and longitudinal gradients together with six elevational gradients) was defined as an indicator of *γ*-diversity[4].

(2) Calculations on biomass of plant community

Aboveground, belowground, and total biomass as well as the root-to-shoot ratio were adopted as biomass indicators [17,18].

4 Data Results and Validation

4.1 Data Composition

This dataset includes six types of data collected for the studied subalpine grasslands in Shanxi province as described below in six tables. Table 1 includes the names and geographical locations of mountains with experimental plots, including the Chinese and English names of mountains, abbreviations of these names, latitude, longitude, and elevation. Table 2 lists the α-diversity indices, including the Patrick, Simpson, Shannon, and Pielou indices. Table 3 provides the division of geographical intervals and the β-diversity indices, mainly covering the geographic gradient range along with the Cody, Sørenson, and Bray–Curtis indices. Table 4 has the γ-diversity indices, mainly covering the geographic gradient range and Richness Index. Table 5 provides the biomass indices, and mainly includes above- and below-ground biomass, total biomass, and the root-to-shoot ratio. Table 6 contains the data for correlations between α-diversity and biomass, which mainly cover the Patrick, Simpson, Shannon, and Pielou indices as well as above- and below-ground biomass, total biomass, and the root-to-shoot ratio. The .xlsx file-format data were from plot surveys and were summarized in an Excel file named “Diversity&BiomassSub-alpineMeadowsShanxi”. The .shp file-format data in GIS, which provide plot locations, were summarized in a file named “SampleSites”.

4.2 Data Products

At each mountain, six survey quadrats for measuring plant community species diversity were established. Four α-diversity indices were calculated by measuring plant growth, specifically the Patrick, Simpson, Shannon, and Pielou indices (Table 3). Based on the division on geographic intervals of different mountains, three β-diversity indices were calculated, specifically, the Cody, Sørenson, and Bray–Curtis indices (Table 4). In addition, one γ-diversity index was calculated for the Richness Index with the same way (Table 5).

Table 3 α-diversity indices of subalpine grasslands in Shanxi province

Mountain	Quadrat	Patrick index	Simpson index	Shannon index	Pielou index
Malun	1	11	0.790	1.906	0.795
	2	10	0.833	1.961	0.852
	3	11	0.787	1.933	0.806
	4	11	0.825	1.988	0.829
	5	10	0.800	1.866	0.810
	6	11	0.812	1.942	0.810
Heyeping	1	12	0.871	2.208	0.888

(*To be continued on the next page*)

(*Continued*)

Mountain	Quadrat	Patrick index	Simpson index	Shannon index	Pielou index
Heyeping	2	14	0.899	2.459	0.932
	3	11	0.851	2.097	0.874
	4	16	0.867	2.319	0.836
	5	14	0.891	2.389	0.905
	6	18	0.901	2.540	0.879
Yunzhong	1	23	0.920	2.787	0.889
	2	22	0.936	2.899	0.938
	3	26	0.939	3.023	0.928
	4	23	0.905	2.711	0.865
	5	35	0.901	2.827	0.795
	6	29	0.921	2.902	0.862
Yunding	1	16	0.890	2.431	0.877
	2	18	0.900	2.507	0.867
	3	18	0.894	2.505	0.867
	4	19	0.872	2.392	0.812
	5	19	0.882	2.529	0.859
	6	17	0.888	2.474	0.873
Dianding	1	23	0.888	2.596	0.828
	2	21	0.927	2.761	0.907
	3	23	0.924	2.817	0.899
	4	21	0.894	2.667	0.876
	5	19	0.904	2.609	0.886
	6	25	0.861	2.619	0.813
Dongtai	1	24	0.925	2.863	0.901
	2	25	0.929	2.878	0.894
	3	24	0.892	2.709	0.853
	4	30	0.905	2.840	0.835
	5	22	0.925	2.797	0.905
	6	25	0.896	2.768	0.860
Beitai	1	13	0.842	2.135	0.833
	2	12	0.859	2.194	0.883
	3	19	0.884	2.574	0.874
	4	18	0.874	2.375	0.822
	5	15	0.850	2.268	0.837
	6	18	0.870	2.400	0.830
Shunwangping	1	19	0.881	2.439	0.828
	2	22	0.868	2.430	0.786
	3	20	0.916	2.709	0.904
	4	21	0.843	2.421	0.795
	5	18	0.864	2.334	0.808
	6	22	0.898	2.664	0.862
Shengwangping	1	19	0.857	2.384	0.810
	2	21	0.901	2.641	0.868
	3	18	0.875	2.451	0.848
	4	22	0.907	2.729	0.883
	5	15	0.905	2.486	0.918
	6	24	0.878	2.609	0.821

Table 4 β-diversity indices of subalpine grasslands in Shanxi province

Geographic belt	Number	Cody index	Sørenson index	Bray–Curtis index
Latitude belt/°	1—2	26.0	0.553	0.395
	2—3	18.5	0.407	1.295

(*To be continued on the next page*)

(*Continued*)

Geographic belt	Number	Cody index	Sørenson index	Bray–Curtis index
Latitude belt/°	3—4	15.5	0.295	1.380
	4—5	14.0	0.318	1.061
	1—2	26.0	0.553	0.395
	1—3	23.5	0.409	0.551
	1—4	23.0	0.426	0.526
	1—5	19.0	0.388	0.587
Longitude belt/°	1—2	18.0	0.429	1.150
	2—3	19.0	0.317	0.803
	3—4	22.0	0.367	0.732
	4—5	13.0	0.295	1.079
	1—2	18.0	0.429	1.150
	1—3	23.0	0.434	0.706
	1—4	16.0	0.381	1.286
	1—5	16.0	0.432	1.252
Elevation belt/m	1—2	25.5	0.459	0.655
	2—3	18.5	0.333	0.987
	3—4	16.0	0.410	1.294
	4—5	12.0	0.387	1.602
	5—6	9.5	0.358	2.660
	1—2	25.5	0.459	0.655
	1—3	22.0	0.512	0.643
	1—4	24.0	0.615	0.392
	1—5	21.0	0.600	0.682
	1—6	24.5	0.710	0.566

Table 5 γ-diversity indices of subalpine grasslands in Shanxi province

Geographical gradient	Range	Richness index
Latitude/°	35–35.5	59
	37.5–38	35
	38.5–39	56
	39–39.5	49
	39.5–40	39
Longitude/°	111.15–111.6	35
	111.6–112.05	49
	112.05–112.5	71
	113.4–113.85	49
	113.85–114.3	39
Elevation/m	1,700–1,800	43
	2,200–2,300	68
	2,500–2,600	43
	2,600–2,700	35
	2,700–2,800	27
	3,000–3,100	26

At each mountain, five survey quadrats were used to measure plant community biomass by measuring the weights of above- and below-ground plant parts, and four biomass indices were obtained as described above (Table 6). Because the plant biomass quadrats were designed as species diversity quadrats, the correlations between α-diversity and biomass could be calculated. Among these correlations, the distribution of eight indices included the Patrick, Simpson, Shannon, and Pielou indices, as well as above- and below-ground

Table 6 Biomass indices of subalpine grasslands in Shanxi province

Mountain	Quadrat	Aboveground biomass /(g/m^2)	Belowground biomass /(g/m^2)	Total biomass /(g/m^2)	Root:shoot ratio
Shengwangping	1	297.00	589.00	886.00	1.983
	2	251.00	330.00	581.00	1.315
	3	227.00	207.25	434.25	0.913
	4	468.75	861.50	1,330.25	1.838
	5	481.00	306.00	787.00	0.636
Shunwangping	1	271.00	466.00	737.00	1.720
	2	405.25	647.50	1,052.75	1.598
	3	206.25	264.50	470.75	1.282
	4	140.00	411.25	551.25	2.938
	5	443.25	288.75	732.00	0.651
Yunzhong	1	127.25	183.25	310.50	1.440
	2	74.00	140.50	214.50	1.899
	3	121.00	244.50	365.50	2.021
	4	106.25	529.25	635.50	4.981
	5	288.50	192.75	481.25	0.668
Dianding	1	154.50	836.50	991.00	5.414
	2	66.25	221.50	287.75	3.343
	3	165.25	334.25	499.50	2.023
	4	103.75	357.50	461.25	3.446
	5	142.25	1,012.00	1,154.25	7.114
Dongtai	1	113.75	397.25	511.00	3.492
	2	114.25	594.50	708.75	5.204
	3	162.75	333.50	496.25	2.049
	4	123.50	403.25	526.75	3.265
	5	111.25	342.00	453.25	3.074
Yunding	1	45.25	614.75	660.00	13.586
	2	73.75	281.00	354.75	3.810
	3	70.75	215.75	286.50	3.049
	4	32.50	275.50	308.00	8.477
	5	52.00	163.25	215.25	3.139
Malun	1	69.00	530.25	599.25	7.685
	2	79.25	390.50	469.75	4.927
	3	72.75	320.75	393.50	4.409
	4	87.25	423.50	510.75	4.854
	5	52.25	183.00	235.25	3.502
Heyeping	1	167.75	632.25	800.00	3.769
	2	154.25	996.75	1,151.00	6.462
	3	317.25	820.00	1,137.25	2.585
	4	292.50	795.00	1,087.50	2.718
	5	244.50	695.25	939.75	2.844
Beitai	1	136.75	1,250.25	1,387.00	9.143
	2	57.25	747.50	804.75	13.057
	3	77.00	1,045.50	1,122.50	13.578
	4	77.25	573.25	650.50	7.421
	5	79.50	890.50	970.00	11.201

biomass, total biomass, and the root–shoot ratio in different quadrats (Figure 5).

The following results were obtained from the above dataset. The α-diversity of subalpine grasslands presented unimodal change patterns with smaller values in the central mountains. The β-diversity had tendencies to decrease with increasing spatial gradients and amplitudes

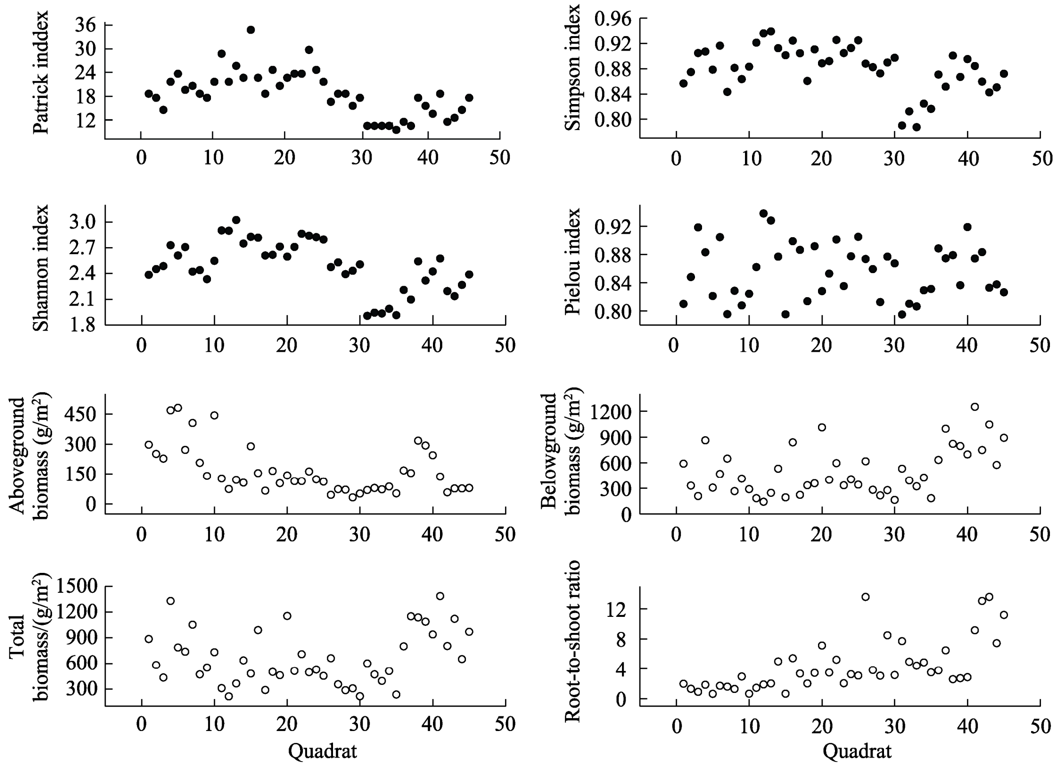


Figure 5 Distribution Data for correlation between α-diversity and biomass of subalpine grasslands in Shanxi province

of variation that were greatest along latitudinal gradients. The *γ*-diversity generally conformed to unimodal change patterns in spatial distribution and the spatial distribution of biomass in subalpine grasslands tended to exhibit high geographical gradients where more biomass was allocated to belowground plant parts with increased spatial gradients[4]. These results are described in detail in Xu *et al.*[4].

4.3 Data Validation

The following conclusions were obtained from the dataset. The unique geomorphological structures with a series of basins between mountain systems from the east of the Loess Plateau have resulted in the subalpine grasslands being mostly distributed along latitudinal directions. As a result, the spatial distributions of species diversity and biomass were more evident along latitudinal gradients, and thus the response of aboveground biomass was more sensitive to variations of spatial gradients and species diversity[4]. Meanwhile, by the published references [12, 19, 20] and the simulated warming experiment in Lvliang Mountain in 2016[21–24], we concluded that species diversity of subalpine grasslands exerted a spatial pattern with an increase from north to south in the eastern Loess Plateau of China.

5 Discussion and Conclusion

Species distribution patterns are the result of many ecological processes, but researchers have come to a wide variety of conclusions during studies of species diversity and biomass together with their correlation, owing to discrepancies in study scales, projects, and areas[25]. This was mainly reflected in: (1) topographical differences were eliminated by using studies at larger geographical scales, but concrete differences in community diversity were neglected when geographical units had small scales; (2) simulation studies were carried out in homogeneous habitats and humanly-modified communities at small scales, but the influence of stronger spatial heterogeneity caused by enlargements of scale were omitted in studies of diversity and productivity; and (3) in research studies conducted in mountainous areas, scales have been focused only on a single space level and lacked systematic research in mountains at overall spatial-scale hierarchies[9, 25]. The conclusion of different distribution patterns as well as the interaction between species diversity and biomass from this dataset probably agreed with the biogeographic affinity hypothesis; that is, the ability of species to tolerate local climate probably developed under dual effects of Earth's climates and species evolution in ecological niches[26]. Meanwhile, this conclusion supports our common understanding that high levels of species diversity provide an important way for ecosystems to maintain biomass; that is, greater species diversity allows for accommodation to an environment by providing for species redundancy and functional complementation[26]. Thereby, from a level of plant population in natural conditions, species diversity has important significance that contributes to the discussion of spatial distributions along with correlations of species diversity and biomass at various levels; this illuminates the internal mechanisms of functional relationships between biodiversity and ecosystems.

Author Contributions

Xu, M. H. designed the algorithms of dataset. Zhao, Z. T. contributed to the data processing and analysis. Xu, M. H. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Fraser, L. H., Pither, J., Jentsch, A., *et al*. Worldwide evidence of a unimodal relationship between productivity and plant species richness [J]. *Science*, 2015, 349(6245): 302–305.

[2] Grace, J. B., Anderson, T. M., Seabloom, E. W., *et al*. Integrative modelling reveals mechanisms linking productivity and plant species richness [J]. *Nature*, 2016, 529(7586): 390–393.

[3] Xu, M. H., Du, R., Li, X. L., *et al*. The mid-domain effect of mountainous plants is determined by community life form and family flora on the Loess Plateau of China [J]. *Scientific Reports*, 2021, 11: 10974.

[4] Xu, M. H., Zhang, S. X., Wen, J., *et al*. Multiscale spatial patterns of species diversity and biomass together with their correlations along geographical gradients in subalpine meadows [J]. *PLoS ONE*, 2019, 14(2): e0211560.

[5] Ma, L., Xu, M. H., Zhou, H. K., *et al*. Geographical distribution of vegetation biomass of subalpine meadow in Shanxi province [J]. *Chinese Journal of Ecology*, 2018, 37(8): 2244–2253.

[6] Poorter, H., Niklas, K. J., Reich, P. B., *et al*. Biomass allocation to leaves, stems and roots: Meta-analyses of interspecific variation and environmental control [J]. *New Phytologist*, 2012, 193(1): 30–50.

[7] Duncanson, L. I., Dubayah, R. O., Enquist, B. J. Assessing the general patterns of forest structure: Quantifying tree and forest allometric scaling relationships in the United States [J]. *Global Ecology and Biogeography*, 2015, 24(12): 1465–1475.

[8] Li, X. L., Xu, M. H., Meng, W. Z., *et al*. Effects of experimental warming on the hydrothermic factor and community structure of subalpine meadow on Yunding Mountain, Shanxi province, China [J]. *Acta Ecologica Sinica*, 2020, 40(19): 6885–6896.

[9] Xu, M. H., Li, X. L. Review of response of grassland community stability to global warming based on correlation between species biodiversity and biomass [J]. *Acta Botanica Boreali-Occidentalia Sinica*, 2021, 41(2): 348–358.

[10] Chao, Q., Wen, J., Yang, X. Y., *et al*. Responses of subalpine meadow species diversity to simulated warming in the Yunding Mountain [J]. *Environmental Ecology*, 2019, 1(4): 34–40.

[11] Wang, Y. T., Bi, Y. T., Wang, Q., *et al*. Spatial differentiation of plant species diversity in subalpine meadows in Shanxi province [J]. *Chinese Agricultural Science Bulletin*, 2018, 34(18): 77–83.

[12] Zhang, S. X., Yang, X. Y., Wen, J., *et al*. Spatial and temporal patterns of species diversity of subalpine meadows in the Lvliang Mountains, Shanxi province [J]. *Acta Ecologica Sinica*, 2018, 38(18): 6685–6693.

[13] Xu, M. H., Ma, L., Jia, Y. Y., *et al*. Integrating the effects of latitude and altitude on the spatial differentiation of plant community diversity in a mountainous ecosystem in China [J]. *PLoS ONE*, 2017, 12(3): e0174231.

[14] Xu, M. H., Li, X. L., Liu, M., *et al*. Spatial variation patterns of plant herbaceous community response to warming along latitudinal and altitudinal gradients in mountainous forests of the Loess Plateau, China [J]. *Environmental and Experimental Botany*, 2020, 172: 103983.

[15] Xu, M. H., Zhao, Z. T. *In situ* dataset of species diversity and biomass of subalpine meadows in Shanxi province of China [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2022. https://doi.org/10.3974/geodb.2022.05.03.V1.

[16] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy.2014.05 (Updated 2017).

[17] Xu, M. H., Wen, J., Zhang, S. X., *et al*. Root biomass dataset for alpine meadows in the Qinghai-Tibetan Plateau under experimental warming [J]. *Journal of Global Change Data & Discovery*, 2017, 1(4): 475–480.

[18] Xu, M. H. Root biomass dataset of alpine meadow in Qinghai-Tibetan Plateau under the artificial climate warming experiment [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2017. https://doi.org/10.3974/geodb.2017.02.15.V1.

[19] Zhang, S. X., Yang, X. Y., Wen, J., *et al*. Dataset of species diversity index of subalpine meadows in Lvliang Mountain, China (2015–2017) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2019. https://doi.org/10.3974/geodb.2019.01.06.V1.

[20] Zhang, S. X., Qin, R. M., Yang, X. Y., *et al*. Patterns of species diversity in herbaceous communities at different altitude gradients and their relationships with environmental factors in Luliang Mountains in Shanxi province, China [J]. *Guihaia*, 2020, 40(12): 1860–1868.

[21] Liu, M., Zhang, X. Y., Li, X. L., *et al*. Short-term responses of under-canopy grasslands to the experimental warming on the Loess Plateau, China [J]. *Acta Ecologica Sinica*, 2020, 40(17): 6009–6024.

[22] Xu, M. H., Du, R., Yang, X. H., *et al*. Response of plants to simulated warming in under-canopy herbaceous layers on the Guancen Mountain [J]. *Chinese Wild Plant Resources*, 2021, 40(10): 45–52.

[23] Yang, X. Y., Qin, R. M., Zhang, S. X., *et al*. Response of herb community to simulated warming and its relationship with environmental factors in Luliang Mountain, Shanxi, China [J]. *Southwest China Journal of Agricultural Sciences*, 2020, 33(6): 1291–1300.

[24] Yang, X. Y., Zhang, S. X., Wen, J., *et al*. Spatial pattern of herbaceous plant species diversity and its changes due to simulated warming in the forest community of the Luliang Mountains [J]. *Acta Ecologica Sinica*, 2018, 38(18): 6642–6654.

[25] Xu, M. H., Ma, L., Bai, H. Y., *et al*. Vertical spatial differentiation of vegetation community diversity in Lvliang Mountains, Shanxi province [J]. *Jiangsu Agricultural Sciences*, 2017, 45(12): 256–260.

[26] Zhu, G. L., Li, J., Wei, X. H., *et al*. Longitudinal patterns of productivity and plant diversity in Tibetan alpine grasslands [J]. *Journal of Natural Resources*, 2017, 32(2): 210–222.