

A dataset of functional traits for compound pinnate leaves of plants in the Huangshui River Valley of Qinghai Province, China

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Abstract

Background

Here, we present data collected from the Qinghai–Tibet Plateau that describes the variation of leaf functional traits across 32 plant species and could be used to investigate plant community functioning and predict the impact of climate change on biogeochemical cycles. The sampling area is located in Huangshui River Valley, in the southeast of Qinghai Province, China (36° 19' to 36° 53' N, 100° 59' to 102° 48' E). The area contains an alpine meadow typical of the Qinghai–Tibet Plateau.

New information

This dataset includes field survey data on the functional properties of compound leaves from herbaceous species in the Huangshui River Basin of Qinghai Province, China, at altitudes from 1800 m to 4000 m in the summer of 2021. Data were collected from 326 plots, including 646 data points of compound leaf plants, spanning 32 compound leaf plant species belonging to 14 genera and four families. The study species were chosen from 47 families, 165 genera and 336 species present in the plots and all compound leaf plants were chosen within each plot. We picked the parts containing leaves, petioles and rachis from the study plants and separated the leaves from the plants. The cut compound leaf part was a leaflet, while the petiole and rachis were linear elements. The dataset includes information about the leaflet trait variation (i.e. leaflet area, leaflet dry mass, specific leaflet area and leaflet nitrogen content per unit dry mass) and linear elements' biomass and nitrogen content per unit dry mass (i.e. both petiole and rachis) of 646 compound leaves. This dataset can be used to analyse the evolution of leaf traits and the

basic functioning of ecosystems. Moreover, the dataset provides an important basis for studying the species distribution and protection of biodiversity of the Qinghai–Tibet Plateau and evaluating ecosystem services. These data also support the high-quality development of the Yellow River Basin and have empirical and practical value for alpine biodiversity protection and ecosystem management.

Keywords

compound pinnate leaves, dataset, functional traits, Huangshui River basin, Qinghai Province

Introduction

Plant organisms are associated with the environment by quantifying the functional characteristics of plants (Lavorel and Garnier 2002). Plant functional traits can be used as predictors of ecosystem services (Garnier and Navas 2012) and are often used to assess plant adaptability to the environment (He et al. 2020). Leaf functional traits are crucial in ecosystem services (Kissling et al. 2019) and are directly linked to the performance of photosynthesis and respiration (Xiong and Jiao 2019). The compound leaves of plants result from the subdivision of simple leaves into individual leaflets (Sinha 1997, Kim et al. 2003). Each leaflet of a compound leaf is the main photosynthetic organ of compound leaf plants (Oliveira et al. 2017). The blade surface area can affect the water loss caused by wind resistance and evaporation. The smaller the surface area, the lower the water loss caused by wind resistance and evaporation (Anten et al. 2010). The leaflets of compound pinnate leaves can regulate resource and energy flux (Hadley and Smith 1990, Brus et al. 2011). Therefore, leaflet trait variation is crucial to ecosystem functioning and services (Hulshof and Swenson 2010, Blue et al. 2015). A better understanding of the relationship between plant traits and trends in trait variation across species is conducive to better management of ecosystems (Wright et al. 2004, Donovan et al. 2011, Osnas et al. 2013, Liu et al. 2020).

The global climate change is the most serious challenge facing mankind at present, promoting the loss of biodiversity in an unprecedented way on Earth. Owing to its unique altitude and climate conditions, the ecosystem of the Qinghai–Tibet Plateau is very sensitive to global climate change and is one of the most sensitive regions around the world (Hu et al. 2009). Ecological protection and high-quality development of the Yellow River Basin is a major matter of national strategic importance in China. Huangshui River is the largest tributary of the upper reaches of the Yellow River, located in the east of Qinghai Province, China. The Huangshui River Basin is an ecologically fragile area of the Qinghai–Tibet Plateau and its ecosystem functions and services are greatly threatened. The protection of plant diversity in the Huangshui River Basin should not only meet the needs of biodiversity protection in the Qinghai–Tibet Plateau, but also support the maintenance and high-quality development of the ecosystems of the Yellow River Basin.

We hope that this large dataset of plant compound leaf functional traits from the Huangshui River Valley in Qinghai Province provides a starting basis for studying the species distribution, evaluating the area's ecosystem functions and services and protecting the alpine biodiversity of the Qinghai–Tibet Plateau.

Sampling methods

Description: The study was conducted in the Huangshui River Valley, which is in the east of Qinghai Province, China, on the eastern end of the Qinghai–Tibet Plateau. Based on the scheme of Fang et al. (2009), 326 sampling plots of 1 m² of area were established in the Huangshui River watershed at altitudes from 1,800 m to 4,000 m (Fig. 1). The field survey was conducted from June 2021 to September 2021. From 326 study plots, we collected all the leaves from at least five individuals for each plant species.

Sampling description: The 326 plots (1 m × 1 m) were distributed systematically in the landscape (Fig. 1). The slope within plots was stable, so the influence of microenvironment heterogeneity on the variation of functional traits was successfully limited. In each plot, we sampled all herbaceous plants bearing compound leaves. A total of 646 occurrences were recorded (mean_(plants/plots) = 1.98 ± 1.16), including 32 plant species, 14 genera and four families. The leaf samples were stored in a cool box in the dark until further processing a total of 646 in the laboratory. The time from sample collection to the laboratory procedures was less than 18 h. The dataset records Plot No., Family name, Genus name, Species name, Authors' name, Classification System, Habitat, Life cycle or leaf phenology type, Coverage, Leaflet area (LA), Specific leaflet area (SLA), Leaflet dry mass (LM), Leaflet nitrogen content per unit dry mass (LN), Petiole and rachis dry mass and Petiole and rachis nitrogen content per unit dry mass. We selected LA (cm²), LM (g), SLA (cm²/g), and LN (mg/g) as related leaflet functional traits, because they are generally considered to be related to major ecological strategy axes.

Quality control: In the data collection stage, we invited botanists for identification training of relevant compound leaf herb species and all data collection personnel started field investigation only after completion of the training. The reference books mainly included *Flora Republicae Popularis Sinicae* (Editorial Committee of the Flora of China, Chinese Academy of Sciences 1999), *Flora Qinghaiica* (ECFQ 1996, Editorial Committee of the Flora Qinghaiica 1996), *Atlas of Vascular Plants in Hainan Tibetan Autonomous Prefecture* (Zhou et al. 2020), *Illustration of Grassland Plants in Gansu Province* (Zhao 2019), *Wild Flowers of Qinghai-Tibet Plateau* (Niu et al. 2018) and *Atlas of Common Plants in Alpine Sandy Land* (Jia and Zhu 2017). In the data processing stage, the identification of all herbaceous plants strictly referred to the classification characteristics described in various books and related publications and all plant species in question were confirmed by experts. With the rapid development of plant systematics, a large number of new species have been described in recent years. The present dataset does not include newly-published species.

Before we quantified the nitrogen content per unit dry mass of leaflet and linear elements (petiole and rachis) samples by Kjeldahl (acid) digestion, the samples of each compound leaf were stored in a clean numbered bag and frozen in -80°C liquid nitrogen to ensure the dryness of the samples and to reduce experimental error.

Step description: Following the methods of Cornelissen et al. (2003), Pérez-Harguindeguy et al. (2013) and Pérez-Harguindeguy et al. (2016), we initially collected at least five fresh compound leaf samples from each plant. Each compound leaf was carefully divided into petiole, rachis and leaflet portions. Parts coming from the same leaf were kept named so that we would not mix parts of different leaves or plants. Leaflet area (LA) was calculated in cm^2 by scanning each fresh leaf digitally and then analysing the images using Easy leaf Area (Easlon and Bloom 2014). After at least 72 h in the drying oven at 65°C , we measured the dry mass of petioles, rachis and leaflets of each leaf in milligrams (mg). SLA was calculated as the ratio of leaf area (cm^2) to dry leaf mass in grams (g). Finally, we used Kjeldahl (acidic) digestion to quantify the nitrogen content (N) in the leaflets, linear elements (both petiole and rachis), followed by colorimetric (flow-injection) analysis. Subsequently, we obtained the nitrogen content per unit dry mass of leaflet and linear elements (petiole and rachis) by dividing the total nitrogen content (in milligrams, mg) by the summed total dry mass of all leaflets and linear elements per leaf (in grams, g), respectively.

Geographic coverage

Description: The Huangshui River Valley in Qinghai Province, China surrounds the Huangshui River, the largest tributary of the upper reaches of the Yellow River in China. It also carries the main run-off of the upper reaches of the Yellow River, maintains the balance of water resources of the Yellow River and plays a role as an ecological protection barrier. Huangshui River is located in the Baohutu Mountains in the east of Qinghai Province, China, serving as the junction of the Qinghai–Tibet Plateau and the Loess Plateau. The total area of the Huangshui River Basin is about $16,100 \text{ km}^2$. Its wide area and large altitude drop shape its unique hydrological geomorphology and plant community composition.

Coordinates: $36^{\circ} 19'$ to $36^{\circ} 53'$; $100^{\circ} 59'$ to $102^{\circ} 48'$.

Taxonomic coverage

Description: The general taxonomic coverage includes four families, 14 genera and 32 plant species. Although the species we found were approximately 33.7% of those previously recorded (Huang et al. 2021), we have provided the geographical coordinates of all species that we observed. It was beyond our intended research scope to conduct a complete inventory of compound leaved herbs in the Huangshui River Valley.

Taxa included:

Rank	Scientific Name
kingdom	Plantae
family	Leguminosae
family	Rosaceae
family	Ranunculaceae
family	Lamiaceae
genus	<i>Oxytropis</i>
genus	<i>Vicia</i>
genus	<i>Astragalus</i>
genus	<i>Potentilla</i>
genus	<i>Sibbaldianthe</i>
genus	<i>Thalictrum</i>
genus	<i>Coluria</i>
genus	<i>Dasiphora</i>
genus	<i>Medicago</i>
genus	<i>Hedysarum</i>
genus	<i>Sphaerophysa</i>
genus	<i>Tibetia</i>
genus	<i>Salvia</i>
genus	<i>Melilotus</i>

Temporal coverage

Notes: Data collection dates: 2021.06.27 to 2021.08.20.

Usage licence

Usage licence: Creative Commons Public Domain Waiver (CC-Zero)

Data resources

Data package title: A dataset of functional traits for compound pinnate leaves of plants in the Huangshui River Valley of Qinghai Province, China.

Resource link: <https://www.scidb.cn/anonymous/YWIFYml5>

Number of data sets: 2

Data set name: Plot information

Description: This dataset records Plot No., Administrative Position, Longitude, Latitude, Elevation, Disturbance degree, Vegetation type, Plot coverage, Slope and Time. Each line represents one plot.

Column label	Column description
Plot No.	We use the combination of the abbreviation of the administrative location and the sampling geographic location number to represent the number of each plot.
Administrative Position	Administrative Position includes county, prefecture-level city (Autonomous Prefecture), province and country. "county": The full, unabbreviated name of the next smaller administrative region than prefecture-level city and Autonomous Prefecture. "prefecture-level city (Autonomous Prefecture)": The name of the prefecture-level city and Autonomous Prefecture of Qinghai Province in which the Location occurs. In our case, it is always Xining City, Haidong City and Tibetan Autonomous Prefecture of Haibei. "province ": The name of the province which the Location occurs. In our case, it is always Qinghai Province. "country ": The name of the country unit in which the Location occurs. In our case, it is always China.
Longitude (°E)	Longitude in decimal degrees, datum WGS84.
Latitude (°N)	Latitude in decimal degrees, datum WGS84.
Elevation (m)	The vertical distance of the ground above sea level. China uses the height from the mean sea level of the Yellow Sea (1985 National Elevation Datum) as the standard for calculation.
Disturbance degree	The degree of interference by human activities. In our study, the traces left by human interference, such as human footprints, garbage residue and combustion residue, are divided into Weak, Medium and Strong according to the degree.
Vegetation type	Vegetation physiognomy characterised by the dominant plants in the plot. In our case, it includes Grassland, Shrub and Forest.
Plot coverage (%)	This refers to the ratio of the projected area of all plants (herbs and woody plants) in the Plot to the total area of land.
Slope (°)	Slope of the land measured with a clinometer in degrees.
Date (yyyy-mm-dd)	Date of data survey.

Data set name: Plot composition

Description: This dataset records Plot No., Plot No.- Species code, Family name, Genus name, Species name, Authors' name, Classification System, Habitat, Life cycle or leaf phenology type, Coverage, Leaflet area (LA), Specific leaflet area (SLA), Leaflet dry mass (LM), Leaflet nitrogen content per unit dry mass (LN), Petiole and

rachis dry mass and Petiole and rachis nitrogen content per unit dry mass. Each line represents one leaf.

Column label	Column description
Plot No.	We use the combination of the abbreviation of the administrative location and the sampling geographic location number to represent the number of the plot.
Plot No.- Species code	Combination of plot number and species number.
Family name	The full scientific name of the plant family.
Genus name	The full scientific name of the plant genus.
Species name	The full scientific name of the plant species.
Authors' name	Name of the person who named the species.
Classification System	The name of the plant classification system. In our case, it mainly is APG III classification system.
Habit	The type of plant structure. In our case, it mainly includes Herb, Shrub and Subshrub.
Life cycle or leaf phenology type	Life cycle or leaf phenology of plants. In our case, it mainly includes Annual, Perennial and Deciduous.
Coverage (%)	It refers to the ratio of the projected area of a certain species in the Plot to the total area of land.
Leaflet area (cm ²)	The leaf area of leaflets measured in centimeters squared (cm ²).
Specific leaflet area (cm ² /g)	The specific leaf area of the leaflets calculated by the ratio between leaf area (cm ²) and leaf mass (g).
Leaflet dry mass (mg)	The mass of the dried leaflets measured in milligrams (mg). The data were converted to grams (g) for the calculation of specific leaflet area (SLA).
Leaflet nitrogen content per unit dry mass (mg/g)	The calculation method is to divide leaflet nitrogen (N) by the summed total dry mass of leaflets to obtain the nitrogen content (N) in the leaflets content per unit dry mass (LN; mg/g).
Petiole and rachis dry mass (mg)	The dry mass of the petiole and rachis. As the data are too small, in our case, "mg" is used as the unit of data record.
Petiole and rachis nitrogen content per unit dry mass (mg/g)	The calculation method is to divide petiole and rachis nitrogen (N) by the summed total dry mass of petiole and rachis to obtain the nitrogen content (N) in the leaflets content per unit dry mass (LN; mg/g).

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References

- Anten N, Alcalá-Herrera R, Schieving F, Onoda Y (2010) Wind and mechanical stimuli differentially affect leaf traits in *Plantago major*. *New Phytologist* 188 (2): 554-564. <https://doi.org/10.1111/j.1469-8137.2010.03379.x>
- Blue E, Kay J, Younginger BS, Ballhorn DJ (2015) Differential effects of type and quantity of leaf damage on growth, reproduction and defence of lima bean (*Phaseolus lunatus* L.). *Plant Biology* 17 (3): 712-719. <https://doi.org/10.1111/plb.12285>
- Brus R, Ballian D, Bogunic F, Bobinac M, Idžojtić M (2011) Leaflet morphometric variation of service tree (*Sorbus domestica* L.) in the Balkan Peninsula. *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology* 145 (2): 278-285. <https://doi.org/10.1080/11263504.2010.549660>
- Cornelissen JH, Lavorel S, Garnier E, Díaz S, Buchmann N, Gurvich D, Reich P, ter Steege H, Morgan H, van der Heijden M, Pausas J, Poorter H (2003) A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. *Australian Journal of Botany* 51 (4): 335-380. <https://doi.org/10.1071/BT02124>
- Donovan LA, Maherali H, Caruso CM, Huber H, Kroon H (2011) The evolution of the worldwide leaf economics spectrum. *Trends in Ecology & Evolution* 26 (2): 88-95. <https://doi.org/10.1016/j.tree.2010.11.011>
- Easlon HM, Bloom AJ (2014) Easy Leaf Area: Automated digital image analysis for rapid and accurate measurement of leaf area. *Applications in Plant Sciences* 2 (7): 1400033. <https://doi.org/10.3732/apps.1400033>
- Editorial Committee of the Flora of China, Chinese Academy of Sciences (Ed.) (1999) 中国植物志. [Flora Republicae Popularis Sinicae]. Science Press, Beijing. [In Chinese]. [ISBN 9787030132291]
- Editorial Committee of the Flora Qinghaiica (Ed.) (1996) 青海植物志. [Flora Qinghaiica]. Qinghai People's Publishing House, Xining. [In Chinese]. [ISBN 7-225-01448-X]
- Fang J, Wang X, Shen Z, Tang Z, He J, Yu D, Yuan J, Wang Z, Zheng C, Zhu J, Guo Z (2009) Methods and protocols for plant community inventory. *Biodiversity Science* 17 (6): 533. <https://doi.org/10.3724/SP.J.1003.2009.09253>
- Garnier E, Navas ML (2012) A trait-based approach to comparative functional plant ecology: Concepts, methods and applications for agroecology. A review. *Agronomy for Sustainable Development* 32 (2): 365-399. <https://doi.org/10.1007/s13593-011-0036-y>
- Hadley JL, Smith WK (1990) Influence of leaf surface wax and leaf area to water content ratio on cuticular transpiration in western conifers, USA. *Canadian Journal of Forest Research* 20 (9): 1306-1311. <https://doi.org/10.1139/x90-173>
- He NP, Li Y, Liu CC, Xu L, Li MX, Zhang JH, He JS, Tang ZY, Han XG, Ye Q, Xiao CW, Yu Q, Liu SR, Sun W, Niu S, Li S, Sack L, Yu GR (2020) Plant trait networks: Improved

- resolution of the dimensionality of adaptation. *Trends in Ecology & Evolution* 35 (10): 908-918. <https://doi.org/10.1016/j.tree.2020.06.003>
- Huang Y, Huo J, Ren L (2021) Dataset of plant community quadrats in Tibetan Plateau (2019). National Tibetan Plateau/Third Pole Environment Data Center-11 <https://doi.org/10.11888/Terre.tpdc.271980>
 - Hu H, Wang G, Liu G, Li T, Ren DX, Wang YB, Cheng HY, Wang JF (2009) Influences of alpine ecosystem degradation on soil temperature in the freezing-thawing process on Qinghai-Tibet Plateau. *Environmental Geology* 57 (6): 1391-1397. <https://doi.org/10.1007/s00254-008-1417-7>
 - Hulshof CM, Swenson NG (2010) Variation in leaf functional trait values within and across individuals and species: an example from a Costa Rican dry forest. *Functional Ecology* 24 (1): 217-223. <https://doi.org/10.1111/j.1365-2435.2009.01614.x>
 - Jia Z, Zhu Y (2017) 高寒沙地常见植物图谱. [Atlas of common plants in alpine sandy land]. China Environmental Science Press, Beijing. [In Chinese]. [ISBN 9787511131928]
 - Kim M, McCormick S, Timmermans M, Sinha N (2003) The expression domain of PHANTASTICA determines leaflet placement in compound leaves. *Nature* 424 (6947): 438-443. <https://doi.org/10.1038/nature01820>
 - Kissling WD, Balslev H, Baker WJ, Dransfield J, Gödel B, Lim J, Onstein R, Svenning JC (2019) PalmTraits 1.0, a species-level functional trait database of palms worldwide. *Scientific Data* 6: 178. <https://doi.org/10.1038/s41597-019-0189-0>
 - Lavorel S, Garnier E (2002) Predicting changes in community composition and ecosystem functioning from plant traits: Revisiting the Holy Grail. *Functional Ecology* 16 (5): 545-556. <https://doi.org/10.1046/j.1365-2435.2002.00664.x>
 - Liu CC, Li Y, Zhang JH, Baird AS, He NP (2020) Optimal community assembly related to leaf economic-hydraulic-anatomical traits. *Functional Plant Ecology* 11: 341. <https://doi.org/10.3389/fpls.2020.00341>
 - Niu Y, Wang C, Peng J (2018) 青藏高原野花大图鉴. [Wild flowers of Qinghai-Tibet plateau]. Chongqing University Press, Chongqing. [In Chinese]. [ISBN 9787568903530]
 - Oliveira DC, Moreira AS, Isaias R, Martini V, Rezende UC (2017) Sink status and photosynthetic rate of the leaflet galls induced by *Bystracoccus mataybae* (Eriococcidae) on *Matayba guianensis* (Sapindaceae). *Frontiers of Plant Science* 8: 1249. <https://doi.org/10.3389/fpls.2017.01249>.
 - Osnas JL, Lichstein JW, Reich PB, Pacala SW (2013) Global leaf trait relationships: mass, area, and the leaf economics spectrum. *Science* 340 (6133): 741-744. <https://doi.org/10.1126/science.1231574>
 - Pérez-Harguindeguy N, Díaz S, Garnier E, Lavorel S, Poorter H, Jaureguierry P, Bret-Harte MS, Cornwell WK, Craine JM, Gurvich DE, Urcelay C, Veneklaas EJ, Reich PB, Poorter L, Wright IJ, Ray P, Enrico L, Pausas JG, Vos AC, Buchmann N, Funes G, Quétier F, Hodgson J, Thompson K, Morgan H, ter Steege H, van der Heijden M, Sack L, Blonder B, Poschlod P, Vaieretti M, Conti G, Staver A, Aquino S, Cornelissen JH (2013) New handbook for standardised measurement of plant functional traits worldwide. *Australian Journal of Botany* 61 (3): 167-234. <https://doi.org/10.1071/BT12225>
 - Pérez-Harguindeguy N, Díaz S, Garnier E, Lavorel S, Poorter H, Jaureguierry P, Bret-Harte MS, Cornwell WK, Craine JM, Gurvich DE, Urcelay C, Veneklaas EJ, Reich PB, Poorter L, Wright IJ, Ray P, Enrico L, Pausas JG, Vos AC, Buchmann N, Funes G, Quétier F, Hodgson J, Thompson K, Morgan H, ter Steege H, van der Heijden M, Sack L, Blonder B, Poschlod P, Vaieretti M, Conti G, Staver A, Aquino S, Cornelissen J (2016)

Corrigendum to: new handbook for standardised measurement of plant functional traits worldwide. Australian Journal of Botany 64 (8): 715-716. https://doi.org/10.1071/BT12225_CO

- Sinha N (1997) Simple and compound leaves: reduction or multiplication? Trends in Plant Science 2 (10): 396-402. [https://doi.org/10.1016/S1360-1385\(97\)90055-8](https://doi.org/10.1016/S1360-1385(97)90055-8)
- Wright IJ, Reich PB, Westoby M, Ackerly DD, Baruch Z, Bongers F, Cavender-Bares J, Chapin T, Cornelissen JH, Diemer M, Flexas J, Garnier E, Groom PK, Gulias J, Hikosaka K, Lamont BB, Lee TL, Lee W, Lusk C, Midgley JJ, Navas M, Niinemets U, Oleksyn J, Osada N, Poorter H, Poot P, Prior L, Pyankov V, Roumet C, Thomas S, Tjoelker M, Veneklaas E, Villar R (2004) The worldwide leaf economics spectrum. Nature 428: 821-827. <https://doi.org/10.1038/nature02403>
- Xiong YY, Jiao YL (2019) The diverse roles of auxin in regulating leaf development. Plants 8 (7): 243. <https://doi.org/10.3390/plants8070243>
- Zhao Z (2019) 甘肃草原植物图鉴. [Illustration of grassland plants in Gansu Province]. Science Press, Beijing. [In Chinese]. [ISBN 9787030614568]
- Zhou H, Ren F, Huo Q (2020) 青海省海南藏族自治州维管植物图谱. [Atlas of vascular plants in Hainan Tibetan Autonomous Prefecture]. Science Press, Beijing. [In Chinese]. [ISBN 9787030645616]

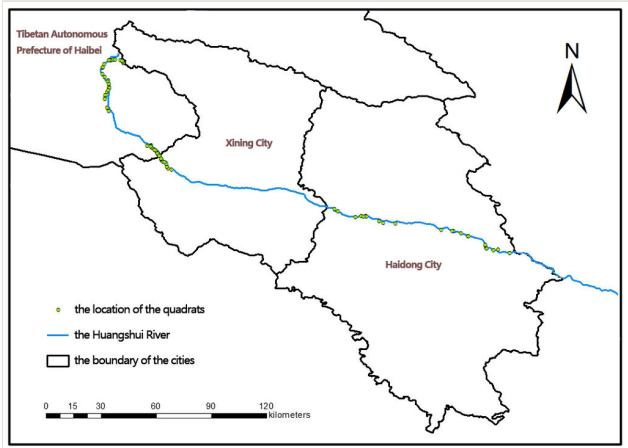


Figure 1.
Distribution map of plots.