Journal of Global Change Data & Discovery. 2025, 9(1): 43-51
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Dataset Development on Wild Yaks Distribution and Potential Habitat Analysis on the Qiangtang Plateau

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Abstract: As a rare and endangered wild species on the Qinghai-Xizang Plateau, the wild yaks (*Bos mutus*) are categorized as a vulnerable (VU) species by the International Union for Conservation of Nature (IUCN) and are designated as a first-class protected animal in China. The habitats of wild yaks are characterized by their inaccessibility, harsh natural conditions. Coupled with their small population size and strong tendency to avoid human contact, there is currently a dearth of distribution point data for wild yaks, and the boundaries of their habitats remain ill-defined. This situation poses significant challenges to the precise conservation of wild yaks. Consequently, this study selected the Qiangtang Plateau, the core distribution area of wild yaks, as the study area. A combined approach of field transect surveys and model simulations was employed to document the current distribution of wild yaks' habitats. Furthermore, future ecosystem types and climate scenarios were simulated to forecast the habitat conditions, with the aim of providing data support for the conservation of biodiversity on the Qinghai-Xizang Plateau. Over a four-year period of conducting transect surveys on the Qiangtang Plateau, a total of 127 wild yak distribution points were collected. The total area of the current habitats was determined to be approximately 251,000 km^2, with a concentrated distribution in the northeastern part of the Qiangtang Plateau. Influenced by climate change, it is projected that by 2050, the Qiangtang Plateau will experience a notable trend of warming and humidification. The habitats of wild yaks will expand towards the northwest, with an approximate increase of 33,000 km^2 in area. Under the RCP4.5 scenario, the habitat area will reach 284,000 km^2, and a large-scale suitable habitat for wild yaks will emerge in the northern part of Ngari Prefecture. This dataset consists of 3 parts: (1) distribution point data of wild yaks; (2) current distribution data of wild yaks' habitats; (3) predicted distribution data of wild yaks' habitats in 2050. The dataset is archived in .tif, .shp, and .txt formats and composed of 35 data files, with a data size of 9.55 MB (compressed into one file, 376 KB).

Received: 02-11-2024; **Accepted:** 23-02-2025; **Published:** 25-03-2025

Foundations: China Academy of Building Research (20231201331030043); National Natural Science Foundation of China (42371283, 32161143025); Ministry of Science and Technology of P. R. China (2019QZKK0603)

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Data Citation: [1] Wei, Z. Q., Xu, Z. R., Wei, X. W., *et al*. Dataset development on wild yaks distribution and potential habitat analysis on the Qiangtang Plateau [J]. *Journal of Global Change Data* & *Discovery*, 2025, 9(1): 43–51. https://doi.org/10.3974/geodp.2025.01.06.

[2] Wei, Z. Q., Xu, Z. R., Wei, X. W., *et al*. Distribution dataset of wild yaks on Qiangtang Plateau and current (2019–2022)/future scenarios of submerged habitats [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2024. https://doi.org/10.3974/geodb.2024.12.09.V1.

Keywords: wild yaks; Qinghai-Xizang Plateau; distribution points; habitats

DOI: https://doi.org/10.3974/geodp.2025.01.06

Dataset Availability Statement:

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.2024.12.09.V1.

1 Introduction

The wild yaks (*Bos mutus*), the rare and endemic species of the Qinghai-Xizang Plateau, are not only classified as a first-class protected animal in China but are also designated as vulnerable (VU) in the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN)[1]. Their distribution is predominantly within China, encompassing the Qiangtang Plateau in northern Xizang, the Altun Mountains in southern Xinjiang, and Hoh Xil in Qinghai. Additionally, scattered evidence of their presence can be found in certain marginal areas of Kashmir[2–4].

Wild yaks bear some resemblance to domestic yaks in appearance; however, adult wild yaks are significantly larger. Their typical coat color is black, yet a small number of "golden yaks" with golden-toned coats exist in the northwest of the Qiangtang Plateau[5]. Wild yaks exhibit a unique lifestyle. They lack fixed abodes and frequently undertake short-distance, resource-driven migrations without specific destinations. The habitats they favor possess distinct ecological features. Regarding terrain, wild yaks show a preference for areas with relatively flat topography and minimal undulations. Through long-term monitoring and analysis of wild yaks' habitats across different regions, scholars have determined that alpine meadows and dwarf semi-shrub forests are the habitats that wild yaks are particularly partial to[6,7]. The selection of habitats by wild yaks is a comprehensive consideration of multiple factors, including the variety and abundance of food, the proximity and quality of water sources, the security of the surrounding environment, and micro-climate conditions[7].

This research centers on the Qiangtang Plateau, a region with a high concentration of wild yaks. Spanning from the Kunlun Mountains in the north to the Gangdise-Nyainqentanglha Mountains in the south, the Qiangtang Plateau covers an area of 775,000 km^2 and falls within Nagqu City and Ngari Prefecture in Xizang. Characterized by high elevation, the Qiangtang Plateau slopes gently towards the southeast, with an altitude ranging from 4,500 to 5,100 m. The natural landscape transitions from alpine grasslands in the southeast to alpine desert steppes and alpine deserts in the northwest. Vegetation, mainly composed of Stipa purpurea and similar species, has a coverage rate of less than 40%[8–10]. As one of the world's best-preserved alpine ecosystems, the Qiangtang Plateau serves as a haven for numerous rare wild animals, hosting endemic species such as wild yaks, Tibetan antelopes, Tibetan gazelles, white-lipped deer, and Tibetan wild asses. In the context of global climate change, the Qiangtang Plateau, an integral part of the Qinghai-Xizang Plateau, demonstrates a high level of sensitivity. Over the past 50 years, it has experienced a notable trend of warming and humidification, with the rate of temperature increase being twice the global average during the same period. This rapid transformation of the natural environment poses significant survival challenges to the endangered wild animals in the region, and their habitats are confronted with multiple uncertainties[4].

Given the inhospitable and harsh nature of wild yaks' habitats, their small population size, and their strong aversion to human contact, there is currently a paucity of distribution point data for wild yaks, and the boundaries of their habitats remain ambiguous. Moreover, the impact of climate change on habitats is highly uncertain, presenting obstacles to the precise

conservation of wild yaks' habitats. Consequently, this study selects the Qiangtang Plateau as the research area, employs the wildlife transect survey method, and sets up transects to gather the distribution points of wild yaks. The Maxent model is utilized to simulate the current (with 2020 as the reference year) habitat distribution of wild yaks. By taking into account the projected changes in future climate and ecosystem types, the study forecasts the habitat conditions around 2050, aiming to offer scientific support for the biodiversity conservation efforts on the Qinghai-Xizang Plateau.

2 Metadata of the Dataset

The metadata of Distribution dataset of wild yaks on Qiangtang Plateau and current (2019–2022)/future scenarios of submerged habitats[11] is summarized in Table 1. It includes the dataset's full name, short name, authors, year of the dataset, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of Distribution dataset of wild yaks on Qiangtang Plateau and current (2019–2022)/future scenarios of submerged habitats

Items	Description
Dataset full name	Distribution dataset of wild yaks on Qiangtang Plateau and current (2019–2022)/future scenarios of submerged habitats
Dataset short name	WildYaksQiangtangPlateau
Authors	Wei, Z. Q., China Academy of Building Research, weizq.a8s@igsnrr.ac.cn Xu, Z. R., Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, xuzr@igsnrr.ac.cn Wei, X. W., Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, 17623589098@163.com Xian, Y. F., Institute of Geographic Science and Natural Resources Research, Chinese Academy of Sciences, 326376678@qq.com
Geographical region	Qiangtang Plateau, in the northern part of Xizang
Year	Current distribution data (2019–2022); Predicted distribution data (2050)
Spatial resolution	1 km
Data format	.shp, .tif, .txt
Data size	376 KB (after compression)
Data files	Distribution points, current distribution of habitats, habitat 2050
Foundations	China Academy of Building Research (20231201331030043); National Natural Science Foundation of China (42371283, 32161143025); Ministry of Science and Technology of P. R. China (2019QZKK0603)
Data computing environment	ArcGIS10.7; Maxent 3.4.4; GeoSOS-FLUS; Python 3.7.8
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	(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 percent 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 newdataset[12]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Methods

3.1 Technical Approach

The study takes into account the habits of wild yaks and the environment of the plateau, and sets up wildlife survey transects to obtain the distribution points of wild yaks. Subsequently, using the distribution points of wild yaks as samples, a total of 16 indicators from four categories of environmental factors are selected and input into the maximum entropy Maxent model to obtain the current habitat distribution of wild yaks. Later, by integrating the future climate patterns under the three greenhouse gas emission scenarios of CMIP5 (Coupled Model Intercomparison Project 5) with the ecosystem data predicted by the Geo-FLUS model, three environmental scenarios for the year 2050 are constructed. Combining with the distribution points of wild yaks, the future habitat distribution results are predicted through the Maxent model. Finally, the habitat distribution status of wild yaks in the current (2020) and under the future scenario (2050) is obtained (Figure 1).

3.2 Acquisition of Wild Animal Distribution Points

From 2019 to 2022, the research team conducted four-year consecutive transect surveys of wild animals on the Qiangtang Plateau. Surveys were carried out in May and August 2019, and August of 2020–2022. Considering wild yaks' habits and the plateau's topography, and drawing on local wildlife protection station experience, 8,221 km survey transects were set up. During surveys, the team, divided into two groups, used rangefinder binoculars to observe wild yaks. When detected, observer coordinates, animal distance, and relative angle were recorded. After fieldwork, data were cross-checked and target coordinates calculated. Then, ArcGIS buffer analysis was applied with a 0.5 km radius; only one point was kept if multiple were in a buffer to reduce spatial redundancy. By referring to previous studies[6,8,13], 127 wild yak presence points were finally obtained (Figure 2).

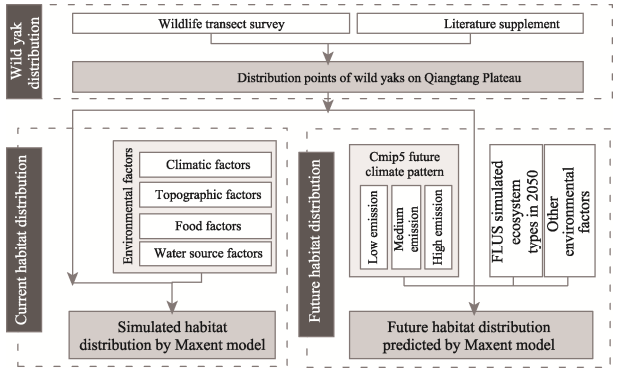

Figure 1 Technical roadmap of the dataset development

3.3 Simulation of Current Habitat Distribution

During the simulation of wild yaks' habitat distribution, the presence points of wild yaks acquired from field measurements served as training and testing samples. The Maxent model, a powerful tool in ecological research renowned for its ability to predict species distributions, was utilized to simulate the habitat distribution. This model has been extensively applied in wildlife conservation studies, leveraging the actual presence-point data of species in conjunction with relevant environmental variables to estimate habitat distributions[14]. Specifically, the Maxent model identifies the solution with the maximum entropy value among a set of model solutions that satisfy specific constraints, which is then employed as the predicted species distribution[15].

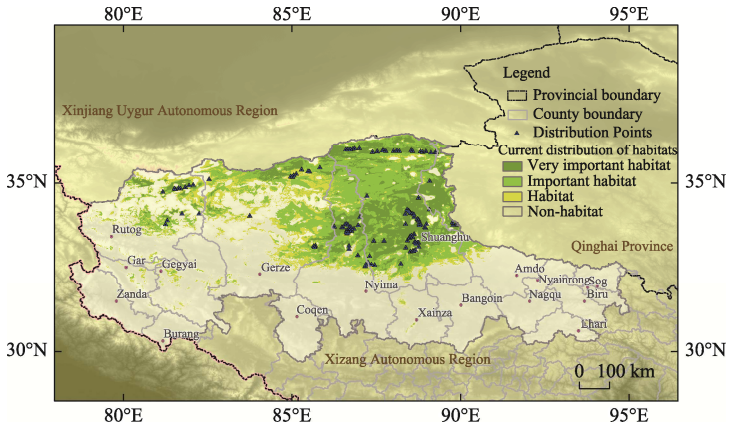

Figure 2 Map of distribution places of wild yaks (2019–2022)

Accounting for the physiological traits of wild yaks and their habitat-selection preferences, four categories of environmental factors directly influencing wild yaks' distribution were selected: climate, topography, food, and water sources. To mitigate collinearity issues and prevent model over-fitting, a comprehensive correlation analysis was conducted on all potential environmental variables. Variables with high correlations and weak associations with wild yaks' habitat-selection preferences were eliminated. In the end, 16 indicators were retained (Table 2). Subsequently, the wild yaks' point data and the four-category environmental factor data were incorporated into the Maxent model. To assess the model's accuracy, 20% of the wild yaks' distribution points were randomly selected. Through model computations, the distribution probability values of wild yaks within the study area were derived, enabling the classification of habitat distributions. Areas with a distribution probability exceeding 0.15 were classified as "Potential habitats", while those with lower probabilities were designated as "Non-habitats". Specifically, areas with a probability higher than 0.6 were identified as "Very important habitats" for wild yaks, those with a probability between 0.25 and 0.6 were considered "Important habitats", and the remaining areas were classified as "Habitats"[9,13,15].

3.4 Prediction of Future Habitat Distribution

This study integrated future climate data and ecosystem-type data predicted by Geo-FLUS to construct the environmental scenarios of the Qiangtang Plateau in 2050, considering four aspects: future climate, topography, food, and water sources (Table 2). Leveraging the current distribution points of wild yaks, the Maxent model was applied to forecast their future habitats. To ensure consistency in habitat classification, the threshold used for classifying current habitats was adopted for the simulation results.

The future climate data for the Qiangtang Plateau were sourced from three Representative Concentration Pathways (RCPs) scenarios in 2050 provided by the CMIP5[16]: RCP2.6, RCP4.5, and RCP8.5. The future ecosystem-type data were predicted using the Geo-FLUS model. The Geo-FLUS model, based on the Cellular Automata (CA) principle, utilizes the Artificial Neural Network (ANN) algorithm to establish relationships between land use, human activities, and natural factors, thereby simulating and predicting future ecosystem types[9]. The environmental factors incorporated in the simulation included average temperature, annual average precipitation, distance from water bodies, altitude, slope, etc., while human-related factors encompassed population density, GDP, and distance from highways. The historical ecosystem-type data consisted of MODIS-MCD12Q1 ecosystem-type data from 2001, 2010, and 2019, which were employed to evaluate the model's accuracy. First, the 2001 ecosystem-type data were used to simulate the 2010

Table 2 Data sources of the input parameters of the models

Data type	Data name	Data source	Models	
			Maxent	FLUS
Wild yaks	Points of wild yaks' distribution	Results of line-transect surveys	√	
Climate	Annual mean temperature (℃)	From WorldClim1.4 (www.worldclim.org/), "Historical Dataset" and "Future Dataset"	√	√
	Mean diurnal range (℃)		√	
	Max temperature of the warmest month (℃)		√	
	Min temperature of the coldest month (℃)		√	
	Mean temperature of the warmest quarter (℃)		√	
	Mean temperature of the coldest quarter (℃)		√	
	Annual precipitation (mm)		√	√
	Precipitation of the wettest month (mm)		√	
	Precipitation of the driest month (mm)		√	
	Precipitation of the warmest quarter (mm)		√	
	Precipitation of the coldest quarter (mm)		√	
Topography	Slope (°)	ASTER_GDEM (earthdata.nasa.gov/)	√	√
	Altitude (m)		√	√
	Net Primary Production (NPP)	The current situation data comes from the Resources and Environment Science Data Center (www.resdc.cn/), and the future data comes from the reference[16]	√	
	Land cover types (2001, 2010, 2020)	MODIS_MCD12Q1 (earthdata.nasa.gov/)	√	√
Water source	Distance from water source (km)	Resources and Environment Science Data Center (www.resdc.cn/)	√	√
Forage	Population density (10^4 person/km^2)			√
	Gross Domestic Product (GDP) (10^8 CNY)			√
	Distance to roads (km)			√

scenario, and the results were compared with the actual 2010 data, yielding a Kappa coefficient of 0.839 and an overall accuracy of 0.913. Subsequently, the 2010 ecosystem-type data were used to simulate the 2019 scenario, and the comparison with the actual 2019 data resulted in a Kappa coefficient of 0.907 and an overall accuracy of 0.949. Given its satisfactory accuracy, the Geo-FLUS model was deemed suitable for future land-use scenario simulations. Based on the 2019 ecosystem-type data, the climate factors were substituted with the CMIP5 2050 climate-scenario data to simulate the future ecosystem types of the Qiangtang Plateau, and the ecosystem-type results under the three greenhouse-gas-emission models were obtained[16,17].

4 Data Results and Validation

4.1 Dataset Composition

This dataset consists of 3 parts: (1) distribution point data of wild yaks; (2) current distribution data of wild yaks' habitats; (3) predicted distribution data of wild yaks' habitats in 2050. The dataset is archived in .tif, .shp, and .txt formats and consists of 35 data files, with a data size of 9.55 MB (compressed into 1 file of 376 KB).

4.2 Data Products

4.2.1 Distribution Results of Wild Yak Transect Surveys

Wild yaks are frequently observed in the northern part of the Qiangtang Plateau, including

the central-northern part of Shuanghu County in Nagqu City, the northern part of Nyima County, the northern part of Amdo County, the northern part of Gerze County in Ngari Prefecture, and Rutog County. These areas are remote alpine hills with few human settlements. Transect surveys have identified that Cuozhe Qiangma Township and Gacuo Township in Shuanghu County, as well as Ejiu Township and Rongma Township in Nyima County, are regions where wild yaks are relatively concentrated. The largest population size detected during the surveys was only 4 individuals. The detected presence points are often far from human activities and are generally not disturbed by activities such as transportation, tourism, and grazing.

The altitude range of the wild yaks' presence points is 4,792–5,620 m, with an average altitude of approximately 5,000 m. Wild yaks prefer to inhabit slopes, and the maximum slope degree of the presence points is 12°. The average annual temperature is –6.4 ℃, and the average annual precipitation is around 178 mm. In the driest areas, the average annual precipitation is only 35 mm. The main vegetation types include sparse vegetation of Saussurea tridactyla and Waldheimia glabra, alpine steppe of Stipa purpurea and Carex montis-everestii, with an average vegetation coverage rate of 19%.

4.2.2 Distribution Results of Current Wild Yak Habitats

The total area of wild yaks' habitats on the Qiangtang Plateau is 251,000 km^2, accounting for approximately one-third of the study area. Among them, the area of very important habitats for wild yaks is 58,000 km^2, accounting for about 7.5% of the Qiangtang Plateau. The area of important habitats is 122,000 km^2, and the area of general habitats is 71,000 km^2. The critically important areas for wild yaks are concentrated in the northeastern part of the Qiangtang Plateau, centered around Duogecuo Lake and its nearby water systems in the northern part of Nagqu City, spreading outwards. In addition, there are also some very important habitats distributed in Rutog County of Ngari Prefecture. The habitats of wild yaks are mainly concentrated in Nagqu City. The habitat area in Shuanghu County reaches 105,000 km^2, accounting for 90% of the total area of Shuanghu County. In Ngari Prefecture, the habitats are relatively concentrated in the northeastern part of Gerze County, and there are scattered habitats in Rutog County, Geji County, and Gar County.

4.2.3 Distribution Results of Future Wild Yak Habitats

Over the next three decades, the habitats of wild yaks will undergo significant changes, showing a clear trend of expansion towards the west. It is predicted that by 2050, a large number of new wild yak habitats will emerge in Gerze County and Rutog County of Ngari Prefecture. These habitats will still be characterized by high altitude and remoteness from populated areas. In the future, the geographical overlap between the distribution boundaries of wild yaks' habitats and the Qiangtang Nature Reserve will further increase. Under the 3 future climate scenarios, the total habitat area will generally increase by about 33,000 km^2. The total areas are 282,000 km^2 under the RCP2.6 scenario, 284,000 km^2 under the RCP4.5 scenario, and 280,000 km^2 under the RCP8.5 scenario. The location of the core area remains basically unchanged, and most of the new habitats are important and general habitats for wild yaks (Figure 3).

Under the three climate scenarios, the total habitat areas of wild yaks are similar, and the distribution patterns are alike, with a northward aggregation, especially in the northwest of the Qiangtang Plateau, where the trend of habitat expansion is obvious. However, the patterns of scattered habitats in the south vary greatly. For example, there are a large number of small-scale wild yak habitats in the southern regions of RCP2.6 and RCP4.5, while in the RCP8.5 scenario, there are hardly any large-scale habitats in the south. Under the RCP4.5 scenario, the total area of habitats on the Qiangtang Plateau will increase to 284,000 km^2 in the future, with 44,000 km^2 of very important habitats, 143,000 km^2 of important habitats, and 97,000 km^2 of general habitats.

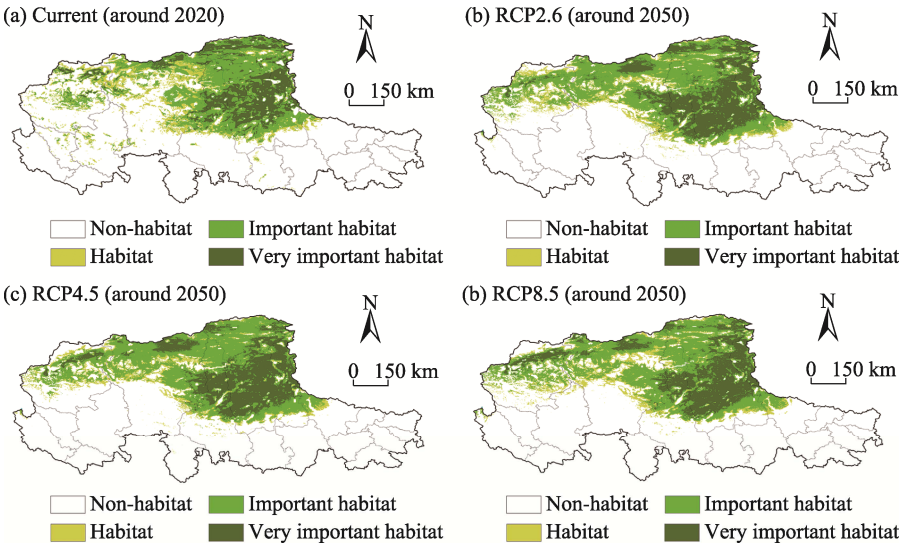

Figure 3 Future distribution maps of the wild yaks habitats in different scenarios (2050)

4.3 Data Validation

When using the Maxent model to simulate the current and future habitats of wild yaks, 20% of all the points were randomly selected to calculate the area under the receiver operating characteristic curve (i.e., the AUC value) corresponding to the distribution probability *p* for accurate verification. The AUC value of the current habitat simulation results was 0.907. For future habitat simulations, the AUC values were 0.908 under the RCP2.6 scenario, 0.907 under the RCP4.5 scenario, and 0.904 under the RCP8.5 scenario. The accuracy of these four simulation results was relatively high, indicating reliable outcomes.

5 Discussion and Conclusion

This study selected the Qiangtang Plateau as the study area and adopted a method combining field surveys and species distribution models. Through four consecutive years of conducting transect surveys of wild animals, distribution data of the wild yak population were obtained. Based on an understanding of the physiological characteristics of wild yaks and their habitat selection preferences, and by using the field-measured wild yak point data, the Maxent model was employed to simulate the current habitat distribution of wild yaks. Meanwhile, considering the changes in future climate conditions and the evolution scenarios of ecosystem types, the model was further utilized to predict the habitat distribution of wild yaks in 2050 and analyze the changing trends. It was found that the research results had a high degree of consistency with previous written records and image materials of related species.

The study revealed that wild yaks tend to inhabit the sparsely-populated alpine hilly areas. In terms of geographical distribution, their habitats are concentrated in the hinterland of the Qiangtang Nature Reserve, including the central-northern part of Shuanghu County, the northern part of Nyima County, the northern part of Amdo County, as well as the northern part of Gerze County and Rutog County in Ngari Prefecture. Statistics show that the total area of their habitats is 229,000 km^2, with Duogecuo Lake in the northern part of Nagqu City and its nearby water systems as the core area, spreading outwards in a radial pattern. By 2050, the Qiangtang Plateau will experience a significant warming and humidification trend. The areas of ecosystems such as grasslands and water bodies will increase, and the habitats of wild yaks will expand to the west and north, with an area increase of approximately

33,000 km^2. A large-scale habitat will emerge in the northern part of Ngari Prefecture, while the scattered habitats in the southern part will disappear.

The habitats of wild yaks are mostly located in alpine steppe deserts, alpine sparse-vegetation areas, and gentle slopes of glaciers and snow-covered areas. Currently, their habitat range is limited, and their survival status is worrying. According to the results of this study, the habitats of wild yaks are expected to expand significantly by 2050. However, the Maxent model used in this study has certain limitations. This model analyzes the environmental requirements of species for habitats based on the relationship between the presence points of wild animals and environmental factors and takes into account factors such as population density and migration barriers. However, due to the extreme complexity of the actual ecological environment, many difficult-to-quantify factors cannot be fully covered, resulting in inevitable uncertainties in model predictions. Due to research limitations, in-depth studies on the population size, male-to-female ratio, age composition, and breeding status of wild yaks have not been conducted. Although the population of wild yaks has shown a restorative increase in the past 20 years, if the population cannot maintain its growth in the future, it will be difficult for the habitats to expand as expected.

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