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Dataset Development of Potential Suitable Areas Estimation for Barley Cultivation on the Qinghai-Xizang Plateau under Two Different Climate Scenarios

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Abstract: As climate change leads to increased volatility and extremes, the vulnerability of agricultural production on the Qinghai-Xizang Plateau has grown, making it necessary to implement more scientific management and rational planning of agricultural production on the plateau in order to enhance the ability to ensure food security there. Based on the current status of highland barley cultivation on the Qinghai-Xizang Plateau, the authors integrated multi-source data, including Digital Elevation Models (DEM), soil parameter indices and eco-meteorological variables, to simulate the current potential suitable areas for barley cultivation. They also projected the potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau under RCP4.5 and RCP8.5 climate change scenarios for various future time periods. The results indicate that from the present period (1970–2000) through the near-term future (2021–2040) to the medium-term future (2041–2060), the area of regions unsuitable for potential highland barley cultivation is gradually decreasing, whilst the area of regions with medium and high suitability is gradually increasing; In both the near future and the mid-long-future, the area of unsuitable zones under RCP8.5 is smaller than that under RCP4.5, whilst the areas of moderate and high suitability are larger than those under RCP4.5. The dataset includes: potential suitable cultivation zones for highland barley in the current period, the near-term future under RCP4.5, the near-term future under RCP8.5, the medium-term future under RCP4.5, and the medium-term future under RCP8.5. The spatial resolution is 2.5′x2.5′. The dataset is archived in .tif format, and consists of 20 data files with data size of 6.27 MB (compressed into 1 file with 2.88 MB). This dataset supported the corresponding author's doctoral thesis in Science.

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Keywords: highland barley, Qinghai-Xizang Plateau, climate change, potentially suitable area, MaxEnt model, doctoral thesis in Science

DOI: https://doi.org/10.3974/geodp.2026.04.05

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.2026.04.06.V1.

1 Introduction

The outline of the Intergovernmental Panel on Climate Change (IPCC) Seventh Assessment Report clearly states that global climate risk assessments have shifted from focusing on single physical variables to a comprehensive integration of complex, compound, and cascading risks, with particular emphasis on the key Earth system thresholds and abrupt changes (such as tipping-point effects) may have potentially irreversible impacts on regional agricultural production, food security, and ecosystem stability[1–3]. Global warming is not merely a single environmental issue; it also triggers a series of systemic social problems, with agricultural production being particularly hard hit. The increasing frequency of natural disasters and extreme weather and climate events in the context of climate change may exacerbate the crisis in an already vulnerable agricultural sector, potentially posing a serious threat to national food security in the future[4].

As the plateau with the highest average elevation in the world, the Qinghai-Xizang Plateau has a unique and complex climate; at the same time, agricultural production in this region has already approached environmental limits along the vertical gradient. Consequently, the impact of various natural disasters caused by extreme weather and climate events on agriculture in this region is more pronounced than in other areas. Currently, arable land resources in the Qinghai-Xizang plateau region are extremely limited and of poor quality, making the contradiction between growing food demand and limited supply capacity increasingly acute[5]. In such a harsh environment, the variety of food crops that can be cultivated on the plateau is very limited; however, due to its cold and drought tolerance, short growing season, and strong stress resistance, highland barley is well-suited for cultivation on the Qinghai-Xizang Plateau[6,7]. Against the backdrop of current global climate change, it is particularly important for the Qinghai-Xizang Plateau to scientifically manage and rationally plan agricultural production using its limited arable land resources. Therefore, this dataset estimates the potential suitable areas for highland barley cultivation under different time periods and scenarios-both currently and in the future-providing a data reference for the rational development of highland barley cultivation on the Qinghai-Xizang plateau and for understanding the distribution of reserve arable land resources.

This dataset uses current data on the area under highland barley cultivation on the Qinghai-Xizang Plateau to generate random highland barley sample points. Based on the MaxEnt model and environmental variables affecting highland barley cultivation, it estimates potential suitable areas for highland barley cultivation in the current period, the near future, and the medium-term future, in order to obtain spatial distribution data at the grid scale for suitable highland barley cultivation areas[8].

2 Metadata of the Dataset

The metadata of the Dataset of potential suitable areas estimation for barley cultivation on the Qinghai-Xizang Plateau under two different climate scenarios[9] including the dataset name, authors, geographic region, year of the dataset, data format, data size, data files, data publisher, are summarized in Table 1.

Table 1 Metadata summary of the Dataset of potential suitable areas estimation for barley cultivation on the Qinghai-Xizang Plateau under two different climate scenarios

Items	Description
Dataset full name	Dataset of potential suitable areas estimation for barley cultivation on the Qinghai-Xizang Plateau under two different climate scenarios
Dataset short name	P.SuitableArea_QZ_Plateau
Authors	Wei, Y., Qinghai Normal University, yingwei202509@163.com Liu, X., Qinghai Normal University, 202547331003@stu.qhnu.edu.cn Ma, W. D., Qinghai Normal University, mwd0910@sina.com Liu, F. G., Qinghai Normal University, lfg_918@163.com Zhou, Q., Qinghai Normal University, zhouqiang729@163.com Chen, Q., Qinghai Normal University, 2025055@qhnu.edu.cn
Geographical region	Qinghai-Xizang Plateau (approximately 25°N–40°N, 73°E–105°E)
Year	1970–2000; 2021–2040; 2041–2060
Spatial resolution	2.5′×2.5′
Data format	.tif
Data size	6.27 MB
Data files	Current period spatial distribution data of suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau; Near-term and medium-term spatial distribution data of potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau (RCP4.5 scenario, RCP8.5 scenario)
Foundation	Ministry of Science and Technology of P. R. China (2019QZKK0606)
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 principle" 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[10]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC, OARL

3 Methods

Based on the current status of highland barley cultivation on the Qinghai-Xizang Plateau, the authors established a comprehensive dataset of highland barley sampling points covering the entire region, identified key habitat variables affecting highland barley cultivation, and used the MaxEnt model to simulate potential suitable areas for highland barley cultivation under various scenarios. To ensure the spatial continuity of potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau and to avoid a large number of fragmented patches in the projected results, this dataset did not exclude land use and land cover types where crop cultivation is impossible, such as water bodies, glacial snow and ice, developed land, and bare ground. In subsequent practical applications of the data, consideration may be given to excluding unsuitable land categories based on actual regional conditions.

3.1 Data Sources

The steps for developing a dataset of potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau under two different climate scenarios are as follows: (1) Based on current data on highland barley cultivation areas on the Qinghai-Xizang Plateau, 134,410 sample points were generated through relevant processing using ArcGIS software. These points were then screened in stages according to the IPCC's definition of likelihood, ultimately identifying 3,066 barley sample points; (2) For 42 habitat variables that could potentially influence the potential suitability zones for highland barley cultivation, KL

divergence calculations were performed, contribution rates were ranked, and multicollinearity was eliminated, ultimately selecting 10 habitat variables for the MaxEnt model; (3) A MaxEnt model was constructed using the 3,066 sample points, with 75% used for training the model to identify environments suitable for barley growth and 25% for validation. By comparing AUC values, the model simulated the current potential distribution area of highland barley and validated its accuracy; (4) The distribution of potential suitable areas for highland barley under different climate scenarios was projected. The specific workflow is shown in Figure 1.

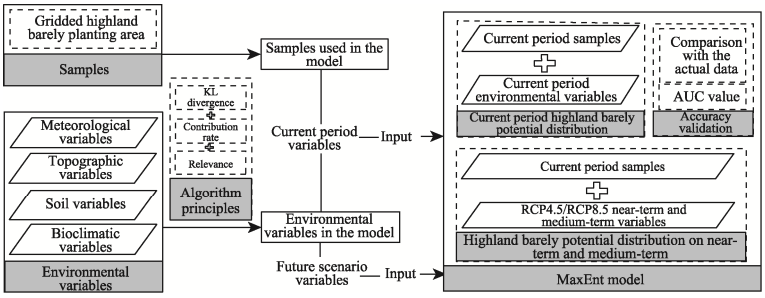


Figure 1 Flowchart of the dataset development

3.2 Data Source

After fully considering all factors affecting the natural suitability for highland barley cultivation, the following data were selected for this study:

(1) The 42 environmental variables that may influence potential suitable areas for highland barley cultivation include climate indicators, soil indicators, elevation, slope, and solar radiation. The elevation data (2010, spatial resolution of 30 m×30 m) were obtained from the United States Geological Survey[1]; soil parameter indices (2012, spatial resolution of 5′×5′) were obtained from the Harmonized World Soil Database[2]; meteorological indicators and bioclimatic variables were obtained from the World Clim database (Version 2.0)[3], where the baseline period for the current period is 1970–2000, and the near-future and medium-term periods are 2021–2040 and 2041–2060, respectively. The dataset selected is RCP 4.5 (temperature increase of 1.0–2.6 ℃, CO_2 concentration change of 650×10^{-6} L/L, precipitation increase of 4.00%) and RCP 8.5 (temperature rise of 2.6–4.8 ℃, CO_2 concentration change of $1{,}350\times10^{-6}$ L/L, precipitation increase of 4.60%) as representative concentration pathways, with a spatial resolution of 2.5′×2.5′.

(2) Data on the area under cultivation of highland barley on the Qinghai-Xizang Plateau (2019, spatial resolution of 15 m×15 m) were used to construct a dataset of highland barley cultivation sample points and were sourced from a dataset previously developed by our team[11];

All of the above data were masked and extracted according to the boundaries of the Qinghai-Xizang Plateau as defined by ZHANG Yili, *et al*.[12,13], thereby serving as the scope for estimating potential suitable areas for highland barley cultivation.

3.3 Algorithm

The representativeness of crop sampling sites and the volume of data, as well as habitat variables that have a substantial impact on crops, are key considerations when using the

[1] United States Geological Survey. https://topotools.cr.usgs.gov.

[2] International Soil Reference and Information Centre. http://www.isric.org.

[3] World Clim. https://www.worldclim.org.

MaxEnt model to estimate potential suitable areas for highland barley cultivation. Based on this, it is necessary to conduct a dual screening of highland barley cultivation sites and the environmental variables that influence highland barley cultivation.

3.3.1 Generation and Screening of Highland Barley Cultivation Distribution Points

The database of highland barley cultivation locations was created using 2019 data on highland barley cultivation areas on the Qinghai-Xizang Plateau. After performing operations such as "vector-to-raster conversion" and "raster-to-point conversion" on the vector layers in ArcGIS software, a total of 134,410 points were obtained. In accordance with the IPCC's definition of likelihood, the highland barley cultivation areas within the grid were divided into 5 groups based on different area ranges. Subsequently, the number of sample points to be selected from each group was determined according to a specific proportion. Ultimately, 3,066 highland barley distribution points were selected for inclusion in the model. For a detailed description of the screening process, please refer to the relevant article associated with the dataset[14].

3.2.2 Screening of Habitat Variables for MaxEnt Model

Based on the number of sample points selected as described above, 42 environmental variables that may influence the potential suitability zones for highland barley cultivation were screened. The steps included: (1) Calculation of the KL divergence, all variables with a KL divergence below 1 were eliminated, and the remaining variables were retained for the next screening step. After calculation, a total of 18 variables were selected; (2) Contribution rate assessment, the remaining 18 habitat variables were input into the MaxEnt model for a second round of screening to eliminate factors with insignificant contribution rates; (3) Autocorrelation analysis of factors, a third round of screening was conducted to avoid including highly correlated indicators in the model, resulting in the retention of the remaining 10 variables, as shown in Table 2.

Table 2 Final 10 habitat variables after screening

Variable name	Variable meaning	Contribution rate	Variable name	Variable meaning	Contribution rate
BIO1	Annual average temperature	50.50%	BIO4	Seasonal temperature	1.70%
BIO12	Annual precipitation	31.60%	BIO8	Average wet season temperature	1.30%
BIO9	Dry season average temperature	5.40%	SDTO	Gravel percentage	1.00%
BIO5	Warmest month's maximum temperature	4.70%	ORGC	Organic carbon content	1.00%
CECC	Cation exchange capacity of clay fraction	2.50%	ECEC	Effective cation exchange capacity	0.30%

4 Data Results and Validation

4.1 Dataset Composition

The dataset includes: potential suitable cultivation zones for highland barley in the current period, the near-term future under RCP4.5, the near-term future under RCP8.5, the medium-term future under RCP4.5, and the medium-term future under RCP8.5. The dataset is archived in .tif format.

4.2 Accuracy Evaluation of MaxEnt Model Simulation Results

The MaxEnt model integrates existing crop distribution data with grid-based environmental gradient indicators to determine whether a region is suitable for growing a particular crop.

Using a quantification range of 0 to 1, this model measures the similarity between the environmental conditions of different regions and the habitat requirements of the target crop; it can predict the potential distribution range of a species and also output corresponding distribution probability estimates. The authors divided 3,066 highland barley sample points into training and validation sets in a 75% to 25% ratio; the corresponding AUC values were 0.888 and 0.885, indicating that the model has high accuracy and can be used to predict potential suitable cultivation areas for highland barley on the Qinghai-Xizang Plateau[14].

4.3 Validation of Preliminary Estimation Results and Accuracy

4.3.1 Preliminary Estimated Results

Using the suitability index (P) as the zoning criterion, the study area was classified into 4 categories. Areas with P values below 1% were defined as unsuitable areas; those with P values from 1% to less than 33% were classified as low-suitability areas; those with P values from 33% to less than 66% were classified as moderate-suitability areas; and those with P values from 66% to less than 100% were classified as high-suitability areas. The spatial distribution of potential suitable areas for highland barley cultivation classified according to these criteria is shown in Figure 2.

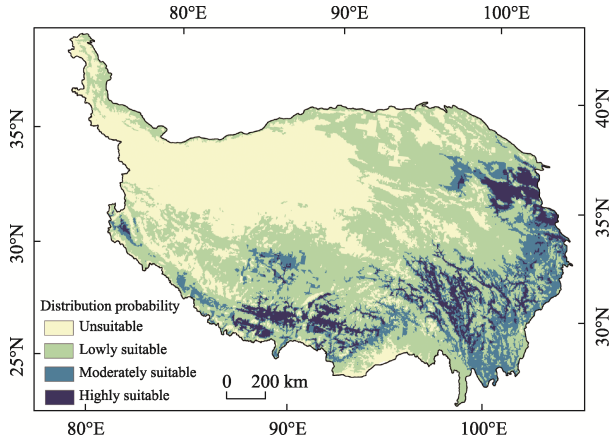


Figure 2 Distribution map of potential suitable areas for highland barley cultivation in the Qinghai-Xizang Plateau during the current period

4.3.2 Validation of the Accuracy of Preliminary Estimation Results

To validate the simulation results for potential suitable cultivation areas of highland barley, actual cultivation area data were used as validation samples. These data were spatially overlaid with the areas predicted by the model as unsuitable and suitable for cultivation, and the actual cultivation area and its proportion within each category were calculated. A lower proportion of actual cultivation area in areas predicted as unsuitable, together with a higher proportion in areas predicted as suitable, indicates better model prediction performance. The validation results are presented in Table 3.

Table 3 Validation of the accuracy of preliminary estimates for highland barley potential suitable areas

Category	Area	Percentage
Area under highland barley cultivation in suitable zones	27.37×10^4 ha	99.88%
Area under highland barley cultivation in unsuitable zones	3.15 ha	0.12%

4.4 Potential Suitable Areas for Highland Barley Cultivation on the Qinghai-Xizang Plateau in the Near-Term Future

The potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau in the near-term future are shown in Figure 3. The spatial distribution pattern is generally consistent with that of the current period, although slight differences can be observed among different climate scenarios. In terms of temporal variation, the area of unsuitable regions gradually decreases, whereas the areas of low-, moderate-, and high-suitability regions gradually increase. The suitable areas are mainly distributed around the river valley zones in the eastern part of the plateau and the Yarlung Zangbo River Basin in the south. Meanwhile, the low-suitability zones, which were originally located in climatic marginal areas, steadily expand toward high-altitude cold regions, indicating an improvement in habitat conditions during the early stage of climate warming and humidification. Across different scenarios, the area of unsuitable regions under RCP8.5 is smaller than that under RCP4.5, while the areas of moderate- and high-suitability regions are larger. This suggests that, in the short term, the greenhouse effect under the high-concentration pathway has a stronger positive driving effect on improving agricultural thermal resources on the Qinghai-Xizang plateau.

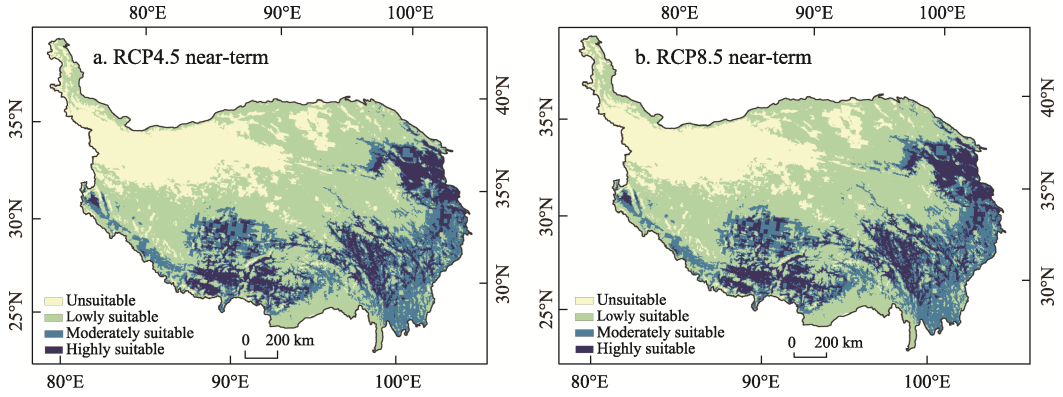


Figure 3 Distribution maps of potential suitable areas for highland barley cultivation in the near-term future on the Qinghai-Xizang Plateau

4.5 Potentially Suitable Areas for Highland Barley Cultivation on the Qinghai-Xizang Plateau in the Medium-Term Future

The potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau under the medium-term future scenario are shown in Figure 4. The potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau under the medium-term future scenario are shown in Figure 4. By the medium-term future, both the spatial boundaries and suitability levels of the potential suitable areas for highland barley cultivation are projected to change significantly. In terms of temporal variation, the cultivation boundaries of suitable areas expand markedly from the current period to the medium-term future. Areas currently classified as having no suitability for cultivation are projected to shrink substantially by the medium-term future. In particular, in the interior of the Qinghai-Xizang Plateau, the eastern part of the Sanjiangyuan Region, and the southern Xizang valleys, habitat suitability for highland barley shows a large-scale transition from no cultivation suitability to low or moderate suitability. From the near-term future to the medium-term future, the spatial structure of potential suitable areas for highland barley cultivation becomes increasingly contiguous. The core areas with high suitability shift from a scattered distribution to large-scale clusters centered on river valleys, while the boundaries of moderate-suitability areas show a clear tendency to extend northward and toward higher elevations.

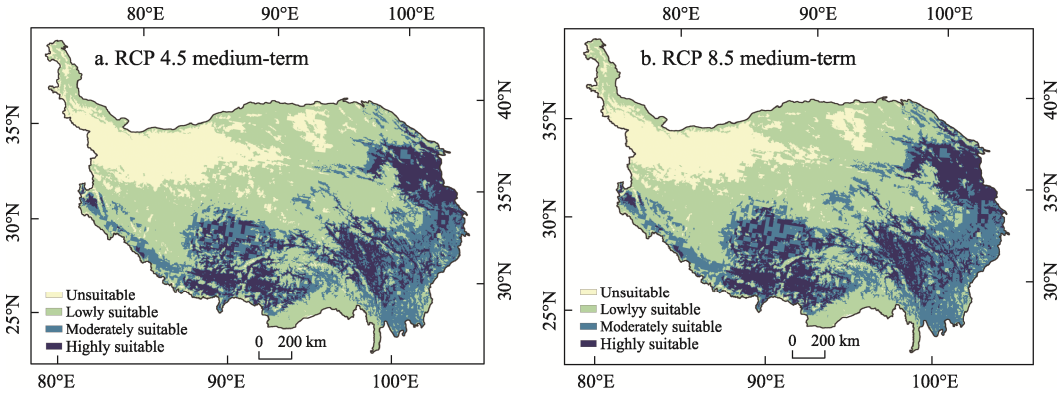


Figure 4 Distribution maps of potential suitable areas for barley cultivation on the Qinghai-Xizang Plateau in the medium-term future

From the perspective of long-term trends, as the three time periods evolved, the area unsuitable for highland barley cultivation has been shrinking, while the area suitable for highland barley cultivation has correspondingly expanded. In the medium-term future, when comparing the two scenarios, the area of medium- and high-suitability zones for highland barley cultivation under the RCP4.5 scenario is smaller than that under the RCP8.5 scenario, while the area of unsuitable zones is larger than that under the RCP8.5 scenario. At the same time, the medium-term future under the RCP8.5 scenario is the period with the lowest proportion of unsuitable areas and the highest proportion of highly suitable areas, reflecting how extreme emission scenarios profoundly reshape the upper limits of high-altitude crop cultivation. In terms of spatial distribution, the suitability for highland barley cultivation in the northwestern Qinghai-Xizang Plateau and the Qaidam Basin decreases or remains largely unchanged, while in the southern, central, and eastern parts of the Qinghai-Xizang plateau, suitability increases significantly, with the rate of increase becoming more pronounced over time.

5 Discussion and Conclusion

This dataset uses current data on highland barley cultivation areas on the Qinghai-Xizang Plateau to generate random highland barley sample points. Based on the MaxEnt model and environmental variables affecting highland barley cultivation, it estimates potential suitable areas for highland barley cultivation in the current period, the near-term future, and the medium-term future. Simultaneously, the accuracy of the simulation results is verified by comparing the current-period estimates with the current highland barley cultivation area data on the Qinghai-Xizang Plateau to ensure greater accuracy in predicting potential suitable areas for highland barley cultivation under the two future scenarios, thereby obtaining spatial distribution data at the grid scale for suitable highland barley cultivation areas. The dataset reflects the overall temporal changes in the spatial patterns of potential suitable areas for highland barley cultivation on the Qinghai-Xizang Plateau across different future periods and scenarios. It demonstrates that while habitat conditions improve during the early stages of climate warming and moistening, extreme emission scenarios also affect the upper limits of cultivation for high-altitude crops.

This dataset can be used to analyze the spatial distribution of suitable areas for highland barley cultivation under various future scenarios. It not only provides a basis for optimizing highland barley cultivation patterns and conducting quantitative assessments of disaster exposure, but also offers data support for decision-making related to the development of distinctive agriculture on the Qinghai-Xizang Plateau, food security, and climate change

adaptation. This dataset supported the corresponding author's doctoral thesis in Science.

Author Contributions

Wei, Y. and Liu, X. processed the data and authored the data paper; Liu, F. G., Zhou, Q. and Chen, Q. designed the algorithms based on the model; Ma, W. D. oversaw the overall design of the dataset development; Wei, Y. implemented and validated the data.

Conflicts of Interest

The authors declare no conflicts of interest.

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