Land Desertification Sensitivity Assessment Based on Comparative Validation of Field Survey and Observation Interpretation: A Case Study of Shaanxi Province (Postprint)

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Abstract

Comparing and validating actual ecological sensitivity survey results with observation-interpretation results, and subsequently making corrections, holds significant theoretical and practical significance for enhancing the accuracy and scientific rigor of ecological sensitivity assessments. Based on remote sensing interpretation and climate observation data, this study constructs an evaluation index system for land desertification sensitivity, assesses land desertification sensitivity in Shaanxi Province, and integrates the findings from the fifth desertification and sandification survey in Shaanxi Province to compare and validate the sensitivity evaluation results, analyze discrepancies between actual survey and observation-interpretation results, and correct the observation-interpretation-based evaluation results of land desertification sensitivity. The results indicate that: (1) Observation-interpretation results reveal significant spatial variation in land desertification sensitivity across Shaanxi Province, with extremely sensitive areas primarily located in Yulin City, Yan'an City, and Weinan City of Shaanxi Province. (2) Actual survey results show that land desertification areas identified in the fifth desertification and sandification survey are mainly distributed along the Great Wall region in northern Yulin City. (3) Discrepancy characteristics demonstrate that 92.5% of land desertification areas from actual survey results exhibit spatial overlap with observation-interpretation-based land desertification sensitivity evaluation results, yet only 71.8% of extremely sensitive zones from observation-interpretation show spatial overlap with actual survey land desertification areas. (4) The causes of these discrepancies lie in three aspects: data source errors, model construction errors, and index assignment errors. (5) The corrected land desertification sensitivity evaluation results for Shaanxi Province indicate that extremely sensitive regions are primarily situated in Yulin City, northern

Yan'an City, and Dali County of Weinan City, representing an area increase of 110.41 km^2 compared to the observation-interpretation-based evaluation results. Based on the causes and characteristics of these discrepancies, the ecological sensitivity evaluation system and analytical framework can be specifically improved.

Full Text

Abstract

Comparing and verifying actual ecological sensitivity survey results against observation and interpretation data, followed by necessary corrections, holds significant theoretical and practical importance for improving the accuracy and scientific rigor of ecological sensitivity assessments. Based on remote sensing interpretation and climate observation data, this study constructs an evaluation index system for land desertification sensitivity to assess land desertification sensitivity in Shaanxi Province. By integrating the actual findings from the Fifth Desertification and Sandification Survey in Shaanxi Province, we verify the sensitivity evaluation results, analyze discrepancies between actual surveys and observation-based interpretations, and subsequently refine the land desertification sensitivity assessment derived from observation and interpretation. The results indicate: (1) Observation and interpretation results reveal significant spatial variation in land desertification sensitivity across Shaanxi Province, with extremely sensitive areas primarily located in Yulin, Yan'an, and Weinan cities. (2) Actual survey results from the Fifth Desertification and Sandification Survey show that land desertification areas are mainly distributed along the northern Great Wall region in Yulin City. (3) Discrepancy characteristics demonstrate that 92.5% of land desertification areas identified in actual surveys spatially overlap with observation-interpretation based sensitivity evaluation results, yet only 71.8% of observation-interpreted extremely sensitive areas overlap with actual survey desertification areas. (4) The causes of these discrepancies stem from three aspects: data source errors, model construction errors, and indicator assignment errors. (5) The corrected land desertification sensitivity evaluation for Shaanxi Province indicates that extremely sensitive areas are primarily located in Yulin City, northern Yan'an City, and Dali County in Weinan City, representing a 71.8% increase in area compared to the observation-interpretation based evaluation. By addressing the causes and characteristics of these discrepancies, we can systematically improve the ecological sensitivity evaluation system and analytical framework.

Keywords: ecological sensitivity; land desertification; sensitivity evaluation; comparison and verification; Shaanxi Province

Ecological sensitivity refers to the responsiveness of ecosystems to natural environmental changes and human disturbances, representing a key research focus in contemporary ecology and geography. Among these, ecological sensitivity evaluation constitutes a critical research priority. Situated in northwestern China, Shaanxi Province's arid and semi-arid regions have long faced land degradation challenges driven by both human activities and natural environmental factors, with land desertification being the predominant sensitivity issue confronting the region's land environment. Land desertification sensitivity denotes the susceptibility to land degradation in arid, semi-arid, and sub-humid dry regions resulting from climate change, human activities, and multiple other factors. As awareness of desertification issues has grown, research on land desertification sensitivity has increased correspondingly. Quantitative assessment of regional land desertification sensitivity provides scientific support for addressing land degradation, promoting ecological conservation, and achieving sustainable development. Enhancing the scientific accuracy and precision of quantitative assessments represents the cornerstone and key challenge in ecological sensitivity evaluation research.

The European Environment and Climate Research Institute conducted the Mediterranean Desertification and Land Use (MEDALUS) project in 1999 to assess and monitor desertification sensitivity. The MEDALUS project primarily evaluates land cover sensitivity to desertification in Mediterranean regions and provides a set of key indicators for mapping specific areas at national scales, becoming one of the most widely used land desertification sensitivity evaluation methods internationally. China proposed a universal land desertification sensitivity evaluation method in 2002, which has been applied in national land desertification sensitivity assessments including the "Technical Guidelines for Ecological Function Zoning," "Guidelines for Ecological Conservation Redline Delineation," and "Evaluation of Resource Environmental Carrying Capacity and Territorial Spatial Development Suitability." For most study areas, the greatest obstacle in ecological sensitivity evaluation is data scarcity, which forces many assessments to rely on extremely coarse data foundations. For small-scale regions, data obtained through field observation and survey methods often suffice for ecological sensitivity evaluation needs. However, for large-scale regions, using observation and survey methods presents difficulties in data acquisition and high costs, while large-scale models often simplify numerous indicators due to data limitations, resulting in poor accuracy of final assessment results. During actual evaluation processes, the relationship between evaluation precision and evaluation objectives should be fully balanced, data sources and evaluation indicators reasonably selected, and final assessment results compared and verified against actual survey and observation data to ensure evaluation accuracy and enable ecological sensitivity assessments to truly support decision-making. Therefore, comparing and verifying land desertification sensitivity evaluation results based on actual surveys and observation interpretations holds significant importance for accurately identifying desertification-sensitive areas, scientifically delineating ecological conservation redlines for land desertification sensitivity, and formulating land desertification prevention and control strategies.

Given this context, this study takes Shaanxi Province as the research area, evaluates land desertification sensitivity based on observation and interpretation data including meteorological observations and remote sensing interpretation, and reveals the discrepancy characteristics and causes of land desertification sensitivity assessment results in the study area through comparative verification and analysis with actual survey data from the Fifth Desertification and Sandification Survey in Shaanxi Province. The ultimate goal is to obtain corrected land desertification sensitivity evaluation results based on comparative verification, providing practical and theoretical foundations for improving the accuracy of land desertification and ecological sensitivity evaluation research.

1 Study Area Overview

Shaanxi Province (105°29 ~111°15 E, 31°42 ~39°35 N) is located in inland China, covering an area of 205,624 km^2. The province features a continental monsoon climate with substantial north-south span, encompassing temperate arid and semi-arid climate, warm temperate semi-arid or semi-humid climate, northern subtropical humid climate, and warm temperate humid climate zones. Its northern region lies at the intersection of the Mu Us Sandy Land and the Loess Plateau, where land texture is loose, erosion resistance is poor, gully density is high, and water erosion is easily promoted. Some areas in Shaanxi Province have low vegetation coverage, coupled with long-term land reclamation and overgrazing, significantly increasing the risk of land desertification. Overall, land desertification in Shaanxi Province results from the combined effects of climate change, natural geographical conditions, plateau uplift, monsoon evolution, and unsustainable production practices.

[Figure 1: see original paper]

2 Data and Methods

2.1 Data Sources

This study covers the entire Shaanxi Province, with data processing conducted using ArcGIS 10.5. Land desertification sensitivity evaluation employs raster cells as assessment units at a resolution of 1 km × 1 km. Data sources and descriptions are provided in Table 1. Meteorological data including temperature, precipitation, and wind speed first underwent quality control using MATLAB to remove stations with severe data gaps, followed by interpolation to fill partial station data gaps. The digital elevation model (DEM) was then used to generate spatially interpolated datasets for temperature, precipitation, and wind speed using the professional meteorological interpolation software ANUSPLIN at a spatial resolution of 1 km. Soil property data including coarse sand, silt, clay, and organic matter were obtained from the China Soil Dataset for Land Surface Modeling, with corresponding soil factors calculated using raster calculations in ArcMAP at a spatial resolution of 1 km. The normalized difference vegetation index (NDVI) dataset was processed using maximum value composition to effectively eliminate atmospheric clouds, building shadows, and solar elevation angle effects. This study applied the dimidiate pixel model to calculate vegetation coverage for vegetation factor calculation at a spatial resolution of 1 km. Land use data were clipped and merged from secondary classifications to primary classes at a spatial resolution of 1 km. These datasets were then used to conduct land desertification sensitivity research in the study area.

2.2 Research Framework

The research framework for land desertification sensitivity evaluation primarily includes: assessing land desertification sensitivity based on observation and interpretation data, analyzing its spatial distribution characteristics and structure, and exploring spatial distribution patterns of land desertification sensitivity; mapping spatial distribution of land desertification areas based on actual survey data and analyzing their spatial distribution characteristics and structure; and finally, conducting mutual verification between the two evaluation approaches, analyzing discrepancy characteristics and causes, and correcting the observation-interpretation based land desertification sensitivity evaluation results (Figure 2).

[Figure 2: see original paper]

2.3 Methods

2.3.1 Universal Land Desertification Sensitivity Evaluation Method Land desertification sensitivity is closely related to factors including wind speed, rainfall, temperature, soil, terrain, and vegetation. Referencing the "Technical Guidelines for Ecological Function Zoning," "Guidelines for Ecological Conservation Redline Delineation," and "Evaluation of Resource Environmental Carrying Capacity and Territorial Spatial Development Suitability," this study classifies ecological sensitivity into three levels: generally sensitive, sensitive, and extremely sensitive (Table 2). The universal land desertification sensitivity evaluation method is employed, which includes four factors: dryness index, sand-driving wind days, soil texture, and vegetation coverage. The universal land desertification sensitivity evaluation formula is as follows:

$$D = I \times W \times K \times C$$

where D is the land desertification sensitivity index for the assessment area; I is the dryness index; W is the number of sand-driving wind days during winter and spring seasons ($>6\ \mathrm{m \cdot s^{-1}}$); K is soil texture; and C is vegetation coverage.

The calculation formulas for each factor in the universal land desertification sensitivity evaluation method are as follows:

(1) **Dryness Index**: The dryness index reflects the degree of dryness in a region and serves as an important indicator for measuring regional climate change. It is the ratio of potential evapotranspiration to precipitation, calculated using the modified Selianinov formula:

$$I = \frac{0.16 \times \sum T_{\geq 10^{\circ}C}}{P_{\geq 10^{\circ}C}}$$

where $\sum T_{\geq 10^{\circ}C}$ is the annual accumulated temperature $ $10°C (°C), and $P_{\geq 10^{\circ}C}$ is the annual precipitation during the period with temperature $ $10°C (mm). The dryness index was calculated using precipitation data from meteorological stations in Shaanxi Province over the past 30 years, with grade maps generated through spatial interpolation.

(2) **Sand-Driving Wind Days**: Wind strength is the most important factor in soil particle transport processes. The threshold wind speed for sandy soil is 6 $m \cdot s^{-1}$. Considering the soil types in the study area, we counted days with wind speeds greater than 6 $m \cdot s^{-1}$. This indicator was extracted by statistically analyzing the number of days with daily average wind speed >6 $m \cdot s^{-1}$ over 30 years to obtain sand-driving wind days.

(3) **Soil Texture**: Soil texture, a physical soil property, refers to the combination of various sizes of mineral particles in soil. In this study, the spatial distribution map of soil texture in the study area was obtained by vectorizing the soil texture map of Shaanxi Province.

(4) **Vegetation Coverage**: Vegetation coverage refers to the influence of vegetation cover and management on land desertification, primarily related to land use type. Vegetation quality can be represented using vegetation indices. Based on ModisNDVI data, vegetation coverage was calculated using the dimidiate pixel model:

$$C = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

where C is vegetation coverage; $NDVI$ is the normalized difference vegetation index; $NDVI_{min}$ is the minimum NDVI value for pure soil cover pixels; and $NDVI_{max}$ is the maximum NDVI value for vegetation cover pixels.

2.3.2 Fifth Desertification and Sandification Survey in Shaanxi Province According to the "National Desertification and Sandification Monitoring Technical Regulations" and the 2014 monitoring results, the monitoring scope for desertified land in Shaanxi Province was determined (including 12 counties: Dingbian, Jingbian, Hengshan, Yuyang, Shenmu, Fugu, Jiaxian, Mizhi, Zizhou, Suide, Qingjian, and Wuqi) and the monitoring scope for sandy land (including 9 counties/districts: Yuyang, Shenmu, Fugu, Hengshan, Jingbian, Dingbian, Jiaxian, Wuqi, and Dali). The Fifth Desertification and Sandification Survey in Shaanxi Province employed a combination of high-resolution remote sensing data interpretation and ground surveys, delineating patches and statistically calculating sandy land area in each region through field surveys and photographic documentation.

2.3.3 Overlay Analysis and Comparative Verification Using ArcGIS spatial analysis functions, land desertification sensitivity assessment results based on observation-interpretation data and land desertification degree evaluation results based on field survey data were subjected to spatial analysis and statistical overlay. Differential area patches were obtained by overlaying the two layers, with the reclassification function used to analyze patch types in discrepancy areas and summarize their characteristics. The Fifth Desertification and Sandification Survey evaluates the degree of land degradation that has already occurred, whereas land desertification sensitivity refers to the likelihood of desertification occurring—an assessment of potential future degradation. Higher degrees of desertification do not necessarily represent higher desertification sensitivity. However, areas that have already experienced desertification are typically regions with long-term high desertification sensitivity. Meanwhile, large-scale remote sensing interpretation evaluation results may suffer from insufficient accuracy, failing to identify all extremely sensitive areas. Field surveys, constrained by limited conditions, can often only be conducted in small-scale regions. Therefore, to obtain relatively accurate and comprehensive land desertification sensitivity evaluation results, this study corrects unidentified areas in the land desertification sensitivity evaluation to extremely sensitive areas based on overlay analysis, ultimately obtaining corrected land desertification sensitivity evaluation results based on comparative analysis.

3 Results

3.1 Comparative Analysis of Evaluation Results

3.1.1 Land Desertification Sensitivity Evaluation Based on Observation-Interpretation Data The evaluation results indicate that extremely sensitive areas for land desertification in Shaanxi Province cover 17,883.2 km^2, accounting for 8.7% of the province's total land area; sensitive areas cover 27,149.8 km^2, accounting for 13.2% of the total land area. Yulin, Yan'an, and Weinan cities have the largest proportions of extremely sensitive and sensitive area coverage. In terms of spatial distribution (Figure 3), the largest extremely sensitive area is in Yulin City, followed by Yan'an City, concentrated primarily in Dingbian County, Jingbian County, Hengshan District, Yuyang District, Shenmu City, and Wuqi County in Yan'an City. Extremely sensitive areas are predominantly distributed in belts, with some larger patches in certain regions. Small patches of extremely sensitive areas are distributed in Fugu County, Jiaxian County, Mizhi County, Wubao County of Yulin City, and Dali County of Weinan City. Sensitive areas are mainly distributed contiguously across most areas of Yulin City outside the extremely sensitive zones, and in belts along the border region between northern Yan'an City and Yulin City. Additionally, sensitive areas are distributed in small patches in Long County and Qianyang County in northern Baoji City, Changwu County and Binzhou City in northern Xianyang City, and southern Xi'an City;

larger areas are distributed in Weinan and Tongchuan cities, with substantial patches of land desertification sensitive areas. Overall, extremely sensitive land desertification areas are primarily located in arid climate zones in northern Shaanxi Province, at the southern edge of the Mu Us Desert, featuring flat terrain, severe wind erosion, low annual precipitation, and sand content significantly higher than other regions in the province. Sensitive areas mainly surround extremely sensitive zones, with small portions also distributed in the Guanzhong Plain region, concentrated primarily in the Weibei Dryland Area at the southern edge of the Loess Plateau, characterized by arid climate and relatively high sand content.

[Figure 3: see original paper]

3.1.2 Land Desertification Degree Evaluation Based on Actual Survey Data The Fifth Desertification and Sandification Survey in Shaanxi Province reveals that land desertification areas in the province cover 411.8 km^2, accounting for 0.2% of the province's total land area. The land type is predominantly grassland. The ranking of desertification area size by county/district is: Yuyang District, Shenmu City, Hengshan District, Dingbian County, Jingbian County, and Jiaxian County. In terms of spatial distribution (Figure 4), land desertification areas show sporadic patches in northern Dingbian County; the largest distribution area is in Yuyang District, with substantial irregular patches in the northeastern region; large areas are also distributed in both Shenmu City and Yuyang District; distribution in Jingbian and Dingbian counties covers the entire county areas but is more concentrated in the north. Additionally, desertification patches exist at the border between northern Jiaxian County and Yuyang District. Overall, land desertification areas in Shaanxi Province are primarily grassland distributed in the northern region along the Great Wall, belonging to arid climate zones bordering the southern edge of the Mu Us Desert, with flat terrain, low annual precipitation, and severe land desertification.

[Figure 4: see original paper]

3.2 Comparative Verification and Analysis

3.2.1 Discrepancy Characteristics from Comparative Verification According to ArcGIS spatial analysis and statistical overlay results, partial spatial overlap exists between land desertification sensitivity assessment results and desertification areas from the Fifth Desertification and Sandification Survey in Shaanxi Province (Figure 5). Overlapping areas between land desertification sensitive areas (including extremely sensitive areas) and desertification areas from the survey are mainly distributed in Yuyang District, Shenmu City, Hengshan District, Dingbian County, Jingbian County, and Jiaxian County of Yulin City, with substantial overlap area—over 92.5% of land desertification areas are land desertification sensitive areas (including extremely sensitive areas). Overlapping areas between land desertification extremely sensitive areas and land desertification areas are mainly distributed in Yuyang District, Shenmu City, Hengshan District, Dingbian County, and Jingbian County of Yulin City, with 71.8% of land desertification areas being extremely sensitive areas.

Non-overlapping areas are located in Yuyang District, Shenmu City, Hengshan District, Dingbian County, and Jingbian County of Yulin City, with relatively small non-overlapping area accounting for 7.5% of total desertification area. Based on land use types, these can be classified into 5 categories, among which grassland accounts for 64.3%, wasteland accounts for 20.2%, forestland accounts for 8.5%, cultivated land accounts for 5.8%, and construction land accounts for 1.2%. Larger forestland patches are located in Yuyang District, Shenmu City, and Jingbian County; larger grassland patches are located in Yuyang District, Shenmu City, Hengshan District, Jiaxian County, Dingbian County, and Jingbian County; larger cultivated land patches are located in Yuyang District, Shenmu City, Hengshan District, Dingbian County, and Jingbian County; larger wasteland patches are located in Yuyang District and Shenmu City; larger construction land patches are located in Yuyang District and Jiaxian County. Overall, non-overlapping areas are dominated by grassland and cultivated land, with cultivated land patches having relatively large total area and concentrated locations with numerous large patches; grassland patches have the largest total area but are scattered with numerous small patches; construction land patches have the smallest total area with relatively concentrated and contiguous locations including some large patches.

[Figure 5: see original paper]

3.2.2 Analysis of Unidentified Areas in Comparative Verification

Based on spatial analysis and statistical overlay results (Figure 6), the overlapping portion between generally sensitive areas and desertification areas represents unidentified regions in the observation-interpretation based land desertification sensitivity evaluation. Results show that 7.5% of land desertification areas in Shaanxi Province do not overlap with land desertification sensitivity evaluation results. Unidentified areas are mainly distributed in Yuyang District, Shenmu City, Hengshan District, Dingbian County, and Jingbian County of Yulin City. According to land use types (Table 5), unidentified areas can be classified into 5 categories, with grassland accounting for 64.3%, wasteland accounting for 20.2%, forestland accounting for 8.5%, cultivated land accounting for 5.8%, and construction land accounting for 1.2%.

[Figure 6: see original paper]

3.2.3 Analysis of Discrepancy Causes in Comparative Verification

Generally speaking, data from actual surveys exhibit relatively high accuracy. Therefore, discrepancy causes should primarily exist in the observation-interpretation based land desertification sensitivity evaluation results. Through analysis of the land desertification sensitivity evaluation model and process, discrepancy causes from comparative verification can be summarized into three aspects:

(1) **Data Source Errors**: Observation-interpretation data primarily originate from satellite remote sensing data and meteorological station observations. Due to limited numbers of satellites and meteorological stations, many fundamental data such as meteorological data require spatial interpolation in areas not covered by observation sources, often causing errors in ecological baseline data. In this study, data for accumulated temperature, precipitation, and wind intensity were obtained from 98 observation stations in Shaanxi Province, with spatial interpolation performed using only one interpolation method, lacking cross-validation and accuracy analysis across different methods, while insufficient consideration of influencing factors such as elevation and latitude/longitude led to final result errors.

(2) **Model Construction Errors**: Mathematical models are important tools for ecological evaluation. When conducting quantitative analysis of complex natural phenomena, complex mathematical models are often required. Applying identical mathematical models across all regions often leads to mismatches between model construction and actual conditions, affecting final evaluation results. This study employed the universal land desertification sensitivity evaluation method including four factors: dryness index, sand-driving wind days, soil texture, and vegetation coverage. Some scholars have improved model accuracy through modifications such as replacing the dryness index with soil moisture as an objective indicator reflecting regional dry-wet changes, or revising the sand-driving wind days factor to a wind power factor based on the revised wind erosion model. This study's use of the unmodified universal land desertification sensitivity evaluation model may have caused final result errors.

(3) **Indicator Assignment Errors**: Ecological sensitivity indicators form the foundation of ecological sensitivity evaluation. During indicator construction and assignment, insufficient consideration of various dimensions and mismatches in methodology or applicable conditions often cause errors in final ecological sensitivity evaluation results. This study applied a uniform evaluation index system for Shaanxi Province, lacking localized evaluation index systems based on actual conditions and inter-regional differences, as well as stratified and zoned evaluation standards and thresholds. This ultimately led to inapplicability and mismatch of the index system in some regions, causing evaluation errors.

3.3 Corrected Observation-Interpretation Land Desertification Sensitivity Evaluation Based on Actual Survey Results

Based on actual survey results, the observation-interpretation land desertification sensitivity evaluation was corrected by reclassifying unidentified areas in the land desertification sensitivity evaluation as extremely sensitive areas (Figure 7). The corrected land desertification sensitivity evaluation results show extremely sensitive areas covering 17,993.7 km^2 (8.8% of Shaanxi Province's total land area) and sensitive areas covering 10,431.7 km^2 (5.1% of total land area). The ranking of extremely sensitive area size by city is: Yulin City, Yan'an City, Weinan City.

In terms of spatial distribution (Figure 7), corrected extremely sensitive areas are primarily located in Yulin City, with small distributions in northern Yan'an City and individual small patches in Weinan City. Specifically, extremely sensitive areas have large distributions in the northern parts of Dingbian, Hengshan, and Jingbian counties; the largest distribution area is in Yuyang District, with substantial irregular patches in both northern and central regions; large patches exist in central, northern, and southern Shenmu City; patches are distributed in northern and southern Fugu County, concentrated in the northeastern region; and small patches are distributed in Dali County of Weinan City. Corrected sensitive areas are mainly distributed in Jiaxian County of Yulin City and Wuqi County of Yan'an City outside extremely sensitive areas. Specifically, sensitive areas have substantial distributions in Yuyang District and Shenmu City; they are distributed throughout Jingbian and Dingbian counties but concentrated in the north; additionally, sensitive area patches exist at the border between northern Jiaxian County and Yuyang District. Overall, areas with higher land desertification sensitivity after correction are primarily distributed in arid climate zones, mainly in belts with some small contiguous areas. The corrected evaluation results increase the extremely sensitive area by 110.4 km^2 compared to the observation-interpretation based evaluation.

[Figure 7: see original paper]

4 Discussion

Existing ecological sensitivity evaluation studies predominantly use either actual survey data or observation-interpretation data as the sole data source to conduct ecological sensitivity evaluation research, lacking comparative verification between actual surveys and observation interpretations. This study focuses on comparative verification across three aspects of ecological sensitivity evaluation between actual surveys and observation interpretations. Through overlay analysis, we compare and verify unidentified areas in ecological sensitivity evaluation results between actual surveys and observation interpretations, and summarize the causes of unidentified areas. Based on actual survey results, we correct observation-interpretation evaluation results to obtain more accurate corrected ecological sensitivity evaluation results. Combining evaluation results with discrepancy causes, ecological sensitivity evaluation research should adopt corresponding measures to improve accuracy and scientific rigor. For example, regarding data sources and interpolation processes, multiple interpolation method cross-validation can improve accuracy; regarding model construction errors, model revision can enhance accuracy; regarding indicator assignment errors, localized evaluation index systems can be constructed from perspectives of different geographical units such as northern Shaanxi, southern Shaanxi, and Guanzhong to improve accuracy.

Actual survey-based ecological sensitivity evaluation methods demonstrate higher accuracy than observation-interpretation based methods, but actual surveys are often limited by high costs and can only be conducted in key areas. Therefore, how to effectively and scientifically combine actual surveys with observation interpretations should become a future research priority in ecological sensitivity assessment. Observation-interpretation based evaluation methods can be applied in larger-scale regions to provide scientific foundations and research bases for actual surveys and mutual verification. On this basis, identifying key areas and conducting actual survey research in these regions to correct observation-interpretation results represents an effective approach for combining actual surveys and observation interpretations. Simultaneously, future research should improve observation-interpretation methods to enhance their accuracy and thereby promote progress in ecological sensitivity assessment research.

5 Conclusions

This study on land desertification sensitivity evaluation based on comparative verification of actual surveys and observation interpretations yields the following conclusions:

(1) Observation-interpretation results reveal significant spatial variation in land desertification sensitivity across Shaanxi Province, with extremely sensitive areas primarily located in northern Yulin region. The ranking of extremely sensitive area size by county/district is: Yuyang District, Shenmu City, Hengshan District, Dingbian County, Jingbian County, and Jiaxian County, distributed mainly sporadically.

(2) Actual survey results from the Fifth Desertification and Sandification Survey show that land desertification areas in Shaanxi Province are predominantly grassland, mainly distributed in the northern region along the Great Wall. The ranking of important area size by county/district is: Yuyang District, Shenmu City, Hengshan District, Dingbian County, and Jingbian County.

(3) Comparative verification shows that 92.5% of land desertification areas from the Fifth Desertification and Sandification Survey in Shaanxi Province spatially overlap with land desertification sensitivity evaluation results, but only 71.8% of desertification areas overlap with extremely sensitive desertification areas. This indicates that observation-interpretation based evaluation results basically identified land desertification sensitive areas, but certain deviations remain in identifying extremely sensitive areas compared to actual survey data.

(4) Corrected land desertification sensitivity evaluation results show extremely sensitive areas distributed in Yulin City, northern Yan'an City, and Dali County in Weinan City. The corrected results increase the

extremely sensitive area by 110.4 km^2 compared to the observation-interpretation based land desertification sensitivity evaluation.

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Note: Figure translations are in progress. See original paper for figures.