Correlation Analysis between Soil and Land Use in Typical Sample Areas of Northern Henan Province

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Abstract: Based on the calculation results of constituent diversity and spatial distribution diversity of soils and land uses in a typical region of northern Henan province, the new pedodiversity methodology was applied for exploring the intrinsic relationship of the geo-spatial distribution patterns between the regional soils and land use types. Our results showed that the soil constituent diversity of case area was 0.819 that means the soil composition in case area was more complicated. There was a certain connection between soil area and soil distribution diversity due to the soil types with the largest area and the highest spatial distribution diversity and the soil types with the smallest area and the lowest spatial distribution diversity have high overlap in various grid scales. Through the calculation and analysis of the correlation coefficient between 4 representative soils and land use types, it was found that the superposition relationship between soil and land use in case area became more complex over time.

1. Introduction

In the early 1990s, Ibáñez et al. [1] introduced the concept of “diversity” widely used in the field of ecology in the study of soil geomorphological landscape complexity, and established the theory and measurement method of soil diversity. In recent years, with the deepening of the cross-combination of different disciplines such as soil science, geography, information technology, geostatistics, information entropy [2] and ecological theory, the spatial pattern of soil and its topography, water body and land use Research reports on the degree of interaction between factors have also appeared at home and abroad, and related research methods are becoming more mature [3-7]. For example, by studying the soil diversity and soil formation factors of the Zain River Valley in central Iran, Toomanian et al. [8] evaluated the degree of soil heterogeneity in the area. The study found that the soil and soil landscape evolution was quantitatively evaluated by the Xiannong entropy. good effect. Zhang Xuelei et al [9-11] based on the soil diversity theory based on the data of Hainan Island, Shandong Province and Jiangsu Province, realized the digital expression of soil diversity analysis methods in the GIS environment. With the deepening of soil diversity research, research methods have become more mature, and more theoretical methods of related disciplines have begun to be integrated. The combination of various methods and soil diversity research has greatly promoted the research progress of soil diversity theory. [12].

There is a direct or indirect link between the diversity of soil distribution and the diversity of land use patterns. This study takes the typical research area in northern Henan as an example. The Xiannong entropy deformation formula, soil diversity theory and spatial grid concept proposed in the previous research [13] provide in-depth analysis and support to quantitatively describe soil and land use. The spatial distribution characteristics and the interaction between the two, in order to grasp the basic information such as the spatial distribution and interaction degree of soil and land use in the study area, provide theoretical and data support for the sustainable and rational use of regional land resources.

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2. Materials and methods

2.1 Overview of the study area

Select the typical research area in the northern part of Henan Province, with a central coordinate of 114°52'E, 35°12'N, including the municipal district of Fuyang City and its jurisdiction of Nanle County, Taiqian County, Neihuang County, Qingfeng County and Fan County. City, Huaxian County, and Xinxiang City, Mayor County, Fengqiu County. The study area is long in the north and south, narrow in the east and west, and located in the middle and lower reaches of the Yellow River. It is a temperate monsoon climate and the terrain is dominated by plains. The soil includes 21 soil types such as small dihedral, dihedral, and sandy.

2.2 Data source

The Landsat image was selected as the remote sensing data source. Two time-phase remote sensing data covering the study area were selected on May 24, 2000 and May 12, 2013. The data for landsat 5 TM sensor in 2000 was 2013. Year is landsat 8 OLI sensor data. Since the two scenes are similar in image acquisition season, the study ignores the time difference between the data. Other relevant data include soil map vector data from the northern part of Henan based on the second soil survey.

2.3 Research methods

The remote sensing data is supervised and classified, and the obtained land use classification images are vectorized to obtain the land use vector classification map of the typical sample area in northern Henan. Calculate the soil diversity index based on soil genus, calculate and calculate the plaque area, and obtain the compositional diversity index of soil and land use in typical sample areas in northern Henan, and calculate soil and land use under different scale grids. Distribution spatial distribution diversity index. Finally, a comprehensive evaluation of the intrinsic relationship between soil and land use spatial distribution and its diversity index is established by establishing correlation coefficients. The study divides the typical plot area land in northern Henan into six types of utilization: urban construction land, water and water conservancy facilities, agricultural land, forest land, transportation land, and other land.

Using the diversity index, the Shannon entropy formula, the diversity measure is calculated as:

$$H = -\sum p_i \ln p_i \tag{1}$$

Where H is the Shannon entropy index, pi is calculated by calculating ni/N, ni is the area covered by the i-th soil category individual, and N is the total area of the study area. H indicates the degree of diversity of soil species, and the value range is [0, lnS]. When H value is 0, it means that the single soil belongs to the whole area. When the soil is completely evenly distributed, the maximum value lnS is taken, and S indicates the number of soil types.

In order to more intuitively describe the spatial discrete distribution characteristics of a single object, a Xiannong entropy deformation formula [13] is used:

$$Y_h = \frac{-\sum_{i=1}^{S} p_i \ln p_i}{\ln S} \tag{2}$$

Where S and pi are defined as follows:

(1) When studying the compositional diversity of soil and land use composition, pi represents the proportion of the i-th soil or land use in the total area of all soils or land use, and S represents the number of soil types. Under this premise, the diversity index Yh indicates the degree of uniformity of all taxa in terms of composition. At this time, the Yh shape is the same as the classic Pielou evenness index in ecological studies.

(2) If the distribution diversity of soil or land use is studied at a spatial scale, pi represents the ratio of the area of the research object contained in a certain grid to the total area of the object, and S represents the number of spatial grids. Yh characterizes the spatial dispersion of a soil type or land use type. The value of Yh is between 0 and 1. When Yh=0, the object is concentrated in a grid. When Yh=1, the study is expressed. The same proportion of objects are distributed in each grid of the region, with the highest degree of dispersion.

In order to explore the relationship between soil spatial distribution and spatial distribution of land use, this study uses the correlation coefficient based on the concept of information theory mutual entropy to qualitatively and quantitatively describe the interaction between the two. The correlation coefficient formula is defined as follows:

$$r(A,B) = \frac{2Y_h(A,B)}{Y_h(A) + Y_h(B)} \tag{3}$$

In the formula, Yh(A) represents the spatial distribution index of soil spatial distribution, and Yh(B) represents the spatial distribution diversity index of land use. It can be known from formula (2) that Yh(A, B) is defined as:

$$Y_h(A,B) = \frac{-\sum_{i=1}^{S}\sum_{j=1}^{S} p(i,j)\ln p(i,j)}{\ln S} \tag{4}$$

Where p(i, j) is called the joint probability, indicating the area ratio when soil type A and some type of land use type B contain both (the common part of the overlap), and Yh(A, B) represents soil A and land. Utilize the spatial distribution diversity of B common plaques.

3. Results and analysis

3.1 Land use supervision classification

In the land use classification (Fig. 1, Table 1), agricultural land mainly includes low urbanization areas such as cultivated land, villages, and rural roads; urban construction land mainly includes high urbanization areas such as main urban areas and townships; unutilized land mainly includes river beaches. The land area mainly includes large-scale forest farms; the water and water conservancy facilities mainly include rivers, lakes, fish ponds, high-grade irrigation ditches and other surface water bodies; roads mainly include highways, national highways, provincial highways, railways, airports, etc.

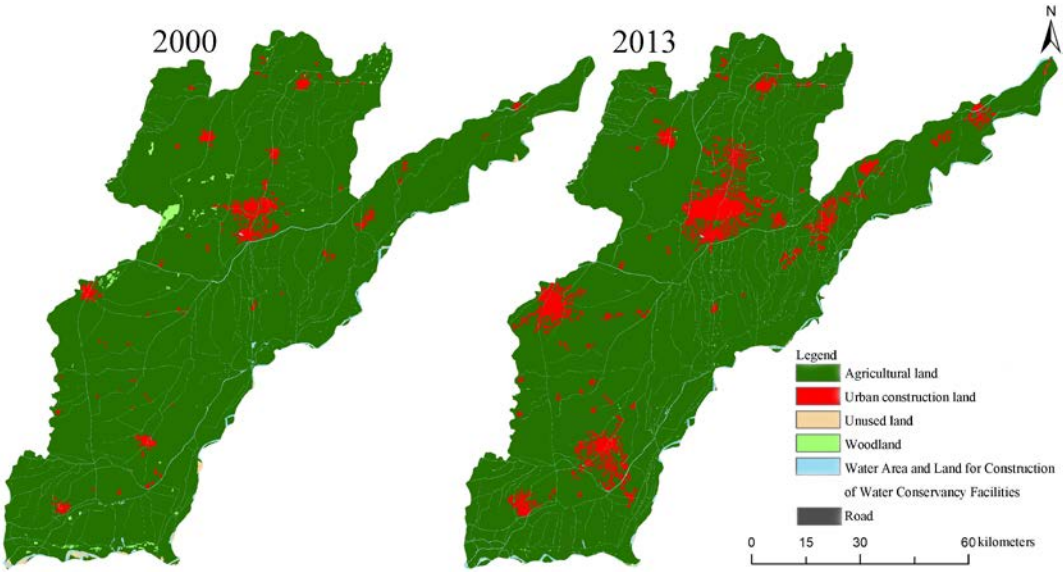

Figure 1 Distribution of land use in the case area in 2000 and 2013

Table 1 Area of land use in the case area (km2)

Year	Water and water conservancy facilities	Agricultural land	Woodland	Transportation land	Urban construction land	Other land
2000	199.69	8791.28	52.23	37.85	200.74	26.72
2013	235.38	8338.74	3.38	164.25	624.88	11.97

3.2 Analysis of compositional diversity

The study area contains 21 soil types and 6 land use types, which can be calculated by formula (2): the soil composition component diversity is 0.819, indicating that the soil types in the study area are generally uniform in area distribution, and there is no The case where a certain type of soil area accounts for a large proportion (the value will tend to zero) or the area of each soil is close (the value will tend to 1). In 2000, the compositional index of land use composition was 0.161, and in 2013 it was 0.257. Combined with the development history of regional cities, it indicated that the agricultural land in the study period decreased by 452.54km2, accounting for 5.15% of the initial value of the study period. This part of agricultural land is mainly converted into The land for transportation and the land for urban construction make the distribution of land use in the region more uniform.

3.3 Analysis of spatial distribution diversity

In the study of spatial distribution diversity, different size grid elements have a greater impact on the results. To more accurately express the spatial distribution discrete characteristics of the research objectives, the study uses a variety of grid scales [14] to comprehensively evaluate the spatial distribution diversity of research elements. Characteristics (Table 1). In this study, three different size grid scales of 5km, 3km and 2km are set, and the mean value is calculated to increase the analysis precision. The spatial distribution diversity index of the same soil is slightly different under different grid scales.

Table 2 Spatial distribution diversity of soil genus in the case area

Name of the soil	Total area/km^2	5km grid	3km grid	2km grid	Mean
Dihedral soil	1465.90	0.813	0.808	0.813	0.811
Silt soil	851.27	0.736	0.740	0.749	0.742
Bottom sticky Dehumidification sandy soil	829.17	0.722	0.731	0.739	0.731
Sandy soil	1148.97	0.787	0.785	0.791	0.788
Flowing meadow wind sandy soil	5.78	0.133	0.215	0.219	0.189
Fixed meadow wind sandy soil	189.94	0.605	0.604	0.609	0.606
Small dihedral soil	1920.50	0.852	0.848	0.848	0.849
Lumbar sandy soil	255.13	0.563	0.590	0.605	0.586
Dehumidification soil	443.35	0.619	0.640	0.655	0.638
Meadow salt soil	3.38	0.0334	0.187	0.103	0.108
Desiccated sandy soil	372.54	0.617	0.636	0.649	0.634
Waist sandy silt soil	196.95	0.575	0.577	0.591	0.581
Alkaline fluvo-aquic soil	416.85	0.651	0.662	0.6723	0.661
Salinized fluvo-aquic soil	479.26	0.666	0.681	0.686	0.678
Sandy soil	24.50	0.355	0.372	0.391	0.373
Irrigation and silt soil	88.12	0.478	0.490	0.506	0.491
Semi-fixed meadow wind sandy soil	56.88	0.440	0.468	0.470	0.459
Meadow alkaline soil	9.41	0.157	0.246	0.244	0.216
Bottom sandy soil	54.18	0.312	0.373	0.416	0.367
Bottom sticky sandy soil	7.05	0.191	0.116	0.195	0.167
Ash alluvial soil	21.44	0.324	0.362	0.372	0.353

It is found that the soils with the highest area in the sample area and the highest spatial distribution diversity index under the three grid scales are small mixed soils with the smallest area in the sample area and the lowest spatial distribution diversity index under the three grid scales. The soil is a meadow salt soil. In addition, taking alkalized fluvo-aquic soil and dehumidification two-combustion soil as an example, the area of the dehumidified two-concrete soil is larger than that of the alkalized fluvo-aquic soil, but the spatial distribution diversity of the alkalized tidal soil is larger than that of the dehumidification.

The study also calculated the spatial distribution diversity of land use types in the two years of the plot in the 3km grid scale (Table 3). Combined with Table 1, the study found that, except for "other land use", the spatial distribution diversity characteristics of each land use type are the same as the area change characteristics, that is, while the area of a certain land use type increases or decreases, the plaque is in the study area. The degree of spatial distribution dispersion shows the same increase and decrease trend.

Table 3 Spatial distribution diversity of land use in the case area

Land use type	2000 Spatial distribution diversity	2013 Spatial distribution diversity
Water and water conservancy facilities	0.898	0.914
Agricultural land	0.988	0.987
woodland	0.548	0.505
Transportation land	0.794	0.925
Urban construction land	0.627	0.740
Other land	0.443	0.492

In summary, there are obvious differences and correlations between the area statistical method and the spatial distribution diversity evaluation method. Combining the calculation formulas of the two evaluation methods, both can objectively reflect the distribution characteristics of the research object in the study area, but the traditional area statistical method focuses on the total distribution evaluation, and the spatial distribution diversity focuses on the distribution breadth and discrete evaluation.

3.4 Correlation analysis of spatial distribution of soil and land use

Four typical soil genera (Fig. 2), which are small mixed soil, dihedral, sandy and silt, were selected as representative soil types in the study area, and soil and land use correlation analysis was carried out. The four soils were simultaneously satisfied. Maximum area and maximum spatial distribution diversity screening conditions. The common area between the four soils and the six land uses was counted (Table 4), and the representative soil types and land use types in the study area were calculated in three grids by formulas (3) and (4). Mean of correlation coefficient at scale (Table 5).

Table 4 Correlation coefficient between representative soil and land use

Year	Associated soil genus	Water and water conservancy facilities	Agricultural land	Woodland	Transportation land	Urban construction land	Other land
2000	Small dihedral soil	0.785	0.965	0.155	0.62	0.357	0.106
	Dihedral soil	0.781	0.967	0.368	0.525	0.355	0.051
	Sandy soil	0.758	0.974	0.315	0.435	0.214	0.001
	Silt soil	0.809	0.97	0.137	0.527	0.266	0.031
2013	Small Dihedral soil	0.824	0.962	0.236	0.845	0.503	0.038
	Dihedral soil	0.8	0.965	0.155	0.854	0.545	0
	Sandy soil	0.78	0.969	0.13	0.725	0.328	0.033
	Silt soil	0.874	0.962	0.131	0.786	0.431	0

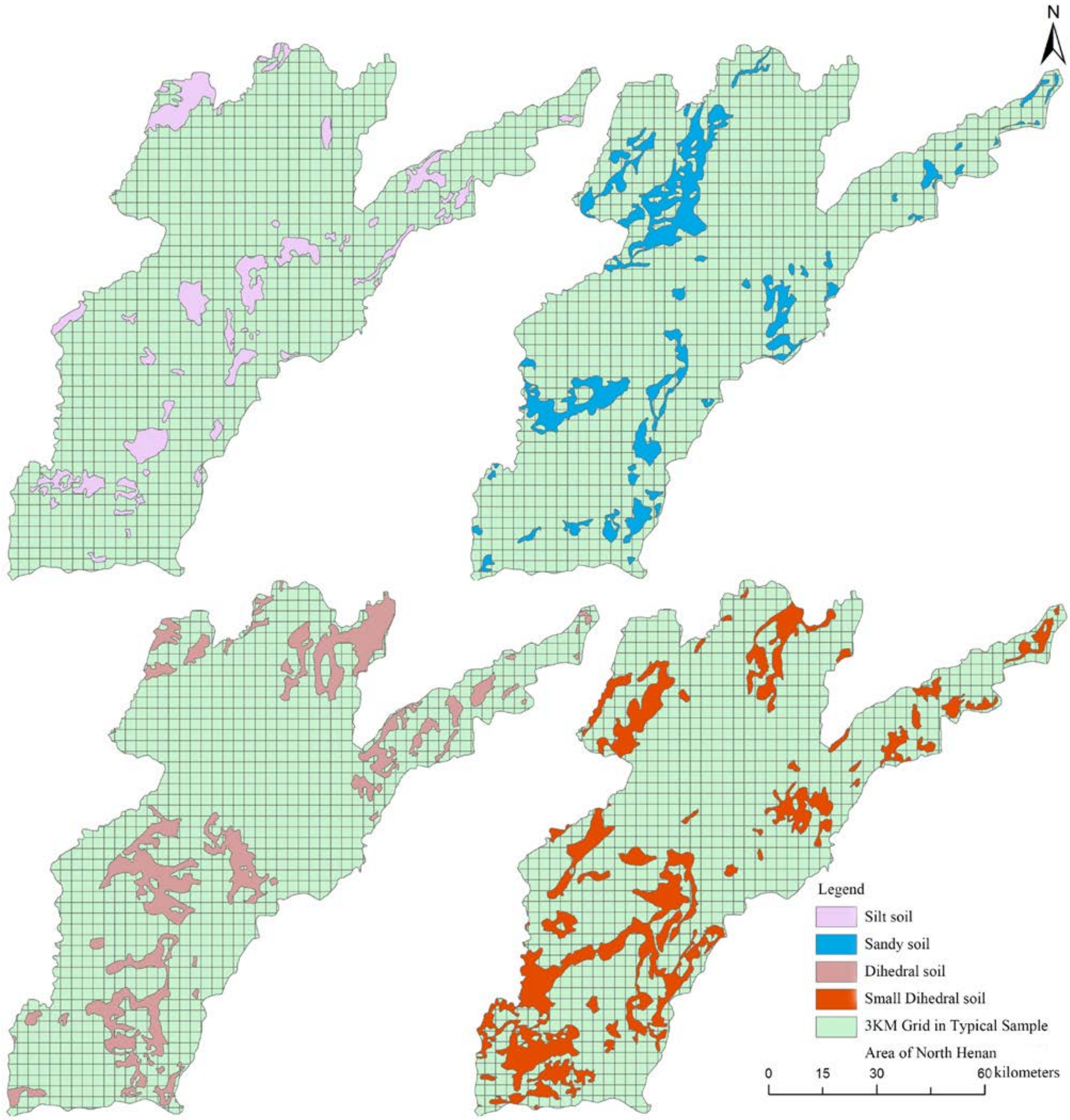

Figure 2 Distribution of representative soil types

Note: The data in Table 4 are the mean values of correlation coefficients at 3 grid scales of 5 km, 3 km and 2 km.

It is generally believed that the priority of urban expansion is always the high-quality soil type with better fertility. Among the representative soil types selected in this study area, the small dihedral, the dihedral, the sandy and the silt are the same as the fluvo-aquic soil. The sub-class of tidal soil is a typical type of cryptodomain soil. The volcanic sub-type distribution area is generally flat, with deep soil layers, rich water and heat resources, and good tillability. The research data show that (Table 4, Figure 3), the correlation coefficient between each representative soil type and transportation land and urban construction land has been significantly improved, of which transportation land is more significant, transportation land and urban construction land The correlation coefficient growth rate is around 0.5. This indicates that the urbanization expansion of the Yubei sample area was carried out simultaneously at the spatial level during the research period, and the construction of roads and railway networks achieved remarkable results. Except for the increase of the correlation coefficient between the small soil and the forest land, the correlation coefficient between the other representative soil types and the forest land is in a negative growth state, and the correlation coefficient between the representative soil types and other land uses is also greatly reduced. The negative growth rate outside the soil is below 0.5. At the same time, the correlation coefficient between each representative soil type and agricultural land showed a certain degree of decline, and the growth rate of the correlation coefficient between the four representative soil types and agricultural land remained at a low level, indicating that within the research period ten Over the years, the city has expanded, and a large number of high-quality soil types have been transformed from cultivated agricultural land to urban areas with hard underlying surfaces, but their correlations have remained above 0.96, indicating that these high-quality soils with good tillage It is still widely used for agricultural cultivation. While the regional urbanization level maintains a relatively high speed development, it also ensures that large areas of high-quality farmland are not encroached. This also reflects the urbanization process of the northern Henan sample area during the research period. While reasonably advancing, there is still much room for development.

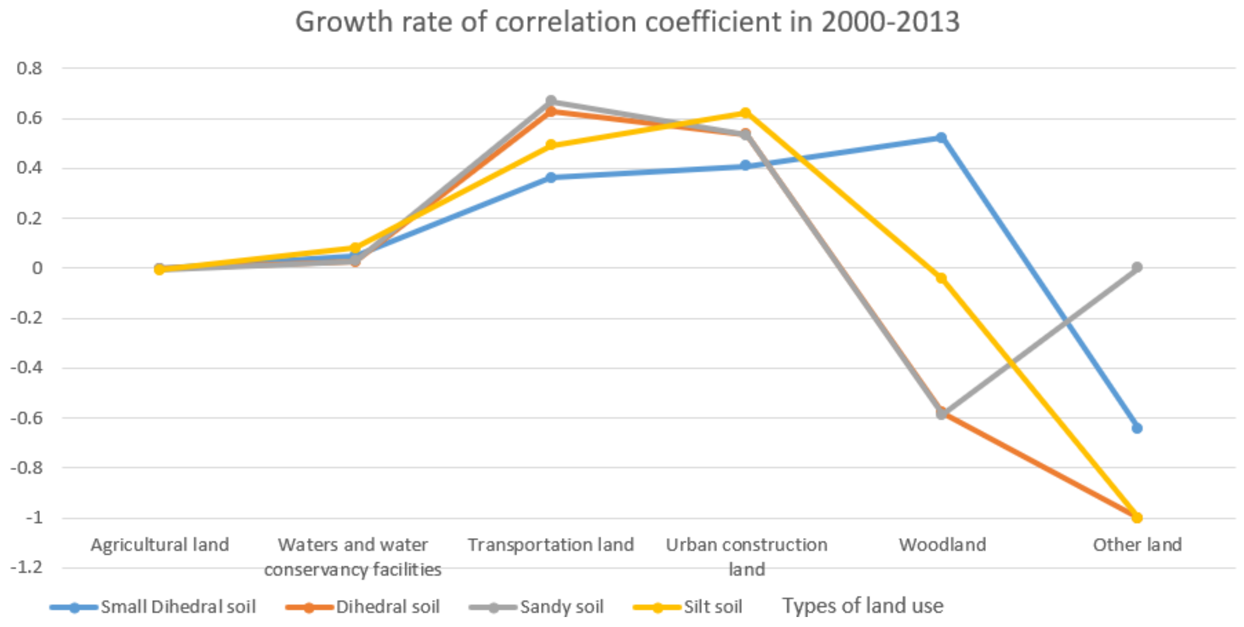

Figure 3 Growth rate line chart of correlation coefficient between representative soil and land use

Note: The water use land is called the water area and the water conservancy facilities. The traffic land is called the transportation land. The urban land is called the urban construction land. Here is the shorthand.

4. Conclusion

Based on the theory and method of soil diversity, the paper deeply analyzes the interaction between soil and land use in the typical research area in northern Henan. The research shows that: (1) the land use change during the study period is large, which is in the area statistics and soil diversity. It is reflected in the calculation that a large number of high-quality soil types are encroached and converted into hard underlying surfaces of urban attributes; (2) The four representative soil types in the study area are small dihedral, dihedral, sandy And the silt, the area of which exceeds 800km2, the spatial distribution diversity is greater than 0.74, and the meadow saline soil should receive more attention and protection as the endangered soil type in the study area; (3) the traditional resource area statistical method focuses on The evaluation of the total spatial distribution of the research objects, while the spatial distribution diversity focuses on the evaluation of the breadth and dispersion of the research objects; (4) During the research period, the correlation between the representative soils of the sample areas and land use is deepening. In particular, the degree of association with the hard underlying surface of urban attributes has been significantly improved, indicating that the transportation development in the Yubei sample area has achieved remarkable results, and the urbanization of the area to maintain the development of agriculture, there is still much room for development in the future.

An in-depth analysis of the degree of correlation between soil and land use can provide theoretical and data support for regional urban development planning and sustainable and rational use of resources, while soil diversity research provides accurate quantitative concepts and methods for future the research has broad application prospects and development space.

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References

[1] Ibáez J J, De-Alba S, Bermúdez F F, et al. Pedodiversity concepts and tools [J]. Catena, 1995, 24: 214-232.

[2] Ren Jintong, Chen Qunli, Mo Shijiang, et al. Scale Effect Analysis of DEM on Terrain and Watershed Characteristics in Typical Karst Mountainous Areas[J]. Journal of Xinyang Teachers College(Natural Science Edition), 2018, 31(2): 247 -253.

[3] Jin Jia, Yan Liang. Analysis of the Correlation between Soil Diversity and Land Use Types in Fuxin City[J]. Surveying and Spatial Geography Information, 2018, 41(01): 205-210.

[4] Zhang Liangliang, Qi Yanbing, Liu Wei, et al. Diversity and Correlation Analysis of Soil and Land Use in Xi'an City[J]. Soils, 2017, 49(06): 1268-1274.

[5] Chen Xinwei, Guo Jianying, Dong Zhi, et al. Effects of different land use types on soil fractal characteristics along the Huanglan section of Wulanbuhe Desert[J]. Journal of Arid Land Resources and Environment, 2015, 29(11): 169-173.

[6] Geng Huanxia, Zhang Xiaolin, Li Hongbo. Study on the Impact of Administrative Center Residents on County Land Use Landscape Pattern--A Case Study of Feng County, Jiangsu Province[J]. RESOURCES AND ENVIRONMENT IN THE YANGTZE BASIN, 2015, 24(1): 1-7.

[7] Gan Xiaoyu, Chen Yi, Zhou Bo. Analysis of Ecological Significance of Urban Landscape of River Corridor[J]. Environment and Environment of Yangtze River Basin, 2014, 23(12): 1678-1683.

[8] Toomanian N, Jalalian A, Khademi H, et al. Pedodiversity and pedogenesis in Zayandeh-rud Valley, Central Iran [J]. Geomorphology, 2006, 81: 376-393.

[9] Zhang Xuelei, Chen Jie, Zhang Ganlin. Analysis of the diversity of soil properties on different topography of Hainan Island[J]. Acta Geographica Sinica, 2003, 58 (6): 839-844.

[10] Wang Hui, Zhang Xuelei, Zhang Wei, et al. Analysis of soil composition and nesting in Nanjing[J]. Chinese Journal of Ecology, 2007, 27(1): 220-227.

[11] Wang Hui, Zhang Xuelei, Zhang Wei, et al. Analysis of Temporal and Spatial Changes of Urbanization Land Use in Nanjing Based on Nested Subset Method[J]. JOURNAL OF SOILS, 2007, 39(3): 421-427.

[12] Zhang Xuelei. Soil Diversity: An Opportunity for Soil Geography Research[J]. Soils, 2014, 46(01): 1-6.

[13] DUAN Jinlong, ZHANG Xuelei. Correlation evaluation of soil diversity and land use diversity based on Xiannong entropy[J]. Journal of Soil Science, 2011, 48(05): 893-903.

[14] Duan Jinlong, Zhao Feifei, Zhang Xuelei. Selection Strategy of Grid Size in Soil Spatial Distribution Diversity Study[J]. JOURNAL OF SOIL, 2014, 46(5): 961-966.