Research Article

Dynamic Study of Soil Erosion in Greater Khingan Forest

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Abstract: Based on the amended model of RUSLE universal soil loss equation and GIS technology, combined with the natural geographical features of Great Khingan, it has conducted quantitative analysis of the factor in Soil loss equation. Uses 2000 and 2010 years TM images classification are land uses/cover type figure, we gets all factors values of space distribution in the RUSLE model, gets soil erosion volume estimates data and soil erosion strength distribution figure based on grid cell data and obtained Great Khingan soil erosion strength grade distribution figure and through the terrain niche index and spatial center of gravity transfer model theory, revealed soil erosion in the temporal and spatial evolution of Greater Khingan in 11 years. Study results indicate that during the 2000 and 2010 period, the amount of soil erosion in Greater Khingan shown overall upward trend, the slightly erosion area is reduced, the low erosion area is increased, several other types of erosion intensity had no obvious change.

Keywords: GIS, great khingan, RUSLE, soil erosion, terrain niche

INTRODUCTION

Soil erosion is the main reasons for the degradation of land resources, as a key point of sustainable development, Soil erosion has become the important factor that worsen ecological environment and restrict agricultural production (Liu *et al.*, 2004). Soil erosion research began in the late 19th century, in 1877 the German soil scientist Bwald Wollny related research, observation and qualitative description is limited to surface phenomena (Fernandez *et al.*, 2003). Starting in the 1920s, some scholars began to quantitative research of soil erosion, in the 60s, the results of such research are also from experience. With the development of the neighboring disciplines, the improvement of test methods and the rise of computer technology, gradually establish a mathematical model of some of the physical simulation of erosion process. In the 80s, with the rapid development of science and technology and computer technology is increasingly perfect, erosion and sediment yield research is developing rapidly, a large number of research results. Especially after the 90s (Mo *et al.*, 2004), the RS and GIS development and extensive application of further research provides a powerful tool for people, model study also began to transition to a distributed by lumped type, scholars at home and abroad a large amount of soil erosion model is put forward. According to the modeling means and methods of soil erosion model is different, generally can be divided into empirical statistical model and the physical cause model (Marques *et al.*, 2007). Empirical statistical models are mainly from the perspective of erosion factors, through the observation data and statistical techniques, studying on the erosion and rainfall, vegetation, soil, topography, soil and water conservation measures such as the relation between factors. Empirical statistical models abroad to the America universal soil loss equation (Nazzareno and Gianni, 2007) 1978 and revised universal soil equation (Wang *et al.*, 2007) 1997 is typical representative. Physical genesis model based on the physical process of soil erosion, use of hydrology, hydraulics, soil science, the basic principle of river sediment dynamics, as well as other related disciplines, according to the known conditions of rainfall and runoff to describe the process of soil erosion and sediment yield and prediction of soil erosion within a given period of time, but as a result of the calculation is very complicated related research is not much. In addition, earth observation system of "3s" technology in spatial information acquisition, storage, management, update, analysis and application of the three major support technology, is one of the scientific method of soil erosion research towards the quantitative, also more and more widely used in the study of soil erosion. Soil erosion is the main reasons for the degradation of land resources, as a key point of sustainable development, Soil erosion has become the important factor that worsen ecological environment and restrict agricultural production.

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This research use the GIS's powerful spatial analysis function to deal with the data of remote sensing image, combined with the basic theory of soil erosion, Terrain niche index and Spatial center of gravity transfer theory model to analyze the situation of soil erosion with quantitative way at the Great Khingan area from 2000 to 2011, to determine the intensity level of soil erosion and analyze it comprehensively.

REGIONAL OVERVIEW AND RESEARCH METHODOLOGY

Greater Khingan is located range longitude 121° 12 ' to 127° 00', north latitude 50° 10 ' to 53° 33'. Things across 6 longitudes, 3 latitude north-south border, are the most northern homeland. Heilongjiang province is located in the northwest, northeast the Inner Mongolia Autonomous Region, Greater Khingan Range Mountains in the northeast slope, in the river and Nenjiang two earthquake fault zone. The East and bordering the West and small Xingan mountains, Inner Mongolia mountains of Greater Khingan Range for the joint line, south of the Songnen Plain, the northern border with Russia, the main channel of Heilongjiang Province as the center line. The area is 83000 km^2, located in the area of the administrative region of Heilongjiang province is 64800 km^2, accounting for 78.1% of the total area, the rest belong to the jurisdiction of the Inner Mongolia Autonomous Region.

This study is based on factor of soil erosion data, using the RUSLE model for quantitative evaluation changes of soil erosion in Greater Khingan from 2000 to 2010; Using the concept of terrain to investigate the change characteristics of soil erosion in study area based on terrain gradient variation; Using the theoretical model, to investigate the transfer characteristics of soil erosion intensity in the study area based on all levels of the spatial scales. To provide the basic data and theoretical basis for industrial and agricultural production layout of Greater Khingan.

RUSLE model and soil erosion calculation: On the basis of RUSLE we can comprehensively analyze that the natural elements influent on the soil erosion, among the entire influential factor, there are five factors is most important that are rainfall erosion force factor, soil erodibility factor, terrain factor, vegetation and crop management factor and soil conservation measures factor. The RUSLE has strong practicability, the general expression (Liu *et al.*, 2004) is:

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P \tag{1}$$

In the expression, A is soil erosion and expresses the Annual average erosion of slope sheet erosion and rill erosion per unit area. the unit is ton/ha, R is the factor of rainfall erosivity, The unit is MJ•mm/ha/h, K

is soil erodibility factor and express the amounts of soil loss per unit area that form under rainfall erosion force in standard area, the unit is ton•h/MJ/mm, L is slope length factor, S is slope steepness factor, generally we can combine the L and S as LS to consider this issue, C is vegetation and crop management factor; P is soil conservation measures factor.

R is a constant based on years of experience. Studies on different level terrain soil erosion intensity distribution, the number and proportion of each soil erosion intensity is the analysis of common indicators.

In order to eliminate the terrain gradient-t segmentation and intensity of soil erosion area differences, this study use the terrain distribution index to describe the distribution characteristics of different soil erosion intensity in the terrain gradient. Calculation formula of distribution (Fernandez *et al.*, 2003) index is as follows:

$$P = \left(S_{ie} / S_i\right) / \left(S_e / S\right) \tag{2}$$

In the expression, P is distribution index, S_{ie} is the soil erosion area of the i level in special grade. S_i is the total area of the i level in the whole study region. S_e is the total area contains e Species terrain niche. S is the total area of study region. P is a standardized dimensionless index. When P value is greater, that shown some types of soil erosion in the higher frequency (Wang *et al.*, 2008). When $p<1$, indicating that the terrain of the soil erosion intensity distribution is non dominant terrain.

RESULT ANALYSIS

In the ArcGIS10.0 platform, using raster calculator which belong to the spatial analysis module, Can obtained the amount of Soil Erosion Spatial Distribution Map which Multiplicated by R, K, C, P, LS five raster layer. The imperial units to convert the unit, multiplied by 224.2 to t/ (km^2•a) metric units, obtained amount of soil erosion of pixel. refers to the classification standard of soil erosion intensity that is enact by ministry of water resources (Hong *et al.*, 2003), as shown in Table 1, get estimation of the soil erosion amount of Greater Khingan in 2000 and 2010 and get the two period spatial distribution of soil erosion in the study area, as shown in Fig. 1.
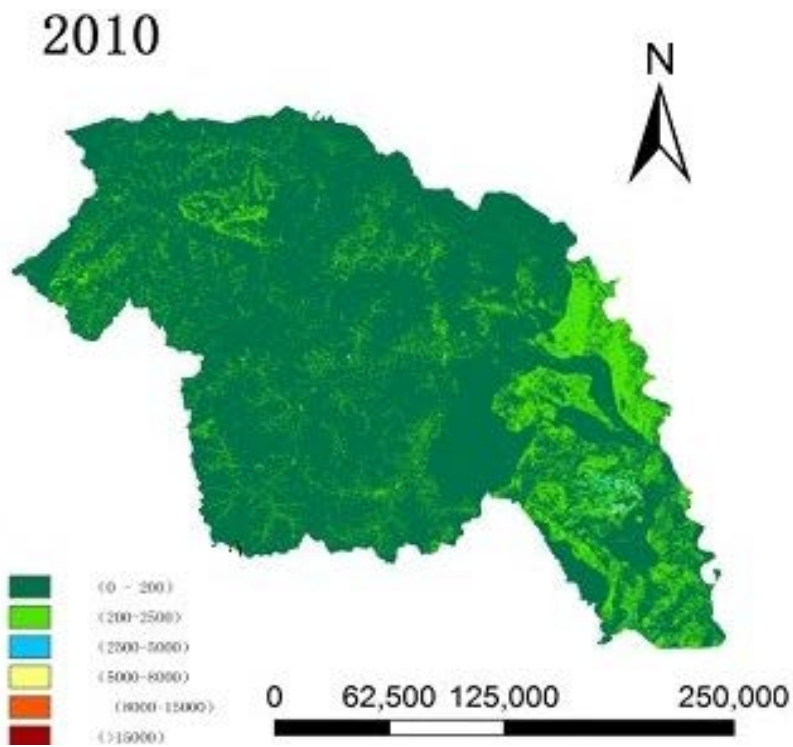
Table 1: The soil erosion intensity classification criterion (SL190-96)

Erosion intensity	Level	Avg. erosion modulus t/ (km^2·a)
No obvious erosion	1	< 200
Slightly erosion SI	2	200-800
Slightly erosion SII	3	800-1500
Slightly erosion SIII	4	1500-2500
Moderate erosion	5	2500-5000
Intensive erosion	6	5000-8000
High intensive erosion	7	> 8000

Avg.: Average
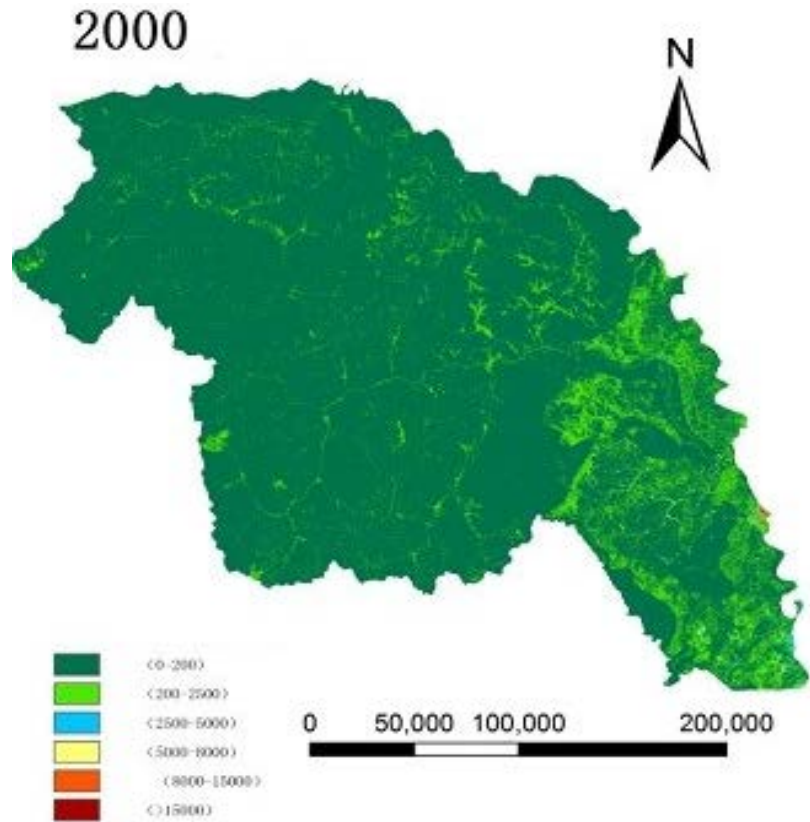
(a)

(b)

Fig. 1: Spatial distribution of soil erosion intensity in greater khingan

Table 2: Characteristic of soil erosion in greater khingan during 2000-2010

Erosion intensity	2000			2010	
	Erosion amount (×106t)	Avg. erosion modulus (t/km^2)		Erosion amount (×106t)	Avg. erosion modulus (t/km^2)
Slightly erosion	2.89	6.21		3.21	7.86
Low erosion	2.59	56.00		4.44	57.81
Medium erosion	0.61	432.26		0.61	417.67
High erosion	0.50	746.32		0.37	780.03
Very high erosion	0.32	1308.60		0.19	1295.70
Extreme erosion	0.15	2487.41		0.03	2547.62
Greater khingan	7.06	5036.80		8.85	5106.69

Avg.: Average

Table 3: Variation of soil erosion intensity in greater khingan during 2000-2010

Erosion intensity	2000		2010		Area change (km^2)	Change rate (%)
	Areas (km^2)	Proportion (%)	Areas (km^2)	Proportion (%)		
Slightly	57855.29	90.25	53925.92	84.12	-3929.3700	-6.13
Low	5953.43	9.29	9865.10	15.39	3911.6800	6.10
medium	176.43	0.28	182.02	0.28	5.5809	0.01
high	82.95	0.13	59.27	0.09	-23.6800	-0.04
Very-high	30.52	0.05	18.74	0.03	-11.7900	-0.02
Extreme	7.78	0.01	1.63	0.00	-6.15000	-0.01

Table 4: The conversion matrix between different grades of soil erosion during 2000-2010

Years	Erosion intensity	2010						2000 total
		Slightly	Low	Medium	High	Very high	Extreme	
2000	Slightly	50958.78	6716.63	101.27	32.28	6.90	0.28	57816.13
	Low	2848.09	3002.86	60.70	19.97	7.32	0.71	5939.66
	Medium	75.76	86.74	10.01	2.54	0.92	0.10	176.07
	High	34.70	39.37	5.31	2.23	1.00	0.07	82.69
	Very-high	7.08	16.33	3.82	1.65	1.47	0.07	30.42
	Extreme	1.51	3.17	0.90	0.60	1.13	0.41	7.71
2010 total		53925.92	9865.10	182.01	59.27	18.73	1.63	64052.67

From 2000 to 2010, the intensity of soil erosion in Greater Khingan showed a rising trend, the result is shown in Table 2.

According to Table 3, in the period of 2000 to 2010, Amplitude of variation of slightly erosion and low erosion areas are large, the slightly erosion area from 57855.29 km^2 in 2000 to 53925.92 km^2 in 2010, area of slightly erosion reduces 3929.37 km^2, proportion of the study area decreased from 90.25% in 2000 to 84.12% in 2010, the change rate is-6.13%; the low erosion area from 5953.43 km^2 in 2000 to 9865.10 km^2 in 2010, low erosion area increased 3911.65 km^2, the proportion of the study area increased by 6.10%. The remaining strength of several soil erosion changed little, medium erosion increased slightly, Erosion intensity, intensity erosion and acute erosion has decreased. High erosion, very-high erosion and extreme erosion has decreased. On the whole, slightly erosion decreased, but low erosion increased and most of the slightly erosion are changed into low erosion.

Using the ArcGIS software, do overlay opera-tions by two periods of soil erosion intensity on 2000 and 2010; get the mutual transformation between the soil erosion intensity grade levels from 2000 to 2010, the statistical results are shown in Table 4.

According to Table 4, the data above The transfer matrix diagonal right is erosion enhanced part between 2000 and 2010 years, the total area is 6947.54 km^2, including slightly erosion metastasis to at least low erosion area is 6857.36 km^2; low erosion metastasis to at least medium erosion area is 88.7 km^2; high erosion metastasis to at least very-high erosion area is 1.07 km^2; Very-high erosion metastasis to at least extreme erosion area is 0.41 km^2.

The data located in the bottom left of the transfer matrix diagonal is reducing part between 2000 and 2010 years, the total area is 5938.25 km^2, including extreme erosion metastasis to at least following Very-high erosion area is 7.31 km^2, Very-high erosion metastasis to at least following high erosion area is 28.88 km^2, high erosion metastasis to at least following medium erosion area is 79.38 km^2, low erosion metastasis to slightly erosion area is 2848.09 km^2.

According to above analysis result, extreme, very high and high erosion are all decreased in Greater Khingan from 2000 to 2010, while slightly erosion to low erosion transformation trend is obvious, the first reason may be human activity of surface vegetation destroyed and the other reason is enhancing of the rainfall erosion force 11 years also increased soil erosion.

Divided the terrain niche index of Greater Khingan into 30 levels and Work out Distribution index of 6 levels which contained slightly, low, medium, high,
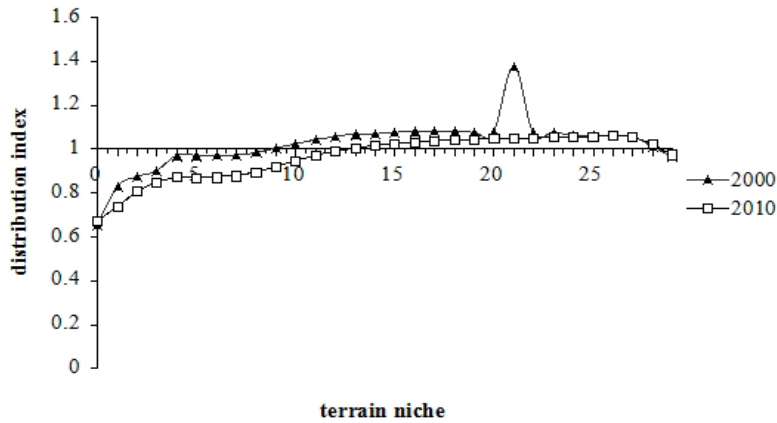
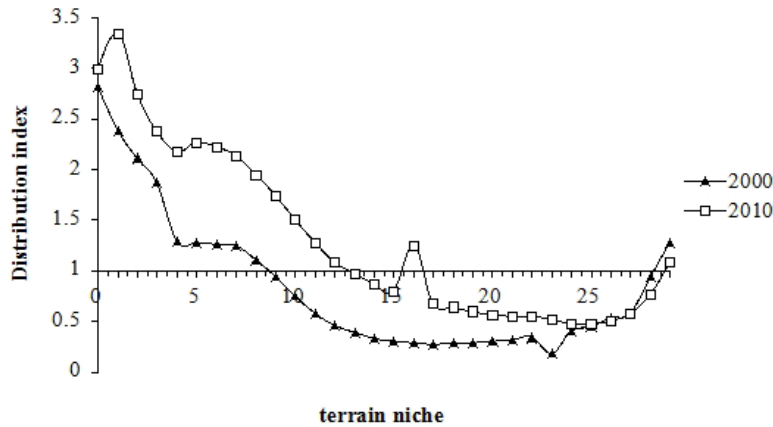Fig. 2: Relationship between slight soil erosion intensity and terrain niche gradient

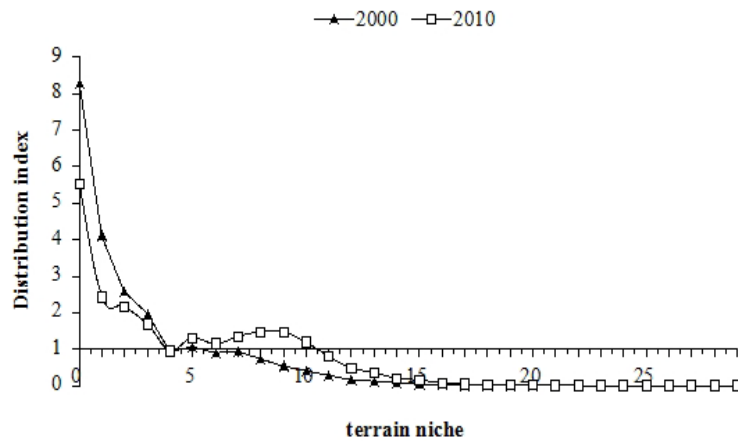Fig. 3: Relationship between low soil erosion intensity and terrain niche gradient

Fig. 4: Relationship between medium soil erosion intensity and terrain niche gradient

very high and extreme in 2000 and 2010. When p>1, it's the advantage of interval of erosion. On the whole, the distribution patterns of soil erosion intensity in different types on terrain gradient performance some changes.

Figure 2 is a distribution on terrain gradient on the erosion of slightly soil in Greater Khingan in 2000 and 2010. In 2000, slightly erosion superiority distribution index is between 9 and 29 which are between 13 and 28 in 2010; It is shown that slightly erosion types decreased in 11 years.

Figure 3 is a distribution on terrain gradient on the erosion of low soil in Greater Khingan in 2000 and 2010. Compared with the slightly erosion, low erosion

are mainly distributed in low and high shape interval. Distribution index showed a rising trend after the first reduction. The peak terrain is 2, From 2000 to 2010, the advantage of terrain from 1-9 and 29-30 into 1-12, 15-17, 30, the advantage of terrain in the expansion trend, The distribution indexs are higher in 2010 than in 2000, it is shown that low erosions is increased in 11 years.

Figure 4 is a distribution on terrain gradient on the erosion of medium erosion in Greater Khingan in 2000 and 2010. On the whole, terrain distribution index of medium erosion is decreases, the peak distributed in 1-2 terrain level, from 2000 to 2010, the advantage of terrain from 1-4, 6 expansion to 1-4, 6-11, but terrain niche index values are decreased in 11 years, it is shown that the overall moderate erosion reduced.

Figure 5 is a distribution on terrain gradient on the erosion of high soil in Greater Khingan in 2000 and 2010. The intensity of erosion distribution index decreased, the peak distribution in 1-2 terrain, from 2000 to 2010, the advantage of terrain from the 1-4 expansion to the 1-4, 8-9, however terrain niche index values decreased in 11 years. It is an Explanation that the overall strength of erosion reduces.

Figure 6 is a distribution on terrain gradient on the erosion of very high soil in Greater Khingan in 2000 and 2010. The intensity of erosion distribution index decreases, the peak distribution in 1-2 terrain, from 2000 to 2010, the advantage of terrain are shrink, from 1-4 to 1 and terrain niche index values are decreased, it explained that the overall intensity erosion in reducing in 11 years.
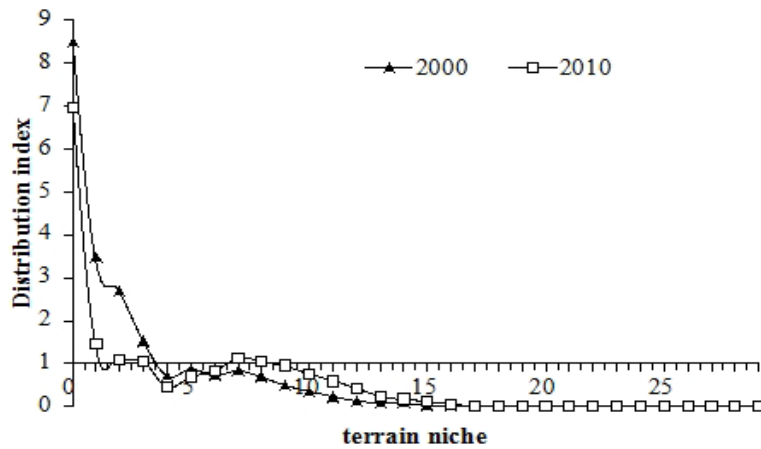

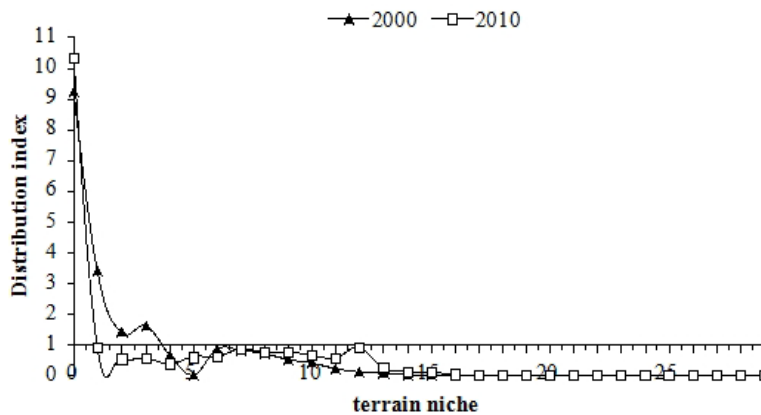Fig. 5: Relationship between high soil erosion intensity and terrain niche gradient

Fig. 6: Relationship between very high soil erosion intensity and terrain niche gradient

Table 5: The direction and distance of gravity transfer of different erosion dintensity in greater khingan from 2000 to 2010

|	Slightly	Low	Medium	High	Very-high	Extreme
2000 latitude and longitude	124.10, 52.35	125.30, 52.04	126.36, 51.56	126.30, 51.58	126.37, 51.66	126.58, 51.70
2010 latitude and longitude	124.06, 52.34	124.99, 52.16	126.08, 51.74	126.26, 51.73	126.37, 51.73	126.57, 51.77
Moving distance (km)	1.98	25.11	29.22	19.07	10.12	8.13
Expansion direction	Southeast	Northwest	Northwest	Northwest	Northwest	Northwest
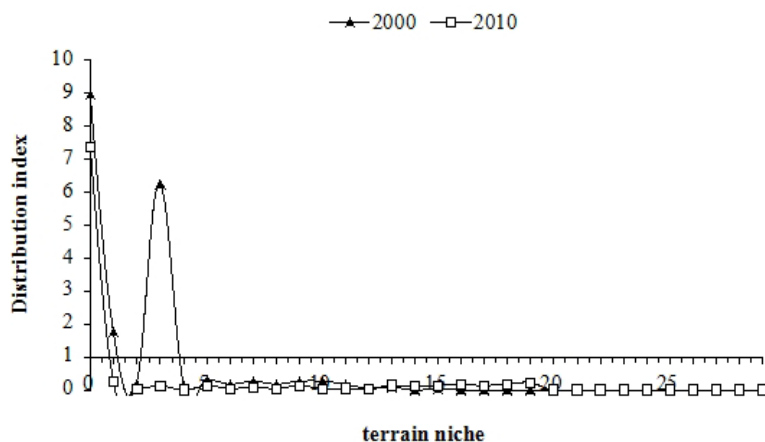
Fig. 7: Relationship between extreme soil erosion intensity and terrain niche gradient
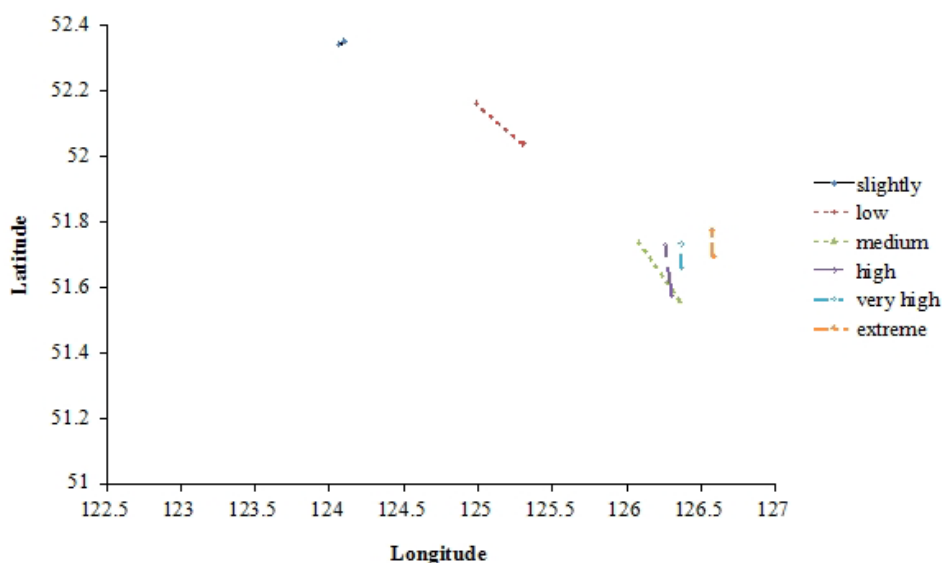

Fig. 8: Transfer center of gravity of different erosion intensity in greater khingan

Figure 7 is a distribution on terrain gradient on the erosion of extreme soil in Greater Khingan in 2000 and 2010. The intensity of erosion distribution index are decreased, the peak distribution in 1-2 terrain, from 2000 to 2010, the advantage of terrain shrink, from 1-2, 4 to 1 and the terrain niche index values are decreased, it is shown that extreme erosion is also declined.

Using the spatial center of gravity transfer model, analysis the soil erosion intensity transfer of Greater Khingan from 2000 to 2010. From 2000 to 2010, is shown in Table 5 and Fig. 8, in addition to slightly erosion expansion to the southeast area, center of gravity of several other types of soil erosion intensity to the northwest shift, but the specific angular offset and offset distance is different. The slightly erosion offset the shortest distance which is 1.98 km and the medium erosion off-set the longest distance which is 29.22 km, the low soil erosion followed by 25.11 km and the other types is shown in Table 5.

CONCLUSION

This study based on the RUSLE model, analyze the situation of soil erosion of Great Khingan area from 2000 to 2011 and through the terrain niche index and spatial center of gravity transfer model theory, revealed soil erosion in the temporal and spatial evolution of Greater Khingan in 11 years. The main conclusion is:

- From 2000 to 2010, the amount of soil erosion in Greater Khingan shown overall upward trend, the slightly erosion area is reduced 3929.37 km[2], the low erosion area is increased 3911.65 km[2], several other types of erosion intensity had no obvious change. On the whole, the decreased area of slightly erosion is fit to the increased area of low erosion. So the total soil erosion is increased in Greater Khingan.

- The Constraint function of Terrain to the time and space of the soil erosion which is in Greater Khingan is very obvious, the distribution pattern of soil erosion intensity in different types on a topographic gradient showed significant variation. During 2000 and 2010, Slightly erosion is shown shrinkage tendency and low erosion is shown expansion trend in the terrain, other types of erosion in the topographic position did not change significantly, it is shown that types of transformation from slightly erosion to low erosion in 11 years.

- From 2000 to 2010, in addition to slightly erosion expansion to the southeast area, center of gravity of several other types of soil erosion intensity to the northwest shift, but the specific angular offset and offset distance is not the same. The slightly erosion offset the shortest distance which is 1.98 km and the medium erosion offset the longest distance which is 29.22 km, the low soil erosion followed by 25.11 km. The regional soil erosion is facing tremendous pressure; it should strengthen the management, formulate corresponding measures for soil and water conservation.

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