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Variations in Ecosystem Service Value in Response to Land use Changes in the Loess Plateau in Northern Shaanxi Province, China

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ABSTRACT: In this paper, we report an investigation of changes in land use and ecosystem services on Loess Plateau in northern Shaanxi Province from 1978 to 2004. We used three LANDSAT TM and/or ETM data sets to estimate changes in the size of five land-cover/land-use categories, and we also used previously published value coefficients to estimate changes in the value of ecosystem services delivered by eachland category. Finally, we ranked the contribution of various ecosystem functions to the overall value of the ecosystem services. we have estimated that the annual value of the ecosystem services is 56.95 billon RMB in the loess plateau in northern shaanxi province in 2004. In the loess plateau in northern shaanxi province, from 1978 to 2004, the economic value of the fixing carbon are higher, the economic value of water conservation are lowest, but the economic value of the NPP, fixing carbon and supplying oxygen account for total value above the ninety percent, obviously the vegetation own created the biggest ecosystem service value.We conclude that future land-use policy formulation should give precedence to the conservation of these ecosystems over uncontrolled reclamation, and that further land reclamation should be based on rigorous environmental impact analyses.

Key words: Landuse, Ecosystem services, Value, Environment, Conservation

INTRODUCTION

Ecosystem service valuation has been a hot topic in ecological economic research. Ecosystem services can be defined as the conditions and processes through which natural ecosystems and the species that comprise them, sustain and fulfill human life (Daily, 1997), or the goods and services provided by ecosystem which contribute to human welfare, both directly or indirectly (Costanza *et al.*, 1997a,b). There is a growing volume of literature on ecosystem service valuation. Abramovitz (1998) pointed out that ecosystem services have extensive economic value but that they are not credited for the non-market values they provide until they become depleted. While economic tools can be used to identify trade-offs between known ecological values, it remains challenging to link technical measures of ecosystem services to attributes that can be effectively evaluated by untrained individuals (Schaberg *et al.*, 1999).For example, Lewandrowski et al. (1999) estimated the costs to regional economies from setting aside land to protect ecosystem diversity. Bolund and Hunhammar (1999) analyzed the ecosystem services generated by ecosystems within the urban area. Woodward and Wui (2001) used ameta-analysis to assess the relative value of different wetland services. Kreuter et al. (2001) estimated changes in land-use and ecosystem service values due to urban sprawl in the San Antonia area, Texas. Konarska et al. (2002) made a comparison of NOAA/AVHRR and Landsat TM datasets and evaluated the scale example, Lewandrowski et al. (1999) estimated the costs to regional economies from setting aside land to protect ecosystem diversity. Bolund and Hunhammar (1999) analyzed the ecosystem services generated by ecosystems within the urban area. Woodward and Wui (2001) used ameta-analysis to assess the relative value of different wetland services. Kreuter et al. (2001) estimated changes in land-use and ecosystem service values due to urban sprawl in the San Antonia area, Texas. Konarska et al. (2002) made a comparison of NOAA/AVHRR and Landsat TM datasets and evaluated the scale.

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MATERIALS & METHODS

The Loess Plateau in northern Shaanxi Province includes Yulin、Yanan cities and Tongchuan city mainly, which is near western Shaanxi province, northern xi'an city in Shaanxi province, eastern Gan Su Province, and southern Inner Mongolia (from E107.3° to

E111.4° and from N34.8° to N39.59°) (Fig. 1). It covers 83990.067km^2, and accounts for 40.81% of the total area in Shaanxi Province. The population is 6059000, which accounts for 17.31% of the total population in Shaanxi Province. The kind of physiognomy is complicated and various, including the transitional region of the sand and wind, the hilly-gully fragile region, the pimple mound region from North to South. The land use patterns are varied. It is obvious that the mixture of farm-meadow zone and farm-forest zone. The soil erosion and hazards of sand storms have been serious for a long time. The loess hills districts, where the forest-grassland of temperate zone distributed, is the transitional region from forest to grassland. There are certain differences between the western and the eastern. There is hay region along the Great Wall in northern Shaanxi Province. In this southern district, the type of vegetation is summer green foliage forest of the temperate zone, which distributes on Huanglong Mountain and Ziwu Hill mainly.

The data used to estimate changes in the size of various ecosystems were extracted from three cloud-free LANDSAT Thematic Mapper (MSS¸Tm and ETM) images obtained in 1978¸1990 and 2004. Although these satellite images were pre-geo-referenced, they could not be compared directly because the coordinate reference system and resolution used in each image was not consistent. To reduce potential position errors between the three data sets, we used a three-step image preparation procedure. First, we identified the X and Y coordinates of pairs of points that represent prominent features on both the 2004 ETM image and the 1:100,000 topographic map of Shaanxi Province (Shaanxi Province Municipal Institute of Surveying and Mapping). Second, we used the same topographic map as the geo-referenced standard together with the GEOREFERENCING and RESAMPLING modules of IDRISIs Release 2 software (Clark Labs, 2001) to resample the 2004 ETM data set into a Universal Transverse Mercator (UTM) coordinate system. Next, using the same procedure as in the second step and the geo-rectified 2004 data as the master dataset, we resampled and rectified the 1990 and 1997 TM RAW images. Average root mean square (RMS) error of less than 0.5 in step 2 and 3 is achieved for all the images and the pixel size was kept as 30_30m^2.

In this study, the data sets were reclassified into eight categories, including Cultivated land, Garden, Forest, Grassland, Residential and traffic land, Water body, Sand, and Unused land (Table 1). The land use map was then edited, calibrated and coded in ARCVIEWGIS software for the subsequent calculation of ecosystem service value and spatial analysis. In order to obtain ecosystem values for each of the five land-cover categories used to classify the LANDSAT datasets, an ecosystem services valuation

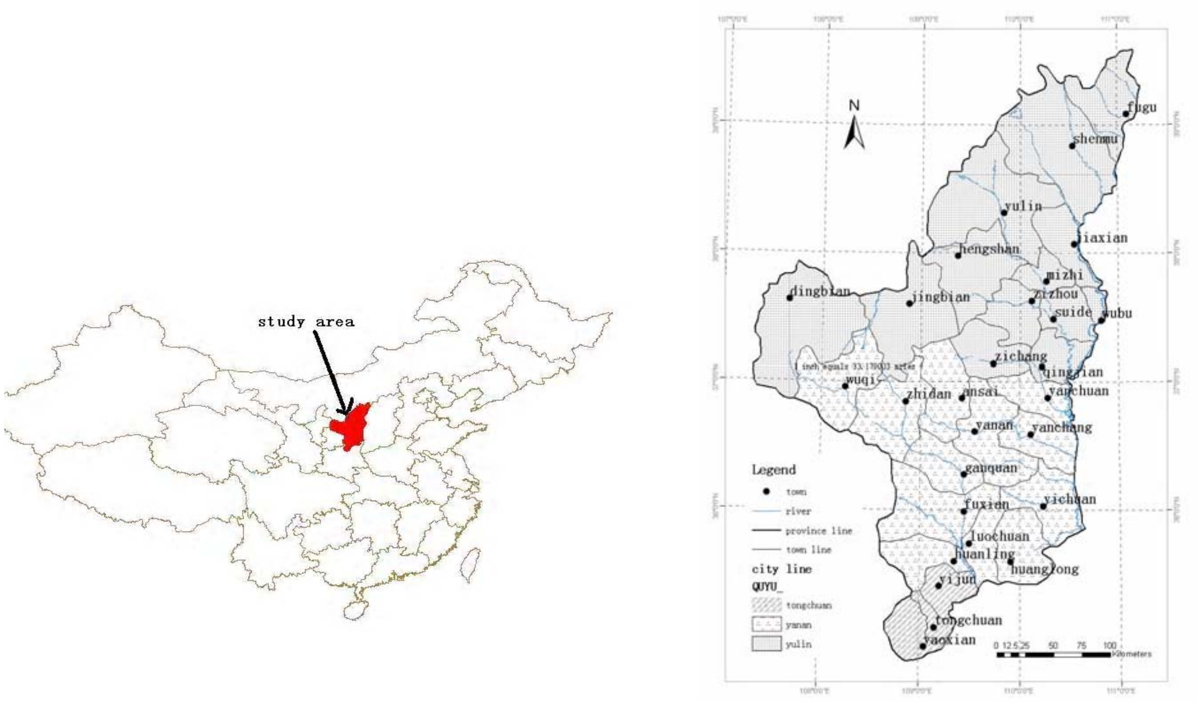

Fig. 1. The regional map of loess plateau in northern shaanxi province

Table1. Land use category in loess plateau in northern shaanxi province

Land use	Area（hm^2）
Cultivated land	1806035.17
Garden	278152.97
Forest	2937199.27
Grass land	2753420.42
Residential and traffic land	220242.11
Sand	114334.17
Water body	100018.88
Unused land	188603.70

model was prepared.

Landuse can make use of energy of sunlight and make inorganic compound, such as CO_2 and H_2O, into organic compound. The process is the most primary and important functions of landuse. It provides primary organic matter and energy for human beings so production capacity of vegetation is called net primary productivity (NPP). NPP refers to various organic matters, including branches, leaves and roots, etc. produced by green plants in unit area and unit time. It reflects production capacity of landuse in a certain natural environment.

Under the natural environment condition, the production capacity of the landuse is limited besides by biological characteristic and soil characteristic of the landuse itself, and affected by climate factor mainly. So it is possible to estimate the net primary productivity of landuse, through the analysis on the correlation between the plant material production and the climate factors including mainly solar radiation, temperature, precipitation. The original model of NPP is aimed at one country or the world, not a region. So in the case study of Loess Plateau in northern Shaanxi Province, an improved model of net primary productivity of landuse (Sun and 2000; Zhou and Zhang 1996; Zhu 1993) is set up by combining ecological characteristics of landuse with energy balance, water balance and the model of regional evapotranspiration and can be applied to different ecological regions. The model is as follows:

$$NPP = RDI \times \frac{r \times Rn(r^2 + r \times Rn + Rn^2)}{(Rn + r)(Rn^2 + r^2)} \times Exp(-\sqrt{9.87 + 6.25 \times RDI}) \quad (1)$$

$$RDI = \frac{R_n}{L} \times r \quad (2)$$

$$R_n = R_a(1 - V^{'}) - I \quad (3)$$

$$I = (0.39 \times T_a - 0.05 \times \delta \times e_a 0.5) \times (0.10 + 0.9 \times \frac{n}{N}) \times (s \times \frac{\delta}{4.18}) \quad (4)$$

Where *NPP* is net primary productivity of landuse (t/$hm^2 \cdot a$); *RDI* is proper degree of dryness; *r* is rainfall (mm); R_n is net radiant intensity (kcal/ hm^2); *L* is latent heat of water evaporation; *Ra* is total radiation; *I* is effective radiation of long wave; *V'* is surface reflectivity, generally which equals to 0.2; *n/N* is percent of sunlight; *Ta* is air temperature; e_a is the mean annual water vapor pressure; δequals to $1353.73 w \cdot m^{-2}$; s equals to $0.567 \times 10^{-4} e \cdot cm^{-1} \cdot s^{-1} \cdot d^{-1}$(Li, 1999). The value of *NPP* of landuse can be replaced by energy equal to goods. Natural energy, such as coal, oil and gas, transformed by organic matter, has its market price. So the value of goods produced by landuse can be calculated by price of energy. The formula is as follows:

$$V = \frac{AQ_1}{BQ_2} \times P_c \quad (5)$$

Where *V* stands for the value of organic matter (in Chinese currency RMB, 8.3 RMB=US$1); *A* stands for dry weight of organic matter; *B* stands for quality coefficient of coal, and it equals to 1 for standard coal; P_c stands for market price of standard coal; Q_1 is quantity of heat amount to dry weight of organic matter; and Q_1 equals to 6.7KJ/G; Q_2 is quantity of heat amount to standard coal, and Q_2 equals to10KJ/G. (Li, 1999).

At present, the theoretical research on the function of landuse's water conservation already becomes more and more ripe domestically and internationally. Water conservation through landuse has two kinds of research approaches: One kind is a water balanced approach of regional landuse; One kind is calculated according to the water power of landuse's soil and the flow of landuse area. According to the actual conditions and special geographical position in Loess Plateau, this research is to utilize the second kind of method to calculate. Water conservation through landuse is made up of three parts: canopy interception, litter containment and soil containment (Lee 1980; Ma 1993). The goods model is as follows:

$$Q_t = W_1 + W_2 + W_3 \quad (6)$$

Where W_1, W_2, W_3 refer to amount of canopy, litter and soil respectively. Q_t refers to the total amount of water conservation.

One of the calculating method on the value of landuse's water conservation is the alternative project . The alternative project is a water storage project which constructed with technology and conserved water with the same as amount of the landuse. Because the investment value of the project can be calculated easily, it is possible to use the price of this alternative project to estimate the value of landuse's water conservation. In addition, according with local actual conditions, it should be considered whether people have payable aspiration for this project and how have done it. (Li 1999), To resolve the qustion of pepole's payable aspiration, the equaiton is multiplied by the coefficient of development stage l. The coefficient of development stage stands for the relative level of people's payable aspiration on a certain sale. In this region and on this time, the coefficient of different development stage l is about 0.15. The valuation method of landuse ecosystem services for water conservation can be described by the following equation:

$$V = l \times \frac{Q_t}{Q_g} V_g \qquad (7)$$

Where V is the value of water conservation (in RMB unit), Q_t is the total amount of water conservation, Q_g is water capacity of alternative project, V_g is the value of alternative project, l is coefficient of different development stage, here it is 0.15.

The amount of soil conserved by landuse ecosystems can be estimated by the difference between potential soil erosion and real soil erosion. (Xiao and Ouyang 2000; Zhou and Li 2000). Real soil erosion refers to amount of soil erosion at current surface covering. Potential soil erosion is amount of soil erosion without covering and influenced by land management. Up to now, the common soil corrodes equation is the experience model used most extensively, which is set up on the basis of the theory of soil corrodes and a large number of observing statistical data on the spot. The model is:

$$A_c = A_p - A_r \qquad (8)$$

$$A_p = R \times K \times L \times S \qquad (9)$$

$$A_r = R \times K \times L \times S \times C \times P_s \qquad (10)$$

Where A_c is the amount of soil conservation (t/hm^2·a); A_p is amount of potential soil erosion (t/hm^2·a); A_r is the amount of real soil erosion (t/hm^2·a); R is erosion index by rainfall (Ft·T·In/A·h); K is soil erosion factor; L is length of slope, S is slope; C is vegetation cover factor; P_s is soil conservation measure factor.

Once landuse are destroyed, their function of conserving soil will weaken or disappear, therefore it will produce a series of serious consequences, which shown mainly as: depositted by the sediment accumulation, service life of the irrigation works is shortenned; Soil erosion makes a large amount of land desertification; The land nutrient loss and fertility drop. So, using market price, opportunity cost and alternative project, the value of landuse's soil conservation is calculated on its role in conserving soil fertility, reducing land abandon and reducing sediment accumulation.

Soil erosion makes a great deal of nutrient matter lose, especially *K, P* and *N*. The content of *K, P* and *N* varies greatly in different soil types. Based on GIS, the mean value of *K, P* and *N* in various landuse ecosystems is calculated. The value model of soil fertility conserved by landuse ecosystems is as follows:

$$E_f = \sum A_c \times C_i \times P_i \, (i = N, P, K) \qquad (11)$$

Where E_f is the value of soil fertility conservation (in RMB unit); A_c is amount of soil conservation; C_i are pure content of *N, P, K*; P_i are the price of *N, P, K* (in RMB unit).

Land area abandoned by soil erosion can be calculated by amount of soil conservation and the average thickness of surface soil (0.6m). Using opportunity cost, the annual loss value caused by land area abandon can be calculated.

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E_s=A_c¡Âρ¡Â0.6¡ÁB_r (12)

Where E_s is the annual loss value caused by land area abandon (in RMB unit), A_c is amount of soil conservation (ton), B_r is annual income from forestry (RMB/hm^2), ρ is soil bulk density (t/m^3).

According to law of mud and sand motion in major valleys in china, 24% of mud and sand accumulates in reservoirs, rivers and lakes. The value of reducing sediment accumulation by landuse ecosystem can be calculated by water storage cost. The model is as follows:

E_n=A_c¡Âρ¡Á24%¡ÁC_r (13)

Where E_n is the value of reducing sediment accumulation (in RMB unit), A_c is amount of soil conservation(ton), C_r is reservoir construction cost (RMB/m^3), ρ is soil bulk density (t/m^3).

There are three methods of assessing the economic value of landuse ecosystem's fixing carbon and supplying oxygen, which are based on (1) the formula of photosynthesis and respiration; ② the test and survey; and ③ a mathematical model (Thomas, 1990; Ian, 1991; Titus, 1992; Robert,1993). In this study, we adopted the method based upon the formula of photosynthesis and respiration.

Based on net primary productivity of natural landuse, using equation of photosynthesis, dry matter per kg produced by landuse ecosystem can fix carbon 1.63kg. By analogy, carbon fixed by various types of landuse can be calculated. The value of carbon fixation can be estimated by using reforestation cost. In this study, reforestation cost adopts 260.90 RMB/TC. (Chen and Zhang, 2000 ; Li, 1999; Ouyang, 1999).

Using equation of photosynthesis, dry matter per kg produced by landuse ecosystem can supply oxygen 1.2kg. By analogy, oxygen supplied by various types of landuse can be calculated. The value of oxygen supply can be estimated by using reforestation cost and industrial method of making oxygen. In this study, reforestation cost and making oxygen cost adopts 260.90 RMB/TC, 0.4RMB/kg, respectively.

Model of Sand-fixing is at least the function of wind speed, air relative humidity, average particle size of soil, soil hardness, vegetation coverage, man-made surface structure damage rate, slope of, the expression as follows:

$$f = 3.91\times(1.0413+0.0441\theta+0.0021\theta^2 -0.0001\theta^3)[V^2(8.2\times10^{-5})^{VCR} \times SDR^2/(H^8\cdot d^2\cdot F)] \quad (14)$$

Qn the base of the time and spatial scales in the amount of sand lost in an instant point, the model uses the integral method to solve ,the final obtained model expressions as follows:

$$Q=\iiint_{t,x,y}\{3.9(1.0413+0.0441\theta+0.0021\theta^2-0.0001\theta^3)[V^2\frac{(8.2\times10^{-5})^{VCR}\cdot SDR^2}{(H^8\cdot d^2\cdot F)},x,y,t\}dxdydt \quad (15)$$

Where: Q- the amount of loss sand (t); V-wind speed (m /s); H-air relative humidity (%); VCR- vegetation cover (%); SDR-artificial surface structure breakage rate (%); d-average particle size (mm); F-soil hardness (N/cm^2); θ-slope (◦); x-km; y-km; ts;

The expected return of capital can be used to evaluate the value of Sand-fixing. According to «Shaanxi » ṙom 1978 to 2004, in Yulin city, desert the sand into agricultural land to restore 34.5 thousand yuan / hm^2, and then set the discount rate was 7%,so calculate the value of Sand-fixing in loess plateau in northern shaanxi province.

Once the ecosystem service value of one unit area for each land use category has been extracted, the service value for each land use category, and service function are given in Eqs. (16)¸(17) and (18).

$$ESV_k = \sum_f A_k \times VC_{kf} \quad (16)$$

$$ESV_f = \sum_k A_k \times VC_{kf} \quad (17)$$

$$ESV_f = \sum_k \sum_f A_k \times VC_{kf} \quad (18)$$

ESV_k, ESV_f and ESV refer to the ecosystem service value of land use category "k", value of ecosystem service function type "f" and the total ecosystem service value respectively. A_k is the area (ha) for land use category "k" and VC_{kf} the value coefficient (Yuan·ha¨¹·a¨¹) for land use category "k", ecosystem service function type "f".

RESULTS & DISCUSSION

Due to uncertainties in the estimated area of land use, observation of changes in the area of land use categories must be treated with caution. However, if the magnitude of the estimated changes in land use is substantial, it may still be possible to draw general inferences about the effect of perceived changes in land use patterns on ecosystem services (Congalton and Green, 1999; Kreuter *et al.,* 2001). The statistics of the land use changes can be seen from Table 4. Forest comprises the largest portion of the total area, over 31.1% of the total area (Table 4). This Forest is located in the southeast part of Loess Plateau in Northern Shaanxi Province (Fig. 2). The area of Forest was 2611289.60 ha in 1978 and 2937199.27 ha in 2004, increasing by 325909.67 ha, at an average increasing rate of 0.48% per year. The area of garden was very small, only 56389.60 ha in 1978 and increasing to 278152.97 ha in 2004. the average annual increasing rate was 15.13% per year. The estimated size of Grass land was relatively large, 2512589.56 ha in 1978 and increasing to 2753420.42 ha in 2004, about 38% of the total area. The area of Cultivated land was 2539500.87 ha in 1978 and 1806035.17 ha in 2004, with a decrease of 733465.7 ha, by about 28.88%, and the average annual decreasing rate was 1.11% per year. The aggregate area of water body was only about 1% of the total area in Loess Plateau in Northern Shaanxi Province. During the urban development, the area of unused land decreased greatly while the Residential and traffic land increased. From 1978 to 2004, unused land decreased by 92470.39 ha, leaving only 188603.7ha in 2004, 2% of the total area. The averaged annual decrease rate was 1.26% per year. Residential and traffic land increased in area from 188634.54 ha in 1978 to 220242.11 ha in 2004, increasing by16.76%, with an average growth rate of 0.64% per year. Overall, Cultivated land, Forest and Grass land were the primary land use categories when the area was considered, contributing to about 80% of the total land use area in Loess Plateau in Northern Shaanxi Province. During 1978 to 2004, Forest and Grass land tended to increase in area while Cultivated land tended to decrease (Table 2).

In order to obtain ecosystem services values for various ground cover types, the eight land cover categories used to classify the LandSat TM data sets were compared with the 16bimes identified in Costanza et al's ecosystem service valuation model.

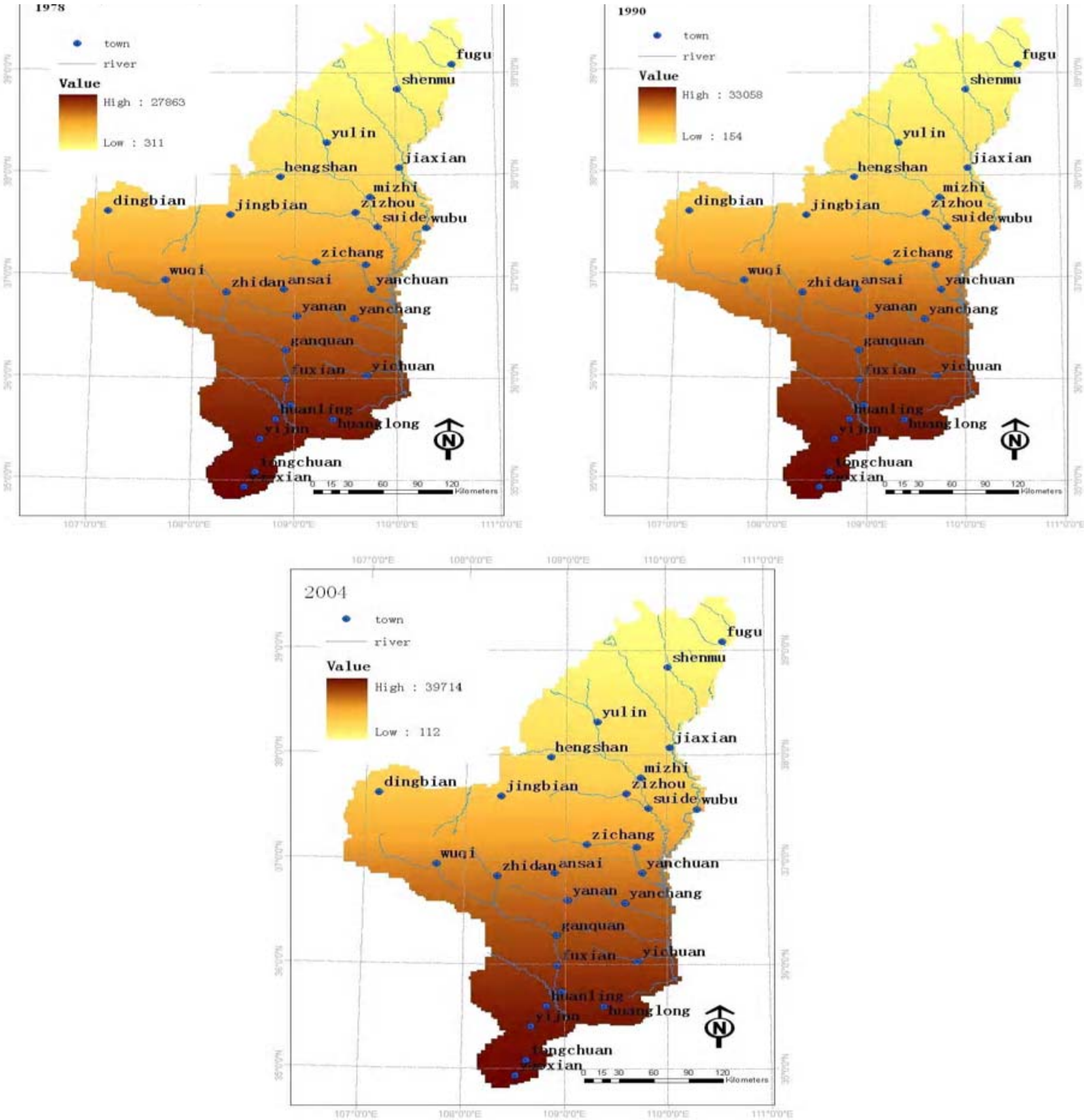
Using the estimated change in the size of each land cover category, together with the ecosystem service value coefficients from 1978 to 2004, reported in Table 3. we found that land-use changes in the 83990.067km^2 of our study area resulted in a 46347 million yuan in 1978; the ecosystem service value in 1990 are 71649 million yuan, its average annual rate of increase is 2.94%; the ecosystem service value in 2004 are 56955 million yuan, its average annual rate of decline is 2.580%. but the ecosystem service value in the loess plateau in northern Shaanxi Province increased by 18.63% in the entire 26 year. Each kind of landuse category provides the difference of ecosystem service value, except nu-landuse, other land category of service values all are increasing.

Look from various functions of the landuse service value, from 1978 to 2004, the economic value of the fixing carbon are higher, the economic value of water conservation are lowest, but the economic value of the NPP, fixing carbon and supplying oxygen account for total value above the ninety percent, obviously the vegetation own created the biggest ecosystem service value. Simultaneously also ecological environment in the loess plateau in northern Shaanxi Province destroyed quite seriously, the economic value of water conservation during 26 years were less.

Each kind of land type provides the ecology service value(ESV_f) is difference, it shows to the ecology service value contribution rate like chart(Table 4). The forest contribution rate is above 45%, the Grass land ecology service contribution rate occupies to the second, the cultivated land contribution rate occupies to the third, the water body contribution rate is smallest. The landuse type contribution rate compared from 1978 to 1990 may see the pastures increases the scope is biggest, was 6.07%, this for many years has continued with the loess plateau in northern Shaanxi Province various local government unceasingly to plant the grass has the close relations. The reduction of for-

Table 2. Area changes of landuse in Loess Plateau in Northern Shaanxi Province

Landuse categories	1978		1990		2004		1978-2004	
	Area(hm^2)	%	Area(hm^2)	%	Area(hm^2)	%	%	%yr
Cultivated la	2,539,500.87	30.24	2,364,548.97	28.15	1,806,035.17	21.50	-28.88	-1.11
Garden	56,389.60	0.67	68,307.80	0.81	278,152.97	3.31	393.27	15.13
Forest	2,611,289.60	31.09	2,644,288.81	31.48	2,937,199.27	34.97	12.48	0.48
Grass land	2,512,589.56	29.92	2,690,611.36	32.03	2,753,420.42	32.78	9.58	0.37
Residential and traffic land	188,634.54	2.25	192,905.75	2.30	220,242.11	2.62	16.76	0.64
Sand	112,365.85	1.34	118,956.47	1.42	114,334.17	1.36	1.75	0.07
Water body	98,060.57	1.17	98,080.29	1.17	100,018.88	1.19	2.00	0.08
Unused land	280,176.09	3.34	221,307.26	2.63	188,603.70	2.25	-32.68	-1.26
Total Area	8399006.68	100	8399006.69	100	8399006.67	100		



Shaanxi Province from 1978 to 2004

Fig . 2. The distribution of ecosystem service value in the loess plateau in northern

Table 3.The ecosystem services values on the Loess Plateau in Northern Shaanxi Province

Land use	ESV in 1978 ($\times 10^8$yuan)	ESV in 1990 ($\times 10^8$yuan)	ESV in 2004 ($\times 10^8$yuan)	1978 – 1990 (%)	1990 - 2004 (%)	1978 -2004 (%)
Cultivated land	76.529	135.519	79.407	43.53	-70.66	3.62
Garden	1.012	2.667	7.724	62.06	65.47	86.90
Forest	253.223	330.264	315.251	23.33	-4.76	19.68
Grass land	131.592	246.938	166.020	46.71	-48.74	20.74
Residential and traffic land	0.359	0.357	0.444	-0.56	19.47	19.03
Sand	0.189	0.232	0.233	18.42	0.10	18.51
Water body	0.027	0.026	0.029	-3.04	9.84	7.10
Unused land	0.535	0.491	0.442	-8.99	-11.08	-21.07
Total	463.467	716.494	569.550	35.31	-25.80	18.63

Table 4. contribution rate of values of ecosystem service funvtions in the loess plateau in northern Shaanxi Province

	NPP	Sand-fixing	soil conservation	water conservation	carbon fixation and oxygen supply	oxygen supply
ESV_f in1976(10^8yuan)	88.53 88.53	14.09	18.50	10.68	162.65	172.78 172.78
contribution rate	**18.95**	**3.02**	**3.96**	**2.29**	**34.81**	**36.98**
ESV_f in 1990(10^8yuan)	109.05 109.05	15.56	26.41	12.83	200.35	212.83 212.83
contribution rate	**18.90**	**2.70**	**4.58**	**2.22**	**34.72**	**36.88**
ESV_f in 2004(10^8yuan)	105.34 105.34	15.74	28.82	12.00	193.52	205.57 205.57
contribution rate	**18.78**	**2.81**	**5.14**	**2.14**	**34.50**	**36.64**

est contribution rate are most, is 8.54%, the main reason is forest destruction in the loess plateau in northern Shaanxi Province is serious.

In 1978 ecosystem service value in the loess plateau in northern Shaanxi Province is equal to same year GDP 69.28 times, in 1990 ecosystem service value is equal to same year GDP 17.24 times, equal to same year GDP 8.56 times in 2004. The ecosystem service value increases by 25.30 millon Yuan in 1990, is 6.09 times than GDP in 1990; The ecosystem service value reduces by 14.69 millon Yuan from 1990 to 2004, approximately is 2 times than GDP in 2004.

On the GIS support, the ecosystem service function value chart in the loess plateau in northern Shaanxi Province from 1978 to 2004 will carry on the overlay analysis. Like the chart shows, from the big region, the ecosystem service function value chart in the loess plateau in northern Shaanxi Province was slowly increasing, and the increasing region of ecosystem service value was mainly in south, change in north is not big. But the reduction of ecosystem service value in the local area very is actually fierce. According to the GIS ,obtains the ecosystem service function value statistics in the loess plateau in northern Shaanxi Province.

The ecosystem service function value statistics in the loess plateau in northern Shaanxi Province has the certain difference in the spatial distribution; From the type of topography, because vegetation cover are higher in the low hills of the loess plateau in northern Shaanxi Province, and woodland (especially shrubs) are more, so ecosystem service function value in the southern loess plateau are higher, the average is 5337.08 yuan/hm^2, especially in Huanglong, Huangling, Fuxian,Ganquan,Yijun,Yichuan and Luochuan , average unit ecosystem service function value are more than 5000 yuan /hm^2. The ecological environment in hills of the loess plateau in northern Shaanxi Province are more damage, vegetation cover are lower, average unit ecosystem service function value are 3845.22 yuan/hm^2. However, the northern sandstorm transition zone, because of carrying out the "Three-north shelter" scheme, better vegetation cover, therefore average unit values ecosystem service function value are 4064.83 yuan /hm^2. The ecosystem service function value in the loess plateau in northern shaanxi province trend from increasing to decreasing in 1978~2004 years, the average in the southern low hills are 6610.05yuan /hm^2 in 1990, the rate of increase is about 46.29% during 1978-1990, the rate of decrease is about 26.13% during 1990-2004; The average in the central hills are 5141.26 yuan /hm^2 in 1990, increased by 63.67% in 1978, while reduced by 42.5% in 2004 ; the average in the northern sandstorm transition are 5623.58yuan /hm^2 in 1990, increased by 87.02% in 1978. This feature is basically identical with the natural environment.

Undergo the overall analysis, may show the following conclusion: the ecosystem service function value in the loess plateau in northern shaanxi province was reducing from 1990 to 2004, but the major tendency was increasing from 1978 to 2004, and reduction of ecosystem service value in the local area was fierce. The ecological environment improvement situation regional distribution is uneven, the improved area in south are lager, but the local improvement in north is comparatively greatly slow.

CONCLUSION

In this study, we have estimated that the annual value of the ecosystem services is 56.95 billon RMB in the loess plateau in northern shaanxi province in 2004. However, because of the lack of ample data and efficient methods, we could not assess every aspect of economic values of forest ecosystem services, such as air purification, decreasing noise, protecting ozonosphere, etc. Despite this limitation the economic value of forest ecosystem is far more than what we had imaged.

During valuing the landue ecosystem services, in order to reflect regional reality exactly, characteristics and percentage of different vegetation types should be considered.

In the loess plateau in northern shaanxi province, from 1978 to 2004, the economic value of the fixing carbon are higher, the economic value of water conservation are lowest, but the economic value of the NPP, fixing carbon and supplying oxygen account for total value above the ninety percent, obviously the vegetation own created the biggest ecosystem service value. Understanding the spatial distribution of natural capital stock is as important as the value of it, especially when the ecosystems are being faced with dramatic changes, it is more urgent. We demarcated the natural capital stock, expressed complex on the map of loess plateau by the means of GIS, providing a foundation for protecting and/or restoring forest capital stock.The economic value of services of the landuse ecosystems in loess plateau is huge. Though the local people obtain little or no profits from it directly, it cannot be doubted that the GNP of the county is produced based on these ecosystem services. In fact, the value of the ecosystem services of approximate 56955million RMB produces local benefits in 2004, such as water supply, soil fertility protection, etc., to support economic development per year. It cannot be imagined that the local people are able to make such huge quantity of investment per year. In addition, many ecosystem services are literally irreplaceable, such as water conservation. In loess plateau ,the value of ecosystem services is an output from the county per year, being a part of support system of human welfare in larger regions, such as hydrological flow regulation, carbon fixation, oxygen supply, etc. With economic development continuing, forest ecosystem services will play a greater role than before and their values will also increase over time.

It is clearly shown that ecosystem services contribute substantially to human welfare on this planet. In the decision-making process, we should give adequate weight to natural capital stock that produces these services and build up the mechanisms of economic compensation for the people who conserve ecosystem services. We should also pay specific attention to conservation of natural capital stock and find ways for its sustainable use. As natural capital and ecosystem services become more stressed and more 'scarce' in the future, we must determine how to use and protect them. The economic valuation of ecosystem services is just a useful starting point.

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