Supplementary Materials

Ecological effects calculation of SLCP

1 Vegetation fraction cover (VFC)

Based on NDVI data, a pixel dichotomy model [48] is selected to calculate VFC. The formula is as follows:

$$VFC = \left(NDVI - NDVI_s\right) / \left(NDVI_v - NDVI_s\right) \quad \text{(S1)}$$

where *VFC* is the vegetation fraction cover (%); *NDVI* is the *NDVI* value of any image element; *NDVIs* is the *NDVI* value of pure soil image element, which is theoretically close to 0; $NDVI_v$ is the *NDVI* value of pure vegetation image element, which is theoretically close to 1. The upper and lower thresholds of *NDVI* were intercepted using 0.5% confidence level, and the 0.5% area with the largest *NDVI* value was averaged to obtain $NDVI_v$, and the 0.5% area with the smallest value was averaged to obtain $NDVI_s$. The VFC of Loess Plateau from 2002-2018 is shown in Figure S1.

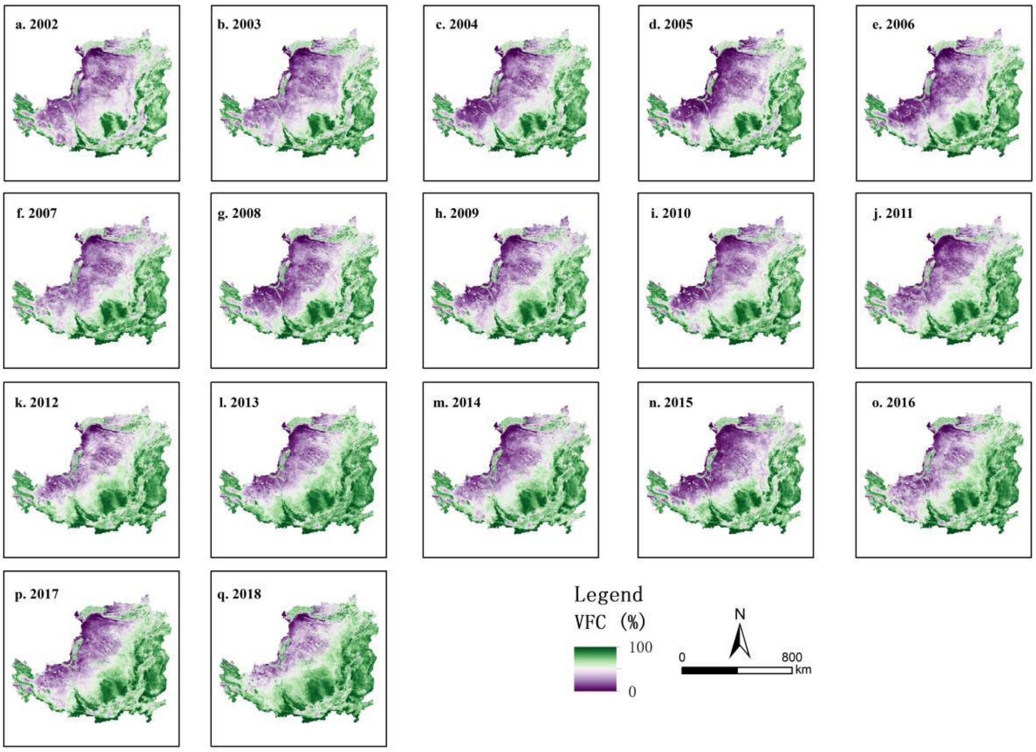

Figure S1. VFC of Loess Plateau, 2002-2018.

2 Vegetation carbon sequestration (VCS)

2.1 VCS simulation

The various vegetation of the ecosystem can effectively absorb carbon dioxide from the air. In plants, by photosynthesis, glucose and other carbohydrates are formed, then the oxygen is released. The following is the chemical equation: $6CO_2{+}6H^2O \rightarrow C_6H_{12}O_6 + 6O_2$, that is, 1.62g of CO_2 may be fixed for every gram of dry matter generated, and carbon content in dry matter contributes to roughly 45% of total NPP [49]. In summary, the following equation can be derived:

$$VCS = \left(NPP / 0.45\right) \times 1.62 \tag{S2}$$

where *VCS* represents the vegetation carbon sequestration ($gC \cdot m^{-2} \cdot yr^{-1}$), *NPP* represents the amount of carbon in the dry matter of the vegetation, that is, the net primary productivity of vegetation. The VCS of Loess Plateau from 2002-2018 is shown in Figure S2.

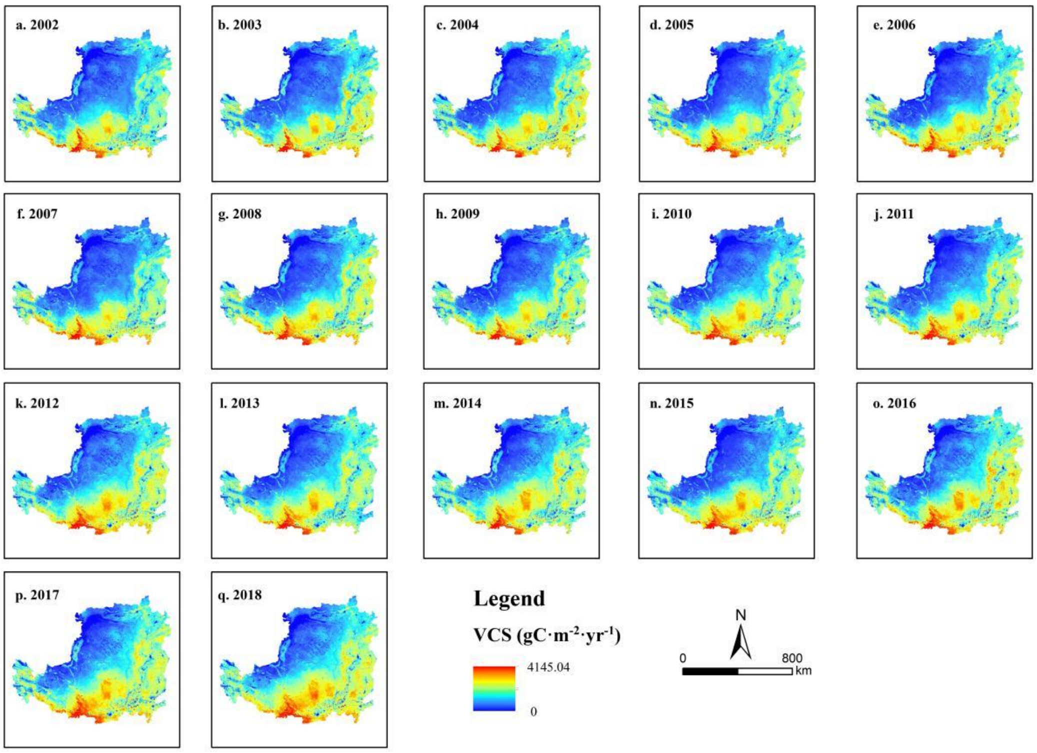

Figure S2. VCS of Loess Plateau, 2002-2018.

2.2 VCS simulation accuracy validation

The accuracy of the calculated VCS in this study can be evaluated by comparing the calculated multi-year average vegetation carbon density in the study area with the measured multi-year average vegetation carbon density in the study area [50,51]. The measured terrestrial ecosystem carbon density data of Loess Plateau were obtained from the 2010_S China Terrestrial Ecosystem Carbon Density Dataset [52], which covers forest, grassland, farmland, wetland and scrub ecosystems, including vegetation aboveground carbon density, vegetation belowground carbon density and soil carbon density at different depths (0-20 cm and 0-100 cm). The time range of the dataset is 2000-

2014, which has been tested by field sampling and evaluated by experts to be authentic and reliable. Through the collation, there are 627 data sample points in the Loess Plateau area (Figure S3a). Since the VCS calculated in this study actually refers to the carbon sequestration generated by the above-ground part of vegetation, we only selected the above-ground carbon density of 627 data sample points in the Loess Plateau area for accuracy verification. The spatial distribution of ecosystem carbon density in the Loess Plateau region was obtained by spatial interpolation of carbon density of different ecosystems in the Loess Plateau region using ArcGIS software (Figure S3b), and the above-ground carbon density of terrestrial ecosystems in the Loess Plateau region can be obtained as 1028.83 gC·hm^{-2}·yr^{-1}. The average vegetation carbon density in the Loess Plateau region from 2002-2018 calculated in this study was 1048.87 gC·hm^{-2}·yr^{-1} (Figure S3c). The accuracy of the VCS data calculated in this study was 98% when comparing the measured data with the simulated values. It indicates that the VCS in the Loess Plateau region obtained by applying NPP conversion in this study is scientifically credible for subsequent studies.

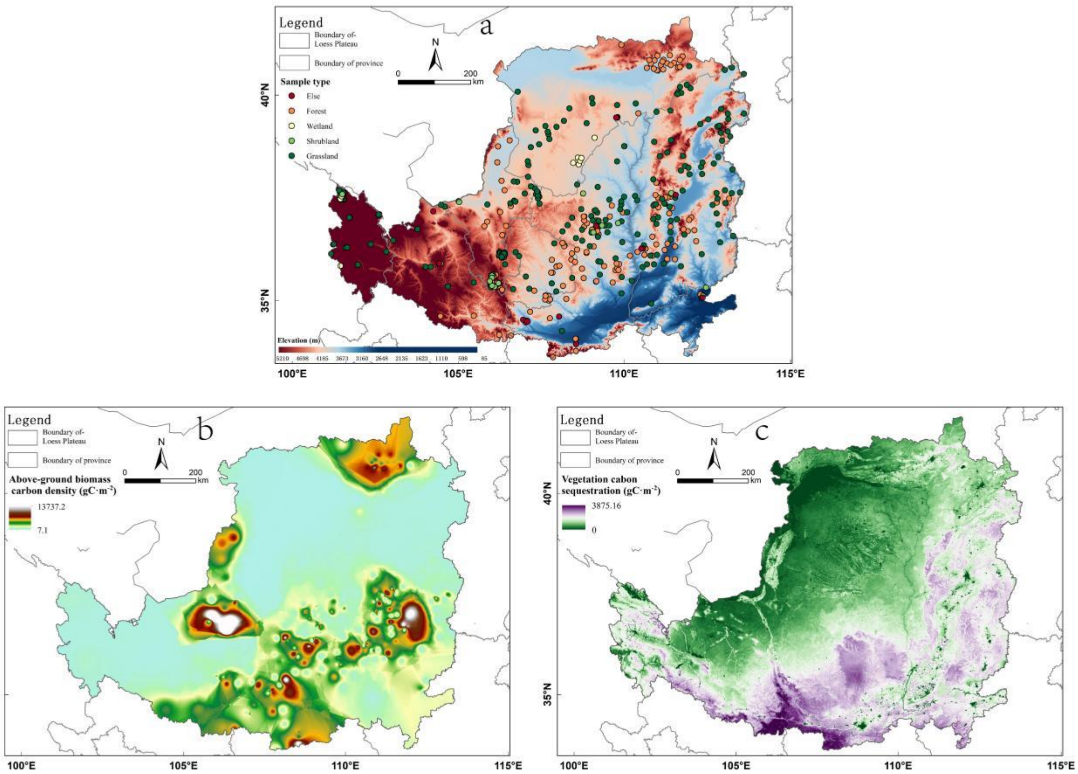

Figure S3. (a) Distribution of sampling sites on the Loess Plateau; (b) Carbon density of above-ground biomass on the Loess Plateau; (c) Average VCS of Loess Plateau from 2002-2018.

3 Soil retention (SR)

In this study, SR was estimated using the Revised Universal Soil Loss Equation (RUSLE) as follows [53]:

$$\begin{aligned} SR &= RKLS\text{-}USLE = R \times K \times LS\text{-}R \times K \times LS \times C \times P \\ &= R \times K \times LS \times (1 - C \times P) \end{aligned} \tag{S3}$$

where SR is the amount of annual soil retention ($t \cdot hm^{-2} \cdot yr^{-1}$); RKLS is the potential soil loss ($t \cdot hm^{-2} \cdot yr^{-1}$); USLE is the actual soil loss ($t \cdot hm^{-2} \cdot yr^{-1}$). The detailed calculation of each factor is as follows.

3.1 Rainfall erosion factor

The rainfall erosion factor (R) is based on the empirical formula proposed by Wischmeier et al. [54].

$$R = \sum_{i=1}^{12} 1.735 \times 10^{\left(1.5\lg \frac{p_i^2}{p} - 0.8188\right)} \times 17.02 \tag{S4}$$

Where R is rainfall erosivity ($MJ \cdot mm \cdot ha^{-1} \cdot h^{-1} \cdot yr^{-1}$), P_i is the monthly rainfall (mm); and P is the annual rainfall (mm). The value 17.02 is the conversion factor from US customary units to SI units.

3.2 Soil erosive factor

Soil erosive factor (K) was calculated by the erosion/productivity impact calculator (EPIC) model based on the soil texture [55].

$$\begin{aligned} K = 0.1317 \times \left\{0.2 + 0.3 \times \exp\left[-0.0256 SAN\left(1 - \frac{SIL}{100}\right)\right]\right\}\left[\frac{SIL}{CLA + SIL}\right]^{0.3} \times \\ \left\{1 - 0.25 \times \frac{C}{C + \exp(3.72 - 2.95C)}\right\}\left\{1 - 0.7 \times \frac{SN_1}{SN_1 + \exp(22.95SN_1 - 5.51)}\right\} \end{aligned} \tag{S5}$$

Where K is the soil erodibility factor ($t \cdot h \cdot MJ^{-1} \cdot mm^{-1}$), *SAN*, *SIL*, and *CLA* are the sand fraction (%), silt fraction (%), and clay fraction (%), respectively, C is the soil organic carbon content (%), and *SNI* is equal to 1–*SAN*/100. The value 0.1317 is the conversion factor from US customary units to SI units.

3.3 Slope length and steepness factor

The slope threshold required to calculate the LS factor was used in the Loess Plateau [56].

$$L = (\lambda / 22.13)^m$$
$$S = \begin{cases} 10.8\sin\theta + 0.03 & \theta < 9\% \\ 16.8\sin\theta - 0.50 & \theta \geq 9\% \end{cases}$$
$$m = \beta / (1+\beta)$$
$$\beta = \sin\theta / [3(\sin\theta)^{0.8} + 0.56] \tag{S6}$$

Where, L is the slope length factor, S is the slope steepness factor. λ is the horizontal projection slope length, m is the variable slope length exponent, β is a factor that varies with slope gradient, θ is the slope angle (%).

3.4 Vegetation cover and management factor

C is the vegetation cover and management factor, dimensionless, obtained by using the regression equation between VFC and C factor established by Cai et al. [57].

$$C = \begin{cases} 1 & VFC = 0 \\ 0.6508 - 0.3436\lg VFC & 0 < VFC \leq 78.3\% \\ 0 & VFC > 78.3\% \end{cases} \tag{S7}$$

3.5 Erosion control practice factor

P is the erosion control practice factor, dimensionless, which is set according to the parameters described in publications relevant to the Chinese Loess Plateau [58]. This study defined the P values of farmland, forestland, grassland as 0.31, 0.05, 0.16, respectively. For the land use types of water, construction land, and unused land, P value equals to 1.

The SR of Loess Plateau from 2002-2018 is shown in Figure S4.

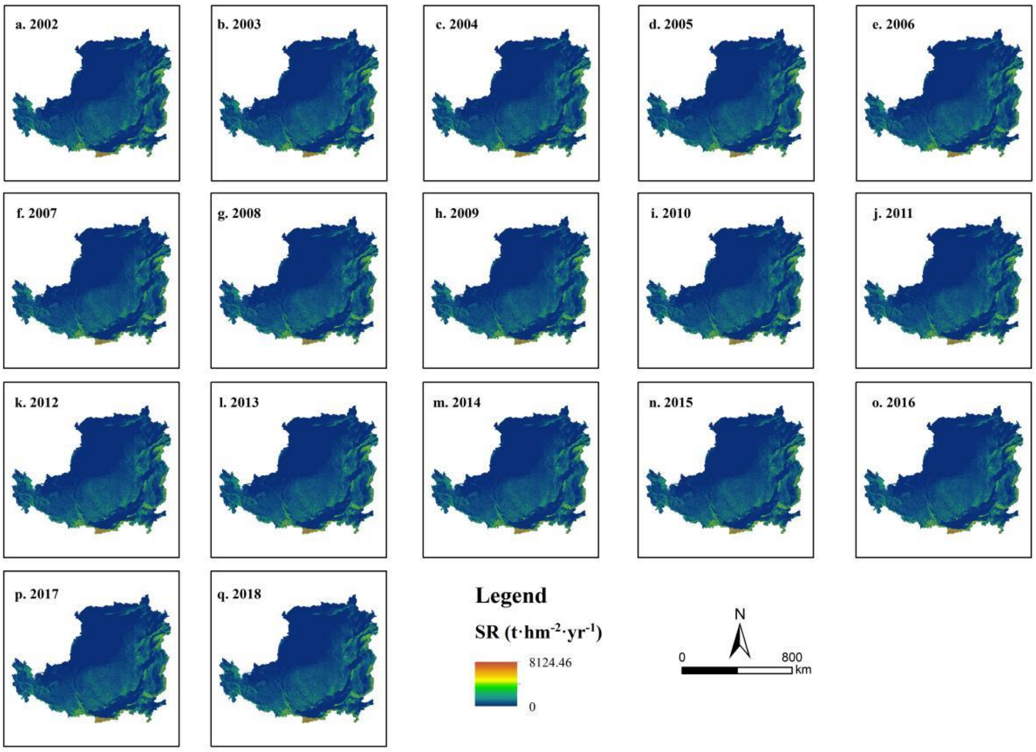

Figure S4. SR of Loess Plateau, 2002-2018.

3.6 RUSLE model simulation accuracy validation

The accuracy of the RUSLE model simulation can be evaluated by comparing the calculated multi-year average soil erosion modulus in the study area with the multi-year average annual sediment transport modulus measured at the hydrological stations in the study area [59–61]. According to the hydrological stations in the Yellow River Basin announced by the Yellow River Conservancy Commission of the Ministry of Water Resources of China (http://www.yrcc.gov.cn/images/map3.htm), there are 15 hydrological stations in the Loess Plateau (Figure S5a). The measured sand transport modulus at the hydrological station was obtained from the Yellow River Sediment Bulletin for the period of 1987-2015 (http://www.yrcc.gov.cn/nishagonggao/2018/index.html#p=16). The spatial distribution of sand transport modulus in Loess Plateau region was obtained after spatial interpolation of sand transport modulus at hydrological stations using ArcGIS software (Figure S5b), and the average sand transport modulus in Loess Plateau region from 1987 to 2015 was 19.15 $t{\cdot}hm^{-2}{\cdot}yr^{-1}$ by statistics. In this study, the average soil erosion modulus of 22.03 $t{\cdot}hm^{-2}{\cdot}yr^{-1}$ in the Loess Plateau region for 2002-2018 was calculated using the RUSLE model (Figure S5c). After comparing the measured values with the simulated values, it is obtained that the simulation accuracy of RUSLE model in this study is up to 85%. It indicates that the SR in the Loess Plateau region calculated by applying the RUSLE model in this study is scientifically credible for subsequent studies.

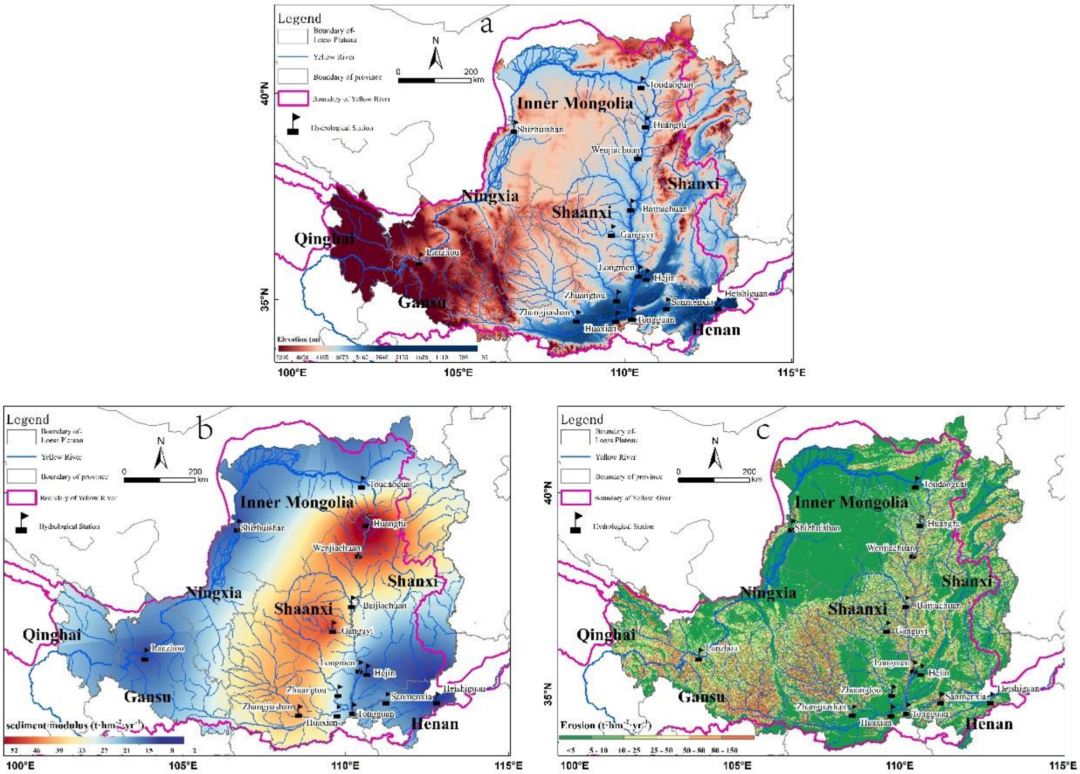

Figure S5. (a) Distribution of hydrological stations on the Loess Plateau; (b) Average sand transport modulus of Loess Plateau from 1987-2015; (c) Average soil erosion modulus of Loess Plateau from 2002-2018.

4 Quantifying functional components of Biodiversity (Biod) and Water conservation (WC)

In this study, we adapted and revised a biophysical approach from Carreño et al. [62], Liu et al.[63], and Duan et al. [64] in order to quantify the Biod and WC functional components. The valuation method assumed that the Biod and WC were directly related to biomass, with NPP as a common variable increasingly used to represent biomass, and the Biod and WC were also related to other biophysical factors (such as slope, temperature, precipitation, etc.)[62,65]. Based on these methods, the equations for Biod and WC were calculated as follows:

$$ES_{Biod} = NPP \times F_{PRE} \times F_{TEM} \times (1 - F_{ELE}) \quad \text{(S8)}$$

Where ES_{Biod} is the value of biodiversity conservation services, dimensionless. NPP_i is the NPP value of the Loess Plateau in the i year, where i=2002,2003,2004, ..., 2018. F_{TEM} and F_{PRE} are factors of annual temperature and precipitation respectively, F_{ELE} is elevation factors. All factors need to be normalized before calculation. The Biod of Loess Plateau from 2002-2018 is shown in Figure S6.

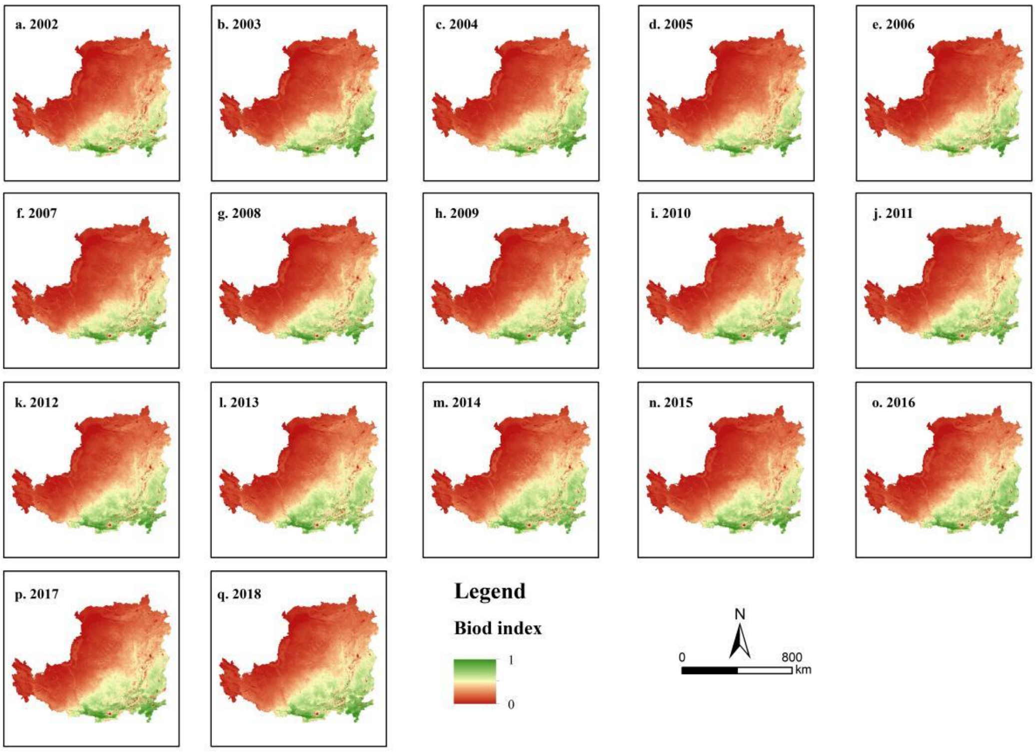

Figure S6. Biod of Loess Plateau, 2002-2018.

$$ES_{wc} = NPP_i \times F_{SIC} \times F_{PRE} \times (1 - F_{SLO}) \quad \text{(S9)}$$

Where ES_{wc} is the value of water conservation service, dimensionless. NPP_i is the NPP value of the Loess Plateau in the *i* year, where i=2002,2003,2004, ..., 2018. F_{SIC} and F_{PRE} are factors of soil seepage capacity and annual precipitation, F_{SLO} is slope factors. All factors need to be normalized before calculation. The WC of Loess Plateau from 2002-2018 is shown in Figure S7.

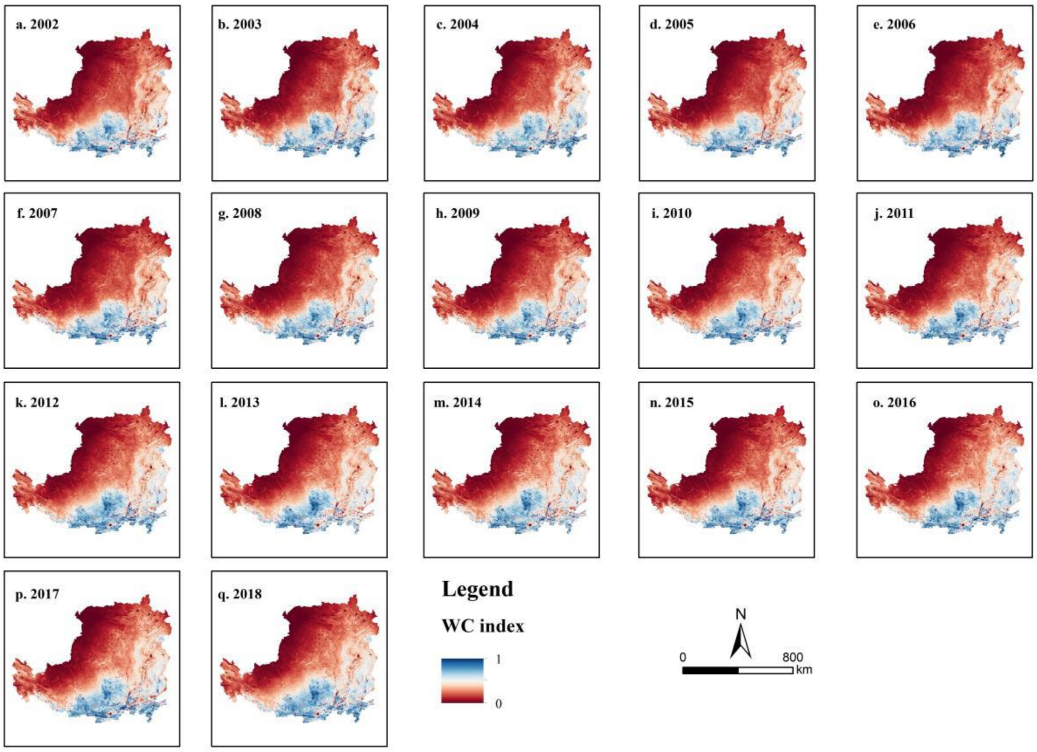

Figure S7. WC of Loess Plateau, 2002-2018.