Effects of Land Use Change on Soil Erosion in Small Watershed of Loess Hilly Region, China

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The study of the relationships of landscape patterns and ecological processes is a core focus in landscape ecology. Analysis of land use and soil erosion is important for comprehensive watershed management and sustainable development. The studies are of practical significance in evaluating ecological environment restoration and comprehensive management effects, scientifically adjusting macroeconomic policy such as constructing an optimized design of landscape pattern, and promoting common development of production and ecological environments in a watershed. A case study was carried out in the small Yangjuangou watershed in the hilly and gully area of the Loess Plateau of China (Figure 1). Based on cesium-137 tracing techniques, using a geographical information system (GIS) and an analysis experiment in the laboratory, we analyzed the characteristic of land use change in the watershed, determined status of soil erosion intensity in regions of different periods of check-dam controls, and evaluated effects of landscape position, landscape type and landscape patterns on soil erosion.

Figure 1. Yangjuangou watershed region in China.

According to the field, slope and watershed units, we analyzed the effects of land use change on soil erosion. The main results are as follows: 1.) For land use change, in the Yangjuangou watershed from 1984 to 2006 (Figure 2), because of societal, economic, and environmental policy driving factors, land use changed enormously. Land use type, especially sloping cropland changed significantly, declining from 29.6% in 1984 to 16.9% in 1996, and further declining to 0.11% in 2006. Forestland increased 15.1%, and shrubland increased rapidly from 0.19% in 1984 to 9.51% in 2006. The dam area increased from 7.04 ha^2 in 1984 to 9.87 ha^2 in 2006, a 40% increase. 2.) Using cesium-137 dating methods and GPS-difference techniques, we estimated that the soil erosion intensity of the drainage areas controlled by check-dam #1 (1955-1963) and check-dam #4 (1979-2004) were 6871.9 and 4052.1 t $km^{-2}yr^{-1}$, respectively. Soil erosion rates decreased from intense to normal. 3.) Based on Cs-137 tracing to study the spatial distribution of soil erosion we found that: a) The land use patterns on slopes had some effects on soil erosion (Figure 3). When the landscape pattern was “grassland(6y) + shrubland(6y)”, we can found that the mass of erosion was greatest near a shallow gully. The soil loss depth was more than 12 mm. The eroded soil in the upslope and middle slope positions was 3.1 times that downslope (Figure

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4). When the landscape pattern was: “wild grass(6y) + forest(25y) + wild grass(25y)”, the annual average erosion depth (>4 mm) in the upper and middle slope positions was 10 mm less than that of the land use pattern “grassland(6y) + shrubland(6y)”. The erosion mass decreased 60% compared to the “grassland(6y) + shrubland(6y)” pattern. b) Different landscape positions, soil layer depths, and landscape types had significant Cs-137 concentrations ($P<0.05$). c) For the watershed region in 1980, 1984, 1996, and 2006, the soil erosion modulus was 7077.6, 6007.8, 5553.7, and 4370.0 t km^{-2} yr^{-1}, respectively.

In conclusion, soil erosion in the existing land use pattern is the result of the joint action of tillage erosion and rainfall erosion. The relationship of land use pattern and soil erosion showed that mature forests and grasslands located at the upper and middle slopes can reduce soil erosion. Seeking reasonable land use patterns to control soil erosion on a slope is an important task. It is necessary to create a spatial mosaic pattern on hillslopes for soil erosion control in the Loess Plateau of China.

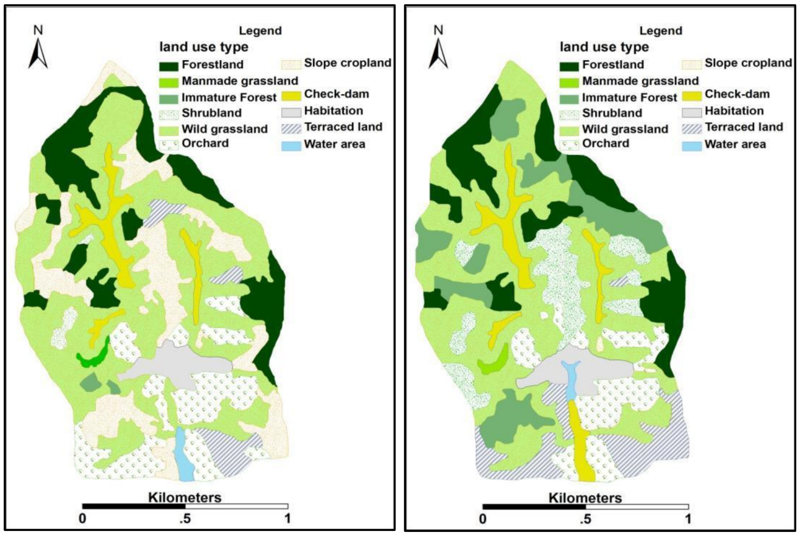

Figure 2. Land use maps in 1996 (left) and 2006 (right).

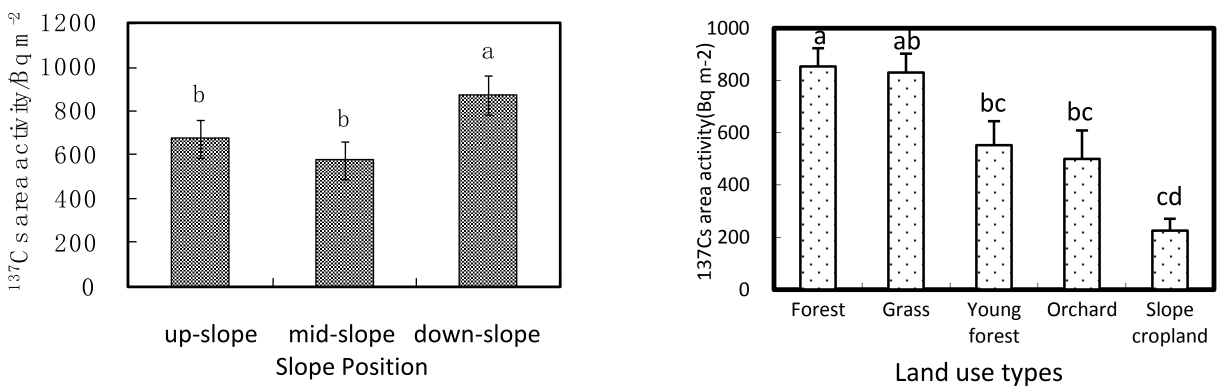

Figure 3. Characteristics of cesium-137 concentrations for different slope position and land use types.

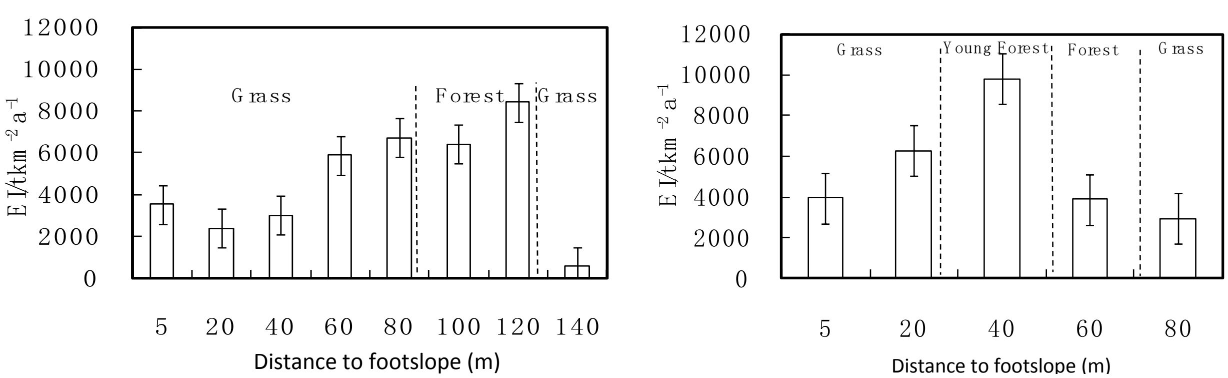

Figure 4. Distribution of soil erosion intensity (EI) in typical slope.