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Distribution of soil organic carbon impacted by land-use change and check dam on the Loess Plateau of China

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Outline

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Introduction

- Vegetation restoration, terrace and check dam construction are the major measures for soil and water onservation on the Loess Plateau.
- There are 584.12×10^4 hm^2 sloping cropland returned to forestland or grassland on the Loess Plateau since 1999.
- Moreover, >5000 main check dams and 10,000 km^2 of terraced land were present at the end of 2011.


Restoration


Terrace


Check dam

Introduction

- Land-use changes caused by human activities have an impact on soil organic carbon (SOC).
- Changes in land-use patterns and the mineralization rates of SOC, as well as soil erosion patterns, have significant effects on the biogeochemical cycles of soil carbon in terrestrial ecosystems by changing the input of above- and below-ground biomass.
- Inappropriate land-use patterns in vulnerable erosion-prone areas can lead to less carbon being imported into the soil and serious carbon loss by rill erosion.
- However, suitable land-use structures can increase soil carbon storage.

Introduction

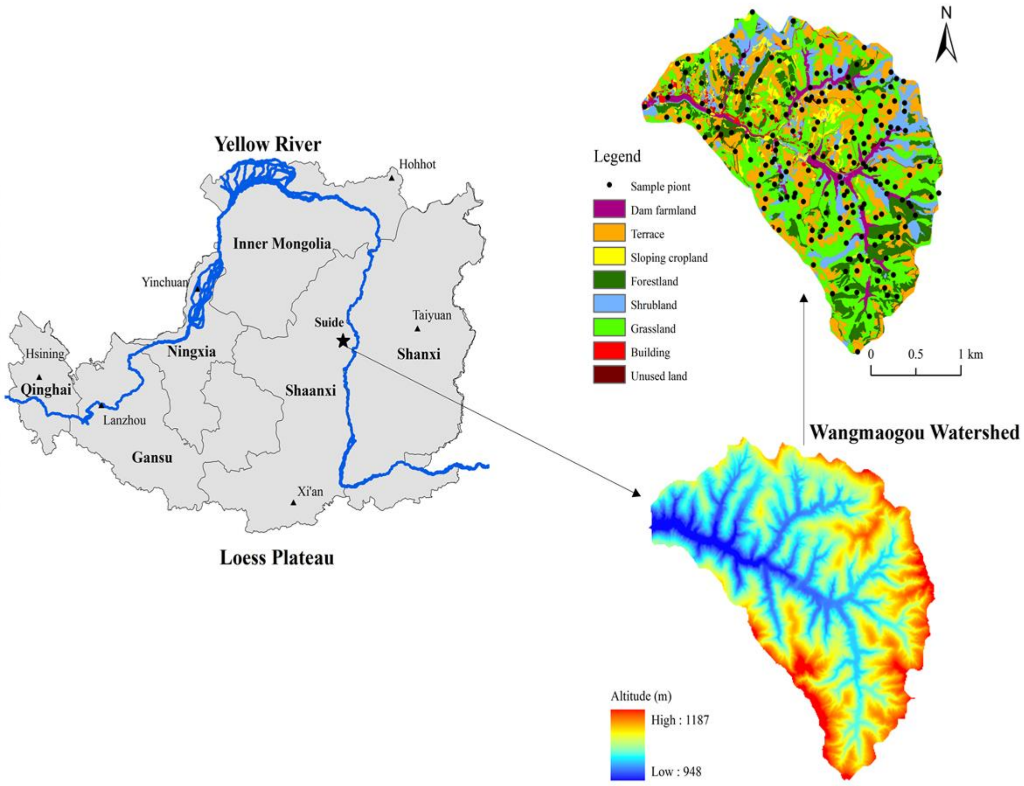
The purpose of this study

- To investigate the impacts of vegetation restoration, terracing and check dam construction on the SOC. distribution in a typical hilly watershed on the Loess Plateau;
- To analyze the environmental factors (e.g., topography, land uses and soil properties) influencing SOC distribution.

Material and methods

Study area

- The Wangmaogou Watershed is located in the Wuding River Basin (37° 34′13″–37° 36′03″ N, 110° 20′26″–110° 22′46″ E).
- At present, grassland, terrace, forestland and shrubland are the main land-use types in the watershed, accounting for 34.4%, 26.3%, 14.1% and 13.0%, respectively.
- The dammed farmland, sloping cropland and building represent 5.3%, 3.9% and 2.5%, respectively, of the total area.

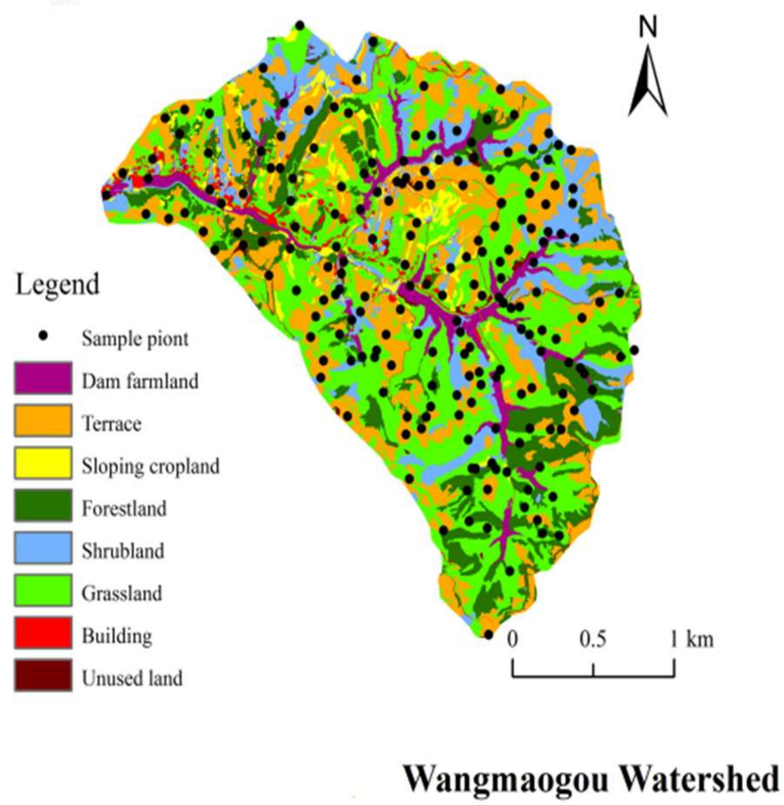


Location of the study area

Material and methods

Soil sampling and laboratory analysis

- Soil sampling points were designated using 150 m × 150 m grids.
- The 0–100 cm soil depth was divided into five layers: 0–20, 20–40, 40–60, 60–80 and 80–100 cm.
- A total of 1060 soil samples were collected from 212 sites.
- The sites from different land-use types were forestland (15), grassland (88), shrubland (17), sloping cropland (19), dammed farmland (16) and terrace (57).
- The SOC, soil bulk density, soil particle size were analyzed in the laboratory.



Samping sites

Results

- The mean SOC concentrations under different land-use types were : shrubland > forestland > terrace > grassland > sloping cropland > dammed farmland.
- Forestland, shrubland and terraces had the highest SOC concentrations in the soil layers of 0–20, 20–40 and 40–60 cm.

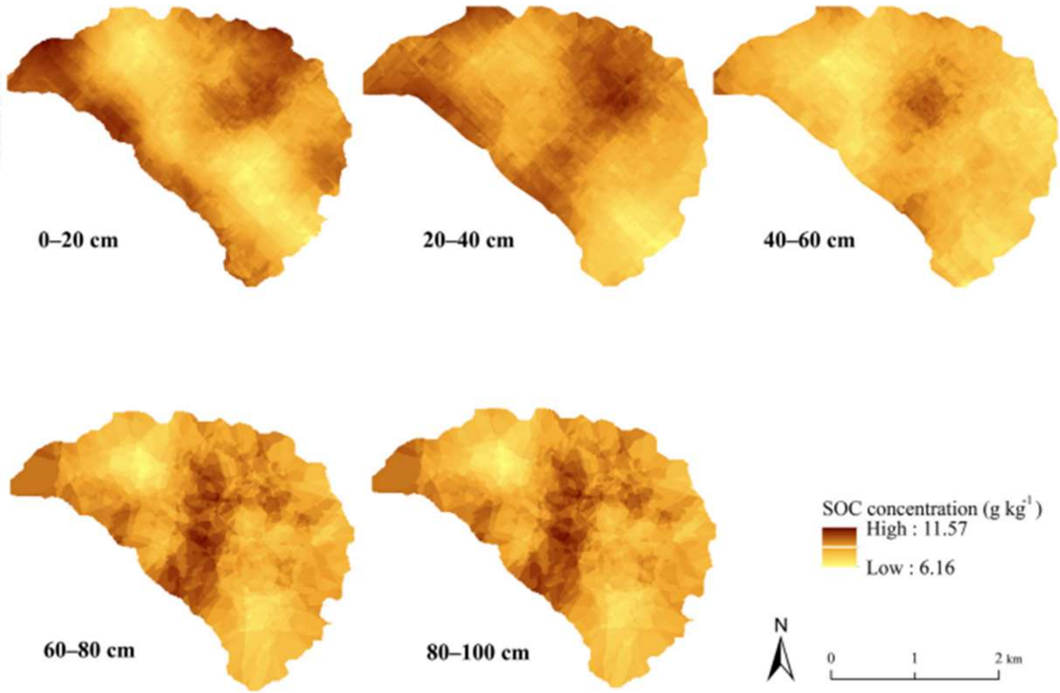
SOC under different land-use types (g kg^{-1})

Soil layer (cm)	Sloping cropland			Forestland			Grassland			Shrubland			Terrace			Dam farmland		
	n	SOC	Bulk density	*n*	SOC	Bulk density	*n*	SOC	Bulk density	*n*	SOC	Bulk density	*n*	SOC	Bulk density	*n*	SOC	Bulk density
0–20	19	8.99b	1.29	15	10.85a	1.27	88	9.82ab	1.26	17	10.01a	1.24	57	9.99a	1.37	16	8.83b	1.28
20–40	19	8.93ab	1.36	15	8.89ab	1.28	88	8.46ab	1.35	17	9.53a	1.23	57	9.07a	1.17	16	7.88b	1.35
40–60	19	8.58a	1.32	15	8.64a	1.32	88	8.65a	1.40	17	8.12a	1.28	57	8.77a	1.33	16	7.64b	1.34
60–80	19	8.19a	1.36	15	8.60a	1.37	88	8.36a	1.36	17	8.76a	1.29	57	8.95a	1.36	16	7.28b	1.28
80–100	19	8.14a	1.37	15	8.55a	1.38	88	8.26a	1.39	17	8.67a	1.35	57	8.23a	1.41	16	7.51b	1.31
Mean		8.31a	1.34		8.84a	1.32		8.71a	1.35		9.02a	1.28		8.78a	1.35		7.61b	1.29

Different letters after the SOC for the same soil depth indicate significant differences at the 0.05 level.

Results

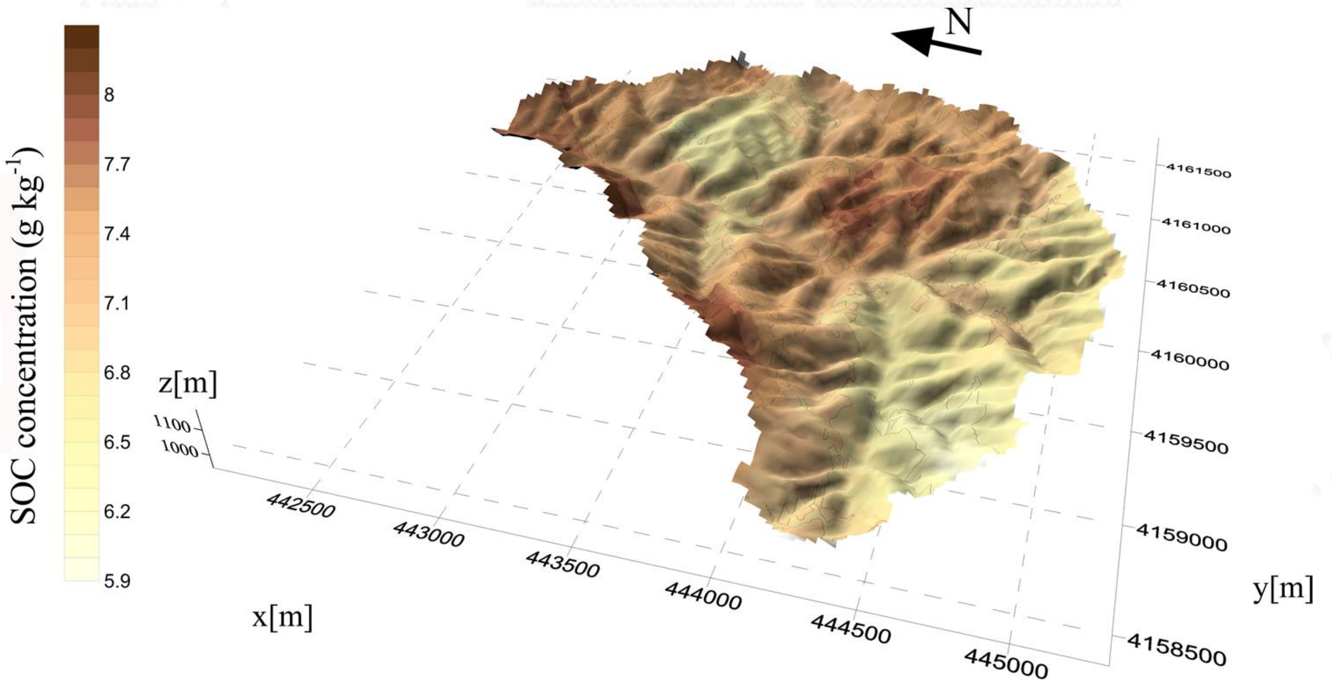
- The spatial difference in the SOC concentration was highest in the 0–20-cm soil layer.
- At the surface depth of 0–20 cm, the lowest SOC concentrations generally occurred in areas of slopping cropland and dammed farmland
- The highest SOC concentrations generally occurred in areas of forestland, shrubland, terrace and grassland.



Spatial distribution of SOC in soil layers of 0–20, 20–40, 40–60, 60–80 and 80–100 cm.

Results

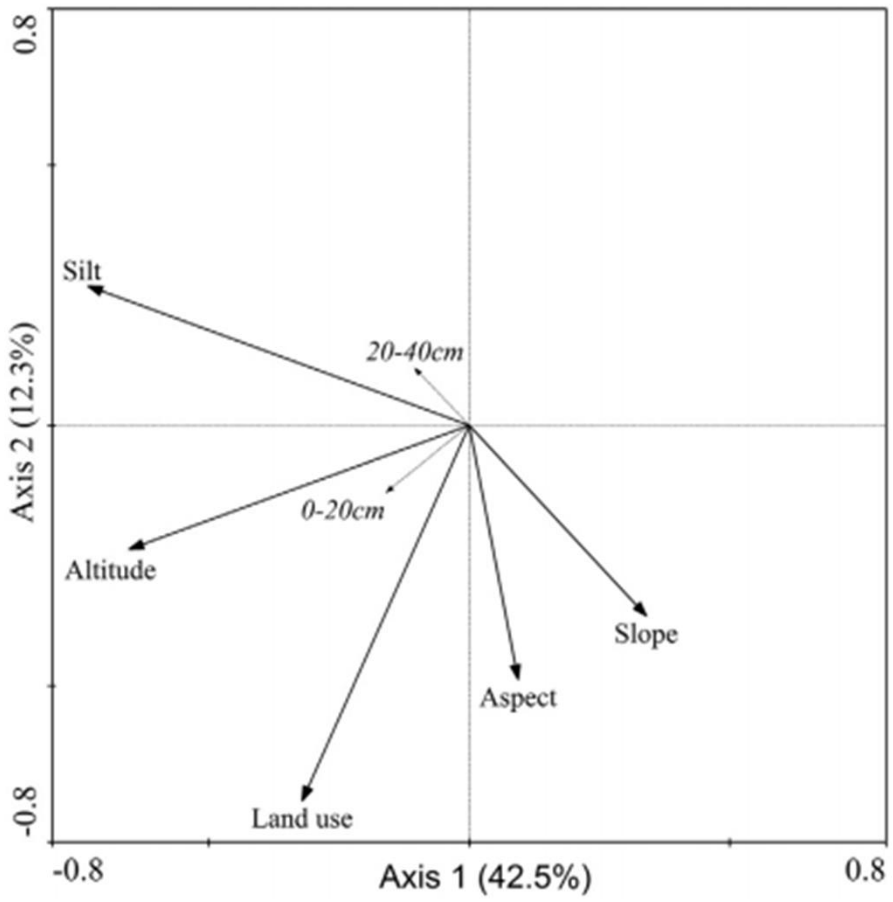
- The SOC densities of terraces, forestland, shrubland, grassland, sloping cropland and dammed farmland at a depth of 0–100 cm were 12.09, 11.99, 11.89, 11.77, 11.41 and 10.11 kg m^{-2}, respectively.
- Land-use types had impacts on the SOC densities: forestland, terraces, grassland and shrubland had higher SOC densities than dammed farmland and sloping cropland.



Spatial distribution of SOC in soil layers of 0–100 cm (kg m^{-2})

Results

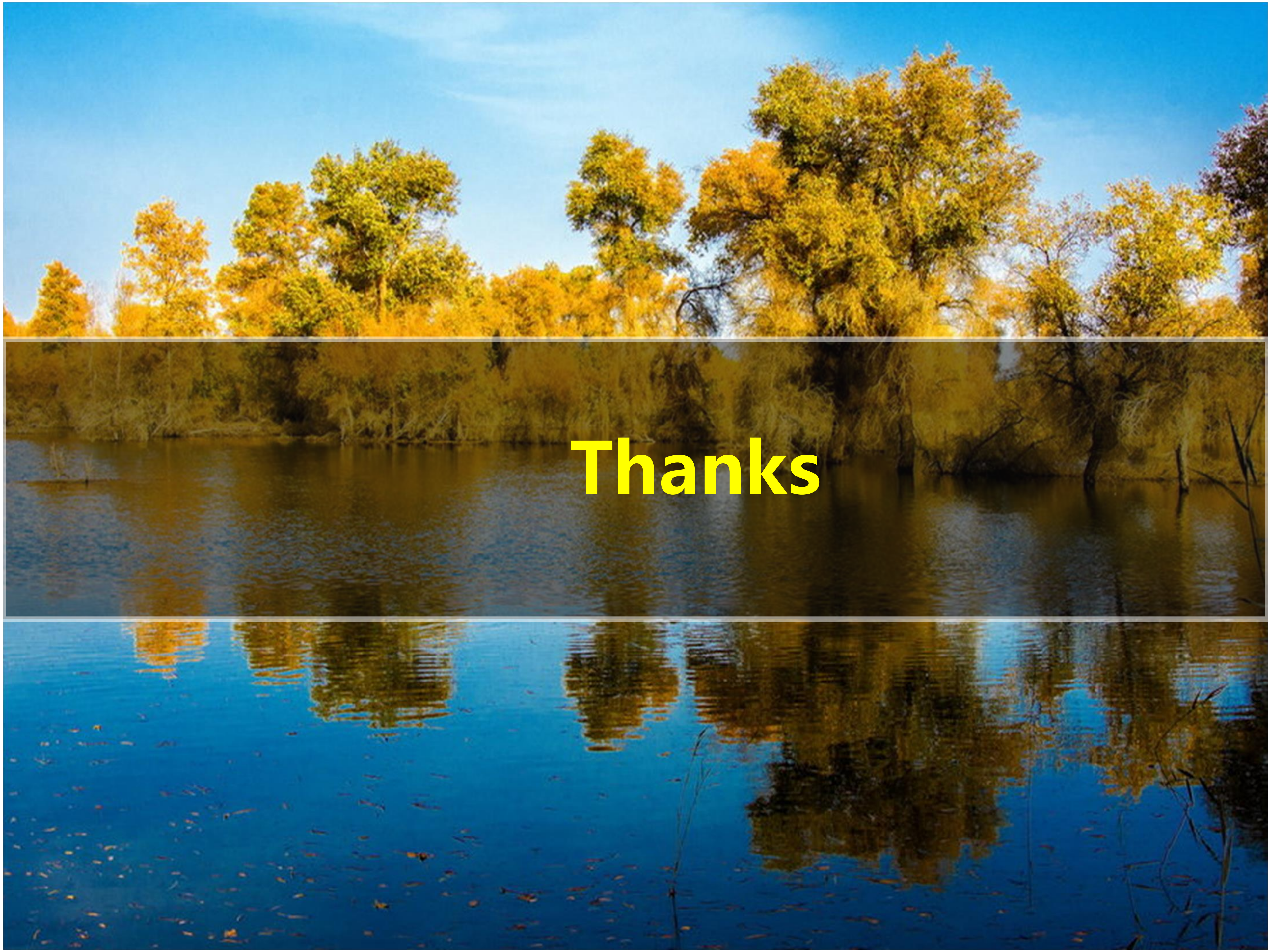
- Both the arrows representing the SOC in the 0–20 and 20–40 cm soil layers pointed approximately in the same direction as the environmental arrows representing altitude, land-use and silt, indicating highly positive correlations. The arrows representing aspect and slope pointed in the opposite direction of those representing SOC, indicating negative relationships.
- Altitude, silt and land-use had longer arrows compared with soil particle sizes, indicating that these factors had higher correlations with SOC.



Redundancy analysis of the relationship between SOC environmental factors.

Conclusion

- Land-use changes influenced soil carbon concentration, and changed SOC's spatial distribution across the watershed.
- Conversions from slope cropland to forestland, shrubland, grassland and terraced fields resulted in greater amounts of SOC. The mean SOC contents decreased as soil depth increased.
- Topographical factors, such as slope gradient, altitude and aspect, had impacts on SOC concentrations.
- In general, revegetation, terracing and check dam construction have great impacts on soil carbon distribution. The effects of vegetation recovery, terracing and check dam construction on carbon retention should be considered comprehensively to quantitatively assess potential impacts of land-use changes on carbon cycling.


Thanks