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Effects of environment factors on soil properties across land uses and the implication in Yanhe watershed, China

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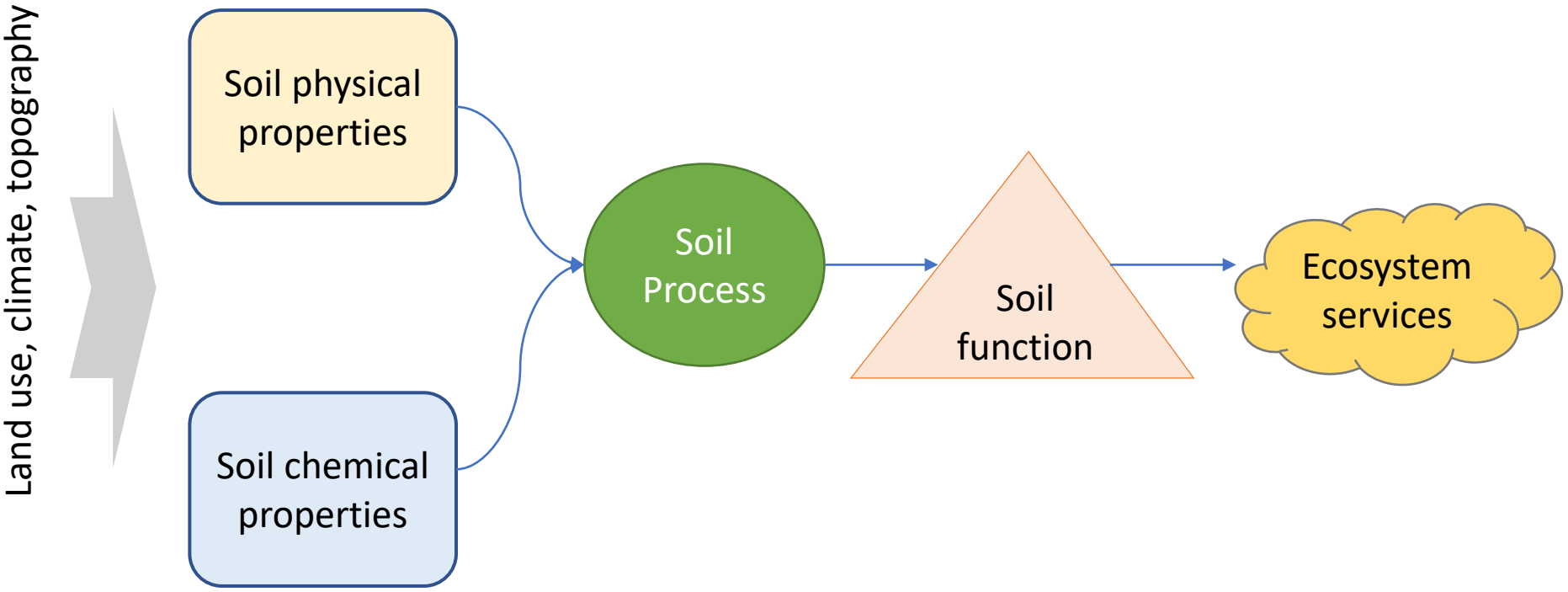
Background



- Land use is a determinant factor on ecosystem services, while soil properties are the foundations to delivery ecosystem services.
- What are the differences between soil properties and their influencing factors across different land uses.

Methods

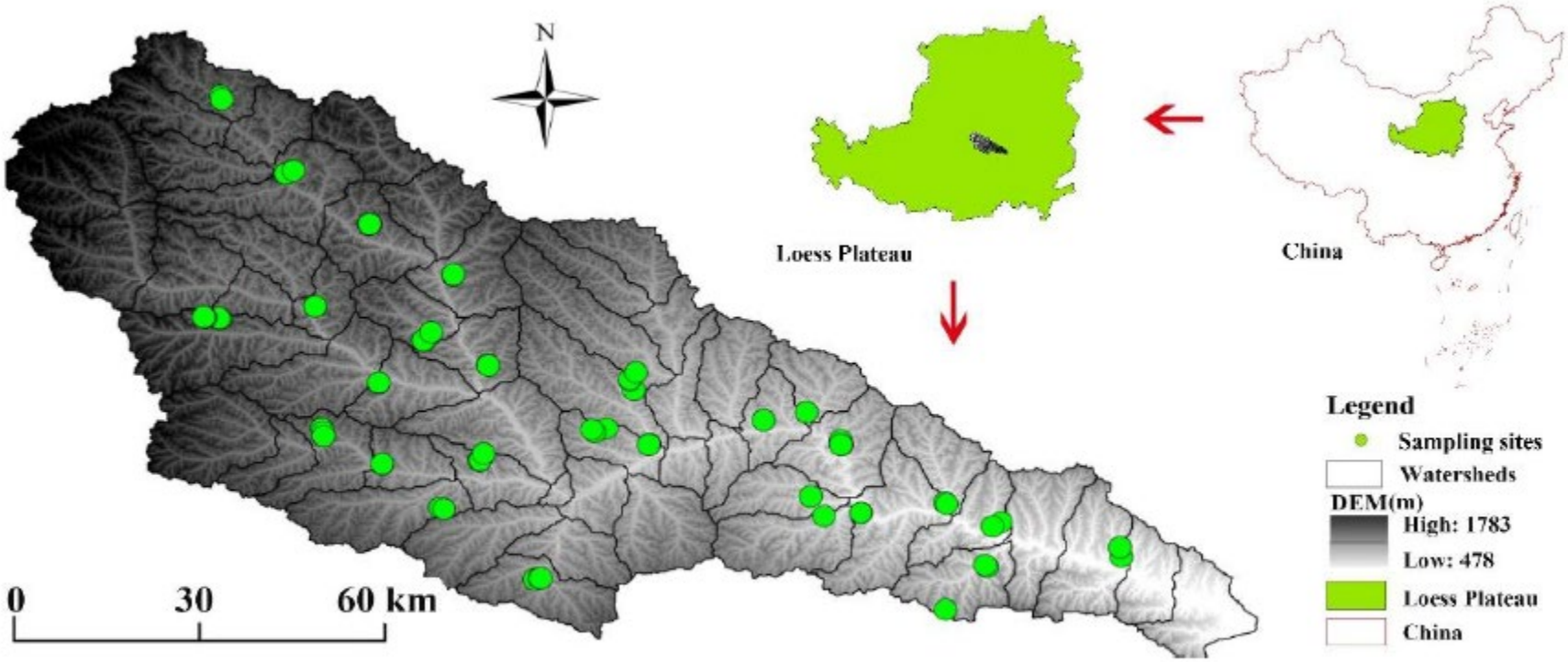


Figure 1. Location of the study area

- The climate is temperate continental semi-arid monsoon. The annual average temperature is 9.0 °C and annual precipitation is 507 mm. The main soil type is Alfisols.
- we sampled in 82 places: forest (27), shrubland (16), grassland (27), and agriculture area (12, combined cropland and orchard).

Methods

- Redundancy analysis (RDA) was applied to identify the variations of soil properties according to the environmental conditions. To identify the collinearities, we conducted hierarchical partitioning (HP) method to acquire the independent explanation power of each environmental factor and used a permutation test to derive significance at a $P<0.05$ level.

- Structural equation model (SEM) is an extension of a multivariate regression model to test the fitness of the correlation matrix against two or more causal relations, thus it is used to identify the direct, indirect effects and total effects of one variable on others.

Results

1. ANOVA

Soil properties	Mean± SE Forest (N=27)	CV%	Mean± SE Shrubland (N=16)	CV%	Mean± SE Grassland (N=27)	CV%	Mean± SE Agriculture area (N=12)	CV%	*P*
BD	1.17±0.025	11.1	1.25±0.033	10.4	1.24±0.027	11.3	1.26±0.046	12.7	0.11
Sand%	30.7±1.30	22.0	34.7±2.36	27.1	32.3±1.58	25.4	30.2±1.57	18.0	0.35
Silt %	64.3±1.34	10.8	62.5±2.31	14.8	63.4±1.59	13.0	66.5±1.26	6.57	0.54
Clay%	5.05±0.22^{a}	23.0	2.86±0.30^{b}	41.3	4.38±0.22^{a}	25.6	3.28±0.54^{b}	57.0	0.00
pH	8.45±0.027	1.66	8.38±0.058	2.74	8.49±0.031	1.88	8.44±0.081	3.32	0.36
SOC	6.81±0.60	44.2	5.52±0.38	27.5	5.5±0.42	40.0	5.37±0.51	32.6	0.27
TN	0.76±0.038	26.3	0.65±0.023	13.8	0.66±0.038	30.3	0.68±0.075	38.2	0.2
TP	1.14±0.015	7.02	1.07±0.02	7.48	1.12±0.019	8.93	1.10±0.023	7.27	0.11
TK	17.6±0.12	3.64	17.3±0.17	3.87	17.8±0.21	6.12	17.7±0.27	5.37	0.36

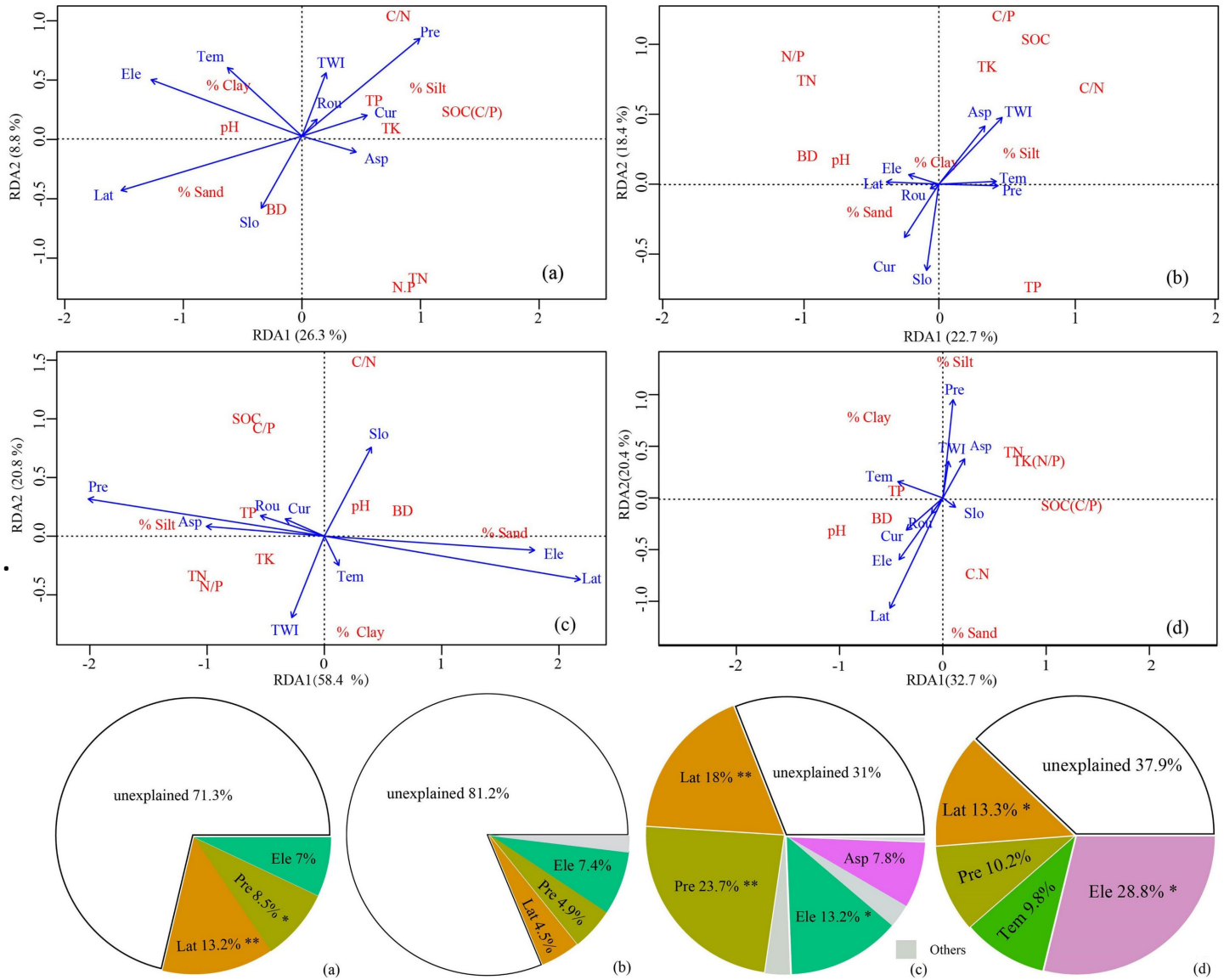
- Topsoil properties almost have no differences across land uses except clay content.

Results

2. RDA and HP

- Climate and topography differentially affect soil properties across land uses.
- Grassland can be explained by more climatic and topographic factors.
- Shrubland had no significant explain factors.

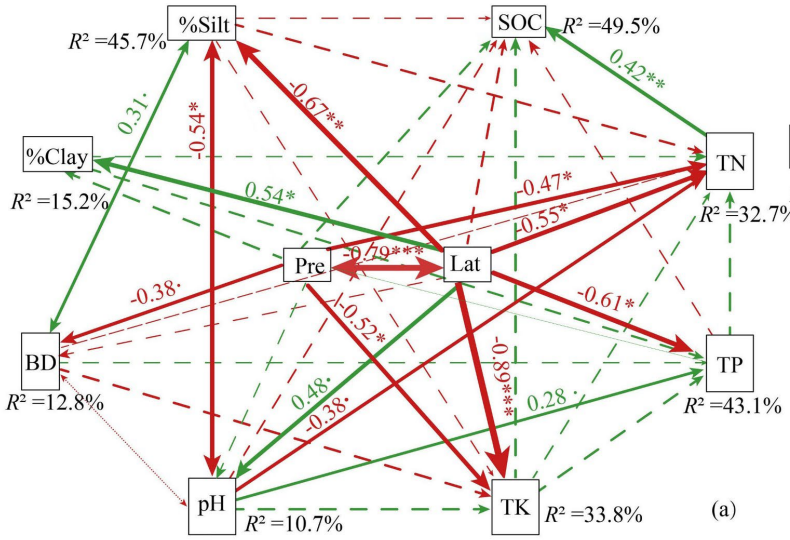
a. Forest
b. Shrubland
c. Grassland
d. Agriculture area



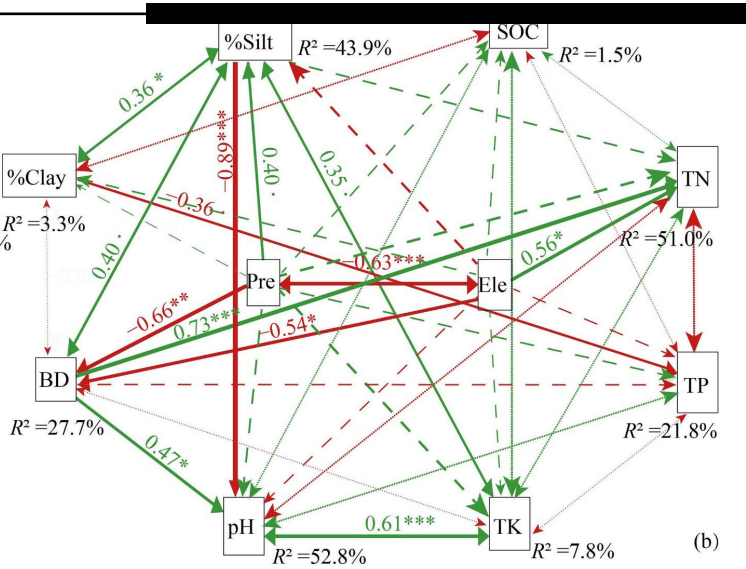
Results

3. SEM

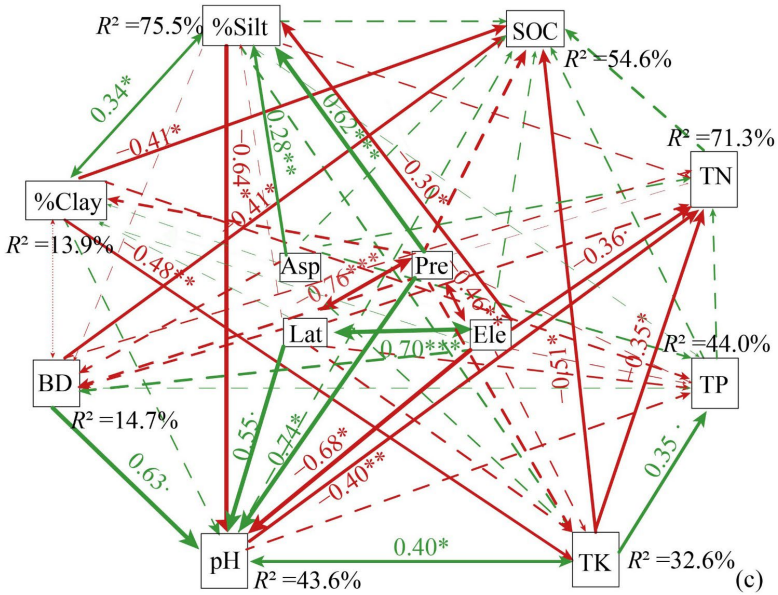
- Soil properties in grassland are influenced by elevation and aspect.
- The pH and bulk density can be mediators between environmental factors and soil properties



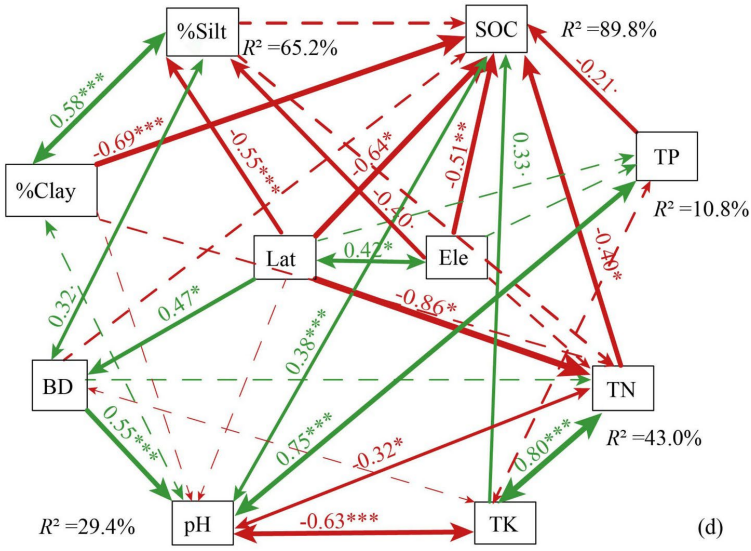
$\chi^2 = 4.462$, $df = 6$, $P = 0.590$, GFI = 0.969, RMSEA = 0.000



$\chi^2 = 3.477$, $df = 6$, $P = 0.747$, GFI = 0.961, RMSEA = 0.000



$\chi^2 = 2.980$, $df = 4$, $P = 0.561$, GFI = 0.983, RMSEA = 0.000



$\chi^2 = 6.274$, $df = 11$, $P = 0.855$, GFI = 0.926, RMSEA = 0.000

Discussion

Interactions among soil properties across land uses

- Clay content had a negative influence on SOC in grassland, which indicates grassland carbon has not yet reached a new steady-state, and the role of clay content on SOC is likely weaker than the negative influence of bulk density on SOC.

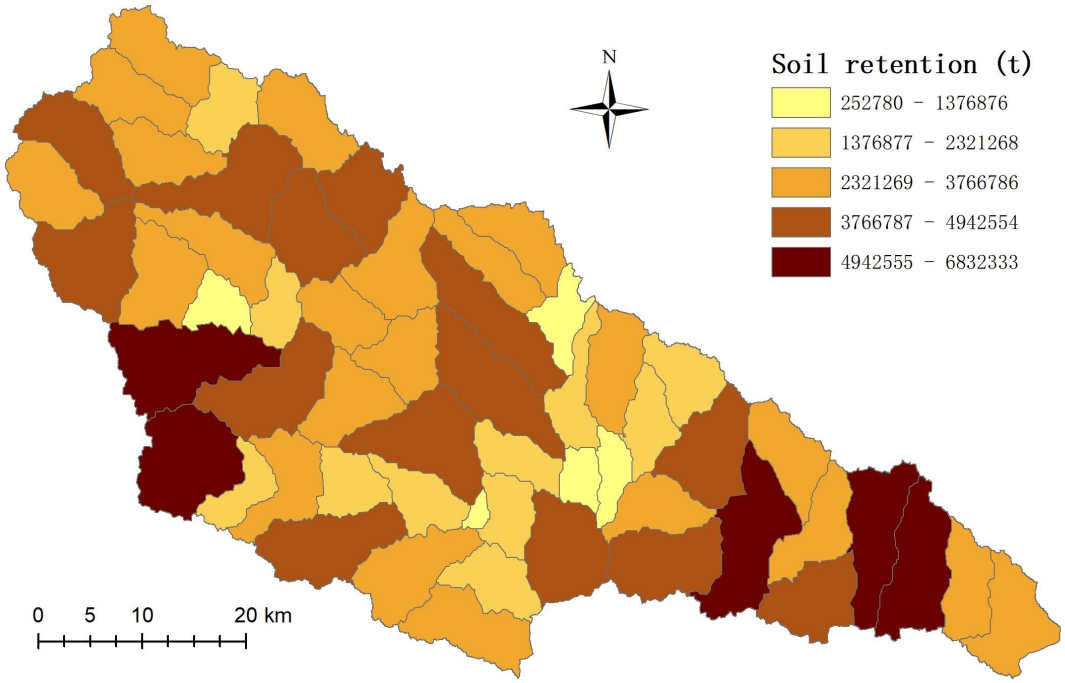
- TP and TK were positively related in forest and grassland, which related to insufficient P is a growth-limiting factor on the Loess Plateau, and higher TK could ameliorate the negative effects of water stress.

Environmental factors affecting soil properties across land uses

- Climatic and topographic conditions have a strong influence on chemical and physical properties, although this impact is different according to the land uses.
- Soil pH is an important mediator variable, which influences SOC and TN, TP via regulating microbial activities.
- TN is vulnerable to climatic factors due to the dependence on biological processes.
- In contrast to forest and grassland, shrubland and agriculture area were less affected by environmental factors.

Conclusion

- Land use, climate, and topography showed varying paths and degrees of influence on soil properties, especially SOC.
- Land management in these areas should pay attention to the dynamic of these nutrients in grasslands.
- Grassland can be further considered in land management, in which the location is very dependent on environmental characteristics.



Implication by soil conservation

Soil retention in 2015---evaluated by InVEST sediment delivery ratio module

	Forest	shrubland	grassland	Cropland
Area(km2)	1036	503	5308	632
Sum(t)	27908873	15357102	135184694	7934619
Mean(t/km2)	26940	30507	25470	12559

- Grassland can conserve more soil loss