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How do shrubs impact the mass failures on the loess sidewall?

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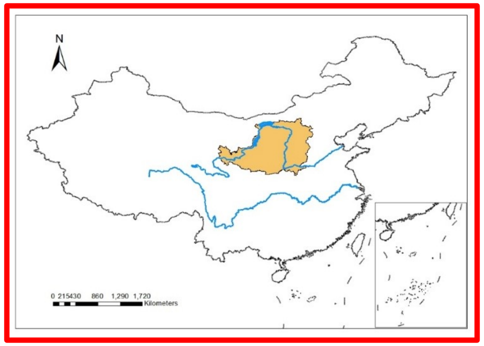
1	Background
2	Test Design
3	Results and discussion
4	Conclusion

01 Background

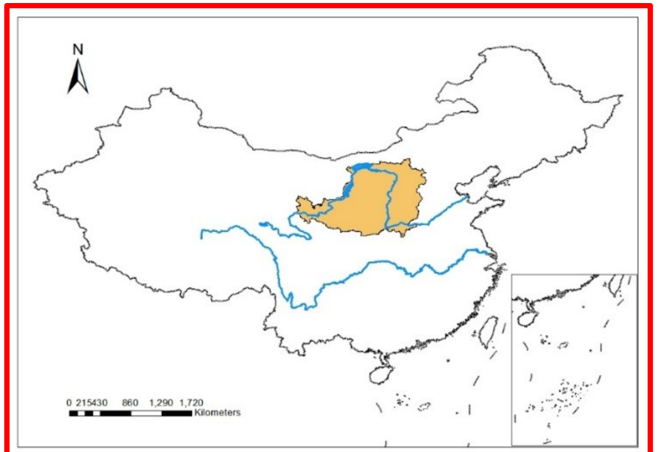
Gravity erosion – mass failure on steep slopes triggered by self-weight – is an important process that controls the sedimentary structures and growth patterns of steep slopes, and it is also one of the major contributors of soil loss to the lower slope reaches. On the Loess Plateau of China, forms of gravity erosion mainly include avalanche, landslide, and mudflow. Most of them are sudden disasters, which seriously threaten the safety of life and property of local people





02 Test Design

The Loess Plateau (33°41′ N–41°16′ N, 100°52′ E–114°33′ E) is a unique ecoregion in China, which lies in the middle reaches of the Yellow River in China.



Most gravity erosion occurs during or immediately after the rainfall. Among the fatal landslides on the Loess Plateau since 1980s, about 40% were triggered by rainfall.

The Loess Hill Ravine and Loess Mesa Ravine regions on the Loess Plateau have been severely affected by gravity erosion, and the terrain is fragmented. A steep bank with a slope of more than 70° in the upper reaches of the small watershed is the main source of the gravity erosion.

01 Background


- Numerous studies have been conducted for the effects of vegetation on soil conservation on the Loess Plateau.
- Effects of plants on gravity erosion are still controversial.

Under the heavy rainstorm and steep slope conditions, it is vital to understand which vegetation effect is more important.

- China government is promoting the eco-environment protection and high-quality development in the Yellow River Basin.
- More attentions will be paid on soil conservation on the Loess Plateau.

In this study, a combination of rainfall simulation and laboratory analysis was used to investigate the effects of shrubs on the gravity erosion of a gully slope under intense rainfall conditions. The study may provide a valuable reference for the ecological construction in the ravine area of the Loess Plateau.

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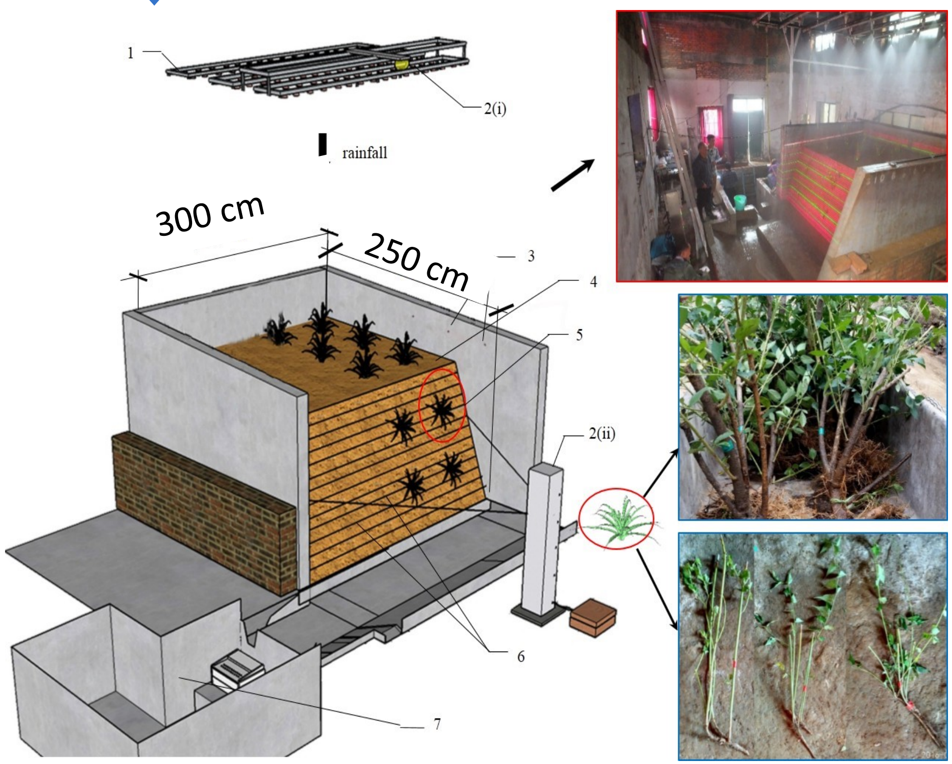

1 – rainfall simulator; 2 – topography meter(2 (i) – video camera, 2 (ii) – laser source); 3 – positioning marks; 4 – model slope; 5 – shrubs; 6 – equidistant horizontal projections; 7 – water receiving pool

- A SX2009 micro-nozzle-styled rainfall simulator was used to simulate rainfall.
- The intensity and duration was 0.8 mm min^{-1} and 60 min.
- Five runs of rainfalls were in turn applied to every conceptual landform.
- A topography meter designed by the authors was used to observe dynamic topography change in real time.
- The soil water content was recorded using a RR-1008 automatic moisture measuring and monitoring system.

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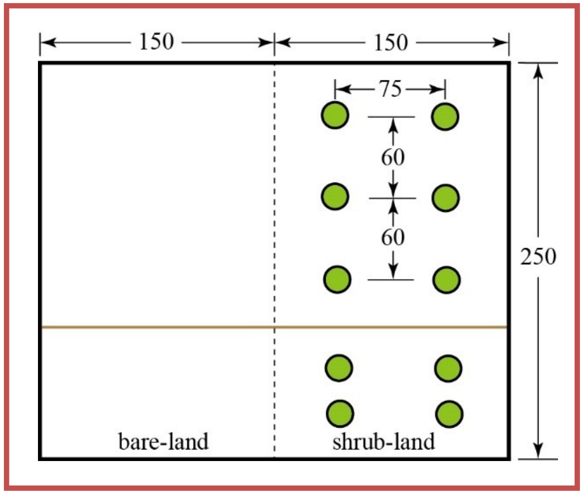
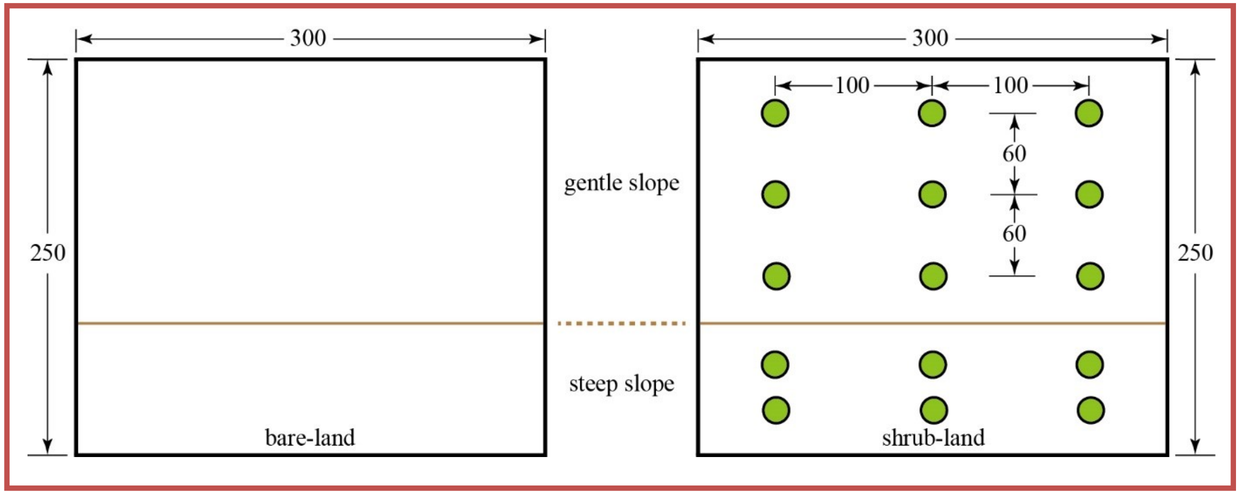
Test Design





Intragroup comparison

Group1： EL2
Group3： EL4

Intergroup comparison

Group2： EL1 and EL3
Group3： EL1 and EL5

Objective:

- Intragroup — To study the impacts of vegetation on the gully sidewall at the same period with different coverages.
- Intergroup — To study the effects of shrubs on the gully sidewalls at a specific location.

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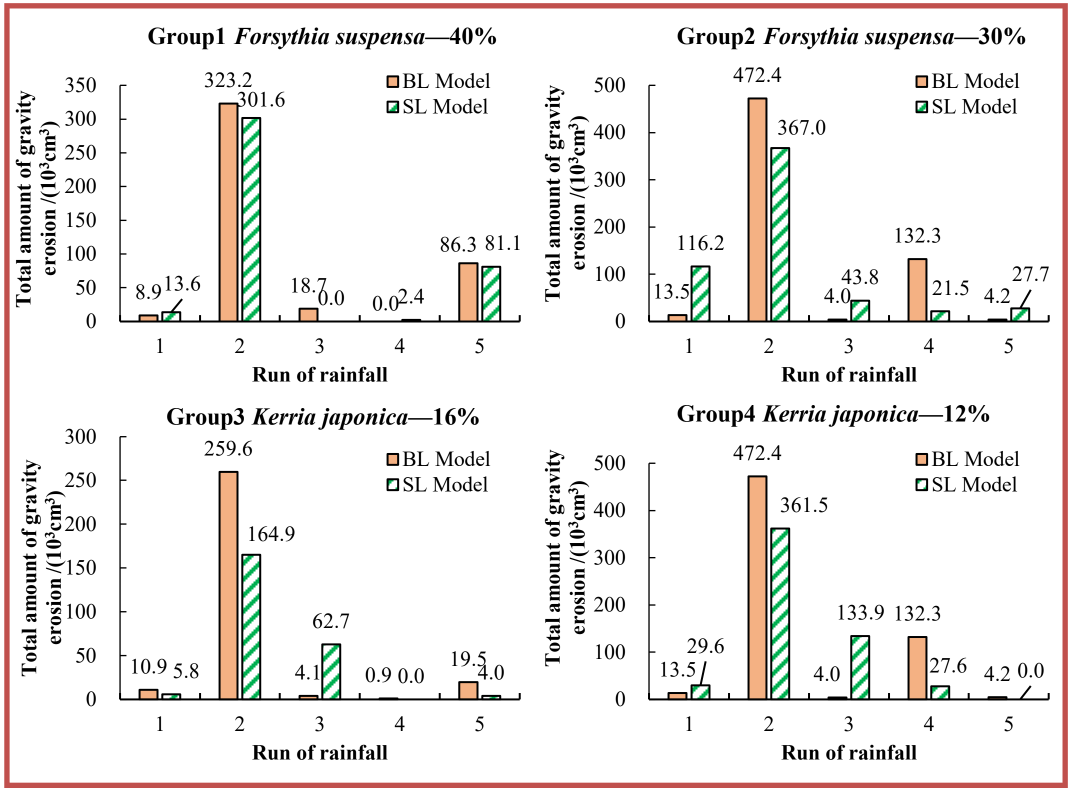
03

Results and Discussion

3.1 Function of vegetation in controlling the total volume of gravity erosion



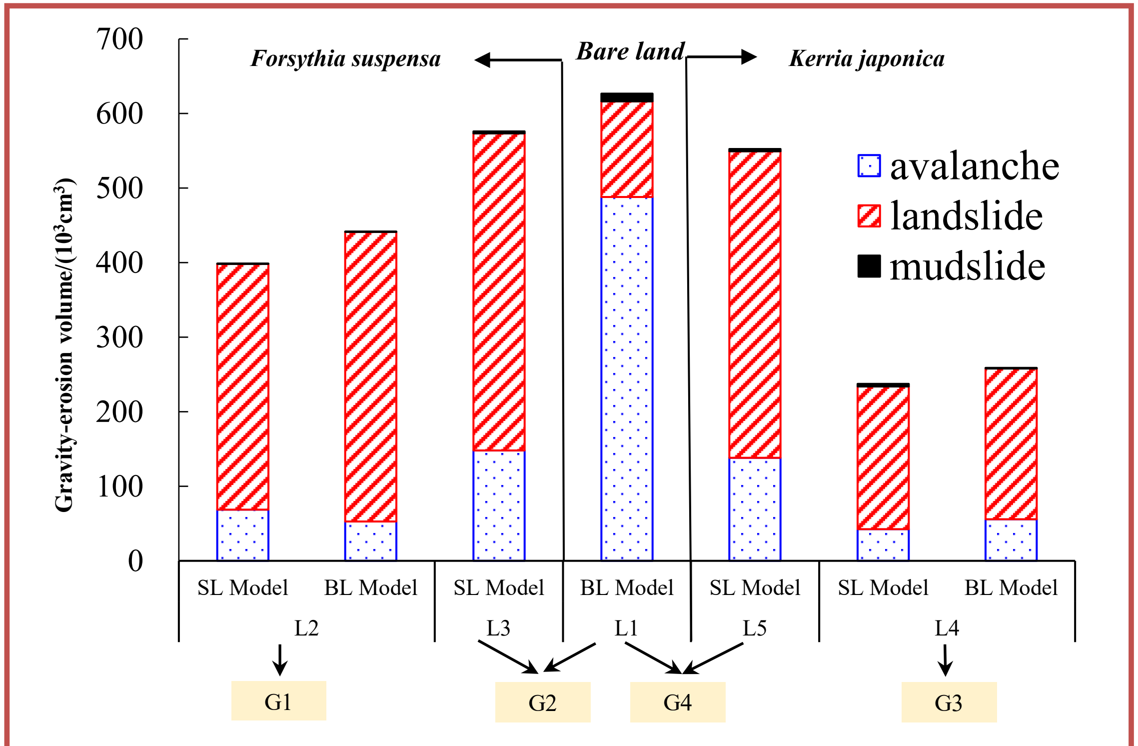
Total volumes for the SL and BL models under five runs of rainfall.

The results revealed only an 8–20% decrease in total gravity erosion in the SL model compared to the corresponding BL model, which indicated that the impact of vegetation on gravity erosion is not significant.

03

Results and Discussion

3.2 Analysis of the different types of mass failure under vegetation cover



Avalanche, landslide and mudslide volumes for the SL and BL models.

Compared with the BL model, the average landslide volume was 42% greater in the SL model, while the average avalanche and mudslide volumes in the SL model were 50% and 36% less, respectively.

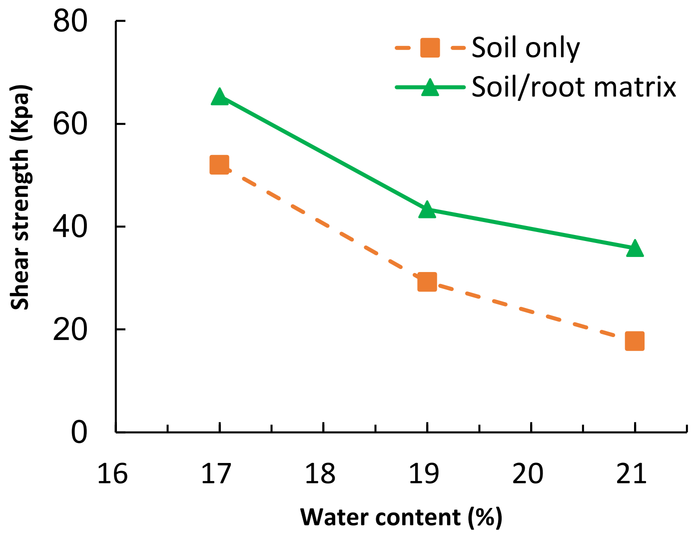
3.3 Features of gravity erosion impacted by vegetation after intense rainfall

Total failure volumes during and after rainfall events

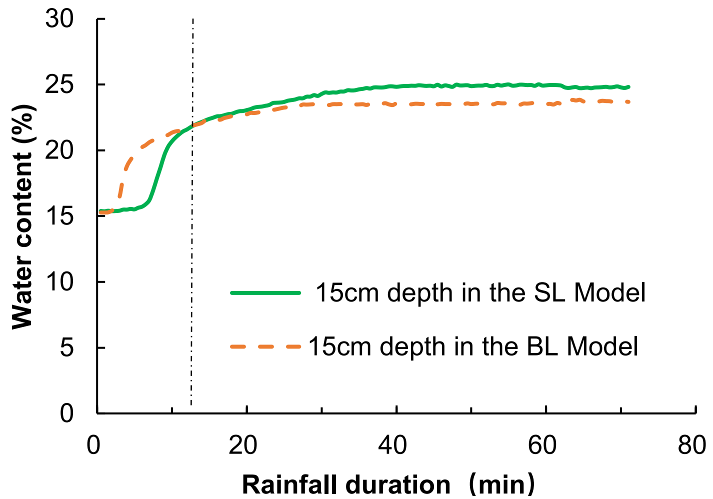
Vegetation type	Rainfall event	Gravity erosion of SL Models			Gravity erosion of BL models		
		Erosion during rain, $D_S/(10^3\ cm^3)$	Erosion after rain, $A_S/(10^3\ cm^3)$	$P_S=A_S/(D_S+A_S)$/%	Erosion during rain, $D_B/(10^3\ cm^3)$	Erosion after rain, $A_B/(10^3\ cm^3)$	$P_B=A_B/(D_B+A_B)$ /%
Forsythia suspensa	Group 1 (L2)	392.2	6.6	2	433.6	3.5	1
	Group 2 (L1 and L3)	545.7	30.5	5	622.8	3.7	1
Kerria japonica	Group 3 (L4)	237.4	0.0	0	283.0	12.0	4
	Group 4 (L1 and L5)	434.1	118.5	21	622.8	3.7	1
Average			38.9	7		5.73	2

The amount of erosion after rain in the SL model was $33.17\times10^3\ cm^3$ more than that in the BL model.

3.4 Effects of shrubs on controlling gravity erosion



Changes in shear strength in soil-only and the soil/root matrix with water content.



Soil water content versus rainfall duration at 15 cm below the topsoil of the gentle slope during the first rainfall of Group 1.

Compared with the anchoring effect of vegetation, the change of soil water caused by vegetation on the slope has a greater effect on the gravity erosion under heavy rains.

3.5 The way forward

- Vegetation Measure:
  - Decrease the volume/frequency of mudslides and water erosion.
  - Be also not appropriate for all situations, such as very steep slopes.
  - Combine structural and management measures to effectively control gravity erosion.
- Due to the limitations inherent in the experimental conditions, some of our conclusions need further discussion.
  - More comprehensive set of experimental parameters;
  - A combination of data on vegetation growth-cycles;
  - More detailed vegetation indicators

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04 Conclusion

- The influence of shrubs on the total volume of gravity erosion may be ignored under intense rainfalls.
- Vegetation can change the type of gravity erosion and improve the degree of soil fragmentation.
- Vegetation may contribute to a delay in the occurrence of mass failure during intense rainfall.
- The vegetation measures can be used to restore the regions where mudflows frequently occur.
- Further studies are needed to evaluate the long-term effects of shrubs on the gravity erosion under the more comprehensive set of experimental parameters.

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Thanks for your attention!

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