Distribution characteristics of gullies with slope gradient in Northeast China

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2020.5

CONTENTS

Introduction

- Serious gully erosion

Faku, Liaoning

Linghai, Liaoning

Introduction

After several years of farming, we can find gullies in most of the slope farmland, and these gullies destroy the land year by year

Hailun, Heilongjiang, May 2013

Gully destroy farmland

Introduction

Meihekou, Jilin, October 2015

The country road cut off by the gully, and farm machine can't across the road

Farmers are worried that their crops will not get out of their fields

Baiquan, Heilongjiang, August 2017

Gully cut off country road

Introduction

Keshan, Heilongjiang, June 2018

Gully also can destroy the woodland and grassland

Trees fell into the developing gully

Hailun, Heilongjiang, October 2015

Huolinguole, Inner Mongolia, July 2018

Gully destroy woodland and grassland

Introduction

The combined use of RS, GIS, and GPS is gradually emerging in the field of soil erosion (Vrieling et al. 2007; He et al. 2014). Although the precision of a remote sensing interpretation is relatively poor compared with that of an interpretation using GPS data and drone imagery (Giménez et al. 2004; Cheng et al. 2007), remote sensing platforms are suitable for the acquisition of data over large spatial scales

Introduction

GPS measurements are used in the study of the distribution of erosion channels in small watersheds and are combined with other watershed data for analysis. Large-scale distribution studies are based on remote sensing interpretation. There is a lack of transition between small watershed studies and large regional studies

Therefore, by selecting 20 small watersheds, erosion gullies are identified via remote sensing interpretation, and the differences in the distribution of erosion gullies between different watersheds are studied. Consequently, this work built the relationship of small-scale and large-scale studies

Materials and methods

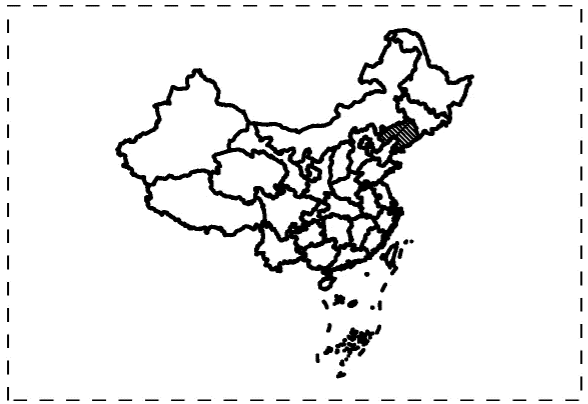
- Study area: Liaoning Province

(118°53′~125°46′E, 38°43′~43°26′N), China

The center is the Liao River plain.The land area proportions of mountainous terrain, plains, and water bodies are 58%, 33% and 9%, respectively. Mountainous hills are roughly distributed along the eastern and western sides.

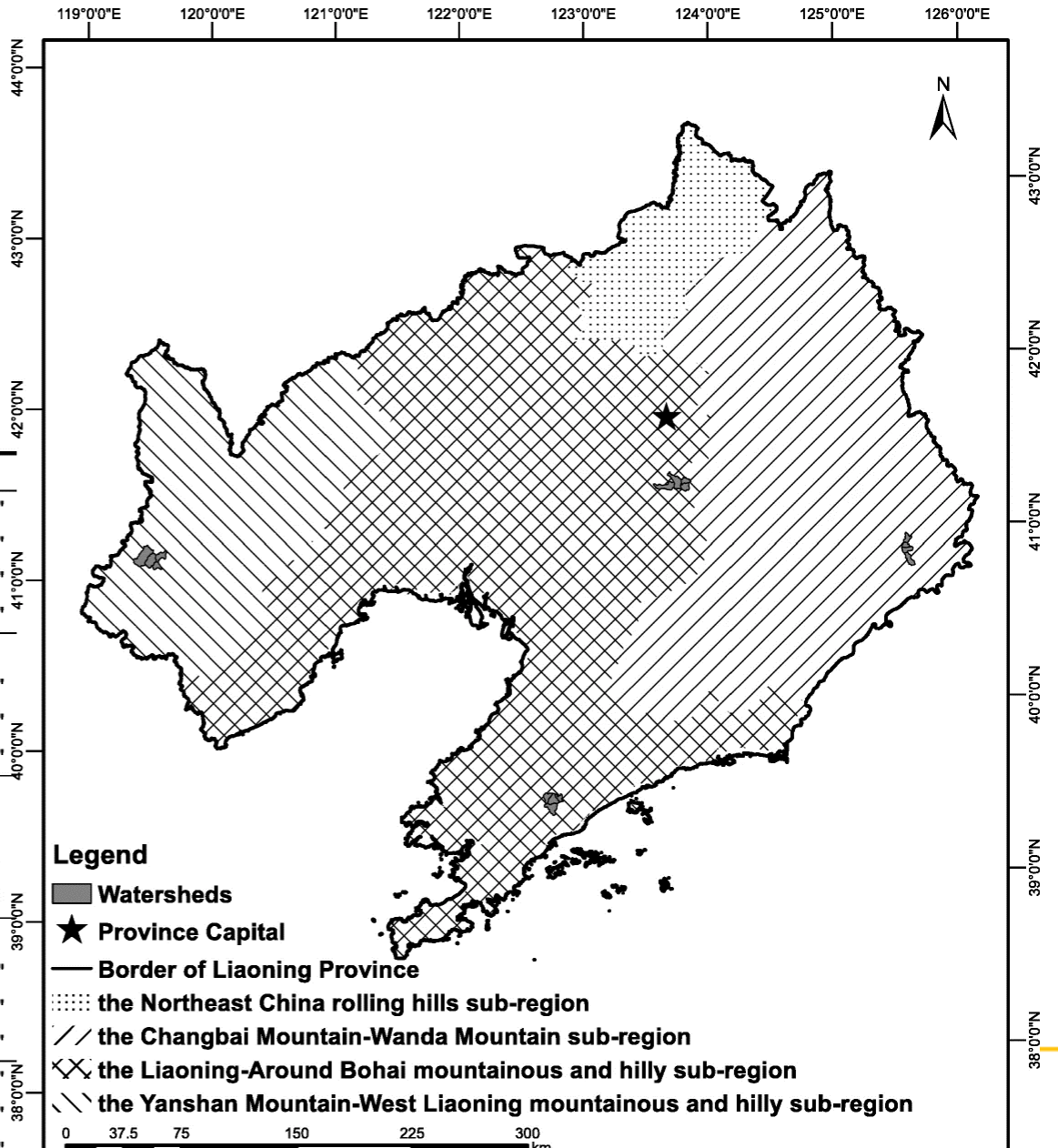
Materials and methods

Location of the small watersheds



Boundary coordinates of the small watersheds

Location	Watershed	East	North	West	South
N	CS	124°6′18"	42°57′14"	124°3′21"	42°54′28"
	FSG	124°9′57"	42°56′42"	124°5′9"	42°53′53"
	EDH	124°10′40"	42°54′57"	124°7′40"	42°52′49"
	QT	124°11′20"	42°54′12"	124°7′1"	42°51′20"
M	LJY	123°35′20"	41°25′37"	123°30′36"	41°23′2"
	ZH	123°31′1"	41°27′53"	123°24′35"	41°21′39"
	CJ	123°27′39"	41°24′45"	123°17′45"	41°21′30"
	TJ	123°34′22"	41°23′42"	123°30′17"	41°20′41"
W	XWP	119°28′4"	41°5′51"	119°23′34"	41°2′51"
	BG	119°24′46"	41°11′46"	119°14′42"	41°4′3"
	SZZ	119°25′48"	41°8′57"	119°20′5"	41°3′32"
	QTPG	119°30′54"	41°9′30"	119°25′4"	41°5′32"
S	GL	122°26′49"	39°38′8"	122°23′13"	39°35′5"
	XT	122°24′57"	39°38′30"	122°19′44"	39°34′30"
	GT	122°22′15"	39°38′45"	122°18′3"	39°34′47"
	DJ	122°24′14"	39°35′18"	122°18′7"	39°30′40"
E	YA	125°14′42"	40°59′57"	125°10′40"	40°56′12"
	ELD	125°13′44"	40°56′35"	125°9′43"	40°54′40"



Tab. 1 Table of parameters of the small watersheds and gullies

Location	Small watershed	Small watershed area (km^2)	Gully characteristics		
			Number (slip)	Length (m)	Area (km^2)
East (E)	DJC	27.12	26	8003.82	0.08
	ELD	12.31	5	5362.57	0.10
	GFZ	19.36	34	13433.26	0.20
	YA	18.17	24	10065.75	0.15
Subtotal		76.96	89	36865.40	0.52
Middle (M)	CJ	40.73	6	5250.26	0.09
	LJY	17.63	4	3741.58	0.07
	TJ	22.58	11	6171.86	0.10
	ZH	44.46	23	13850.36	0.25
Subtotal		125.40	44	29014.05	0.51
North (N)	EDH	9.04	12	2889.74	0.14
	FSG	19.44	18	5435.42	0.18
	QT	10.67	13	2906.32	0.14
	CS	12.92	7	2371.43	0.14
Subtotal		52.06	50	13602.91	0.61
South (S)	DJ	37.44	46	11545.93	0.24
	GL	15.47	47	9197.65	0.14
	GT	22.21	31	5637.70	0.06
	XT	31.02	95	13284.79	0.18
Subtotal		106.14	219	39666.07	0.2
West (W)	BG	84.43	36	28635.58	1.72
	QTPG	28.06	23	13245.74	0.46
	SZZ	44.06	18	6565.11	0.16
	XWP	18.87	6	1841.21	0.06
Subtotal		175.42	83	50287.64	2.40
Total		535.98	485	169436.06	4.66

Materials and methods

➢ Data acquisition

The data on the small watersheds and gullies in this study were based on the soil erosion census data of LN collected in 2015. The extraction threshold for small watersheds was iteratively established based on a 1:50,000 digital elevation model (DEM) and 845 river basins in LN with an area of more than 50 km^2, and the threshold was then compared with that of a typical small watershed. Finally, the threshold was set to 10000

Materials and methods

A general investigation of gullies was carried out based on remote sensing images with a resolution of 2 m and a 1:50,000 DEM. Interactive GIS techniques were used to extract information on the length, area, type, longitudinal gradient, and location of the gullies. The steps in these interactive GIS techniques include (1) transforming the projection, (2) correcting the RS images to eliminate band and spot errors, (3) joining and splitting the images, and (4) loading the images into a database. The RS data are then checked through interpretation and field surveys to avoid missing data and errors, and an attribute table and spatial data for each gully can then be successfully created. The gully survey object is a channel with a length of 100~5000 m, which can be clearly identified in a remote sensing image (Wang et al. 2017)

Materials and methods

The slopes were divided into nine classes (0~0.25°, 0.25~1.5°, 1.5~3°, 3~4°, 4~5°, 5~8°, 8~15°, 15~25°, and 25~90°), which were derived from the Standard of Water and Soil Conservation in the Black Soil Region (SL-2009)

The DEM of the slope was converted into polygons and stored as shape files to enable the distributions to be extracted. The small watershed data and gully data were superimposed to ensure that no erosion gullies within the small watershed were statistically lost; subsequently, related parameters, such as the erosion gully length and area, were calculated. These parameters were then superimposed with the slope layer to obtain the gully slope distribution features

Results and discussion

➢ Distribution characteristics of gullies in the small

Tab. 2 Correlation coefficients between the areas of small watersheds and gully parameters

	CA (M)	GN (M)	GL (M)	GA (M)	
CA (E)	-	0.610	0.700	0.708	CA (M)
GN (E)	0.662	-	0.986*	0.975*	GN (M)
GL (E)	0.269	.900	-	0.998**	GL (M)
GA (E)	-0.171	0.624	0.903	-	GA (M)
	CA (E)	GM (E)	GL (E)	GA (E)	
	CA (S)	GN (S)	GL (S)	GA (S)	
CA (N)	-	0.339	0.619	0.706	CA (S)
GN (N)	0.594	-	0.828	0.432	GN (S)
GL (N)	0.866	0.904	-	0.863	GL (S)
GA (N)	0.939	0.819	0.985*	-	GA (S)
	CA (N)	GN (N)	GL (N)	GA (N)	
	CA (W)	GN (W)	GL (W)	GA (W)	
	-	0.881	0.894	0.916	CA (W)
		-	0.968*	0.909	GN (W)
			-	0.981*	GL (W)
				-	GA (W)

Note: Small watershed area (CA), gully number (GN), gully length (GL), gully area (GA).

* Significance level < 0.05, **Significance level < 0.01

Results and discussion

➢ Distribution characteristics of gullies in the small

Tab. 3 Correlation coefficients between the small watershed area and gully parameters

	Catchment area	Gully number	Gully length	Gully area
Catchment area		0.259	0.801**	0.803**
Gully number			0.524*	0.190
Gully length				0.847**
Gully area				

Results and discussion

- Distribution characteristics of gully density along slope gradient

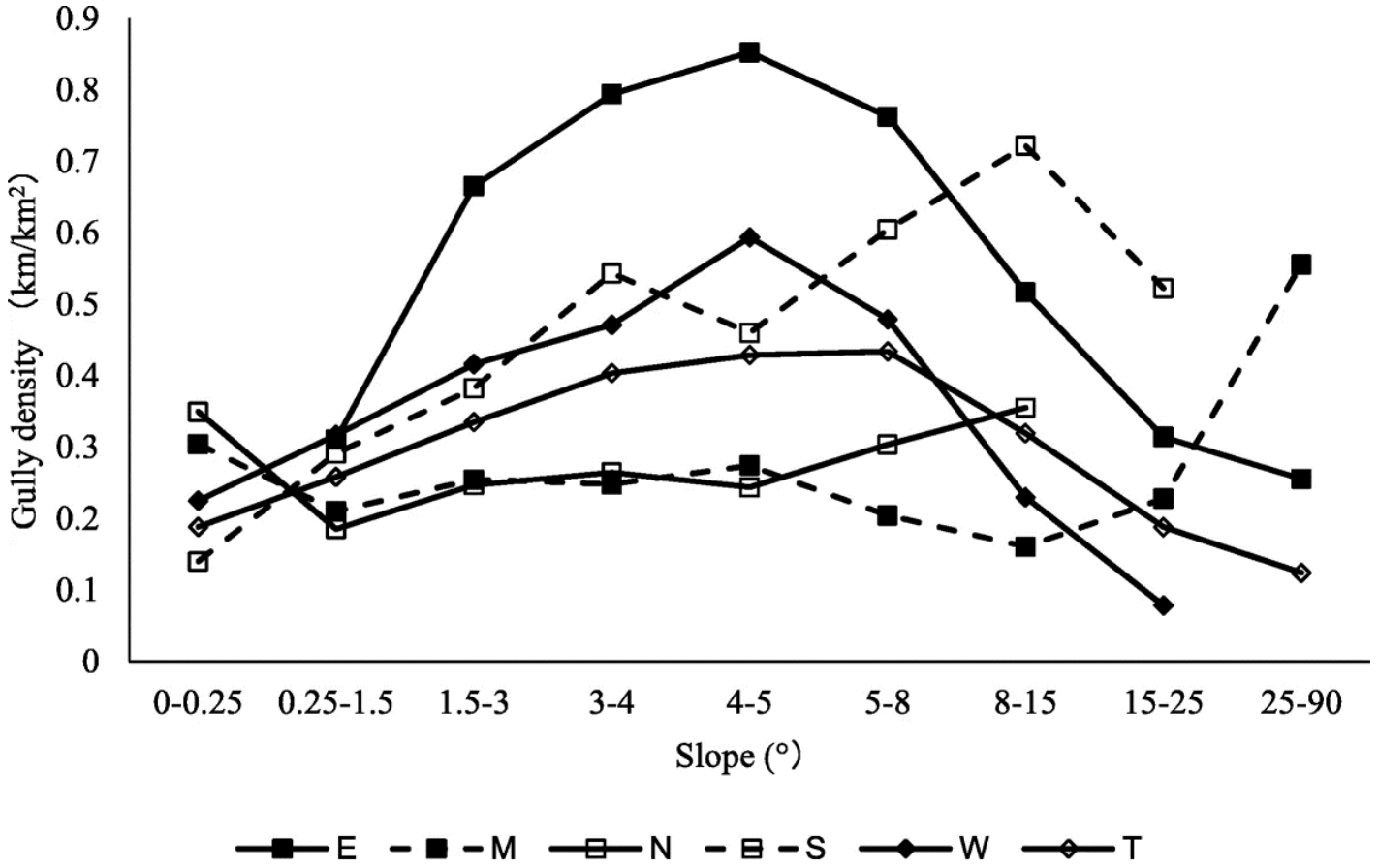


Fig. 2 Distribution of the gully density

Results and discussion

➢ Distribution characteristics of gully density along slope gradient

Table 4 Correlation between the slope and gully density in the watershed sets

	Small watershed set					
	E	M	N	S	W	T
Pearson	-0.07	-0.653	0.389	0.183	-0.155	-0.017

Although the gully density is not related to the proportion of each slope range in the small watershed, the influence of the topography on the gully density distribution can be determined by comparing the trend of the gully density distributions among the different small watersheds and the five watershed sets.

Results and discussion

For slopes of 0~0.25°, the gully densities are higher in the northern and middle small watershed sets than in the. This pattern is chiefly because the proportions of the slope areas in the northern and middle watershed sets are smaller than those of the gullies within this slope range. The gully density in the middle small watershed set is obviously higher than those in the other small watershed sets in the slope gradient range from 25 to 90°. Although the proportion of the slope gradient (0.16%) and the proportion of the gully length (0.39%) are low, they are different by a factor of 2.44, which is obviously larger than the differences associated with the other slope classes in this small watershed set. Therefore, the distribution of gullies is correlated with the topography

Results and discussion

➢ Distribution characteristics of the proportion of dissected land along the slope gradient

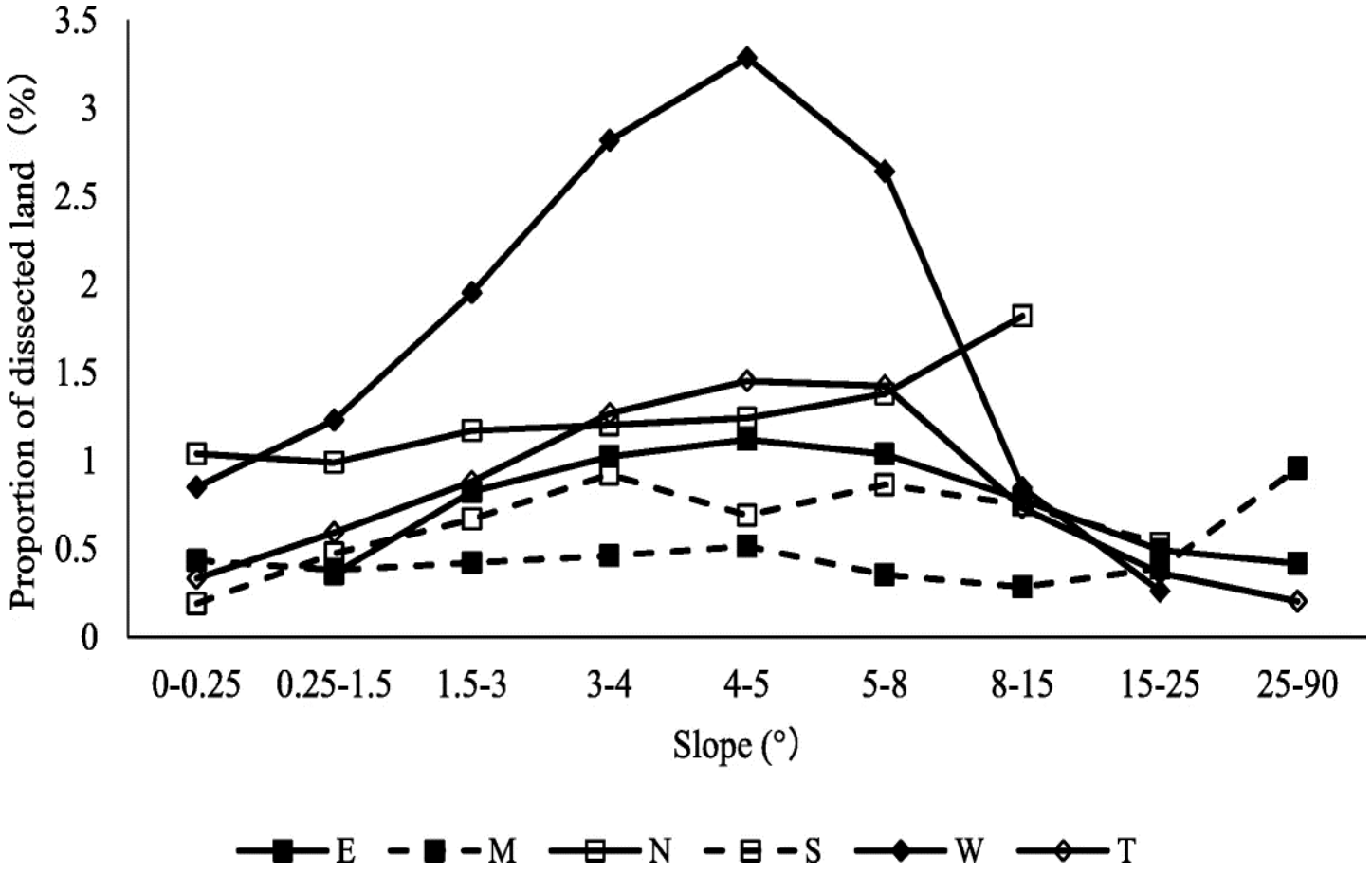


Fig. 3 Distribution of the proportion of land cut by gullies

The gully data from the five watershed sets were again integrated with the terrain data. The results show that the proportion of land cut by gullies increases with the slope gradient, forming a single-peak curve consistent with the gully density distribution curve. The proportion of dissected land first increases and then decreases with the slope gradient, and it increases when the slope gradient is greater than 5°

Results and discussion

➢ Distribution characteristics of the gully length-width ratio along the slope gradient

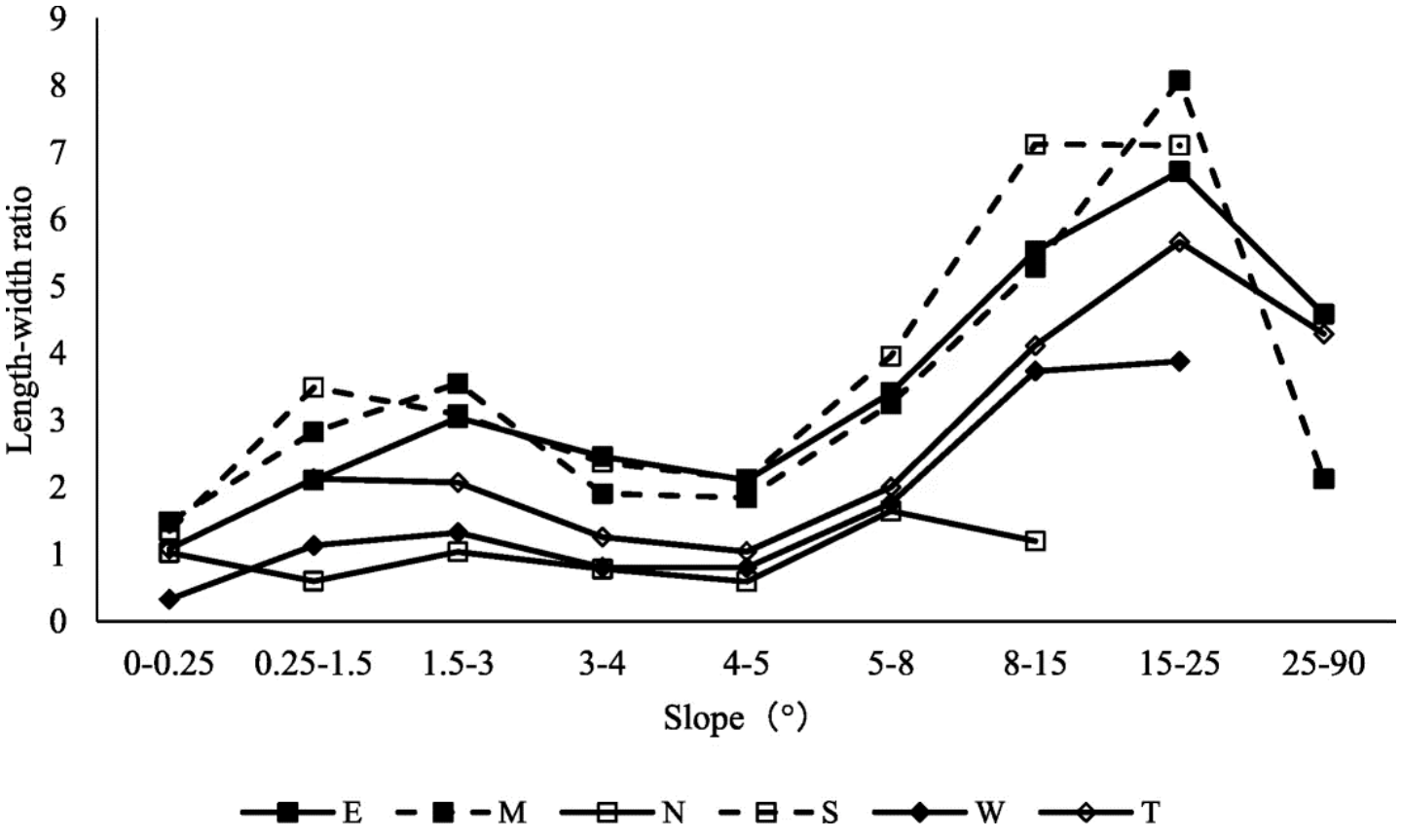


Fig. 4 Length-width ratio distribution of gullies

As the slope increases, the gullies gradually change from short and wide to long and thin upon reaching the first slope threshold. Although only one threshold exists in the western small watershed set, two slope thresholds exist in the eastern, middle, and southern small watershed sets. The southern small watershed set displays the first gradient threshold at 1.5°, while the other three sets present their first gradient threshold (the only one in the western small watershed set) at 3°. In these small watershed sets, when the slope is 5°, the gullies transition from being short and wide to being long and thin

Conclusions

- Each watershed set has its own distribution characteristics in terms of the gully density, the proportion of dissected land and the gully length-width ratio. The distribution of gullies with respect to the slope depends on both the gully parameters and the proportion of terrain in the slope grade ranges
- The gully density and the proportion of land dissected by gullies in Liaoning Province showed single-peak curves with increasing slope, with slope thresholds of 8° and 5°, respectively. The constructed distribution equations have a high degree of fit
- The length-width ratio of each small watershed set changes repeatedly with increasing slope. However, an analysis of the gully density and the proportion of dissected land revealed that the gully density and proportion of dissected land are larger in the slope range of 3~8° and that the length-width ratio is small in this slope range. Therefore, many relatively short gullies are located within this slope range and that gully erosion is serious

Thanks for your attention

More information: Wang, D., Fan, H. Distribution characteristics of gullies with slope gradient in Northeast China. Environ Monit Assess 191, 379 (2019). https://doi.org/10.1007/s10661-019-7501-5, https://doi.org/10.5194/egusphere-egu2020-2875

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