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IMPACT OF LAND USE CHANGE ON SOIL EROSION IN NORTHEAST CHINA



Baixing Yan, Xingyi Zhang, Xingtu Liu
Northeast Institute of Geography and Agroecology
Chinese Academy of Sciences

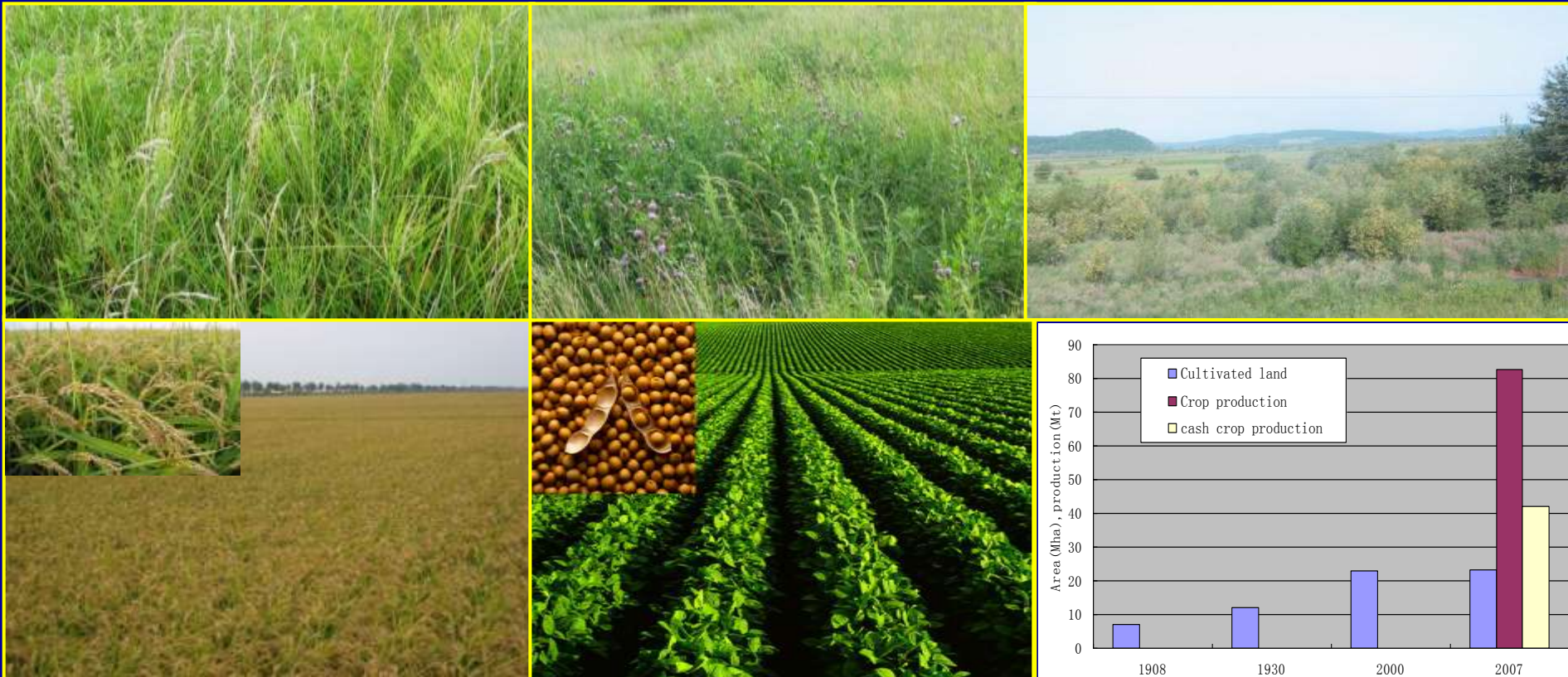
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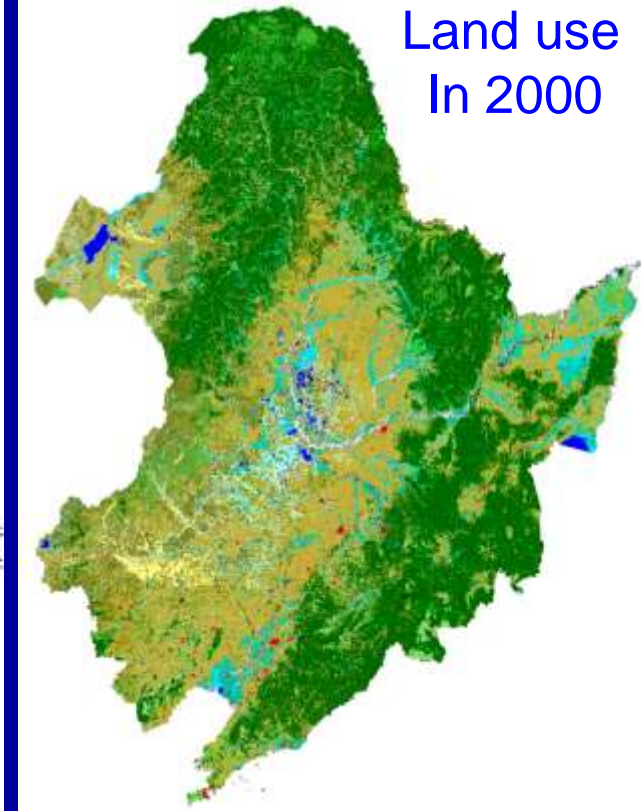
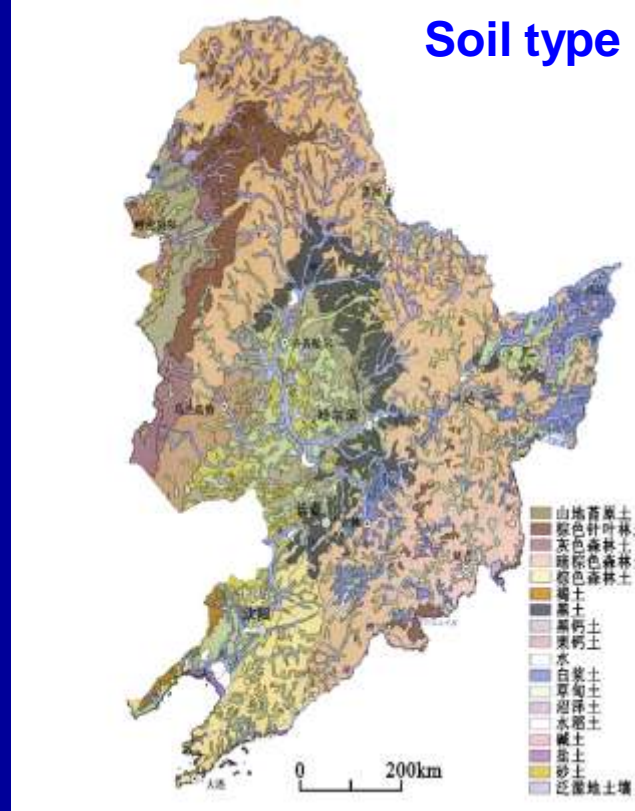
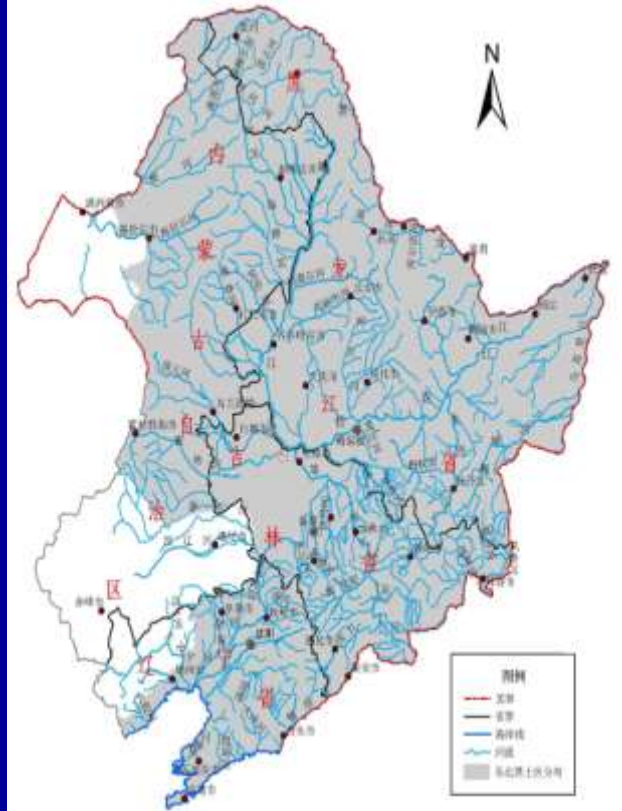
INTRODUCTION

- Water-induced soil erosion and associated environmental impacts have been becoming a great issue in China and other countries for last three decades.
- The impact of land use change on soil erosion is remarkable. Soil erosion is frequently identified as a primary cause of degradation of land productivity.
- It's a dominant transport vector carrying agricultural non-point source (NPS) pollutants which damage the aquatic habitats.



➤ Northeast China, with the area of 103 million ha, is not only the important bases for production of energy source, steel, chemical industry and timber, but also the biggest base for production of cash crop in China. Land use/cover had been obviously changed there due to the intensive reclamation of forest, grass and wetland since last century.





Source: Zhang S W, et al.

Soil erosion occurs wherever vegetation disappeared has become a serious ecological and environmental problem in Northeast China. The purpose is to reveal the evolution of soil erosion, humus layer thickness, the number of gully, erosion rate, NPS, and the impact of soil erosion on land productivity.



2 METHODS

➤ Data sources

The data in this study came from TM image, relief map, vegetation map, land use map, investigation information, historical statistic information of provinces.

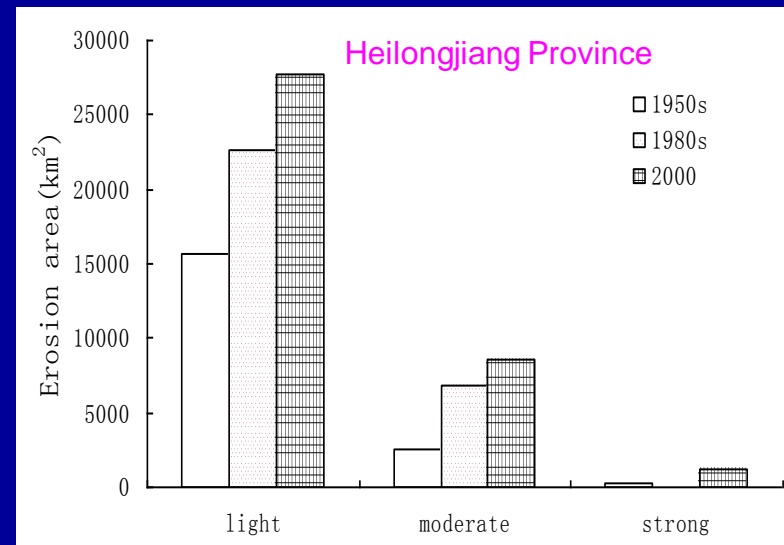
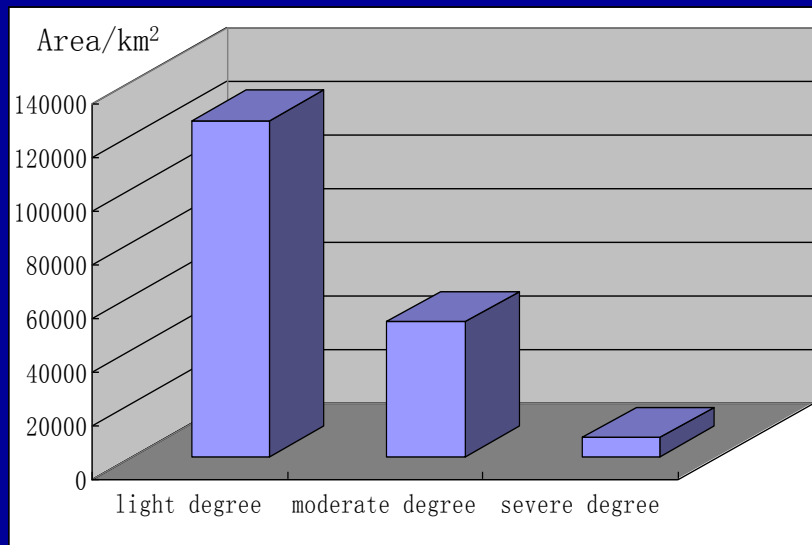
➤ Soil samples

Soil samples for nutrient analyses and physical properties test were collected in some representative plots. For caesium-137 analyses, sectioned samples were collected at undisturbed profiles and bulk soil samples were collected in representative sloping transects.

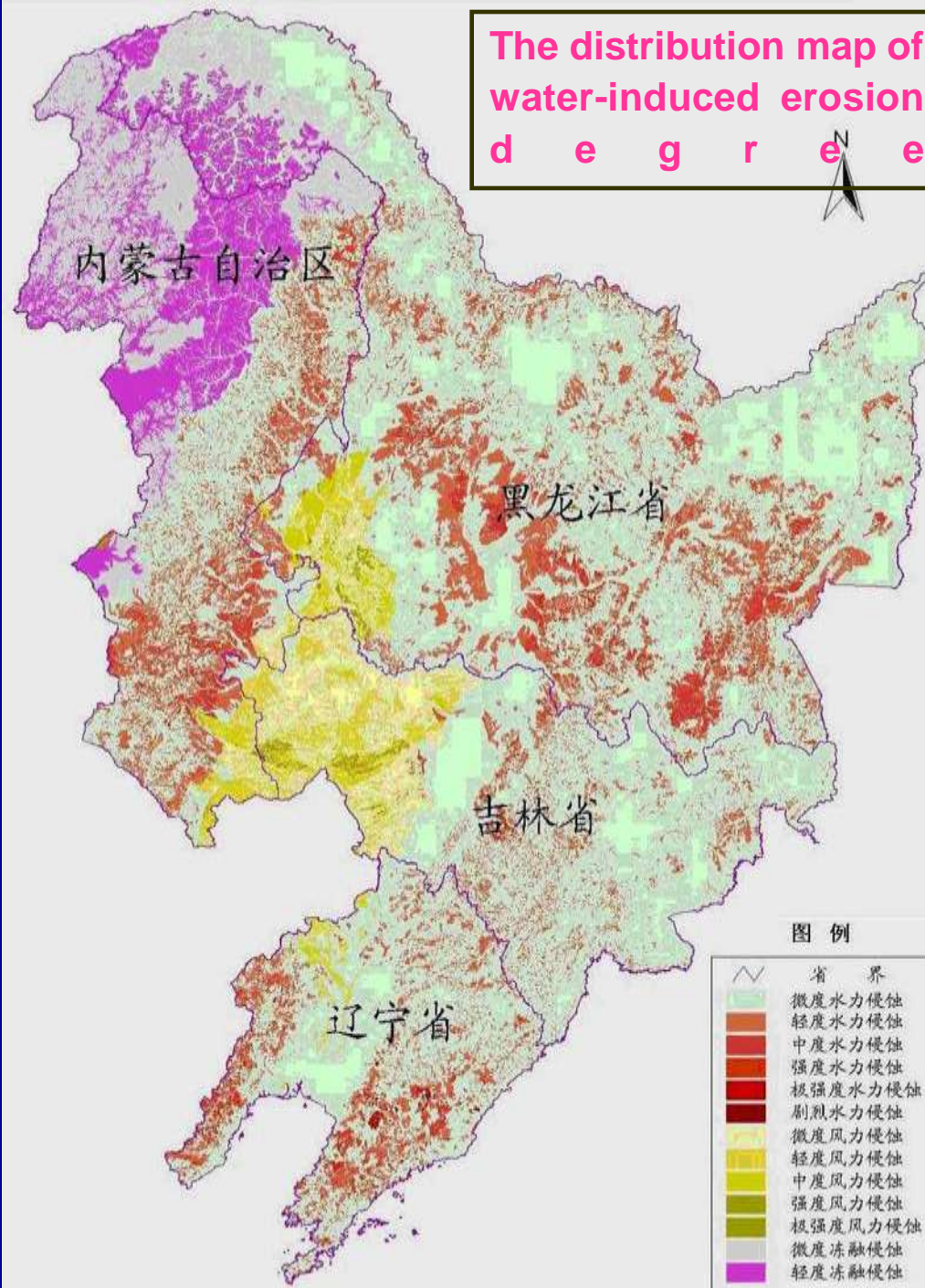
RESULTS AND DISCUSSION

1 Development of soil erosion

The area of water-induced erosion was 18.27 million ha in 2000 in Northeast China, which account for 17.7% of total land area and most of which is fallen into the light erosion degree. But the domain fleetly spread, especially for light degree erosion. For example, the water erosion area in the middle Heilongjiang Province increased from 24292.40 km² in 1950s, 36649.52 km² in 1980s to 45106.51 km² in 2000, most of which attributed to light and moderate degree.

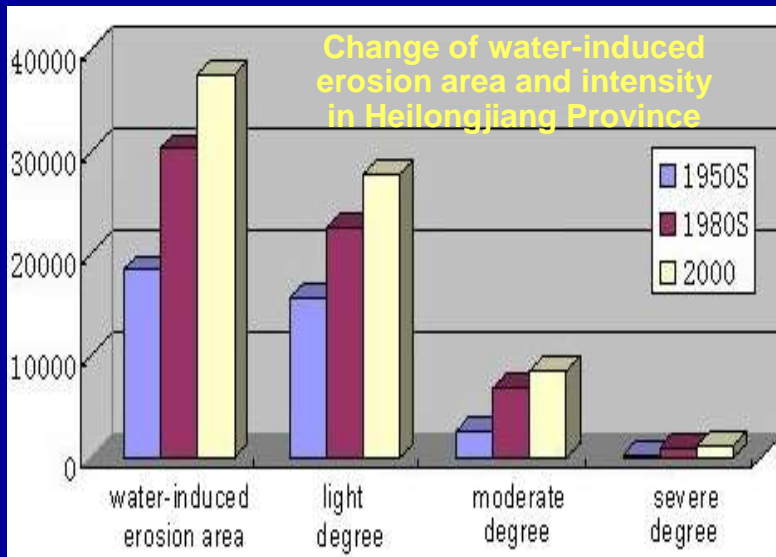


The distribution map of water-induced erosion degree

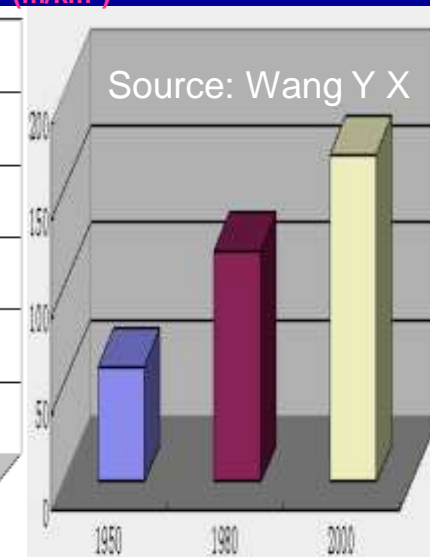
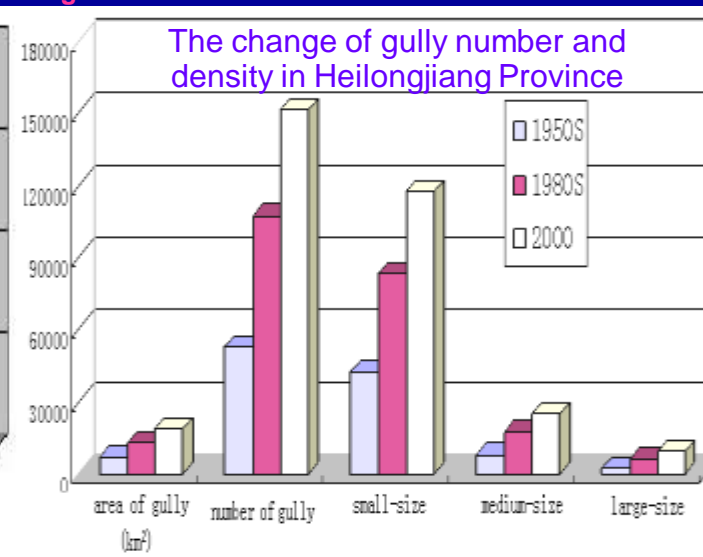


Gully numbers rapidly increase too, gully courses ceaselessly expand and trace to the source, gully density is evidently enhanced. It is estimated that there are 250 thousand gullies in Northeast China based on the investigation in some typical regions, which occupy 4830 km² of farmland. The small-size gullies are still ascendant in number, but developing rates of medium-size and large-size gullies are faster in the middle Heilongjiang Province. The gully numbers had trebled since 1950s.

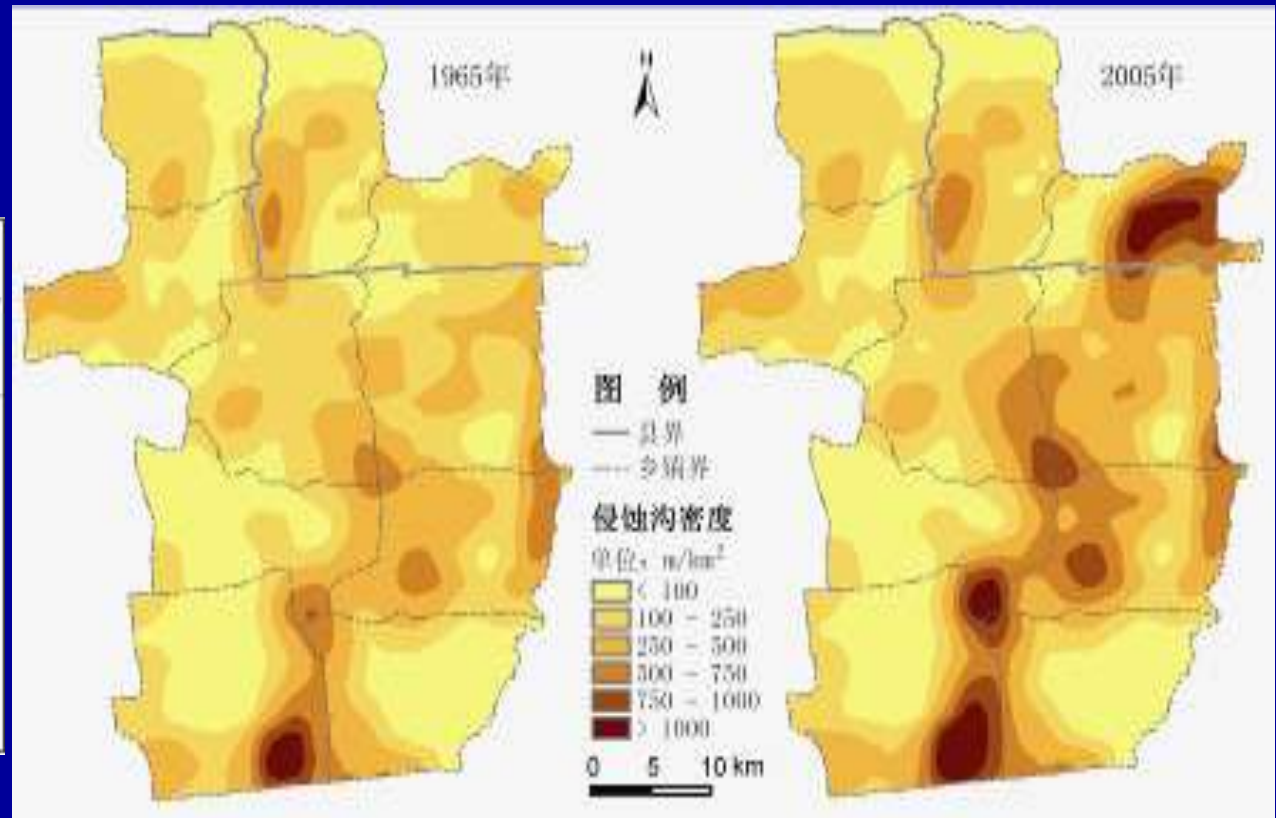
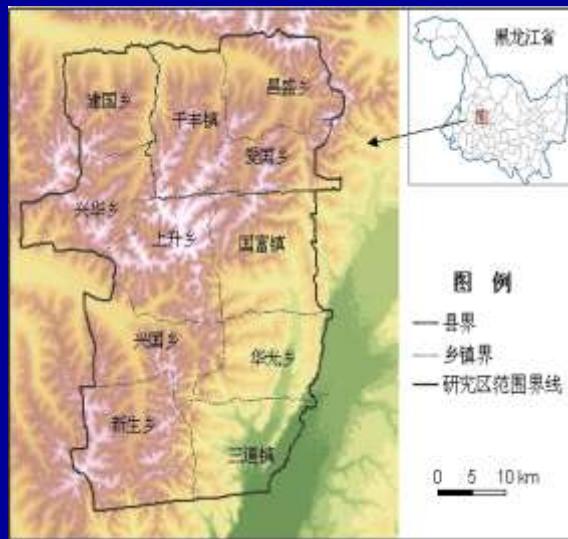
Number and area of gullies



Gully density (m/km²)

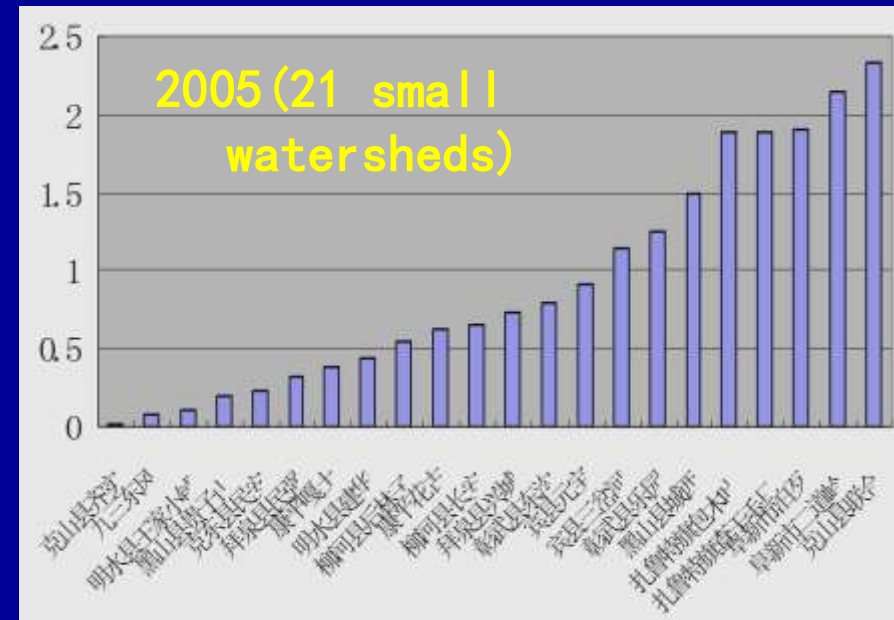
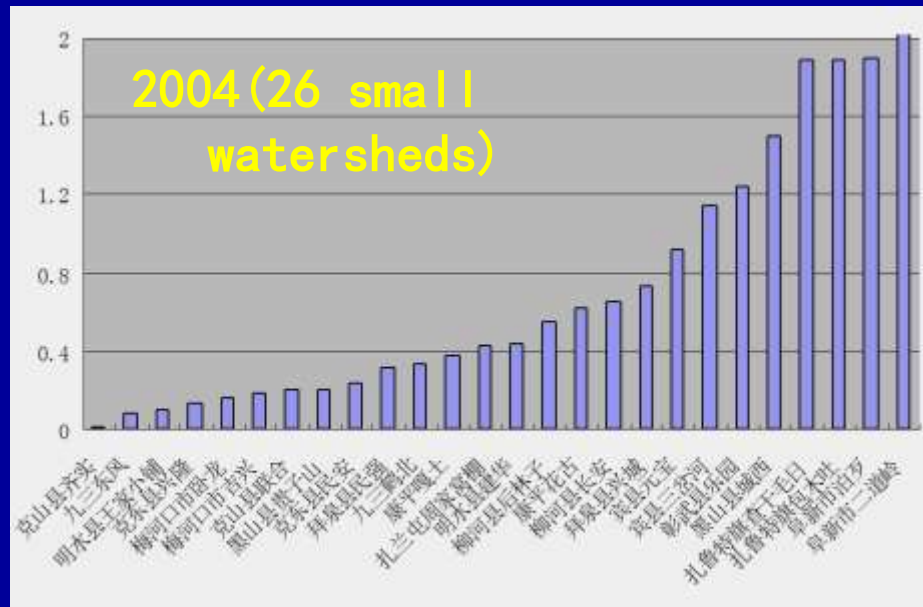


The study using RS method in a typical area of ten towns shows gully number and density developed from 1712, 202m/km² in 1965 to 2565, 283m/km² in 2005, respectively.



Source: Zhang S W, et al.

The investigation in 26 small watersheds in 2004-2005 found the mean gully density reach to **0.91** km/km² with the range of 0.01-2.33 km/km². The gully density in 21 small watersheds in 2005 increased 12.2% than in 2004. Gullies in 6 small watersheds traced 1.10m (0.02-3.5m), deepened 5.64 cm(0.5-13.16cm) and widened 30.6cm(0.6-147.67cm) in 2005.





Sheet erosion in spring



Gully erosion



05/22/2005

The main driving factors of soil erosion are runoff and storm in this area, but the freeze thawing action and freezing layer trigger the erosion intensity. The former breaks the viscosity of soil granules and makes granules loosened, which weakens the erosion resistance. The latter acts as an aquiclude and blocks the infiltration of snow-thawed runoff and rain runoff in late spring and early summer, which accelerate the water erosion above the freezing layer. Furthermore, dilation-frozen conduces the formation of cranny along the gully. When the runoff infiltrate through the crannies, landslip and falling will easily take place in the gully wall. It makes the gully widened rapidly, which accelerate the development of gravity erosion. The research in USA shown soil erosion increased 24%~90% for the treat with alternation freezing and thawing compared with the treat without the action.

2 Soil erosion rate of slope farmland

Erosion rates in two typical slopes were surveyed using caesium-137 tracer method. It shows the average erosion rates had reached 2.08-4.95mm/yr after 1963 and the erosion intensities had fell into moderate and severe degree according to “Standards for Classification and Gradation of Soil Erosion, China (SL190-96)”.

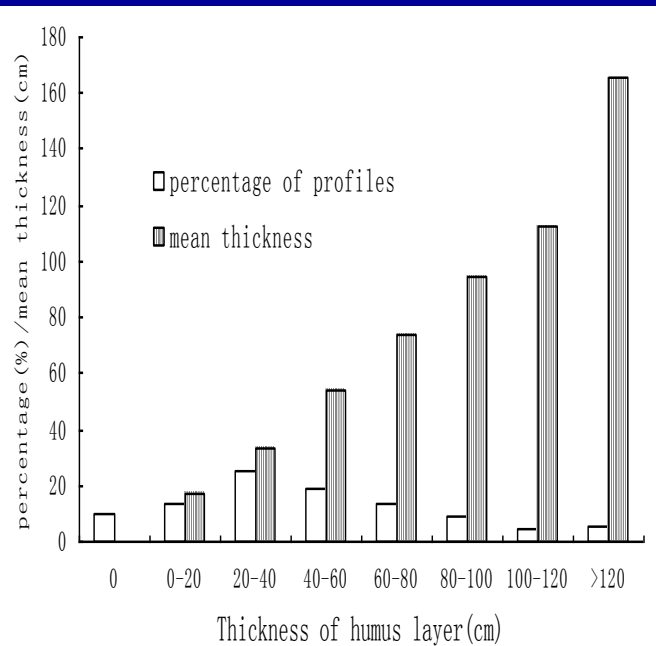
Site	Distance to summit (m)	Grade (°)	Bulk density (g/cm ³)	Distribution Depth (cm)	Cs-137 activity (Bq/m ²)	Erosion Rate (mm/a)	Erosion intensity (t/km ² .a)
D1	0	3	0.96	0-25	1499.45±101.73	3.16	3033.6
D2	100	5	0.91	0-25	1246.05±85.90	4.33	3940.3
D3	150	4	0.88	0-25	1267.44±87.96	4.22	3713.6
S1	320	7	1.08	0-20	1129.77±74.57	4.95	5346.0
S2	170	5	1.09	0-20	1471.76±93.17	3.28	3575.2
S3	50	3	1.11	0-20	1779.42±108.60	2.08	2308.8

3 Evolvement of humus layer thickness

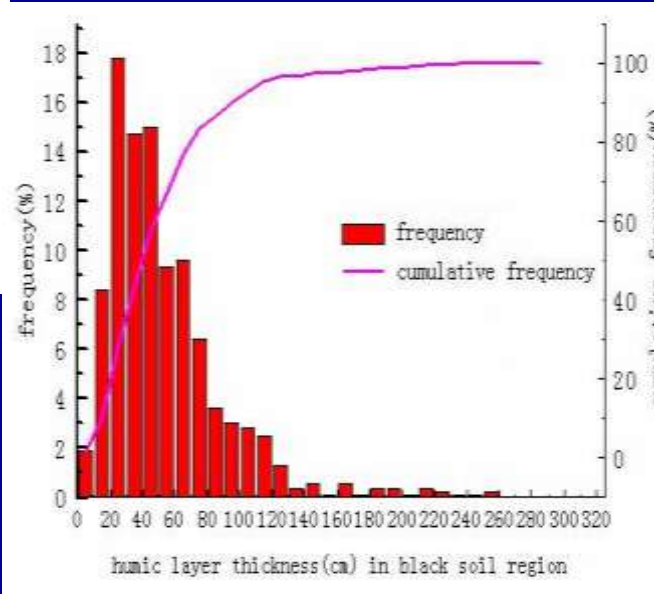
The average thickness of humus layer was **43.7** cm with the range of **16-72** cm for 81 typical soil profiles in **1982**.

Province	Area of humus layer thickness<20cm (km ²)	Percentage (%)	Area of humus layer disappeared (km ²)
Jilin	1030	12.4	170
Heilongjiang	871	2.4	Very little

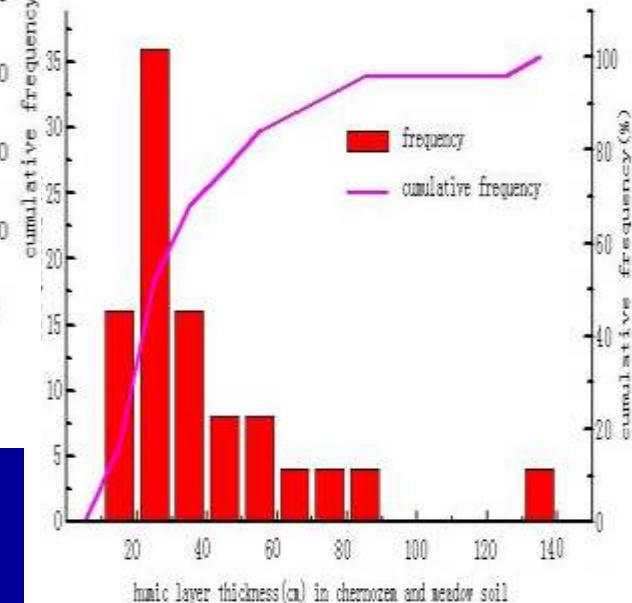
There were 48.6% among 856 profiles of which the average thickness of humus layer was thinner than 40cm in black soil region, 51.8% among 27 profiles of which the average humus layer thickness was thinner than 20cm and 74% was thinner than 40cm in chernozem and meadow soil region. It shows humus layer thicknesses are gradually thinned.



(2004-2005)



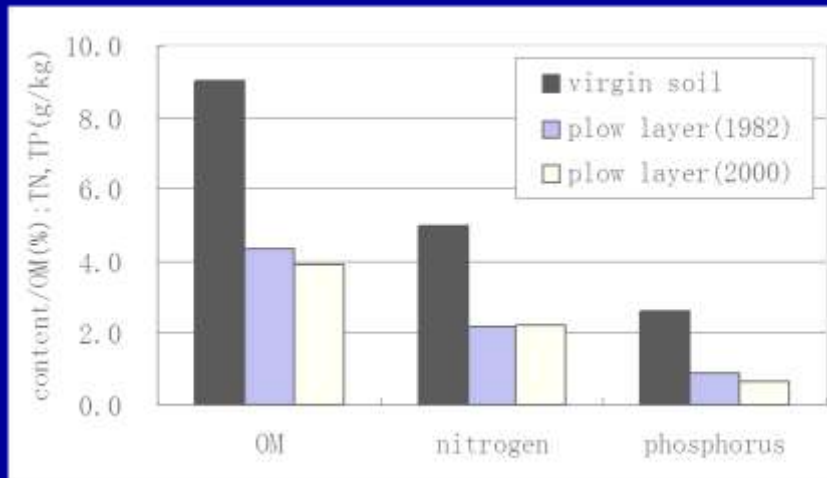
The mean thickness of humus layer and profile percentage



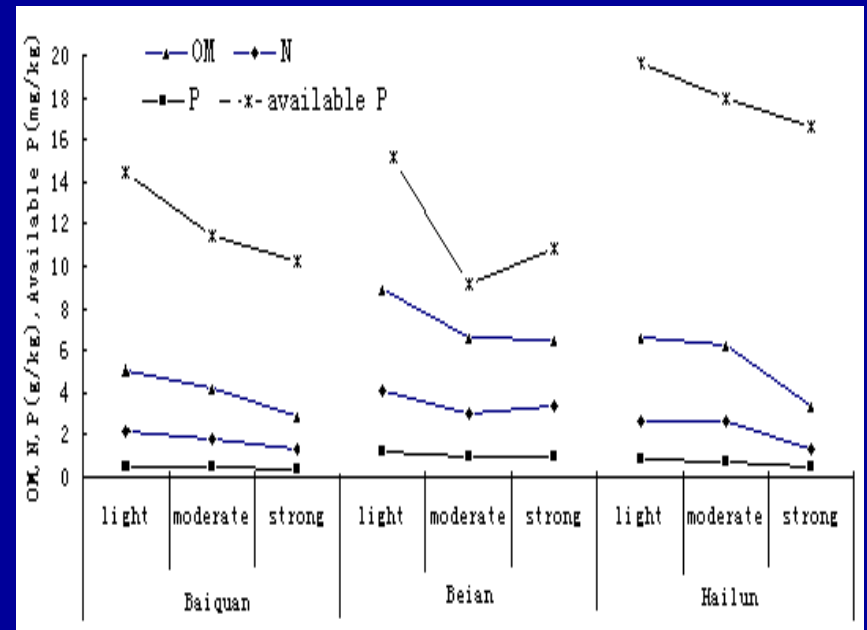
Source: Liu B Y

4 The impact of erosion on nutrient contents and physical properties

Erosion makes fertile and loamy top soil lost, which contains more nutrient. The sequence is that not only humus layer is thinned, soil structure get worsened and hardened, moisture content declined, fertility lowered, but also biological activity depressed, productive capacity descended and capabilities to combat natural disasters weakened.



Based on an investigation in 23 counties



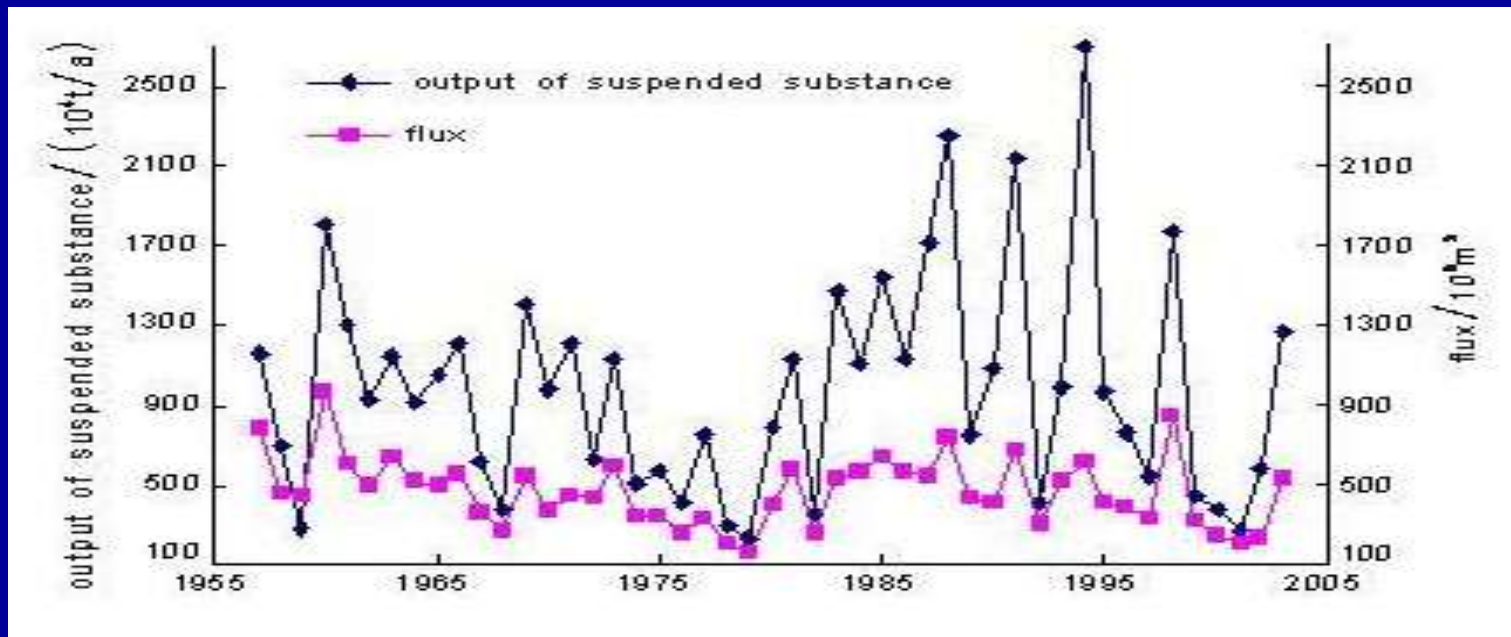
Erosion Degree	Bulk Density (g/cm ³)	Field Moisture capacity(%)	Penetration Velocity (mm/min)	Dispersive index	Structural index	Anti-rush intensity (kg/g)
Light	0.90-0.96	46.03-63.31	5.83-12.39	50.31-58.14	49.09-60.87	1.43-2.95
Moderate	0.91-1.29	42.95-56.05	1.18-9.38	48.28-58.69	41.86-47.37	1.44-1.67
Severe	1.01-1.22	41.8-52.55	1.6-6.82	32.72-59.68	40.32-51.72	0.81-1.37
Intensive	1.35	28.04	1.63	47.37	52.63	4.47

The investigation in plow layer in 4 counties

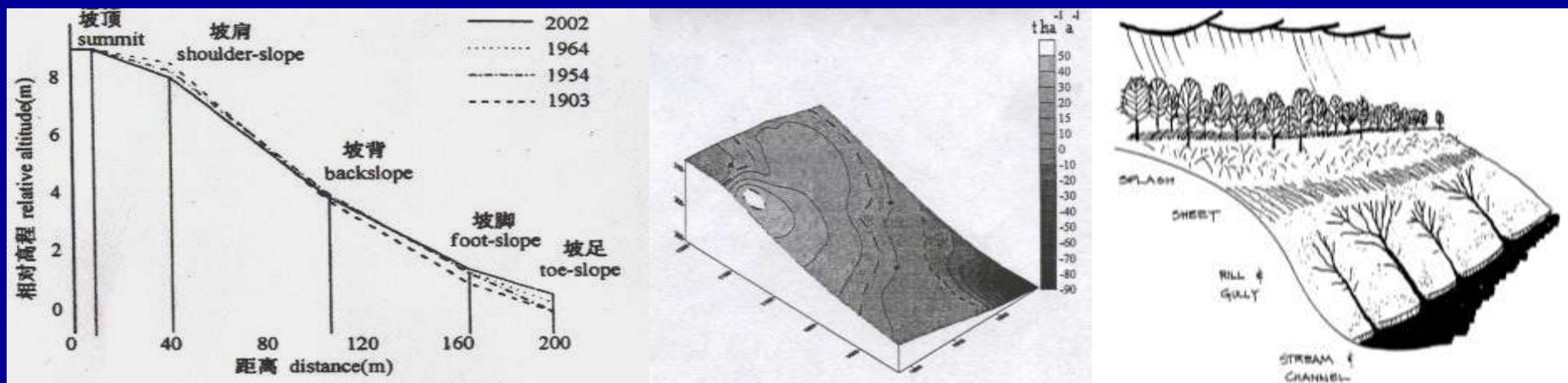
The results show that soil nutrient elements, moisture condition and anti-erosive capacity reduced and physical property worsen quickly. Soil loss is one of the main impact factors led to land quality degeneration.

5 The transportation output change of suspended substance

The flux was in the trend of declining in 1955-2005, but the output of SS tardily increased. This shows the soil erosion synchronously increased in Songhua River basin. The annual mean output of SS in 1980-2000 rose 20% than that in 1956-1979. The annual mean output of SS increased from 11.57 million tonnes in 1961-1991 to 19.37 million tonnes in 1991-1997. The sand content ascended to 0.064-0.127kg/m³ in 2000 in Jiamusi Hydrological Station.

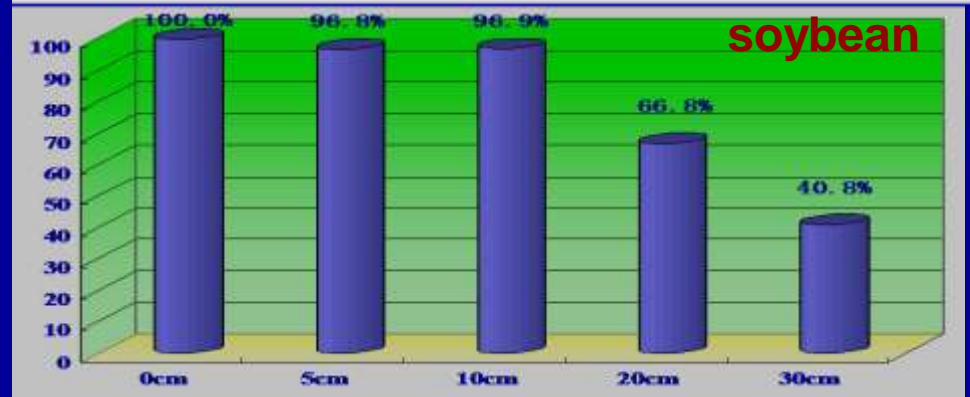
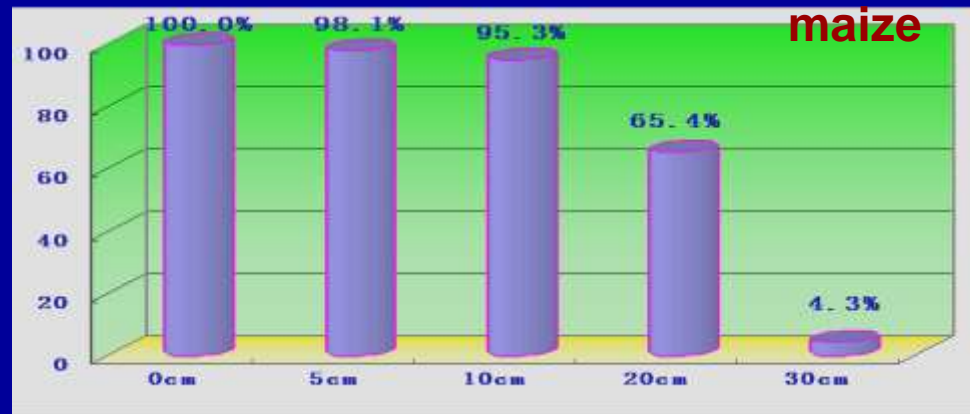


As the grades in plow land are less than 5 degrees, granules eroded mostly sedimentate in foot-slope. The study in the slope with the grade of 3 degrees shows **56.6%** of soil granules eroded sedimentate in the foot-slope. Part lost granules will be silted in depression, ponds and reservoirs downstream out of the slope. Consequently, it is estimated that the long-distanced transported of granules eroded are less than **30%**, which will finally flow into the main rivers. So, the output of SS in main rivers increased slowly.



6 The effect of soil erosion on land productivity

The artificial peeling experiment shows maize yield reduced 95.7% for 30cm peeled, 34.6% for 20cm peeled, 4.7% for 10cm peeled compared with the treat without peeling. Soybean yield decreased 59.2% for 30cm peeled, 33.2% for 20cm peeled, 3.1% for 10cm peeled compared with the treat without peeling. The impact of soil erosion on maize is more visible than soybean.



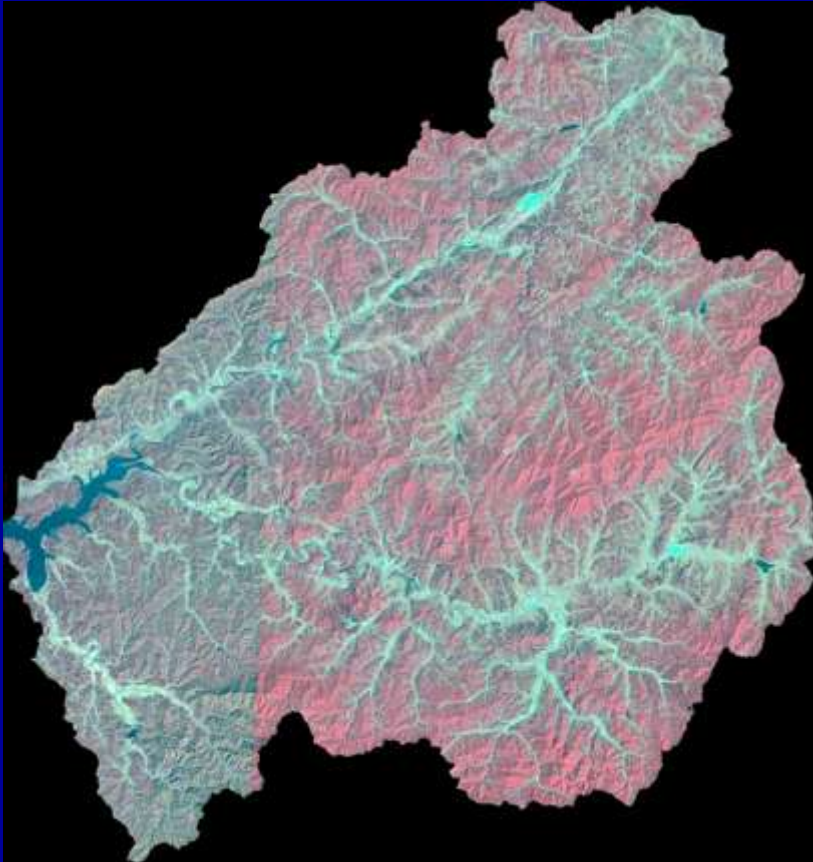
Gully erosion loses a great lot of farming land, and erosion in slope degrades the land fertility. Thus, land productivity will be depressed due to soil erosion.

All the gullies in Northeast China permanently lose **483** thousand ha of cultivated land, which lose **3.6** million tonnes of maize every year. Based on the investigations, field experiment, it is estimated that reduction of crop yield may get to **15%** for slope cultivated land. Hereby, crop yield will reduce **7.20** million tonnes for all slope cultivated land of **7.0** million ha yearly. The total reduction of crop yield induced by soil erosion is presently at the level of **10.8** million tonnes yearly, which was about the **13%** of total crop yield in 2007 at present erosion level.

7 Enhance the NPS pollution

Site	Erosion intensity (t/km ² ·a)	TN (t/km ² ·a)	NH ₄ ⁺ -N kg/km ² ·a	NO ₃ ⁻ -N kg/km ² ·a	TP (t/km ² ·a)	PO ₄ ³⁻ - P (kg/km ² ·a)
D1	3 033. 6	1. 18	9. 17	6. 75	0. 27	1. 77
D2	3 940. 3	1. 34	20. 06	14. 78	0. 38	3. 72
D3	3 713. 6	1. 36	15. 95	4. 48	0. 33	1. 70
S2	5 346. 0	1. 90	45. 62	12. 79	0. 43	1. 32
S3	3 575. 2	1. 60	22. 82	5. 60	0. 33	1. 37
S4	2 308. 8	0. 75	13. 96	9. 88	0. 21	1. 31
mean	3652. 9	1. 36	21. 26	9. 05	0. 33	1. 87

Dahuofang Reservoir—drinking water source for Shenyang and Fushun cities



TN= 1927.6t/a, 18% from runoff

TP=57.7t/a;23% from runoff

Advice for further research

- The influence of soil erosion on food production and warning in regional scale
- Soil erosion process and prediction, forecasting in multi-scale
- Dynamics and load of NPS pollution induced from soil erosion
- The role of freeze-thaw erosion in soil erosion
- Developing and technique integration of practical preventing measures
- Ecological, economic and environmental benefits for different preventing measures

Feasible prevention and cure measures

Contour terrace

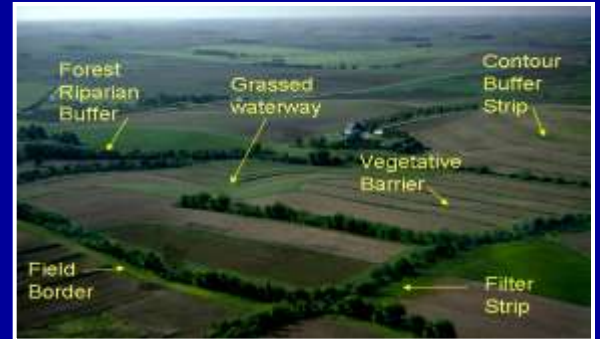




Stubble mulch tillage



No tillage



Forest
Riparian
Buffer

Grassed
waterway

Contour
Buffer
Strip

Vegetative
Barrier

Field
Border

Filter
Strip



Contour buffer strip



Grassed waterway

CONCLUSION

- Water-induced soil erosion had expanded and led to obviously ecological and environmental problems due to fast change in land use in last 50 years.
- soil erosion has become an important issue for the sustainable development in Northeast China.
- It is necessary to strengthen the soil and water conservation. An immediate attention from the concerned authorities is required in order to protect the soil from further erosion and deterioration.



*Thanks for your
attention!*