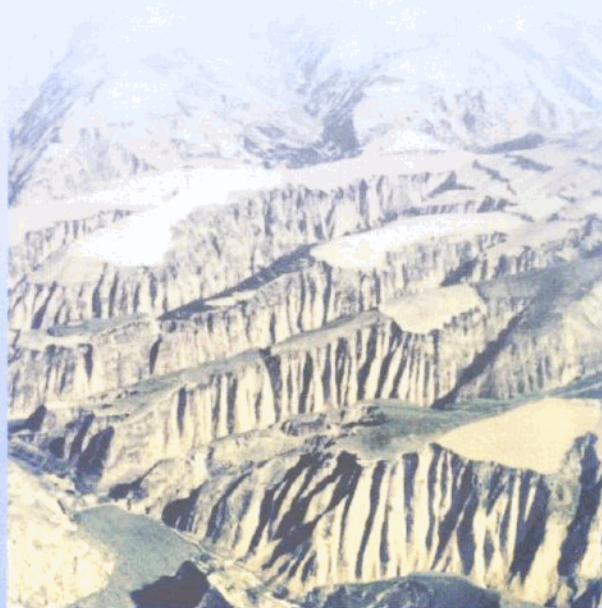


土壤侵蚀与 水土保持讲义

Teaching Book of Soil Erosion
Soil and Water Conservation

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前 言

《土壤侵蚀与水土保持讲义》是根据编者自2002年起在UNEP/UNESCO/BMU发展中国家和新兴国家环境管理研究生培训班（UNEP/UNESCO/BMU International Postgraduate Training Programme on Environmental Management for the Developing Countries and Emerging Countries）讲学材料的基础上编写而成的。讲义中引用了他人的图片和文字资料，特别是引用了朱显谟院士编著的《中国黄土高原土地资源》中的部分照片和美国著名教授R. Lal博士编写的《Encyclopedia of Soil Science》中的部分照片和文字材料，所有引用照片和文字材料都进行了标注，编者对所有引用材料的原作者表示衷心的感谢。

《土壤侵蚀与水土保持讲义》共有六章：第一章介绍土壤侵蚀的基本概况，包括世界土壤侵蚀概况及土壤侵蚀的类型、方式和过程；第二章介绍土壤侵蚀研究方法；第三章介绍土壤侵蚀的监测技术；第四章介绍土壤侵蚀预报模型，主要介绍了修正通用土壤流失方程（RUSLE）、水蚀预报模型（WEPP）、风蚀预报系统（WEPS），同时还介绍了土壤侵蚀环境效应评价模型，如农业面源污染模型（AGNPS）；第五章介绍了水土保持主要措施及中国水土保持概况；第六章介绍了编者在土壤侵蚀过程、预报模型、近地面水文条件下土壤侵蚀过程及其对养分流失和水质的影响、植被演变过程对土壤侵蚀过程的影响以及植被恢复过程对土壤质量的影响等四个案例研究。参加该讲义编写人员的具体分工是：第一章和第五章由郑粉莉、李锐、杨勤科负责完成，第二章由Chi-hua Huang和郑粉莉负责完成，第三章和第四章由郑粉莉和高学田负责完成，第六章由郑粉莉负责完成，最后由郑粉莉汇总定稿。

《土壤侵蚀与水土保持讲义》的出版得到下列研究项目资助：国家重点基础研究发展计划项目“中国主要水蚀区土壤侵蚀过程与调控研究”（批准号：2007CB407201）、国家自然科学基金重点项目“黄土高原小流域分布式水蚀预报模型”（批准号：40335050）、中国科学院知识创新重要方向项目“水蚀预报模型研究”（批准号：KZCX3-SW-422）、国家自然科学基金西部重大研究计划项目“近140年子午岭地区植被—侵蚀—土壤互动作用及机理”（批准号：90302001）、

农业部948项目“土壤侵蚀及其环境效应评价模型”(批准号:2003-Z57)。

《土壤侵蚀与水土保持讲义》涵盖了国际土壤侵蚀和水土保持的主要成果资料,可供从事水土保持与荒漠化防治、水土资源利用与管理、自然资源保护、国土整治、农林牧和水利等方面工作的科技工作者及大专院校相关专业的师生参考。

由于编者才识浅薄,水平有限,难免有错误和不妥之处,敬请国内外同仁赐教。

编 者

2007年2月26日

Preface

“Teaching Book of Soil Erosion, Soil and Water Conservation” was compiled based on lectures Dr. Fenli Zheng delivered since 2002 to UNEP/UNESCO/BMU International Postgraduate Training Programme on Environmental Management for the Developing Countries and Emerging Countries. This book contains lots of photos and materials cited from other books and multimedia, especially from “Land Resources in the Loess Plateau of China” edited by Academician Xianmo Zhu and “Encyclopedia of Soil Science” edited by R. Lal. The data sources of all cited materials were referred and credited.

There are six chapters in this text. Chapter 1: Overview of Soil Erosion, written by Fenli Zheng, Rui Li and Qinke Yang; Chapter 2: Soil Erosion Research Methodology, written by Chi-hua Huang and Fenli Zheng; Chapter 3: Soil Erosion Monitoring Technology, written by Fenli Zheng; Chapter 4: Soil Erosion Prediction Model, edited by Fenli Zheng and Xuetian Gao; Chapter 5: Soil and Water Conservation, written by Fenli Zheng, Rui Li and Qinke Yang; Chapter 6: Case Study, written by Fenli Zheng.

This text was published with supports of following projects: National Basic Research Program of China (grant No. 2007CB407201) , Chinese National Science Foundation (grant No. 40335050 and 90302001) , Significant Orientation Program of Knowledge Innovation Project for the Chinese Academy of Sciences (grant No. KZCX3-SW-422), and 948 Project of Ministry of Agriculture (grant No. 2003-Z57) .

This book reflects main research achievements from international studies and studies in China in soil erosion, soil and water conservation. We hope this book will provide a reference for scientists and technologists who work in soil and water conservation, desertification control, soil and water resource utilization and management , natural resource con-

servation, territory harnessing, agriculture and water conservancy etc., also provide training and sources for teachers and students in universities and colleges who teach or study in the above related fields.

There are some unavoidable errors remaining in this text, we would appreciate comments and constructive criticisms to help improve this publication.

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Chapter 1 Overview of Soil Erosion

第一章 土壤侵蚀概况

Chapter 1

Overview of Soil Erosion

Section 1

Overview of Soil Erosion in the World

1. Definition

Soil Erosion is detachment or breaking away soil particles from a land surface by a certain agent and two/above agents, most commonly water or wind, and subsequent transportation of the detached particles to another location.

Source: Dennis Flanagan, Encyclopedia of Soil Science, 2002

2. Erosion Impacts: onsite/offsite

◆ On-Site Effects

Erosion impacts water, soil, air qualities, and human life

- Causes soil quality degradation
- Reduces grain production and food safety
- Fragment landscape and Reduces land resources
- Causes geological disasters
- Influences environmental quality(biological diversity)
- Impacts human living conditions and life

◆ Off-site Effects

- Influences water resources (quantity and quality)
- Causes air quality
- Deposits sediment in water bodies
- Causes flood disasters and traffic accidents
- Influences human living conditions and life

Erosion Impacts Crop Growth and Production



Flood



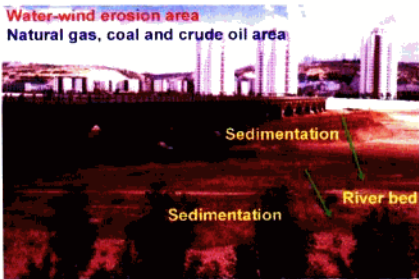
Flood



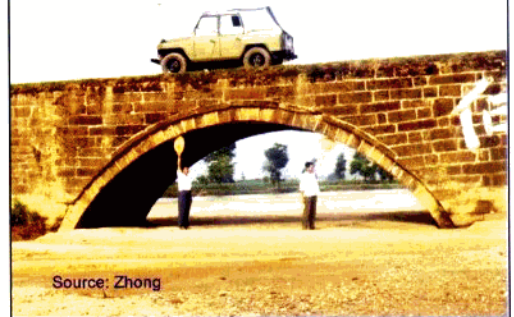
Source: Zhong

Sedimentation in the River (on the Loess Plateau)

Water-wind erosion area
Natural gas, coal and crude oil area



Sedimentation in the River (Jiangxi Province)



Source: Zhong

Sedimentation in the Reservoir (Zhejiang Province)

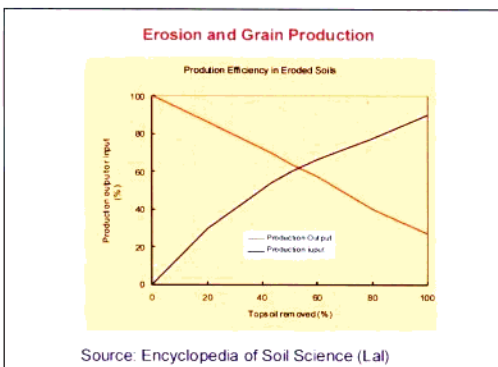
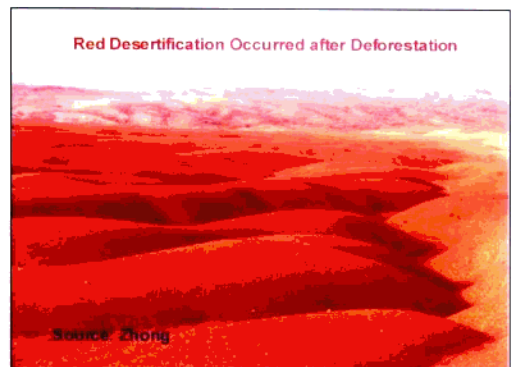


Source: Zhong

Sedimentation in Crop Lands and the River (Jiangxi Province)



Source: Zhong



Erosion and grain production

Source: Encyclopedia of Soil Science (Lal)

Degree of erosion	Crop Yield (kg/ha)	
	Corn	Soybeans
Grenadu silt loam soil 0-5% slope		
None	6000	2700
Eroded	5300	2000
Severe	440	1600
Cecil sand clay, 2-10% slope		
Deposition	6200	—
eroded	5800	2100-2300
Severe	1900	1500-2400

Source: Encyclopedia of Soil Science (Lal)

Erosion and grain production

estimate of how soil erosion affecting crop productivity

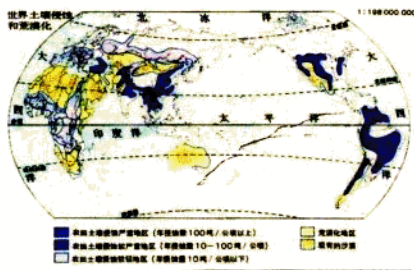
Degree of erosion	Crop Yield (kg/ha)	
	Corn	Soybeans
Marshall clay loam soil 2.5-6% slope		
None	—	—
Slight	6700	2800
Moderate	6200	2600
Iida Silt loam, 6-10% slope		
None	—	—
Moderate	5200	2200
Severe	4300	1700

Source: Encyclopedia of Soil Science (Lal)

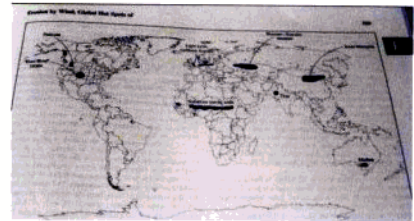
3. Erosion in the World

- Geographical distribution of soil erosion in the world: Latitudes 40° N and 40° S.
- Especially in Asian and African.
- Total soil erosion area: 25 mi. sq km², occupying 16.7% of Continent Area (510 mi. sq km²)

The Map of Soil Erosion



The Distribution of Wind Erosion



Source: Encyclopedia of Soil Science (Lal)

Soil Erosion in Countries

Countries	Area (10 ⁴ sq km ²)	%	Soil loss (Bi.t/a)
Japan	31	85.0	0.3
India	261.49	79.54	6.0
Australia	593.37	77.0	0.9
Former USSR	1,500	67.0	2.5
China	579	60.66	5.0
USA	427	45.6	5.0
New Zealand	10.5	39.3	
Total	2,500	16.7	26

Source: Soil Erosion and Control (Ayres)

Sediment Delivery in Rivers

Rivers	Area (10 ⁴ sq km ²)	Sus. Sd. Con (kg/km ²)	Sd. deli (t/km ² a)
Huanghe	75.24	37.6	2,800
Yangtze	180.72	0.52	264.5
Ganges	95.5	3.92	1,519.4
Mississippi	323	0.55	96.6
Missouri	137	3.54	159.1
India	96.6	2.49	448.9
Nile	297.8	1.25	37.3

Soil Erosion in Africa

- Africa is the 2nd largest continent.
- Total area is 29,820,000 km².
- Desert occupies: 40%, including Sahara—the largest desert in the world, 7.78 million km², and Namib and Kalahari desert.
- The Equatorial Forest occupies 7% of total.

Source: Soil Erosion and Control (Ayres)

Soil Erosion in Africa

- Due to either increasingly converting permanent vegetation cover to cropland or overgrazing, the 6,000 km long Sahara desert border has been shifted southward by 1.5 to 10 km per year during the last 50 years.

Source: Soil Erosion and Control (Ayres)

Soil Erosion in Africa

- The erosion and drought are most pronounced in Egypt, Tunisia, Lybia, Morocco, Algeria N. Sudan, Nigeria, Mali etc.

e.g.

✧ From 1960's to 1980's, woodland in Tunisia decreased by above 30%, woodland only occupied 3.2% of the total land now

✧ 18 000 ha land is damaged by wind erosion annually.

Source: Soil Erosion and Control (Ayres)

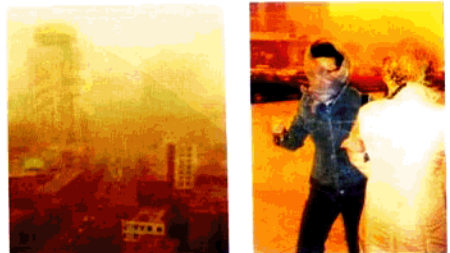
Dust Storm in US (1934)



Dust Storm in US (1934)



Dust and Sand Storm —Gansu Province, China



Source: Xinhua website

Severe Soil Erosion in USA



Source: www.ars.usda.gov

Severe Soil Erosion in Europe

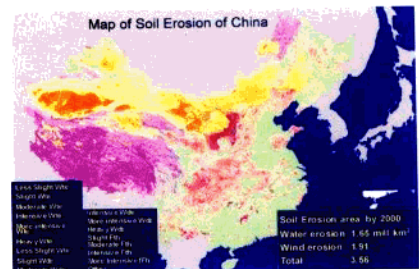


Source: De Roo, Morgan, and Ritsersma

4. Soil Erosion in China

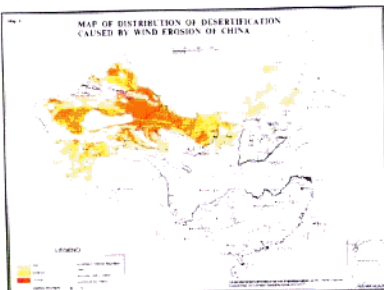
- Eroded area: 3.56 million km² (2000 yr) ;
- 5 billion tons of sediment deposits into river/sea per year;
- 3 million ha cropland was lost in the last 50 years;
- 10 billion ¥ was lost per year;
- 90% of poor people live in eroded regions.

The Map of Soil Erosion in China



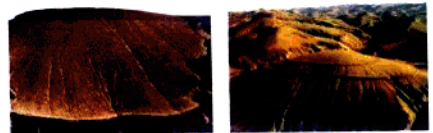
Source: yang and Li

The Distribution of Wind Erosion



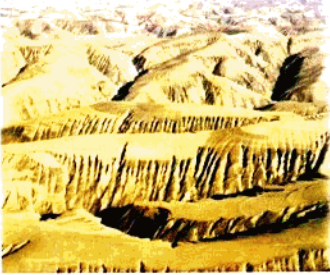
Source: Skidmore

Severe Erosion (rill, ephemeral gully and gully)



Source: Zhu

The Eroded Loess Plateau



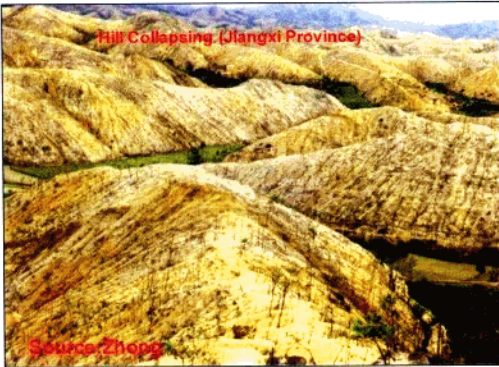
Source: Zhu



Gully formation during a storm event
in black soil areas

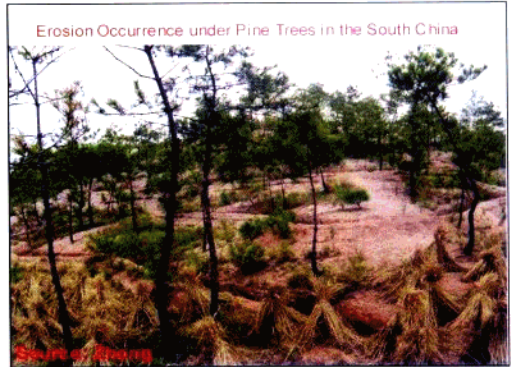
Source :Liu

Hill Collapsing (Jiangxi Province)



Source: Zhong

Erosion Occurrence under Pine Trees in the South China



Source: Zhong

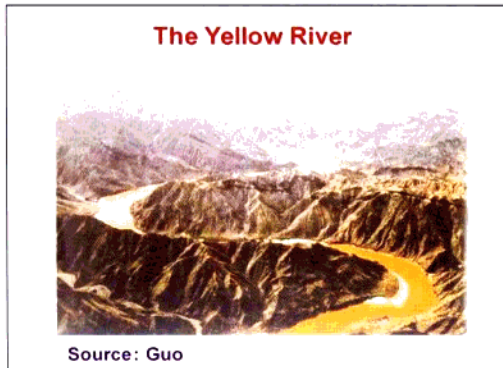
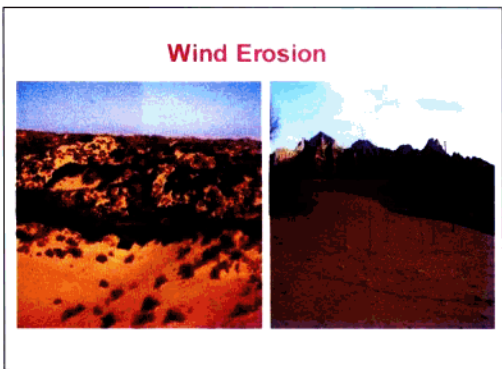
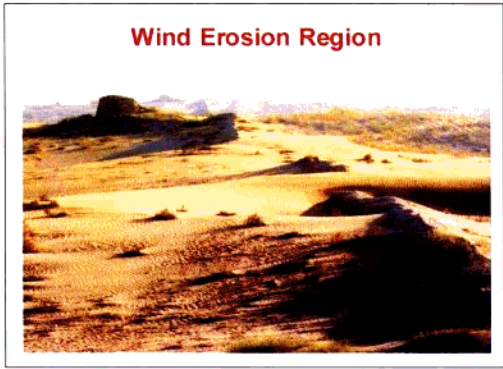
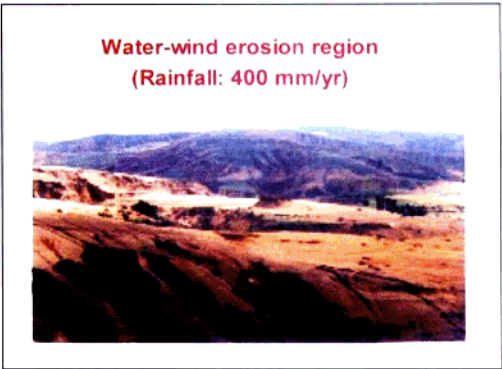
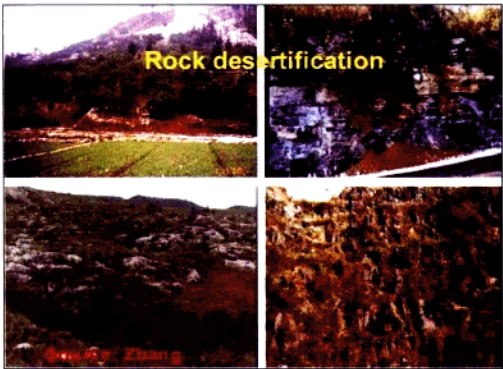
Sichuan Province —
sediment source of the
Yangtze River



Southwest of China



Source: Zhong



Classification of soil erosion on the Loess Plateau

Grade of erosion	Soil loss (tons km ⁻² yr ⁻¹)	Area (km ²)	Percentage occupying total (%)
Very slight	< 1,000 (500)	99,434	15.94
Slight	1,000(500)–2,500	192,348	30.83
Moderate	2,500–5,000	40,622	6.51
Severe	5,000–10,000	111,384	17.85
Very severe	10,000–15,000	94,162	15.00
Extreme	> 15,000	86,049	13.79

What Causes Several Soil Erosion in China

● Fragile ecological environment

@ 2/3 area for Mt and hill, intensively tectonic movement; complex landforms; lower vegetation cover; highly erodible soil; large rain storm and dust;
—The Loess Plateau, SW region, the upper reaches of Yangtze River

● Long-term human activity

@ Agriculture started 2,000 yr ago in the Loess Plateau, original vegetation was destroyed in the most area of China

What Causes Several Soil Erosion in China

● Population expansion

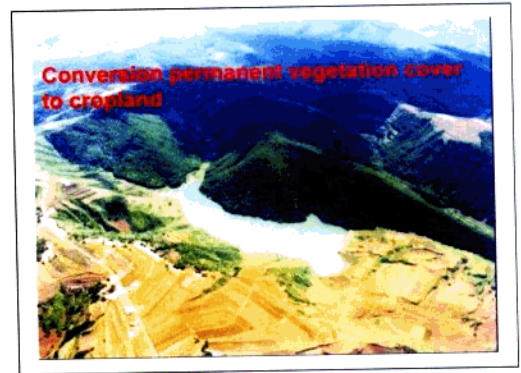
@ 0.5 billion population in 1950; 1.3 billion population now (more double)

● Improper land-use

@ Deforestation; overgrazing; conversion permanent vegetation cover to cropland.

● Expansion of mining, rural industry, urbanization and infrastructure cause new erosion issues

@ Since 1980's



Soil Loss from deforested land

Topography	Slope length (m)	Slope Degree (°)	Soil Loss (t/km ² .yr)
Hillslope	86	5-32	10,371
	99	5-32	10,448
Gully slope	50	32-42	24,222
	41	32-41	20,192
Whole slope	142	5-42	15,969

Soil loss from forestland is only 10-15 t km².yr⁻¹

❖ Protect Forest for Generations