
FAO中文出版计划项目丛书
联合国粮食及农业组织 编著
陈保青 董雯怡 张润哲 译
土壤侵蚀：
可持续土壤
管理的巨大挑战
SOIL
EROSION
the greatest challenge
for sustainable soil management
中国农业出版社
联合国
粮食及
农业组织

FAO

土壤侵蚀：可持续土壤管理的巨大挑战

2021 · 北京

引用格式要求：

2021

https://doi.org/10.4060/ca4395zh

12-CPP2020

Soil erosion: The greatest challenge for sustainable soil management

2019

ISBN 978-92-5-134691-4

ISBN 978-7-109-28152-3

FAO中文出版计划项目丛书

指导委员会

主　任

副主任

委　员

FAO中文出版计划项目丛书

译审委员会

主　任

副主任

编　委　　珺

本书译审名单

翻　译

审　校

缩　略　语

FRNs | Fallout radionuclides

GAEC | Good Agricultural and Environmental Condition

GLASOD | Global Assessment of Land Degradation

GSP | Global Soil Partnership (of FAO)
( )

IPBES | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

ITPS | Intergovernmental Technical Panel on Soils (of FAO) (
)

LIDAR | ground-based light detection and range

MODIS | Moderate Resolution Imaging Spectroradiometer

MUSLE | Modified Universal Soil Loss Equation

NCP | Nature's Contributions to People

PES | Payment for Ecosystem Services

RUSLE | Revised Universal Soil Loss Equation

RWEQ | Revised Wind Erosion Equation

RWSC | Revised World Soil Charter

SLEMSA | Soil Loss Estimation Model for South Africa

SOC | Soil Organic Carbon

SOM | Soil Organic Matter

SSM | Sustainable Soil Management

SWAT | Soil and Water Assessment Tool

SWSR | Status of the World ' s Soil Resources (Report)

UNCCD | United Nations Convention to Combat Desertification

USDA | United States Department of Agriculture

USLE | Universal Soil Loss Equation

VGSSM | Voluntary Guidelines for Sustainable Soil Management

WEAM | Wind Erosion Assessment Model

WEPS | Wind Erosion Predictions System

WEQ | Wind Erosion Equation

WOCAT | World Overview of Conservation Approaches and Technologies

术　语　表

保护性农业：

Palm　2014

荒漠化：

UN

可蚀性：　Lal Elliot　1994

动态交换：

Hardin　1999

生态系统服务功能：

UN

大气散落放射性元素：　^{137}Cs

Mabit　2018

河流运输：

沟蚀：　0.3　Castillo Gomez　2016

细沟间侵蚀：

Lal　Elliot　1994

免耕：

Derpsch 2010

降雨侵蚀力：

Lal　Elliot　1994

细沟侵蚀：　0.3　Castillo Gomez　2016

径流：

跃移：

沉积物：

沉积作用：

面蚀： “ ”

土层：

A B C

土壤侵蚀：

土壤颗粒： <2
2 5 0.05 2

悬移：

耕作侵蚀： Govers Lobb
Quine 1999

容许土壤流失量：

SSSA 2001

表土层：

概　　要

8　50　/

·　　2　4　/　　·

0.2　2.2　　1　11

2015　　FAO

0.4

目　录

©Matteo Sala

1　什么是土壤侵蚀?

2015

(ITPS　2015

Web of Science

2016—2018　　7 348

20　　1931—1999　　5 698　　Web of Science　2019

Boardman　2006

1.1　侵蚀类型：水力侵蚀、风力侵蚀和耕作侵蚀

Lupia-

Palmieri　2004

Poesen　2018

FAO ITPS 2015

20

30

1935

20 90

1.2 土壤侵蚀速率

Boardman 2006 “ ”

“ ”

“ ”

/ .

10 4 10^2 10^4 10^9

“ ”

/ / Montgomery 2007
1 200 /
1 0.08

表1 全球和区域土壤侵蚀研究中平均土壤下降深度和平均净土壤流失量概览

土地利用类型	地区	方法	土壤下降深度（毫米／年）	净土壤流失量［吨／（公顷·年）］	参考文献
			3.9	49[b]	Montgomery 2007
			0.12	1.6[b]	
			0.05	0.66[b]	
			0.17	2.2[b]	
			1.0 1.2[a]	12 15	Den Biggelaar 2003
			0.29[a]	3.6	Cerdan 2010
			0.18[a]	2.2	Panagos 2015
			0.21[a]	2.7	
			0.60	7.5[b]	Wilkinson McElroy 2007
			0.22[a]	2.8	Borrelli 2018
			1.0[a]	13.0	
			0.01[a]	0.16	

土地利用类型	地区	方法	土壤下降深度（毫米／年）	净土壤流失量［吨／（公顷・年）］	参考文献
			0.31[a]	3.9	Van Oost Cerdan Quine 2009
	7		0.01[a]	0.15	Evans 2013
			0.26	3.3	Van Oost Cerdan Quine 2009
			0.84	11.0	Doetterl Van Oost Six 2012
			0.02[a]	0.193	Chappell 2013
			0.01[a]	0.167	
			0.03[a]	0.359	

a. 1 200 / Montgomery 2007
b. 1 200 / Montgomery 2007

1

“ ”

Montgomery

2007 3.9 1.5 Den Biggelaar 2003

0.2 0.6

1.3 容许土壤流失量

FAO 2017

FAO 2015

(

T_{sl} “ ”

“ ”

“ ”

A

A A

p Ap

E B C A

A

1 Ap

T_{sl}

Verheijen

2009 Di Stefano Ferro 2016 Duan 2016

T_{sl} Montgomery

2007 188

0.173 2.2

3.9 Verheijen

2009

0.3 1.4 0.02 0.11 Bui Hancock

Wilkinson 2011

0.2 0.015

/

Wilkinson Humphreys 2005

/

Wischmeier Smith 1978

4.5 11.2

1

5 Bui Hancock Wilkinson 2011

0.85 0.065 /

75

Duan 2016

Verheijen 2009

Bui Hancock Wilkinson 2011

FAO 2015

Verheijen 2009

容许土壤流失量是指所有侵蚀类型共同作用下的累计平均土壤侵蚀速率，该速率能保证土壤所提供的功能及生态系统服务不发生显著的恶化。

1.4 土壤侵蚀、土壤功能及土壤生态系统服务功能

Boardman 2006

Diaz 2018

2

表2 土壤侵蚀对土壤提供的生态系统服务的影响

生态系统服务	土壤功能	侵蚀影响

生态系统服务	土壤功能	侵蚀影响
	CO_2 N_2O CH_4	CO_2

Weigeit 2015 15

Weigeit 2015 2

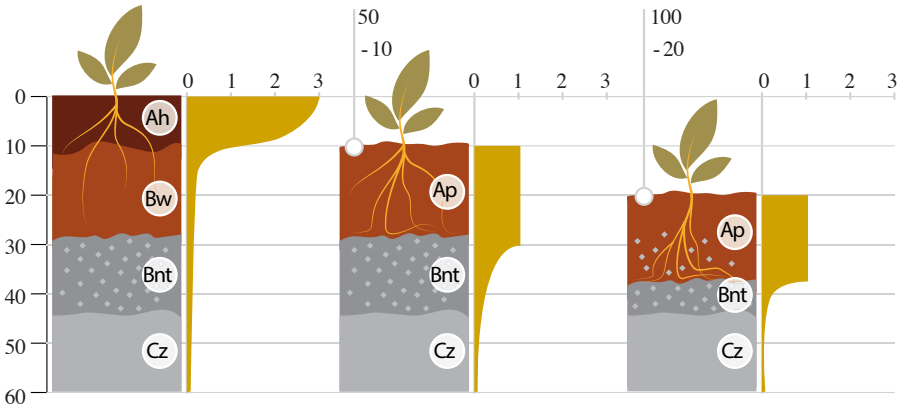
2 2.4.1 “
”

1.4.1 土壤侵蚀对土壤生产力和农作物产量的影响

Van Oost Bakker 2012

1

A



1

Ah Ap Bnt
Cz 0.2

1 A

3
1

Larson Pierce 1994
Pennock 1997

表3 极易受土壤侵蚀造成表层土壤流失的土层和土壤等级

土层	特点和制约	与土层相关的土纲
30		

土层	特点和制约	与土层相关的土纲

Larson Pierce 1994 Pennock 1997

20

4 2000 Den Biggelaar 2003 Bakker Govers Rounsevell 2004 Scherr 2003 Crosson 2003

0.1 0.4 2

0.3

16

0.4 Panagos 2016

1.4.2 侵蚀导致减产对经济和社会的影响

Adhikari Nadella 2011

Panagos 2018

1 200 0.4 2010

12.5 3

0.12 1.55

Vargas Omuto
2016 Soil Loss Estimation Model for South
Africa SLEMSA

0.9 10
0.9 6.4
11.2 19.8
10

2

2 Lemuta Naisikie Lazier

Asfaw 2018

10

0.26

0.42

50

1.28

2.1

0.10 0.55

Chrysopogon zizanioides

3

3

Stocking 2013 Stocking Tengberg 1999

—

50

4

2

6 1 000

4 000 Stocking 2003

表4 部分年侵蚀速率及由侵蚀导致产量下降达到每年每户1 000千克粮食的安全阈值所需时间

土壤和坡度	年土壤流失速率［吨／（公顷·年）］		达到每户粮食安全阈值时间（年）	
27 34	20	86	19	4
16	94	187	2	1
13	157	200	3	1
24	5	9	42	23
1 2	0.6	5	65	7

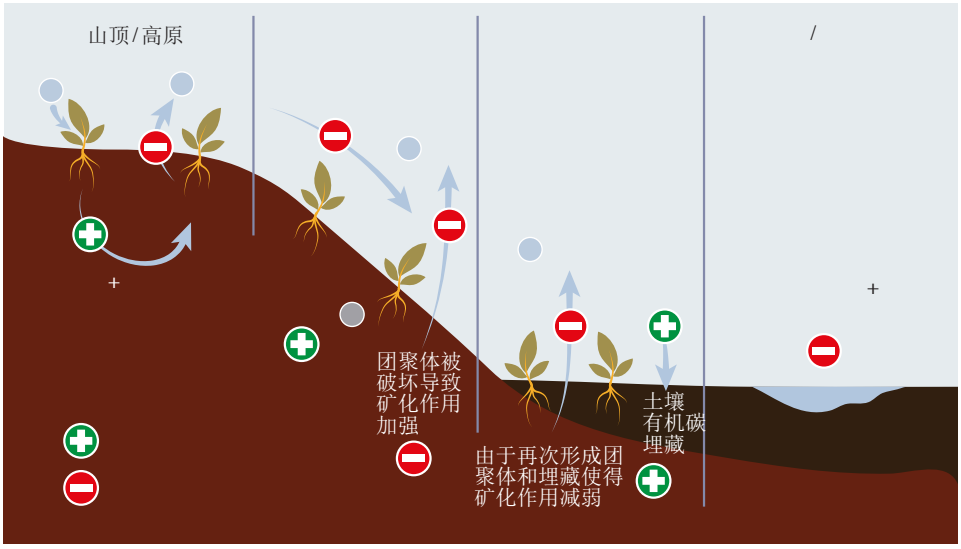
Stocking 2003 Stocking Tengberg 1999

1.4.3 土壤有机碳及其对温室气体的调控

4

Doetterl 2016

CO_2



4

Harden 1999

4

Doetterl 2016 CO_2

CO_2

Van Oost 2007

0.12 petagram / 0.06 0.27

CO_2

128 / CO_2 118.7 /

Lugato 2016

Van

Oost 2007 0.068 / · 0.16 / ·

Lal 2019

Chappell 2019

Chappell 2019 2011—2016

1.0 7.0

0.1 0.4

1.4.4 土壤侵蚀和沉积作用

Owens 2005

5

Palmieri 2003

7 000

5

0.5 1.0 2003 130

Kondolf 2014

Zhou Zhang Lu 2013
91 77 83

1.4.5 水道中的农业化学污染物

Owens 2005

Harmel 2006 15 2

3

Steffen 2015 Steffen 2015

Steffen Cordell 2009

1.4.6 风力侵蚀、荒漠化及人类健康

D'Odorico 2010 6

6

D’Odorico 2010

Ginoux 2012 75 25

55 8 75

10.0 2.5 Goudie 2014

Goudie 2014

Sayyah

2014

1.4.7 侵蚀所造成的经济范畴之外的影响

Diaz

2018

7

7

2 侵蚀过程

2.1 水力侵蚀过程

/ /

/ Torri Borselli 2012

>40

/ /

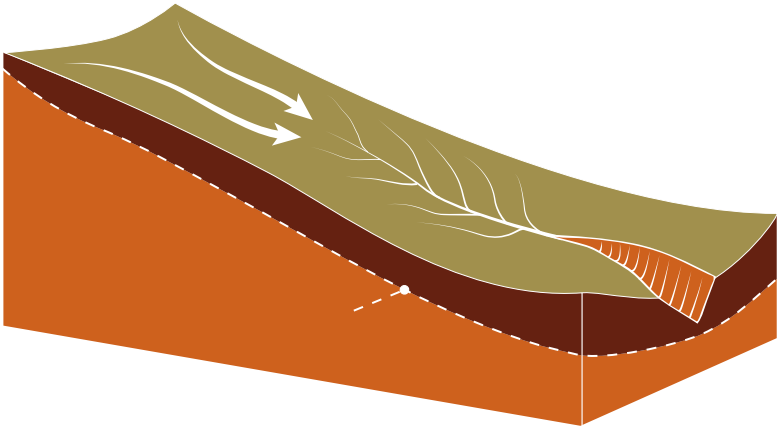
8 A

A

8

“ ”

9 10



9

0.3

Castillo Gomez 2016

Sidle 2018

Sidle 2018

10

-

11

12

13

11

12

13

2.2 风力侵蚀过程

Fryrear 2012

Chappell

2019 Shao Raupach Leys 1996

0.14 0.36 /

60 1 000

60 Shao 1996

25 Shao 2011

2.3 耕作侵蚀过程

1990 20 80 ^{137}Cs

Govers 1999

14

14

(

15

15

Van Oost 2006

3　侵蚀过程的控制

20

5

3.1　影响水力侵蚀的因素

3.1.1　气候

/

Wischmeier　1959　　30
Panagos　　2015

3.1.2　土壤

5

表5　按照种植作物时土壤经过长期湿润后最小入渗速率对土壤进行等级分类

组别	最小入渗速率（毫米／小时）	土壤特性
A	8　12	
B	4　8	
C	1　4	
D	0　1	

Dunne　Leopold　1978　*Water in Enrironmental Planning*

250　　250　　10

Bryan　2000

Bryan　2000

Torri Borselli 2012

RUSLE *K*(

4.2.1 *K* *K*

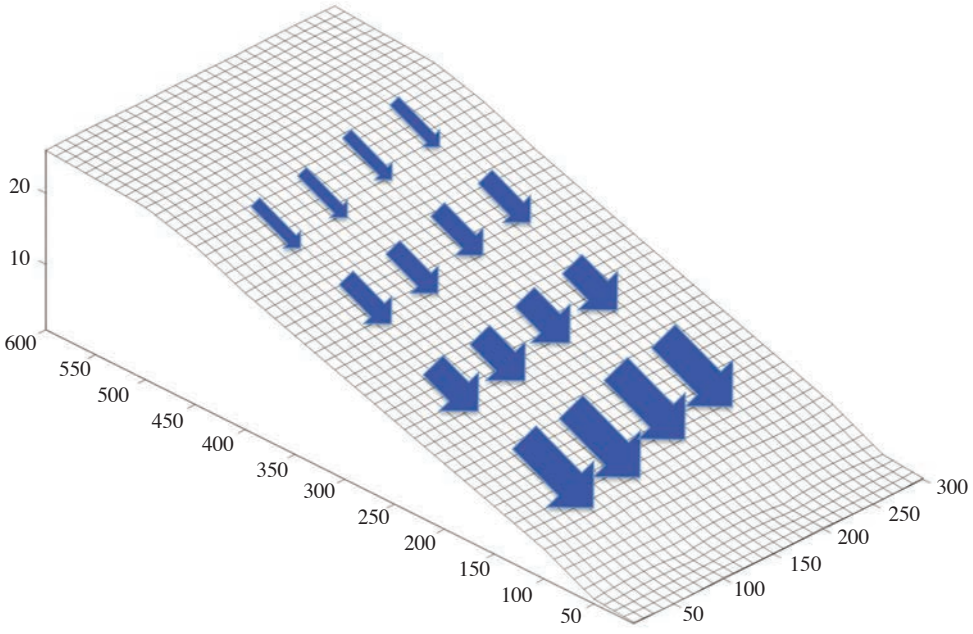
\+

K *K*

Bryan 2000

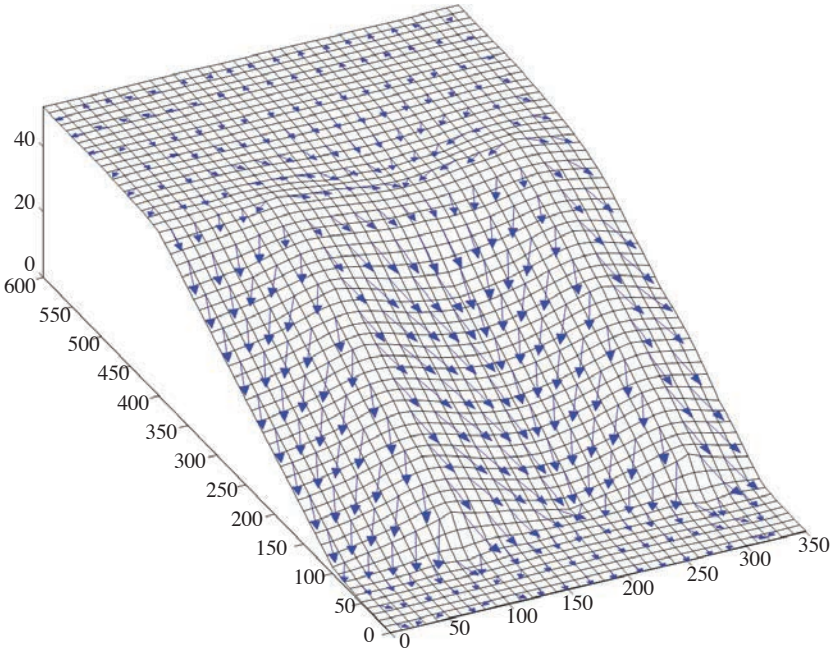
3.1.3 地形

16



16

17



17

3.1.4 植被

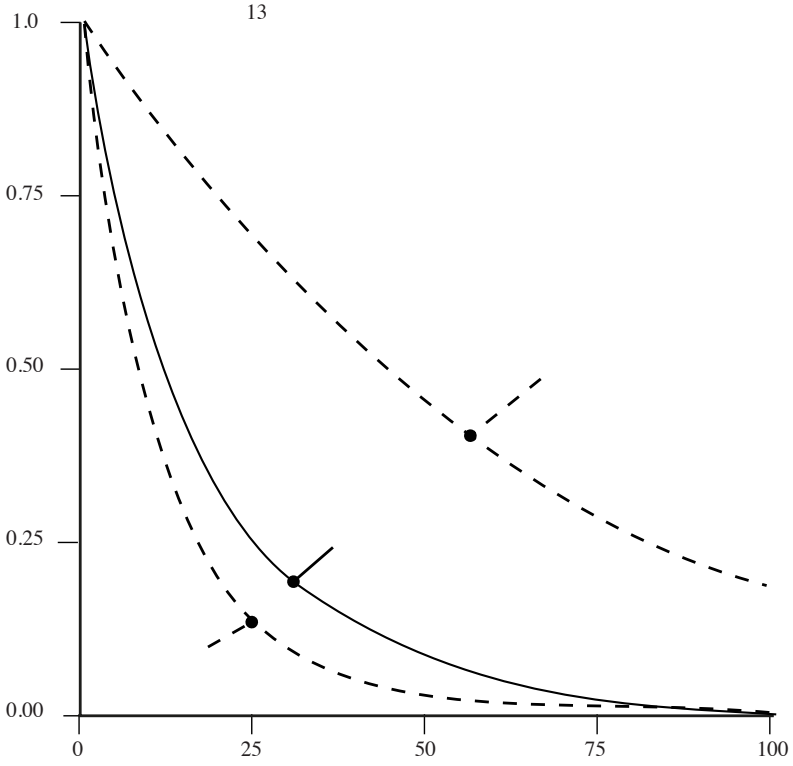
Torri Poesen 2014

Gyssels 2005

Torri Poesen 2014

18

13



18 13

Gyssels 2005

20 50 30 35

75 60

90 Gyssels 2005

3.2 影响风力侵蚀的因素

3.2.1 气候

Fryrear 2012

Shao Raupach Leys 1996

3.2.2 土壤

Fryrear 2012

(

Fryrear 2012 0.06 0.25
Fryrear 2012

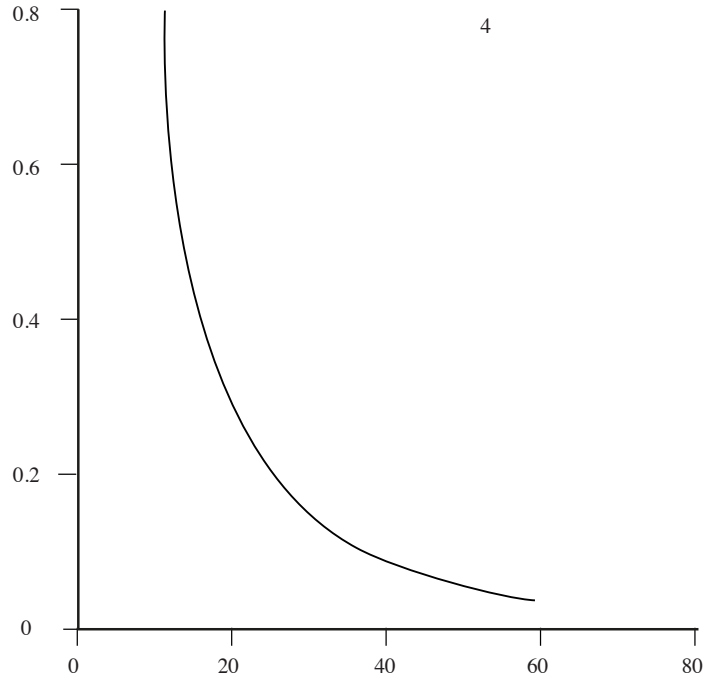
3.2.3 地形及田间配置

Goossens Offer 1997 “ ”

Revised Wind Erosion Equation Fryrear 2012

3.2.4 植被

19



4

19 4

Fryrear 1985

Fryrear 1985 0 40

80 90 <10

6

Fryrear 2012

20 Wolfe

Nickling 1993 1 14

14 40

40

Ravi 2010

20

3.3 影响耕作侵蚀的因素

Lobb 1999 Van Oost 2006

20 90

Van Oost 2007

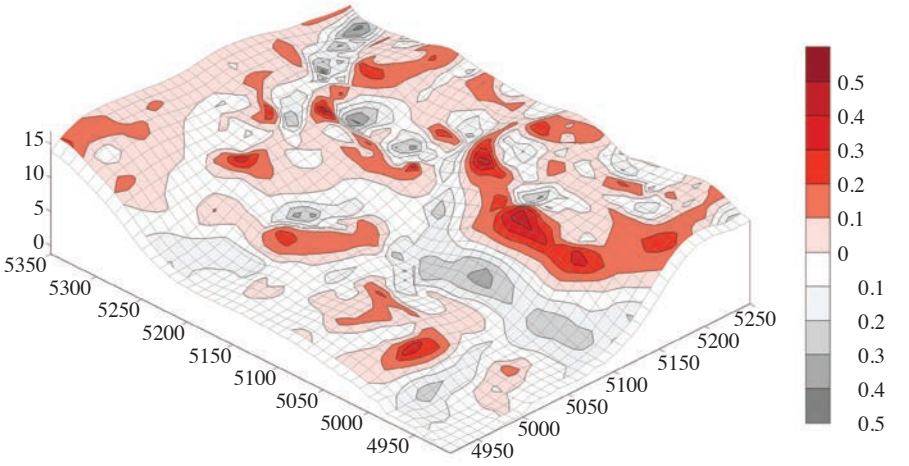
0.25

0.15

21

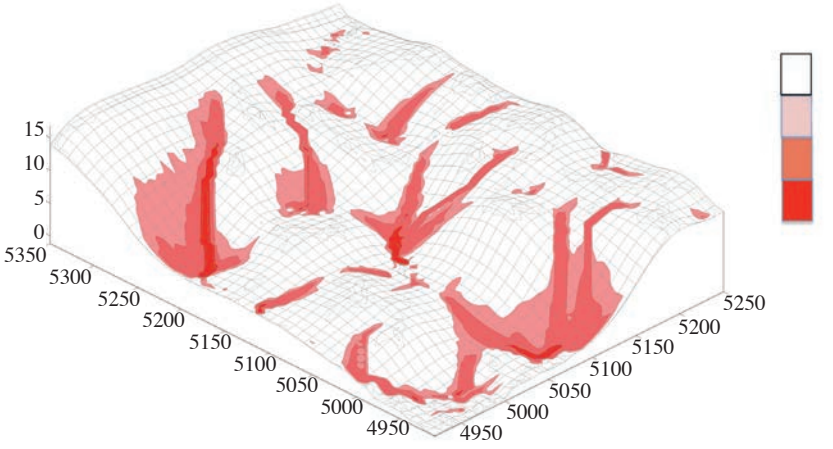
22

耕作侵蚀空间格局



21

水力侵蚀空间格局



22

4 土壤侵蚀评估方法：实地测量与模型研究

4.1 侵蚀的现场评估

4.1.1 水力侵蚀

Stocking Murnaghan 2001

Stocking Murnaghan

23 24

Evans 2013

Evans

1

10

Bennett Wells 2019

Bennett Wells 2019

23

24

Meyer 1994

Kinnell 2016

22.1 4.1
25

25

10 000

Montgomery

2007 Montgomery

Cerdan 2010 19 81 2 741

23.7

378 Poesen 2018

24 000

10^{3} 10^{2}

Kinnell

2016

Van Oost Bakker 2012

Vanmaercke 2012

4.1.2 流域产沙率

Walling 1994

Poesen 2018 1 287 507
10^3 10^7

/ .

Walling 1994

Walling
1994

“ ”

Garcia-Ruiz 2017

4.1.3 风力侵蚀

Fryrear
2012

100

80 120

Wu
2018
Ginoux
2012 MODIS
10

4.1.4 耕作侵蚀

Fiener 2018

Fiener
2018

4.1.5 大气沉降放射性核素在侵蚀评估中的应用

20 70 ^{137}Cs
^{137}Cs $^{239+240}$Pu
^{210}Pb ^{7}Be

Mabit 2018
^{137}Cs ^{210}Pb ^{7}Be
$^{239+240}$Pu
^{7}Be 53.3 ^{239}Pu 24 110 ^{137}Cs 30.2 ^{210}Pb
22.8
^{137}Cs
Pennock Appleby 2002 ^{137}Cs
^{137}Cs
^{137}Cs
Parsons Foster 2011
Parsons Foster
2011 Mabit 2013

20 80 90 ^{137}Cs
Govers 1999

4.2 模型研究

4.2.1 水力侵蚀模型

Torri
Borselli 2012

RUSLE Renard 1997 USLE
Wischmeier Smith 1978

USLE
USLE
USLE Renard
1997 USLE

$$A \quad R \times K \times L \times S \times C \times P$$

A / ·
R -
K
L
C -
P

Kinnell
2016
Agricultural Non-Point Source Model
WATEM-SEDEM De Vente 2013

(Renard 1997
RUSLE 2 Foster Toy Renard 2003

USLE
Kinnell 2010 *R*
Modified
Universal Soil Loss Equation MUSLE
Sadeghi 2014
Soil and Water Assessment Tool SWAT de
Vente 2013 Benavidez 2019

Pandey 2016 50

4.2.2 风力侵蚀模型

Wind Erosion Equation WEQ
(Woodruff Siddoway 1965
/
WEQ
Revised Wind Erosion Equation RWEQ RWEQ
Fryrear 2012

20 90 (Wind
Erosion Predictions System WEPS
WEQ
Chappell 2019
(
MODIS

4.2.3 耕作侵蚀模型

Van Oost 2013

Li 2008

5　区域和全球土壤侵蚀模型

Amundson　(2015

Oldeman, Van Engelen　Pulles　1991　Oldeman

Hakkeling　Sombroek　1991

30　20　80

5.1　修正通用土壤流失方程模型研究

Panagos　(2015

——RUSLE 2015

RUSLE　Panagos

25

Panagos　2015　2010　1

10

2.5　/　·

76　2　/　·

/

9.47 / ·

RUSLE 2015

2015 25

1

RUSLE 2015

Panagos 2016 RUSLE 2015 25 30

>11 / · 8

<11 / ·

Panagos 2015

Evans Boardman 2016a

RUSLE 2015

Evans 2013 4.1.1

RUSLE 2015 *C* *P* Panagos 2016a

RUSLE 2015 Evans Boardman

2016b Panagos 2016a

Fiener Auerswald 2016

RUSLE 2015 *R* *K* *C*

RUSLE 2015 *C*

RUSLE 2015

Cerdan 2010

Panagos 2016b

Borrelli 2018 RUSLE 2015 2001—2012

2001 2.8

/ · 2012 2.5

6.1 10 / ·

0.8 8.3 12.7 /

· 0.16 / · 78 1.84
/ · 6 RUSLE 2015
RUSLE 2015

5.2 风力侵蚀和耕地侵蚀模型

4.1.3 MODIS Chappell 2016
2019 MODIS

Google Earth Engine
Chappell 2019 2001 2016
1.0 7.0 / ·
0.1 1.0 /
·

Van Oost 2007
RUSLE
GTOPO 30
1 SRTM 90 CORINE
100
3 12.1 / · vs 3.5 / ·
3.5 / · Detterl 2012
USLE/RUSLE

30 / ·

6　土壤可持续管理和土壤侵蚀控制

6.1　土壤侵蚀控制方法

FAO　2017

“　　”　World Overview of Conservation Approaches and Technologies　WOCAT

Voluntary Guidelines for Sustainable Soil Management　VGSSM　　FAO　2017

Meta　30　40　Guo Gifford　2002　Poeplau　2011　Wei　2014　Li　2018　Wei　2014　Li　2018

/

17　18

FAO 2017

26

Mekonnen 2015 27

Mekonnen 2015

26

27

6.2 免耕与侵蚀控制

2009 111 Derpsch 2010

Palm 2014

Meta

Mhazo Chivenge Chaplot 2016

60

33

Sun 2015

>33

Meta

Mangalassery 2015

Powlson 2014

Meta

Pittelkow 2015 5.1

15.1 3.4

Lundy 2015

85 ± 12

43 CGIAR 2013

6.3 覆盖法及其他植被法

Prosdocimi 2016

Prodocimi Tarolli Cerda 2016

68.9 48.8

3.2.4

Cornelius Gabriels 2005

Kowalchuk de Jong 1995

6.4 沉积物截留及梯田法

28

28 ——

Arnáez

2015 Mekonnen 2015 Wei 2016

5 000

Wei 2016

Montgomery 2007

Wei

2016 60

Arnáez 2015

Vanentin 2005

29 Vanentin

Poesen Li 2005

29

7　土壤治理及社会经济因素驱动下的侵蚀管理

10

Juerges　Hansjürgens

2018

United Nations Convention to Combat Desertification

UNCCD　　Global Soil Partnership　GSP　Weigelt

2015

FAO　2015

FAO　2017

Weigelt　　2015

Soil Thematic Strategy of the European

Union

Montanarella　Panagos　2015

Ronchi　　2019

Juerges　Hansjürgens　2018　Shiferaw　　2009　Weigelt　　2015　Fairhead　Scoones　2005　Stocking　2003

Stocking　2003

Stocking

2003

10

Shiferaw

Okello Reddy 2009

Fairhead Scoones

2005

Scherr Shames Friedman 2012

Juerges Hansjurgens 2018

Juerges Hansjürgens 2018

Wunder 2018

Jack Kousky Sims 2008

8　未来的发展趋势

Boardman　2006
13　　70

8.1　土壤侵蚀发生在哪些地方

Boardman　2006　　“　　”

Boardman　2006
6

表6　模型研究结果与 Boardman（2006）提出的侵蚀热点地区的对比

国家／地区（Boardman，2006）	Borrelli 等（2018）［水蚀，吨／（公顷·年）］	其他研究
	20　50	
	20　50	
	1　10	
	10　>50	
	10　>50	
	10	Ginoux
	>50	2012
	1　10	
	10　>50	

国家／地区（Boardman，2006）	Borrelli 等（2018）［水蚀，吨／（公顷·年）］	其他研究
	1 10	20 50 / ·
	10 50	Panagos 2015
		13 Cerdan
		2010
	10 >50	
	10 >50	
		0.1 7.0 / · Chappell
		2019
	3 10	20 60 Ginoux
		2012
	10 >50	
	10 >50	
	10 >50	
Borrelli 2018		Boardman 2006
	10 20	
	20 >50	Hempel 2015
	20 >50	
	20 >50	
	20 50	
	10 20	

Boardman 2006 Borrelli 2018
Boardman
Borrelli Borrelli
Boardman

Boardman 2006 Panagos
2015 Borrelli 2018 Cerdan 2010
Cerdan 2010

Boardman 2006

8.2 侵蚀的严重性及代价

FAO 2015

8.3 侵蚀率持续上升的原因及对此我们该怎么做

参考文献

Adhikari, B. & Nadella, K. 2011. Ecological economics of soil erosion: a review of the current state of knowledge. *Annals of the New York Academy of Sciences,* 1219:134-152.

Amundson, R., Berhe, A. A., Hopmans, J. W., Olson, C., Sztein, A. E. & Sparks, D. L. 2015. Soil and human security in the 21st century. *Science,* 348(6235): 1261071-1 to 1261071-6.

Arnáez, J., Lana-Renault, N., Lasanta, T., Ruiz-Flaño, P. & Castroviejo, J. 2015. Effects of farming terraces on hydrological and geomorphological processes. A review. *Catena,* 128: 122-134.

Asfaw, S., Orecchia, C., Pallante, G., & Palma, A. 2018. *Soil and nutrients loss in Malawi: an economic assessment*. FAO, UNDP-UNEP Poverty- Environment Initiative, and Ministry of Agriculture, Irrigation and Water development, Malawi.

Bakker, M. M., Govers, G. & Rounsevell, M. D. A. 2004. The crop productivity-erosion relationship: an analysis based on experimental work. *Catena*, 57(1): 55-76.

Bennett, S. J. & Wells, R. R. Gully erosion processes, disciplinary fragmentation, and technological innovation. *Earth Surface Processes and Landforms,* 44(1): 46-53.

Boardman, J. 2006. Soil erosion science: reflections on the limitations of current approaches. *Catena,* 68(2-3):73-86.

Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., Modugno, S., Schutt, B., Ferro, V. et al**.** 2017. An assessment of the global impact of 21st century land use change on soil erosion. *Nature Communications,* 8(1):2013.

Bryan, R. B. 2000. Soil erodibility and processes of water erosion on hillslope. *Geomorphology,* 32: 385-415.

Bui, E., Hancock, G., & Wilkinson, S. 2011. 'Tolerable' hillslope soil erosion rates in Australia: Linking science and policy. *Agriculture, Ecosystems, and Environment*, 144: 136-140.

Castillo, C. & Gómez, J. A. 2016. A century of gully erosion research: urgency, complexity and study approaches. *Earth-Science Reviews,* 160:300-319.

Cerdan, O., Govers, G., Le Bissonnais, Y., Van Oost, K., Poesen, J., Saby, N., Gobin, A., Vacca, A., Quinton, J., Auerswald, K. et al**.** 2010. Rates and spatial variations of soil erosion in Europe: a study based on erosion plot data. *Geomorphology,* 122(1-2):167-177.

CGIAR. 2013. The Nebraska Declaration on Conservation Agriculture. CGIAR Independent Science and Partnership Council. [cited 10 April 2019). Available at *https://ispc. cgiar. org/sites/default/files/ISPC_StrategyTrends_ ConservationAgriculture_NebraskaDeclaration. pdf*.

Chappell, A. & Webb, N. 2016. Using albedo to reform wind erosion modelling, mapping and monitoring. *Aeolian Research*, 23: 63-78.

Chappell, A., Webb, N. P., Leys, J. F., Waters, C. M., Orgill, S., & Eyres, M. J. 2019. Minimising soil organic carbon by wind is critical for land degradation neutrality. *Environmental Science and Policy,* 93: 43-52.

Chappell, A., Webb, N. P., Butler, H. J., Strong, C. L., McTainsh, G. H., Leys, J. F. & Viscarra Rossel, R. A. 2013. Soil organic carbon dust emission: an omitted global source of atmospheric CO2. *Global Change Biology,* 19(10):3238-3244.

Clearwater, R. L., T. Martin and T. Hoppe (eds.)2016. Environmental sustainability of Canadian agriculture: Agri-environmental indicator report series – Report #4. Agriculture and Agri-Food Canada. Ottawa, Canada.

Cordell, D., Drangert, J. -O. & White, S. 2009. The story of phosphorus: Global food security and food for thought. *Global Environmental Change*, 19(2):292-305.

Cornelius, W. M. & Gabriels, D. 2005. Optimal windbreak design for wind- erosion control. *Journal of Arid Environments*, 61: 315-332.

Crosson, P. 2003. Global consequences of land degradation: an economic perspective. In K. Wiebe, ed. *Land Quality, Agricultural Productivity, and Food Security*, pp. 36-46. Cheltenham, UK, Edward Elgar.

D'Odorico, P., Bhattachan, A., Davis, K. F., Ravi, S. & Runyan, C. W. 2013. Global desertification: drivers and feedbacks. *Advances in Water Resources*, 51:326-344.

Den Biggelaar, C., Lal, R., Eswaran, H., Breneman, V. E. & Reich, P. F. 2003. Crop losses to soil erosion at regional and global scales: evidence from plot-level and GIS data. In K. Wiebe, ed. *Land Quality, Agricultural Productivity, and Food Security*, pp. 262-279. Cheltenham, UK, Edward Elgar.

Derpsch, R., Friedrich, T., Kassam, A. & Hongwen, L. 2010. Current status of adoption of no-till farming in the world and some of its main benefits. *International Journal of Agricultural and Biological Engineering,* 3: 1-26.

Di Stefano, C. & Ferro, V. 2016. Establishing soil loss tolerance: an overview. *Journal of Agricultural Engineering,* 47:127-133.

Diaz, S., Pascual, U., Stenske, M., Martin-Lopez, B., Watson, R. T., Molnar, Z., Hill, R., Chan, K. M. A., Baste, I. A., Brauman, K. et al. 2018. Assessing nature's contributions to people. *Science,* 359: 270-272.

Doetterl, S., Van Oost, K. & Six, J. 2012. Towards constraining the magnitude of global agricultural sediment and soil organic carbon fluxes. *Earth Surface Processes and Landforms,* 37(6):642-655.

Doetterl, S., Berhe, A. A., Nadeu, E., Wang, Z., Sommer, M. & Fiener, P. 2016. Erosion, deposition and soil carbon: a review of process-level controls, experimental tools and models to address C cycling in dynamic landscapes. *Earth-Science Reviews,* 154:102-122.

Duan, X., Shi, X., Li, Y., Rong, L. & Fen, D. 2016. A new method to calculate soil loss tolerance for sustainable soil productivity in farmland. *Agronomy for Sustainable Development,* 37(1).

Dunne, T. and Leopold. L. B. 1978. *Water in environmental planning*. San Francisco, USA, Freeman and Company.

Evans, R. 2013. Assessment and monitoring of accelerated water erosion of cultivated land - when will reality be acknowledged? *Soil Use and Management* 29(1):105-118.

Evans, R. & Boardman, J. 2016a. The new assessment of soil loss by water erosion in Europe. Panagos P. *et al.,* 2015 *Environmental Science & Policy* 54, 438–447—A response. *Environmental Science & Policy,* 58: 11-15.

Evans, R. & Boardman, J. 2016b. A reply to Panagos *et al*., 2016 (*Environmental Science & Policy* 59, 53–57). *Environmental Science & Policy*, 60:63-68.

Fairhead, J. & Scoones, I. 2005. Local knowledge and the social shaping of soil investments: critical perspectives on the assessment of soil degradation in Africa. *Land Use Policy,* 22(1): 33-41.

FAO. 2015. *Revised World Soil Charter.* Food and Agriculture Organization of the United Nations. Rome. 10 pp. (also available at *http://www. fao. org/ documents/card/en/c/e60df30b-0269-4247-a15f-db564161fee0/).*

FAO. 2017. *Voluntary guidelines for sustainable soil management*. Food and Agriculture Organization of the United Nations. Rome. 26pp. (also available at *http://www.fao. org/3/a-bl813e. pdf*).

FAO & ITPS. 2015. *Status of the world's soil resources – main report*. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils. Rome. 649pp. (also available at *http://www. fao. org/3/a-i5199e. pdf*).

Fiener, P. & Auerswald, K. 2016. Comment on "The new assessment of soil loss by water erosion in Europe" by Panagos *et al*. (*Environmental Science & Policy* 54 (2015) 438–447). *Environmental Science & Policy,* 57:140-142.

Fiener, P., Wilken, F., Aldana-Jague, E., Deumlich, D., Gómez, J. A., Guzmán, G., Hardy, R. A., Quinton, J. N., Sommer, M., Van Oost, K. et al**.** 2018. Uncertainties in assessing tillage erosin-how appropriate are our measuring techniques? *Geomorphology,* 304: 214-225.

Foster, G. R., Toy, T. E., & Renard, K. G. 2003. Comparison of the USLE, RUSLE1. 06 and RUSLE2 for application to highly disturbed lands. In K. G. Renard, S. A. McIlroy, W. J. Gburek, H. E Cranfield, & R. L. Scott, eds. *First Interagency Conference on Research in Watersheds, October 27–30, 2003*. US Department of Agriculture.

Fryrear, D. W. 2012. Soil cover and wind erosion. *Transactions of the ASAE*, 28: 781-784.

Fryrear, D. W. 2012. Wind Erosion**.** In P. M. Huang, Y. Li & M. E. Sumner, eds. *Handbookof soil sciences resource management and environmental impacts, second edition*, pp. 23-1 to 23-19. Boca Raton, USA, CRC Press.

García-Ruiz, J. M., Beguería, S., Lana-Renault, N., Nadal-Romero, E. & Cerdà, A. 2017. Ongoing and emerging questions in water erosion studies. *Land Degradation & Development,* 28(1):5-21.

Ginoux, P., Prospero, J. M., Gill, T. E., Hsu, N. C., & Zhao, M. 2012. Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue Aerosol products. *Review of Geophysics,* 50: RG3005 (on-line, cited 15 March 2019) *https://agupubs. onlinelibrary. wiley. com/doi/10. 1029/2012RG000388.*

Goossens, D. & Offer, Z. Y. 1997. Aeolian dust erosion on different types of hills in a rocky desert: wind tunnel simulations and field measurements. *Journal of Arid Environments,* 37: 209-229.

Goudie, A. S. 2014**.** Desert dust and human health disorders. *Environment International,* 63.

Govers, G., Lobb, D. & Quine, T. 1999. Tillage erosion and translocation: emergence of a new paradigm in soil erosion research. *Soil and Tillage Research*, 51: 167-174.

Guo, L. B. & Gifford, R. M. 2002. Soil carbon stocks and land use change: a meta analysis. *Global Change Biology.* 8: 345-360.

Harden, J. W., Sharpe, J. M., Parton, W. J., Ojima, D. S., Fries, T. L., Huntington, T. G., & Dabney, S. M. 1999. Dynamic replacement and loss of soil carbon on eroding cropland. *Global Biogeochemical Cycles,* 13: 885-901.

Harmel, D., Potter, S., Casebolt, P., Reckhow, K., Green, C. & Haney, R. 2006. Compilation of measured nutrient load data for agricultural land uses in the United States. *Journal of American Water Research Association*, 42: 1163- 1178.

Jack, B. K., Kousky, C. & Sims, K. R. 2008. Designing payments for ecosystem services: lessons from previous experience with incentive- based mechanisms. *Proceedings of the National Academy of Sciences of the United States of America,* 105(28): 9465-9470.

Juerges, N. & Hansjürgens, B. 2018. Soil governance in the transition towards a sustainable bioeconomy – A review. *Journal of Cleaner Production,* 170: 1628-1639.

Kinnell, P. I. A. 2016. A review of the design and operation of runoff and soil loss plots. *Catena*, 145: 257-265.

Kondolf, G. M., Gao, Y., Annandale, G. W., Morris, G. L., Jiang, E., Zhang, J., Cao, Y., Carling, P., Fu, K., Guo, Q. et al. 2014. Sustainable sediment management in reservoirs and regulated rivers: experiences from five continents. *Earth's Future,* 2: 256-280.

Kowalchuk, T. & de Jong, E. 1995. Shelterbelts and their effect on crop yield. *Canadian Journal*

of Soil Science, 75: 543-550.

Lal, R. 2019. Accelerated soil erosion as a source of atmospheric CO2. *Soil and Tillage Research,* 188: 35-40.

Lal, R, & Elliot, W. 1994**.** Erodibility and Erosivity. In R. Lal , ed. *Soil erosion research methods. Second Edition*. Pp. 181-210. Soil and Water Conservation Society and St. Lucie Press, Florida, USA.

Larson, W. E. & Pierce, F. J. 1994. The dynamics of soil quality as a measure of sustainable production. In J. Doran, D. C. Coleman, D. F. Bezdicek & B.

A. Stewart, Eds. *Defining soil quality for a sustainable environment*. Soil Science Society of America Special Publication No 35, pp. 37-51. Madison, USA, Soil Science Society of America and American Society of Agronomy.

Li, S., Lobb, D. A., Lindstrom, M. J., Papiernik, S. K. & Farenhorst, A. 2008. Modeling tillage-induced redistribution of soil mass and its constituents within different landscapes. *Soil Science Society of America Journal,* 72(1): 167-179.

Li, W., Ciais, P., Guenet, B., Peng, S., Chang, J., Chaplot, V., Khudyaev, S., Peregon, A., Piao, S., Wang, Y. and others. 2018. Temporal response of soil organic carbon after grassland-related land-use change. *Global Change Biology,* 24(10): 4731-4746.

Lobb, D. A., Kachanoski, G. & Miller, M. H. 1999. Tillage translocation and tillage erosion in the complex upland landscapes of southwestern Ontario, Canada. *Soil & Tillage Research,* 51: 189-209.

Lugato, E., Paustian, K., Panagos, P., Jones, A. & Borrelli, P. 2016. Quantifying the erosion effect on current carbon budget of European agricultural soils at high spatial resolution. *Global Change Biology,* 22: 1976-1984.

Lundy, M. E., Pittelkow, C. M., Linquist, B. A., Liang, X., van Groenigen, K. J., Lee, J., Six, J., Venterea, R. T. & van Kessel, C. 2015. Nitrogen fertilization reduces yield declines following no-till adoption. *Field Crops Research,* 183: 204-210.

Lupia-Palmieri E. 2004. Erosion. In A. S. Goudie, ed. *Encyclopedia of Geomorphology*, pp. 331–336. London, UK, Routledge.

Mabit, L., Meusburger, K., Fulajtar, E. & Alewell, C. 2013. The usefulness of ^{137}Cs as a tracer for soil erosion assessment: a critical reply to Parsons and Foster (2011). *Earth-Science Reviews,* 127: 300-307.

Mabit, L., Bernard, C., Yi, A. L. Z., Fulajtar, E., Dercon, G., Zaman, M., Toloza, A. & Heng, L. 2018. Promoting the use of isotopic techniques to combat soil erosion: an overview of the key role played by the SWMCN Subprogramme of the Joint FAO/IAEA Division over the last 20 years. *Land Degradation & Development,* 29: 3077-3091.

Mangalassery, S., SjÖGersten, S., Sparkes, D. L. & Mooney, S. J. 2015. Examining the potential for climate change mitigation from zero tillage. *The Journal of Agricultural Science,* 153(07): 1151-1173.

Mekonnen, M., Keesstra, S. D., Stroosnijder, L., Baartman, J. E. M. & Maroulis, J. 2015. Soil conservation through sediment trapping: a review. *Land Degradation & Development,* 26(6): 544-556.

Mhazo, N., Chivenge, P. & Chaplot, V. 2016. Tillage impact on soil erosion by water: discrepancies due to climate and soil characteristics. *Agriculture, Ecosystems & Environment,* 230: 231-241.

Montanarella, L., & Panagos, P. 2015. Policy relevance of critical zone science. *Land Use Policy,* 49: 86-91.

Montgomery, D. R. 2007. Soil erosion and agricultural sustainability. *Proceedings of the National Academy of Sciences of the United States of America,* 104(33):13268-13272.

Oldeman, L. R., van Engelen, V. W. P. & Pulles, J. H. M. 1991. The extent of human-induced soil degradation. In L. R. Oldeman, R. T. A. Hakkeling & W. G. Sombroek, eds. *World map of the status of human-induced soil degradation: an explanatory note*, pp. 27-33. Wageningen, Netherlands, International Soil Reference and Information Centre & Nairobi, United Nations Environment Programme.

Oldeman, L. R., Hakkeling, R. T. A., & Sombroek, W. G. 1991. *World Map of the status of human- induced soil degradation*. Wageningen, Netherlands, GLASOD-ISRIC.

Owens, P. N., Batalla, R. J., Collins, A. J., Gomez, B., Hicks, D. M., Horowitz, A. J., Kondolf, G. M., Marden, M., Page, M. J., Peacock, et al**.** 2005. Fine-grained sediment in river systems: environmental significance and management issues. *River Research and Applications,* 21: 693-717.

Palm, C., Blanco-Canqui, H., DeClerck, F., Gatere, L. & Grace, P. 2014. Conservation agriculture and ecosystem services: an overview. *Agriculture, Ecosystems & Environment,* 187: 87-105.

Palmieri, A., Shah, F., Annandale, G. W., & Dinar, A. 2003. *Reservoir conservation: the RESCON approach*. Washington, D. C., World Bank.

Pandey, A., Himanshu, S. K., Mishra, S. K. & Singh, V. P. 2016. Physically based soil erosion and sediment yield models revisited. *Catena,* 147: 595- 620.

Panagos, P., Standardi, G., Borrelli, P., Lugato, E., Montanarella, L., & Bosello, F. 2018. Cost of agricultural productivity loss due to soil erosion in the European Union: from direct cost evaluation approaches to the use of macroeconomic models. *Land Degradation & Development,* 29: 471-484.

Panagos, P., Borrelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L.

& Alewell, C. 2015. The new assessment of soil loss by water erosion in Europe. *Environmental Science & Policy,* 54: 438-447.

Panagos, P., Borrelli, P., Poesen, J., Meusburger, K., Ballabio, C., Lugato, E., Montanarella, L. & Alewell, C. 2016a. Reply to "The new assessment of soil loss by water erosion in Europe. Panagos P. *et al*., 2015 *Environmental Science and Policy* 54, 438–447—A response" by Evans and Boardman (*Environmental Science & Policy* 58, 11–15). *Environmental Science & Policy,* 59: 53-57.

Panagos, P., Borrelli, P., Poesen, J., Meusburger, K., Ballabio, C., Lugato, E., Montanarella, L. & Alewell, C. 2016b. Reply to the comment on "The new assessment of soil loss by water erosion in Europe" by Fiener & Auerswald. Environmental Science & Policy, 57:143-150.

Panagos, P., Ballabio, C., Borrelli, P., Meusburger, K., Klik, A., Rousseva, S., Tadic, M. P., Michaelides, S., Hrabalikova, M., Olsen, P. et al**.** 2015. Rainfall erosivity in Europe. *Science Total Environment,* 511: 801-14.

Parsons, A. J. & Foster, I. D. L. 2011. What can we learn about soil erosion from the use of ^{137}Cs? *Earth-Science Reviews,* 108: 101-113.

Pennock, D. J. 1997. Effects of soil redistribution on soil quality: pedon, landscape, and regional scales. In E. G. Gregorich & M. R. Carter, eds. *Soil quality for crop production and ecosystem health*, pp. 167-186. Amsterdam, Elsevier.

Pennock, D. J. & Appleby, P. G. 2003. Site selection and sampling design. In F. Zapata, ed. *Handbook for the assessment of soil erosion and sedimentation using environmental radionuclides*, pp. 59-65. Amsterdam, Kluwer.

Pittelkow, C. M., Linquist, B. A., Lundy, M. E., Liang, X., van Groenigen, K. J., Lee, J., van Gestel, N., Six, J., Venterea, R. T. & van Kessel, C. 2015. When does no-till yield more? A global meta-analysis. *Field Crops Research,* 183: 156-168.

Poeplau, C., Don, A., Vesterdal, L., Leifeld, J., Van Wesemael, B. A. S., Schumacher, J. & Gensior, A. 2011. Temporal dynamics of soil organic carbon after land-use change in the temperate zone - carbon response functions as a model approach. *Global Change Biology*, 17(7): 2415-2427.

Poesen, J. 2018. Soil erosion in the Anthropocene: research needs. *Earth Surface Processes and Landforms,* 43(1): 64-84.

Powlson, D. S., Stirling, C. M., Jat, M. L., Gerard, B. G., Palm, C. A., Sanchez, P. A. & Cassman, K. G. 2014. Limited potential of no-till agriculture for climate change mitigation. *Nature Climate Change,* 4: 678- 683.

Prosdocimi, M., Tarolli, P. & Cerdà, A. 2016. Mulching practices for reducing soil water erosion: a review. *Earth-Science Reviews,* 161: 191- 203.

Ravi, S., Breshears, D. D., Huxman, T. E. & D'Odorico, P. 2010. Land degradation in drylands: Interactions among hydrologic–aeolian erosion and vegetation dynamics. *Geomorphology,* 116(3-4): 236-245.

Ronchi, S., Salata, S., Arcidiacono, A., Piroli, E. & Montanarella, L. 2019. Policy instruments for soil protection among the EU member states: a comparative analysis. *Land Use Policy,* 82: 763-780.

Sadeghi, S. H. R., Gholami, L., Khaledi Darvishan, A., & Saeidi, P. 2014. A review of the application of the MUSLE model worldwide. *Hydrological Sciences Journal,* 59: 365-375.

Sayyah, A., Horenstein, M. N. & Mazumder, M. K. 2014. Energy yield loss caused by dust deposition on photovoltaic panels. *Solar Energy,* 107: 576-604.

Scherr, S. J. 2003. Productivity-relatedeconomicimpactsofsoildegradation in developing countries: an evaluation of regional experience. In K. Wiebe, ed. *Land quality, agricultural productivity, and food security*, pp. 223-261. Cheltenham, UK, Edward Elgar.

Shao, Y., Raupach, M. R. & Leys, J. F. 1996. A model for predicting aeolian sand drift and dust entrainment on scales from paddock to region. *Australian Journal of Soil Research,* 34: 309-42.

Shao, Y., Wyrwoll, K. -H., Chappell, A., Huang, J., Lin, Z., McTainsh, G. H., Mikami, M., Tanaka, T. Y., Wang, X. & Yoon, S. 2011. Dust cycle: an emerging core theme in Earth system science. *Aeolian Research,* 2(4): 181- 204.

Shiferaw, B. A., Okello, J. & Reddy, R. V. 2007. Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Environment, Development and Sustainability,* 11(3): 601-619.

Sidle, R. C., Jarihani, B., Kaka, S. I., Koci, J. & Al-Shaibani, A. 2018. Hydrogeomorphic processes affecting dryland gully erosion: implications for modelling. *Progress in Physical Geography: Earth and Environment*, 43(1): 46-64.

Soil Science Society of America, 2001. *Glossary of Soil Science Terms*. Soil Science Society of America, Inc., Madison WI, p. 140.

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A. and others. 2015. Sustainability. Planetary boundaries: guiding human development on a changing planet. *Science*, 347(6223):1259855-1 to 1259855-10.

Stocking, M. A. 2003. Tropical soils and food security: the next 50 years. *Science,* 302: 1356-1359.

Stocking, M. A. & Murnaghan, N. 2001. *Handbook for the field assessment of land degradation*. London, UK, Earthscan Publications Ltd. 169 pp.

Stocking, M. A. & Tengberg, A. 1999. Erosion-induced loss in soil productivity and its impacts

on agricultural production and food security. In H. Nabhan, A. M. Mashali, & A. R. Mermut, eds. *Integrated Soil Management for Sustainable Agriculture and Food Security in Southern and East Africa,* pp. 91-120. Rome, FAO. (Also available at *http://www. fao. org/tempref/agl/agll/docs/misc23. pdf*).

Sun, Y., Zeng, Y., Shi, Q., Pan, X. & Huang, S. 2015. No-tillage controls on runoff: a meta-analysis. *Soil and Tillage Research,* 153: 1-6.

Torri, D. & Borselli, L. 2012. Water erosion. In P. M. Huang, Y. Li & M. Sumner, eds. *Handbook of soil sciences resource management and environmental impacts, second edition*, pp. 22-1 to 22-9. Boca Raton, USA, CRC Press.

Torri, D. & Poesen, J. 2014. A review of topographic threshold conditions for gully head development in different environments. *Earth-Science Reviews*, 130: 73-85.

Valentin, C., Poesen, J. & Li, Y. 2005. Gully erosion: impacts, factors and control. *Catena,* 63(2-3): 132-153.

Vanmaercke, M., Maetens, W., Poesen, J., Jankauskas, B., Jankauskiene, G., Verstraeten, G. & de Vente, J. 2012. A comparison of measured catchment sediment yields with measured and predicted hillslope erosion rates in Europe. *Journal of Soils and Sediments,* 12(4): 586-602.

Van Oost, K. & Bakker, M. M. 2012. Soil productivity and erosion. In D. H. Wall, R. D. Bardgett, V. Behan-Pelletier, J. E. Herrick, H. Jones, K. Ritz, J. Six, D. R. Strong, & W H. van der Putten, eds. *Soil ecology and ecosystem services*, pp. 301-314. Oxford, UK, Oxford University Press.

Van Oost, K., Govers, G., de Alba, S. & Quine, T. A. 2006. Tillage erosion: a review of controlling factors and implications for soil quality. *Progress in Physical Geography,* 30(4): 443-466.

Van Oost, K., Cerdan, O. & Quine, T. A. 2009. Accelerated sediment fluxes by water and tillage erosion on European agricultural land. *Earth Surface Processes and Landforms,* 34(12): 1625-1634.

Van Oost, K., Govers, G., Van Muysen, W., Heckrath, G., & Quine, T. A. 2003. Simulation of the redistribution of soil by tillage on complex topographies. *European Journal of Soil Science,* 54: 1-14.

Van Oost, K., Quine, T. A., Govers, G., De Gryze, S., Six, J., Harden, J. W., Ritchie, J. C., McCarty, G. W., Heckrath, G., Kosmas, C. et al**.** 2007. The impact of agricultural soil erosion on the global carbon cycle. *Science,* 318(5850): 626-629.

Vargas, R. & Omuto, C. 2016. *Soil loss assessment in Malawi*. FAO, UNDP-UNEP Poverty-Environment Initiative, and Ministry of Agriculture, Irrigation and Water development, Malawi.

Verheijen, F. G. A., Jones, R. J. A., Rickson, R. J. & Smith, C. J. 2009. Tolerable versus actual soil erosion rates in Europe. *Earth-Science Reviews*, 94(1-4): 23-38.

Walling, D. E. 1994. Measuring sediment yield from river basins. In R. Lal, ed. *soil erosion research methods, second edition*, pp. 39-82. Delray Beach, USA, Soil and Water Conservation

Society and St. Lucie Press.

Web of Science 2019. (www. webofknowledge. com), accessed 20 March 2019.

Wei, W., Chen, D., Wang, L., Daryanto, S., Chen, L., Yu, Y., Lu, Y., Sun, G. & Feng, T. 2016. Global synthesis of the classifications, distributions, benefits and issues of terracing. *Earth-Science Reviews,* 159: 388-403.

Wei, X., Shao, M., Gale, W. & Li, L. 2014. Global pattern of soil carbon losses due to the conversion of forests to agricultural land. *Nature Scientific Reports,* 4: 1-6.

Weigelt, J., Müller, A., Janetschek, H. & Töpfer, K. 2015. Land and soil governance towards a transformational post-2015 development agenda: an overview. *Current Opinion in Environmental Sustainability,* 15: 57-65.

Wilkinson, B. H. & McElroy, B. J. 2007. The impact of humans on continental erosion and sedimentation. *Geological Society of America Bulletin*, 119(1-2): 140-156.

Wilkinson, M. & Humphreys, G. 2005. Exploring pedogenesis via nuclide- based soil production rates and OSL-based bioturbation rates. *Australian Journal of Soil Research*, 43: 767-779.

Wischmeier, W. H. 1959. A rainfall erosion index for a universal soil loss equation. *Soil Science Society of America Proceedings,* 23: 246-249.

Wischmeier, W. H. & Smith, D. D. 1978. *Predicting rainfall erosion losses–a guide to conservation planning*. United States Department of Agriculture, Agriculture Handbook No. 537. 58 pp.

WOCAT. The World Overview of Conservation Approaches and Technologies [cited 10 April 2019]. *https://www. wocat. net*.

Wolfe, S. A. & Nickling, W. G. 1993. The protective role of sparse vegetation in wind erosion. *Progress in Physical Geography,* 17: 50-68.

Woodruff, N. P. & Siddoway, F. H. 1965. A wind erosion equation. *Soil Science Society of America Proceedings,* 29: 602-608.

Wu, W., Yan, P., Wang, Y., Dong, M., Meng, X. & Ji, X. 2018. Wind tunnel experiments on dust emissions from different landform types. *Journal of Arid Land,* 10(4): 548-560.

Wunder, S., Brouwer, R., Engel, S., Ezzine-de-Blas, D., Muradian, R., Pascual, U. & Pinto, R. 2018. From principles to practice in paying for nature's services. *Nature Sustainability,* 1(3): 145-150.

Yuan, Z., Jiang, S., Sheng, H., Liu, X., Hua, H., Liu, X., & You, Z. 2018. Human perturbation of the global phosphorus cycle: changes and consequences. *Environmental Science and Technology* (on-line; cited 15 March 2019). *https://pubs. acs. org/doi/abs/10. 1021/acs. est. 7b03910*.

Zhou, J., Zhang, M., & Lu, P. 2013. The effect of dams on phosphorus in the middle and lower Yangtze river. *Water Resources Research*, 49: 3659– 3669 (on-line; cited 15 March 2019). *https://agupubs. onlinelibrary. wiley. com/ doi/10. 1002/wrcr. 20283*.

图书在版编目（CIP）数据

/

—

2021.6

FAO

ISBN 978-7-109-28152-3

. … . … … … … .

IV. S157

CIP 2021 070592

01-2021-2166

土壤侵蚀：可持续土壤管理的巨大挑战

TURANG QINSHI: KECHIXU TURANG GUANLI DE JUDA TIAOZHAN

18

100125

2021 6 1

2021 6 1

700mm × 1000mm 1/16

5

150

50.00

.

010 59195115 010 59194918

封面设计：田　雨

ISBN 978-7-109-28152-3

定价：50.00元

欢迎登录中国农业出版社网站：http://www.ccap.com.cn

欢迎拨打中国农业出版社读者服务部热线：010-59194918，65083260

购书敬请关注中国农业出版社
天猫旗舰店：

乡村振兴分社投稿邮箱：1377642004@qq.com