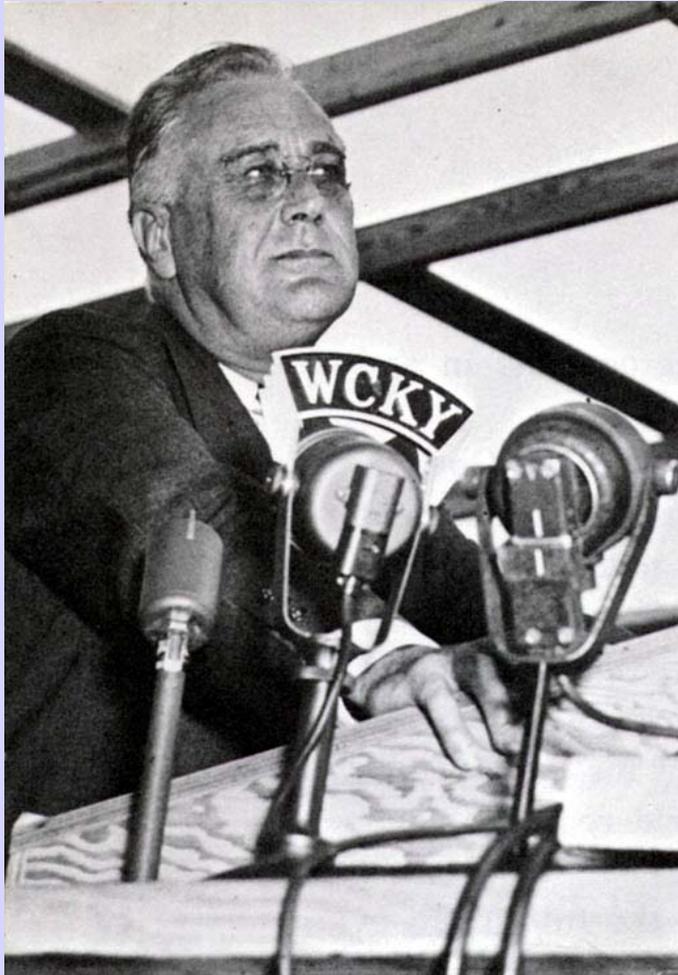


SOIL EROSION



“A nation that destroys its soil
destroys itself”

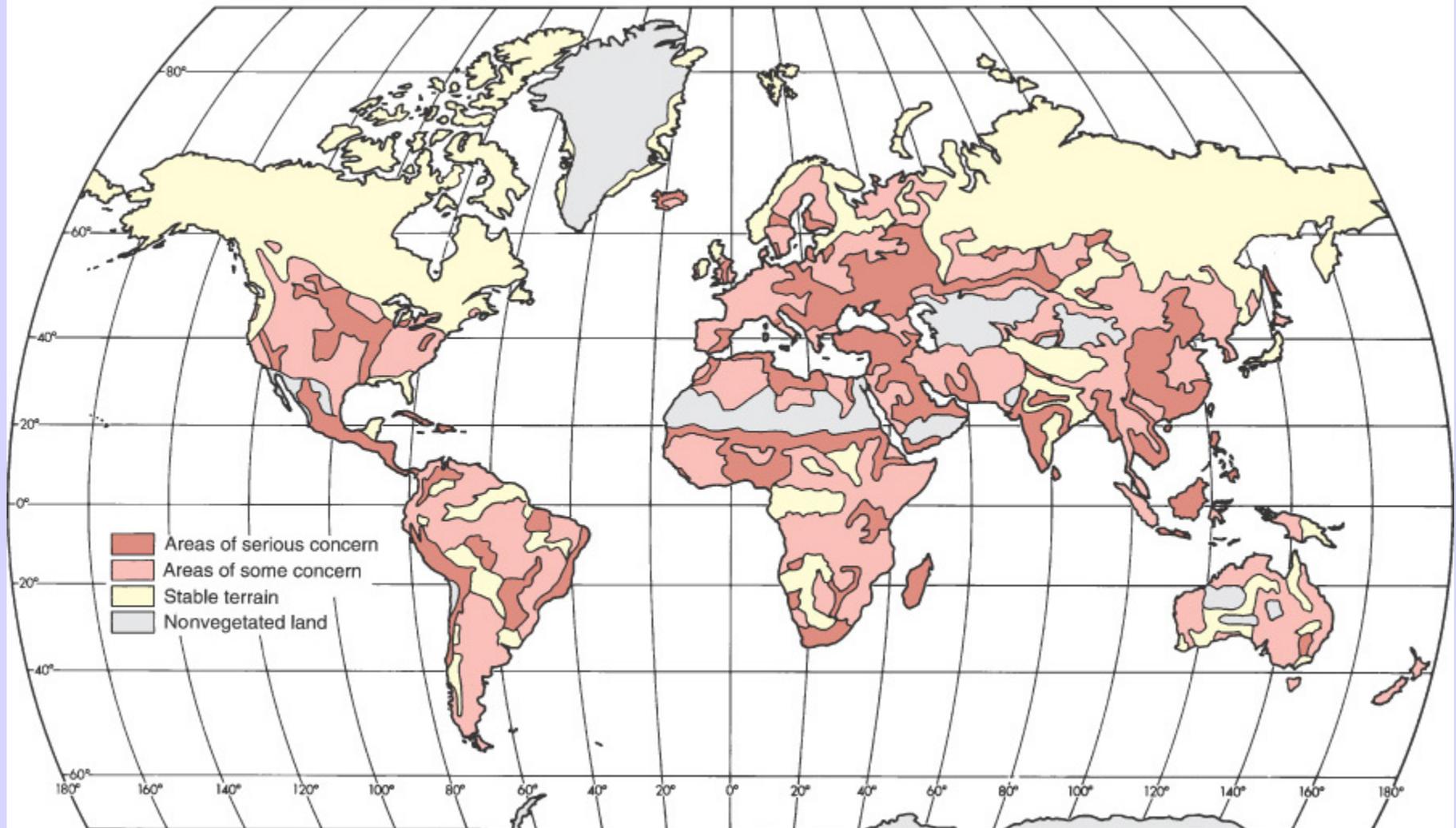
F.D.R.

- 1982: 2000 report to the
President:

*“Soil erosion and pollution
continues to be the number one
problem we face”*

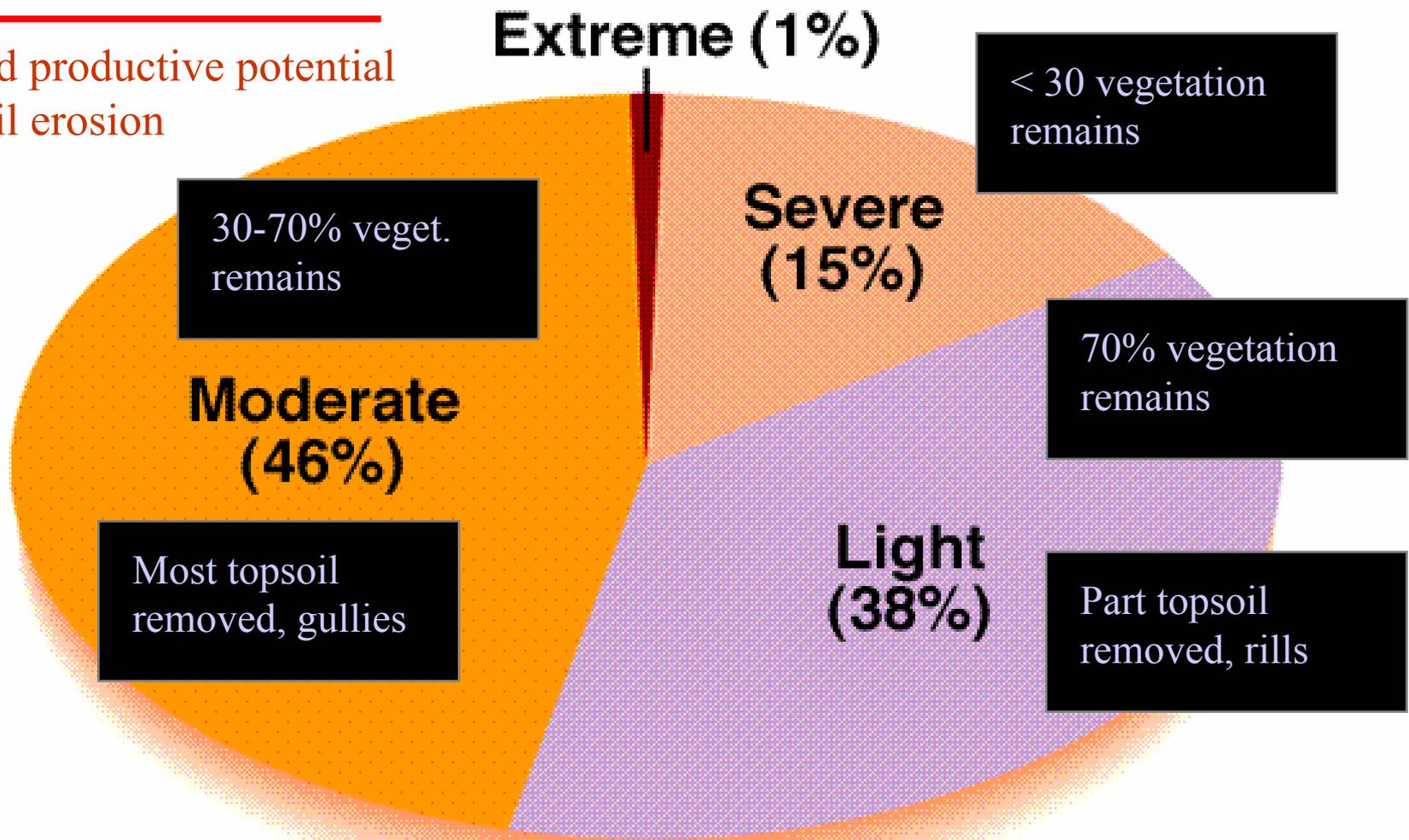
SOIL EROSION

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Most of the world's soils that have been surveyed show some level of degradation due to human activities.

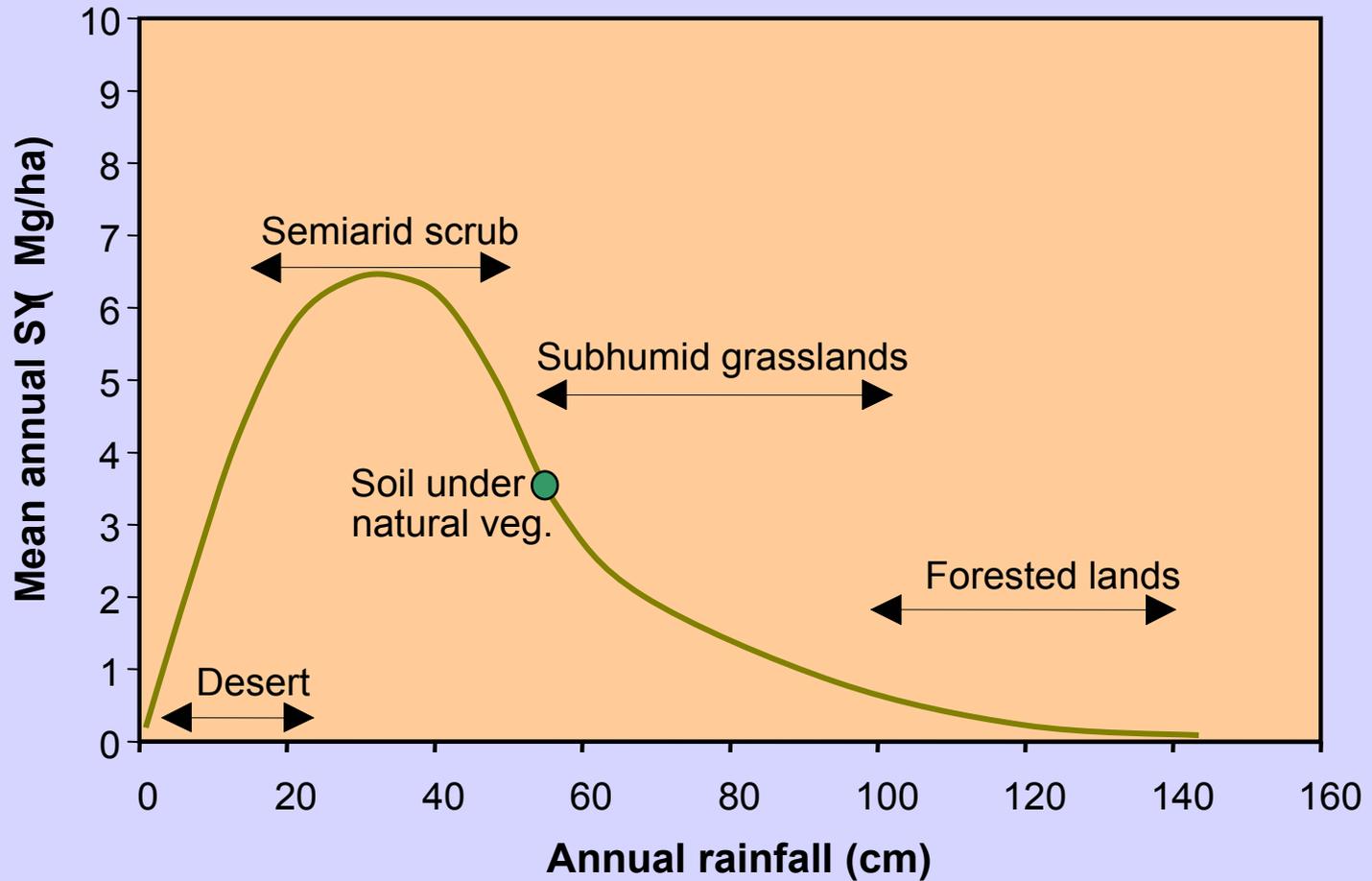
- Reduced productive potential
- 85% soil erosion



SOIL EROSION



SOIL EROSION





SOIL EROSION





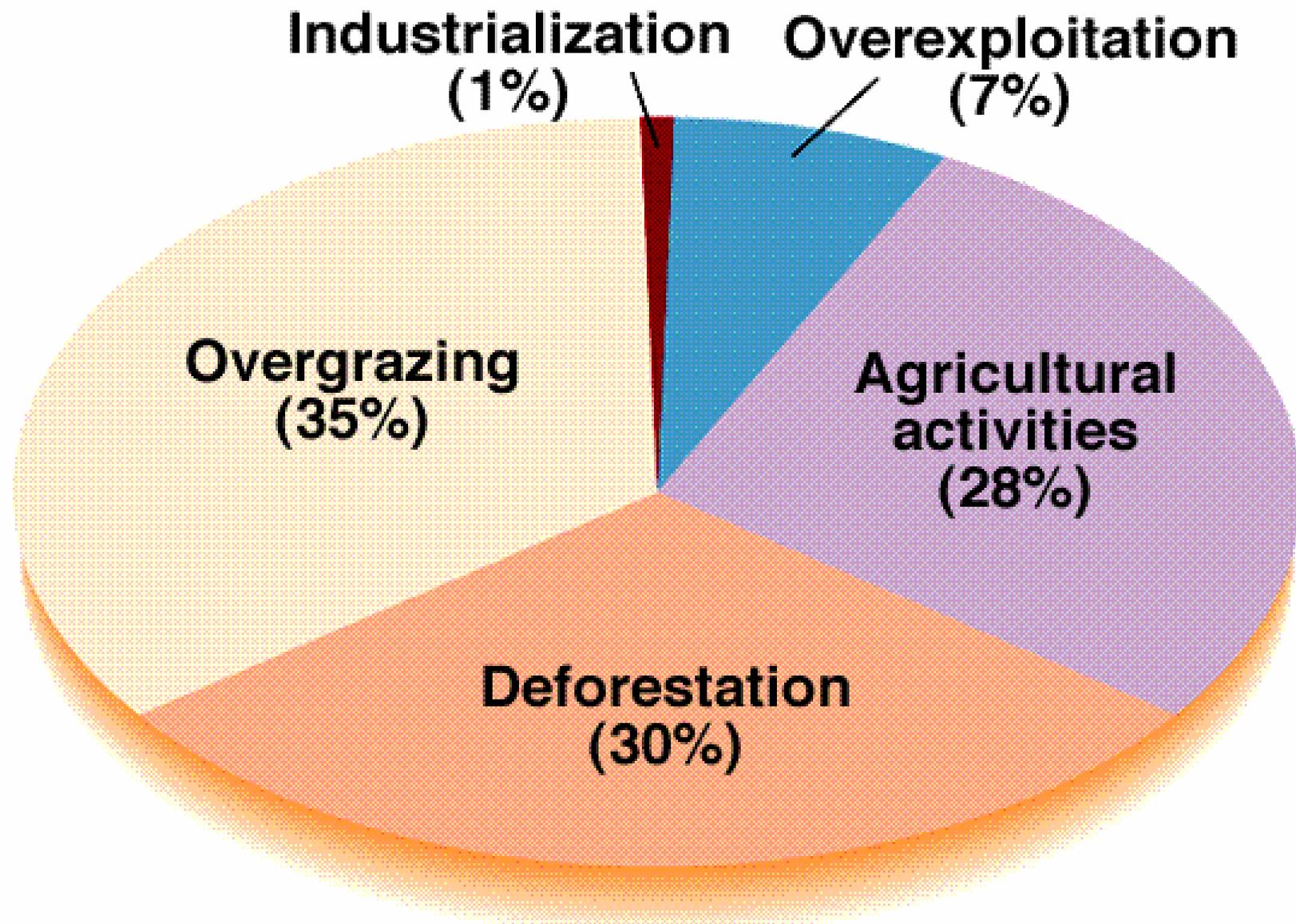
SOIL EROSION

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Causes of soil degradation worldwide for all land uses.



Physical degradation

(4%)

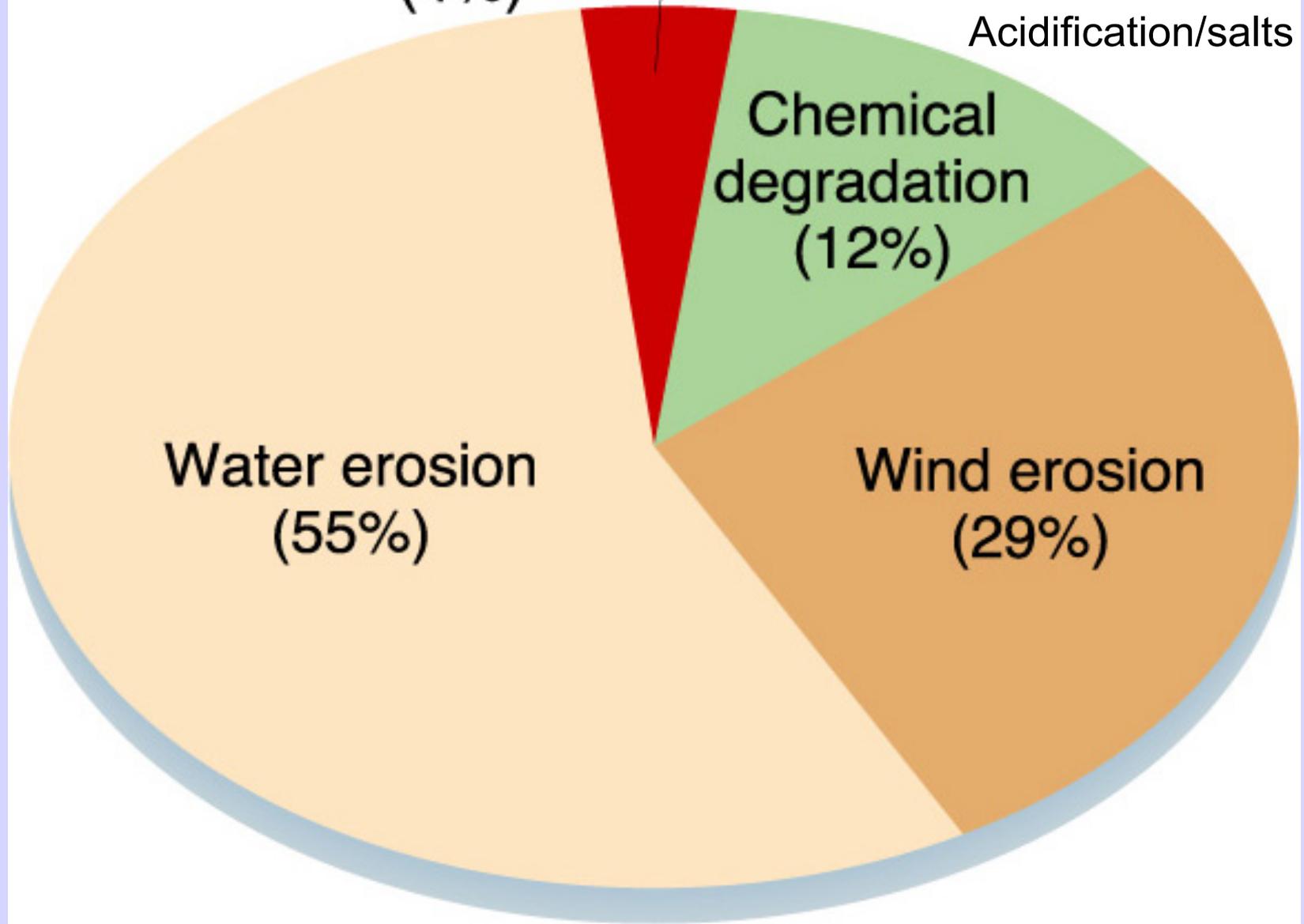
Compaction/crusting

Acidification/salts

Chemical degradation
(12%)

Water erosion
(55%)

Wind erosion
(29%)





HOW MUCH ARE WE LOSING?

- 1/3 of world's arable land lost since 1950
- Asia/Africa/S. America: 30-40 t/ha/a
- 30% of US farmland abandoned (erosion, waterlogging, salinization)

HOW MUCH ARE WE LOSING?



1982: 3 billion t

1992: 1.8 billion t

12 t/ha (12k lbs/ac)

8 = water

4 = wind

Mississippi River:

300 m/t/yr

10 t/sec!



HOW MUCH ARE WE LOSING?

T value = Tolerable erosion

“Maximum soil erosion loss that is offset by the theoretical maximum rate of soil development, which will maintain an equilibrium between soil gains and losses.”

“The maximum average annual soil loss that will allow continuous cropping and maintain soil productivity without requiring additional management inputs.”

- T ranges from: 2 – 11 t/ha/yr
 1-5 t/ac/yr
 < 25 cm = 2.2 t/ha/yr > 152 cm = 11.2 t/ha/yr

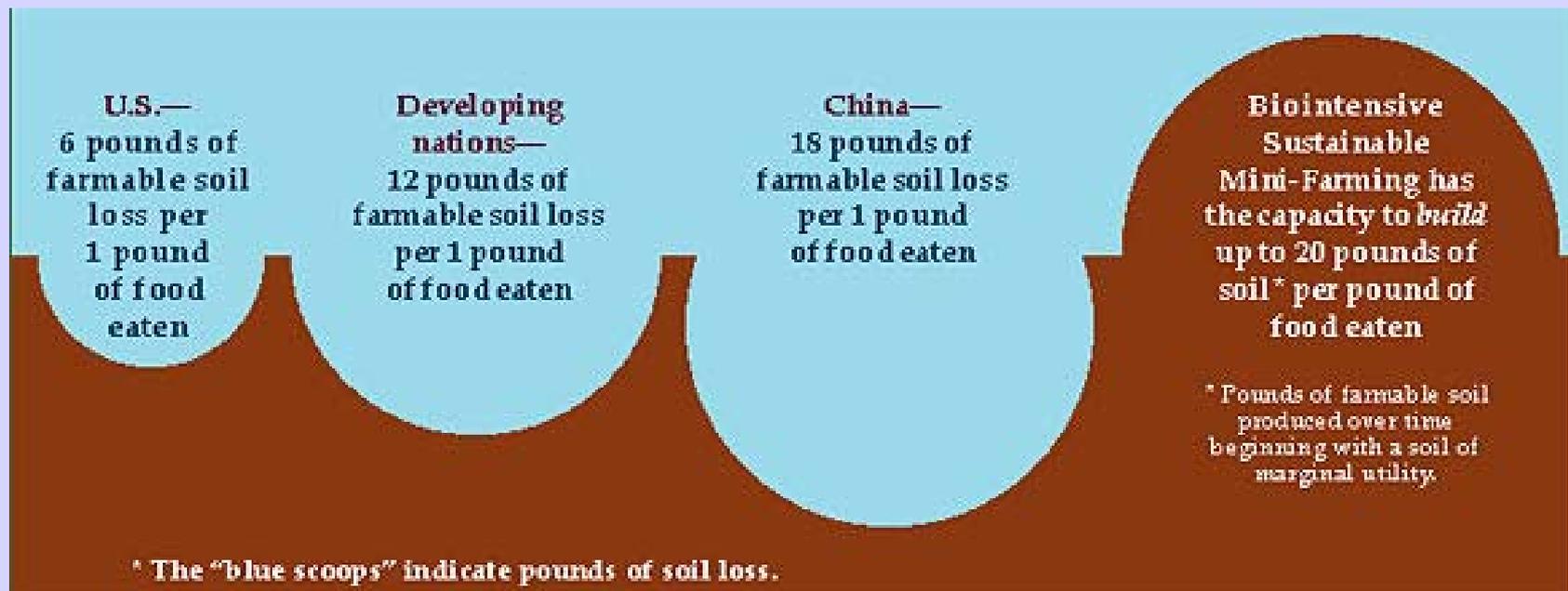


HOW MUCH ARE WE LOSING?

1994: 12,000 lbs of soil lost per acre

...since average person consumes 2,000 lbs per annum

6 lbs of soil lost per pound of food eaten annually!



HOW MUCH ARE WE LOSING?

Normally takes 500 years to build up an inch of topsoil

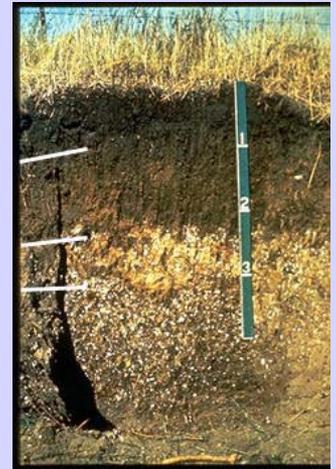
To grow good crops requires approximately 6 inches

3,000 years required to build up a reasonable topsoil

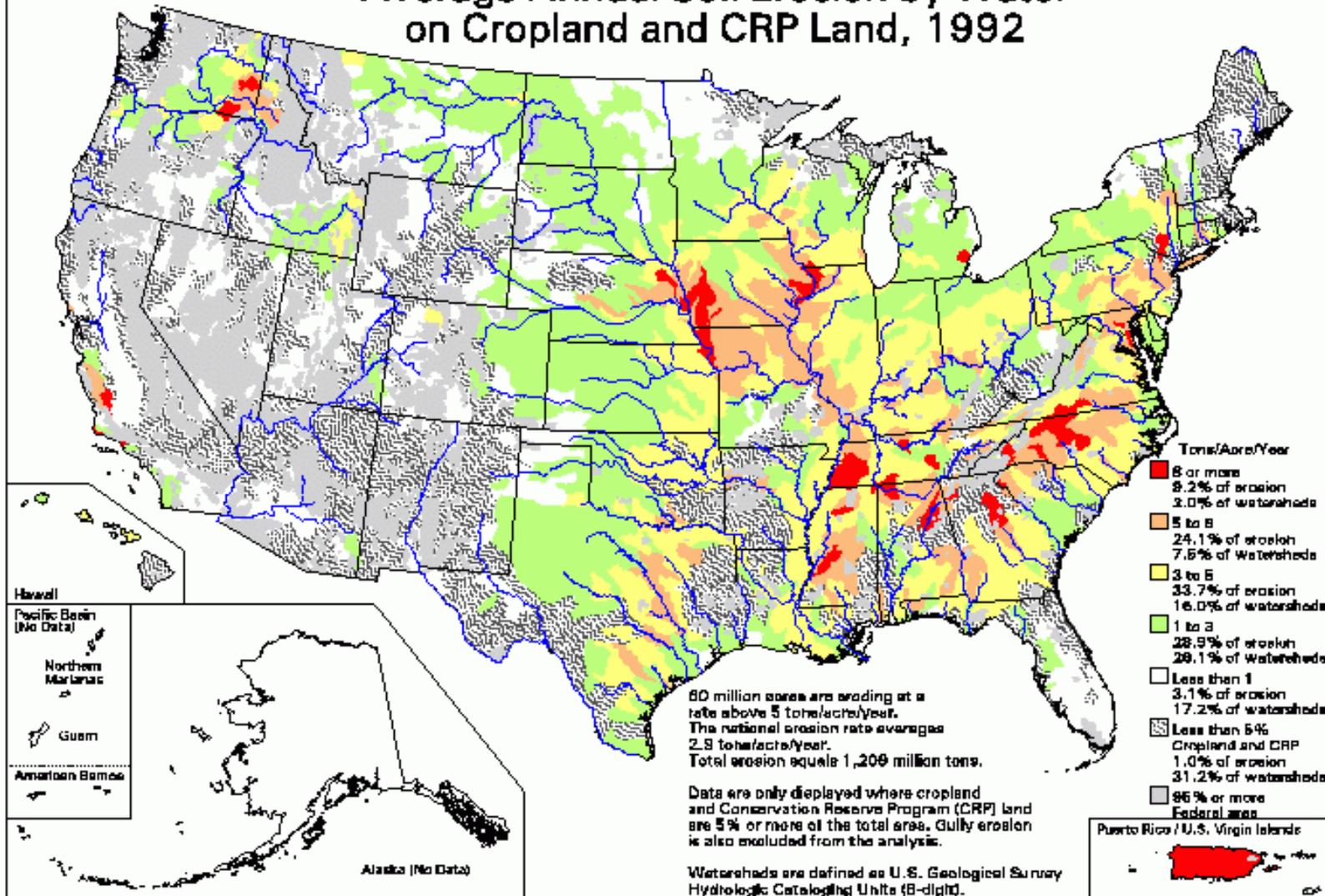
12,000 lbs/acre = 0.0356 inch (1/28th)

Since 1/500th of an inch is being built up naturally annually

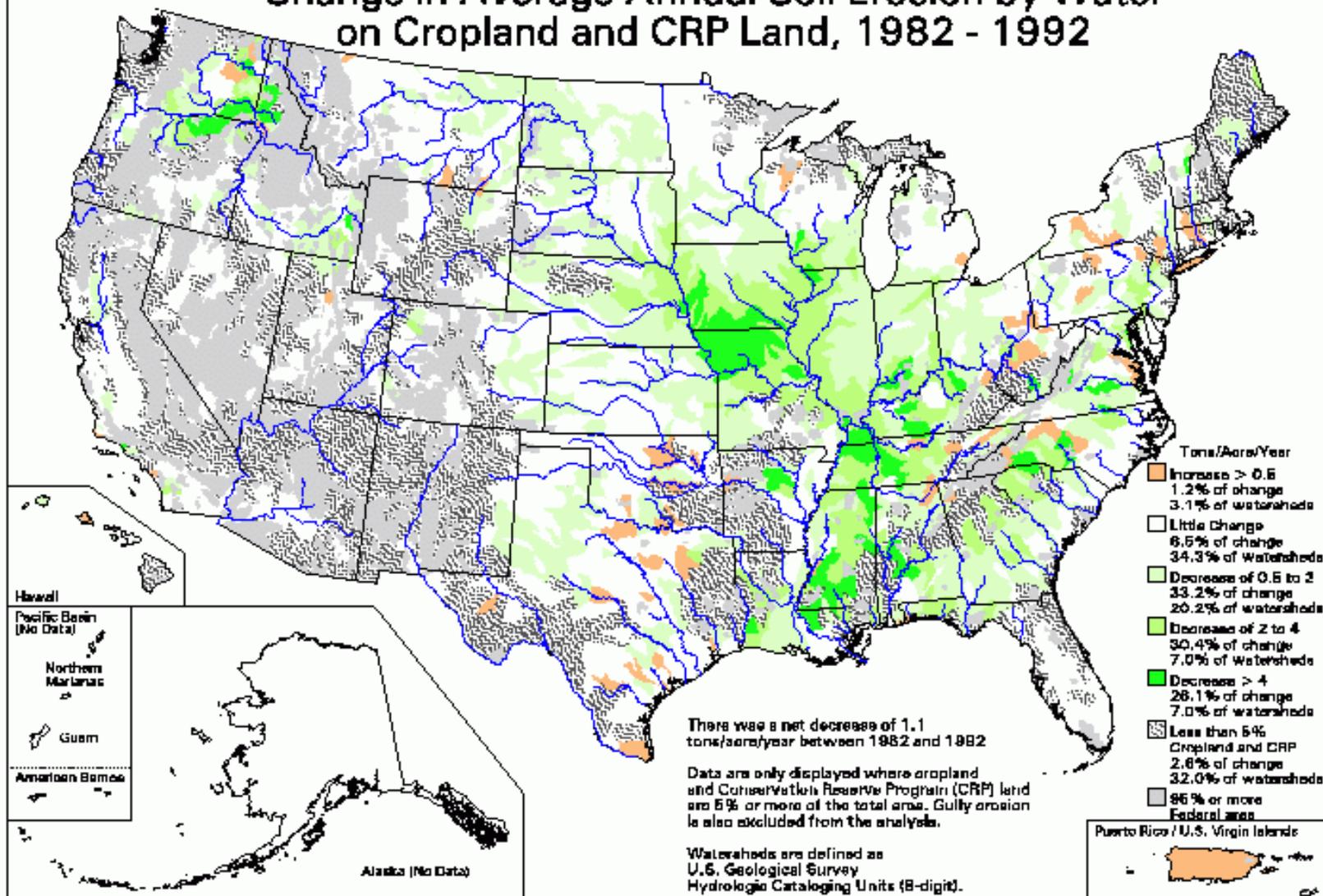
Soil is being depleted on the average each year 18 times faster than it is being built up in nature!



Average Annual Soil Erosion by Water on Cropland and CRP Land, 1992



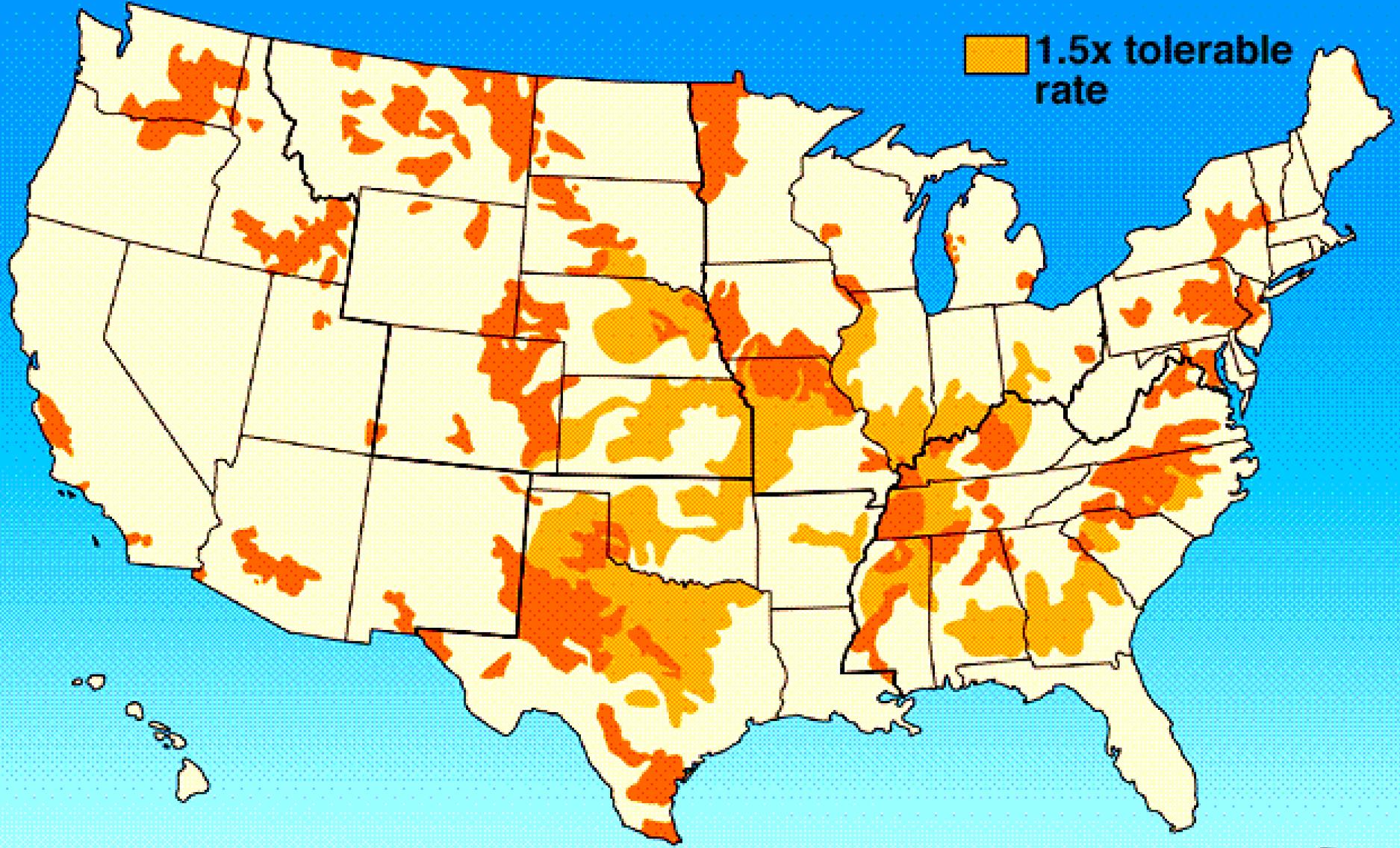
Change in Average Annual Soil Erosion by Water on Cropland and CRP Land, 1982 - 1992



Soil erosion as a proportion of the tolerable rate in 1992.

 2x tolerable rate or more

 1.5x tolerable rate





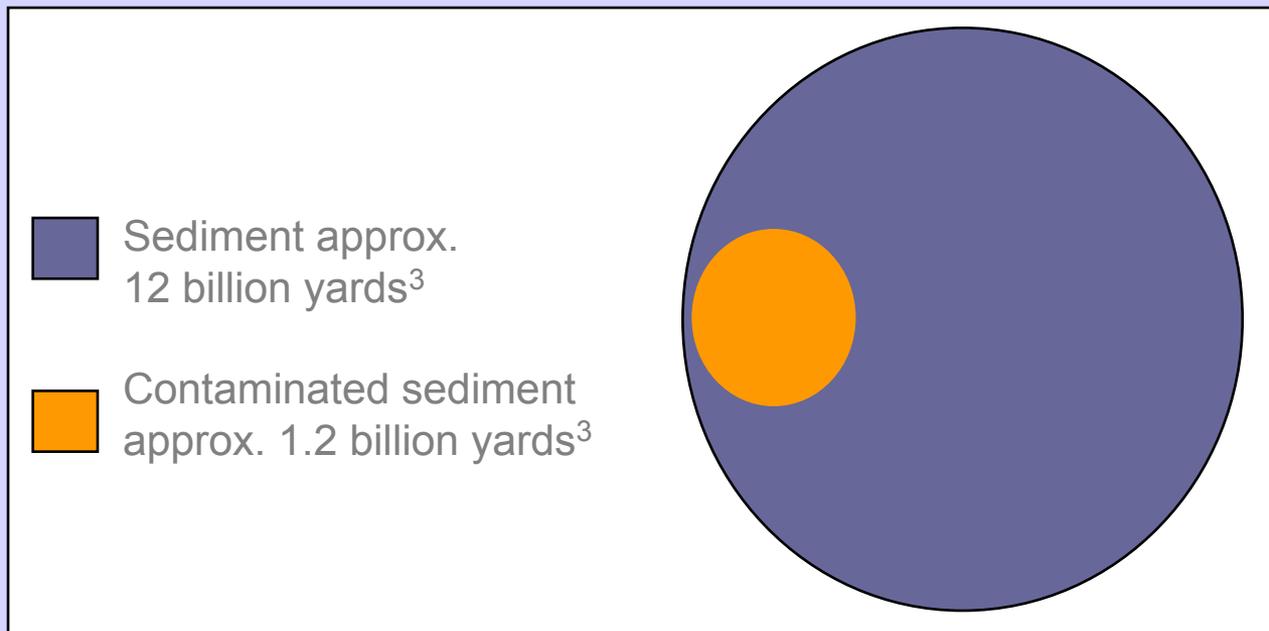
ON-SITE VERSUS OFF-SITE





ON-SITE VERSUS OFF-SITE

- Much of the contaminated sediment in the U.S. was polluted years ago by such chemicals as DDT, PCBs, and mercury
- Estimated that 10% of the sediment underlying our nation's surface water is significantly contaminated



ON-SITE VERSUS OFF-SITE





ON-SITE VERSUS OFF-SITE



ON-SITE VERSUS OFF-SITE



ON-SITE VERSUS OFF-SITE

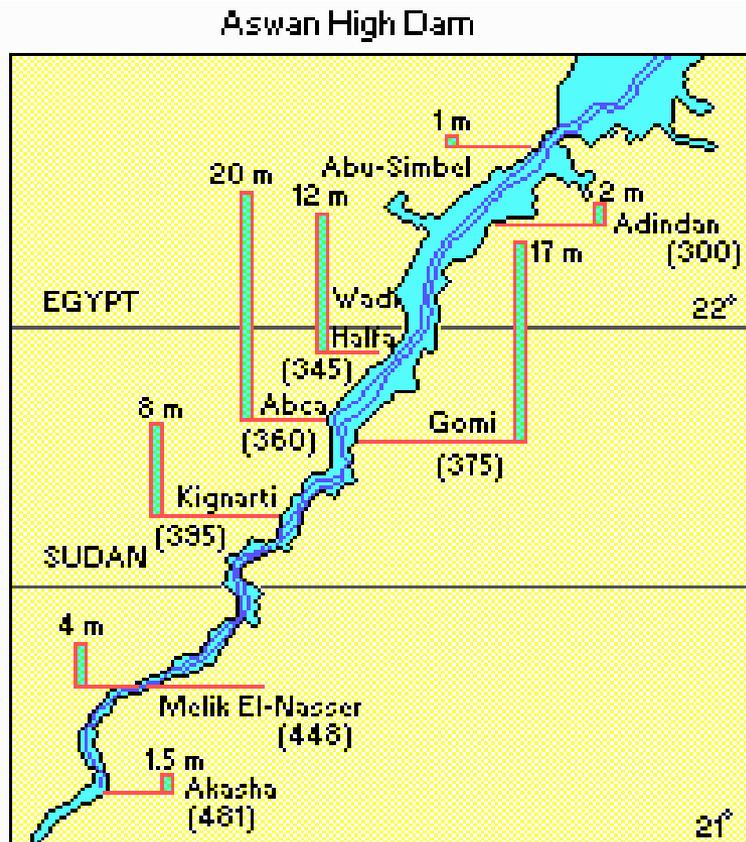
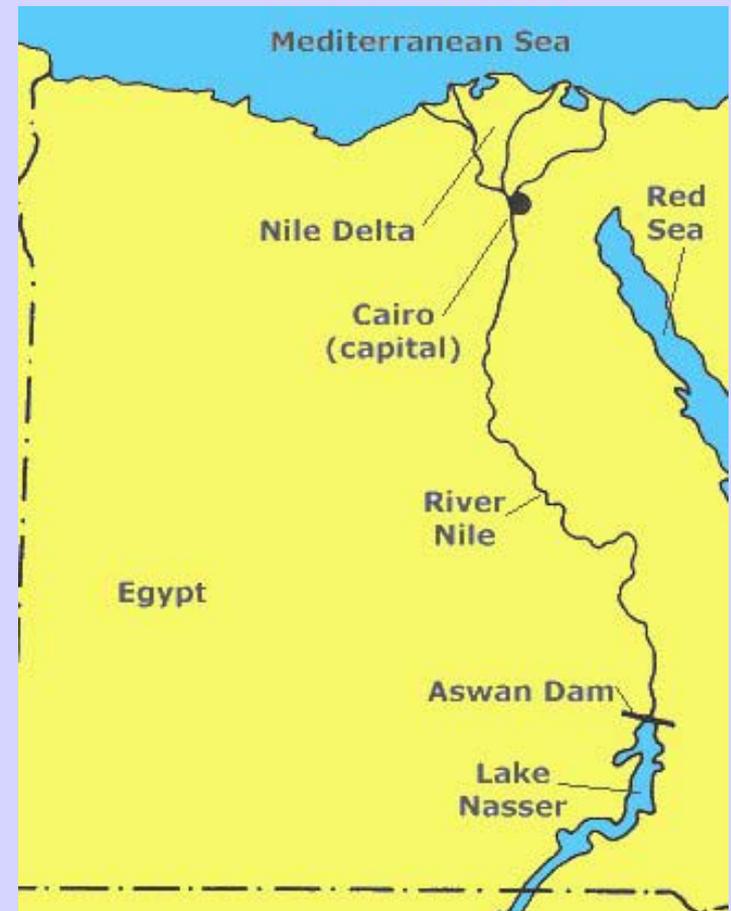


Fig. AFR-19-15 Distribution of siltation depth in the reservoir, 1975(1).

Figures between brackets indicate the distance in km from the High Dam



ON-SITE VERSUS OFF-SITE





SOIL EROSION

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TABLE 7.2 Soil Cover and
Soil Erosion

CROPPING SYSTEM	AVERAGE ANNUAL SOIL LOSS (tons/hectare)	PERCENT RAINFALL RUNOFF
Bare soil (no crop)	41.0	30
Continuous corn	19.7	29
Continuous wheat	10.1	23
Rotation: corn, wheat, clover	2.7	14
Continuous bluegrass	0.3	12

Source: Based on 14 years of data from Missouri Experiment Station, Columbia, Missouri.



SOIL EROSION

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TABLE 11.3 Cropland by Region
and per Capita

REGION	POPULATION (MILLIONS)	CROPLAND (10 ⁶ HA)	CROPLAND PER CAPITA
Africa	778	190	0.24
Europe	729	316	0.43
North America	304	233	0.77
Central America	131	41	0.31
South America	332	115	0.35
Asia	3,589	622	0.17
Oceania*	29	52	1.79
World	5,892	1,569	0.27

*Oceania includes Australia, New Zealand, and many small-island nations.

Source: Data from *World Resources 1998–99*, World Resource Institute.

SOIL EROSION





MECHANICS OF SOIL EROSION

Definition of soil erosion

Soil erosion is a two-phase process:

Detachment of individual particles from soil aggregates

Transport of particles by erosive agents - wind or water.

Particles are eventually *deposited* to form new soils or to fill lakes & reservoirs



MECHANICS OF SOIL EROSION

Definitions:

"Erosive" means tending to cause erosion. Wind and water are erosive agents.

"Erodible" means susceptible to erosion. Soils vary in their erodibility.



MECHANICS OF SOIL EROSION



MECHANICS OF SOIL EROSION





MECHANICS OF SOIL EROSION

Erosive energy

Kinetic energy is the energy of motion

$$\text{KE} = 1/2mv^2$$

Units $\text{kg m}^2 \text{s}^{-2} = \text{Joules}$

Energy of detaching agents:

I. The falling raindrop

2 cm of rainfall over 1 ha of land

Velocity of the raindrops = 8 m/s

$$\text{KE} = 0.5 * 200,000 \text{ kg} * 64 \text{ m}^2/\text{s}^2 = 6,400,000 \text{ J}$$



MECHANICS OF SOIL EROSION

Erosive energy

Kinetic energy is the energy of motion

$$\text{KE} = 1/2mv^2$$

Units $\text{kg m}^2 \text{s}^{-2}$ = Joules

Energy of detaching agents:

2. Runoff water

50% runs off at a velocity of 1 m/s

$$\text{KE} = 0.5 * 100,000 \text{ kg} * 1 \text{ m}^2/\text{s}^2 = 50,000 \text{ J}$$



MECHANICS OF SOIL EROSION

- Rainsplash





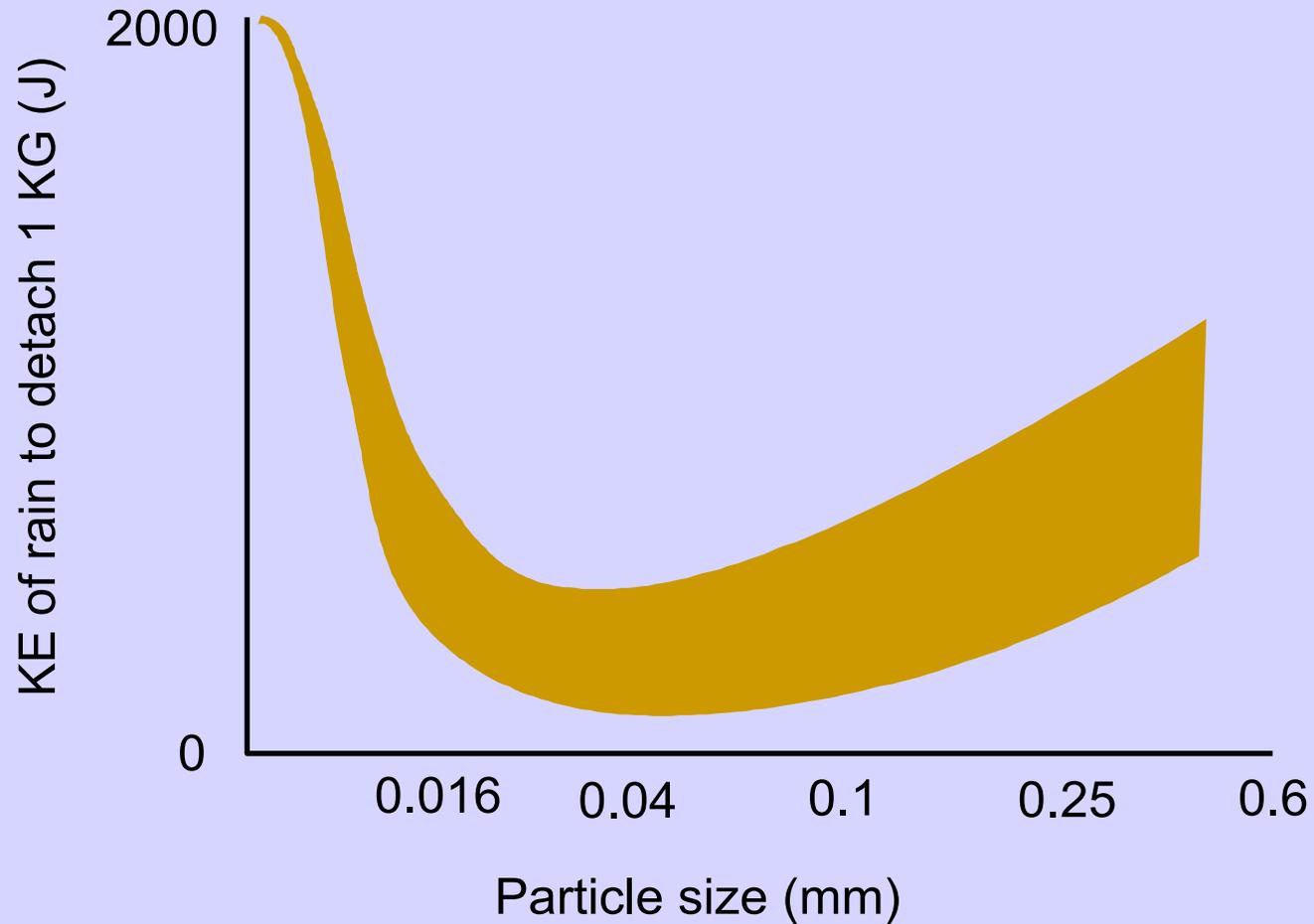
MECHANICS OF SOIL EROSION

- Compaction (destroys granulation) and disruption of soil surface (detachment)





MECHANICS OF SOIL EROSION



MECHANICS OF SOIL EROSION





MECHANICS OF SOIL EROSION

- Sheetwash vs concentrated flow





MECHANICS OF SOIL EROSION



A. Sheet erosion



MECHANICS OF SOIL EROSION

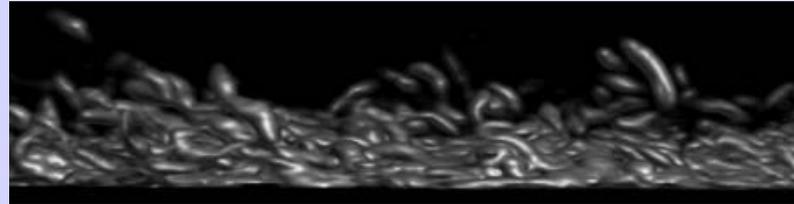
$$R_e = \nu r / \nu$$

$$F = \nu / \sqrt{gr}$$

Reynolds number = flow turbulence

< 500 = laminar

> 2000 = turbulent



Froude Number = gravity waves

< 1.0 = smooth (tranquil) flow

> 1.0 = rapid, supercritical (erosive) flow



MECHANICS OF SOIL EROSION



B. Rill erosion

MECHANICS OF SOIL EROSION





MECHANICS OF SOIL EROSION

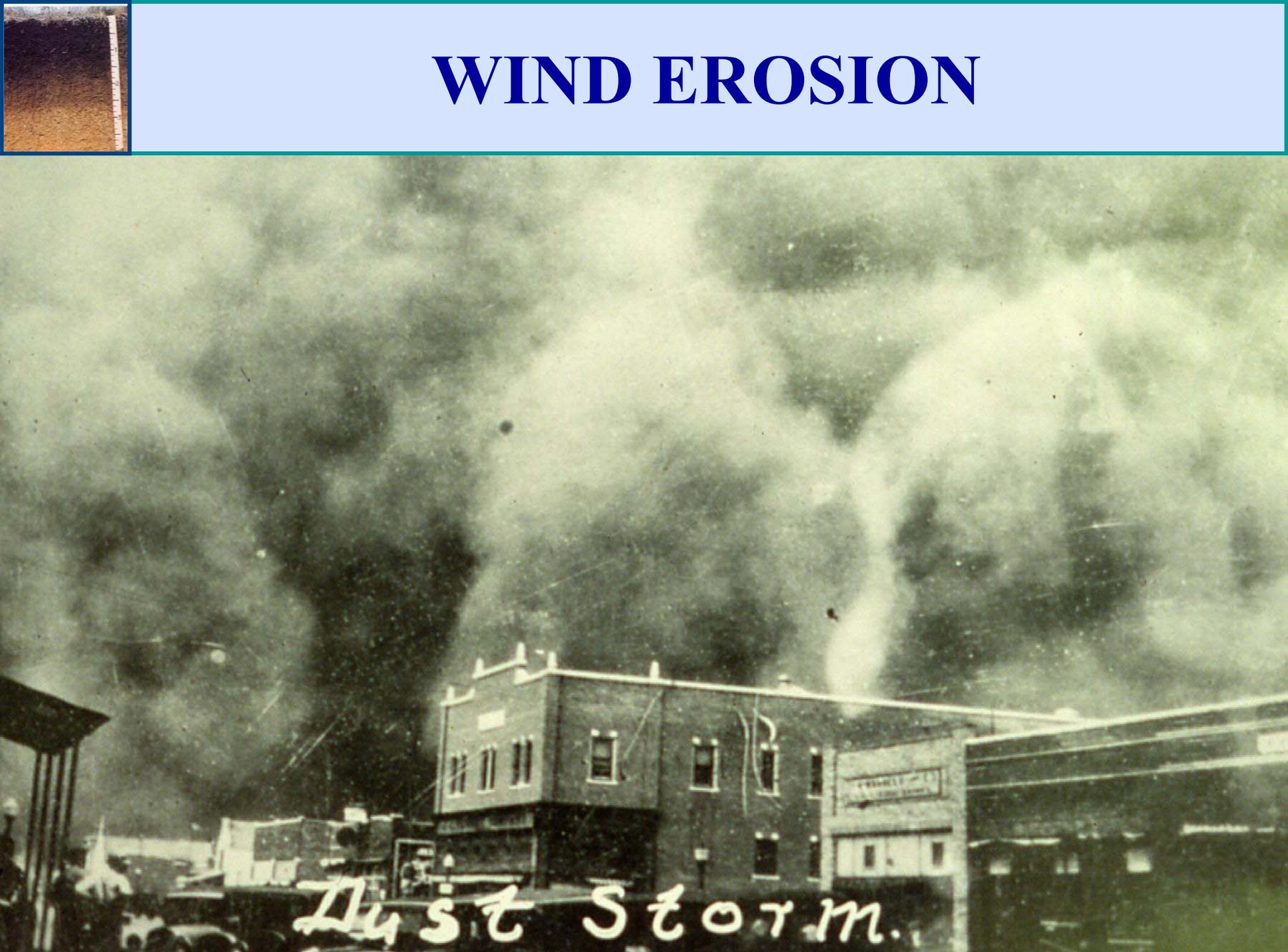
- Gully erosion



WIND EROSION



WIND EROSION

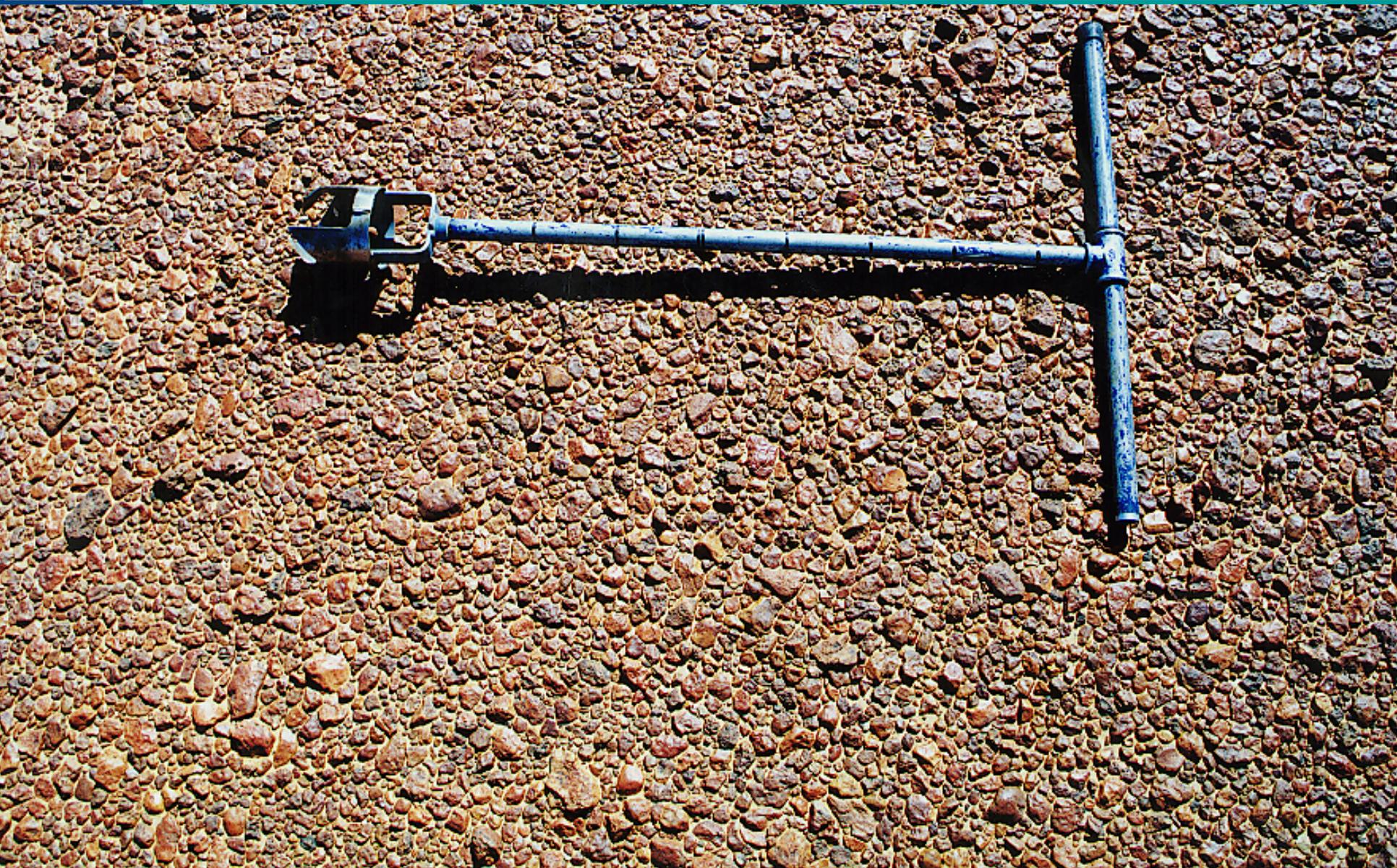


Dust Storm.

WIND EROSION

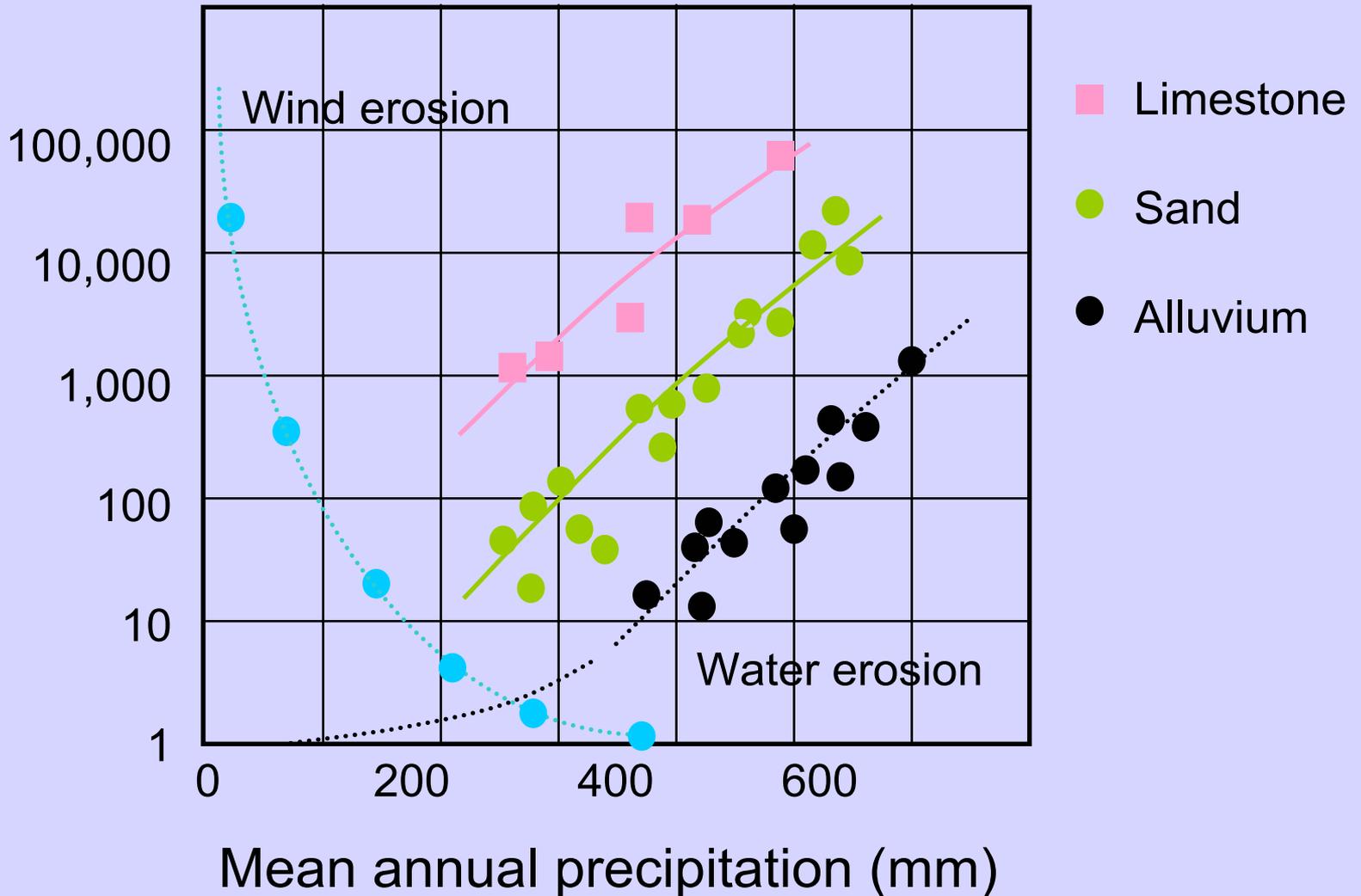


WIND EROSION



WIND EROSION

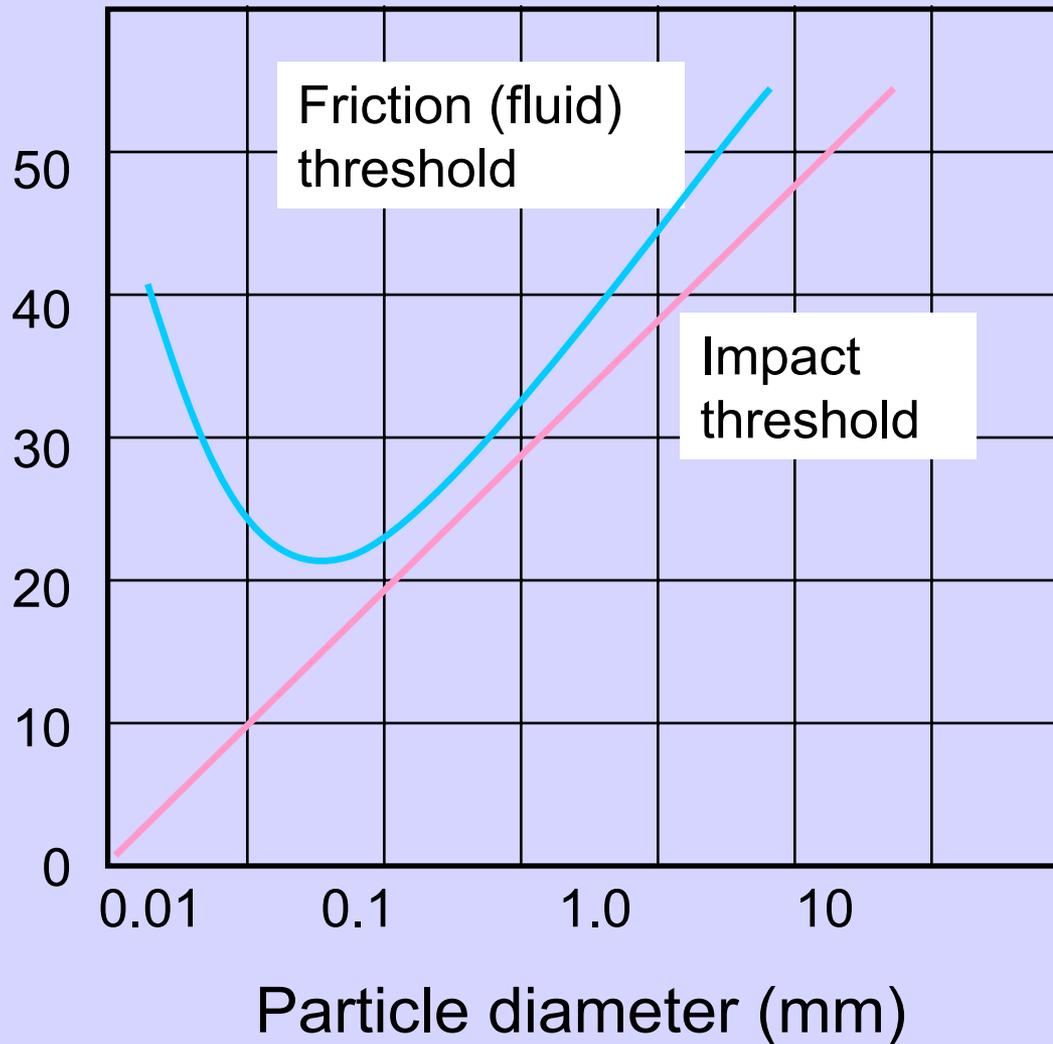
Sediment yield ($t/km^2/yr$)



WIND EROSION



V_{*t} (cm/sec)



WIND EROSION

