

**3rd Annual**  
**Midwest Soil Improvement Symposium:**  
**2013**

*Research and Practical Insights into Using Gypsum*

*March 7, 2013*

***Keynote Presentation:***  
***“Dirt: The Erosion of Civilizations”***

***Dr. David R. Montgomery***  
***Professor***  
***University of Washington, Seattle, WA***



David R. Montgomery




The Erosion of Civilizations



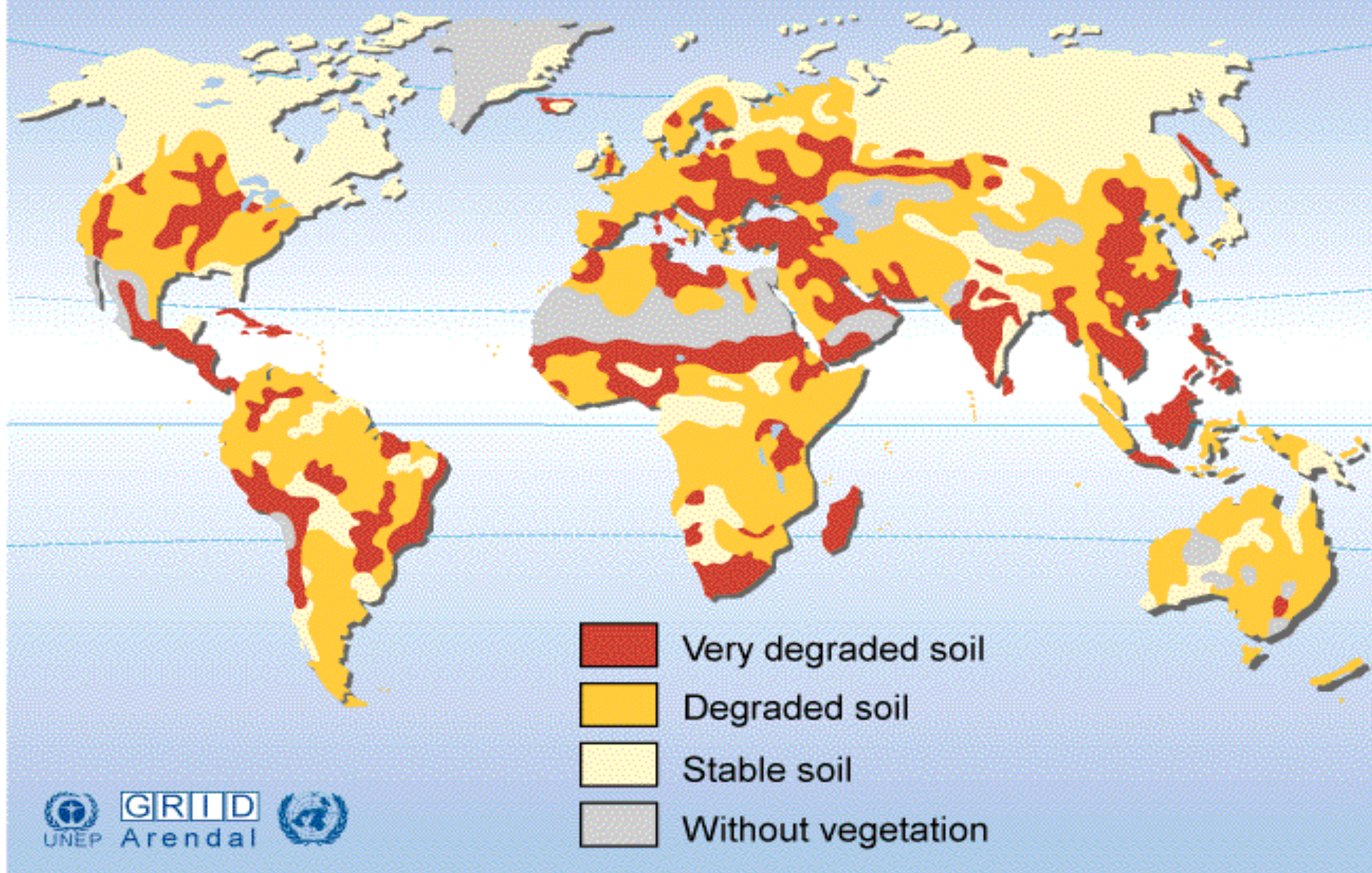


# Soil is a Strategic Resource



Global soil degradation is an under appreciated crisis

# Soil degradation





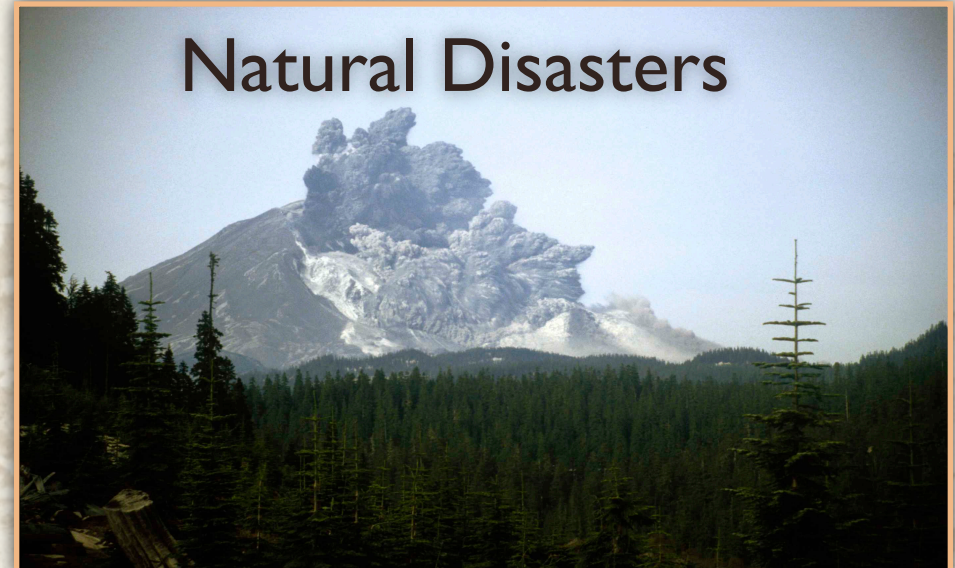
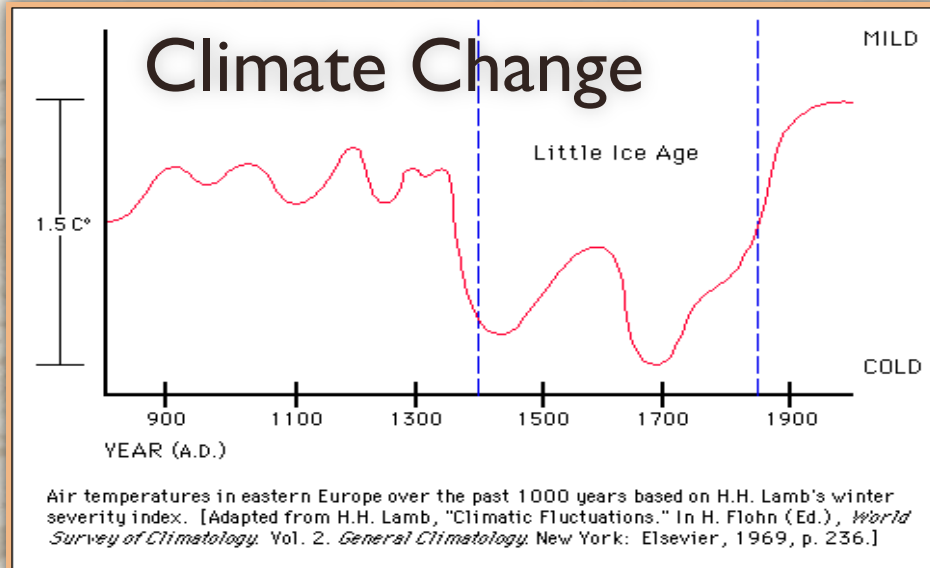
Over the last 40 years soil erosion has caused farmers to abandon about 430 million ha of arable land, an area equivalent to about one-third of all present cropland.

The estimated rate of world soil erosion in excess of new soil production is 23 billion t yr, or about 0.7% loss of the world's soil inventory each year.

Pimental et al., 1992, BioScience



No real mystery that some of the key controls on the longevity of human societies are ...



But what about soil?  
The fundamental condition for sustaining a civilization is sustaining the soil and its fertility.



Soil erosion resulting from deforestation has been proposed to explain the demise of ancient civilizations around the world.



Mesopotamia

Minoans

Greece

Rome

Indus

Angkor Watt

Olmec

Maya

Inca



But in many regions  
trees can grow back  
before soil  
disappears...

Was the agriculture  
that followed the real  
culprit?

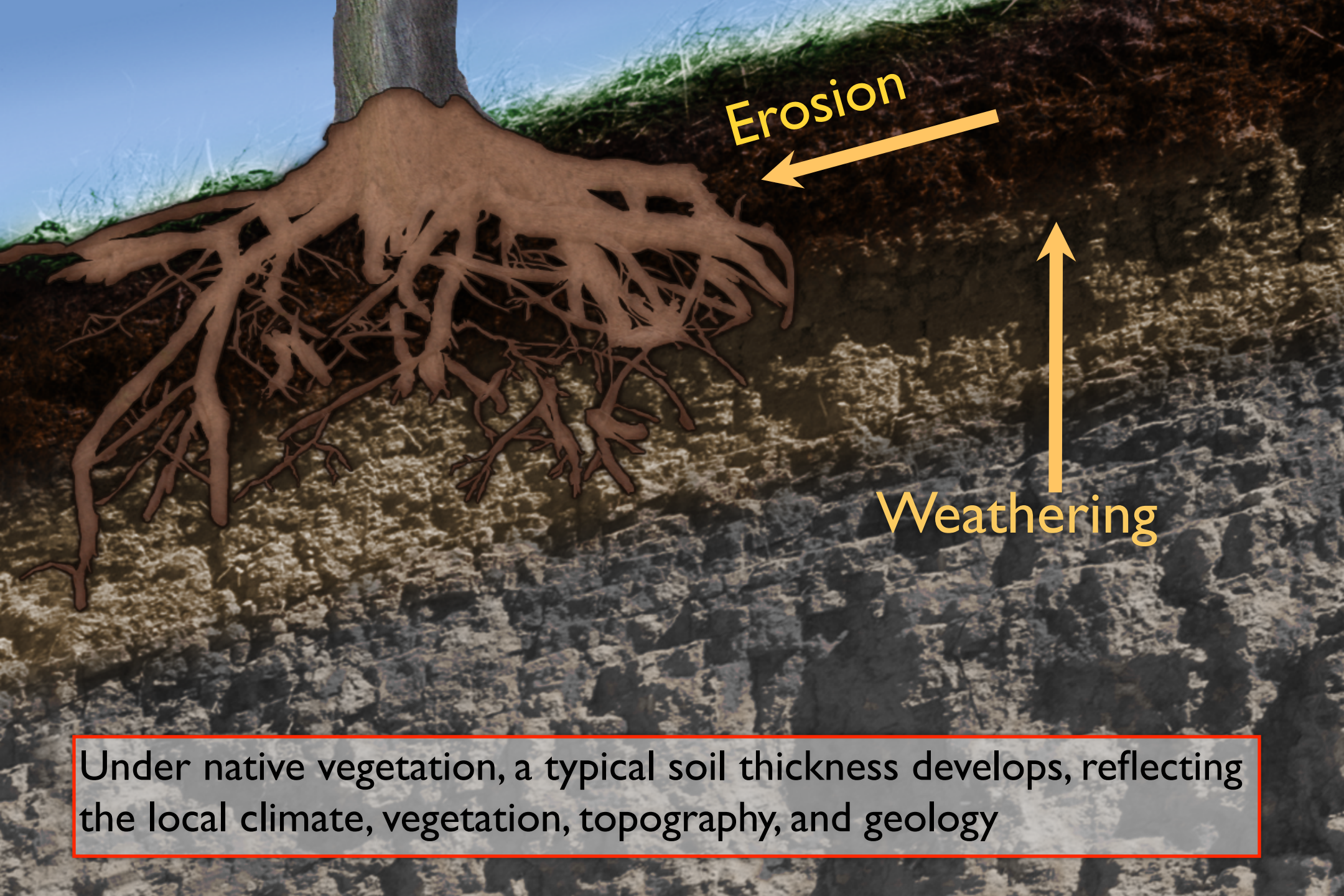




Could agricultural soil erosion and degradation limit the life span of civilizations?







Under native vegetation, a typical soil thickness develops, reflecting the local climate, vegetation, topography, and geology



Invention of the plow fundamentally altered the balance between soil production and soil erosion, dramatically increasing soil erosion...

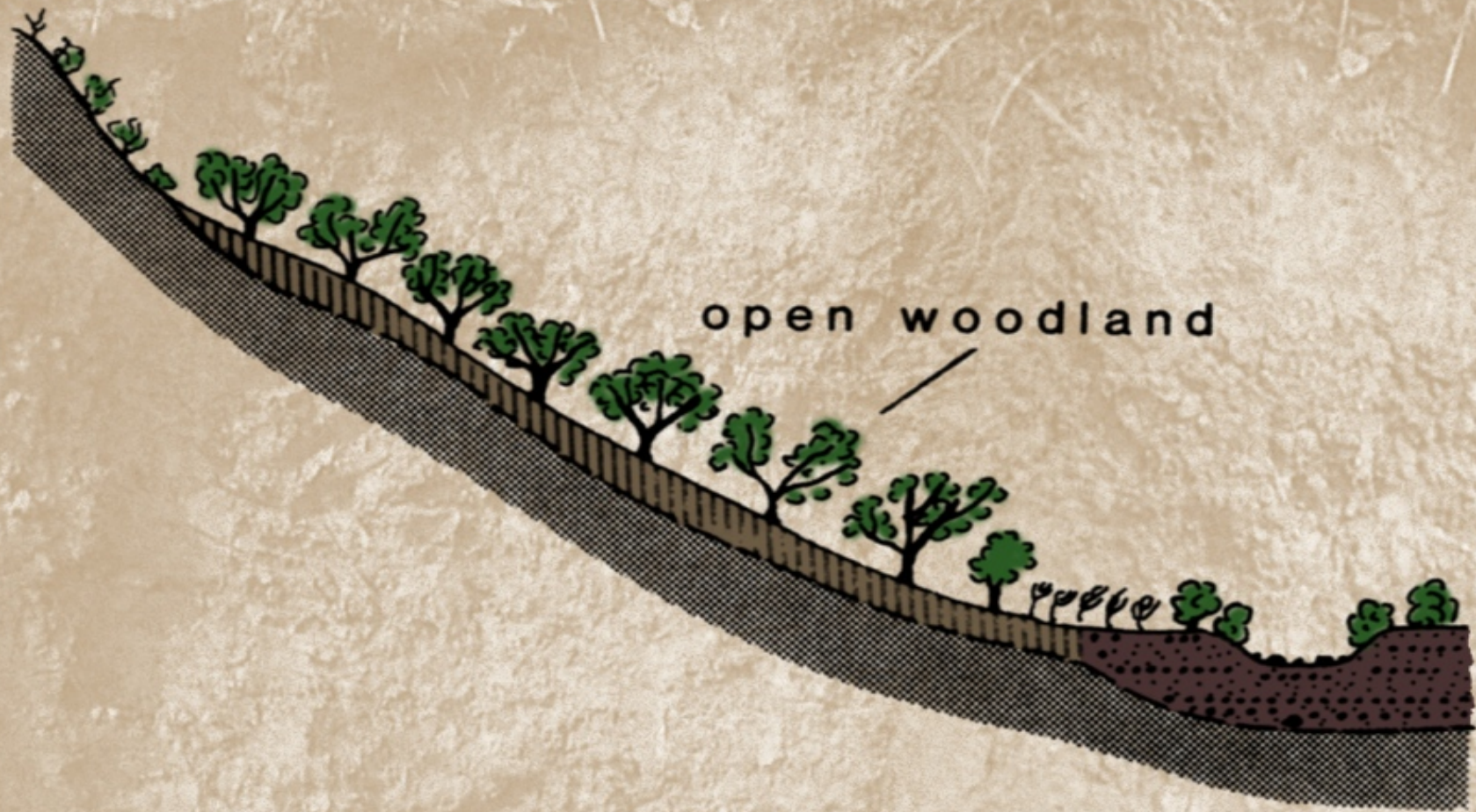






Cycles of erosion and soil formation in ancient Greece began with Bronze Age erosion after introduction of plow-based agriculture.

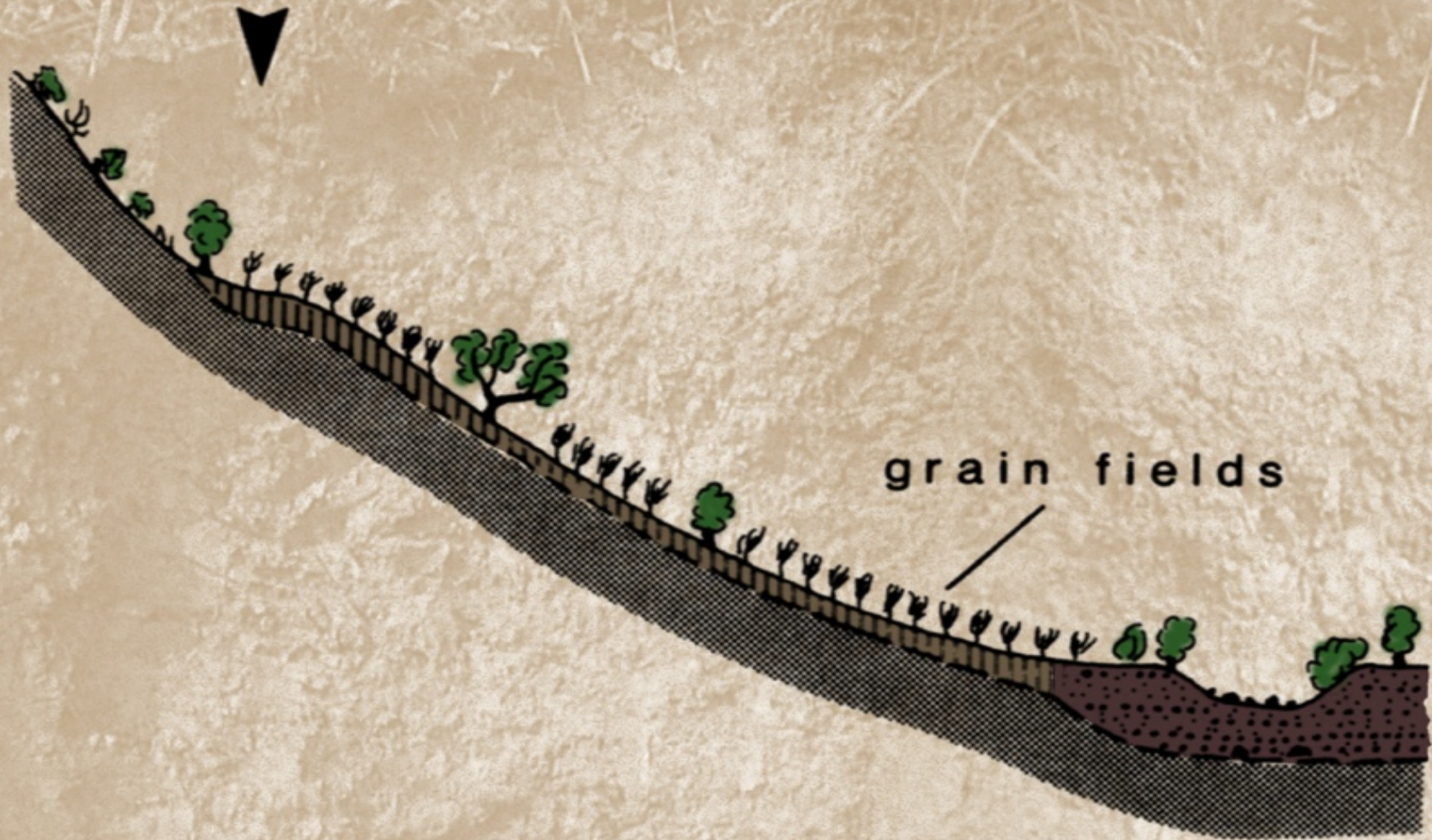




Van Andel and Runnels (1987)

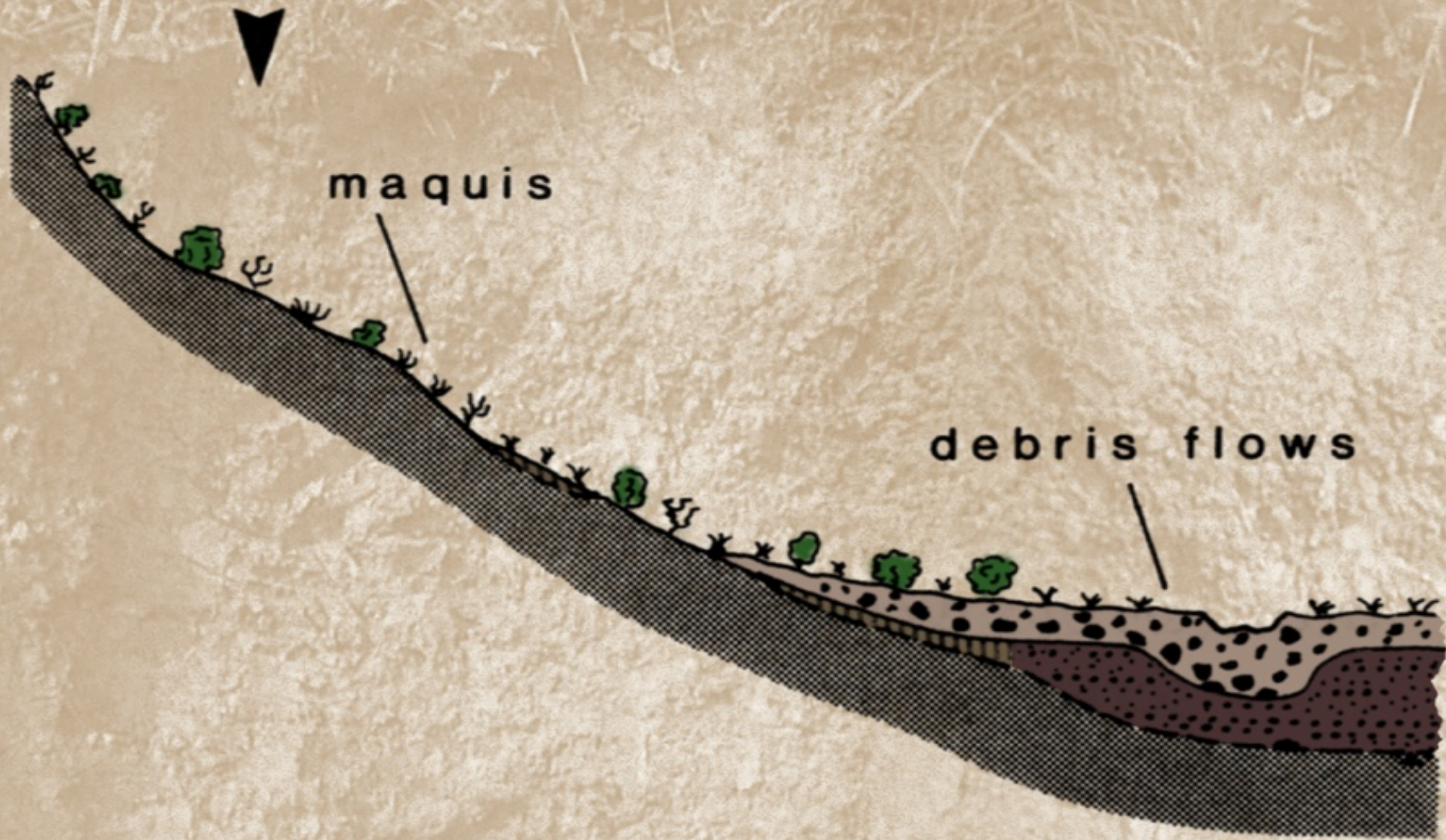


cultivation



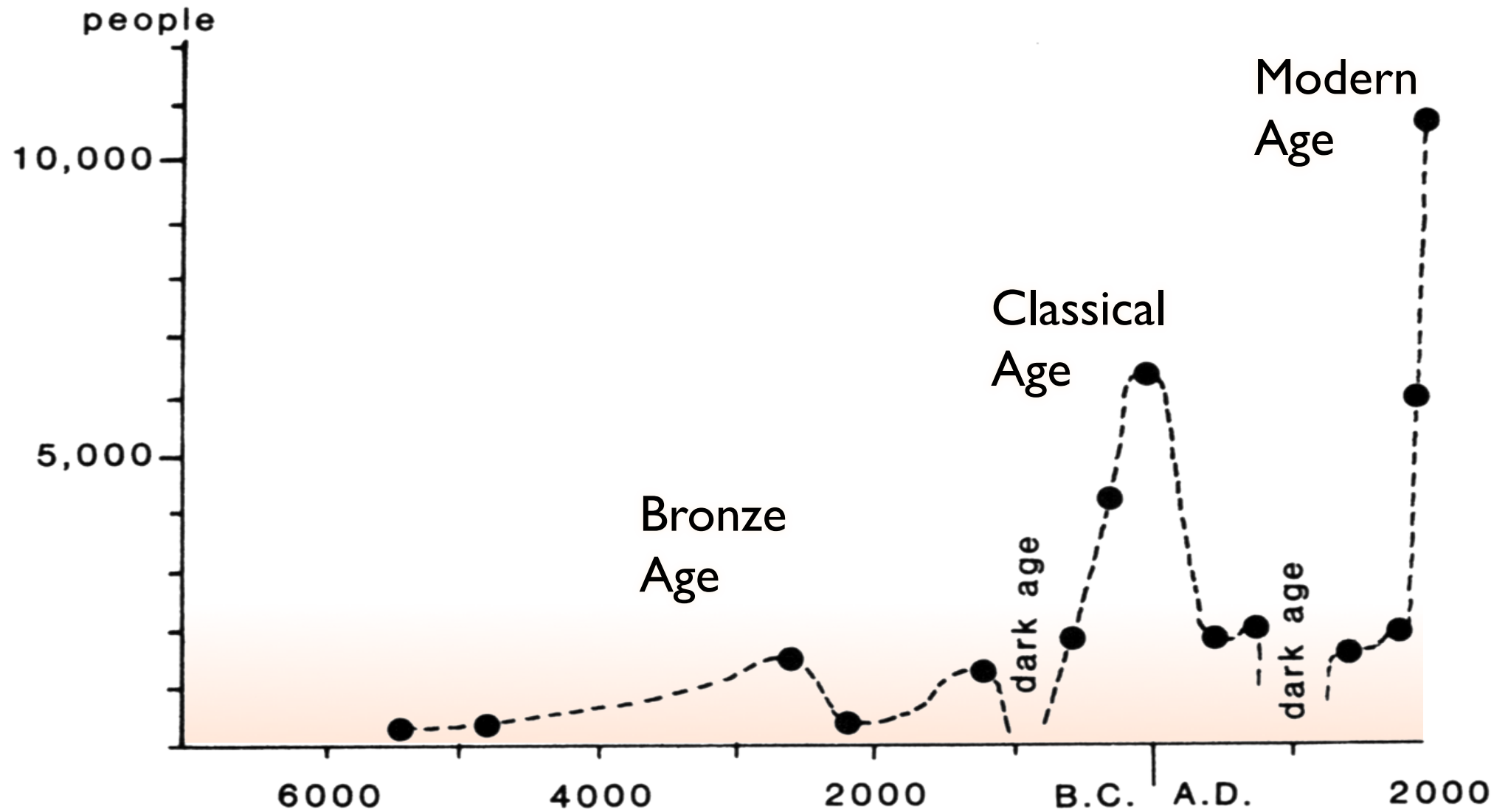


soil erosion





# Population density of the Southern Argolid



Van Andel and Runnels (1987)



# Plato

427-347 B.C.

The rich, soft soil has all run away leaving the land nothing but skin and bone. But in those days the damage had not taken place, the hills had high crests, the rocky plain of Phelleus was covered with rich soil, and the mountains were covered by thick woods, of which there are some traces today.

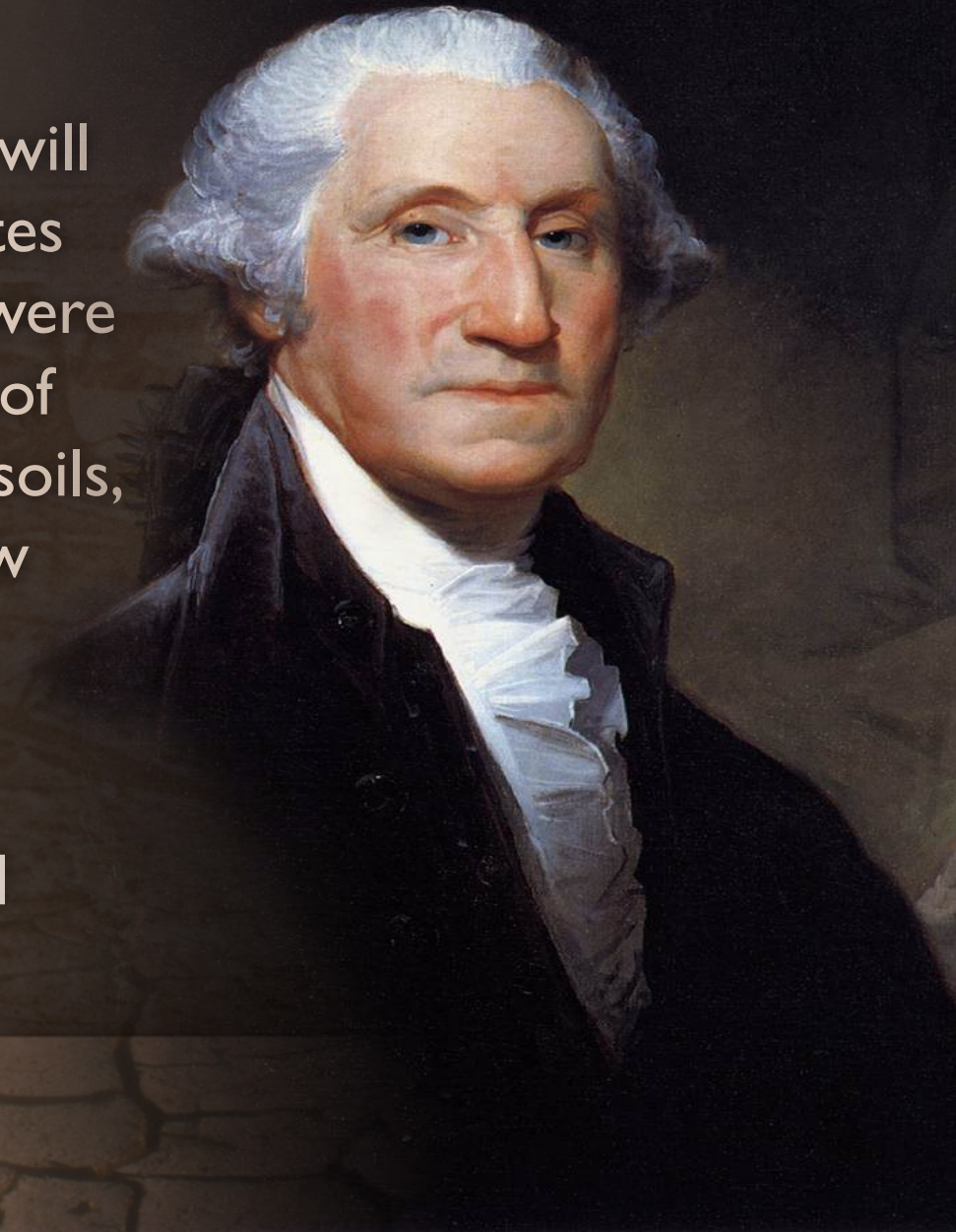




In a 1796 letter to Alexander Hamilton...

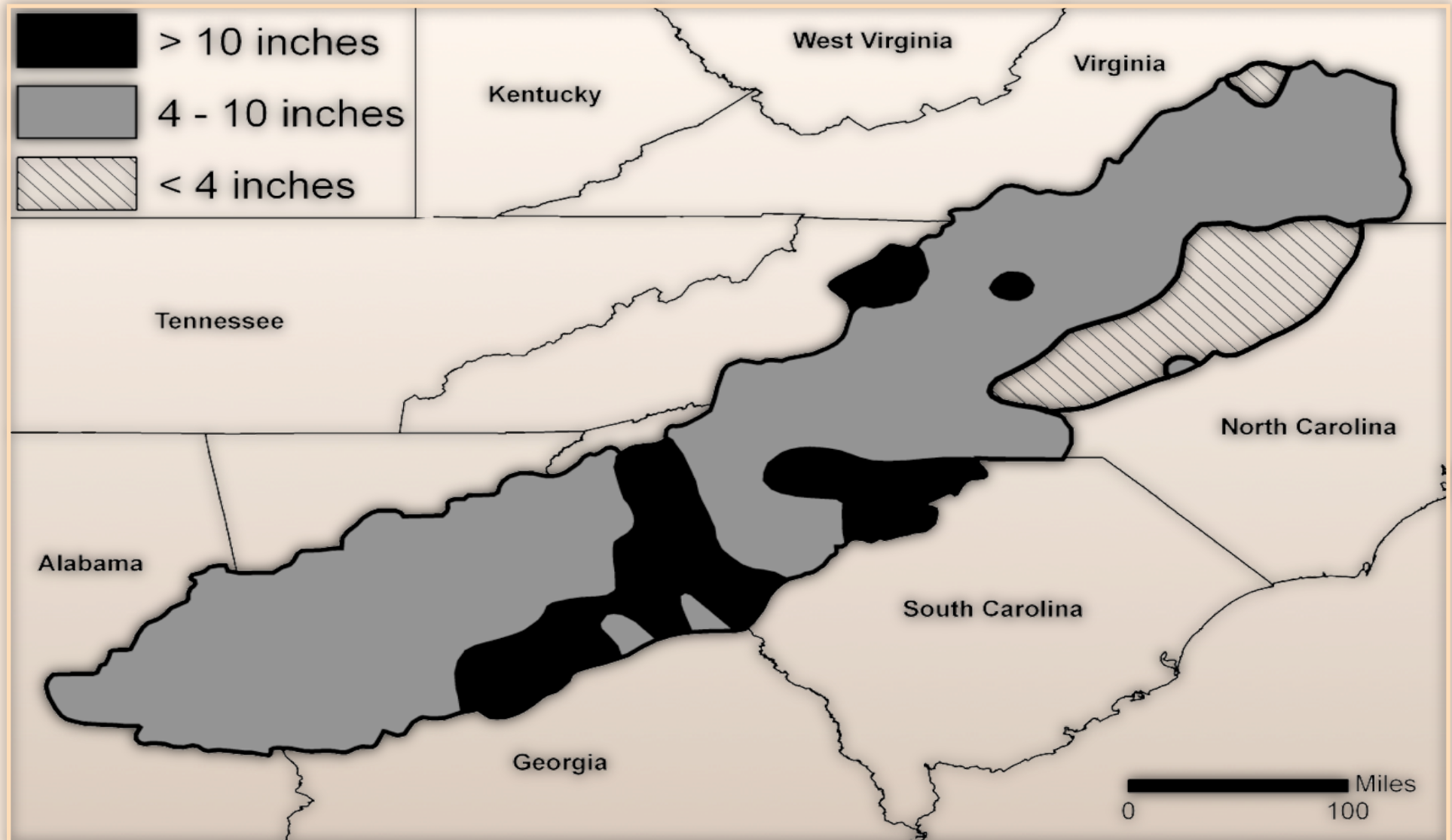
A few years more of increased sterility will drive the Inhabitants of the Atlantic States westward for support; whereas if they were taught how to improve the old, instead of going in pursuit of new and productive soils, they would make these acres which now scarcely yield them any thing, turn out beneficial to themselves.

- [G.Washington, 1892, v. XIII, p. 328-329]





# Historical soil erosion in the Piedmont region



after Trimble



# Palouse, Washington

1970



USDA (1979)



# Palouse, Washington

1911

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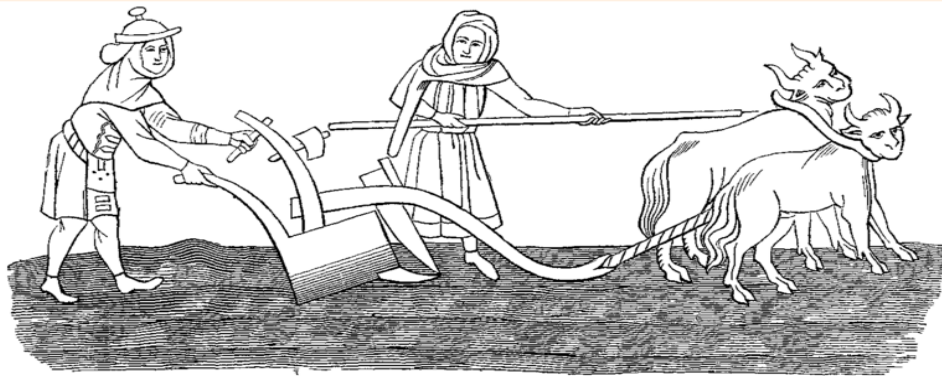
1961

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Kaiser (1961)



In researching the book, I began compiling additional data on both contemporary and long-term (geological) erosion rates—and agricultural erosion rates in particular...



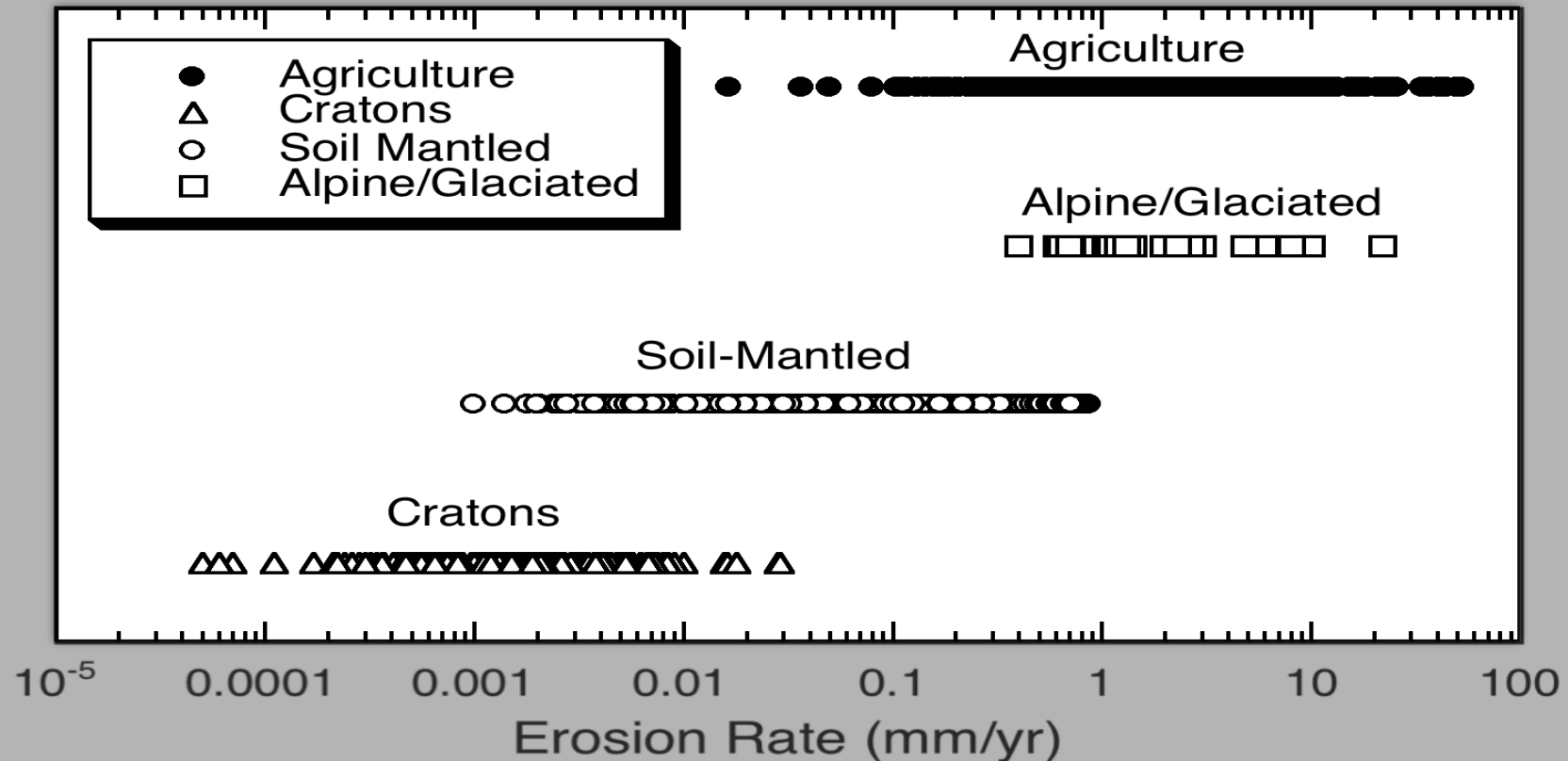
David R. Montgomery

# dirt

The Erosion of Civilizations



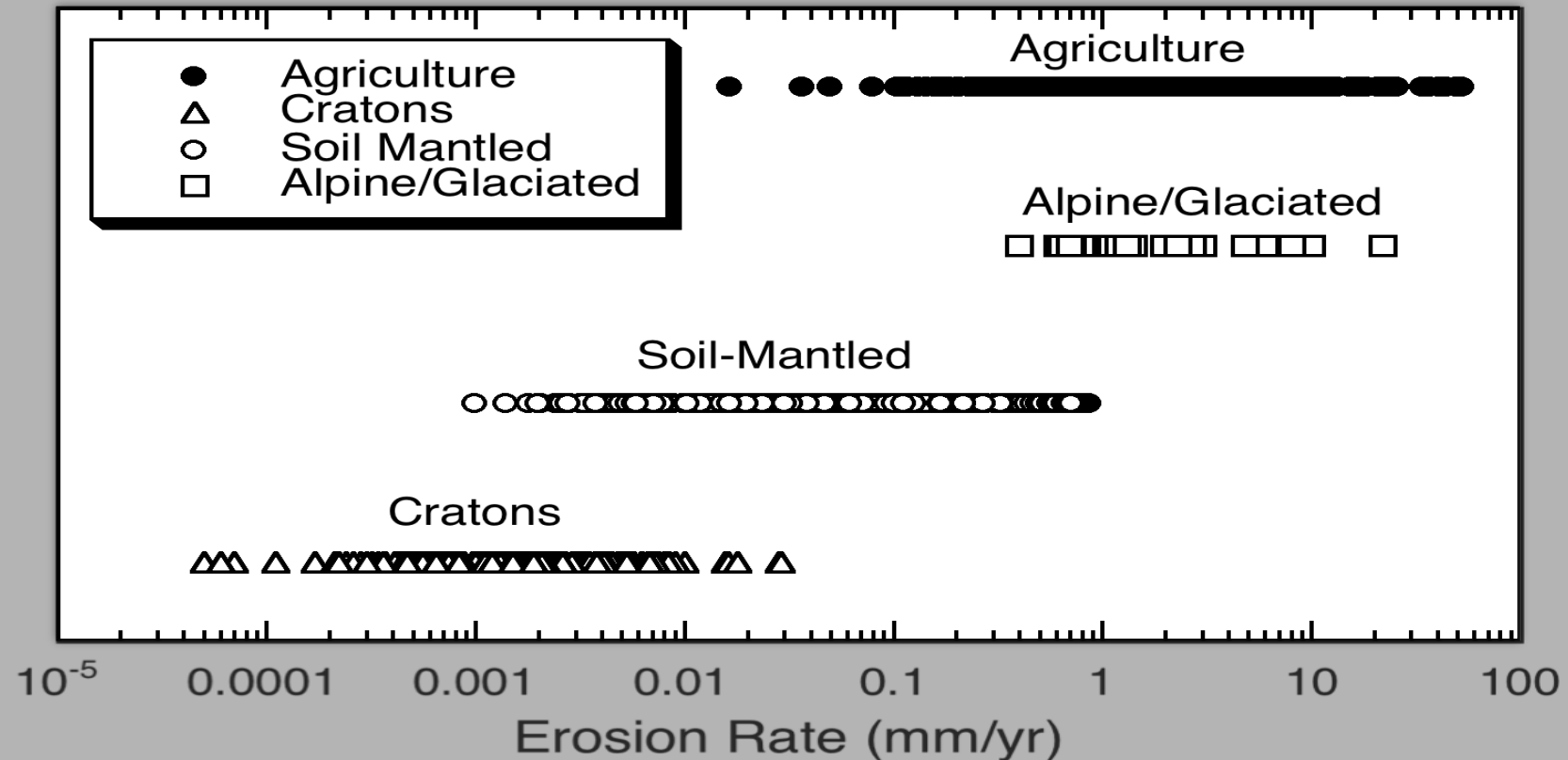
# 1402 measurements of agricultural and geological erosion rates



Did not include sediment yield and USLE-based studies



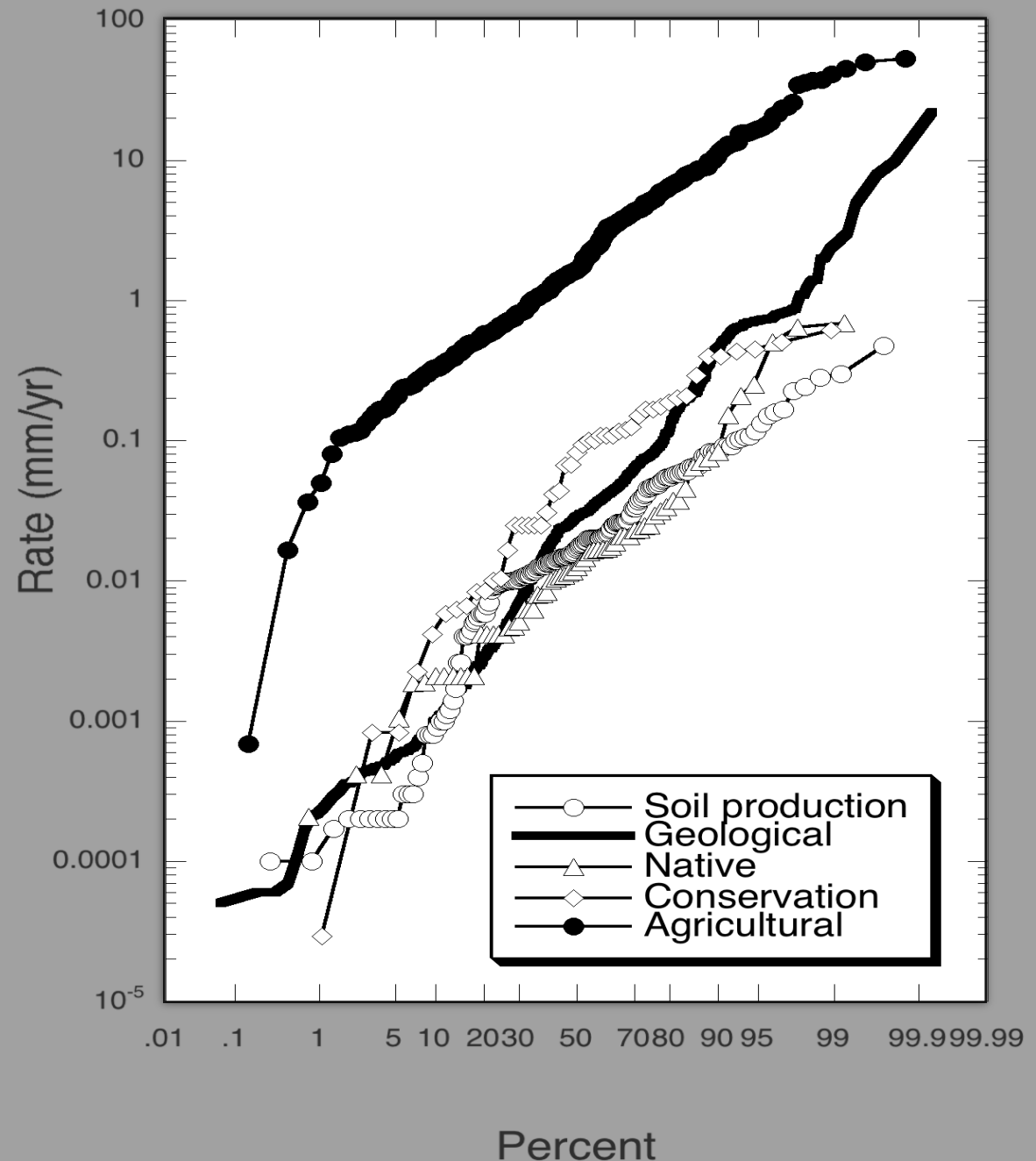
# Conventional farms erode like steep alpine topography





Probability distributions for geological erosion rates, erosion under native vegetation, and by no-till agriculture are all comparable.

Agricultural soil loss is not because humanity farms but arises from how we farm — from using the plow.

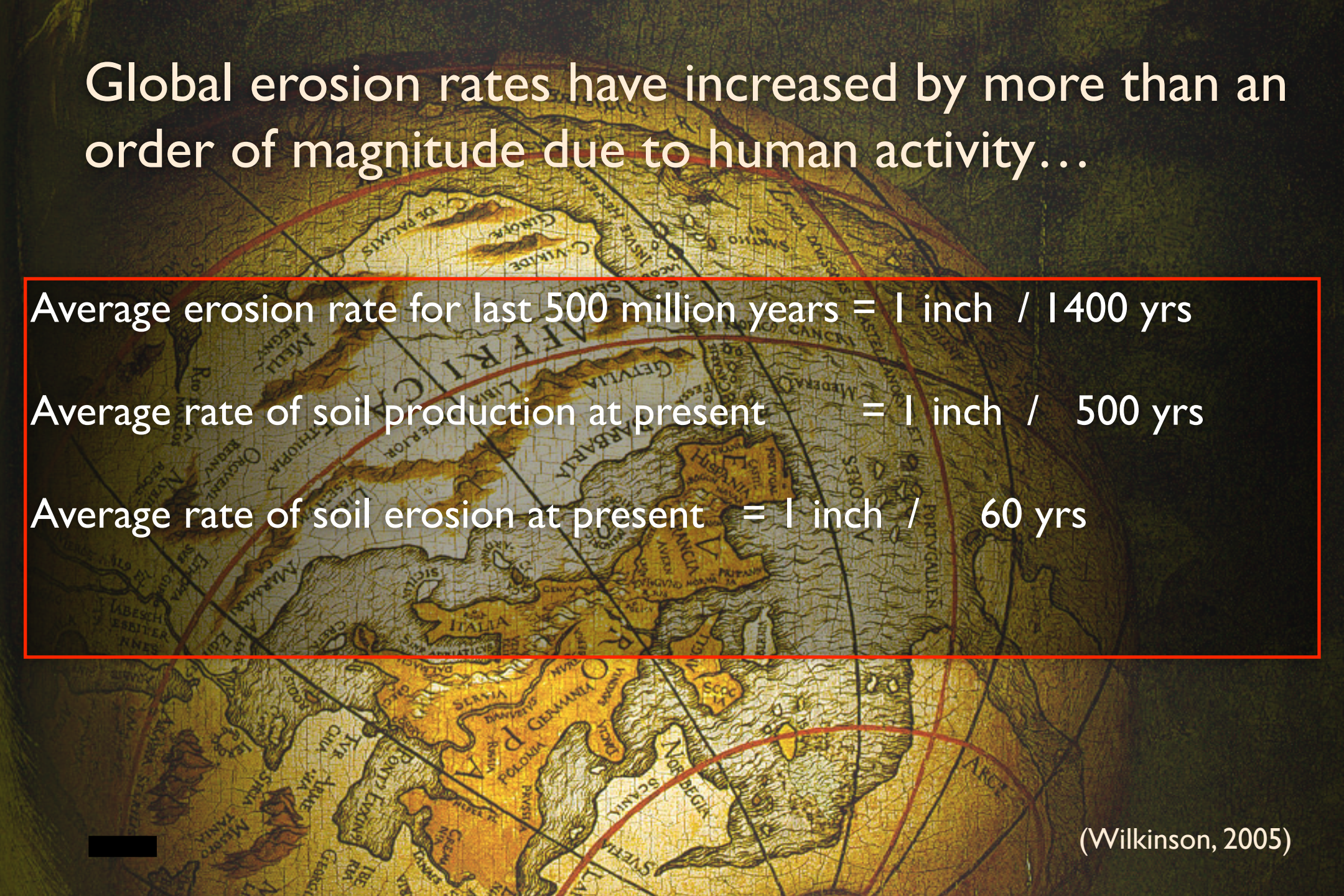




# Erosion Rates

Measurement type (sample size)	median (mm/yr)	mean (mm/yr)
Conventional Agriculture (448)	1.537	3.939
No-till Agriculture (47)	0.082	0.124
Native Vegetation (65)	0.013	0.053
Soil Production (188)	0.017	0.036
Geological (925)	0.029	0.173





# Global erosion rates have increased by more than an order of magnitude due to human activity...

Average erosion rate for last 500 million years = 1 inch / 1400 yrs

Average rate of soil production at present = 1 inch / 500 yrs

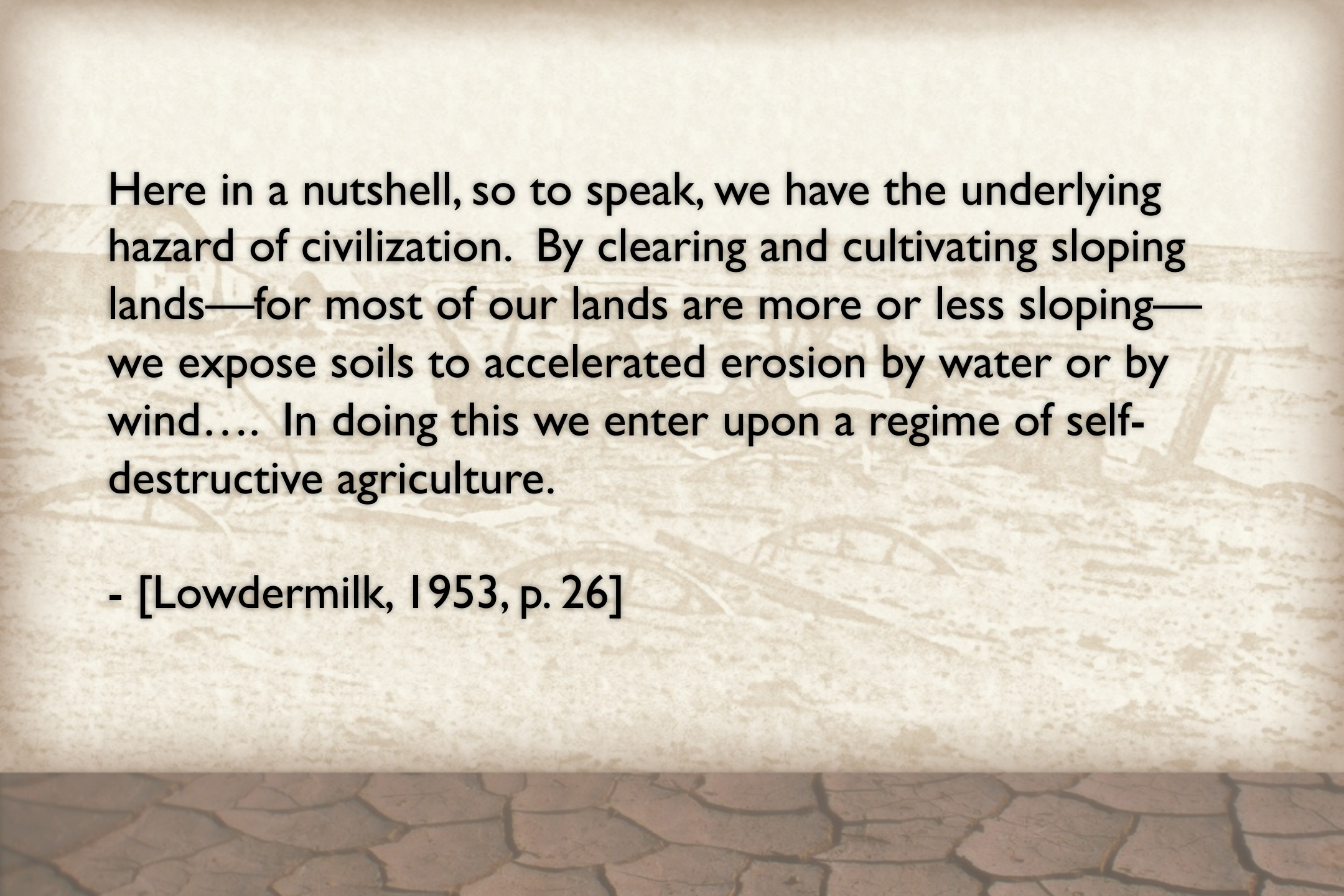
Average rate of soil erosion at present = 1 inch / 60 yrs





Net soil loss of  $\approx 1$  mm/yr implies that erosion of a typical 0.5 - 1 m thick hillslope soil could occur in roughly 500 to 1000 years; approximately the lifespan of most major civilizations outside of major river floodplains...





Here in a nutshell, so to speak, we have the underlying hazard of civilization. By clearing and cultivating sloping lands—for most of our lands are more or less sloping—we expose soils to accelerated erosion by water or by wind.... In doing this we enter upon a regime of self-destructive agriculture.

- [Lowdermilk, 1953, p. 26]



A nation that destroys its soils, destroys itself.  
– President Franklin D. Roosevelt, Feb. 26, 1937.





# Is Soil Restoration Possible?

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Can we reverse the historical pattern?







How? Change our agricultural practices...

- reduce subsidies for conventional, erosive farming practices;
- increase support for no-till practices on land where they are suitable;
- promote practices that increase soil organic matter to both sequester carbon and improve soil fertility.



# Rebuilding Soil

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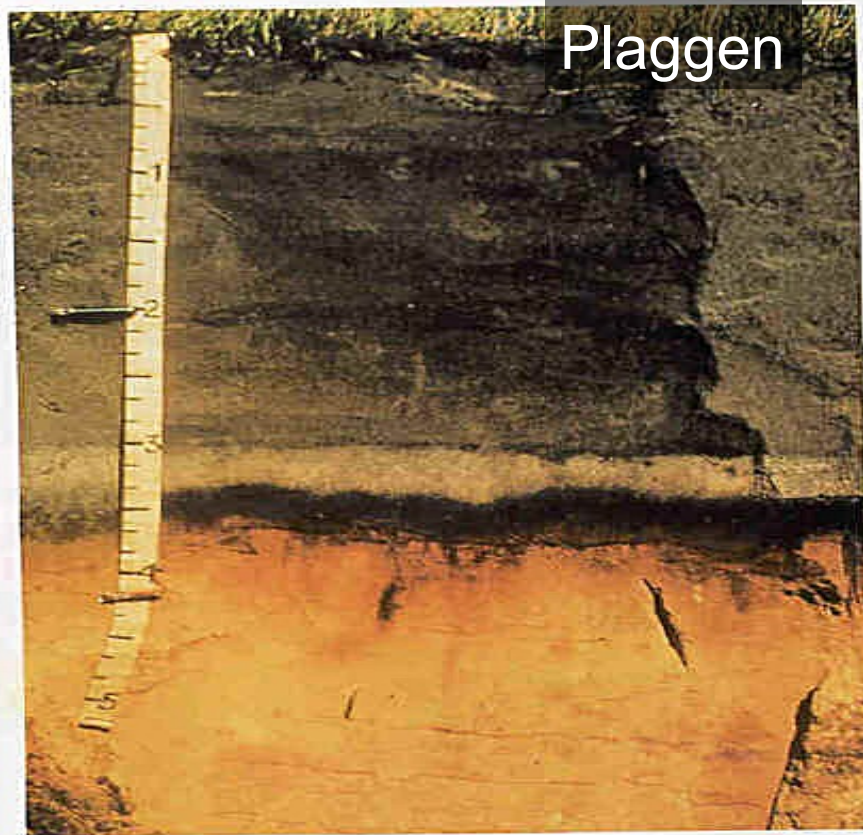
We can make soil surprisingly fast — faster than nature does...

It takes organic matter and labor — what we have in cities (organic waste and people).





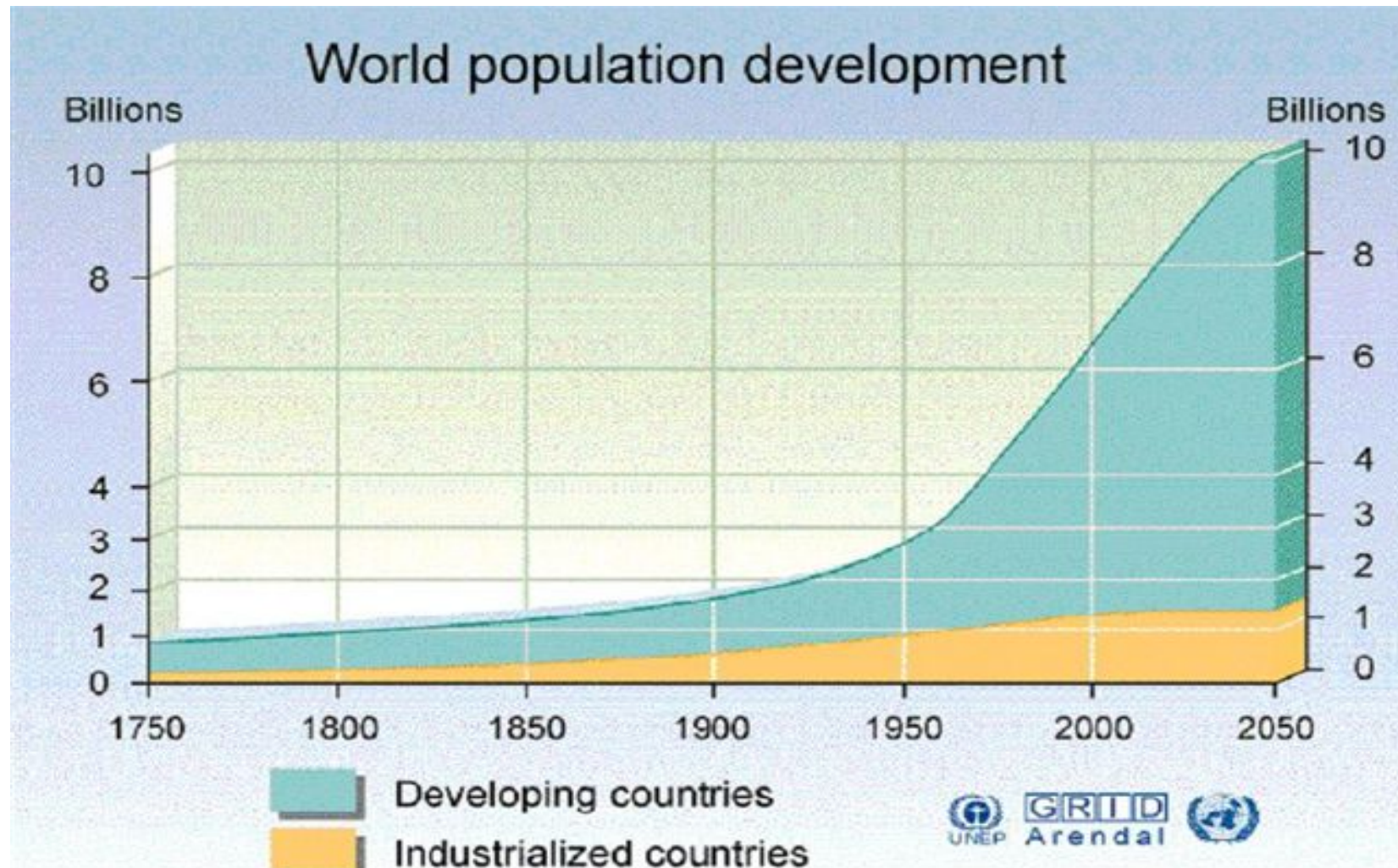
Fertile carbon-rich soils built by anthropogenic activity in the Amazon and reclaimed sea beds in northern Europe.





# Feeding A Growing Population ...

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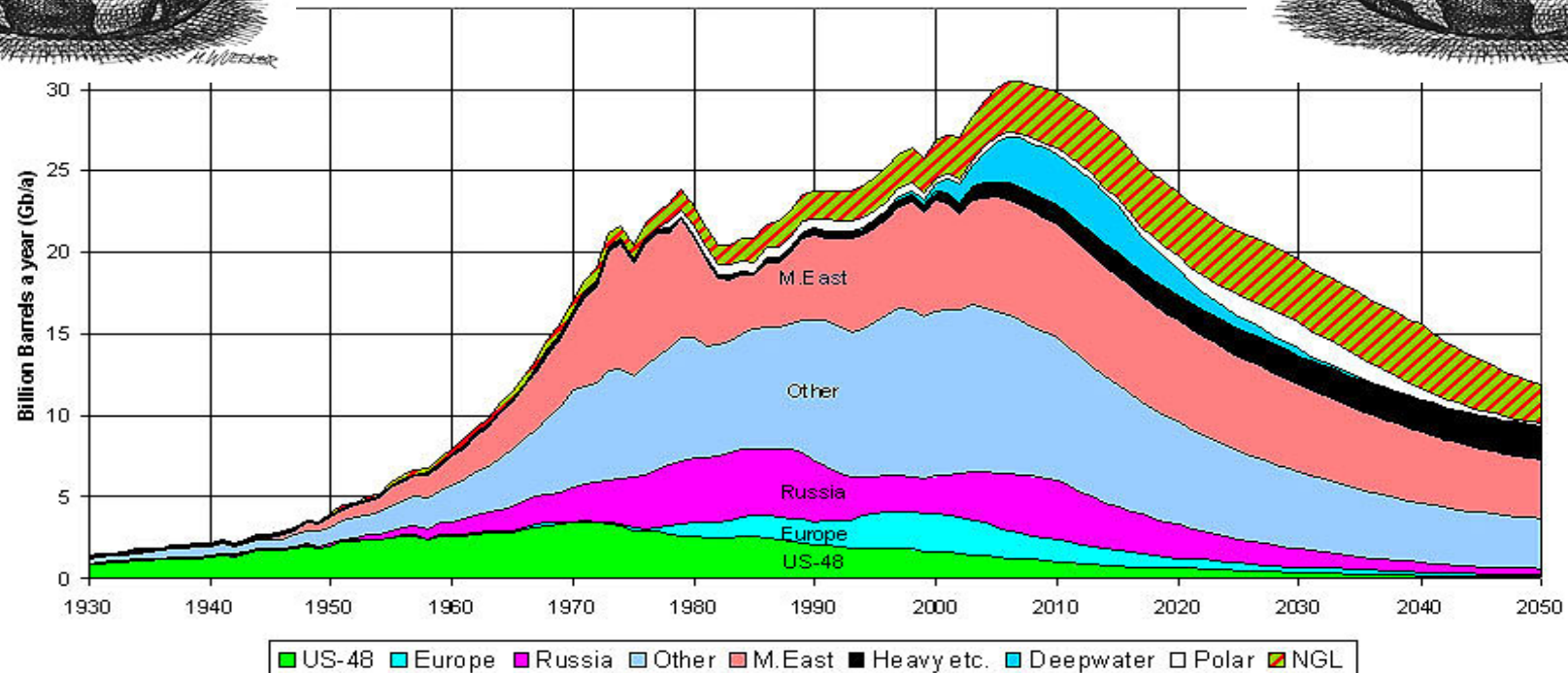
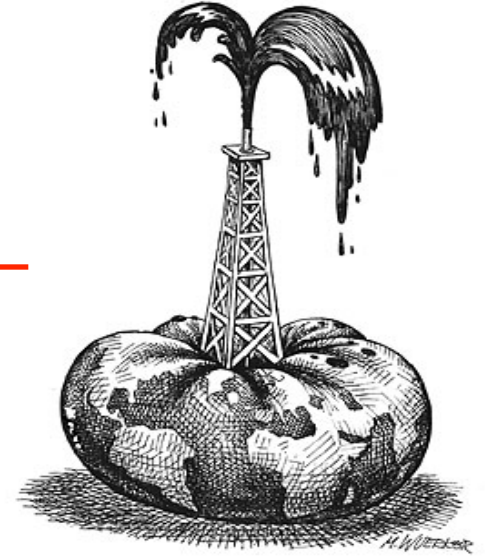




# Peak Oil

## A Question of When

OIL AND GAS LIQUIDS  
2004 Scenario



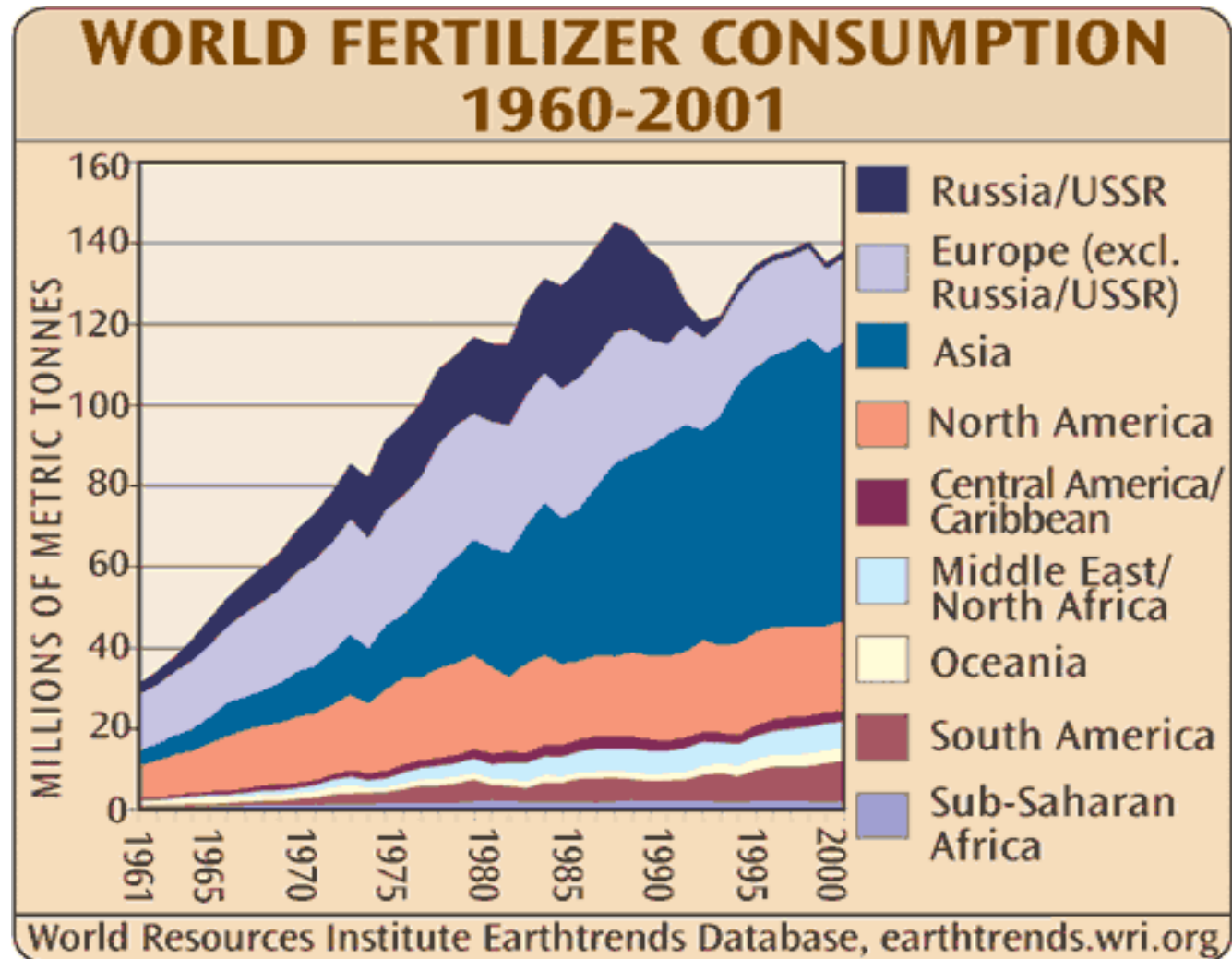


# 20<sup>th</sup> Century Strategy

## Intensification of Fertilizer Use

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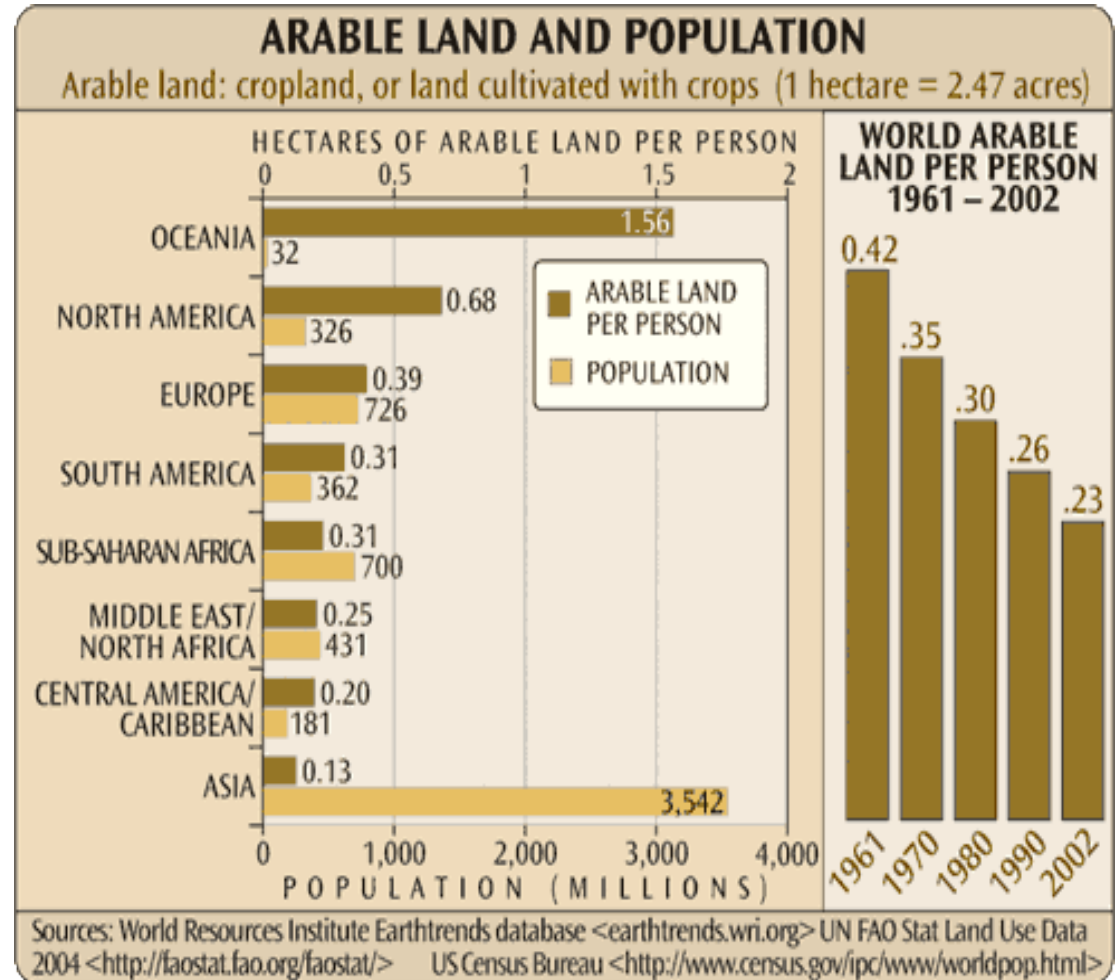
Can we maintain this strategy in the long run as oil supplies dwindle and prices rise dramatically later this century?





## ... A Growing Problem

Amount of arable land per person is declining and is projected to fall to  $\approx 0.1$  ha per capita by 2050.





How will we feed a post-oil world without  
fertilizer-intensive agriculture?





# Time for a Greener Revolution?

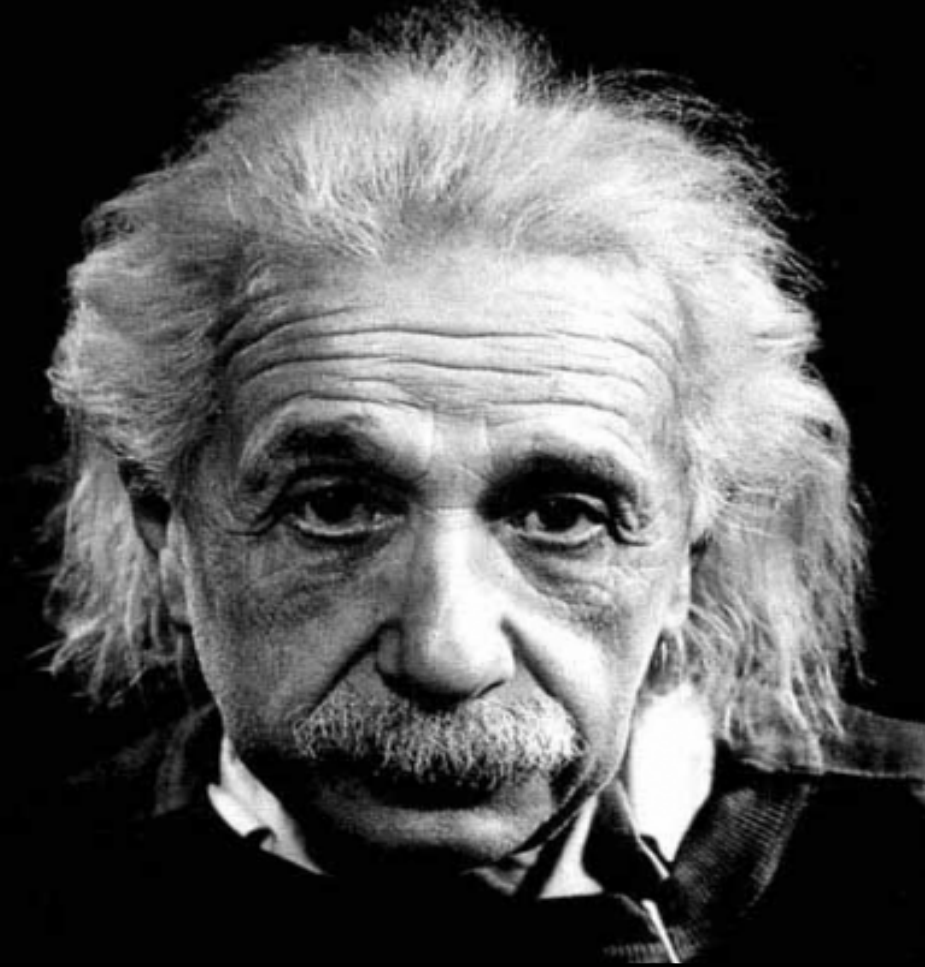
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Recent reviews of the scientific literature indicate that crop yields from no-till and organic agriculture could match those from conventional agriculture...

No matter how one looks at it restoring native soil fertility will be important for sustaining agriculture in a post-oil (and post-cheap fertilizer) world.



# Time For A New View of Soil?



*“The significant problems we face cannot be solved at the same level of thinking we were at when we created them.”*

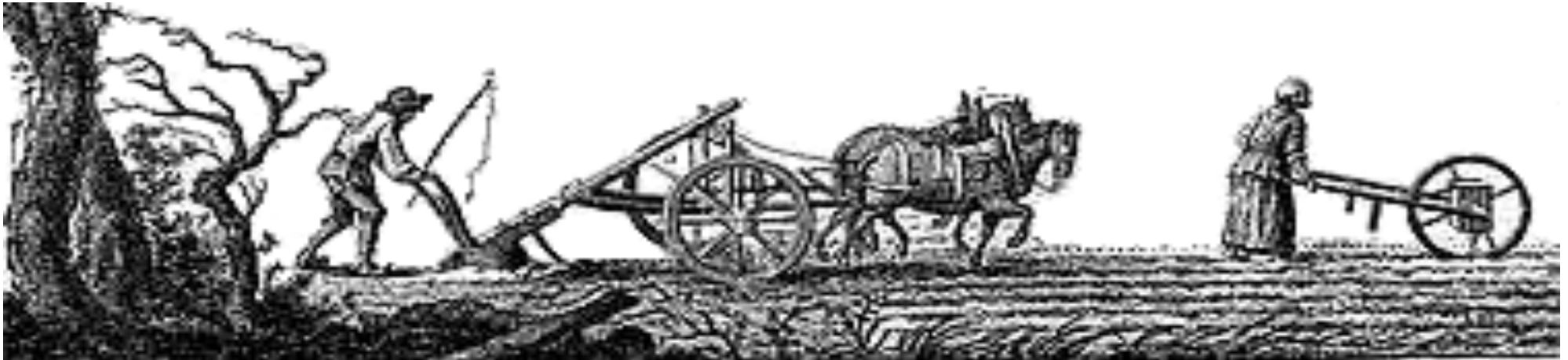
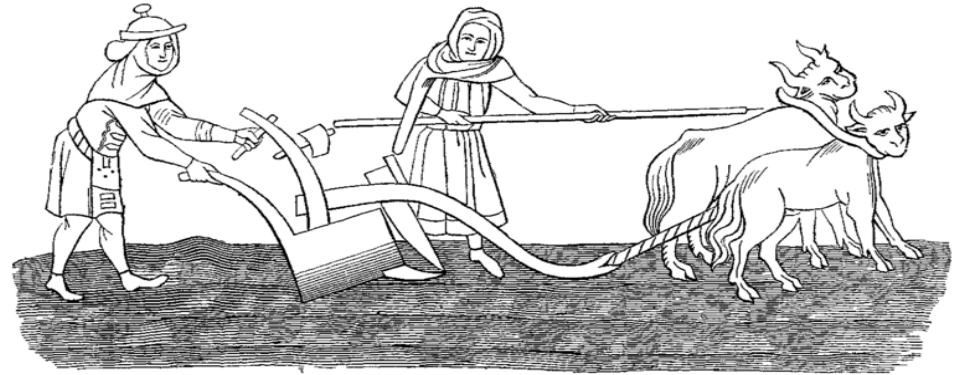


Soil as a mystery, fertility to be personified, deified and revered.





Soil as a means to a living,  
land to be worked.





Soil as a decipherable mystery, something to be studied and understood.



*We know more about  
the movement of  
celestial bodies than  
about the soil underfoot.*

*- Leonardo da Vinci*



Soil as a chemical reservoir, a medium to be fertilized as needed.



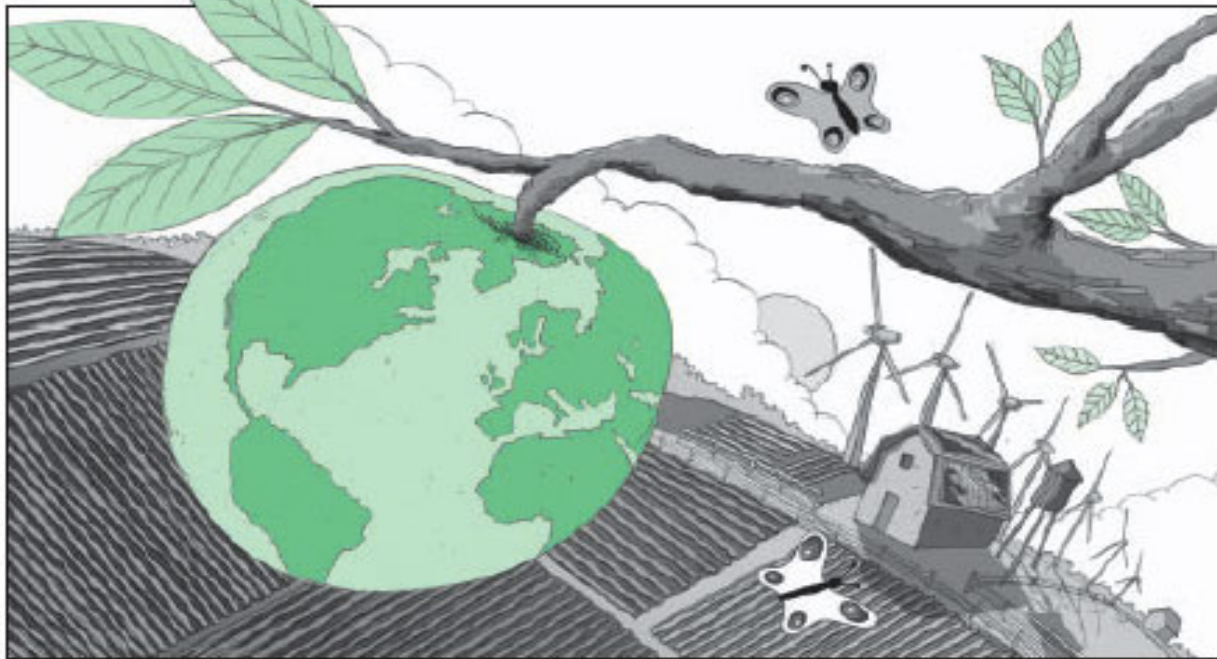


Soil as an industrial commodity to be used (and used up).





Soil as an ecosystem to  
be understood and worked  
with...





# Soil Ecology — the Future of Agriculture?

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We need to harness the insights of soil ecology to restructure agricultural technology and feed the world based on soil-building ecological processes and nutrient cycling.





First and foremost soil restoration means ...



... we can no longer treat soil like dirt!



David R. Montgomery



The Erosion of Civilizations

# KING OF FISH



THE THOUSAND YEAR FALL OF  
**SALMON**

DAVID R. MONTGOMERY





DAVID R. MONTGOMERY

# THE ROCKS DON'T LIE

A GEOLOGIST INVESTIGATES  
NOAH'S FLOOD

