

David R. Montgomery




dirt

The Erosion of Civilizations

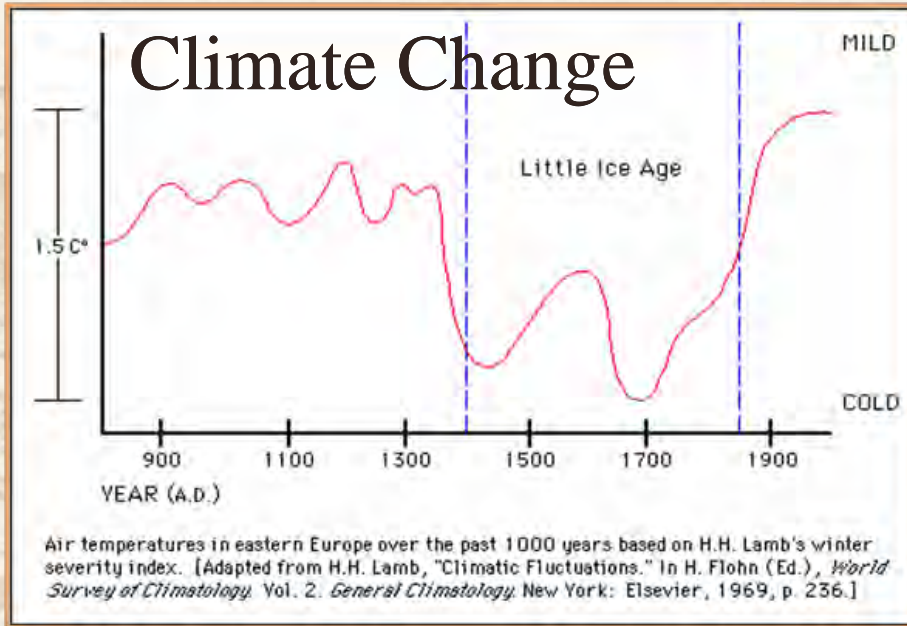


Soil is a Strategic Resource



Global soil degradation is an under appreciated crisis

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



Politics, War, and Social Evolution



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 civilizations around the world.



Mesopotamia

Minoans

Greece

Rome

Indus

Angkor Watt

Olmec

Maya

Inca

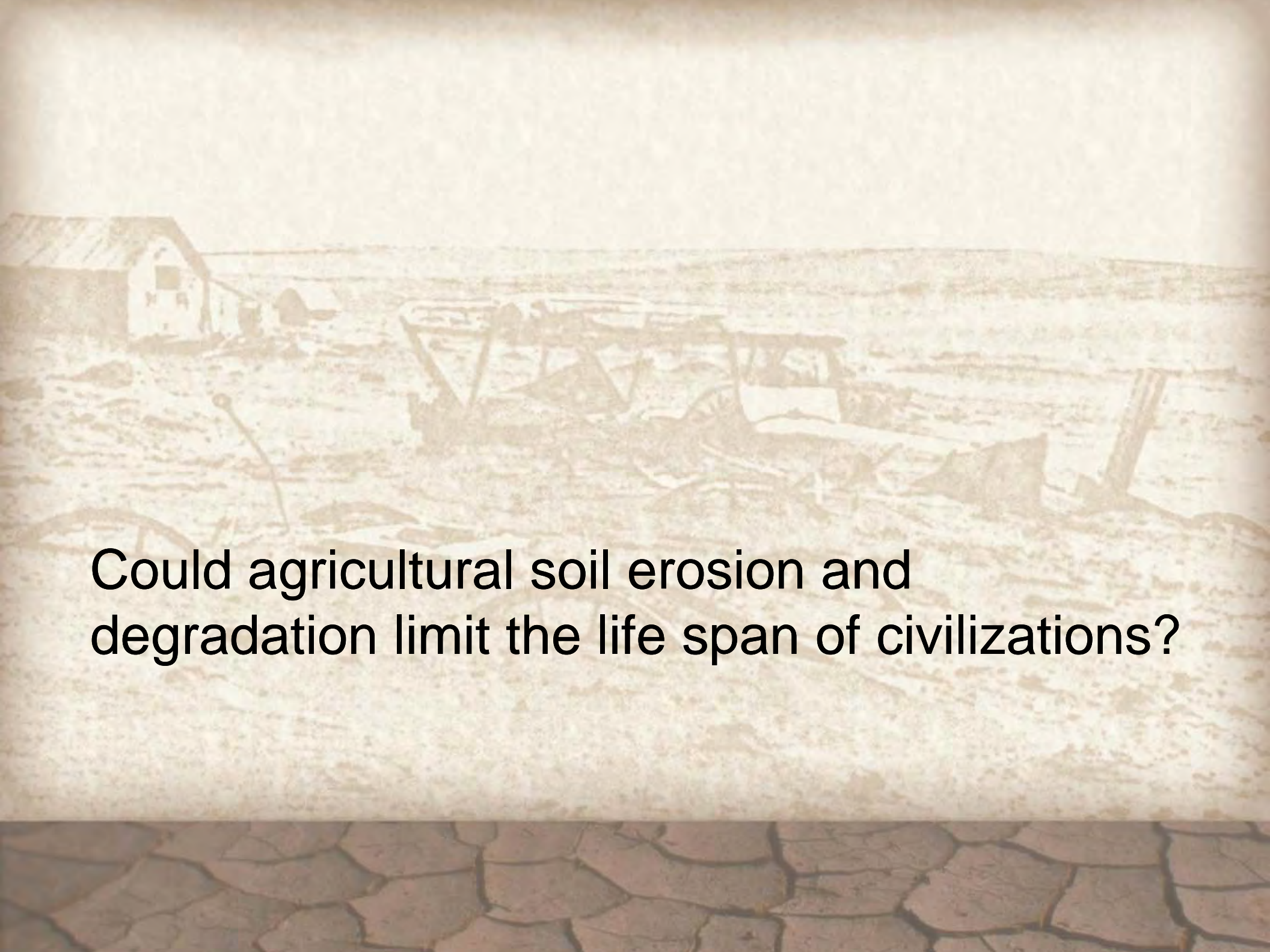


But in many regions
trees can grow back
before soil
disappears...



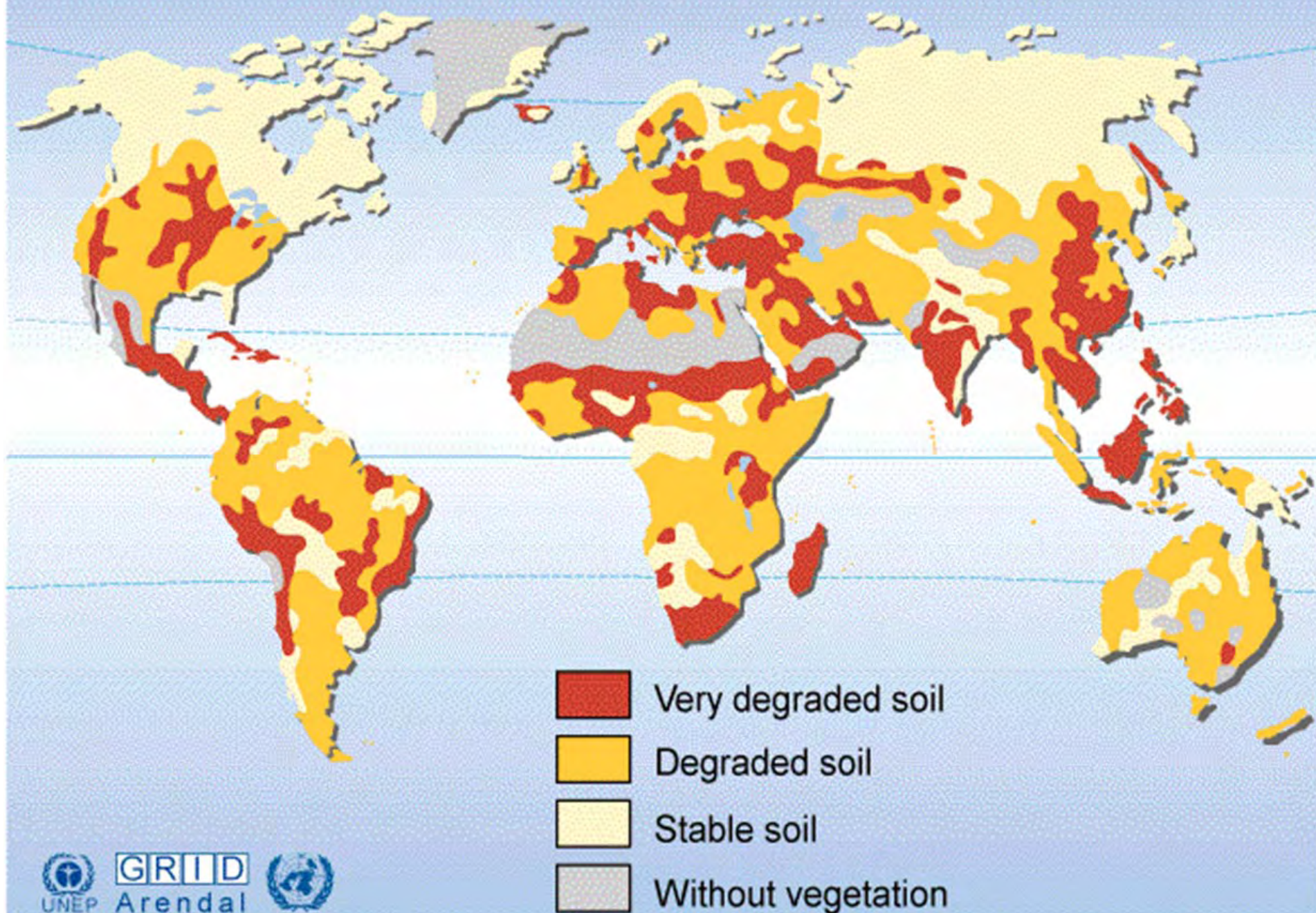
Was the agriculture that
followed the real culprit?





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

Soil degradation



GRID
Arendal

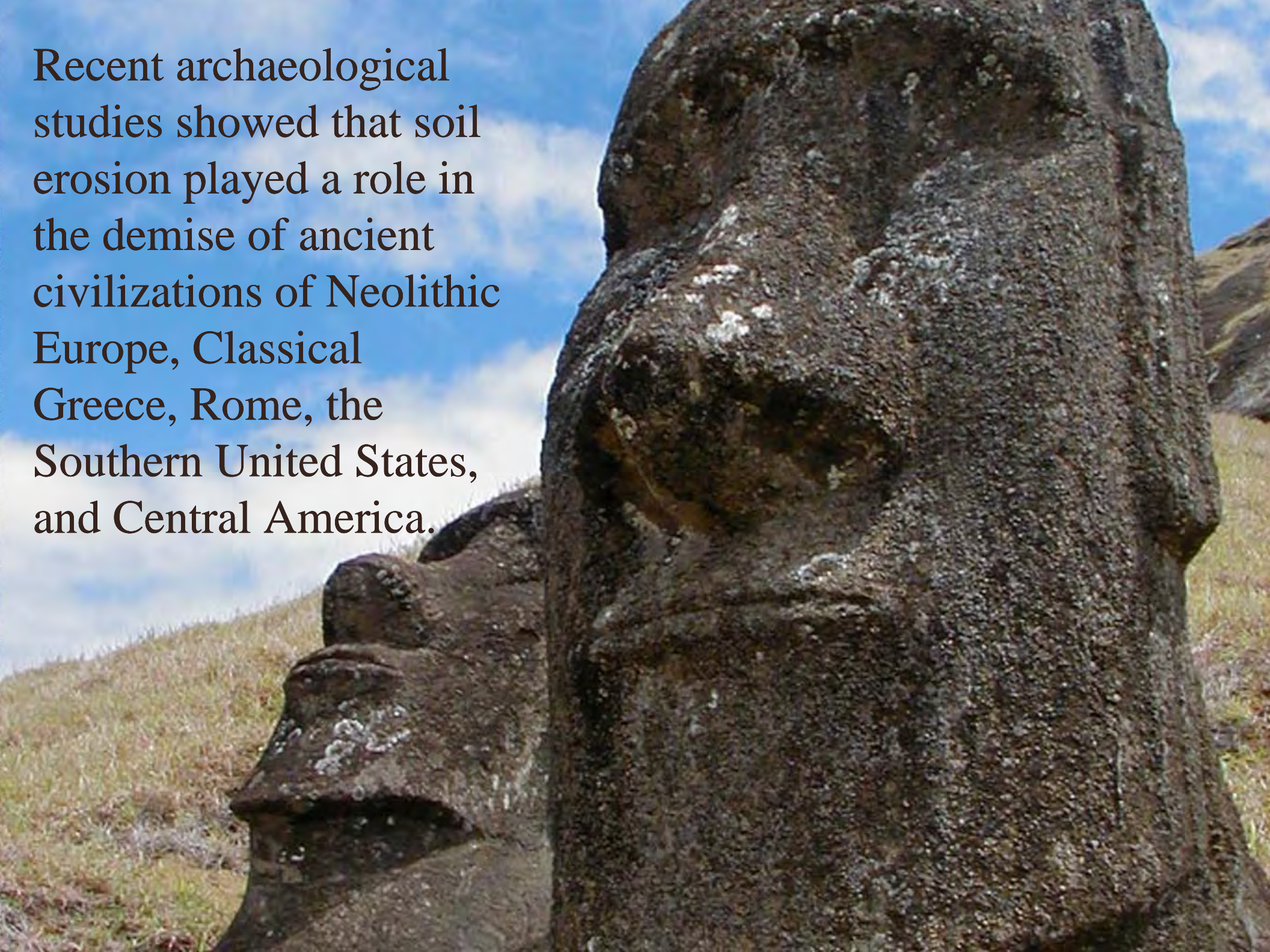


Over the last 40 years soil erosion has caused farmers to abandon about 430 million ha of arable land, an area equivalent to about one-third of all present cropland.

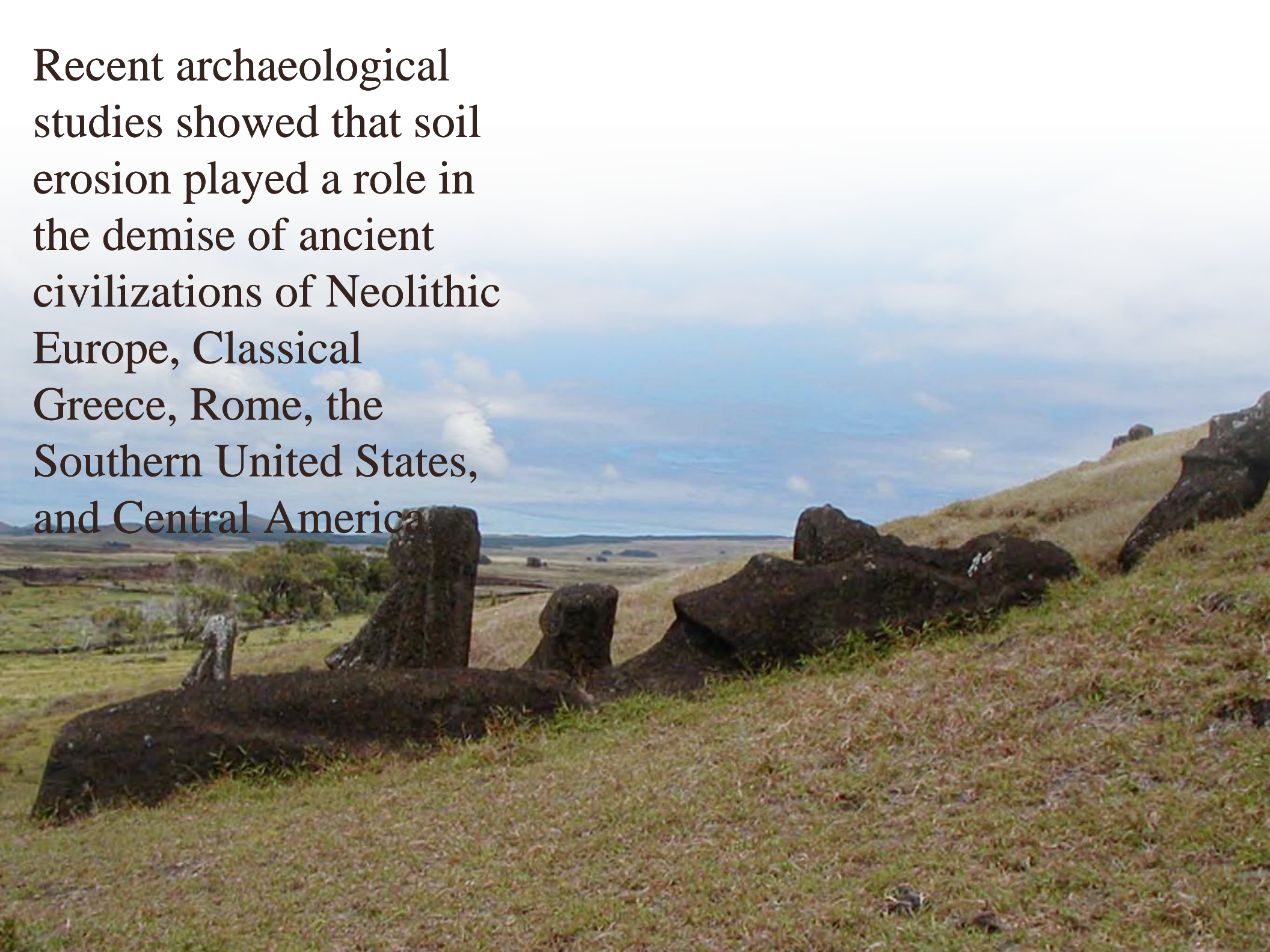
The estimated rate of world soil erosion in excess of new soil production is 23 billion t yr, or about 0.7% loss of the world's soil inventory each year.

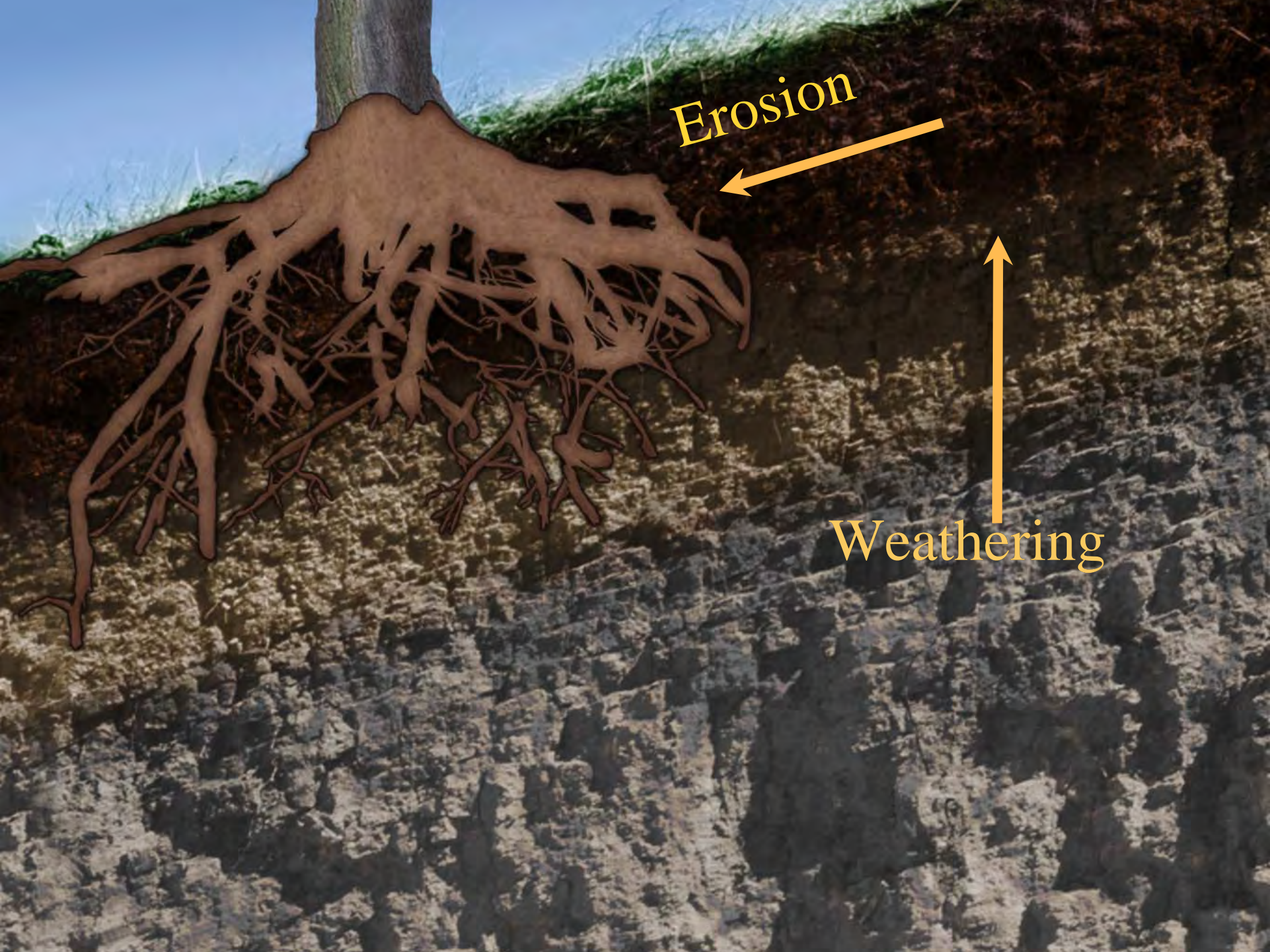
Pimental et al., 1992, BioScience

Recent archaeological studies showed that soil erosion played a role in the demise of ancient civilizations of Neolithic Europe, Classical Greece, Rome, the Southern United States, and Central America.



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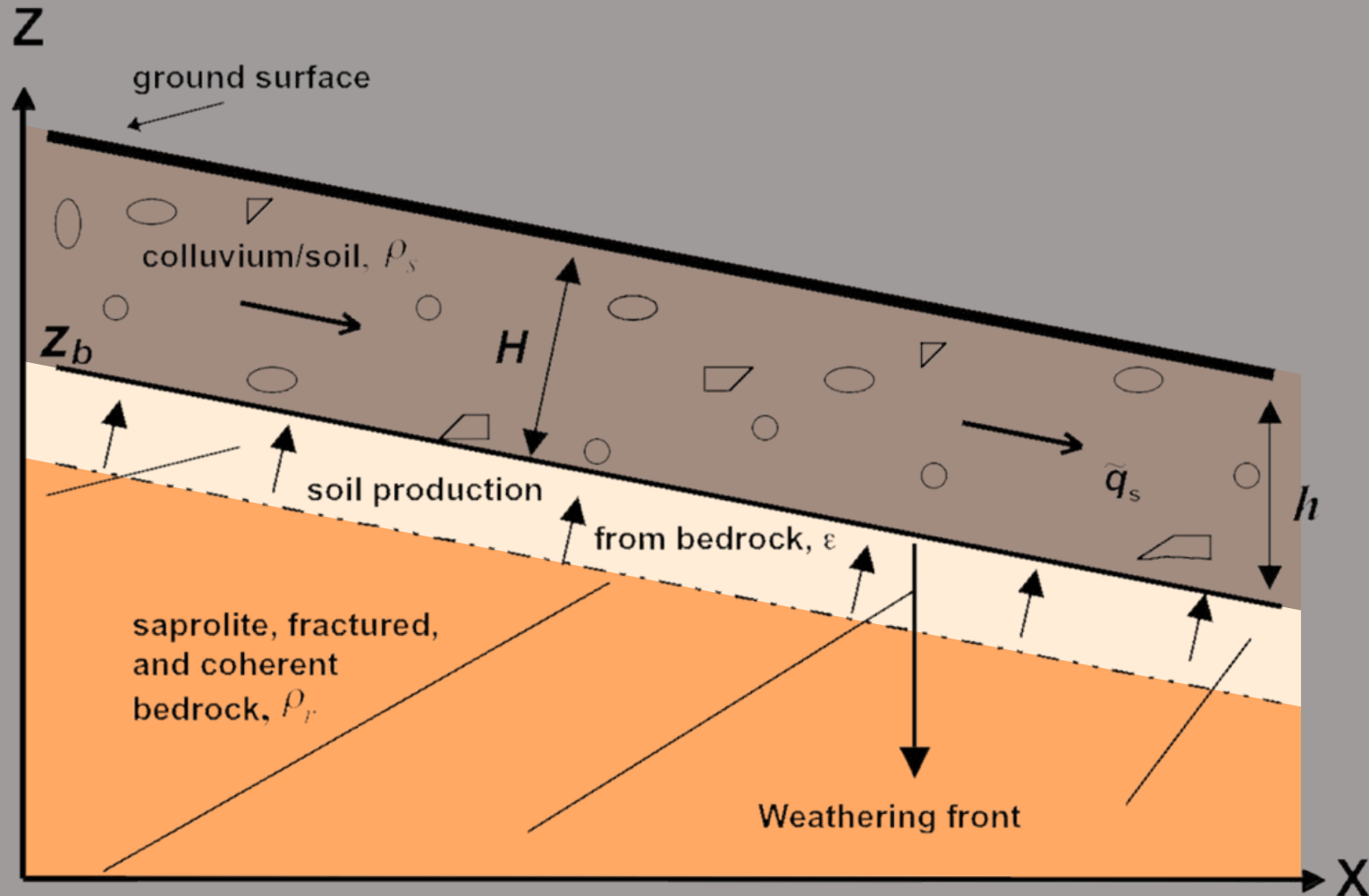




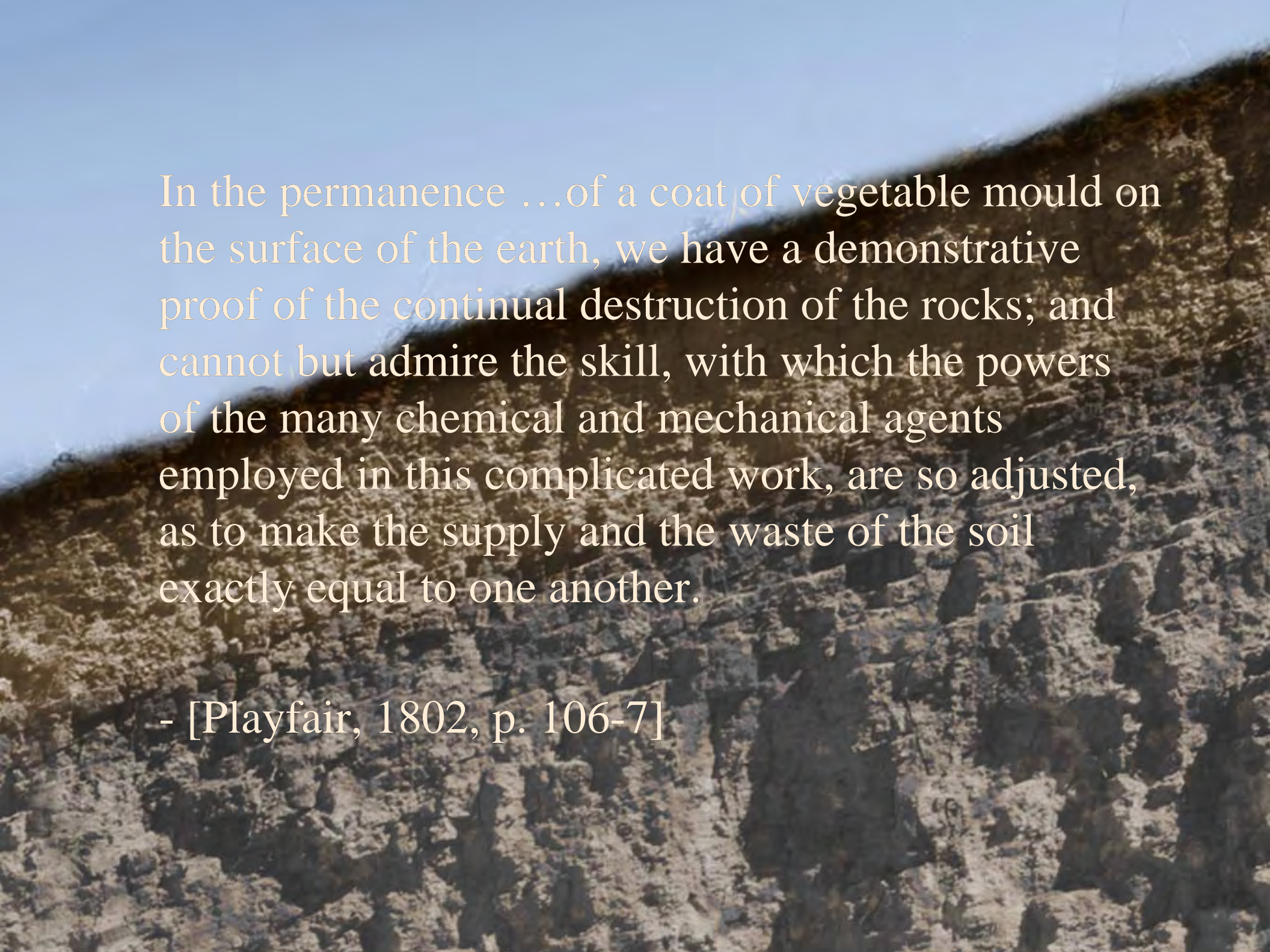
Erosion

Weathering

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



Over time, the change in soil thickness equals the net difference between soil production and soil loss.



In the permanence ...of a coat of vegetable mould on the surface of the earth, we have a demonstrative proof of the continual destruction of the rocks; and cannot but admire the skill, with which the powers of the many chemical and mechanical agents employed in this complicated work, are so adjusted, as to make the supply and the waste of the soil exactly equal to one another.

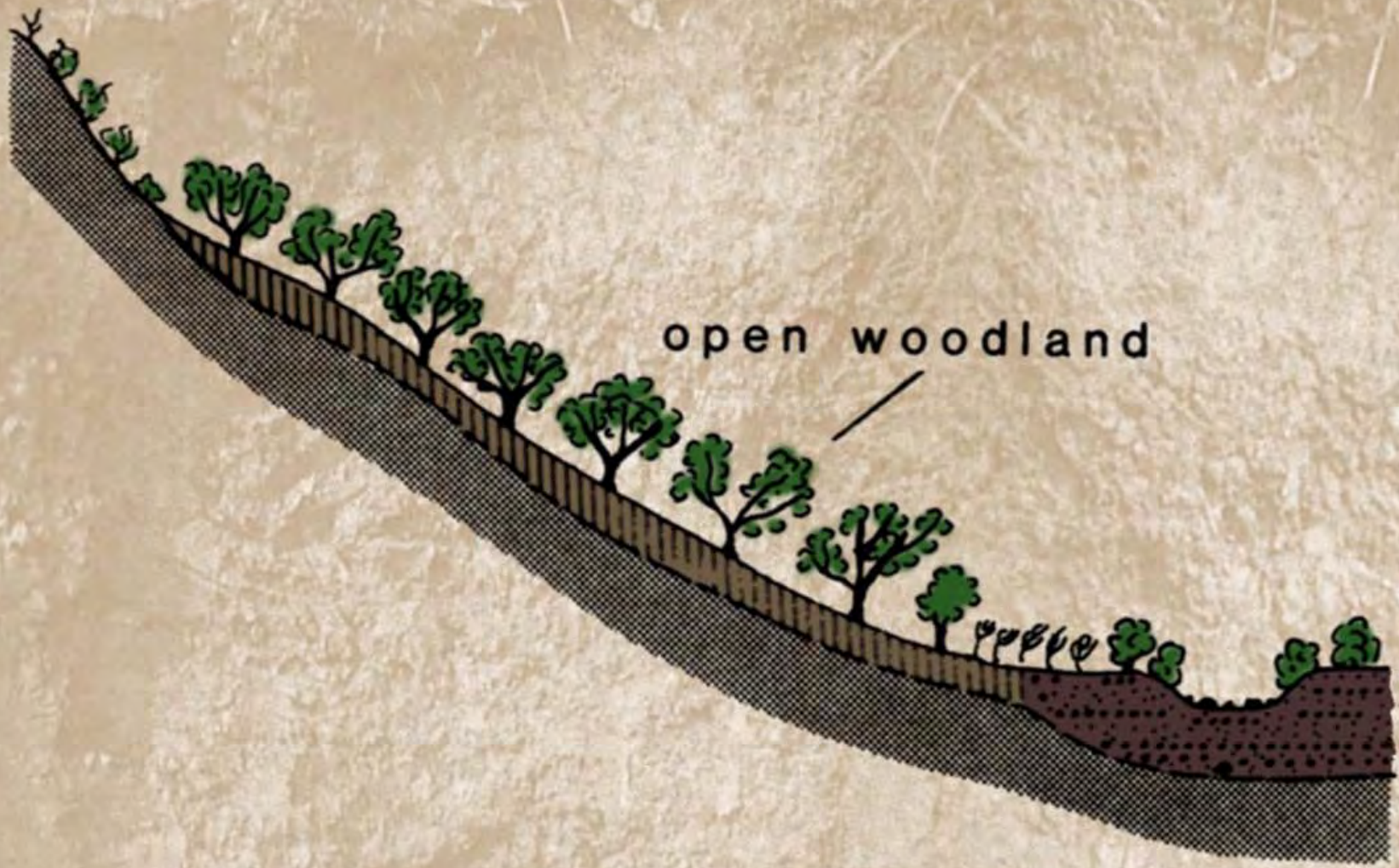
- [Playfair, 1802, p. 106-7]

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



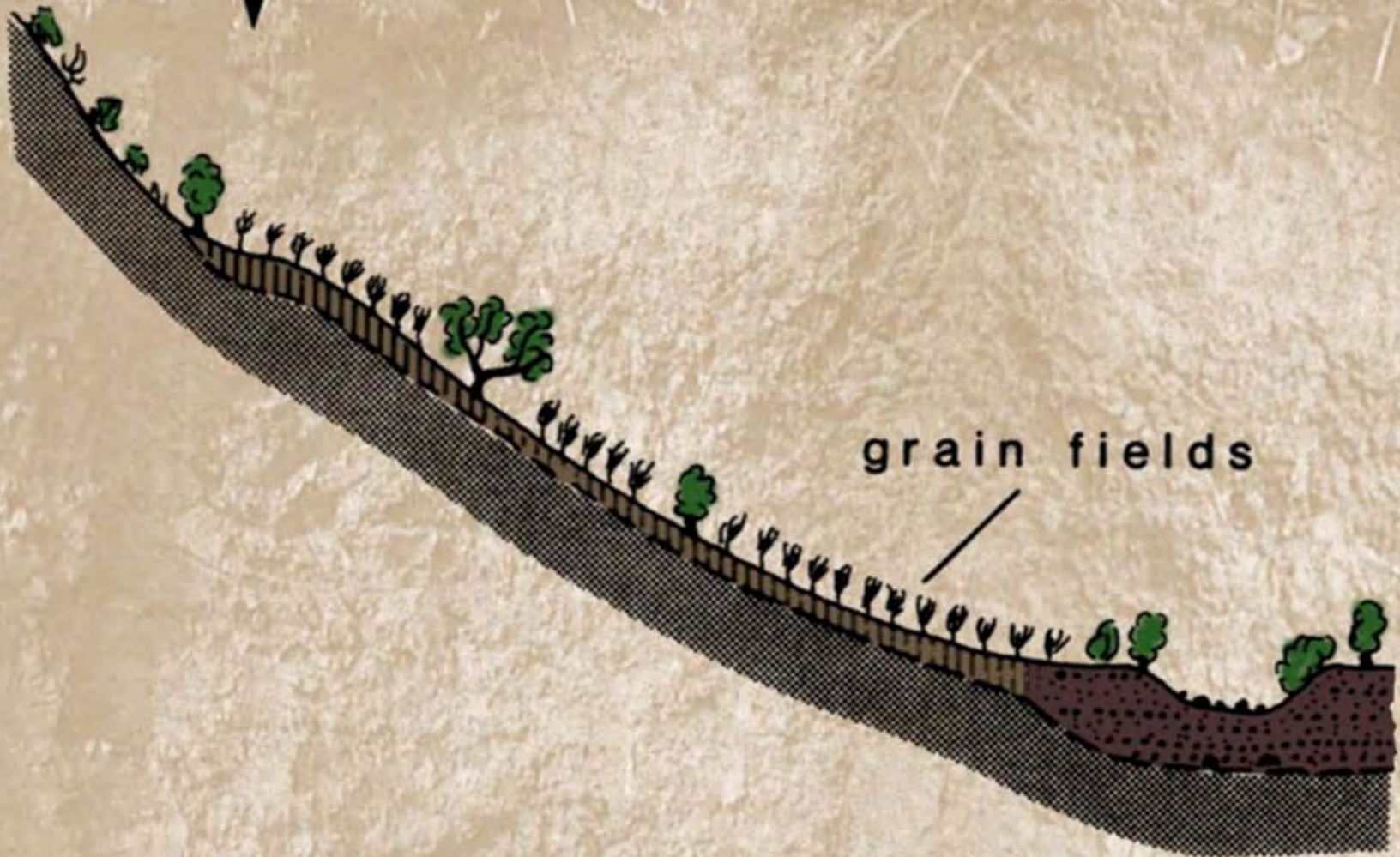


Cycles of erosion and soil formation in ancient Greece began with Bronze Age erosion after introduction of plow-based agriculture.



Van Andel and Runnels (1987)

cultivation



grain fields

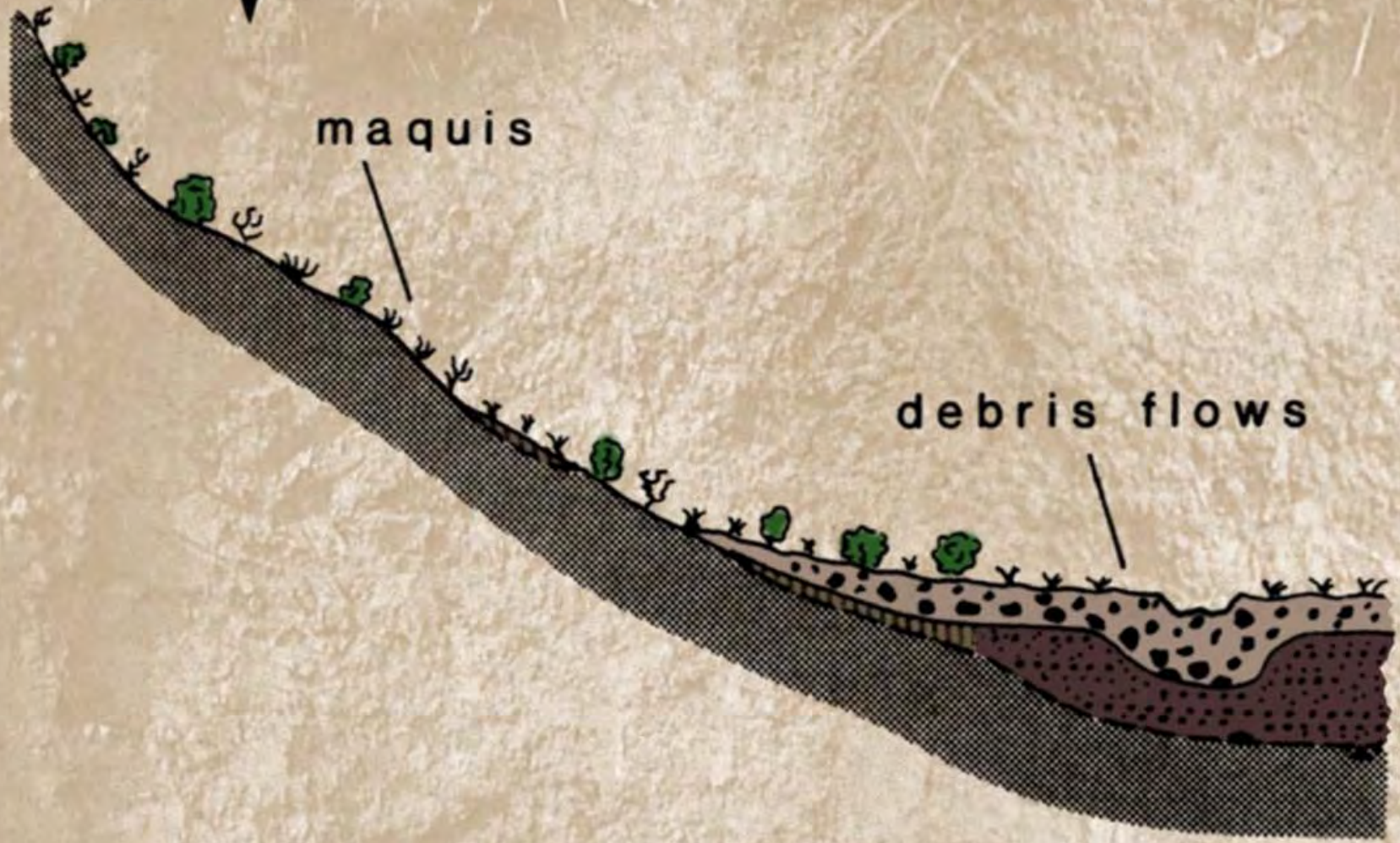
soil erosion



maquis



debris flows



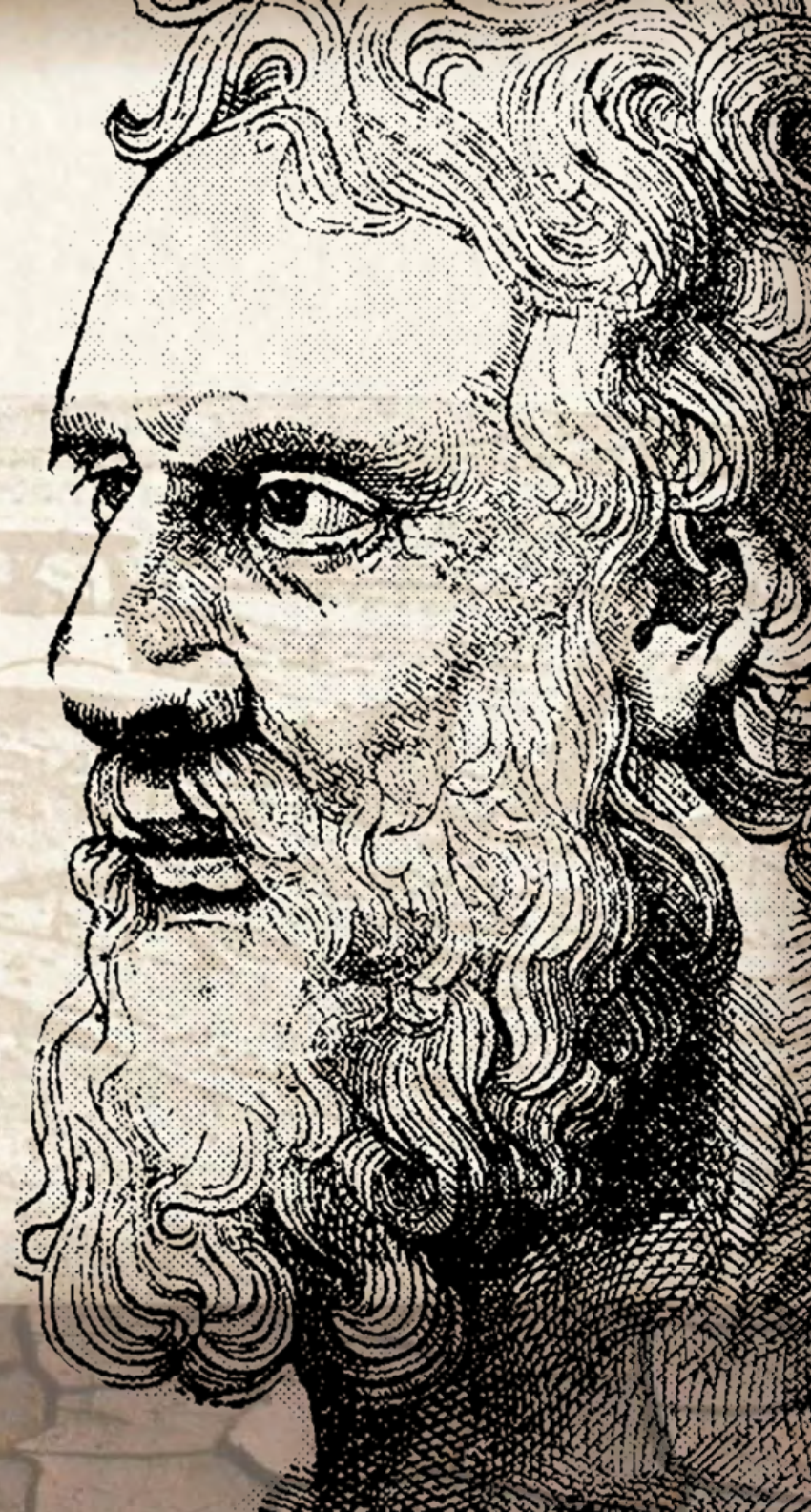
Population density of the Southern Argolid



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.





Erosion rates in the Roman heartland increased by an order of magnitude starting about the 2nd century B.C.

Judson (1963; 1968)

You have all traveled through many lands;
have you seen any country more fully
cultivated than Italy? [Varro, 1.2.6]

It is also a science,
which explains what
crops are to be sown and
what cultivations are to
be carried out in each
kind of soil, in order
that **the land may
always render the
highest yields.**
[Varro, 1:3]

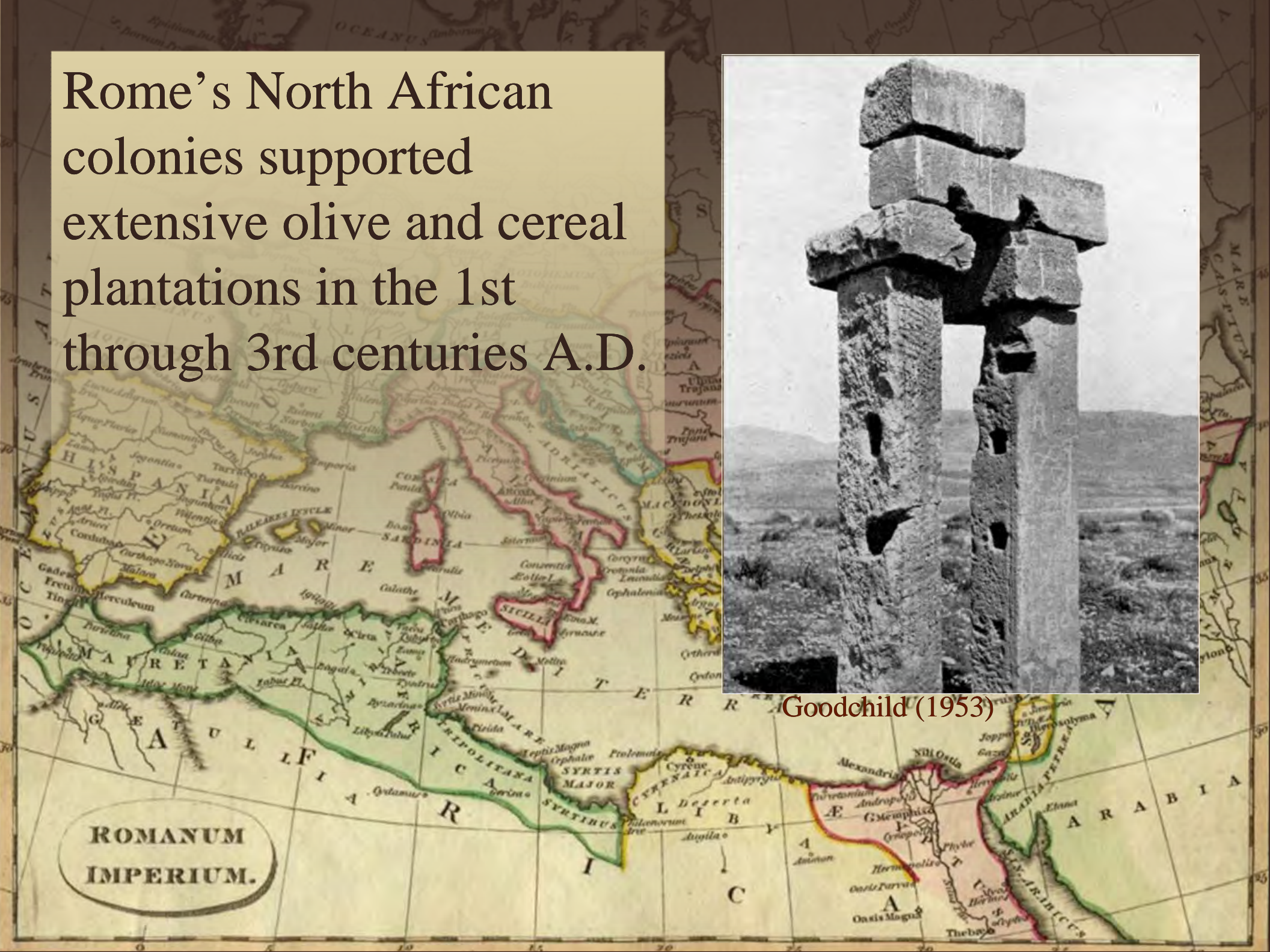


Roman ruins in Northern Syria

Rome's North African colonies supported extensive olive and cereal plantations in the 1st through 3rd centuries A.D.



Goodchild (1953)



Walter Lowdermilk

Timgad,
Libya



Over a large part of the ancient granary of Rome we found the soil washed off to bedrock and the hills seriously gullied as a result of overgrazing.

Colonial America

So it is at present that Tobacco swallows up all other Things, every thing else is neglected.... By that time the Stumps are rotten, the Ground is worn out; and having fresh Land enough ... they take but little Care to recruit the old Fields with Dung.

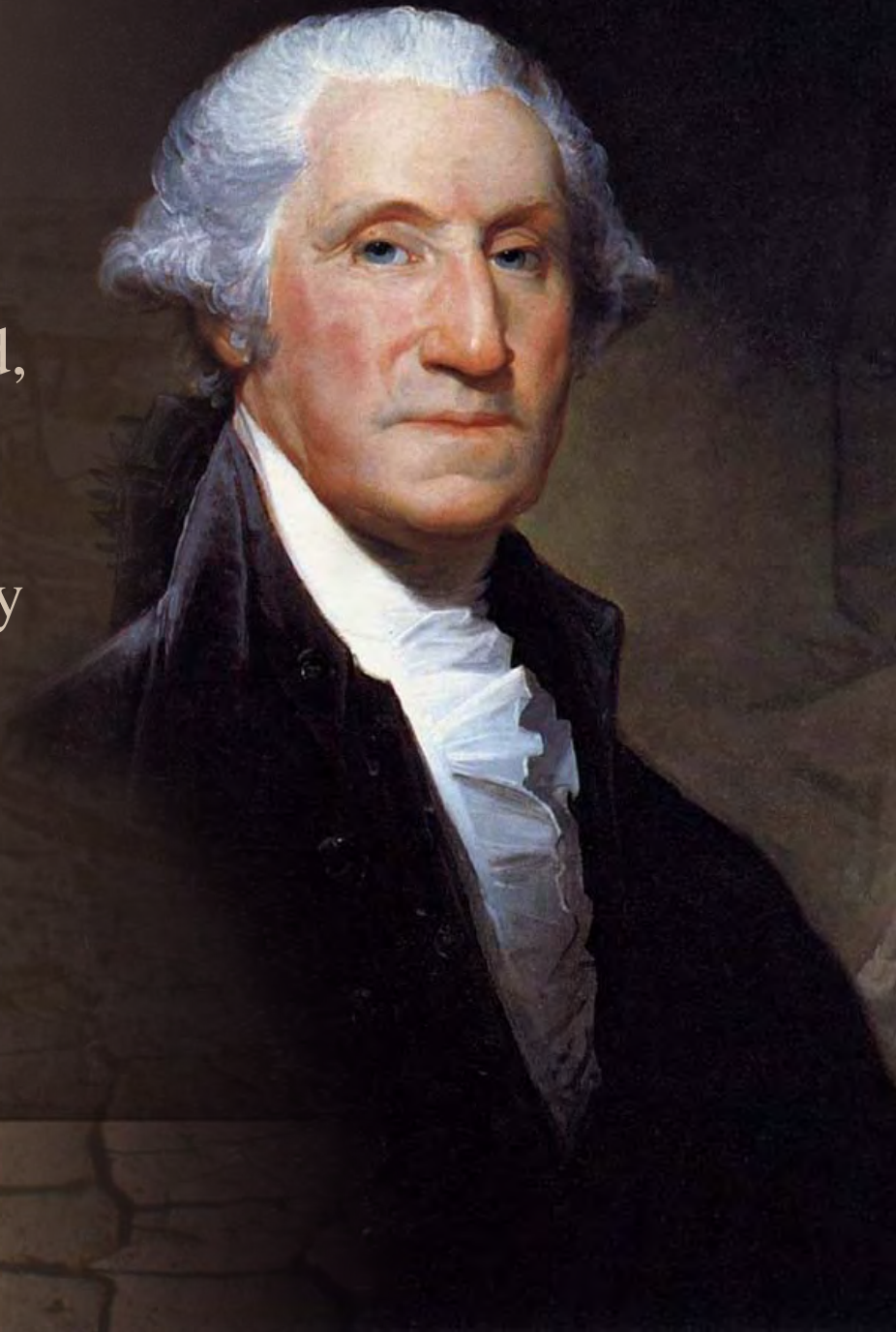
[*The Present State of Virginia*,
Hartwell, Blair, and Chilton, 1727,
p. 6,7]

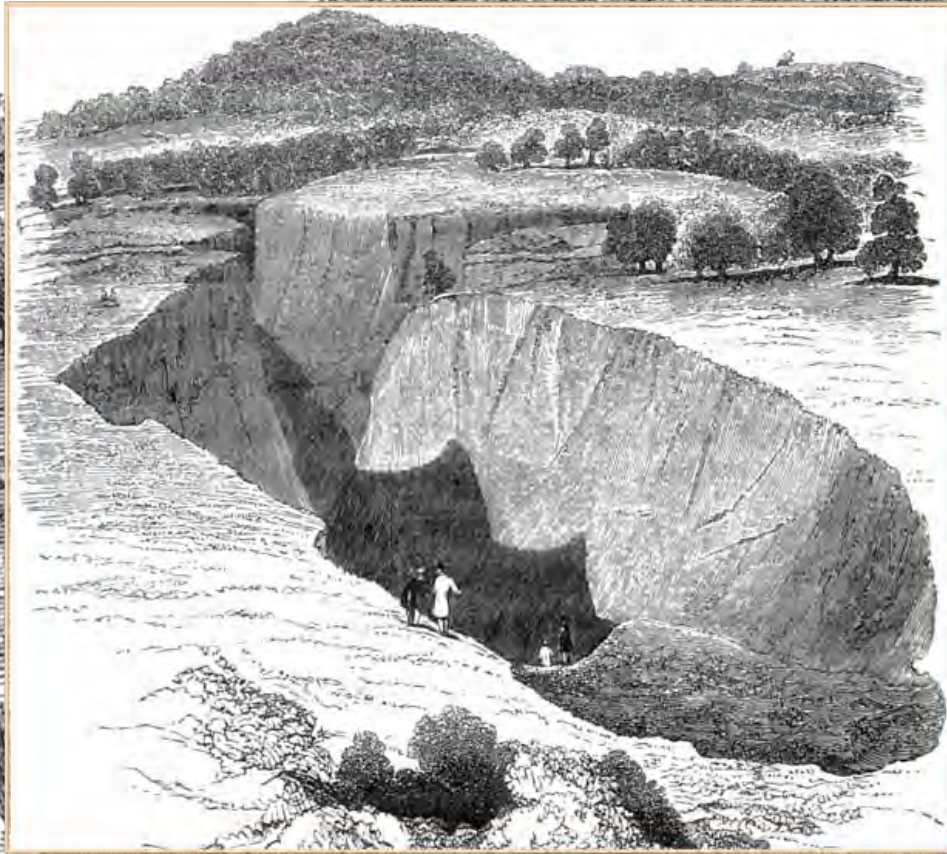


In a 1796 letter to Alexander Hamilton...

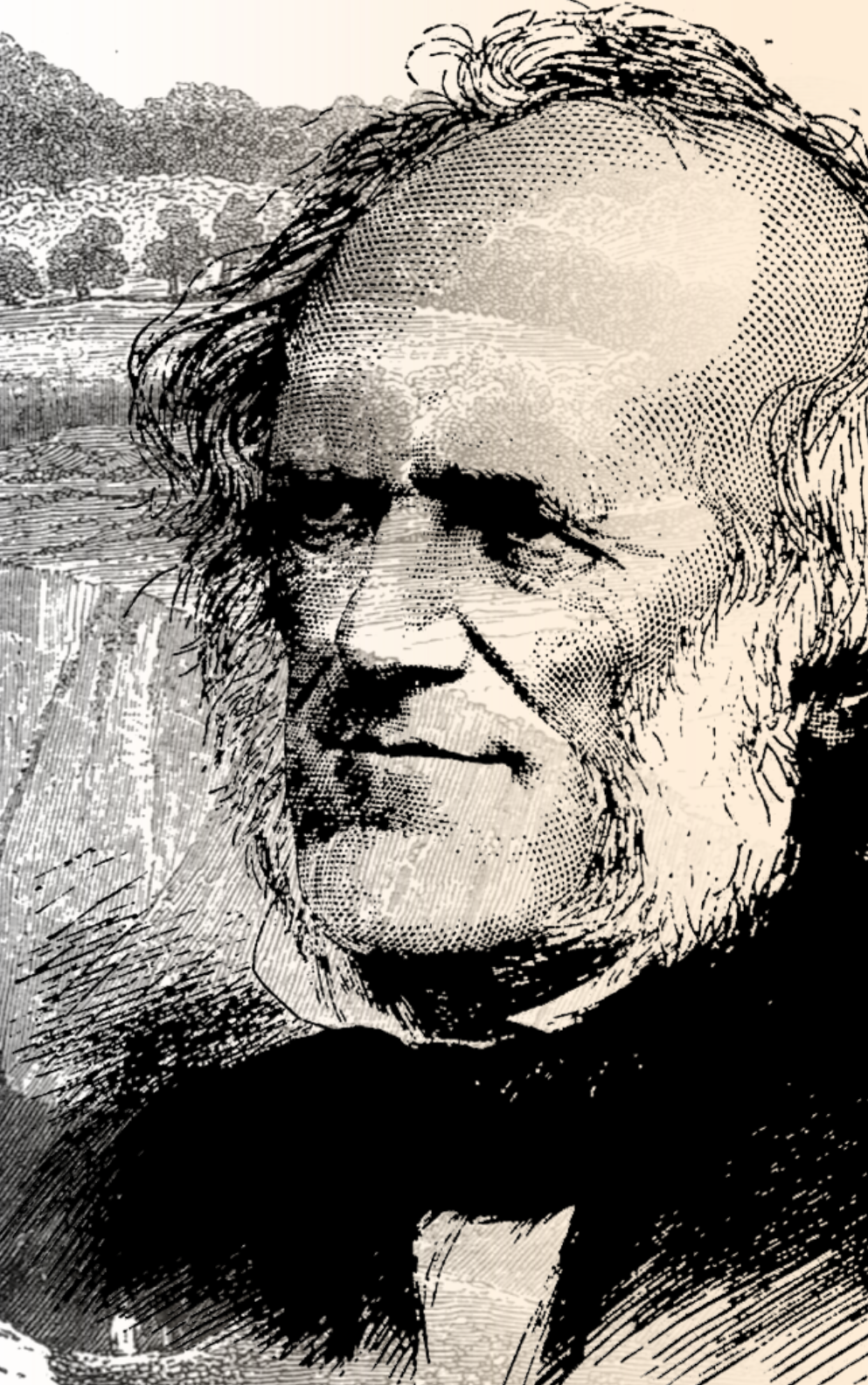
A few years more of increased sterility will drive the Inhabitants of the Atlantic States westward for support; whereas if they were taught how to improve the old, instead of going in pursuit of new and productive soils, they would make these acres which now scarcely yield them any thing, turn out beneficial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

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

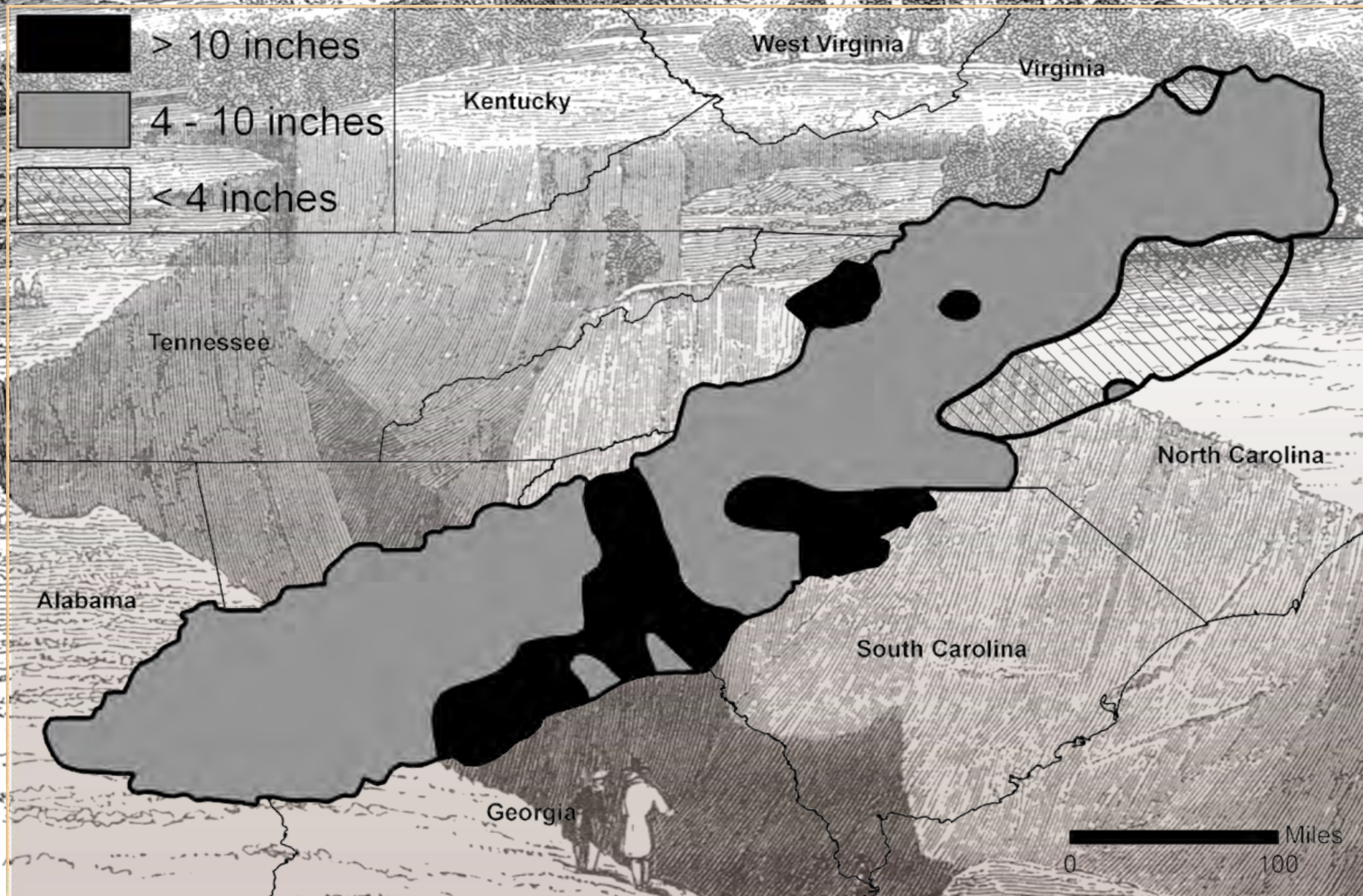




I infer, from the rapidity of the denudation caused here by running water after the clearing or removal of wood, that this country has been always covered with a dense forest, from the remote time when it first emerged from the sea. [Charles Lyell, 1849, v. II, p. 24]



Historical soil erosion in the Piedmont region



after Trimble and Meade

Extensive soil erosion did not occur because of ignorance of soil conservation practices



Most of the erosion-control practices in use at the present time ... were either developed by the Virginia farmers or became known to them during the first half of the nineteenth century.

- [Hall, 1937, p.]



Men may, because of ignorance or habit, ruin their soils, but more often economic or social conditions, entirely outside their control lead or force them to a treatment of their lands that can end only in ruin.

- Craven (1925)



I suspect that when people along the seaboard of the eastern United States began to taste fresh soil from the plains 2,000 miles away, many of them realized for the first time that somewhere something had gone wrong with the land.

- Soil Conservation Chief Hugh Bennet, 1941

Palouse, Washington

1950s



Kaiser (1961)

Palouse, Washington

1970



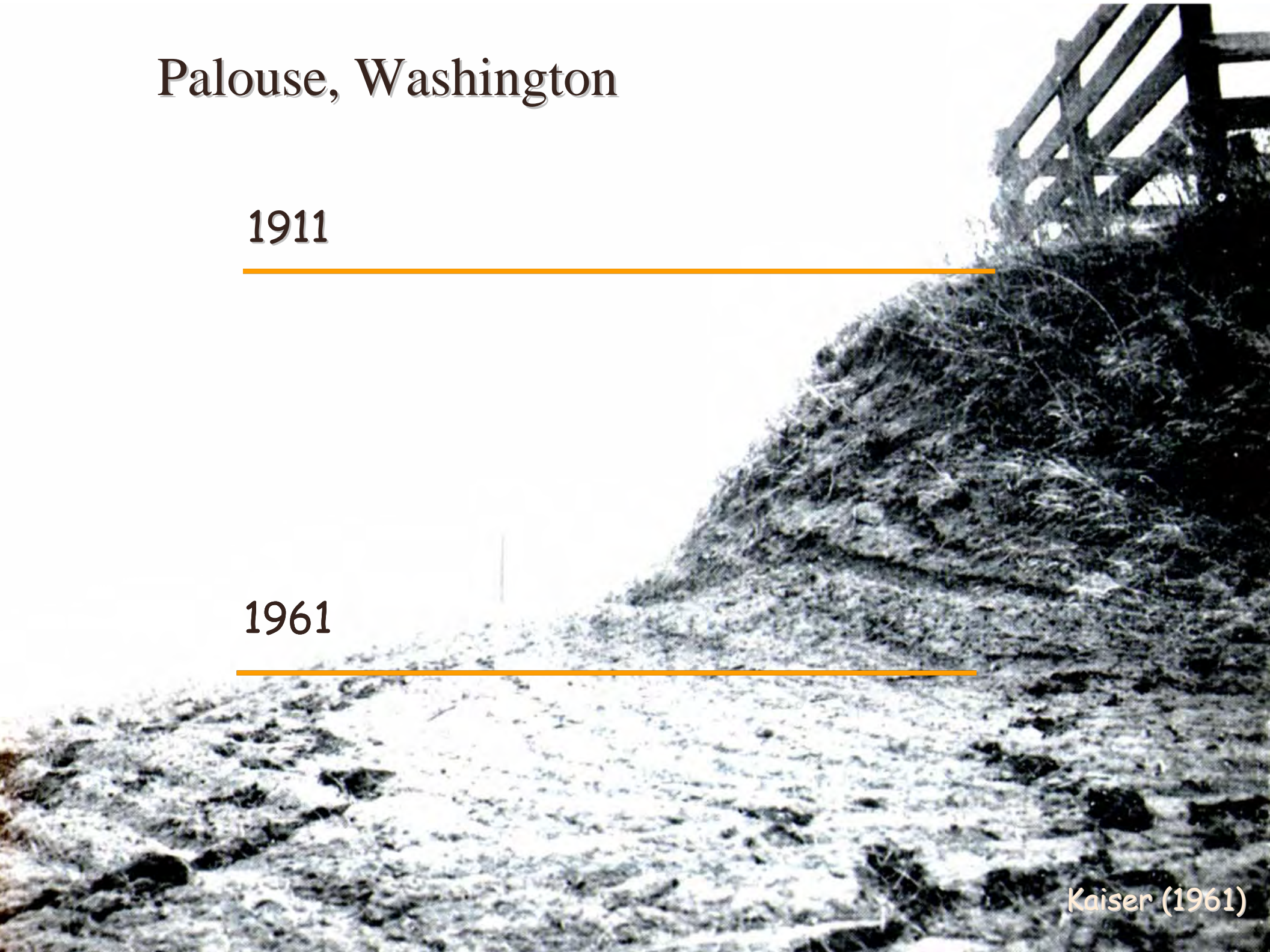
USDA (1979)

Palouse, Washington

1911

1961

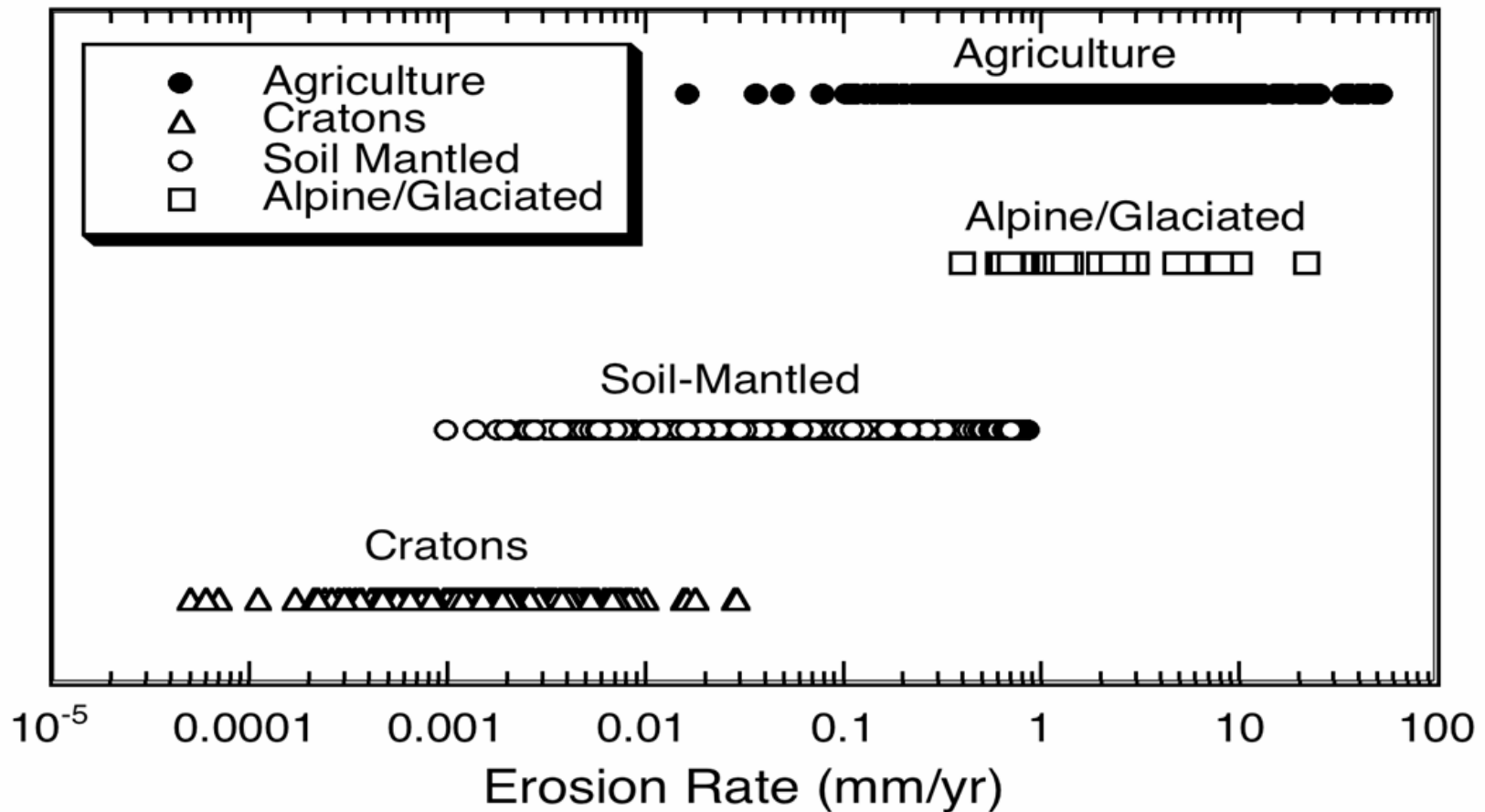
Kaiser (1961)



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

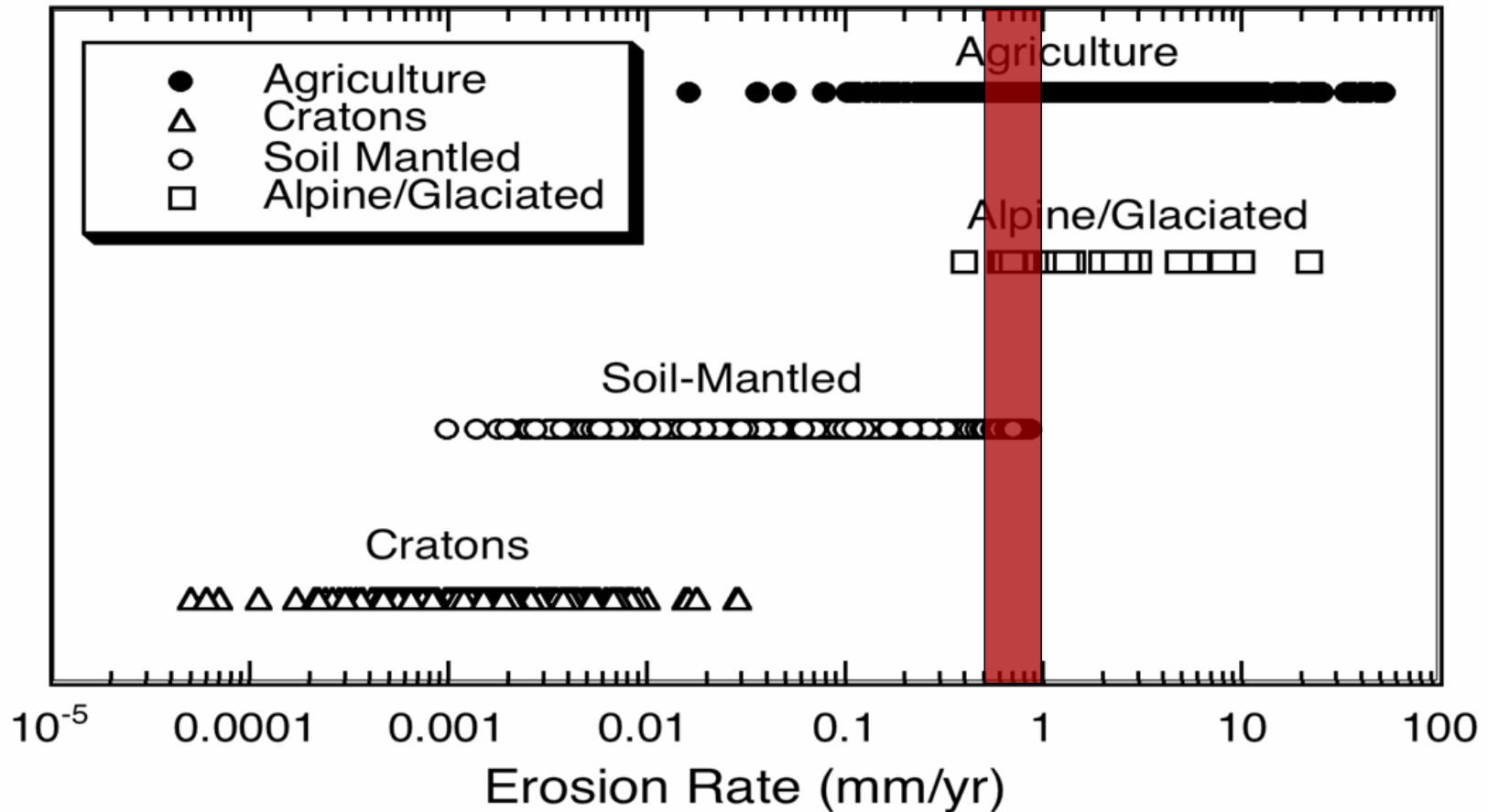


1402 measurements of agricultural and geological erosion rates



Did not include sediment yield and USLE-based studies

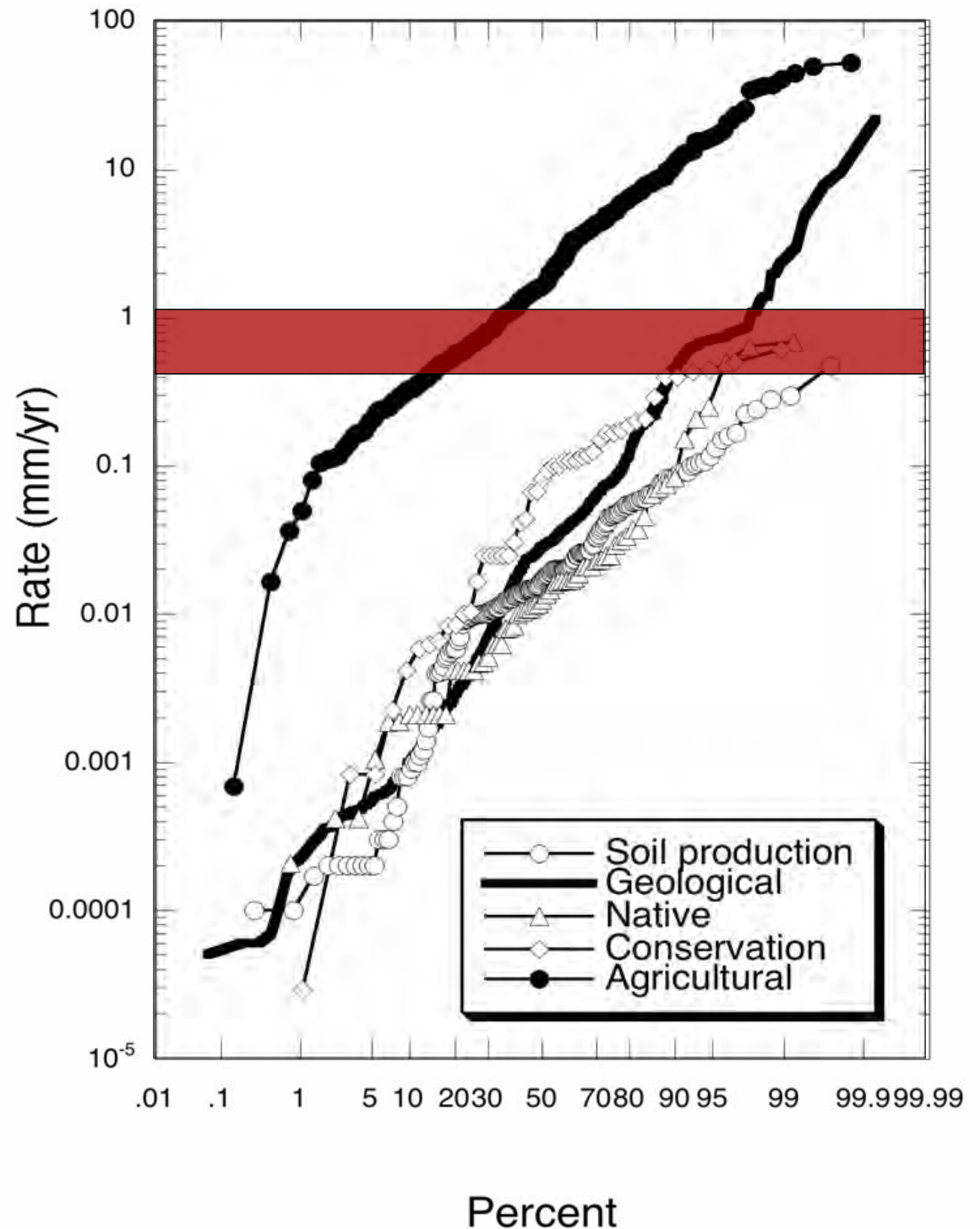
USDA soil loss tolerance values range from 0.4 to 1 mm/yr



Conventionally plowed farms erode like alpine topography
Conventional agriculture unsustainable in soil-mantled landscapes

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.



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...

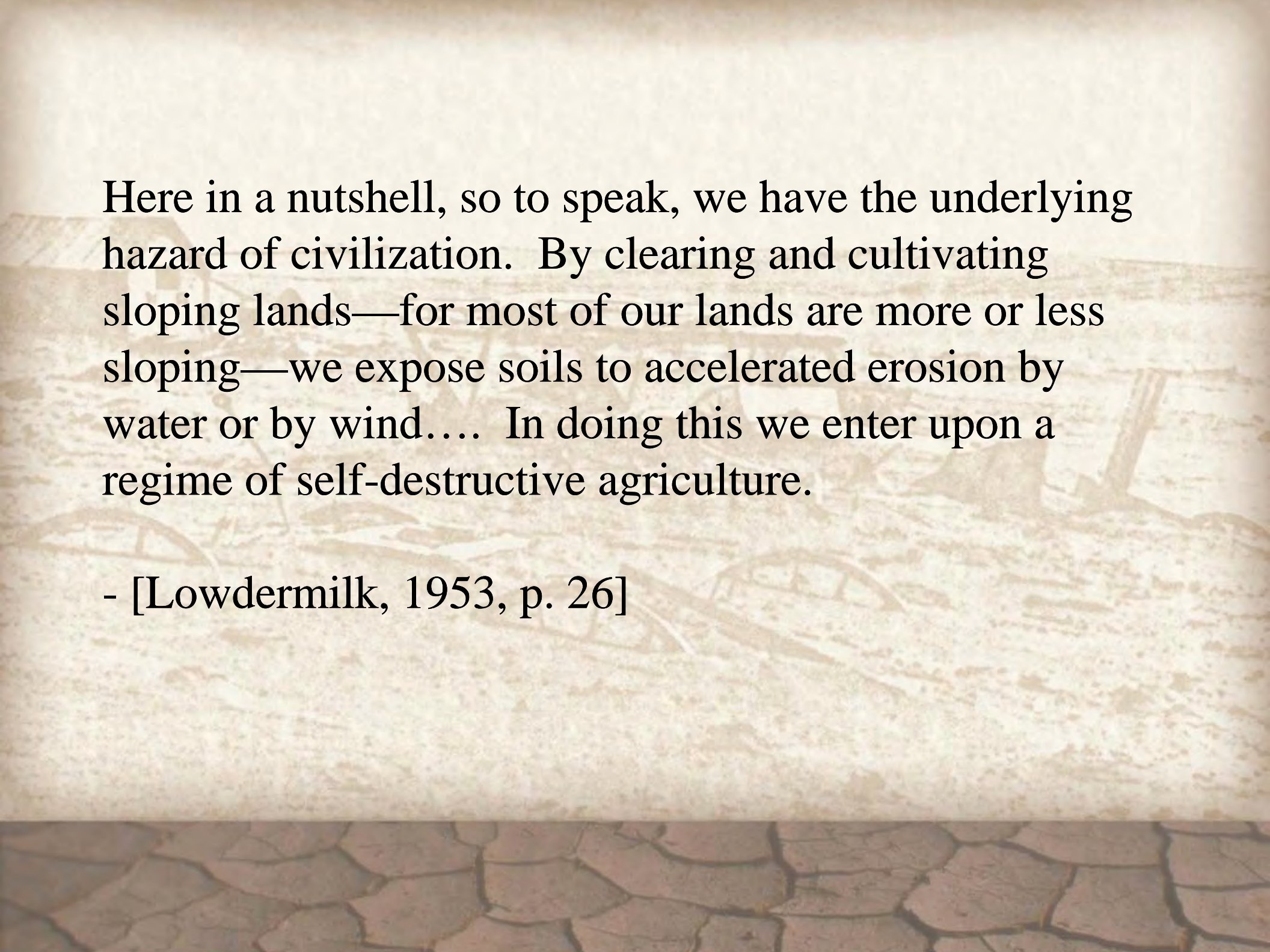
Average erosion rate for last 500 million years = 1 inch / 1400 yrs

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

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



Net soil erosion under conventional agriculture of ≈ 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...



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]



Key challenges for 21st century

- adapt farming methods to the local soil type and conditions;
- maintain crop yields as the era of cheap oil (and fertilizers) comes to an end by reinvesting in soil fertility;
- adapt upland farming to reduce soil loss to “background” levels (not a big problem for floodplain agriculture).

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



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