Soil degradation

- Very degraded soil
- Degraded soil
- Stable soil
- Without vegetation
Over the last 40 years soil erosion and degradation has caused farmers to abandon about 430 million ha of arable land, an area equivalent to about one-third of all present cropland.

Pimental et al., 1995
Humanity loses another 0.3% of our global food production capacity each year to soil erosion and degradation.

UN Global State of the Soil Assessment, 2015
Soil erosion played a role in the demise of ancient civilizations, from Neolithic Europe, to Classical Greece, Rome, the Southern United States, Central America, and more...
Invention of the plow fundamentally altered the balance between soil production and soil erosion, dramatically increasing soil erosion...
Palouse, Washington
Palouse, Washington

1911

1961
Historical soil erosion in the Piedmont region

- > 10 inches
- 4 - 10 inches
- < 4 inches

Map showing the extent of soil erosion in the Piedmont region of the United States, with different shades indicating the severity of erosion, from > 10 inches to < 4 inches.
In researching *Dirt*, I compiled data on both contemporary and long-term (geological) erosion rates—and agricultural erosion rates.
<table>
<thead>
<tr>
<th>Measurement type</th>
<th>median (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (448)</td>
<td>1.54</td>
</tr>
<tr>
<td>No-till (47)</td>
<td>0.08</td>
</tr>
<tr>
<td>Native Vegetation (65)</td>
<td>0.01</td>
</tr>
<tr>
<td>Soil Production (188)</td>
<td>0.02</td>
</tr>
<tr>
<td>Geological (925)</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Net soil loss of $\approx 1$ mm/yr implies that erosion of a typical 0.5 to 1 m thick hillslope soil could occur in roughly 500 to 1000 years.

This is approximately the lifespan of most major civilizations outside of major river floodplains...
Is Soil Restoration Possible?

Can we reverse the historical pattern?
THE HIDDEN HALF OF NATURE
THE MICROBIAL ROOTS OF LIFE AND HEALTH

DAVID R. MONTGOMERY
AND ANNE BIKLÉ
a = wood chips & compost
d = fresh grass & leaves - N
c = zoo doo - N
e = coffee (composted) - N
f = pine needles - C
The LIVING Goods
We can build soil surprisingly fast — faster than nature
The rhizosphere is a zone rich with microbial life, a living halo that surrounds plant roots.
The rhizosphere is a biological bazaar where microbes and plants trade nutrients, metabolites, and exudates.
Plant Defense & Health
Fertilizer Diet

N, P, K

micro-nutrients

good microbe metab’s

Soil Health Diet
Rebuilding soil fertility would be useful for sustaining agriculture in a post-cheap-oil-and-fertilizer world.
GROWING A REVOLUTION

BRINGING OUR SOIL BACK TO LIFE

DAVID R. MONTGOMERY

coauthor of The Hidden Half of Nature
Visiting farms around the world that had rebuilt soil health I saw how by adopting soil-building principles farmers could match conventional yields using far less oil and chemical inputs.
Biochar Can Be Carbon-Negative

**Left Panel:**
- **Net carbon withdrawal from atmosphere:** 0%
- **Carbon release:** 50%
- **Carbon sequestration by photosynthesis:** carbon neutral

**Right Panel:**
- **Net carbon withdrawal from atmosphere:** 20%
- **Carbon release:** 5%
- **Biochar sequestration:** carbon negative (reduces emissions from biomass)
- **Pyrolysis:** 25%
- **Bioenergy:** carbon neutral (reduces emissions from fossil fuels)
Biochar:

Global soil $C \approx 1500$ Gt
Global atmospheric $C \approx 760$ Gt

Average residence time for SOC globally is less than 2 decades.

Biomass decay $\approx 60$ Gt/yr
Fossil fuel emissions $\approx 7$ Gt/yr

Capture of $\approx 10\%$ of global annual biomass decay as biochar would offset global fossil fuel emissions.
Principles of Conservation Agriculture

- **minimal or no disturbance**  
  (direct planting of seeds / no-till)

- **permanent ground cover**  
  (cover crops / retain crop residues)

- **diverse crop rotations**  
  (to break up pathogen carryover)
Adopting no-till, cover crops, and complex rotations reduced inputs of diesel, fertilizer and pesticide by more than half.

**Traditional Yield**
soybeans:  63 bushels/acre  
corn:  217 bushels/acre

**Complex Rotation Yield**
soybeans:  79 bushels/acre  
corn:  235 bushels/acre
Traditional (slash and burn) vs. no-till with cover crops

**Erosion**
Traditional: 1787 kg/ha/yr
No-till: 77 kg/ha/yr

**Traditional Yield**
corn: 1.5 tons/ha
cowpeas: 0.8 tons/ha

**No-till Yield**
corn: 4.5 tons/ha
cowpeas: 1.5 tons/ha
Brandt Farm, Ohio
Neighboring conventional
Full tillage, 200 lbs N & 2.5 quarts Roundup / acre

Total cost ≈ $500/acre
Corn yield ≈ 100 bushels/acre
At $4/bushel = - $100 / acre

44-year no-till with cover crops
No tillage, 24 lbs N & 1 quart Roundup / acre

Total cost ≈ $320/acre
Corn yield ≈ 180 bushels/acre
At $4/bushel = + $400 / acre
CARDINGTON CLAY SOIL

2014 1971

10.15.2013
Ditch the Plow, Cover Up & Grow Diversity

-- Growing A Revolution
This is not a question of organic versus conventional…

… but how to apply an understanding of soil ecology to build soil health and sustain — if not increase — crop yields using far less inputs.
Benefits of Conservation Agriculture

• comparable or increased yields

• greatly reduced fossil fuel and pesticide use

• increased soil carbon and water retention (crop resilience)

• higher farmer profits & less pollution
The First Revolution

Cultivation & Tillage
We know more about the movement of celestial bodies than about the soil underfoot.

- Leonardo da Vinci
The Third Revolution

Mechanization & Industrialization
In his 1863 book, *The Natural Laws of Husbandry*, the father of fertilizers recommended returning organic matter to the fields to provide crops with a full complement of nutrients.
The Fourth Revolution

Green Revolution & Biotechnology

Wheat yields in Least Developed Countries
The Fifth Revolution

Soil-Health

GROWING A REVOLUTION
BRINGING OUR SOIL BACK TO LIFE

DAVID R. MONTGOMERY
coauthor of The Hidden Half of Nature
The Soil Health Revolution

Restoring organic matter to the world’s soils can help …

Restore farm profitability

Feed the world

Climate change resilience (carbon sequestration)

Reduce environmental degradation
Website: www.Dig2Grow.com
Twitter: @Dig2Grow
Facebook.com/Dig2GrowBooks