How to Help Yourself Become a Continuous No-Tiller

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Penn State University
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The Need

“Before World War II, we stood arraigned as the most wasteful people in all history. Nowhere else, except in the fabled Garden of Eden, had a people taken such a rich, virgin territory and in a short three centuries ruined large parts of it for all time and semi-destroyed other parts, while busily trying to do away with the rest. We were not husbandmen in the best sense of the word. We were miners.” Homestead and Fite, 1955. ‘The Agricultural Regions of the United States.’ p. 24
The Problem

- Tillage – hoe, disk, moldboard
- One-crop agriculture
  - 1600 - Tobacco in the Chesapeake Region
  - 1793 - Cotton in the South
  - 1837 – Corn in the Midwest
  - 1870 - Wheat in the Plains and Palouse
The Results

- In the Chesapeake, after 2-3 years of tobacco and a few years of corn and wheat farmers moved on to the new fields.

- It was estimated that the Potomac carried annually 1.7 billion lbs of dissolved nutrients and 470 million lbs of sediment to the Chesapeake Bay, while the James carried 3-4 million cubic yards from north of Richmond and the Roanoke 3-4 million tons from the Piedmont.

From "Craven, 1925. Soil exhaustion as a factor in the agricultural history of Virginia and Maryland, 1606-1860":p.28  
http://d.lib.ncsu.edu/collections/catalog?f[location_facet][]=North+Carolina&page=140
Devastation in the South

• In the South soil degradation in continuous cotton took its toll – as a result 1000s of miles of gullies ran through the South.

• In the Southern Piedmont average soil erosion was estimated at 7 inches.

• Unproductive soil reverted back to brush, grassland, or pine plantations as cotton moved west.

Soil Mining in The Midwest

- In the Midwest, erosion took its toll and soil organic matter content was mined – the Morrow Plots, IL show that in 50 years up to 46,000 lbs/A of soil carbon was lost from organic matter, releasing 3300 lbs of N, 400 lbs of P, and 400 lbs of S. Soils eroded but effects noticeable only after many decades or centuries.

NRCS Image Gallery picture NRCSIA99124
Devastation in the Plains

- 60% of farmers in northern Plains went bankrupt between 1925-31

- 2.5 million people moved out of Plain States after Dust Bowl years (1930-36).

- In the Palouse 10% of land lost all topsoil, and 60% of the land lost \( \frac{1}{4} - \frac{3}{4} \) of the topsoil.

http://www.drought.unl.edu/kids/impacts/1934.htm
How to To Become Husbandmen

- Our mindset is our first need!
- Soil degradation remains a threat of national proportions
- The buffer of virgin land is gone
- The demands from the land will increase
- Shallow or deep tillage combined with ‘one crop agriculture’ were at the base of the problem

Dust storm, TX Panhandle, Dec 19, 2012
Courtesy Ray Archuleta

Mudrain, Arkansas, Dec 2012
Courtesy Greg Roth
How to To Become Husbandmen
How to To Become Husbandmen

✓ Eliminate the tillage conundrum:
  ✓ Limit soil movement to eliminate tillage erosion
  ✓ Mulch cover to control water/wind erosion
  ✓ Mulch to increase infiltration/reduce evaporation
How to To Become Husbandmen

- Eliminate the tillage conundrum:
  - Limit soil movement to eliminate tillage erosion
  - Mulch cover to control water/wind erosion
  - Mulch to increase infiltration/reduce evaporation

- Eliminate ‘one-crop agriculture’:
  - Organic mulch and continuous living root systems to favor soil biological activity and profile modification
  - Diverse crop rotations to help improve soil, manage nutrients, weeds, pests and diseases.
Mulch Cover for Erosion Control

Soil loss (%) vs. Soil cover (%)

MidWest Plan Service, 200. Conservation Tillage Systems and Management

Thursday, January 17, 13
Our Challenge: How to Maintain Enough Residue!
Tillage in Rotation Decreases Residue Levels
High Mulch Cover for Increased Infiltration

More than 70% cover results in greatly increased infiltration

Roth et al., 1988. Effect of mulch rates and tillage systems on infiltrability and other physical properties of an Oxisol in Parana, Brazil. Soil Tillage Res 11:81-91
High mulch and “0” soil disturbance Effect on avg Annual Runoff (”) from Watersheds
Permanent high-mulch no-till vs bare w. moldboard plow

<table>
<thead>
<tr>
<th>Year</th>
<th>No-Till</th>
<th>Conventional Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>0.1</td>
<td>5.5</td>
</tr>
<tr>
<td>1980</td>
<td>0.2</td>
<td>12.5</td>
</tr>
<tr>
<td>1981</td>
<td>0.0</td>
<td>5.6</td>
</tr>
<tr>
<td>1982</td>
<td>0.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Average</td>
<td>0.2</td>
<td>7.0</td>
</tr>
</tbody>
</table>

% of precip  0%  16%

Coshoto, OH, no till was on 9% slope, conventional till on 6% slope. Average rainfall 42 inches

High Mulch Cover for Evaporation Reduction

Permanent No-Till for Improved Surface Aggregation

Data from long-term tillage study, Penn State University
Permanent No-Till for Improved Trafficability

Permanent no-till will look like this

Well-structured pasture without plow-pan
Arable land with plowpan
Long-term no-till soil resists compaction
Long-term no-till soil resists compaction
Long-term no-till soil resists compaction.
Long-term no-till soil resists compaction.
Long-term no-till soil resists compaction.
Long-Term No-Till and Diversity to Improve Earthworm Populations

<table>
<thead>
<tr>
<th></th>
<th>No-Till</th>
<th>Plow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cont. Corn</td>
<td>75,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Cont. Soybean</td>
<td>500,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Clover/Ryegrass</td>
<td>2,000,000</td>
<td></td>
</tr>
<tr>
<td>Pasture+manure</td>
<td>5,000,000</td>
<td></td>
</tr>
</tbody>
</table>

Data from Indiana
Crop and management systems continuous for at least 10 years

Kladivko. Earthworms and crop management. AY 279, Purdue University.
Permanent No-Till to Build Humus and Stimulate Microbial Life

Data from Long-Term Ecological Research, MI

Permanent No-Till to Stimulate Microbial Activity

Profile Modification with Continuous No-Till

Tilled Ecosystem vs. No-till Ecosystem

Crust vs. Crop Residue
High OM vs. Firm Aggregates
Pulverized Soil Aggregates vs. Root Channel
Plow Pan vs. Worm Burrows

0 inches to 24 inches
Are Corn Yields Reduced in Long-Term, Continuous No-Tillage?
Tillage effects on corn yields Landisville, southeast PA
Corn Yields in Continuous No-Till Improve on Poorly Drained Soil

- Wooster B
- Hoytville

Well Drained Soil

Poorly Drained Soil

No-till vs plowed corn yield differences (bu/ac)
Crop rotation to Improve No-Till Performance in Poorly Drained Soils

<table>
<thead>
<tr>
<th></th>
<th>No-Till</th>
<th>Conv.Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Corn</td>
<td>112</td>
<td>125</td>
</tr>
<tr>
<td>Corn-Soybean</td>
<td>129</td>
<td>129</td>
</tr>
<tr>
<td>Corn/Soy/Meadow</td>
<td>127</td>
<td>133</td>
</tr>
</tbody>
</table>

20-yr average corn yields (Bu/A) on a poorly drained Hoytville silt, Ohio
Crop Rotations to help You Become a Continuous No-Tiller

- To reduce risk of weather and price fluctuations
- To reduce fallow periods
- To reduce need for fertilizer
- To reduce the build-up of pests – weeds, diseases
- To reduce reliance on agricultural chemicals
- To spread the workload
- To improve yields

Corn after sod  Corn after corn
Crop rotations to improve soil structure

Soil aggregate stability for four cropping systems under inorganic fertility of Hunter Rotation Experiment (1990)

## Crop Rotation Improves Disease Control

<table>
<thead>
<tr>
<th>Disease</th>
<th>Major Crops Attacked¹</th>
<th>Best Control Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common root rot</td>
<td>wheat, barley, grasses</td>
<td>Rotation, seed trt.</td>
</tr>
<tr>
<td>Ergot</td>
<td>rye, wheat, grasses</td>
<td>Rotation, tillage</td>
</tr>
<tr>
<td>Bacterial blights</td>
<td>wheat, barley, grasses, rye</td>
<td>Rotation</td>
</tr>
<tr>
<td>Scab</td>
<td>wheat, barley, corn, rye</td>
<td>Rotation</td>
</tr>
<tr>
<td>Tan spot</td>
<td>wheat, durum</td>
<td>Rotation, fungicide</td>
</tr>
<tr>
<td>Net blotch</td>
<td>barley</td>
<td>Rotation, fungicide</td>
</tr>
<tr>
<td>Septoria (different species)</td>
<td>wheat, barley</td>
<td>Rotation, fungicide</td>
</tr>
<tr>
<td>Pasmo</td>
<td>flax</td>
<td>Rotation, variety</td>
</tr>
<tr>
<td>Wilt (flax)</td>
<td>flax</td>
<td>Rotation, variety</td>
</tr>
<tr>
<td>Rust (flax)</td>
<td>flax</td>
<td>Resistant Variety, rotation</td>
</tr>
<tr>
<td>Seedling blight</td>
<td>wheat, barley, corn, oats, rye</td>
<td>Seed treatment</td>
</tr>
<tr>
<td>Smut (corn)</td>
<td>corn</td>
<td>Rotation</td>
</tr>
<tr>
<td>Bacterial wilt</td>
<td>alfalfa</td>
<td>Variety resistance</td>
</tr>
<tr>
<td>Crown rot</td>
<td>alfalfa</td>
<td>Variety resistance</td>
</tr>
<tr>
<td>Verticillium wilt</td>
<td>potato, sunflower, safflower</td>
<td>Rotation, variety</td>
</tr>
<tr>
<td>Rust (sunflower)</td>
<td>sunflower</td>
<td>Variety, rotation</td>
</tr>
<tr>
<td>Sclerotinia (white mold)</td>
<td>sunflower, dry beans safflower, soybean, potato, canola</td>
<td>Rotation 4 to 5 years</td>
</tr>
<tr>
<td>Phoma</td>
<td>sunflower</td>
<td>Rotation</td>
</tr>
</tbody>
</table>

¹ Common crops attacked by various disease pathogens can vary by region and crop management practices.

[www.ag.ndsu.edu/pubs/plantsci/crops/eb48-1.htm](http://www.ag.ndsu.edu/pubs/plantsci/crops/eb48-1.htm)

**Thursday, January 17, 2013**
Crop Rotation for Weed Control

Varying patterns of:
- Resource competition
- Allelopathic interference
- Herbicide application timings
- Herbicide modes of action
- Cultural practices (e.g. mowing)

Adapted from Liebman and Dyck, 1993
Crop Rotation Improves Yield

Rotation Effect on Corn Yields - Penn State Hunter Plots 1990-2006

C=Corn   S=Soybean   A=Alfalfa   O=Oats   W=Wheat   R=Red clover/grass

C=CC    S=CS    A=CCCCAAA_    O=CCCCAAAA    W=CCCCAAAA    R=COWRR
Cover Crops to Help You Become a Continuous No-Tiller

• Maintain and improve soil structure
• Absorb and retain (recycle) nutrients
• Fix atmospheric N
• Maintain and improve organic matter content
• Provide weed control
• Provide forage
Cover Crops to Improve Soil Structure

Cover Crops for Nutrient Fixation, Liberation and Recycling

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Cover Crops for Nutrient Fixation, Liberation and Recycling
Clover Cover Crop Benefits

![Graph showing corn yield (bu/A) vs. N fertilizer (lb/A) with different treatments.]

- **No Red Clover**
- **Poly. (No Red Clover)**
- **Red Clover**
- **Poly. (Red Clover)**

Note: ~30 bu/A higher yield with Red Clover regardless of N applied

Clover frost seeded into wheat the previous year with no clover harvest, corn no-till in clover residue

Johnson, PSU

SE Pennsylvania, 2007
Nutrient recycling with cover crops

Rye cover crop

N content (lbs/A) in spring

\[ y = 57.204x \]
\[ R^2 = 0.75 \]

P content (lbs/A)

\[ y = 9.2098x \]
\[ R^2 = 0.91305 \]

Cover crop dry matter (T/A)

Courtesy Doug Beegle, On-farm research 2007-2009
Cover Crops for Biological P “Banding”

(White and Weil, 2011)
How to Help Yourself to Become a Continuous No-Tiller

1. Realize its importance
2. Realize its benefits
3. Move away from ‘One-Crop Agriculture’ by increasing *rotation diversity*
4. Implement the principle of continuous living cover by plugging the fallow holes
5. Move to greater profitability and sustainability
Let us be Husbandmen!