SOIL HEALTH : CROP ADVISING

University of Missouri Crop Management Conference
December 17-18, 2019
Paul W. Tracy – Soil Health Institute
Our combined experiences are the key to providing comprehensive soil health and sustainable land management information to farmers, landowners and the general public.
Reactions to the Term “Soil Health” Over the Past Decade

Soil Health – 2009 Com’on Man

October 11, 2009 Minnesota Vikings 38 : St. Louis Rams 10
St. Louis, Missouri

Soil Health 2019– Oh what fun it is…..

December 25, 2018, Tamarack Ski Hill
Donnelly, Idaho

What’s Changed?
SOIL HEALTH:
The capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans.
Mission

Safeguard and enhance the vitality and productivity of soil through scientific research and advancement

https://soilhealthinstitute.org
Premise...

SHI’s Comprehensive Strategy to Improve Soil Health

Premise........
Stakeholder Input
THE MOST CRITICAL INGREDIENT:

You have always known the value of healthy soils
What Role do Crop Advisers and Land Managers Play and what Tools can we use to Improve Soil Productivity and Sustainability?

- Continue to make defendable rec's
- Utilize client trust
- Keep learning
  - Measurements
  - Programs
  - Opportunities
- Initiate activity and new partnerships
- Lead the conversation – you have much to offer!

North American distribution of individual Certified Crop Advisers, Professional Agronomists and Professional Soil Scientists – Tri Societies

Photo by James Fashing
Know Your Soils: Intrinsic Properties and Crop Management and Their Interactive Affect on Soil Health

Menfro Silt Loam: Fine-silty, mixed superactive Typic Hapludalf

usda/nrcs

usda/nrcs

usda/nrcs
Understand Soil Health Measurements and how they Relate to Making Quality Land-use Decisions

- Biological
- Physical
- Chemical
Soil Health Is a Holistic Science

Biology

Climatology

Agronomy

Chemistry

Physics

Geology
Soil Health Decisions are Driven by Many Interactive Factors

- Biology
- Chemistry
- Physics
- Geology
- Agronomy
- Climatology
- Economics
- Geography
- Sociology
- Politics
- Religion
- Logistics
Carbon - Underlying Factors for the Challenges of the Coming Decades
Jansen, 2009

- Food Quantity
- Food Quality
- Food Cost

Human Nutrition

A significant component of soil fertility/health

Carbon

- Climate Change
- Cheap Energy
- Bioenergy
- Etc.

Land

- Land Use
- Soil Quality
- Water Use & Quality
- Waste Disposal
- Etc.

Soil OM
Many Factors Associated with Soil Organic Carbon (SOC)

- Available Water Holding Capacity
- Soil Aggregate Stability
- Water infiltration/movement
- Soil Erosion/Deposition
- Soil compaction/root growth
- C:N ratios (Quality vs Quantity)
- Crop nutrient interactions & CEC
- CO₂ source/sink
- Food for soil fauna

Adapted from Hudson (1994)
Crop Production and tillage have contributed to soil carbon depletion and elevated atmospheric CO$_2$ levels: is this a fair claim?

Crop Production and tillage are targeted as major factors necessary to solve this global issue: is this a fair expectation?
### Loss of Soil Organic Carbon (0-15 cm)

<table>
<thead>
<tr>
<th>Yrs.</th>
<th>Soil</th>
<th>Uncultivated SOC (%)</th>
<th>Cultivated SOC (%)</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>Alboll</td>
<td>5.96</td>
<td>4.16</td>
<td>Anderson</td>
</tr>
<tr>
<td>2</td>
<td>Andept</td>
<td>10.8</td>
<td>8.5</td>
<td>Wood</td>
</tr>
<tr>
<td>40</td>
<td>Aqualf</td>
<td>1.72</td>
<td>1.18</td>
<td>Sharpley</td>
</tr>
<tr>
<td>16</td>
<td>Aquoll</td>
<td>5.58</td>
<td>3.26</td>
<td>Dormaar</td>
</tr>
<tr>
<td>14</td>
<td>Boralf</td>
<td>2.69</td>
<td>1.32</td>
<td>Newton et al.</td>
</tr>
<tr>
<td>20</td>
<td>Boroll</td>
<td>2.79</td>
<td>1.41</td>
<td>Dormaar</td>
</tr>
<tr>
<td>54</td>
<td>Fluvent</td>
<td>2.47</td>
<td>1.21</td>
<td>Haas &amp; Evans</td>
</tr>
</tbody>
</table>
The Effect of Tillage on Losses of C, N, P and S After 17 Years of Winter Wheat/Summer Fallow Cropping Systems when Compared to a Native Sod Check Soil – W. Nebraska (Tracy, 1986)

<table>
<thead>
<tr>
<th>Tillage Treatment</th>
<th>Soil Depth</th>
<th>C</th>
<th>N</th>
<th>P</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches</td>
<td>% loss to native sod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-tillage System</td>
<td>0-1</td>
<td>31</td>
<td>20</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>1-2</td>
<td>19</td>
<td>0</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>12</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>V-Sweep Stubble Mulch</td>
<td>0-1</td>
<td>44</td>
<td>34</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>1-2</td>
<td>27</td>
<td>13</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>13</td>
<td>9</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Plow/Disc</td>
<td>0-1</td>
<td>57</td>
<td>52</td>
<td>37</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>1-2</td>
<td>46</td>
<td>34</td>
<td>28</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>2-6</td>
<td>22</td>
<td>15</td>
<td>4</td>
<td>22</td>
</tr>
</tbody>
</table>
## Improving Soil Health with Tillage Management

<table>
<thead>
<tr>
<th>LOC</th>
<th>YR</th>
<th>Depth (cm)</th>
<th>Soil</th>
<th>CT</th>
<th>NT</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>2.5</td>
<td>30</td>
<td>Paleudult</td>
<td>23.5</td>
<td>26.2</td>
<td>Terra et al.</td>
</tr>
<tr>
<td>IA</td>
<td>15</td>
<td>20</td>
<td>Hapludoll</td>
<td>60.3</td>
<td>71.1</td>
<td>Karlen et al.</td>
</tr>
<tr>
<td>IL</td>
<td>8-9</td>
<td>30</td>
<td>Argialboll</td>
<td>46.4</td>
<td>58.5</td>
<td>Yang &amp; Wander</td>
</tr>
<tr>
<td>IN</td>
<td>11</td>
<td>20</td>
<td>Haplustoll</td>
<td>60.0</td>
<td>73.0</td>
<td>Elliott et al.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Haplaquoll</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KY</td>
<td>5</td>
<td>30</td>
<td>Paleudalf</td>
<td>45.9</td>
<td>52.8</td>
<td>Blevins et al.</td>
</tr>
<tr>
<td>NE</td>
<td>24</td>
<td>30</td>
<td>Argiudoll</td>
<td>63.3</td>
<td>75.3</td>
<td>Varvel &amp; Wilhelm</td>
</tr>
</tbody>
</table>
Impact of Fertilizer N on SOC Levels After 39 Years of Continuous Cropping and Cover Crops
Grove & Blevins, Kentucky, 2007

Sod – Can we obtain “reference state” status within cropping systems?

Convert grass sod to continuous corn
Use no-tillage soil management
Add fertilizer N

Profile SOC (tons/acre)
Annual Fertilizer Rate lbs. N/acre
Effect of Cropping system on Long-term Carbon Losses at Sanborn Field, Missouri 1888-1988

What is happening here

C, kg m⁻² in 0 - 20 cm layer

Year

Timothy + Manure
Corn no nutrients
Agriculture Contribution to GHG Emissions – USEPA 2017

Note: The USEPA has estimated that an 11% decrease in GHG emissions can be obtained by modifying or converting land use practices – Potentially countering all agricultural sources
N Rates Above Agronomic Optimum can Increase Risk of N$_2$O Emissions – Finding Optimum is Important

**Figure 5.** Balanced median N$_2$O emission rates as a function of applied N (adapted from Bouwman, Boumans, and Batjes, 2002).
SOIL Health Recommendations

MAXIMIZE CONTINUOUS LIVING ROOTS
- Crop Rotation
- Relay Crops
- Forage and Biomass Planting
- Perennial Crops
- Cover Crops

MINIMIZE DISTURBANCE
- No-till
- Reduced Tillage
- Controlled Traffic
- Avoid Tillage When Wet
- IPM

MAXIMIZE BIODIVERSITY
- Crop Rotation
- Rotational Grazing
- IPM
- Pollinator Plantings
- Organic Fertilizers
- Legumes in Mix
- Agroforestry
- Cover Crops
- Crop/Livestock Integration

MAXIMIZE SOIL COVER
- Mulching
- Reduced Tillage
- Forage and Biomass Planting
- Residue Retention
- Cover Crops
- Green Manures
USDA Censes: “No-till”

- Acres increased from 96 mill to 104 mill
- 37% of arable acres reported no-till
- Tennessee has 78.6% (Top State)
- Missouri 45% (15.6% increase from 2012-2017)

USDA Census: Percent Cropland Available with “No-till”, 2017
USDA Census: Cover Crops

- Acres increased from 10.3 million to 15.4 million
- Number of farms increased by 15%
- 11 states has > ¼ of crop land planted to cover crops
- Missouri increased cover crop acres by 115.9% from 2012 to 2017
USDA Census: Percent Cropland Available with Cover Crops, 2017
USDA-SARE, CTIC Survey

2012 corn yield drought states

<table>
<thead>
<tr>
<th>With Cover Crops</th>
<th>Without Cover Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>114</td>
<td>103</td>
</tr>
</tbody>
</table>

Bushes / acre
**SARE Survey: Yield Increase**

**Table 1**

Summary of percentage yield increase recorded on corn and soybeans grown after cover crops, years 2012 to 2014.

<table>
<thead>
<tr>
<th>Crop year surveyed</th>
<th>Corn (%)</th>
<th>Soybeans (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>9.6%</td>
<td>11.6%</td>
</tr>
<tr>
<td>2013</td>
<td>3.1%</td>
<td>4.3%</td>
</tr>
<tr>
<td>2014</td>
<td>2.1%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>
## Tillage & Cover Crop Impacts on Infiltration rate

<table>
<thead>
<tr>
<th>Location</th>
<th>Years</th>
<th>Tillage &amp; Crop</th>
<th>Impact on Infiltration Rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>KS</td>
<td>15</td>
<td>NT Winter Wheat- Sorghum</td>
<td>182% Increase with Cover Crop</td>
<td>Blanco-Canqui et al. (2011)</td>
</tr>
<tr>
<td>MD</td>
<td>11</td>
<td>NT Corn</td>
<td>164-462% Increase with Cover Crop (different sites &amp; years)</td>
<td>Steele et al. (2012)</td>
</tr>
<tr>
<td>KS</td>
<td>11</td>
<td>NT Wheat- Sorghum-Fallow</td>
<td>132-194% Increase with No-Till</td>
<td>Stone and Schlegel (2010)</td>
</tr>
<tr>
<td>Malawi</td>
<td>3</td>
<td>NT Corn</td>
<td>165% Increase in No-Till</td>
<td>TerAvest et al. (2015)</td>
</tr>
</tbody>
</table>
## Cover Crop Impacts on Nitrate Leaching

<table>
<thead>
<tr>
<th>Location</th>
<th>Cover Crop</th>
<th>Reduction in Nitrate Leaching (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>Rye</td>
<td>65-70</td>
<td>Wyland et al. (1996)</td>
</tr>
<tr>
<td>DE</td>
<td>Rye</td>
<td>30</td>
<td>Ritter et al. (1998)</td>
</tr>
<tr>
<td>France</td>
<td>Ryegrass</td>
<td>63</td>
<td>Martinez and Guirard (1990)</td>
</tr>
<tr>
<td>IN</td>
<td>Winter Wheat (and reduced fertilizer)</td>
<td>61</td>
<td>Kladivko et al. (2004)</td>
</tr>
<tr>
<td>IA</td>
<td>Rye</td>
<td>61</td>
<td>Kaspar et al. (2007)</td>
</tr>
<tr>
<td>KY</td>
<td>Rye</td>
<td>94</td>
<td>McCracken et al. (1994)</td>
</tr>
<tr>
<td>KY</td>
<td>Hairy Vetch</td>
<td>48</td>
<td>McCracken et al. (1994)</td>
</tr>
<tr>
<td>MD</td>
<td>Rye</td>
<td>77</td>
<td>Staver and Brinsfield (1990)</td>
</tr>
<tr>
<td>MD</td>
<td>Rye</td>
<td>80</td>
<td>Staver and Brinsfield (1998)</td>
</tr>
<tr>
<td>MI</td>
<td>Rye</td>
<td>28-68</td>
<td>Rasse et al. (2000)</td>
</tr>
<tr>
<td>MN</td>
<td>Rye</td>
<td>13</td>
<td>Strock et al. (2004)</td>
</tr>
</tbody>
</table>
GOAL: Assess Profitability of Soil Health Systems

APPROACH: Calculate & Integrate Enterprise Budgets from On-Farm and Experimental Settings

Funders: USDA Natural Resources Conservation Service, Cargill

Partners: USDA Natural Resources Conservation Service
Policy, Conservation and Incentive Programs

Katie Harrigan and Alyssa Charney
https://soilhealthinstitute.org/resources/catalog/#farmbill.

Compared 2014 & 2018 Farm Bill funding for soil health

Additional incentives for cover crops and crop rotation

Mandates data collection and reporting on soil health

Soil health designated as a priority in the CSP

Promotes more soil health field trials and demonstrations

Changes to CRP make it more likely to continue soil health improvement post contract

The report summarizes 60 provisions in the 2018 Farm Bill related to soil health and lists authorized funding levels.
ESMC Founding Circle members include: ADM; Bunge; Cargill; Corteva Agriscience; Danone North America; General Mills; Land O’Lakes Inc.; McDonald’s USA; National Fish and Wildlife Foundation; Nestle; Noble Research Institute, LLC; Nutrien; The Nature Conservancy; the Soil Health Institute; and Syngenta. ESMC Legacy Partner members include: Almond Board of California; American Farmland Trust; American Soybean Association; Anuvia Plant Nutrients; Arizona State University; Arva Intelligence; Bayer; the Conservation Technology Information Center; Farm Foundation; Field to Market: The Alliance for Sustainable Agriculture; Impact Ag Partners; Mars, Inc.; National Association of Conservation Districts; National Corn Growers Association; National Farmers Union; NativeEnergy; Newtrient, LLC; OpenTEAM; Pivot Bio; Sand County Foundation; Soil Health Partnership; The Fertilizer Institute; Tatanka Resources; the Tri-Societies; Tyson Foods and World Wildlife Fund.

https://www.c-agg.org
Summary – Paul’s Perspective

1) Crop advisers and land managers are a vital link in providing highly productive & sustainable agroecosystems. Always have – Always will!

2) Soil health enhancing practices are required in today’s agriculture.

3) Non-agriculture-based segments of society will continue to look to us to lead the way. A golden opportunity to promote our value.

4) Economic opportunities centered around soil health are out there for those who seek them

5) Partnerships will be required as we move forward