Marlon Winger
USDA-NRCS Soil Health Division, MT, WY & ID

Enhancing Soil Health in Potato Systems Workshop
March 27-29, 2017
Ardmore, OK

Principles of Soil Health and Their Application
Goals of the new NRCS Soil Health Division

- **Leverage Partners**
  NACD, SARE, TNC, EDF, Soil Renaissance, ARS, SH Partnership, NIFA, Hatch, Colleges & Universities, Nonprofits, Industry …

- **Ensure Scientific Basis**

- **Evaluate Economics**

- **Quantify Benefits**

Soil health training

Soil Health Assessment

Soil Health Management Planning

Soil Health Management Systems Implementation

Observation, Adaptation
Soil health taught 2015-16
Soil Health
What is It?

• The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans
  – Nutrient cycling
  – Water (infiltration & availability)
  – Filtering and Buffering
  – Physical Stability and Support
  – Habitat for Biodiversity
Soil Health Principles

- Maximize duration living roots
- Minimize disturbance
- Maximize diversity
- Maximize cover
What is your resource concern?

“And then, this morning, I suddenly noticed she didn’t look so good”
“These fields are naked, hungry, thirsty and running a fever” (R. Archuleta)
Erosion from bare fields into river

Sediment runoff from conventional-till field

Sediment is still the largest water quality pollutant by volume

Oklahoma October 2012 I-35

Aberdeen ID 2013

Lubbock Texas Oct. 17, 2011
The Battle is Won or Lost Here
Reicosky et al., 1995
Working with Producers / Employees to:

• Regenerate our soils
• Understand the carbon cycle
• Realize the potential of a soil health system
• Knowledge changes our paradigms
• Identify and fix the symptom or problem
• Implement soil health principles
1. Minimize Soil Disturbance

- **Physical (tillage)**
  - Water and wind erosion – transport soil, nutrient & water
  - Ponding water, reduced infiltration
  - Crusting, breakdown of aggregate

- **Biological**
  - Overgrazing, limits ability to implement the carbon cycle
    (CO2 & sunlight)

- **Chemical**
  - Over application of nutrient and pesticide can disrupt the soil food web functions. (80 ppm P2O5 can’t get in the plant)
Will it work in furrow irrigated ground?
1,000 acres in Ada/Canyon county 2014 (6,000 in 2105)
Payette, ID 2014  no till wheat into corn silage residue flood irr
6 way mix: wheat, turnip, radish, soybean, cowpea, sudan grass
Planted: July 25, 2012
Marsing, ID
Deruyter dairy & McIntyre Farms

1,260 acres corn silage planted no till
1,260 acres fall triticale planted no till into silage residue
New pivot planted 5 way warm season mix, then no tilled fall triticale

Oct 31, 2012
No Till winter wheat into alfalfa stubble

Drilled 10-1-15
Yield 156 bu/ac???
McIntyre Farms, Caldwell Id
J. Parkinson, St. Anthony, ID
I’ve been doing the no-till for a couple of years now for wheat,” Parkinson said. “I thought, ‘Why wouldn’t it work for potatoes?’” Parkinson, who farms on the Egin Bench between Rexurg and St. Anthony, has highly erodible sandy-loam soil. “Wind erosion is a big problem for us here. That’s why I went into no-till,” Parkinson said. Within a 35-acre quarter of a pivot, Parkinson cut his wheat short at harvest, leaving residue and a couple of inches of stubble. After harvest, using his no-till grain drill, he direct-seeded radish into the stubble as a cover crop, planted solely for soil-health benefits. By the next spring, the cover crop had broken down. (Capital Press, Feb 9, 2016)

• Brendon Rockey, CO
Altieri M.A. The ecological role of biodiversity in agroecosystems. Agriculture, Ecosystems & Environment 74: 19-31
2. Keep the Soil Covered (Armored)

- Soil armor
- Reduce soil erosion
- Take E out of ET
- Moderates temperature
- Water drop energy dissipated
- Reduced sunlight to weed seeds
Simplot: Dr. Terry Tindall
Arena Valley, ID
cover crop: winter wheat – following potatoes
72% forage utilization
300 cows on 3 acres per day
If you can’t keep the soil covered then consider reducing the length of unsheltered distance.
Biofumigation
white mustard, oriental mustard, pacific gold
Strip Till Equipment

Schlagel

Orthman

Campbell Tractor sold 5, 12 row units in 2012

Twin Diamond, Strip-Cat
Soil and residue is undisturbed from harvest to planting except for a tilled strip of the crop row.

2011 sugar beet summer field day in Burley, ID
8 companies demonstrated strip till machines
Strip till; Pinto beans into wheat stubble, Hazelton, ID
Idaho Falls, Id
Stripper header

Nearly perfect residue mgt.
Wind erosion?
Capture your neighbors snow
Armor your fields
3. Maximize Diversity

- Native landscapes covered with abundant plant diversity
- Polyculture landscapes been replaced by monoculture annuals
- Rotations: high / low water use, tap /fibrous root, high / low carbon, legumes and non legumes
- Include 4 crop types back into rotations
  - WSG, WSB, CSG, CSB
Working With Mother Nature

Improving Soil Health
White worm casts on brown top soil

No till w. wheat into Alfalfa stubble
4. Maximize Duration of Living Root

• Cropland typically grows cool or warm season cash crops, dormant periods before and planting and/or after harvest.

• Cover crops: Harvest CO₂ provides C exudates
  – Builds aggregates – pore space – H₂O infiltration
  – Armor soil, soil erosion, soil temperature, rainfall compaction
  – Catch & release nutrients
  – Pollinator/predator food/habitat
  – Crop diversity – adjusts C:N ratio
McIntyre Farms: 2013
Caldwell, ID
Cover crop mix: Radish, Turnip, Sudangrass, Millet, Buckwheat, Oats, Soybean, Rape, vol wheat
Planted: 8/10/2013. Grazed beginning on 10-17-13,
End grazed: Dec 17, 2013; grazed for 61 days
No till drilled cover crop mix into winter wheat stubble
Clipped 13,684 lbs DM/ ac
23.1 % DM
CCPI – St.Anthony field office: 1,000 acres of cover crops

“If you do nothing you still have nothing”
Gabe Brown = 40 cover crops
Sid Hanks = 8 cover crops / 2 mixes
Some years you take what you can get! Maybe a biopore 12’ deep
Rexburg, ID 2013
J, Raybould – St. Anthony, ID
Planted 9/7/12
40 DAP = Oct 17
2014 St. Anthony
Sid Hanks, St Anthony – Oct 21, 2014

Cover crop: Annual Ryegrass after Potato harvest

Planted Sept 10, 2014

Planted Sept 28, 2014

3 No till drills purchased in Fremont and Madison counties -2014
8 producers that no tilled covers into grain stubble
3,772 acres planted to cover crops -2014 EQIP
1,000 acres planted to cover crops on their own - 2014

2014 Idaho: 29 EQIP contracts with cover crop – 8,950 acres
Arugula / Turnip
Planted after potato harvest

S. Hanks, Idaho: Turnip/ Pea
## Cover Crop Periodic Table

### Cool Season Plants

<table>
<thead>
<tr>
<th>Grass</th>
<th>Broadleaf Plants</th>
<th>Legumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oat (wk)</td>
<td>Arugula</td>
<td></td>
</tr>
<tr>
<td>Ryegrass</td>
<td>Flax (wk)</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>Rape</td>
<td>Turnip</td>
</tr>
<tr>
<td>Cereal rye</td>
<td>Phacelia</td>
<td>Radish (wk)</td>
</tr>
<tr>
<td>Triticale</td>
<td>Canola / Mustards</td>
<td>Beet</td>
</tr>
<tr>
<td>Forage Oat</td>
<td>Ethiopian Cabbage</td>
<td>African Cabbage (wk)</td>
</tr>
</tbody>
</table>

### Warm Season Plants

<table>
<thead>
<tr>
<th>Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl Millet (wk)</td>
</tr>
<tr>
<td>Safflower (wk)</td>
</tr>
<tr>
<td>Buckwheat (wk)</td>
</tr>
<tr>
<td>Goat (wk)</td>
</tr>
</tbody>
</table>

(wk) = winter killed

USDA is an equal opportunity provider and employer.
### Cool Season Early Cover Crop Seed rate PLS/A

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>Seed rate PLS/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barely</td>
<td>8</td>
</tr>
<tr>
<td>Oat</td>
<td>5</td>
</tr>
<tr>
<td>Lentil or Vetch</td>
<td>2</td>
</tr>
<tr>
<td>Pea</td>
<td>15</td>
</tr>
<tr>
<td>Clover, Crimson</td>
<td>1</td>
</tr>
<tr>
<td>Radish</td>
<td>1</td>
</tr>
<tr>
<td>Canola or Rape</td>
<td>1</td>
</tr>
<tr>
<td>Turnip</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34 Lbs / ac</strong></td>
</tr>
</tbody>
</table>

### Warm Season cover Crop Seed rate PLS/ac

<table>
<thead>
<tr>
<th>Crop</th>
<th>Seeding rate PLS/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl Millet</td>
<td>3</td>
</tr>
<tr>
<td>Sudangrass</td>
<td>4</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>3</td>
</tr>
<tr>
<td>Safflower</td>
<td>2</td>
</tr>
<tr>
<td>Radish</td>
<td>1</td>
</tr>
<tr>
<td>Turnip</td>
<td>1</td>
</tr>
<tr>
<td>Canola</td>
<td>1</td>
</tr>
<tr>
<td>Spring Lentil</td>
<td>2</td>
</tr>
<tr>
<td>Pea</td>
<td>15</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>33 lbs / ac</strong></td>
</tr>
</tbody>
</table>
Livestock Integration

• Animals, plants and soils- synergistic roles together
• Recent years animals placed in confinement
• Balance C:N ratios, convert high C to lower C:N ratio
• Harvest additional sunlight and CO$_2$
• Reduce nutrient export:
  – feed to feedlot vs cattle to the feed
• Manage weed pressure, grazing in lieu of herbicide
• Higher nutritional diets
• Reduce livestock waste
300 head of wild mother cows on 3 acres per day
Stock density: ~106,000 lbs / acre
Previous crop: winter wheat
Planned crop in spring 2014 grain corn
Not grazed / Grazed
April 29, 2014 evaluating soil of the cover crop field: Worms underneath decomposing cow pie. 165 worms per cubic foot. 7.2 million worms per acre.
Soil Health Comparison

Positive

• Improved Organic matter
  – Water holding capacity
• Increased diversity of rotation
• Took the E out of ET (D. Beck)
• Take the T out of Can’t (D. Beck)
• Nutrient cycling
  – Improved biology
• No Erosion (restorative system)
• Following the BIG 5 principals
# McIntyre Farms, Caldwell, ID

Measuring Soil Health – Haney Test

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</thead>
<tbody>
<tr>
<td>70 ac pivot 0702c</td>
<td>18.5</td>
<td>202.7</td>
<td>17.0</td>
<td>11.9</td>
<td>5.6</td>
<td>70 ac pivot 0702c</td>
<td>72.4</td>
<td>254.3</td>
<td>26.8</td>
<td>9.5</td>
<td>12.5</td>
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<tr>
<td>6 ac 0703c</td>
<td>11.6</td>
<td>215.0</td>
<td>17.8</td>
<td>12.0</td>
<td>5.1</td>
<td>6 ac</td>
<td>60.1</td>
<td>248.5</td>
<td>32.0</td>
<td>7.8</td>
<td>11.7</td>
</tr>
</tbody>
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Gaining Knowledge and Humility!

McIntyre brothers and Ray Archuleta
Measuring Soil Health – Haney Test  
C. Williams, Grace, ID

Hay field results – becoming Carbon poor

<table>
<thead>
<tr>
<th>Year</th>
<th>1-day CO2-C</th>
<th>Organic C</th>
<th>Organic N</th>
<th>Organic C:N</th>
<th>Soil Health Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>52.69</td>
<td>288.08</td>
<td>33.69</td>
<td>8.55</td>
<td>12.41</td>
</tr>
<tr>
<td>2015</td>
<td>40.8</td>
<td>217.6</td>
<td>30.7</td>
<td>7.1</td>
<td>9.3</td>
</tr>
<tr>
<td>2016</td>
<td>43.1</td>
<td>75.0</td>
<td>11.9</td>
<td>6.3</td>
<td>6.3</td>
</tr>
</tbody>
</table>
Managing for Soil Health

• Minimize disturbance of the soil (mechanical, biological, chemical)
• Keep the soil covered at all times with plants and plant residues
• Maximize diversity of plants in rotation/cover crops
• Keep living roots in the soil as much as possible
• Integrate livestock into the farming system
• Create the most favorable habitat possible for the soil food web