Advances in Dryland Farming in the Inland Pacific Northwest

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The Advances Team
Advances in Dryland Farming in the Inland Pacific Northwest

1. Climate Considerations
2. Soil Health
3. Conservation Tillage Systems
4. Crop Residue Management
5. Rotational Diversification and Intensification
6. Soil Fertility Management
7. Soil Amendments
8. Precision Agriculture
9. Integrated Weed Management
10. Disease Management for Wheat and Barley
11. Insect Management Strategies
12. Farm Policies and the Role for Decision Support Tools
Regional Approaches to Climate Change (REACCH)

OBJECTIVE:
Ensure sustainable cereal production in the inland Pacific Northwest under the risks of regional climate change

APPROACH:
Interdisciplinary research and extension, investigating complex systems and responses to drivers of change
REACCH Conceptual Framework and Logic Model

**Situation**
- Changing climate
- Diverse socio-economics
- Soil quality/erosion concerns
- Low crop diversity
- Increasing demand

**Inputs**
- Diverse expertise and resources
  - K-12 curriculum development
  - Undergraduate internships
  - Integrated graduate education

**Activities**
- Downscaled climate models
  - Transdisciplinary framework
  - GHG, C, N, water monitoring
  - Dynamic AEZs
  - Long-term experiments
  - Biotic factor monitoring and modeling
  - Socioeconomic description

- Develop diverse extension platforms
  - Cyberinfrastructure development

**Outputs**
- Integrated models/scenarios
  - RAPs/AEZ/LCA/CropSyst
  - C, N, water, energy budgets
  - GHG flux models
  - Recommended climate-friendly strategies
  - Assessment of socioeconomic environment’s capacity to support change

- K-12 curricula
  - Trained graduate and undergraduate students

- Webinars
  - Apps
  - Field days
  - Publications
  - Interactive tools

- Networks and cyberinfrastructure

**Outcomes and Impacts**
- Decreasing GHG emissions
- Increasing N, water, and energy efficiency
- Improving tillage and residue management practices
- Crop diversification
- Utilization of decision tools
- Trained scientists and educators
- Increased grower knowledge

- RAPs/CropSyst/LCA/AEZ
- Improved understanding of biotic factors
- Long-term experiments
- Data and data archives

**Impacts beyond REACCH:** National and international connections and framework for long-term interdisciplinary research
History Behind Advances

http://pnwsteep.wsu.edu/tillagehandbook/
Building Soil Health

**Long standing challenges:**
Soil erosion, soil organic matter (SOM) depletion, and consequent soil fertility loss

**Diversity of regional agriculture:**
Climate and topography variability makes identifying best management practices difficult

**What does it mean to manage for soil health?** *Build and maintain soils to function as a living ecosystem that sustains plants*
Chapters Related to Soil Health in Advances

1. Climate Considerations
2. Soil Health
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Agroecological Classes (AECs) of the inland PNW

Image credit: Huggins et al. in preparation
# Dryland Agroecological Classes (AECs)

<table>
<thead>
<tr>
<th>Class</th>
<th>Percent Fallow</th>
<th>Common Grower Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Crop ▪️</td>
<td>&lt;10% fallow</td>
<td>3- or 4-year crop sequence; e.g., winter wheat-spring wheat, or barley-spring broadleaf, or winter wheat-spring grain-winter wheat-spring broadleaf.</td>
</tr>
<tr>
<td>Annual Crop-Fallow Transition ▲</td>
<td>10–40% fallow</td>
<td>2- or 3-year crop sequence; e.g., winter wheat-fallow or winter wheat-spring wheat-fallow. Crop choice is more limited by available water.</td>
</tr>
<tr>
<td>Grain-Fallow ■</td>
<td>&gt;40% fallow</td>
<td>Typical 2-year crop sequence is winter wheat-fallow. Growers rely on fallow practices to store and retain winter precipitation in the soil profile to establish winter wheat.</td>
</tr>
</tbody>
</table>
Projected climate change:
Increases the importance of a focus on sustainable management practices

(Figure courtesy of John Abatzoglou)
Practices that enhance soil health

- Reducing tillage
- Cropping intensification and diversification
- Enhancing crop residue retention
- Applying organic amendments
Assessing Soil Health

<table>
<thead>
<tr>
<th>Physical</th>
<th>Chemical</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Soil color</td>
<td>✓ Organic C and N</td>
<td>✓ Soil respiration</td>
</tr>
<tr>
<td>✓ Aggregate stability</td>
<td>✓ Particulate organic matter</td>
<td>✓ Potential mineralizable nitrogen</td>
</tr>
<tr>
<td>✓ Water infiltration</td>
<td>✓ Active carbon</td>
<td>✓ Microbial biomass</td>
</tr>
<tr>
<td>✓ Bulk density</td>
<td>✓ pH</td>
<td>✓ Soil enzymes</td>
</tr>
<tr>
<td>✓ Penetration resistance</td>
<td>✓ Cation exchange capacity and base saturation</td>
<td>✓ Earthworms</td>
</tr>
<tr>
<td>✓ Water-holding capacity</td>
<td>✓ Electric conductivity</td>
<td>✓ Crop condition, root growth</td>
</tr>
<tr>
<td>✓ Runoff and erosion</td>
<td>✓ Heavy metals</td>
<td>✓ Weed and disease pressure</td>
</tr>
<tr>
<td>✓ Rooting depth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure adapted from Busacca and Montgomery 1992
Soil Aggregate Stability

a) Aggregated soil

Soil infiltration

b) Soil seals on breaking aggregates

Runoff

(Magdoff and Van Es 2009)
Soil Water Dynamics: Infiltration, Hydraulic Conductivity, and Water Content

Table 2-6. Mean annual ground cover, runoff, and soil erosion measured for two tillage systems near Pendleton, Oregon.

<table>
<thead>
<tr>
<th>Tillage</th>
<th>‡Cropping systems</th>
<th>Ground cover</th>
<th>Runoff</th>
<th>Soil erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>WW-ChF-WW-CP/SP</td>
<td>73</td>
<td>1.46</td>
<td>0.10</td>
</tr>
<tr>
<td>Conventional</td>
<td>WW-F</td>
<td>44</td>
<td>3.15</td>
<td>4.90</td>
</tr>
</tbody>
</table>

SLR: soil loss ratio, an indicator of wind erosion with 0 = no erosion and 1 = maximum erosion potential. (Adapted from Feng et al. 2011)
Soil pH:
N fertilizer has decreased soil pH in the PNW

To increase soil pH: retention of residues, application of manure, compost, and alkaline biochar

(Adapted from Machado et al. unpublished.)
Annual crop fallow transition AEC
Cation exchange capability under different treatments

![Bar chart showing CEC (meq/100 g soil) for different treatments]

- **N fertilizer 0 lb/acre**: 6.40
- **N fertilizer 80 lb/acre**: 5.95
- **Pea Vines 30 lb/acre**: 6.40
- **Beef Manure 100 lb/acre**: 7.00
- **Grass Pasture 0 lb/acre**: 7.15

(Adapted from Bandick and Dick 1999.)
Soil Organic Matter

Management
- tillage
- residue
- fertilizer
- irrigation
- rotation
- lime
- manure
- pesticides

Carbon Inputs
- residues
- manure
- compost

Carbon Outputs
- decay
- leaching
- erosion

SOM turnover
Microorganisms play important roles:
• Nutrient cycling and retention
• Formation of soil aggregates
• Degradation of agricultural pollutants
• Disease suppression
• Indicators of soil health
• Bacteria and fungi are agents for biochemical transformation of organic matter

(Adapted from Eickhorst and Tippkoetter 2016.)
Soil Fauna: Earthworms, Nematodes, and Soil Insects

Worm excrement (cast) increases soil microbial activity and soil aggregate stabilization.

Effect of tillage on mean earthworm density under winter wheat-spring barley-spring pea (WW-SB-SP) rotation in northern Idaho

(Adapted from Johnson-Maynard et al. 2007.)
Factors contributing to loss of SOM in the inland PNW

- Low quality and quantity of crop residue inputs
- Crop residue removal (for biofuel, bedding for animals, mushroom cultivation)
- Residue burning
- Limited biomass production due to low precipitation
- Multiple tillage operations causing increased biological oxidation of SOM
- Farming on steep slopes (up to 45%), accelerating soil erosion

Photo Credits (L-R): Emily Lincoln USFS Rocky Mountain Research Station; Indian Institute of Horticultural Research; Charles Knowles, all photos © creative commons by NC 2.0
Soil Health Assessment

Selection of indicators based on management goals

Interpretation of Indicators
(Scoring Function)

Integration
(Calculate Soil Health Index)

(Adapted from Andrews et al. 2004.)
Grower Considerations: Opportunities to Improve and Maintain Soil Health

- Conservation tillage (Ch. 3)
- Minimize bare-fallow systems with alternative cropping systems such as chemical-fallow, annual cropping, and cover cropping (Ch. 5)
- Increase residue retention and cover (Ch. 4)
- Increase cropping intensification and diversity (Ch. 5)
- Use efficient fertilization to minimize nutrient loss (Ch. 6)
- Apply of organic amendments such as manure, compost, residues (Ch. 7)
- Apply of lime and alkaline biochar to address soil acidity (Ch. 6)
Conservation Tillage Approaches

1. Ridge-tillage
2. Mulch-tillage
3. No till/ chemical fallow
4. Reduced tillage
5. Undercutter tillage

Additional conservation systems:
1. Three-year rotation and annual cropping
2. Flexible cropping (Flex cropping)
Use of Conservation Cropping Systems is Expanding in the Inland PNW

- Conventional tillage: 24.6%
- Conservational tillage: 39.4%
- No-till: 30.2%
Residue Management to Support Soil Health

- Residue incorporated into the soil
- No till
- Residue returned to soil after tillage

(Adapted from Williams and Wuest 2014)
Alternate Crop Opportunities

Oilseeds • Winter Legumes
Winter Triticale • Cover Crops

• Rotational Benefits
• Greater crop choice

Challenges
• Rotational fit (stand establishment, weed management & herbicide carryover)
• Market price variability

‘Windham’ winter peas near Ritzville (Photo: S. Guy)

Cattle grazing dual-purpose canola near Ritzville (Photo: K. Sowers.)
Soil amendments (biosolids and manure) slow carbon losses

(Adapted from Young and Pan 2015)
Improvement in soil quality with organic amendments in dryland crop production

- **Physical quality**: Bulk density, water infiltration, and aggregate stability
- **Chemical quality**: Organic C and N, pH, available P, available K, Zn
- **Biological quality**: Mineralizable C and N, fungal activity, microbial biomass, enzyme activity, bacteria: fungi ratio, earthworm population

Agricultural sustainability, Environmental quality, Economic viability
<table>
<thead>
<tr>
<th>Issues</th>
<th>Adaptive Strategies</th>
</tr>
</thead>
</table>
| **Annual Crop** | • High productivity  
• Steep slopes and erosion Reduced tillage  
• Persistent grass weeds  
• Cold wet springs | • No-till  
• Winter legumes  
• Spring canola and other oilseeds  
• Herbicide-resistant canola  
• Cover crop  
• Perennial crops |
| **Transition** | • Moderate productivity  
• Erosion (wind and water)  
• Deficient seed zone moisture  
• Reduced tillage  
• Persistent winter annual grass weeds  
• Areas of shallow soils | • No-till or improved fallow practices (e.g., tall cereals, stripper header, undercutter method)  
• Diversify  
• Flex crop (intensification)  
• Cover crop |
| **Grain Fallow** | • Poor soil health; low productivity & residue  
• Reliance on fallow  
• Erosion (wind)  
• Intensive tillage  
• Persistent winter annual grass weeds  
• Marginal profitability | • Diversify winter wheat phase  
• Winter triticale, barley, pea, lentil, canola  
• Facultative wheat or barley  
• Flex crop with adequate moisture  
• Cereal or broadleaf  
• Improved fallow practices |