Advances in Dryland Farming in the Inland Pacific Northwest

Chad Kruger, Ian Burke, Stephen Machado, Georgine Yorgey, and Karen Hills
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
- Developing diverse extension platforms
- Stakeholder engagement
- Cyberinfrastructure development

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

## 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

## 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

## Increased knowledge, infrastructure, trained scientists and educators, and resources

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

http://pnwsteep.wsu.edu/tillagehandbook/
Fertility management strategies vary across the landscape
Fertility affected by rainfall and nutrient use efficiencies

Practices that maximize nitrogen use efficiency:
Fertilizer placement, source, timing, and rates that match crop species’ nitrogen needs

Weed, pest and disease pressures are variable and ever-changing
There are a wide range of management strategies to address pest pressures– need more assessment of impacts and tradeoffs of specific strategies
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. Integrated Disease Management
11. Integrated Insect Management
12. Farm Policies and the Role for Decision Support Tools
Soil Fertility Management

• Variable growing conditions impact crop yield and complicate nutrient management strategies
• Improper use of fertilizer leads to nitrogen losses, soil erosion and nutrient runoff, and decreasing soil pH
• There is a need for farm-specific management approaches, regular soil testing, and detailed record-keeping
## Nutrient Supply and Removal in Harvested Grain Across the Main Wheat-producing Counties of the Inland Pacific Northwest

<table>
<thead>
<tr>
<th>Nutrient Source</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>commercial *</td>
<td>143,570</td>
<td>41,439</td>
<td>30,172</td>
</tr>
<tr>
<td>recovered manure**</td>
<td>1,377</td>
<td>2,013</td>
<td>6,242</td>
</tr>
<tr>
<td>biologically fixed by legumes**</td>
<td>25,322</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total nutrient supply</td>
<td>170,269</td>
<td>43,452</td>
<td>36,414</td>
</tr>
<tr>
<td>crop removed**</td>
<td>171,203</td>
<td>63,331</td>
<td>102,602</td>
</tr>
<tr>
<td>balance (supply - removed)</td>
<td>-934</td>
<td>-19,879</td>
<td>-66,188</td>
</tr>
<tr>
<td>removal ratio (removal/supply)</td>
<td>1.01</td>
<td>1.46</td>
<td>2.82</td>
</tr>
</tbody>
</table>


**Farm census data from United States Department of Agriculture National Agricultural Statistical Service (USDA-NASS) Census of Agriculture, summarized by IPNI.
Grain Yield Versus Nitrogen Supply at Different Points Along a Hillslope

(Fiez et al. 1994b.)
Basic Nitrogen Fertilizer Rate Calculation

Step 1:
The amount of N fertilizer needed per acre of wheat can be calculated by multiplying the anticipated yield goal by the unit N required (UNR). Yield goals and UNRs already account for plant available water and grain protein, respectively.

Yield Goal (bushels/acre) x UNR (pounds of N/bushel) = N fertilizer required (pounds of N/acre)

Step 2:
Account for residual soil N contributions in the soil profile to a depth of 5 feet. Residual N can be measured with soil tests and should be calculated prior to applying fertilizer.

Pounds of N fertilizer required per acre (from Step 1) – Residual Soil N (pounds of N/acre) = N fertilizer recommendation (pounds of N/acre)

Adapted from Koenig 2005; Lutcher et al. 2005; Mahler 2007.
Relationship Between Available Water and Grain Yield of Dryland Wheat in Eastern Washington

Recent study (1993-2005)
\[ y = 5.8x - 13.5 \]
\[ r^2 = .74 \]
\[ P < .001 \]
\[ n = 175 \]

Leggett (1953-1957)
\[ y = 5.6x - 22.3 \]
\[ r^2 = .72 \]
\[ P < .001 \]
\[ n = 90 \]
Integrated Approach to N Recommendations:

Adapted from Pan et al. (2016) and Pan (2015)
N Uptake by Wheat Estimated by Growth Stage

(Adapted from Waldren and Flowerday 1979)
Fertilizer Efficiency and Availability at Different Soil pH Levels

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>% Fertilizer Efficiency</th>
<th>% Fertilizer Unavailable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>7.0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6.0</td>
<td>89</td>
<td>52</td>
</tr>
<tr>
<td>5.5</td>
<td>77</td>
<td>48</td>
</tr>
<tr>
<td>5.0</td>
<td>53</td>
<td>34</td>
</tr>
<tr>
<td>4.5</td>
<td>30</td>
<td>23</td>
</tr>
</tbody>
</table>

(Modified with permission from The Mosaic Crop Nutrition Fertilizer Use Guide 2016)
Integrated Weed Management

A decision support system for assisting a grower in identification, selection, and use of weed control tactics

Requires:
1) Knowledge and application of ecological principles
2) Knowledge of plant interference and crop-weed competition
3) Use of thresholds
4) Integration of multiple control techniques
Community Associated with a Wheat Plant

Nontrophic linkage → Trophic linkage

- Generalist Predators
- Herbivores
- Pathogens
- Saprophages Earthworms Microbes
- Weeds
- Phytophagous Nematode
- Wireworms
- Fungal Pathogens
- Viral Pathogens
- Aphids
- Aphid parasitoids
- Hessian fly parasitoids
- CLB parasitoids
- Cereal leaf beetle
- Other folivores/ granivores

Soil
- Plant available nutrients
- Unavailable nutrients/SOM

Management + Inputs
- N
- Other nutrients
- Tillage

Wheat root

Wheat shoot

Wheat grain

Yield

Climate inputs
- Precip
- CO₂
- Solar Rad.
- Therm.

Social/economic
Developing an Integrated Pest Management System

- Problem diagnosis
- Program execution
- Method evaluation
- Program selection
Ecological Principles of Weed Management

1. Weed ecology
2. Climate change impacts
3. Weed life cycles
4. Weed reproduction and dispersal
5. The weed seedbank
6. Interactions between weeds and other crop pests
Weed Management

1. Preventative

2. Cultural: crop rotation, in-season crop competitiveness, competitive cultivars, seeding rate, row spacing, fertilization, varying seeding date

3. Mechanical: primary and secondary tillage

4. Chemical weed management
   - Societal and environmental considerations
Selected Problematic Weeds

- Downy brome
- Russian thistle
- Jointed goatgrass
- Italian ryegrass

Photo credits, clockwise from top left: brandyb © creative commons BY NC 2.0; desertusa.com © creative commons BY NC 2.0; Massey University NZ © creative commons BY NC 2.0; USDA © creative commons BY NC 2.0
Types of Pathogens Affecting PNW Small Grains

• Foliar or head

• Root-infecting fungal pathogens and nematodes

• Viral

Characteristic yellow striping of Cephalosporium stripe disease. (Photo: Tim Murray)
Selected Diseases or Pathogens Of Wheat and Barley

- Stripe Rust
- Rhizoctonia Root Rot
- Pythium Root Rot
- Fusarium Crown Rot
- Eyespot
- Cephalosporium Stripe
- Root-Lesion & Cereal Cyst Nematodes
- Take-all
- Wheat Soilborne Mosaic
- Barley Yellow Dwarf
### Cropping System Practices that Impact Disease Management in the Inland PNW

Table 1. Cropping system practices that can impact (+) disease management in the PNW, or that have no effect or are not available (-).

<table>
<thead>
<tr>
<th>Disease</th>
<th>Cultural practices</th>
<th>Variety selection</th>
<th>Chemical control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Foliar</td>
</tr>
<tr>
<td>Stripe rust</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Eyespot</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cephalosporium stripe</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fusarium crown rot</td>
<td>+</td>
<td>+/-</td>
<td>-</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Snow molds</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Barley yellow dwarf</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Take-all</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cereal cyst nematode</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Root-lesion nematode</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Adapted from Murray (2016). Green boxes indicate greatest impact.
Table 2. Cultural management practices that impact disease incidence.

<table>
<thead>
<tr>
<th></th>
<th>Seeding date</th>
<th>Tillage</th>
<th>Green bridge</th>
<th>Fertility</th>
<th>Soil pH</th>
<th>Crop rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter</td>
<td>Spring</td>
<td>MinTill</td>
<td>NoTill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stripe rust</td>
<td>↓L</td>
<td>↓E</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Eyespot</td>
<td>↓L</td>
<td>-</td>
<td>↓</td>
<td>↓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cephalosporium stripe</td>
<td>↓L</td>
<td>-</td>
<td>-/+</td>
<td>↑</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>+/-E</td>
<td>+/-L</td>
<td>-/+</td>
<td>↑</td>
<td>+</td>
<td>-/+</td>
</tr>
<tr>
<td>Fusarium crown rot</td>
<td>↓L</td>
<td>-</td>
<td>-</td>
<td>↑↓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>↓E</td>
<td>↓L</td>
<td>-</td>
<td>↑</td>
<td>+</td>
<td>-/+</td>
</tr>
<tr>
<td>Snow molds</td>
<td>↓E</td>
<td>↓L</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barley yellow dwarf</td>
<td>↓L</td>
<td>↓E</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Take-all</td>
<td>↓L</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cereal cyst nematode</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Root-lesion nematode</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: Adapted from Murray (2016).

Key: (↑) Practice can favor pathogen; (↓) Practice can reduce risk; E=early and L=late; (+) Practices can impact management; (-) Practices do not impact management or are unavailable; Tillage impact is relative to conventional tillage.
Insect Pests Affecting Inland PNW Systems

- Pressures vary across the region and year-to-year
- Collecting information about biology and life cycles, types of injury to crops
- Various farming practices can affect each pest
- Must anticipate possible changes in pressure from pests

Representative photos of adult aphids, courtesy Kansas Department of Agriculture

*Tools and guidelines to identify and manage different aphid species in the region*
Insect Pests: Status, Life Cycle, Impacts, Control Strategies

- **Hessian fly larvae**, Photo credit: Dennis Schotzko, University of Idaho
- **Adult female *Collops* beetle**, Photo credit: Brad Stokes, University of Idaho
- **Adult cereal leaf beetle**, Nate Foote, University of Idaho
- **Black cutworm larva**, Photo Credit: John Capinera, University of Florida
### Effects Of Climate Change On Cereal Pests

<table>
<thead>
<tr>
<th>Pest</th>
<th>Effects on cereal production</th>
<th>Observed and projected impacts of Climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal aphids</td>
<td>vectors of Barley yellow dwarf virus</td>
<td>Flights of these aphids are influenced by weather and have been occurring earlier (Halbert et al. 1985; Davis et al., in preparation). Phenology of their flights and vulnerable stages of spring or winter wheat could shift with climate, affecting prevalence of the disease caused by this virus (Halbert et al. 1985).</td>
</tr>
<tr>
<td>Cereal leaf beetle (CLB) Oulema melanopus</td>
<td>invasive pest</td>
<td>Projected climate conditions may be more favorable for CLB, at the same time the phenological overlap between this pest and a successful biological control agent, the parasitoid wasp (Terastichus julis) (Roberts and Rao 2012), is largely unaffected or increases under projected climates (Eigenbrode and Abatzoglou, in preparation). Warmer springs were associated with lower rates of T. julis using a 10-year record of surveys in Utah, suggesting that longer term warming trends could hamper CLB control (Evans et al. 2012).</td>
</tr>
<tr>
<td>Pest caterpillars</td>
<td></td>
<td>Reproduction by the parasitic wasp, Cotesia marginiventris, which attacks many species of pest caterpillars including those affecting NW crops, was found to be reduced drastically by a 3 °C (5.4 °F) increase in summer temperatures, potentially disrupting biological control and allowing pest numbers to increase (Trumble and Butler 2009).</td>
</tr>
</tbody>
</table>
Contact:

Chad Kruger, Center for Sustaining Agriculture and Natural Resources, Washington State University
cekruger@wsu.edu

Request a Copy!

reacchpna.org
pubs.wsu.edu