Crop Diversity and Intensity in the Dryland PNW: Current Status and Future Opportunities

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Stephen Machado, CBARC
Trans-disciplinary project aimed at ensuring the long-term viability of cereal-based farming in the inland Pacific Northwest amid a changing climate

### Mitigation and Adaptation Strategies

- Nitrogen Management
- Diversify/Intensify Cropping
- Reduced Tillage/Direct Seed
- Organic Amendment Recycling
Agro-ecoregions and zones

Unique zones and regions often defined by major biophysical drivers (e.g. climate, geology, physiography, soil, native plant communities)

- EcoRegions (US EPA)
- NEON Domains (Hargrove et al., 2006)
- Hydrologic Units (USGS)
- Major Land Resource Areas (NRCS)
- Agronomic Zones iPNW (Douglas et al., 1992)
Land Use Classification

- **Strengths:**
  - Zones classified using integration of relatively stable data layers of biophysical drivers (e.g., Climate, Soil, Native vegetation)

- **Weaknesses:**
  - Boundaries relatively static
  - Weighting importance of biophysical drivers is uncertain
  - Relevancy to managed ecosystems?
    - Zones often contain diverse land uses and management practices
Dynamic Agro-Ecological Classes (AECs)

- Establish land use baseline and the capacity to evaluate shifts in land use over time (e.g. diversification, intensification)
- Develop geospatial land use context for research, education and outreach activities

Grain-Fallow  Annual Crop-Fallow Transition  Annual Cropping
Defining Dynamic AECs

- Assumes that agricultural systems and land uses have emerged as a consequence of biophysical and socioeconomic drivers.

Major AECs defined:
1. Annual Cropping (<10% fallow)
2. Annual Crop-Fallow Transition (10-40% fallow)
3. Grain-Fallow (>40% fallow)

- Major AECs can be derived annually from NASS cropland data layer.

![2010 Cropland Data Layer](image)
Dynamic AECs (D. Huggins et al.)

2007 Agroecological Zones for the REACCH Study Area

Legend
- Research Sites
- AEZ
- Annual Crop
- Annual Crop - Fallow Transition
- Grain - Fallow
- Irrigated
- Douglas et al., 1992 Agroclimatic Zones
- Rivers

2009 Agroecological Zones for the REACCH Study Area

Legend
- Research Sites
- AEZ
- Annual Crop
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- Irrigated
- Douglas et al., 1992 Agroclimatic Zones
- Rivers
Agro-Ecological Classes, 2007

**Annual Cropping**
- 1.38 million ac
- MAP = 22 in

- **W. Wheat**: 49
- **S. Wheat**: 10
- **S. Barley**: 14
- **S. Lentil**: 7
- **S. Pea**: 4
- **S. Garbanzo**: 5
- **Canola**: 1
- **Fallow**: 3

**Annual Crop-Fallow Transition**
- 1.38 million ac
- MAP = 17.7 in

- **W. Wheat**: 28
- **S. Wheat**: 14
- **S. Barley**: 7
- **S. Lentil**: 2
- **S. Pea**: 1
- **S. Garbanzo**: 0.3
- **Canola**: 0.3
- **Fallow**: 0.2

**Grain-Fallow**
- 2.68 million ac
- MAP = 11.8 in

- **W. Wheat**: 47
- **S. Wheat**: 2
- **S. Barley**: 5
- **S. Lentil**: 0.7
- **S. Pea**: 0.0
- **S. Garbanzo**: 0.1
- **Canola**: 0.8
- **Fallow**: 0.4
- **0.1**: 0.7
Grain-Fallow AEC: Issues

Water

- Reliance on stored soil water (fallow)
- Seed-zone water

Winter annual grass weeds

- Feral rye
- Downey brome
- Jointed goatgrass

Annual spring cropping not proven economical (D. Young)

- NT annual HRSW averaged returns over total costs about $40/ac less than WW/SF at Ralston, WA

Wind erosion

Visibility dropped to zero in parts of eastern WA on October 4, 2009
## Alternatives to Conv. Wheat-Fallow

- Moro, MAP 9 in 2005-2010
- Winter wheat yield reduction (36%) following winter peas

### Cropping System

<table>
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<tr>
<th>Cropping System</th>
<th>Av. Profit ($/rot. ac)</th>
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<tr>
<td>Chem. F-WW</td>
<td>8.28a</td>
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<tr>
<td>Conv. F-WW</td>
<td>2.26a</td>
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<tr>
<td>Chem. F-WW-SB</td>
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<td>Cont. SW</td>
<td>-29.86b</td>
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<tr>
<td>WW-WP</td>
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<td>Cont. SB</td>
<td>-49.21b</td>
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<tr>
<td>Cont. WW</td>
<td>-52.40b</td>
</tr>
</tbody>
</table>

S. Machado, D. Young
Grain-Fallow AEC: Strategies

- **Alternative winter crops**
  - Winter triticale
  - Winter canola
  - Winter pea
  - Facultative wheat

- **Equipment**
  - Stripper header
  - New drill design

![Diagram showing proportion of different crops and equipment]
Grain-Fallow Strategies: W. Triticale

- Early-planted WT produced average of 18% greater grain yield than early-planted WW
- Late-planted WT produced equal grain yield as early-planted WW at Ritzville (4 yrs)

W. Schillinger
The Rise of the Canola Industry

- Washington Biofuels Cropping Systems Team

Dr. Bill Pan
WSU
Grain-Fallow Strategies: W. Canola

- Winter canola established into heavy winter triticale residue
  - Reduced soil temperature and wind speed leads to more soil water retention
  - More uniform soil water in no-tillage

Ralston, WA

F. Young and L. Young
Grain-Fallow Strategies: W. Canola

- Early seeding winter canola in fallow
  - Bigger plants going into winter
  - Wider window to sow when seed-zone water available
  - Tradeoff: deep soil water depletion may stress plant

W. Schillinger, M. Reese
Grain-Fallow Strategies: W. Canola

- Management of feral rye in winter canola

Infestation of feral rye in w. canola field near Okanogan, WA; before and after fall glyphosate app.
Annual Cropping

✓ Steep slopes
✓ High grain yield
✓ Post-harvest residue loads also high

Unique Agricultural Challenges
Canola in Annual Cropping Systems

- Spring canola well adapted to residue
- Aids weed mgmt.
- Early seeding spring canola boosts yields

Cook Agronomy Farm, 9 year avg. 2200 kg/ha

D. Huggins
Canola yield (kg/ha) = 4.8 kg/ha x precip (mm) - 813 kg/ha for veg. bio.

N Supply (soil + fert. N kg/ha) = [11 x canola yld (100 kg/ha)] + 32 kg N/ha for veg. bio. N

Wilke Farm and PCFS
T. Maaz, A. Hammac, W. Pan
Tracking Canola production

- Annual Cropping
- Annual Crop Fallow Transition
- Grain-Fallow
- Total Canola

Canola (ha)

Year

2007 2008 2009 2010 2011 2012 2013
Winter Pea in Fallow Systems

- WW-SW-F vs. AWP-SW-F
- Ritzville, WA: 11-13 in annual precip.
- Good winter hardiness in AWP
- 2011-2013 avg AWP yield= 2225 lbs/ac

Winter Wheat    Austrian Winter Pea
Replacing Fallow with Spring Pea

- Pendleton, 17 in MAP
- S. pea yields 750-3,000 kg/ha
- Winter wheat yield similar after fallow or pea

Fig. 1. Comparisons of wheat yields following fallow and dry peas at Columbia Basin Agricultural Research Center, Pendleton, OR, (2000-2006). Means with similar letter are not significantly different

S. Machado
Annual cropping (CAF, Pullman, WA)
Crop Net Returns, 2006 (Painter et al., 2007)

Precipitation
Sept. 1 to Aug. 31
530 mm (21 in)

Net Returns, 2006 ($/ac)
-225 - -100
-100 - -50
-50 - 0
0 - 50
50 - 100
100 - 200
200 - 455

WW
81 bu/ac
12.0%

SW
51 bu/ac
14.3%
Annual Cropping: Grain Legumes

- Spring garbanzo bean (Chickpea) returns greater than winter wheat (2009)  K. Painter
Trends in grain legumes (garbs, pea, lentil)
Future AEC shifts

- Prediction of AEC shifts due to climate change using bioclimatic variables (Precipitation, GDD)

H. Kaur

RCP 4.5, 2056-2065

RCP 8.5, 2056-2065
Current, future efforts

- Crop modeling linked to assessing ecosystem services, decision aids

C. Stockle

- soil
- weather
- cropping systems
- management

- biomass
- Yield
- GHG emissions
- \( \Delta \text{SOC} \)
- water, N, C balance
Current, future efforts

- Long-Term Agroecosystem Research (LTAR)
USDA LTAR Funding
(March 5, 2014)

• USDA-ARS FY 2014 budget
  – Land Management and Water Conservation Research Unit;
  – Renamed: **Northwest Sustainable Agroecosystems Research Unit**
  – Addition to base funds (annual)
    • $180,000 for LTAR
    • $810,000 for “sustainable systems”
    • Cook Agronomy Farm LTAR: Knowledge Intensive Precision Agro-ecology
Precision Farming

Problem: Lack science-based decision support for precision N management
LTAR Related Activities

- **Farm**: purchased state-of-the-art precision fertilizer application equipment (Exactrix)

- **Field equipment upgrades**: auto-boom for sprayer, weigh wagon, quad-track
Progress and Future Activities

- Augmented WSU AgWeatherNet in dryland cropping locations to aid crop simulation research supporting farmer decisions including flex-cropping and diversification.

- **Field monitoring:** water quality—continuous *in-situ* sensors for P and N, portable velocity meter, rain gauge, specialized soil sampling equipment.
Thank you,
Questions?

Photo: David Barton
Shannon’s Diversity Index

\[ H = \sum_{n=1}^{s} (Pi \times \ln Pi) \]
AEC Diversity

Shannon’s Diversity Index (H)

Graph showing the diversity index over the years for different land use categories: Annual Cropping, Annual Cropping Fallow Transition, Grain Fallow, Annual Cropping, Annual Crop Fallow Transition, Grain-Fallow, and Total Fallow.