Crop diversity and intensity in Pacific Northwest dryland cropping systems

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Increasing cropping system diversity (e.g., developing different crop options) as well as intensity (e.g., less fallow) are two strategies that can help both mitigate climate change and provide options for adaptation. Relevant questions include (1) How can we assess cropping system diversity and intensity from a regional perspective? (2) What REACCH research efforts are addressing this issue? and (3) What is our current situation and future prognosis under climate change?

IMPACT

Growers will benefit from more crop options that diversify and intensify current cropping systems. REACCH efforts are helping to define agronomic factors and advance the feasibility of alternative cropping system strategies. In turn, these research efforts will contribute to the development of cropping systems that help mitigate climate change as well as provide options for adapting to future shifts in weather and economic uncertainties.

Dryland cropping systems

Decisions regarding crop choice are a function of interactive biophysical (e.g., precipitation, soil) and socioeconomic (e.g., commodity prices, fertilizer costs) factors and are expressed geographically through land use and cover. Spatially georeferenced cropland use/cover data are available annually for the REACCH region since 2007 through the National Agricultural Statistics Service (NASS) (Figure 1). We have used these data to define relevant agroecological classes (AECs), consisting of three dryland AECs and one irrigated AEC, for the REACCH region (Figure 2). Once defined, crop choices and shifts in cropland use/cover as well as AECs can be characterized over time (Figures 2 and 3).

The grain-fallow AEC comprises the largest acreage, nearly twice that of the annual cropping and annual crop-fallow transition AECs. Winter wheat is the predominant crop grown. In the annual cropping AEC, spring cereals (wheat and barley) as well as grain legumes and canola complement winter wheat, which was 49% of the crop acreage in 2007. Fallow largely replaces grain legumes and canola in the annual crop-fallow transition AEC, while spring cereal acreage persists. The grain-fallow AEC is almost evenly split between winter wheat and fallow, with small percentages of spring wheat (Figure 3).

Not surprisingly, crop diversity, assessed for each AEC using Shannon's diversity index, was low for all AECs but lowest for the grain-fallow AEC and highest for the annual cropping AEC (Figure 4). Changes in diversity using this measure appear quite modest for the 2007 through 2013 period, though diversity trends upward for the annual cropping and fallow transition AECs (Figure 4). Basically, a Shannon's diversity index for a region that grew one crop would be zero. In our example, we include fallow as part of the analysis. One interpretation of these findings is that regions with low diversity would be more vulnerable to shifts in weather, commodity prices, and input costs, as little opportunity exists to vary crop choices. On the other hand, replacement of crops with fallow can lend stability to winter wheat performance.

REACCH research on developing improved cropping system strategies

The grain-fallow AEC has traditionally relied on fallow practices to store soil profile water and maintain seed-zone moisture for winter wheat establishment and yield stability. Challenges for this

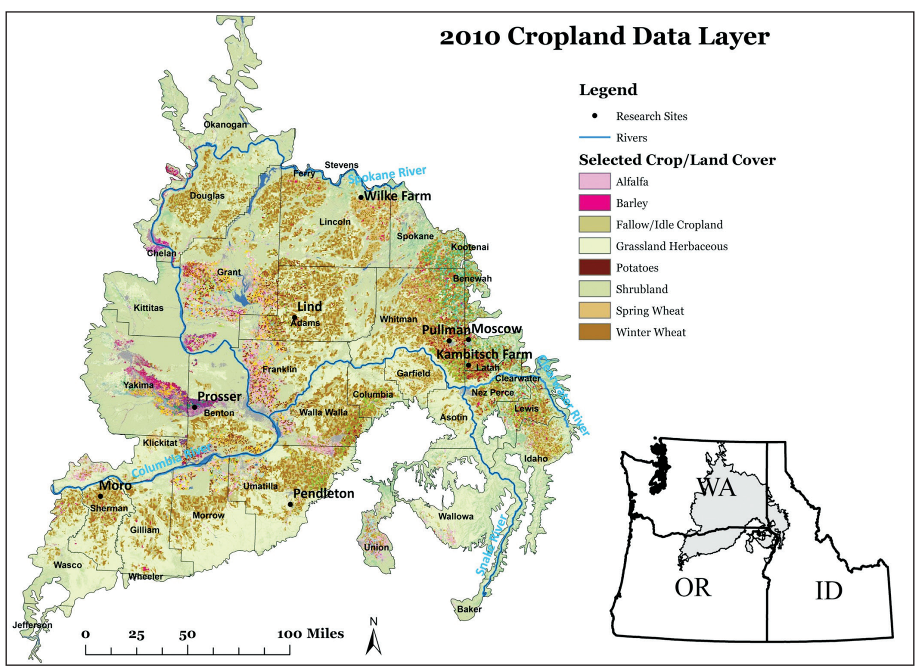

Figure 1. *2010 cropland data layer for the REACCH region.*

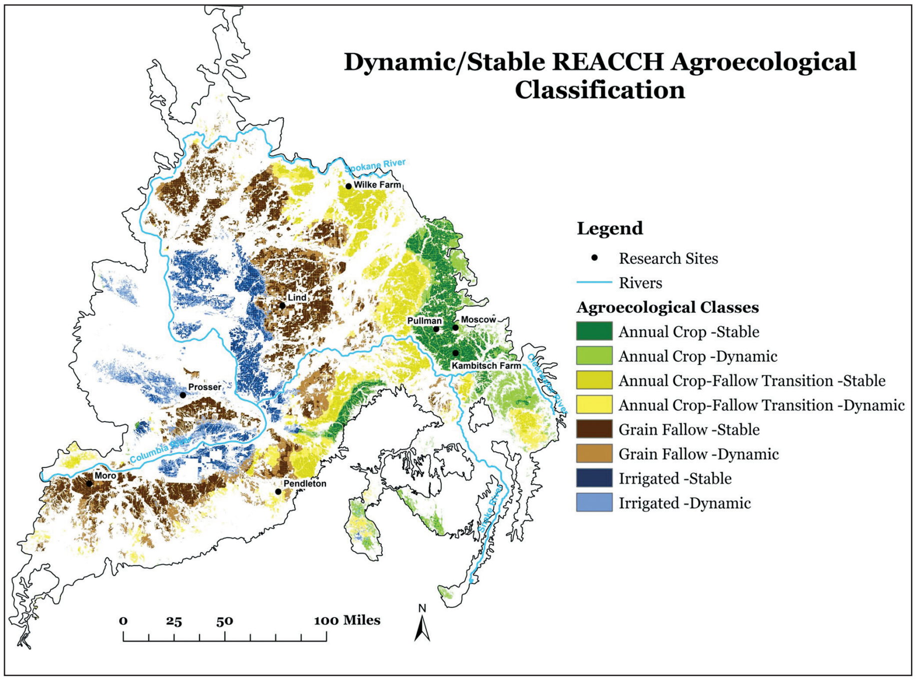

Figure 2. *Agroecological classes (AECs) for the REACCH region. Stable AECs have had the same AEC for the years 2007 through 2013, while dynamic AECs represent areas where the AEC has changed for one or more years during the same time period.*

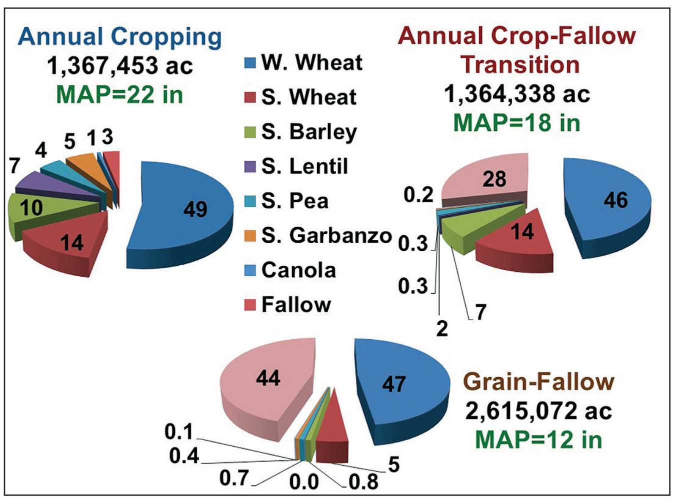

Figure 3. *Crop and fallow percentages as well as total area for the three dryland agroecological classes in 2007. (MAP refers to mean annual precipitation.)*

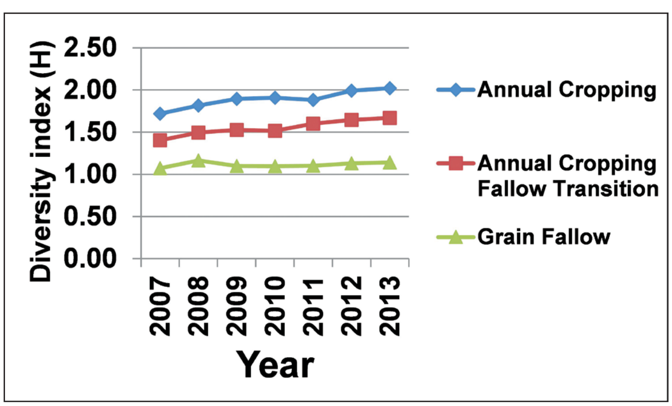

Figure 4. *Shannon's diversity index for each agroecological class from 2007 through 2013.*

AEC include winter annual grassy weeds (e.g., feral rye, downy brome, jointed goatgrass) as well as vulnerability to wind erosion. Annual spring cropping has not been economical to date, and current research efforts are directed toward diversifying the winter wheat leg of the grain-fallow cycle. Candidates for replacing winter wheat (WW) include winter triticale (WT), winter canola (WC), winter peas (WP), and facultative wheat. Schillinger and co-workers have shown that early-planted WT produced an average of 18% greater grain yield than early-planted WW, while late-planted WT produced equal grain yield compared to early-planted WW near Ritzville, WA, averaged over four years. Greater flexibility in planting date could reduce the necessity for tillage-intensive practices aimed at maintaining seed-zone water for late August sowing targets. In turn, opportunities for reduced tillage and inclusion of cover crops might be increased. Young and co-workers have demonstrated in research near Ralston, WA, that the relatively tall WT stubble (particularly when combined with a stripper header) in no-till systems can result in reduced soil temperatures and greater seed-zone water, furthering opportunities to establish small-seeded crops such as WC. Including WC in traditional grain-fallow rotations would provide rotation benefits with respect to grassy weed and disease management. Schillinger and co-workers have also researched planting date alternatives for WC establishment. Earlier seeded WC under more favorable seed-zone water conditions can result in more successful stand establishment. But trade-offs exist, as larger, earlier established WC consumes more stored soil water than later seeded WC, which could adversely affect winter survival as well as final yield. Also near Ritzville, WA (11- to 13-inch annual precipitation), Schillinger and co-workers have shown that WP exhibit good winter hardiness and reasonable yields, averaging 2,200 pounds per acre from 2011 through 2013. Rotations of WW, spring wheat (SW), and fallow (F) are being compared with WP-SW-F rotations.

In the annual crop-fallow transition AEC, research has emphasized opportunities to replace fallow, thereby intensifying cropping systems. Machado and co-workers, near Pendleton, OR (17-inch annual precipitation), have demonstrated that replacing fallow with spring pea can produce pea yields ranging from 750 to 3,000 pounds per acre while having little impact on subsequent WW yields as compared to fallow. Intensification of cropping systems with this grain legume that uses relatively low amounts of water is an exciting option that growers are beginning to adopt.

Diversification of direct-seed cropping systems has been a research goal for the Cook Agronomy Farm (CAF). Huggins and co-workers have demonstrated that spring canola as well as garbanzo beans (chickpeas) can be readily established into heavy WW stubble using no-tillage, leading to excellent yields. Spring canola yields, however, have been very sensitive to planting date, with yield decreasing by about 50 pounds per acre per day after an April 15 sowing date. Analyzing enterprise budgets comparing crops at the CAF, Painter and co-workers reported that garbanzo beans were one of the most profitable crops grown, surpassing WW in some years.

Acreage of canola and grain legumes increased substantially within the REACCH region from 2007 through 2013 (Figures 5 and 6). Canola acreage increases have been predominantly in the annual cropping zone, ranging from a low of 4,200 acres in 2011 to nearly 30,000 acres in 2013 (Figure 5). Total acreage of canola across all AECs was also highest in 2013 at nearly 65,000 acres. Increases in canola production have no doubt been spurred by favorable prices, establishment of regional processing facilities, and efforts of the WA biofuels cropping systems and REACCH-supported teams led by Bill Pan and co-workers that have provided research on agronomic factors and feasibility. Grain legumes have also benefited from favorable prices, although at this point the opportunity has primarily been explored in the annual cropping AEC, where grain legume acreage increased from a low of 19,000 acres in 2011 to over 31,000 acres in 2013. Much of this increase in grain legume production was from garbanzo bean (chickpea) (Figure 6). Interestingly, spring pea is currently the most prominent grain legume in the annual crop-fallow transition AEC, likely reflecting its relatively modest requirements for water. However, the potential for garbanzo bean production throughout the more dryland cropping AECs is still relatively unexplored, particularly as a replacement option for WW. Finally, although acreage of canola and grain legumes has increased, the total amount of fallow for the REACCH region remained relatively constant from 2007 through 2013, indicating that diversification has not replaced fallow, but rather has replaced other crops such as spring cereals (Figure 5).

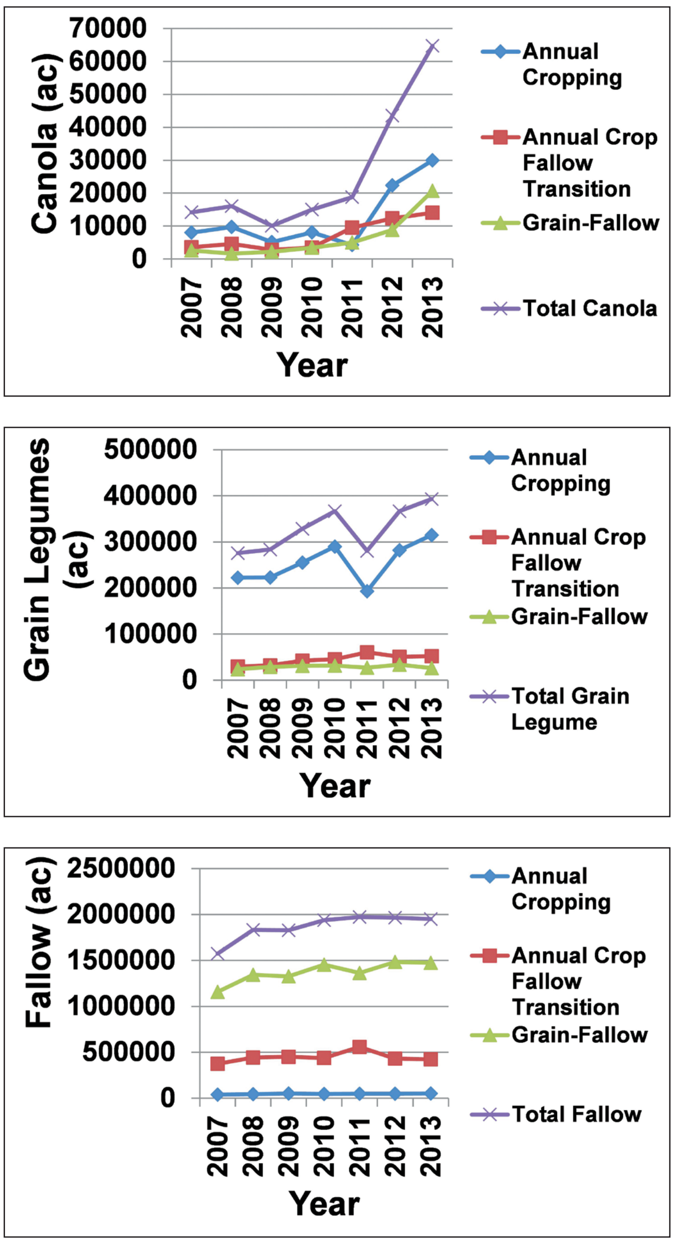

Figure 5. *Changing acreage of canola, grain legumes, and fallow by agroecological class from 2007 through 2013.*

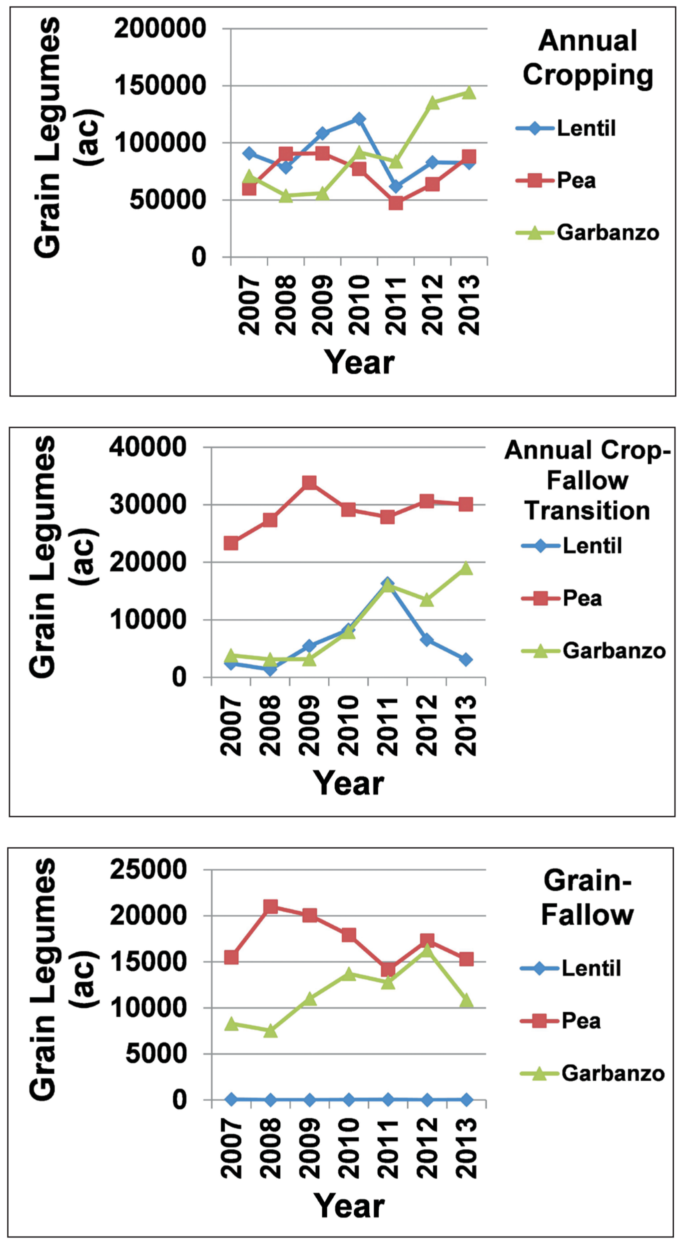

Figure 6. *Changing acreage of lentil, pea, and garbanzo bean for each agroecological class from 2007 through 2013.*

Future research efforts will continue to advance the potential for increasing cropping system diversification and intensification. Integration of process-oriented modeling and economic efforts through REACCH will further advance decision support. Complementarily, the AEC framework will continue to support efforts that (1) provide information on annual crop choices and help to assess shifts in cropland use/cover over time; (2) geospatially quantify and identify opportunities for crop diversification and intensification; (3) evaluate biophysical (e.g., climate, soils, terrain) and socioeconomic (e.g., commodity prices) drivers of crop choice, thereby aiding in the development of decision support tools; and (4) geospatially target research, education, and outreach efforts that enable future crop diversification and intensification.

Photo by Leigh Bernacchi.