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Biosphere-relevant earth system model

2017 Agricultural Adaptation Scenarios Stakeholder Workshop Summary Report

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On February 16, 2017 the BioEarth research team convened a stakeholder advisory workshop focused on challenges and opportunities for agricultural systems adapting to changing conditions in the Pacific Northwest. The workshop was held at the WSU TriCities campus in Richland, Washington. As was the case in previous BioEarth stakeholder workshops, this event was structured to share research results with diverse stakeholders and to build understanding among WSU researchers of how integrated earth systems models might inform natural resource management decisions. Participants discussed the potential implications of a range of strategies for adapting diverse regional agricultural systems to changing climatic conditions, as well as expectations about emerging economic, technological and social changes. This report summarizes perspectives that participating stakeholders shared during the workshop.

The workshop was organized around three key objectives:

1. Present current research on projected climate change impacts and possible adaptation strategies.
2. Gather input about possible co-benefits or negative consequences of specific agricultural management decisions.
3. Discuss usable research outputs and regional needs related to training and education.

I. Stakeholders represented at the workshop

Invitations to participate in the Agricultural Adaptation Scenarios workshop were sent to nearly 700 individuals in the Northwest representing federal, state and tribal government agencies, non-governmental organizations, research institutions and the agriculture industry. A total of with 25 attendees participated.

- WSU BioEarth team members: 5
- Other WSU Extension and research faculty: 3
- Washington State government agency representatives: 2
- USDA representatives: 4
- Tribal government representative: 1
- County Conservation District representative: 1
- Perennial crop producers: 6
- Annual crop producers: 2
- Agriculture industry representative: 1

Wheat near Odessa, Washington. Photo by Seattle.roamer, CC BY 2.0.

II. Reflections on specific adaptation strategies

Variety selection: Variety selection is among the most impactful management decisions a producer makes. The most important variables to select for are typically marketable yield and quality for the consumer. Annual crop producers need to make decisions about varieties each year and there are new options continually emerging. In one example, a producer might test 200 onion varieties each year. For irrigated crops, the question of suitability for temperature regimes is significant. But in the case of dryland wheat, water is the most important climatic variable, followed by temperature. Many crops have varieties adapted for very specific growing conditions; corn is a classic example of this, where growing degree-days and daily minimum and maximum temperatures have profound effects.

Red Hills Vineyard in the Willamette Valley, Oregon. Photo by Stuart Seeger, CC BY 2.0.

Each crop may have a different base temperature and cutoff. Producers agreed that it would be helpful to ground-truth temperature means, lows and highs, and to standardize variety selection recommendations based on updated climate zones. Generalized climate projections are of limited utility; the seasonal forecasts are often neither detailed nor precise enough to directly influence decisions about variety selection. For some crops, potatoes for example, a shorter growing season does not necessarily mean a lower yield. Thus, it is critical to tease out the various physiological effects of climate warming and the influence of CO_2 levels, fertilization, pest and disease pressures, and management decisions. In some cases, one driver of crop yield insignificant relative to other factors that influence yield. Crop growth potential models usually can't predict exactly what will happen in a growing season.

Implementing efficient irrigation technologies: Irrigation management may be the most important short-run adaptation strategy available to producers. Workshop participants discussed what factors drive changes in irrigation technologies that are used—switching systems is motivated by potential for increased crop yield and crop quality in addition to water savings and controlling runoff. Reflecting on what led to the widespread transition from furrow irrigation to more efficient technologies in the Columbia River basin, participants suggested that convenience of management plays a big role in decisions about implementing new technologies and practices. Growers use center pivots for efficient water applications, and can manage water within a field more precisely with new technologies that allow control of individual sprinklers. The ability to make real-time measurements of soil moisture in the field increases the ease with which farmers can make efficient irrigation management decisions.

Deficit irrigation: This is a strategy to minimize losses in the context of drought, as well as to reduce overall water use and increase quality of specific crops. The total effects of drought on investments made by producers are important for researchers to understand. In addition to yield losses, there may also be a lost fixed investment cost as well. This is especially true of perennial crops, for example hops, which might cost a grower $25,000/acre to put in. Economic analysis could shed light on questions related to how initial investments in a crop depreciate over time and how producers would respond to damage to specific crops in specific locations in drought conditions. There are some crops, such as grapes, for which deficit irrigation to protect a long-term investment makes economic sense. However, an onion producer, for example, would not deficit irrigate. Some farms use an all-in or all-out approach and would not plant at all in certain conditions.

III. Factors that shape decisions about when and how to implement new management practices

Drought: Producers expect that there may be an increasing need to consider drought resistant traits in variety selection and, in some cases, to consider new drought-resistant crops, such as quinoa. Models of growers' responses to drought must account for considerable variation across different agriculture systems and among individual producers, who have varying degrees of risk tolerance. Economic science literature and anecdotal evidence suggest that when an individual is vulnerable to a loss they become more risk averse.

Temperature stress: Along with selecting varieties to maximize crop quality and minimize losses under future climate change, tree fruit producers and growers of other high-value and perennial crops may increasingly invest in shade cloth or other cooling mechanisms.

Changing pest pressures: There are concerns about new pests in the Northwest US because of changing climate conditions that enable new migrations or overwintering of pests that were not previously concerns in the region. In some irrigated cropping systems of the Columbia River basin there is evidence of producers selecting rotational crops to mitigate pest problems. There are some opportunities to use cover crops such as early-fall planted mustards to manage nematodes, however, this has not yet proven to be a useful in high value crops due to variable results. A great deal of industry investment for crop protection focuses on genetic solutions for weed and pest control, but the current market forces are slowing the adoption of this technology.

Interannual climate variability: Northwest US producers are accustomed to managing under considerable interannual variability in temperature and precipitation trends. Workshop participants do not perceive a correlation between El Nino and La Nina events and drought in specific areas of the Northwest, thus information about these interannual cycles may be of limited relevance in making management decisions.

Climate change effects in other regions: As climate change in other regions impacts the quality and yield of agricultural products, the Northwest US may see migration and expansion of some agricultural systems. For example, there is some evidence pointing toward dairy industry growth in the Northwest during the past two decades. This has increased the demand for feed crops. There has also been some northward migration of California vegetable production. If production of certain commodities increases in the Northwest, increased storage and processing facilities would also be needed.

Consumer demand: Consumer preferences are a major driver of decisions made by growers about variety selection and management practices. For example, producers responded to consumer preferences for decreased trans fats in crops. Stakeholders expect that emphasis on certification programs will continue to increase in coming decades. In some cases, this makes it more difficult for small and mid-scale producers to compete with larger industries.

Different rules for different systems: Research must different between irrigated and dryland systems because the decision framework for growers in these two systems is very different. Whether or not a producer participates in a farm program is also a big driver of management decisions. Generally, management decisions are based around the goal of ensuring profits and the long-term sustainability of the operation.

IV. Expectations about emerging regulations, policies, and technologies

These are factors, which, while note directly related to regional climate, are expected to influence the future of agricultural operations in the Northwest US. Projected climate change impacts must be understood in combination with these regulatory, policy-related, and technological changes.

Regulation of chemical inputs: Stakeholders expect to see more global and national restrictions on pesticides that can be used. Increased global trade and tightening regulations may lead to more frequent residue testing of crops destined for export. To address consumer demand and comply with these regulations there will be a need to create programs that support farmers in getting more comfortable with integrated pest management and approaches to crop protection that do not require synthetic chemicals. Emerging technologies—notably CRISPR targeted genome editing— may present new opportunities to develop crop varieties that resist pests and plant disease pressures without chemical inputs. There is considerable uncertainty about the social and political implications of this and other emerging technology. Producers close to population centers who cannot use chemical pest control may increasingly look toward biological controls, such as planting mustard as an alternative to fumigation.

Possible consolidation in the agriculture industry: Some workshop participants expect to see future consolidation in the industry due to federal and state regulations that make it difficult for small farms to comply with complex standards, and thus unable to compete with larger industrial farms. On the other hand, there may be future regulations designed to protect small, urban and peri-urban farms that serve local markets. The current political climate does not favor direct payments to growers, but there were some speculations that direct payments could return under the next iteration of the federal Farm Bill.

Interest rate regimes: Workshop participants remarked that recent years have been characterized by a low interest rate regime. There are questions about whether this will continue in the future and how changes in producers' ability to obtain low-interest loans for new equipment might affect management decisions.

Labor issues: For labor-intensive agricultural systems the availability and affordability of skilled labor is a major constraint on production capacity. Stakeholders expect to see increasing investment in new robotics technology development, especially within the tree fruit industry.

Environmental health: Over the past decade, growers have implemented management practices designed to reduce agriculture's contribution to nitrates in groundwater. There may be increasing state and federal focus on the goal of reducing nitrates in groundwater in coming years. This could affect regulations related to fertilizer application and groundwater use for irrigation.

New crops: Northwest agricultural systems are continually evolving, for example the blueberry industry and the winegrape industry have expanded considerably in recent decades. Crop shifts in the region may be driven by climate change in other regions that restricts production, climate change in the Northwest that enables new crops and varietals to be produced, and consumer demand. Crops that are expected to emerge or expand in the Northwest in coming years include peanuts, cotton, sweet potatoes, quinoa, and buckwheat. Winegrape growers consider crop quality over long time horizons, and-- based on projected climate shifts-- may transfer where certain winegrape varietals are grown. These shifts would require transfer of water rights.

V. Examples of regional producers making management decisions based on expectations about climate change

Double cropping: As average annual temperature rises, the length of the frost-free season is also lengthening, thus enabling increased double cropping. Some of the rotations in use include: potatoes to buckwheat, timothy to beans, and alfalfa to beans. Research is needed to identify areas where double cropping could be used and to assess the total acreage where it would be possible. There is also 1.5 cropping in some areas, in which producers harvest the first cutting and then do for a shorter-season crop. There are market limitations that restrict where second crops are a viable strategy.

Use of cooling systems: Perennial fruit systems have significantly curtailed water usage in recent years by converting to drip irrigation. Producers may increasingly use overhead irrigation for cooling—which would require more water usage. Some varieties are especially sensitive to sunburn and use of netting could increase to provide shade for those sensitive crops, however, this requires a considerable investment.

(L) Healthy yield of onions. Photo by NRCS OR, CC BY ND 2.0. (R) Soil rich in organic matter. Photo by USDA, CC BY 2.0.

VI. Future scenarios of most interest to stakeholders

Workshop participants were interested in seeing models explore unlikely, but potentially highly impactful changes in the Northwest, i.e. "X-factor" scenarios. Examples of these scenarios of interest include:

- A 5°F increase in average temperature for an entire growing season
- Multi-year drought on par with that seen in California in recent years. This could have severe impacts for junior water rights holders who have planted perennial crops.
- Major immigration and NAFTA policy changes that cause severe lack of labor
- Closure of ports in the Northwest
- Summer heat waves like those seen in 2015, contrasted with a longer warm season, as was seen in 2016. This involves looking at the timing of heat exposure relative to phenological stages, and impacts will vary for dryland and irrigated systems
- Aberrant climatic events such as heavy late-season precipitation or early frost events
- Technology-aided water trading

VII. Drawbacks of adaptation strategies

Producers have a range of reasons for not pursuing specific adaptation strategies. Reasons may be ties to initial investment required, uncertainty about effectiveness, and uncertainty about other economic or environmental consequences. Drawbacks or downsides of adaptation measures discussed at the workshop include the following:

- Existing climate change impacts projections are generally not certain or salient enough to influence producers to modify their practices. Many regional agricultural systems are not particularly vulnerable under current and near-term projected conditions.
- Some new technologies are prohibitively expensive. For example, installing drip-line irrigation (about $1000/acre) may improve yields slightly, but the increased productivity would not cover the investment cost. Furthermore, drip-line irrigation cannot be used on all fields or all crops for technical reasons.
- Weed control is difficult in no-till and reduced tillage systems and these management strategies may not be suitable for some locations.
- Use of cover crops may lead to new plant disease issues. There are policy restrictions on where some cover and rotational crops can be used.

VIII. Information producers would need in order change management practices or implement adaptation strategies

Seasonal forecasting: Annual crop producers need to understand what the climate will look like *during the growing season* before they make planting decisions. This kind of information could actually influence decisions about variety selection and cropping strategies.

Probability charts for key climate events: It would be useful to see statistics for first frosts and last frosts, for example, re-created based on current climate data. The USDA may be in the process of developing updated hardiness zone maps. Producers would be interested in seeing projected severity of impacts communicated in a simple format, for example, "red, yellow, green" growing conditions.

Water outlook: River flow and water availability data is provided on an annual basis from Irrigation Districts and others. Producers would benefit from information about drought severity probabilities over multiple years. Irrigators also want information about impacts due to changes to the Columbia River Treaty.

Changing wind patterns: Both water and wind drive soil erosion in the region; shifts in wind patterns could change which zones are most vulnerable to erosion. Changes to wind patterns would also affect the number of allowable spray days.

Shifting pest pressures: Producers need information about emerging threats related to changing ranges and phenology of crop pests associated with climate change, as well as changing and pesticide management regulations.

Regional fire regimes: Livestock producers could use real-time decision support tools to manage the location of livestock during fire conditions.

Water storage: Better remote sensing data is needed to assess the existing amount of on-farm water storage (generally only for very short term needs in the Columbia River basin) and understand the potential for using on-farm ponds, and also the extent of aquifer storage. There are also questions about how regulations related to nitrates in groundwater will affect decisions about storage.

Physiological thresholds for crops: Most of the available data about climate impacts on crops comes from work done prior to 1950's, much of which is not stored in any readily retrievable format. Producers would benefit form a phenological database cataloguing variables such as minimum and maximum temperature thresholds and vulnerabilities around nutrient management. There is a need to link updated plant physiology research with field station climate data.

IX. Most useful approaches to sharing research results about adaptation scenarios and climate change impacts

Interactive models: Decision-makers benefit from the ability to play with parameters, such as with slider-based calculators in water market games to simulate water leasing.

Visual maps: Again, it is useful when maps are interactive, but the computing power required to produce these interfaces is immense, and tools are often slow.

Back-projecting: Climate impacts models are trusted and perceived to be useful and actionable when they can back-project scenarios, for example, showing historic stream flows under different climatic conditions. There is interest in comparing crop yield impact projections against NASS data to assess whether regional differences in yield are being captured. This is very complex, because when we look at county-scale crop yields there are many management factors that account for differences and cannot be easily modeled.

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Tree fruit Extension work in Oregon. Photo by Scott Bauer, USDA, CC BY 2.0.

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