Climate Change and Agriculture in the Pacific Northwest

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Introduction

Public discourse surrounding agriculture and climate change in the U.S. has primarily focused on agriculture's role in carbon sequestration and greenhouse gas mitigation. However, concern over the potential impact of climate change on agricultural production is growing, particularly in the arid West where agricultural water security is already a concern. A February 2004 article in Science (Service 2004) entitled "As the West Goes Dry" painted a stark picture of a possible future of severely constrained water supplies that made many in the Pacific Northwest (PNW) take interest in the issue of climate change for the first time. This article and other earlier research into climate change impacts on agriculture have shown that changes in the climate represent a significant new source of risk and management challenges to the agricultural enterprises we depend on for food production and rural economic vitality.

Our regional agricultural systems have evolved within a variety of existing regional and local climatic patterns and the continued success of these systems depends on our capabilities to adapt to change. For instance, in addition to concerns regarding irrigation water supply, other climate-driven vulnerabilities include the need for adequate soil moisture at seeding time for rain-fed cereal grain production, plants' sensitivity to temperature extremes during critical life-stages (such as flowering), shift of seasonal patterns and production zones, and temperature-driven controls that limit the incidences of insect pests and diseases. Changes in any of these factors could dramatically impact the resiliency and viability of our PNW cropping systems. We can no longer afford to "ignore" the risks that climate change presents to the sustainability of future cropping systems in the Pacific Northwest.

In response to this concern, numerous research teams in the Pacific Northwest have initiated studies to assess the vulnerability of agriculture to climate change in order to improve decision-making, investment, and planning for adaptation. Completed studies include the projected impact of future climate change on wine grape production (Jones 2005; White et al., 2006; Jones 2007; Jones and Goodrich 2008), on pests and plant diseases (Sutherst et al., 2007; Scherm and Coakley 2003; Coakley et al., 1999), on Eastern Washington agriculture (Stockle et al., 2010), and on water supply for agriculture in the Yakima River Basin (Vano et al., 2010). Current work includes a forecast of future water supply and demand for the Columbia River Basin of Washington, funded by the Washington Department of Ecology, that will be completed in 2011 (Adam et al., 2009). Also, two new projects funded by USDA's National Institute for Food and Agriculture will address climate change impacts on PNW agriculture: a Coordinated Agricultural Project that will assess potential climate change induced production zone shifts, changes in beneficial organisms, and incidence of weed, disease and insect pests for wheat-based cropping systems of the Pacific Northwest (Eigenbrode et al., 2011) and a second project that will couple atmospheric, forest, crop, hydrological and economic models to assess the impact of changing climates on agricultural, forest and water resources and management (Adam et al., 2011).

Using Process Models to Project Future Impacts

Most climate change studies rely on the use of process models capable of integrating the complex set of factors (e.g. biophysical conditions and management and policy decisions) necessary to project climate change impacts in an uncertain future. While modeling is a well-accepted methodology in the scientific community, it can be a source of apprehension to stakeholders in the agricultural community who are more familiar with experimental research methodologies. To address this concern, we need to emphasize a few important principles of modeling:

1. Models are, by definition, a simplification of a particular process in the real world. As such, they are useful for understanding the relative impact of a change in conditions. They are not a "crystal ball" and do not "predict" the future, but rather they are useful for simulating the probability of a given future outcome.
2. Each sub-process within a model is based on existing experimental research and is, therefore, an integration of prior experimental science. Models are tested and evaluated against known values (e.g. the past) in order to determine confidence in projections where existing data are not yet available (e.g. the future).
3. Assumptions that are made in the context of applying models to real world cases should be evaluated along with model results when comparing with real world conditions and/or experimental data.
4. The ultimate value of modeling tools is to inform and aid in decision-making by providing projections of probable future conditions and helping to clarify what those conditions mean for management.

While the idea of using models to project future conditions can be controversial, it is important to understand that we regularly utilize models and model outputs as decision aids. For instance, farmers frequently use local weather reports (generated by models) to aid in a variety of farm management decisions (e.g. planting, harvesting, freeze/frost management, irrigation, etc.). In spite of the fact that these model outputs are not "perfectly accurate," we know they are quite useful. Similarly, using model projections for future climate change scenarios can be useful for assessing vulnerabilities and planning for change.

Findings to Date

To date, the most comprehensive assessment of potential climate change impacts on PNW agriculture was completed as part of the Washington Climate Change Impact Assessment[1] (WACCIA) project funded by the Washington Legislature (HB 1303) and led by the University of Washington Climate Impacts Group.

[1]The full WACCIA report is available at: http://cses.washington.edu/cig/res/ia/waccia.shtml.

University of Washington climate modelers provided regional climate scenarios “downscaled” from global climate models to teams of scientists who used these scenarios to evaluate potential impacts on various aspects of Washington’s environment and economy, including agriculture (Stockle et al., 2010) and water supply (Vano et al., 2010). Potential impacts were assessed for three future time frames (2020’s, 2040’s, and 2080’s). Stockle et al. (2010) used a cropping systems model (CropSyst) and a set of existing pest models to project climate impacts on yields of wheat (three locations), potatoes and apples; as well as project potential changes in the occurrence of codling moth and the incidence of powdery mildew on grapes and cherries. Vano et al. (2010) used a multi-model ensemble (hydrology, reservoir, cropping systems and water management models) to assess the impact of changes in water supply in the Yakima River Basin on water allocation for irrigation and consequent impacts on the agricultural economy. Detailed findings from these studies are available in a special issue of the journal Climatic Change (102:1-2) published in 2010. Several key conclusions can be drawn from the results:

- Assuming no change in available irrigation water:
    1. Projected increases in temperature would likely reduce yields of wheat, apples and potatoes moderately by the 2020’s and severely by the 2080’s, where irrigation is utilized.
    2. Increased CO_2 levels in the atmosphere, however, provide a “fertilization effect” that may offset much of the potential yield reduction caused by increased temperature.
    3. Reasonable adaptation strategies, including plant breeding and cultural practices, could further offset any potential losses in yields and may even lead to increased yields under future climates.
- The probability of reduced water supply in the Yakima Valley greatly increases under future climate scenarios, leading to more regular curtailment of irrigation water for junior water rights holders in the future. Regular curtailment without adaptation/intervention would likely lead to significant reductions in agricultural production and significant negative economic impact on the allied industry and communities.
- Insect pests are likely to have additional “generations” each season (insect lifecycles are driven by “degree days”) leading to increased costs for control and the potential for reduced efficacy of control methods earlier than expected.
- Incidence and severity of plant disease outbreaks are more uncertain due to a more complex set of biophysical drivers than for insects, but more “high risk days” were projected for powdery mildews.

Conclusions and Future Directions

The agriculture-related vulnerabilities reported in the WACCIA study are actually far more modest than those reported for agriculture in other regions of the U.S. (Schlenker and Roberts, 2008). In general, higher latitudes are expected to fare better than lower latitudes, where the options for adaptation are more limited. While this appears to be good news for our region, it is critical that we do not underestimate the necessary planning and investment in adaptation that will be required even under relatively modest impact.

As noted above, modeling tools can be valuable tools for risk assessment, but they do have important limitations. While these models are sophisticated, they are still relatively simple representations of the real world. Even though they enable greater capability to evaluate the dynamics of complex systems than experimental approaches, the application of the models usually only considers a few factors (e.g. yield, temperature, and water use) and may not consider other factors that are critical to the success of a crop or agricultural enterprise (e.g. fruit quality and extreme weather events like floods and hail storms). While research into the development of more sophisticated modeling methodologies that will improve this capacity is increasing, we are a long way from being able to project these kinds of agricultural vulnerabilities and impacts with confidence.

Furthermore, even within the existing projections we can conclude that there are real and significant vulnerabilities that need to

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be addressed in order to secure a sustainable future for agriculture. For instance, we know from Vano et al. (2010) that we cannot assume a status quo of sufficient water supply for agricultural production. We just do not know yet the extent of this vulnerability for agriculture outside of the Yakima River Basin. Additional information will be provided by the initial effort to assess the vulnerability of Columbia Basin-wide water supply as it relates to agricultural, municipal and in-stream demands that is currently underway on behalf of the Washington Department of Ecology's Office of Columbia River (Adam et al., 2009). This project is using a multi-model ensemble approach to project water supply and demand out to 2030 under a variety of future scenarios, including economic as well as climate changes. These results (expected in December 2011 and available through the Washington State Department of Ecology web site) will be used by the Washington Department of Ecology to inform public decision-making processes on the investment of $200M for water supply development in Washington State.

Finally, the adaptation strategies assumed in Stockle et al. (2010) depend on continued and increased investment in plant breeding and agronomic and plant protection research at a time when regional investment in agricultural research is actually waning. USDA's agricultural research divisions (Agricultural Research Service – ARS and National Institutes for Food and Agriculture – NIFA) have recognized the need to increase federal research investment in agriculture and climate change and the Pacific Northwest universities have collaboratively capitalized in the first round of climate change funding solicitations (Eigenbrode et al., 2011; Adam et al., 2011). While this is an excellent start to better positioning our agricultural industries and rural communities, long-term success will depend on a renewed commitment to both public and private regional investment in research and implementation of that research by farmers to ensure successful adaptation to climate change.

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White, et al. 2006. Extreme heat reduces and shifts U.S. premium wine production. Proceedings of the National Academy of Sciences, 103(30): 11217–11222.

RECOMMENDED RESOURCES

Washington Climate Change Impact Assessment (WACCIA) project report:
cses.washington.edu/cig/res/ia/waccia.shtml.

Washington Department of Ecology Office of Columbia River:
ecy.wa.gov/programs/wr/cwp/crwmp.html

Regional Approaches to Climate Change for Pacific Northwest Agriculture (REACCH PNA):
reacchpna.uidaho.edu/reacchpna

BioEarth: Biosphere Relevant Earth System Model for the Pacific Northwest:
cereo.wsu.edu/bioearth

Better positioning our agricultural industries and rural communities for long-term success will depend on a renewed commitment to both public and private regional investment in research and implementation of that research by farmers to ensure successful adaptation to climate change.