Climate change and agriculture: Model projections

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Farmers, industry representatives, and other citizens of the Pacific Northwest have pressing questions about agriculture and climate change. These questions include: How will climate change affect pest pressures and crop yields? How much carbon could soils in the region store? And, by how much is it possible to reduce nitrous oxide (N_2O)emissions? The only way to systemically address these and other pressing questions about future change is through a combination of experimental research and computer-based modeling. Applying information from models will require that stakeholders understand model assumptions and feel comfortable with interpreting the types of results that models provide.

The northeastern part of the REACCH Region in Eastern Washington. Photo by Roger Nelson.

IMPACT

Using and understanding appropriate models for your region and farming practices is critical in applying and making decisions for sustainable wheat production in the future under predicted climate change scenarios. REACCH is on the cutting edge of research by using coupled modeling frameworks to incorporate climate, cropping system, and economic models for a set of possible future scenarios to project agricultural productivity, potential types of agricultural practices, and profitability into the mid-21st century.

An oft-quoted maxim from scientist George Box says, "All models are wrong, but some are useful." This is a way of saying that because models are simplifications they can never represent reality in all of its complexity. Yet, models can be useful because they allow exploration of how a system works and investigation of the relationships between various parts of the system. Models won't ever give us the exact answer to the questions we ask, but they provide meaningful insight into likely outcomes. And, models can be valuable tools because they enable decision makers to evaluate how sensitive a system will be to a disturbance or change.

Experimental scientists and modellers from the U.S. Department of Agriculture-Agricultural Research Service, Oregon State University, University of Idaho, and Washington State University have been working closely together over the past decade to construct models of agricultural systems in our region. In these computer-based models, physical, biological, and, more recently, economic and social data are integrated, based on the best available scientific literature. Throughout the process, experimental scientists work with modellers to test and evaluate model results against empirical data from our region. Multiple models are being developed and tested in our region, and as different models begin to suggest similar future conditions, researchers feel increasingly confident in the reliability of model results.

Stakeholders are generally experienced at understanding the context in which a certain set of experimental results was obtained. For example, they know that having information about the soils, rainfall, and crop rotation in which results were measured can help them evaluate whether similar results might occur on their farm. Similarly, for modeling results, it is critical to understand the model's built-in assumptions in order to assess the

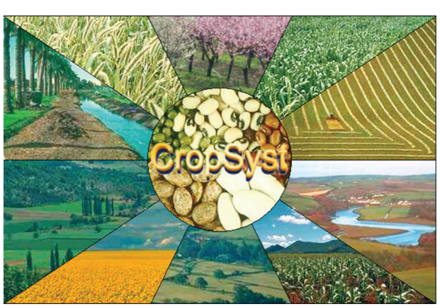

Figure 1. *CropSyst is a user-friendly, conceptually simple, but sound multi-year, multi-crop daily time step simulation model. The model has been developed to serve as an analytic tool to study the effect of cropping systems management on productivity and the environment. The model simulates the soil water budget, soil-plant nitrogen budget, crop canopy and root growth, dry matter production, yield, residue production and decomposition, and erosion.*

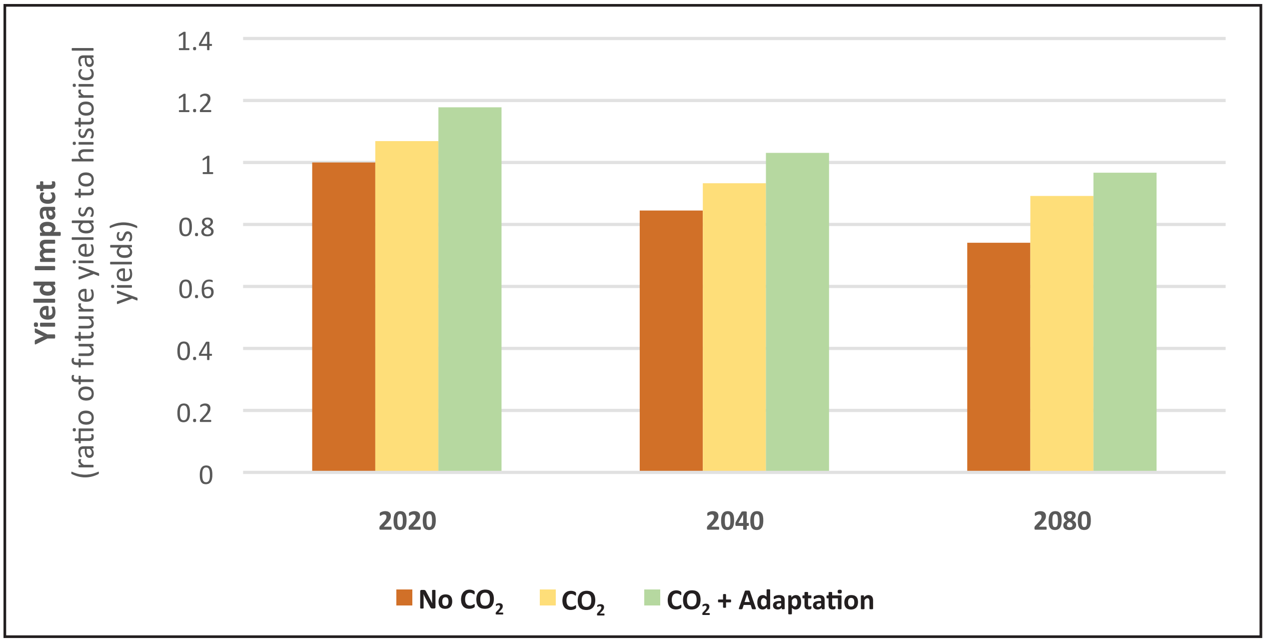

Figure 2. *Modeled impact of climate change on yields of spring wheat in St. John, Washington (2020, 2040, and 2080). A value of "1" on the graph indicates no change from the baseline historical yield. The scenario "no CO_2" includes the impacts of changes in precipitation and temperature, while "CO_2" also includes the impact of increased CO_2 concentration on plant growth, and "CO_2 + adaptation" also includes the impact of planting 2 weeks earlier.*

relevance of model-generated results. Looking at one example of previous modeling work in our region can illustrate how this is helpful.

CropSyst (Figure 1), a cropping systems simulation model, has been used frequently in the Pacific Northwest to address questions about the impacts of climate change on agriculture. In 2010, as part of the Washington Climate Change Impact Assessment Project, CropSyst was used to study potential climate change impacts on yields of three economically important Pacific Northwest crops at specific representative locations. Crops and locations were as follows: winter wheat (modeled at Pullman, Saint John, Lind, and Odessa, Washington), spring wheat (Pullman, Saint John), potatoes (Othello, Washington), and apples (Sunnyside, Washington). Overall, model projections suggested that climate change impacts on these crops would be mild over the next 2 decades, but more risky by the end of the century.

However, understanding the specific assumptions underlying the model scenarios generates additional insight into this general conclusion. Figure 2 shows the changes projected for spring wheat in St. John, Washington, under three different sets of assumptions in the CropSyst model. In general, by 2040, climate changes are projected to have a negative impact on spring wheat yields, if only changes in temperature and precipitation are considered (orange bar). However, these potential negative impacts are counter-balanced by benefits from increased carbon dioxide levels on plant growth (called the "CO_2 fertilization effect") (yellow bar) and by the fact that growers may be able to plant earlier (green bar).

It is also important to understand that while the study considered changes in climate, the impacts of increased CO_2 on plant growth, and a few possible adaptations by farmers, there are numerous other expectations built into the model. These include assumptions that crops would receive adequate nutrients; that weeds, pests, and diseases would be controlled; and that irrigated crops would receive adequate water. Each of these assumptions merits further scientific evaluation and, in some cases, new scientific investigation. For instance, a key effort of REACCH scientists is to incorporate potential climate change impacts on weed, pest, and disease pressures into modeling efforts.

In an effort to further facilitate the understanding of REACCH modeling results, we are developing a more comprehensive fact sheet introducing stakeholders to some of the fundamental considerations of interpreting environmental modeling results. We anticipate that this fact sheet will be available in spring of 2014 and will be available on the REACCH website.

Ripe wheat ready for harvest. Photo courtesy Stone-Buhr Flour Company.