Economic impacts of climate change on winter wheat

John Antle (john.antle@oregonstate.edu) OSU, Jianhong Mu OSU, Hongliang Zhang OSU, Susan Capalbo OSU, Sanford Eigenbrode UI, Chad Kruger WSU, Claudio Stockle WSU, J. D. Wulfhorst UI, and John Abatzoglou UI

Updated climate projections from most recent global climate models have estimated climate change in the Pacific Northwest (PNW) by the middle of this century, with warming of 1.8° to 9°F (1° to 5°C), drier summers, and reduced spring peak flow. Preliminary research has shown that winter wheat yields in this region could increase with the combined effects of changes in climate and an increase in atmospheric carbon dioxide concentrations (see the companion article "Agricultural productivity under future climate scenarios" page 112). However, changes in farmers' profits from winter wheat production in the future will be determined not only by climate change, but also by other factors, including changes in commodity prices, production costs, production technology, farm policies, and the occurrence of pests and diseases. We have incorporated these other factors into an analysis of climate change impacts by constructing plausible future "pathways" using global economic model projections for prices and by using expert judgment for factors such as policy that cannot be modeled. Here we summarize some research results that project the economic impacts of climate change on the winter wheat production system in the REACCH region under three plausible projections of future conditions that we call representative agricultural pathways and scenarios, or RAPS.

IMPACT

Results of this study will help policy makers and governments create more target-oriented farm policies. Although even the average net impacts of climate change are beneficial in this region, there are still some losers due to variations in weather, biophysical, and socioeconomic conditions. In addition, information from this study could help in the development of improved climate change adaptation and mitigation strategies by presenting a range of uncertainties from climate model projections, emission scenarios, and future world development.

Figure 1 shows the research framework. This study uses downscaled climate data from multiple climate model projections for different emission scenarios (representative concentration pathways, or RCPs), simulated crop yields from a crop simulation model (CropSyst), economic data from the Census of Agriculture, and regional RAPS. Members of the REACCH team collaborated to develop three regional RAPS for conditions in midcentury (2050) based on historical data, global economic model projections, and experts' judgments (these RAPS are described in the companion article "Representative agricultural pathways and scenarios for integrated assessment" page 106). These regional RAPS were developed to be consistent with global pathways called shared socioeconomic pathways (SSPs), which are used along with climate change projections in an economic model called Tradeoff Analysis Minimum Data (TOA-MD) to simulate future economic, environmental, and social outcomes for the winter wheat-based farms in the REACCH area.

The TOA-MD economic model uses a statistical description of the winter wheat-producing farms in the REACCH region (based on agricultural census data) to assess the economic impacts of climate change. We used the TOA-MD model to analyze the average impacts on winter wheat-producing farms and the vulnerability of farms to economic losses. Figure 2 shows one of the key inputs to the TOA-

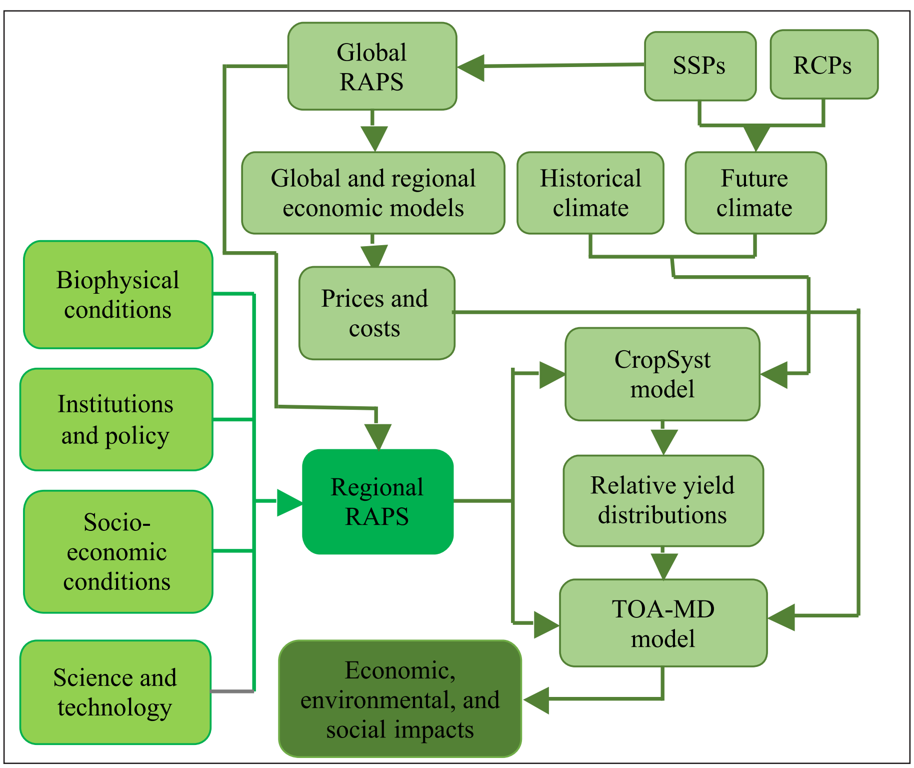

Figure 1. *An integrated regional impact assessment framework. (Note: RCP = representative concentration pathway, SSP = shared socioeconomic pathway, RAPS = representative agricultural pathways and scenarios, TOA-MD = economic impact assessment model.)*

MD model: the distributional changes in future winter wheat yields across global climate projection models for two emission scenarios by midcentury. This figure shows two important features: first, the impact on average yield is likely to be positive; however, because of the heterogeneity of the winter wheat production system across farms under future climate conditions, a substantial proportion of farms could still be vulnerable to losses from climate change.

Figure 3 answers the question of how the current winter wheat production system responds to climate change, summarizing outputs from the economic model. We find the results shown here across multiple climate projection models and two emission scenarios for midcentury (2050), although it is unlikely that current economic conditions will prevail in the future. The average net impact as a percentage of net farm returns ranges from 6% to 22% under the lower-emission scenario and from 3% to 24% under the higher-emission scenario, whereas 22% to 39% and 19% to 44% of farms are vulnerable to economic losses from climate change under the lower- and higher-emission scenarios, respectively. These results also suggest that a larger variation in climate change impacts is coming with projections of a warmer and drier climate.

To answer how the future winter wheat production system will respond to climate change, Figure 4 summarizes results from the TOA-MD model. As shown in the figure, the economic impacts differ substantially depending on the scenario used in the simulation. For each RAPS, four alternative conditions are simulated: a world with high commodity prices and high costs of production (HH), a world with high commodity prices and low costs of production (HL), a world with low commodity prices and high costs of production (LH), and a world with low commodity prices and low costs of production (LL). These results show that under the “business as usual” RAP1 and high prices, in which higher wheat prices are projected, wheat farmers would gain on average from 30% to 50% (in farm net returns), but about 20% of farms would be losers, with losses in the range of 15% to 25%. The most pessimistic scenario (RAP3, with low prices) shows average economic gains of 0% to 20%, with 22% to 55% of farms vulnerable to losses. We can conclude that there is a high degree of uncertainty associated with climate change, but it is clear that the overall impact as well as the degree of vulnerability will depend substantially on future economic conditions as well as on climate change.

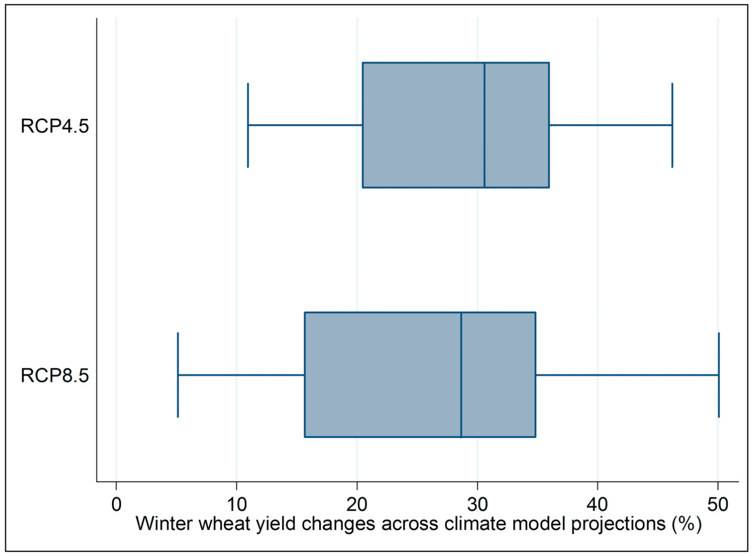

Figure 2. *Changes in winter wheat yield across climate projection models. (Note: RCP 4.5 is the lower-emission scenario, and RCP 8.5 is the higher-emission scenario.)*

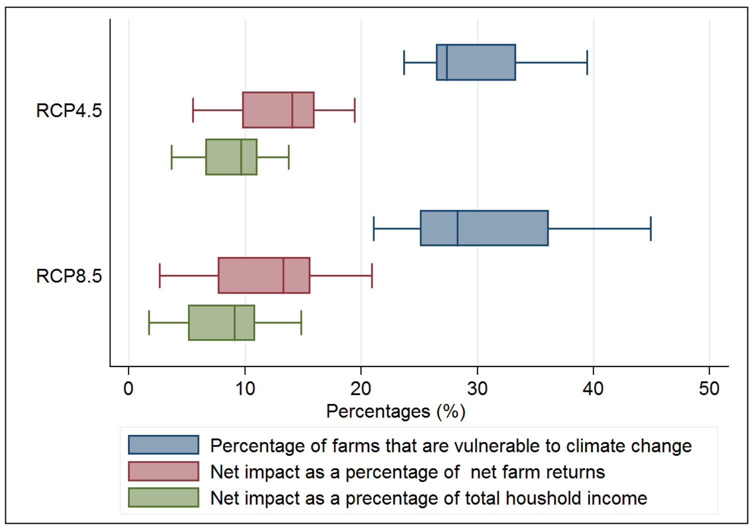

Figure 3. *Effects of climate change on the current winter wheat production system. (Note: RCP 4.5 is the lower-emission scenario, and RCP 8.5 is the higher-emission scenario.)*

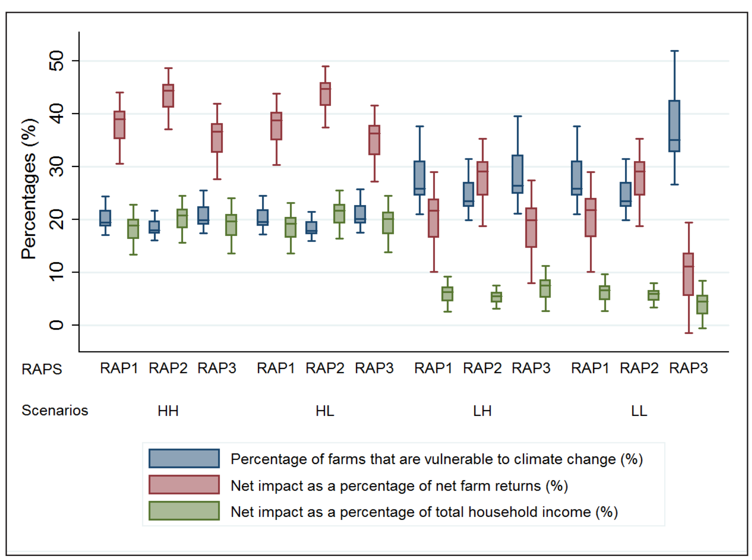

Figure 4. *Effects of climate change on the future winter wheat production system (Note: RAP = representative agricultural pathway; RAP1 = business as usual, RAP2 = dysfunctional world, RAP3 = sustainable development. HH scenario = high wheat price and high cost of production, HL scenario = high wheat price and low cost of production, LH scenario = low wheat price and high cost of production, LL scenario = low wheat price and low cost of production.)*