Research Highlights from Objective Team 1 – Modeling Framework

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Goals of Objective Team 1

- Create a framework that integrates biophysical and socioeconomic aspects of regional cereal production systems under current and projected climate scenarios;
- Implement this framework to evaluate climate change impacts, adaptation and mitigation potential in the PNW wheat-based systems.

Representative Agricultural Pathways and Scenarios for Integrated Assessment

Representative agricultural pathways (RAPs) are projections of plausible future biophysical and socio-economic conditions used to carry out climate impact assessments for agriculture. This study aims to present the development of RAPs for the principal winter wheat-producing region of the Pacific Northwest. Specifically, we describe what RAPs are and why needed, summarize procedures, present developed RAPs and discuss implications for impact assessments.

REACCH team members have collaborated to develop three RAPs for this region by the mid-century based on historical data, global economic model projections and expert opinions, including (1)"Sustainable Development" indicating rural development continues with moderate increases and more restrictive fuel policies; (2) "Business-as-Usual" indicating the future world with current trends continue; and (3) "Dysfunctional World" suggesting an unbalanced rural development with ineffective policies. Each RAP includes a set of key variables to project plausible future conditions of biophysical, institutional/policy, socio-economic, and technology. To quantify these projections for modeling purpose, likely trends with possible ranges are developed for each key variable, with which, other modeling teams could calibrate parameters accordingly to incorporate sort of uncertainties from the future world development in their impact assessment.

Likely trends of variables for each RAP

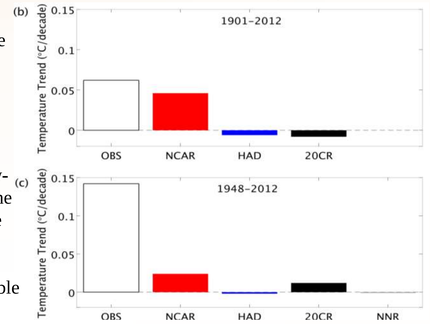
CATEGORY	VARIABLE/ INDICATOR	RAP1 (*Sustainable Development*)	RAP2 (*Business-as-Usual*)	RAP3 (*Dysfunctional World*)
Bio-Physical*	Soil erosion reduction	↗	→	↗
	Irrigation	↗	↘	↘
	Pests, weeds and diseases control	↗	→	→
Institutional /Policy*	Commodity subsidies	↘	↘	↘
	Crop insurance subsidies	↘	↗	↘
	Conservation and environment programs	↗	→	↘
Socio-Economic*	Farm Size -commercial	↗	↗	↗
	GDP	↗	↗	↗
	Population	↗	↗	↗
Technology*	Improvements in conservation technologies	↗	→	→
	Pest management effectiveness	↗	→	→
Prices from Global/National Models(without climate change)	Wheat	↗	→	↘
	Corn	↗	→	↘
	Cattle	↗	→	↘
	Chemicals	↗	→	→
	Fertilizers	↗	→	↗
Prices from Global/National Models(with climate change)	Wheat	↗	→	→
	Corn	↗	→	→
	Cattle	↗	→	→
	Chemicals	↑	→	↗
	Fertilizers	↑	→	↗

Abatzoglou, Rupp, and Mote Respond to 'Questionable Evidence of Natural Warming' Article.

John Abatzoglou, David Rupp, and Phil Mote recently responded to a paper published in September 2014 by Johnstone and Mantua concluded that all of the observed warming in the PNW was due to natural circulation variability. Their letter was published in *Proceedings of the National Academy of Sciences.*

REACCH scientists addressed this confounding result with prior research and conducted a follow-up analysis of the data which clearly show that the PNAS study was completely reliant on the single dataset that Johnstone and Mantua chose (other datasets did not corroborate their findings), and secondly the proposed mechanism is largely unable to explain the warming we have seen since 1948 when most of the observed warming and anthropogenic forcing has been in play.

Linear temperature trends for annual SAT for the northwestern United States (Oregon, Washington, Idaho, and western Montana)

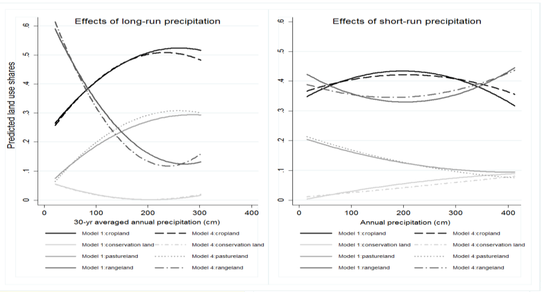


Abatzoglou, J. T., D. E. Rupp, P. W. Mote. 2014. Questionable evidence of natural warming of the northwestern United States, *Proceedings of the National Academy of Sciences USA* December 30, 2014, vol. 111 no. 52

Climate Change, Weather Shocks and Future Socio-Economic Scenarios in a Semi-Reduced Form Model of Agricultural Land Use

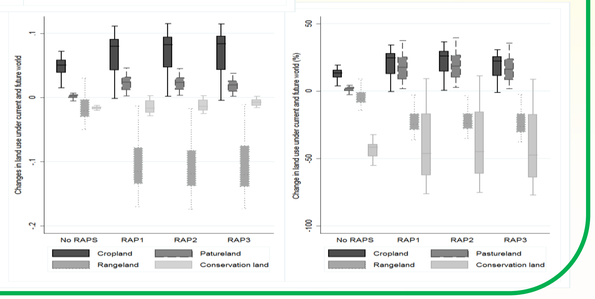
This paper develops a "semi-reduced form" agricultural land use model, and applies this model to assess impacts of climate change and weather shocks under future socio-economic conditions in Pacific Northwest. We show that modeling farmers' land use decisions as short-term allocations (within-system) nested within long-term allocations (choices between systems) leads to a semi-reduced form that depends on long-run average weather (climate), near-term weather shocks, current prices and price expectations, capital stocks, and other socio-economic factors such as conservation policy and demographics. Results from this paper show that:

- Little sensitivity of reduced-form weather and climate parameters to the inclusion of prices and other socio-economic variables in the semi-reduced form, and impacts of climate variables to be larger in magnitude than effects of annual weather;
- Under plausible future global and regional socio-economic scenarios and global economic models' price projections, changes in socio-economic conditions are found to substantially offset and in some cases reverse the projected impacts of climate change on land use, demonstrating the importance of incorporating prices and other socio-economic variables in climate impact assessments along with meaningful socio-economic scenarios;
- A comparison of uncertainties associated with climate models, economic models and socio-economic scenarios shows the need for all of these dimensions to be represented in assessments of climate impact and adaptation.



Note: in the left graph, we compare the "semi-reduced form" model (Model 1) with the "reduced form" model (Model 4) for short-run and long-run precipitation effects on agricultural land uses

Note: in the right graph, we show the projected land use changes from present to future conditions taking both climate and other changes into account, relative to the current no-climate baseline. "No RAPS" is the case with current socio-economic conditions and future climates; "RAP1", "RAP2" and "RAP3" are three representative agricultural pathways we developed for REACCH region. Please see the left box for details of RAPs.



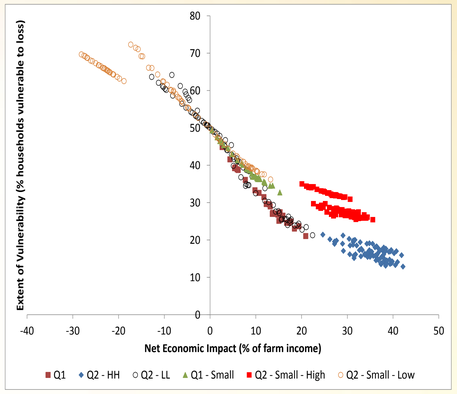
Economic Impacts of Climate Change on Winter Wheat

We use the TOA-MD tradeoff analysis model to analyze the average impacts of climate change on the economic vulnerability of winter wheat producing farms in the REACCH region. This required using output from downscaled climate model projections, simulated crop yields from a crop simulation model (CropSyst), economic data from the Census of Agriculture and several socio-economic scenarios.

Results show that:

- The average impact of climate change is likely to be positive in this region but due to 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;
- 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 climate change.

Extent of Vulnerability without adaptation: REACCH-PNA winter wheat – fallow

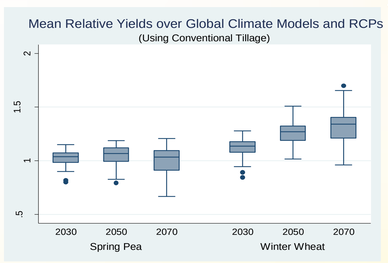


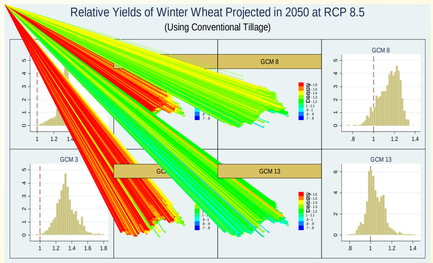
Note: "Q1" and "Q2" indicates climate impacts on current and future winter wheat production system; "LL" and "Low" indicates a world with low commodity prices and low costs of production; "HH" and "High" indicates a world with high commodity prices and high costs of production; "Small" indicates small farms.

Agricultural Productivity under Future Climate Scenarios

A relative yield methodology was used to study the REACCH region based on projected yields from a crop simulation model called CropSyst, and 14 climate models under two emissions scenarios (known as RCP4.5 and RCP 8.5). We find that:

- Climate change will likely benefit winter wheat productivity on average by increasing average relative yields under most projections of future climate but lower spring pea productivity by reducing average relative yields in the annual system;
- The climate change impacts on crop productivity are not uniformly distributed among farms, and due to this heterogeneity, while a majority of farms would tend to have higher yields with climate change, there could be a substantial proportion that would have lower yields;
- There is substantial uncertainty in the impacts on crop productivity due to future climate uncertainty.





Plan of Future Research

Future research of objective team 1 includes:

- The climate team will
  - Assess climate suitability of novel cropping systems in the PNW;
  - Project change in false springs with climate change across the continental US.
- The crop simulation model team will simulate future yields of oil seeds for the annual cropping system;
- The economic team will analyze proportion of farms that would benefit economically from adoption of "adapted" or alternative systems and the productivity and economic effects of these systems, under current as well as future climate and socio-economic conditions. The adaptation scenarios include:
  - Change in tillage practices;
  - Changes in cropping systems;
  - Precision N management;
  - Introduction of bio-fuel crops into the annual cropping system;
  - Changes in policy options.

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