# Impact of climate change on agricultural production in the Columbia River basin.

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## Introduction

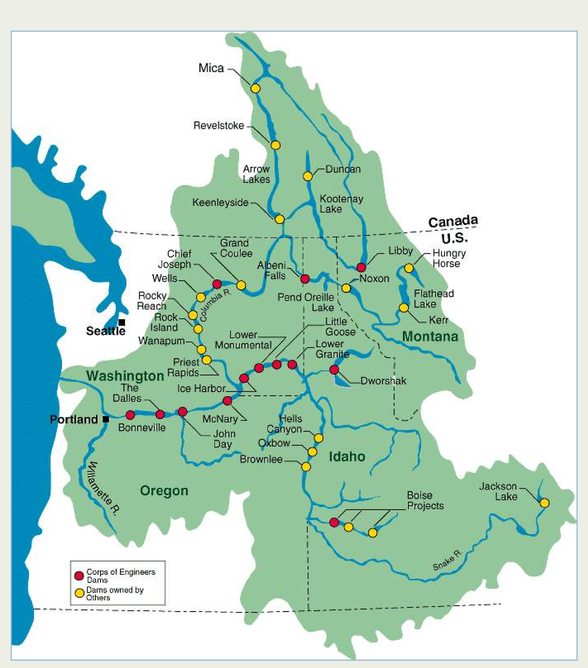
- Rising temperature and changes in the frequency and magnitude of precipitation events due to climate change (IPCC-AR4 report) are anticipated to affect crop production, water availability and quality, and flood risk in the PNW (Stockle et al 2009, Elsner et al 2009, Hamlet and Lettenmaier 2007).
- Agriculture is a vital part of the economy in the Pacific Northwest (PNW) , with an annual value over $5 billion in Washington State alone. In 2008, PNW wheat production alone accounted for $1.7 billion, the third largest value in the United States (NASS, 2009) .
- The eastern side of the Cascade Mountains, which receives only 5-25" of rain annually, is particularly vulnerable to drought. In the last decade, there have been 10-20% yield losses during severe drought years, with an average of $90 million/year (NASS, 2009).
- The challenge is to anticipate the probable effects of climate change on the hydrological cycle and make sound land use, water use, and agricultural management decisions that will best serve the needs of agricultural production while protecting our freshwater resources.

## Objective

- Characterize the **direct impacts** of climate change and $CO_2$ levels on **irrigation demands and crop yields** in the 2030s in the Columbia River basin (CRB)
- Characterize the **indirect impacts** of climate change and $CO_2$ levels on crop yields through **water rights curtailment** for the Washington part of the CRB

## Basin Description

- The Columbia River Basin in the Pacific Northwest has a drainage area of about 670,000 square kilometers covering all or parts of seven states in the US as well as British Columbia.
- Water resources are managed to meet several competing demands including hydropower generation, irrigation, navigation, recreation, and fish flows.
- Irrigated agriculture is an important part of the economy. Crops of high economic value like tree fruits, wine grapes and hops are grown in the region.

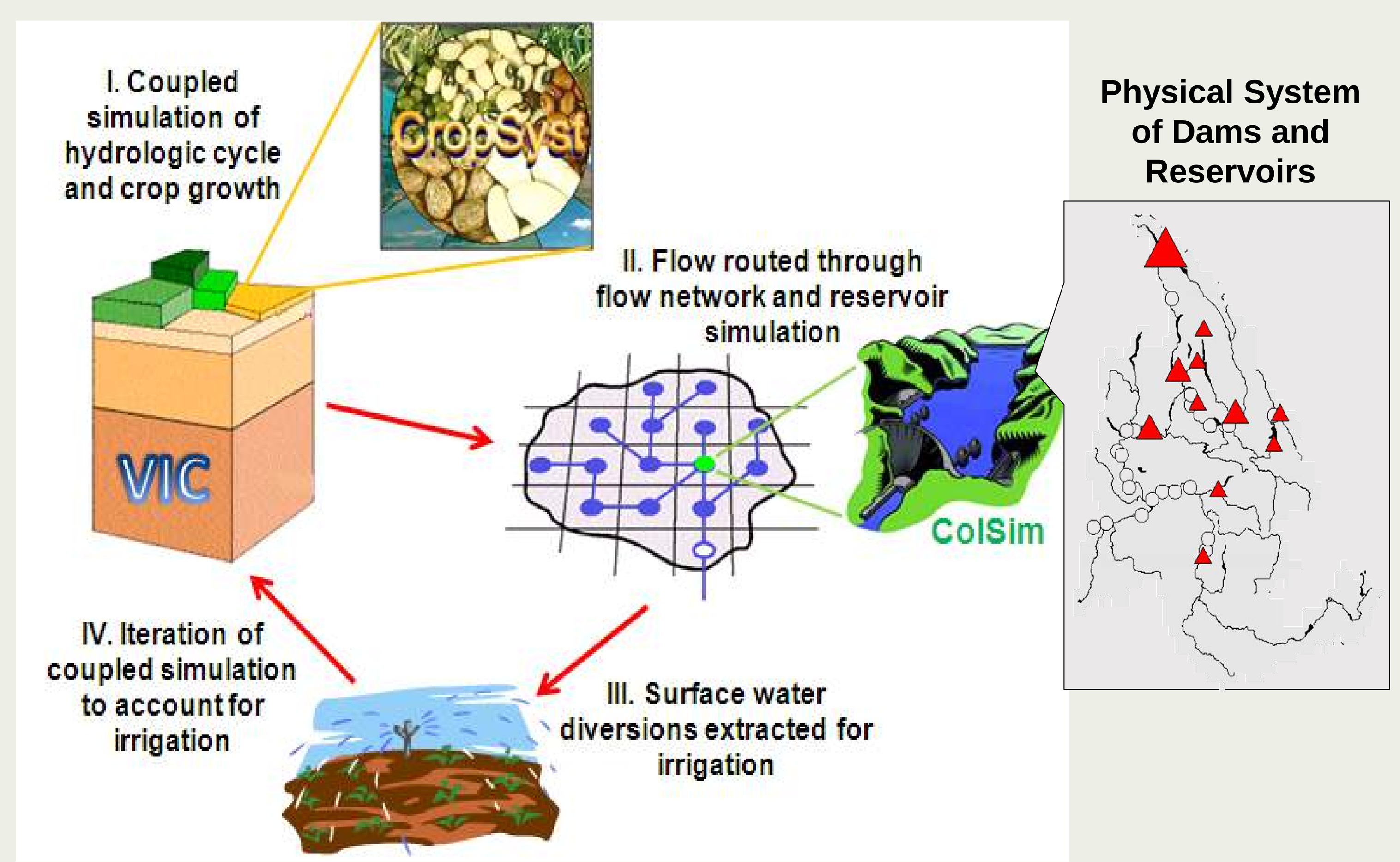



- Water allocation for irrigation water right holders have been regularly curtailed historically in several parts of the basin. This situation is expected to be exacerbated by climate change.

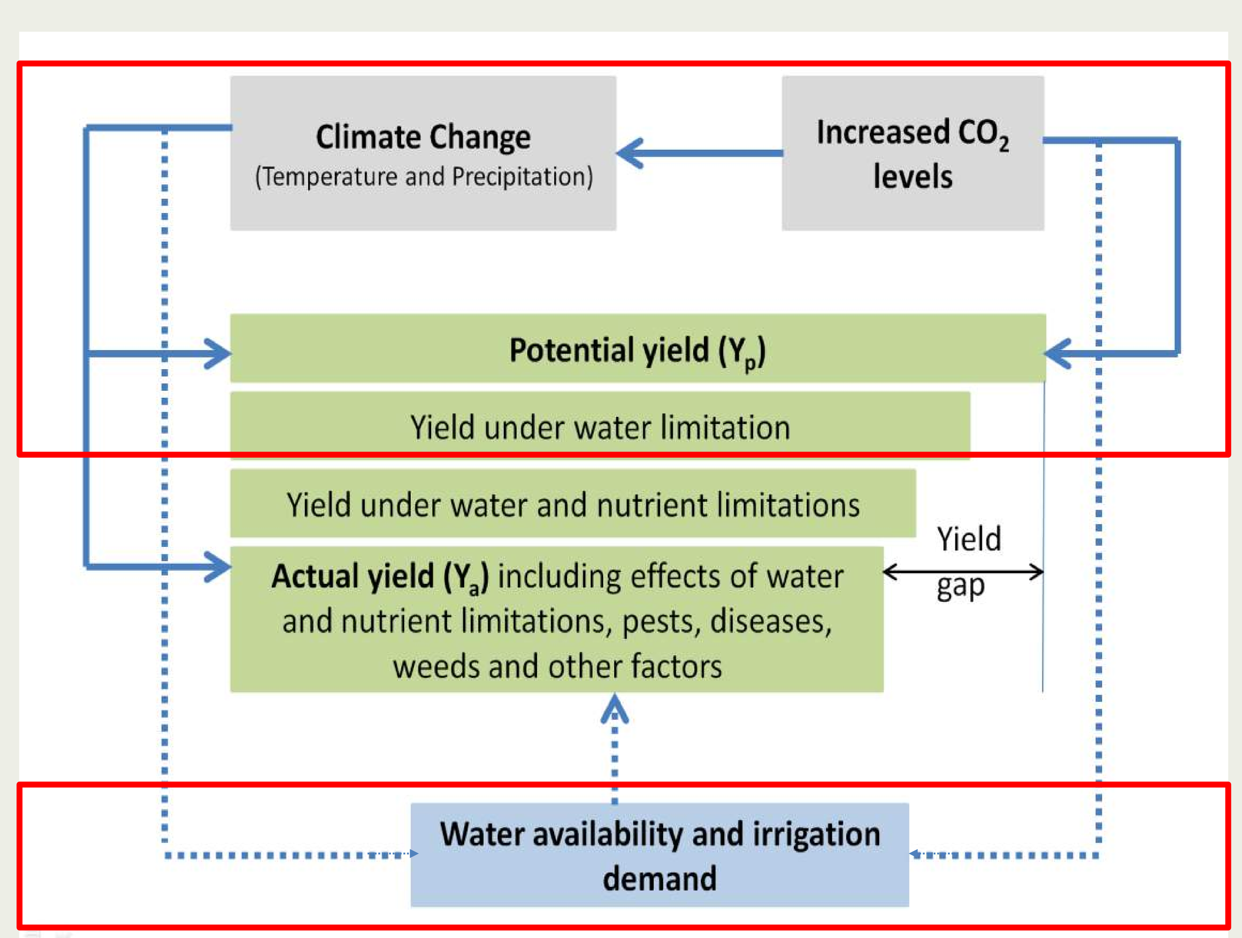
## Modeling Framework

- We applied our newly-developed system of linked models, including the VIC hydrology model (Liang et al. 1994), a dynamic crop systems model (CropSyst: Stockle et al. 2003), reservoir models for the Columbia River Mainstem (ColSim: Hamlet et al. 1999) as well as select tributaries.
- Irrigation demand and crop yield for each crop type in the basin as well as supply are simulated using VIC-CropSyst, while water management (reservoirs and curtailment) are simulated as a separate process. If curtailment occurs, VIC-CropSyst simulations with reduced irrigation are repeated to examine the effects of curtailment.

### Biophysical Modeling System




### Direct and Indirect Effects of Climate Change




## Representative Results

- There is a small change in annual water supply and irrigation demands (around 5%) in the 2030s at the CRB scale. There are seasonal, regional and crop-specific differences.

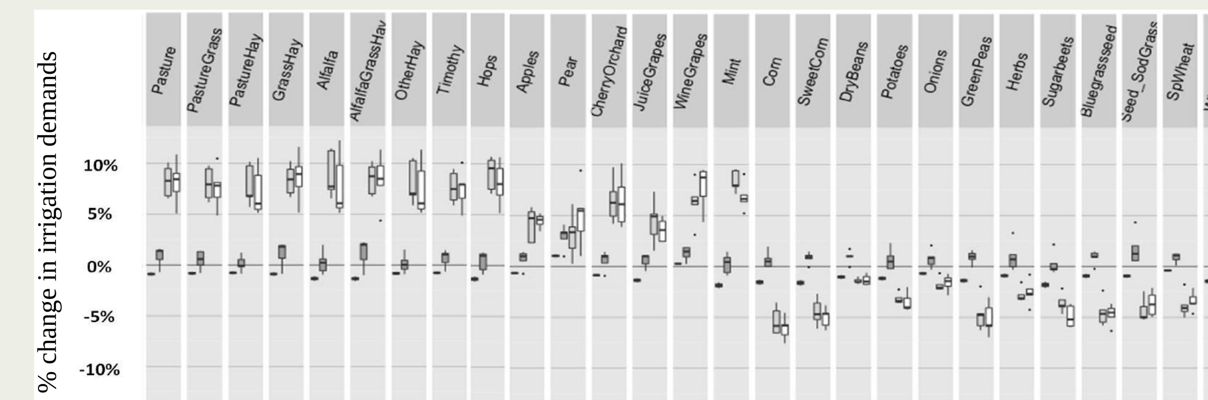
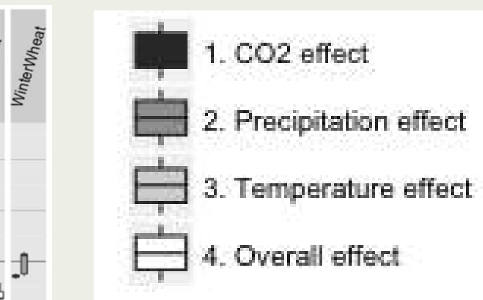


Figure 1a



Legend for figures 1a, 1b and 1c

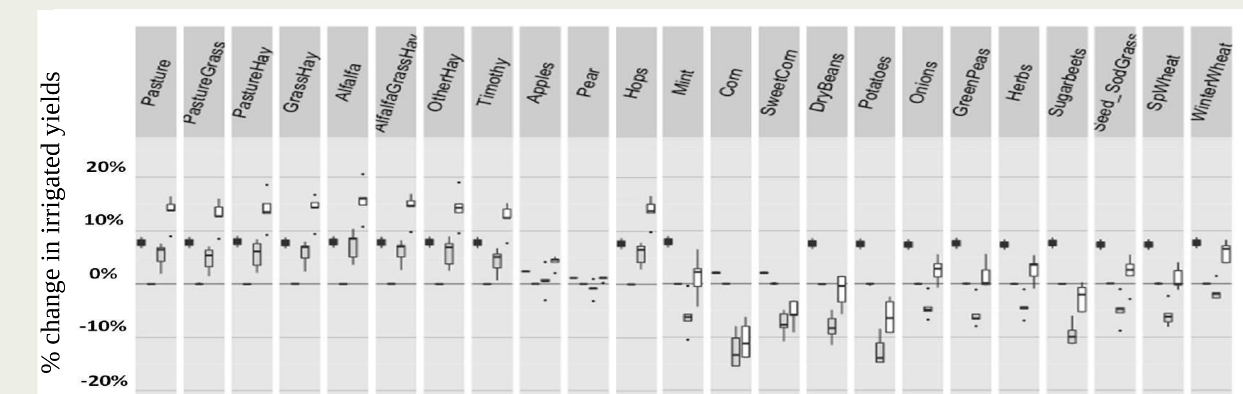
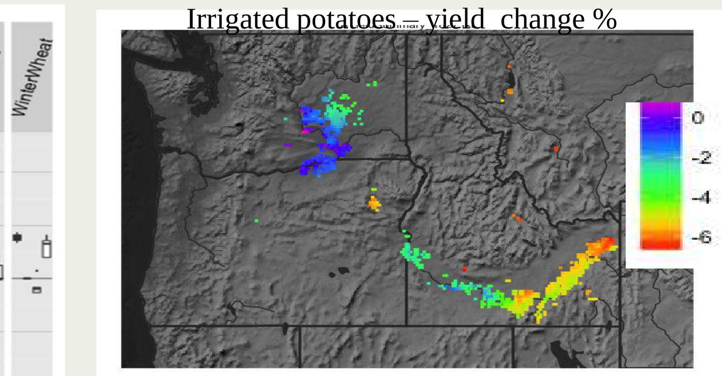


Figure 1b

Irrigated potatoes – yield change %



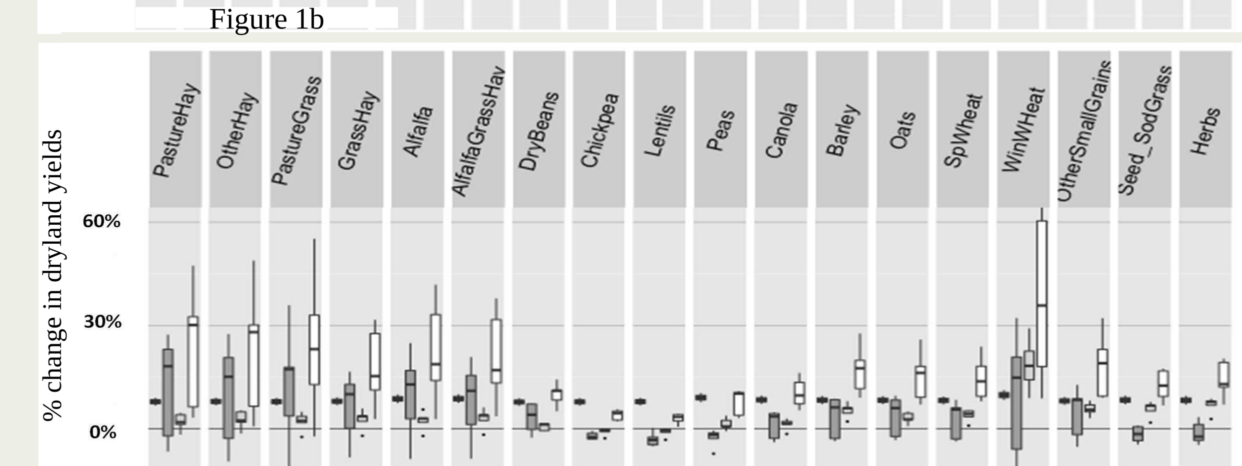
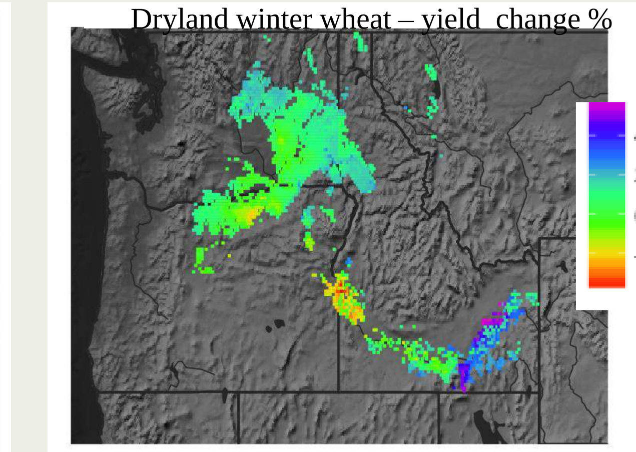
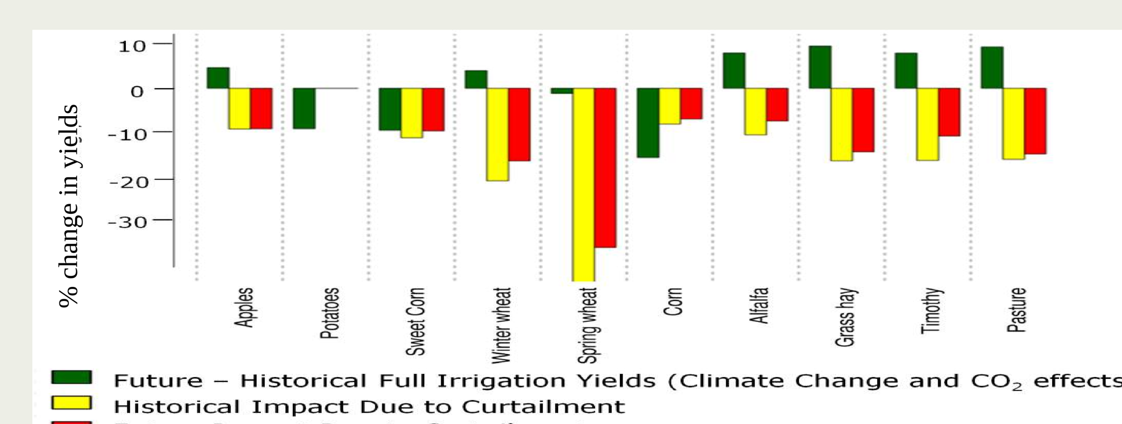


Figure 1c

Dryland winter wheat – yield change %



- The temperature effect is the most dominant effect for changes in irrigation demand. Crops that are able to utilize the longer available growing season through multiple cuttings (pasture, alfalfa, mint) see increases in irrigation demand. Annual crops generally see decreases in demand due to an earlier sowing date (more precipitation available) and shorter time to maturity.
- The temperature and $CO_2$ effects are both dominant for changes in irrigated crop yields. Crops that utilize the longer available growing season see increases in yields. For annual crops the net effect depends on the relative temperature and $CO_2$ effects.
- The precipitation effect is the dominant factor for changes in dryland yields.




- Although the frequency and amount of curtailment is higher in the 2030s, the effect of curtailment on yields are not larger than historical effects.
- Higher water use efficiencies under elevated $CO_2$ levels and earlier as well as faster accumulation of biomass could account for this.

## Conclusions

- Yield response to various factors are crop-specific with regional differences. It is important to consider the full range of crops in estimating regional effects of climate change.
- In the short term, there are both positive and negative effects of climate change on irrigation demands and crop yields. These net effects could change over time due to the non-linear, non-monotonic and competing nature of multiple effects.
- There are regions of water stress with implications for water managers.