Which groundwater-irrigated crops contribute to aquifer stress in California and the High Plains?

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Introduction

- global rate of groundwater depletion has more than doubled since the 1960s
- groundwater accounts for ~40% of the total consumptive irrigation water use globally
- agriculture consumes most of the groundwater abstracted

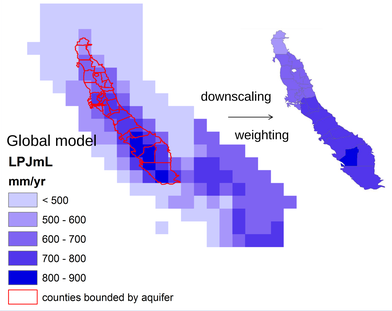
→ But how do specific crop types impact groundwater resources of a specific aquifer system?

Case study:
- USA has the 2nd highest rate of groundwater abstraction in the world
- the Central Valley (California) and High Plains aquifer systems:
  - have the highest rate of groundwater abstraction in the USA
  - respectively represent 7% and 11.7% of the USA's $300 billion in agricultural revenue (2007)

Methodology

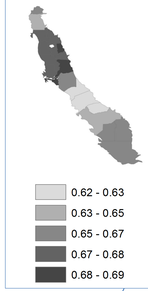
$B_{corn,cty}$

Net blue water requirement



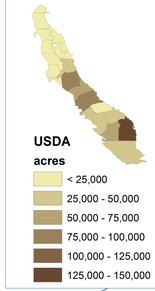
$e_{corn,cty}$

Total irrigation efficiency



$Acr_{corn,cty}$

Irrigated acreage



p_{corn}

Proportion of irrigated acreage irrigated with groundwater

Groundwater abstraction:

- **at county scale (cty)**

$$Ga_{corn,cty} = \frac{B_{corn,cty}}{e_{corn,cty}} \times Acr_{corn,cty} \times p_{corn}$$

- **at aquifer scale (aq)**

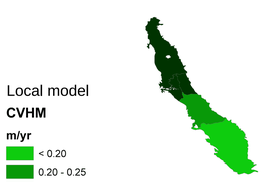
$$Ga_{corn,aq} = \sum_{\{\forall\ cty, cty \cap aq \neq \emptyset\}} Ga_{corn,cty}$$

Groundwater footprint:
"the area required to sustain groundwater use and groundwater-dependent ecosystem services of an aquifer"

$$GF_{corn,aq} = \frac{Ga_{corn,aq}}{R_{aq} - E_{aq}}$$

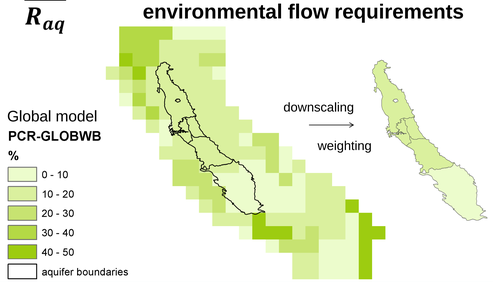
R_{aq}

Groundwater recharge



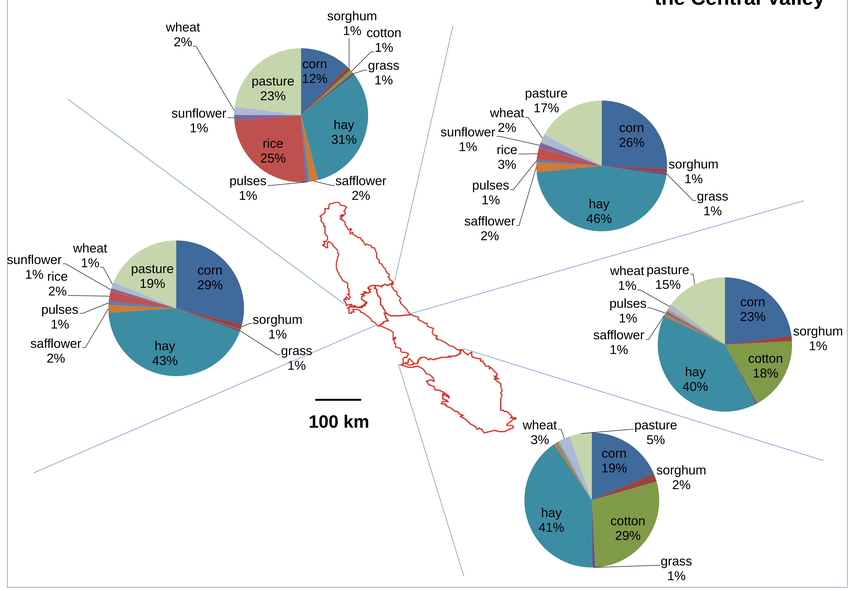
$\frac{E_{aq}}{R_{aq}}$

Fraction of recharge needed to sustain environmental flow requirements

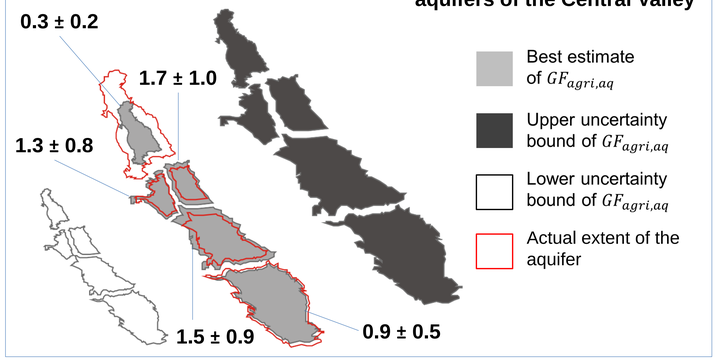


Results

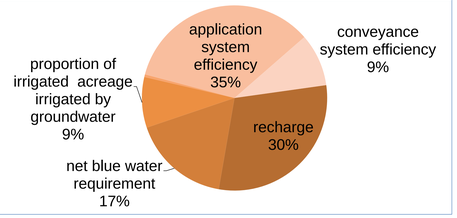
Crop type contribution to the agricultural groundwater footprint in the aquifers of the Central Valley



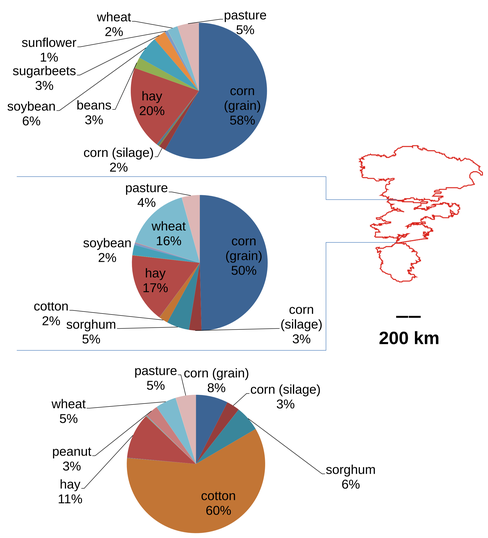
Extent of the agricultural groundwater footprint in the aquifers of the Central Valley



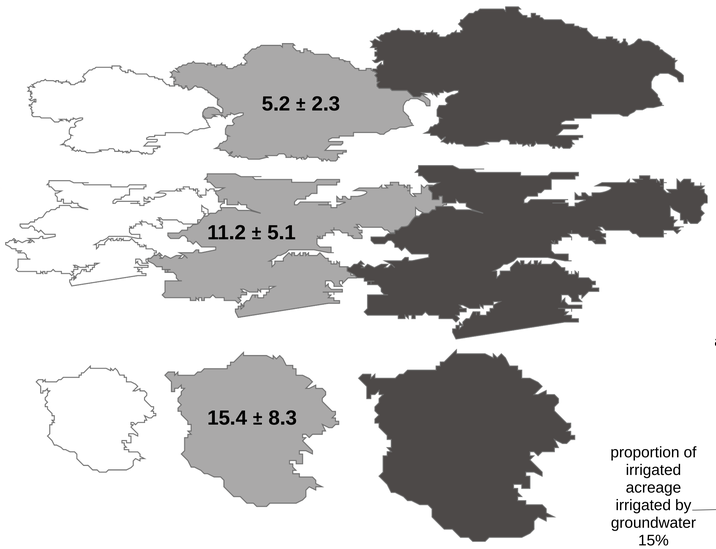
Parameter contribution to the uncertainty of the agricultural groundwater footprint in the Central Valley



Crop type contribution to the agricultural groundwater footprint in the aquifers of the High Plains



Extent of the agricultural groundwater footprint in the aquifers of the High Plains



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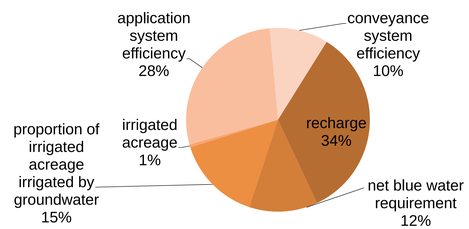

Conclusion

- crops grown for cattle-feed and ethanol production are the biggest stressors → impact of meat consumption and economic policies on aquifer stress
- lower groundwater footprint than previously estimated in the Central Valley, likely due to large-scale surface water diversions increasing artificial recharge
- recharge and irrigation application efficiency are among the most uncertain measured parameters → need for improved data