



# Pumping it up: Managing and controlling groundwater depletion

Rebecca Nelson, Jessica Reeves, Vanessa Mitchell

*Connecting the Dots: The Food, Energy, Water, and Climate Nexus*

Stanford University

Friday, April 22, 2011



# Overview

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1. Groundwater depletion – high level
  - The big picture problem
  - Policy and legal issues
  - Technical issues and uncertainties
  - Big picture connections

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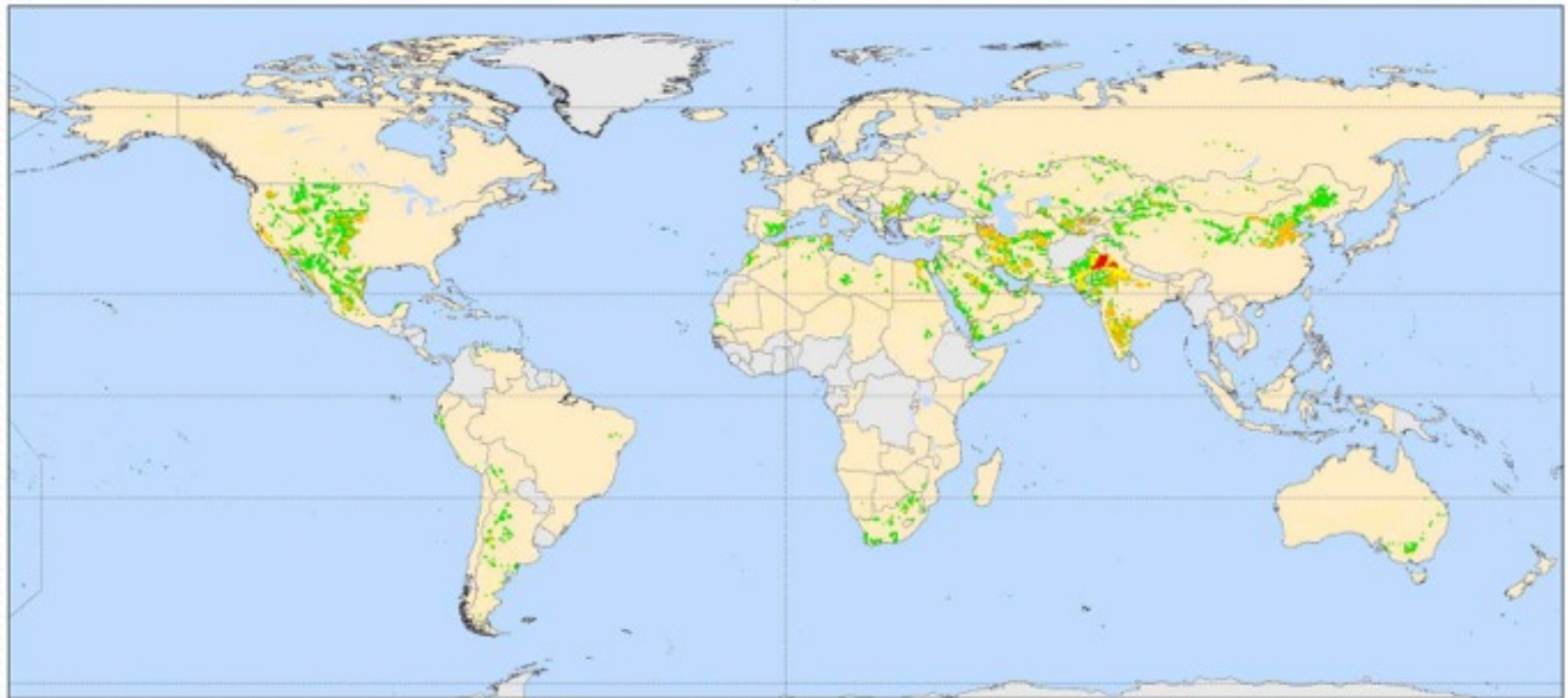
1. Groundwater depletion – high level
  - The big picture problem
  - Policy and legal issues
  - Technical issues and uncertainties
  - Big picture connections
2. Groundwater depletion – the example of the San Luis Valley, CO
3. A taste of Stanford research



# 1. Groundwater depletion at a high level

# Groundwater depletion: The big picture problem

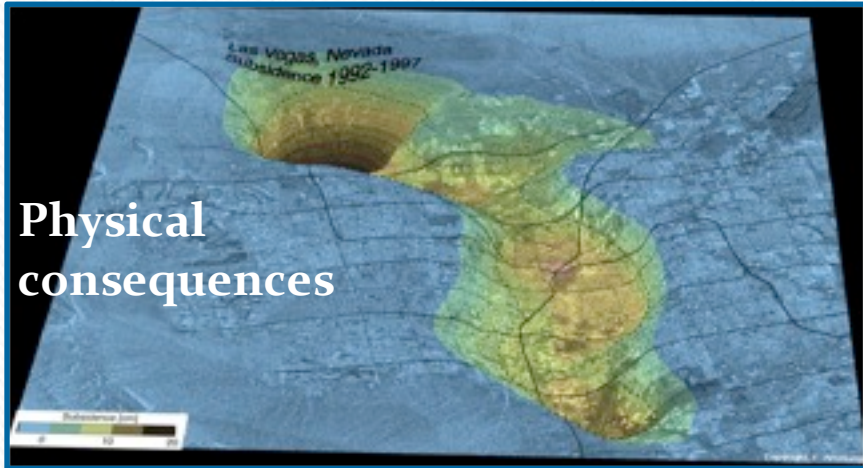
Groundwater depletion in mm/yr



(C) No Data 0 - 2 2 - 20 20 - 100 100 - 300 300 - 1000

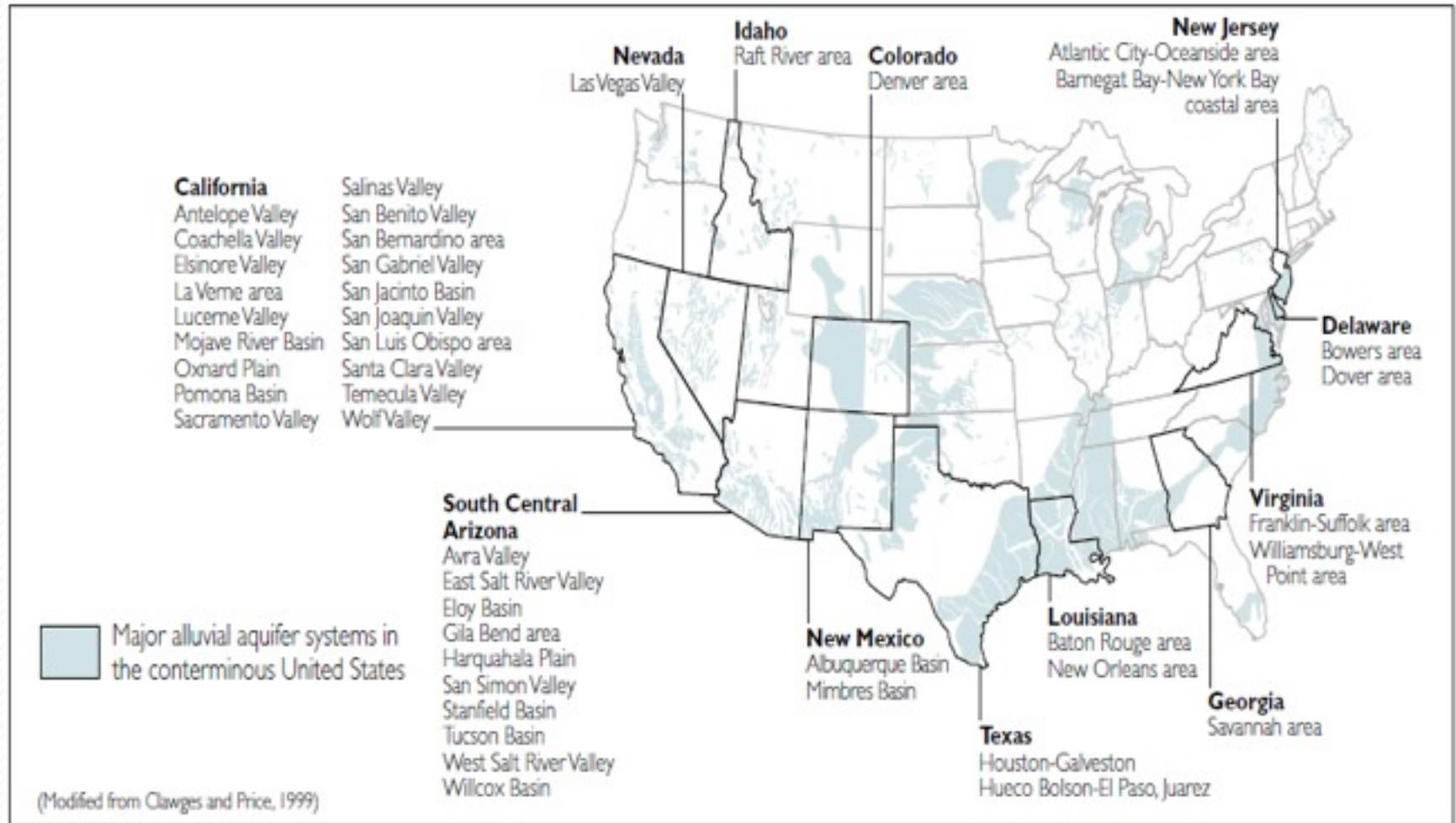
Source: Wada et al, 2010.

# Groundwater depletion: The big picture problem

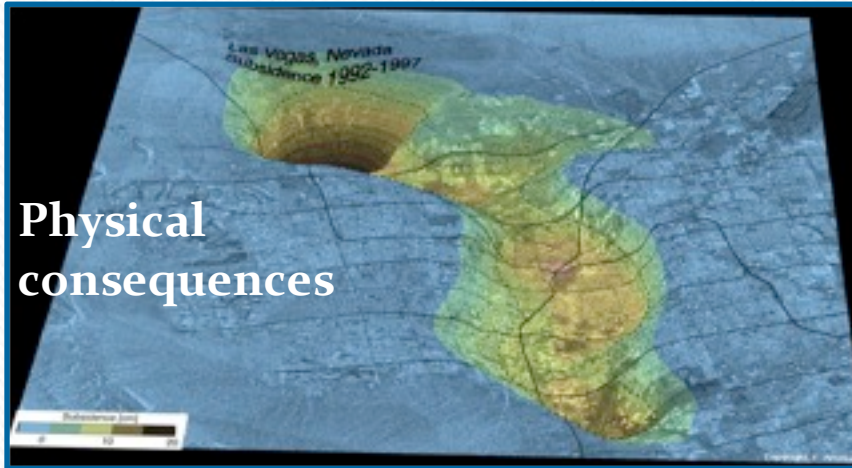




# Groundwater depletion: The big picture problem

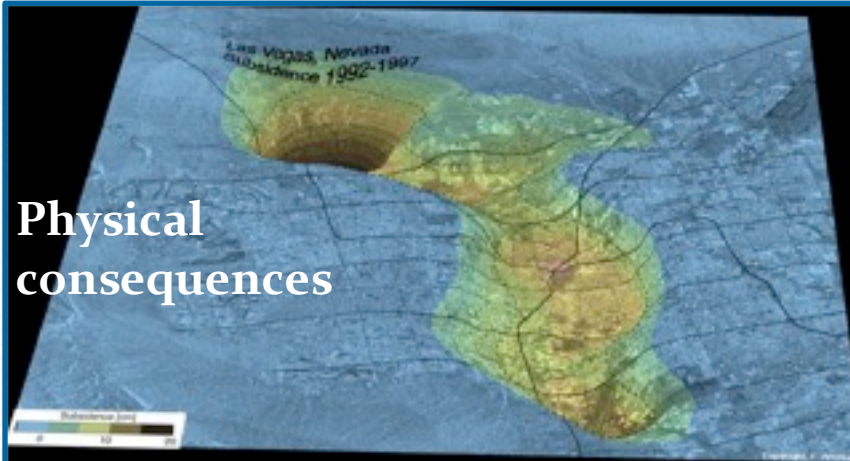


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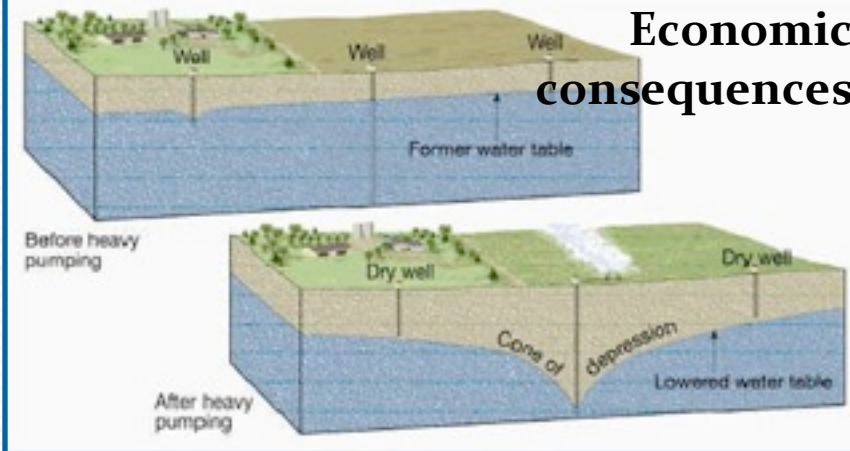
**Physical  
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**Social consequences**

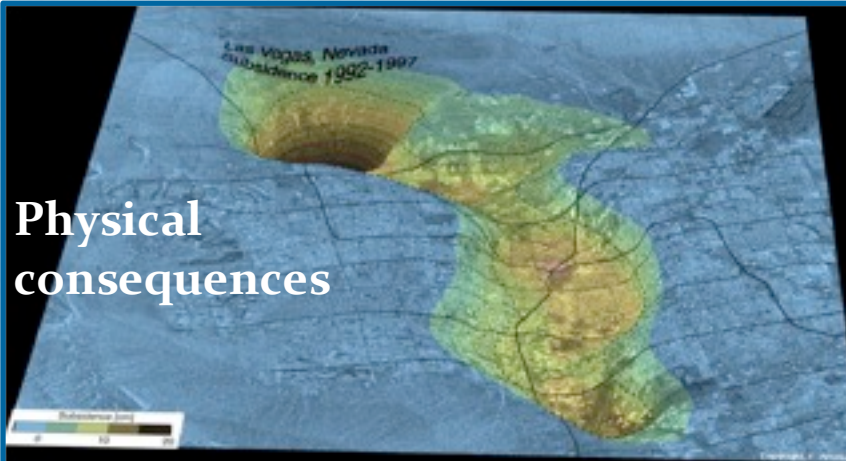


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# Groundwater depletion: The big picture problem

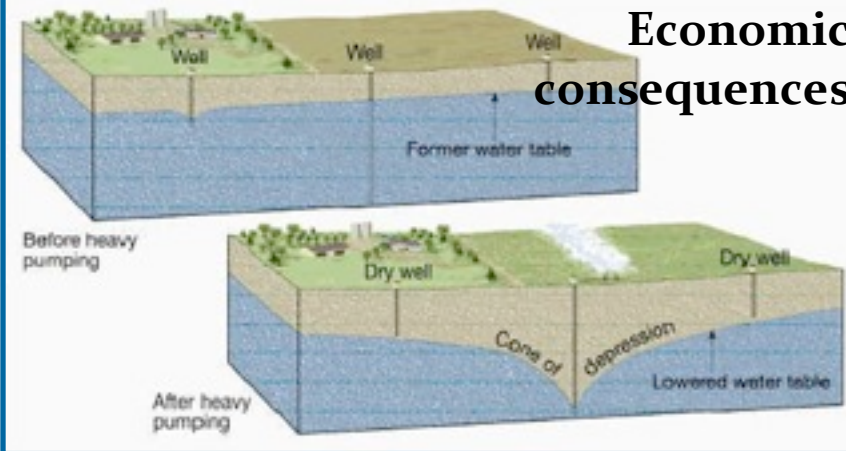
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**Ecological  
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# Groundwater depletion: Policy and legal issues



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**Limiting extraction**



**Exempting small uses**



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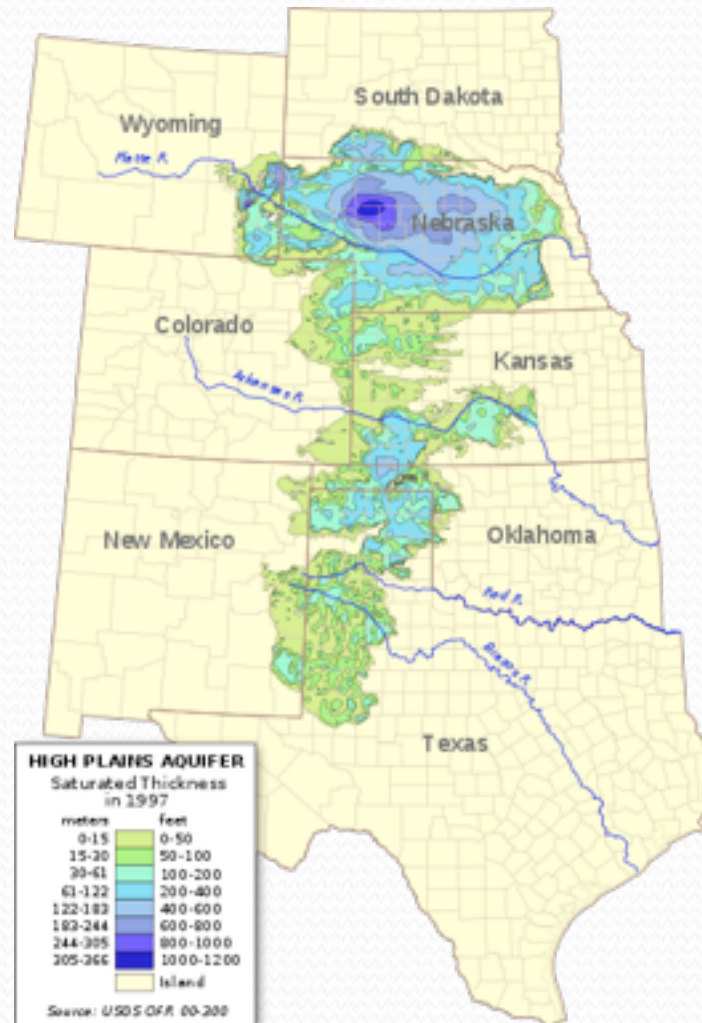


**Gathering groundwater information**



# Groundwater depletion: Technical issues & uncertainties

How much water is there?





# Groundwater depletion: Technical issues & uncertainties

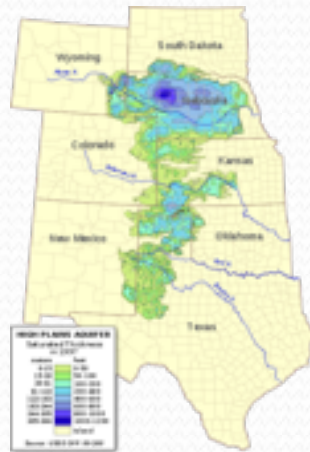
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Where will it move, and how fast?

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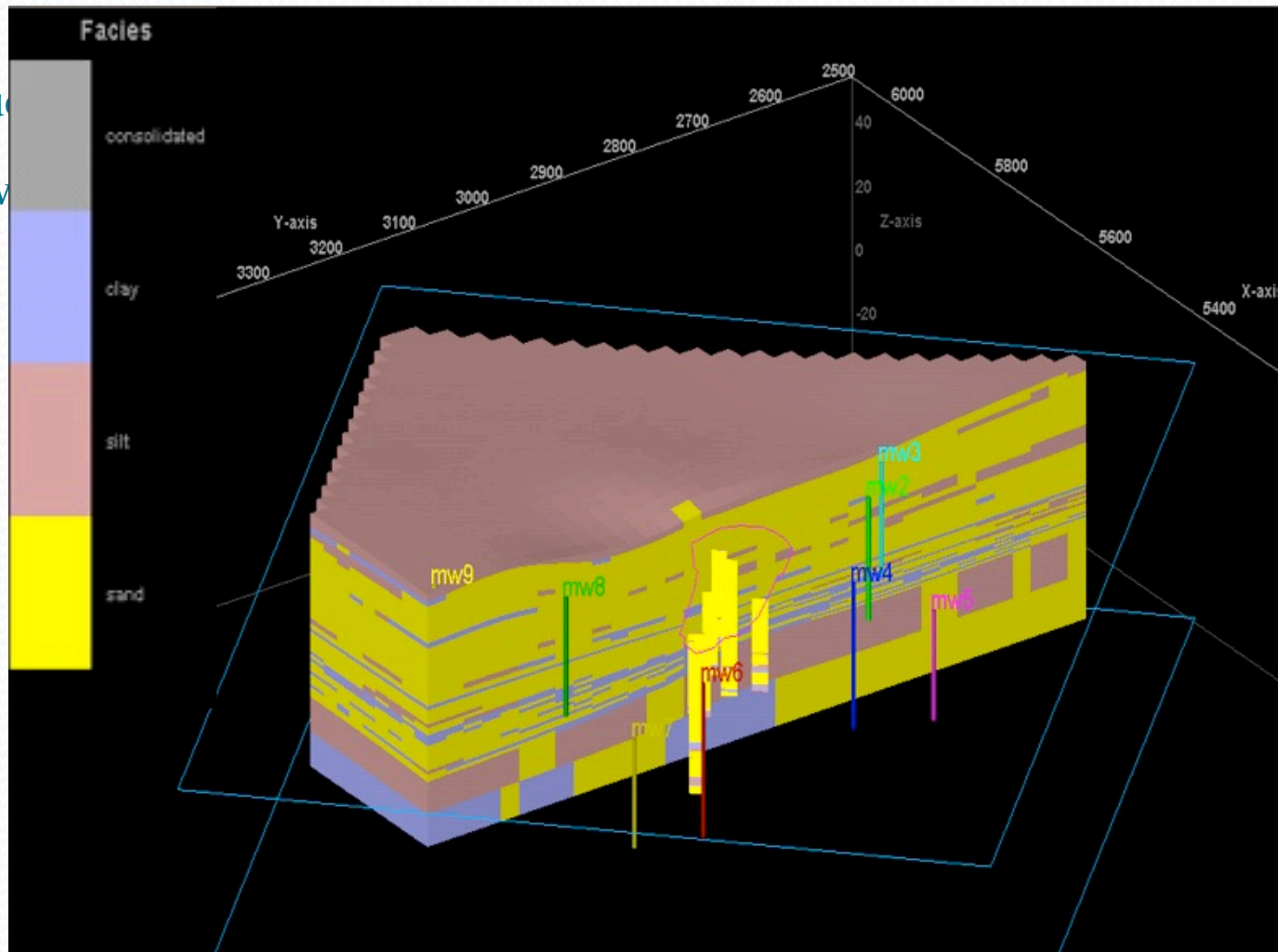
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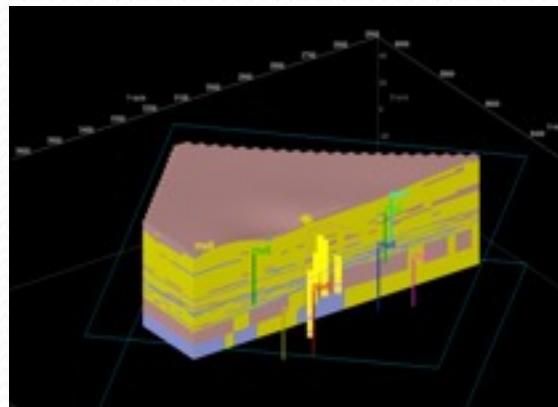
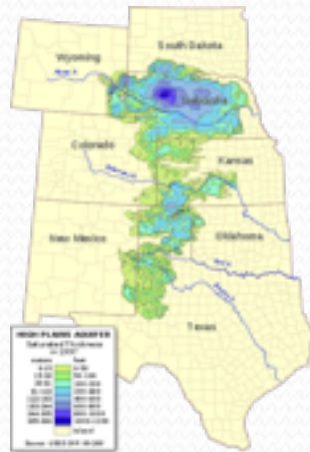
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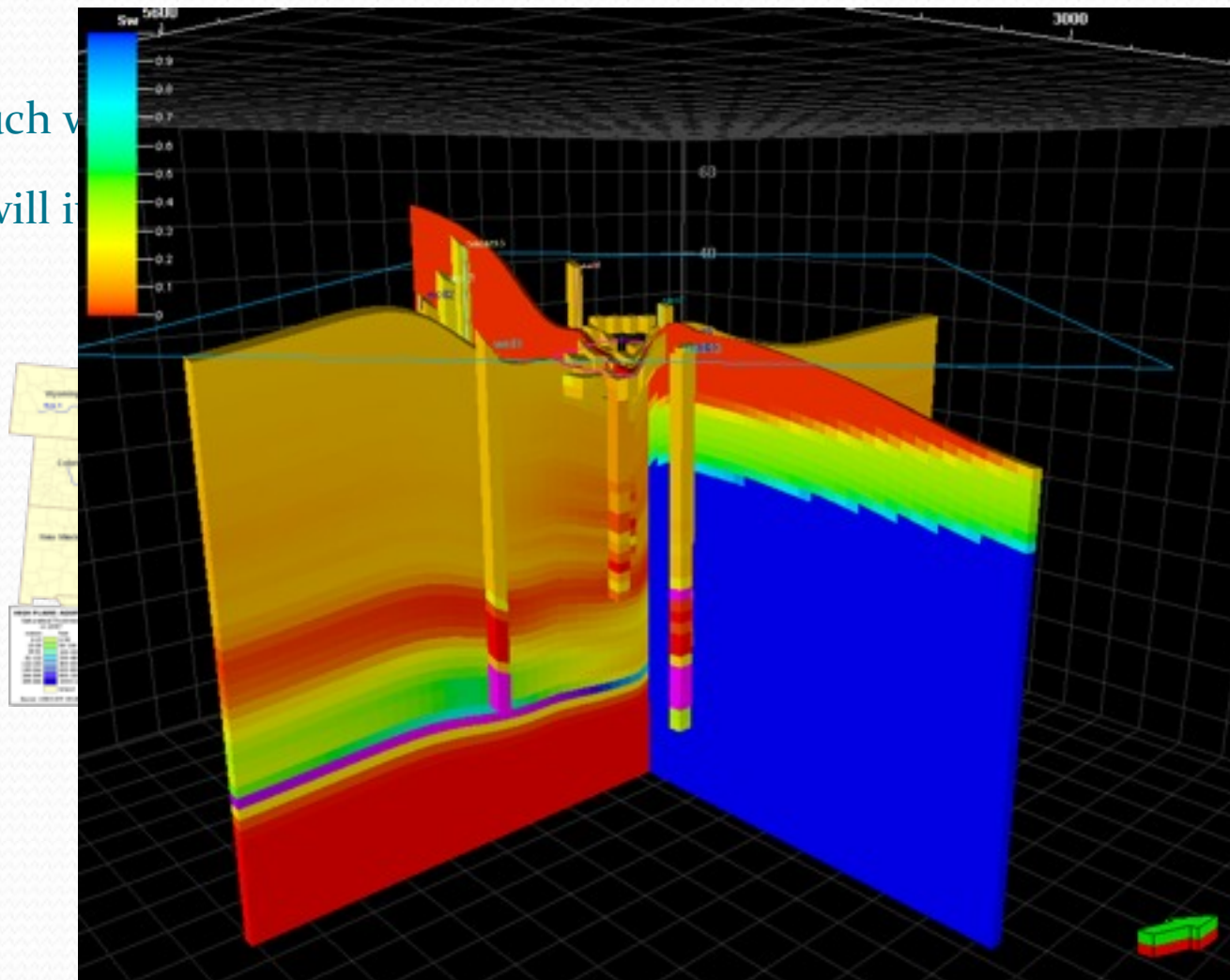
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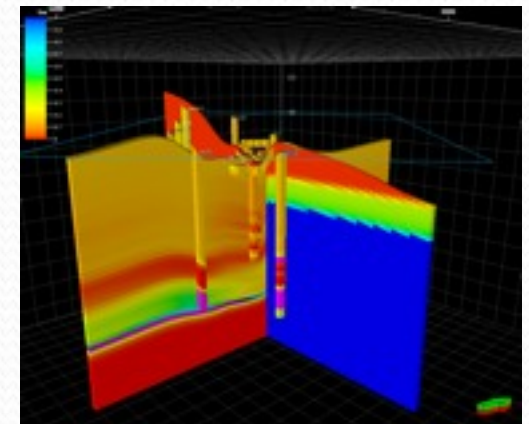
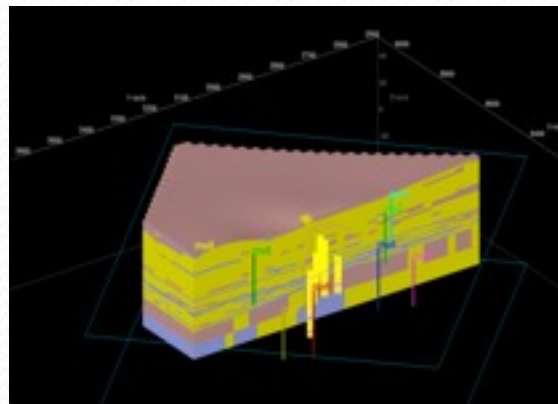
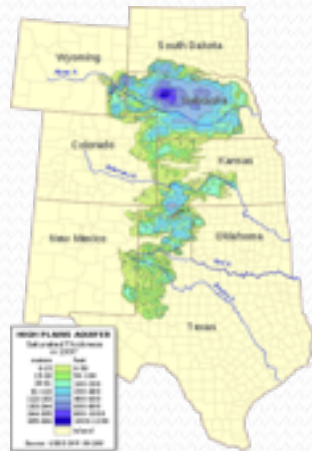
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Where will it move, and how fast?



# Groundwater depletion: Big picture connections

## Agricultural groundwater use

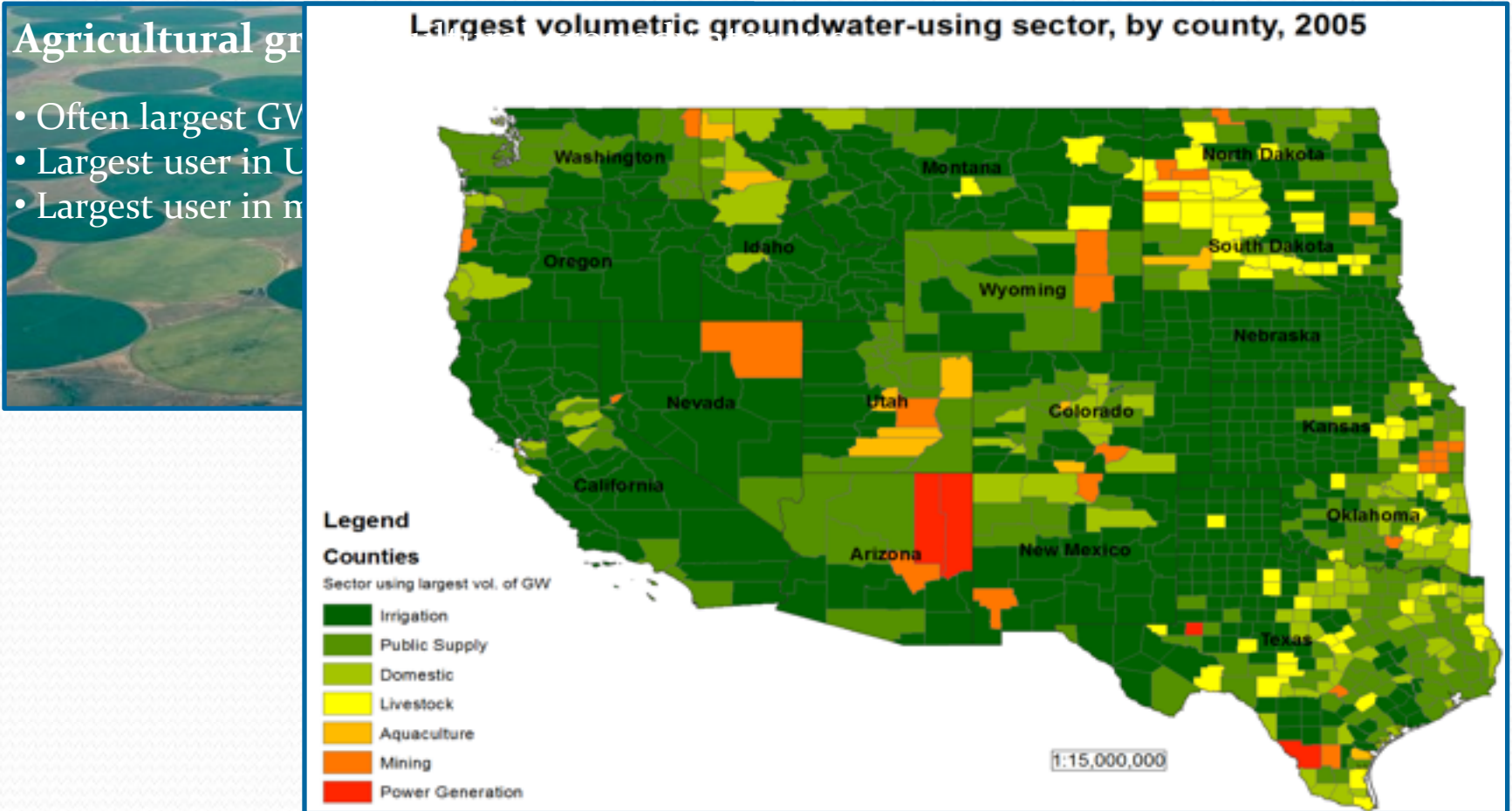
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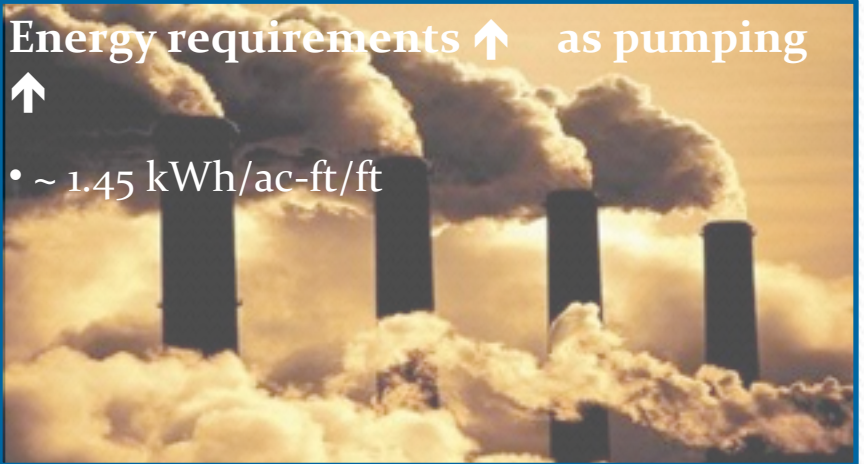
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## Energy requirements ↑ as pumping



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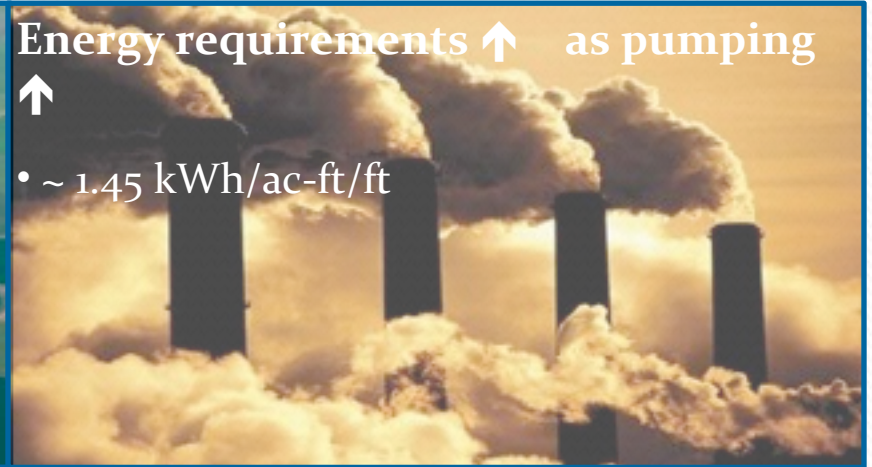
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## Climate change

- Surface water: ↓ reliability, \$ ↑
- ↑ ET ↑ water demand
- \$ power ↑
- *Central Valley, CA: climate induced decline in groundwater levels of 45-234 feet (Dale et al, 2008)*



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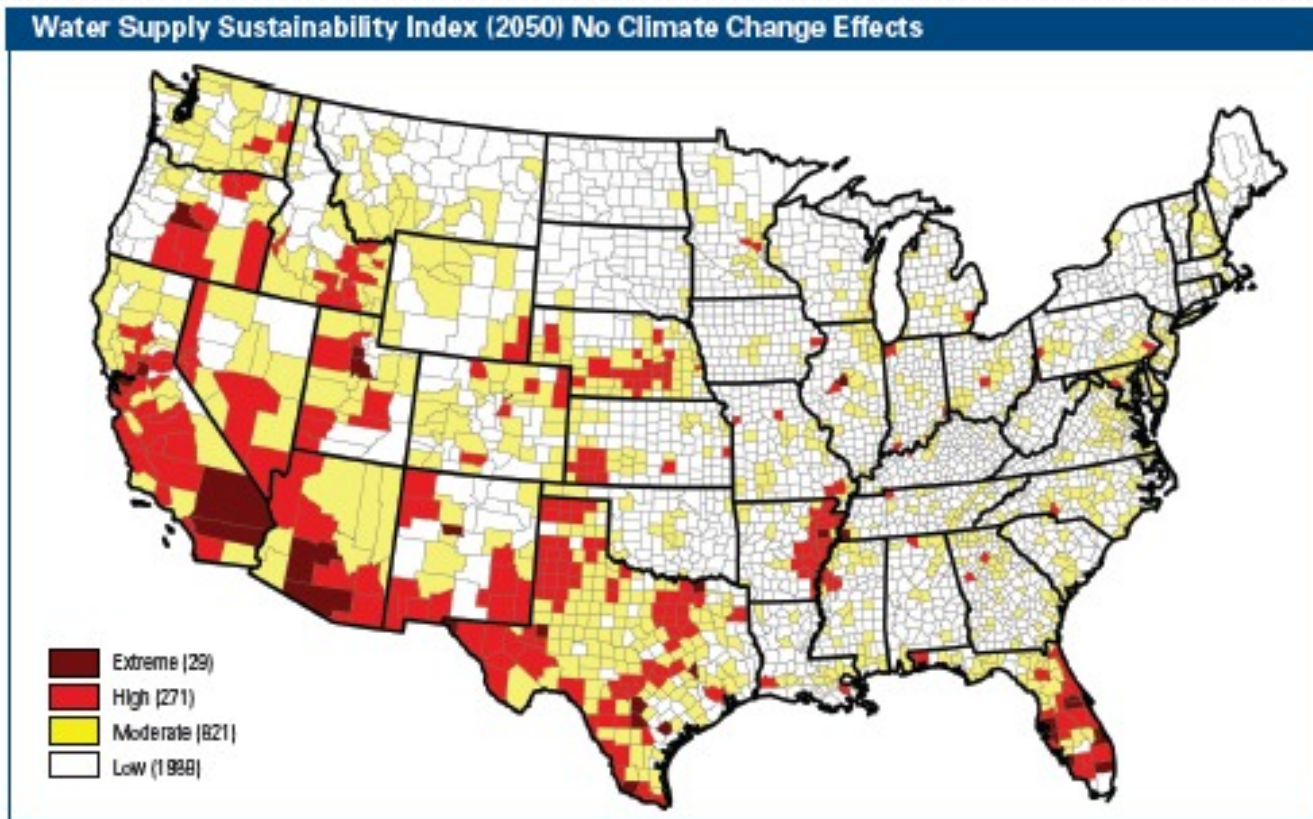
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## Effects of climate change on overall water supply sustainability

- Water demand, deficit & withdrawals
  - Groundwater use
  - Drought susceptibility
- (NRDC, 2010)

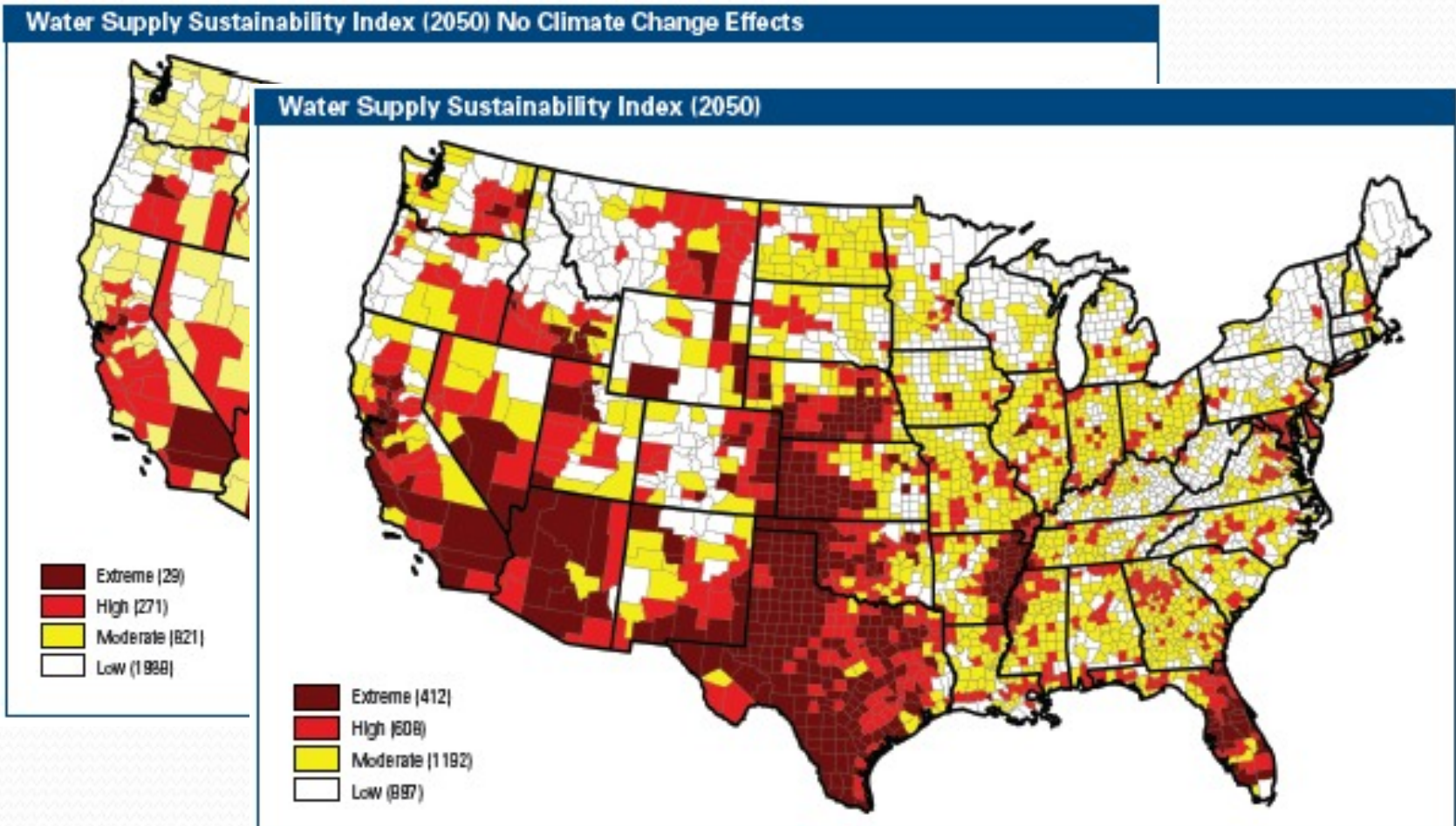
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Source: NRDC, 2010

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## 2. Groundwater depletion in the San Luis Valley, Colorado

# Groundwater depletion in the San Luis Valley: Introduction

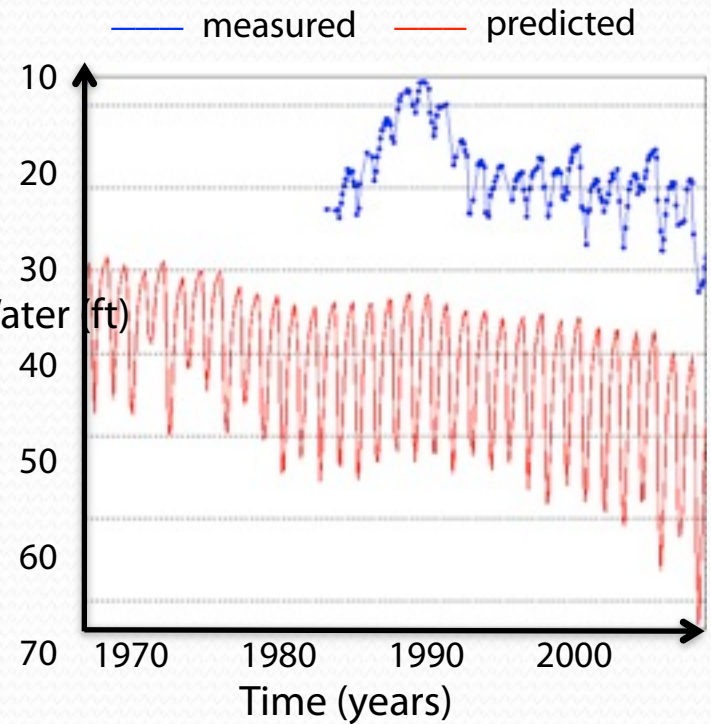


- The Rio Grande Compact (1939)
- Closed Basin Project (1980)
- The Baca Project (1986)
- Rio Grande Decision Support System(1998)
- Confined Aquifer Rules decision (2006)

# Groundwater depletion in the San Luis Valley: Introduction



Depth to Water (ft)



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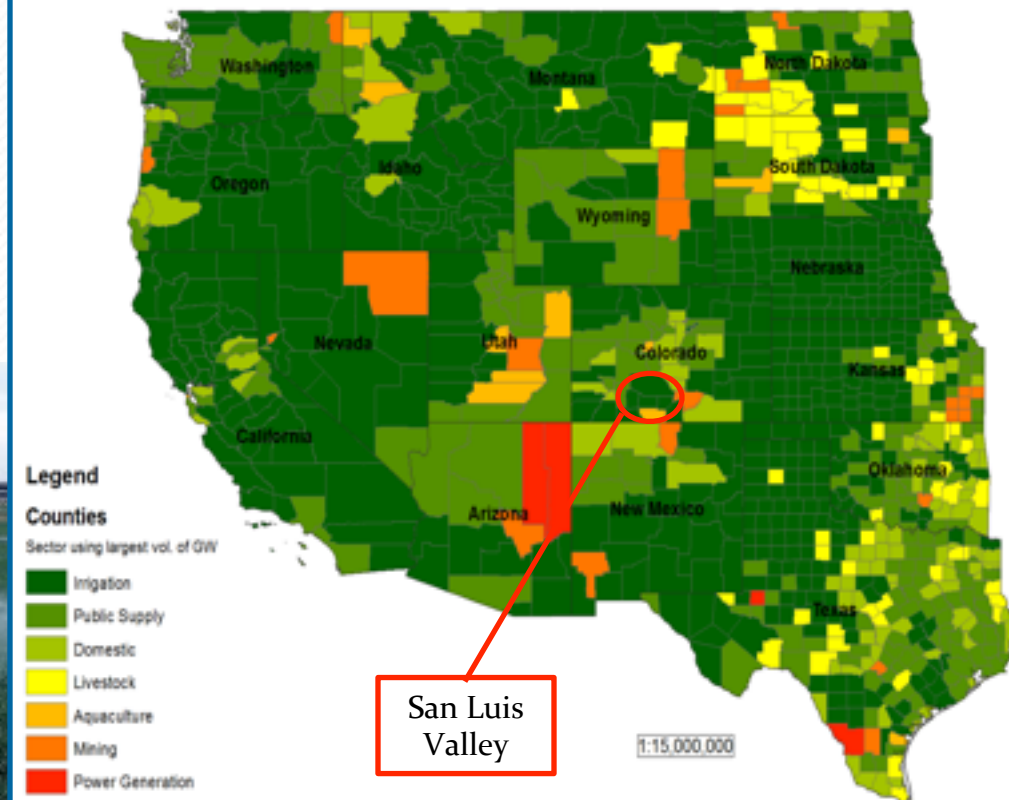
# Groundwater depletion in the San Luis Valley: The groundwater-ag connection



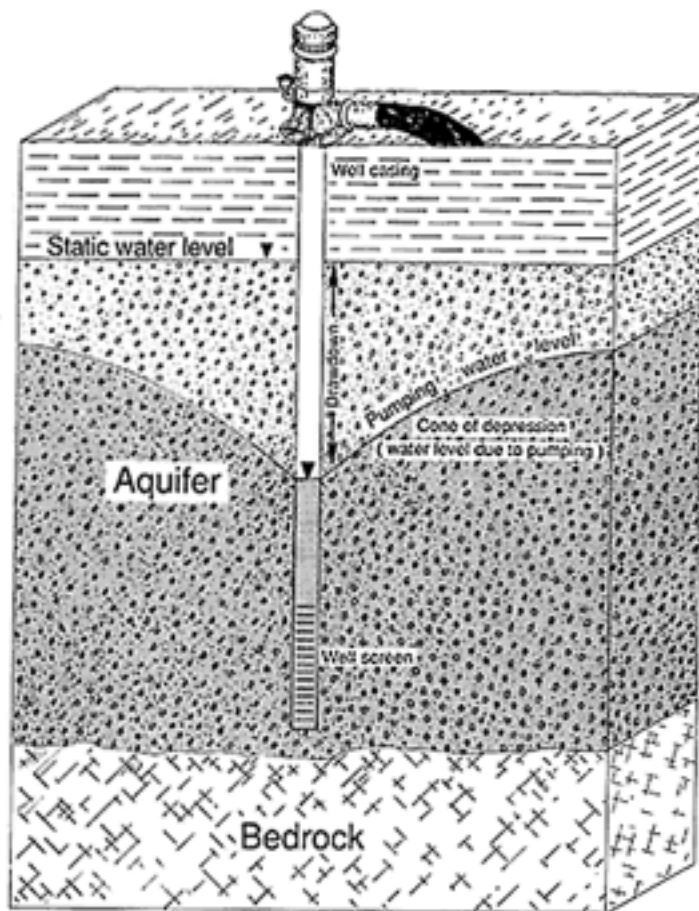
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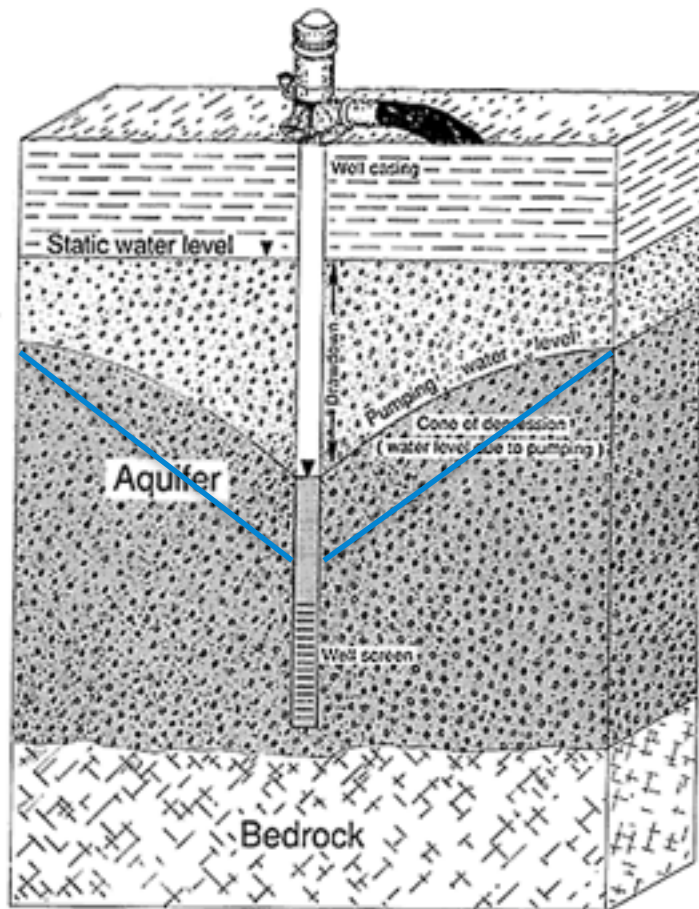
Largest volumetric groundwater-using sector, by county, 2005



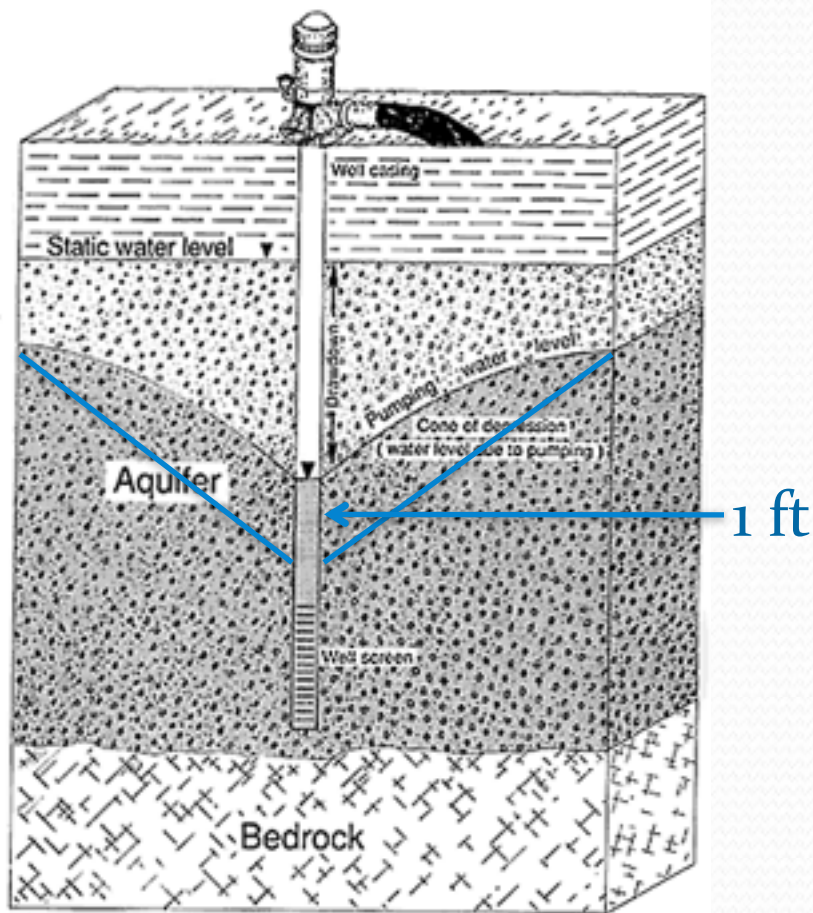
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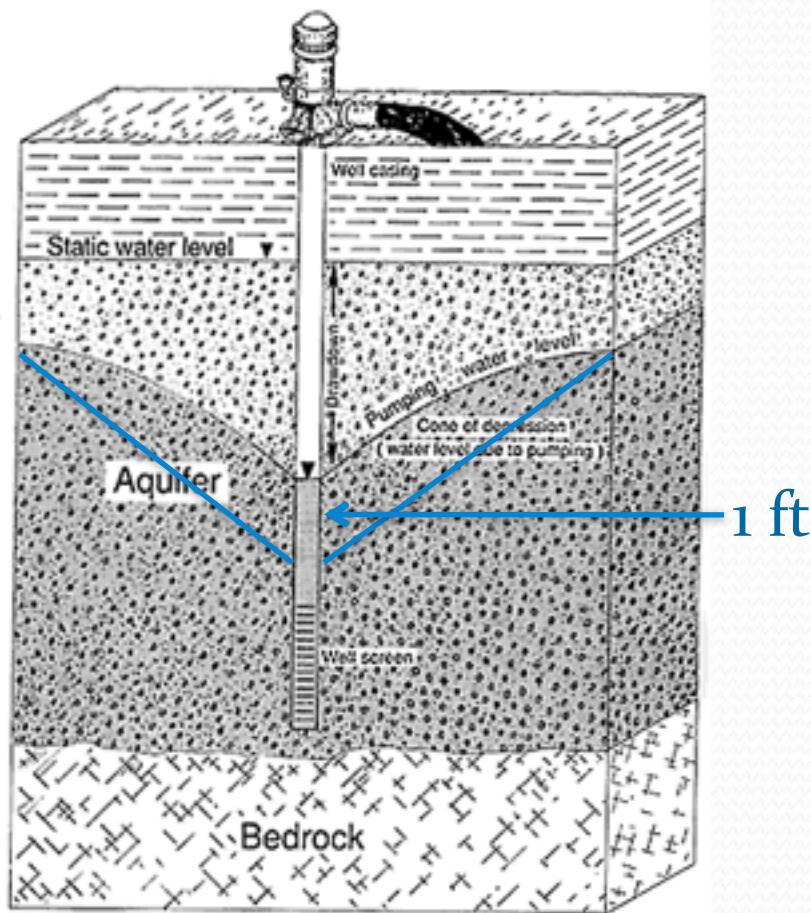


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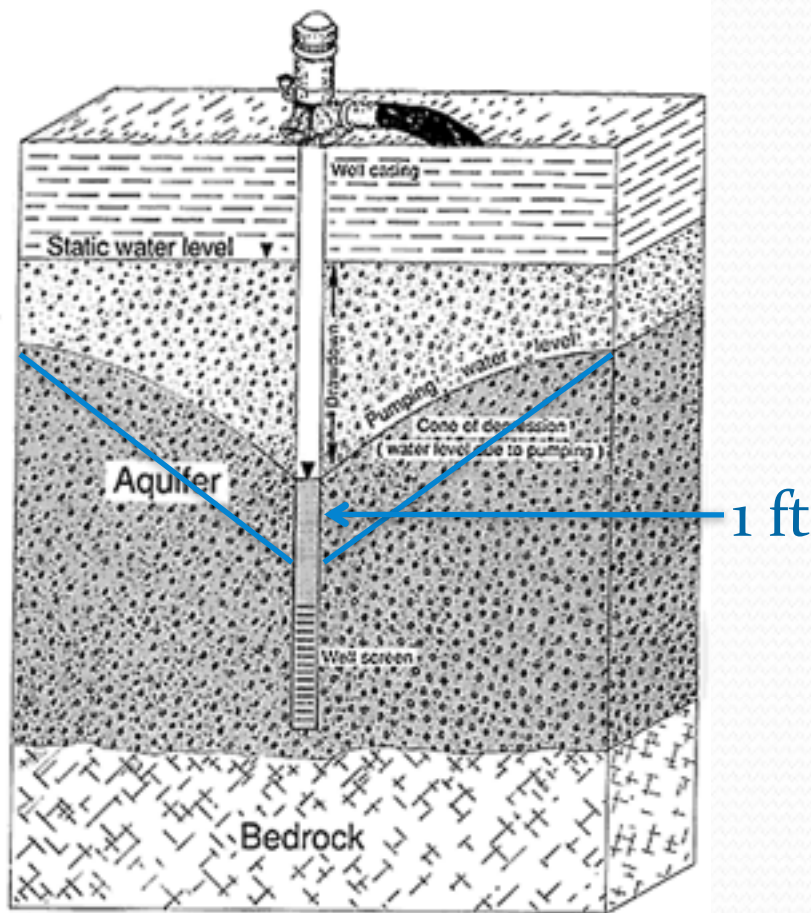


\$ 0.25/acre-foot for every foot of lift

Source: DWR California, Center for Irrigation Technology CSU

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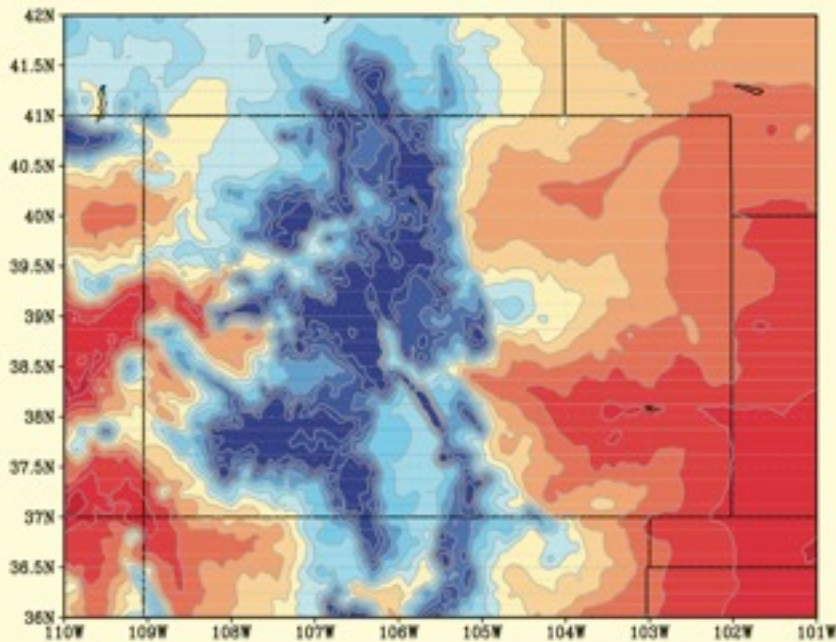


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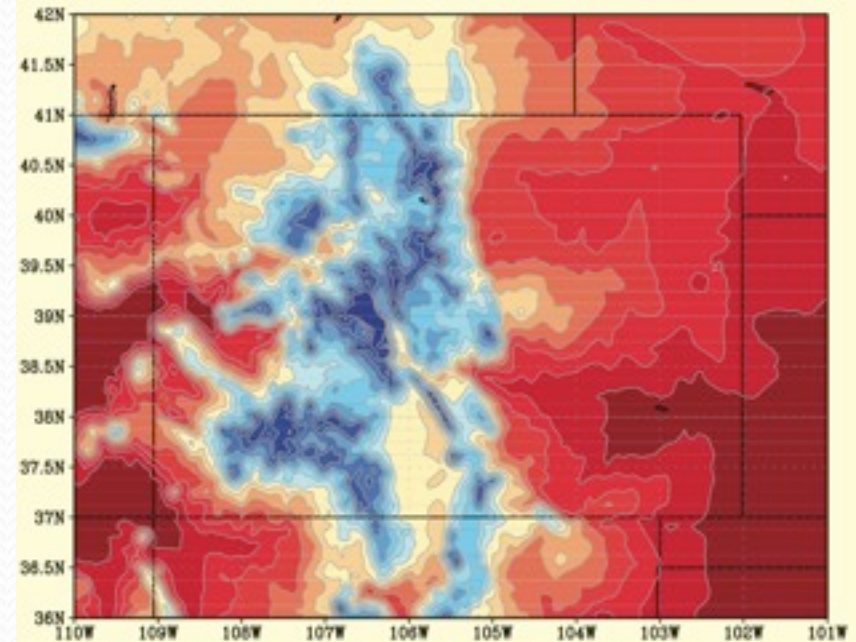
The SLV pumps 1.1 million acre-feet/year  
= \$300 000/year

# Groundwater depletion in the San Luis Valley: The groundwater-climate connection

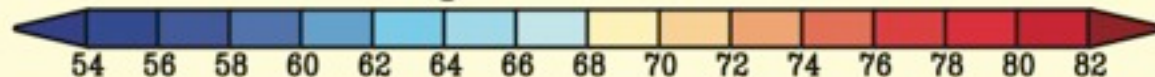
July Annual Average Temperature (1950–99)



July Annual Average Temperature (2050)

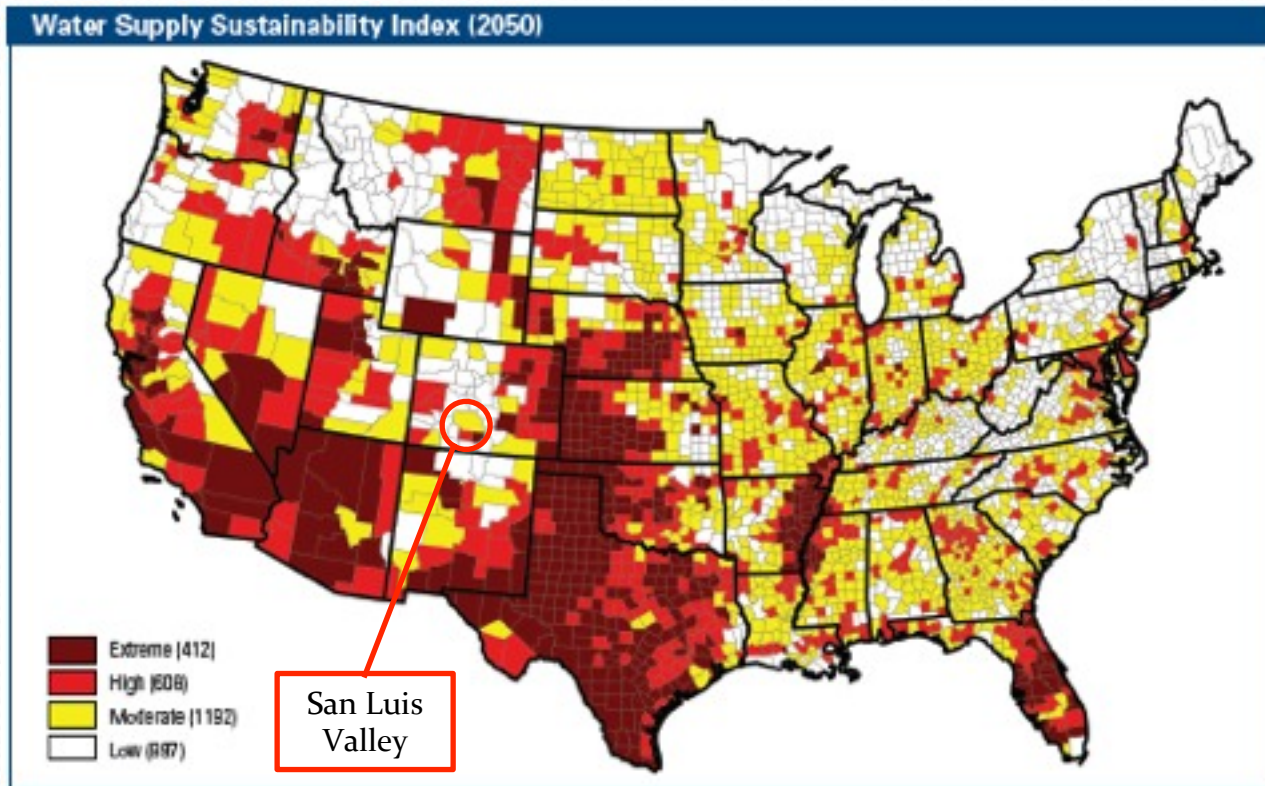


Degrees Fahrenheit



Source: Colorado Water Conservation Board

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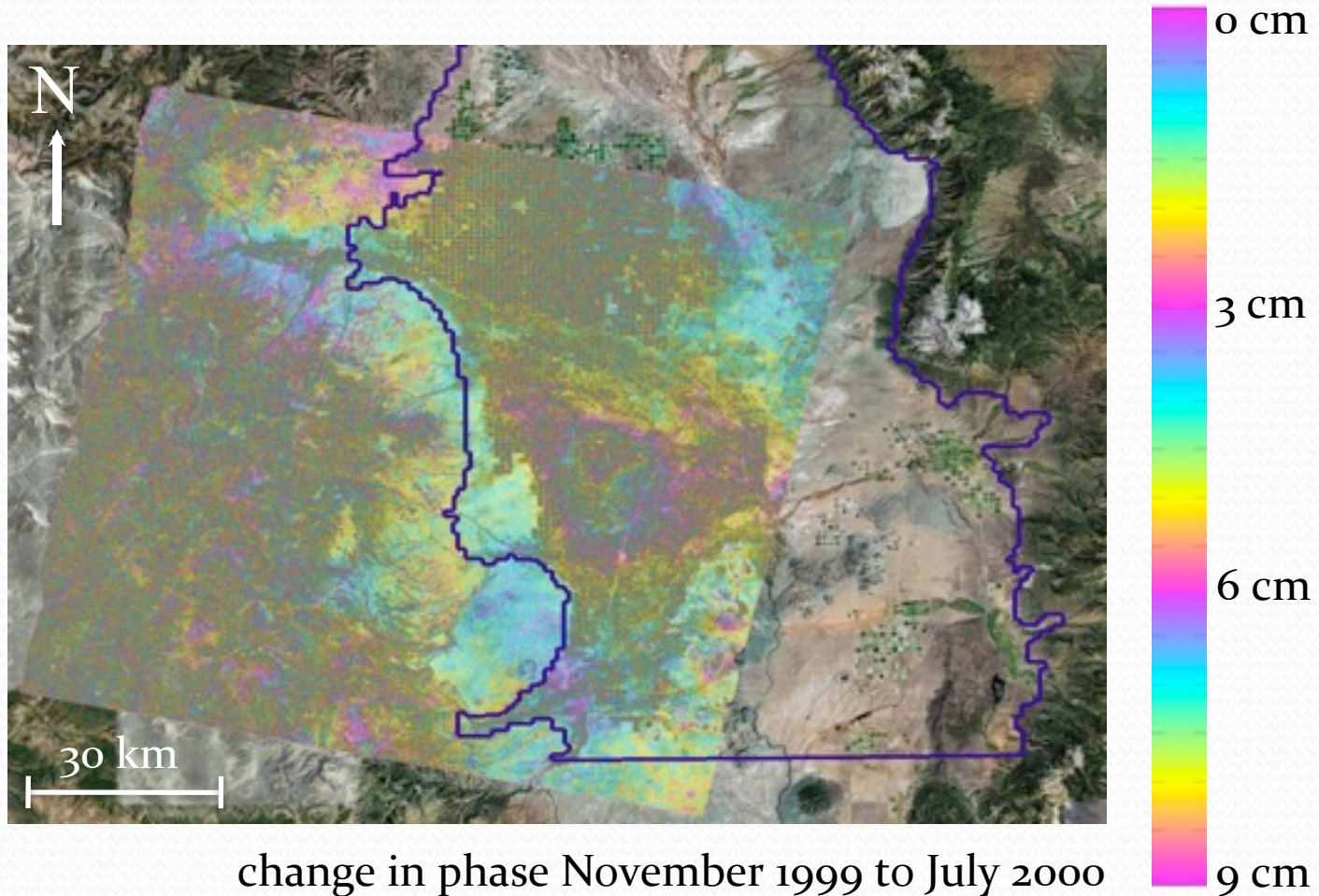
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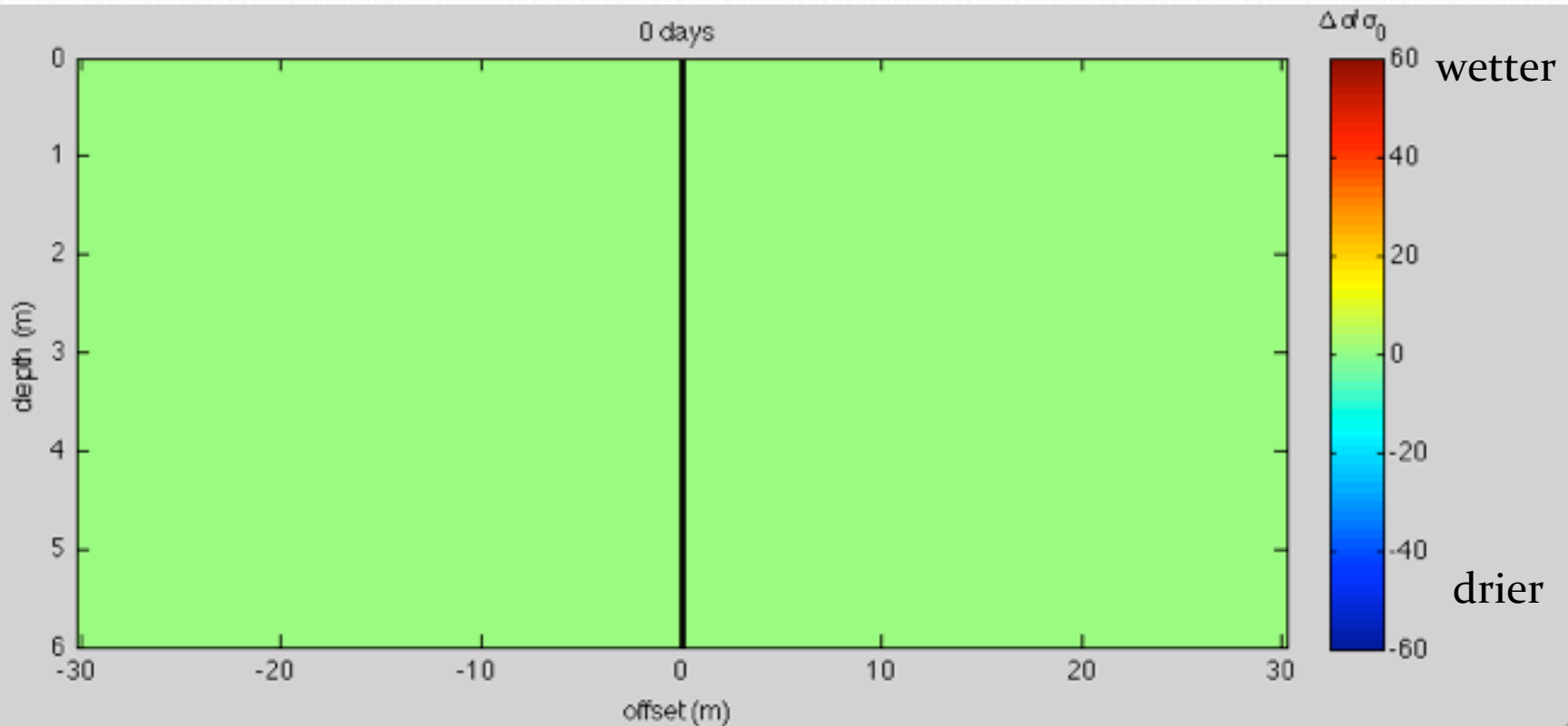
# 3. A taste of Stanford research on groundwater depletion



# Addressing groundwater depletion through research: Satellite-based InSAR (Jess Reeves)



# Addressing groundwater depletion through research: Recharge & saltwater intrusion (Vanessa Mitchell)



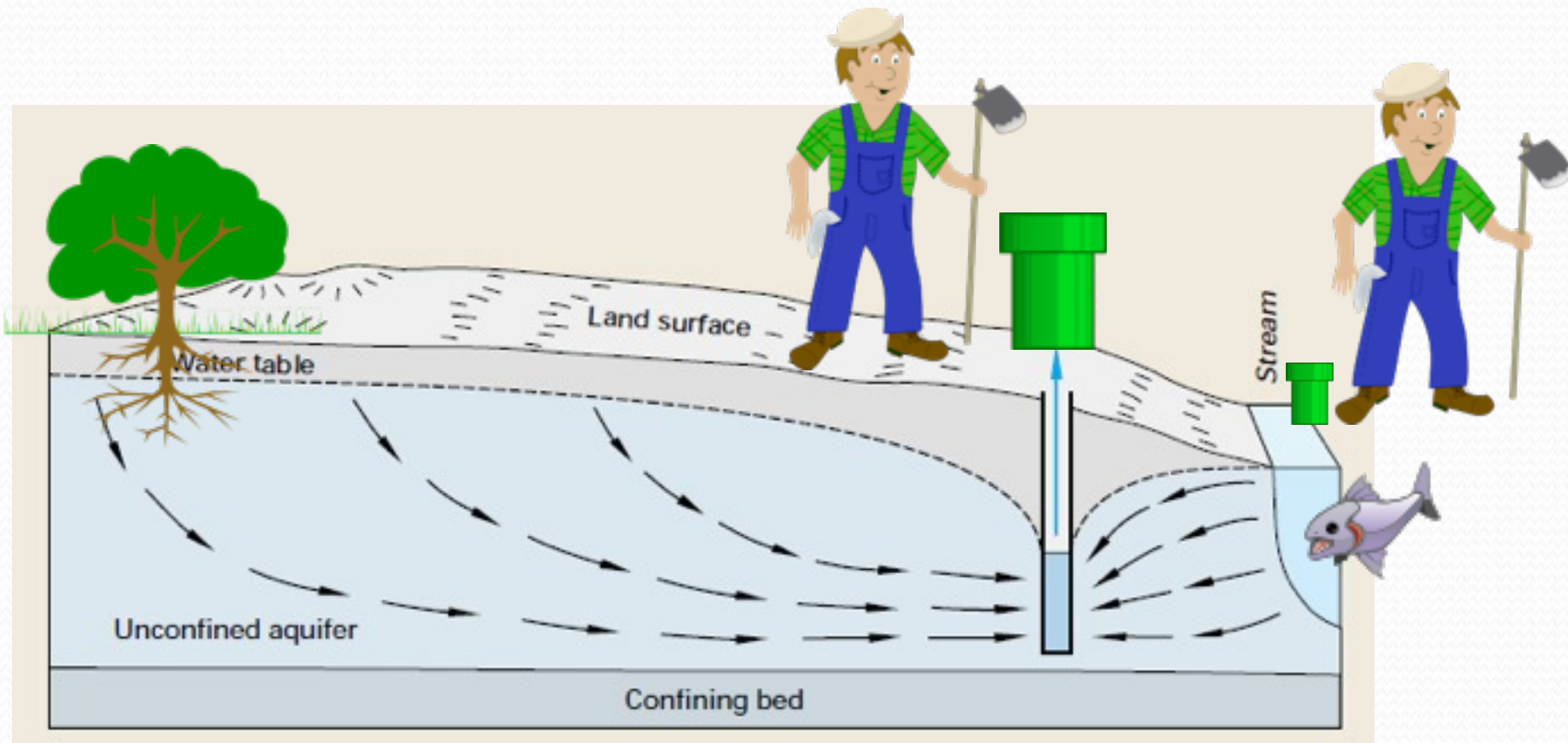
# Addressing groundwater depletion through research: Recharge & saltwater intrusion (Vanessa Mitchell)

wetter

drier



# Addressing groundwater depletion through research: Laws that recognize connections (Rebecca Nelson)



Source: Modified from T.C. Winter et al, *Ground Water and Surface Water: A Single Resource: USGS Survey Circular 1139* (1998), Fig. C-1



# Question time

# References

- Wada et al. (2010). “Global Depletion of Groundwater Resources”, *Geophysical Research Letters* 37, L20402.
- Dale et al. (2008). “The Interaction of Water and Energy in California: Climate Change and Price Impacts”, available at <http://www.circleofblue.org>.
- Natural Resource Defense Council (2010). “Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable”, available at <http://www.nrdc.org>.
- Colorado Water Conservation Board (2008). “Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation”, available at [wwa.colorado.edu/CO\\_Climate\\_Report/index.html](http://wwa.colorado.edu/CO_Climate_Report/index.html)