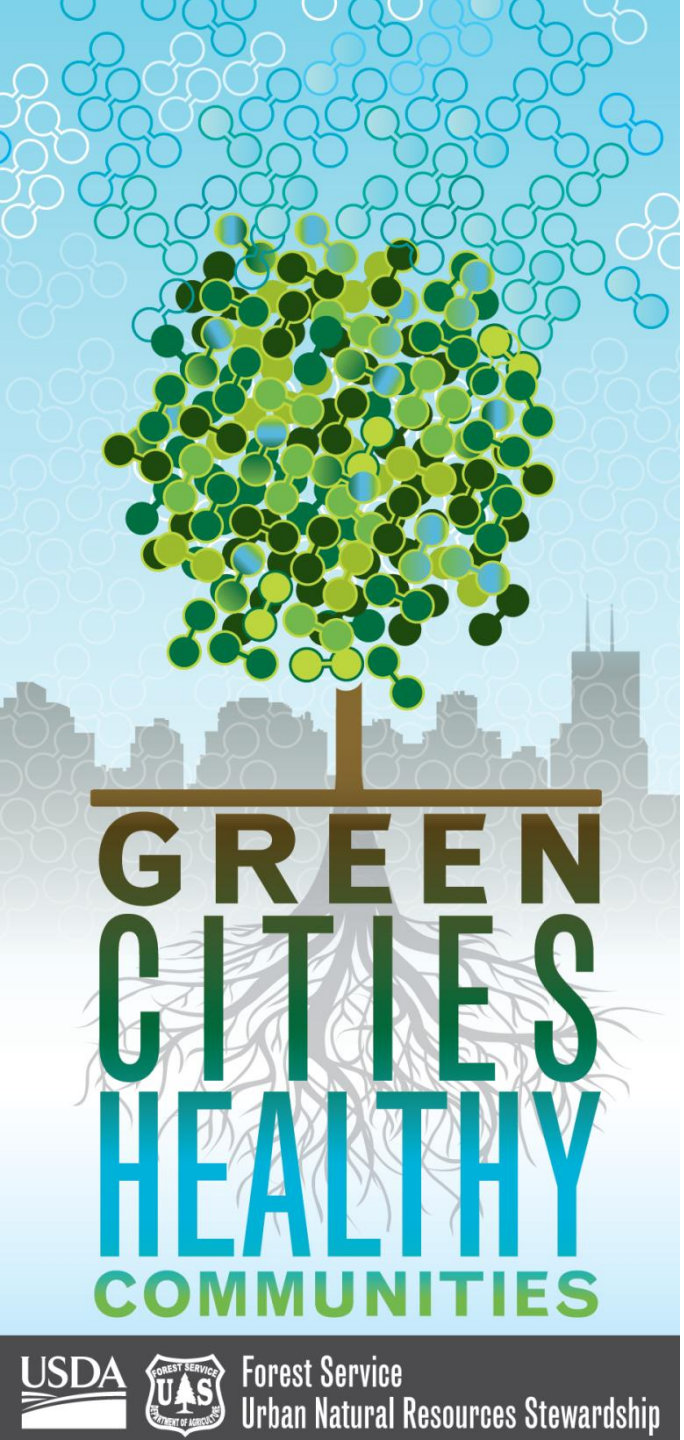

USDA Forest Service

URBAN FOREST CONNECTIONS

webinar series

Second Wednesdays | 1:00 – 2:15 pm ET

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Adapting Landscape Plants, Policies, and Management to a Water-Limited Future

Tom Brown

Economist

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Heidi Kratsch

Horticulture Specialist, Cooperative Extension

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Future Water Supply Vulnerability in the U.S.

Tom Brown
Rocky Mountain Research Station
U.S. Forest Service

UFC webinar -- 13 September 2017

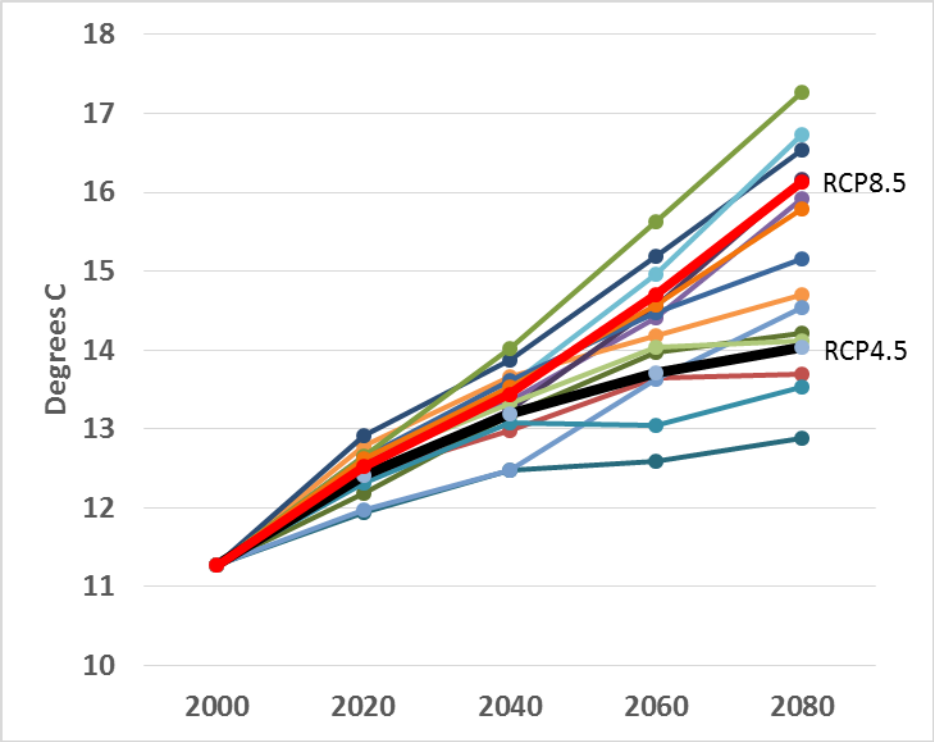
Topics covered

1. **Projections of climatic and water supply conditions.**
2. Projections of potential water shortages.
3. Estimates of the amount of water used for irrigation.

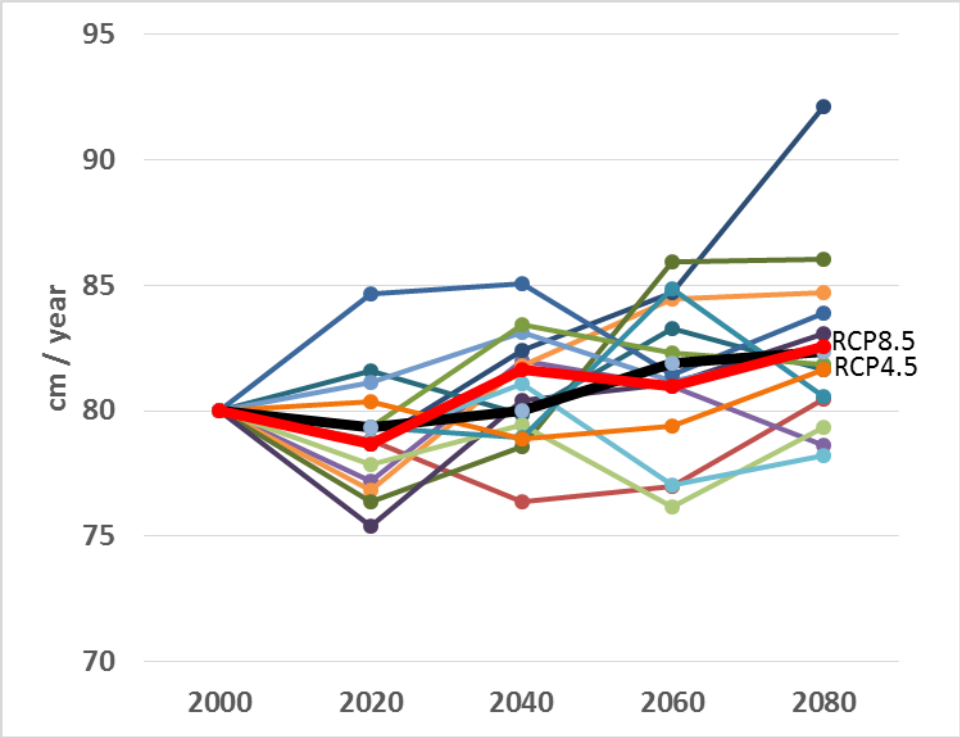
U.S. temperature and precipitation of 14 climatic futures

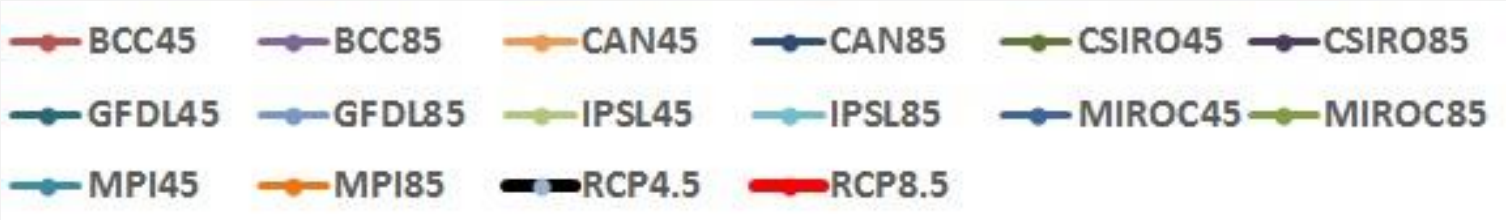
For five 20-year periods centered at 2000, 2020, 2040, 2060, 2080

Mean daily temperature



Mean annual precipitation

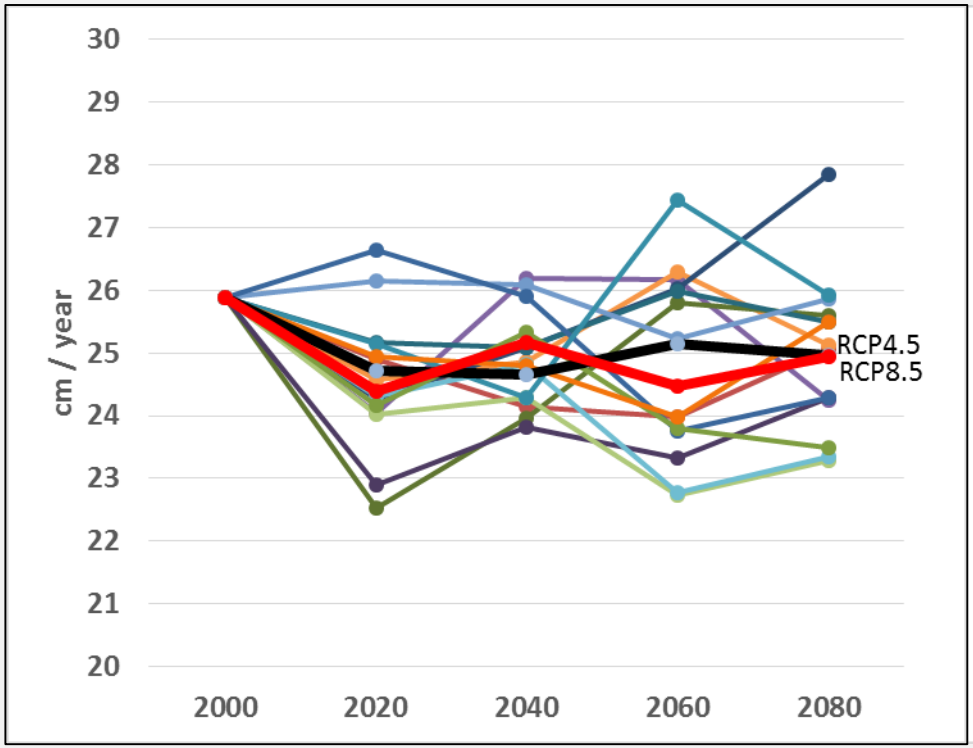




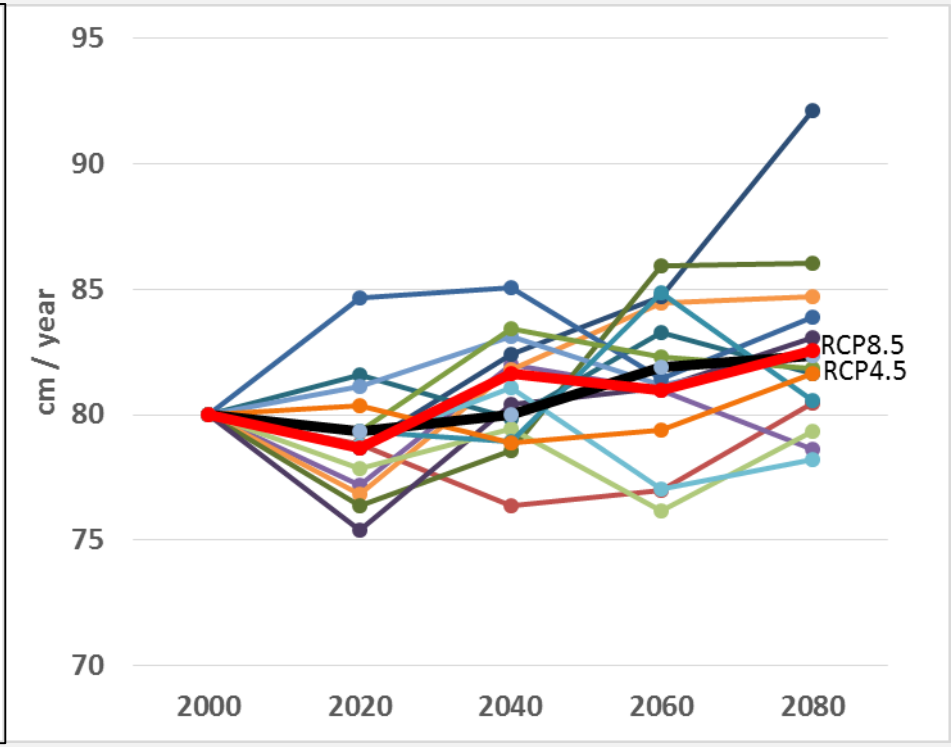
U.S. water yield and precipitation of 14 climatic futures

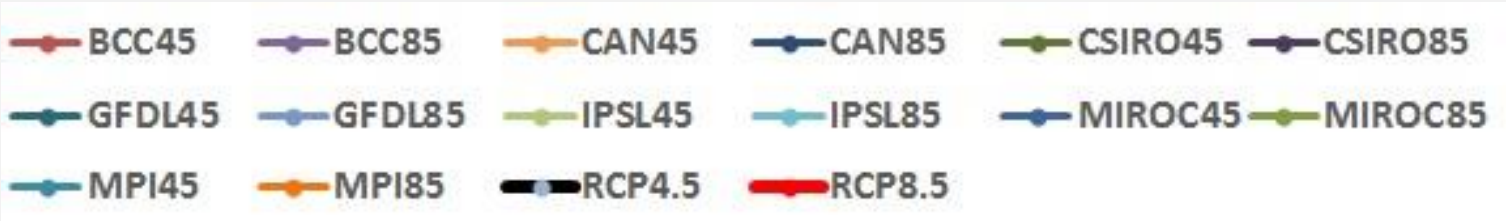
For five 20-year periods centered at 2000, 2020, 2040, 2060, 2080

Mean annual yield



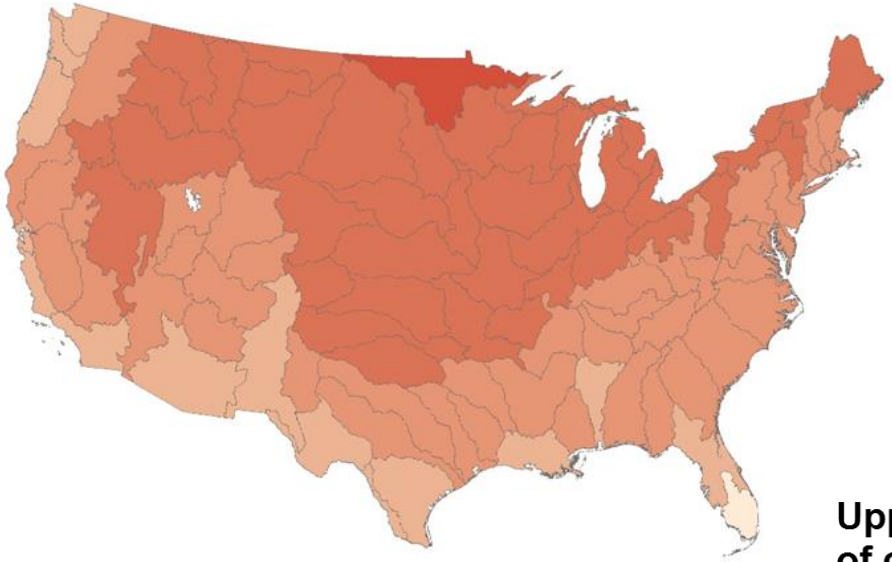
Mean annual precipitation



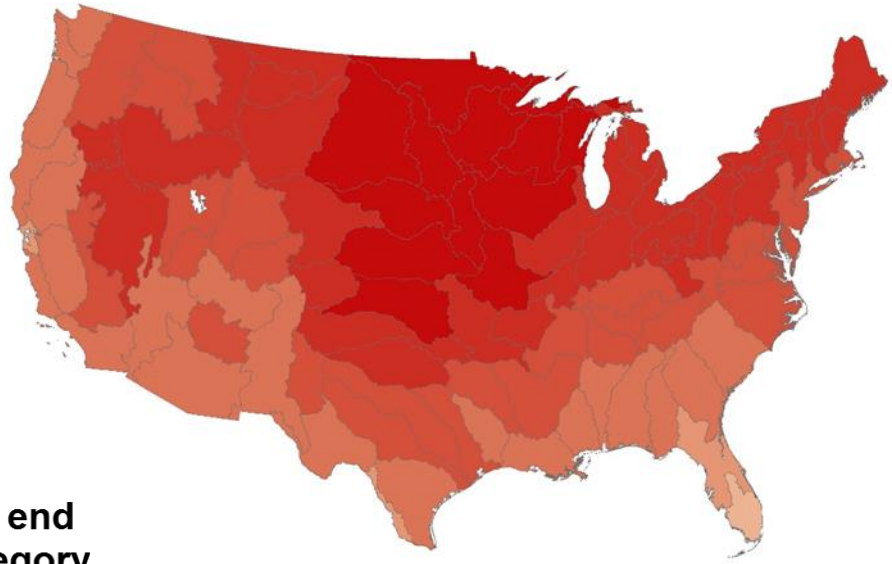


Change from 2000 to 2060 in mean daily temperature

RCP 4.5



RCP 8.5



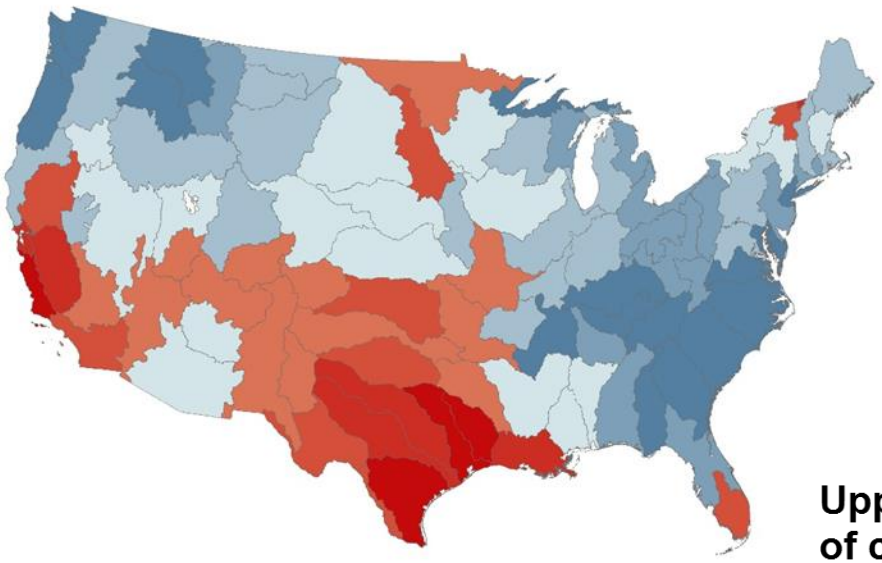
Upper end of category

- 1 degrees C
- 1.5
- 2
- 2.5
- 3
- 3.5
- 4
- > 4

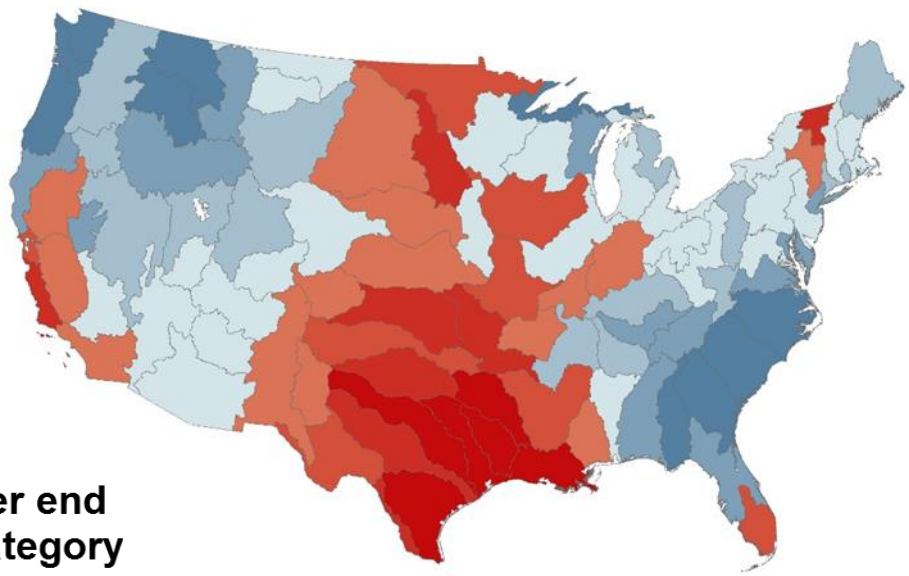
Average across 7 climate models

Change from 2000 to 2060 in annual precipitation

RCP 4.5



RCP 8.5



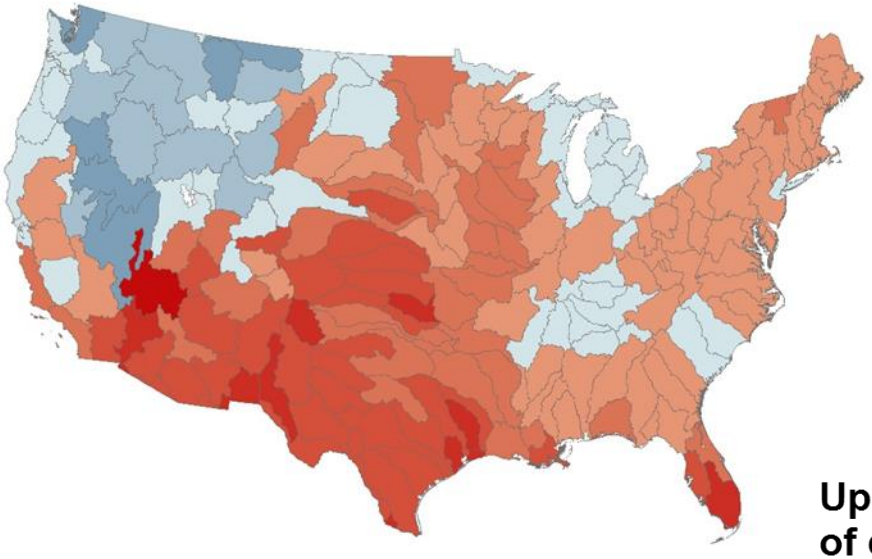
Upper end of category

- -60 cm / yr
- -40
- -20
- 0
- 20
- 40
- 60
- > 60

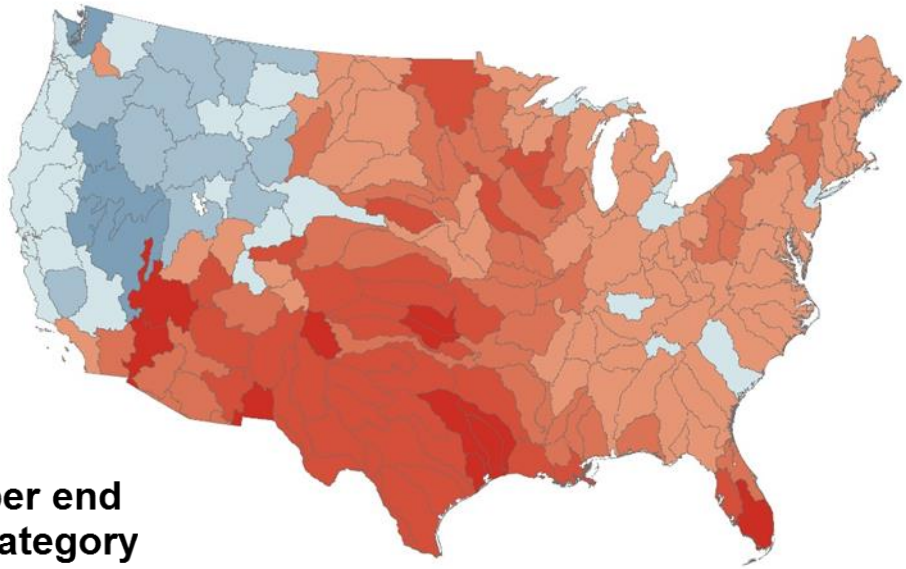
Average across 7 climate models

Percent change from 2000 to 2060 in annual water yield

RCP 4.5



RCP 8.5



Upper end of category

- -40 %
- -30
- -20
- -10
- 0
- 10
- 20
- >20

Average across 7 climate models

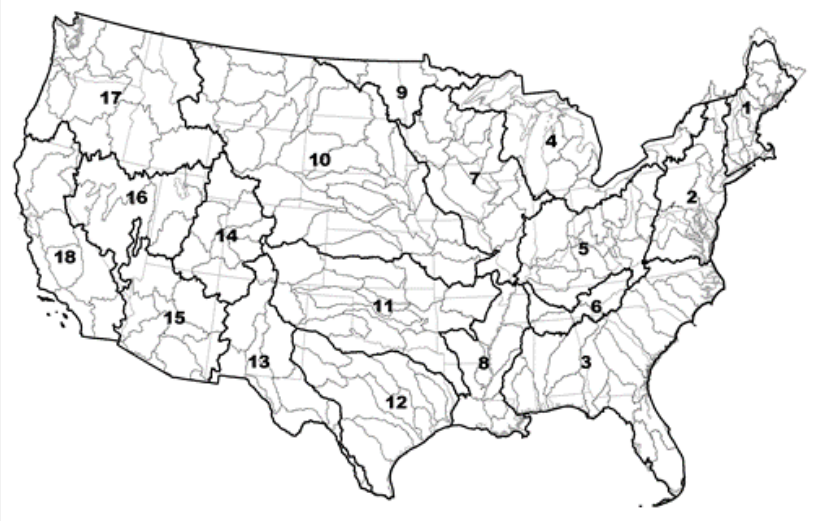
Topics covered

1. Projections of climatic and water supply conditions.
2. **Projections of potential water shortages.**
3. Estimates of the amount of water used for irrigation.

Modeling approach – General

Water supply and demand modeled at:

- HUC-4 spatial scale (204 basins) →
- Monthly time step



- A shortage occurs when demand > supply
- Shortage frequency of each multi-year period = $\frac{\text{number of months with shortage}}{\text{months in the period}}$

This assessment relies critically on data from several federal agencies:
USGS, NOAA, DOE, COE, USBR, ERS, Census Bureau, BEA, USFS

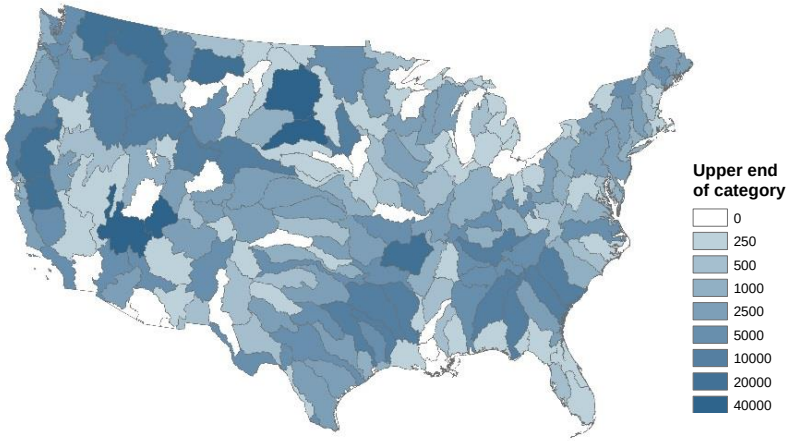
Water supply

Water potentially available for delivery to off-stream uses in a basin in a given month =

water yield within the basin
+ inflow from upstream basins
+ net trans-basin diversion into the basin
+ water left reservoirs in the basin or upstream basins in the previous month (after accounting for reservoir evaporation)
– required in-stream (environmental) flow of the basin
– required release from the basin to satisfy downstream demands.

Water allocation priorities in a given month:
1. instream flow constraint, 2. off-stream demands, 3. water storage.

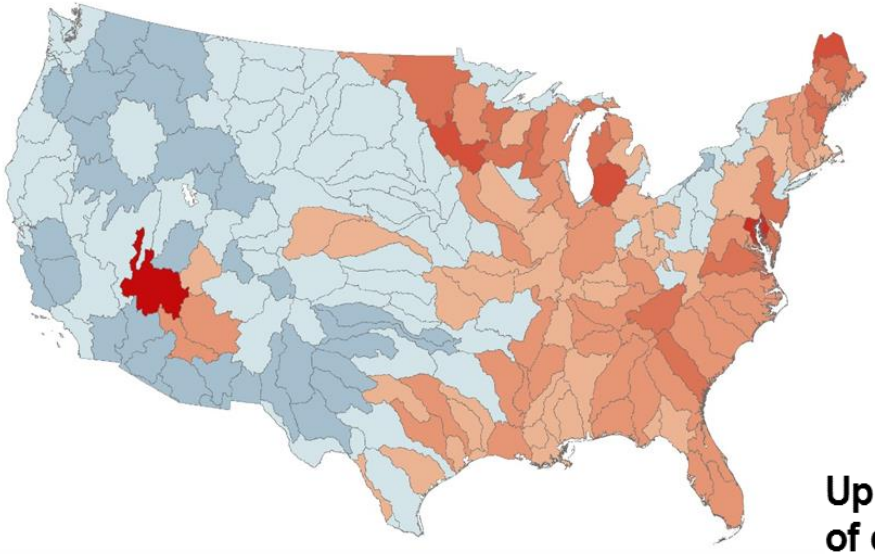
Basin reservoir storage capacities (Mm^3)



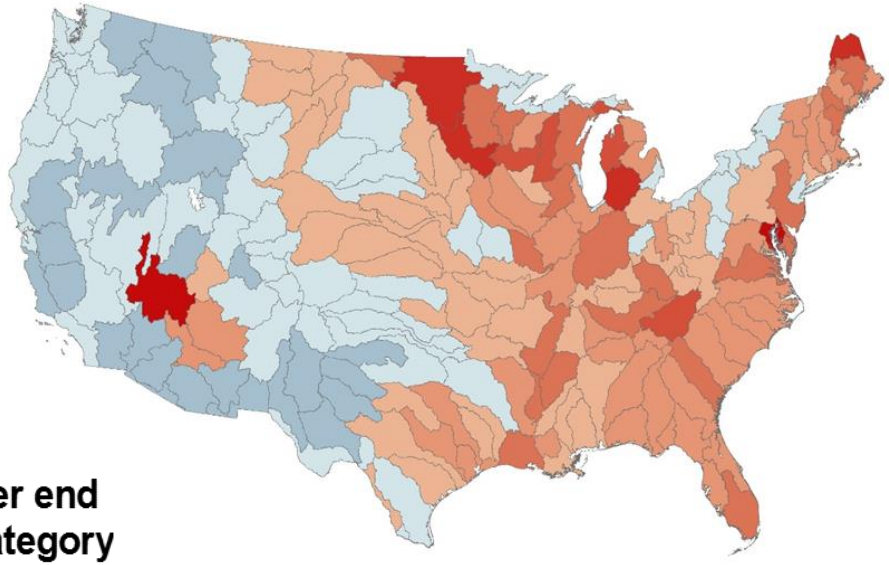
Basin interconnections

Percent change from 2000 to 2060 in water demand

RCP 4.5



RCP 8.5



Upper end of category

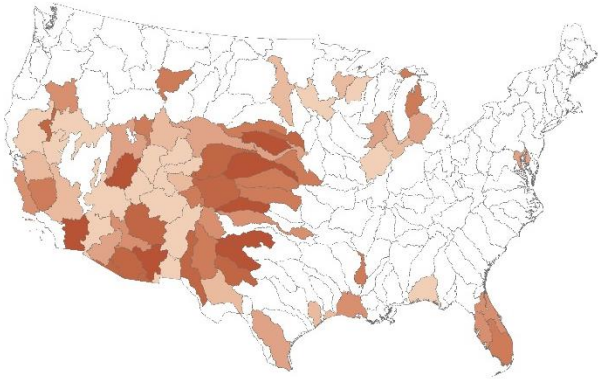
- -20 %
- 0
- 20
- 40
- 60
- 80
- 100
- > 100

Average across 7 climate models

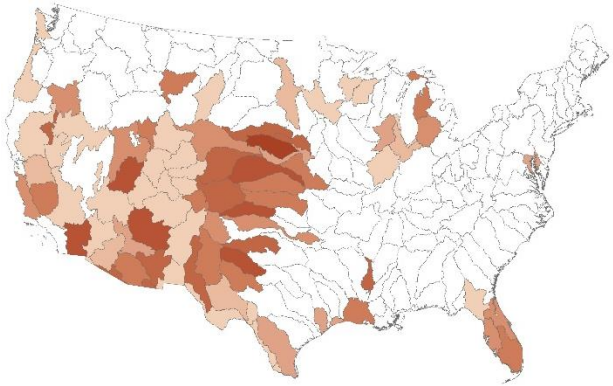
Frequency of monthly shortage in mid-future period

Average across 7 climate models

RCP45



RCP85



Upper end of category

- 0
- 0.01
- 0.05
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
- 1

Mid-future period: 2046-2070

Frequency of monthly shortage in mid-future period

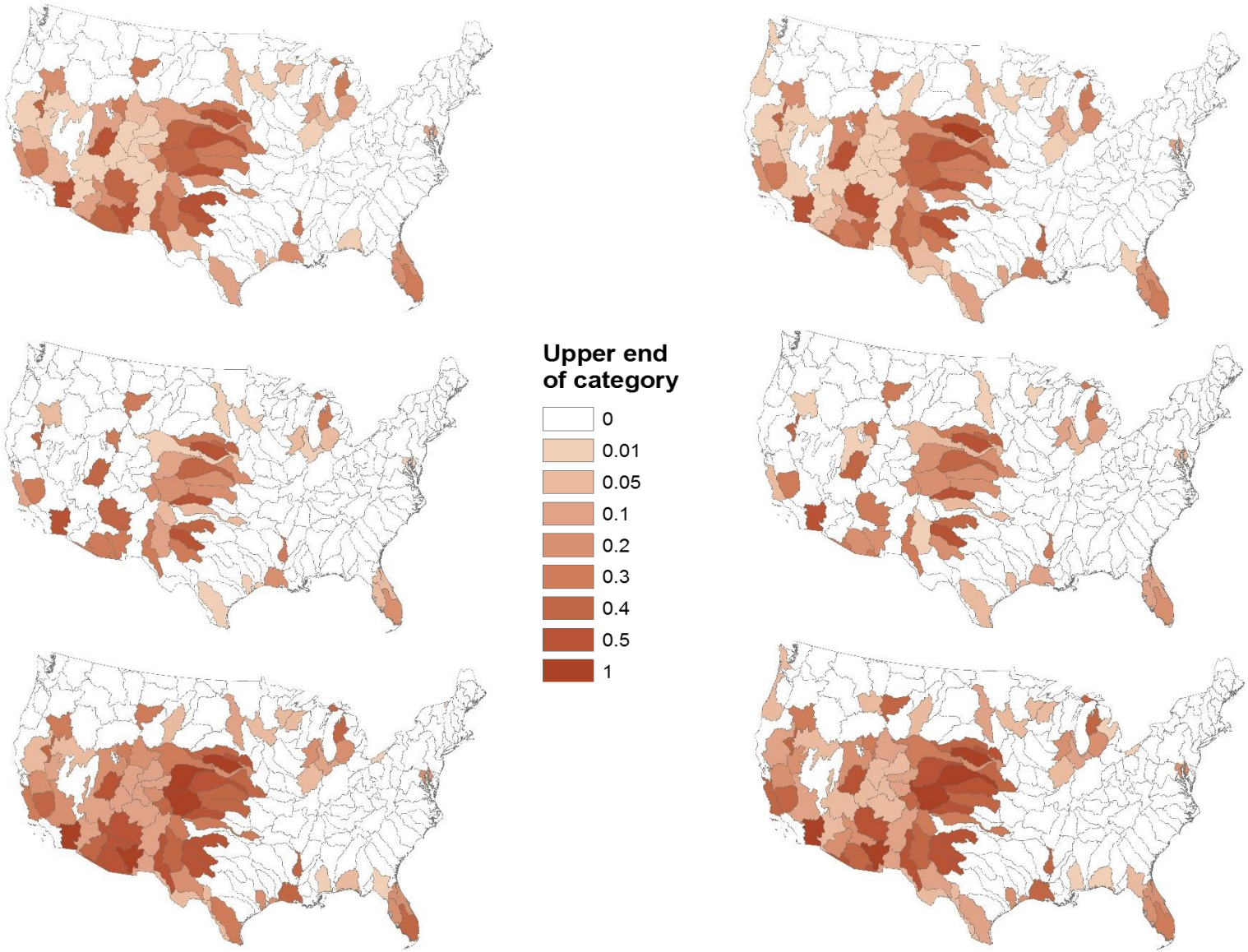
RCP45

RCP85

Average across 7 climate models

Min

Max



Mid-future period: 2046-2070

Topics covered

1. Projections of climatic and water supply conditions.
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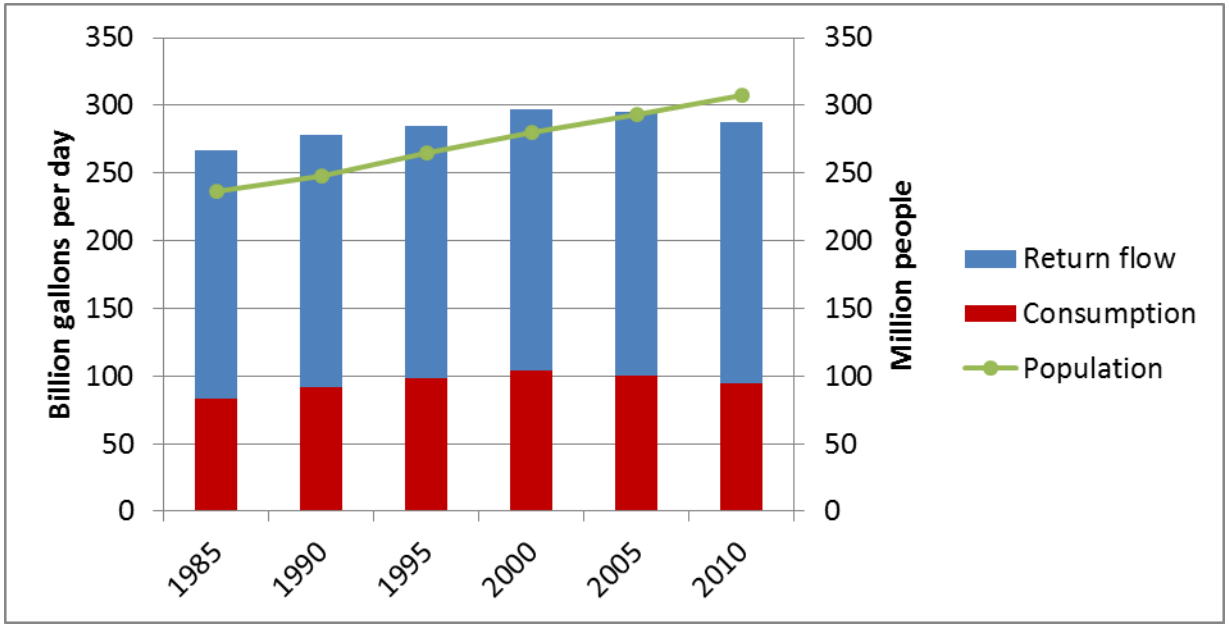
3. **Estimates of the amount of water used for irrigation.**

Annual off-stream water use in the U.S.

Withdrawal separated into consumption and return flow



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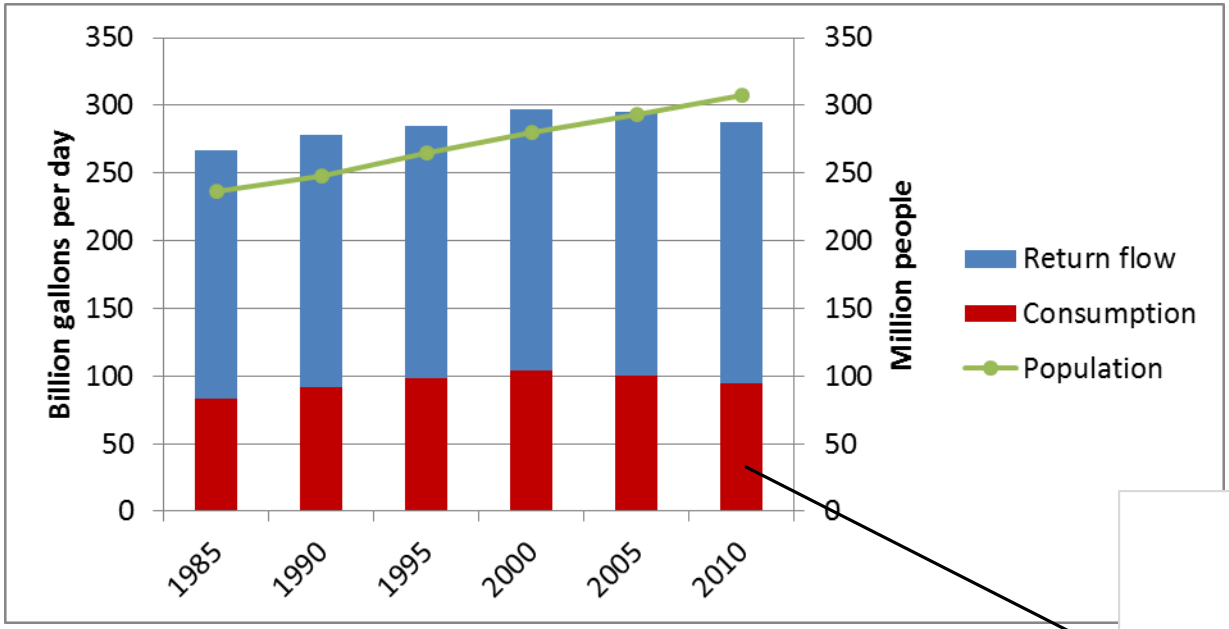
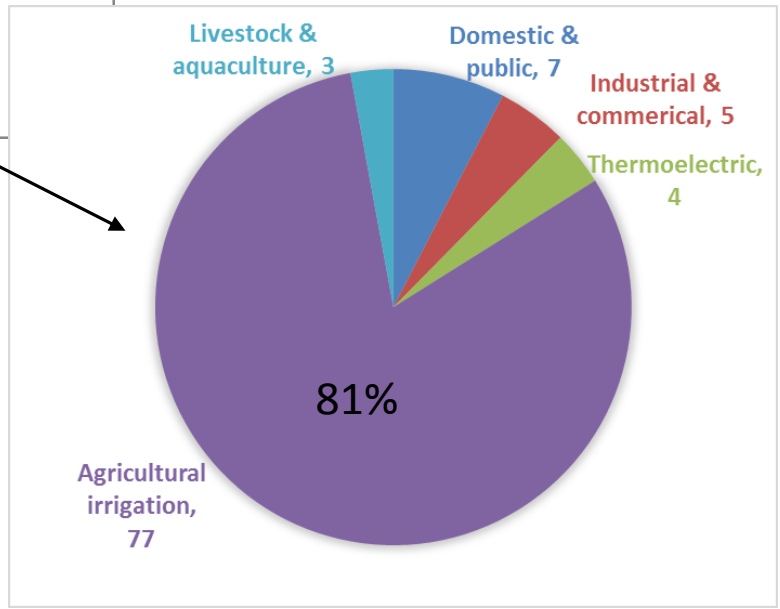
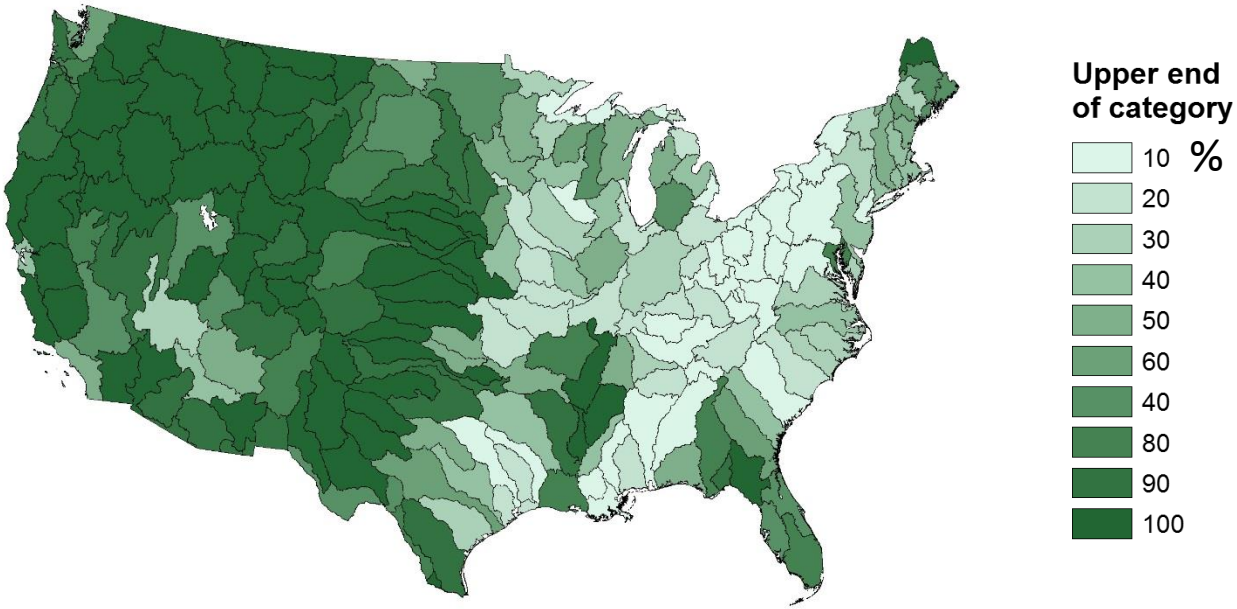


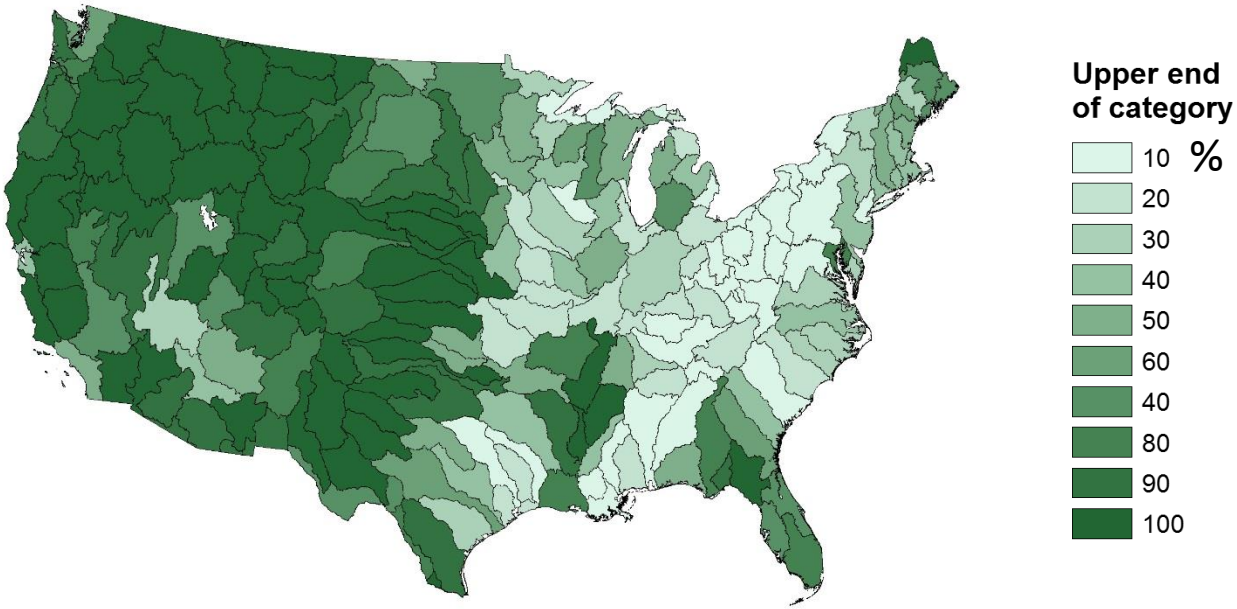
2010 water consumption by sector, million gallons per day

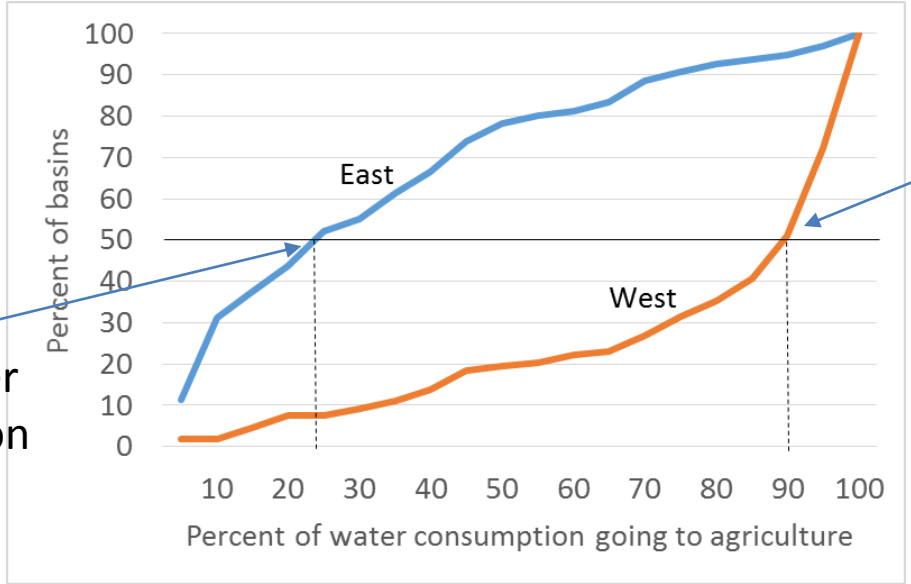


Percent of 2010 water consumption that goes to agriculture



Percent of 2010 water consumption going to agriculture



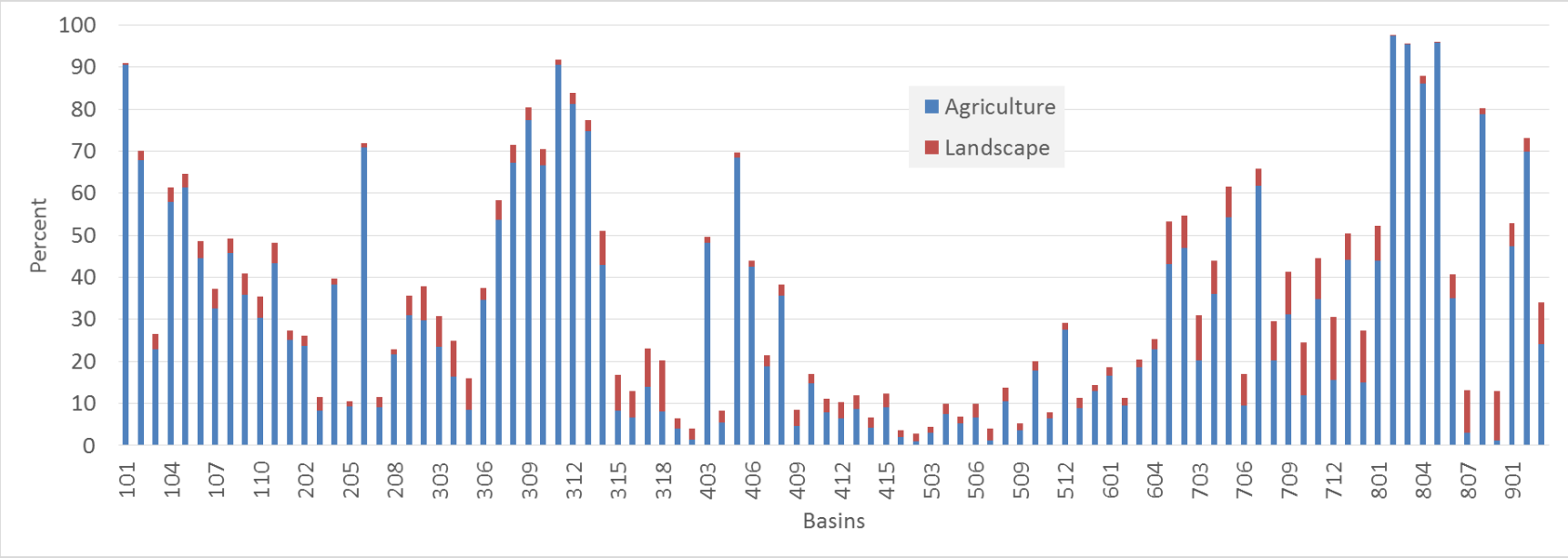


Half of eastern basins use <23% of their water for agricultural irrigation

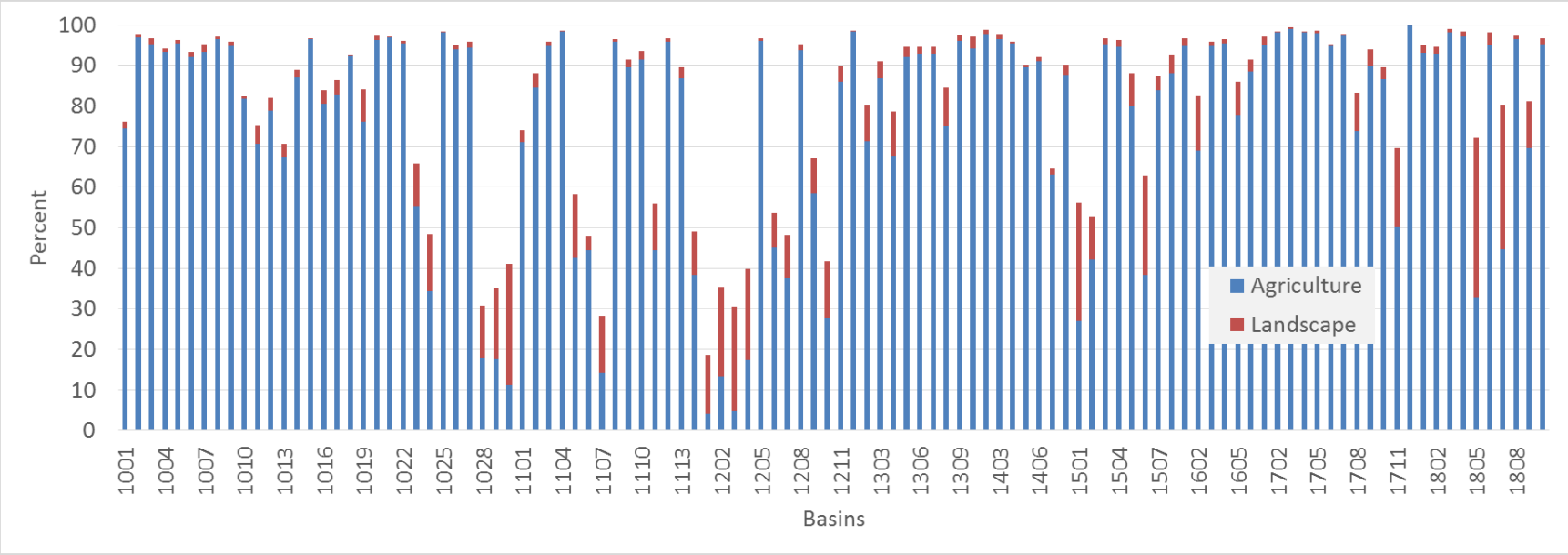
Half of western basins use >90% of their water for agricultural irrigation

Percent of 2010 total water consumption going to irrigation

East



West



Wrap-up—key points

- Precipitation is expected to decrease in roughly 1/3rd of the US (mainly in the Great Plains, Southwest, and California) and increase elsewhere.
- Water yield is expected to decrease in roughly 3/4ths of the US (exceptions include the larger Northwest and parts of the upper Midwest).
- Future water shortages are most likely in the central and southern Great Plains, the Southwest, and California.
- Vulnerability increases typically are caused by a combination of decreasing water yield and increasing water demand.
- Much uncertainty remains about the future levels of precipitation, water yield, and water supply vulnerability (as indicated by the differences among the projections based on the different climate models).
- For the US as a whole, 81% of total water consumption currently goes to agriculture, and another 4% goes to landscape irrigation. Future changes in relative shares are likely.

Some pubs on the prior (ASR/annual time step) assessment

Brown, Thomas C., Romano Foti, and Jorge A. Ramirez. 2012. Water resources. Chapter 12 of Future of America's forests and rangelands: Forest Service 2010 Resources Planning Act Assessment," General Technical Report WO-87, U.S. Forest Service, Washington, DC. 198 p.

Foti, Romano, Jorge A. Ramirez, and Thomas C. Brown. 2012. Vulnerability of U.S. water supply to shortage: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-295. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 147 p.

Brown, Thomas C., Foti, Romano, Jorge A. Ramirez. 2013. Projected freshwater withdrawals in the United States under a changing climate. *Water Resources Research* 49(3):1259-1276.

Foti, Romano, Jorge A. Ramirez, and Thomas C. Brown. 2014. A probabilistic framework for assessing vulnerability to climate variability and change: the case of the US water supply system. *Climatic Change* 125 (3-4): 413-427.

Foti, Romano, Jorge A. Ramirez, and Thomas C. Brown. 2014. Response surfaces of vulnerability to climate change: the Colorado River Basin, the High Plains, and California. *Climatic Change* 125(3-4): 429-444.

Brown, Thomas C., Travis Warziniack, Vinod Mahat, and Jorge A. Ramirez. 2016. Water resources. Chapter 10 of Future of America's forests and rangelands: Update to the Forest Service 2010 Resources Planning Act Assessment, Gen. Tech. Rep. WO-94, U.S. Forest Service, Washington, DC.

Mahat, Vinod, Jorge A. Ramirez, and Thomas C. Brown. 2017. Twenty-first-century climate in CMIP5 simulations: Implications for snow and water yield across the contiguous United States. *Journal of Hydrometeorology* 18(8):2079-2099.

Thanks

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