



**PURDUE**  
UNIVERSITY

College of Agriculture  
College of Engineering

# Water: Enough in Indiana

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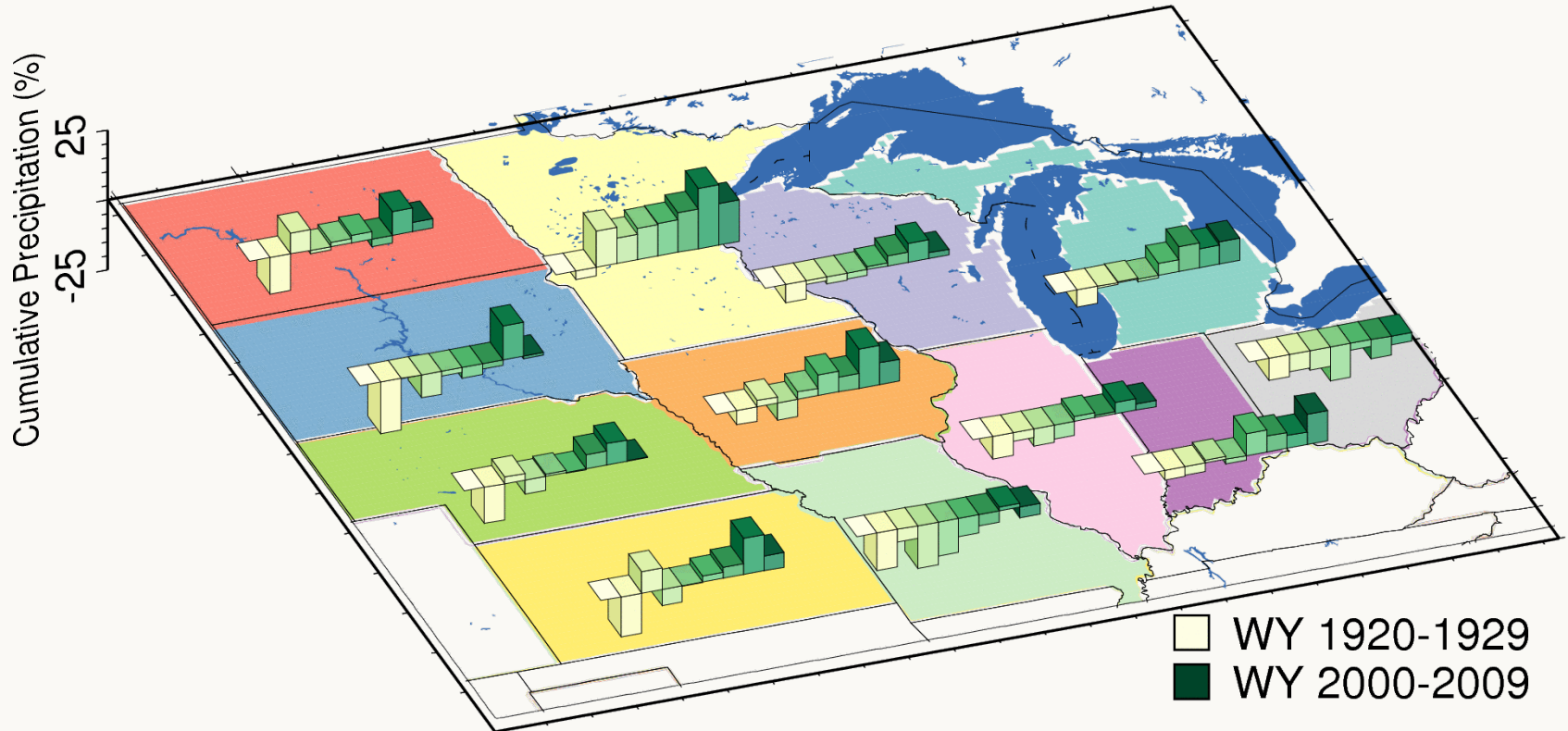
Will there be enough water in  
Indiana in the future?





Or will there be too much?

# Annual Precipitation

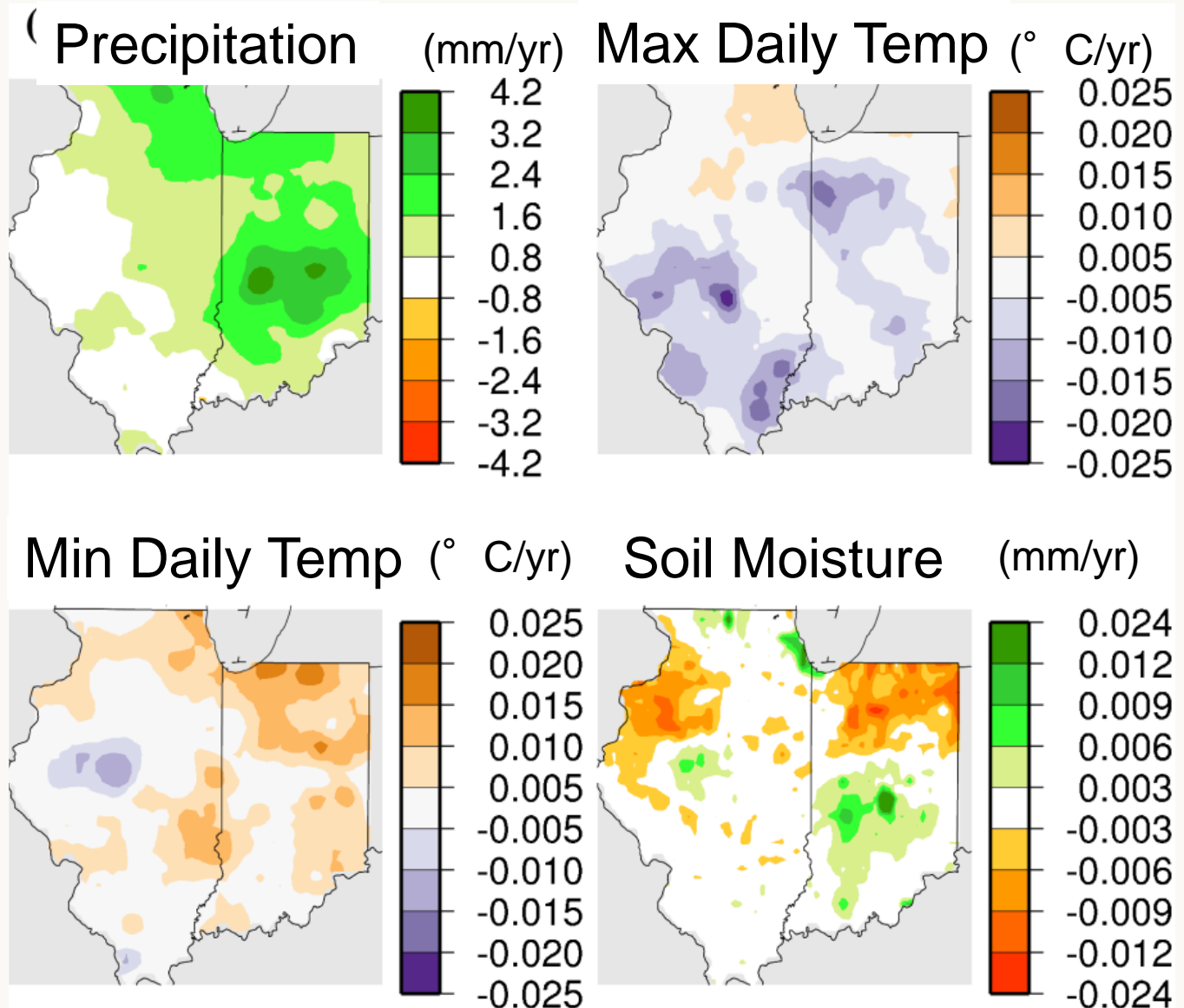




# Annual Average Air Temperature



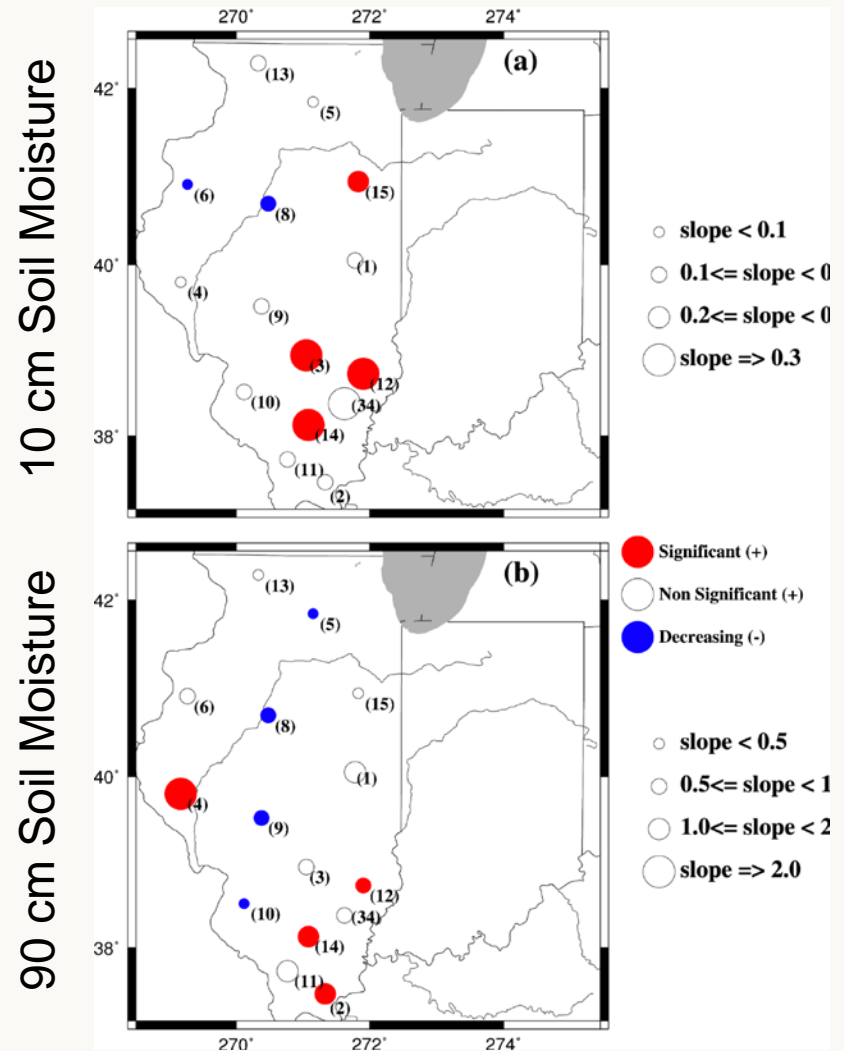
# Observed Trends 1916-2007



Mishra and  
Cherkauer, 2010

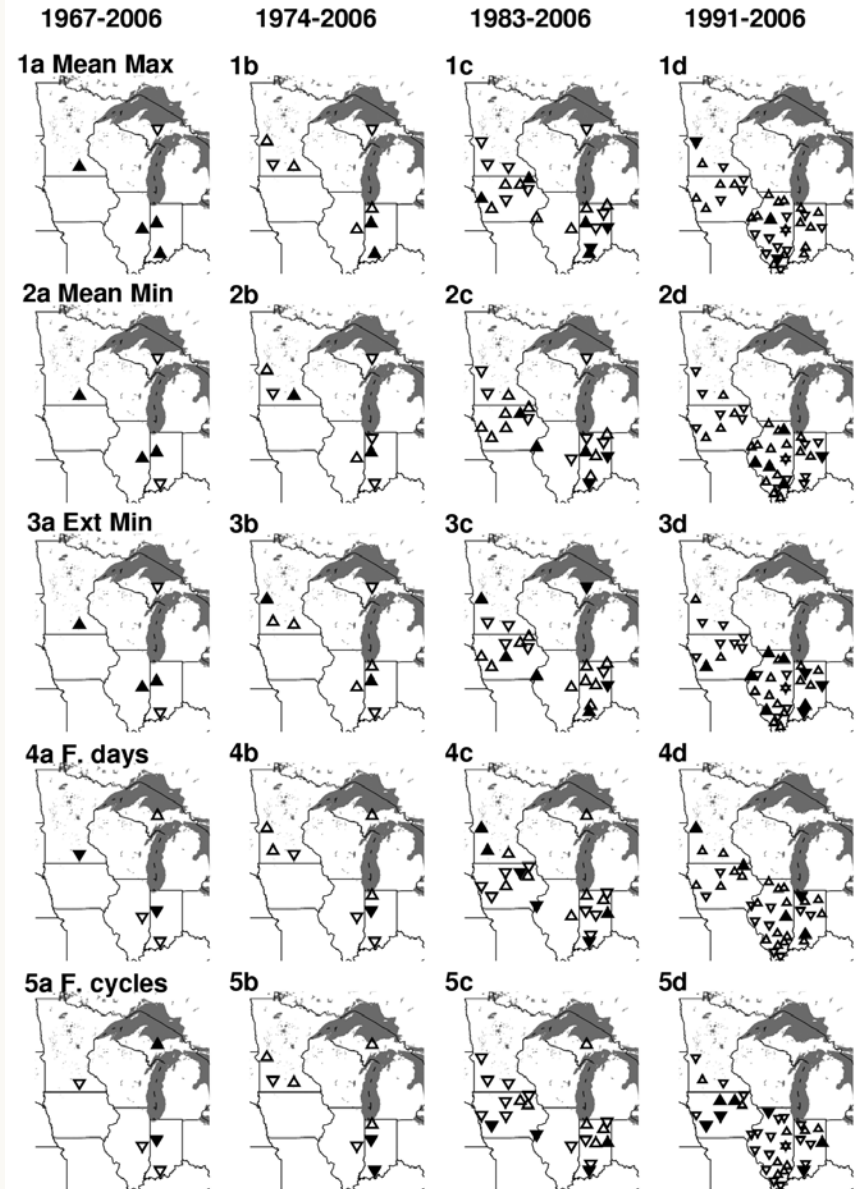
# Soil Moisture Trends

- › Observed soil moisture trends from 1981 to 2007
- › Wetter annual conditions to the south, less change to the north
- › Spring soil moisture especially important to planting



# Soil Frost Trends

- › Long-term (1967-2006) trends in soil temperatures indicate warming
- › Shorter term observations are more mixed
- › Confounded by changes in snow cover
- › Spring soil temperatures important for planting

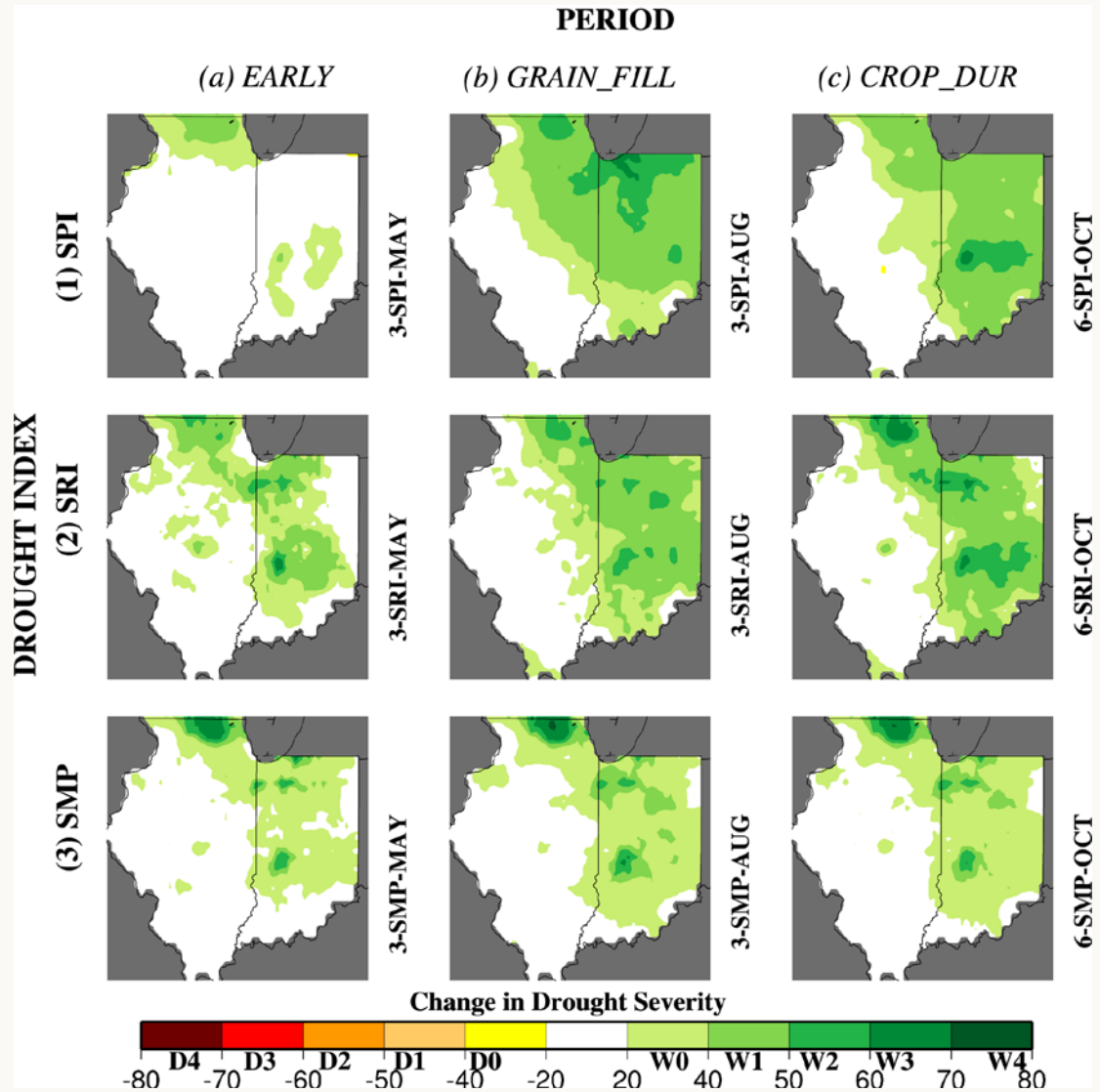


Triangle indicates direction of trend, fill indicates significance

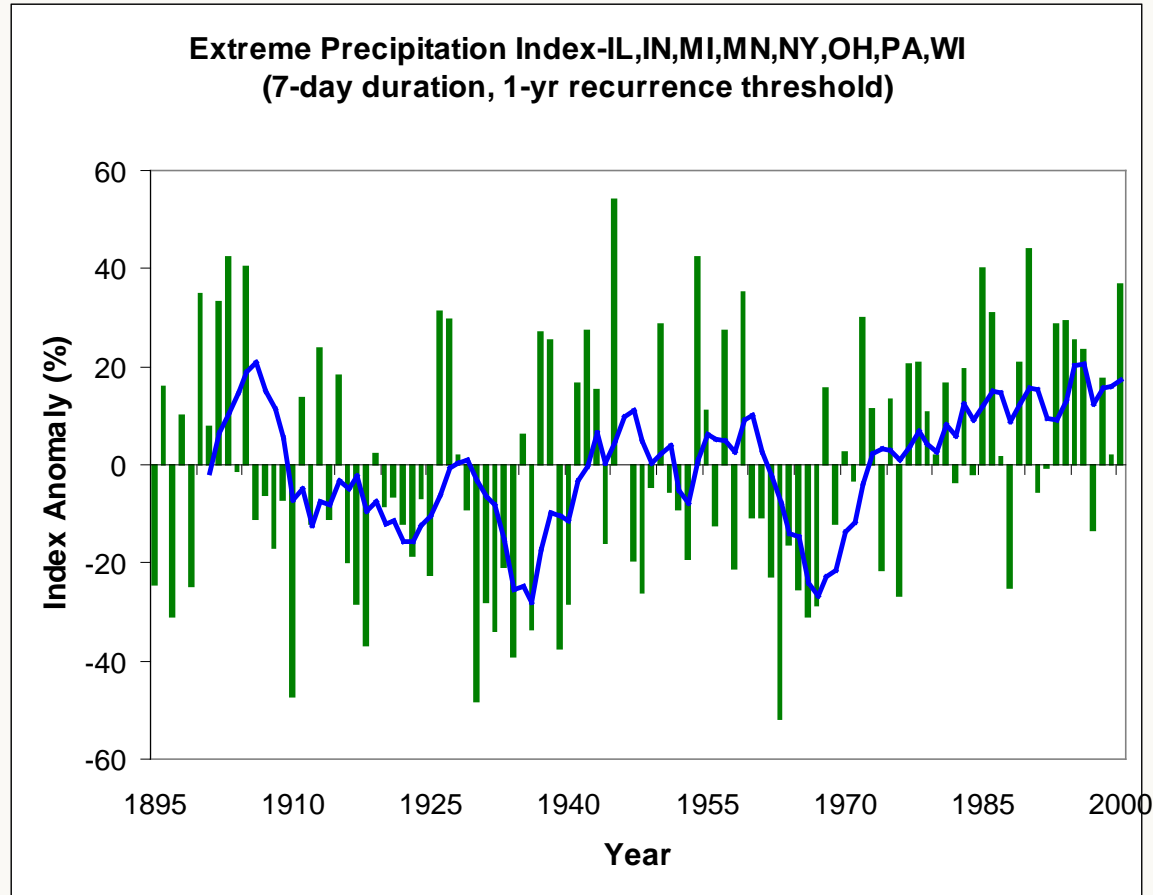


# Trends in Drought Severity

- › Drought severity and occurrence have generally decreased between 1915 and 2007
- › Of the 7 agricultural droughts that affected the entire growing season, only 1 has occurred since 1950
- › The extent of droughts has also decreased
- › The drought of 1988 reduced corn production by 30%, and was more severe than the 1930 droughts for 5% of the area



# Increases in Heavy Rainfall Events





# Upper White River Watershed Delineated to USGS Gage Station 03351000 at Nora, Indiana

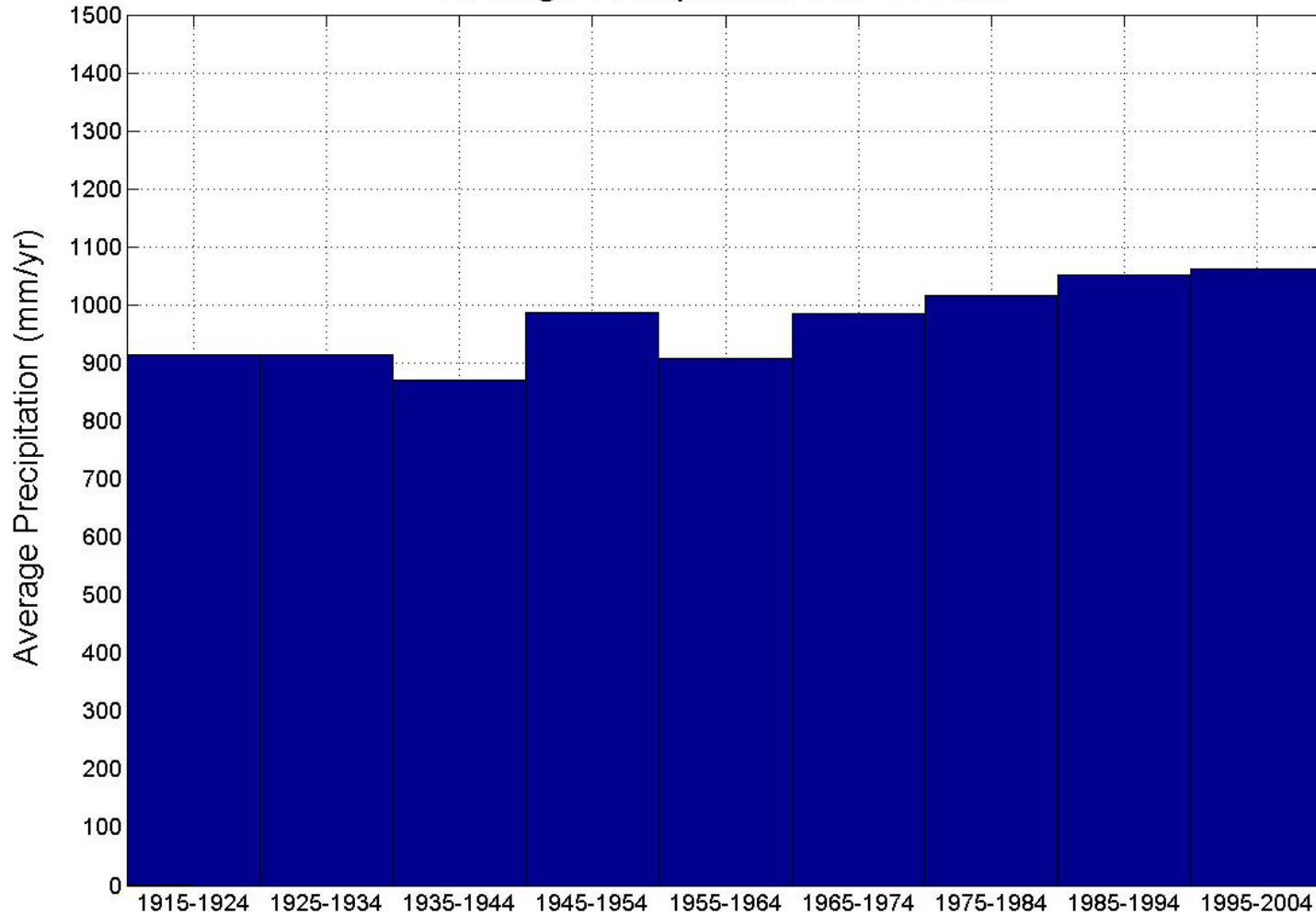


Watershed Area (USGS) = 1219 square miles  
Delineated Area = 1210 square miles



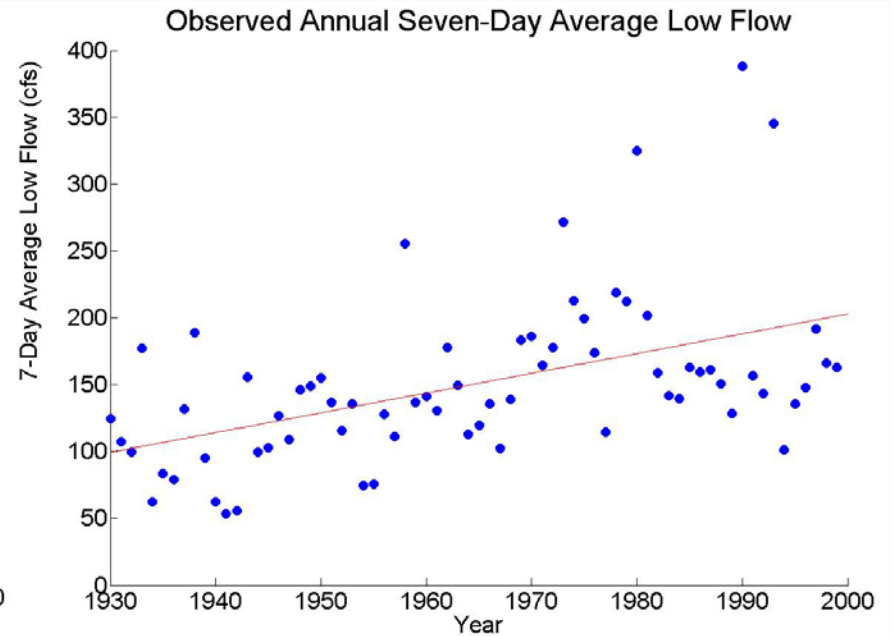
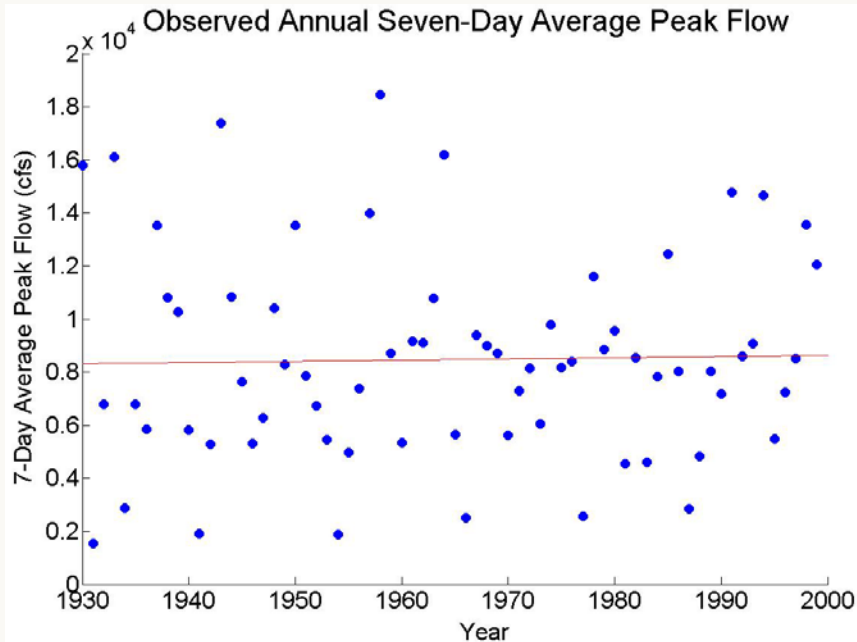
-  Upper White River and Branches
-  Watershed Boundary

# Annual Average Precipitation





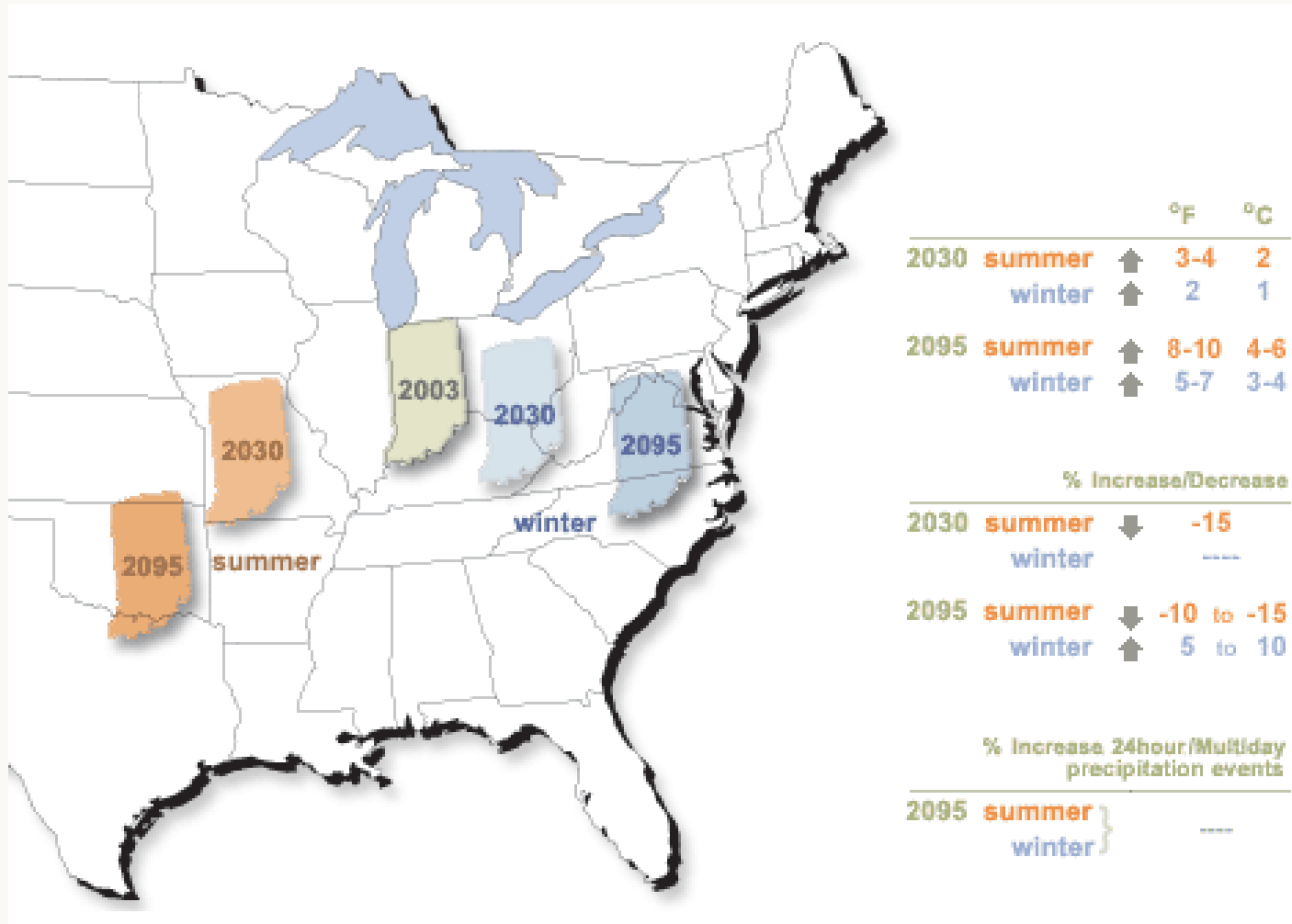
# Observed Streamflow Trends White River at Nora, IN gage station



Statistical Measure	Seven Day High Flow	Seven Day Low Flow
Kendall's t value	0.0418	<b>0.3797</b>
Z-Value	0.507	<b>4.6438</b>

Significant trend if Z-Value is greater than Z-Critical (1.96)

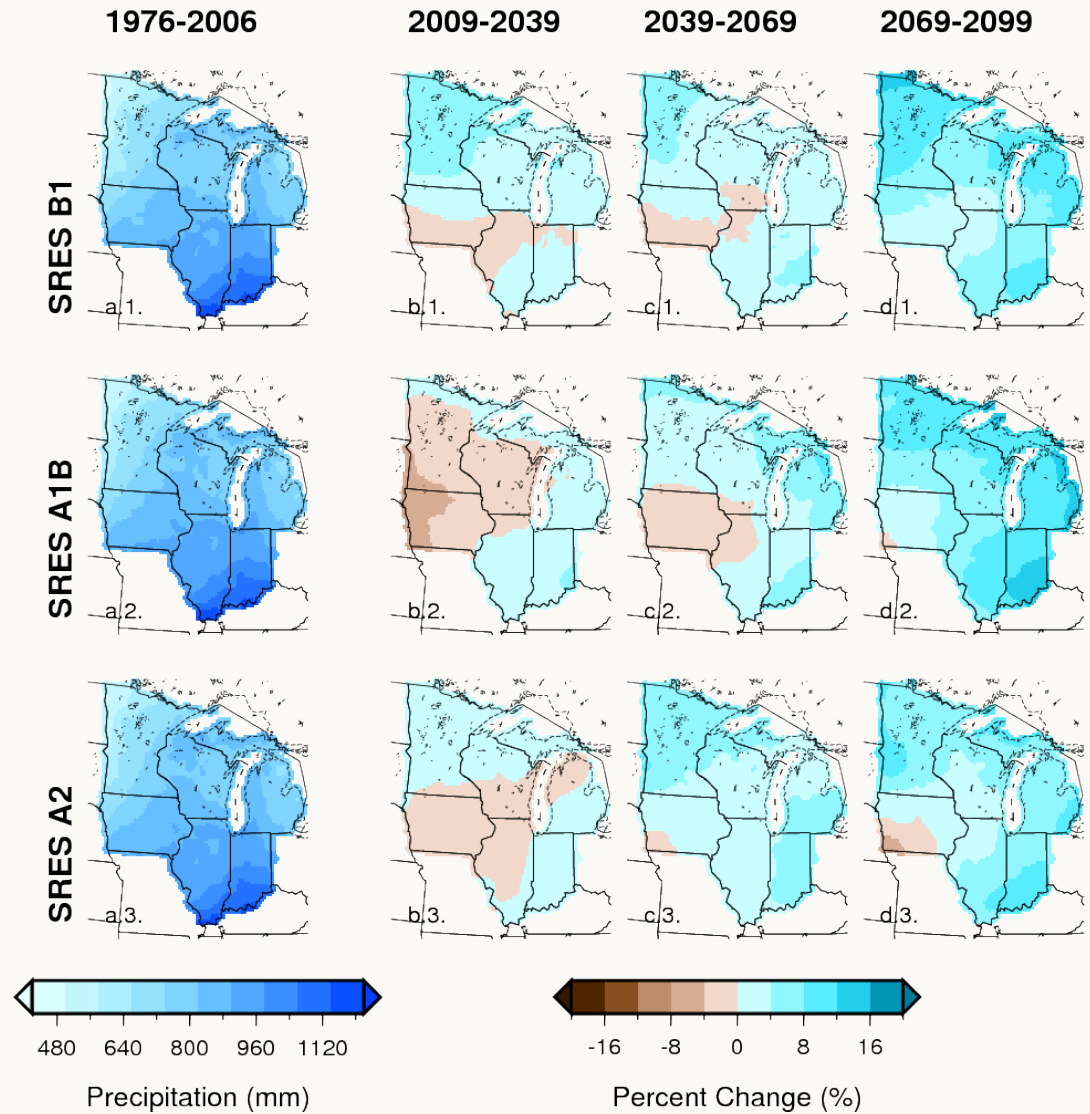
# What Might Indiana Be Like?





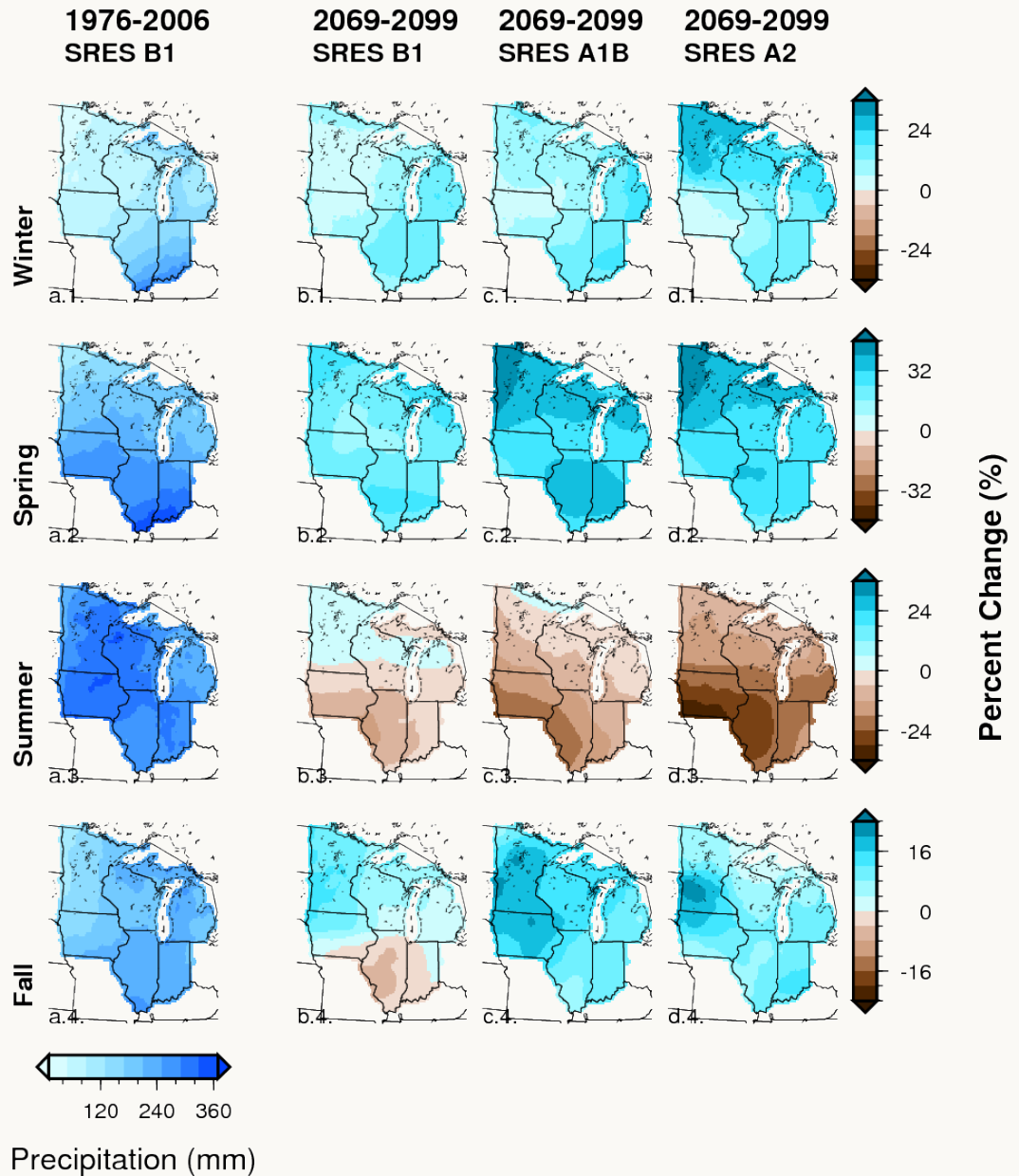
# Annual Precipitation

- › Some decrease in precipitation in the early part of the century
- › By end of century, precipitation mostly increased

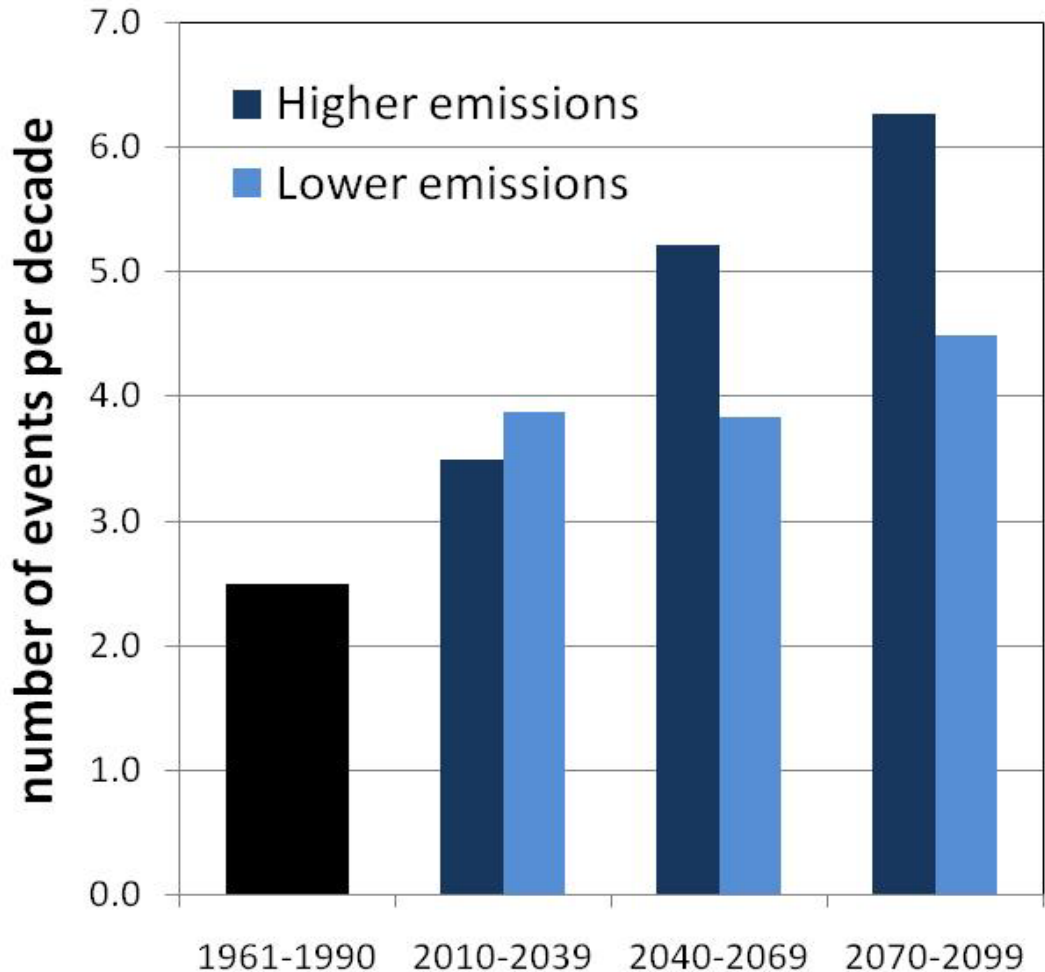


# Seasonal Precipitation

- › Some decrease in precipitation in the early part of the century
- › By end of century, precipitation mostly increased



# Heavy Rainfall Events (> 2.5 inches) Northern Indiana and Illinois

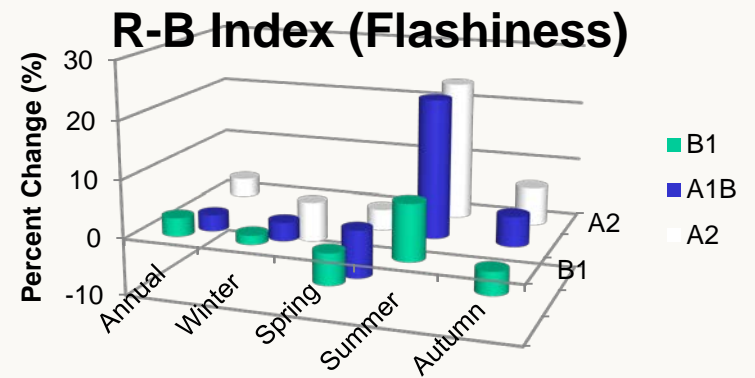
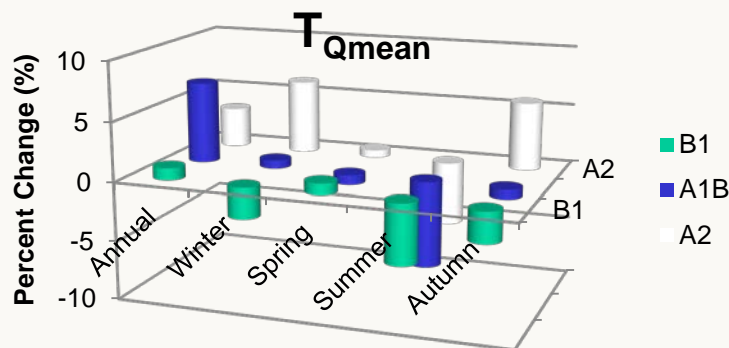
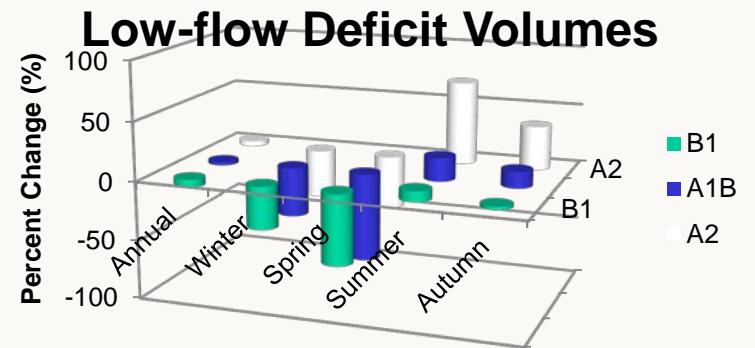
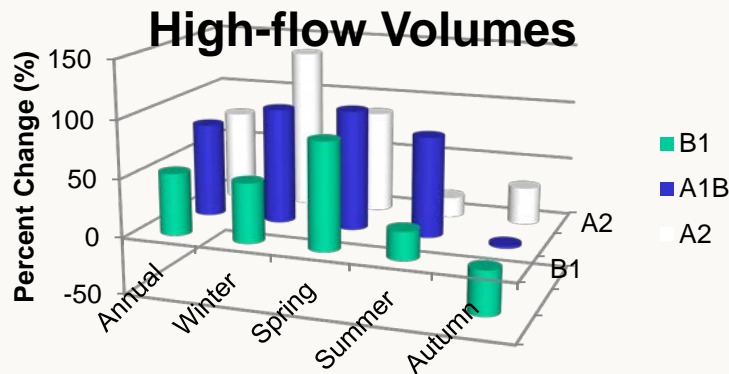
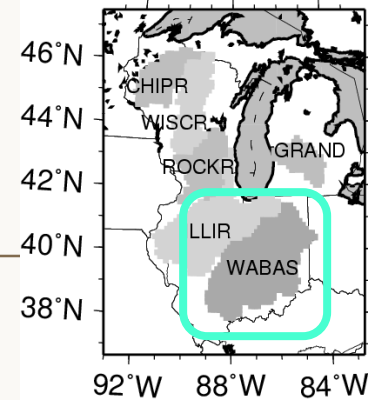


Increases of almost 2x  
under lower emissions  
and 3x under higher



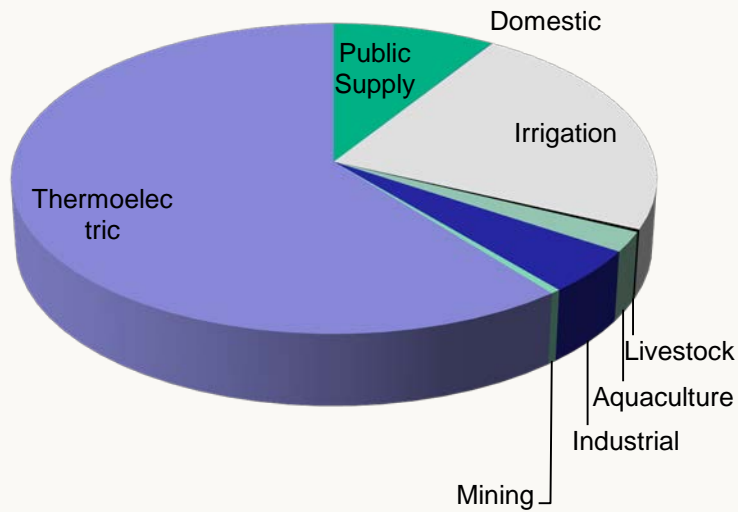


# Changes to Daily Flows Wabash River

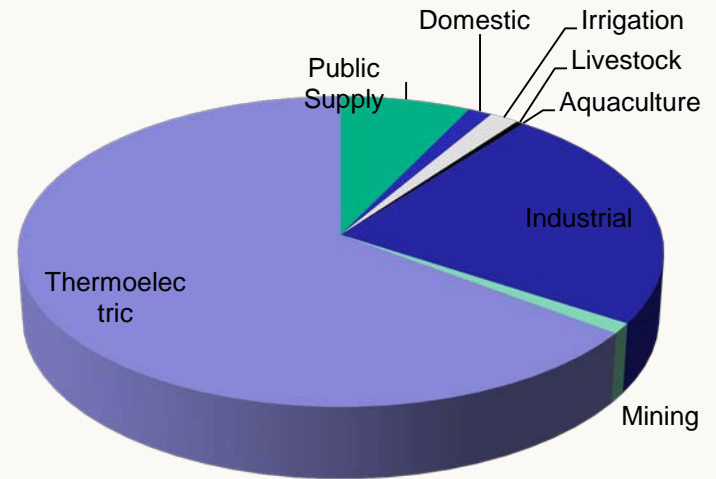


# Water Use by Category

## Water Usage: National



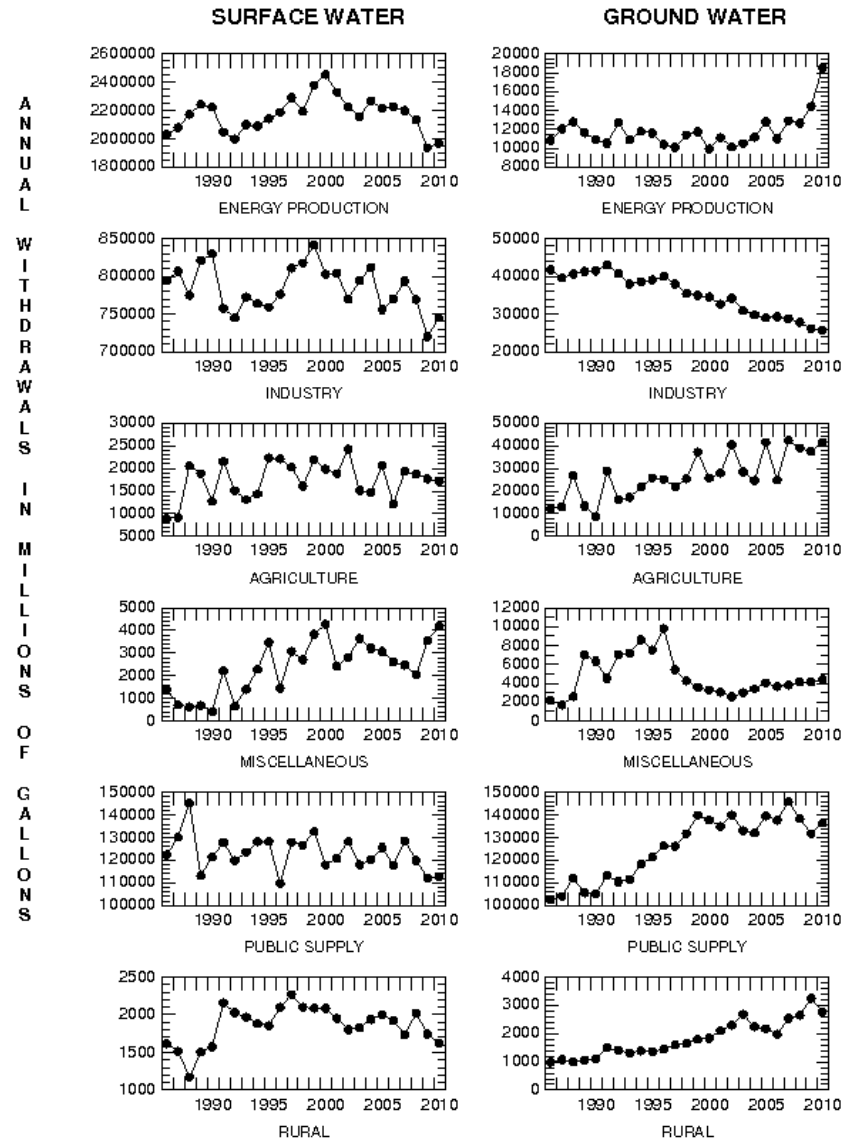
## Water Usage: Indiana



# Water Use in Indiana

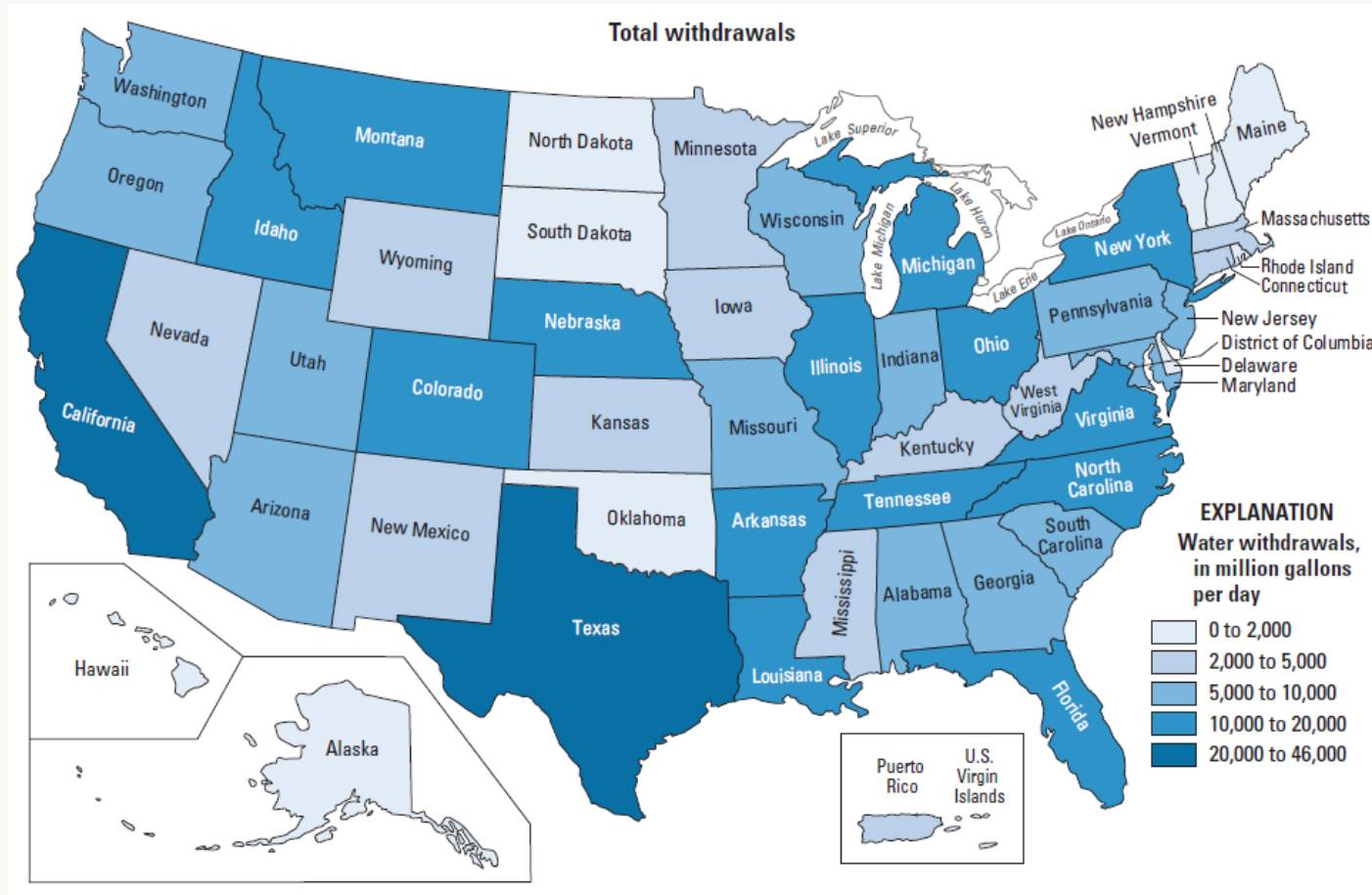
- › Energy – use of water in power generation
- › Industry – use in manufacturing
- › Agricultural – use for crop production and golf courses
- › Miscellaneous – All other uses
- › Public – distribution for use by others
- › Rural use – use for livestock and fish

Statewide -- Reported Withdrawals, 1986-2010

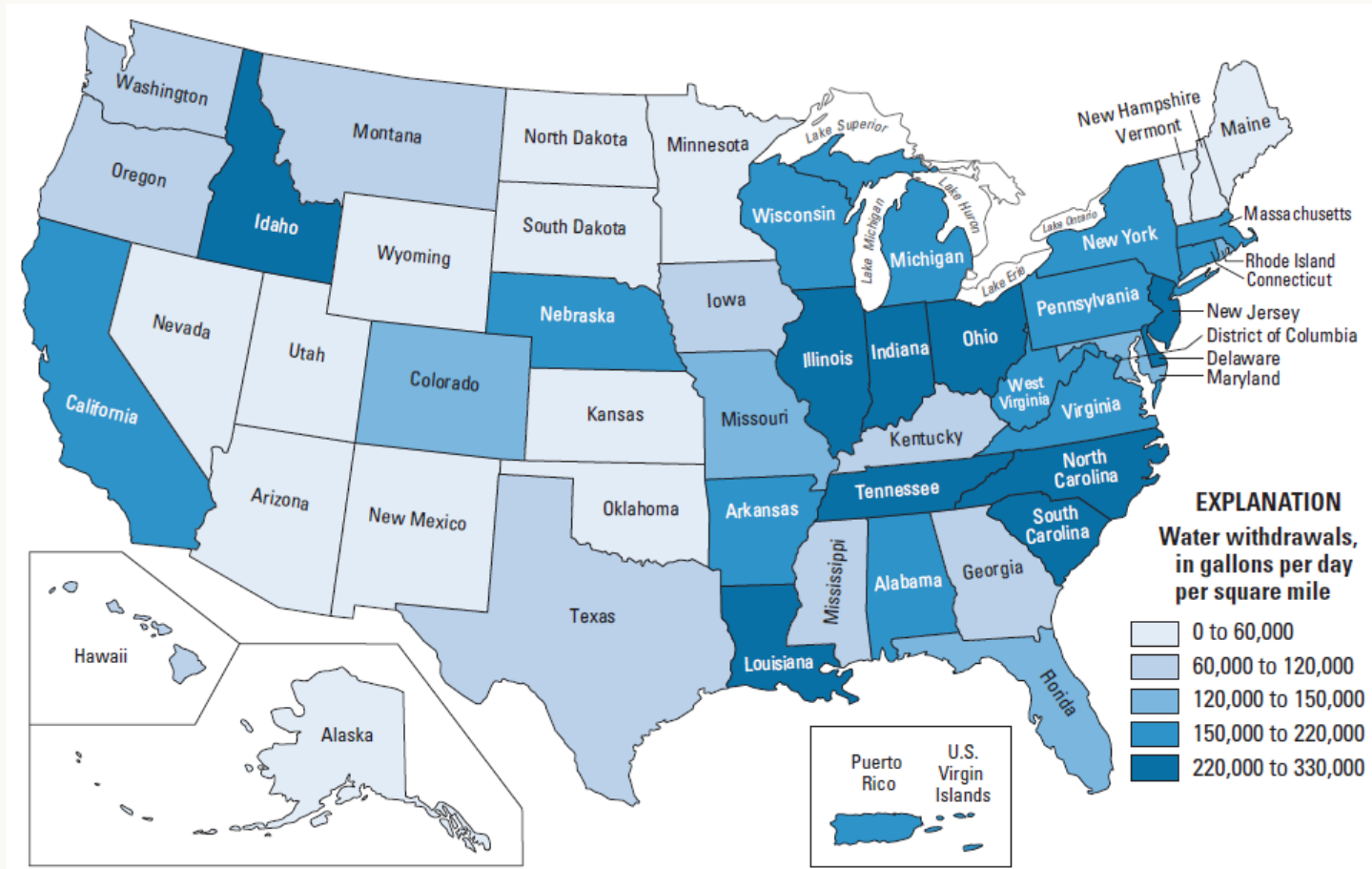




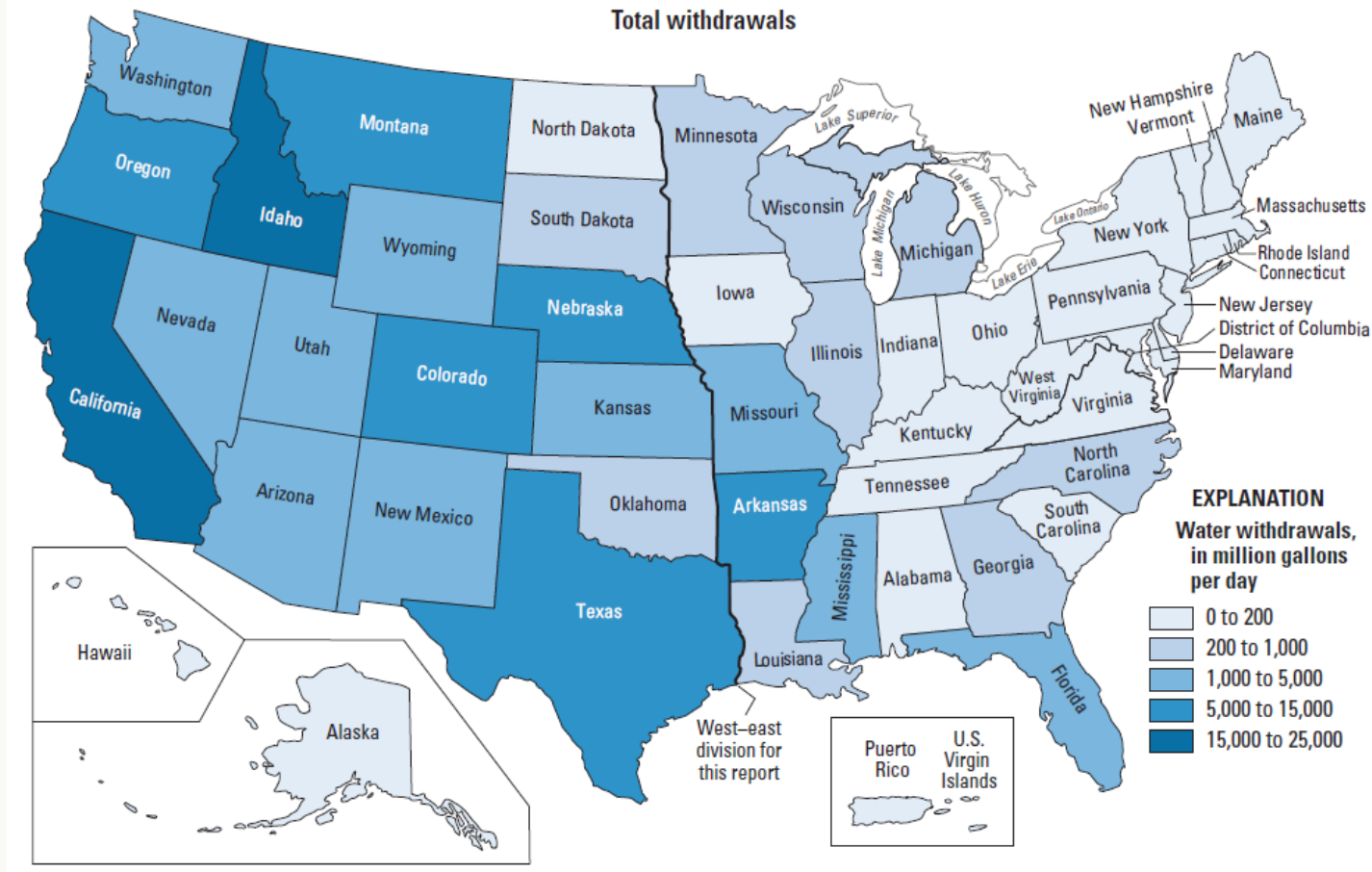
# National Water Withdrawal Rates



# National Water Withdrawal Intensity

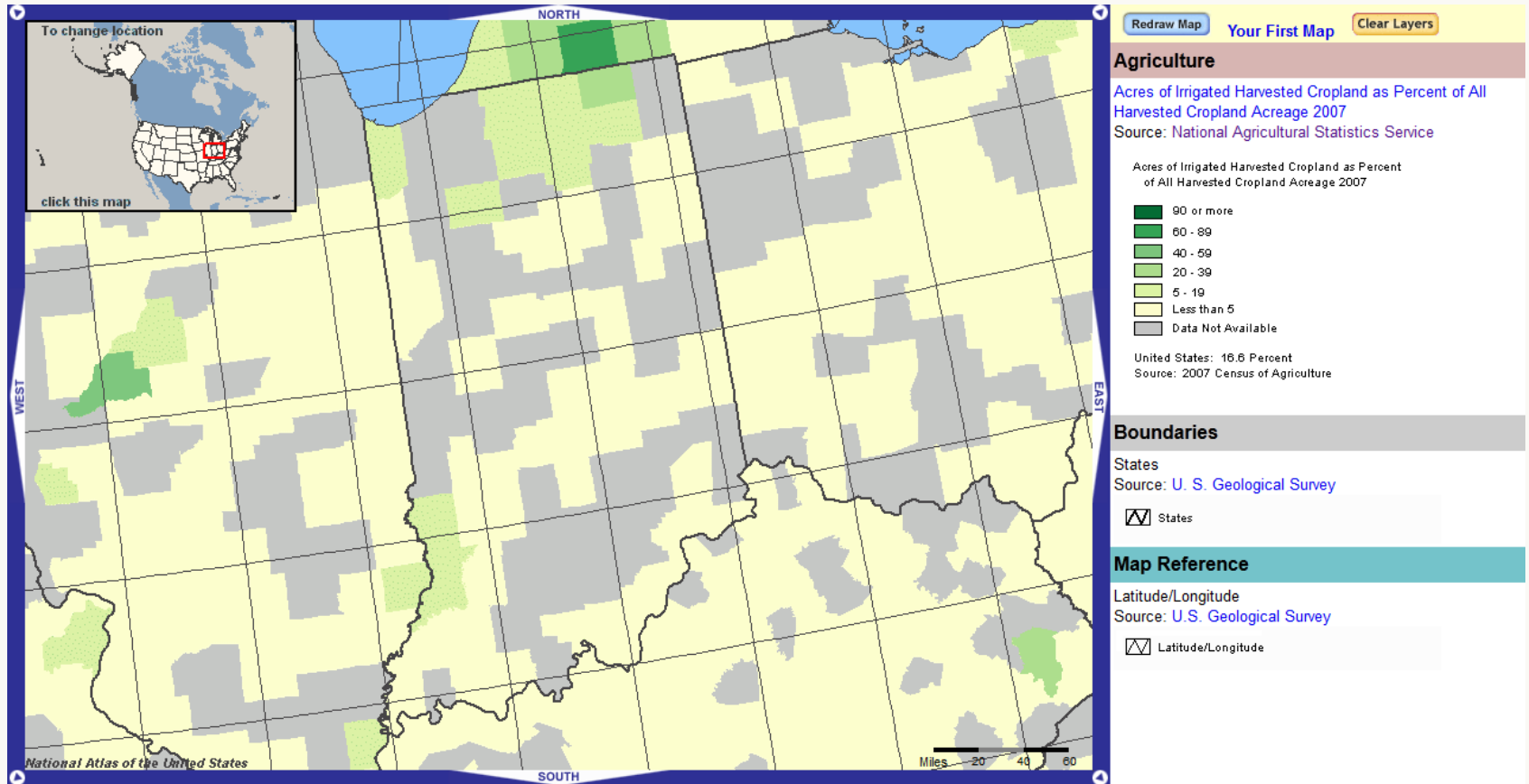


# National Irrigation Withdrawals





# Irrigation Use in Indiana



# Irrigation Use in Indiana

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- › Between 2002 and 2008 irrigated acreage in Indiana increased by 29%
- › Rate of adoption has increased since 2012 drought
- › Conflicts
  - Pumping for irrigation in Jasper County left the town of Parr, IN without water during the summer of 2012
  - Even in the spring of 2013, wells in Benton County went dry due to the installation of a new irrigation well
- › Indiana has enough water, but is it in the right place at the right time?

# Management

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- › Management of water resources will become increasingly important
- › Indiana's laws are more reactive than proactive
  - When a supply problem occurs, the source is identified and required to compensate the affected parties
- › More states are starting to look at cooperative solutions
- › For example, implementing “unitization” from the oil industry
  - Designate a single “unit operator” who could extract from and develop the reservoir with other parties tapping the non-renewable groundwater resource share
  - Helps slow down the race to the pump

# Warning

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- › Could the Ogallala Aquifer show us the future?
  - In 2000, the aquifer supplied 17 billion gallons of water per day for irrigation
  - This exceeds the renewal rate for most of the aquifer.
  - Since 1950 water in the aquifer has declined
    - *By up to 70 meters*
    - *By about 324 billion cubic meters*
  - The aquifer is being “mined” and will not support continued use at current levels for much longer
- › If Indiana can avoid this problem, it can benefit greatly!





Questions?

For more information, check out the Purdue  
Hydrologic Impacts Group web page:  
[www.agry.purdue.edu/hydrology](http://www.agry.purdue.edu/hydrology)