Water Resources in Indiana: Past, Present and Future

Keith Cherkauer

Agricultural and Biological Engineering, Purdue University
Purdue Climate Change Research Center

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OBJECTIVE:
The **IN CCIA** will bring together the best available climate change research into a series of reports that will help Hoosiers better understand climate change-related risks so they can **prepare for challenges** and **capitalize on opportunities**.

- Led by the Purdue Climate Change Research Center (PCCRC)
- Contributions from nearly 100 experts across the state
- Actively engage stakeholders throughout this process
- Reports started rolling out in 2018
- The Water Resources Report will come out in April 2019
Reduced water and air quality.
Decreased productivity of corn and soybean crops.
Loss of species, such as the Karner Blue Butterfly.
Increased heavy rainfall, leading to more flooding.
Delayed fall freeze, extending the ragweed allergy season.
Record-breaking heat waves.
What will climate change mean in Indiana?
Since the beginning of the 20th century in Indiana, temperatures have risen 1°F and total annual precipitation has increased nearly 5 inches. What does that mean for Hoosiers?
Shorter winters, increasing exposure to ticks and Lyme disease.
Increased demand for cooling.

Agriculture  Climate  Ecosystems  Energy  Health  Infrastructure  Tourism & Recreation  Water Resources
Historical Changes to Indiana Water Resources
Long-Term Indicators of Change

Observed U.S. Precipitation Change

Change to Extreme Precipitation

- Based on observations from 1950 to 2012
- Change in the heaviest 1% of precipitation storm events


Mishra and Cherkauer, 2010

Precipitation
Observed

Soil Moisture
Simulated

Mishra and Cherkauer, 2010
Observed Trends in Flood Magnitude


Kines and Cherkauer, in review
www.agry.purdue.edu/indiana-waters
Global Temperature and CO2

Observed U.S. Temperature Changes

Observed Increase in Frost-Free Season Length

Current State of Indiana Water Resources

Analysis for the current water year can be found at:

https://www.agry.purdue.edu/indiana-water
Surface Water (Streamflow) Rank

Maximum Flow Rank

End of Year Rank

WY 2017 ranked versus previous 28 years

Source: https://www.agry.purdue.edu/indiana-water
Groundwater (Water Table) Rank

Mean Flow Rank

End of Year Rank

WY 2017 ranked versus previous 28 years

Source: https://www.agry.purdue.edu/indiana-water
What might the future look like?
The Greenhouse Effect

› It is a naturally-occurring phenomena
  - water vapor, carbon dioxide, methane, and other naturally-occurring gases trap heat in the atmosphere

› Sustains life here on Earth
  - Without it, average temperature would be about −20°F instead of 55°F
So What is Global Warming?

› The problem is that we are increasing the concentration of heat-trapping gases

› This is like wrapping an extra blanket around the Earth

› This blanket is the “enhanced greenhouse effect”, or global warming
Global Energy Balance

Heat flux from Earth’s core ≈ 1/10,000 of solar radiation

From: southwestclimatechange.org
Separating Human from Natural Influences on Climate

What Might Indiana Be Like?
Change in Summer Precipitation
Change in Winter Precipitation

![Map showing change in winter precipitation over different time periods and climate scenarios.](image-url)

- **RCP8.5**
  - 2020s
  - 2050s
  - 2080s

- **Precipitation Change (%)**
  - -40 to 40

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PURDUE UNIVERSITY
Rain or Snow?
Fraction of Nov-Mar precipitation falling as snow

PRELIMINARY DATA
Based on high emissions scenario for 2050s
Days With Snow On The Ground

Annual count

PRELIMINARY DATA
Based on high emissions scenario for 2050s

Central Indiana

Past: 60
Future: 36
More Water Entering Our Rivers in 2050s

Change in total runoff

Annual Change  +10%

Future data based on high emissions scenario;
Percent change is relative to 1984-2013 average
PRELIMINARY DATA
## Seasonal Patterns of Runoff

### 2050s

<table>
<thead>
<tr>
<th>Season</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>14%</td>
</tr>
<tr>
<td>Spring</td>
<td>24%</td>
</tr>
<tr>
<td>Summer</td>
<td>-14%</td>
</tr>
<tr>
<td>Fall</td>
<td>-16%</td>
</tr>
</tbody>
</table>

Future data based on high emissions scenario; Percent change is relative to 1984-2013 average

PRELIMINARY DATA

Central Indiana Average
Seasonal Patterns of Runoff

2080s

Winter Change 35%
Spring Change 23%
Summer Change -24%
Fall Change -23%

Future data based on high emissions scenario;
Percent change is relative to 1984-2013 average
PRELIMINARY DATA
Change in Subsurface Tile Drainflow

Winter Change

2050s: +27%

2080s: +50%

Future data based on high emissions scenario;
Percent change is relative to 1984-2013 average
PRELIMINARY DATA
High Streamflows

Events in the top 10% of high flows

<table>
<thead>
<tr>
<th></th>
<th>2050s</th>
<th>2080s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Change</td>
<td>+12%</td>
<td>+15%</td>
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</tbody>
</table>

Future data based on high emissions scenario;
Percent change is relative to 1984-2013 average
PRELIMINARY DATA

Central Indiana Average
Changes in Monthly Streamflow

- Winter and spring flows increase
- Summer flows stay the same or decrease

### Discharge (m³/s)

- a. Tippecanoe River
- b. White River
- c. Patoka River

<table>
<thead>
<tr>
<th>Period</th>
<th>RCP 4.5</th>
<th>RCP 8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020s</td>
<td></td>
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<tr>
<td>2050s</td>
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<tr>
<td>2080s</td>
<td></td>
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</tbody>
</table>
Changing Water Demand
Recent water conflicts in the news

“Water wells drying up in Jasper Co.” WLI, Wednesday, August 1, 2012

“Some Benton Co. residents without water blame farmer's new irrigation system”, RTV 6, The Indy Channel

“Entire state under water shortage warning”, Journal Gazette

“Numerous factors could be causing water problems”, Rensselaer Republican, Tuesday, July 31, 2012

“Groundwater ‘dries up in Benton County: Irrigator may be liable if town's residents have to dig deeper for water, state official says’”, Lafayette Journal and Courier, July 17, 2013
Adaptation and Mitigation

› BMP effectiveness
› Natural habitat/wetland restoration
› Infrastructural changes
› Water regulation changes
› Economic impacts
What can/should we do to manage future water resources?
Management

› In-year water management will become increasingly important as winter and spring excess will be followed by summer and fall deficits.

› This will require increased short-term water management to mitigate spring flooding and wet conditions, while increasing storage or groundwater recharge so that more of that excess water is available during the growing season.
Management

› Overall distribution of daily flows will increase by the end of the century for Indiana’s rivers.

› Higher mean and low flows due to overall wetter annual trends mean that surface water will become more available, but increases in high flows and the increased risk of larger peak flows mean that water infrastructure should be evaluated for future flow conditions.

› Groundwater storage will also be affected by increased infiltration earlier in the year.
Management

› While annual conditions will be wetter in the future, the need for drought risk management will also increase.

› Specifically, we will need better information on groundwater storage and long-term changes in its availability, given that it appears to already be in decline in some parts of the state.
Management

› Existing Agricultural and Stormwater Management practices for water quality management are expected to be less effective in the future because of the change in seasonal water availability.

› Wetter spring conditions in particular are likely to overwhelm some practices and bypass others through increased subsurface drainage flows.

› Practices such as controlled drainage could play an important role in addressing these challenges.

› Practices relying on vegetation will have to deal with increased spring wetness and summer dryness.
Adaptation

› Climate is variable

› We already design and build for a variable climate

› We need to plan for increased variability
Adaptation

› Stationarity is the statistical assumption that variability in the future is constrained by what we have observed in the past.
  - Is stationarity dead?
  - Or did it never exist?

› How do we plan for the future when we cannot rely on the past to predict that future?
Thank You!

For more information, go to
https://www.agry.purdue.edu/hydrology
https://www.purdue.edu/climate