Climate Change, Rainfall and Wisconsin Communities

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Aldo Leopold Nature Center
Madison 7/24/14

Kate Barrett
Scientific consensus on climate change

“There is a strong, credible body of evidence, based on multiple lines of research, documenting that climate is changing, and that these changes are in large part caused by human activities.”

— US National Research Council, 2010

Wisconsin Initiative on Climate Change Impacts

Understanding how we can adapt to the consequences of a changing climate.

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Upper Midwest Precipitation Trends
1910 - 2012

8 of 10 of the wettest years for daily precipitation have occurred since 1978

S. Vavrus, Center for Climatic Research
Wisconsin rainfall has changed

$\uparrow 7'' - \downarrow 4''$ since 1950
Projected change in annual precipitation

+ 5-15% 1980-2055 (SRES A1B)

It’s likely to become wetter, not drier
Projected change in heavy rainfall

Projected change in >2” rain, +2-5 per decade

**1980-2055 (SRES A1B)**

Large storms become more frequent, with heavier precipitation
Increase continues over time

Projected change in >2” rain, +4-7 per decade

1980-2090 (SRES A1B)
Why we are concerned about future precipitation

Flooding and extreme rainfall threaten life prosperity
What a rainstorm can do
June 1-15, 2008

38 River gauges broke records
810 Square miles of land flooded
161 Communities overflowed 90 million gallons raw sewage
2,500 Drinking water wells tested - 28% contaminated

$34M in damage claims paid

Source: FEMA, WEM
## Record Rainfall

### Milwaukee Record Daily Precipitation

<table>
<thead>
<tr>
<th>Rank</th>
<th>Rainfall (in.)</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.81</td>
<td>August 1986</td>
</tr>
<tr>
<td>2</td>
<td>5.61</td>
<td>July 2010</td>
</tr>
<tr>
<td>3</td>
<td>5.40</td>
<td>June 1917</td>
</tr>
<tr>
<td>4</td>
<td>4.93</td>
<td>June 2008</td>
</tr>
<tr>
<td>5</td>
<td>4.49</td>
<td>June 1940</td>
</tr>
<tr>
<td>6</td>
<td>4.42</td>
<td>July 2000</td>
</tr>
<tr>
<td>7</td>
<td>4.32</td>
<td>September 1941</td>
</tr>
<tr>
<td>8</td>
<td>4.23</td>
<td>June 1997</td>
</tr>
<tr>
<td>9</td>
<td>3.74</td>
<td>September 1872</td>
</tr>
<tr>
<td>10</td>
<td>3.65</td>
<td>August 1998</td>
</tr>
</tbody>
</table>

6 of 10 of the wettest days have occurred since 1986

**World-wide - 72” in 24-hours** La Reunion, Indian Ocean (1966)

**Wisconsin - 11.75” in 24 hours** Stoddard, Vernon County (August 18, 2007)
Extreme Rainfall

Milwaukee, July 22, 2010 - 6.73” in one hour

2,000 calls for sewer backups into basements
Sanitary sewers overflow 2 billion gallons
Beaches closed through July 25th

$37M Damage

Source: Milwaukee Journal-Sentinel
Soil loss from increased precipitation

“Soil conservation and water quality are compatible with current and emerging expectations of Wisconsin’s farmlands, provided that practices we largely know how to do are widely implemented by our farmers.”

- WICCI Soil Conservation Working Group

Figure 3. Wisconsin Buffer Initiative estimates of sediment delivered to watershed outlet.

(1 t/acre = 224 tonnes/sq km) - Diebel et al. 2005

Climate Impacts on erosion difficult to predict, best estimate +130-150%
Stormwater Runoff

Runoff from large storm events transports nutrients and sediment to lakes, degrading water quality and causing eutrophication.
Projected change in mean annual temperature

+6°F  1980-2055 (SRES A1B)

Wisconsin will warm by 3° – 9° F by mid-21st century
Projected change in annual peak temperatures

1980-2055 (SRES A1B)

+10-25 days >90°F

+0-5 days >100°F
Brook Trout Habitat Loss
- John Lyons, Matt Mitro, Wisconsin DNR

+1.8°F -43%

+5.4°F -94%

+9°F -100%

Present Loss

Present Loss

Present Loss

Present Loss

[Images of maps and trout]
Increasing surface water temperature

= More frequent algal blooms

Fig. 5. Raw SSM summer (Jul–Sep) means (light curve) and SSM open-lake proxy data (annual and decadal, heavy curves).
Increasing water temperature = Higher surface wind speeds

Higher wind speeds = Increased turbidity

Southern Lake Michigan Turbidity Index 1956–2000
(10 and 25 mg/L exceedances)
Projected seasonal change in max temperature

1980-2055 (SRES A1B)

Winter +6-7°F

Spring +5-6°F

Summer +4-5°F

Fall +6°F
Seasonal change in precipitation

1980-2055 (SRES A1B)

Winter +20-25%

Spring +10-20%

Summer +0-5%

Fall +5-10%
Higher temp + Less summer rain = Drought

Summer temperature $+4-5^\circ\text{F}$

Summer rainfall $+0-5\%$

An incentive to irrigate?
Potential reductions in stream base flow?
Heat waves and drought = *Increased water use*

**Wisconsin has over 7,500 high capacity wells**
Seasonal change in max temperature

1980-2055 (SRES A1B)

Winter +6-7°F

Spring +5-6°F

Summer +4-5°F

Fall +6°F
Warmer winters = Less ice cover

Ice breakup is 15 days later on average than 150 years ago.

Ice breakup date

April 12, 2014

Lake Mendota, Dane County - John Magnuson
Warmer winters + less ice cover = **Increased surface evaporation**

Projected Great Lakes water levels

**December 2012**
Seasonal change in precipitation

1980-2055 (SRES A1B)

Winter: +20-25%

Summer: +0-5%

Spring: +10-20%

Fall: +5-10%
More winter/spring precipitation

- Flooding from increased winter spring rains
- Heavier snow and/or ice storms
Changing winter weather

Minneapolis weather changing to...

Warmer Winters
Less snow?
Changing winter weather

...Rockford weather.

Warmer Winters ⇒ More freezing rain?

Snow

Melts (rain)

Freezes
Increased road de-icing
More winter/spring precipitation = *Increased groundwater recharge*

Winter +6-7°F

Winter +20-25%

**Mean Annual Change (mm)**

- **Runoff**
- **Recharge**
- **ET**
- **Precipitation**

**Evan Murdock**
Increased recharge
= *Groundwater flooding*

Rising water table can result in groundwater contamination

Especially in communities that do not disinfect

Spring Green - 2008

Gotkowitz & Liebl, 2013
Adapting to changing climate

Resiliency

If a system is prepared for current variability, it’s likely to be prepared for future trends.

Many communities design and manage their systems based on recent experience.

Is east-central Wisconsin prepared?
Planning for Climate Impacts

Long planning horizon
Climate change occurs over decades, what community planning and management strategies are on the same time scale?

Predictive uncertainty
Are management strategies flexible enough to respond to the range of climate impacts and uncertainty?

Sustainable alternatives
More of the same may not be the best long term solution?

Look for high risk + good cost-benefit
Climate Ready Communities

Climate Awareness

Vulnerability Assessment:
- Extreme heat
- Drought
- Heavy rainfall
- Warm winters

Adaptation Capacity:
- Planning
- Resiliency

*Communities should be prepared for today’s rare weather extremes, they will become more common* - WICCI
Planning for Climate Change

The Team
Natural resource and infrastructure managers, public health and safety and government officials.

The Process
1) Understand climate impacts
2) Assess vulnerability
3) Identify adaptation opportunities
4) Plan for adaptation:
   – Range of strategies
   – Implementation plan
   – Communicate
How far do we need to look ahead?

**Planning Horizons**
- Budget 1-2 years
- Staffing 3-5 years
- Buildings 25-50 years
- Roads, Sewers, etc. >50 years

Comparing: Late 20th to mid-21st
Community Vulnerability Assessment - Rainfall

- Floodplains and surface flooding
- At-risk road-crossings
- Stormwater BMPs
- Hazardous materials storage
- Emergency response capacity
- Wells and septic systems
- Sanitary sewer inflow and infiltration
Tools for assessing vulnerability

Understand vulnerability to prepare for extreme events

- Model flood vulnerability

East River 500 year flood damage estimate = $124M

Floodplain mapping to identify vulnerable areas

500-year flood elevations shown
## Extreme Storm Transposition

<table>
<thead>
<tr>
<th></th>
<th>Rainfall</th>
<th>Rise</th>
<th>Stage*</th>
<th>Outflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 storm</td>
<td>10.7”</td>
<td>2.3’</td>
<td>852’</td>
<td>632 cfs</td>
</tr>
<tr>
<td>Transposed storm</td>
<td>13.6”</td>
<td>2.9’</td>
<td>853’</td>
<td>752 cfs</td>
</tr>
</tbody>
</table>

100yr flood = 852’ *

*from 850.1’

- Doug Brugger

NOAA CSI-SARP
NA12OAR4310098
Tools for assessing vulnerability

To anticipate the future we must understand the present

- Monitoring stream flows
- Measuring groundwater elevations

Stream Flow
241 USGS gage sites
88 active long-term gages

Groundwater
1954 270 monitoring wells
2013 97 active
Climate Adaptation Strategies

Use nature to best advantage
- Preserve floodplains and wetlands
- Avoid development on hydric soils

“We also encourage county and municipal governments to adopt an approval process, or place land use controls on development over hydric soils in areas that will experience future flooding.”
– WICCI Stormwater Working Group
Sustainable Water Management

Capture – Treat - Infiltrate
Kinnickinnic River, Milwaukee

Building long term resilience

Adaptation to low-risk high-cost events requires political support
Kinnickinnic River, Milwaukee

Planning for impacts 25 or 50 years out is possible

The Vision

The Work

The Result
Further Reading

Understand climate science and impacts
Wisconsin’s climate adaptation report

Changes:
- Climate Trends in Wisconsin
- Understanding Adaptation

Impacts:
- Water Resources
- Natural Habitat and Biodiversity
- Agriculture and the Soil Resource
- Coastal Resources
- People and their Environment

Actions:
- Implementing Adaptation
- Moving Forward

www.wicci.wisc.edu
Winter 2013-2014 was the 8th warmest on record (+ 1°F) Even though it was cold in some places.

Winter 2013-2014 Temperature vs 1981-2010 average - WMO
June 2014 set record for global temperature