Adapting to Climate Change in Wisconsin

Strategies for Conservation Professionals

Wisconsin Association
of Land Conservation
Employees
March 3, 2011

David S. Liebl

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Wisconsin Initiative on Climate Change Impacts
Identifying Impacts and Adaptation Strategies

WICCI mission:
Assess and anticipate climate change impacts on specific Wisconsin natural resources, ecosystems and regions.

Evaluate potential effects on industry, agriculture, tourism, and other human activities.

Develop and recommend adaptation strategies.

www.wicci.wisc.edu

WICCI was created by a partnership of the UW-Madison Nelson Institute for Environmental Studies and the Wisconsin Department of Natural Resources.
Overview

• Understanding climate change
• Wisconsin’s changing climate
• Expected impacts
• Adaptation strategies
Solar radiation

Absorbed by ozone

Visible Light

Absorbed by the earth

Upper Stratosphere
(ozone layer)

Troposphere

Reflected by atmosphere (34%)

Radiated by atmosphere as heat (66%)

Greenhouse effect

Heat radiated by the earth

Energy in = Energy out
Recent Warming of the Atmosphere

There is broad scientific consensus that earth’s atmosphere is warming. WICCI is concerned with the impacts of that warming.....

...whatever the cause of it.
What is Climate?

“Climate is properly the long average of weather in a single place”
- *The Cornhill Magazine*, 1860

Köppen climate subdivisions -1884 (30 year averages)
Indicators of a changing climate

Global Temperatures

Source: IPCC 2007

Lake Mendota Ice Duration 1855-6 to 2008-9

A longer record is better!
What about climate concerns us?

Humans experience climate as weather.
Impacts of Weather (temperature)

Connecting climate to weather impacts

Change in the Frequency of 90°F Days Per Year from 1950 to 2006

Projected Change in the Frequency of 90°F Days Per Year from 1980 to 2055 (A2)

Source: Center for Climatic Research & Center for Sustainability and the Global Environment, Nelson Institute, University of Wisconsin-Madison
Impacts of Weather (rainfall)

Daily rainfall over 5”

Historical 5” Exceedances and Maximum Daily Event 1950 - 2007

14” over a few days in June 2008
Acting on climate change in Wisconsin

Climate Mitigation

2008 - Governor’s Task Force on Global Warming addressed ways to reduce greenhouse gas emissions.

Climate Adaptation

2011 - Wisconsin Initiative on Climate Change Impacts addresses ways to adapt to consequences of climate change.
Wisconsin’s Past Climate

We’ve been measuring temperature and rainfall in Wisconsin since 1870

WI Cooperative Weather Stations
Summary of recent **historic** climate
1950-2006 (based on NWS records)

**Annual average temp**
+1.5°F (-1°C to +3°C)

**Winter days** +2°F

**Winter nights** +3°F

**Change in below 0°F Nights**
(days) 1950 to 2006

Source: Center for Climatic Research & Center for Sustainability and the Global Environment, Nelson Institute, University of Wisconsin-Madison
Summary of recent **historic** climate
1950-2006 (based on NWS records)

**Change in annual average precipitation (inches) 1950 to 2006**
- ↑7” to ↓4” (drought)

**Increase in 2” rainfalls (days/decade) 1950 to 2006**
- ↑3.5 days to ↓1.5 days (regionally variable)
Summary of recent **historic** climate
1950-2006 (based on NWS records)

**Change in length of the growing season**
(days) 1950 to 2006

Growing Season

↑36 days (NW)

to

↓-4 days (SE)
### Earlier arrival of spring in Wisconsin

#### Bird migration

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geese Arrival</td>
<td>29 days</td>
</tr>
<tr>
<td>Cardinal first song</td>
<td>22 days</td>
</tr>
<tr>
<td>Robin arrival</td>
<td>9 days</td>
</tr>
</tbody>
</table>

#### Vegetation

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baptista first bloom</td>
<td>18 days</td>
</tr>
<tr>
<td>Butterfly weed first bloom</td>
<td>18 days</td>
</tr>
<tr>
<td>Marsh milkweed first bloom</td>
<td>13 days</td>
</tr>
</tbody>
</table>

55 ecological indicators of spring occurred (on average) 1.2 days earlier per decade from **1936 to 1998**

So...we live in a changing climate.

How does this compare to projected climate?
General Circulation Models (GCMs) simulate the effects of incoming and outgoing thermal radiation on global climate, and include:

- Atmosphere
- Clouds
- Oceans
- Topography
- Rainfall
- Etc.
WICCI Climate Working Group

- Used 14 General Circulation Models (GCM’s) from IPCC 2007 assessment
- Verified using historical Wisconsin weather station data
- Result: a statistical range of probable climate change

Downscaling:
Focus global projections to a scale relevant to climate impacts in Wisconsin

D. Vimont, UW-Madison
Temperature
(°F)

Change in average annual temp
1980 to 2055

Mid-Century mean
across all GCMs

Significant warming is projected

<10% and >90% are outliers
Projections are less certain further into the future.

2090 annual mean +10ºF [± 4ºF]

10th Percentile Among Models’ Projected Change in Annual Average Temperature (ºF) from 1980 to 2090 (A1B Scenario)

90th Percentile Among Models’ Projected Change in Annual Average Temperature (ºF) from 1980 to 2090 (A1B Scenario)

>10th probability  mean  <90th probability
Precipitation

Change in annual average
1980 to 2055 (inches)

Increase in 2” rainfalls
1980 to 2055 (days/decade)

1.25” to 2.25” and 2-3 days/decade = modest future increase
Wisconsin Impacts Study

Downscaled GCM Data

- 14 GCMs
- Historical and mid-21st Century (2046-2065) time periods
- SRES A1B Scenario (720 ppm CO₂)
- Daily precipitation probability distributions

Metrics

- 100-Year, 24-Hour Quantiles
- Winter/Spring Precipitation
- Precipitation as Rain/Snow
## 100-Year, 24-Hour Quantiles

<table>
<thead>
<tr>
<th>City</th>
<th>1961-2000</th>
<th>2046-2065</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eau Claire</td>
<td>5.61 in</td>
<td>6.03 in</td>
<td>+ 7.5%</td>
</tr>
<tr>
<td>Madison</td>
<td>6.97 in</td>
<td>7.60 in</td>
<td>+ 9.1%</td>
</tr>
<tr>
<td>Green Bay</td>
<td>5.15 in</td>
<td>5.77 in</td>
<td>+ 12.0%</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>5.65 in</td>
<td>6.27 in</td>
<td>+ 11.0%</td>
</tr>
</tbody>
</table>

100-Year, 24-Hour Quantile = Daily Precipitation x 1.13
- Huff and Angel, 1992

Schuster
Our ability to predict precipitation is uncertain.

Projected size of 100-year 24-hour storm for Madison, WI, based on 14 GCMs

Which 100-year event do you prefer? 6” or 9”

? Wetter or drier in summer?
Implications for Stormwater Management

• The downscaled GCMs confirm what we know about physical processes, but still have high variability

• New models have potential to increase modeling ability, but….

• Modelers agree that models don’t model convective summer storms well

Bottom Line: Precipitation is likely to get more intense, but models are not advanced enough to serve as design tool
Precipitation as snow reduced by 20% by mid-century
= 30% decrease in midwinter snow depth
Warming means more rainfall in winter

Percent Precipitation as Rain
Madison, WI 1961-2000 and 2046-2065

<table>
<thead>
<tr>
<th>Month</th>
<th>Historical (in)</th>
<th>Future (in)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.24</td>
<td>0.65</td>
<td>174.9%</td>
</tr>
<tr>
<td>February</td>
<td>0.35</td>
<td>0.72</td>
<td>107.5%</td>
</tr>
<tr>
<td>March</td>
<td>1.21</td>
<td>1.83</td>
<td>50.8%</td>
</tr>
<tr>
<td>April</td>
<td>3.00</td>
<td>3.42</td>
<td>13.9%</td>
</tr>
<tr>
<td>May</td>
<td>3.37</td>
<td>3.48</td>
<td>3.4%</td>
</tr>
<tr>
<td>June</td>
<td>3.99</td>
<td>3.99</td>
<td>0.0%</td>
</tr>
<tr>
<td>July</td>
<td>3.95</td>
<td>3.88</td>
<td>-1.5%</td>
</tr>
<tr>
<td>August</td>
<td>4.01</td>
<td>3.89</td>
<td>-2.9%</td>
</tr>
<tr>
<td>September</td>
<td>3.44</td>
<td>3.42</td>
<td>-0.5%</td>
</tr>
<tr>
<td>October</td>
<td>2.37</td>
<td>2.66</td>
<td>12.4%</td>
</tr>
<tr>
<td>November</td>
<td>1.83</td>
<td>2.02</td>
<td>24.3%</td>
</tr>
<tr>
<td>December</td>
<td>0.54</td>
<td>1.11</td>
<td>105.3%</td>
</tr>
</tbody>
</table>
Changing Winter Precipitation

Minneapolis weather changing to...

Warmer Winters ⇒ Less snow?
Changing Winter Precipitation

Rockford weather.

Warmer Winters $\Rightarrow$ More freezing rain?

- Snow
- Melts (rain)
- Freezes
Summary of projected Wisconsin climate

- Warming nighttime and winter temperatures
- Significant increase of rain during winter
- Reduced snowcover
- Moderate increases in frequency and intensity of precipitation

*Impact on short term variability (i.e. weather) not understood*
Temperature Impacts (human)
Average temperatures increasing 4-9°F by 2050
= More Heat Waves
Wisconsin’s Tension Zone
Present Day

Figure 5.—Summary of range limits for 182 species. The figures in each county indicate the number of species attaining a range boundary there. The shaded band is the tension zone. Its exact location was determined from the densest concentration of individual range lines. - Curtis 1959
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Late - Century

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Changing Character of Forests

White Birch

Northern Forests

Boreal, pioneer species at risk
– Warmer winter temps and late summer droughts
– Species at southern range limit in WI: aspen, white birch, white spruce, black spruce, and balsam fir

Current species declines could be accelerated
– Tree species that are difficult to maintain will be increasingly difficult to regenerate
– Hemlock, white birch, spruce

Altered hydrology may jeopardize lowland forests
– Forests relying on saturated soils could be vulnerable to drying out, extreme stress, wildfires
– Black ash dominated
Brook Trout Fishery

John Lyons, Matt Mitro, Wisconsin DNR
Temperature Impacts (wildlife)

**Winners:**
- Short generation times
- Wide distributions
- Move easily across landscape
- General habitat requirements
- Not sensitive to human activity

**Losers:**
- Long generation times
- Narrow distributions
- Poor dispersal ability
- Special habitat requirements
- Sensitive to human activity
Precipitation Impacts
Changing patterns of precipitation

More rain in winter
+ More intense rainfall
= More high water events
= More groundwater recharge

Vulnerability is already high during winter and spring
Changing patterns of rainfall

Recent increase in records storms

A decadal cycle, or persistent trend?
Intense rainfall occurrences

Are these communities prepared for >100 year events?

Note low frequency in east-central
Assessing Vulnerability

Historic occurrences of persistent rainfall

Note the accumulation from single storm events

Are any communities prepared for these events?
Adapting to Climate Change

Humans have always adapted to climate.

But projected changes lead us into unknown territory!
Mitigation is the idea that we can avoid, prevent or minimize undesirable things happening in the future.

Adaptation is the idea that changes are occurring or will occur, and we can manage the impacts of those changes.

WICCI recommends a risk management approach

Climate presents hazards of varying severity and likelihood.
WICCI on Adaptation

WICCI Encourages no-regrets strategies

- Clear present benefit
- Building future resiliency
- Don’t gamble on uncertainty
- Flexibility to respond to new information

Are higher levees a good idea?

Anticipate future rainfall when installing drains
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
Conservation tillage and other low-impact ag practices

Conservation Tillage Practice Guide
A Guide to USDA-NRCS Practice Standards 329 No Till/Strip Till/Direct Seed and 345 Mulch Till

Practice Standard 329 - NoTill/Strip Till/Direct Seed

No Till

- 25% Soil Disturbed
- 75% Soil Undisturbed

No-Till Planter

1 PASS
Strip Till or (Zone-Till)

- 70% Soil Undisturbed
- 30% Soil Disturbed

Zone-Till Planter

2 PASS
Strip Till or (Zone-Till)

- 70% Soil Undisturbed
- 30% Soil Disturbed

Zone-Till Builder

First pass make strips
Second pass plants

Practice Standard 345 - Mulch Till

- Examples of full width tillage implements, Allowed for Mulch Till Practice Standard.
Adaptation

Vulnerability assessment, maintenance and monitoring of erosion control practices
Impact

Groundwater flooding from increased recharge
Mapping Hydric Soils

We recommend that WDNR develop an approval process for prior converted wetlands that are being removed from agricultural use, that will encourage their restoration and prevent development in flood-prone areas.

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
Impact

Damage from High-Water Events
High water impacts
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
Adaptation

Vulnerability Assessment

“Build upon the experiences of communities that have experienced recent extreme rainfalls to guide a state-wide evaluation of vulnerabilities…..”
- WICCI Stormwater Working Group

Assess:

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

Building long term resilience

- Planning for impacts 25 or 50 years out is challenging
- Adaptation to low-risk high-cost events requires political support
- Use hydrologic simulation to understand high water impacts
Great Lakes Coastal Vulnerabilities

Wisconsin has about fifty communities on Lakes Michigan and Superior.

Runoff impacts from contributing watersheds are likely the greater source of risk.

City of Green Bay watershed
Vulnerabilities

Economic -
Upland impacts, including degraded beach health and aesthetics, may impact tourism in coastal communities.

Environmental -
Plant and animal communities along the Great Lakes, including coastal wetlands, degraded by nutrients and sediment.

Source: Michigan Sea Grant
Vulnerabilities

Land Use -
Residential and commercial structures and property on the coast are vulnerable to bluff recession, erosion and high water.

Lowering of the Ordinary High Water Mark during extended periods of low lake levels may encourage development in flood prone areas.

Source: WI Sea Grant
Research and Professional Education

- Periodically reevaluate and revise climate and resource management models and criteria.

- Develop tools to distinguish the effects of human activities from those of climate change.

- Evaluate and improve strategies for managing heat and high water.

- Establish curriculum to build professional capacity among resource managers.
Filling Gaps

Data and Monitoring

- Fine scale rainfall data
- Real time stream-flow data
- Update estimates of flood profiles
- Identify at-risk road-crossings
- Robust groundwater monitoring
- Models to predict groundwater impacts
- Impact of events on wastewater treatment capacity
- Locate flood-prone/at-risk areas; wells and septic systems; hazardous materials and petroleum storage
WICCI Working Group Reports

• Fifteen topic areas

• Detailed information on climate impacts

• Suggested adaptation strategies
WICCI Adaptive Assessment 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

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WICCI Next Steps

• Continued research into climate
• Identify impacts and adaptation strategies
  Great Lakes Energy
  Mississippi River Valley Tourism
  Groundwater Community Planning
  Air Quality Economics
• Outreach education to resource managers and communities

2050...It’s only forty years away

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