Northern Institute of Applied Climate Science

Climate
Carbon

Provides **practical** information, resources, and technical assistance related to forests and climate change.

Regional multi-institutional partnership among:

NIACS
Northern Institute of Applied Climate Science

USFS
Forest Service

MiTEC
Michigan Technological University

The University of Vermont

The Trust for Public Land

University of Minnesota

Great Lakes Indian Fish & Wildlife Commission
Practical Resources & Technical Assistance

• USDA Forest Service Climate Change Resource Center

• USDA Climate Hub

• Forestadaptation.org

• AdaptationWorkbook.org
Agenda

1. Introduction
2. Preview of Workshop process
3. Climate changes
   1. General observed climate trends
   2. Potential climate impacts
4. Homework before the workshop

Source: wisconsinbirds.org
Questions you might be asking...

1. How might climate change affect the resources that I manage?

2. What management actions could help prepare for those effects?

*Focus of the workshop!*
Responding to climate change

**Mitigation** = actions that reduce the human contribution to the greenhouse gas effect.

**Adaptation** = actions to prepare for and adjust to new conditions.
Adaptation Concepts

Resistance
- Reduce impacts / Maintain current conditions

Resilience

Transition (Response)
- Forward-looking/Promote change

Millar et al. 2007, Stein et al. 2014
Adaptation Concepts

Manage for Persistence:
Ecosystems are still recognizable as being the same system (character)

Manage for Change:
Ecosystems have fundamentally changed to something different

Reduce impacts / Maintain current conditions

Forward-looking/Promote change

Millar et al. 2007, Stein et al. 2014
Intentionality

• Explicitly consider and address climate change

• Sure we might get lucky...

• Intentionally assessing risk and vulnerabilities makes our plans more robust!
Adaptation Resources + workbook

- **Practical process** to intentionally consider climate & customize adaptation actions
- Designed to be flexible – for diverse goals, and values
- Does not make recommendations
- New online version!

Swanson and Janowiak 2016; [www.nrs.fs.fed.us/pubs/52760](http://www.nrs.fs.fed.us/pubs/52760)
1. DEFINE management goals.
2. ASSESS climate change impacts.
3. EVALUATE management goals.
4. IDENTIFY adaptation tactics.
5. MONITOR and evaluate effectiveness.

Preview to the Workshop process
Adaptation Workbook

Swanson and Janowiak 2016; www.nrs.fs.fed.us/pubs/52760
1. Where are you and what do you care about?

2. How is that particular project vulnerable to climate change?

3. What challenges or opportunities does climate change present?

4. What actions can help systems adapt to change?

5. How can you know whether those actions were effective?

Swanson and Janowiak 2016; www.nrs.fs.fed.us/pubs/52760
## Document your Thoughts

<table>
<thead>
<tr>
<th>Management Objectives</th>
<th>Challenges</th>
<th>Opportunities</th>
<th>Feasibility</th>
<th>Other Considerations</th>
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### Adaptation Actions

<table>
<thead>
<tr>
<th>Approach (From Chapter 2)</th>
<th>Tactic</th>
<th>Time Frame</th>
<th>Benefits</th>
<th>Drawbacks/Barriers</th>
<th>Practicability</th>
<th>Recommend Tactic?</th>
</tr>
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Worksheets!  
Worksheets!  
Worksheets!  
Worksheets!
An Uncertain Future

Don’t wait for a crystal ball...

Common Q:
“How can I adapt and prepare if I don’t know what the future holds?”
We Don’t Need Certainty

Instead: think about risk management!

Better Q:
“What can I do to reduce my risk and take advantage of opportunities?”
Purpose: Connecting the Dots

A clear train of thought shows **intentionality**

- Management Goals & Objectives
- Climate Change Impacts
- Challenges & Opportunities
- Intent of Adaptation (Option)
- Make Idea Specific (Strategy, Approach)
- Action to Implement (Tactic)

Swanson and Janowiak 2016; www.nrs.fs.fed.us/pubs/52760
Adaptation Resources

Strategies & Approaches

Menu of adaptation actions

Adaptation Workbook

Structured process to integrate climate change considerations into management.
- Workbook approach

Swanson and Janowiak 2016; www.nrs.fs.fed.us/pubs/52760

Also online: AdaptationWorkbook.org
Testing a new menu

**Goal:** test menu of adaptation resources for wetland managers with a diversity of management goals

**Wisconsin Initiative on Climate Change Impacts**

Plants and Natural Communities Group

A “Menu” for Adaptation

Translating concepts to actions

Adaptation options (concepts):
- Resistance, Resilience, Transition

Strategies:
- Broad adaptation responses considering ecology & mgmt.

Approaches:
- More specific adaptation responses applicable to a specific ecosystems

Tactics:
- Prescriptive site-specific actions designed for local conditions and mgmt. objectives
Connecting the Dots

A clear train of thought shows *intentionality*

Management
Goals & Objectives

Climate Change Impacts

Challenges & Opportunities

Intent of Adaptation (Option)

Make Idea Specific
(Strategy, Approach)

Menu of adaptation
strategies and approaches

Action to Implement
(Tactic)

Swanston and Janowiak 2016;
www.nrs.fs.fed.us/pubs/52760
A “Menu” for Adaptation

Translating concepts to actions

The Menu helps you create clear rationale for your actions by connecting them to broader adaptation ideas.

Concept
- Strategies
- Approaches
- Tactics

Action

Intentionality
Success
Adaptation Resources: more menus

Menus to try

- **Forests**
- **Urban forests**
- **Agriculture**

- Non-forested wetlands
- Forested watersheds
- Wildlife
- Tribal perspectives
- Carbon...?
- Ranching...?

Swanston et al. 2016 (2nd edition)
www.nrs.fs.fed.us/pubs/52760

Janowiak et al. 2016. USDA

Coming soon
Real World Examples

+200 Projects underway

Forestadaptation.org/demos
How has the climate changed over the last century?
A changing climate...

**Annual**

**Observed:** 1895 – 2017

1.8 °F

**Winter temp**

**Observed:** 1895 – 2017

3.3 °F

**Precipitation**

**Observed:** 1901 – 2016

3 inches more annual precipitation

**Extreme events**

**Observed:** More frequent extreme rain events (>3” over last 30yr)

**Soil moisture**

**Observed:** Drier than average in some areas, moderate drought during growing seasons

Sources: NCA, NIACS and NOAA Climate at a Glance for WI (statewide) https://www.ncdc.noaa.gov/cag
A changing climate...

**National Climate Assessment** - Climate Science Special Report
science2017.globalchange.gov

**NIACS** - N. Wisconsin Forest Ecosystem Vulnerability Assessment
forestadaptation.org/vulnerability-assessment

**NOAA** Climate at a Glance tool (data)
https://www.ncdc.noaa.gov/cag/

... at the forum! Go to Dan Vimont’s presentation
How is the climate expected to change over the next century?
Future changes

Observed and Projected Temperature Change

Wisconsin

- Observations
- Modeled Historical
- Higher Emissions
- Lower Emissions

Year

1900 1925 1950 1975 2000 2025 2050 2075 2100

Temperature Change (°F)

Figure source: NOAA WI State Climate Summary, CICS-NC and NOAA NCEI
Projected climate...

- 2 - 9 °F
- Winters will become shorter, more rain

- More rain in winter and spring (1”-3”)
- Snow reduction 10—30%

- Growing season lengthen by 1-2 months
- Dry end of season – limited soil moisture

More frequent extreme rain events + wind

Climate change Ecosystem Vulnerability Assessment at forestadaptation.org/vulnerability-assessment
### Future Changes

#### Variable | What We Know (High Certainty)
--- | ---
**Temperature** | Warmer temperatures  
More hot days, fewer cold nights  
More frequent & longer heat waves  
Milder winters, longer warm season

#### Precipitation | More rainfall annually & some seasons  
More frequent & intense heavy rains  
Reduced snowpack, earlier melting
## Future Changes

<table>
<thead>
<tr>
<th>Variable</th>
<th>What We Don’t Know as Well (<em>Greater Uncertainty</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Amount of warming: How much?</td>
</tr>
<tr>
<td></td>
<td>Rate of warming: How fast?</td>
</tr>
<tr>
<td></td>
<td>Delay in warming: Role of Atlantic Multidecadal Oscillation</td>
</tr>
<tr>
<td></td>
<td>Annual &amp; seasonal variability</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Extreme rain events: Will frequency &amp; intensity continue to increase?</td>
</tr>
<tr>
<td></td>
<td>Changes in summer precipitation</td>
</tr>
<tr>
<td></td>
<td>Relationship between warmer temperatures &amp; altered precipitation</td>
</tr>
<tr>
<td></td>
<td>Annual &amp; seasonal variability</td>
</tr>
<tr>
<td>Sea-level</td>
<td>Amount of rise: How much?</td>
</tr>
<tr>
<td></td>
<td>Storm characteristics</td>
</tr>
</tbody>
</table>

*Star et al. 2015*
Regional climate change impacts

**Climate Changes**
- Warmer, shorter winters
- Warmer, wetter springs
- Warmer growing season
- Slight increase or large decrease in summer precip.
- More heavy rain

**Physical Impacts**
- Less extreme cold
- Less frozen ground
- More low-streamflow days in summer
- Flooding and erosion
- Longer dry spells
- Less snowfall, snowpack, and ice cover
- More high-streamflow days in winter
- More extreme heat
- Changing water tables
- Warmer water – lakes and streams

**Ecosystem Impacts**
- Changes in phenology
- Longer growing seasons
- Increases in non-native plant spp.
- Increased evapo-transpiration
- Increases in southern spp.
- Reduced water quality
- Deer herbivory
- More damage from pests and pathogens
- More drought stress in summer and fall
- Increases in wildfire activity
- Others?

**Impacts**
drawn from regional vulnerability assessments at: forestadaptation.org/vulnerability-assessment
How could ecosystems be affected?
Increased Carbon Dioxide

Image: www.science.howstuffworks.com
Increased Carbon Dioxide

**Opportunity:** Increased productivity*
- Increased photosynthesis
- Increased water use efficiency

*Effect likely limited:
- Limited sink strength
- Interactions with nitrogen
- Ozone damage
- Other reductions in productivity (e.g., moisture stress, disturbance)

Longer Growing Seasons

Projected to increase by 2-7+ weeks by 2100

Opportunity:
Longer period for plant growth

Challenge:
Potential risks from altered seasonality

• Early bud break/loss of cold hardening
• Frost damage during spring freezing
• May advantage some invasive plants

Image: Sciencedaily.com

Season length in days
End of Century vs. Current

2081-2099 vs 1981-2000

Low Emissions

High Emissions
Shorter Winter = Less Snow

Projected decreases in snow fall, cover, and depth
- 30-50% decreases in snowfall (Notaro 2015)

Challenge:

Decreased snowpack
- Increased soil frost and root damage in cold temps
- Warmer soil temperatures and altered processes

Janowiak et al. 2014
Shorter Winter = Less Snow, More Rain

Precipitation is projected to increase = more rain

Challenge: Altered stream flow timing and amount

• Earlier spring peak flows
• Potential increases in flashiness and episodic high flows
  • Erosion, washouts
• Potential declines in summer seasonal stream flow
Climate change + Water

Weather & climate drive hydrology.

Challenge: Increased risk of moisture stress
Warmer temperatures = ↑ vapor pressure deficit (VPD)
• More evaporation from soils & open water
• More transpiration from plants

Source: Midwest Regional chapter, Fourth National Climate Assessment, Vol. II (in review)
Climate Change + Water = Wetter

**Observed:**
- 3+ inches more annual precipitation
- More frequent extreme rain events

**Future:**
- Precip increases: annual, winter, spring, and fall
- More extreme events
- More runoff, less retained in system

*July 12, 2016*
Northern Wisconsin

Photos: Linda Parker/ USFS
Climate Change + Water = Wetter AND Drier

**Observed:**
- Dry periods in some areas

**Future**
- Summer rainfall may not change much.
- Possibility of more consecutive dry days

- Warmer temperatures dry air & soils
- Extreme events increase runoff

**Result:** Risk of moisture stress & drought

---

**Diagram Description:**
- **Evaporation** (Water loss from soils & open water)
- **Transpiration** (Water loss from trees)
- **Groundwater recharge**
- **Runoff**
- **Summer**
- **Precipitation**

- **Observed:**
  - Dry periods in some areas

- **Future:**
  - Summer rainfall may not change much.
  - Possibility of more consecutive dry days
Changes in Ecosystem Species assemblages

Habitat based on:
• **Temperature**
• **Precipitation**
• **Elevation**
• **Latitude**
• **Soils**
• **Slope & Aspect**
• **Land use**
• **Competition**
• **Management**

Map: Charles Lane, US EPA
Photos: wisconsinwetlands.org
Changes in Ecosystems Composition

**Challenge:** Decline of northern/boreal species

**Opportunity:** Increased habitat for some species

- Some species: reduced habitat suitability in the future
- Changes will occur slowly—not instant dieback
- Immense lags to occupy habitats
- Critical factors: competition, management, & disturbance
Extreme Events

**Challenge:** Increased disturbance from extreme events

- Heavy precipitation
- Ice storms
- Heat waves/droughts
- Wind storms

“Events” are not well modeled
Interactions: Insects and Disease

**Challenge:** Increased forest insects & diseases

**Indirect:** Stress from other impacts increases susceptibility

**Direct:**
- Pests migrating northward
- Decreased probability of cold lethal temperatures
- Accelerated lifecycles

Interactions: Invasive Plants

Challenge: Increased invasive & noxious plants

Indirect: Stress or disturbance from other impacts can affect the potential for invasion or success

Direct:
• Expanded ranges under warmer conditions
• Increased competitiveness from ability of some plants to take advantage of elevated CO₂

Dukes et al. 2009, Rustad et al. 2011
A “Threat Multiplier”

- Interactions can trigger big changes
  - Stress
  - Disturbance
  - Invasive species
  - Insect pests
  - Forest diseases
How could wetlands be affected?

**Generally Challenges**
- Reduced growth: moisture stress
- Decline of northern/boreal species
- Disturbance from extreme events
- Wildfire potential
- Pests & disease
- Invasive species
- Altered land uses

**Generally Opportunities**
- Increased productivity: longer growing season
- Increased productivity: more CO$_2$
- Increased habitat for some species

*What would you add?*
Non-forested Wetland vulnerability

**High vulnerability**
- Boreal rich fen
- Calcareous fen
- Central poor fen
- Coastal plain marsh
- Sandy moist meadow
- Shore fen

**Moderate-High vulnerability**
- Bog relict
- Ephemeral pond
- Muskeg
- Poor Fen
- Nor. sedge meadow
- So. sedge meadow
- Open bog
- Pattered Peatland

**Low-Moderate vulnerability**
- Alder thicket
- Emergent marsh
- Shrub-carr

Dive deeper:
Regional climate change impacts

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- Increases in southern spp.
- Reduced water quality
- Deer herbivory
- More drought stress in summer and fall
- Increases in wildfire activity
- More damage from pests and pathogens
- Declines in northern and boreal spp.

**Impacts drawn from regional vulnerability assessments at:**
forestadaptation.org/vulnerability-assessment
Location, Location, Location

Research and assessments describe **broad trends** but **local conditions** and **management** make the difference.
How can I get ready for next week?
Workshop prep: Step 1

Bring a project, it sets context & a starting point

“Emergent marsh with arrowhead and pickerel-weed. Fish Creek Sloughs, Bayfield County.”

“Northern Sedge Meadow. Northern Great Lakes Visitor Center, Bayfield County.”

Where?
## Workshop prep: Step 1

### Management goals and objectives for your project!

<table>
<thead>
<tr>
<th>Resource Areas</th>
<th>Goals</th>
<th>Objectives</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland Next to Highway 2</td>
<td>• Control exotic invasive species</td>
<td>• Plant seedlings of X, Y, Z                                                                                      • Monitor and spray roadsides each summer. - Focusing on management of A, B, and C species.</td>
<td>5 years</td>
</tr>
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<tr>
<td>Wetland #124</td>
<td>• Maintain a diverse system with many species</td>
<td>• Replace undersized and poorly placed culverts                                                                   • Stabilize eroding banks due to agriculture runoff to reduce impacts on water quality.</td>
<td>10 years</td>
</tr>
<tr>
<td></td>
<td>• Restore hydrologic function and water quality</td>
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</table>

Learn more, find the Adaptation Workbook at: forestadaptation.org/far
Maintain flexibility!

There is no single answer.

People will make different choices, and **that’s OK.**
Local knowledge and experience is crucial

Research and assessments describe broad trends but local conditions and management make the difference.
Adaptation actions may not look that different from current management actions, especially in the near term.

*Same actions—climate change just makes them that much more important*

*Small “tweaks” that improve effectiveness*

*New & different actions, even some that seem wild & crazy*
Before the workshop – do this

Get comfortable w/ regional climate projections

A list of resources can be found at: forestadaptation.org/wi-wetlands

Learn the Adaptation Workbook process

Complete Step 1 worksheet!

Go to the WWA symposium (Thurs 2/22)
Between then and now

Ask questions

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dshannon@mtu.edu, 906-482-6303x 1325

Todd Ontl
tontl@fs.fed.us, 906-482-6303x 1324

See you February 23!