Lest we be cavalier:
The challenge of adapting effectively
to climate change

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The Climate is Changing
Temperature Trends: 1901 to 1998

Red circles reflect warming
Blue circles reflect cooling
Source: National Climatic Data Center/NESDIS/NOAA
Precipitation Trends: 1901 to 1998

Green circles reflect increasing precipitation
Brown circles reflect decreasing precipitation
Source: National Climatic Data Center/NESDIS/NOAA
More Rainfall Occurring in Intense Downpours

Trends in Proportion of Annual Precipitation of Extreme Intensity (i.e., more than 2 in. per day): 1910-1995

Similar trends seen in southern Canada

(Source: Karl and Knight, 1998)
Health Impacts
- Weather-related Mortality
- Infectious Diseases
- Air Quality - Respiratory Illnesses

Agriculture Impacts
- Crop yields
- Irrigation demands

Forest Impacts
- Change in forest composition
- Shift geographic range of forests
- Forest Health and Productivity

Water Resource Impacts
- Changes in water supply
- Water quality
- Increased competition for water

Impacts on Coastal Areas
- Erosion of beaches
- Inundate coastal lands
- Costs to defend coastal communities

Wildlife and Ecosystems
- Shift in ecological zones
- Loss of habitat and species
Any Smart Policy Portfolio Must Consist of Both Mitigation and Adaptation Strategies

- Consists of a mix of strategies to **mitigate** GHG emissions and to **adapt** to a changing climate

- **Mitigation**: essential to slow the rate of change

- **Adaptation**: essential because climate will continue to change
  - regardless of actions taken to mitigate
  - due to **natural variability** in climate
  - as well as **human-induced** climate change

- Adaptation increases resilience to change
  - reduces **risks** and takes advantage of **opportunities**
  - potential payoffs *today*
We are already seeing the impacts from a changing climate
Note: Opening along the Russian Northern Sea Route

Sea Ice Extent September 2006

Yellow Outline is the Average of the Extent between 1979 and 2004
Glacier loss

Glacier Bay National Park, 1941. The glacier is 2,000 feet thick. USGS photo, available www.coasttocoastam.com/shows/2005/01/29.html
Portage Glacier, Alaska

1914 - 2004
Extent of ice melt in Greenland, 1992 and 2002

Arctic Climate Impact Assessment 2004
Changing Ice Cover in the Gulf of St. Lawrence

1987:
Sea ice reduces wave action and amount of shore erosion.

March 25, 1987

1999:
Little sea ice is present. (Most white areas are clouds.)
Shore exposed to wave action of winter storms.

March 26, 1999

Source: Environment Canada
Lake-Effect Snowstorms

Buffalo, Christmas Eve, December 24, 2001

Record 7-foot snowfall

Cost: Snow removal
Benefit: Skiing industry
Global Change and Birds: A Fingerprint for Warming
Species Movement North

Stocks of Pollock are moving North

Pollock (Saith) - Pollachius virens - 70-100 cm
Impacts to energy systems of extreme weather events
Major Refined Product Pipelines

From Allegro Energy Group

Principal interstate gas pipeline flows
Dominance of the Gulf Coast supplies

EIA, Natural Gas Annual, Figure 7.
3/4th of the 4,000 offshore oil and gas platforms (under MMS) were directly in the combined paths of the two hurricanes. Leading up to each hurricane, virtually all Gulf coast production and import facilities and many of the region’s refining/processing facilities were evacuated or operations were otherwise suspended.
Example: Gulf Coast
Shell Oil Company Mars Platform – pre/post Katrina
Alabama oil refinery – submerged

An oil refinery is submerged in water in Alabama in
Many opportunities exist to anticipate and adapt to a changing climate
We can plan ahead…. or we can react

Wildlife can only react

But humans can anticipate

(Main CN Line Near Amherst, NS)
Many Opportunities to Adapt Exist (examples)

- Modify long-term planning, engineering standards, and infrastructure design (e.g., to deal with melting permafrost)
- Land use planning (e.g., limit development in flood-prone areas!)
- Development of riparian buffer zones
- Shipping: shallower draft ships; dredging ports; length of shipping season; shift to land transport
- Restore and maintain watersheds as an integrated strategy for managing water quality and quantity
- Changes in management and political institutions
- Develop response management plans for invasive species
- Establish heat stress warning systems
- Reduce urban heat island effect
- Enhance water use efficiencies
• “The severity and duration of summertime regional air pollution episodes are projected to increase in the Northeast and Midwest US by 2045-2052 due to climate-change-induced decreases in the frequency of surface cyclones.” (IPCC, 2007)

• By 2050, warming alone may increase by 68% the number of Red Ozone Alert days across the Eastern US. (IPCC, 2007 -Bell et al, 2006)
For Madison, if 20% of car trips were replaced by bike trips:

1. **10 lbs (4.5 kg)** lost /person/yr (for 6.8 mi. roundtrip commute)

2. 12% fall each in **Ozone** and **NOx**: 2% drop in **PM$_{2.5}$**
   - 17,990 fewer lost-work days/yr
   - 1,906 fewer Asthma admissions/yr
   - 14,586 fewer acute respiratory cases/yr
   - $40 million saved in health costs/yr

3. **16,687 tons of CO$_2$** not emitted

**The Triple Win**

(Source: Grabow et al, in preparation)
USA: Combined sewer overflows

Courtesy: Kellogg Schwab

1.2 trillion gal of sewage & stormwater a year discharged during combined sewer overflows – would keep Niagara Falls roaring for 18 days

Center for Water & Health, JHU Bloomberg School of Public Health
People can adapt effectively

“It all begins with a trip to the Vermont woods!”

Founded in 1915, Maple Grove Farms is the largest packer of Pure Maple Syrup in the US

But it’s now a product of USA and Canada!
Energy Systems and Adaptation to Climate Change

(Source: Susan F. Tierney)
Wind Resources by Region – “potential”

http://rredc.nrel.gov/wind/pubs/atlas/maps/chap2/2-01m.html
Investments in Adaptation

It’s not a question of *if* you’ll pay to adapt…

It’s a question of *when* you’ll pay.

We can plan ahead and get to where we want to go (Anticipatory Adaptation)

GREEN ROOFS Programs in Urban Areas

*Help address:*

- stormwater runoff
- urban heat island effect
- regional warming due to global climate change

We can incur damages later, clean up the mess, and live with the consequences (Reactive Adaptation)

*or…*
Lest we be cavalier
The direct health effects of heat
Increased Mortality Risk During Heat Waves (1993, 2020 and 2050)

Sources: Kalkstein and Green (1997); Chestnut et al. (1995)

Note: Includes both summer and winter mortality. Assumes full acclimation to changed climate. Includes population growth.

GFDL Climate Change Scenario
approx. 30,000 deaths over 11 days

Heat Index Summer 2003
European heat wave, 2003


<table>
<thead>
<tr>
<th>Country</th>
<th>Mortality</th>
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<tbody>
<tr>
<td>UK</td>
<td>2,091</td>
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<tr>
<td>Italy</td>
<td>3,134</td>
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<td>France</td>
<td>14,802</td>
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<td>Portugal</td>
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<td>Spain</td>
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<td>Switzerland</td>
<td>975</td>
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<tr>
<td>Netherlands</td>
<td>1,400-2,200</td>
</tr>
<tr>
<td>Germany</td>
<td>1,410</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29,817-30,617</strong></td>
</tr>
</tbody>
</table>
Alaska Pipeline

Built on permafrost that is now melting!
Newtok, Alaska

(Source: Stanley Tom)
Newtok Shoreline Erosion


October 2007

Historic shorelines digitized from USGS topographic maps and digital aerial photos. Projected shorelines are from statistically derived averages and have not been calculated based on actual Ninglick River data. Therefore, conservative erosion rate values were used for these projections, ranging from 36 ft/yr (west/downstream) to 83 ft/yr (east/upstream). Actual observations by residents and raw, non-averaged data indicate periods of much higher erosion rates. July 2003 shoreline represents a rate of 110 ft/yr.
Landfill lost in 1996: Submerged under water
Housing Shortage

US Army Corps of Engineers

N

Hoglick River
Arctic Changes Drive Coast Guard Mission Expansion North

All Coast Guard missions in Southern Alaska must be expanded to Northern Alaska.
Growing Eco-Tourism

- **M/S Explorer**
  - Nov 2007: 154 people abandon a cruiseliner that struck an iceberg and sank in the Antarctic
It Pays to Plan Ahead: Reactive Adaptation During a 1957 Kentucky Flood

The pig knew how to get to higher ground… Getting back down was a problem.

(KY Power office in Lothair, 1957)

(Scheraga, 2004)
New Orleans, 2005

(Scheraga, 2005)
Climate change and global warming are no long simply an environmental issue, it is a economic and human well-being issue!

So we need to mitigate and adapt to a changing climate.

Thank You