Webcast Sponsored by EPA's Watershed Academy

Wetlands and Climate Change

Webcast on May 13, 2008, 2:00-4:00pm EST

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Today's Webcast

- **Key findings from the IPCC Report related to anticipated climate impacts on wetlands**
- **Effects of climate change on coastal wetlands in Maine**
- **Changes observed at inland and coastal wetlands in Alaska and local adaptation management issues**
- **The importance of implementation and building coalitions at the local level, specifically in helping Hudson Valley communities adapt to climate change**

Key Messages

- The structure and function of wetlands is intimately linked with many aspects of climate change - not just water availability.

- Wetlands and aquatic ecosystems are among the most vulnerable to climate change, in part because of human development impacts. Effects cascade among physical and biological components and processes.

Threshold-type responses and interactive effects are complex and difficult to predict.

- Adaptation and mitigation can reduce adverse impacts.

(FWS photo)

Virginia Burkett
U.S. Geological Survey

Intergovernmental Panel on Climate Change

IPCC terms for describing uncertainty:

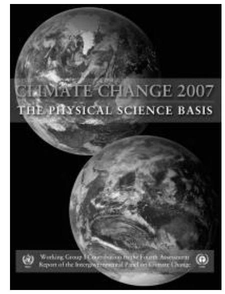
1. Quantitative statements about likelihood

Virtually certain:	**>99% probability of occurrence**
Very likely:	**90 – 99% probability**
Likely:	**66 – 90% probability**
About as likely as not	**33 – 66% probability**
Unlikely:	**10 – 33% probability**
Very unlikely:	**1 – 10% probability**
Exceptionally unlikely:	**<1% probability**

2. Quantitative levels of confidence

"Very high confidence"	**At least 9 out of 10 chance of being correct**
"High confidence"	**About 8 out of 10 chance**
"Medium confidence"	**About 5 out of 10 chance**
"Low confidence"	**About 2 out of 10 chance**
"Very low confidence"	**Less than 1 out of 10 chance**

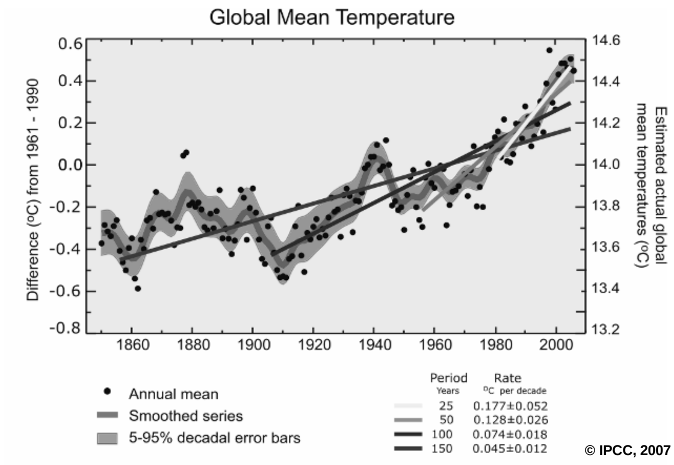
Key Findings – IPCC WGI
Physical Science Basis

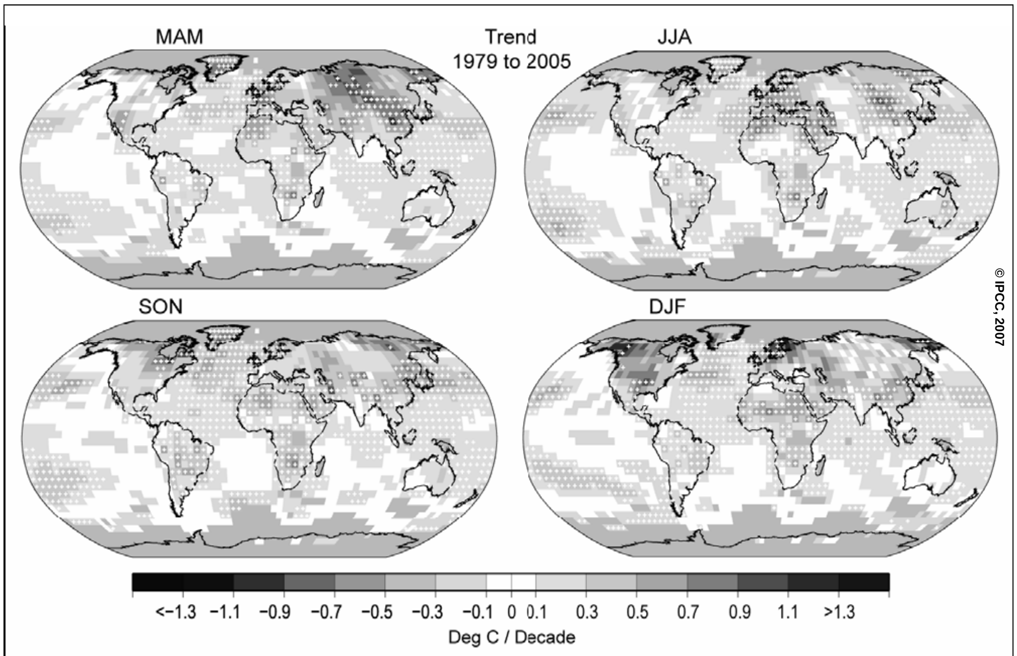


- $C0_2$ = 379 ppm in 2005
  (280 ppm pre-industrial, increase attributed to fossil fuel use and land use change)
- Methane = 1774 ppb in 2005 (715 ppb pre-industrial) increase attributed to agriculture and fossil fuel use
- Slight cooling effect of aerosols (black C, sulphate, nitrate and dust)
- Greenhouse gas concentrations now exceed levels of past 650,000 years

Past 100 years:

• **Global average T increased 0.74°C in the past 100 yrs and 0.65°C past 50 yrs**

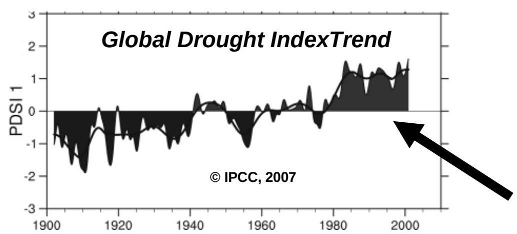




Seasonal temperature trends - 1979 to 2005

Observed Change - Hydrology

- **Atmospheric water vapor content has increased - consistent with effect of increased air temperature**
- **Average precipitation increased globally and across most of the Northern Hemisphere**



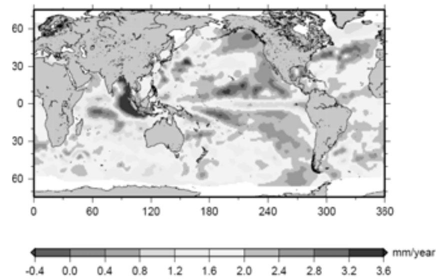
- **Intensity of rainfall events increased over most land areas -- but so did the number of dry days**
- **Increased occurrence and intensity of droughts**

- **Less snow at low altitudes and earlier spring runoff**
- **Mountain glaciers declined globally**

Observed Change - Oceans

- **Ocean temperature increased from surface down to at least 3000 m**
- **Increase in N. Atlantic hurricane activity**
- **Global sea level rise**
  - **1.7 mm/yr during 20th century**
  - **3.1 mm/yr during 1993-2003** **(acceleration or natural variability?)**

Geographic Variability in the Rate of Sea Level Rise (1955 to 2003)



Projected *future changes* in the physical climate system

- Warming is expected to be about **0.4° C** during next **20 years**
- Warming is projected to be greatest over land and at high latitudes in the northern hemisphere
- **GHG emissions at or above current rates** would induce many changes in climate that would *very likely* be larger than those observed during the 20th century.
- Little difference in temperature outcomes among emission pathways until **2040** and beyond

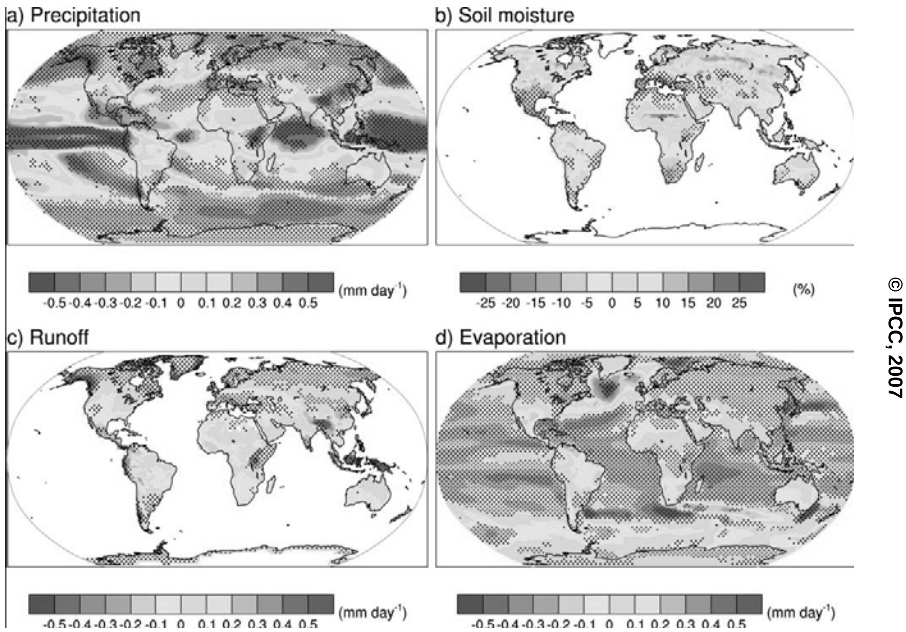


Figure 10.12. Multi-model mean changes in a) precipitation (mm day–1), b) soil moisture content (%), c) runoff (mm day–1), and d) evaporation (mm day–1). Changes are annual means for the scenarios SRES A1B, for the period 2080–2099 relative to 1980–1999.[11]

Projected Mean T and Precip. Change in North America

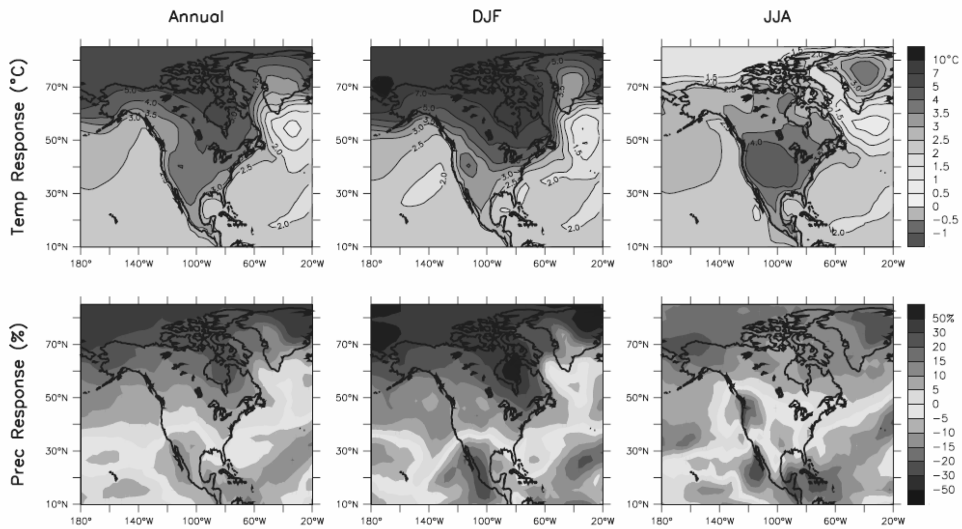


Figure 11.12. *Temperature and precipitation changes over North America from the MMD-A1B simulations. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Bottom row: same as top, but for fractional change in precipitation.*

Key Findings – IPCC Working Group 2, Impacts, Vulnerability and Adaptation

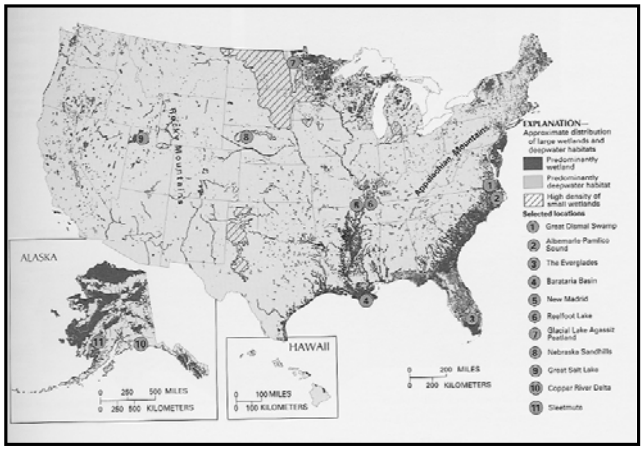
Physical and biological systems on all continents and in some oceans are already being affected by recent climate changes, particularly regional temperature increases (very high confidence).

Global-scale assessment of observed changes shows that it is likely that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems (high confidence).

Globally ~20% to ~30% of species will be at increasingly high risk of extinction by 2100 if global mean temperatures exceed a warming of 2 to 3°C above pre-industrial levels (medium confidence). Freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change

Current conservation practices are generally poorly prepared to adapt to this level of change, and effective adaptation responses are likely to be costly to implement (high confidence).

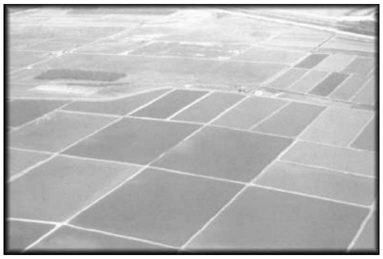
Hydrology - determines wetland location, plant community structure, and ecological function



Source: USGS Technical Paper 2425,1996

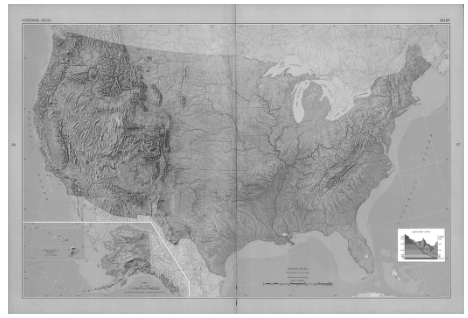
Wetlands occupy 5.5% of the acreage of the lower 48 states and 46% of Alaska

One half of the wetlands in the lower 48 states have been lost since 1880.



USGS photo

Most inland wetland losses are related to ag practices.



Land Cover Map of the Southeast Region

Figure 1. The Southeast region includes all of nine states (Alabama, Florida, Georgia, Kentucky, Louisiana, North Carolina, Mississippi, South Carolina, and Tennessee), the southern portion of Virginia, and 50 counties in east Texas. Four subregional workshops were conducted in the Southeast region.

Most losses have occurred in the southeastern United States.

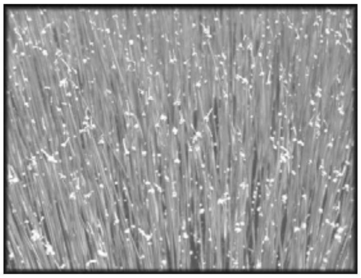
One half of losses were in wetland forests.

US National Assessment, 2001

Many climate related variables and drivers can affect wetland systems – some directly, some indirectly

Elevated Atmospheric CO_2

- has a fertilization effect on plant growth
- affects competition – plant community structure



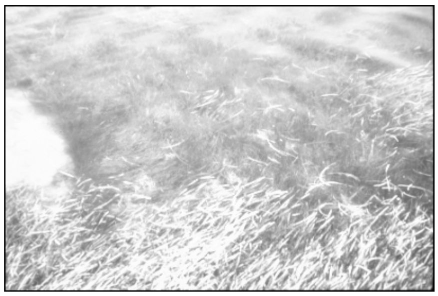
C3 plants show greater response to CO_2 enrichment ....

.... than C4 plants.

(USGS photos)

Elevated Atmospheric CO_2

- Increases dissolved $C0_2$ in coastal waters
- Enhances submerged aquatic plant growth
- Enhances algal growth



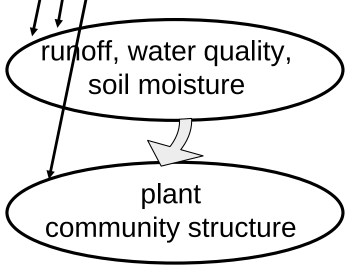
(USGS photos)

Thresholds and interactive effects make outcomes difficult to predict in wetlands and aquatic systems

Primary drivers

- Changes in temperature
- Changes in precipitation patterns, water availability
- Accelerated sea-level rise and increased storm intensity
- Changes in atmospheric and aquatic CO_2

Direct and higher-order impacts



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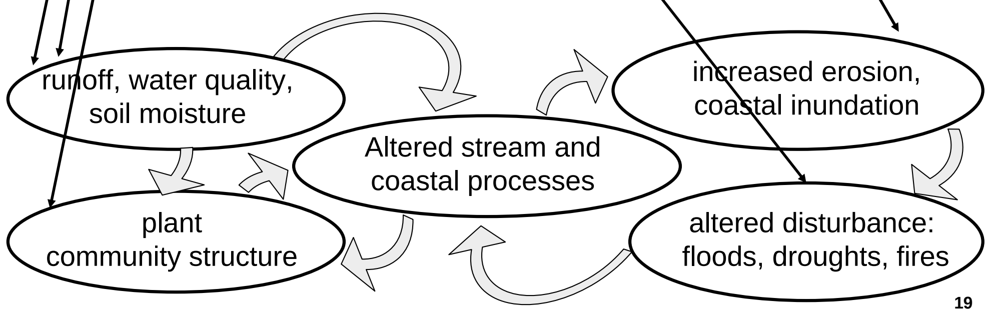
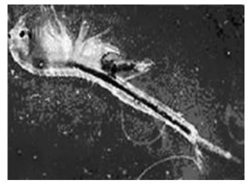


Examples of Wetland Impacts

1. **Increasing temperatures and drought lead to more intense drying (or permanent loss) of ephemeral streams and vernal pools (seasonal wetlands)**

Typical vernal pool, Oregon



Endangered vernal pool fairy shrimp

(US Fish and Wildlife Service photos)

Vernal pool
Sacramento NWR

2. **Lower soil moisture leads to more intense, frequent, and widespread fires**

Coastal LA marsh

North Slope AK, tundra fire

(Alaska Fire Service Photo)

(

Examples of Wetland Impacts

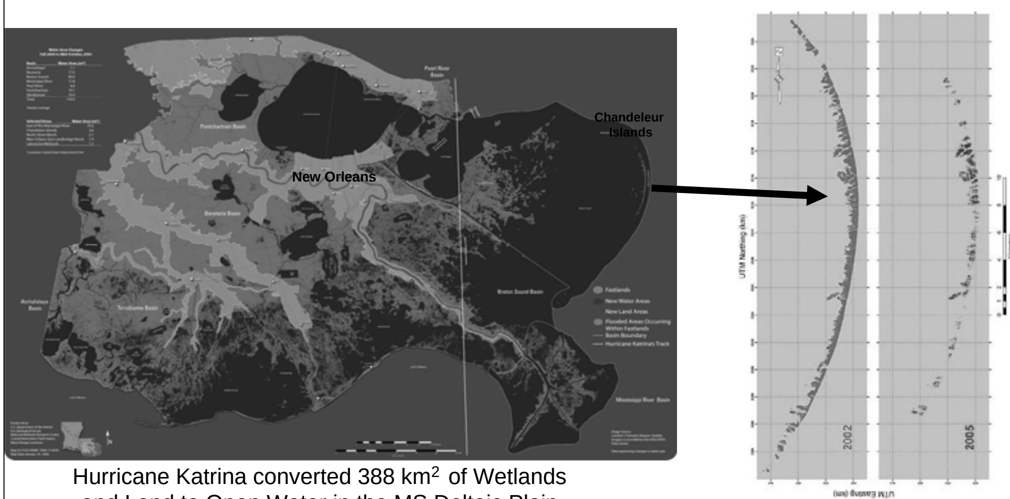
3. Higher temperatures thaw permafrost and drain or dry Alaskan wetlands and lakes

(USGS photo)

Numerous Arctic lakes will dry out with a 2-3°C temperature rise. Seasonal migration patterns and routes of many wetland species will need to change and some may be threatened with extinction. (IPCC 2007)

Examples of Wetland Impacts

4. **Sea level rise and more intense storms accelerate coastal erosion and wetland loss**



Hurricane Katrina converted 388 km^2 of Wetlands and Land to Open Water in the MS Deltaic Plain (USGS)

Examples of Wetland Impacts

5. **Adaptation strategies to climate change can adversely affect wetland, aquatic, and coastal ecosystems**

6. **Saltwater intrusion into shallow coastal waters alters plant and animal community composition**

(USGS photos)

Examples of Wetland Impacts

7. **Many wetland-dependent endangered species will be placed at higher risk of extinction.**

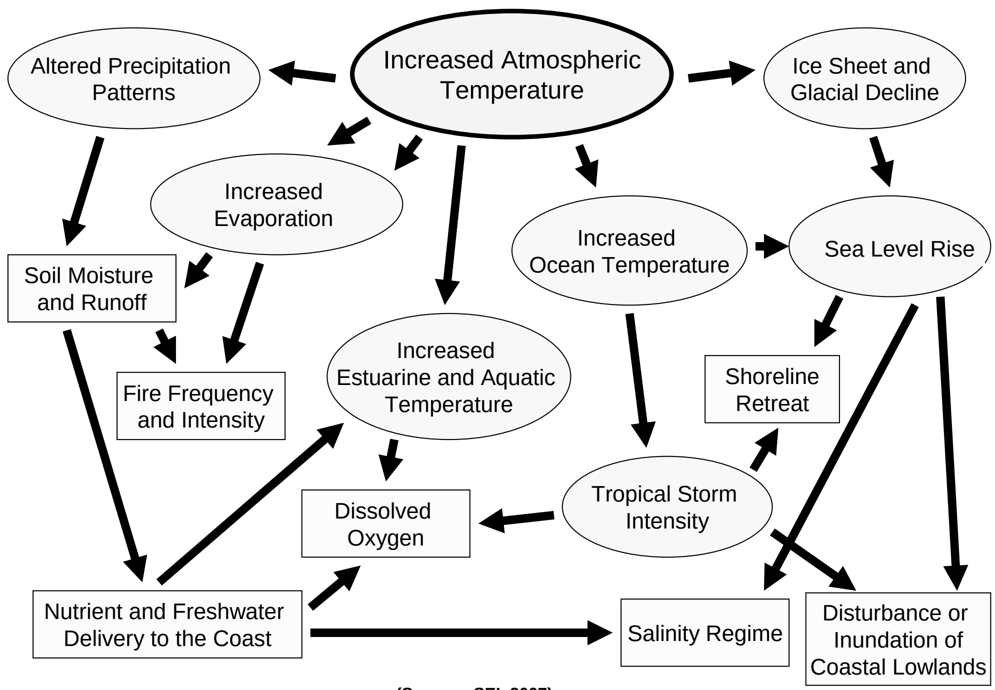
Red legged frog

Four Main Avian Species of Concern in South Florida

(US Fish and Wildlife Service photo)

(Sustainable Systems Institute photos)

Conceptual Model of Climate Change Effects on Physical Systems in S. Florida



(Source: SEI, 2007)

Implications for Everglades restoration and management:

• Even if storms do not intensify as the climate and sea surface warms, accelerated sea level rise alone will amplify the effects of storm surge on coastal shorelines, wetlands and other low-lying features.

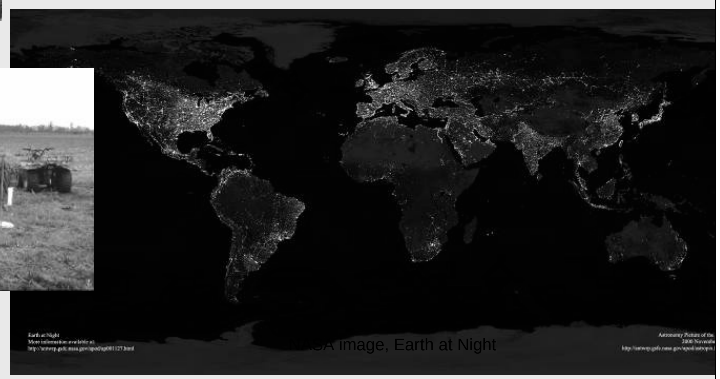
• Transition to more saline environments, inland expansion of mangroves, and contraction of freshwater and mesohaline habitats in the south Everglades appears inevitable and there are few practical coping strategies.

• The importance of freshwater flows to the gradual adaptation and sustainability of coastal brackish and freshwater habitats will increase as sea level rises.

What can be done to reduce impacts?

Combination of Mitigation & Adaptation

USGS photos



SA image, Earth at Night

Questions?

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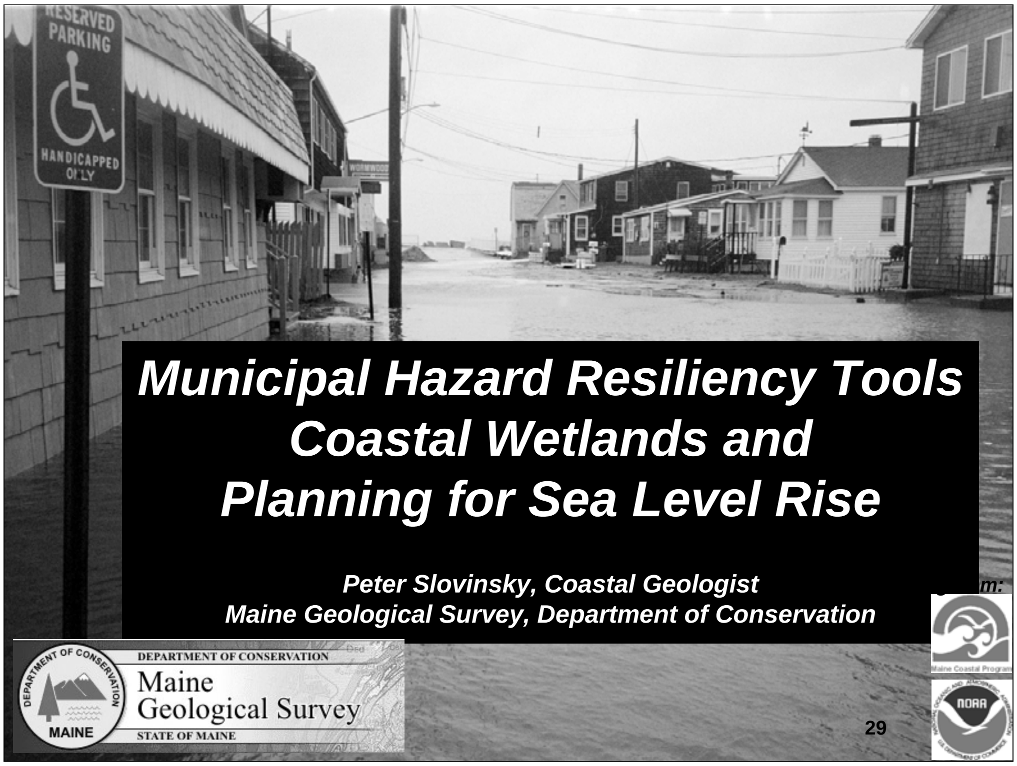

Mention the concept of resiliency – an ability to recover from or adjust to misfortune or change and the overall community resiliency project that is going on right now in Maine. The goal of the project is to enable coastal municipalities to better *understand*, *review*, provide *feedback on* tools available, and to *implement* plans to reduce coastal hazard vulnerability and improve community resiliency.

How to achieve said goal?

Outreach, Partnership Development, and Education

Outreach and Partnership Development

State Agencies – Regional Planning Commissions - Municipalities

Maine Coastal Program

Town of Scarborough, ME

Old Orchard Beach

MAINE'S PREMIER FAMILY BEACH RESORT

Department of Conservation
Maine Geological Survey
State of Maine

SACO MAINE

Southern Maine Regional Planning Commission

Biddeford

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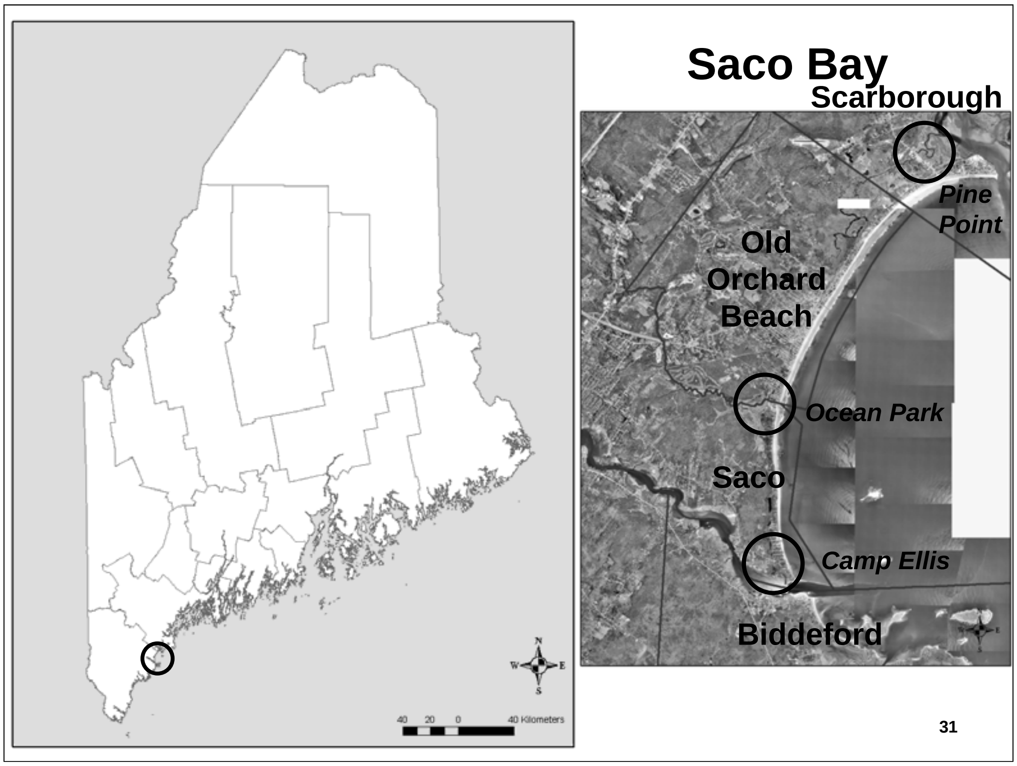
The goal of the project is to really bring the tools and data to the communities to show that 1) data is relatively accurate 2) data does not need to be collected; and 3) planning can be done now with the data.



The study area chosen for this project was the sandy beach areas of Saco Bay. This area accounts for the longest stretch of sandy beaches in maine (7 miles), the largest contiguous expanse of coastal wetlands – many of which are part of the Rachel Carson National Wildlife Refuge, and a variety of different anrthopogenic uses. Condominium and hotel development, pier development, areas of high erosion and accretion, flood prone areas, etc. Bound by Saco river in South and Scarborough River in North, and Goosefare Brook in the middle. Sediment transport generally from S-N in the bay, with erosion along southern part, and accretion at northern end of bay. I want to share with you examples of how we are presenting data to communities – notably two examples – located in Saco and in Old Orchard Beach.

Education – GIS Data and Tools

Available Hazard Vulnerability Assessment Tools

Maine Beach Scoring System: guidance/management/decision-making tool to assess hazard vulnerability and management need. GIS coverage (Historic shorelines, short term erosion, etc.)

Erosion Hazard Area Designation: Regulatory GIS coverage.

Coastal Sand Dune Boundaries: Regulatory GIS coverage.

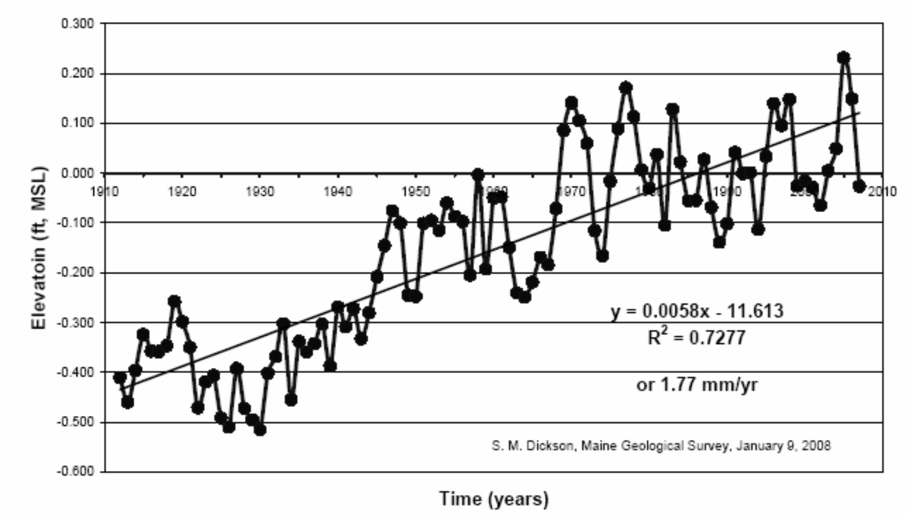
Shoreline Structures: GIS coverage

LIDAR: 2004 NOAA data available

Digitized Flood Insurance Rate Maps: “homemade” DFIRMs

Sea Level Rise/Inundation Mapping: **GIS coverages simulating the potential impacts of 2 feet of sea level rise.**

Portland Sea Level



The trend in sea level at the Portland Tide gauge is similar to that of the global ocean in the 20th century.

Summary of Sea Level Rise

Since 1912 sea level has risen at a rate of 1.8 $\pm$ 0.1 mm/yr (0.6 ft/century) in Portland.

Matching the global ocean rise of 1.8 mm/yr $\pm$ 0.5 mm/yr (IPCC 4th Assessment, February 2007)

The historical rate of Maine sea-level rise is the fastest in the last 3,000 years along our coast.

Satellite altimetry from 1993 to 2003 shows global sea level is rising 3.1 $\pm$ 0.7 mm/yr (1.0 ft/century; IPCC, 2007)

Potential Future Sea Level Rise

Maine has opted to plan for 2 feet of sea level rise over the next 100 years, which is generally a "middle-of-the road" prediction for global sea level rise changes.

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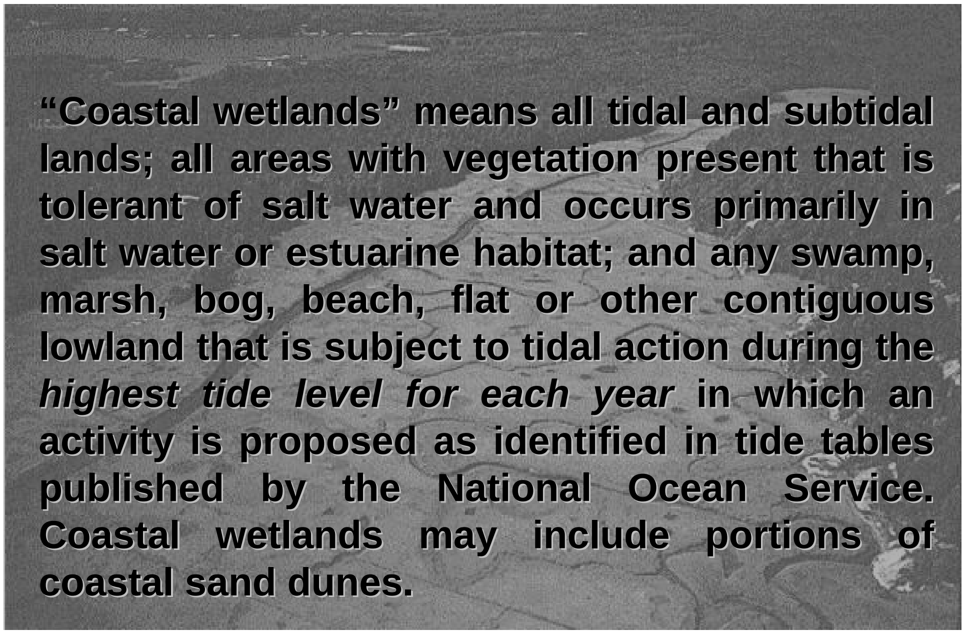
The maine Coastal Sand Dune Rules take into account 2 feet of sea level rise for the planning of new and redeveloped structures. This is mostly along the open coast. Little planning has been completed for the potential impacts of sea level rise on the developed back marsh areas, and on coastal wetland habitats themselves.

Coastal Wetlands



"Coastal wetlands" means all tidal and subtidal lands; all areas with vegetation present that is tolerant of salt water and occurs primarily in salt water or estuarine habitat; and any swamp, marsh, bog, beach, flat or other contiguous lowland that is subject to tidal action during the *highest tide level for each year* in which an activity is proposed as identified in tide tables published by the National Ocean Service. Coastal wetlands may include portions of coastal sand dunes.

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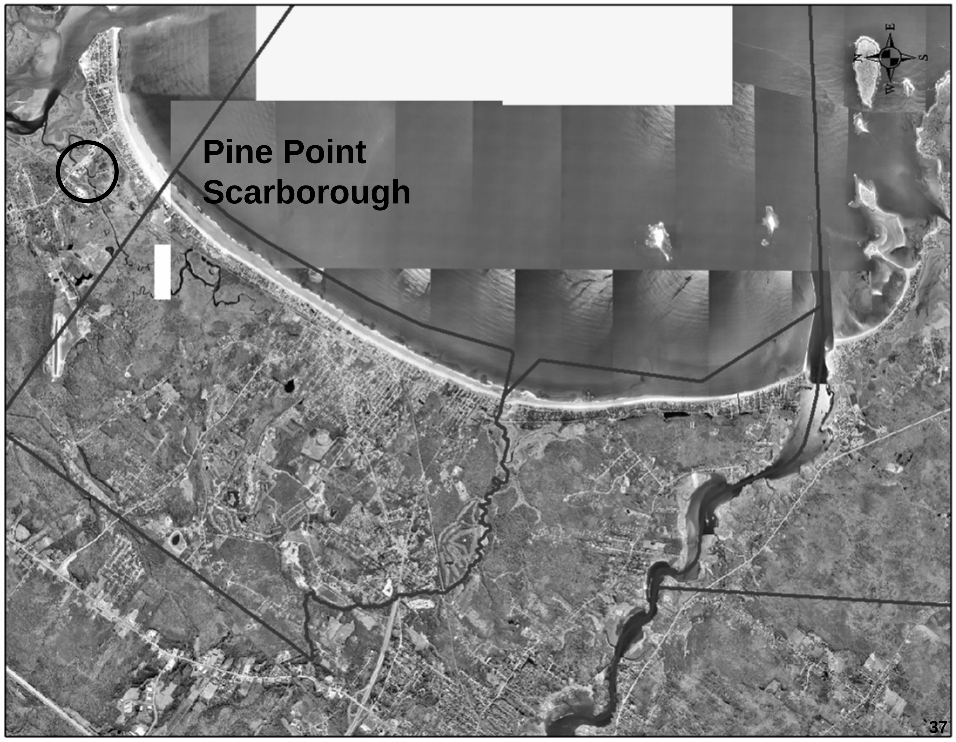
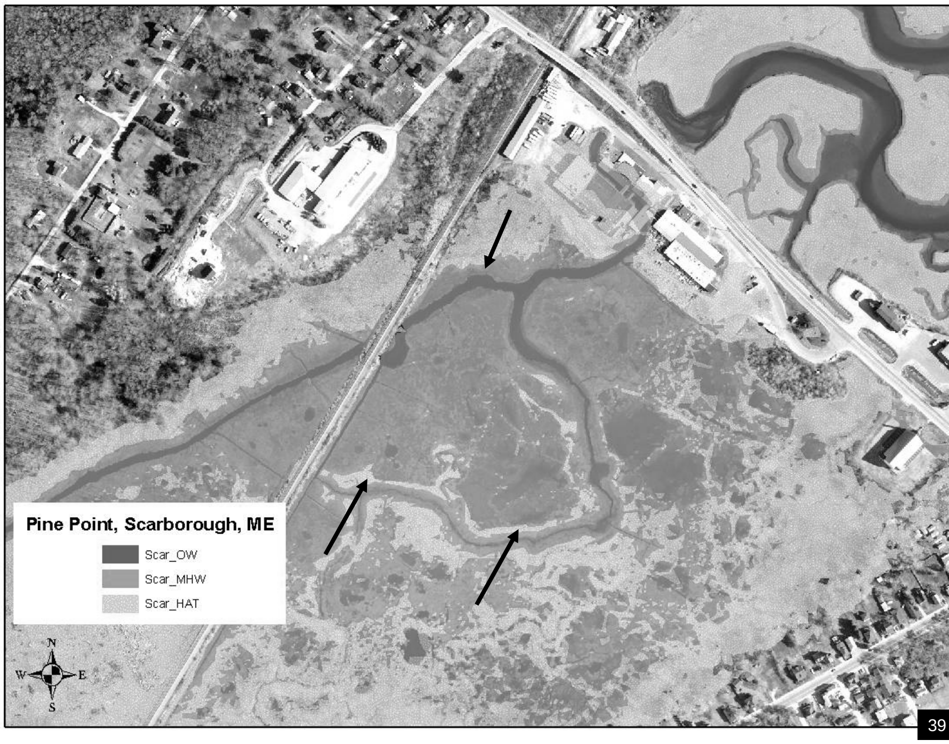
Our regulations do include the definition of a coastal wetland. Part of this definition involves the highest tidal level for each year (or highest annual tide). We have determined by overlaying different topographic elevations of MHW and HAT onto orthorectified aerial photographs that these tidal levels define the different coastal wetland types in Maine – low marsh (OW to MHW) and high marsh (MHW-HAT). These elevations can be used as a proxy for establishing the regulatory boundary of a "coastal wetland", and also for establishing the spatial extent o f existing marsh habitats. However, there is nothing that supports the definition or protection of future wetlands.


Pine Point
Scarborough
N
E
S
W
37

Using LIDAR topography, we can clearly delineate between the different marsh elevations.


Pine Point, Scarborough, ME
Scar_OW
Scar_MHW
Scar_HAT
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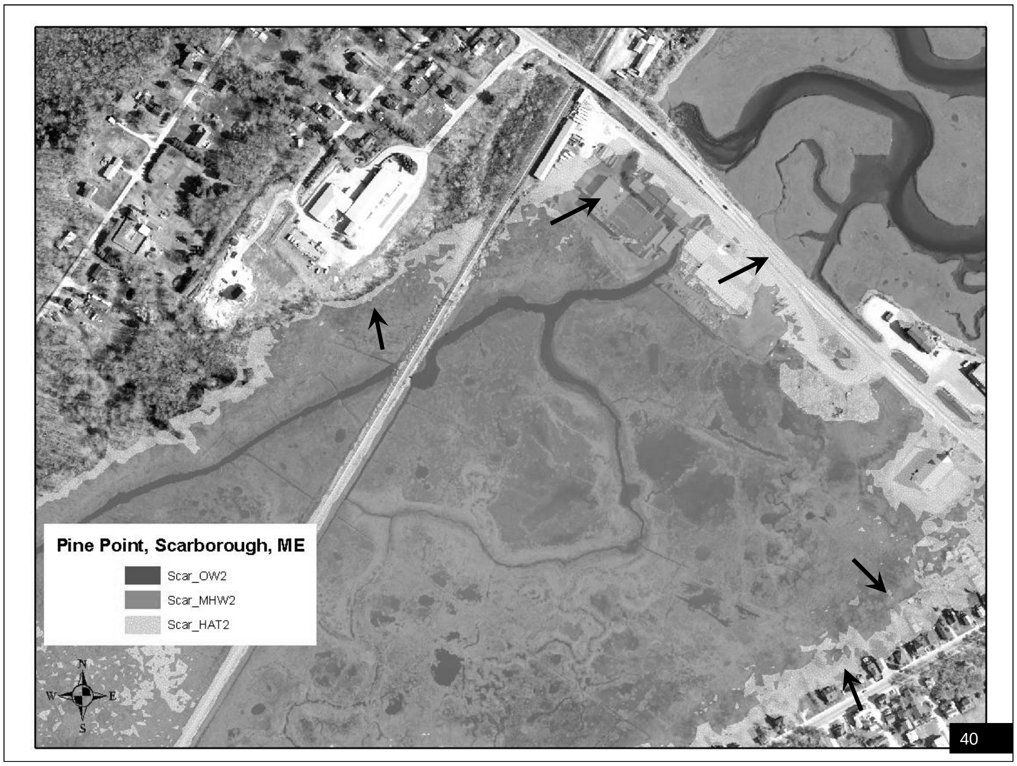
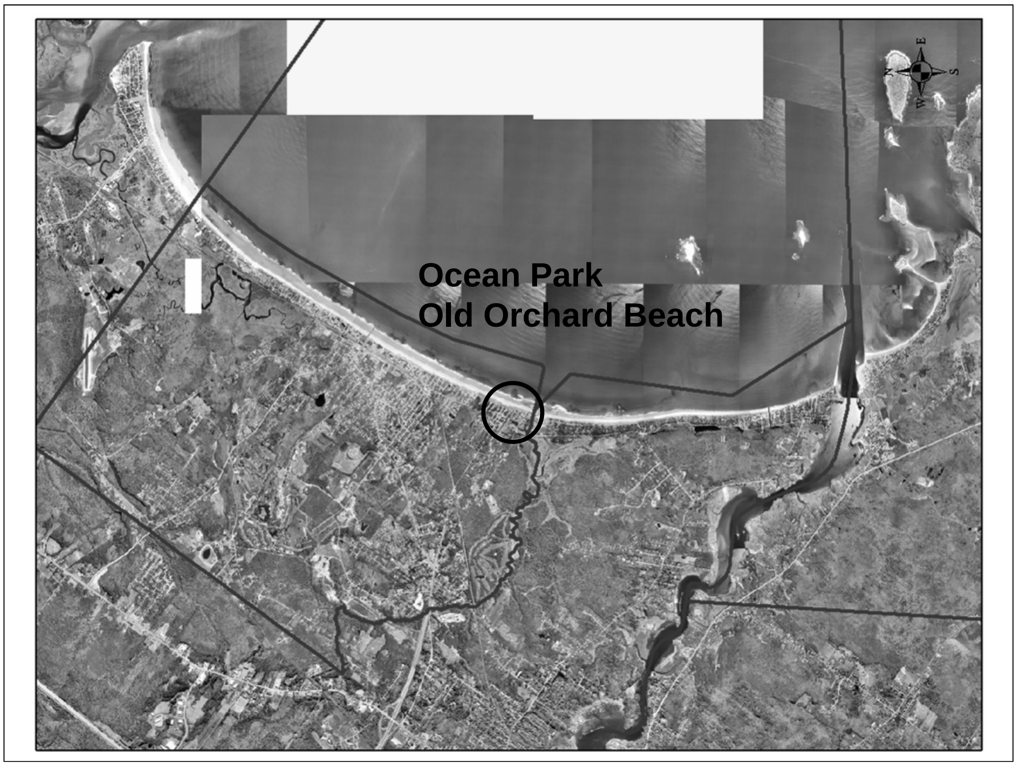


This picture represents a 1000 words. When we look at +2 ft SL rise conditions, several things are noted immediately. First, note the potential impacts to the high marsh – it is effectively pinched out by the transgressing low marsh. This is a worry since currently most marshes in Maine are dominated by high marsh. Many marsh areas in Maine, especially in highly developed areas, lie adjacent to either steep upland banks, or roadways, bulkheads, etc. This does not allow for effective high marsh transgression. Thus, the tool could be used to pinpoint areas that should be left open space to allow for marsh transgression. Note the black arrows; these mark areas that would be flooded under both MHW and HAT conditions – including roadways, commercial infrastructre, and private homes. Thought must be given on how to deal with sea level rise from the aspect of restoring tidal flow to many areas as well.



The next example of how the data that we are using could be used to help planning efforts is in Ocean Park, Old Orchard Beach. The focal area here suffers from both freshwater and tidal flooding due to poorly designed ditching and tide gates that are not functioning properly. This has resulted in impacts to existing infrastructure, and an overall change in an existing salt marsh. Improvements to the area need to closely look at potential impacts of future flooding after sea level rise.

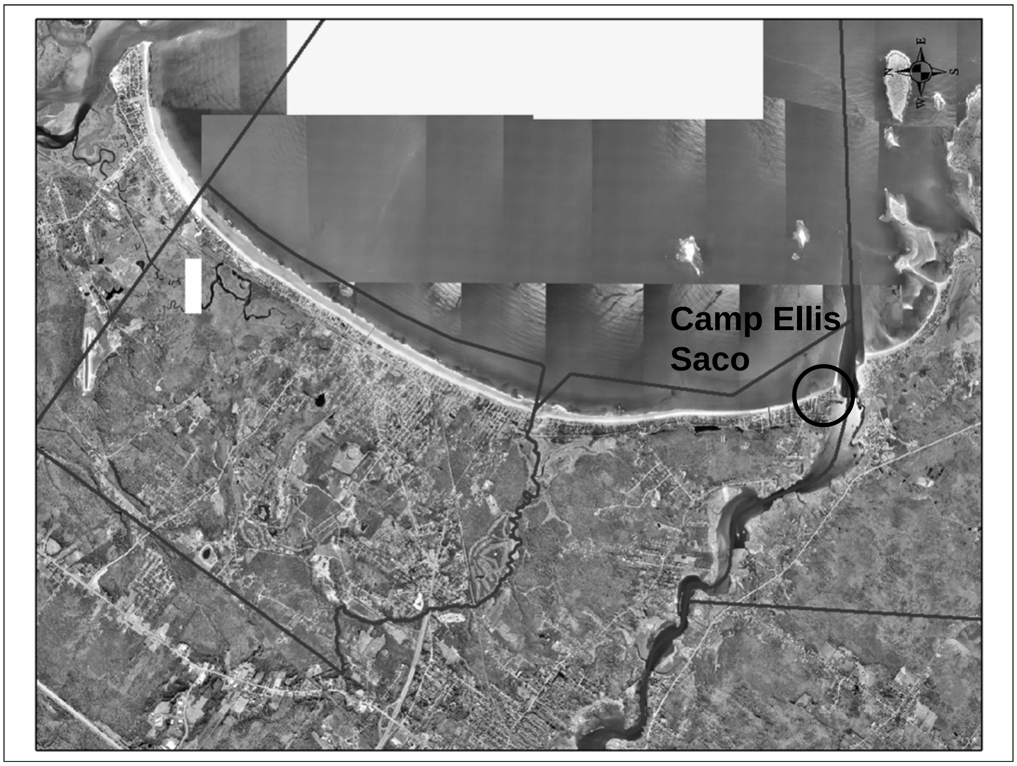

Sea Level Rise
Existing Conditions
Old Orchard Beach, ME
OOB_HAT
OOB_MHW
OOB_OW

To note is the potential takeover of areas of high marsh (even though it expands) by areas of low marsh. This is due to the existing high marsh, in general, being at its maximum capacity currently. As sea level rises, the high marsh is being pinched out by steeper upland banks, seawalls, and bulkheads. This image is also very good for demonstrating the potential impacts of sea level rise on the flood hazards of the area. Note that the entire stretch of West Grand Avenue (the major roadway) would be underwater under future HAT conditions.

Wetland Management

Tidal Restrictions
Restoration
Conservation
Development Siting
Marsh Transgression Planning
Impacts to habitats

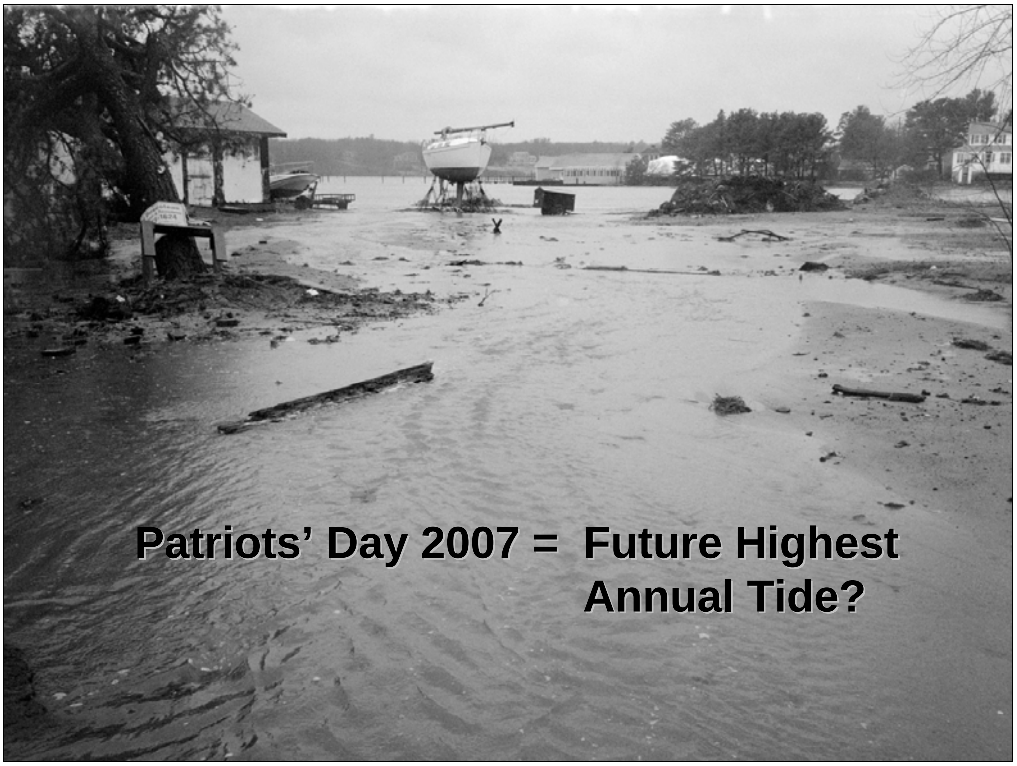
This area is well known for tidal restrictions that have limited tidal flow, and made an over 3 acre coastal wetland into a brackish-dominated marsh that transitions from spartina patens, to phragmites, to cattails. Restoring tidal flow here is a goal, but flooding of coastal development is a concern. The data can be used to simulate the impacts of SL rise on marshes so that areas of tidal restriction could be focused on for restoration and conservation, while making sure that restoration of flow would not have significant flooding impacts on other development.



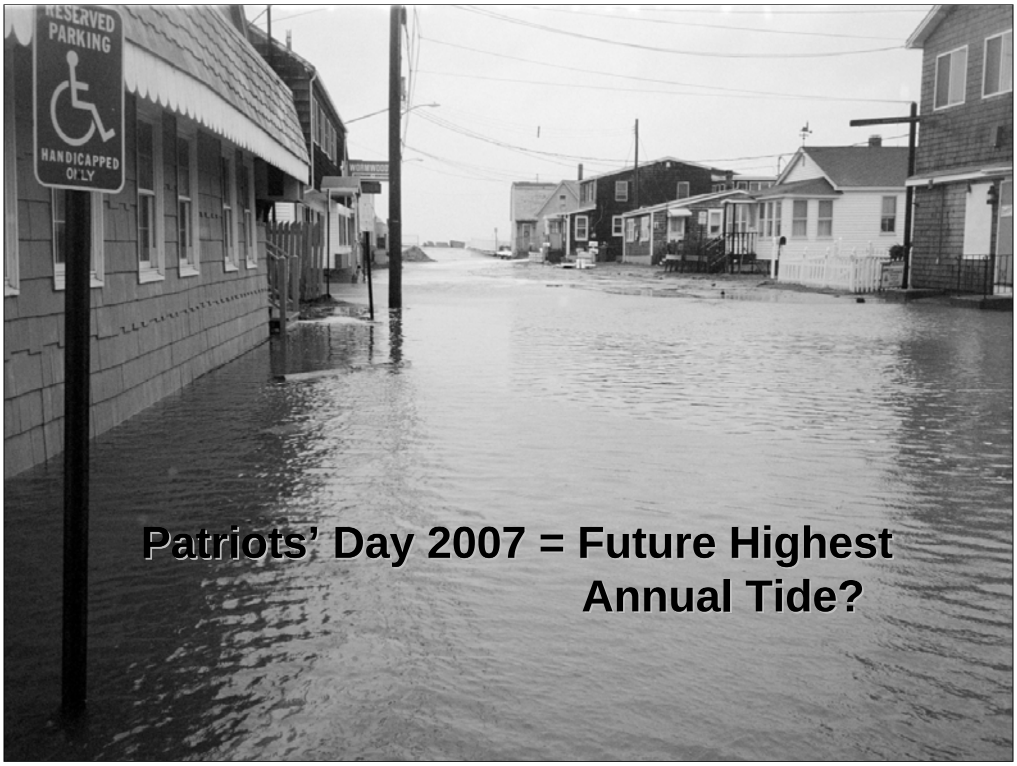
The next example of how we are using this data to help communities comes from Camp Ellis, the southernmost portion of Saco, ME. This area is notorious for its high erosion rates, and flooding during coastal northeast storms. The area is low-lying, and is really “anchored” into place by a federal jetty which was constructed in the late 1860s.

This slide shows the existing delineations for the MHW and HAT, which is approximately 1.83 m NAVD. For this area, we are less interested in the impacts to the marsh, and more interested in the potential impacts on road infrastructure and development. We simulated this example prior to the 2007 Patriots Day Storm (April 17).

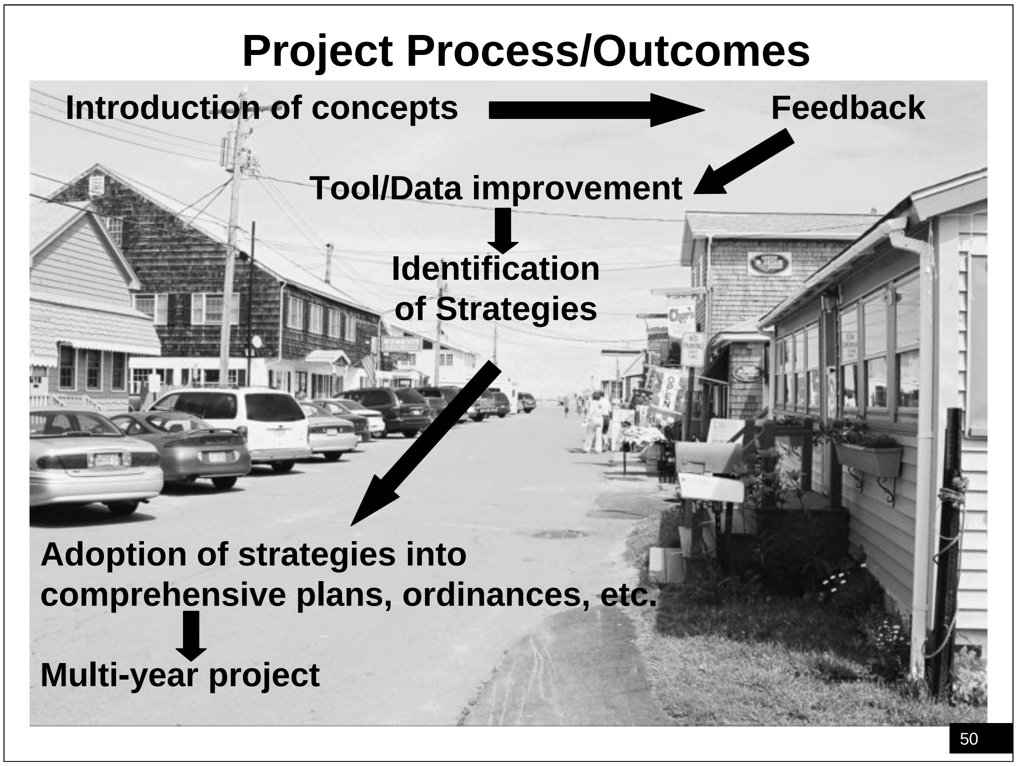
This image shows the future extent of the HAT after 2 feet of sea level rise. Here, the HAT would be equivalent to 2.44 m. Interestingly enough, the Patriots Day Storm of 2007 had a storm surge that was equivalent to 2.48 m. So what we saw then is what could be expected in the future under HAT conditions. Flooding occurred from the beach side, and also from the marsh side. The area between the red arrows was entirely flooded to the beach. The arrows show where images were taken.



Here is an image represented by the upper red arrow. The storm surge elevation reached was equal to that of the future HAT condition.



This is a view down the street from the 2nd red arrow. The street is entirely flooded from both bay-side and ocean-side overwash and flooding. The water here was over 2 feet deep. The predictions made in the simulations were very close to what actually occurred, which helped with the public "trusting" the data that was presented.



SMRPC will provide feedback to MGS and SPO regarding additional materials and resources needed by towns in order to analyze, understand, prioritize, estimate costs/benefits or make decisions related to coastal storm hazards and sea level rise.

MGS and SPO will use this feedback to develop additional resources (most likely in subsequent grant years) for towns and regional planning commissions. A memo from SMRCP to SPO and MGS in December 2008 will constitute completion of this task.
By December 2008, at least one of three Maine municipalities identified above will have made substantial progress towards – a) understanding their vulnerability to coastal storm hazards and sea level rise, b) considering a menu of tools and options to build community resiliency and c) incorporating one or more tools approaches as part of a municipal strategy. Tools, methods and results from these pilot efforts will be shared with other coastal towns via SPO's website. Important feedback about additional resources needed by towns to address sea level rise will be considered in the design of subsequent work programs.

This is an image from the opposite side of the street that was flooded during the Patriots Day Storm. Things look nice and rosy.

Project Strategies:
Coastal Wetlands and Sea Level Rise

State Level:

- **Regulatory changes (i.e., defining the "future coastal wetland" or the "future floodplain"**
- **State funded land acquisition, marsh conservation, restoration programs**

Municipal Level:

- **Improved *coordination* to address hazards, SL rise and wetlands management**
- **Land use/development planning**
- **Capital improvements planning**
- **Stormwater and road infrastructure management**
- **Habitat restoration**
- **Land acquisition and conservation**
- **Flood proofing, elevating**
- **Emergency access planning**
- **Shoreland Zoning changes, comprehensive plans, etc.**

There are a multitude of strategies that could be implemented as a result of this project. The ones listed are not exhaustive, and mainly relate to potential hazards from flooding and coastal wetland management.

Questions?

Peter Slovinsky

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on June 18, 2008, 1-3 pm EST

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Alaska Wetlands and Climate Change

Presentation

- Context and some factoids
- Hydrology and Ecology
- Wetlands and northern lakes
- Wild fire
- Effects
- Adaptations

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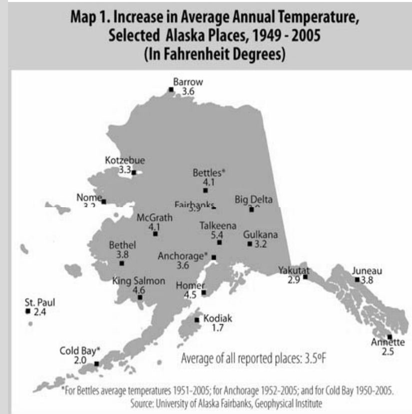
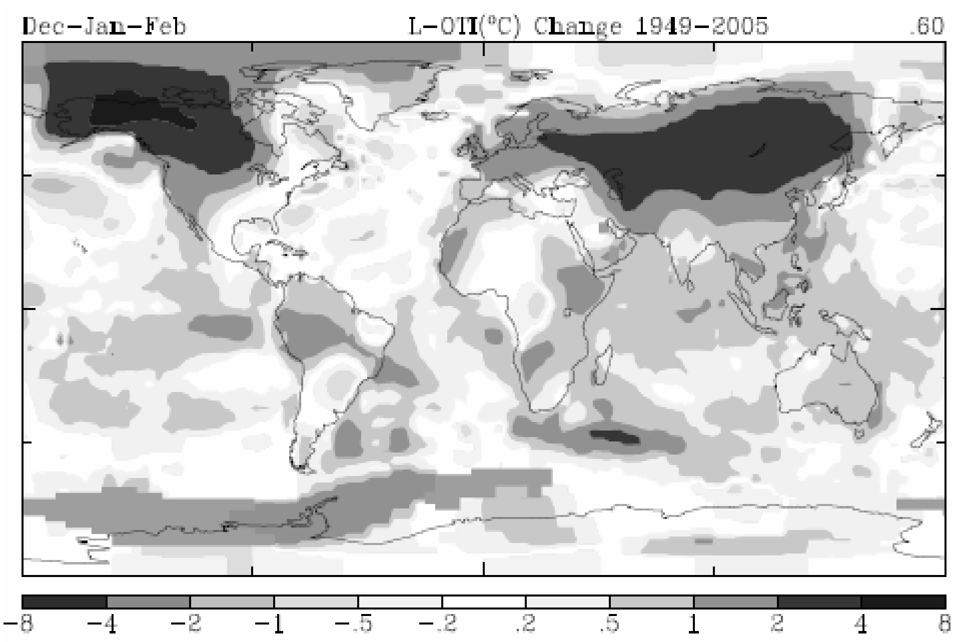
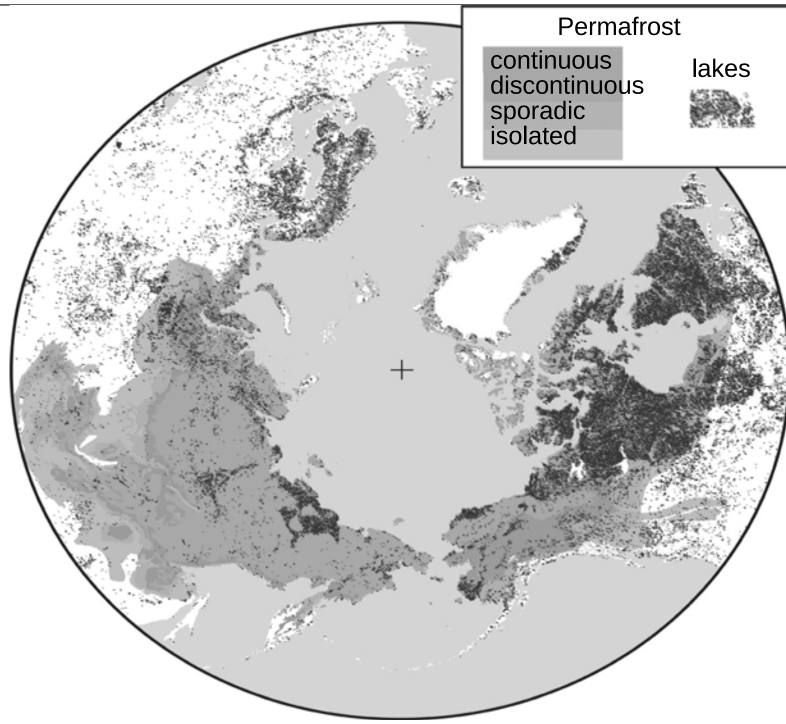
Some Factoids

- Alaska
  - 40% of landscape is classified as a wetland
  - 60 % of the US's total wetland ecosystems
- Most wetlands are projected to disappear by the end of the 21st Century
- Since 1950 air temp increased by 0.4 ^{o}C /decade
- Growing season increased 2.6 days
- Thawing permafrost along lake margins
- Increase in forest fires
- Changes in hydrology




Dec-Jan-Feb
L-OTI(°C) Change 1949-2005
.60
-8
-4
-2
-1
-.5
-.2
.2
.5
1
2
4
8



Source: Walter, K. et al.

Wetlands, Lakes, and Climate Change

Hydrology

- **Peat wetlands – 30 % of all terrestrial carbon often locked in permafrost (Bridgham 1995)**
- **Losses of up to 33% in some wetland complexes.**
- **Modest increase in precipitation**
- **Increase in evapotranspiration**
- **Lakes in N. Siberia – thaw lakes 5X more methane – 58% increase.**

Wetland Ecology and Climate Change

Hydrology

- Soil drying
- Low lands, permafrost thaw creates pools and wetlands whereas uplands it amplifies soil drying through improved vertical draining.
- Large predicted increases in permafrost thaw would profoundly alter the hydrologic controls over ecosystem processes and challenges ecological resilience.
- Lowered regional water tables

Wetland Ecology and Climate Change

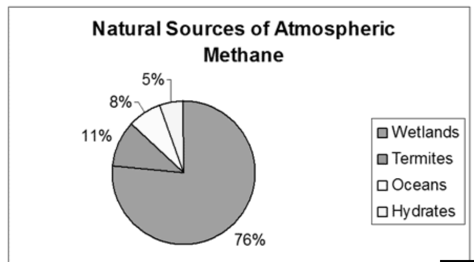
Ecological

Reduction in tree growth

- Bark beetle outbreaks
- Insect outbreaks increased – fire and salvage logging
- Permafrost thaw occurs more rapidly after fire because loss by combustion of the insulative organic mate making temp. more responsive to warming air

Lake Edge Wetlands

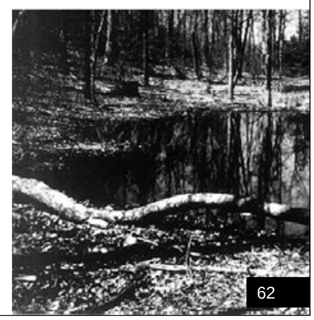
- Responsible for approximately 3/4 of global methane emissions from natural sources,
- Wetlands provide a habitat conducive to methane-producing (methanogenic) bacteria that produce methane during the decomposition of organic material. These bacteria require environments with no oxygen and abundant organic matter, both of which are present in wetland conditions.



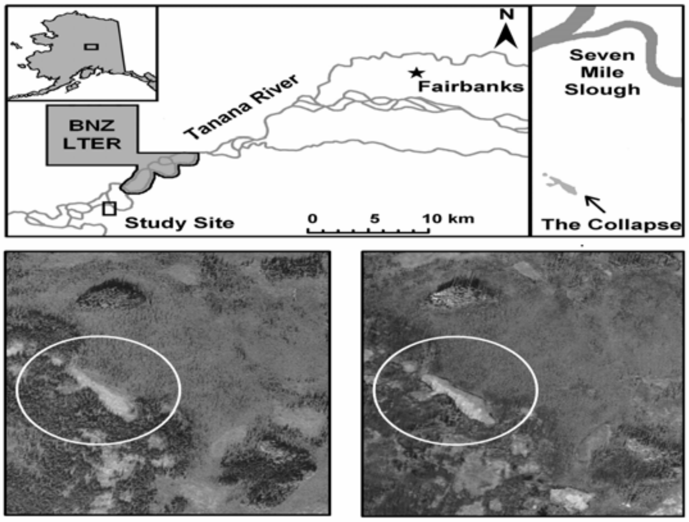
Lake Edge Wetlands and Northern Lakes

- Dominant landscape feature – up to 48 % of land surface
- Important source of atmospheric CH_4 -95% from ebullition, 5X more than expected, thawing along lake edge.
- If melted (oxidized upon thaw under aerobic conditions, could double current atmospheric CO_2
- Massive ice wedges melted – increase in lake area initially
- As permafrost thaws and then disappears – 50% loss of lake area & CH_4 emissions.

US EPA, Leo Kenney Region 1
Inland Wetlands: Sources of methane wetlands



Effects of Wild Fire on Permafrost Wetlands



Study Site Pre-Fire **Study Site Post-Fire**

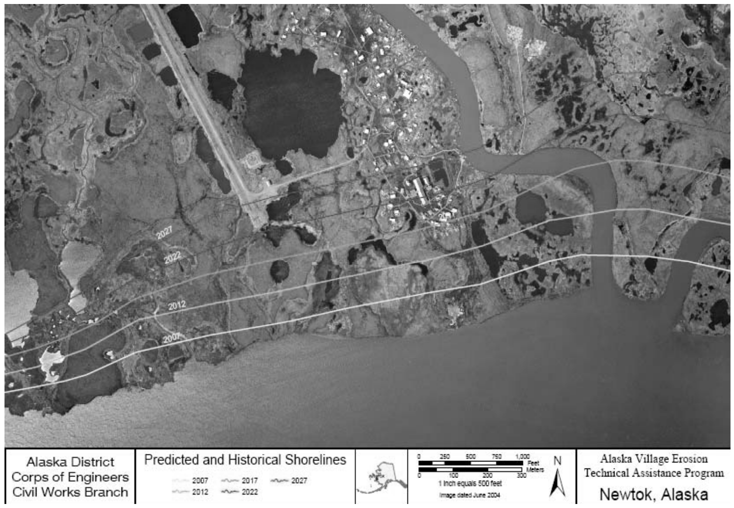
Interior Alaska, a permafrost collapse scar Tanana River floodplain Images show the collapse scar prior to and after the Survey-line Fire burned through the study site in late June 2001.

Source: . H. Myers-Smith, J. W. Harden, M. Wilmking, C. C. Fuller, A. D. McGuire, and F. S. Chapin III. 2007.**Wetland succession in a permafrost Collapse: interactions between fire and thermokarst. Biogeosciences Discussions, 4, 4507-4538,2007**

Wild Fire

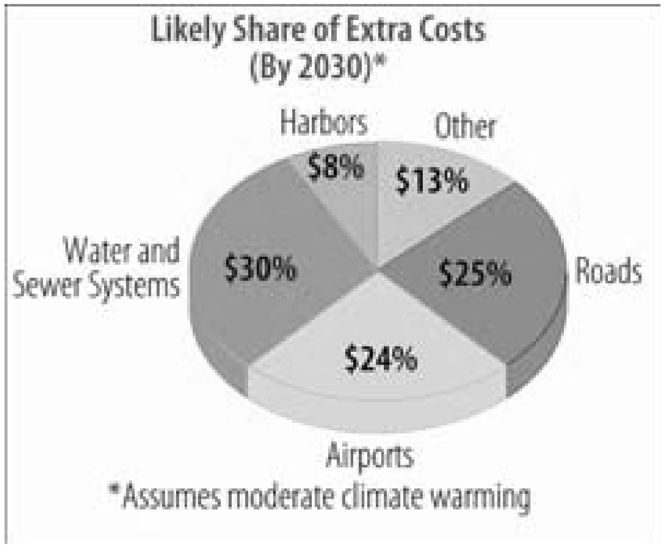
- Direct temperature effects ecological processes
- Increase in area burned by wild land fires
- Varies with human interaction
- Vegetation changes
- Carbon loss from boreal wetlands reduces carbon sequestration contributing to global warming.
- Fire disturbance in Alaska-Canada region has doubled in frequency since 1970

Coastal Erosion



Coastal Erosion

Fairbanks Permafrost



Source: Peter Larson, ISCR, UAA

Summary of Effects

Public Infrastructure - Climate Change

1. *Melting Permafrost* - causes roads and foundations to prematurely buckle.
2. *General Sea-level Rise* - directly damages adjacent built environment and accelerates erosion.
3. *Rapid Coastal Erosion* - Increased storm activity/sea-level rise rapidly erodes exposed coastal communities.
4. *Increased Flooding* - damage bridges, roads, landing strips, and water utility systems, etc.
5. *Increased Fire Activity* - directly damage built structures including government buildings.

Adaptation and Resilience

- Expect change
- Increased agriculture – longer growing season
- Decreased winter tourism
- Increase in wildland fires
- Less stable permafrost
- Altered salmon runs
- More invasive species
- Storm erosion along northern coasts

Expecting Change, pop, DGP Northern Hemsiphere Temp, all are changing. And will continut to change.

How do we think about climate change, Sustainability is maintain the past. However now things are changing in a directional fashion

Fast and slow moving varibles – socials and external controls that influence slow variables, NO way to

Projections for Juneau include:

- Changes in climate may out pace the capacity of some plants and animals to adapt, resulting in local or global extinctions.

- Rapid changes in the ecology of terrestrial and marine environments will alter commercial, subsistence, and recreational harvesting in ways that cannot be readily predicted.

- Increase intensity and frequency of coastal storms will negatively impact shoreline and wetland nursery areas for many marine species.

Projections for Juneau include:

- Air temp increase 10°F by the end of the current century.
- 21^{st} Century - shrubs and trees will have colonized elevations currently characterized as alpine or tundra habitat in southeastern Alaska.
- Ecological responses not predictable, some counterintuitive. For example, yellow cedar trees are freezing in spring as temperature warms due to a loss of insulating snow cover.
- Increase temp and precip. likely will alter the ecology of salmon in southeastern Alaska. Early entry into the marine environment - when food resources are low or absent - will decrease growth and survival.

Suggestions transferable to other communities

- Expect change, unpredictability, the unexpected
- Identify main drivers
- Slow and fast moving variables
  - Institutions slow to change
  - climate may outpace some plants and animals
- Ecological changes unpredictable
- Energy audit
- Ecological services will change
- Increase in intensity and frequency of storms
- Cues are changing

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References:

Arctic Council. 2004. *Impacts of a Warming Arctic – Arctic Climate Impact Assessment*, Cambridge University Press, Cambridge, UK. pp.1042.

Bridgham, Scott D., Johnson, Carol A. 1995. *Potential feedbacks of northern wetlands on Climate change*" Bioscience. vol. 45 Issue 4, p262.

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Questions?

Jim Powell

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Rising Waters

Helping Hudson Valley Communities Adapt to Climate Change

David VanLuven
Hudson River Estuary Landscape Director

Eastern NY Chapter
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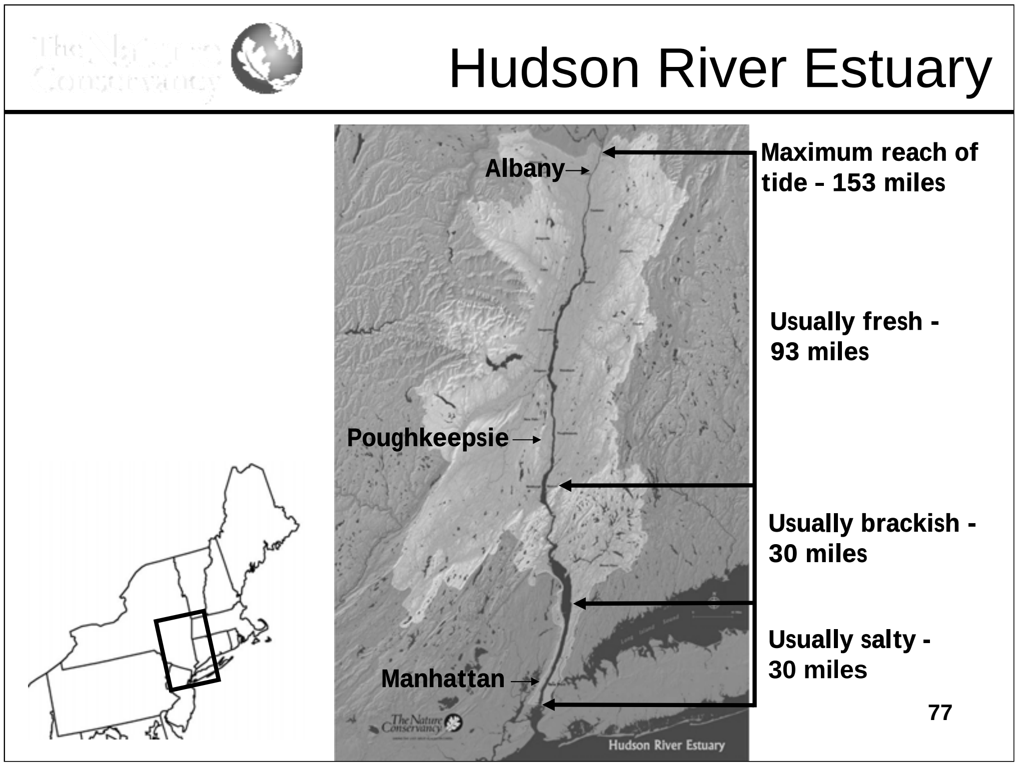
Freshwater Tidal Wetlands

What does “protect” mean with sea levels rising more rapidly?

Tim Howard, NY Natural Heritage Program

- The Nature Conservancy is best known for buying land, so a couple of years ago, when I was brand new to this job, I was paddling through a freshwater tidal marsh like this one at Tivoli Bay and wondering how I was supposed to protect it when sea level rise threatened to have it underwater in 50-100 years. This was a big shift for me, because only a few months earlier I was thinking about climate change purely in the context of emissions reduction and, finding it completely overwhelming, had decided that it was not an issue I could possibly do anything about.

Then I realized that climate change was going to affect all sectors of our society, and as such was an opportunity. I realized that, as a universal challenge, climate change was an opportunity. An opportunity for different stakeholders in the valley to come together to collectively implement solutions to common problems but with very different motivations. And as with anything else, when you build diverse coalitions, you dramatically deepen the pool of state and federal dollars for implementation, and you have a much greater chance of forging the political will for action.



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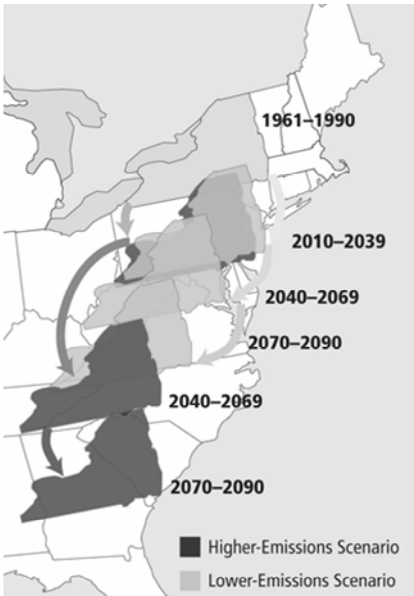
We need to adapt



Source: NECIA, 2007 (see: www.climatechoices.org/ne/)

New York's climate will continue to change for the next 30-50 years even if we stop emitting greenhouse gases tomorrow.

Key challenges include:

- Higher sea and lower Great Lakes levels
- Altered weather patterns
- Our responses

Usual Solutions

To help biodiversity adapt,
need connectivity & migration corridors.

How?

To protect wetlands,
need stronger regulations
& more direct conservation.

How?

Climate Change Challenges

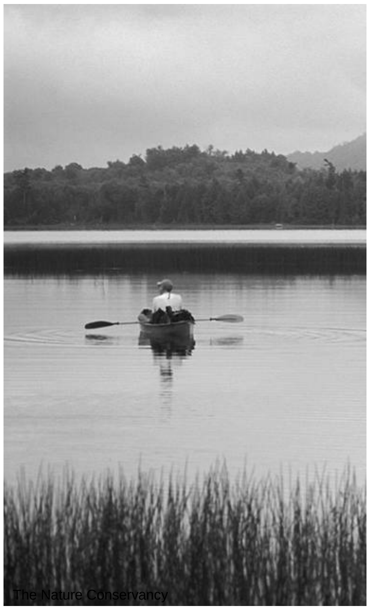

Geoff Eckerlin, Hudson River National Estuarine Research Reserve

Climate change is still viewed as an environmental, not a social, problem

Responses to climate change still emphasize emissions reduction

Public and political leaders want to know what climate change effects will be – uncertainty is confusing

Wetland Challenges



Wetland conservation is viewed as an environmental issue, so stronger regulations are not a priority

There is limited funding for wetland conservation relative to what needed

Shifting Perspectives

The Nature Conservancy
Eastern NY Chapter

Cary Institute of Ecosystem Studies

Hudson River Estuary

Hudson River National Estuarine Research Reserve

New York State Water Resources Institute at Cornell University

Sustainable Hudson Valley

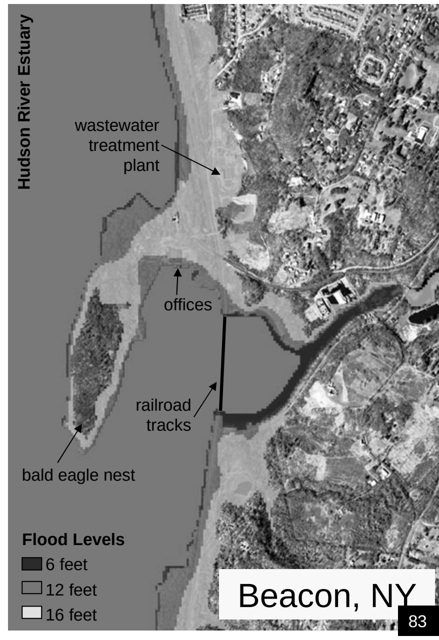
Rising Waters

The Nature Conservancy
is spearheading
a collaborative effort
to use climate change
as a catalyst for conservation

We are all affected

- wastewater treatment plants
- businesses & residents in floodplains
- emergency first responders
- roads, bridges, railroads
- natural systems

not an "environmental" issue



Participant Interests

Multi-stakeholder scenario planning

Business/Economic
academic - economics
agriculture
business groups from imper. areas
development - county
development - private
development - real estate
development - region
development - town
employer - large
employer - small
financial community
fishing
insurance
marinas & boat clubs
planning - county
planning - local
planning - regional

Biological/Social
academic - biology
academic - climatology
academic - modeling
academic - social science
art
conservation
env. justice/low-income advocates
faith
historic preservation
philanthropic interests
toxics interests

Land
landowners - in flood prone areas
landowners - major private
landowners - major public

Infrastructure/Service
education
emergency responders
engineers
health care
infrastructure - shoreline
infrastructure - transportation
infrastructure - utilities
infrastructure - water supply & treat.

Other
political leader
steering committee
z-(not sure)
publishing

Multi-stakeholder **scenario planning**

Stories simplify the uncertainty
of climate change into something
we can think about productively

The New York Times

August 2, 2006

Hundreds Evacuated in Chicago as Heat Wave Persists

By GRETCHEN RUETHLING

CHICAGO, Aug. 1 — About 1,300 residents were evacuated from more than a dozen high-rise apartment buildings on the city's South Side on Tuesday after a power failure left many in sweltering conditions as a heat wave stretched into a fifth day.

The evacuations came after about 3,400 customers lost power on Monday night when an underground cable failed, said Tom Stevens, a spokesman for Commonwealth Edison, the electric company. The failure's cause is under investigation, Mr. Stevens said.

Credit: Applied Science Associates, Inc.. Source: Google, Sanborn Map Company, Inc.. NECIA, 200
(see: www.climatechoices.org/ne/).

2 Possible Scenarios

Chris Bowser, NYS DEC Hudson River Estuary Program

Scenario #1

Two major floods in the tributaries and upper estuary are followed in the fall by a category 3 hurricane hitting New York City. Officials panic & respond with short-term solutions.

Scenario #2

The region is hit with heat waves and severe droughts every 4-5 years, further straining water supplies in growing municipalities and health care facilities in disadvantaged communities.

Moving from Stories to Implementation

1. assess likely impacts on each interest
2. consider different responses & their ramifications
3. identify strategies that benefit many interests
4. implement solutions

The Nature Conservancy

Benefits

- Diversifies concern about climate change & wetlands
- Wetland conservation will surely be a central strategy benefitting many interests
- Broad coalitions = more political clout
- Broad coalitions can access more govt. $
- More political clout + more $ = implementation

Questions?

David VanLuven

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http://www.clu-in.org/conf/tio/owwcc/resource.cfm

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http://www.clu-in.org/conf/tio/owwcc/feedback.cfm

Jim Powell's References:

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