Framework for a Hydrologic Climate-Response Program in Maine

Robert Lent, Glenn Hodgkins, Robert Dudley
USGS Maine Water Science Center

People and Nature
Adapting to a Changing Climate:
Charting Maine's Course

"Climate change adaptation will require an on-going effort. It will need to incorporate new information and continue to adapt and evolve... ***Consequently, data-gathering, monitoring, and assessment are critical tools that Maine must utilize to inform decision makers, resource managers, stakeholders, and the public. Our decisions must be founded on the*** *best available scientific data, and Maine's planning must support continuing research."*

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Climate Response Program Goals

- Provide systematic information to resource managers
- Provide an early warning of hydrologic response to climate change
- Provide locations for place-based research

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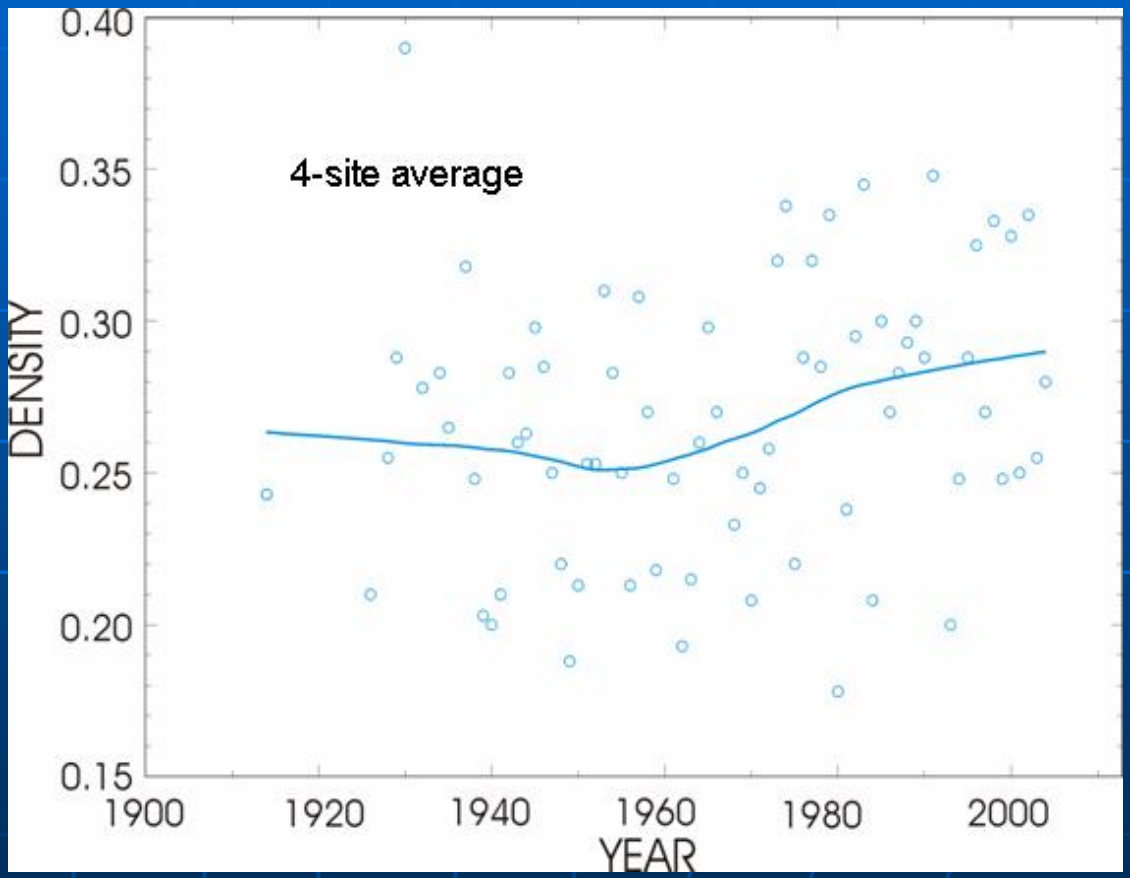
Why Study Climate Change in Maine?

- Changes in snowpack over time
- Decrease in depth or increase in density



Hodgkins and Dudley, 2006

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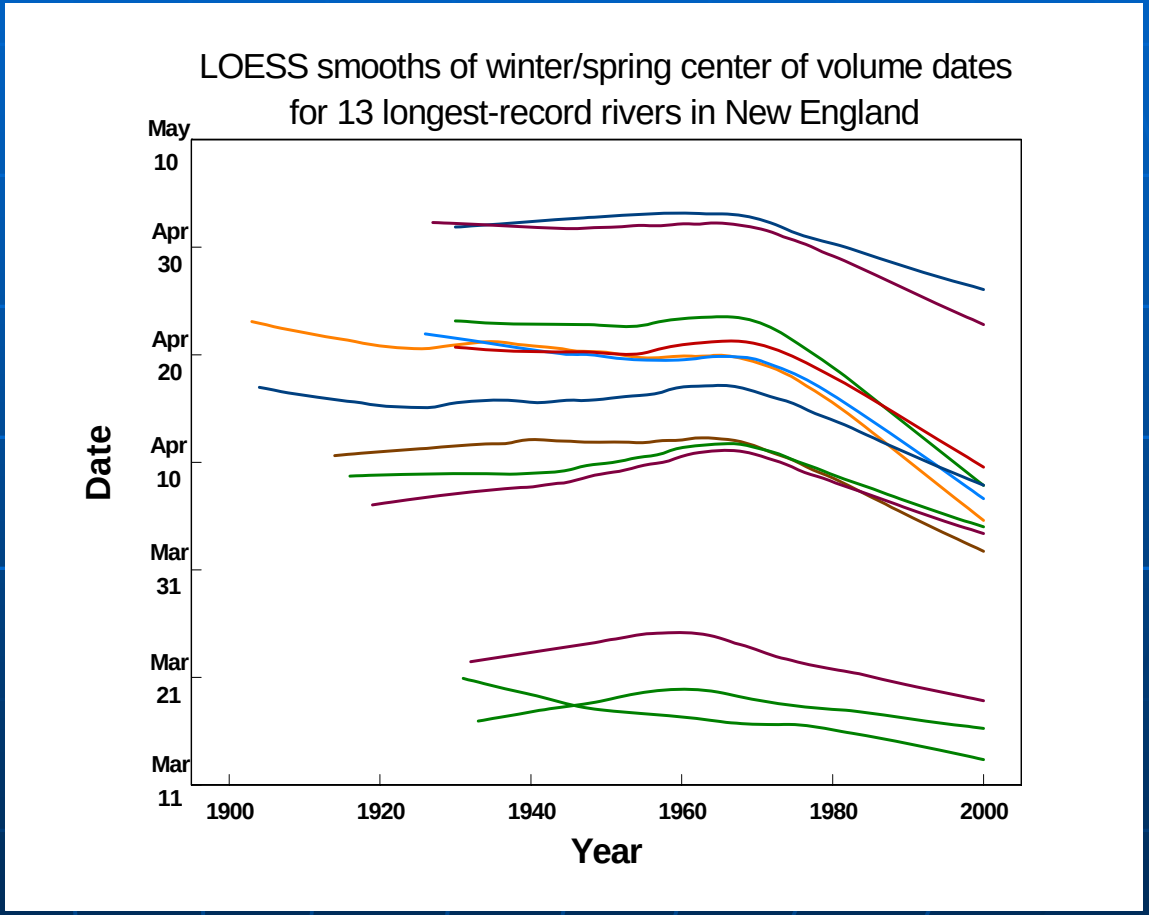
Why Study Climate Change in Maine?

- Spring runoff dominates the annual hydrograph
- Occurring significantly earlier in northern New England in recent years
- Timing related to air temperatures



Hodgkins and others, 2003

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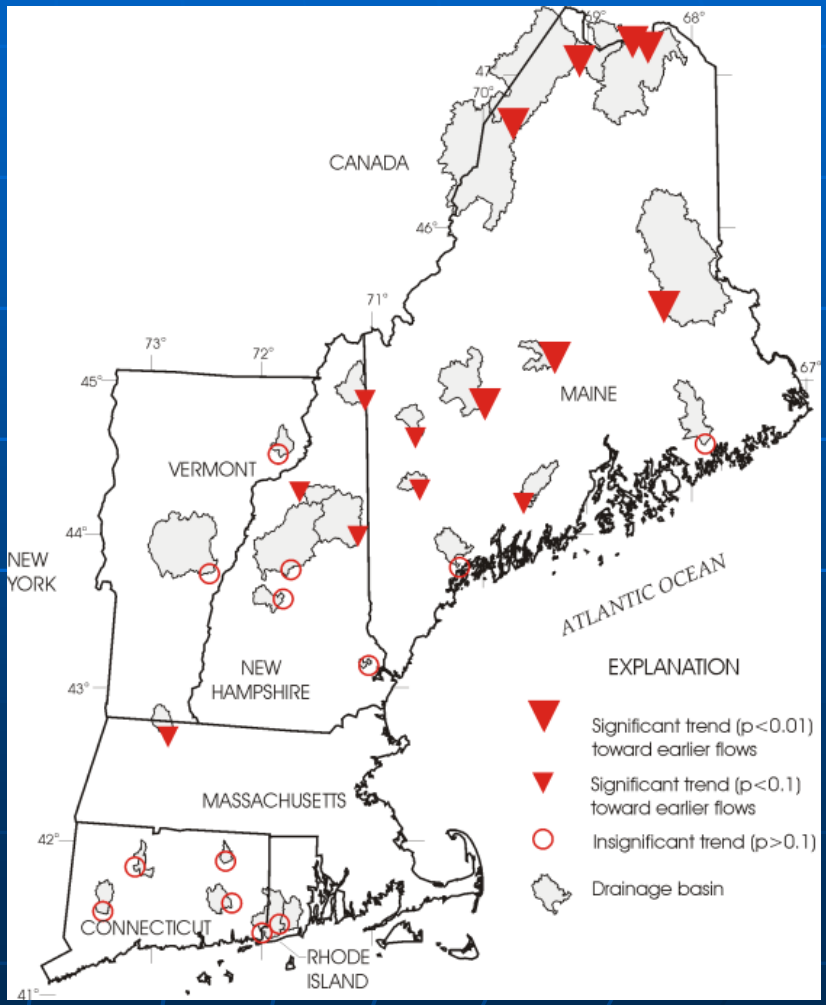
Why Study Climate Change in Maine?

- Abundance of historic hydrologic stations
  - Long-term records
  - Not impacted by flow regulation
  - Little urbanization
- Large climate gradient
  - Mountains to the Atlantic Coast
  - Part of a larger regional gradient



Hodgkins and others, 2003

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Climate Research in the USGS Maine Water Science Center

- Since 2001 the USGS MeWSC has evaluated the impact of climate change on long-term hydrologic records in New England
- Primary work demonstrated strong relationships between climate and some hydrologic variables
- Hydrologic variables displayed consistent temporal and geographic trends

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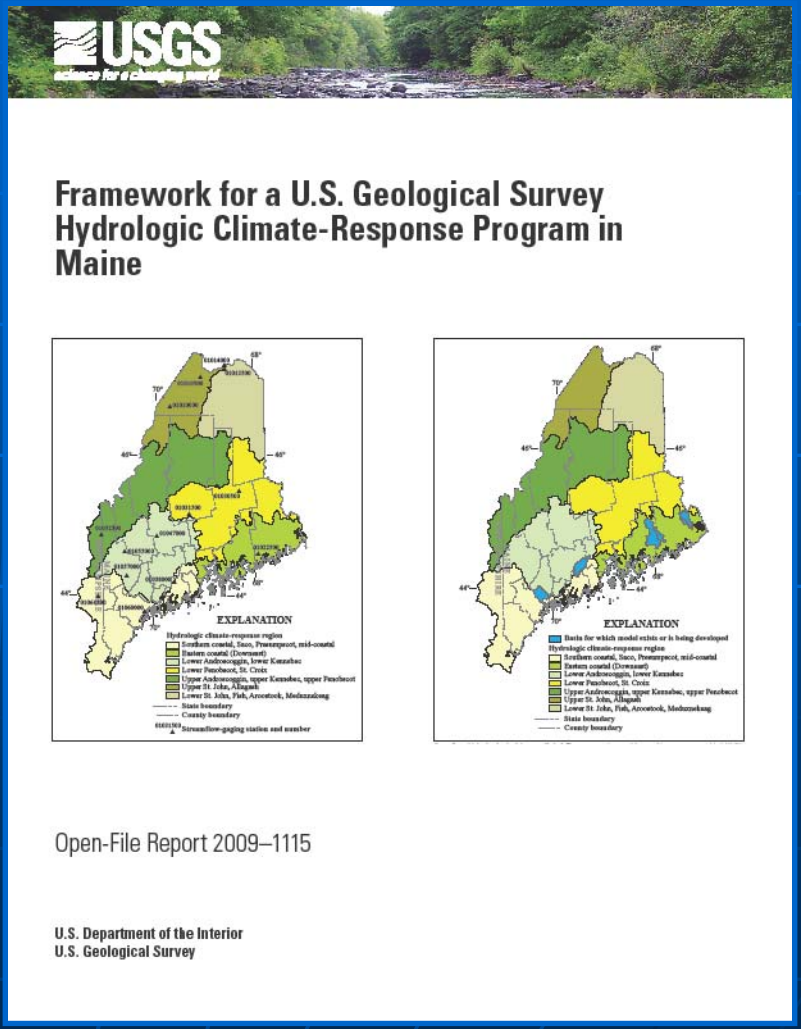
Climate Response Program Framework

- Identify key hydrologic variables that respond to climate change
- Identify homogeneous climate response regions
- Schedule trend updates of key variables
- Establish basins for process-based studies
- Strategy for reporting results



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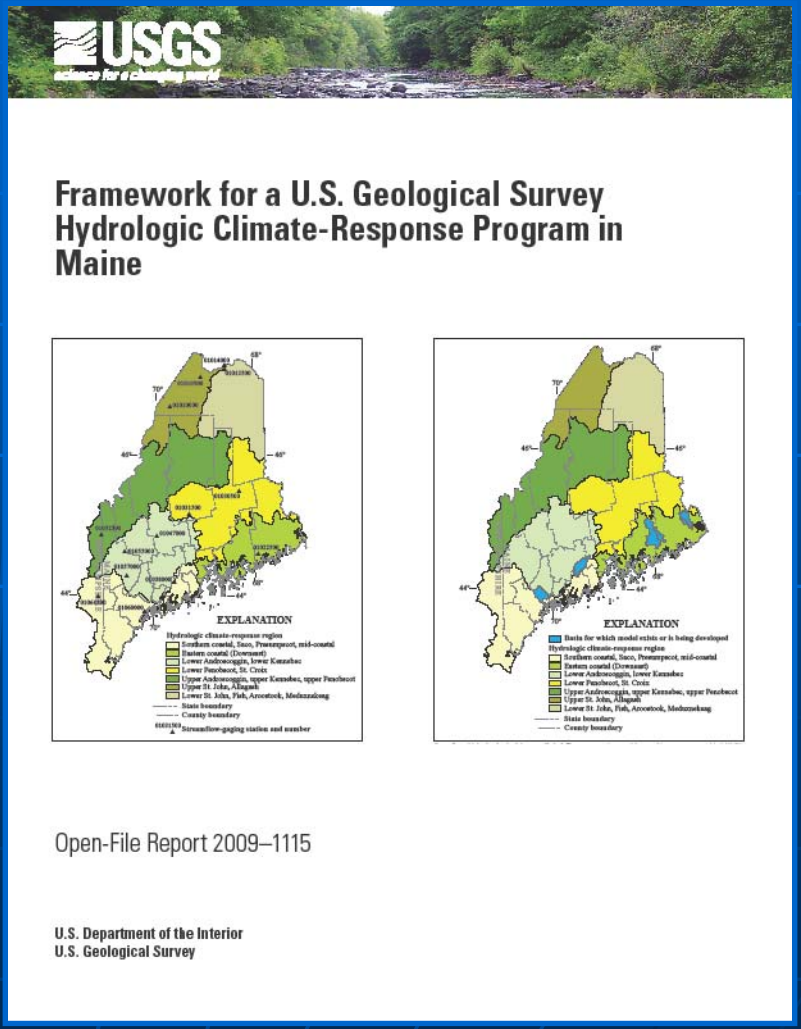

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Summary of Candidate Hydrologic Variables

- Streamflow
  - Annual and monthly low, medium, high flows
  - Flood flows
    - 5-year
    - 100-year
  - Streamflow runoff
    - Timing of seasonal runoff
- Groundwater
  - Seasonal recharge
  - Baseflow
- River ice
  - Formation date
  - Break-up date
  - Total days of winter ice
  - Thickness
- Lake ice
  - Ice-out date
- Late winter snowpack
  - Depth
  - Water equivalent
  - Density

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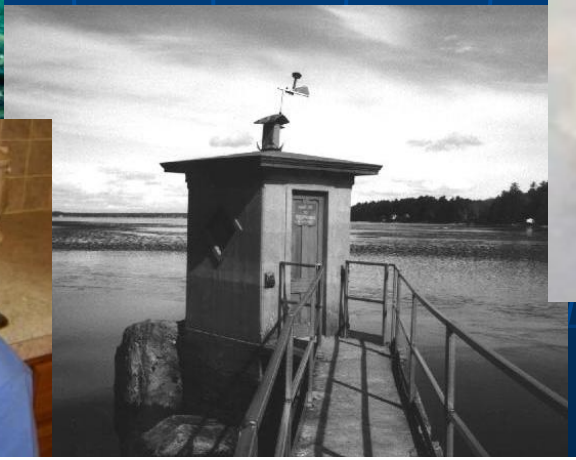
Choosing Key Hydrologic Variables

- Response to climate change
- Important to resource managers
  - Ecosystem function
  - Water availability and use



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Key Hydrologic Variables

- Streamflow
  - Timing of winter-spring runoff
  - Magnitude of annual peak flow
  - Magnitude of summer baseflows
- Groundwater
  - Amount of winter recharge
  - Amount of spring recharge
- River ice
  - Days of ice-affected flow
  - Ice thickness
- Lake ice
  - Date of spring ice-out
- Late-winter snowpack
  - Depth
  - Density
  - Water equivalent

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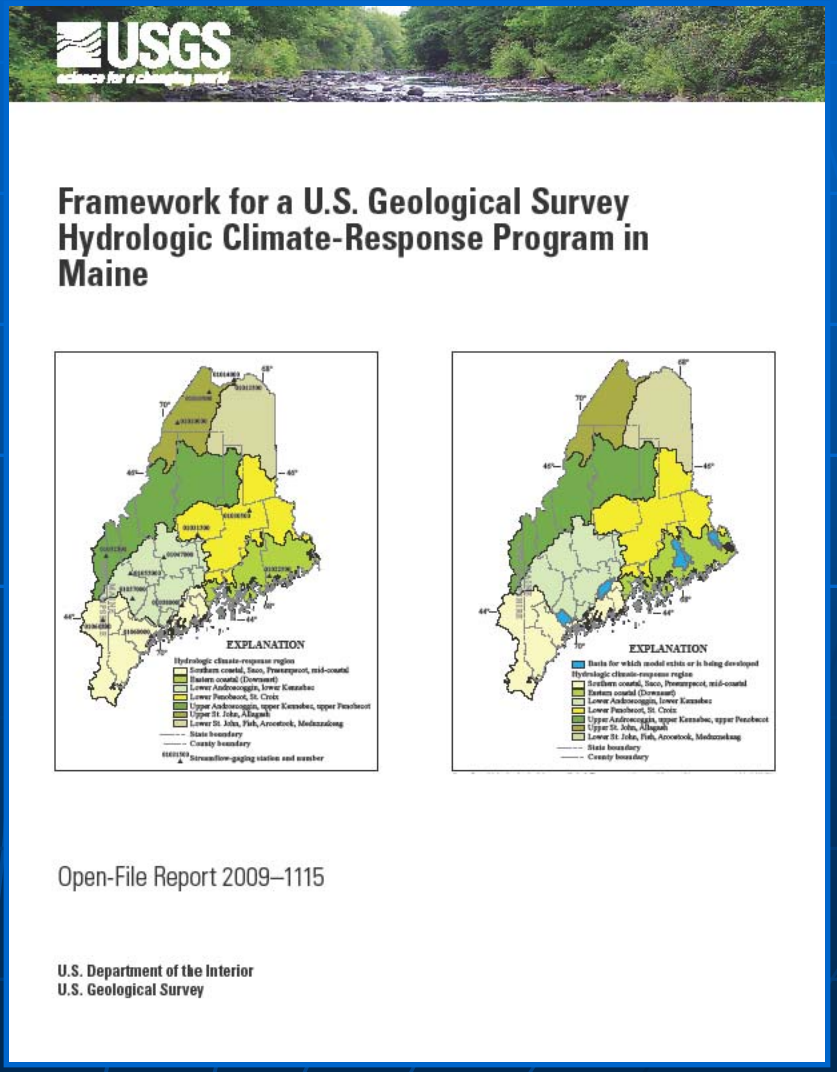

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Climate Response Regions

- Spatial variability of the hydrologic variables
- Major watersheds (8-digit HUCs)
- USEPA Ecoregions
- Important resources
  - Native American lands
  - Federal lands
  - Drinking-water supplies

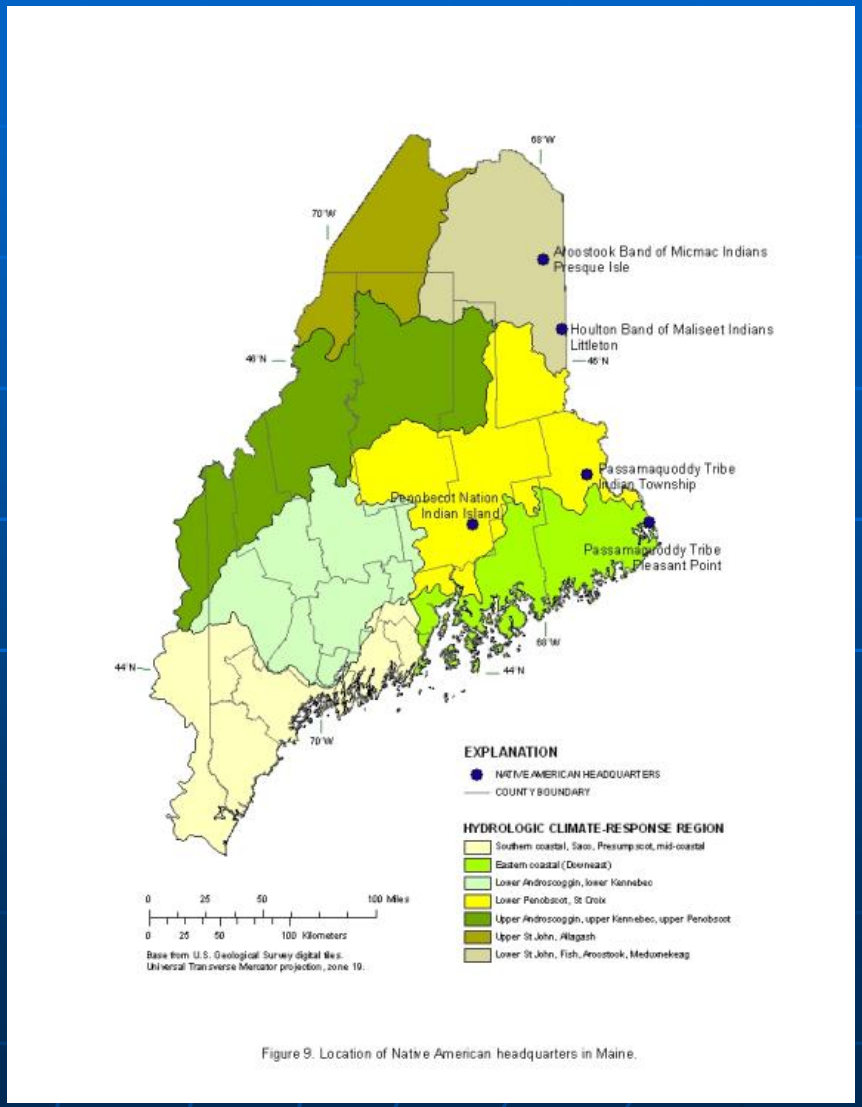

Figure 9. Location of Native American headquarters in Maine.

Native American headquarters

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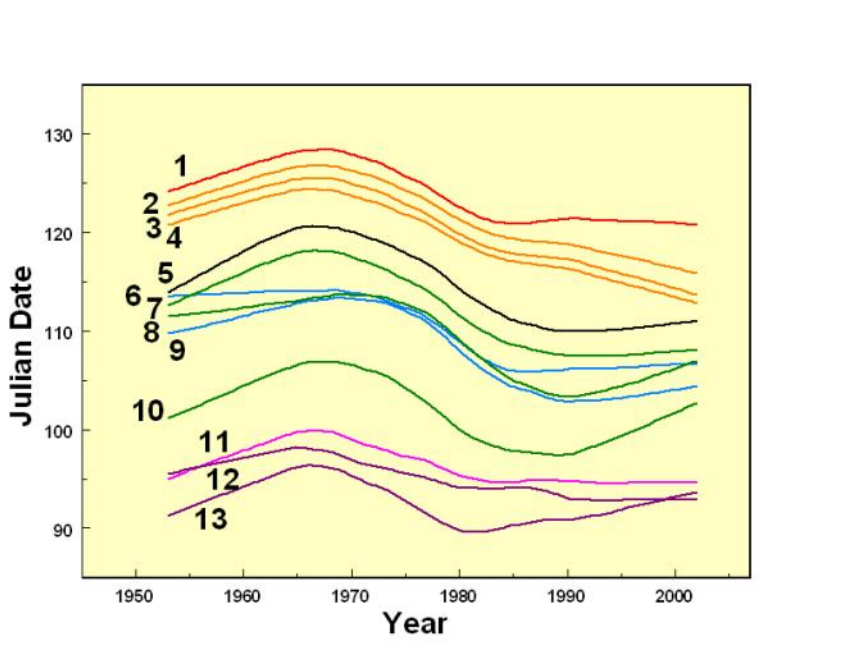
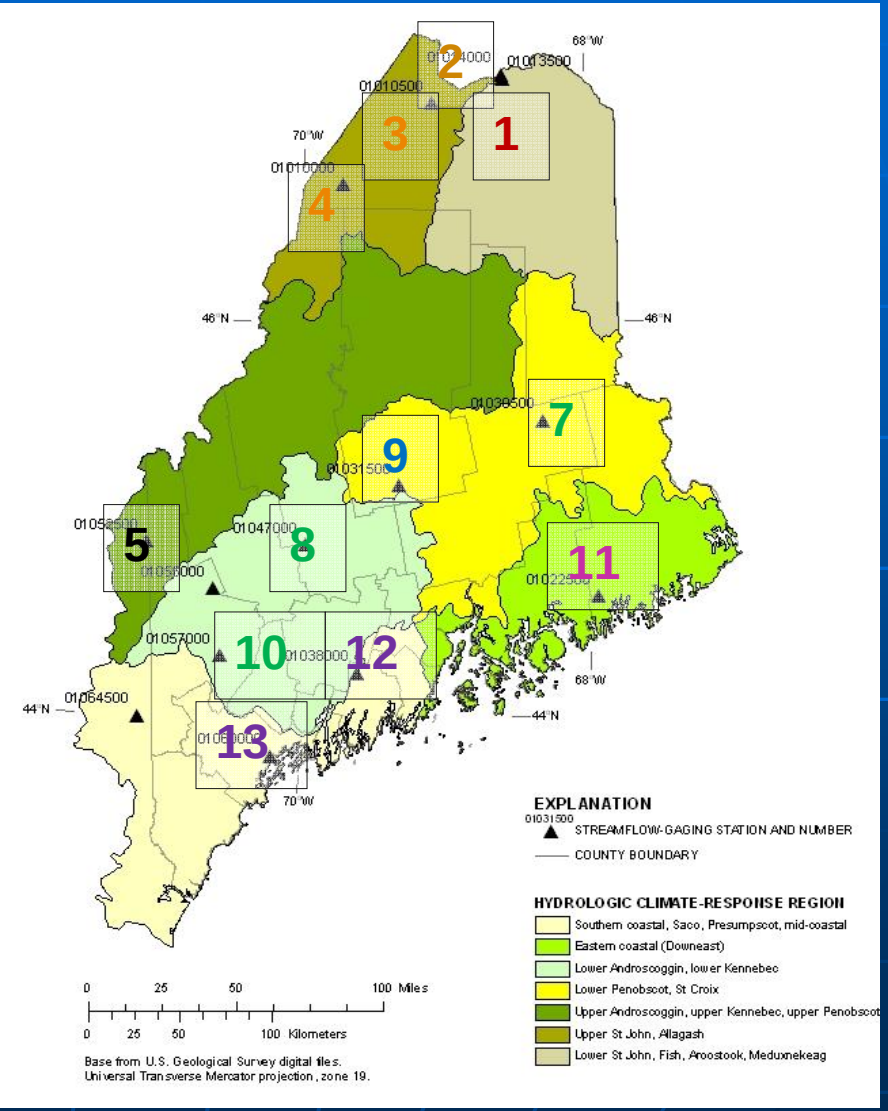
Hydrologic Climate-Response Regions

- Historical changes in timing of winter/spring runoff, 1953-2002





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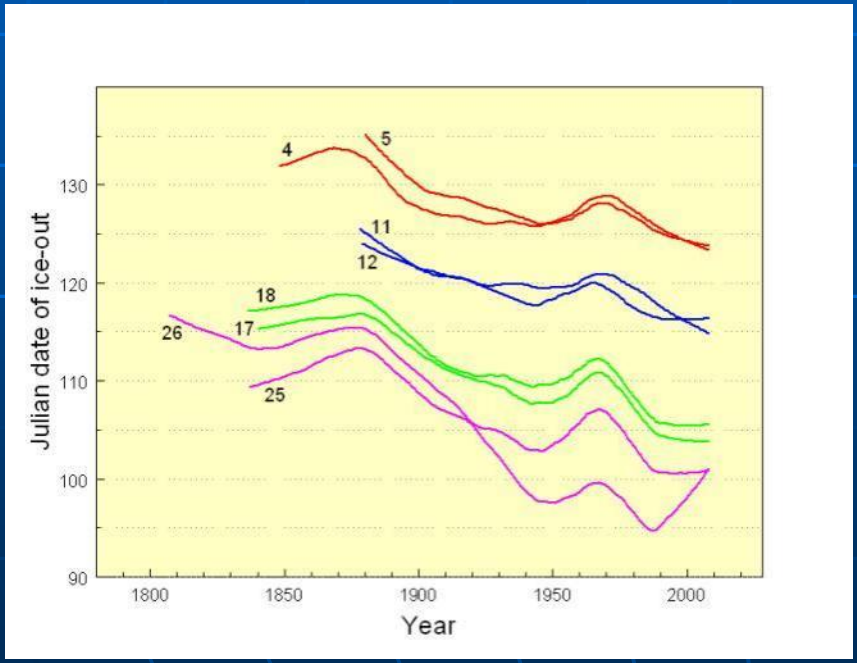
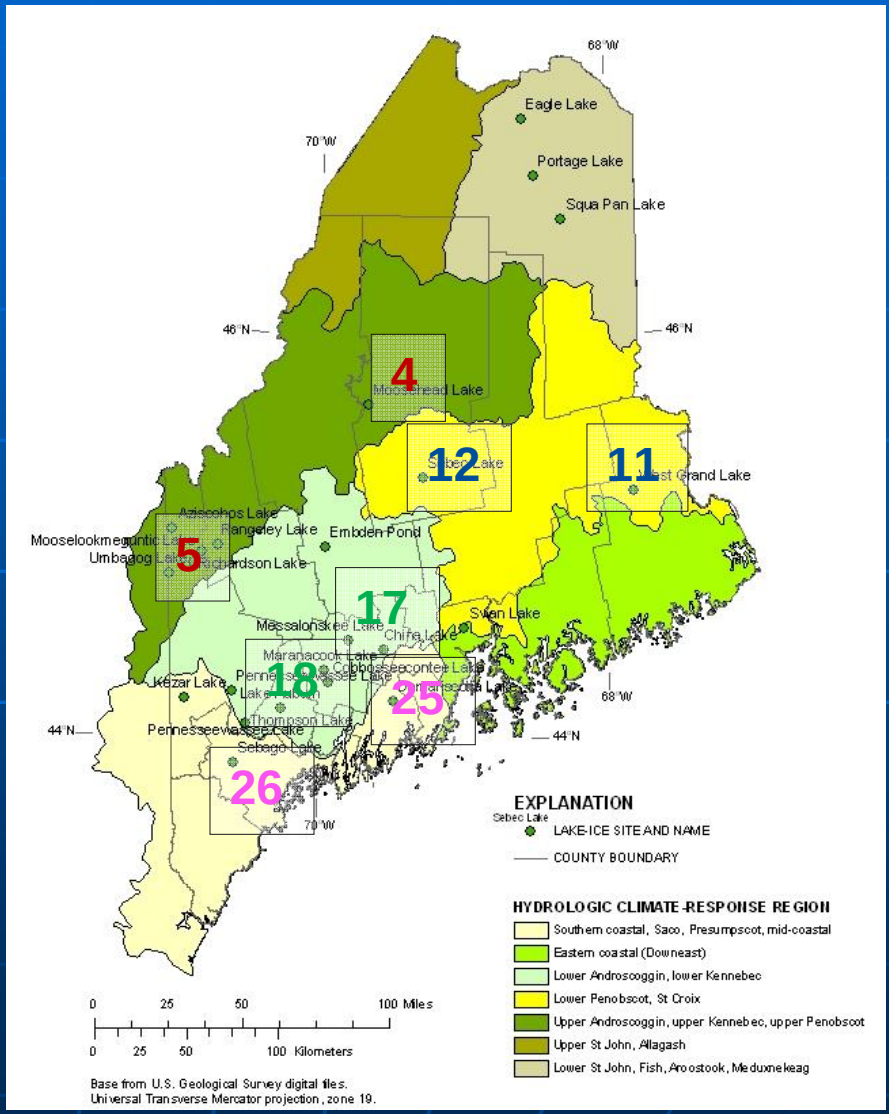
Hydrologic Climate-Response Regions

- Historical changes in timing of lake ice-out dates, 1834-2008





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Hydrologic Climate-Response Regions
Existing Data Networks

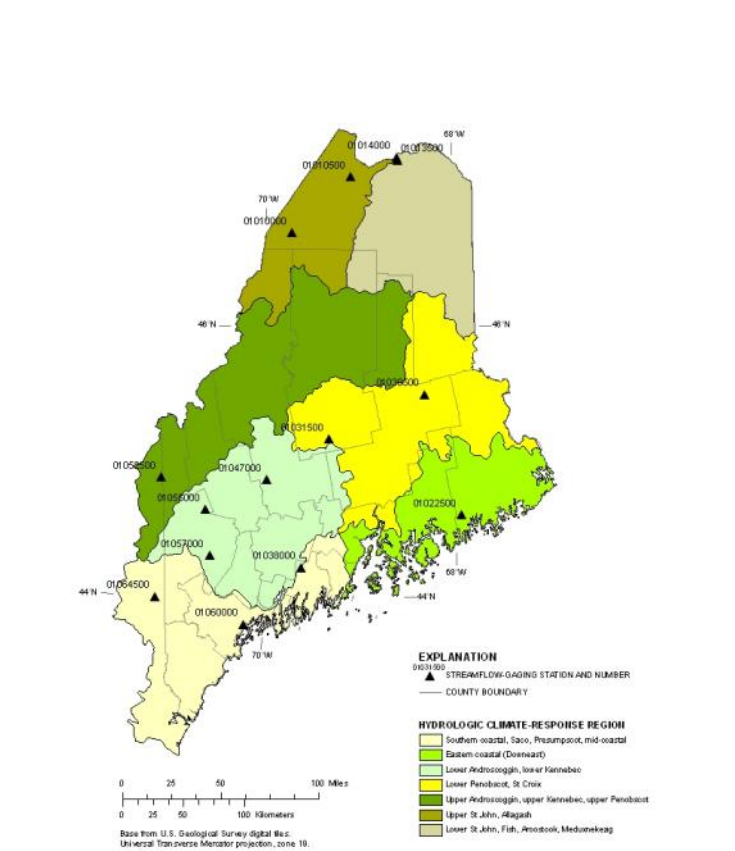

Figure 5. Location of long-term streamflow-gaging stations that drain relatively natural basins in Maine.

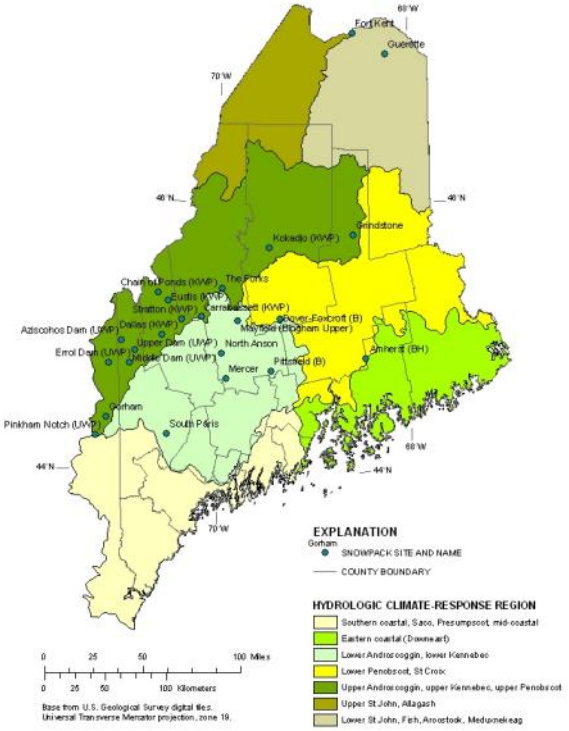

Figure 8. Location of long-term snowpack sites in and near Maine.

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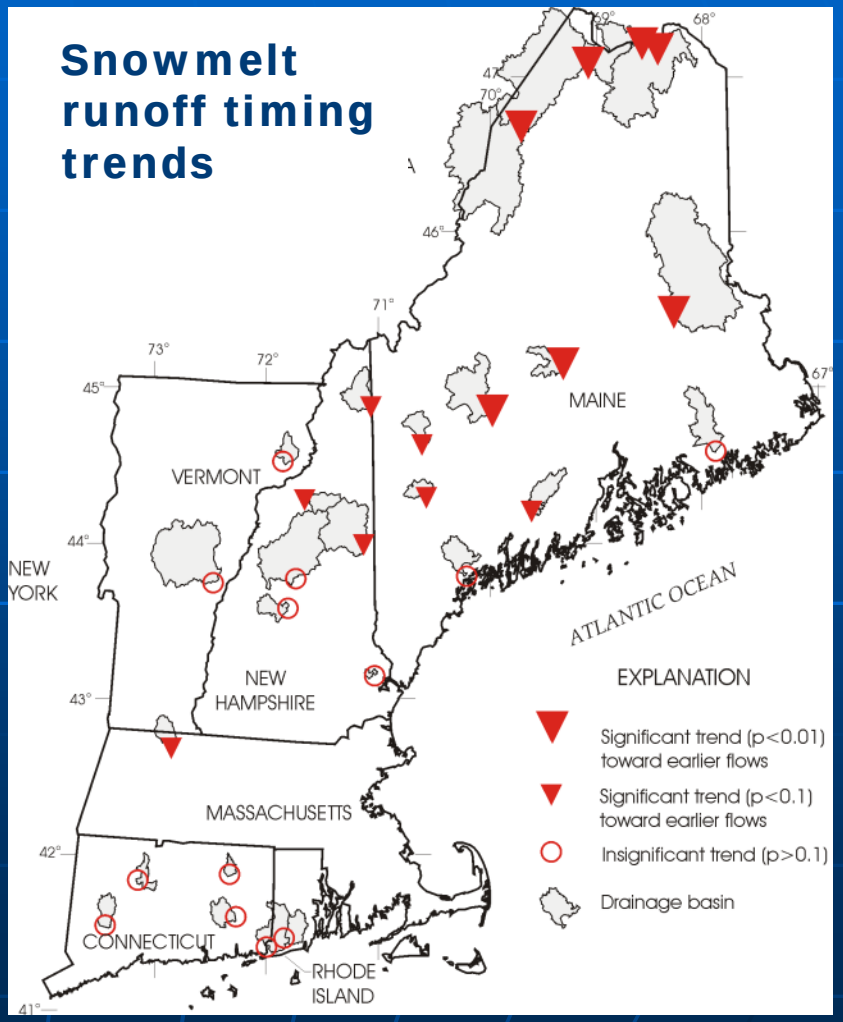
Long-term unregulated streamflow stations

Long-term snowpack data

Hydrologic Climate-Response Regions

- Different areas of New England may have different key variables—even adjacent areas



Hodgkins and others, 2003

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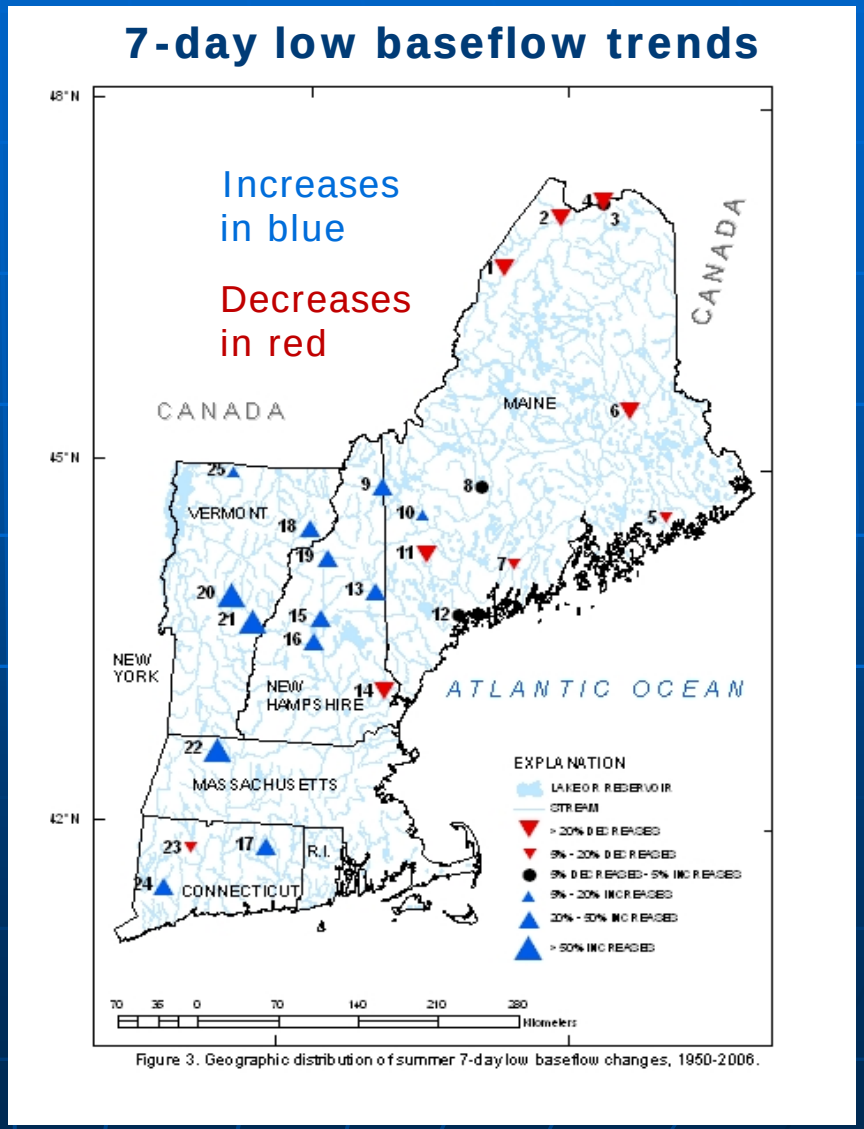
Hydrologic Climate-Response Regions

- Some variables may be appropriate for larger scales



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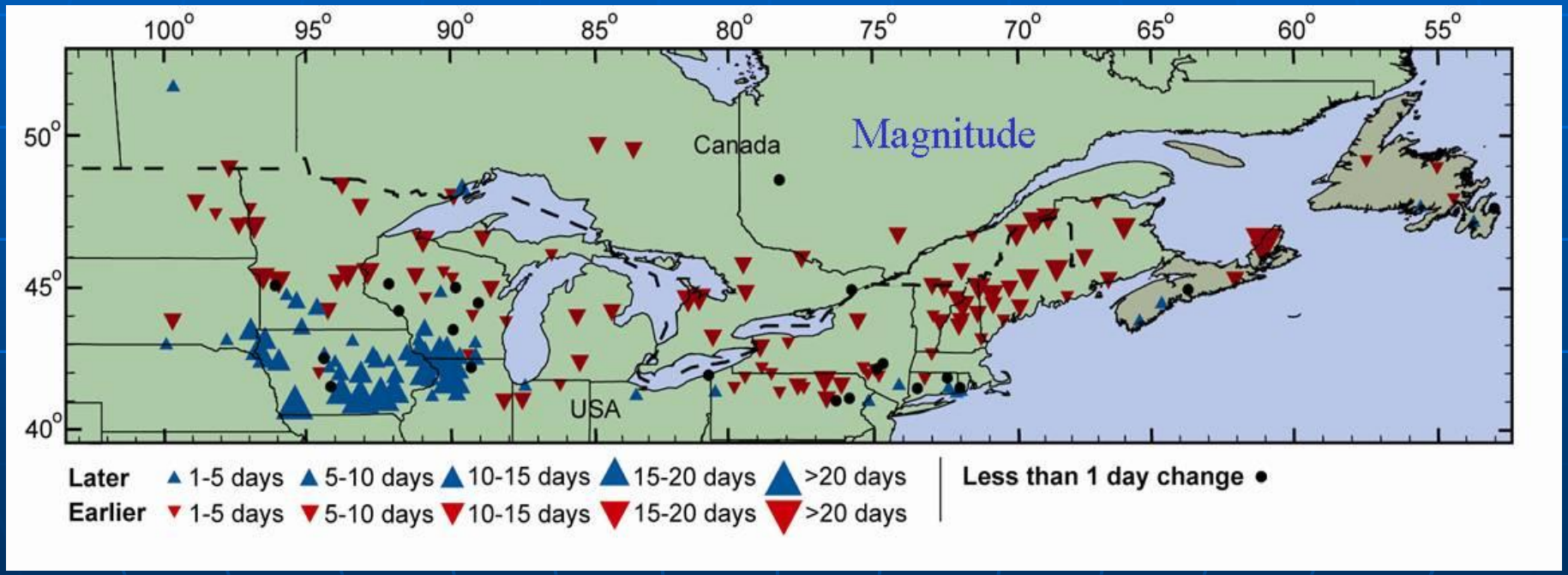
Hodgkins and Dudley, 2010

Hydrologic Climate-Response Regions

Timing of winter-spring snowmelt runoff, 1953-2002



Hodgkins and Dudley, 2006

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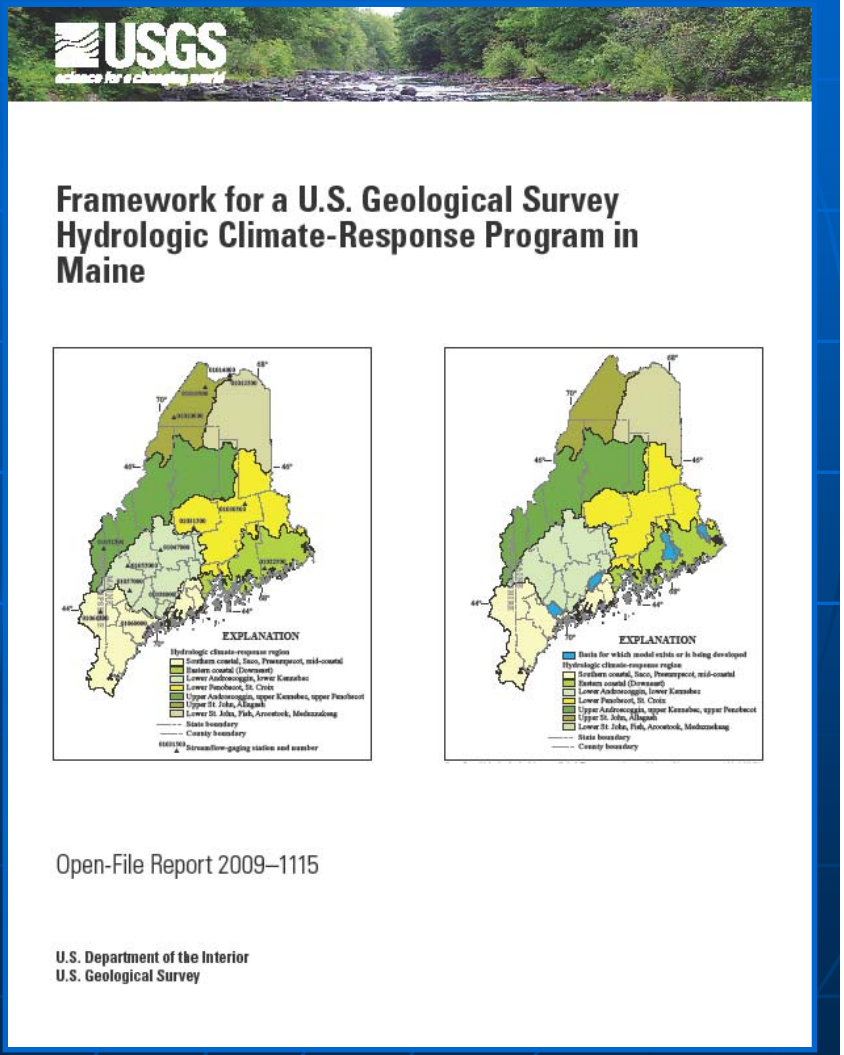

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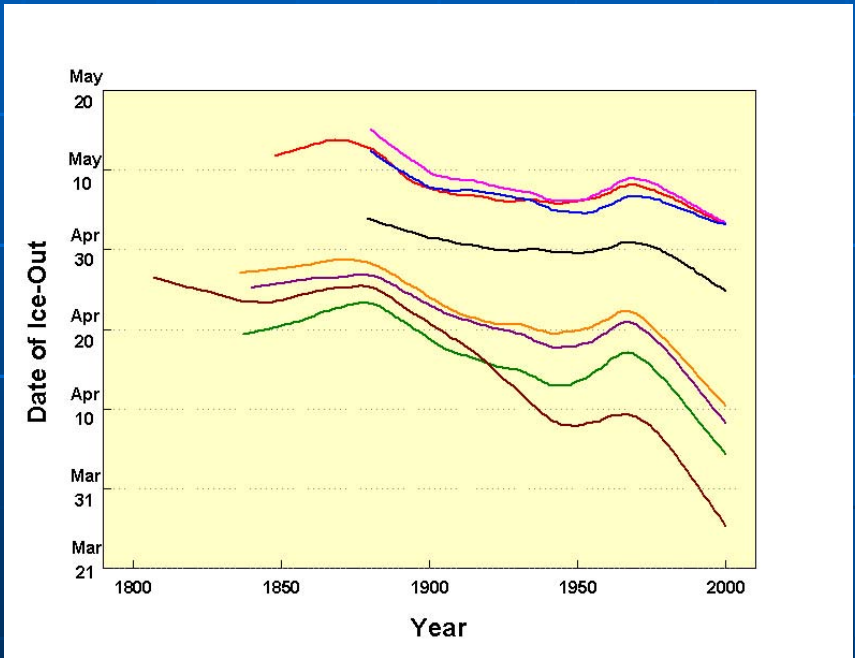
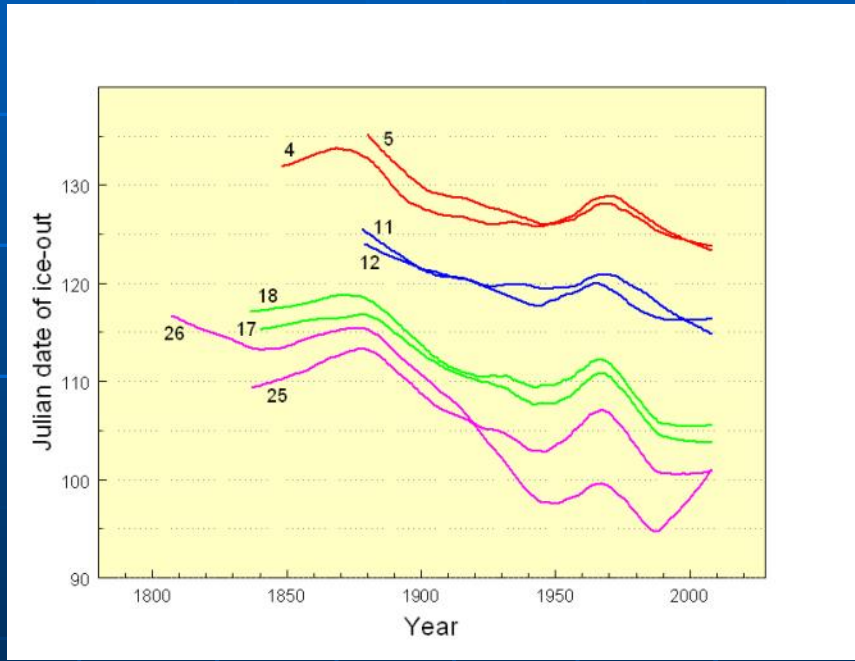
Regular Updates of Trends

Lake Ice-Out Dates

Completed in 2000



Completed in 2009



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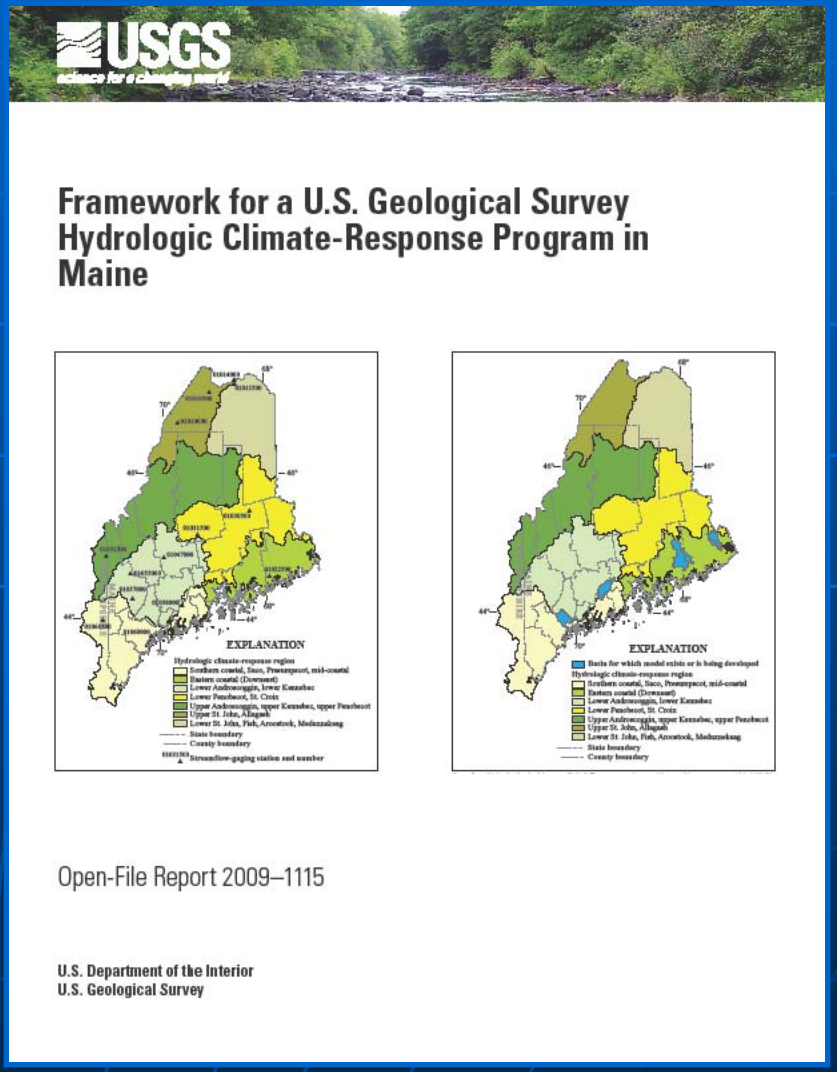

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Process-Based Studies

- Identify watersheds in each region
  - Representative
  - Important to resource managers
- Watershed models
  - Calibrated for key HCRN variables
- Additional data collection
  - Continuous water temperature

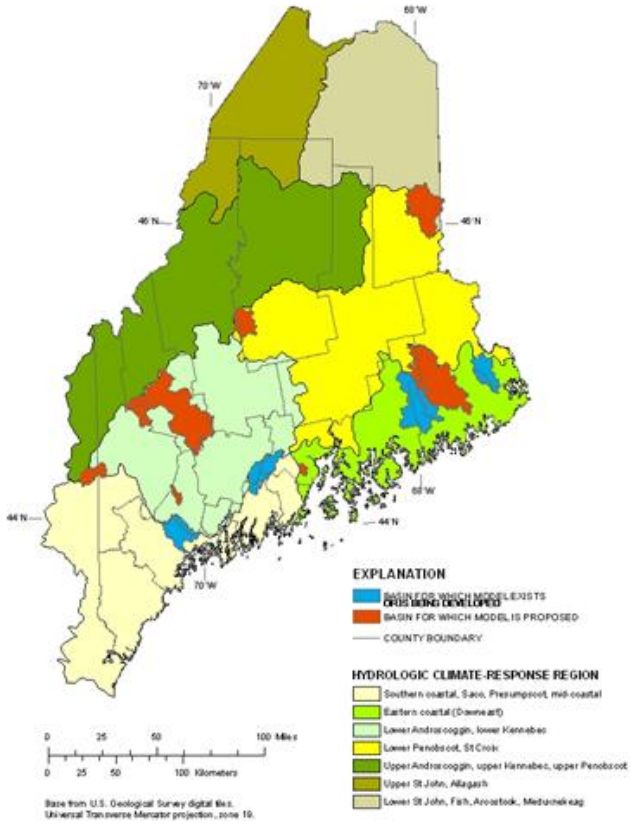

Figure 12. Location of drainage basins with rainfall-runoff models in Maine.

Completed and planned watershed models

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Climate Response Program Framework

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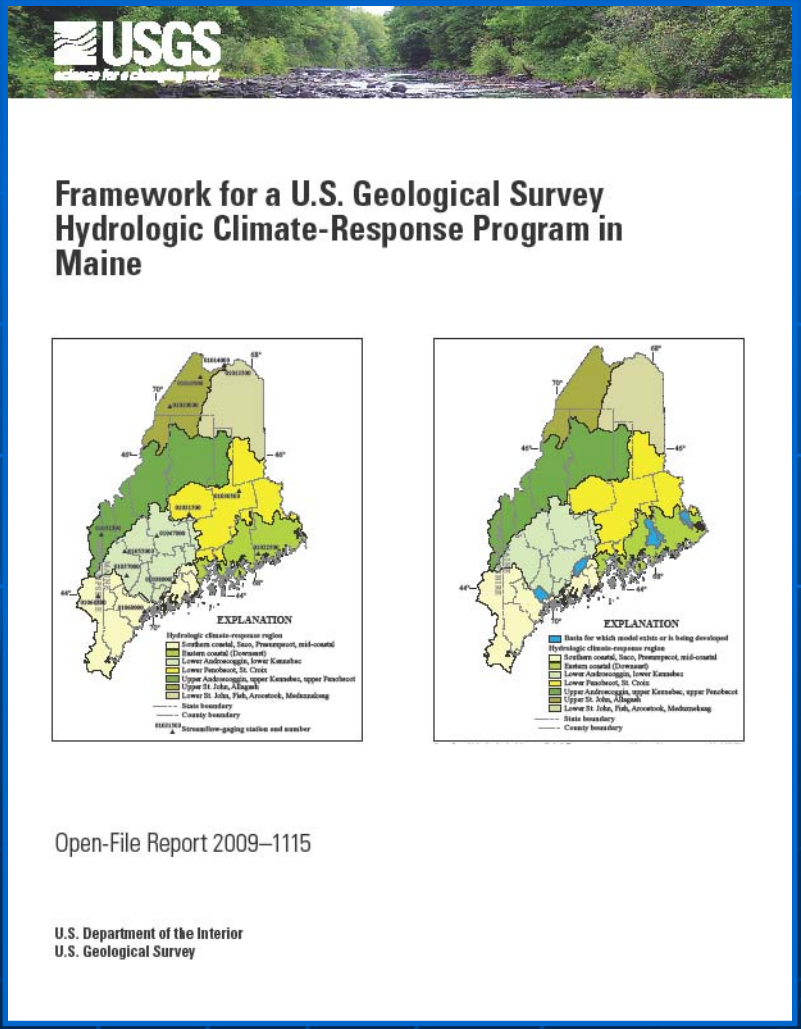
- **Develop a strategy for reporting results**



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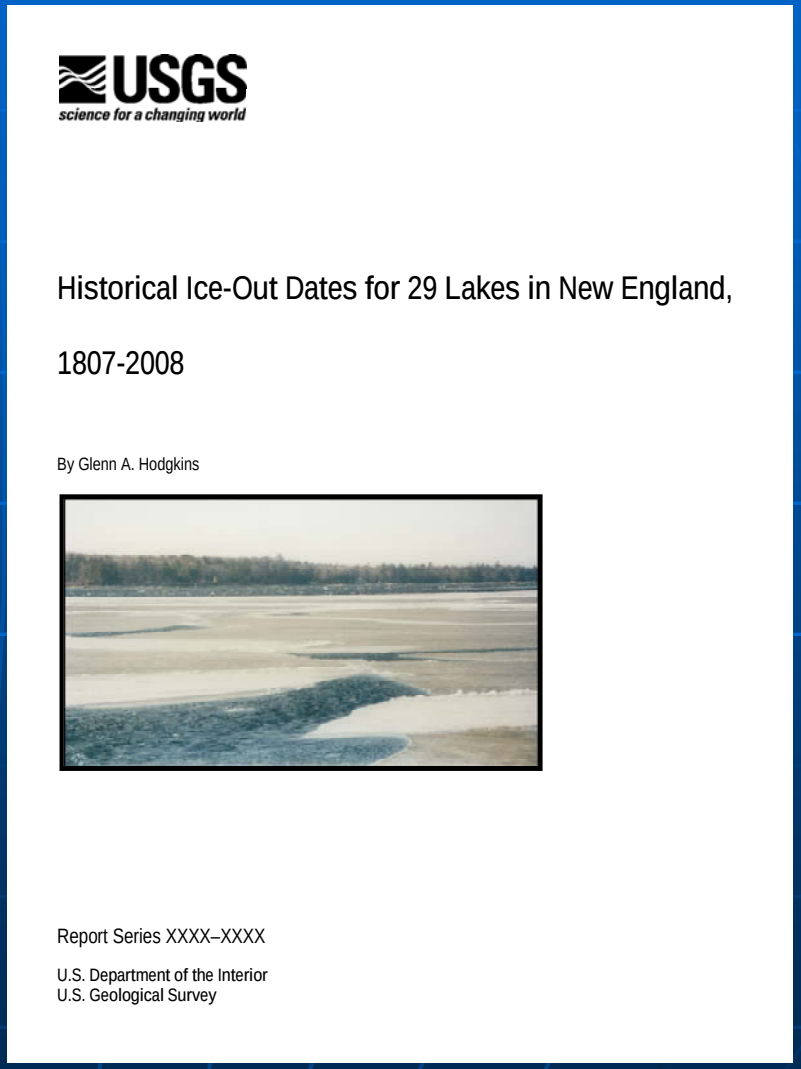
Strategy for Reporting Results

- Produce annual report updating results from at least one key variable
- Incorporate results into existing publications
- Develop web-based products



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Interaction between Climate Response Network and Watershed Models

- Hydrologic Climate Response Network provides:
  - Key hydrologic variables sensitive to climate changes
  - Temporal and geographic context
- Calibrated watershed models provide:
  - Ability to make projections
  - Means to link climate and hydrology to ecological models
  - Evaluation of key hydrologic variables
  - Guide for process-based studies
  - Temporally and spatially explicit water budgets

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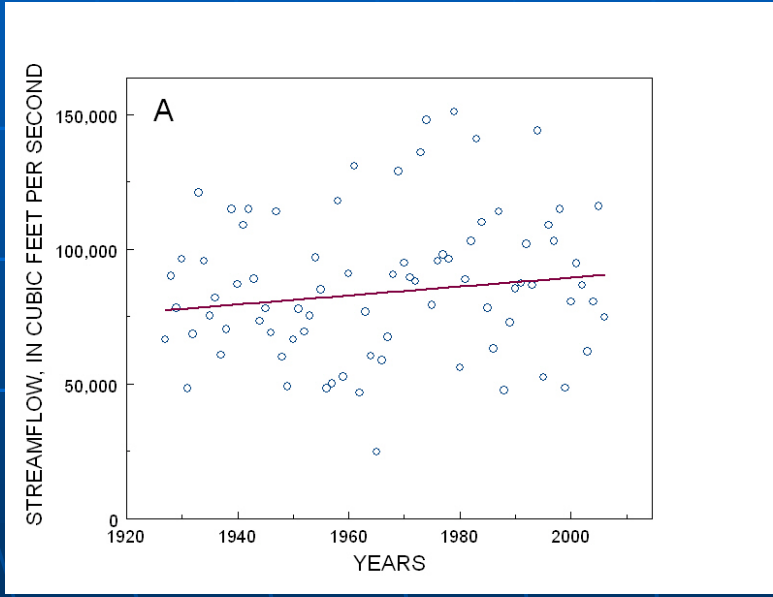
Effect of Historical Climate Change and Variability on Design Flood Flows in Maine

- **HCRN key variable:**
  Annual peak flow



- **Resources impacted:**
  Bridges and culverts

- **Resource agencies:**
  Maine DOT, Acadia National Park

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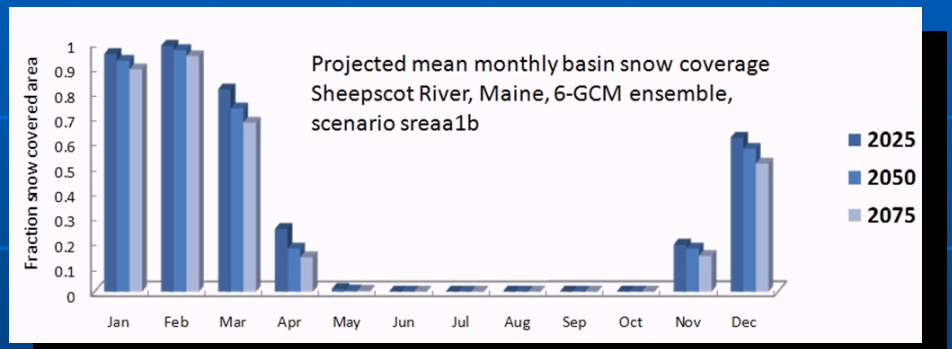
Effect of Future Climate Change and Variability on Design Flood Flows in Maine

- **HCRN key variable:**
  Annual peak flow



- **Resources impacted:**
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- **Resource agencies:**
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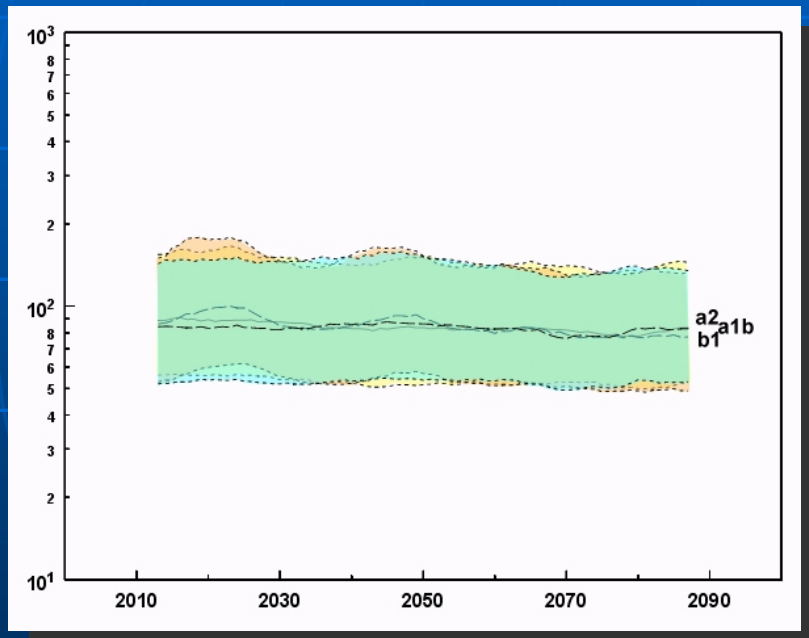
Effects of Climate Change on Low Flows and Water Temperatures

- HCRN key variable:
  Summer baseflows



- Resources impacted:
  A. Salmon survival during summer low flow conditions
- Resource Agencies:
  NOAA-NMFS/USFWS/MDMR

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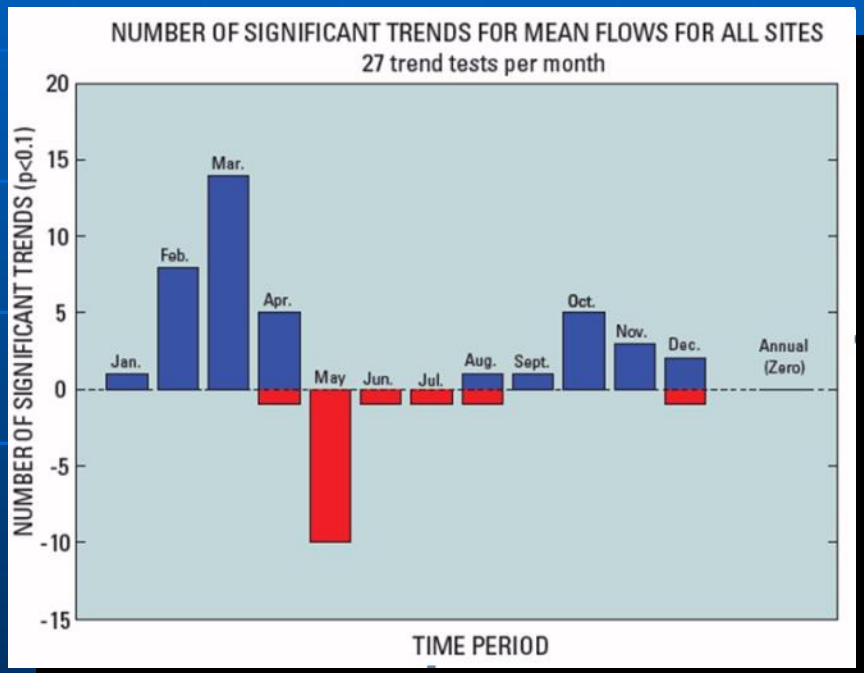
Timing of Snowmelt Runoff in Downeast Rivers

- HCRN key variable:
  Winter/spring runoff



- Resources impacted:
  Timing and success of Atlantic salmon smolt migration
- Resource Agencies:
  NOAA-NMFS/USFWS/MDMR

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Snowpack and Forest Carnivores

- HCRN key variable: Snowpack density and depth

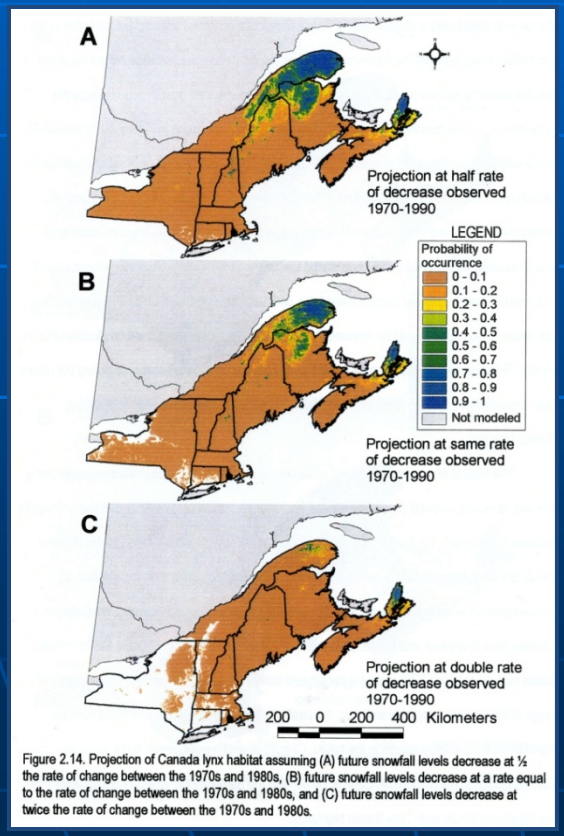

Figure 2.14. Projection of Canada lynx habitat assuming (A) future snowfall levels decrease at ½ the rate of change between the 1970s and 1980s, (B) future snowfall levels decrease at a rate equal to the rate of change between the 1970s and 1980s, and (C) future snowfall levels decrease at twice the rate of change between the 1970s and 1980s.

- Resources impacted: Canada lynx and snowshoe hare
- Resource agency: U.S. Fish and Wildlife

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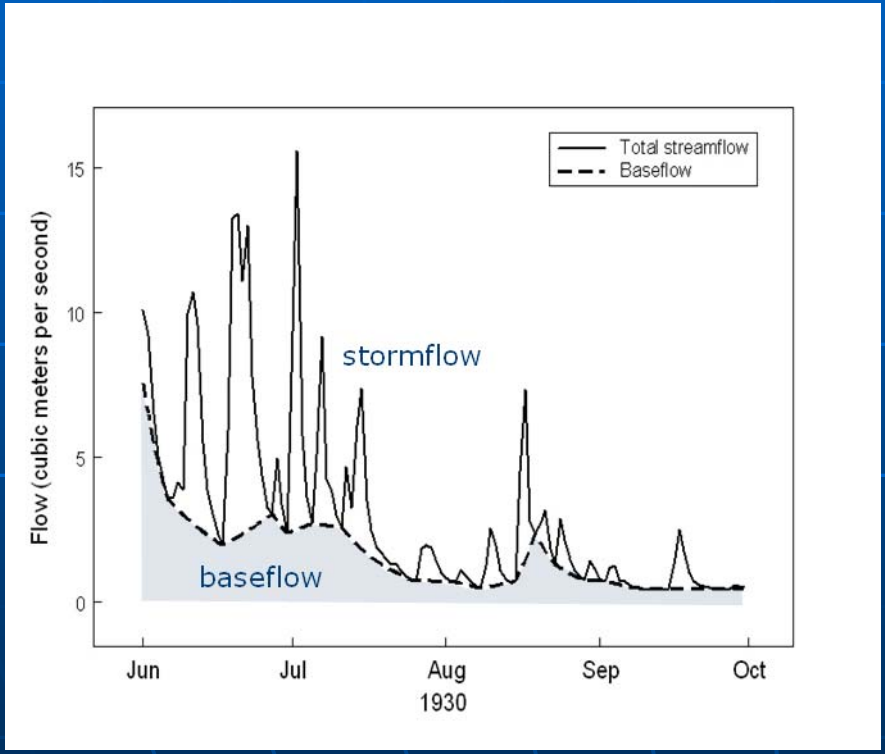
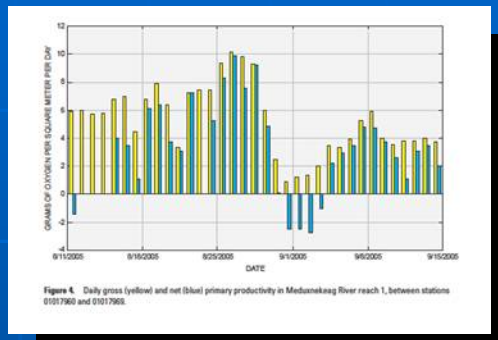
Community Metabolism in Freshwater Streams

- **HCRN key variable:** Summer baseflows





- **Resources impacted:** Primary productivity and community respiration in the Meduxnekeag River
- **Resource agencies:** Houlton Band of Maliseet Indians, BIA

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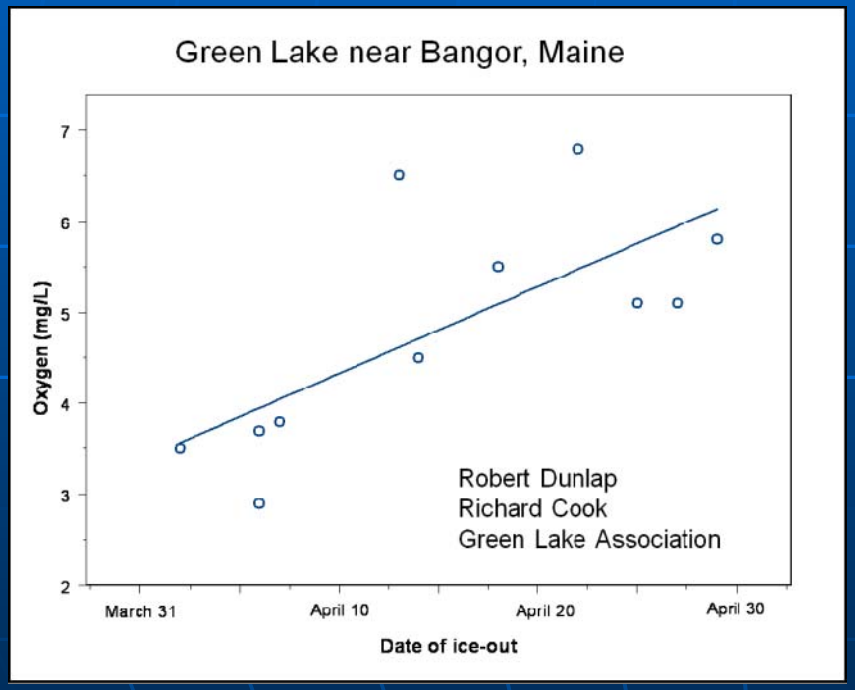
Effects of Climate Change and Eutrophication on Hypolimnetic Oxygen Demand in Lakes

- HCRN key variable:
  Lake ice-out date



- Resource impacted:
  Hypolimnetic Biota
- Resource agency:
  Acadia National Park

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Climate Response Program Goals

- Provide systematic information to resource managers
- Provide an early warning of hydrologic response to climate change
- Provide locations for place-based research

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Hydrologic Climate Response Program Lessons Learned

- Climate-driven changes in response variables have temporal and geographic patterns
- Different regions, even adjacent regions, may have different response variables
- Different spatial scales may have different response variables

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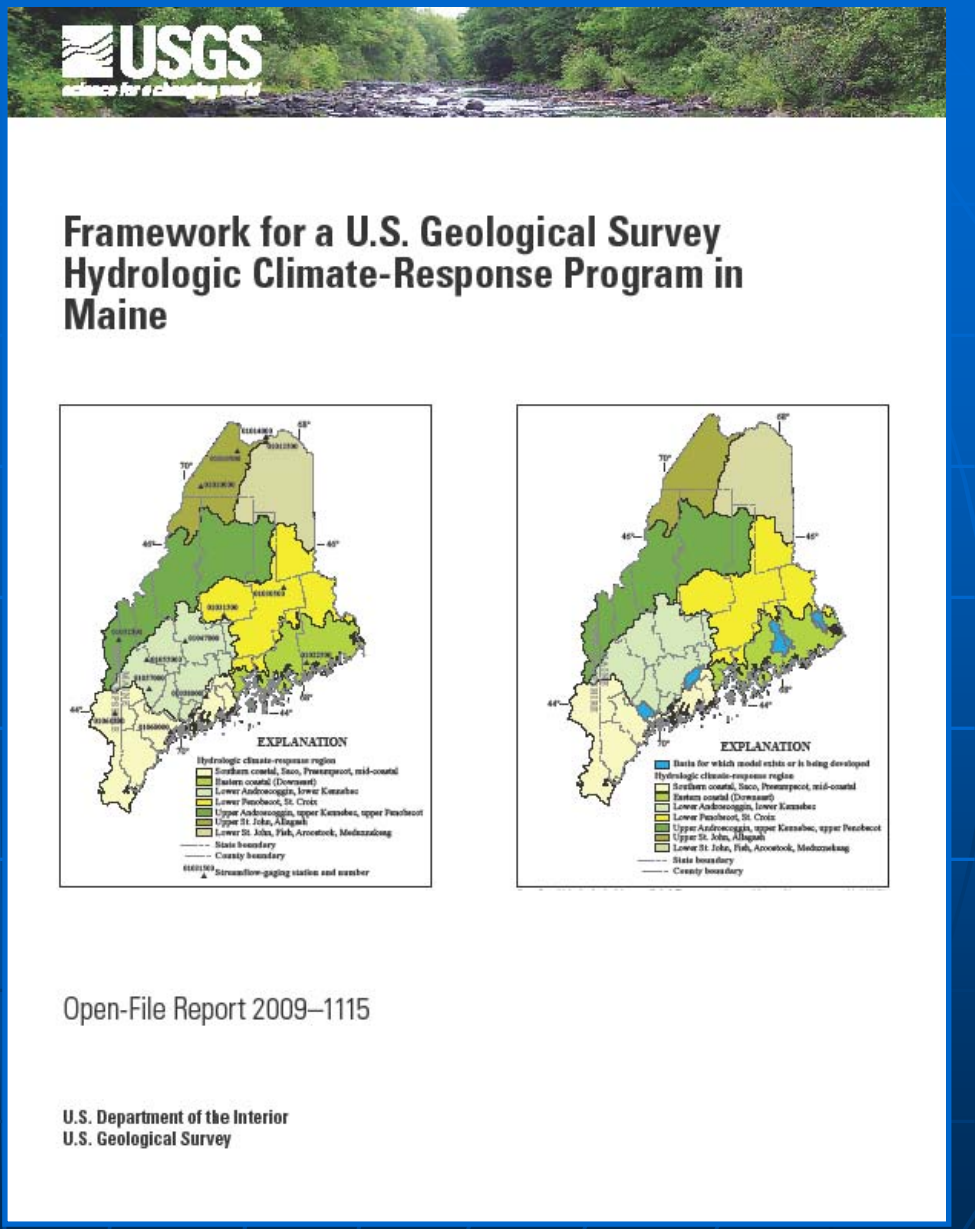
- Contact information
  rmlent@usgs.gov
  207-622-8201 ext. 102
- Full report:
  http://pubs.usgs.gov/of/2009/1115/
- Fact Sheet:
  http://pubs.usgs.gov/fs/2009/3044/
- All reports and info:
  http://me.water.usgs.gov/



Hodgkins, Lent, Dudley, and Schalk, 2009

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