Climate Change & Infrastructure Resilience
Gro-WA Work Component E

Introduction

Climate change, the long-term broad patterns of weather, is happening in Maine (http://gro-wa.org/climate-change-impacts). It is well documented[1] by more frequent and stronger storm events, higher tides, hotter summers, greater precipitation, shifting ranges of plant and animal species, expanded ranges of southern pests and disease, rising sea levels and acidification of the waters of the Gulf of Maine.

The short and long term impacts associated with climate change are significant and far-reaching. Storm severity and frequency has and will continue to cause flooding, erosion and property damage. Sea levels will rise at an accelerated rate and threaten coastal infrastructure including roads, rail, working waterfronts, water and sewage treatment plants and many downtown centers. The temperature and salinity of the Gulf of Maine is reducing the productivity of the entire aquatic food chain with significant declines in zooplankton and stresses on shellfish. Pest species like Lyme disease bearing ticks are reaching further north as winters become milder. Agricultural production is threatened with both drought and extreme precipitation as well as pests and pathogens. In addition to the arrival of new pest species like the southern blueberry gall midge, the Colorado potato beetle, which complete one full generation per season in Maine under current conditions, may complete multiple generations (as they do in Massachusetts and Connecticut) under warmer temperatures and a longer growing season. The forest products industry might benefit from higher growth rates for some species. However a longer mud season and shorter periods of hard freeze will reduce harvest opportunity and large shifts in species composition (from insect, disease, or dieback) could ripple across the forest products industry. The public health impacts are also a concern, particularly for the elderly or infirm, as extreme temperatures increase risk of heat stroke and, during coastal flooding, isolation from services or emergency response. Natural systems also face loss of wetlands and wildlife are exposed to exotics and temperature-related stress.

Some changes may bring more tourism to Maine; increase forest productivity (and carbon sequestration), and increased variety and security in food production. All of these changes must be monitored and strategies adopted to adapt and reduce our vulnerability to their most dangerous effects.

Climate vulnerability assessment (http://www.gro-wa.org/climate-vulnerability-assessment) is a collection of tools and analyses used to understand how we are vulnerable or resilient in terms of impacts on people, infrastructure, public health, natural systems, and the economy. It asks what systems, species, populations, entities, etc. are most vulnerable to expected climatic changes, often depending on factors such as exposure, sensitivity, and adaptive capacity.

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[1] *Maine's Climate Future* An Initial Assessment; February, 2009. University of Maine; People and Nature Adapting to a Changing Climate - Charting Maine's Course, February, 2010 – a Summary of the Report Presented by the Maine Department of Environmental Protection to the Joint Standing Committee on Natural Resources of the 124th Legislature

Climate Change & Infrastructure Resilience
Gro-WA Work Component E

Geographic information systems (GIS) mapping tools are a powerful means of visualizing our vulnerability, recognizing the gaps in our understanding of our vulnerability, and focusing our efforts on gathering necessary information and preparing for risk and change.

Findings

In the fall of 2013, the Washington County Council of Governments, working in cooperation with the University of Maine at Machias GIS Service Center presented a series of 5 town- and bay-specific climate vulnerability assessment (CVA) that anticipate a variety of storm impact scenarios (http://gro-wa.org/washington-county-climate-change-response). The GIS Service Center adapted the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model, a computerized numerical model developed by the National Weather Service (NWS)[2] to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account atmospheric pressure, size, forward speed, and track data. The SLOSH model is applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, levees and other physical features.

The bay-specific CVAs were based on SLOSH model output of a hypothetical but entirely plausible hurricane that makes landfall in Penobscot Bay. The five CVA presentations identified vulnerable infrastructure and vulnerable populations for first responders and public works personnel and sought their input and feedback for refinement of the assessments.

The data used to perform the GIS analyses represents the culmination of several years of partnership between WCCOG and UMM prior to and including the support of the GROWashington-Aroostook regional planning grant. In the past decade, we have implemented several regional planning projects that have received widespread support and practical use, including a regional conservation strategic plan, an inventory of scenic resources, low-cost shoreland zoning maps and ordinances for small municipalities, and digitizing tax parcel maps for use in land use planning. Not only has this work increased the capacity for planning in this rural region, it has laid the foundation for the work of the Gro-WA project, including data resources, expertise, working relationships, and trust among planners, municipal and county officials, researchers and the public.

Until mid-2012 our only source of flood mapping information, the FEMA flood maps, was useless, at best, and expensive and dangerous, at worst, because of error and imprecision. By May of 2012 we obtained the precise LiDAR (light detection and ranging) elevation data for use in the elevation model (at least along the immediate coast). This allows us to make a much more accurate assessment of what actually is vulnerable to flooding for the coastal areas. We do not use the FEMA floodplain data for our analysis for storm surge and will not use it for models of river flooding unless FEMA comes up with better data.

The UMM-GIS Service Center uses, and seeks continual improvements in, the ESRI ArcGIS and Global Mapper software and is producing graduates with high level GIS credentials for the Maine workforce.

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[2] According to the NWS, the surge height predictions from the SLOSH model are accurate to within +/- 20% for storms that follow the track and force patterns within the model. National Weather Service Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Model. 2013.
http://www.nhc.noaa.gov/surge/slosh.php

Climate Change & Infrastructure Resilience
Gro-WA Work Component E

The final innovation, completed by the end of 2013, was to host all of the parcel maps, vulnerable infrastructure, and coastal inundation scenarios on-line (see: http://www.gro-wa.org/washington-county-climate-change-response). This allows municipal officials to run alternative scenarios in their towns according to their own assumptions of tidal height (medium and high) and storm intensity (Category 1 through 4).

Analysis and Basic Conclusions
The utility of the CVAs to property owners, municipal officials and first responders is not to predict the exact height of water or the date a storm will arrive – they cannot know this. These are scenarios based on a single modeled storm hitting Penobscot Bay; actual conditions depend on wind speed, direction, and the track of the storm, largely random variables. The vulnerability of Washington County is high when we are eastward of a Penobscot Bay hurricane landfall as the highest winds are on the east side of the storm and drive storm surge from the south to the northern ends of the long bays situated between our southern oriented peninsulas.

The CVAs provide scenarios of possible impacts from severe storms. Each time a storm takes aim at Maine, we roll the dice. Most of the time, we win the toss and the conditions are such that we don't see major impacts. Sooner or later, we'll lose the toss. With climate change, we'll be rolling the dice more and more often (more storms), and the stakes will get higher (stronger storms). Add sea level rise to that, and you raise the stakes even more. Vermont and NYC have recently lost the toss. Neither place had seen a storm like Irene or Sandy in recorded history, but they could have predicted the impacts of those storms. In the case of NYC, at least, they had SLOSH model storm scenarios that looked exactly like the impacts of Sandy.

The initial CVA outreach strategy put a focus on first responders and municipal officials in charge of roads and public services. Feedback directed us to add the following information to the scenarios and CVAs:
  • single and 3 phase electric utility infrastructure,
  • culverts (more inventory work needed),
  • working waterfront (led to a successful Coastal Communities grant to extend the inventory),
  • historic storm surge heights,
  • public and private fuel storage facilities,
  • vulnerable populations (additional inventory needed; confidentiality provisions) and,
  • specific adaptation, preparation and response actions.

All audiences were very interested in having on-line access to the data and the mapping scenarios. In addition to on-line access to the inundation scenarios we completed a users guide to assist anyone with navigation and running of alternative scenarios. Towns who request one we receive a town-specific Climate Vulnerability Assessment (http://www.gro-wa.org/washington-county-climate-change-response).

Suggested Actions
Feedback from first responders indicated that they will pre-position equipment to areas that will be cut off during a storm. Road commissioners will also examine the structural soundness of vulnerable roadbeds to minimize permanent washouts as a result of inundation.

There is a range of adaptation responses that landowners, businesses, and municipalities can

Climate Change & Infrastructure Resilience
Gro-WA Work Component E

take to limit exposure to our vulnerabilities (http://gro-wa.org/adaptation-to-climate-change-impacts). These include:

For any and all concerned:
- train all personnel on use of on-line scenario mapping tool
- always document impacts from severe storms (Damage and Injury Assessment AKA "Form 7" & photos)

For storm adaptation:
- evacuation and shelter planning including in real time
- establish communications protocol between UMM-GIs Service Center Director and County EMA Director to ensure real time scenario development in event of actual predicted hurricane in the Gulf of Maine
- pre-position equipment to areas that will be cut off during a storm
- print alternative scenario maps
- map house bound and elderly residents; add to CVA

For roads, bridges and transportation:
- Inventory transportation infrastructure
- Participate and update in culvert mapping inventory
- Keep sand & salt piles above flood levels
- Improve stormwater capacity
- Improve culverts, flow under causeways
- Evaluate substructure of roadways most vulnerable to inundation

For municipal officials:
- Limit building in flood prone areas
- Adopt construction codes for coastal properties
- Maintain wetlands and floodplains to absorb flood waters

For Public Health:
- Plan for heat emergencies
- Distribute education about pest borne illnesses especially Lyme disease; translate into Spanish
- Assist elders and low income households with air conditioning/cooling

For Fisheries, Wildlife, Agriculture and Forestry:
- Several adaptation options are noted in the CVAs though biological impacts go beyond the scope of this task (Climate Change and Infrastructure Resilience) in the GROWashington-Aroostook initiative.

Implementation already occurring

The Climate Vulnerability Assessments and on-line access to the inundation scenarios will be complete by March 2014. While under development we asked for detailed feedback and for new information to help us in our research and reporting, such as reports of past storm surges or changes people have observed while working on the water. Also, we provide our contact information and often meet and correspond with attendees after the initial meetings. CVAs and related web-based maps are were created to reflect the needs and concerns expressed. We also make clear to community partners that we are committed to supporting long-term and real-time decision-making related to climate vulnerability.

Climate Change & Infrastructure Resilience
Gro-WA Work Component E

We are actively cultivating funding sources to support local planning for adaptations to climate change. WCCOG obtained a Coastal Communities Regional Planning Grant from the Maine Coastal Program to further the work of the CVAs to the working waterfront infrastructure of Washington County's primary harbors. WCCOG also helped the towns of Perry and Pembroke to obtain and Shore and Harbor Planning grant to complete mooring ordinances and assist with GIS mapping of mooring infrastructure.

Past and on-going outreach (http://www.gro-wa.org/new-england-collaborations) is linking the GROWashington-Aroostook efforts to those of the New England region. Tora Johnson and Judy East attended the EPA New England-sponsored "*Preparing for Climate Change Leaders Summit*" on November 8, 2013 in Providence RI. Several others attended from Maine including Maine DEP Commissioner Patricia Aho, Maine DEP Sustainability Coordinator George MacDonald, and Maine State Geologist Pete Slovinsky.

The Summit yielded 6 Action Teams, with associated "Champions" to work collaboratively on the Summit goal "To launch collaborative actions from regional leaders that will make New England municipalities resilient to climate change":
A. Vulnerability Assessment and Resilience Planning: Laboratory and Road Map
   Champion – Macky McCleary, CT DEEP and Jane Downing, EPA New England
B. Commissioner Convened State Roundtable with Federal Partners to Coordinate Assessment Resources
   Champion: Ellen Mecray
C. Integrate Adaptation Planning into Business as Usual staring with Public Safety
   Champions: Judy East, Washington County Council of Governments, ME; Martin Pillsbury, Metropolitan Area Planning Council (MAPC) Boston MA
D. Common Data Platform for New England
   Champions: Cameron Wake,(UNH; Paul Miller, NESCAUM; David Grass, VT DPH; Keith Robinson, USGS; Linda Sohl, Columbia University; John Daigle, UMaine
E. Multi-level communication initiative: Making Climate Impacts and Solutions Local and Personal
   Champions - Nick Cohen,(NEIWPCC ;Jonathan Stone,(Save the Bay; Christa Daniels,(Antioch University
F. Public-private workgroup to scope smarter spending on resilient infrastructure
   Champions: Ken Moraff, EPA; Deb Markowitz, VT DEC:

All of the Action Teams will convene at the Local Solutions: Northeast Climate Change Preparedness Conference (http://www.antiochne.edu/innovation/climate-change-preparedness/) in Antioch NH on May 19-21.

Tora Johnson and Judy East have shared and will be sharing the tools and results of the Climate Vulnerability Assessments at several other conferences in 2014 including:
- Machias Rotary Club on "Risk of Floods from Rain and Storm Surges"; October 15, 2013
- Keynote presentation to the joint conference of the Maine GIS Users Group and Maine GIS Educators "21st Century Tools for Rural Maine: GROWashington-Aroostook.", Augusta, ME; November 25, 2013
- Maine Harbor Master's Association Training Program, Castine, ME; March 19, 2014)
- Luncheon address at the Maine Municipal Association's Technology Conference, Portland ME; May 1, 2014

Climate Change & Infrastructure Resilience
Gro-WA Work Component E

(http://www.memun.org/2014TechnologyConference/Agenda.aspx)
- Proposed session: Northern New England Chapter of the American Planning Association, Stowe VT; September 11-12, 2014 (http://nnecapa.org/resources/2014-nnecapa-annual-conference-stowe-vt/)

Additional resource needs
While a survey is currently circulating among municipalities in Washington County to assess the state of existing culvert inventories, funding is needed to complete culvert mapping. Funding to extend the CVA to capture river flooding as it affects inland areas and adds to the surge analyses along the coast. Will require extended inland LiDAR flights and/or additional stream gauge installations.

Likewise current GIS database tell us the locations of some elderly housing complexes, day care centers, and emergency facilities. However additional resources and local knowledge is need to accurately map house-bound individuals.

As part of her PhD dissertation research UMM GIS Service Center Director Tora Johnson will conduct follow up to measure the efficacy of the CVAs in 1) communicating information about climate issues, 2) providing effective support for local decision makers, 3) engendering trust among the audience, and 4) inspiring changes in behavior and local actions to plan for climate change. The study will compare the results in towns in Washington County that did take part in the development of a CVA with those who did not. The study will use primarily qualitative methods, including surveys, comparative case studies, and focus group interviews.