Forest and Water Climate Adaptation:
A Plan for Bath, Maine

Bath Conservation Committee
Author-Samantha L. Ricker

Model Forest Policy Program | Cumberland River Compact

Foreword

In 2011, the Model Forest Policy Program (MFPP), the Cumberland River Compact, and the Bath Conservation Committee came together to create a climate adaptation plan for the community of Bath, Maine. Development of the plan came about because all parties, led by MFPP, recognized the critical need for local community resilience against the impacts of climate change by protecting forest and water resources. This climate adaptation plan for Bath, Maine presents the results of a community team effort, deep and broad information gathering, critical analysis and thoughtful planning. The Bath Conservation Committee took the local leadership role to engage with the Climate Solutions University: Forest and Water Strategies program (CSU) and lead their community toward climate resilience with an adaptation plan that addresses their local climate risks and fits their local conditions and culture. This achievement was made possible by the guidance and coaching of the Climate Solutions University: Forest and Water Strategies program (CSU) created by the Model Forest Policy Program in partnership with the Cumberland River Compact. The goal of CSU is to empower rural, underserved communities to become leaders in climate resilience using a cost effective distance-learning program. The result of this collaborative effort is a powerful climate adaptation plan that the community can support and implement in coming years. The outcome will be a community that can better withstand impacts of climate upon their natural resources, economy and social structure in the decades to come.

Acknowledgements

Climate Solutions University would not have been possible without the major funding of the Kresge Foundation, which allowed us to develop the in-depth curriculum and provide grants for local community participation. We also gratefully acknowledge the Merck Family Fund for their support of the Tennessee Plan and federal policy project, and the Confidence Foundation for their kind support of program development.

The team that leads the CSU program includes: Nancy Gilliam, Gwen Griffith, Todd Crossett, Toby Thaler, Margaret Hall, Jeff Morris, Hannah Murray, and Dan Schmit.

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Author

Samantha L. Ricker

Editors

Gwen Griffith, Toby Thaler, Todd Crossett, Jeff Morris

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Executive Summary

The impacts of climate change continue to be more evident across the country every year and the City of Bath, Maine is no exception to that trend. Current estimations are that Maine will see annual temperature increases that will shift our seasons over the next century to more resemble the current weather of Maryland. This 3-5 degree Fahrenheit increase will affect not only the quality of life of Bath residents who are accustomed to cool winters and short, mild summers, but it will also directly affect our water resources, forests, natural environment and economic conditions as each is forced to adapt and change to warmer temperatures.

To address the needs of a growing community along with the effects of a warming climate the City of Bath's Conservation Committee applied for and received a grant from the Model Forest Policy Program to participate in the *Climate Solutions University: Forest and Water Strategies Program*. The Committee, led by City Arborist Tom Hoerth, participated in a rigorous 10-month program to assess local climate-related risks and opportunities and create a Climate Adaptation Plan (CAP) that examines the effects of climate on Bath's water, forests, and economics. The CAP process was integrated into the city's larger open space planning process and will guide city policy, planning and growth management going forward for many years to come.

This plan reviews the key climate risk assessment findings for Bath, Maine and the surrounding county and outlines adaptation strategies that can help protect the social, ecological, and economic conditions of the region in the face of the impacts of climate change.

FORESTS

The area surrounding Bath has large forested tracks of lands which will be greatly affected by climate change, as increases in yearly Growing Degree Days (GDD) bring new tree and pest species, and increased precipitation loosens soil and weakens root system efficacy. Bath will have to work with the local landowners to discuss ways to handle this added stress on their forested lands, and to protect the natural environment that surrounds the City. In the process of doing so, new forestry Best Management Practices (BMP's) will have to be identified, developed and adopted.

RISK ASSESSMENT:

- Increased yearly GDD and higher daily low temperatures will have a varied effect on the tree species – some will increase in growth, while others will decrease – which will require a change in management practices.
- Increase in pests and non-native invasive species will challenge the existing native tree species, and potentially limit diversity.
- Reduced Chilling Days will mean a shorter season for winter forestry management.
- Development pressure on the region's forested lands will increase as the population increases, within the greater Kennebec River and Nequasett Lake watersheds.

STRATEGIES:

- Research and categorize current and forecasted invasive pests and diseases, then create prioritization tools to help landowners and city managers develop management & mitigation strategies.
- Map existing forested blocks & land ownership, then work with land owners to incentivize development and conservation of forest connector blocks.
- Broaden the diversity of existing tree stock, while maintaining current stocking levels.
- Identify and adopt new climate-adapted forest BMPs and strategies based on the changing species and increased yearly GDD and longer growing seasons.

WATER

In 2005 the Bath Water District published a Source Water Protection Plan, in order to reduce or eliminate potential and existing risks to Nequasset Lake through a series of public educational workshops about watershed protection. As climate change increases risks to the watershed, such as rural development, excessive runoff, and increased invasive plant and aquatic species, this plan will prove invaluable to the City of Bath as we move forward in the protection of our water quality, and will require constant updates to reflect the changing climate.

RISK ASSESSMENT:

- The increase of acid in ocean waters, due to higher absorption of atmospheric CO2, is lowering the ability for clams, lobsters, and mussels to form carbonate and develop their shells and hard parts.
- Warmer waters have increased the risk of non-native invasive aquatic species and such as Asian shore crab, catfish, and harmful algae blooms (red tide) that pose significant risks on native aquatic species.
- Sea level rise, of an estimated 2 feet by 2100, will flood much of the Kennebec Estuary and cause severe damage to the aquatic ecosystem near-shore public and private infrastructures.
- Increases in precipitation levels in both volume and per storm event, especially during winter months, will affect the quality of drinking water in the Nequasset Watershed, by increasing the amount of spring runoff that will carry altered nutrients and organic matter.

STRATEGIES:

- Map the projected sea level rise on the downtown area and research options to mitigate or manage damage on downtown, while examining the costs of each, in particular the location of the water treatment plant.
- Work with Maine Geological Survey and the Maine Department of Environmental Protection to map out all aquifers, and ask the Bath Water District to help maintain records of aquifers and recharge levels.
- Create a database of current native aquatic fish and plant species, current non-native species and projected non-native species in order to establish management rules and guidelines.

- Implement all aspects of 2005 Bath Water District Source Water Protection Plan and continue to review plan, and develop working relationships with all towns connected to the watershed.

ECONOMICS

Our identity has long been associated with the Bath Iron Works and the history of shipbuilding along the Kennebec River, but as we move forward, we need to expand and broaden this identity. We have industries, like Bath Iron Works and fishing, but we also have a thriving urban center, as well as, agricultural and forested lands along the outer edges. Part of looking forward into the face of climate change is to understand the effects on all three of these aspects of Bath's identity, then building a sense of community around our unique assets that will encourage economic growth, as well as, protect our natural and built environments against some of the aforementioned risks.

RISK ASSESSMENT:

- Increasing sea levels and warming waters will increase severity of storm events, such as Hurricanes, which will cause billions of dollars of damage to the existing built environment, and have a negative impact on tourism and recreation.
- Earlier spring ice-out dates will shorten the ice fishing season, and limit other recreational activities, such as skiing, skating and snowmobiling, etc.
- Increase in severity of storm events could potentially do extensive damage to the City's infrastructure, as well as to the infrastructure around the Nequasset Watershed – roads, culverts and bridges.
- Area agricultural production will change dramatically in the future – increased yearly GDD and longer growing periods will be beneficial to some plants, while others, that require a snowpack in the winter, could suffer winterkill and may not reproduce as well the following spring.
- Shorter winter season and earlier mud season will drastically affect forest management/harvesting activities.
- Increased daily high temperatures in the summer will increase heat-related illnesses, and support invasive disease carrying pests, such as deer ticks, while increasing our risk for infectious diseases.

STRATEGIES:

- Work with the Maine Office of Tourism, Maine Department of Inland Fisheries, Maine Recreation and Parks Association, Main Street Bath, and Kennebec Estuary Land Trust to increase Bath's visibility as a tourist and recreation attraction.
- Develop partnerships and infrastructure to assist in forest management and agricultural activities.
- Provide a forum to connect local fisherman with Maine Sea Grant to protect fishing industry and identify opportunities.
- Educate residents in climate change and affects on health by creating and maintaining a resource website and offering public health classes.
- Research grants and funding for installation of new storm water management practices, and to educate city officials, business owners and residents of the potential damage to infrastructure.

The City of Bath will lead efforts to achieve these adaptation strategies in partnership with numerous agencies and organizations in the region. When all, or some, of the aforementioned strategies are implemented, Bath and the surrounding Midcoast Region will experience a higher quality of life and the assurance of preparedness for the changing climate. Building relationships with organizations, nonprofits, businesses, city officials and residents will help develop a regional network where each community can help create the framework necessary to adapt to the changes we have highlighted above. Most importantly, this plan could help influence regional, state and federal policies about land management and economic development.

Introduction

The City of Bath is located on the Kennebec River in southwestern coastal Maine and is centered in the heart of Midcoast Maine. It is the hub of the region including Bath, West Bath, Phippsburg, Woolwich, Arrowsic and Georgetown and serves as an employment and service center hub for a much larger region of southern Maine. Bath is renowned for shipbuilding, which began here in 1743 when Jonathan Philbrook and his sons built 2 vessels. Since then, roughly 5,000 vessels have been launched in the area, which at one time had more than 200 shipbuilding firms. Bath became the nation's fifth largest seaport by the mid-1800s, producing clipper ships which sailed to ports around the world. The most famous shipyard is the Bath Iron Works. Founded in 1884 by Thomas W. Hyde, it has built hundreds of wooden and steel vessels, mostly warships for the U.S. Navy. During World War II, Bath Iron Works launched a new ship every 17 days. The shipyard is a major regional employer, and operates today as a division of the General Dynamics Corporation.

Bath offers a unique geographic experience not available anywhere else in Maine. It is adjacent to two of the most important ecological systems in the State - the Kennebec River and Merrymeeting Bay. The Kennebec offers unique deep water access in protected river isolation and serves as a conduit for the largest river system in Maine. The water quality is sufficient to provide extensive wildlife support and is particularly renowned for its bluefish and striper runs. The Kennebec flows through and out of Merrymeeting Bay, which is fourteen miles in length and has been identified as being one of the most critical marine estuarine systems in the Northeast. The Bay fulfills an important link in the food chain for the Gulf of Maine and Great Georges Bank. Like the Kennebec, much of Merrymeeting Bay and its environs remain undeveloped.

In 2010 a convergence of opportunities came together for the people of Bath, Maine and the surrounding county region. First the City of Bath convened a Conservation Committee as one of the recommendations in the city's comprehensive planning document. A public invitation was made by Jim Upham, Bath's City Planner, to citizens and local environmental organizations who might work with the City Planning Board to help give advice and guidance in evaluating proposals for growth and development in Bath. At the first meeting, Mr. Upham provided a broad overview of the genesis for convening the committee and identified the charge the group would address. It was decided that meetings would be held on the last Tuesday of every month and as an initial project, to develop an Open Space Plan for the City Planning Board and City Council to adopt. The skill sets necessary to fully evaluate applications presented to the Bath Planning Board have increased such that the Board needs to call on a wider reach of professionals, City Staff and other recognized consultants and experts to provide consultation and to advise on how best to assess and weigh the merits of an application with the goals the Board has adopted for how Bath wishes to grow and develop. Initial meetings had the committee review existing Open Space plans and similar, local documents as well as having state and regional speakers discuss the process of developing such a plan.

Later in 2010, the City of Bath applied for and was accepted into the Model Forest Policy Program's *Climate Solutions University: Forest and Water Strategies Program* (CSU). The CSU program was identified as a resource to provide guidelines of a process that would realize a deliverable plan in a timely

manner, through on-line collaboration and instruction as well as feedback, homework and access to resources and information that would allow for a comprehensive consideration of all the moving parts to be included in such a plan, as it relates and pertains to the impacts of climate change on the Bath/Mid-Coast region and its resources. Such a Climate Adaptation Plan (CAP) would become part of a broader Open Space Plan, and would be the initial project for the group to undertake. The City was awarded entrance into the CSU and has worked with their curriculum and instructors over the 10-month program in 2011. The committee continues to meet monthly and will use the momentum of the CAP development to continue on to implement the recommendations in the CAP and expand it into an Open Space Plan.

This CAP could not have been completed without the thoughtful in-put, perspective and consideration of many people so that the Bath/Mid-Coast region would have the information and tools necessary to direct and inform local governments and organizations on how best to sustain and manage their natural resources and to assist those living in the region to make considered, informed decisions.

The Bath Conservation Committee

* Samantha Ricker, Kennebec Estuary Land Trust
* Thomas Hoerth, Bath City Arborist & Tree Warden
* Brenda Cummings, Bath Assistant City Assessor
* Jim Upham, Retired Bath City Planner
* Andrew Deci, Bath City Planner
* Steve Balboni, Bath Parks & Recreation Department Director
* Fred Cichoki, The Chewonki Foundation
* Jaqueline Dwinal, Small Woodlot Owners Association of Maine
* Lori Morse, Bath Citizen
* Steve King, Bath Citizen
* Mary Ellen Bell, Maine Volunteer Lake Monitoring Program
* Nancy Perkins, Bath Cool Community
* Bill McElman, Bath Citizen
* Beth Haskell, Bath Community Forestry Committee
* Ed Benedikt, Bath Citizen

Climate Adaptation Plan Advisory Team Members

* Susan Breau, Maine Rural Water Association
* Ed Freidman, Friends of Merrymeeting Bay
* Don Kale, Maine Department of Environmental Protection
* Julia Coes, Couture, Bath Water District
* Paul Anderson, Maine SEAGrant Program
* Robert Roper, University of Maine System
* Ken Canfield, Maine Forest Service
* David Vail, Bowdoin College (ret.)

Summary of Climate Change Likely in Bath, Maine

WHAT IS CLIMATE CHANGE?

Climate Change is the term used to explain natural and human-made effects on the global atmosphere that leads to increasing global average temperatures resulting in significantly altered weather systems and other ecological effects. Climate change, according to the Intergovernmental Panel on Climate Change (IPCC), "refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persists for an extended period".[1] The climate changes naturally, but with increases in human-made greenhouse emissions into the atmosphere, the current rate of change is faster than the natural world can adapt to. This plan is a guideline for the City of Bath to encourage and support adaptation to climate change by evaluating our current natural landscape, understanding how climate change will affect it, and establishing a system of actions and responses that will protect our community and allow us to continue to live reasonably within the projected changes.

The Earth is considered a closed system because it, and its atmosphere, is enveloped in a protective layer that lets energy in, while not letting all of it out. This protective layer is like the cloudy film you can put over windows for privacy – the sun's Ultraviolet Rays get through, but the filtering keeps the intensity to a tolerable amount. (See Figure 1.) The atmosphere is the most important part of our planets' system, but our current human activities are putting it at risk. The burning of fossil fuels coupled with deforestation is releasing Carbon Dioxide (CO_2) into our atmosphere at increasing rates with predictable and measurable consequences.

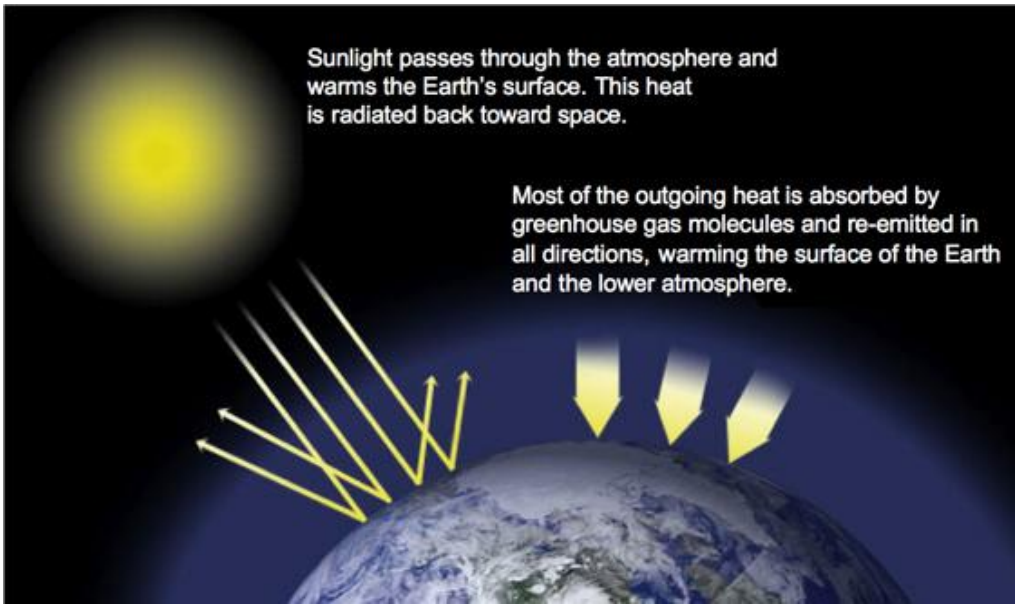


Figure 1: NASA's image of the atmosphere as a blanket around the Earth.
Photo Source: National Aeronautics and Space Administration

[1] IPCC, 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

It is estimated that with our current rates of CO_2 emissions, by 2100 the Earth's surface temperature will go up anywhere from 2° to 10° F.[2] According to the IPCC, global air temperatures have already increased by 1.3°F between 1906 and 2005, with most occurring in the last half of the 20th Century.[3] The IPCC has determined with nearly 100 percent certainty that the increase in temperatures and CO_2 in the atmosphere can be directly attributed to human activities.[4] Greenhouse gases, like CO_2, can be directly attributed to activities such as the burning of fossil fuels, industrial smog, large scale agricultural practices, deforestation, and population growth.

There are two options when dealing with climate change. One is to mitigate the changes by reducing greenhouse gas emissions in order to reduce the severity of climate change. One way to tackle mitigation is to actively alter the human behaviours that are affecting the natural world. The City of Bath has already put a plan in place that attempts to do that in their 2008 Bath Energy Plan, which establishes municipal and residential recommendations for energy use.[5] Mitigating climate change through this type of plan is an attempt to slow and reverse the effects of such change by pinpointing impacts that can be avoided through shifts in human behaviours.

The second option to deal with climate change is through adaptation strategies, which analyze the effects of climate change and prepare for the impacts that cannot be avoided. These adaptation activities can include a variety of methods such as protecting natural forest and water resources, promoting smart growth and low impact development, preparing for extreme weather events, enhancing public health systems to deal with changing disease patterns, and adapting farming systems to new water and climate conditions. The best possible scenario is to implement both mitigation and adaptation within a community, in order to ameliorate and deal with currently observed and forecasted changes.

CLIMATE CHANGE EFFECTS

In the dozen years between 1995 and 2006, eleven of those years rank among twelve of the warmest years since 1850, when global surface temperatures began to be measured by instruments.[6] In the Northeastern United States since 1970 there has been a 0.45°F average temperature increase every decade, with the surface temperatures of Maine's coastal waters increasing almost 2°F.[7] (See Figure 2) As ocean waters begin to warm, this is causing thermal expansion, which will increase sea levels by a projected 2 feet by the end of the century.[8] In addition, melting of the Greenland and Antarctic ice caps is adding to global sea level rise.[9] As sea levels rise, the result is expected storm surges that push salinity further up-river in up-stream coastal communities, drastically affecting quality of water, native aquatic species, and altering estuaries and surrounding marshlands. Built infrastructure along coastal areas will also be impacted by rising incoming tides and increasing storm events.

[2] Harrison, R.M. (1999), p. 17
[3] IPCC, 2007
[4] IPCC, 2007
[5] http://www.cityofbath.com/gov_documents_area26.html
[6] IPCC, 2007
[7] http://climatechange.umaine.edu/files/Maines_Climate_Future.pdf
[8] http://ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-es-8-sea-level.html
[9] Mernild, (2011)

The IPCC points out that warmer global temperatures mean more frequent and extreme weather events. They state that cold days, nights, and frosts are being experienced less frequently, while hot days and nights are becoming more frequent. More areas are experiencing longer and more frequent heat waves and increased precipitation events, and the likeliness of extreme sea level rise is being seen in a broad range of sites worldwide. Tropical Cyclonic activity has increased in the North Atlantic since 1970, and average temperatures in the Northern Hemisphere during the last 50 years were higher than any other 50 year span in the last 500 years.[10]

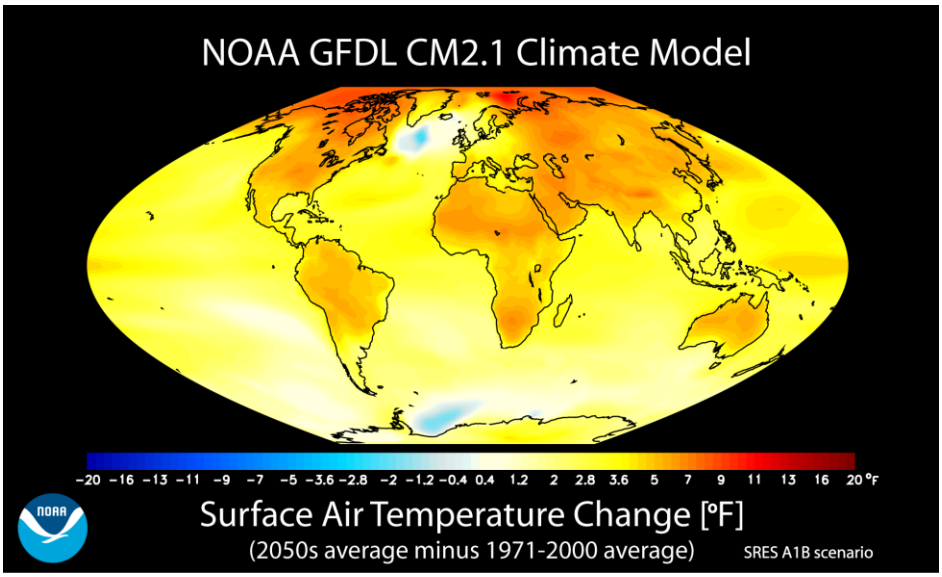


Figure 2: National Oceanic and Atmospheric Pressure Association model of projected global surface temperature changes due to climate change activities. New England can expect anywhere from a 2 to 5 degree increase on land and water.
Photo Source: National Ocean and Atmospheric Administration

In looking at changes in temperature and the impact on the region, a consideration of this change will be the increase in Growing Degree Days (GDD) over the course of a year, as well as, changes in Chilling or Dormant Rest Requirements. Growing Degree Days are a measure of heat accumulation used by horticulturists, gardeners, and farmers to predict plant and pest development rates. Nature rebels at any attempt to match seasonal changes to a calendar. Every year is different for every region and there are too many variables to say that Codling Moth, for example, will hatch on May 17 every year. Most accurate predictions are based on accumulated GDD, often called thermal units. Both of these degree days are estimates of plant or insect growth based on ambient temperature measurements. One (1) degree day is accumulated for each degree above a base temperature for each day. Thus, if 40° F is the base temperature, and the average temperature is 65° F, 25 degree days will have accumulated during that day. It is safe to predict that apple trees will bloom when 430 degree days above 40° F have accumulated.

[10] IPCC, 2007

Likewise, the amount of cold needed by a plant to resume normal spring growth following the winter dormancy period is referred to as it's Chilling Requirement. During the fall and winter, deciduous perennial plants enter a dormant period, which is generally referred to as the plants' "rest period." Plants enter the rest period in the fall as air temperatures begin to drop below 50°F, leaf fall occurs, and visible growth ceases. Another less visible change takes place as well. Plants enter the dormant, or rest period, as the level of growth-regulating chemicals in buds changes. In other words, as the growth-regulating inhibitors increase and the growth-regulating promoters decrease, plants begin their dormant period. As the chilling requirement of a plant is being satisfied by cold temperatures, the level of promoters begins increasing while the level of inhibitors decreases. The higher levels of promoters in the buds allow normal resumption of growth and flowering in the spring as the chilling requirement is met. The type of cold temperatures needed to satisfy the rest requirement of plants has been carefully studied, especially in fruit trees, but more studies are needed looking at a wider range of plant material, so as to better understand the changes in GDD. The most efficient temperature at which a plant receives chilling is 45°F. Temperatures of 32°F and lower contribute little or nothing to the actual chilling being received by the plant. And daily temperatures of 70°F and higher, for 4 or more hours, can actually negate chilling that was received by the plant during the previous 24 to 36 hours.[11]

There are two aspects of all this that will impact plant species and how they react to climate change. There will be an increase in the total number of degree days over the course of a year. This will cause a lot of species to not be able to sufficiently harden-off buds for the winter rest period, as well as, not provide a long enough chilling period to allow normal bud development in the ensuing growing season. Species more adapted to this kind of yearly growing conditions will be favoured, while species found in northern areas will not be as successful and may be out competed by more successful southern varieties.

EFFECTS OF CLIMATE CHANGE IN BATH

The effects of climate change, whether from human activity or natural, will drastically change the physical landscape of Bath, such as the surrounding estuaries, the level and use of the Kennebec River, the urban and rural forest and agricultural lands, and the native species of plants, trees, insects, birds and fish. Current estimates are that Maine will see annual temperature increases that will shift our seasons over the next century to more resemble the current weather of Maryland.[12] This 3-5 degree Fahrenheit increase will affect not only the quality of life of Bath residents who are accustomed to cool winters and short, mild summers, but it will also directly affect our water resources, forests and natural environment as each is forced to adapt and change to warmer temperatures.

Although Bath is surrounded by water, both fresh and salt, the obvious climate change affects on that water puts us a great risk. The community needs to begin planning for the future of these water systems in order to maintain the health and comfort of the residents, as well as, the well-being of the plants, animals, birds and sea life that thrive on the water systems, and simultaneously support the physical landscape of the region. Bath is located within the Nequasset Watershed, which is located within the larger St. George-Sheepscot Watershed. This latter watershed is ranked as the top tenth watershed in a recent USDA Forest

[11] Herms, (2004) 49-59.
[12] NOAA, 2007

Service study, of watersheds with the greatest development pressure on private forests important for drinking water supplies.[13] Although for the last century Bath Water District has obtained 100 percent of its water from Nequasset Lake, the 21 square mile watershed actually lies in the surrounding towns of Woolwich (61%), Dresden (32%), and Wiscasset (7%). (See Figure 3) The Bath Water District owns 370 acres of the watershed, including 70% of the lake shoreline, and has worked directly with these other towns to manage development in the area in order to maintain a high quality of drinking water, while still allowing recreation on the lake.[14]

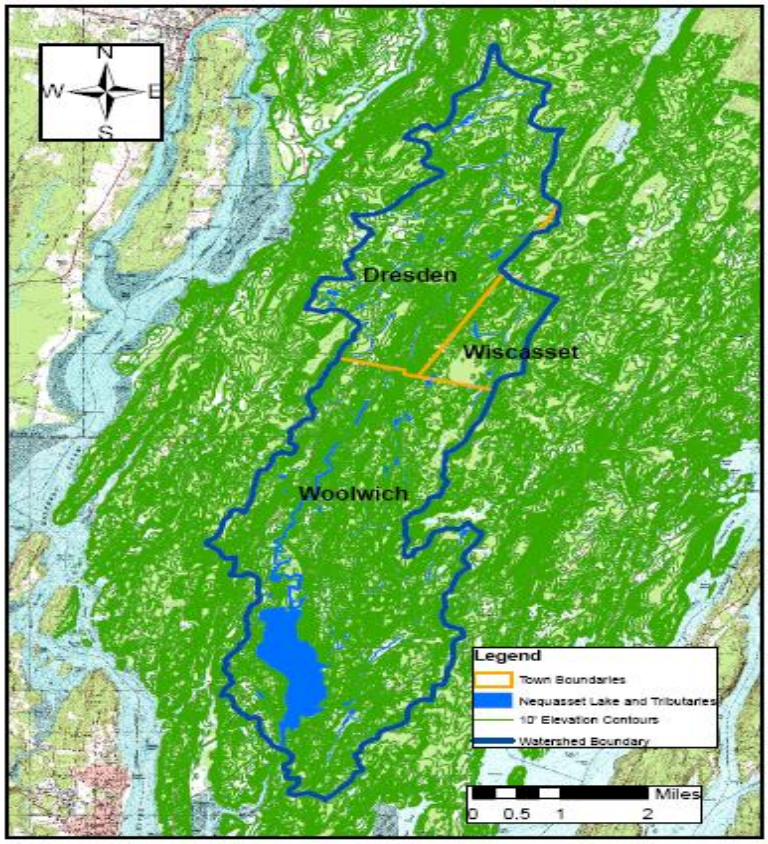


Figure 3: Nequasset Watershed town boundaries, lake and tributaries.
Photo Source: Maine Rural Water Association

In 2005 the Bath Water District published a Source Water Protection Plan, in order to, "reduce or eliminate potential and existing risks to Nequasset Lake"[15] through a series of public educational workshops about watershed protection. As climate change increases risks to the watershed, such as rural development, excessive runoff, and increased invasive plant and aquatic species, this plan will prove invaluable to the City of Bath as we move forward in the protection of our water quality, and will require constant updates to reflect the changing climate.

[13] Barnes (2009), p. 29
[14] Bath Water District, 2005
[15] Bath Water District, 2005

Another major risk to the water around Bath has to do with rising sea levels in the Kennebec Estuary and River, with an estimated increase of at least 2 feet in the next century.[16] This region is also the drainage area for nearly two-thirds of the state of Maine, so as precipitation increases all over the state, that water will eventually find its way to Bath, the Kennebec River, and the Nequasset Watershed. This could effectively compound the negative impacts of likely sea level rises in the Kennebec beyond the projected 2 feet.

The community is situated along the banks of the Kennebec River, and is only miles from the Estuary, so an increase in sea level could drastically affect important infrastructure, including the waste water treatment plant, and the ecological make-up of the Estuary. Bath's entire downtown district, the hub of its economic activity, is located at or near sea and river level. The physical make-up of the Estuary and River is completely unique to the state and could suffer damage with this projected increase in sea levels. Valuable low lying marshes will be flooded, with an excessive loss of habitat, while shifting salinity levels will affect the quality of water and the aquatic species that the local fishing industry depend on for a livelihood.

Bath has a historical legacy of significant trees and is ranked second in communities state-wide with the largest number of "State Champion" specimen trees, with fourteen. The community has 6,000 street-side trees, and 14,000 public trees. Bath is primarily an urban forest (See Figure 4), which means that unlike large forested woodlands, the community's trees and shrubs coexist with buildings, asphalt, cars, power lines and people. An Urban Forest provides temperature and precipitation control, water conservation, and noise insulation, visual buffering and improved air quality. Trees also sequester carbon, so maintaining or increasing the City's current forest levels, where possible, will help reduce greenhouse gas effects.

The area surrounding Bath has large forested tracks of lands which will be greatly affected by climate change, as increases in yearly GDD bring new tree and pest species, and increased precipitation loosens soil and weakens root system efficacy. Bath will have to work with the local landowners to discuss ways to handle this added stress on their forested lands, and to protect the natural environment that surrounds the City, and especially in the Nequasset Lake Watershed. In the process of doing so, new forestry Best Management Practices (BMP's) will have to be identified, developed and adopted. For example, increased yearly GDD will alter access to forested lands due to a lack of sufficient chilling to allow for frozen ground. This region is already seeing a decrease in the time that the ground is frozen enough to drive machinery over and reach the forested areas that are unreachable in warmer, wetter months.

[16] IPCC, 2007

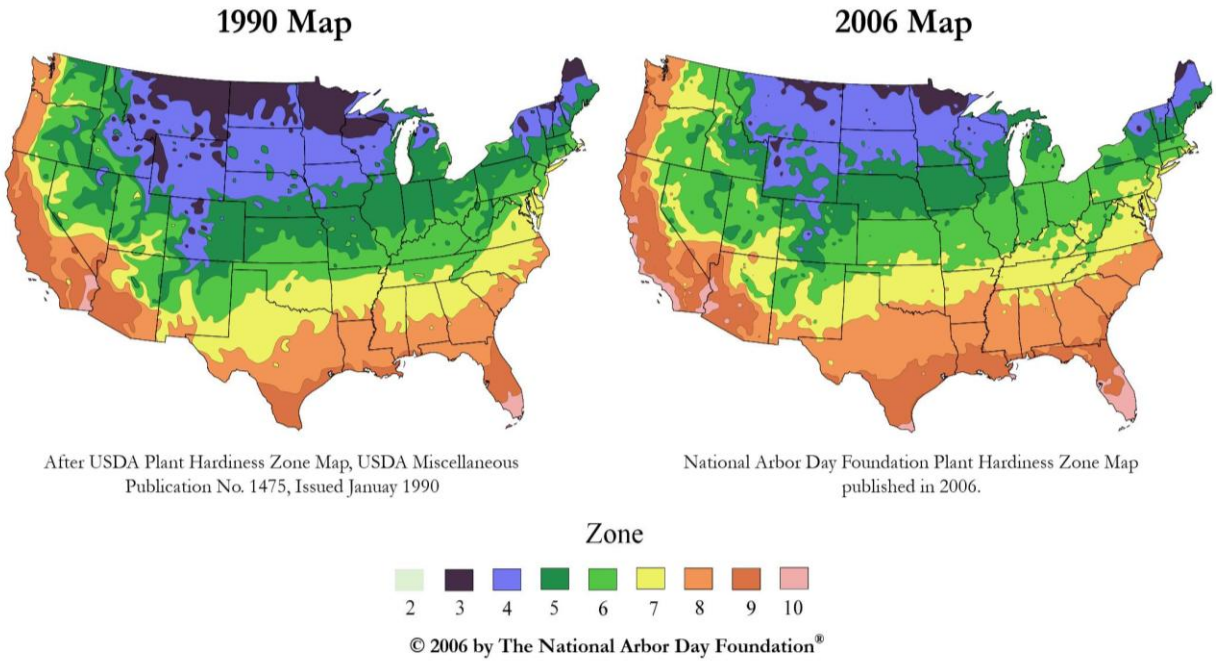


Figure 4: Change in Maine Plant Hardiness Zones from 1990 to 2006.
Photo Source: National Arbor Day Foundation.

Overall, Maine has experienced a warming effect that has lengthened growing seasons and changed the horticulture plant hardiness zones (See Figure 4), introducing plant, pest and animal species from more southern and foreign regions. Although this change can have positive impacts – increased growing seasons and the ability to grow plants not common in Maine – there are negative impacts, too, such as increases in yearly GDD. For example, the potato farmers of Northern Maine will see a drastic 25%-35% reduction in their crop yields as the seasonal GDD increase, because potatoes need fewer seasonal GDD and lower daily high temperatures to grow.[17] This change also directly affects the current forest tree composition and stocking. Currently Maple, Beech and Birch are predominant tree species in the Maine landscape, but it is projected in the next 60 to 90 years these species will be sublimated by Oak, Pine, and Hickory species of trees. (See Figure 5) This species shift may have impacts on the ecosystem by reducing biodiversity, altering habitats, modifying genetic diversity, and providing new vectors allowing exotic diseases and pests access to native species and if left unchecked could impact the entire forest ecosystem and tree stock.

[17] Maine's Climate Future (2009), p. 42

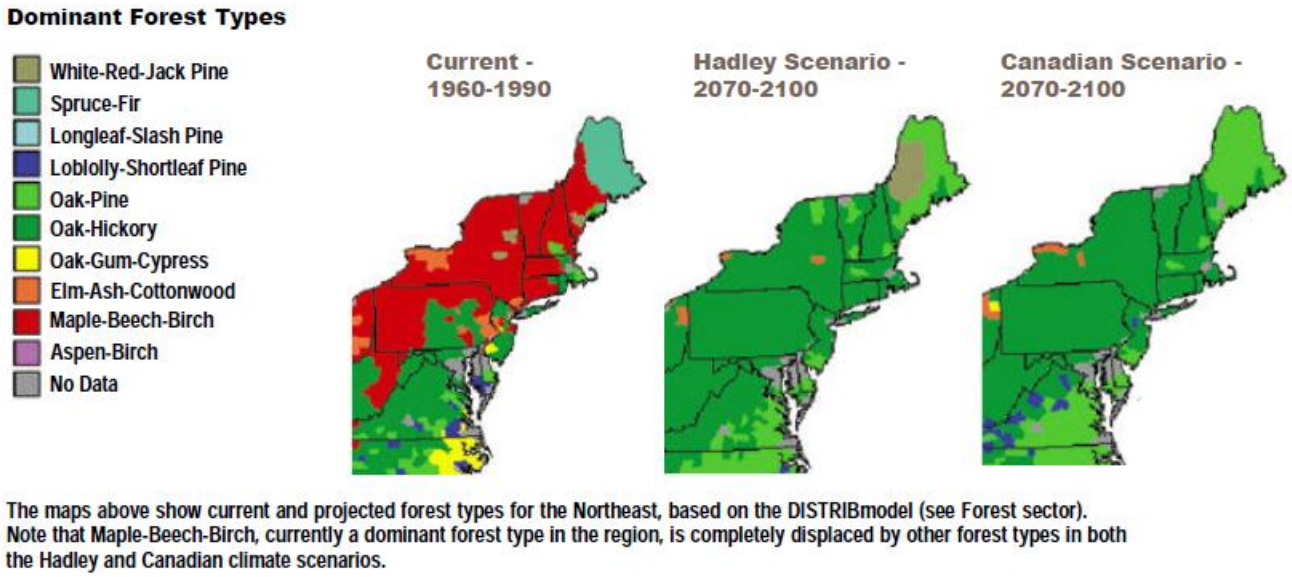


Figure 5: Detailed map of three projected tree species shift in the next century.
Photo Source: Maine's Climate Future

Agricultural lands in the area will be impacted as well, as climate change affects seasonal GDD, precipitation levels and soil quality. Although Bath has limited farmlands, the areas surrounding it provide a great deal of food for the region. With climate change there is the possibility of food scarcity by local growers. Bath should develop broader relationships within the agricultural community and farm owners, in order to provide them with the tools to adapt to the changing climate and increase productivity.

Overall, the economic effects of these associated risks put Bath in a position to act or react. Planning for these risks is vital to the sustaining of our city and the region. Our identity has long been associated with the Bath Iron Works and the history of shipbuilding along the Kennebec River, but as we move forward, we need to expand and broaden this identity. We have industries, like Bath Iron Works and fishing, but we also have a thriving urban center, as well as, agricultural and forested lands along the outer edges. Part of looking forward into the face of climate change is to understand the effects on all three of these aspects of Bath's identity, then building a sense of community around our unique assets that will encourage economic growth, as well as, protect our natural and built environments against some of the aforementioned risks.

Synthesis of Risk and Opportunity Assessment Findings

Evaluating the current data on climate change affects in the Bath/Mid-coast region, the team found there was abundant information in some areas, while others were lacking the necessary data. Part of our assessment is that we need to know more, especially in terms of the near future effects, and there needs to be more cohesion among the region's towns and conservation and preservation organizations. The likelihood of Bath adapting to the changes will depend in no small part on the value the surrounding region puts on these changes, and the ability to come together to create new policies and guidelines for adaptation and mitigation.

Figure 6: Map of Communities involved in SRRRI
Photo Source: Sagadahoc Region Rural Resources Initiative

Several of the listed potential impacts of a changing climate to the region have already begun to occur – increased yearly GDD and water temperatures, increased storm occurrence and severity and precipitation levels, invasive aquatic and plant species – and although Bath has adopted an Energy Use Plan, and the State, a Climate Plan, there is still more to be done by the City to ameliorate the long-term effects of these impacts. In the 2009 the University of Maine's Climate Change Institute and, then, Governor John Baldacci, came together to create the *Maine Climate Future: An Initial Assessment*. This thorough report looks at past climate change, the recent acceleration of these changes, and the immediate and continued effects of such on the State's natural resources, which directly affects the state of Maine's economy. Our rivers, lakes, estuaries, tidal waters, forests, fish populations, and forests, supply most of Maine residents with employment, and as the climate changes and these are affected, our way of life is at risk.

Bath has become aware of the effects of human activity on these natural resources, and in 2008, along with Cool Communities, the City Council was presented with the City of Bath Energy Inventory and CAP. The plan discusses the effects of greenhouse gases on Bath's climate, the causes of the emissions, and establishes a city-wide energy use plan to cut down these emissions. These two plans combined can give Bath the basis to establish and develop its own CAP by understanding what the changes are, and how they will affect the region. This CAP is a natural progression from the Energy

Inventory Plan, and with other local organizations, such as the Kennebec Estuary Land Trust (KELT), Manomet Maine, the Climate Change Institute, Beginning with Habitat, Cathance River Education and Alliance, and the Friends of Merrymeeting Bay, Bath should be able to successfully implement the goals and objectives of this plan.

FORESTS

In researching the forestry piece of the CAP, the team used information from the City's routine management practices, work with the Maine Forest Service and discussions with a number of forestry professionals. What the team learned was that the City of Bath is not only a healthy urban forest, but that the forested lands surrounding the City play a vital role in climate adaptation. Tree shade from urban forests help reduce the need for air conditioning in warm weather. They also provide carbon sequestering, which is the natural process of turning CO2 in the air into plant-based carbon, which reduces the amount of atmospheric greenhouse gas levels. Outside of the City, forests around the Nequasset Lake Watershed will protect the lake from runoff. These are important natural services and in order to receive them, the City of Bath should evaluate the risks below so that a plan of action to protect this natural resource can be put into place. Further on in the document, the team will propose strategies and activities to help the City do this.

As the climate change affects the tree growth in Bath and the surrounding areas, especially within the Nequasset Watershed, the City will have to continually update their Best Management Practices in order to meet the changing needs of the forests. Each summer sees warmer weather that will shift the plant hardiness zone. This will require the City's forestry division to monitor the existing tree species, and take note of invasives, their affect on the native species, and the likelihood of their adaption into our forests, including the risks of such. On top of the tree species, the City will also have to monitor and assess the risks of new invasive pest species, which can be disastrous on our native forests. Because of the severity of these risks, it is important that the City of Bath act in a timely manner on their forest management practices. Most of the risks listed below are currently happening and require immediate attention. The City already has an engaged and active forestry division, but in order to meet the needs of the changes associated with climate, large landowners will have to be more active in the decisions surrounding the City's trees.

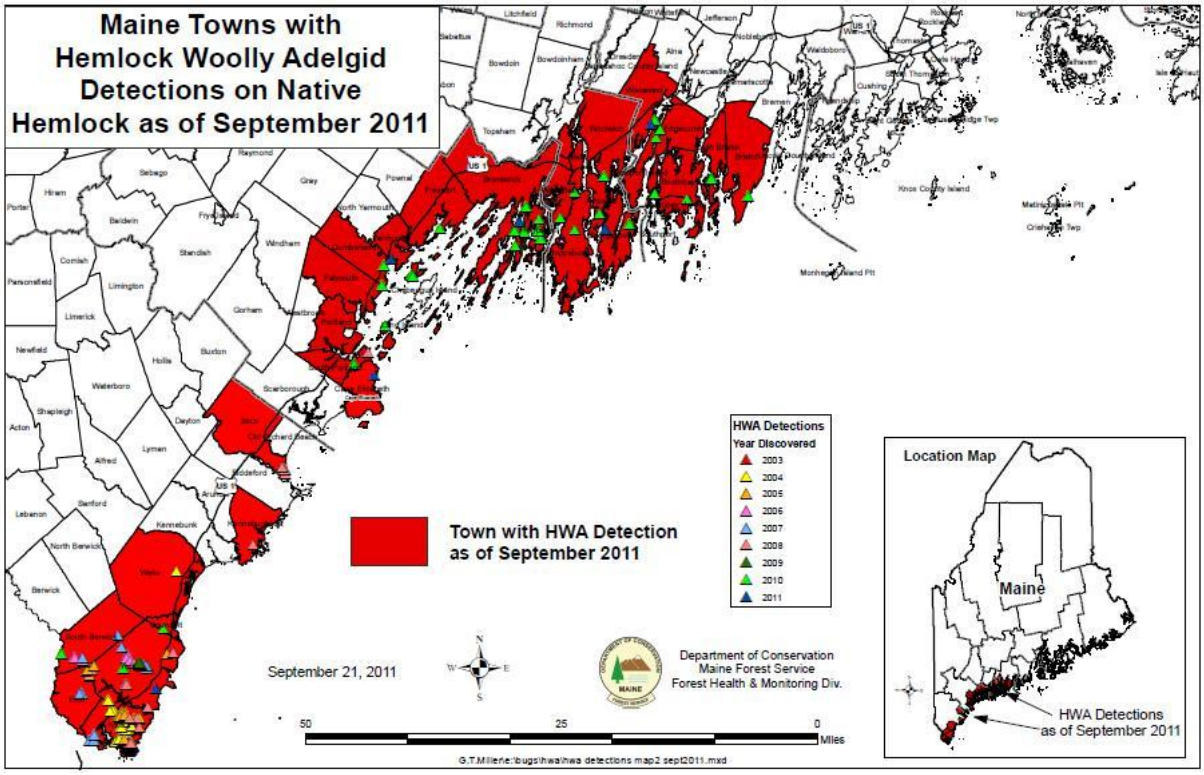
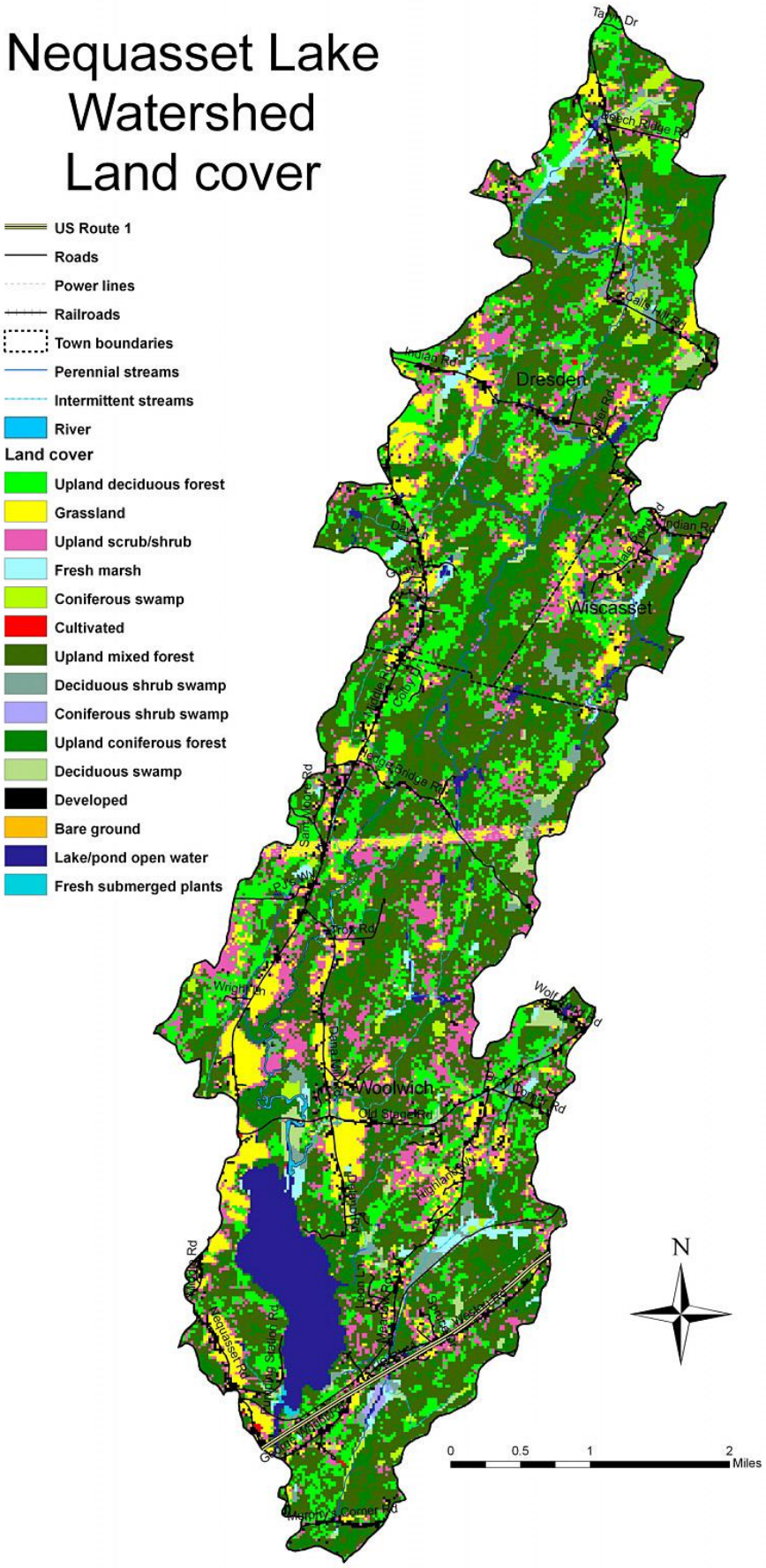


Figure 7: Maine Towns with Hemlock Wooly Adelgid Detections on Native Hemlock trees.
Photo Source: Department of Conservation Maine Forest Service

The City's vested interest in the watershed will make it imperative to invite the Bath Water District into the planning process, in order to protect the forested areas around the lake. (See Figures 8 & 9) It will also be equally important that the towns surrounding the lake are brought into the discussion of the protection of the forests. Currently, in the team's research, we discovered that there is long-standing protection of the undeveloped area in an attempt to limit runoff associated with development. The watershed is at a high-risk due to the climate change affects associated with tree diversity, pests, and the overall health of the forested regions.


Nequasset Lake
Watershed
Land cover
US Route 1
Roads
Power lines
Railroads
Town boundaries
Perennial streams
Intermittent streams
River
Land cover
Upland deciduous forest
Grassland
Upland scrub/shrub
Fresh marsh
Coniferous swamp
Cultivated
Upland mixed forest
Deciduous shrub swamp
Coniferous shrub swamp
Upland coniferous forest
Deciduous swamp
Developed
Bare ground
Lake/pond open water
Fresh submerged plants
Dresden
Wiscasset
Woolwich
N
0
0.5
1
2
Miles

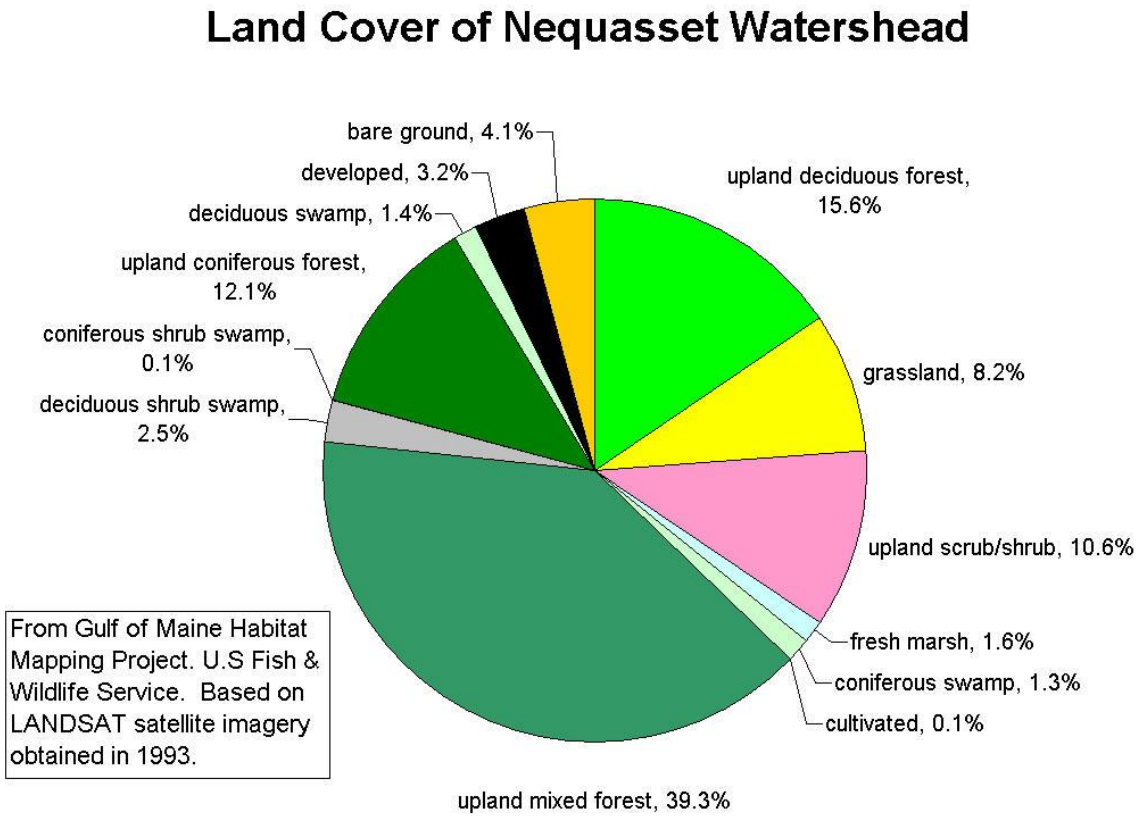


Figure 8 & 9: Nequasset Lake Watershed Land Cover Map and Pie Chart.
Photo Source: Nequasset Lake Watershed Project, Bowdoin College

RISKS:

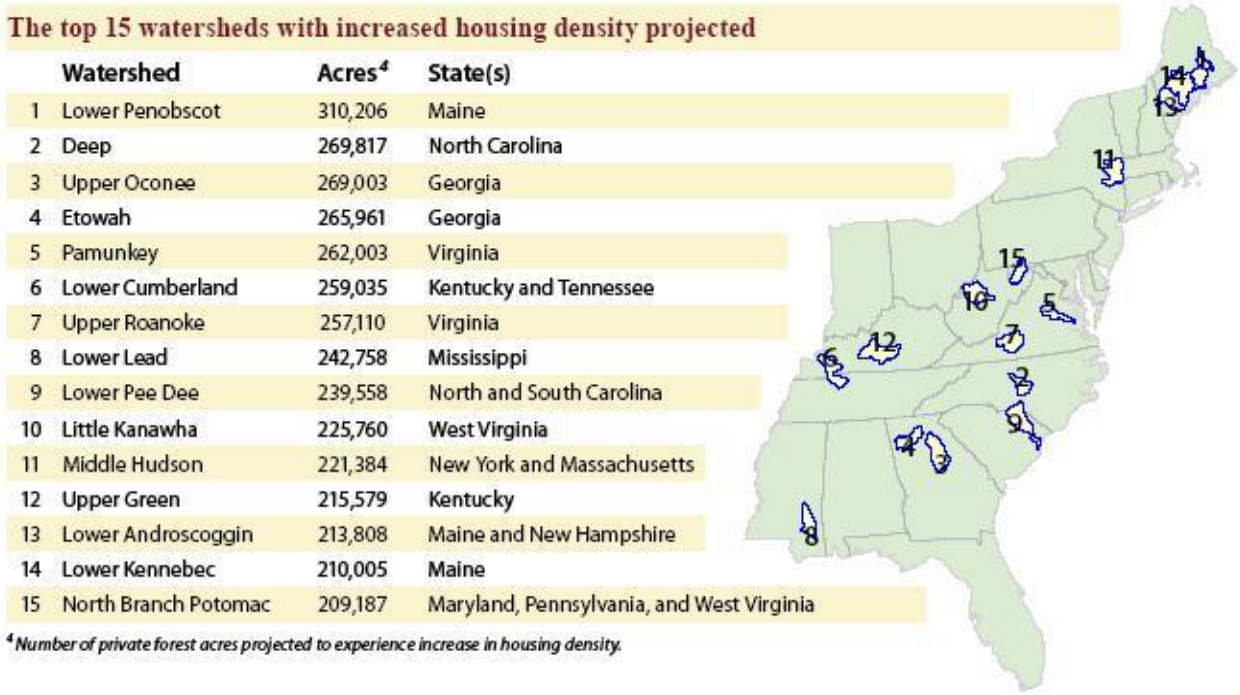
- Increased yearly GDD and higher daily low temperatures will have a varied effect on the tree species – some will increase in growth, while others will decrease – which will require a change in management practices.
- Increase in pests and non-native invasive species will challenge the existing native tree species, and potentially limit diversity.
- Reduced Chilling Days will mean a shorter season for winter forestry management.
- Development pressure on the region's forested lands will increase as the population increases, within the greater Kennebec River and Nequasett Lake watersheds.

WATER

The water information obtained by the team for this CAP came from information from the Bath Water District, the Clean Water Act Section 319 Grant, The Nequasset Watershed Stakeholders Group, and the Kennebec Estuary Land Trust (KELT). In looking at the City's water risks associated with climate change, it was necessary to examine both the drinking supply from the watershed, and the Kennebec River and its estuary, in which the City is located. Each of the organizations provided us information

regarding what the future will look like with warmer temperatures, increased sea levels, and potential development. In preparing the CAP, we combined the two water sections into one. Below is a list of the team's water risk assessment of the area, and further on will be strategies and activities to adapt to these risks.

The quality of Bath's drinking water was top of the list in risks associated with climate change. The Nequasset Lake Watershed, because of its location outside of the City's limits, and the potential for development in the area, make for potential catastrophes. As mentioned above, the ability for Bath to work directly with the other communities within the watershed will be crucial in its protection. Establishing a long-term goal of limiting development and maintaining the existing water structures (culverts, bridges, etc.) will give the City and its residents the security they need in their drinking water.



The top 15 watersheds with increased housing density projected

	Watershed	Acres[4]	State(s)
1	Lower Penobscot	310,206	Maine
2	Deep	269,817	North Carolina
3	Upper Oconee	269,003	Georgia
4	Etowah	265,961	Georgia
5	Pamunkey	262,003	Virginia
6	Lower Cumberland	259,035	Kentucky and Tennessee
7	Upper Roanoke	257,110	Virginia
8	Lower Lead	242,758	Mississippi
9	Lower Pee Dee	239,558	North and South Carolina
10	Little Kanawha	225,760	West Virginia
11	Middle Hudson	221,384	New York and Massachusetts
12	Upper Green	215,579	Kentucky
13	Lower Androscoggin	213,808	Maine and New Hampshire
14	Lower Kennebec	210,005	Maine
15	North Branch Potomac	209,187	Maryland, Pennsylvania, and West Virginia

[4] *Number of private forest acres projected to experience increase in housing density.*

Figure 10: Top 15 East Coast Watershed's at risk for increased development.
Three of the watersheds that surround Bath are on the list, at number 1, 13 and 14.
Photo Source: "Forest On The Edge", USDA Forest Service Technical Bulletin PNW-GTR-636

The Kennebec River and its estuary are a vital piece of Bath's history and economy. It provides local fisherman with jobs, it houses the Bath Iron Works, and it connects the ocean to the Merrymeeting Bay. With the projected sea level rise of 2 feet, the river can just as quickly stifle the City. The increase in salinity in the estuary has already had a negative affect on shellfish, and the warmer waters have made the river more habitable for invasive aquatic species. The estuary provides a number of ecosystem services, which makes it at a very high risk for affects of climate change. KELT will be an invaluable presence in the City to help create a plan of strategies that will prepare for the projected sea level rise.

The other risk associated with sea level rise is the effect of the rising river on the City's downtown district's infrastructure, the Waste Water Treatment Plant (which already lies below sea level), and the infiltration of saline into the City's wells. Much of the downtown, which has the majority of the City's businesses, and the City government buildings, lies below sea level. The projected rise will require a serious consideration by the City of how to adapt, and can be assisted by a structural engineering firm's evaluation of reinforcement techniques.

RISKS

- The increase of acid in ocean waters, due to higher absorption of atmospheric CO2, is lowering the ability for clams, lobsters, and mussels to form carbonate and develop their shells and hard parts.
- Warmer waters have increased the risk of non-native invasive aquatic species, such as Asian shore crab, catfish, and harmful algae blooms (red tide) that pose significant risks on native aquatic species.
- Sea level rise, of an estimated 2 feet by 2100, will flood much of the Kennebec Estuary and cause severe damage to the aquatic ecosystem and near-shore public and private infrastructures.
- Increases in precipitation levels in both volume and per storm event, especially during winter months, will affect the quality of drinking water in the Nequasset Watershed, by increasing the amount of spring runoff that will carry altered nutrients and organic matter.

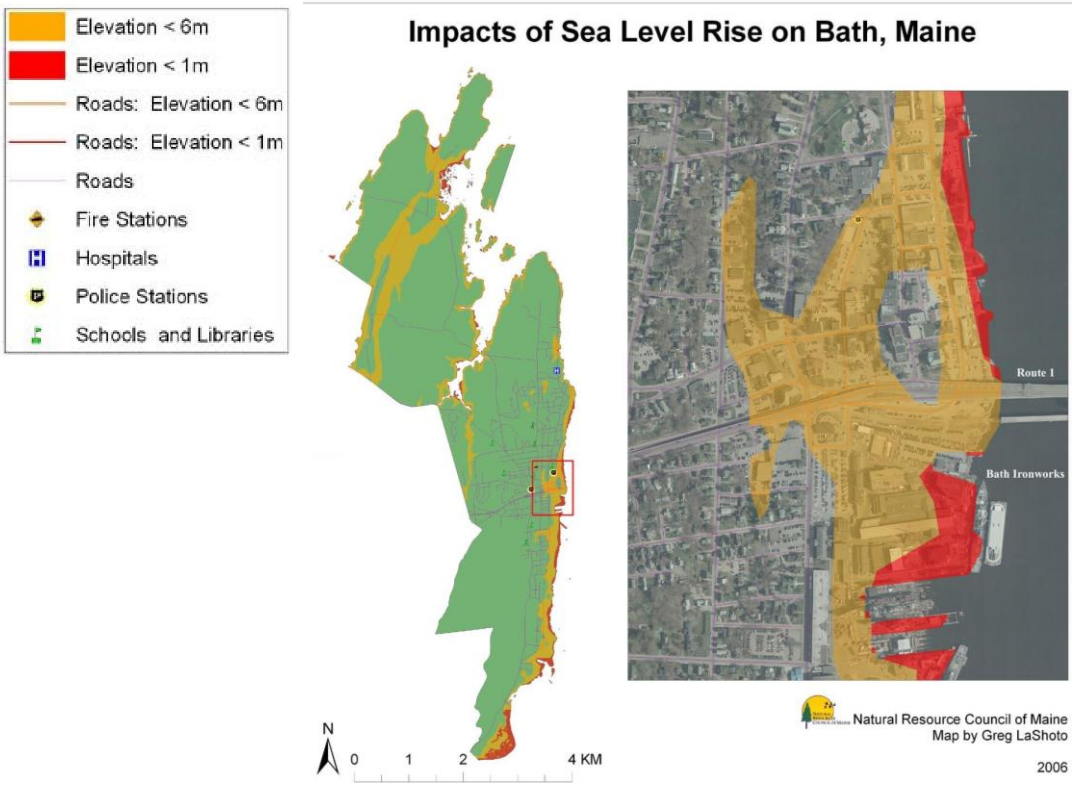


Figure 11: Projected sea level rise in Bath, and the surrounding area, along the Kennebec River and Merrymeeting Bay. 1 meter = 3.3 feet.
Photos Source: Natural Resource Council of Maine.

ECONOMICS

The team's research into the economic risks of the projected climate change effects on Bath and the surrounding region was assisted by ongoing discussions with Main Street Bath, the economic hub for downtown Bath, and the most recent census data. Outside assistance came from intensive discussions with Rob Roper from the University of Maine, Keith Bisson at Coastal Enterprise, Inc., and David Vail, retired Bowdoin College Economics Professor. With their assistance, the team was able to determine that many of the aforementioned water and forest risks will have a detrimental affect on the economy of Bath. Without adaptation, the City will see a drastic reduction in residents, as well as a loss of jobs in the fishing, boatbuilding and independent business sectors.

Bath has a long history of boatbuilding, and at one time had over 200 shipbuilding firms, launching nearly 5,000 ships from the shores of the Kennebec River. There is now only the Bath Iron Works, owned by General Dynamics, which is a major regional employer, handling primarily war ships for the U.S. Navy. With the projected sea level rise, most of the BIW's operations will be under water, which will have a drastically negative impact on the region's employment levels. It is important that as the City moves forward assessing these risks and creating strategies for adaptation, that they work to get the BIW staff into discussions about their plans in the future.

The other major water-based industry that helps build Bath's economy is fishing, and if the above mentioned risks become reality, which many have already, then there will need to be adjustments to the fishing industry. Currently the increase of salt water in the estuary has weakened the carbonate structures of shell fish. Maine is known for its lobsters, clams, and mussels, and if these numbers are lowered, or are not as harvestable, this will cause serious economic distress to the region's fisherman. There is also the risk of warmer waters in the estuary, Kennebec, and Merrymeeting Bay creating an influx of invasive aquatic species that are having a negative effect on the native species. As temperatures continue to increase, this will become more of a problem.

The other major economic stressor associated with climate change is the effect of storm damage on current infrastructure. As mentioned before, Bath's downtown business and government district is at risk for flooding with an increase in sea levels. Without proper planning, the historic architecture that makes Bath famous in the northeast will be tragically damaged, if not entirely ruined. Preparing for climate change can be costly, but the long-term cost of not preparing and having to deal with increased sea levels, more severe hurricanes and winter weather events, will be exponentially more costly. In order to best understand these two price tags, Bath will need to invite a structural engineering firm to do an analysis of the downtown region's ability to adapt to climate change effects.

RISKS

- Increasing sea levels and warming waters will increase severity of storm events, such as hurricanes, which will cause billions of dollars of damage to the existing built environment, and have a negative impact on tourism and recreation.
- Earlier spring ice-out dates will shorten the ice fishing season - and limit other recreational activities, such as skiing, skating and snowmobiling, etc.

- Increase in severity of storm events could potentially do extensive damage to the City's infrastructure, as well as to the infrastructure around the Nequasset Watershed – roads, culverts and bridges.
- Area agricultural production will change dramatically in the future – increased yearly GDD and longer growing periods will be beneficial to some plants, while others, that require a snowpack in the winter, could suffer winterkill and may not reproduce as well the following spring.
- Shorter winter season and earlier mud season will drastically affect forest management/harvesting activities.
- Increased daily high temperatures in the summer will increase heat-related illnesses, and support invasive disease carrying pests, such as deer ticks, while increasing our risk for infectious diseases.
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Although the aforementioned risks will force the City of Bath/Mid-coast Region, to re-evaluate public service delivery capacity, there are also opportunities with the changing climate. Increased yearly GDD and extended growing seasons can be beneficial to future forest growth, such as with hardy high-value wood like white aspen and pine. An increase in these trees would bring about an increase in forest-based production, which is currently a $5.31 billion dollar industry that provides nearly 20,000 jobs.[18] Extended growing will also positively impact the summer tourism season, which is a staple to the Maine economy. The region can expect to see an increase in summer recreation – fishing, canoeing, and biking – and an increase in summer beach visitors.

As for handling the costs and strategic planning for the risks brought on by regional effects of the changing climate, it is vital that the City improve dialogue with other organizations within our region that are working on similar climate activities. Currently Manomet Maine is writing a regional climate adaptation plan. The Sagadahoc Region Rural Resource Initiative (SRRRI) wrote and is working on implementing a Conservation Blueprint for the cities within the county. The Androscoggin Valley Soil and Water Conservation District is working on preserving the quality of water within the Nequasset Watershed and surrounding region. Bowdoin College has done research on the Nequasset Lake Watershed, the University of Maine has a climate change institute, and the Maine Department of Environmental Protection has published a climate change guideline, *People & Nature Adapting to a Changing Climate – Charting Maine's Course.* Lastly, there is the Sagadahoc County Administration, which has an Emergency Management Agency that provides the residents and tourists of Sagadahoc County with hazard planning and preparedness.

The City of Bath will not be going it alone in trying to adapt to climate change, and although the risks are many and varied, there are opportunities to work closely with these other organizations to develop strategies to not only mitigate climate change, by cutting greenhouse gas emissions (as outlined in the Bath Energy Plan), but to adapt to the changes that are already under way. It is cost effective to protect our natural and built environments from these changes, and it will be part of the process to understand

[18] http://climatechange.umaine.edu/files/Maines_Climate_Future.pdf

these costs, search out funding to assist the City in managing these costs, while comparing them to the costs of ignoring the changing climate and the damages and threats it poses for the City and the surrounding region.

Analysis of Findings and Strategic Options

The team examined the above risks and then strategized to develop goals and objectives to meet the demands of those risks. The over-reaching goal is to minimize the effects of climate change on the region while adapting the areas forest, water supply, and Kennebec River and Estuary to the expected changes in a way that does not limit the region's economic stability. The following section outlines the high priority goals, objectives, activities, and federal, state and regional groups that can assist with each, as well as, proposed strategies to achieve these goals, based on the analysis of the risks outlined in the previous section.

FORESTS

- Research and categorize current and forecasted invasive pests and diseases, then create prioritization tools to help landowners and city managers develop management & mitigation strategies.
- Map existing forested blocks & land ownership, then work with land owners to incentivize development and conservation of forest connector blocks.
- Broaden the diversity of existing tree stock, while maintaining current stocking levels.
- Identify and adopt new forest BMP's and strategies based on the changing species and increased yearly GDD and longer growing seasons.

WATER

- Map the projected sea level rise on the downtown area and research options to mitigate or manage damage on downtown, while examining the costs of each, in particular the location of the water treatment plant.
- Work with Maine Geological Survey and the Maine Department of Environmental Protection and map out all aquifers, and ask the Bath Water District to help maintain records of aquifers and recharge levels.
- Create a database of current native aquatic fish and plant species, current non-native species and projected non-native species in order to establish management rules and guidelines.
- Implement all aspects of 2005 Bath Water District Source Water Protection Plan and continue to review, plan, and develop working relationships with all towns connected to the watershed.

ECONOMICS

- Work with the Maine Office of Tourism, Maine Department of Inland Fisheries, Maine Recreation and Parks Association, Main Street Bath, and Kennebec Estuary Land Trust to increase Bath's visibility as a tourist and recreation attraction.
- To develop partnerships and infrastructure to assist in forest management and agricultural activities.

- Provide a forum to connect local fisherman with Maine Sea Grant to protect fishing industry and identify opportunities.
- Educate residents in climate change and effects on health by creating and maintaining a resource website and offering public health classes.
- Research grants and funding of installation of new storm water management practices, and educate city officials, business owners and residents of the potential damage to infrastructure.

Action Plan

In the implementation process of the above strategies, the City of Bath will have to work closely with other organizations and towns within the region that are also currently working on climate adaptation and conservation plans. In particular, the team proposes re-establishing contact with the eleven other communities involved in the Sagadahoc Region Rural Resources Initiative (SRRRI) – Arrowsic, Bowdoin, Bowdoinham, Brunswick, Georgetown, Harpswell, Phippsburg, Richmond, Topsham, West Bath and Woolwich – and working towards the goals of the *2010 Conservation Blueprint* proposed by the group. In conjunction with Beginning with Habitat – a collaborative program of federal, state and local agencies, and non-governmental organizations – the SRRRI group has mapped out open space and natural resource areas in the 12 cities in the Sagadahoc County, which coincides entirely with the goals and objectives of this climate adaptation plan.

Below is a detailed action plan, organized in three key areas (forests, water, and economics), including goals, objectives, strategies and activities to the meet the needs of the City in the changing climate. Many of these will require close association with other communities, organizations, businesses and residents in order to effectively work, so it can be stated the over-arching goal of the entire climate adaption plan is to develop a working relationship with all who are invested in the conservation and preservation of this region.

FORESTS

In order to maintain and grow the forested lands in and around Bath, there will have to be a cooperative effort between the City and the landowners. As warmer temperatures increase pest risks, create a shift in diversity and type of species, and increase the risk of forest fires, the goal needs to be protection of the existing tree stock, education of the projected risks, and adaptation of new management practices. Several of the strategies below will address these tasks.

The forested areas in the region also provide a number of vital ecosystem services that protect the watershed, provide habitats for wildlife, and create a canopy that can assist in cooling techniques during hotter weather. With the strategies outlined below, these services, and the many others not listed, have been taken into account. Although warmer temperatures and increased storm damage cannot be avoided, creating a solid management plan that protects and adapts our tree stock to these changes will have a number of benefits.

It can also be noted that trees are natural carbon sequesters, so the more trees in an urban setting, the more the carbon emissions are absorbed and offset. This will increase the quality of life of Bath residents and visitors - and lower the cost of emission control procedures outlined in the Bath Energy Plan.

GOAL #F1

Ameliorate the overall impact of pest and disease pressures on regional forest populations.

OBJECTIVE - Establish tools and guidelines to mitigate and manage invasive species

STRATEGY - Research and categorize current invasive species, then create prioritization tools to help landowners and city managers develop management & mitigation strategies.

ACTIVITIES -

1. Develop a database of invasives;
2. Establish a level of threat, prioritization criteria and identify management options, and develop into a management tool;
3. Develop a Public Private Partnership (PPP) and distribute management tools.

WHO – APHIS, US FS, MBPC, SWOAM, ME FS, IPANE, MOFGA

TIMELINE – 1 to 3 years

GOAL #F2

Maintain and expand the connectivity of regional forested blocks.

OBJECTIVE - Examine land ownership in the region to determine potential blocks to reforest, to connect to pre-existing forested blocks

STRATEGY - Map existing forested blocks & land ownership, then work with land owners to forest to identify and conserve connector blocks.

ACTIVITIES –

1. Work with Bath Assessors Office, State Planning Office and ME GIS to develop maps showing forested blocks.
2. Review current Bath LUC for revision to incentivize forest conservation or reforestation.
3. Develop a list of owners and identify programs and means by which they would participate in forestation activities
4. Work with interested owners to develop forestation program, looking at funding sources and suppliers.

WHO – Brenda Cummings, KELT, Bath Conservation Commission, MEFS, BCFC, SWOAM

TIMELINE – 1 to 3 years

GOAL #F3

Increase the resiliency to environmental and pest and development pressures to the regions forest stands.

OBJECTIVE - Identify the current regional vulnerabilities, and then identify pertinent timber stand improvement (TSI) practices and development guidelines.

STRATEGY - Broaden the diversity of existing stock, while maintaining current stocking levels and expanding current canopy levels.

ACTIVITIES –

1. Create a partnership between the Bath forestry committee, landowners, and the nursery program to establish a tree exchange, with a focus on stronger native species.
2. Do an annual assessment of pest species and their potential damages.
3. Provide educational outreach to citizens explaining the current pests, household management, and avoidance practices.
4. Review Existing Bath Land Use Code to identify modifications that would protect stocking and canopy levels.
5. Revise Bath Land Use Code to include provisions and incentives to the development process to maintain or mitigate any changes in stocking levels and canopy levels.

WHO – Bath Forestry Committee, SWOAM, Bath Assessors Office, Project Canopy, Bath Planning Department

TIMELINE – 3+ years

GOAL #F4

Identify, adopt and implement Best Management Practice's (BMP) to provide for sustainable levels of forest management activities.

OBJECTIVE - Minimize the environmental impact of forest management practices

STRATEGY - Identify and adopt new forest management activities & strategies

ACTIVITIES –

1. Work with Federal, State & Regional agencies and organizations to compile current and forecasted invasives.
2. Review Forestry BMP’s of warmer climate regions and identify those practices that Maine currently does not recommend for consideration.
3. Build stream crossing bridge sections.
4. Create a Carbon Credit Program for the Bath and Midcoast Region.

WHO – ME FS, SWOAM, BCFC, Bath Forest Division, CEI, MCBED, Bath Public Works, USDA FS, National Arbor Day Foundation, University of Maine Forestry

TIMELINE – 1 to 3 years

WATER

Bath has several water resources that will be affected with the changing climate. Its unique location along the Kennebec Estuary, and as the drainage spot for two-thirds of the state, mean that taking a proactive stance in climate change is necessary. The Kennebec River and its estuary are vital pieces of the region, providing both jobs and quality of life. As the risks of climate change begin affecting them, the City has a lot to lose. With the strategies and activities listed below, the team is proposing management and adaptation policies that will not only protect the River and its estuary, but also create jobs from the prospective changes. This can provide a necessary boost to the region.

The other risk with the Kennebec River is how the rise in sea level will affect the downtown region, which is entirely at risk for structural damage due to flooding. It is the team's proposal that the City act immediately to prepare for this risk by having a water engineering firm prepare a risk analysis of the City and the wastewater treatment plant, which is currently below sea level. It will most certainly benefit the City to be proactive in this situation.

The other piece of Bath's water resources is the Nequasset Watershed, which is not within the City's jurisdiction, but much of it is under the control of the Bath Water District. Some of the strategies below will encourage more cooperative work between the BWD and the towns which house the watershed in order to continue to be able to provide clean drinking water the region. The Nequasset Watershed is currently thriving, but as runoff from surrounding regions' development infiltrates the watershed, there is a high-risk for environmental disaster. It is important that the watershed is continually monitored and communication between towns is not only open, but active.

GOAL #W1

To protect the downtown area and waste water treatment facility from potential flooding due to sea level rise.

OBJECTIVE - Work with city officials to map out impacts of sea level rise on downtown and to discuss options of water treatment facility relocation.

STRATEGY - Map the projected sea level rise on the downtown area and research options to mitigate or manage damage on downtown, examine the costs of each, discuss options for covering costs, and research new locations for treatment plant and new kinds of treatment options.

ACTIVITIES –

1. Contact a hydraulic engineering firm to evaluate infrastructure.
2. Locate Waste Water Treatment specialist to evaluate new technologies and locations.
3. Engage Bath Iron Works in talks to plan for or mitigate sea level rise.

WHO – Wright-Pierce, BWD, BIW, ME DEP, UMAINE, Nequasset Watershed Group, Maine Sea Grant, Army Corps of Engineers, FOMB, ME DEP IF&W, Sagadahoc County Administration

TIMELINE – 3+ years

GOAL #W2

Maintain present aquifer recharge levels and frequencies.

OBJECTIVE – Locate all aquifers within Bath and collect data on recharge levels & frequencies.

STRATEGY - Work with Maine Geological Survey and the Maine Department of Environmental Protection and map out all aquifers, and ask the Bath Water District to help maintain records of aquifers and recharge levels.

ACTIVITIES –

1. Establish a map of Bath's aquifers, including recharge levels and frequencies.
2. Identify areas around aquifers and recharge areas that should be protected.
3. Evaluate the cost of connecting residents that currently use well water to the Bath Water District infrastructure.
4. Identify and implement strategies to protect natural land cover in source water protection areas

WHO – Maine Geological Survey, Chewonki, ME DEP, BWD, UMAINE, Bath Planning Office, Public Works, ME Dept of Inland Fisheries & Wildlife

TIMELINE – 1 to 3 years

GOAL #W3

Limit the effects of invasive aquatic species on native aquatic species.

OBJECTIVE - Research current invasive species, projected invasive species, and determine their effects on native aquatic species.

STRATEGY - Create a database of current native species, current non-native species and projected non-native species, and establish management rules and guidelines for each.

ACTIVITIES –

1. Market or promote increased fishing of invasive species
2. Public education with water district and the state
3. Create a business plan to harvest invasives for use as bait for local fisherman

WHO – Chewonki, ME DEP IF&W, Nequasset Watershed Group, BWD, KELT, ME Loberstmen Association, Sportsman's Alliance of Maine, Maine Dept of Tourism, Atlantic Salmon Organization

TIMELINE – Less than 1 year

GOAL #W4

Work with communities in the Nequasset Watershed to promote SMART development, and reduce runoff and improve water quality.

OBJECTIVE - Evaluate implementation of 2005 Bath Water District Source Water Protection Plan and research gaps.

STRATEGY - Implement all aspects of 2005 Bath Water District Source Water Protection Plan and continue to review plan, and develop working relationships with all towns connected to the watershed.

ACTIVITIES –

1. Prepare a Nequasset Forest/Watershed Management Plan.
2. Work with Homeland Security and USDA Forest Service to allocate funds for updating & implementing BWD's Source Water Protection Plan.
3. Create an ongoing working relationship with Wiscasset, Woolwich & Dresden to protect the watershed.

WHO – BWD, USDA FS, Dept of Homeland Security, BWD, Wiscasset, Woolwich & Dresden Conservation Committees, Bath Forestry, Nequasset Watershed Group, Project Canopy, Androscoggin Soil & Water Conservation, Bowdoin College, SWOAM, Sagadahoc County Administration

TIMELINE – 1 to 3 years

ECONOMICS

Climate change will affect the economy of Bath, and surrounding regions. It is the goal of this climate plan to adapt to the changes projected in order to protect the quality of life within the City, but it is also important that we create an economic model that can benefit from these changes and adaptations. Bath is unique because it is at once urban, quaint, and industrial. In order to benefit the economy, the strategies we list below will take all three of these pieces into consideration in hopes to maintain and protect our image, giving the City's residents a sense of community, which is extremely important as we move forward.

GOAL #E1

Create a tourism and recreation campaign to increase revenues compatible with changing climate conditions.

OBJECTIVE - Increase Bath's visibility as a tourist attraction.

STRATEGY - Work with the Maine Office of Tourism, Maine Department of Inland Fisheries, and Maine Recreation and Parks Association, Main Street Bath, and KELT to increase Bath's visibility as a tourist & recreation attraction.

ACTIVITIES –

1. Work with Main Street Bath to create a tourism campaign highlighting the Midcoast's natural resource attractions.
2. Adapt recreational activities to a changing climate, including, but not limited to, increased fishing of invasive species, and marketing warm-weather related activities (hiking, biking, canoeing/kayaking, and swimming).

WHO – Main Street, Maine Office of Tourism, Sportsman Alliance of Maine, KELT, Maine Parks & Recreation, Maine Snowmobile Association, Bicycle Coalition of ME, DOT, Maine Marine Trades Association, Maine Restaurants Association, Maine Island Trail Network

TIMELINE – Less than 1 year

GOAL #E2

Maintain current levels of economic base for existing forest and agricultural lands

OBJECTIVE - Analyze current industry economics, and identify the BMP's, types of crops & sources for landowners.

STRATEGY - Develop partnerships and infrastructure to assist in forest management and agricultural activities.

ACTIVITIES –

1. Promote estate planning with landowners to create a plan of action for future activity with their land.
2. Create food security by working with farms and the Department of Health and Human Services to connect SNAP (formerly Maine Food Stamps) recipients with farm fresh foods.

WHO – USDA, DHHS, ME Dep of Ag, Mofga, Maine Farmland Trust, ME FS, SWOAM, CEI, State Planning Office, Bath Farmer's Market, Maine Grocer's Association, Bath Natural Market, Bath General Assistance Office, Bath Food Pantry, Davenport Trust, RSU 1, Bowdoin, Hyde School

TIMELINE – 1 to 3 years

GOAL #E3

To protect and increase existing fishing industry.

OBJECTIVE - Identify threats & pressure to the industry

STRATEGY - Provide a forum to connect local fisherman with Maine Sea Grant to protect fishing industry and identify opportunities

ACTIVITIES –

1. Encourage fishing of invasive species; evaluate current issues w/ industry & gaps. Sea Grant Program, Inland Fisheries & Wildlife, local Sportsmen's Orgs, Friends of Merrymeeting Bay
2. Create a business plan to harvest invasives for use as bait for local fisherman

WHO – Maine Sea Grant, ME Dept IF&W, Sportsman's Alliance of Maine, FOMB, Island Institute, LL Bean's, Maine Clammer's Association, Maine Lobsterman's Association

TIMELINE – 3+ years

GOAL #E4

Increase education of public and health officials about health risks due to climate change.

OBJECTIVE - Determine health risks of climate change and make information available to the general public.

STRATEGY - Educate residents in climate change and affects on health; create and maintain a resource website

ACTIVITIES –

1. Work with ME Med Infectious Disease Dept to create an online/paper resource of climate related health risks

2. Create a plan of action with MELNA and local nursery's to encourage production of female plant species because they produce less pollen
3. Encourage landscape architect organization to promote landscape designs that use plant material that won't encourage climate change related health issues

WHO – ME Med Infectious Disease Dept, DHHS, MELNA, Skillin's Greenhouses, Hawke's, York's Hardy Rhododendrons, MSLA, Midcoast Hospital, Parkview Hospital, Bath Garden Club, Bath Conservation Committee, Sagadahoc County Board of Health

TIMELINE – Less than 1 year

GOAL #E5

Protect current infrastructure and prepare for increased storm damage.

OBJECTIVE - Maintain current capacity for delivery of services and identify BMP's and strategies for risk management.

STRATEGY - Research grants and funding of installation of new storm water BMP's; and educate city officials, business owners and residents of the potential damage to infrastructure.

ACTIVITIES –

1. Get an engineering firm to evaluate certain immediate & long-term infrastructure possibilities to protect against storm damage
2. Locate Waste Water Treatment Specialist to evaluate ability to turn marshland into treatment plant
3. Engage BIW in talks to plan for or mitigate sea level rise

WHO – Wright-Pierce, BWD, BIW, ME DEP, UMAINE, Nequasset Watershed Group, Maine Sea Grant, Army Corps of Engineers, FOMB, ME DEP IF&W, Sagadahoc County Administration

TIMELINE – 3+ years

Implementation

The first step of action to start implementing the goals listed above would be to establish a commission directly in charge of managing and tracking the progress of the climate adaptation plan. This team of local citizens, city employees, and interested parties would organize the activities by timeline and research Federal, State and City agencies, businesses, nonprofits and non-governmental organizations that could assist the City with completing the activities. It would also be beneficial for the City to create a Sustainability Coordinator position that would oversee the commission and research available grants and funding to implement the activities.

The commission would need to meet on a monthly basis as a whole, and would host outreach events with the organizations listed in the appendix, including the SRRRI group, Manomet Maine, and the Kennebec Estuary Land Trust.

Climate scientists are continually making discoveries about the exact effects of climate change. This climate adaptation plan is a living document that will need annual updating and revising in order to keep the activities accurate. The Bath Water Districts 2005 Source Water Protection Plan should also be updated in 2012, and every 5 years, to reflect the changing climate, the watershed, and the needs of the communities associated with it. Bath's 2008 Energy Plan is due for revision by 2013, and could come under the climate adaptation plan and the commission in charge of it.

The science of climate change is still not widely accepted by all, so it should be noted that implementing this climate adaptation plan will be met with conflict. In order to overcome this, the commission and the City will have to continue its efforts to educate the general public about the facts and figures surrounding climate change, while using language that is non-aggressive. It should be noted that the changing climate is not only caused by human activity, but a natural progression of the cyclical nature of the environment.

Finally, the team is well aware that the cost of implementing some of these activities may be outside the scope of the City. There are, however, several grant opportunities for funding climate research and adaptation policies. Finding and allocating these funds would best be handled by the City Planning office, Forestry Division, and Main Street Bath. Again, creating a Sustainability Coordinator position would help in this area as well. See Appendix for funding opportunities.

Outcomes

When all, or some, of the aforementioned activities are implemented, Bath and the surrounding Midcoast Region will experience a higher quality of life and the assurance of preparedness for the changing climate. Building relationships with organizations, nonprofits, businesses, city officials and residents will help develop a regional network where each community will help to create the framework necessary to adapt to the changes we have highlighted above. Most importantly, this plan could help influence regional, state and federal policies about land management and economic development.

Implementation of the forest activities outlined in the action plan would increase Bath's forested regions, develop a working relationship between the City and landowners, and update the forestry management practices to better reflect the changing environment. Although the City cannot predict what the invasives will be, it can tightly monitor the changes in the forest, including plant species and pests. Tracking this information will better prepare the City and landowners for the changes, and help implement the updated management practices.

The water activities listed in the action plan will help the City of Bath in two areas of water security. First, there is the Nequasset Watershed, which, if the activities outlined are implemented, will create a working relationship between the City and the communities that the watershed resides in. The outcome of this relationship will protect the City's drinking water while preserving the natural landscape. Second, there is the Kennebec River and Estuary, which is a predominant feature of the City, and at some of the greatest risks due to climate change. With the activities suggested in this plan, the City can prepare for what may potentially be a disastrous effect on the downtown district, and perhaps most importantly our waste water treatment plant. By having an engineering firm evaluate the infrastructure risks with the sea level rise, and evaluate potential new sites and technology for a waste water treatment plant, the City is proactive in preparing for what seems to be the inevitable damage to much of our infrastructure. Also, the estuary protection activities will engage local land conservation and preservation organizations in protecting a unique area that provides a plethora of natural services, and is a vital area for the local fishing industry.

Throughout the plan, several of the activities outlined will have an economic impact, and most of those listed under the economics section will be affected by the forest and water activities. The economic boost from the activities will help Bath, and the surrounding region, create revenues. They will also increase the resident's quality of life, help develop a sense of community, and give a boost to the job market. Bath and the surrounding region is unique with its thriving estuary, the Kennebec River, and the surrounding agricultural and forested tracts of land. With the activities listed above, the City has the potential to embrace the climate changes listed, and turn them into an economic stimulus that will encourage development while maintaining a rural landscape.

APPENDIX

- ACRONYMS USED

- LOCAL PARTNERSHIP GROUPS, ORGANIZATIONS AND AGENCIES

- CRITERIA FOR LISTING INVASIVE TERRESTRIAL PLANTS

- FRACTURED BEDROCK AQUIFERS & WELL FIELDS, BATH, MAINE: A SUMMARY OF FINDINGS

ACRONYMS USED

APHIS – Animal and Plant Health Inspection Service

BCFC – Bird Conservation Funding Coalition

BIW – Bath Iron Works

BWD – Bath Water District

CEI – Coastal Enterprise, Inc.

DHHS – Department of Health and Human Services

FOMB – Friends of Merrymeeting Bay

IPANE - Invasive Plant Atlas of New England

KELT – Kennebec Estuary Land Trust

MBPC – Maine Board of Pesticides Control

ME DEP – Maine Department of Environmental Protection

ME DOT – Maine Department of Transportation

ME FS – Maine Forestry Service

MELNA – Maine Landscape and Nursery Association

MOFGA – Maine Organic Farmers Association

MSLA – Medical Science Liaison Association

SWOAM – Small Woodland Owners Association of Maine

UMAINE – University of Maine

USFS – United States Forestry Service

LOCAL PARTNERSHIP GROUPS, ORGANIZATIONS AND AGENCIES

Bath Community Forestry Committee
Thomas Barrington
1 Oak Grove Avenue
Bath, ME 04530
207-443-8345
www.cityofbath.com/forestry_pages_642_area.html
thoerth@cityofbath.com

Bath Garden Club
Barbara Richards
369 Barley Neck Road
Woolwich, ME 04579
207-443-2869
www.mainegardenclubs.org/Bath.php
barbjrichards@comcast.net

Bath Water District
Julia Couture
1 Lambard Street
Bath, ME 04530
207-443-2391
www.bathwd.org

Friends of Merrymeeting Bay
Ed Friedman
PO Box 233
Richmond, ME 04357
207-619-1945
www.friendsofmerrymeetingbay.org/fombnew/index.htm
edfomb@comcast.net

Kennebec Estuary Land Trust
Carrie Kinne
PO Box 1128
Bath, ME 04530
207-442-8400
kennebecestuary.org/
info@kennebecestuary.org

Maine Association of Conservation Commissions
Bob Shafto
451 Blackstrap Road
Falmouth, ME 04105
207-878-8933
www.meacc.net/index.html
meacc@meacc.net

Maine Farmland Trust
John Piotti
97 Main Street
Belfast, ME 04915
207-338-6575
www.mainefarmlandtrust.org

Maine Land Trust Network
Warren Whitney
1 Bowdoin Mill Island, Suite 201
Topsham, ME 04086
207-729-7366
www.mltn.org/
wwhitney@mcht.org

Maine Organic Farmers & Gardeners Association
Russell Libby
PO Box 170
Unity, ME 04988
207-568-4142
www.mofga.org
mofga@mofga.org

Midcoast Council of Government
W. Bradshaw Swanson
7 Park Street
Bath, ME 04530
207-443-5790
www.midcoastcog.org/index.html
midcoastcog@midcoastcog.org

Project Canopy
Jan Santerre
22 State House Station
Augusta, ME 04332-0022
207-287-4987
www.maine.gov/doc/mfs/projectcanopy/
jan.santerre@maine.gov

Small Woodlot Owners Association of Maine
Tom Doak
PO Box 836
Augusta, ME 04332-0836
207-626-0005
www.swoam.org
tom@swoam.org

The Chewonki Foundation
Peter Arnold
485 Chewonki Neck Road
Wiscasett, ME 04578
207-882-7323
www.chewonki.org
info@chewonki.org

The Maine Forest Service
Ken Canfield
356 Shaker Road
Gray, ME 04039
207-441-3712
www.maine.gov/doc/mfs/index.shtml
ken.canfield@maine.gov

The Phippsburg Land Trust
Brenda Cummings
PO Box 123
Phippsburg, ME 04530
207-443-5993
www.phippsburglandtrust.org/default.htm
kennebec1@gmail.com

Topsham Conservation Committee
100 Main Street
Topsham, ME 04086
207-725-5821
www.topshammaine.com/

CRITERIA FOR LISTING INVASIVE TERRESTRIAL PLANTS

Department of Agriculture, Food and Rural Resources Division of Animal and Plant Health[19]

SUMMARY: This chapter establishes criteria to be used in evaluating non-native terrestrial invasive plants that could have adverse impacts on the Maine landscape. Plants that are evaluated and meet the criteria may be included on a list of invasive plants in the future.

I. Definitions

A. **Biological potential** – The ability of a species to increase its numbers, either sexually and/or asexually

B. **Invasive plant** – A non-native species that has spread into native or minimally managed plant communities (habitats) in Maine. They cause economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to native species. *As defined here "species" includes all synonyms, subspecies, varieties, forms and cultivars of that species unless proven otherwise by a process of scientific evaluation.*

C. **Likely invasive plant** – A non-native species that is naturalized in Maine, but is not widespread, but has been found to be invasive in other states or provinces with similar climates.

D. **Minimally managed habitats** – Minimally managed habitats are habitats where management efforts and investments of time, money and labor are infrequent or nonexistent. These habitats may have been intensively managed by humans at one time in history. In some instances, management may be more intense, but management is done for conservation purposes and is primarily aimed at preserving elements of biological diversity such as an imperiled species or critical natural communities. Minimally managed habitats are similar to "natural areas" but the distinction is made in order to remove bias, misconceptions or ambiguities that surround the term natural areas.

E. **Non-native** – A species that is not native or naturally occurring (based on its biology, phylogeny, distribution and current knowledge of the species) within Maine. A species may be native to North America, but non-native in Maine. Synonymous with nonindigenous, exotic or alien.

F. **Potentially invasive plant** – Non-native species not currently known to be naturalized in Maine, but that can be expected to become invasive within minimally managed habitats within the state.

G. **Spatial gaps** – This term is used in reference to the ability of a species to disperse away from existing occurrences. The concept of crossing spatial gaps is used to distinguish those species that can disperse over discontinuities and become established elsewhere from species that spread across a habitat only by continual, uninterrupted growth.

II. Criteria for Evaluating Terrestrial Plant Species

[19] http://maine.gov/agriculture/pi/horticulture/InvasivePlants.htm

In order to include a plant on a list of invasive terrestrial plant species administered by the Maine Dept of Agriculture the following criteria must be met:

A. The following criteria must be met for a terrestrial plant species to be considered **invasive**. The species must:

1. Be non-native to Maine.
2. Have the potential for rapid growth, dissemination and establishment in minimally managed habitats.
3. Have the biological potential for widespread dispersion and for dispersing over spatial gaps.
4. Have the biological potential for existing in high numbers or large colonies away from intensively managed artificial habitats.
5. Have the potential to displace native species in minimally managed habitats.
6. Be widespread in a region or habitat type(s) in Maine.
7. Have many occurrences of numerous individuals or colonies that displace native species in minimally managed habitats in Maine.

B. The following criteria must be met for a terrestrial plant species to be considered **likely invasive**. The species must:

1. Be non-native to Maine.
2. Have the potential for rapid growth, dissemination and establishment in minimally managed habitats.
3. Have the biological potential for widespread dispersion and for dispersing over spatial gaps.
4. Have the biological potential for existing in high numbers or large colonies away from intensively managed artificial habitats.
5. Have the potential to displace native species in minimally managed habitats.
6. Be naturalized in Maine (persist without cultivation)
7. Have at least one occurrence in Maine that has high numbers of individuals forming dense stands in minimally managed habitats. **OR**
8. Have demonstrated to be invasive in nearby states and provinces or areas with similar climates, but its status in Maine is unknown or unclear. (this may result from lack of field experience with the species or from difficulty in species determination or taxonomy)

C. The following criteria must be met for a terrestrial plant species to be considered **potentially invasive**. The species must:

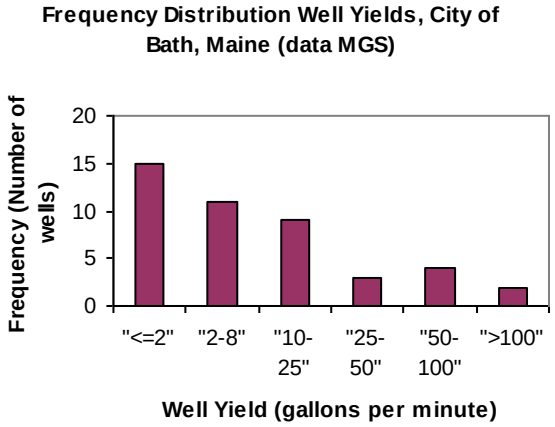
1. Be non-native to Maine.
2. Have the potential for rapid growth, dissemination and establishment in minimally managed habitats.
3. Have the biological potential for widespread dispersion and for dispersing over spatial gaps.
4. Have the biological potential for existing in high numbers or large colonies away from intensively managed artificial habitats.
5. Have the potential to displace native species in minimally managed habitats.
6. Have no known naturalized occurrences in Maine.
7. Have demonstrated to be invasive in nearby states and provinces or areas with similar climates.
8. Be anticipated to naturalize in Maine.

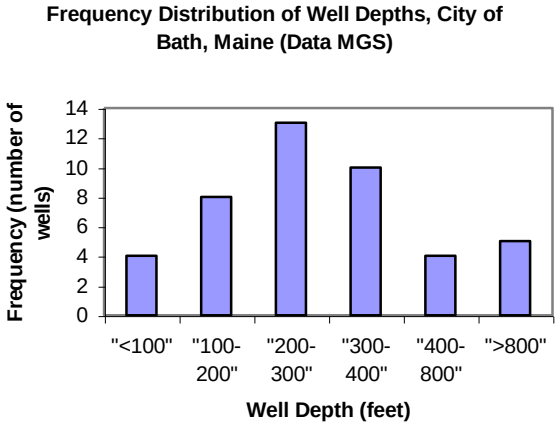
FRACTURED BEDROCK AQUIFERS & WELL FIELDS, BATH, MAINE:
A SUMMARY OF FINDINGS

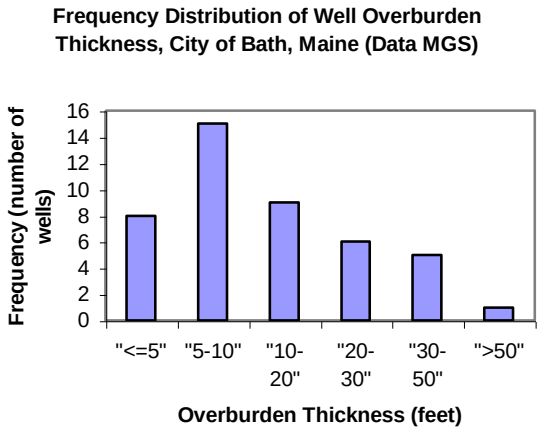
F. Cichocki

Examination of Maine Geological Survey maps (Open file 10-34, 10-35, 10-36: 2010; 85-89d: 1985; and 86-67: 1986) shows that fractured bedrock aquifers support about 45 wells in Bath, of which about 20 are high-yield (> 10 gallons per minute, GPM), and of the latter all but three are located near the approximately 15 major geological lineaments within the City. The only potential aquifer recharge areas in the region delineated on map 86-67 lie north and west of Bath (in Bowdoinham adjacent to Merrymeeting Bay; in the vicinity of Tate Hill, Topsham; and along the Androscoggin River, Topsham & Brunswick). This may or may not be the case. Map 85-89d indicates that the regions of greatest ground water transmissivity are associated not with the largest, first-order lineaments but rather with those of second and third order (see below for discussion of lineaments and bedrock fracture fabric).

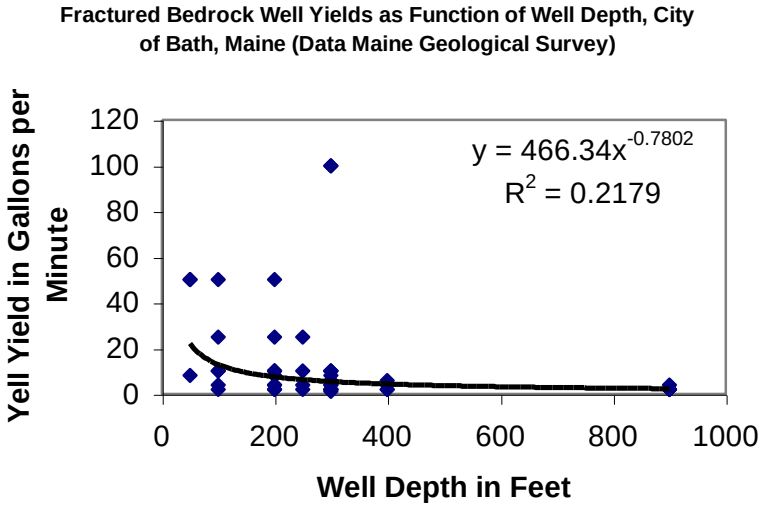
In the City of Bath, the frequency distributions of well yield (median: 4-6 GPM), well depth (median: (200-300 feet) and aquifer overburden thickness (median: 5-10 feet) are more or less congruent with those for the region at large. The yield and overburden thickness distributions are strongly skewed toward the low end, while well depth has a more nearly Gaussian distribution:







Although there is a great deal of variability in the pattern, and the relationship is rather weak, well yield seems to be a negative power function of well depth:



Thus, shallower wells tend to be more productive, apparently a fairly common feature of fractured bedrock aquifers along the east coast (see, Cohen, *et al.*, 2007 for northern Virginia), but this may not hold everywhere (see, Moore, *et al.*, 2002 for New Hampshire). Apparently, the reason for the decrease in well yield with depth is that the fracture frequency in the rock fabric (which determines water holding capacity) decreases with depth (Boutt, *et al.*, 2010). Of course, although productive, relatively shallow wells could be a liability through surface intrusion of contaminants, effects of rock blasting activities, etc. In fact, Levison & Novakowski (2009) suggest that in areas with thinner overburden, especially those under agriculture, fractured bedrock aquifers may be particularly vulnerable to degraded water quality through introduction of bacteria, fertilizers and organic carbon compounds. Also at risk in this regard could be aquifer recharge areas, which, for the aquifers in Bath, may be much more local than the MGS currently indicates (*e.g.*, see Rodhe & Bockgard, 2006; Lipfert, *et al.*2001?).

According to conventional wisdom, wells on or near large-scale, linear bedrock features called ***lineaments*** (*i.e.*, joints, cracks, faults, vertical walls, etc.) resulting from old compressional/relaxational tectonic forces, should be more productive. However, it appears that the smaller scale, ***fracture fabric*** of the rock is more important in this regard. Thus, only lineaments that correlate closely with the fracture fabric are indicative of high well productivity; the others do not bear well on the issue (see, Mabee, 1999; Mabee, *et al.*, 1994 for the lineament-well productivity relationship on Georgetown Island). Maine Geological Survey (MGS) map 85-89d clearly shows that the ***major*** lineaments in Bath have relatively little relationship with well yield, while secondary and third-order linear features correlate closely with it, presumably because they follow the small-scale bedrock fracture fabric. Gleason & Novakowski (2009) go further to suggest that the major lineaments may represent zones of ***reduced*** water permeability and actually be ***barriers*** to water recharge and transmissivity in fractured rock aquifers.

The potential connectivity among what could well be fairly isolated, localized aquifers in Bath is at present unknown.

In summary, studies by Mabee (1999) and others suggest that, in ***decreasing order of importance***, the following factors (annotated) are likely to affect well productivity in Bath:

- **Fractured bedrock type**--Amphibolite schists & gneisses seem best, fractured granite worst, other kinds of metamorphic rock of intermediate value. Interestingly, in Bath a stringer of amphibolite runs due South under Wiskeag Creek from Wiskeag Road to beneath Lily Pond. There are relatively few wells in this region of the City, some productive, some not, so the relationship is not consistent. More important, however, is that Lily Pond might represent a major but unrecognized surface water recharge basin for what could be a productive well field. In contrast, much of East and Northeast Bath is underlain by a granite pluton, with wells there of relatively low yield. Lipfert, *et al.*(2001?) suggest that such fractured granite aquifers, especially with thick overburden, will be difficult to characterize and understand.

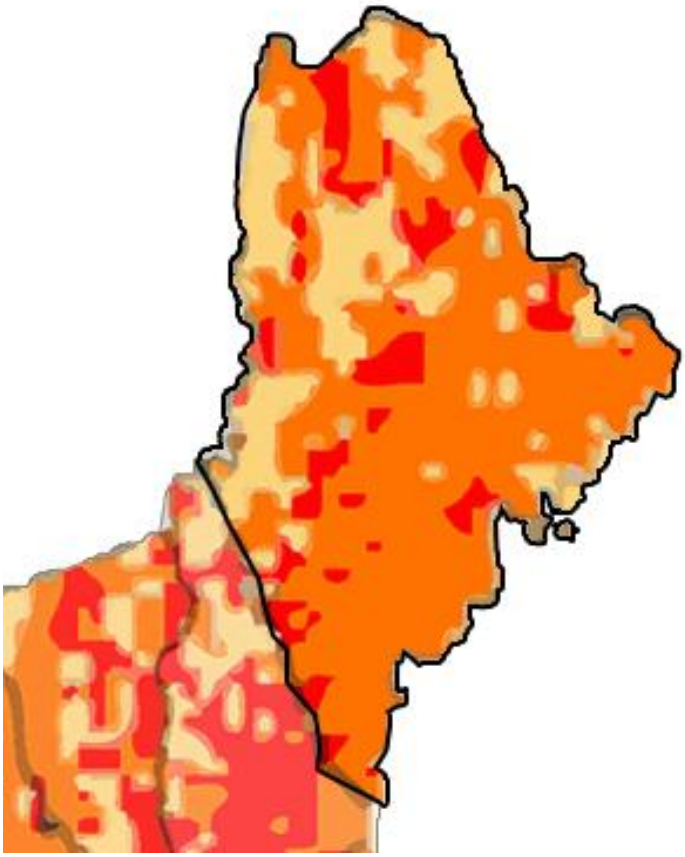
- **Shallowness of the water table**

- **Proximity to lineaments well correlated with the bedrock fracture fabric—**See above.

- **Flatness of the hydrologic gradient—**Steep gradients make for unproductive wells.

- **Proximity to surface water—**Presumably surface water serves to recharge and pressurize the well field.

LYME DISEASE RISK IN MAINE[20]

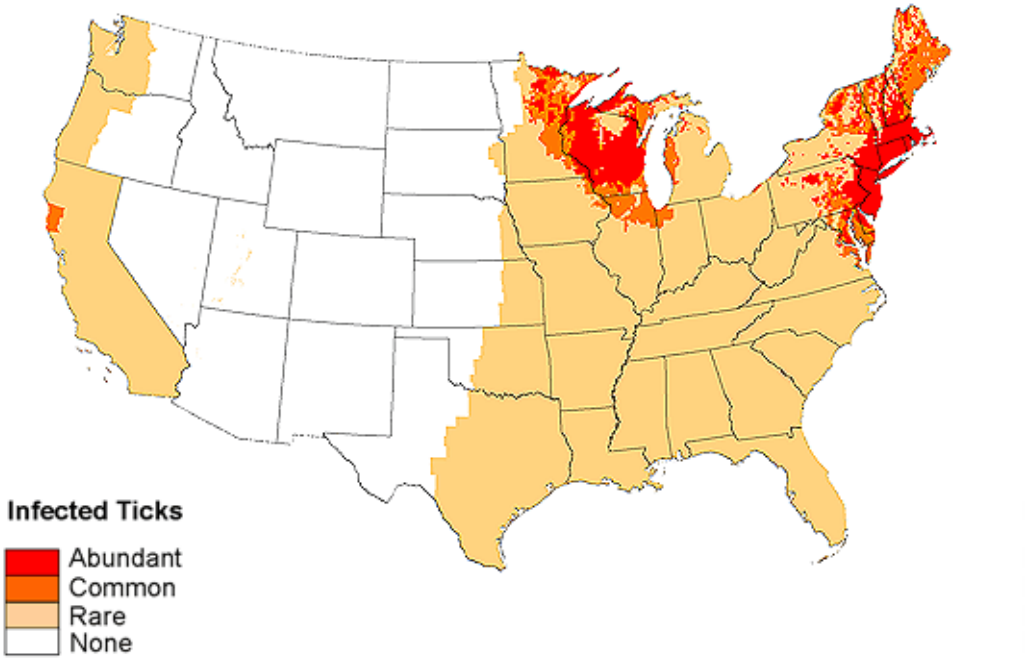


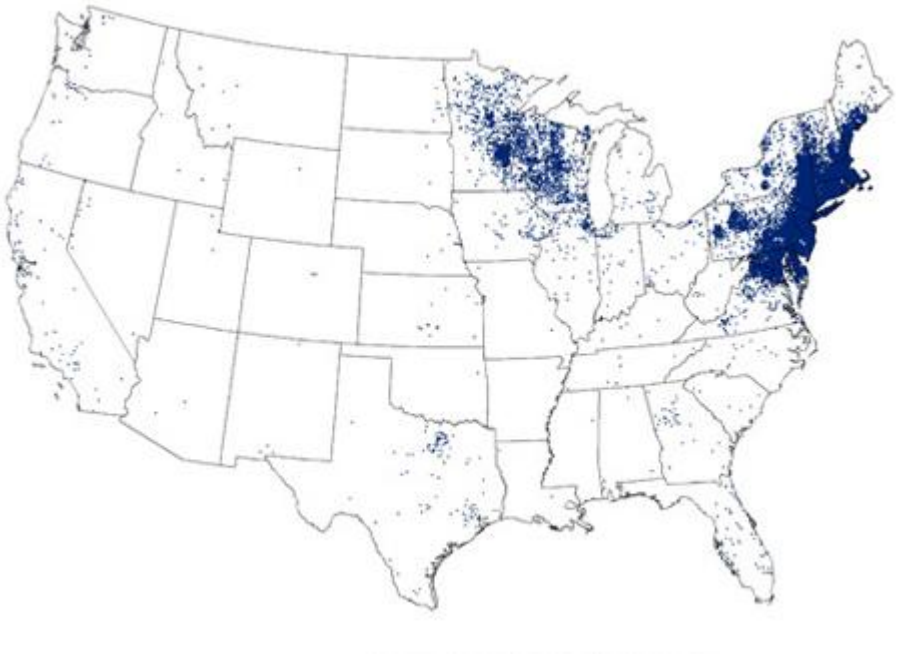
Source: The American Lyme Disease Foundation
http://www.aldf.com/index.shtml

Risk Classification:
Abundant: High density of host-seeking nymphal *I.scapularis* ticks.
Common: Medium density of host-seeking nymphal *I.scapularis* ticks or where at least 2% of *I. pacificus* ticks have been shown to be infected with *B. burgdorferi*.
Rare: Areas where *I. scapularis* or *I. pacificus* ticks have been reported, but host-seeking nymphs are extremely rare (*I. scapularis*) or infection prevalence is low (*I. pacificus*).
None: No reports of *I. scapularis* or *I. pacificus* ticks.

Data Sources: Diuk-Wasser, M.A., Gatewood, A.G., et al., 2006.

[20] http://www.cdc.gov/lyme/





- 1 dot placed randomly within county of residence for each reported case.

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