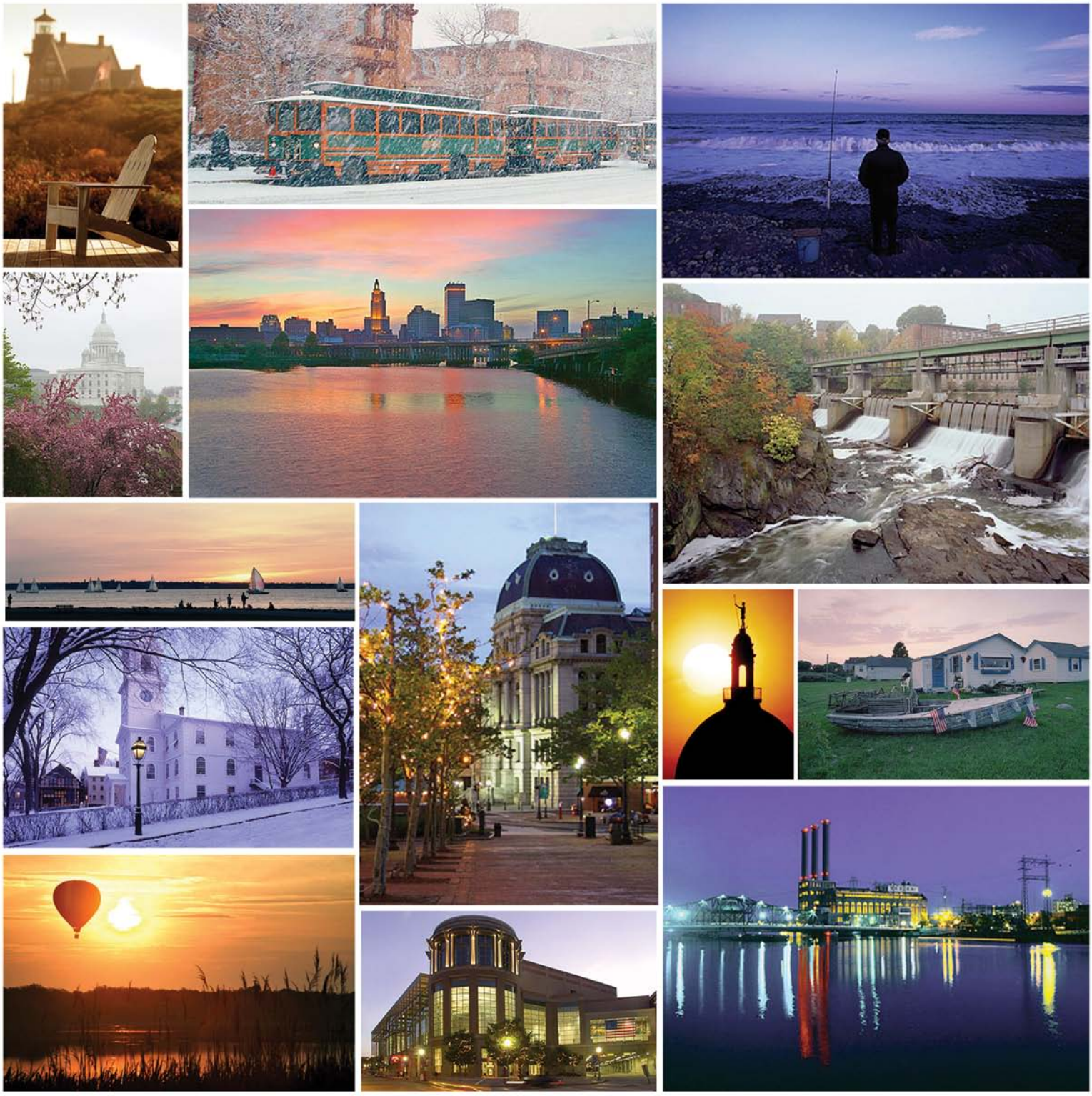

Summary: Preliminary Assessment of Rhode Island's Vulnerability to Climate Change and its Options for Adaptation Action

SUMMARY REPORT: This report is based on three background documents which are in final revisions and will be available in March 2010 online at:

http://envstudies.brown.edu

Supplementary outreach materials and a website to facilitate NGO/school partnerships are in development.

February 2010

Brown University Center for Environmental Studies

Graduate Seminar on Special Topics in Environmental Studies:
Urban Adaptation to Climate Change

Professor Timmons Roberts, Kathryn Birky, Kimberly Damm, Noah Fisher, Dayanch Hojagyedliyev, Jeremy Knee, Loreana Marciante, Cicely Marshall, Courtney Mattison, Courtney McCracken, Sara Mersha, Jessica Pagan and Kyle Poyar

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Musée du quai Branly Green Wall (www.greenroofs.com. Source: Inhabit).

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We would like to thank the many people from state and city agencies, academic institutions, and local and national organizations who led us to the information upon which we based this report. We are grateful for their time and patience, and for that of the over 100 people we interviewed and who participated in focus groups for this report. This list is not comprehensive, but those lending ideas and support included Ames Colt, RI Coordination Team Chair, Rhode Island Bays, Rivers and Watersheds; Janet Freedman, Geology, and James Boyd, Coastal Policy, Coastal Resource Management Council; Barbara Morin, Supervising Environmental Specialist, RIDEM Office of Air Resources; David Everett, Planner, City of Providence Department of Planning and Development; Garry Bliss, City of Providence Department of Planning and Development; Doug Still, City Forester, City of Providence; David Segal, RI State Representative; Don Pryor, Visiting Lecturer, Brown University Center for Environmental Studies; Jo Ann Carmin, Associate Professor of Environmental Policy and Planning, Department of Urban Studies and Planning, MIT; Lesley Bunnell, Office Manager, Conservation Law Foundation; Melissa Stults, Program Manager, ICLEI; Peter Lord, Environmental Reporter, Providence Journal; Sheila Dormody, Rhode Island Director, Clean Water Action; Pam Rubinoff, University of Rhode Island Coastal Resources Center; Caroline Karp, Environmental Law, Brown Center for Environmental Studies; Harold Ward, Emeritus Faculty, Center for Environmental Studies; Kathryn DeMaster, Environmental Social Scientist, Brown Center for Environmental Studies. Greg Gerritt, Environment Council of Rhode Island; Amelia Rose, Lead Organizer, Environmental Justice League of Rhode Island; Members of the CARE Alliance; Lisa Reels and Judith Reilly, Board members, Fred Ordoñez, Executive Director, Mary Kay Harris, Lead Organizer, Gina Leary and Ama Donker, Youth and Parent Organizers, members, and Seeds of Change leaders, Direct Action for Rights and Equality; Christina Cabrera and the Level 4 Students, English for Action; Shannah Kurland and the members of the Olneyville Neighborhood Association and TIGRA Justice Promoters Program; and Lucy Colville and the Green Academy Students, YouthBuild Providence.

As always, any errors are our own.

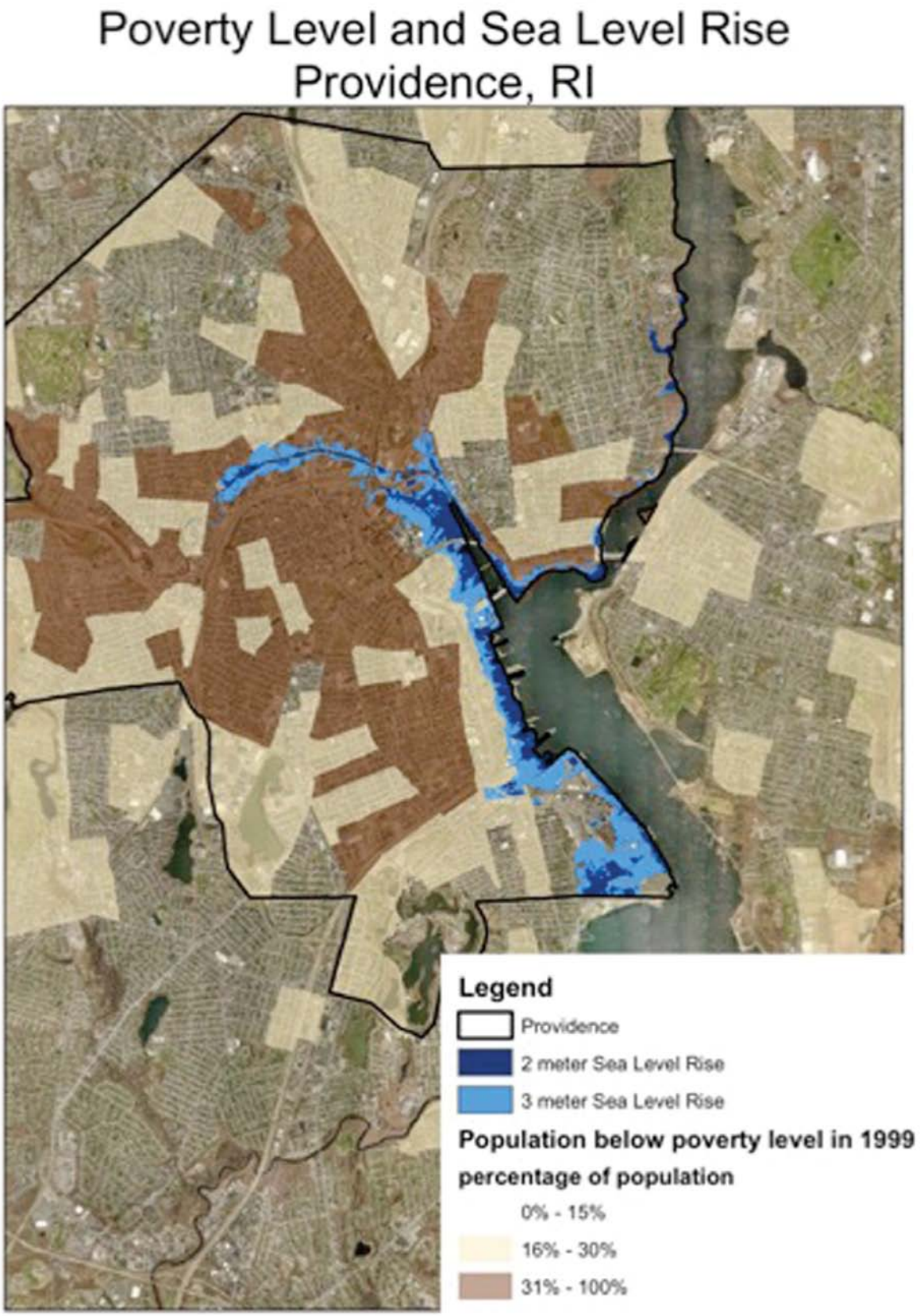


Figure 1. Areas of higher poverty are often more vulnerable to sea level rise.

Introduction, Background & Rationale

Climate change isn't coming to Rhode Island: it's already here. Average temperature in the state has increased by 1.5°F since 1970, and mean winter temperatures are up by 4°F.[1] Droughts are becoming longer and more frequent, storms cause worse flooding, and sea level is measurably rising. The changes that farmers, fishers, scientists and gardeners alike are observing cannot be explained by natural warming trends; the billions of tons of carbon dioxide, methane and other greenhouse gases we are pumping into the atmosphere explain the trends very well. What's more, since these gases stay in the atmosphere and trap heat for decades, we are locked into serious disruptions in our way of life.

Rhode Island's residents and the ecosystems that sustain us face increasing risks of three main sorts: rising temperatures (which put stress on human health and ecosystems), more extreme weather (bringing heavy thunderstorms and flooding, heat waves and more intense hurricanes), and the pounding of the state's over 400 miles of coastline by

1 Frumhoff et al., 2007.

Top: Hurricane Damage in 1938 (RI Historical Society).

Any effort to address climate change must have two parts – reducing emissions ("mitigation") and "adaptation" to the impacts that are already locked in. This report is among the first to focus exclusively on a broad range of adaptation issues arising from likely climate change in Rhode Island.

Mitigation: Efforts to reduce greenhouse gas emissions such as carbon dioxide pollution, which comes from burning coal, oil, and natural gas, and methane from livestock and landfills.

Adaptation: Efforts to reduce the damaging impacts of climate change, by observing and anticipating its manifestations, and preparing the communities that are or will be impacted, to avoid some of the worst possible consequences.

storm surges and rising waters.[2]

Communities around the U.S. and the world are beginning to address these increased risks by adjusting their building codes, improving and updating their emergency plans, identifying their greatest vulnerabilities and prioritizing actions to address them, and incorporating climate change projections in planning for long-term infrastructure investments.[3] Potential federal climate change legislation, which passed the House of Representatives in June 2009 as the Waxman-Markey Bill, is likely to provide significant federal funding and other resources to help states and localities begin planning and taking adaptation actions. To receive these funds, state governments must complete climate change response plans; this report seeks to assist the state in beginning the process of preparing such a plan.

"In this report, we endeavor to support the cities and state of Rhode Island as they prepare for climate change risks by assessing and prioritizing these threats to its people, its key infrastructure, its ecosystems, and its major economic sectors."

In this report, we endeavor to support the cities and state of Rhode Island as they prepare

Why Adaptation? Why Now?

Events such as Hurricane Katrina and extended drought in the Southeast US are sobering reminders that even we in the world's wealthy nations are not immune to the impacts of climate change. This report draws on scientific projections for the many ways that climate change is likely to impact Rhode Island over time, including increased temperatures, sea level rise, increased flooding and drought, health effects, and impacts on our water and food systems.

These effects are likely to continue and increase, even if we stopped or drastically reduced all greenhouse gas emissions today. Because carbon dioxide from our fossil fuel use today will still be having a warming effect on Earth 100 years from now, we are locked into substantial changes in our climate. If we do not prepare for projected climate change impacts, we will be leaving ourselves vulnerable to a great deal of harm.

2 CRMC, 2008; Frumhoff et al.,2007.
3 Poyar and Beller-Simms, 2009.

Years	Revenue from Emissions Permits	Percentage of Funds for U.S. Adaptation	Annual Funding for U.S. Adaptation
2012-2021	$60 billion	2%	$1.2 billion
2022-2026	$113 billion	4%	$4.5 billion
2027-2050	> $113 billion	8%	> $9 billion

Table 1. Federal Funding for Climate Change Adaptation in the Waxman-Markey Bill

for climate change risks by assessing and prioritizing these threats to its people, its key infrastructure, its ecosystems, and its major economic sectors. Our goal is to encourage the state's active response to climate change impacts by identifying some of the most critical issues that will have to be addressed, and by proposing cost-effective solutions for the state and its localities to consider implementing. In suggesting actions, we have sought to build upon existing initiatives and local strengths, and to identify ways in which governments might pay for them. Many of these solutions will help to build economies and communities that are more resilient not just to climate change, but to a series of potential economic and environmental impacts.

Here we describe the main threats and the reasons to take up this challenge sooner, rather than leaving it for later. We also provide some scientific background on expected changes over the next few decades, and discuss how those changes

This is not an argument to ignore mitigation, for if we do not drastically reduce greenhouse gas emissions, the impacts will be far more catastrophic. The scenarios of what Rhode Island will be like if there are lower or higher emissions over the next few decades make this point painfully clear. Our collective efforts to cut back consumption of fossil fuels are absolutely necessary, and as the country that has the highest historical responsibility for the causes of climate change, we in the U.S. have a moral duty to sharply reduce our emissions.

The good news is that there is a lot we can do. Communities, cities, states, and countries around the world have been developing ways to prepare for these impacts. We in Rhode Island can learn from and build upon these efforts. Some communities are even discovering opportunities in this crisis to address longstanding vulnerabilities, and the potential to develop new industries to supply adaptation technology and advice to communities coming after us. This is our hope for Rhode Island.

"How Can We Act Now? The Budget is a Disaster of its Own!" Opportunities for Federal Funding for Climate Adaptation

Much of what we do to adapt our lives to climate change is through individuals and households, institutions like hospitals, schools and churches, and companies large and small. Some actions, however, like developing or improving community disaster plans and preparing our infrastructure, will require state and local government leadership and coordination. Funding these actions is a serious concern in this time of budget crisis. Until recently, the federal government has offered few incentives for state and local governments to begin adapting to climate change. If approved by the Senate, pending climate change legislation would produce sweeping changes to the status quo.

In June 2009, the House of Representatives passed its version of the climate bill, referred to in the House as Waxman-Markey. The Senate version of the bill, referred to as Kerry-Boxer, was introduced at the end...

will have an impact on humans and the natural resources of Rhode Island. Going beyond the natural science, we seek to provide insights into the social and political factors that will determine Rhode Island's future, with special regard to the most vulnerable Rhode Islanders.

Throughout the Report, we lay out a series of options that the State might consider, some based on efforts being taken around the world to adapt to climate change, and some based on the ideas of many local people and officials we interviewed. Much further detail on these and other points in this summary can be found at http://envstudies.brown.edu.

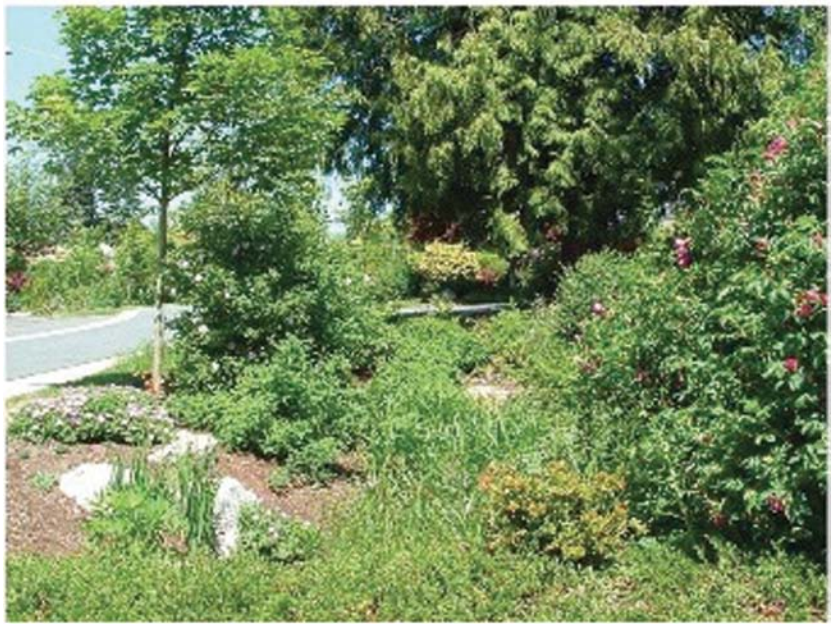
Rhode Island citizens are saying:

"I work in construction, so when it rains a lot, we can't work and I lose money."

"We had an extreme amount of rain over this past summer. Over the past 4-5 summers it has seemed nearly unbearable to conduct outdoor activities."

"Things are starting to change. If we have kids, they will suffer."

"My children will grow up in a different climate."



Bioretention swale in Seattle.
(AHBL, from LID Technical Guidance Manual for Puget Sound. 2005. Puget Sound Partnership & Washington State University Extension

These options include addressing the economic "incentive structure" for people to act wisely or unwisely in the face of a shifting climate, the value of building our state's "green infrastructure," adjustments that we can make to regulations and planning protocols, and ways we can help protect local ecosystems. We have no *silver bullet* solutions on "what to do" about climate change. Rather, we seek here to provide a useful foundation for much more work in this area in the immediate future, by cities, the state, community groups, and individual Rhode Islanders.

Climate Change Scenarios

What happens in Rhode Island depends largely upon what happens around the world regarding emissions of the key greenhouse

...of September 2009. Both bills provide key incentives and mandates for state governments to adapt to climate change. In fact, our calculations suggest the amount of money available each year for domestic climate adaptation will be $1.2 billion as early as 2012, and will rise to $9 billion in 2027.

To qualify for funding, state governments would be required to prepare state climate change response plans, which the U.S. Department of Interior must then approve. Importantly, these plans need to assess and prioritize the vulnerability of the state to the impacts of climate change, giving particular consideration to the groups most sensitive to these impacts. The plans must also outline specific cost-effective programs and projects that build resiliency to climate change impacts, particularly among the state's most socially and economically vulnerable populations.

While climate legislation is uncertain at this time, cities and states qualify for various other sources of federal funding that they could utilize for adaptation measures.

The Effects of Climate Change in Rhode Island

Climate Parameter	Late century High emissions	Late century Low emissions
Summer temperature rise	6°F to 14°F	3°F to 7°F
Winter temperature rise	8°F to 12°F	5°F to 8°F
Days over 90°F (per year)	60 days	30 days
Days over 100°F (per year)	14-28 days	3-9 days
Sea Level Rise	10 -23 in	7 - 14 in
Sea-surface temperature rise	6°F to 8°F	4°F to 5°F
Intensity increase once-a-yr extreme precipitation events	10% more rain	20% more rain

Table 2: NERA and NECIA climate change predictions cited in UCS 2007 summary (Frumhoff et al., 2007).

gases: carbon dioxide, methane, and a few others. The two leading and most recent climate change assessments for the Northeast – the New England Regional Assessment (NERA) and the New England Climate Impact Assessment (NECIA) – show the drastic difference that reducing emissions will make for how we will need to adapt here in Rhode Island.

Table 2 summarizes how several significant climate parameters are predicted to change under different emissions pathways by NERA and NECIA. The rest of this section goes into greater depth on several of the most important climatic changes in Rhode Island, namely warmer mean temperatures, more extreme weather, and increasingly devastating coastal impacts.

What's Coming: Warmer Mean Temperatures

Since 1970, mean annual temperature has already increased here by 1.5°F, and mean winter temperatures by 4°F. The winter and summer temperatures are expected to rise 3-7°F and 6-14°F by 2100, respectively. Extreme heat is predicted to worsen drought conditions Furthermore, the annual number of hot days (over 90°F) is expected to grow sharply from about 5 per year today to about 50-60 per year at the end of the century.[4] We are likely to be in a similar situation to neighboring cities like Boston and Hartford, who by 2100 are predicted to experience roughly 25 days over 100°F every summer if we continue on a high emissions pathway, compared with roughly seven such days if we drastically cut such emissions. Under the high emissions scenario, Rhode Island's summer heat index in 2100 will resemble Georgia's current levels (Fig. 2).[5]

With much warmer summers and winters, Rhode Island is expected to

4 Frumhoff et al., 2007.
5 IPCC, 2007.

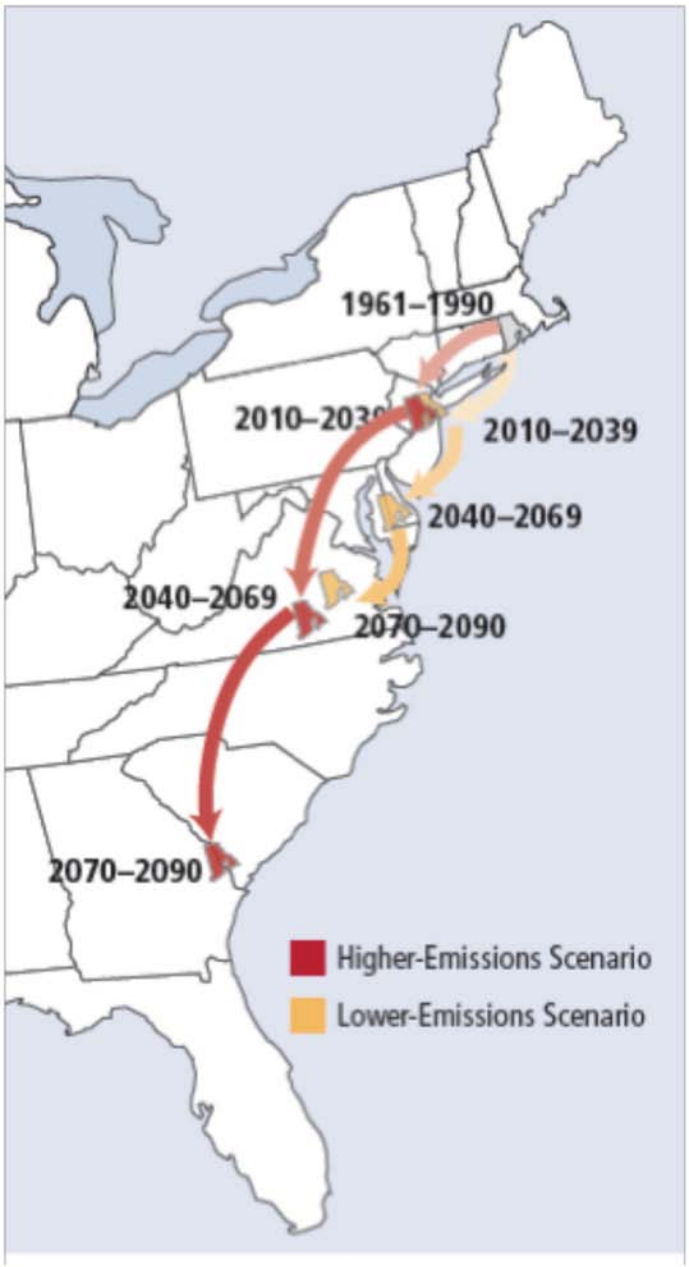


Figure 2. Migrating Rhode Island Summers (Union of Concerned Scientists, 2007).

experience reduced snowfall and snowpack, higher pollution levels, human health risks, damages to agriculture, and increased cooling costs. Ground-level ozone (a part of lung-burning smog) is worsened by high temperatures. Pollution in waterways may further contaminate valuable shellfish and groundwater supplies. Demand for groundwater, which we use for drinking, bathing, and irrigation in the south of the State, will be higher if droughts notably worsen. Such risks threaten the state's citizens and its economy, which gains $50 million annually from its agricultural sector.[6] By 2050, under the high emissions scenario, the winter chilling requirements of high-value fruits, such as blueberries, raspberries, cranberries, and certain varieties of apples, would not be met across most of the state.[7]

6 Frumhoff et al., 2007.
7 Frumhoff et al., 2007.

"With much warmer summers and winters, Rhode Island is expected to experience reduced snowfall and snowpack, higher pollution levels, human health risks, damages to agriculture, and increased cooling costs."

Critical Public Infrastructure: Fox Point Hurricane Barrier

The Fox Point Hurricane Barrier in Providence was completed in 1966 and stands at the union of the Providence and Seekonk Rivers. It protects thousands of people and roughly $5 billion of property in downtown Providence.[1] The barrier was built at 25 feet above mean sea level, and contains three 56-ton gates that take 25 minutes to close completely and 75 minutes to fully open. Pursuant to the 2001 Energy and Water Development Appropriations Act, the city of Providence has received over $2 million in funds (plus additional local funds) to make various repairs on the barrier. There is, however, repair work that still needs attention, but who is responsible for these final repairs is unclear. Congress required the City of Providence to release responsibility of the barrier to the U.S. Army Corps of Engineers.[2]

It is debatable whether the barrier will protect the city in the event of another large hurricane, especially if tides are high.[3] The larger concern, from the perspective of this report, is that no consideration was given to long-term sea level rise during the barrier's design and construction given when it was built.[4] If sea levels rise 5-7 feet, a hurricane or nor'easter could potentially overwhelm the barrier.

1 Morang, 2007
2 USACE, 2009.
3 Landis, 2006.
4 Bowman et al., 2005.

More Extreme Weather

Extreme weather events, such as storms and heat waves, is likely to lead to more flooding particularly in the winter, more frequent and more intense droughts, and more extreme heat days. Winter precipitation is expected to increase 20-30%, which, when combined with warmer temperatures, will cause more rain and less snow cover.[8] Higher short-term drought frequency will likely cause higher irrigation demands for agriculture, and the drying out of wetlands – important filters for downstream ecosystems and water supplies, as well as habitats for Rhode Island's fish and game.

Increasingly Devastating Coastal Impacts

In addition to serious existing coastal erosion problems, the Rhode Island coastline is expected to undergo changes due to rising sea level and an increase in the number of and damage caused by storm surges. Such changes will threaten coastal human populations and

8 Frumhoff et al., 2007.

"Sea level rise of the predicted magnitudes will cause devastating flooding, further coastal erosion, economic hardship, and loss of animal and plant species that are characteristic of our region."

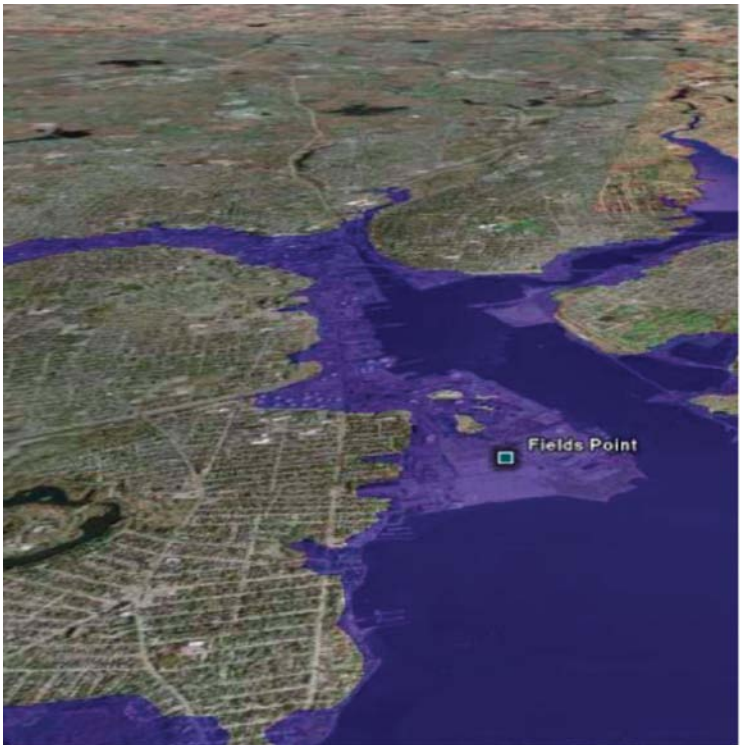


Figure 3. GIS Model of 7-m Storm Surge in Providence, RI (CRMC, 2009).

infrastructure like roads and water systems, worth billions of dollars, as well as fisheries, seagrass, and marsh ecosystems, whose value is priceless. Under the scenario where humans continue to dump out high levels of greenhouse gases (the high emissions scenario), sea level is expected to rise between 10-24 inches by 2100.[9] Sea level rise of the predicted magnitudes will cause devastating flooding, further coastal erosion, economic hardship, and the loss of animal and plant species that are characteristic to our region. Tourism – the state's largest industry that is almost exclusively focused on the coast – faces grave uncertainties if climate change continues unabated. Since geological processes cause Rhode Island's coast to slowly sink, the state's Coastal Resources Management Council (CRMC) has begun to plan for 3-5 feet of sea level rise by 2100.[10] Local fisheries,

9 IPCC, 2007.
10 CRMC, 2008; URI, 2009.

Hurricane Storm Surge	Baseline Frequency (2000)	Approximate Frequency in 2100
5.5 ft.	1-in-10 years	1-in-1 year
10 ft.	1-in-50 years	1-in-10 years
13 ft.	1-in-100 years	1-in-50 years

Table 3: Projected Hurricane Frequency in 2100.

The Impacts of Climate Change on Human and Natural Resources

Year	Hurricane	PVD Storm Surge	Category in RI	Economic Damages in RI ($ 2009)	Total Damages ($ 2009)	Lives Lost
1938	Great September	13 ft.	4	$1,500 million	$4.7 billion	600
1954	Carol	10 ft.	3	$700 million	$3.7 billion	60
1955	Dianne	*	*	$1,400 million	$6.7 billion	185-200
1960	Donna	*	2	$15 million	$2.8 billion	50
1985	Gloria	4.5 ft.	2	$40 million	*	*
1991	Bob	5.5 ft.	2	$180 million	$4 billion	*

Table 4. Hurricane Damages in Rhode Island from 1900-2000.

including those of lobster and shellfish, are expected to collapse mid-century as sea temperatures exceed these animals' heat-stress thresholds, even under the lowest emissions scenario. The lobster fishery alone contributed $23 million to the Rhode Island economy in 2005.[11]

Economic Impacts of Extreme Weather

Extreme weather already has already had tremendously damaging effects on the state of Rhode Island. Since 1938, hurricanes alone caused an average of more than $50 million in losses per year. Today there are 15,000 National Flood Insurance Program policies across the state, which account for $3.5 billion in overall insured property.[12] In adding moisture to warmer air and energy to storm systems, climate change is expected to increase the intensity of such hurricanes in Rhode Island.

11 Frumhoff et al., 2007.
12 CRMC, 2009.

The following "driver tree" details how hurricanes affect Rhode Island's economy and how climate change will escalate those effects. Worsening hurricanes in Rhode Island will lead to loss of life, widespread property damage, rising insurance premiums and discontinued insurance coverage in some areas. Preventative action can help, but is going to be increasingly expensive.

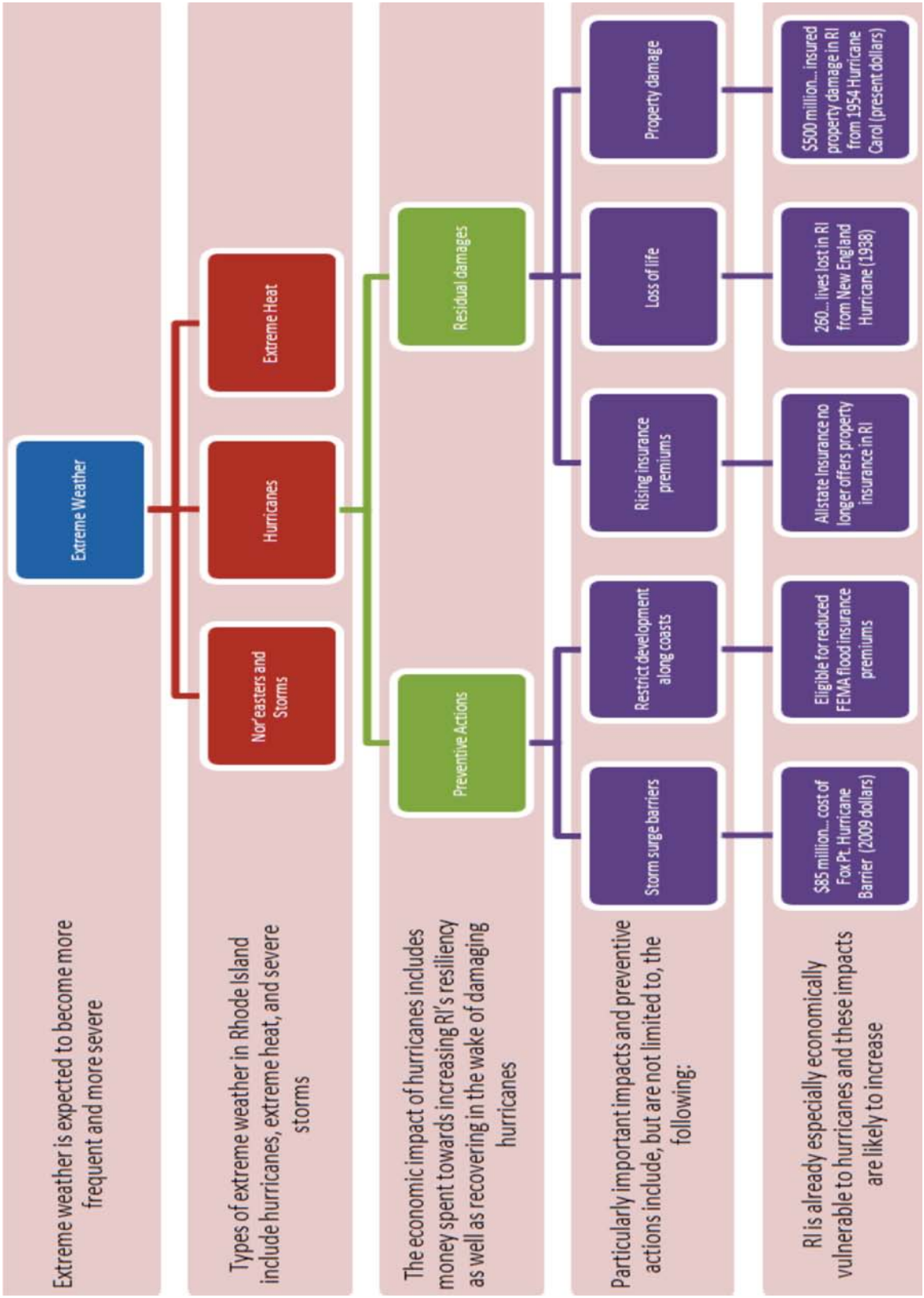


Figure 4. Simplified Driver Tree of the Impacts of Climate Change on Extreme Weather.

A First Step: A Study Commission for Climate Change Adaptation in Rhode Island

Of the state and local governments that have already initiated climate adaptation planning efforts, nearly all have convened a Study Commission or Blue Ribbon Committee to oversee the process.[1] These committees tend to include a combination of government officials, relevant experts, and stakeholders directly affected by or with an important interest in the adverse impacts of climate change. In Keene, NH, leading government officials, including department heads, the Mayor, and the City Manager, and climate change researchers served on the Blue Ribbon Committee. In Chicago, leading representatives from business (including the President of Merchandise Mart and the Chief Technology Officer at Boeing), government, society, and the community served on the committee.

A Study Commission in Rhode Island should include representatives from each of the following sectors: state government, municipal and other government, academia, the private sector, and community groups. When considering particular individuals from each of these sectors, it is important to consider personal investment and experience around relevant issues, and ability to contribute understanding and information not otherwise fully represented on the Commission.

1 Poyar and Beller-Simms, 2009.

Without climate change, Rhode Island would likely spend between $2.5 and $4.5 billion through the end of the century to recover from major hurricanes. Our calculations indicated that if we continue on a high emissions pathway, and if Rhode Islanders fail to take new precautionary action, climate change is likely to cause between $2 and $6 billion in additional hurricane damages in Rhode Island from now through the end of the century. This conservative figure assumes that Rhode Island does not further develop along the coasts, that the population remains stable, and that future costs are valued lower than costs today. More information on the methods for calculating these damages is included previously in Table 4.

"Climate change is likely to cause between $2 and $6 billion in additional hurricane damages in Rhode Island."

"Heat waves can cause heat-related deaths, illness, and increased summer cooling costs."

The Union of Concerned Scientists predicts that New England cities will see a drastic increase in the number of extreme heat days and heat waves due to climate change.[13] Escalating extreme heat can cause economic hardship in Rhode Island in two ways: by increasing prevention costs, and by worsening the unpreventable effects of heat waves. Prevention costs from escalating extreme heat events can range from operating emergency cooling centers during heat waves, to increasing spending on air conditioners and electricity, and to developing emergency heat alert systems to protect the sick and the elderly. Without prevention, heat waves can cause heat-related deaths, illness, and increased summer cooling costs. Currently, Rhode Island has very few reported heat-related deaths during the summer. Based on initial calculations, under a high emissions scenario and without adapting, Rhode Island is likely to suffer from at least 45 more heat-related deaths from now through 2090, in addition to higher numbers of heat related illnesses.

13 Frumhoff et al, 2007.

Calculating Possible Hurricane Damages from Climate Change

To calculate the additional damage caused by hurricanes due to climate change, we first compiled historical data on how hurricanes have affected Rhode Island in the past, and then adjusted that data to reflect inflation. Climate change is expected to increase both the frequency and intensity of severe storms. The frequency (and corresponding damages) of severe hurricanes in Rhode Island is often based on its storm surge above mean high high water (MHHW). By including sea level rise projections into historical storm surge probabilities, we can determine the expected frequency of severe hurricanes in Rhode Island due to climate change (Table 3). Next, we multiplied the updated hurricane frequency estimates by scientific projections (from Nordhaus (2006) and the Association of British Insurers (2005)) of climate change's effects on the intensity of hurricane wind speeds. This figure returned the expected future hurricane damages attributable to climate change.

Air Quality and Public Health

Researchers estimate that approximately 10% of Rhode Islanders have asthma.[14] Air pollution can exacerbate asthma, especially in the summer months. Decades of work to improve Rhode Island's air quality is at risk of being reversed by climate change. As of 2004, the EPA classified Rhode Island as a moderate nonattainment area for ground-level ozone. As a result, the state was required to submit a State Implementation Plan detailing how it will be an attainment area for the 8-hour standard by 2009.[15]

There are two prongs to any effort to address the air pollution effects of climate change. First, emissions must be reduced, but local efforts to increase vegetation can make a notable difference in how much people suffer. Vegetated ecosystems, including forests, are sinks for carbon and also moderate ground-level ozone. The National Forest Service's Urban Forest study for Rhode Island shows how the urban areas of Rhode Island could benefit from increased green

14 RIDOH, 2009.
15 RIDEM, 2007.

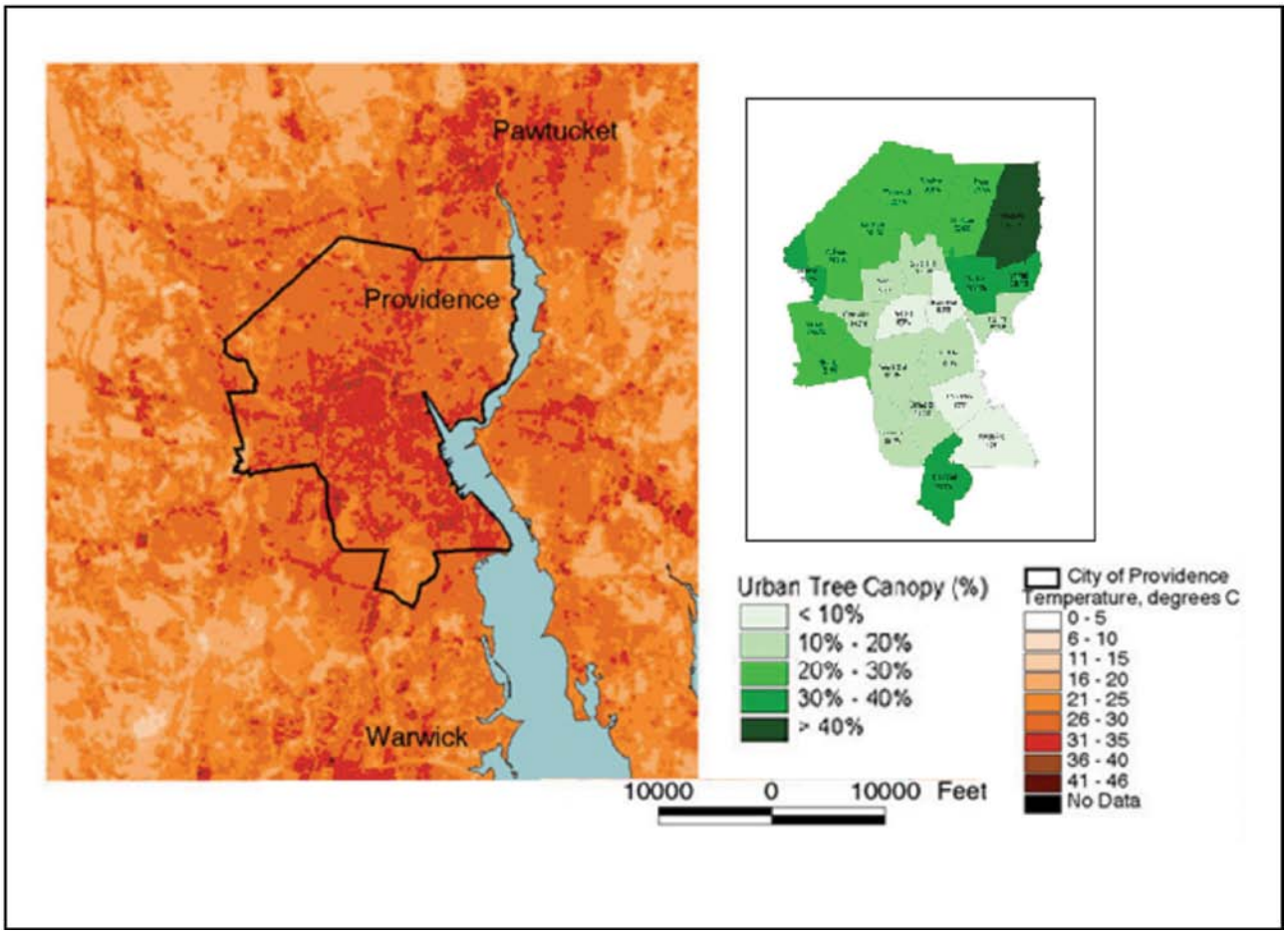


Figure 5. Summer Surface Temperatures in Providence, with Insert Showing Corresponding Variation in Urban Tree Cover (Arzamassova et al., 2003).

Initiative: Increase Access to Community Health Services

As the largest priority reported by the Rhode Islanders whom we surveyed, increasing access to community health services is a key step that has the potential to benefit large numbers of those most vulnerable to expected climate impacts on human health. Such efforts would boost the overall health of the state.

space and especially trees.[16] Urban greening programs, including tree planting, could greatly improve air quality, especially in Providence.

Municipal Government and Utilities

Municipal governments and utilities manage a wide array of resources that are at risk from climate change – including water, sewer, and transportation infrastructure; disaster and emergency preparedness; and land use and zoning. A recent study commissioned by the U.S. Conference of Mayors found that adapting to droughts and floods worsened by climate change over the next 25 years may increase the municipal investment required in water and sewer infrastructure between 15-30%, or between $1-2 trillion nationally.[17] Meanwhile, researchers estimate that coastal inundation from sea level rise in the Mid- and Upper-Atlantic Region will affect more than 500,000 people and 1,000 km of roadways by 2100.[18] Evaluating

16 Nowak and Greenfield, 2008.
17 Anderson, 2007.
18 Wu et al., 2009.

Trees as Adaptation

Tree canopy cover within the city of Providence stands at 23%. Recent analysis found a maximum potential cover of 53%, revealing space for "green infrastructure" expansion. State-wide, urban trees remove 2,420 metric tons of air pollution each year, a service worth nearly $20 million.[1]

Urban greening programs, including tree planting, could significantly improve air quality, mainly through the moderation of summer temperatures. Trees also help with the management of stormwater and improve water quality. Regarding mitigation, Rhode Island's urban trees store 100,000 metric tons of carbon, worth over $2 million if carbon markets value carbon at $20 a ton, a frequent estimate in climate policy research.[2]

1 Cicilline et al., 2008.
2 Still, 2009.

the impacts of climate change on municipal governments in Rhode Island and identifying strategies to adapt to those impacts should be areas prioritized in assessing the state's overall vulnerability to climate change.

Threats to Biodiversity

Increased fresh- and seawater temperatures and evaporation in wetlands could potentially diminish or completely destroy vital habitats for aquatic and semi-aquatic groups, such as crustaceans and amphibians, respectively.[19] Many economically important species, such as those of lobster and shellfish, are expected to collapse by 2050 due to heat stress, while juvenile winter flounder are more vulnerable to predation in warmer winter waters.[20]

"...seagrass and salt marsh communities may drown out altogether, as their habitats are restricted on one side by deep water and on the other by urban and suburban development."

Seagrasses and cordgrasses play key roles in stabilizing coastlines and providing ecosystems to hundreds of marine and coastal species. As rates of sea level rise increase, populations of seagrasses (such as eelgrass) must either migrate towards the shore or perish in the lower light levels.[21] Further upshore in salt marshes, cordgrasses must migrate towards land at the expense of higher-marsh species to avoid tidal inundation.[22] If the predicted increases in rates of sea level rise are realized, seagrass and salt marsh communities in New England may drown out altogether, as their habitats are restricted on one side by deep water and on the other by urban and suburban development, with its hardened seawalls.

One immediate example of the changes we will likely see across the state's flora and fauna is competition between natives and invasive species. Coastal native birds in Rhode Island face expanding populations of the double-crested cormorant, an aggressive competitor. Studies suggest that the migration range of the double-

19 Frumhoff et al., 2007.
20 Save the Bay, 2006.
21 Save the Bay, 2006.
22 Donnelly and Bertness, 2001.

From Impacts to Response: Adaptive Capacity in Rhode Island

crested cormorant is shifting northward as Rhode Island's seasons become warmer.[23] If the cormorant is allowed to migrate unrestricted, it will likely pose far greater problems for local birds, some of which may already be struggling to catch sufficient coastal marine prey from dwindling communities.

How will Rhode Islanders respond to climate change? Whether we respond proactively and cooperate, or passively, individually, and only after disaster is at our doorstep, depends upon our cultural beliefs, our understanding of involved issues, our organizational skills, and whether our institutions (like schools, churches, employers and governments) lead us to make good decisions.

Studies around the world have assessed communities' capacities to respond to climate change-related crises, and researchers have developed a series of measures to help improve that capacity by building resiliency at different levels. We conducted a small survey and a series of focus groups to explore Rhode Islanders' views on climate change and its causes; to learn how they are already being impacted by climate change; and to collect their ideas of possible steps that the state could take to adapt to climate change and build community resilience and sustainability.

Local communities who are, or will be, most impacted by any problem are indispensable towards creating real solutions to the problem. Our exploratory and non-random survey of 100 people and 5 focus groups from lower-income communities reached some of Rhode Island's most vulnerable populations, as well as representatives of other broad segments of the State's population. Though much more work is required to capture a complete picture, participants in our study shared how they think Rhode Island can engage climate change adaptation in a pro-active way, and address potential problems before they

23 US Fish & Wildlife Service, 2003.

(Image courtesy of Tara Gancos)

Action: Outreach and Support for Capacity-Building

A comprehensive outreach plan requires the engagement of communities from the start of the process. Focus groups, individual meetings, guest speakers and surveys not only informed the recommendations outlined in this report, but also initiated a larger dialogue about urban adaptation. As a next step, access to useful and accessible information regarding urban adaptation will allow all communities to continue their involvement in the process and also to engage further. As a supplement to the report, we will circulate outreach materials aimed at presenting a concise, accessible and useful summary of urban adaptation recommendations, and create a website to facilitate the formation of partnerships between NGOs and schools.

become dire. Our findings suggest that we can collectively do more than just prevent tragedy; we can also create positive benefits by strengthening community resilience and building sustainability in the process.

Understanding of and Concern About Climate Change

Over 80% of our survey respondents from Rhode Island's vulnerable communities reported knowing, or at least having an idea about, the nature of climate change. Approximately 69% of participants attributed the causes of climate change to greenhouse gas emissions from people and corporations, while 13% believed that the causes are "natural." When considering age-related trends in the different responses to this question, we found that those who self-identified as "youth" were all certain that the climate is changing, and nearly all of the other respondents reported believing

"Seventy-three percent of respondents [in Rhode Island] rated climate change as a serious problem, in line with several recent national surveys."

that changes are occurring. When asked whether they believed that climate change will significantly affect their everyday lives, 75% of respondents projected that it would affect them within their lifetime, including 29% who reported already being affected.

We asked respondents to rate their level of concern regarding different kinds of impacts that scientists predict could happen in Rhode Island as a result of climate change. Over 60% of respondents reported a high level of concern about each of the possible climate change impacts assessed, with the highest levels of concern (over 80% of respondents) in the areas of air pollution, flooding, and greater stress on public social services. Approximately 73% of respondents rated climate change as a serious problem, in line with several recent national studies,

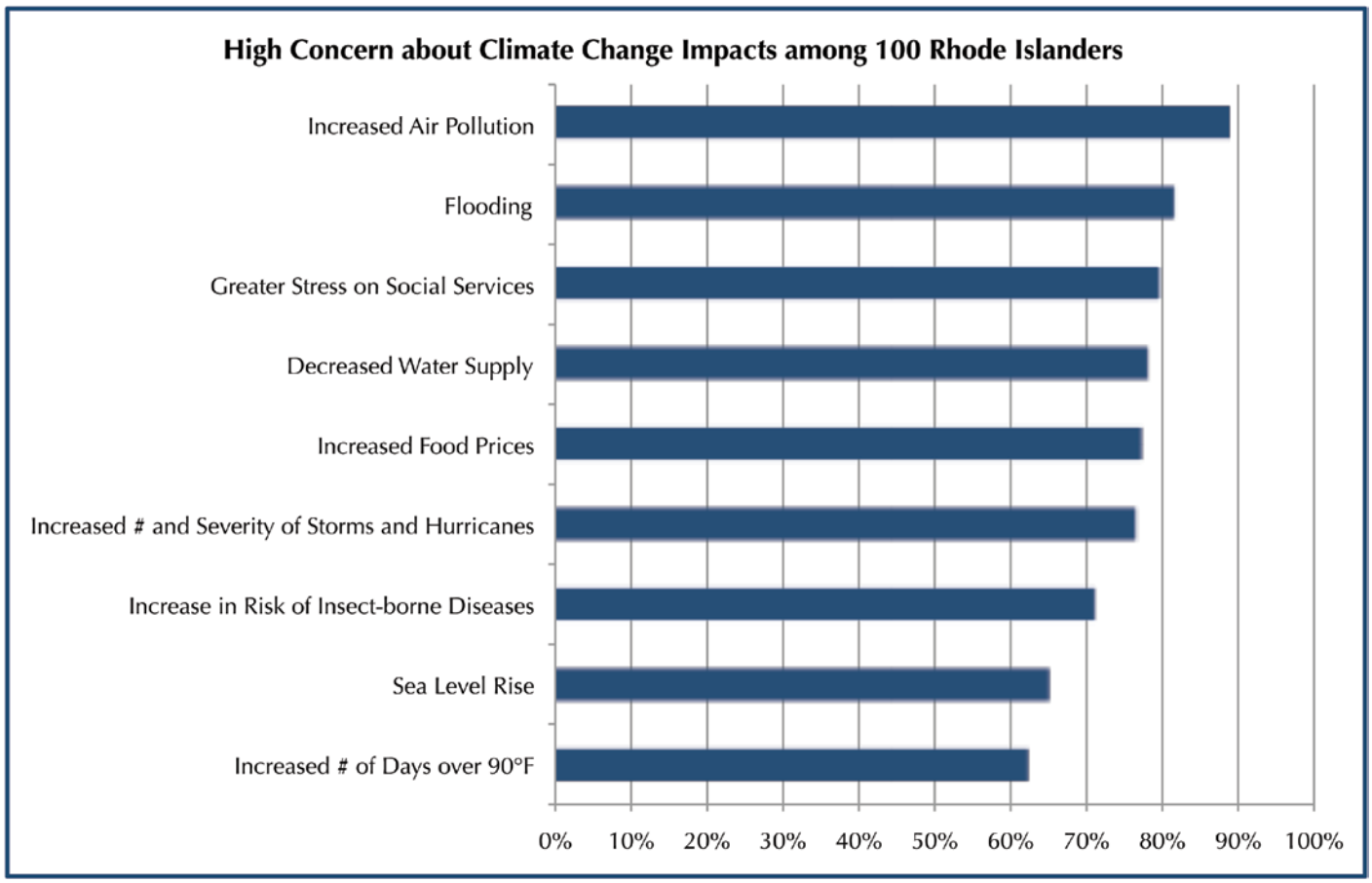


Figure 6. Areas of Climate-Related Concern for Rhode Islanders

with 85%,[24] 90%,[25] and 84%[26] of respondents saying it was a very or somewhat serious problem. Additional data, including respondents' desire for additional information on climate change, and analysis of responses by income, are available in our complete online report.

Building on Strength: Who's Doing What that Could Mobilize to Address Climate Adaptation – Rhode Island Stakeholders and Initiatives

Fortunately, we are not starting from scratch in addressing climate change in Rhode Island. From grassroots organizations to corporate working groups, Rhode Island has taken substantial steps in addressing a series of environmental issues. One of Rhode Island's greatest strengths, attributed in part to its abundance of NGOs and academic institutions as well as its small geographic size, is its wealth of social capital. Capacity built in some seemingly unrelated areas provides foundations for new efforts on climate adaptation. By evaluating existing efforts, identifying potential partnerships, analyzing social choices and investing in social capital, these networks and locally-developed efforts may assist our recommendations for urban adaptation.

Action: Boost Collaboration between Institutions and Individuals

The most effective cross-sector partnerships will involve full participation from Rhode Island's diversity of organizations and agencies. Grassroots organizations, corporations, member-based NGOs, foundations, small businesses, state agencies, municipal offices, academic institutions and individuals together bring the perspectives and resources necessary to implement effective adaptation plans.

Corporations: Small and large firms are key in finding solutions for Rhode Island. Taking into account both philanthropy and operations, companies already support non-profit organizations that could focus more on this issue; some are factoring warming trends and increased flooding into their core business decisions. For example, CleanScape is a recycling and landscaping company established in South Providence in 1999 that sees its work as "part of a larger effort to

24 ABC News/Stanford University/Time Magazine Environment Poll #1, 2006.
25 Woods Institute et al., 2006.
26 ABC/Washington Post/Stanford University Poll, 2007.

develop environmentally-motivated businesses as a means of community development,"[27] and Blue Cross Blue Shield has constructed its new headquarters in compliance with LEED Certification standards. Some companies are utilizing an increased awareness of and support for Corporate Citizenship and Responsibility.

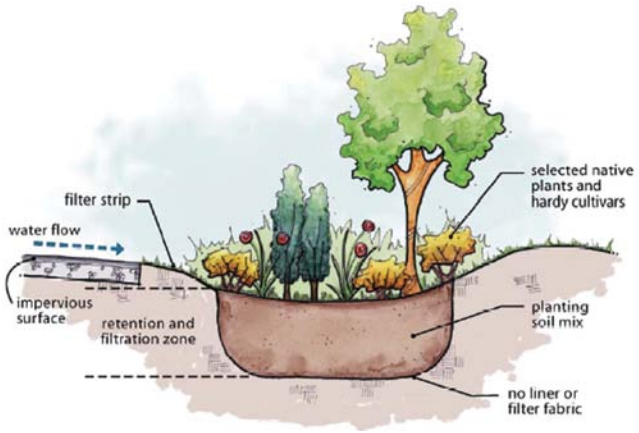
Academic Institutions: Rhode Island is home to a host of academic institutions, including University of Rhode Island; Roger Williams University; Brown University; and Johnson and Wales University, all of which have been engaged in environmental sustainability initiatives for decades. Their projects benefit surrounding neighborhoods and provide experiential learning opportunities for the academic community. With this momentum, new environmental projects continue to form. The University of Rhode Island's Graduate School of Oceanography hosts several units engaged in pioneering work on coastal impacts and adaptation strategies, both locally in the state and regionally in the Northeast through work with the National Oceanic and Atmospheric Administration, as well as in the developing world through work with the U.S. Agency for International Development.

"One of Rhode Island's greatest strengths is the wealth of social capital. Capacity in different areas provides foundations for new efforts on climate adaptation."

Non-Governmental Organizations: NGOs promote public understanding of climate change adaptation by providing research, risk assessment, ideas for action, and best practices. The Environment Council of Rhode Island and the Union of Concerned Scientists have led the way with prescient informational brochures on climate impacts and options for Rhode Island. NGOs also provide support to environmental efforts of local governments, and some have a strong base in the communities that climate change will most impact.

Government Agencies: Government agencies play an active role in local climate change adaptation efforts. Understanding the impacts of climate change can lead local municipalities to adaptation planning. In 2002, the State of Rhode Island published the Greenhouse Gas Action Plan, advocating an 85% reduction of greenhouse gas emissions from 1990 levels. Rhode Island Public

27 CleanScape, 2009.



The Policy Context

Transportation Authority (RIPTA) is taking action to reduce air pollution and make buses more fuel efficient. The Rhode Island Government has also introduced economic incentives to promote renewable energy production and consumption through tax credits for households producing and using renewable energy. The city of Providence's "Greenprint" publication takes a wide view of efforts to reduce the city's environmental impact and improve living conditions.

Consciously or unwittingly, state and local governments greatly influence private choices regarding climate risks. This influence manifests itself through taxes and subsidies, zoning, land management, utility ratemaking, and countless other actions within the authority of government policymakers. This section outlines existing incentives and disincentives for climate adaptation in the private sector, and how government policies shape them.

Top: Graphic by AHBL (LID Technical Guidance Manual for Puget Sound, 2005). Puget Sound Partnership & Washington State University Extension.

Action: Expand Riparian Buffers

Riparian buffers are development-free wooded borders along creeks, rivers, lakes and bays. Their benefits are numerous, including cooling neighborhoods, slowing and filtering stormwater, and increasing property values. A study in Seattle found that "trees have saved the Seattle urban area approximately 355 million cubic feet in avoided stormwater retention area, worth an estimated $710 million."[1] In Rhode Island, resources are needed to map current and potential buffer sites, to develop and institute adequate legislation to support enhanced streamside buffers, to train public officials to deal with them, and to form grant programs for open space preservation, including riparian buffers.

1 Portland Bureau of Environmental Services, 2007.

Stormwater and the Heat Island Effect

As rainfall events become more severe with climate change, addressing flooding, sewage spills, and the impacts of so much water on landscapes and in the bay should be a top priority for localities and the State. The City of Providence has made commitments to create incentives for stormwater control measures including green roof construction, rain barrels to collect water from gutters and downspouts, and increased on-street parking to prevent homeowners and businesses from paving green space.[28] Presently, however, these remain aspirations. Partnerships between the City of Providence and local nonprofits have made good progress in creating incentives for private residents to help reduce stormwater runoff, counteract the heat island effect, and save energy by planting trees.

The heat island effect worsens ground-level ozone. When ozone levels exceed federally determined safety standards, the Department of Environmental Management (DEM) issues an "Air Quality Alert Day Warning." Local media issue these warnings to the public. With federal funding support, Rhode Island Public Transit Authority (RIPTA) estimated it carried 316,227 passengers free of charge on Air Quality Alert Days in 2008.[29] It is unclear, however, to what extent ridership increases – if at all – on Air Quality Alert Days relative to other days. These areas require broader efforts.

Food Security

While food security does not seem to be as urgent an issue, a modest framework currently exists to insulate against some effects of climate change. In a country where the average bite of food travels some 1,600 miles, urban residents are made somewhat more secure in the face of climate-related disasters by securing

28 City of Providence, 2008.
29 RIPTA, 2008.

Initiative: Enhance Food Security

Community gardens, community supported agriculture and farmers' markets are three important mechanisms to ensure an accessible food supply in case of climate-related catastrophe. Policymakers could establish more gardens on public land – as Providence has begun to do – subsidize water rates to gardens, install water infrastructure, build fences, support the establishment of "green roofs" and "vertical farms" to maximize urban food production, offer incentives for establishing community gardens, and more aggressive public-awareness campaigns.

independent and local food sources. Local farms also receive support through the roughly 37 farmers' markets that operate during Rhode Island's summer months and the few that run all winter. Rhode Island municipalities have established a modest number of community gardens as well. Providence established three such gardens on municipal parklands and has committed to establishing three more, but no formal system of State-sponsored incentives exists to spur municipal leaders to establish community gardens.[30]

Reducing Disincentives for Adaptation

Disincentives for adaptation also exist. The National Flood Insurance Program (NFIP) provides flood insurance protection at below market premiums to anyone living in a participating municipality. With the exception of a few coastal barrier acres, all

30 City of Providence, 2008.

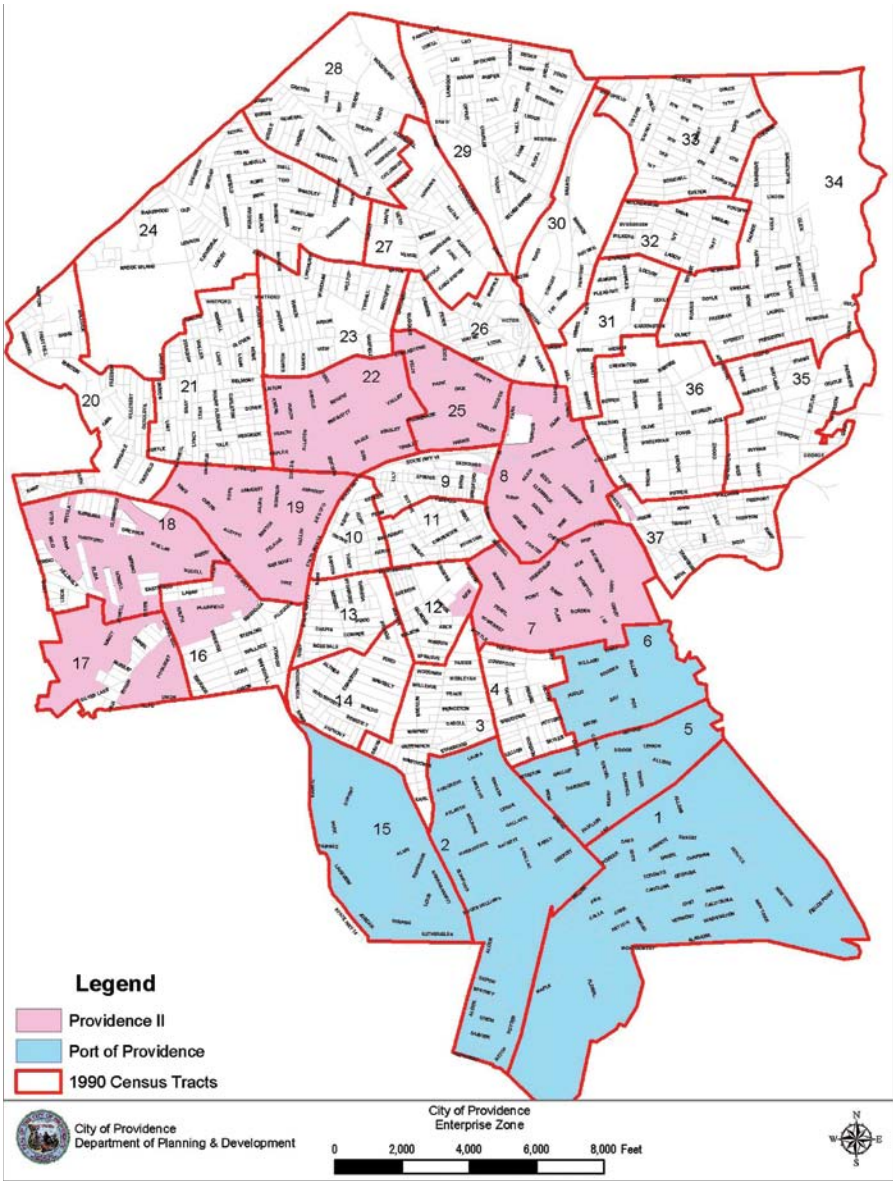


Figure 7. Enterprise Zones in Providence (City of Providence, 2009).

Rhode Island communities participate in NFIP because "lenders will not usually finance development or support resale of property in flood prone areas."[31] Risk to coastal development, however, is continuously accelerating due to our changing climate. Furthermore, NFIP must insure repetitive loss properties where rates have clearly failed to reflect actual risks. Infrastructure that exists prior to communities joining the NFIP receives flood insurance at an estimated 38% of market costs. New infrastructure receives an implicit subsidy by the Federal Emergency Management Agency's (FEMA) practice of retroactive rate setting. FEMA sets insurance rates for new development based on a moving 25-year loss experience, thereby failing to reflect higher expected future risks.[32]

With subsidized insurance rates, individuals and businesses have substantially fewer incentives to avoid developing in disaster prone flood zones. Likewise, local zoning authorities (municipalities and the Coastal Resources Management Council) feel only a fraction of the political and economic damage engendered by high-risk real estate development, while gaining all the tax revenue.[33] Consequently, high-risk areas are zoned for development.

31 Juergensmeyer, 2007.
32 Pidot, 2007.
33 Thomas and Medlock, 2008

Action: Define "Natural Disasters" to Exclude Climate Disasters in High-Risk Areas

Rhode Island law provides significant tax relief to businesses whose facilities experience substantial damage due to "natural disasters." According to statute, "Disaster means an occurrence, natural or otherwise, which results in the destruction of sixty percent (60%) or more of an operating manufacturing business facility."[1] While providing much needed relief to helpless victims of "occurrences," it also provides relief and encouragement to businesses that knowingly and unnecessarily choose to operate in disaster prone areas.

Though not entirely predictable, many of the effects of climate change are foreseeable, and Rhode Island development policy should reflect this reality. Rhode Island should amend the definition of "disaster" to account for the impending climate-related events by excluding forecasted climate-related disasters (e.g. coastal flooding and erosion) in high-risk areas. This amendment should apply prospectively to prevent further development of already highly developed disaster areas, and should exclude location-specific firms, like maritime-dependent businesses, that must operate in high risk areas by necessity.

1 R.I. GEN. LAWS § 42-64.5-2(4) (2009).

One recent commentator declared NFIP to be "a public policy disaster, both because of the burden it has imposed on the federal taxpayer and because it has failed to stem the tide of development in hazardous floodplains."[34]

Rhode Island state law may also hinder climate adaptation. Under Rhode Island's Jobs Development Act, manufacturers who have lost 60% of their facilities' value due to a natural disaster, thereby forcing employees out of work, may qualify for corporate income tax reductions and a sales tax exemption on reconstruction materials. While providing relief to ailing workers and businesses, the unqualified protection against "natural disasters" stimulates further development in disaster prone areas.

The Rhode Island Economic Development Corporation designates special "Enterprise Zones" throughout the state. The Enterprise Zone Program was established to encourage greater employment opportunities for particular regions of the state, and qualifies any business that grows its workforce in one of these zones by at least 5% to a significant business tax credit. The value of the tax credit extends up to 75% of the annual wages to new employees. Many Enterprise Zones overlap significantly with areas at high risk for climate-related disasters. While pursuing important economic goals, policymakers may also be putting new development—and the people surrounding the development—in harm's way.

Action: Adjust State 'Enterprise Zones' Away From the Highest-Risk Areas

To the extent to which overlap occurs, Rhode Island's Economic Development Council should consider adjusting the "Enterprise Zone" designation from the highest risk areas. For existing businesses that are by necessity fixed in a particular high-risk area – e.g. maritime businesses – the Enterprise Zone designation could remain in effect. Modest shifts in existing Enterprise Zones would perpetuate job creation in low-income areas while preventing the worst climate disasters from befalling the very populations the Program seeks to aid. Shifting the Enterprise Zones would redirect job growth, and therefore population growth, away from the most disaster prone areas. This shift could gradually diminish the economic and safety threats posed by our changing climate.

34 Pidot, 2007.

Hydrological and climatic functions of the green infrastructure

	Corridors	Patches	Matrix
Retention	• • •	• •	•
Infiltration	•	• •	• • •
Evapotranspiration	•	• •	• • •
Shading	•	• •	• • •

Figure 8. (Susannah Gill, adapted by Pauleit <http://www.els.salford.ac.uk/urbannature/outputs/others/sazburg/SPauleit_GIChallenges_3.pdf>.

Urban Forestry and Green Infrastructure

The urban forest of Providence includes trees on public, private and institutional land. Providence's urban forest is an asset that is valued at $2.9 million in annual environmental benefits, more than three times the amount spent on the city's tree program each year. The city has approximately 25,000 street trees of over 95 species, overseen by the City Forester.[35] As well as their mitigation value, the trees have significant adaptation value, because they help reduce the negative impacts of climate change for humans by improving thermal comfort in summer and winter, reducing air pollution associated with summer highs, and

35 City of Providence Urban Forestry Report, 2008.

"Trees... help reduce the negative impacts of climate change for humans by improving thermal comfort in summer and winter, reducing air pollution associated with summer highs, and reducing storm-water damage."

Initiative: Expand Urban Greenspace

Providence's Urban Tree Cover stands at 23% of an identified 53% possible cover, with residential land showing the greatest potential for increased cover.[1] One of our top recommendations is that state and local forestry efforts be supported and expanded in Rhode Island. The Providence Neighborhood Planting Program and Trees 2020 are two active planting programs; the latter aims to increase cover to 30% by 2020. This represents an increase of 7%, which could be modestly stretched to 10% and more ambitiously to the full 30%. These projects should target neighborhoods with high potential tree cover, such as Mount Hope and Charles, as well as those with low cover. Research could easily determine which tree species are best adapted to climate change in Rhode Island.

1 Cicilline et al., 2008.

reducing storm-water damage.

The highest surface temperatures are in parts of the city with the lowest tree cover, providing evidence for the temperature-moderating effect of trees in Providence. In the summer, trees stay cooler than buildings because water evaporates from their leaves. Trees also shade buildings, reducing the urban heat island effect. In winter, trees block wind flow into buildings, reducing heat loss.[36] One study found that adding 10% green cover to town centers and high density residential areas held maximum surface temperatures at or below the 1961-1990 baseline temperatures in those areas, up to but not including the 2080s high emissions scenario, a remarkable result.[37]

Trees help manage storm water volume and water quality by filtering out pollutants, facilitating storm water infiltration to groundwater supplies, intercepting rainfall (by delaying peak flows into drainage or sewer systems, thereby reducing the risk of sewerage overflows) and by securing soil to reduce erosion. Each year, Providence's street trees intercept 30.6 million gallons of storm water runoff, a service with a dollar value of $244,495. In 2006, Providence's street trees intercepted 29 tons of air pollution.[38] Although trees produce biogenic volatile organic compounds (BVOCs) that can form ozone, this emission is more than offset by the temperature reduction that trees confer, notably reducing ozone formation.

36 Gill et al, 2007.
37 Gill et al, 2007.
38 City of Providence Urban Forestry Report, 2008

The distribution of trees within Providence is uneven, with the lower income neighborhoods of South Providence, Elmwood, Washington Park, Olneyville and West End having lower canopy cover. We may find that populations least able to cope with the financial burden of climate change are thus the most susceptible. We noted some progress in the greening of these neighborhoods. Tree cover has increased in the smaller residential area of the Washington Park neighborhood, although the Port of Providence and a large industrial area also in that neighborhood will likely remain non-conducive to tree planting.[39] Contributing to the current low canopy cover in these neighborhoods is Providence's municipal parking ordinance that restricts on-street nighttime parking, and landlord parking provision requirements of two spaces per housing unit. When a property is densely occupied, these requirements often mean that front and back yards are entirely paved for parking, leaving no room for trees.

Action: Expand Green Roofs and Walls

Although far less known in Rhode Island, "green roofs" and "green walls" are being widely adopted to fight heat island effects and stormwater runoff in major cities around the world. Vegetated coverings can keep the ambient temperature at lower levels. Air conditioners function best below 95°F, so this allows for higher efficiency and energy savings. A Canadian study revealed that a green roof

39 Still, 2009

"Vegetated coverings use existing space to manage stormwater by collecting precipitation and recycling it through transpiration."

Vegetated Roof on a county building in Portland (AHBL, from the LID Technical Guidance Manual for Puget Sound. 2005. Puget Sound Partnership & Washington State University Extension.

can reduce a building's heat gain by 95% annually. If Toronto greened 50% of its roof space, the temperature of the entire city would drop by nearly 4°F. Green roofs can provide a space for urban agriculture as well as improving air quality by absorbing contaminants and noise pollution by absorbing sound waves.[40] A square meter of grass on a roof removes 0.2 kg of airborne particulates annually.[41] Perhaps just as importantly, vegetated coverings use existing space to manage stormwater by collecting precipitation and recycling it through transpiration.

Decentralized Energy

Certain incentives that programs created for reasons unrelated to adaptation also achieve the goal of spurring adaptive behaviors. Small, decentralized renewable energy, for example, promotes energy independence, creates jobs, and helps prevent climate change, but, more relevantly for this report, it can provide a steady supply of power in the event of disruption to electricity service. The Department of Energy's Lawrence Berkeley Laboratory conducted a study in 2004, finding that power outages result in $80 billion in lost economic output annually.[42] The increased occurrence of extreme weather and flooding — including the possible inundation of a natural gas power plant in Providence's industrial waterfront — make decentralized energy a potentially important economic innovation.

Rhode Island encourages the development of decentralized energy in a number of ways. Net-metering allows public facilities as well as small (up to 1.65MW) private solar and wind electricity production to significantly reduce electricity bills by spinning electricity

Initiative: Encourage Decentralized Renewable Energy Supplies

Decentralizing energy provides a buffer against electricity grid disruptions and the economic losses that follow. Increased extreme weather events and higher summertime peak energy demand periods will add stress to an overburdened northeastern electricity grid. Expansion of business and residential tax credits and loan and grant programs can encourage business- and home-owners to build Rhode Island's energy safety net. Enhanced net-metering terms would allow business- and home-owners to operate their energy systems more profitably. Furthermore, expanding decentralized energy would create private sector jobs in system installation and maintenance.

40 Oberndorfer, 2007.
41 City of Chicago, 2009.
42 Hamachi LaCommare and Eto, 2004.

meters backwards. The Rhode Island Economic Development Corporation provides roughly $1 million in loans and grants for small renewable energy projects on homes and businesses.[43] The Rhode Island Tax Code also encourages renewables. Renewable energy systems are exempted from sales tax and local property tax, and qualify for personal or business tax credits of up to 25% of the cost of the system.[44] Interestingly, the nonprofit sector has influenced energy incentives as well. People's Power and Light, a Rhode Island nonprofit group, offers $.03 per kWh to purchase renewable energy credits generated by small wind and photovoltaic sources.[45] All of these mechanisms increase the profitability and therefore the adoption of decentralized renewable energy.

43 Rhode Island General Laws § 39-2-1.2(2009).
44 Rhode Island General Laws § 44-18-30, 44-3-21 and 44-57-1 (2009).
45 N.C. Solar Center, 2009.

Vulnerability and Resilience

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability of extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Action: Lift Municipal Regulations on Night-time Parking

Municipal regulations on night-time off-street parking should be revised. Lifting these restrictions could greatly reduce the amount of impervious surface cover in the city and increase the space available to plant trees, gardens, and other forms of vegetation. State and municipal governments should also encourage homeowners to construct permeable driveways through tax incentives and information campaigns. Adding green strips along sidewalks, park space, and other impermeable surfaces would also help control stormwater.

Some Quick-and-Easy, and Some Tough-But-Crucial Suggested Actions

Moving to Solutions

Our recommendations fall into six groups: understanding climate change's likely impacts; protecting the most vulnerable people in the state; improving our planning and preparation; intelligently expanding our green infrastructure; building neighborhoods and infrastructure more sustainably; and educating and engaging the community. In this final section, we review priorities for adaptation solutions and highlight some of these specific initiatives in greater detail.

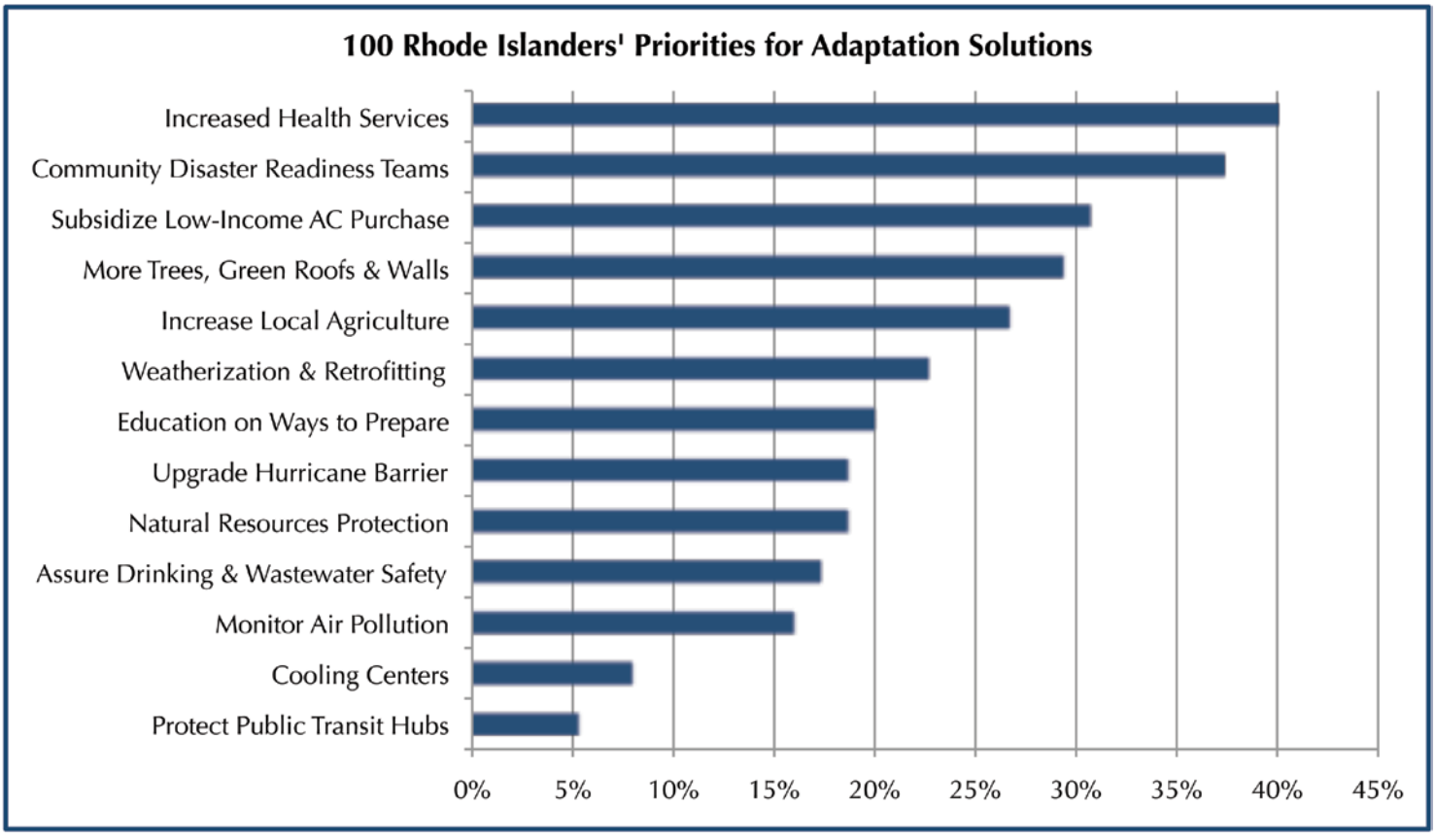


Figure 9. Prioritized Areas of Climate-Related Adaptation Solutions.

Category	Specific Initiatives (More economically feasible initiatives are *italicized*. Higher impact initiatives are in **bold**)
Understanding Climate Change Impacts	1.) ***Improve data collection and availability through advanced topographic technologies like LIDAR*** 2.) *Increase collaboration and partnerships to increase climate change resiliency* 3.) *Enhance the understanding of climate change impacts and projections of urban planners and other decision-makers* 4.) *Continue to monitor climate change impacts across the state*
Protecting the Most Vulnerable	1.) *Develop effective heat and hurricane alert systems to protect against catastrophic events* 2.) **Expand access to cooling and relief centers, such as libraries and pools, during heat waves** 3.) **Require National Grid to not shut-off electricity access during summer months** **4.) Provide energy audits and weatherization to poor Rhode Islanders, while drawing labor from low-income communities** 5.) Provide financial incentives for low-income individuals to have access to energy-efficient products *6.) Support the work of community disaster relief preparedness teams* 7.) Increase access to community health services
Better Planning and Preparation	1.) **Amend Rhode Island's comprehensive planning statute to require consideration of climate change projections in all municipal comprehensive plans** 2.) **Investigate the vulnerability of all critical public facilities, such as hospitals and schools, across Rhode Island** 3.) Encourage urban planners to incorporate climate change in all long-range planning for critical public infrastructure
Expanding Green Infrastructure	1.) *Research tree species that will be most resilient to climate change e.g. capitalize on shifting growing conditions* 2.) **Increase urban tree canopy by 10-30%** 3.) **Expand wetlands, buffers, riparian zones, and other critical green infrastructure** 4.) Increase local agriculture, including urban community gardens 5.) Provide incentives for rain gardens, green walls, and green roofs, particularly in urban areas
Developing Sustainably	1.) ***Mandate the notification of potential home buyers of a property's flooding and sea level rise risks*** 2.) *Reduce current disincentives to climate adaptation* 3.) **Mandate tougher building codes along the coast to protect Rhode Islanders from hurricanes and severe weather** 4.) **Enhance existing energy efficiency programs, such as home weatherization programs** 5.) Create new, innovative energy efficiency programs, such as municipal energy efficiency revolving loan fund
Education and Community Engagement	1.) *Enhance understanding of climate change and climate adaptation in the community* 2.) *Increase collaboration for climate change adaptation among community members and public and private institutions*

Table 5: Recommended Adaptation Actions for Rhode Island

Community Support and Successful Adaptation in Rhode Island

Our survey revealed support for adaptation action in Rhode Island. Support was especially strong for improving health services, more tree planting, building community disaster readiness teams, expanding local agriculture, and assisting the lowest income families in purchasing air conditioners and fans. Focus groups discussed these options in more detail, prioritizing cooling centers, the retrofitting and weatherization of homes and other buildings, and consistently expressing the importance of linking emissions reductions with adaptation efforts. These were willing recruits to the cause of our state moving forward proactively in preparing for the uncertain weather ahead.

That focus group participants were so enthusiastic about being part of these solutions shows the importance of including communities in planning and decision-making on how Rhode Island adapts to the likely changes that face us. Any of the recommendations discussed in this report will only be successful if local communities who will be most impacted are respected as experts with first-hand knowledge of what is likely to work in their places. In preparing these plans, it will be crucial to attend especially to low-income neighborhoods and communities of color. The work of adapting to climate change provides opportunities to build better relations between parts of our state's population, and between its governments and its people.

"Any of the recommendations discussed in this report will only be successful if the local communities who are and will be most impacted are respected as experts towards the creation of adaptation solutions."

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