Connecticut Climate Change Preparedness Plan

Adaptation Strategies for Agriculture, Infrastructure, Natural Resources and Public Health Climate Change Vulnerabilities

A Report by the Governor's Steering Committee on Climate Change (GSC)
Adaptation Subcommittee
2011

Acknowledgements

The Adaptation Subcommittee would like to acknowledge the climate change projection work, including counsel of its members, from the New York Panel on Climate Change (NPCC 2009) and the Northeast Climate Impacts Assessment (NECIA; Frumhoff et al. 2007) used in the analysis of climate change impacts to Connecticut, summarized in this report. (See the inset box in the introduction of this report for a complete list of Adaptation Subcommittee members.) The Adaptation Subcommittee also would like to acknowledge the commitment and dedication of all of the Adaptation Subcommittee workgroup co-chairs and participants.

Cover Photo

Water quality and quantity, a critical climate change adaptation consideration, is represented by the Lower Beaver Brook is located in Barkhamsted, a cold water stream that feeds the Metropolitan District Commission (MDC) Lake McDonough or Compensating Reservoir. Projected changes of water quality and quantity caused by climate change will impact all sectors of Connecticut society. For more information about adaptation strategies to compensate for changes in water quality and quantity see the *Common Climate Change Concerns* section. Photo is courtesy of CT DEEP.

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Executive Summary

Background

In accordance with Public Act No. 08-98, *An Act Concerning Connecticut Global Warming Solutions*, Section 7 required the Governor's Steering Committee on Climate Change to establish an Adaptation Subcommittee to evaluate the projected impacts of climate change on Connecticut agriculture, infrastructure, natural resources and public health and develop strategies to mitigate these impacts. Given this charge, the Adaptation Subcommittee established four workgroups to cover each area in the *Act*. The Adaptation Subcommittee chose qualified subject matter co-chairs from among its members to lead these workgroups, and each workgroup then assembled a team of experts to assess climate change impacts and adaptation strategies.

The Adaptation Subcommittee detailed the projected impacts of climate change in a 2010 report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*[1]. This second report is a response to the legislative requirement that the Adaptation Subcommittee identify strategies for adapting to the impacts of a changing climate in Connecticut. Further preparedness planning and implementation work remains, which will require ongoing cooperative efforts of regional, state and local stakeholders.

Recommendations

The most effective adaptation strategies affect multiple sectors of Connecticut society, utilize available resources, have a positive cost to benefit ratio, create jobs, have political support (e.g., existing government priority and legal and regulatory framework) and have identifiable leadership. Adaptation strategies should retain the cultural values of Connecticut and empower local communities to take direct action in concert with state, regional, and national efforts. The strategies include achievable benchmarks within a defined timeframe, a detailed implementation plan, and offer co-benefits for other non-climate management programs. Small demonstration projects will help define broader implementation plans, and garner public, political and financial support by demonstrating early and larger potential successes. Building on these successes requires an informed public which dictates the need for expanded public education and properly targeted messaging.

In assessing the impacts of a changing climate in "The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health" (Adaptation Subcommittee 2010) it became clear that a number of impacts cross the topical planning areas that the General Assembly established in Section 7 of Public Act No. 08-98. Section 4 of the Impacts Report identified that water quality and quantity, ecosystem services, buildings and transportation significantly impact agriculture, infrastructure, natural resources and public health interests in Connecticut. The adaptation strategies for these intersecting issues mostly concern land use and resource planning, and include a number of assessments/inventories needed to further inform the adaptation planning process.

[1] The Impacts Report can be found on www.ct.gov/deep/climatechange.

Each workgroup provided a number of overarching and specific adaptation strategies, which were grouped into three categories, 1. Best Management Plans, 2. Research, Monitoring and Education, and 3. Policy, Legislation, Regulation and Funding, and most follow five basic themes:

1. intensify efforts to ensure preparedness planning;
2. integrate climate change adaptation planning into existing plans;
3. update standards to accommodate anticipated change expected during design life (i.e., build for conditions of the future);
4. plan for flexibility and monitor change; and
5. protect natural areas and landscape features that buffer changing climatic conditions.

Below is a list of the adaptation strategies featured in this report:

Best Management Practices

- Encourage development practices that ensure water recharge *(Intersections, pg. 18)*
- Encourage sustainable water capture and storage by homeowners, municipalities, businesses, and industries, and the agriculture sector with incentive programs to supplement capture and storage infrastructure *(Intersections, pg. 22)*
- Develop water reuse guidelines for industry *(Intersections, pg. 23)*
- Encourage adaptation strategies, including natural habitat conservation, Low Impact Development (LID) Best Management Practices (BMPs), agriculture water BMPs and drinking water treatment standards that will ameliorate the effects of water inundation *(Intersections, pg. 23)*
- Identify and conserve ecosystem services vulnerable to climate change *(Intersections, pg. 26)*
- Encourage land management behaviors that support ecosystem services *(Intersections, pg. 26)*
- Minimize water use across all agricultural sectors *(Agriculture, pg. 35)*
- Develop decision tools to evaluate replacement, modification, and design life for infrastructure *(Infrastructure, pg. 49)*
- Apply adaptive management procedures *(Natural Resources, pg. 57)*
- Increase active management of upland forests and reduce non-climatic stressors *(Natural Resources, pg. 57)*
- Consider the public health needs of vulnerable populations in climate change adaptation planning *(Public Health, pg. 64)*
- Evaluate ozone non-attainment alert systems *(Public Health, pg. 65)*
- Evaluate current early extreme weather events warning system and emergency response plans *(Public Health, pg. 65)*
- Continue to develop and update all municipal emergency preparedness plans for extreme weather events *(Public Health, pg. 65)*
- Develop cooling station best management practices *(Public Health, pg. 66)*
- Develop criteria for school closings and outdoor play during extreme heat events *(Public Health, pg. 66)*

Research, Monitoring and Education

- Assess current and future needs for potable water uses and to plan for infrastructure improvements to the public water system *(Intersections, pg. 14)*
- Assess future needs for non-potable water uses *(Intersections, pg. 15)*
- Assess future flooding risks to natural and built infrastructure, including agricultural operations and public health and safety *(Intersections, pg. 15)*
- Analyze the competing demands on Connecticut water quantity and quality statewide in a consistent and comprehensive manner and develop new approaches to ensure public health, agricultural sustainability, ecosystem health, while supporting multiple and conflicting needs *(Intersections, pg. 21)*
- Target water conservation education towards specific consumer groups *(Intersections, pg. 22)*
- Assess the impact of climate change on wastewater treatment facilities, and encourage the development of facility-specific adaptation plans *(Intersections, pg. 24)*
- Develop Connecticut- specific climate change projections for temperature, precipitation and sea level rise and support monitoring efforts for these climate drivers *(Intersections, pg. 24)*
- Develop educational campaigns for climate change adaptation awareness in Connecticut targeted at multiple sectors *(Intersections, pg. 25)*
- Identify champions for each adaptation strategy *(Intersections, pg. 25)*
- Identify research needs and disseminate current climate change adaptation research and technical resources to the appropriate stakeholders, and encourage future efforts through state grants *(Intersections, pg. 25)*
- Identify and collaborate with educational partners *(Intersections, pg. 25)*
- Include students (future stakeholders) in climate change programs *(Intersections, pg. 26)*
- Determine the critical public buildings, including public health facilities, schools and cultural/historic buildings that will be impacted by coastal and inland flooding, and recommend appropriate adaptation strategies that will not adversely impact natural resources *(Intersections, pg. 27)*
- Examine new opportunities for building usage considering projections for climate change *(Intersections, pg. 27)*
- Determine vulnerable transportation routes and transportation options that may adversely impact natural resources and human mobility needs under future climate change projections *(Intersections, pg. 28)*
- Provide for increased research, technology transfer and technical assistance to develop and disseminate adaptation strategies to producers and agriculture service providers *(Agriculture, pg. 37)*
- Engage and educate private landowners to manage their lands to minimize risk from climate change *(Infrastructure, pg. 49)*
- Conduct research to understand effects of potential adaptation approaches and develop new, innovative approaches to support adaptive management *(Infrastructure, pg. 49)*
- Advance regional research and modeling to guide conservation efforts *(Natural Resources, pg. 59)*
- Build public consensus for adaptation strategies through education and outreach *(Natural Resources, pg. 59)*

- Partner with educational institutions or organizations that conduct research *(Natural Resources, pg. 59)*
- Perform a comprehensive modeling assessment of the extent of inland migration of tidal marshes essential for directing adaptation actions *(Natural Resources, pg. 59)*
- Educate other sectors of state government about public health climate change impacts and adaption *(Public Health, pg. 68)*
- Educate local health department staff on climate change impacts *(Public Health, pg. 68)*
- Develop educational materials concerning poor air quality *(Public Health, pg. 68)*
- Continue to monitor health ailments caused by ozone non-attainment levels *(Public Health, pg. 68)*
- Assist local health departments with climate change adaptation *(Public Health, pg. 68)*
- Incorporate climate change preparedness strategies into public health education *(Public Health, pg. 69)*
- Develop a database of morbidity and mortality caused by climate change *(Public Health, pg. 69)*
- Intensify vector associated disease monitoring *(Public Health, pg. 69)*
- Increase airborne pollen monitoring *(Public Health, pg. 69)*

Policy, Legislation, Regulation and Funding

- Broaden water use planning to include climate change projections *(Intersections, pg. 14)*
- Adopt a water hierarchy that includes water conservation, capture and storage and water reuse, similar to the well known solid waste management 'reduce, reuse and recycle' hierarchy *(Intersections, pg. 14)*
- Target headwaters for protection throughout the state *(Intersections, pg. 17)*
- Implement rate structures to accommodate long term system improvements and encourage conservation *(Intersections, pg. 21)*
- Examine opportunities for water conservation strategies within the building code, in appliance standards and in regulatory decisions *(Intersections, pg. 21)*
- Continue to support regional cooperation on climate change adaptation through involvement in regional planning activities *(Intersections, pg. 28)*
- Proceeds from RGGI auctions should support climate change adaptation work identified in this report and in accordance with Section 22a-200c(c). *(Intersections, pg. 28)*
- Adopt policies that encourage a viable, local agriculture market *(Agriculture, pg. 38)*
- Provide public funds needed to assist with agriculture infrastructure improvements *(Agriculture, pg. 38)*
- Provide support for agriculture climate change adaptation education and research *(Agriculture, pg. 38)*
- Minimize combined sewer overflows *(Agriculture, pg. 40)*
- Protect critical soil landscapes *(Agriculture, pg. 40)*
- Implement new or modified policies that would encourage appropriate land use and reduce repetitive losses *(Infrastructure, pg. 49)*
- Reevaluate Connecticut's Green Plan and open space grant programs to prioritize acquisition of land and conservation easements for habitats most at risk from climate change *(Natural Resources, pg. 60)*

- Acquire land and conservation easements to provide upslope "advancement zones" adjacent to tidal marshes *(Natural Resources, pg. 60)*
- Acquire land and conservation easements in riparian areas adjacent to coldwater streams *(Natural Resources, pg. 60)*
- Collaborate among state agencies, municipalities and non-profits within Connecticut to implement regulations and policies that promote and facilitate the conservation of habitats and species most at risk from climate change *(Natural Resources, pg. 60)*
- Collaborate with other states and federal agencies to develop a coordinated regional adaptation plan *(Natural Resources, pg. 61)*
- Further regulate the introduction and spread of invasive species *(Natural Resources, pg. 61)*
- Apply climate change projections to future stream flow regulations *(Natural Resources, pg. 61)*
- Develop legislation to allow regulatory agencies to respond to extreme heat conditions in occupational settings *(Public Health, pg. 71)*
- Continue to support funding to provide for adequate updates to municipal sewage infrastructure *(Public Health, pg. 72)*
- Support funding to provide for adequate updates to municipal water infrastructure *(Public Health, pg. 72)*

Implementation

While the strategies described within this report begin to establish a plan for the future, more remains to be done. Each workgroup identified the need for both continued monitoring of the anticipated impacts of climate change and the ongoing evaluation of the success of actions taken. In many cases, the workgroups identified a need for a finer level of detail such as localized inventories of what is at risk.

The many partners involved in the development of this report should individually and collectively begin the work of implementing the identified strategies, continue to assess climate change impacts, and develop more specific action plans. State agencies must begin to integrate climate planning and preparedness into their existing planning processes and a deliberative process will need to be established to ensure that agencies do integrate such considerations into their planning efforts. Municipalities also must undertake the hard work of identifying critical areas at risk. At the same time consideration should be given to establishing a panel or committee of state and local officials, and members from business, academia, and the general public to continue to evaluate success and provide ongoing guidance. Finally, to assure success across Connecticut additional outreach and education is needed to garner the necessary stakeholder support.

Introduction

The Need for Climate Change Preparedness

The United Nations Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment, released in 2007, concludes that the earth's climate is warming. Fortune 500 companies, including the insurance industry, have examined the risk that climate change presents and are preparing their operations to meet those risks. The findings of the Northeast Climate Impacts Assessment (NECIA) show that the Northeast has been warming at a rate of nearly 0.5 degrees F per decade since 1970, with winter temperatures rising faster, at a rate of 1.3 degrees F per decade since 1970. This warming correlates with the following climate changes across the region:

- More frequent days with temperatures above 90° F (Figure 1.1);
- A longer growing season;
- Less winter precipitation falling as snow and more as rain;
- Reduced snowpack and increased snow density;
- Earlier breakup of winter ice on lakes and rivers;
- Earlier spring snow melt resulting in earlier peak river flows; and
- Rising sea-surface temperatures and sea levels.

What is the difference between weather and climate?

While **Weather** describes daily or short-term conditions, such as a snow storm, **Climate** is the average weather pattern over a long period of time.

The debate continues on the degree of change that can be expected to occur and how fast this change is to occur. Scenarios vary, depending upon the level of success that is attained in mitigating the emissions of greenhouse gases. Continued efforts to reduce greenhouse gas emissions will affect the overall degree of change and the timeframes predicted by the models; however, while the models show variation later in the century they indicate similar results under varying emission scenarios for mid-century. The evidence that indicates our climate is warming dictates that preparedness planning, otherwise known as adaptation, is prudent and necessary to ensure the future viability of the built and natural environs, as well as the health and safety of the public.

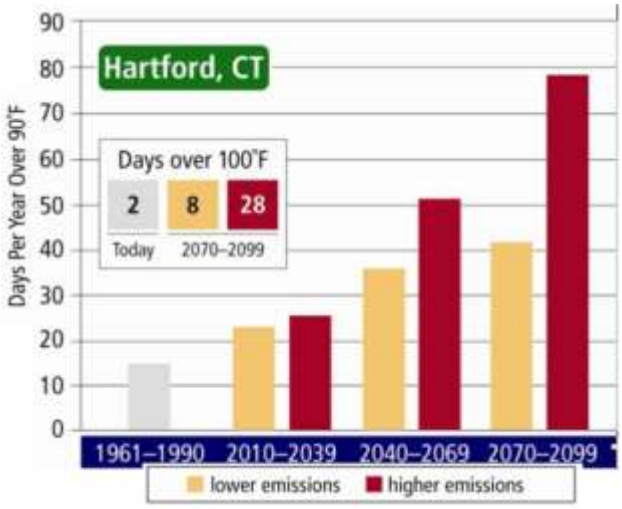


Figure 1: *Days per year over 90 and 100 ° F for the lower and higher IPCC emissions scenarios (Frumhoff et al. 2007; see NECIA* www.climatechoices.org/ne/*).*

Adaptation planning is not a substitute for greenhouse gas mitigation efforts. While most recent work is directed at reducing emissions, greenhouse gases will still persist in the atmosphere. Even if greenhouse gas emissions ceased tomorrow, we would still be

Climate Projections for the Next Century

(NPCC 2009)

Temperatures

- Temperatures may increase by 4 to 7.5°F by the end of the century.
- There may be more days over 90 and 100° F.
- Heatwaves may increase in frequency, duration and intensity.
- Extreme cold events may become less frequent.

Precipitation

- Precipitation may increase by 5 to 10% by the end of the century.
- More precipitation may fall in the winter.
- More of the winter precipitation may fall as rain.
- There may be more severe storm events causing flooding.
- Droughts may increase in frequency, duration and intensity.

Sea Level Rise

- Sea level may increase by 12 to 23 inches by the end of the century.
- Sea level may increase by 41 to 55 inches by the end of the century with the 'Rapid Ice-Melt Sea Level Rise' scenario.
- There may be more coastal flooding caused by extreme storm events.

subject to climate change impacts related to historic emissions. A focus on adaptation should not be interpreted as a recommendation to diminish emission reduction efforts and related policy implementation. Adaptation planning works in concert with mitigation efforts, further supporting the need for more energy efficient buildings and water conservation, while protecting and conserving biodiversity and ecosystem services. Similarly, adaptation efforts without the coordinated efforts of mitigation planning could result in unfavorable mitigation outcomes.

This report seeks to offer strategies to address the climate change vulnerabilities for the built and natural environment, agriculture and public health in Connecticut identified in the 2010 report entitled, "The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health" (herein referred to as the "Impacts Report"). Ultimately, these strategies will prepare Connecticut for a changing climate future, and be linked with preparedness efforts in other states, including northeast regional planning efforts, and the efforts of the federal government.

Climate Change Adaptation Opportunities

Regardless of the outcome of climatic change, adaptation efforts in Connecticut offer the opportunity to provide a future vision for agriculture, more efficient infrastructure, continued natural resources conservation and increased public health capacity. Planning in these areas offers an opportunity to increase Connecticut's resilience to non-climate change stressors, such as increased development and demand on utilities and services as well as to create sustainable jobs. In addition, opportunities for climate change mitigation are realized through adaptation strategy implementation, as mentioned above.

Building more resilient agriculture, infrastructure, natural resources and public health in Connecticut provides for sustainable job creation. Agriculture already contributes $3.5 billion to Connecticut's economy, so protecting and enhancing this sector through adaptation strategies identified in the agriculture section of this report helps sustain this economic sector. Changes in climate are projected to be less in the northeast, particularly for precipitation, than the rest of the country, which allows Connecticut agriculture to take advantage of the projected longer growing season and current large, local market. Adaptation strategies that require retrofitting, rebuilding or building new infrastructure will create direct jobs in the fields of engineering and construction. Natural resources adaptation strategies create opportunities for habitat

restoration, progressive engineering solutions, recreation and tourism as well as forestry jobs, while public health adaptation strategies create job opportunities in the areas of disease surveillance and emergency preparedness.

Climate Change Adaptation Course of Action

In accordance with Section 7 of Public Act No. 08-98, *An Act Concerning Connecticut Global Warming Solutions*, the Governor's Steering Committee on Climate Change is required to establish an Adaptation Subcommittee. The Adaptation Subcommittee is charged with evaluating, ". . . the projected impact of climate change in the state on: (1) Infrastructure, including, but not limited to, buildings, roads, railroads, airports, dams, reservoirs, and sewage treatment and water filtration facilities; (2) natural resources and ecological habitats, including, but not limited to, coastal and inland wetlands, forests and rivers; (3) public health; and (4) agriculture." This vulnerability assessment effort is the subject of the earlier Impacts Report. This subsequent report considers the results of the above impacts assessment and, makes "…recommendations for changes to existing state and municipal programs, laws or regulations to enable municipalities and natural habitats to adapt to harmful climate change impacts and to mitigate such impacts."

Given this charge, the Adaptation Subcommittee established four workgroups, Agriculture, Infrastructure, Natural Resources and Ecological Habitats and Public Health. The Adaptation Subcommittee chose qualified subject matter co-chairs from amongst its members to lead the workgroups. Each workgroup then assembled a team of experts to assess climate change vulnerabilities and identify the adaptation strategies presented in this report.

Climate Change Impacts

The full analysis of agriculture, infrastructure, natural resources and public health is captured in the individual reports presented in the appendix of the Impacts Report. These reports provide far greater detail on the evaluation and potential impacts. Presented below is a summary of the key vulnerabilities in each interest area.

Adaptation Subcommittee Members

- Co-chair Amey Marrella, Chair, GSC and Former Commissioner, CT DEEP
- Co-chair Lise Hanners, Director of Conservation for the Eastern Division, CT TNC
- Former Commissioner F. Philip Prelli, Agriculture Workgroup Co-chair, CT DoA
- Commissioner Steven K. Reviczky, Agriculture Workgroup Co-chair, CT DoA
- Denise Savageau, Infrastructure Workgroup Co-chair, Greenwich Municipal Official
- Paul Stacey, Infrastructure Workgroup Co-chair, CT DEEP, retired
- William Hyatt, Natural Resources Workgroup Co-chair, CT DEEP
- Dr. Adam Whelchel, Natural Resources Workgroup Co-chair, CT TNC
- Former Commissioner J. Robert Galvin, represented by Pamela Kilbey-Fox, Public Health Workgroup Co-chair, CT DPH
- Dr. Dennis McBride, Public Health Workgroup Co-chair, Milford CT DPH
- Thomas R. Baptist, CT Audubon
- Former Commissioner Peter Boyton, represented by Dana Conover and Anthony Dembek, CT DEMHS
- Former Commissioner Raeanne V. Curtis, represented by Jeff Bolton, CT DPW
- Former Commissioner Jeffrey A. Parker, represented by Colleen Kissane and Paul Corrente, CT DOT
- Former Commissioner Joan McDonald, CT DECD
- State Senator John McKinney, represented by Jaclyn Ferro
- Former Commissioner Thomas R. Sullivan, represented by George Bradner, CT DoI
- Mark Way, Swiss Reinsurance
- Dr. Robert Whitlach, UConn
- State Representative Patricia M. Widlitz
- Norman Willard, EPA Region1
- Dr. Michael Willig, UConn
- Dr. Gary Yohe, Wesleyan University
- Paul Farrell, CT DEEP
- Bob Kaliszewski, CT DEEP
- Roslyn Reeps, CT DEEP

CT Climate Change Impacts

Agriculture
- Maple Syrup
- Dairy
- Warm Weather Produce
- Shellfish
- Apple and Pear Production

Infrastructure
- Coastal Flood Control and Protection
- Dams and Levees
- Stormwater
- Transportation
- Facilities and Buildings

Natural Resources
- Cold Water Streams
- Tidal Marsh
- Open Water Marine
- Beaches and Dunes
- Freshwater Wetlands
- Offshore Islands
- Major Rivers
- Forested Swamps

Public Health
- Public Health Infrastructure
- Environmental Justice Communities
- Air Quality and Extreme Heat Ailments
- Vector-borne Diseases

Most *agriculture* in Connecticut is likely to be highly impacted by climate change, and most of these potential impacts are negative. The top five most likely imperiled agricultural products are maple syrup, dairy, warm weather produce, shellfish and apple and pear production. Agriculture is most affected by changes in temperature and both the abundance and lack of precipitation, which can result in decreased production yields, contamination of agricultural goods such as shellfish and the need for costly infrastructure to compensate for these effects. On the other side of the equation, there are some opportunities for production expansion, including biofuel crops, witch hazel and grapes.

The most impacted *infrastructure* in Connecticut is coastal flood control and protection, dams and levees, stormwater management, transportation and facilities and buildings. Infrastructure would be most affected by changes in precipitation and sea level rise, which could cause substantial structural damage, and require expensive mitigation technology and methods.

The *natural resources* most at risk from climate change are cold water streams, tidal marshes, open water marine areas, beaches and dunes, freshwater wetlands, offshore islands, major rivers, and forested swamps. These habitat types are broadly distributed across Connecticut from Long Island Sound to upland watersheds and forests.. The degree of impact will vary but, likely changes include conversion of rare habitat types (e.g., cold water to warm water streams, tidal marsh and offshore islands to submerged lands), loss and/or replacement of critical species dependent on select habitats, and the increased susceptibility of habitats to other on-going threats (e.g., fragmentation due to development and establishment of invasive species).

The *public health* areas that would be most affected by climate change include public health infrastructure, environmental justice communities, air quality and extreme heat ailments and vector-borne diseases. Climate change impacts public health infrastructure including hospitals, health departments, emergency medical services, private practices and shelters, due to direct impacts from extreme weather events and increased use of resources to treat and shelter victims. Specifically, environmental justice communities may be most impacted because of a lack of access to adequate public health infrastructure, including shelter or evacuation transportation. Decreased air quality may increase the incidence of, and exacerbate existing, respiratory ailments, and increased extreme heat events would increase heat-induced ailments, especially in those populations that do not have the benefit of air conditioning. Finally, climate change alters ecosystems in a way that may favor increased survival of vector organisms, replication, biting frequency, and geographic range.

Adaptation Strategies for Climate Change Impacts

Guiding Principles for Adaptation Strategies

Adaptation strategies to respond to climate change impacts on agriculture, infrastructure, natural resources and public health in Connecticut were developed by workgroups, composed of subject matter experts, and under the guidance of the Adaptation Subcommittee of the Governor's Steering Committee on Climate Change. During the development process, the workgroups also sought stakeholder and public comment.

The most effective adaptation strategies will likely be those that affect multiple sectors of Connecticut society, and have available resources, a positive cost to benefit ratio, political support (e.g., existing government priority and legal framework) and identifiable leadership. Adaptation strategies should seek to retain the cultural values of Connecticut, including independence and home rule, by empowering local communities. Adaptation strategies are best advanced by a defined timeline with achievable benchmarks, a detailed implementation plan, and are most beneficial when they offer co-benefits for other non-climate management programs. In addition, experience gained through small demonstration projects will be helpful in further defining the implementation plan, and garnering public, political and financial support through successes that can be easily and clearly communicated through the media.

Perhaps the most important guiding principle to ensure the success of an adaptation strategy is to have a clearly-defined entity responsible for implementation. To ensure adequate coordination across political and societal boundaries, consideration should be given to establishing a panel or committee of state and local officials, members from business, academia and the general public that is charged with evaluating the success of efforts and providing ongoing guidance. Establishing a structure that provides ongoing state and local government support and collaboration will be critical to ensure success.

Common Climate Change Concerns of Connecticut Agriculture, Infrastructure, Natural Resources and Public Health: *Adaptation Strategies for Water Quality and Quantity, Research and Education, Ecosystem Services, Buildings and Transportation*

In assessing the impacts of a changing climate for the "The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health" (Adaptation Subcommittee 2010) report, it became very clear that a number of impacts cross the topical planning areas that the General Assembly established in Section 7 of Public Act No. 08-98. Section 4 of the Impacts Report identifies water quality and quantity, ecosystem services, buildings and transportation issues as ones that significantly impact agriculture, infrastructure, natural resources and public health interests in Connecticut. Further research and education about climate change vulnerabilities and analysis of appropriate adaptation strategies to address them is needed. As impacts from climate change become more apparent, particularly in these intersecting areas, our communities will see the buffers between our natural and built environments shrink.

Below is a discussion of some of the appropriate adaptation strategies, as well as research and education needs, to address water quality and quantity, , ecosystem services, buildings and transportation impacts as they cut across agriculture, infrastructure, natural resources and public health interests. These adaptation strategies mostly concern land use and resource planning, and include a number of assessments/inventories needed to further inform the adaptation planning process. Far from being exhaustive, the text below identifies a few key strategies and provides an overall direction to guide future planning. The discussion below also considers non-target impacts of adaptation strategies, and suggests approaches to ameliorate potential conflicts.

Water Quality and Quantity

Planning and Inventory

- **Broaden water use planning to include climate change projections**

Water planning, especially during times of drought and intense precipitation events, is critical to water quality and quantity. Although stakeholder's perspectives may differ, adequate water supply (surface and groundwater) for core functions is important to each: the agriculture community expressed the critical importance of an adequate water supply for the production of warm weather crops and animal husbandry; the infrastructure and public health interests noted the importance of maintaining the quality and adequate quantity of potable water supply; and the natural resources managers and conservation organizations pointed to the need for adequate stream flow to support the ecological and functional requirements of Connecticut ecosystems. Careful water supply planning and accounting for projected changes in extreme heat and precipitation frequency is necessary to avoid conflict among competing uses. Improved water supply planning is critical and would benefit from increased inter-governmental and non-governmental coordination among water supply control authorities (e.g., The Water Planning Council, including DEEP, DPH, DPUC, and Water Utility Coordinating Committees (WUCC)), as well as other entities with water interests (e.g., DoA, DECD, Clean Water Action, TNC, development and industrial interests) and water suppliers.

- **Adopt a water hierarchy that includes water conservation, capture and storage and water reuse, similar to the well known solid waste management 'reduce, reuse and recycle' hierarchy**

As discussed further below, water conservation and reuse can reduce pressure on the use of potable water. The "reduce, reuse and recycle" hierarchy can provide a priority for water supply protection essential to ensuring both adequate human supply for potable and non-potable needs and the need to protect fish and wildlife. Such assessments should be considered in advanced water supply planning stages that incorporates the potential effects of climate change to ensure that every drought does not become an emergency that could compromise public health and safety as well as environmental quality.

- **Assess current and future needs for potable water uses and to plan for infrastructure improvements to the public water system**

Efficient and effective water supply planning requires an accurate assessment of consumers' current and future water needs that accommodates for projected climate impacts that could affect supply and outlines possible infrastructure improvements to the public water system that will be required. In order to have a complete picture of Connecticut's water supply system, this planning should include an assessment of private water supplies in addition to those of the public

water utilities. This inventory of private water supply wells should include an assessment of wells that may be at risk of future supply shortages, not only from drought, but also from impacts such as salt water intrusion. As new water resources are developed to support future consumers, the projected impacts of climate change, such as potential seasonal changes and other impacts to groundwater hydrology, must be evaluated. (See the "Adaptation Today" case study below, for more information about the impact of climate change on potable water.)

- **Assess future needs for non-potable water uses**

As water demands increase, it is worth evaluating the suitability of using non-potable water sources to meet some needs including those that currently depend upon potable water supplies, such as agricultural, domestic and industrial uses. Agricultural operations could constitute one of the largest potential future demands for new or increased water supply as a result of more severe and prolonged drought. Currently, a number of large-scale agricultural crops, such as fruit orchards, are not irrigated, but farmers may soon have to develop management practices and irrigation infrastructure to combat extreme heat events and droughts that may increase in intensity and frequency as a result of climate change. Opportunities for wastewater reuse, including stormwater runoff capture, for agricultural, recreational (e.g., golf courses and sports fields) and domestic (lawn and landscape) irrigation should be fully explored. In addition, any increased use of irrigation should ensure that irrigation runoff does not contaminate surrounding drinking wells or increase nutrient loading into natural habitats.

- **Assess future flooding risks to natural and built infrastructure, including agricultural operations and public health and safety**

More frequent and intense precipitation events, coupled with any rise in sea levels, will increase flooding throughout Connecticut. Currently, flood planning is addressed in the state and municipal Natural Disaster Mitigation plans, which identify pre-disaster mitigation projects, including flood mitigation. The Natural Disaster Mitigation planning process would benefit from local, climate change projections of future precipitation models and inundation scenarios, in order to adequately assess the risks resulting from these events and subsequent flooding. A special emphasis should be placed on identifying key landscape features that deserve protection and consideration in the planning process, including headwaters, inland wetlands, watercourses, riparian areas, tidal wetlands, aquifer protection areas, well head protection areas, public water supply watersheds, ground water recharge areas, groundwater discharge areas and floodplains/flood storage areas. Accurate, local precipitation models and flooding scenarios will also be valuable to plan for the continued viability of agricultural operations, while minimizing increased waste run-off, and reducing impacts on public health and safety.

Adaptation Today

Developing a Voluntary Adaptation Plan for Connecticut Drinking Water

Climate change is projected to increase the frequency and intensity of extreme weather events, including droughts and precipitation events. Droughts decrease the amount of available drinking water, while precipitation events increase pollutants.

Some water utilities are already evaluating climate change impacts on water resources. In order to encourage all utilities to plan for extreme events, CT DPH Drinking Water Section (DWS) plans to add a voluntary section to Water Supply Plans where utilities use a uniform process to include consideration of impacts of "extreme conditions" caused by climate change on their water sources and infrastructure.

Drinking water will be vulnerable to increased extreme weather events. (Photo credit: CT DPH)

The DWS currently has a process for receiving water quality data from public water systems. When a water quality issue arises, there is a process that informs customers and outlines steps to take to provide safe sources of potable water to the public, while also working to identify and correct the reason for the water quality problem. The current water supply planning process also addresses many other issues such as available water, margin of safety, sale of excess water, infrastructure adequacy, treatment capacities, conservation and emergency response planning.

DWS plans to add a voluntary section to the water supply plan where utilities describe their considerations of the impact of severe conditions, including climate change, on water sources and infrastructure. (Photo credit: Microsoft Clip Art)

As part of a proactive effort, DWS works with the regional Water Utilities Coordinating Committees (WUCC) to provide solutions for regional water resource issues including any regional interconnections needed to move water around the state for both primary use and redundancy purposes. Through a Water Supply Planning Technical Advisory Committee (WSPTAC), DWS is requesting public water systems to voluntarily address climate change preparedness in their water supply plan. This will be included in the revised Water Supply Plan Guidance Document.

To address extreme weather events that could exacerbate quality and quantity of public water supplies and systems, the proposed voluntary section of water supply plans would address the following:

1. safe yield of sources;
2. changes in demand and availability and margin of safety,
3. future sources and their reliability;
4. added risks to infrastructure including dams, treatment facilities, transmission and distribution facilities;
5. increased risk of water quality degradation and impact on treatment;
6. greater promotion of conservation to reduce demand for water and energy;
7. reevaluation of water rate structures to accommodate added costs incurred by water utilities to implement system improvements;
8. capital improvement plans to accommodate the required modifications;

Based on current data and a potential for more frequent and severe extreme events, water quality standards and land use planning and zoning may have to be reevaluated to accommodate the extreme fluctuations. DWS encourages Local Health Directors in conjunction with the Environmental Health & Safety section of CT DPH to engage local residents in a process that addresses the impacts of potential extreme events on their communities, including private wells.

For more information about Connecticut drinking water, see the CT DPH website www.ct.gov/dph .

Source Protection

- **Target headwaters for protection throughout the state**

In accordance with Connecticut's Water Quality Standards and Classifications (WQS), headwaters generally classified as A or AA waters are afforded a very high level of protection. Connecticut is one of only two states in the nation that does not allow municipal and industrial point source discharges into Class A and AA waters as a designated use per Connecticut General Statute (CGS 22a-417). In many cases, water utilities also protect water supply watersheds through land acquisition and programs that help ensure the quality of headwater streams that contribute to the resources maintained in Class AA (active water supply) waters. Connecticut WQS and the requirements of Connecticut General Statute (CGS) 22a-417 also provide for high standards and stringent criteria in both Class AA and A waters used by the state to regulate all activities that have the potential to impact or degrade high quality headwaters. These policies should be continued as a means for protecting and enhancing watershed features that protect water quality and build resilience to climate change.

- **Encourage development practices that ensure water recharge**

In addition to the application of WQS and CGS 22a-417 to headwaters as described above, water protection programs also focus on a few key strategies that help ensure maintenance of high quality in other waters to the maximum extent practicable. Primary tools include securing development rights around surface water supply sources and headwaters and reducing nonpoint and stormwater pollution that could contaminate surface and groundwater supplies. Other tools include local plans of conservation and development, and the consistency of actions in local inland wetlands, conservation and planning and zoning commissions and aquifer protection area programs with the overall state Plan of Conservation and Development. Reinforcing water supply protection goals through appropriate land use planning and conservation of priority open space is critical. Municipalities and non-profits should be encouraged to purchase open space that protects key recharge areas and headwaters. Municipalities should adopt Low Impact Development (LID) best management practices (BMPs) into their planning and zoning regulations, and developers and homeowners should be educated as to the benefits and cost savings of LID and buffers to reduce nonpoint and stormwater pollution and improve groundwater recharge. (For more information about LID, see the "Adaptation Today" case study below.)

Adaptation Today

The Green Capitols Low Impact Development Project: A Strategy to Protect Water Quality and Quantity within Connecticut

LID encompasses alternative construction techniques that try to minimize or replicate natural landscape features that allow stormwater to infiltrate, rather than run off, developed properties. Low Impact Development (LID) projects can help mitigate both water quantity extremes such as drought and flooding and the degradation in water quality caused by alterations in land use and climate change. By mimicking the natural environment, LID techniques, which include pervious pavement, rain gardens, vegetated swales and green roofs, allow stormwater to be retained and naturally treated on site and infiltrate into groundwater or gently runoff to surface waters. These practices serve to not only produce higher quality and more stable volumes of

A Low Impact Development (LID) demonstration project, illustrated in the above aerial photograph, is underway at the Connecticut State Capitol. LID features, such as permeable pavers and rain gardens, allow stormwater to be retained and filtered on site. (Map Credit: MDC GIS Services)

surface and ground water, but also to mitigate the erosive effects of flooding and water shortages that occur during drought, and to build resilience against flooding and water quality impacts caused by climate change. By limiting runoff from a developed property, LID decreases the number of sewer overflow incidences, further reducing the amount of pollution and sediments that contaminate Connecticut's fresh water resources and Long Island Sound. LID techniques also can have the added benefits of improving fish and wildlife habitat, saving energy, and decreasing construction and future management costs of traditional infrastructure, such as streets, curbs, sidewalks and storm drains.

A LID demonstration project is underway at the Connecticut State Capitol. The Green Capitols Project in Harford, a partnership of the Connecticut Department of Environmental Protection (CT DEEP) and the Metropolitan District Commission (MDC) features several LID retrofits on the Capitol building and grounds including: a green roof, rain gardens, and the construction of new walkways designed to allow rainwater to soak into the ground instead of running off into the sewer system. The purpose of the project is to reduce runoff into the stormwater system, while demonstrating to cities, towns, and homeowners the value of installing such systems in their town and homes. The discharge of stormwater runoff from this location has impacted natural resources in the area, including the Connecticut River, both as a direct discharge and by contributing to sewage overflows in the wastewater/storm water combined system.

The plants on the "green roof" at the Capitol are able to retain and filter stormwater runoff, while producing the co-benefit of reducing heating and cooling costs by providing insulation. The green roof at the Capitol is situated at ground level so visitors can view the improvements. The Connecticut-grown plants of the rain gardens, which differ from normal terrestrial perennial gardens in structure and composition to facilitate water capture and storage, will reduce stormwater runoff from the Capitol grounds. Former impervious surfaces on walkways and parking areas have been replaced with pervious concrete and asphalt paving, which further reduces stormwater runoff, with the added co-benefit of reducing the need for de-icing substances, saving money and further reducing pollution.

Green roof plants on a ground-level roof at the Capitol will retain and filter stormwater runoff. (Photo credit: CT DEEP)

The Green Capitols project is as an example intended to encourage municipalities to review their own local ordinances and regulations and remove barriers to implementation of these and other LID techniques that can combat projected water quality and quantity effects and begin to address climate change preparedness. These actions provide many additional benefits in their communities by promoting new, "greener" development and, where appropriate, as retrofits during repair and maintenance work.

In addition to the LID work at the Capitol, settlement of an environmental enforcement action has allowed DEEP to provide grants to towns within the Farmington River Watershed for the purpose of revising local land use ordinances to promote LIDs that would lead to improved water quality in the basin. See the town of Plainville website for an example (http://www.plainvillect.com under "Boards and Commissions, Planning and Zoning").

For more information on the Green Capitols project and LID, visit the CT DEEP's website www.ct.gov/deep/watershed.

Conservation

- **Analyze the competing demands on Connecticut water quantity and quality statewide in a consistent and comprehensive manner and develop new approaches to ensure public health, agricultural sustainability, ecosystem health, while supporting multiple and conflicting needs**

The state should convene a diverse group of stakeholders under the Water Planning Council to examine opportunities for improved water conservation of both potable and non-potable supplies. Stakeholders will be challenged to consider new water-saving methods, including but not limited to conservation strategies, and new technologies. Examples of water conservation strategies include: smart meter technology; agricultural management practices that help regenerate the soil and improve soil moisture content; livestock management that relies on natural systems (e.g., trees, breezes) to cool animals; and the municipal Model Water Use Restriction Ordinance to implement conservation during periods of water shortage. Comprehensive watershed planning can also provide opportunities to reduce runoff, encourage recharge, reduce impacts from development and conserve water at the household level by using low impact development practices that also provide resilience against floods, heat and drought.

- **Implement rate structures to accommodate long term system improvements and encourage conservation**

The state should prioritize the work of the diverse group of stakeholders tasked by the Water Planning Council with ensuring current water rates and structures are sustainable and adequate to providing long term water supply capacity development and infrastructure replacement/development. The group also needs to consider rate structures that reflect declining water use in some sectors while promoting and expanding current conservation efforts.

- **Examine opportunities for water conservation strategies within the building code, in appliance standards and in regulatory decisions**

Water conservation strategies should focus on the water consumer, and could include building code changes, such as requiring WaterSense fixtures or incentive programs for homeowner purchases of WaterSense appliances, irrigation BMPs (e.g., drip irrigation vs. overhead irrigation) and technologies (e.g., rain sensors on automatic sprinkler systems), and other water conservation measures and incentives. Guidance should also be developed for conservation practices for homeowners, commercial and industrial users and application of LID practices, especially for private well users, that improve climate change resilience.

In order to conserve valuable potable water, activities that use potable water for activities where non-potable is suitable should be limited, whenever possible. The state should examine and encourage options for usage of non-potable water sources and wastewater reuse for non-potable industrial and commercial uses, such as industrial cooling or golf course irrigation. Furthermore, industry should be encouraged to adopt practices and technologies that improve efficiency and thus minimize resource use (e.g., water, energy) and waste discharges.

- **Target water conservation education towards specific consumer groups**

Each water conservation strategy should include an educational component, in order to secure consumer support and promote available water conservation strategies. These educational campaigns would benefit from partnerships that reach the widest audience and take advantage of existing resources. Furthermore, educational campaigns should be tailored to each consumer sector (i.e., agriculture vs. homeowner vs. industry). Education strategies should embrace the multiple benefits of water efficiency (e.g., cost savings, natural resource protection, and easing impacts of water shortages) that help provide "something for everyone."

Water Capture and Storage

- **Encourage sustainable water capture and storage by homeowners, municipalities, businesses, and industries, and provide the agriculture sector with incentive programs to supplement capture and storage infrastructure**

As noted above, there are several strategies to capture and store water during precipitation events for future use during drier periods, especially landscaping techniques and LID management practices. (See the "Adaptation Today" case study on the Green Capitols LID project for more information.) With adequate storage capacity, it may be possible to take advantage of projections for likely increased winter/spring precipitation due to climate change. Rain barrels for homeowner irrigation are one small step that could alleviate non-potable homeowner pressure on the potable water supply during droughts. An incentive program to offset the cost of rain barrels for the average homeowner could help to encourage this water conservation strategy. Other activities that "soften the landscape" using LID practices can contribute to storage in groundwater for later extraction.

Similarly, large cisterns and farm ponds for agricultural irrigation could be used to alleviate pressure from non-potable agricultural activities on the potable water supply during droughts. Currently, "farm ponds of three acres or less essential to the farming operation" are, "permitted in wetlands and watercourses, as of right" (General Statutes of Connecticut Sec. 22a-40). However, in light of the climate change projections for extreme heat, ponds this size may not fully meet the needs of agricultural activities and depending on design and construction specifics, new ponds may trigger a need for permits from the local Inland Wetlands Commission and/or the CT DEEP and the Army Corps of Engineers (USACE). In addition, since pond impacts on wetlands may make producers ineligible to participate in United States Department of Agriculture (USDA) grant programs, use of runoff containment reservoirs outside of wetlands and watercourses should be encouraged. Large-scale agricultural water capture and storage may also have an impact on water recharge, especially as a result of the timing of the water diversion that could impact the quality and quantity of drinking water and water available within natural habitats. Therefore, in preparation for a possible adaptation strategy to accommodate agriculture capture and storage, CT DoA and DEEP could conduct a study on the need for and impacts of large-scale agricultural water diversion. Further defining the applicability of, and streamlining the permitting process for, farm irrigation ponds as well as an evaluation of potential incentives to install farm irrigation ponds could contribute to this effort.

Water Reuse

- **Develop water reuse guidelines for industry**

As introduced above, water reuse can take many forms, from wastewater recycling to supporting industrial cooling water or irrigation needs, to capturing stormwater at the homeowner level, to lessen the need for potable water supplies for yard maintenance. Water reuse from gray water sources (i.e., untreated water from sources such as sinks, tubs and dishwashers, but not toilets) or treated wastewater effluent provide other options. Gray water could be used to supplement additional non-potable uses, such as toilet flushing, dairy farm wash water, golf course irrigation and industrial cooling. Reuse would help to alleviate demand on potable water sources during extreme weather events such as extended droughts or heat waves that increase demand. Guidelines concerning the reuse of gray water or treated wastewater will need to account for concerns related to residual contaminants, such as pathogens, as well as nutrients and other chemicals present in soaps and detergents that could cause adverse effects on natural habitats and drinking water.

Water reuse adaptation strategies should include a program designed to educate the potential user on the benefits and safe use of gray water and consideration of an incentive program to install gray water capture and use systems.

Water Inundation

- **Encourage adaptation strategies, including natural habitat conservation, LID BMPs, agriculture water BMPs and drinking water treatment standards that will ameliorate the effects of water inundation**

While projections show the overall annual increase in precipitation is expected to be only about five percent, changes in timing of precipitation could have a more pronounced impact. Precipitation patterns, especially in the form of winter rain and extreme precipitation events, while unpredictable, may increase the quantity of water at times when existing natural habitats are less capable of attenuating the flows that otherwise contribute to property and environmental destruction caused by flooding and groundwater related impacts. Furthermore, water quality may be impacted by the resulting increased stormwater runoff, which could in turn increase water treatment requirements for drinking water and nutrient and chemical loading to surface waters, as well as to natural terrestrial habitats and agricultural systems.

The functionality of natural habitats, which naturally filter and retain precipitation, should be bolstered by reducing existing stressors such as invasives and habitat fragmentation, and by increasing natural habitat conservation within and around developed areas. These approaches not only provide relief from any immediate impacts, but also build resilience to future climate change impacts. Reducing stressors and increasing habitat conservation could be encouraged through state matching grants, cost sharing programs and tax incentives. LID BMPs could help minimize increased water runoff by encouraging more pervious development surfaces and green infrastructure measures that incorporate existing hydrology and mimic water retention of natural systems (e.g., rain gardens, green roofs, retention ponds). Agricultural systems could reduce water runoff by planting cover crops, installing vegetated swales, and handling manure through alternative manure technologies (e.g., manure biodigester). Guidelines could be developed for drinking water treatment facilities that adjust standards to compensate for potential increased water contamination.

Waste Water Treatment Facilities

- **Assess the impact of climate change on wastewater treatment facilities, and encourage the development of facility-specific adaptation plans**

The ability for wastewater treatment facilities to adapt to climate change will be critical to future water quality within Connecticut. Extreme precipitation events will put additional pressure on storm sewer systems (state and municipally managed) and further stress combined sewer-stormwater systems that may continue to exist in older, urban areas. While our predictions of the impact of climate change on specific facilities depends on the accuracy of predictive tools for precipitation patterns, increased rainfall or more intense storm events is likely to impact the effectiveness of long-term control plans for combined sewer systems and result in higher and more frequent overflow volumes with greater environmental impact. Therefore, the impacts of climate change on water treatment facilities require further assessment. Facilities in larger, older urban areas, especially Bridgeport, Hartford and New Haven, are most at risk and should be identified with individual adaptation plans. Climate change effects should be considered in adaptation planning, development and implementation strategies for combined sewer communities under EPA delegated National Pollutant Discharge Elimination System (NPDES) permitting authorities to DEEP, and as a part of Combined Sewer Overflow (CSO) abatement long-term control plans to facilitate water treatment facility preparedness for climate change.

Research and Education

- **Develop Connecticut- specific climate change projections for temperature, precipitation and sea level rise and support monitoring efforts for these climate drivers**

Fortunately, the Adaptation Subcommittee began its climate change preparedness planning effort with the benefit of a number of scientifically rigorous, regional climate change studies that produced projections sufficient for this initial planning effort. However, further development of vulnerability inventories, including a quantitative analysis of potential damages and costs due to climate change, and development of adaptation strategies to mitigate them will require more localized climate change projections for temperature, precipitation and sea level rise. These climate drivers will also need to be continuously monitored in order to update projections and further refine vulnerability inventories and adaptation strategies. Continued support for existing monitoring efforts, such as the Sentinel Monitoring for Climate Change in Long Island Sound project that monitors ocean temperature, sea level rise and precipitation, can help establish a foundation for Connecticut climate change monitoring efforts.

- **Develop educational campaigns for climate change adaptation awareness in Connecticut targeted at multiple sectors**
- **Identify champions for each adaptation strategy**

Education of stakeholders, the public/consumers, decision makers and industry is critical to conveying the importance of determining climate change vulnerabilities, as well as the need to develop robust adaptation strategies that would mitigate impacts and help to conserve our environment and quality of life. Furthermore, each adaptation strategy needs to have an educational component that provides direction to those implementing the strategy and for the targeted audience. Champions for each adaptation strategy should be identified to support educational needs, and to help develop strategy implementation plans. Ultimately, educational campaigns should establish a consistent message and should be targeted, focused, clear, effective and sustainable in order to get people to pay attention amidst other demands for their time.

Public education efforts should target homeowners and consumers, and include a variety of topics ranging from home water conservation strategies to the preparation and cooking of new crop varieties. Decision maker education must focus on the removal of obstacles or use of incentives to implement adaptation strategies, and focus on the importance of long-term planning. Education directed at vulnerable industries needs to emphasize the economic advantages of adaptation planning, including avoided costs of rebuilding after an extreme event. These programs should build upon, and complement, existing state agency initiatives, especially pollution prevention and watershed management programs that have already established outreach and communication activities with overlapping objectives. These activities should also take advantage of a burgeoning amount of material available from federal partners and the private sector.

- **Identify research needs and disseminate current climate change adaptation research and technical resources to the appropriate stakeholders, and encourage future efforts through state grants**

Research and technical assistance tailored towards specific sectors is critical. Such research and technical assistance could include varietal choice and planting methods for farmers, potential new design standards for drinking water treatment facilities, or new habitat management practices. Current climate change adaptation research and technical resources, such as academic institutions, government agencies (e.g., the Connecticut Agricultural Experiment Station) and non-profits, should be identified and their research communicated to the appropriate stakeholders. Future research and technical assistance grant programs should prioritize the most vulnerable areas and promote collaboration between research/technical assistance entities.

- **Identify and collaborate with educational partners**

Educational partners are a vital component of any adaptation educational strategy. Appropriate educational partners could include, among others, federal agencies; regional planning organizations (RPOs), who may be best suited to help municipalities plan for adaptation to climate change; and non-profit organizations, such as ICLEI– Local Governments for Sustainability and The Nature Conservancy, that have successfully cultivated many partnerships and networks and are currently conducting educational campaigns. "Train the trainer" programs could create new educational partners and a knowledge network of adaptation experts. Higher education institutions play an important role as educational partners, especially in the research

field. Climate change adaptation information should also be incorporated into existing science curriculum from kindergarten through college and vocational programs. Specifically, adaptation education should be incorporated into specific discipline job training, such as innovative stormwater management and climate-ready design as a component of architecture design coursework and new techniques for cooling livestock as a component of agricultural training. One excellent opportunity for this is through the Connecticut community college sustainable jobs certificate program, known as Sustainable Operations: Alternative and Renewable Energy Initiative (SOAR).

- **Include students (future stakeholders) in climate change programs**

Students engaging in studies that may be affected by the impacts of climate change or who are interested in the general field should be recruited to be a part of climate change initiatives. Students are the future stakeholders who would be responsible for implementing adaptation strategies in the future. This is an ongoing strategy that will help in the maintenance of climate adaptation strategies.

Ecosystem Services

Ecosystem services refer to the many ways in which ecosystems support and benefit individuals and communities. These services include production of goods (food, timber), life-support processes (maintaining soil fertility, purifying water, providing water infiltration, mitigating floods, stabilizing climate), and life-fulfilling conditions (providing aesthetic beauty, biodiversity and cultural/spiritual connections).

- **Identify and conserve ecosystem services vulnerable to climate change**

Ecosystem services that provide protection for adjoining habitats and man-made structures are particularly important in building natural resiliency to the effects of sea level rises and extreme weather events. Currently, coastal wetlands provide an important buffer against coastal storms, but sea level increases would convert some of these areas to open water. Critical wetlands often have the ability to naturally advance inland if they are unimpeded by barriers, such as development or coastal infrastructure. Therefore, identifying and preserving future inland advancement zones would help create future protective storm buffers for coastal communities while providing the co-benefit of preserving an ecologically important habitat helping protect Long Island Sound from pollutants.

- **Encourage land management behaviors that support ecosystem services**

Industrial land management behaviors that support ecosystem services should be encouraged. For example, in the agriculture sector, practices such as organic farming, natural pest control methods, crop rotation and no-till agriculture will reduce the negative impact on ecosystem services by conserving soil properties and moisture, increasing the organic content of soil, and supporting biodiversity. Organic agriculture also can have the co-mitigation benefit of sequestering carbon. Artificially constructed oyster reefs could buffer shoreline development and wetlands against waves produced by extreme weather events, while also providing prime habitat for ecologically and agriculturally important species. Therefore, the feasibility of artificially constructed oyster reefs should be explored, and appropriate locations identified.

Urban tree plantings can provide localized cooling for buildings, a benefit during extreme heat events, and while at the same time offering water capture and storage areas that could mitigate flooding. Similarly, using alternative LID construction and landscaping practices can help support ecosystems by build resiliency. These LID practices start with minimizing the footprint of any construction project, especially minimizing the disturbance of native vegetation and soils. Conservation sub-division approaches afford the opportunities to position footprints to minimize impacts to natural hydrology and existing habitats. Identification of appropriate urban tree species that would thrive under different climate conditions is needed to guide future urban tree plantings to ensure their successful bio-functioning.. The establishment of localized urban forests could also be encouraged during urban planning efforts.

Buildings and Cultural/Historic Structures

- **Determine the critical public buildings, including public health facilities, schools and cultural/historic structures that will be impacted by coastal and inland flooding, and recommend appropriate adaptation strategies that will not adversely impact natural resources**

Adaptation strategies directed toward buildings and cultural/historic structures vulnerable to climate change may include relocation and are likely to impact individuals, communities, industry and natural habitats. A study should be conducted to identify critical state and local public structures, to including public health facilities, schools and cultural/historic structures that will be impacted by coastal and inland flooding. The study also should include recommendations for appropriate adaptation measures for vulnerable buildings that do not counter other mitigation strategies.

For example, existing and new locations of buildings and structures could create direct conflict with natural resource protection by blocking advancement zones for coastal wetlands and contributing to habitat fragmentation. In order to ameliorate this potential conflict, incentives to relocate any such buildings and structures inland in a non-advancement zone should be considered. In addition, environmental impact evaluations (EIEs) for new state projects should include an evaluation of potential climate change impacts on the project so as to understand the current and future effects of the project on the surrounding environment. Furthermore, LID BMPs should encourage a reduction of run-off into natural habitats from existing and new buildings.

- **Examine new opportunities for building usage considering projections for climate change**

The agricultural sector in Connecticut has expressed interest in using or reusing buildings in new and efficient ways to help adapt to climate change. For example, vertical agriculture utilizes buildings, often in urban settings, to increase the area available for crop production. High tunnels- unheated structures covered in translucent plastic-can offer a moderate amount of weather protection, especially from frost, and unlike greenhouses are inexpensive and movable. However both vertical agriculture and high tunnels have encountered opposition from local planning and zoning boards. Adaptation planning may need to include education components targeted at decision-makers as well as legislative proposals to address regulatory barriers.

Additional agriculture strategies could include incentive programs for installing water conservation measures in greenhouses, and retrofitting barns with cooling features to facilitate adapting existing buildings to deal with climate change effects.

Transportation Systems and Structures

Flooding and associated debris could interrupt routine transportation needs, including transport of commercial and agricultural goods to markets as well as getting the injured and sick to treatment facilities. Existing undersized culverts can prevent natural resource adaptation (e.g., fish passage), and new or relocated transportation infrastructure may further exacerbate habitat fragmentation.

- **Determine vulnerable transportation routes and transportation that adversely impact natural resources and human mobility needs under future climate change projections**

A locational study could be conducted to determine the transportation that is most at risk from potential coastal and/ or inland flooding increases and to identify alternative routes and sources of transportation for evacuation and commerce. Culverts and culvert size should be inventoried throughout the state to identify those that should be replaced or retrofitted to facilitate, and not impede, natural resource adaptation and to reduce projected flooding impacts. Furthermore, state transportation planning should incorporate the effect of climate change projections on meeting state transportation needs and the synergistic effect of new transportation and climate change on natural resources should be included.

Regional Cooperation

- **Continue to support regional cooperation on climate change adaptation through involvement in regional planning activities**
- **Proceeds from RGGI auctions should support climate change adaptation work identified in this report and in accordance with Section 22a-200c(c).**

The northeast region has been at the forefront of climate change planning, with multiple entities coordinating climate change research, action and adaptation assessments. In 2005, the Regional Greenhouse Gas Initiative (RGGI) was formed by the northeast states and two Mid-Atlantic States to reduce greenhouse gases in the region through a cap and trade program for fossil fuel-fired electricity generating units. This unique, multiple state-led initiative has successfully reduced greenhouse gases and strengthened regional bonds and cooperation in addressing greenhouse gas emissions. Proceeds from RGGI auctions should continue to provide revenue for both climate change mitigation actions within the state and "to fund assessment and planning of measures to. . . mitigate the impacts of climate change" (i.e., climate change adaptation; Section 22a-200c(c) of the General Statutes of Connecticut).

Each state in the northeast has either developed or is planning to develop a climate change adaptation plan. The 2008 Conference of New England Governors and Eastern Canadian Premiers included a forum to discuss regional climate change concerns and adaptation priorities, and connected the region by adopting a resolution on adaptation. Interstate agencies, such as the

New England Interstate Water Pollution Control Commission (NEIWPCC) and Northeast States for Coordinated Air Use Management (NESCAUM), have informed states on climate change vulnerability and are in the process of modeling potential regional adaptation strategies. Non-profits, such as Sea Grant and The Nature Conservancy, have also contributed to regional climate change adaptation coordination concerning natural resources in the northeast.

As climate change impacts would not be limited to Connecticut's borders, a coordinated, regional approach will help ensure holistic climate change adaptation planning, and that individual states benefit from knowledge and expertise throughout the region. Regional approaches can often provide the best use of existing resources, while preventing duplication of effort and avoiding strategies that could negatively impact other states within the region. Connecticut should continue to support regional cooperation on climate change adaptation through involvement in regional planning activities, and support regional adaptation strategies through the New England Governors and Eastern Canadian Premiers annual conference (e.g., Blue Ribbon Commission on Land Conservation 2010).

Adaptation Strategies for Connecticut Agriculture, Infrastructure, Natural Resources and Public Health

Agriculture

In 2009, the Agriculture Workgroup of the Adaptation Subcommittee of the Governor's Steering Committee on Climate Change developed the report, *Climate Change Impacts on Connecticut Agriculture*, released January 2010. That report was consolidated with companion reports on Infrastructure, Public Health, and Natural Resources to produce the Adaptation Subcommittee's report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*, issued in April, 2010. The report was developed in accordance with Section 7 of Public Act No. 08-98, *An Act Concerning Connecticut Global Warming Solutions*, to evaluate "…the projected impact of climate change in the state on: . . . (4) agriculture" as well as for the non-agriculture components of infrastructure, natural resources and public health.

In order to assess the impacts of climate change on Connecticut agriculture, the Agriculture Workgroup was formed. The Agriculture Workgroup is co-chaired by the commissioner of the Department of Agriculture (CT DoA) and the Executive Director of the Connecticut Farm Bureau, and included agriculture stakeholders from academia, government, non-profits and the farming community. The Agriculture Workgroup examined potential climate change impacts on Connecticut agricultural sectors, which included dairy, poultry, fruit orchards, small fruits, produce, forestry production, aquaculture, non-poultry animal livestock, tobacco and nursery, greenhouse and sod.

The Key Findings of the Agriculture Workgroup stated in the 2010 report were:

> *Most of the agricultural features were determined to be highly impacted by climate change, and most of these impacts were negative. The top five most imperiled agricultural planning areas or features in Connecticut were maple syrup, dairy, warm weather produce, shellfish and apple and pear production. There were opportunities for production expansion, including biofuel crops and witch hazel and grapes, with the future climate, as well as benefits identified for all agricultural planning areas.*

Planning for Connecticut agriculture climate change adaptation is a critical and iterative process. It requires an eye for the existing and potential economic impact on individual agricultural products, as well as an integrated approach that addresses both positive and negative impacts to multiple agricultural sectors and the State, regional and national agricultural systems. Adaptation strategies should build upon the unique strengths of Connecticut agriculture, while allowing for new, innovative opportunities for growth in some agriculture sectors. Strategies should be geared towards long-term sustainability to help regenerate natural systems to support agriculture as well as to build resilience for adapting to climate change.

Based on specific stakeholder input and the experience and knowledge of its members, the Agriculture Workgroup recommends the following principles and adaptation strategies. Specific adaptation strategies for different agriculture sectors can be found in Appendix A. The Agriculture Workgroup envisions a hierarchy of steps that would guide current and future agriculture planning and implementation of adaptation strategies for Connecticut:

- **Create a vision for the future of Connecticut agriculture**

Connecticut agriculture contributes $3.5 billion to the State's economy, and accounts for more than 20,000 jobs (Lopez et al. 2010). Its strength may be attributed to many factors, such as a close, densely populated customer base, farm and farm product diversification and a highly educated population that values local agriculture and rural character. In order to support Connecticut agriculture and provide for economic growth and future job creation, there needs to be a vision for the future of Connecticut agriculture that includes strategies to reduce stressors and adapt to climate change, with the ultimate goal of promoting food security for the State. Creation of a future vision for Connecticut agriculture should be developed through a stakeholder process and should be expansive and iterative. The vision should build upon strengths, seize opportunities, address risks and maintain an unwavering focus on sustainability and resilience.

- **Create a framework for continued dialogue with the agricultural community to engage stakeholders in creating a shared vision for building resilience and sustainability in Connecticut agriculture**

Adaptation is an iterative process that requires continued dialogue with stakeholders in order to assess adaptation implementation strategies and their likely success. New research, on both climate change projections and new technologies that could help Connecticut agriculture adapt, should be incorporated into planning on an on-going basis. This effort should be led by a partnership of government agencies, agriculture non-profits and educational institutions and stakeholders from each of Connecticut's agriculture sectors within a framework that engages stakeholders in creating a shared vision for building resilience and promoting sustainability in Connecticut agriculture.

- **Conserve ecosystem services for Connecticut agriculture**

Connecticut agriculture depends on naturally occurring ecosystem services, such as fertile soil, clean and abundant water and good air quality to produce quality produce, ornamental plants and animal products. Connecticut farmers can foster and conserve ecosystem services through sustainable production systems and management practices, including organic growing methods (See the "Adaptation Today" feature on organic agriculture for more information), no-till soil practices, crop rotation, integrated pest management and energy and water conservation. Government agencies, agricultural non-profits and academic institutions can support conservation of ecosystem services on Connecticut farms by providing funding and developing training in these sustainable production systems.

- **Align policies and funding to support resilient agriculture in Connecticut**

Policies and grant funding that support resilient agriculture in Connecticut will be important to ensure that agricultural systems are able to adapt to climate change. Provisions that encourage climate change adaptation can be incorporated into existing policies, rules, regulations, standards, outreach and funding programs. Policies and funding programs should have the ultimate goal of managing the sustainable use of natural resources by all user groups. Funding for agriculture climate change research should be prioritized.

- **Encourage new agricultural technology and infrastructure that minimizes additional greenhouse gas emissions and impacts to natural resources**

Consideration of the impact that new agricultural technology and infrastructure might have on greenhouse gas emissions and natural resources such as water, that will be most impacted by climate change, should be considered before adoption or investment in such. An analysis of the best available research, latest technology, generally accepted agricultural practices and public policies should be conducted to determine this impact.

- **Provide integrated education and support to farmers and consumers to facilitate the implementation of agricultural adaptation strategies**

Entities such as agricultural non-profits, CT DoA and educational institutions should incorporate climate change adaptation into their curricula in order to facilitate the implementation of agricultural adaptation strategies. Education directed at farmers should include strategies to conserve water and suggestions of new crops and animals that would be more suitable to changing climatic conditions. These farmer-oriented educational activities could be best delivered in vocational or higher learning institutions or by agricultural extension programs. Education directed at the consumer should include information about new crops available in stores and at local farmers' markets, and strategies to sustain local agriculture, such as "buy local" campaigns.

Connecticut Farmers Markets provide an opportunity for consumers to support local agriculture. (Photo credit: CT DoA)

Adaptation Today

Organic Agriculture:
Growing Methods to Increase Farm Resiliency to Climate Change

"As climate change occurs, the ecosystem on a diversified organic farm is more likely to go through natural stages of succession, adapting in ways that prevent whole agroecosystem collapse" (Borron 2006)

Organic agriculture describes a management system that encourages biodiversity, reduces watering needs and maintains soil organic matter content and ecological cycles, while minimizing off-farm and synthetic inputs. Organic agriculture adheres to certifiable standards, however certification is not a requirement for implementing organic methods. Although organic agriculture was not designed as a response to climate change, organic farming methods have been shown to increase farm resiliency to stressors, including climate change, especially for small farming operations which constitutes the majority of farms in Connecticut. Ultimately, organic agriculture methods will better ensure future food security for Connecticut residents.

Organic agriculture includes the following farming methods that could promote resiliency to climate change:

- Diversified crop production, which will increase farm flexibility and decrease pest populations;
- Crop rotation, including a fallow period, which will decrease pest population numbers;
- Organic matter compost, such as leaf litter or manure, which will return nutrients and carbon lost through agricultural production to the soil, rather than as carbon dioxide emissions (a greenhouse gas mitigation co-benefit), and help retain soil moisture;
- Minimum tillage for soil preparation, which will help maintain soil structure and protect soil organic matter;
- Cover crops, which will decrease soil erosion and add nutrients to the soil; and
- Natural vegetation in the margins of agricultural production, which will maintain diversity and decrease pests.

Diversified crop production, as seen in this photograph of Fort Hill Farm in New Milford, will increase farm flexibility and decrease pest populations.
(Photo credit: Paul Bucciaglia, Fort Hill Farm)

The Northeast Organic Farming Association of Connecticut (CT NOFA) is a non-profit organization that promotes organic agriculture in Connecticut by providing members with educational opportunities. CT NOFA also offers either a path to certification or the less rigorous option of the Farmers' Pledge, in which farmers confirm their commitment to organic principles. CT NOFA has been providing their 800 members, comprised of farmers, gardeners, consumers, land care professionals, educators and scientists in Connecticut, with information on increasing farm resiliency to climate change through on-farm workshops.

Hairy vetch can be grown as a cover crop to reduce soil erosion and increase soil nitrogen, and then used as mulch to increase soil organic matter and decrease weeds between crop rows, as seen in the above picture between rows of tomato plants on Fort Hill Farm in New Milford.

(Photo credit: Bill Duesing, CT NOFA)

A CT NOFA member and owner of organic certified Fort Hill Farm in New Milford, Paul Bucciaglia, says that he has found that the two most important organic methods that every farmer can adopt to make their production more resilient to changes in temperature and precipitation are use cover crops and increasing soil organic matter. Paul notes that the usage of cover crops is a generally accepted agriculture practice to reduce erosion, but he has also found that leguminous crops, such as crimson clover, field peas and hairy vetch, instead of the more popular winter rye, have the added benefit of increasing nitrogen, an essential nutrient, naturally in the soil. Paul also has found that using organic compost to increase organic matter greatly increases the water holding and nutrient content of his soil better than other more conventional uses of synthetic and manure fertilizers.

For more information on organic agriculture methods, visit the CT NOFA website www.ctnofa.org .

Using the above guiding steps, the following general adaptation strategies were developed, and can be grouped into the categories of "Generally Accepted Practices," "Research, Monitoring and Education" and "Policy, Legislation, Regulation and Funding:"

Generally Accepted Practices

- **Minimize water use across all agricultural sectors**

Reduced water consumption across all agricultural sectors can be achieved by conserving water use and employing techniques to store precipitation and re-use water. Water use can be conserved by using irrigation efficiencies, such as drip or pulse irrigation, reducing water loss in existing irrigation systems and by growing and raising crop and animal varieties with a greater drought tolerance. Water runoff from barn and greenhouse roofs, parking lots and other impervious surfaces can be captured and stored in ponds, cisterns and tanks for use in non-food, agriculture operations such as greenhouse ornamental plant irrigation and animal wash water and cooling waters. Farms also can promote infiltration and retention of water in soils by using such generally accepted practices as mulch, which increases soil water-retention properties, and no-till methods, which reduces compaction. (See the "Adapting Today" feature on page 37 and entitled "Connecticut Agriculture Prepares for Climate Change with Water-Saving Practices and Technologies" for more information on minimizing water use in agricultural operations.) Collaboration between the Connecticut Departments of Agriculture, Environmental Protection and Public Health will be required to facilitate adaptation strategies related to minimizing water use on farms. The Agriculture Workgroup determined that reducing water use on farms was of high urgency, with relatively low to medium resource need and little room for regret in the near term.

Adaptation Today

Connecticut Agriculture Prepares for Climate Change with Water-Saving Practices and Technologies

As climate change leads to changes in precipitation patterns and temperature levels, Connecticut is likely to see more frequent short-term drought and more days with high temperature extremes. This will impact the availability of water for all users, including the Connecticut agricultural sector. A number of Connecticut's agricultural businesses have already adopted water-saving irrigation technologies and generally accepted practices, which will enable them to better adapt to changes in climate. Part of the $270 million a year Connecticut nursery and greenhouse industry, Geremia Greenhouses in Wallingford is an example of a water resilient operation that will be prepared for changes in precipitation patterns resulting from climate change.

Joe Geremia, owner of Geremia Greenhouses, shows off his water and nutrient efficient, flooding bench plant irrigation system.
(Photo Credit: CT DEEP)

Joe Geremia, a third generation farmer, operates a successful greenhouse small business, Geremia Greenhouses, with forty full-time employees and over $5 million in annual sales. Joe grows vegetables, herbs and ornamental plants, which he primarily distributes to local businesses. Geremia Greenhouses is an industry leader in applying water-use reductions that result in both savings and a more disease-resistant product. Furthermore, Joe believes that there is an opportunity for efficient, climate change-ready greenhouses to provide more produce for the local fresh market, which will be especially important for local food security in the future.

Conventional greenhouse irrigation uses overhead watering systems that apply excessive amounts of water and nutrients to ensure that plant media is fully saturated. This costly method over uses both water and fertilizers and can leach up to 75% of nutrients from a potted plant. Excessive plant saturation can increase disease and pest susceptibility, which could lead to more pesticide applications, increasing expenditures and threatening employee health and the environment. Surplus irrigation runoff, containing excess nutrients and pesticides, can negatively impact the environment and may subject the grower to increased regulation.

Geremia Greenhouses use an irrigation system that delivers the correct amount of water and nutrients directly to the growth media by flooding the floor or bench where the plant grows. The water is pumped up through openings in the floor or bench and then quickly drained and filtered for future irrigation. The benches and floors are divided into sections that can be individually controlled by a computer, with feedback from water gauges, for watering time, duration and nutrient mixture to ensure that watering is tailored for each species. With this innovative irrigation system, Joe uses substantially less water and has seen a savings of 60% in fertilizer usage. Joe also uses less pesticides, and finds that his plants are healthier, producing better blooms and fruit.

Flooding floor plant irrigation systems are more efficient than traditional, overhead watering, and reduce plant susceptibility to pests and diseases. (Photo Credit: CT DEEP)

For more information about water-saving measures in Connecticut agriculture, contact the Connecticut Agricultural Experiment Station (www.ct.gov/caes), the Connecticut Cooperative Extension System (www.extension.uconn.edu) or the United States Department of Agriculture Natural Resources Conservation Service (www.ct.nrcs.usda.gov).

Research, Monitoring and Education

- **Provide for increased research, technology transfer and technical assistance to develop and disseminate adaptation strategies to producers and agriculture service providers**

Academic institutions and state agencies, including CT DoA and the Connecticut Agricultural Experiment Station (CAES), should provide for increased research, technology transfer, and technical assistance to develop and disseminate adaptation strategies to producers and agriculture service providers. For example, educational programs could include training framers on adopting new crop varieties that are better adapted to climate change, identifying emerging pests and pathogens and new soil, crop and water management practices. Additional staff and funding will be required to enhance the University of Connecticut Cooperative Extension System technical assistance in forestry and agriculture and CAES research and education initiatives in order to include climate change adaptation work. Regional cooperation and funding between the CT DoA, out-of-state academic institutions, such as Cornell University and the University of Vermont, and the U.S. Department of Agriculture will be required to provide access for Connecticut farmers to existing and future research, training programs and assistance, such as advanced regional weather monitoring, offered by these universities.

Policy, Legislation, Regulation and Funding

- **Adopt policies that encourage a viable, local agriculture market**

Connecticut should adopt policies that encourage a viable, local agriculture market by supporting the infrastructure and programs needed to grow, process, store, market and sell local agricultural products. For example, local agricultural businesses such as The Farmer's Cow, LLC, a cooperative of Connecticut dairy farmers that produce and process milk and milk products, allows the members to sustain and grow their agricultural business with the added adaptation benefit of protecting ecosystem services. (For more information about a Farmer's Cow farm, see the "Adaptation Today" feature below entitled "Infrastructure improvements help the dairy industry adapt to climate change".) Specifically, Connecticut should adopt supportive policies, including funding and grant opportunities, repeal counterproductive land ordinances, and allow for property tax reductions to accelerate farmland protection and expansion of agriculture operations. The State should create incentives for the transition and adoption of new adaptation practices and technologies, and support the development of in-state agricultural processing and packaging facilities, such as produce canning plants, dairy processing cooperatives, and animal slaughter facilities. The State also should set an example of "buying local" by supporting local food choices in State-owned and operated office buildings, schools, hospitals and other institutions. The Agriculture Workgroup determined that State support of locally produced agriculture was of high urgency, with relatively low to medium resource need and little room for regret in the near term.

- **Provide public funds needed to assist with agriculture infrastructure improvements**

Public funding and other incentives will be needed to assist with infrastructure improvements necessary to help Connecticut agriculture adapt to climate change. Infrastructure improvements include, but are not limited to, passive and active cooling technologies for dairy facilities (See "Adaptation Today" feature below entitled "Infrastructure improvements help the dairy industry adapt to climate change" for more information on cooling strategies for dairy facilities), post-harvest cooling methods for shellfish, efficient irrigation systems for greenhouses, nurseries, orchards and row crops, frost protection systems for fruits and warm weather crops, and greenhouse cooling technologies. Public funding for agriculture infrastructure improvements is considered to be of high urgency, with relatively low to medium resource needs and little room for regret in the near term by the Agriculture Workgroup.

- **Provide support for agriculture climate change adaptation education and research**

Support will be needed for agriculture climate change adaptation education and research. Educational programs should be directed at the farmer as well as the consumer, and adaptation topics could be integrated into existing training opportunities and marketing programs, such as "Farm to Fork." Support also could leverage public/private marketing initiatives between CT DoA and non-profit agriculture advocacy organizations. Support of agriculture climate change research will be critical to help farmers adapt to climate change by providing information on new crop varieties and farming methods. Support for agriculture climate change adaptation education and research is determined to be of high urgency, with relatively low to medium resource needs and little room for regret in the near term by the Agriculture Workgroup.

Adaptation Today

Infrastructure Improvements Help the Dairy Industry Adapt to Climate Change

The Connecticut dairy industry, both field crops and animal husbandry, is one of the five agricultural sectors at highest risk from the potential effects of climate change, according to the Agricultural Working Group. Animal husbandry is challenged by higher temperatures which stress dairy cows and other livestock, decreasing appetite, lactation and calving, and straining the overall health of individual animals and the herd. Lactation can decrease at temperatures in the mid-70 degrees Fahrenheit. Climate change projections indicate that both drought duration and the number of days over 90 degrees Fahrenheit are expected to increase.

A dairy cow must be kept cool and comfortable to maximize feed intake, milk production and health of the animal. Robin Chesmer and his son, Lincoln, who own and manage a herd of 400 dairy cows at Graywall Farms in Lebanon, make it their priority to keep their dairy herd cool and comfortable. As members of the Farmer's Cow, LLC milk producers' cooperative, they have employed a number of building design and technology improvements to keep their cows cool, which will help prepare and adapt their agricultural business for the impacts of climate change.

The Chesmers have made significant capital investments in new cattle barns, a milking facility, feed center, and a manure management system. Lincoln designed these structures, with funding partially provided by the Connecticut Department of Agriculture (CT DoA). The free stall barn is oriented on the landscape to maximize natural ventilation and reduce solar radiation. The sides of the barn are designed to roll up to allow for natural air flow and circulation in the summer, and roll down to offer protection from cold winter winds. When needed, fans and water misters are employed to cool cows, thus maintaining their comfort and production.

The design of the Chesmers' free stall barn has adapted their Graywall Farms dairy operation to high temperatures by maximizing natural ventilation which keeps the cows cool enough to produce milk.
(Photo Credit: Graywall Farms)

In order to offset water usage from the cooling misters, the Chesmers have worked with the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) to develop a Water Conservation Plan, which budgets water on the farm and improves the quality of the water run-off. Most of the water from the misters evaporates, but the residual water is captured in the manure management system, which was partly funded by the USDA NRCS. This liquid-solid separator maximizes the reuse of waste for bedding and fertilizer, further reducing energy costs, improving soil health and reducing agricultural waste run-off.

- **Minimize combined sewer overflows**

Combined sewer overflows (CSOs) can negatively impact water quality in Long Island Sound, which can contaminate shellfish used in aquaculture operations. State agencies and sewage treatment plant owners should work together to plan for infrastructure improvement to sewage treatment plants to minimize or halt CSOs. This strategy was determined to be of high urgency and will require a high degree of financial resources as well as cooperation/collaboration with partners outside of the agriculture sector.

- **Protect critical soil landscapes**

Soil landscapes designated by USDA NRCS, the State of Connecticut, and local municipalities as Prime, Statewide Important, and Locally Important Farmland soils are not only essential to protecting sustainable food production with the least input and environmental risk, but they also provide other critical ecosystem services such as flood protection, habitat for plants and wildlife, ground water recharge and water quality. State, federal and municipal governments, as well as water companies and land trusts, should work together to identify these soil landscapes, and provide support through legislation and funding to protect these areas. One existing method to preserve critical soil landscapes is farm preservation programs, such as the Connecticut Department of Agriculture Farmland Preservation Program and the USDA NRCS Farm and Ranch Lands Protection Program. The Chesmers, featured in the "Adaptation Today" feature above, were able to acquire 570 acres at agricultural value through the assistance of these programs. Farmland preservation programs not only keep farms affordable, but have the added benefit of protecting ecosystem services and local food supply, both important strategies for climate change adaptation. Protecting critical soil landscapes was determined to be of high urgency and require a high degree of financial resources as well as cooperation/collaboration with partners outside of the agriculture interest area.

Reducing combined sewer overflows (CSOs), which will be more prevalent as a result of projected increases in extreme precipitation events, will help protect Connecticut's valuable oysters. (Photo credit: CT DoA)

Infrastructure

In 2009, the Infrastructure Workgroup of the Adaptation Subcommittee of the Governor's Steering Committee on Climate Change developed the report, *Climate Change Impacts on Connecticut Infrastructure*, released January 2010. That report was consolidated with companion reports on Agriculture, Public Health, and Natural Resources to produce the Adaptation Subcommittee's report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*, issued in April, 2010. The report was developed in accordance with Section 7 of Public Act No. 08-98, *An Act Concerning Connecticut Global Warming Solutions*, to evaluate "…the projected impact of climate change in the state on: (1) Infrastructure, including, but not limited to, buildings, roads, railroads, airports, dams, reservoirs, and sewage treatment and water filtration facilities…" as well as for the non-infrastructure components of natural resources, public health and agriculture.

The Key Findings of the Infrastructure Workgroup stated in the 2010 report were:

> *The infrastructure planning areas determined by the Infrastructure Workgroup to be most impacted by climate change were coastal flood control and protection, dams and levees, stormwater, transportation and facilities and buildings. Infrastructure planning areas were most affected by changes in precipitation* [patterns] *and sea level rise, which could cause substantial structural and economic damage.*

In their review of seven primary planning areas (Transportation, Energy and Communications, Solid Waste Management, Water Supply, Wastewater, Dams and Levees, and Coastal Flood Control and Protection), the Infrastructure Workgroup categorized all seven planning areas into broader LAND and WATER divisions, which related to the potential impacts of climate change from precipitation and sea level rise, especially under extreme weather (storm and flood) conditions. Using a Federal Emergency Management Authority (FEMA) methodology, the Infrastructure Workgroup's gross estimation of property at potential risk from today's 100-year flood exceeds $18 billion.

Based on their analysis of potential risk to infrastructure from climate change, the Infrastructure Workgroup suggests the need for additional information to improve the analysis and to support further development of adaptation strategies required by PA 08-98. Among these baseline informational needs are:

1) **Research and detailed assessment to better understand climate change effects on infrastructure, and the ability to adapt to those changes;**
2) **Exact locations, elevations and valuations of public and private infrastructure to allow more accurate and useful risk assessments;**
3) **Updated flood and sea level maps that account for the effects of climate change and the projected time frame for those effects to support better risk assessment and, along with infrastructure location mapping (recommendation 2), provide potential and priorities for site-specific adaptive actions; and**

4) **Ongoing monitoring of climatic conditions and sea level, and associated research on climate change effects, are essential to effective planning and adaptation.**

Along with the other three work groups, the Infrastructure Workgroup acknowledged and supported the need to consider impacts and adaptation measures that overlapped the four workgroup target areas, recognizing co-benefits of specific adaptive actions, and the importance of strong public participation and public engagement in an effective climate change adaptation strategy and program. (See the section on common climate change concerns.)

Strategic Planning for Infrastructure Adaptation

Building on what was learned during the assessment phase of the climate change adaptation process, the Infrastructure Workgroup identified several attributes of the planning process that would maximize efficiency and completeness in the development of an infrastructure adaptation strategy. These attributes set out an actionable approach for the diverse, but interrelated planning areas and infrastructure types presented in the Infrastructure Adaptation Menu (See Appendix A) that supports this strategy. Some of these principles address the four recommendations of the Infrastructure Workgroup that were identified as primary needs during the assessment of impact, or risk assessment for infrastructure. Others provide additional detail to those recommendations.

Of special concern is the need and ability to take advantage of co-beneficial management activities already incorporated into regulatory or technical standards that partially or wholly address present, as well as future, climate conditions. These activities range from land management programs that protect water quality today and build resilience against future climate change, or construction standards that will satisfactorily protect infrastructure investments and provide durability against extreme weather events, including incremental climate change effects, through anticipated life cycle or utility span of infrastructure investments.

The Infrastructure Workgroup identified the following assessment needs to guide current and future planning and implementation of climate change adaptation strategies for Connecticut infrastructure:

- **A spatial analysis of infrastructure locations, values and vulnerabilities**

A spatial analysis of infrastructure locations, vulnerabilities and values with regular updates to monitor and track changes over time, is needed to improve planning and assessment capability. The resulting database and maps would be used to track implementation and effectiveness of an adaptation strategy in protecting infrastructure against the effects of climate change. Existing plans and resources, such as the Natural Hazards Mitigation Plan, should provide a foundation for this analysis. (For an example of a spatial analysis of infrastructure locations, values and vulnerabilities, see the "Adaptation Today" case study on Groton adaptation planning, below.)

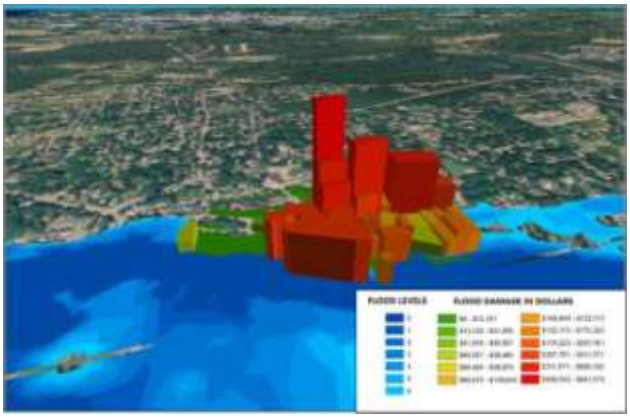
Adaptation Today

Planning Together for Climate Change in Connecticut's Coastal Communities: A Vulnerability Assessment and Adaptation Strategies for Groton's Coastal Infrastructure

The Connecticut Department of Environmental Protection (CT DEEP) Office of Long Island Sound Programs (OLISP) has made substantial efforts to address potential climate change adaptation needs of Connecticut's infrastructure in the coastal management zone of Long Island Sound. Much of the success of this work was made possible by partnering with relevant stakeholders and leveraging and building upon existing efforts.

Among these efforts is the Groton Coastal Climate Change Adaptation Project, a series of cutting edge workshops that engaged state, local and federal governments in an adaptation planning process using Groton as a pilot. With funding from the EPA's Climate Ready Estuaries through the Long Island Sound Study, OLISP partnered with ICLEI-Local Governments for Sustainability to design and host the workshops that brought representatives, across political boundaries, from state, federal and local entities and university researchers, advocacy groups and the public together to collaborate in preparing to address climate change impacts. The first workshop provided participants with information on climate change projections, an inventory and overview of Groton's infrastructure, and a definition of adaptation and adaptation goals. The presenters at the second Groton workshop explored the risk to coastal communities from climate change, and introduced some possible adaptation strategies. Participants during the last workshop defined strategies for maximizing resilience to climate change impacts.

More frequent extreme precipitation events coupled with coastal storm surge, like this one that hit Groton in Spring of 2010, was one of the climate change impacts that were considered during the Groton Coastal Climate Change Adaptation Project workshops held in 2010.
(Photo credit: John DeCastro, CT DOT)



An analysis of Mystic showed that a 10-year flood with a sea level rise of 1 m in 2070 would result in a cumulative expected loss of $8,768,776. The color and height of the buildings in the above map correspond with the amount of economic loss. (Photo credit: Sam Merrill, New England Environmental Finance Center)

As part of the series, the New England Environmental Finance Center and Battelle Memorial Institute modeled the cost of various scenarios, including property and building contents loss, and the cost of adaptation strategies, including the cost of no adaptation actions. Maps were then created to visually present the risks and potential solutions. For example, an analysis of downtown Mystic, a section of Groton, showed that a ten year flood event with a sea level rise of 1m in 2070 would result in cumulative expected losses of nearly nine million dollars. Adaptive actions, such as a hurricane barrier, elevating a road and building a dike were shown to provide some protection to Mystic.

Groton is a great pilot community; they have their own climate change task force and the local government is beginning to incorporate adaptation elements into their Capital Improvement Plan criteria and Plan of Conservation and Development. Following the workshops, the Town of Groton formed the adaptation task force made up of representatives from the various departments who will continue the Town's efforts on climate adaptation after the grant period ends. Additionally, the workshops have generated cohesion within local areas vulnerable to climate change, which has allowed for dialogue on potential solutions.

Participants discussed possible infrastructure adaptation strategies for the town of Groton during the Groton Coastal Climate Change Adaptation project workshop.
(Photo Credit: CT DEEP)

In December 2010, the draft report was presented at a meeting called by Groton's Planning and Development Department that included invited elected officials, stakeholder Boards and commissions, and town staff involved with the adaptation process.

For more information on the Groton Coastal Climate Change Adaptation Project, see the Connecticut Climate Change website (www.ct.gov/deep/climatechange) or the ICLEI website (http://www.icleiusa.org).

- **An assessment of current infrastructure design standards**

An assessment of current siting, setback and design standards and associated regulatory authorities is needed to provide a basis for implementing the regulatory and performance standards to address projected changes in risk to infrastructure from climate change. An assessment of current design standards should include an evaluation of current design life specifications, or life expectancy, for any infrastructure component. (For more information about climate change design life for infrastructure, see the "Adaptation Today" case study on the infrastructure of Connecticut parks.) From a regulatory and prevention effectiveness perspective, such an assessment will be complementary to the database and maps, identified in the previous spatial analysis of infrastructure locations, values and vulnerabilities.

- **An evaluation of infrastructure design that protects ecosystem services**

An assessment of the natural resiliency and infrastructure adaptation co-benefits provided by existing management programs and practices that are designed to protect general environmental attributes of habitat and water quality should evaluate many land and water management actions. These actions include low impact development (LID) and green infrastructure techniques that buffer or mitigate the impacts of flooding and storm surge and extreme temperature, as well as protect natural resources, agriculture and the public health. (See the text box on the right for more information about one aspect of green infrastructure.)

- **An evaluation of the timing, phasing and/or scheduling of adaptive actions**

Timing, phasing and/or scheduling of adaptive actions should be determined by the level of urgency or imminent threat situations that require immediate action to protect infrastructure and public health and safety. This evaluation should also consider long-term planning factors such as obsolescence of infrastructure or life-cycle replacement cost and variance in climate change pressures that would modify design standards, location, etc. This might be done in an actuarial framework that takes advantage of insurance based economic and property value assessments in relation to the costs of adaptation, especially with respect to engineering solutions such as armoring or reconstruction (Economics of Climate Adaptation Working Group 2009).

Urban Trees, An Important Component of Green Infrastructure

Trees in urban areas are an important component of green infrastructure, or infrastructure that mitigates the impacts of flooding and storm surge and extreme temperature. Urban planners and landscape architects should choose trees that would do well now, as they are establishing, and continue to thrive over the next several decades, as winters warm, summers become hotter and precipitation patterns change. The below are some suggestions for trees that may thrive under climate change (trees marked with an asterisk may be appropriate for planting under utility lines):

- American hophornbeam*
- American hornbeam*
- bald cypress
- black gum
- black maple
- bur oak
- cucumber tree
- dawn redwood
- eastern redbud*
- elms, including American elm
- ginkgo
- golden raintree
- hackberry, including sugarberry
- honey locust
- Kentucky coffeetree
- London plane
- magnolias (star magnolia*)
- northern red oak
- 'october glory' red maple
- persimmon
- pin oak
- post oak
- river birch
- sawtooth oak
- shingle oak
- shumard oak
- southern red oak
- swamp white oak
- sweet gum
- trident maple*
- tulip tree
- white oak
- willow oak
- yellowwood

For more information, see *Urban Tree Selection Manual* (Alexopoulos et al. 2007).

Adaptation Today

Effects of Climate Change on Design Life of Connecticut's Coastal Recreation Infrastructure

Coastal state recreation areas are some of Connecticut's most visited, and treasured natural areas. They provide access to Long Island Sound for sun bathers, boaters, anglers, bird watchers and outdoor enthusiasts, as well as respite from the hustle and bustle of civilized life. They also contribute to Connecticut's tourism industry and the local tourist economy. Coastal recreation infrastructure, such as boardwalks, boat launches and bathhouses, not only provide access, but also protect sensitive natural resources from human activity because their placement provides relief from foot traffic. However, coastal infrastructure is increasingly threatened by climate change, especially sea level rise. Recreation planners at the Connecticut Department of Environmental Protection (CT DEEP) have identified Connecticut's most vulnerable coastal recreation resources, and are developing strategies to mitigate these impacts, including adjusting infrastructure design life.

Hammonasset Beach State Park will be mostly inundated by sea level rise by the end of the century. (Photo Credit: CT DEEP)

Coastal recreation infrastructure vulnerability was assessed by CT DEEP at recreation sites located along Long Island Sound that are owned or managed by CT DEEP. Using locational data provided by CT DEEP and the University of Connecticut, CT DEEP assessed infrastructure vulnerability for several sea level rise scenarios consistent with projected sea level benchmarks reported in the *Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health* for early, mid and late 21st century. The analysis showed that the infrastructure in the following six sites will be the most vulnerable as compared to other sites because there is a higher potential for inundation even with a minimal rise in sea level rise:

1. Barn Island Wildlife Management Area & State Boat Launch, Stonington
2. Bluff Point State Park & Coastal Reserve, Groton
3. Charles E. Wheeler Wildlife Management Area, Milford
4. Hammonasset Beach State Park & Natural Area Preserve, Madison
5. Great Island Wildlife Management Area, Old Lyme
6. Rocky Neck State Park, East Lyme

Design life, or life expectancy, of infrastructure components has become an increasingly important consideration when selecting materials and locations for coastal parks infrastructure in anticipation of potential impacts from climate change. As one of Connecticut's most visited state parks, Hammonasset Beach State Park and Natural Area Preserve in Madison has an infrastructure network to service the recreational needs of visitors that includes parking lots, bath houses, camping facilities and boardwalks. The assessment predicted that the beach area is the most vulnerable and that the area where the Middle Beach bathhouse is located may be much less vulnerable to sea level rise. Accordingly, the CT DEEP Parks Department factored in a long-term design life for the new Middle Beach bathhouse using appropriate building materials, such as a lead-coated copper roof, which would last 60 years or more. On the other hand, the beachfront boardwalk was designed in "release" sections intended to dissipate storm wave energy and provide added adaptation to the Hammonasset infrastructure. The boardwalk was constructed of wood, rather than longer-lived concrete, so that the boardwalk would not "outlast" the current beach.

The Hammonasset Beach State Park Boardwalk was built with a shorter design life and "release" sections to dissipate storm wave energy.
(Photo Credit CT DEEP)

CT DEEP is continuing to evaluate findings of the coastal park vulnerability assessment and to develop adaptation strategies for vulnerable parks that are both protective of park features, make them more adaptive to climate change, and that are cost effective given projected design lives of infrastructure. For more information about Connecticut coastal parks, visit the CT DEEP website www.ct.gov/deep .

Note: In response to damage by Hurricane Irene, State Parks has reached the conclusion that maintaining the shoreline at west beach is not, in the long run, sustainable. Repairing storm damage to the bathhouse and boardwalk, while doable, leaves these structures vulnerable to continued storm impact. Taking a "retreat" strategy we are proposing to demolish the West Bathhouse and have initiated a project request through the Department of Construction Services to build a new facility inland, in the vicinity of the current parking lot. Additionally we are planning to relocate the westerly 400 feet of boardwalk to the inland side of the dunes, connecting it to the new west beach bathhouse. The design of and materials selected for these new projects will be matched with their vulnerability to sea level rise, among other factors.

The Infrastructure Workgroup also identified the following principles to guide current and future planning and implementation of climate change adaptation strategies for Connecticut infrastructure:

- **Climate change adaptation activities should focus on three different stages of infrastructure development: 1) new development; 2) modification; and 3) replacement of infrastructure.**

Climate change adaptation activities should focus on three different stages of infrastructure development, new development, redevelopment, and replacement of infrastructure, including consideration of retreat and relocation options. A priority risk-based evaluation is needed of possible structural modifications to existing infrastructure, such as re-engineering and armoring, with specific consideration of costs, benefits, environmental impacts, other ancillary effects and legal/regulatory implications of each action. Ultimately, the public and private sectors should be informed of individual actions deemed necessary to protect infrastructure and build natural resiliency.

- **Wherever possible, infrastructure adaptation strategies should identify ancillary effects and co-benefits of climate change adaptation actions, including opportunities for climate change mitigation.**

The identification of ancillary effects and co-benefits of climate change adaptive actions on land and water management needs, regulations and programs should be incorporated into both comprehensive short and long-term planning. For example, adaptation strategies that reduce energy consumption may result in the mitigation of greenhouse gas emissions. This will ensure full social and economic considerations of the most environmentally protective, socially acceptable and cost-effective courses of action.

- **Outreach and public engagement will be an important aspect of each adaptation strategy.**

Outreach and public engagement will be an important aspect of each adaptation strategy because so many of the actions will require adaptation practices that can only effectively be implemented by private land owners, both individual and corporate. A strong outreach and education component is essential to ensure public engagement in the role of building resilience against climate change and operating and maintaining infrastructure to maximize its benefit in mitigating the forces of climate change without compromising public safety and economic prudence.

Building on these attributes, there are many other climate change adaptation and mitigation "tools," including regulations, tax incentives, government grants, insurance, and ancillary programs and activities, such as land management practices and hazard mitigation plans, that should be considered. There is a growing library of climate change adaptation resources produced by federal, state and local entities as well as university researchers that include models and tools to assist management authorities with assessment and implementation of climate adaptation technologies and practices.

Climate Change Adaptation Strategy for Infrastructure – A Framework for Action

The magnitude of potential impacts on infrastructure is enormous given its prevalence in the landscape and much of its proximity to risk features such as the coastline or rivers that may flood. It is impossible to address the risk to properties on a broad scale in the short term or all eventualities that might be related to climate change and it may be that mitigating or avoiding some risks may be impracticable. Options for climate change adaptation are growing with increased attention and research, and today's practices may quickly be supplanted by newer and more cost-effective technologies and approaches. Further, infrastructure often competes with some of the preferred management practices incumbent to the adaptation strategy attributes

outlined above. Finally, some infrastructure can only be placed in high risk areas that are in close proximity to rivers and or coastlines. These include dams for water supply reservoirs and treatment facilities that provide drinking water and sewage treatment plants that are generally gravity-fed and at low points in the landscape near rivers and Long Island Sound, where they discharge.

To account for these complexities, the Infrastructure Workgroup suggests three overarching actions:

Best Management Practices

- **Develop decision tools to evaluate replacement, modification, and design life for infrastructure**

Decision support tools are needed for analysis of alternatives, trade-offs, costs and benefits of adaptation approaches. Technical support will be needed to develop decision tools that provide for consideration of economic, societal and environmental effects of climate change impacts and potential adaptation approaches. The decision tools should be created for engineers and planners to determine if replacement or modification of infrastructure is warranted and to guide selection of the most appropriate alternatives. The decision tools also will include information to determine the appropriate design life for future infrastructure components. For existing infrastructure, the vulnerability database should be used, in conjunction with these decision tools to assign priorities for action that could include re-engineering, relocation, and/or removal, based on social, economic and environmental considerations of the infrastructure value and cost/benefits of various actions.

Research, Monitoring and Education

- **Engage and educate private landowners to manage their lands to minimize risk from climate change**

Public engagement is essential to effective climate change adaptation for infrastructure. This is especially critical to influence the ways private-landowners manage their lands to minimize risk from climate change as well as to build resiliency that mitigates climate impacts and contributes to the co-benefits for Connecticut's environment identified above. Specifically, education directed at landowners could include information that will help them understand the risks from climate change and that promotes appropriate land use practices to mitigate that risk. However, given the economic value of much vulnerable property such as coastal residences, public education alone is unlikely to be sufficient, and therefore some regulatory policy changes will likely be necessary.

- **Conduct research to understand effects of potential adaptation approaches and develop new, innovative approaches to support adaptive management**

Apply science-driven adaptive management including progressive research, monitoring, data management, cost/benefit analyses and subsequent refinement.

Policy, Legislation, Regulation and Funding

- **Implement new or modified policies that would encourage appropriate land use and reduce repetitive losses**

Going forward, new and reconstructed infrastructure should be designed with consideration for climate change impacts, and sited, engineered, operated and maintained in a manner that

minimizes future concerns and preventable economic losses. Existing state statutes, regulations and policies regarding development in vulnerable areas should be evaluated, and the viability of implementing new or modified policies that would encourage appropriate land use and reduce repetitive losses should be investigated. Such policies could discourage building or rebuilding in high-hazard and projected inundation areas through such means as the Statewide Plan of Conservation and Development, zoning regulations, rolling easements and tax incentives. In order to be effective, adaptation policies should attempt to mitigate or reverse the economic factors that lead landowners and municipalities to undertake development of vulnerable areas. At present, the real estate market does not adequately account for the risks of climate change, especially sea level rise.

Natural Resources

In 2009, the Natural Resources Workgroup of the Adaptation Subcommittee of the Governor's Steering Committee on Climate Change developed the report, *Climate Change Impacts on Connecticut Natural Resources*, released January 2010. That report was consolidated with companion reports on Agriculture, Infrastructure and Public Health to produce the Adaptation Subcommittee's report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*, issued in April, 2010. The report was developed in accordance with Section 7 of Public Act No. 08-98, *An Act Concerning Connecticut Global Warming Solutions*, to evaluate "…the projected impact of climate change in the state on: (2) natural resources and ecological habitats, including, but not limited to, coastal and inland wetlands, forest and rivers…" as well as for the non-natural resources components of agriculture, infrastructure and public health.

The Natural Resources Workgroup determined that climate change will have a significant impact on Connecticut's habitats and the plants and wildlife they support. The Natural Resources Workgroup stated in their 2010 Impacts report that:

> *The degree of impact will vary among habitats and species. Likely changes will include conversion of rare habitat types (e.g., cold water to warm water streams, tidal marsh and offshore islands to submerged lands), loss and/or replacement of critical species dependent on select habitats and the increased susceptibility of habitats to other on-going threats (e.g., fragmentation, degradation and loss due to irresponsible land use management, establishment of invasive species) in addition to climate change.*

In their review of eighteen different terrestrial and aquatic habitat types, identified in Connecticut's Comprehensive Wildlife Conservation Strategy (CT DEP 2005), the Natural Resources Workgroup determined that the habitats most at risk were Cold Water Streams, Tidal Marsh, Open Water Marine, Beaches and Dunes, Freshwater Wetlands, Offshore Islands, Major Rivers, and Forested Swamps. An increase in temperature was identified as the dominant risk driver for both terrestrial and aquatic habitat types, such as Upland Forest Complexes and Cold Water Streams, while changes in precipitation patterns will primarily impact aquatic habitats, such as Freshwater Wetlands and Bogs and Fens. Sea level rise will impact coastal habitats, such as Tidal Marsh and Beaches and Dunes.

In a subsequent review of over 800 Connecticut species, the Natural Resources Workgroup determined that a number of species of plants and animals will be affected by climate change. The Workgroup expects seventy-five species classified as Greatest Conservation Need or State listed as Endangered/Threatened or Special Concern to experience a population decline, while nineteen invasive or potentially invasive species may experience a population increase.

The Natural Resources Workgroup is lead by the Chief of the Bureau of Natural Resources for CT DEEP and the Director of Conservation Programs for The Nature Conservancy in Connecticut (CT TNC), and comprised of an assemblage of experts, who provide information on the impacts of climate change on the state's natural resources. The solicitation and assessment of

impacts and adaptation strategies were developed through a workshop, small group meetings and one-on-one interviews with natural resources stakeholders, including representatives from academia, non-governmental organizations, private sector and state and federal agencies.

The ultimate goal of climate adaptation for Connecticut natural resources is to reduce the risk of environmental degradation including actions that increase resilience. Resiliency is the ability of an intact, well functioning habitat to accommodate change, both climatic and non-climatic (e.g., invasive species, development pressure, degraded water quality), and return to a well functioning, if slightly altered, state. For example, managing for resiliency in coastal and freshwater wetlands may allow for the specific plant species to change, but ultimately the function of wetlands, such as filtering and storing water before it reaches Long Island Sound, remain intact. For some habitats and species it may be possible to build up resistance to the impacts and/or accommodate climate changes. For example, targeted land and water conservation measures may be sufficient to maintain much of the current distribution of coldwater-dependent trout in Connecticut streams, despite temperature increases.

Adapting Connecticut's natural resources to climate change requires ongoing research and monitoring and the iterative implementation and evolving development of adaptation strategies. Public and political support, achieved through education, is integral to the process. Climate change adaptation strategies for natural resources will reshape the following three tools of natural resources conservation:

1. Land Acquisition,
2. Ecosystem Restoration, and
3. Natural Resources Management.

Historically, land acquisition in Connecticut has been focused on protecting rare ecosystems and imperiled species from non-climatic stressors, most notably from development pressure. However, land acquisition through the lens of climate change must establish additional goals, with longer planning horizons, to assure the protection and persistence of natural resources that may be threatened by climate change today and in the future. Land acquisition cannot only preserve habitats and species as static features on the Connecticut landscape, but also must accommodate change to maintain habitat functioning or allow for the migration of new habitats and species assemblages. Land acquisition that improves connectivity of critical habitat and migration corridors, especially in forest lands, headwaters, riparian lands and shorelines, is needed to maintain long-term ecosystem resiliency to climate change. Land acquisition guidelines reflecting climate change and adaptation should be included in the State's *Green Plan: Guiding Land Acquisition and Protection in Connecticut* (referred to herein as the "Green Plan"), a strategic plan for land acquisition and protection, and, whenever possible, land acquisition planning should consider the regional scale to ensure maximum connections across the landscape.

An essential part of fostering natural resources resilience to climate change is to maintain ecosystems by reducing non-climatic stressors. Non-climatic stressors in Connecticut can occur in many ways, including:

- On-going habitat loss and fragmentation,

- Loss of forest understory from deer grazing,
- Invasion by non-native species,
- Overharvesting,
- Wetland filling and dredging,
- Stream channel modification and impediments, from dams, culverts, etc.,
- Excessive nutrient loading,
- Shoreline modification and armoring,
- Point and non-point source pollution,
- Control of natural disturbances, such as fire, and
- Competition for water resources.

Addressing these non-climatic stressors will require on-going education, legislation and regulation, as well as incentives for private landowners to reduce non-climatic stressors on private lands. Ultimately, ecosystem conservation needs to focus on maintaining or restoring habitat functions, such as carbon sequestration, nutrient cycling and filtering, and retaining water.

One consequence of climate change, even with aggressive habitat conservation and restoration, is the probability that species composition will change and some native species may disappear. Land and resource managers will need to apply an adaptive management approach whereby strategies, based on the best available data, are developed, implemented and continuously monitored and changed, as needed, based on measurable results. Land and resource managers must determine when and where strategies that impart resistance or resilience are most appropriate, and alter existing best management practices to complement these adaptation strategies. (For more information on scenario planning, see the "Adaptation Today" case study on coastal scenario planning, below.)

Invasive species are just one of the stressors that will need to be managed to allow habitats to adapt to climate change. CT DEEP uses the Marsh Master, a low-impact, field vehicle, to apply herbicides in an effort to restore the marshes along the West River in West Haven. (Photo credit: CT DEEP)

Adaptation Today

Visualizing the Future of Connecticut's Coast using Scenario Planning

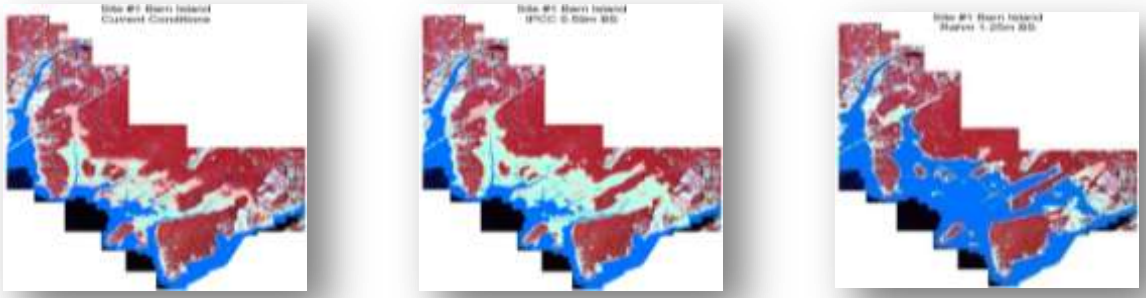
Connecticut tidal marshes are critical to the vitality of Long Island Sound, an estuary of national importance. Tidal marshes provide essential services including retaining and filtering stormwater, sequestering carbon, creating a natural buffer to storm surges, and providing habitat for a wide array of dependent fish and wildlife species. During the tidal cycle, salt marshes and the network of tidal creeks and pools provide food and important nursery grounds for shellfish and finfish, including many commercially and recreationally harvested species. Unfortunately, tidal marshes in Connecticut are already exhibiting effects of climate change; the pace of which is likely to rapidly accelerate with more frequent and intense storm events and sea level rise.

Tidal marshes in Connecticut are already exhibiting impacts from sea level rise and more extreme storm events caused by climate change. (Photo credit: Frank Slack, CT TNC)

Despite a growing awareness of coastal impacts from storm events and sea level rise, federal, state and local decision makers have lacked tools to engage in scenario planning, that would consider future projections and identify critical management and policy choices. As a consequence, decision makers are unable to comprehensively evaluate and accommodate for sea level rise in a manner that both reduces risk and s increases the resilience of communities and resources such as tidal marshes. To address this problem, federal, state and local agencies, academia and non-profit organizations have developed various tools and outreach programs to assist community planning including:

- CT DEEP's Coastal Hazards Analysis Management Project (CHAMP) - web site providing sea level rise visualization tool and coastal hazards information/guidance for Connecticut (http://deepweb.dms.uconn.edu/)
- EPA Long Island Sound Study/CT DEEP/ICLEI Local Governments for Sustainability– Groton Coastal Climate Change Adaptation Project (http://www.groton-ct.gov/depts/plandev/docs/Final%20Report_Groton%20Coastal%20Climate%20Change%20ProjectJP.pdf)
- The Nature Conservancy's Coastal Resilience Program- ecological/socio-economic planning tool & outreach program for Long Island Sound (www.coastalresilience.org)

These tools and outreach programs are helping increase awareness of the impacts on natural resources and communities and will advance scenario planning around key adaptation strategies. These efforts assist with the 1) identification of 'advancement zones" as tidal marshes migrate inland, 2) economic benefits of natural resources that protect critical infrastructure and livelihoods, 3) impacts of storm events to inform and limit future losses via possible regulations on new development and/or post-storm re-development, and 4) alternative, environmentally-friendly engineering solutions for coastal shoreline protection.



The University of Connecticut and The Nature Conservancy use sea level rise data from current climate change models that take the current sea level (left) around Barn Island Wildlife Management Area in Stonington and project inundation based on sea level rise scenarios of 0.5 m (middle) and 1.25m (right).

(Source: University of Connecticut and The Nature Conservancy – Connecticut, June, 2010.)

With additional support and focus, advancement of innovative adaptation strategies shown through scenario planning can enable the implementation of long-term solutions to coastal climate change impacts. There are real opportunities for identifying win-win solutions that combine the need to mitigate coastal hazards and preserve natural resources while protecting coastal infrastructure, communities and their livelihoods.

The Natural Resources Workgroup identified a set of overarching strategies that apply across multiple habitats within Connecticut as well as habitat specific climate adaptation priority actions. These strategies aim to conserve and enable the persistence of a representative array of habitats, as possible. Ultimately, the goal is to maintain the function of critical habitats. Wherever possible, these strategies should be consistent with regional goals, and protect habitats and species that are most important for conservation in Connecticut. The ultimate goal is to establish a systematic and effective approach to implementing progressive climate adaptation strategies for Connecticut's natural resources. The following strategies are the highest priority overarching and habitat specific (Table 1) actions. (The complete list of habitat specific strategies can be viewed in Appendix A and in the table below.)

Highest Priority Actions

- **Acquire land and conservation easements to provide upslope "advancement zones" adjacent to tidal marshes.**
- **Perform a comprehensive modeling assessment of the extent of inland migration of tidal marshes needed to inform adaptation decisions.** (For more information about predicting tidal march advancement, see the "Adaptation Today" case study.)
- **Acquire land and conservation easements in riparian areas adjacent to coldwater streams.** (For more information about conservation of coldwater stream resources, see the "Adaptation Today" case study.)
- **Adopt regulations that provide stream flow levels necessary to ensure the resilience and ecological integrity of coldwater streams**
- **Increase active management of upland forests to improve regeneration, diversity and resilience** (For more information about active management of Connecticut upland forests, see the "Adaptation Today" case study.)
- **Collaborate with other northeast states and federal agencies to develop a coordinated regional adaptation approach for conservation of habitats and species at risk**
- **Advance connectivity among habitats**

Protecting and connecting critical habitat, such as the Eight Mile River watershed, will contribute to the adaptation of natural resources in Connecticut. (© Jerry Monkman)

Table 1: Climate change adaptation actions for specific habitats. See Appendix A for more details on these strategies.

Habitat	Near Term Strategies	Mid-term	Long-term
Coldwater Streams	• Acquire riparian lands • Re-establish connectivity • Adopt stream flow regulations • Prioritize restoration and management • Stock more resilient trout strains • Monitor fish population changes	• Explore water rights option that protect fish and wildlife • Diversify fish species in CT DEEP hatcheries • Advance progressive land use policy/regulations • Identify and protect ground water sources	
Tidal Marsh	• Acquire "advancement zones" for migration • Adopt sea rise monitoring tool • Promote eco-friendly coastal protection alternatives • Support coastal land use policy reform • Evaluate new techniques for new and post-storm redevelopment	• Research up-slope migration & marsh stabilization	• Implement new management techniques • Educate public on mitigation co-benefit
Open Water Marine	• Monitor marine resource changes • Reduce pollutant runoff via watershed management	• Identify ways to diversify fisheries	
Beaches and Dunes	• Acquire "advancement zones" for migration • Nourish coastal beaches • Promote eco-friendly coastal protection alternatives • Require softer engineering for coastal protection	• Evaluate new techniques for new and post-storm redevelopment • Require native vegetation buffers • Construct shoreline oyster reefs • Restore beach and dune plants and wildlife	
Herbaceous Freshwater Wetlands	• Advance policies that reduce runoff and temperature • Ensure that new infrastructure will not alter hydrology	• Reduce pollutant runoff via watershed management • Protect land adjoining habitat • Manage water withdrawals/diversions	
Intertidal Flats and Shores	• Inventory key habitats for birds and other wildlife	• Construct shoreline oyster reefs	• Restore land from disincentive programs
Major Rivers and Associated Riparian Zones	• Remove or modify structural impediments to flow • Advance land uses that reduce temperature impact • Acquire easements in strategic areas	• Modify upstream flood control infrastructure • Update standards for warm water effluent, as needed	• Promote warm water game fish • Reduce warm wastewater discharges
Forested Swamps	• Employ BMPs that reduce thermal impacts	• Ensure that new infrastructure will not alter hydrology • Protect land adjoining habitat • Manage water withdrawals/diversions • Monitoring hydrologic changes	
Subtidal Aquatic Beds	• Examine watershed management practices impact • Examine land acquisition strategies impact • Restore or enhance habitat • Research and monitor impacts of climate		
Lakes, Ponds, Impoundments and Shorelines	• Reduce pollutant runoff through land use management • Promote shoreline vegetative buffers	• Promote alternative manure technologies	
Upland Forest Complex	• Manage invasive species • Research southern tree expansion impacts • Promote diverse forest habitat • Manage deer population densities • Monitor seedling regeneration • Provide education for private forest landowners • Encourage zoning reform to conserve forest size	• Include extreme event impacts in management • Provide education on extreme event impacts • Manage for maximum carbon sequestration	• Promote "smart growth" principles •Increase preparedness for wildland fires

Best Management Practices

- **Apply adaptive management procedures**

Land and resource managers need to apply science-driven adaptive management practices, including progressive research, monitoring, data management, cost/benefit analyses and subsequent refinement based on measurable results.

- **Increase active management of upland forests and reduce non-climatic stressors**

Upland forest habitat provides the State with valuable ecosystem services, such as clean air and water. Upland forest habitat is predicted to be moderately vulnerable to climate change, due to projected increases in temperature, which would displace some current tree species, especially ones at the southern extent of their range, and provide suitable conditions for new pests and diseases. Active management through timber harvesting and preventing over-browsing by deer will improve regeneration and diversity and help increase upland forest resilience to climate change. Active management also will help conserve large forest blocks by increasing the profitability and providing greater recreational opportunities on private forestlands. (For more information about active management of Connecticut upland forests, see the "Adaptation Today" case study below.)

Adaptation Today

Building Upland Forest Resilience to Climate Change through Active Management

Connecticut upland forest habitat, characterized as areas with a high density of trees and located upland from water features, is the dominate habitat in Connecticut. This habitat provides Connecticut residents with clean air and water, wildlife habitat, scenic vistas, recreational opportunities, including hunting, and buffers against extreme weather. The soil and biomass in upland forests are carbon sinks, a climate change mitigation benefit. Connecticut upland forest habitat is predicted to be moderately vulnerable to climate change, due to projected increases in temperature. Increased temperature will displace some current tree species, especially ones at the southern extent of their range, and provide suitable conditions to new pests and diseases.

Mohawk Forest in Cornwall is just one example of a Connecticut upland forest. Connecticut upland forests have been identified as moderately vulnerable to climate change. (Photo credit: CT DEEP)

In order to increase the resiliency of upland forest habitat to climate change, a goals of the Connecticut Department of Energy and Environmental Protection (CT DEEP) is active management of all of its forest lands. CT DEEP has developed an initiative to increase the percentage of Connecticut forests that are actively managed, from 50,000 to 100,000 acres, of the 170,000 acres of State Forest. Active management through timber harvesting will lead to diversity of species and tree ages and sizes. The forest management planning process that precedes the active harvest and removal of timber identifies areas at risk for forest pests and pathogens. The process also identifies opportunities to improve important wildlife habitat. Timber harvesting facilitates the regeneration of tree and shrub species on the forest floor, which increases the resilience of the forest habitat to extreme weather events, projected to increase due to climate change. Planned timber harvesting also balances the dead and

Timber harvesting, a tool in active management, will facilitate resilience to climate change by providing for the advanced regeneration of seedlings on the forest floor.
(Photo Credit: CT DEEP)

downed trees needed for wildlife habitat with the need to minimize the amount of potential wildland fire fuel. Furthermore, timber harvesting in Connecticut State Forests provides sustainable forest products and an increase in revenue and jobs for the state.

Approximately 85% of Connecticut forest land is privately owned. An important aspect of active management of State forest land is that it demonstrates to private landowners the value of keeping 'forests as forests,' in the form of financial and recreational incentives, so that critical upland forest habitat is voluntarily retained and managed by private owners. A healthy network of upland forests on private lands could help to facilitate adaptation by providing a source of genetic diversity and opportunities for species movement.

For more information about the active forest management of Connecticut forests, visit the CT DEEP website (www.ct.gov/deep).

Research, Monitoring and Education

- **Advance regional research and modeling to guide conservation efforts**

Climate change adaptation research and modeling should be conducted on a regional scale to inform adaptation collaboration and planning with other states and federal agencies. Research should focus on the inventory of existing and future key habitats and species, and identify habitats and species that are more effectively conserved in Connecticut, in neighboring states or jointly.

- **Build public consensus for adaptation strategies through education and outreach**

The public needs to understand the vital role natural resources play in providing ecosystem services and the potential reduction in the services due to climate change. Natural resources are vital to Connecticut residents' way of life and the economy. A multi-media educational campaign directed at natural resources professionals, land managers, decision-makers, town planners and the general public will help build support for natural resources conservation.

- **Partner with educational institutions or organizations that conduct research**

Utilize educational institutions and organizations that conduct research to refine natural resources strategies by gathering and analyzing baseline natural resources data, such as species inventories, and creating models based on that information to more accurately identify climate change impacts. These institutions and organizations also could help with monitoring the continuing impacts of climate change and the effectiveness of adaptation strategies.

- **Perform a comprehensive modeling assessment of the extent of inland migration of tidal marshes essential for directing adaptation actions**

Tidal marshes are identified as one of the most imperiled habitats, due to the projected increase in sea level rise and increased storm frequency, intensity and duration. As sea level rises, tidal marsh habitat moves inland to "advancement zones," replacing traditional upland habitat. However, decision makers lack comprehensive modeling assessments as to the location and extent of inland migration of tidal marshes needed to better inform adaptation decisions. As a

consequence, decision makers are unable to comprehensively evaluate and accommodate for sea level rise in a manner that would reduce risk and simultaneously increase the resilience of communities and resources like tidal marshes. Continued support for current research, such as Sentinel Monitoring of Climate Change in Long Island Sound, as well as additional research is needed to update and improve existing models. (See the "Adaptation Today" case study on coastal scenario planning above, for more information.)

Policy, Legislation, Regulation and Funding

- **Reevaluate Connecticut's Green Plan and open space grant programs to prioritize acquisition of land and conservation easements for habitats most at risk from climate change**

Land acquisition can improve connectivity of the critical habitat and provide more robust migration corridors, especially in forested lands, headwaters, riparian lands and shorelines that are integral to maintaining long-term ecosystem resiliency to climate change. Therefore, land acquisition guidelines reflecting climate change and adaptation needs should be included in the State's *Green Plan*.

- **Acquire land and conservation easements to provide upslope "advancement zones" adjacent to tidal marshes**

As sea level rises, tidal marshes will move inland to upslope, "advancement zones." However, tidal marshes will not be able to move to advancement zones if barriers, such as private development and infrastructure impede natural migration. Tidal marshes and the benefits they impart on the Connecticut coast, such as flood and storm protection, will be lost if current undeveloped land adjacent to tidal marshes is not protected through direct purchase, conservation easements or setbacks. These advancement zones should be identified and prioritized for protection. (See the "Adaptation Today" case study on coastal scenario planning above, for more information on Connecticut's tidal marshes.)

- **Acquire land and conservation easements in riparian areas adjacent to coldwater streams**

Coldwater streams were identified as one of the most imperiled habitats to the negative impacts of climate change. Conserving riparian areas, or land that surrounds and protects these streams, will be an important climate change adaptation strategy in order to ensure the quality and quantity of water in Connecticut and protect the plants and wildlife that depend on this habitat. Critical riparian areas should be identified and prioritized for protection. (See the "Adaptation Today" case study on riparian area land acquisition and conservation in the Tankerhoosen River Watershed below, for more information.)

- **Collaborate among state agencies, municipalities and non-profits within Connecticut to implement regulations and policies that promote and facilitate the conservation of habitats and species most at risk from climate change**

Adapting to climate change is a collaborative and iterative process, especially when the focus is a shared resource like natural resources. Therefore, a collaborative group of state agencies, municipalities, non-profits should be formed to discuss and plan the implementation of regulations and policies that promote and facilitate the conservation of the habitats and species most at risk from climate change.

- **Collaborate with other states and federal agencies to develop a coordinated regional adaptation plan**

Using the best available regional research and monitoring data, Connecticut should collaborate with other states and federal agencies to develop a coordinated regional adaptation plan. This plan will better ensure habitat resiliency by providing better habitat connectivity, habitat diversity, buffer zones and expansion of existing protected forest blocks beyond those of conserved by Connecticut alone. The need for collaboration and regional adaptation planning is consistent with the New England Governors' Conference Blue Ribbon Commission on Land Conservation, that references the need for land conservation to address climate change in its 2010 report (Blue Ribbon Commission on Land Conservation 2010).

- **Further regulate the introduction and spread of invasive species**

Invasive species are identified as one of the stressors that prevent natural resource resilience to climate change. Climate change may cause current non-aggressive, exotic species to proliferate and become invasive, and new invasive species may become able to thrive in Connecticut due to changes in climate. The introduction and movement of currently listed invasive species are regulated in Connecticut. However, this list needs to be reevaluated on a regular basis to ensure that Connecticut adequately regulates the movement of future invasive species. Any future regulatory actions should be coupled with statewide and regional prevention efforts, monitoring, rapid response and control measures.

- **Apply climate change projections to future stream flow regulations**

Proposed Stream Flow standards and regulations use the best available science to protect Connecticut's river and stream systems, and promote better, more efficient management of water resources and supplies, so that needs, both human and ecological, can be met today and in the future. Higher temperatures and changes in precipitation patterns are projected to cause more droughts in Connecticut, which would limit available water in streams for all uses at certain times. Therefore, climate change projections should be considered in regulations regarding stream flows to ensure the resilience of Connecticut streams, with particular attention to coldwater stream habitat.

Acquiring land and conservation easements in riparian areas, and applying climate change projections to future stream flow regulations will help Connecticut streams adapt to climate change.

(Photo credit: CT DEEP)

Adaptation Today

The Tankerhoosen River Watershed: Protecting Water Quality, Quantity and Wildlife Habitat through Watershed Conservation

Small to medium size headwater/coldwater streams are the source of the surface water feeding our larger rivers, lakes and reservoirs. These headwater streams are home to a variety of coldwater fish and invertebrate species that are highly vulnerable to some impacts of climate change including increases in water temperature, runoff, sedimentation and fluctuations in water quality and quantity. Conserving land that surrounds and protects these streams will be an important climate change adaptation strategy to ensure the quality and quantity of water in Connecticut. An undeveloped riparian buffer of natural vegetation adjacent to coldwater streams and associated wetlands can ameliorate many of the anticipated impacts of increasing temperatures and changing precipitation patterns. A natural landscape protects the stream from damage caused by episodes of extreme runoff and stabilizes flow and water temperatures during droughts by maximizing recharge and gradual release of groundwater throughout the year.

Existing and potential open space in the Tankerhoosen watershed, which is located in the towns of Vernon, Tolland, Bolton and Manchester.
(Photo Credit: CT DEEP)

The largely undeveloped, approximately 13-square mile, Tankerhoosen River Watershed is located in north-central Connecticut, within the towns of Vernon, Tolland, Bolton and Manchester. The watershed contains a wide diversity of habitats and species including a number of state-listed (endangered, threatened, or greatest conservation need) birds, reptiles, invertebrates and plants. In addition, the river supports the strongest remaining population of wild self-sustaining trout (brook trout and brown trout) within central Connecticut. The area also offers a showcase for other vulnerable habitats including herbaceous freshwater wetlands, upland forests and forested swamps.

The Tankerhoosen River is a cold water stream that supports a self-sustaining population of wild trout.
(Photo credit: CT DEEP)

The Tankerhoosen River is well positioned to serve as a model for watershed scale climate adaptation in southern New England. Approximately 730 acres of the watershed adjacent to the river and its tributaries are already protected, including the Belding Wildlife Management Area, Valley

Brook trout (left) and brown trout (right) are expected to decline in Connecticut as coldwater streams warm with climate change.
(Photo Credit: CT DEEP)

Falls Park and Bolton Notch State Park. Protection of these lands has been the result of a broad-based collaborative effort involving a number of State, municipal, land trust, and private partners. All of the protected lands provide the public with opportunities to explore and learn about headwater watershed protection as a climate change adaptation strategy. A formal education program has been established at the Belding Wildlife Management Area that provides environmental instruction to hundreds of local school students each year. In addition, annual sampling of the Tankerhoosen River's trout population (since 1988) has created a long-term database that can be used to monitor our success at conserving one of our most climate sensitive taxa.

Environmental education is provided to local students at the Belding wildlife Management Area.
(Photo Credit: CT DEEP)

The combination of diverse partnerships, a long-term database, and an established education and outreach program with dedicated staffing make this an ideal demonstration project site for watershed based climate adaptation. This program will ultimately seek to establish a network of concerned and informed stakeholders who will expand to address threats to watersheds throughout the region in a climate changed future.

For more information on the Tankerhoosen River Watershed, see the CT DEEP website (www.ct.gov/deep).

Public Health

Public Act 08-98 tasked the Governor's Steering Committee on Climate Change to assess the impacts to Connecticut public health due to expected climate changes. The Adaptation Subcommittee of the GSC established a Public Health Workgroup to specifically address these threats. The Public Health Workgroup is co-chaired by the Chief of the Local Health Administration Branch at the Connecticut Department of Public Health, and the Health Director for the City of Milford Health Department, and comprised of leaders in the areas of Connecticut air quality, epidemiology, public health, and health infrastructure.

The Public Health Workgroup determined that increases in temperature, changes in precipitation and extreme weather events and decreases in air quality would increase air quality and extreme heat ailments, including asthma and heat exhaustion. Changes in climate would be a threat to sanitation and food quality, and also tax the resources of public health infrastructure. The Public Health Workgroup also determined that existing vectors, such as mosquitoes or ticks, may increase, and vectors that are currently unable to survive the winter in Connecticut could become better able to establish and proliferate. Both of these changes in vector populations may increase adverse health conditions and vector-associated diseases. In addition, the Public Health Workgroup determined that environmental justice communities and other vulnerable communities would be disproportionately affected by these climate change impacts. Due to limited resources and competing priorities of the Public Health Workgroup members, the scope of the impacts report was by necessity, limited. Therefore, the Public Health Workgroup believes that a more thorough vulnerability and impacts assessment of these areas is required to further refine the adaptation strategies presented in this report.

In order to effectively respond to climate change, Connecticut will need to develop programs to educate public health stakeholders on the impacts of climate change and to monitor climate-related diseases. Public health infrastructure should be strengthened so that it will effectively respond to climate-related public health emergencies, especially for Connecticut's most vulnerable populations. Adaptation strategies for Connecticut's public health sector should recognize and support the collaborative relationship between state and local health departments and public and private health infrastructure, including hospitals. Furthermore, partnerships with states in the New England region should be encouraged. Translational research should be implemented in order to undertake research that is applicable to the practice of public health.

The Public Health Workgroup finds that in order to mitigate the impacts of climate change on public health, Connecticut should:

Best Management Practices

- **Consider the public health needs of vulnerable populations in climate change adaptation planning**

The public health needs of vulnerable populations, such as environmental justice communities, children, the disabled, the elderly and outdoor workers, must be considered in climate change adaptation planning because these populations can be more exposed or affected by impacts from climate change, such as extreme heat. Furthermore, these populations may not have access to preventative care and/or health education, which may place them at even greater risk to climate

change related ailments. Local health departments should be made aware of the Connecticut Department of Public Health (CT DPH) Database of Vulnerable Population Locations, and how to use it for adaptation planning purposes. Public health stakeholders should collaborate to ensure that the climate change-related, public health needs of vulnerable populations are being met. Local health departments should also consider flood areas around vulnerable populations to determine appropriate response during emergencies. Provisions for vulnerable populations should be incorporated into climate change adaptation planning in the near-term.

- **Evaluate ozone non-attainment alert systems**

Exposure to ozone has been linked to a number of respiratory health effects, including significant decreases in lung function and inflammation of airways. Children, the elderly and individuals with existing respiratory diseases, such as chronic obstructive pulmonary disorder (COPD) and asthma, are particularly vulnerable to ozone exposure. Currently, the state alerts residents when the Connecticut Department of Energy and Environmental Protection (CT DEEP) determines that the level of ozone exceeds federal attainment standards. CT DPH should work with CT DEEP to determine the effectiveness of ozone non-attainment alert systems. CT DPH is well positioned to help determine if vulnerable populations are receiving the alerts and understand the necessary precautions they should take to prevent high ozone-induced ailments. The ozone non-attainment alert system should be evaluated as a near-term strategy.

- **Evaluate current early extreme weather events warning system and emergency response plans**

More frequent and intense extreme weather events (e.g., heat waves, hurricanes) will tax public health infrastructure. Currently, early extreme weather event warnings originate in the Connecticut Department of Emergency Management and Homeland Security (CT DEMHS) and are transmitted to CT DPH and the Red Cross. CT DPH then notifies the local health departments, hospitals and elder-care facilities and provides them with recommendations. The State, through a partnership of CT DPH and DEMHS, local health departments, the Red Cross, first responders and hospitals, should evaluate this current early extreme weather events warning system and emergency response plans to determine if the public health community is sufficiently alerted to these events, and if the projected frequency and intensity of these events would require updating the alert plan. The evaluation should consider the potential for increased use of the established CT DEMHS reverse 911 system to alert Connecticut's public health infrastructure to extreme weather events. An evaluation of the extreme weather events warning system and emergency response plans should be a mid-term strategy.

- **Continue to develop and update all municipal emergency preparedness plans for extreme weather events**

All municipalities should have emergency preparedness plans for extreme weather events specific to their jurisdiction. It is important that these plans be kept up to date. Local Health Departments in coordination with the CT Department of Emergency Management and Homeland Security (DEMHS) should ensure these plans are kept current. To test these plans, exercises and drills should be conducted.

- **Develop cooling station best management practices**

Extreme heat can cause cramps, exhaustion, stroke and death. Certain populations, such as the elderly and people who are economically disadvantaged, tend to be more vulnerable to extreme heat events because they may not have access to air conditioning. Cooling stations are established, when needed, by various entities, including the state, municipalities and the Red Cross, to serve the public who may not have access to air conditioning. Cooling station best management practices should be developed to ensure that populations most vulnerable to extreme heat are best served. These best management practices should establish recommendations for equipment in cooling centers and include information on choosing the right location to establish a cooling center so that the target population can best access it. Best management practices also should include information on effective cooling center advertising. Cooling station best management practices should be incorporated into existing municipal extreme heat plans within emergency preparedness plans. Cooling station best management practices should be developed as a mid-term strategy, before extreme heat events dramatically increase in frequency and intensity. (For more information about extreme heat preparedness, see the "Adaptation Today" case study below.)

- **Develop criteria for school closings and outdoor play during extreme heat events**

Children may be particularly vulnerable to extreme heat events because they tend to spend more time outside and may not recognize the early warning signs of heat exhaustion. Currently, there are no criteria or recommendations from the State for school administrators to define an extreme heat event, to determine if their children are at risk and to implement the appropriate actions, such as limiting outdoor play and/or closing the school. A partnership of CT DPH and the Connecticut Department of Education (CT DoE) should develop criteria and recommendations for school closings and outdoor play during extreme heat events. These plans should assist schools without cooling capacity, and should include suggested actions such as modification of school day hours and closures. Schools can use these recommendations to develop plans specific to their district. This adaptation strategy should be implemented as a mid-term strategy, before extreme heat events dramatically increase in frequency and intensity.

Adaptation Today

State and Local Health Departments Prevent Heat-Related Illnesses through Multiple-Media Communication

The number and intensity of extreme heat events are expected to increase in Connecticut, with Hartford expected to experience 8 to 28 days a year over 100° F by the end of century. Heat-related illnesses caused by extreme heat weather events are preventable if the public is well informed about over-heating prevention. In order to educate as many people as possible, Local Health Departments have been using different forms of media to communicate with the public, from printed fact sheets to the internet.

Extreme heat preparedness communication includes strategies to prevent heat-related illness by staying cool.
(Photo credit: CT Culture & Tourism)

The Connecticut Department of Public Health (CT DPH) published a heat wave guidance document for local health departments in July 2010. The purpose of this guidance document is to help local health departments answer heat related questions from the public, outdoor workers and office employees. The guidance document specifically provides information on the hazards of extreme heat, the symptoms of heat-related illnesses and suggestions to prevent these illnesses, including information about cooling centers. The guidance document also counsels local health departments on their regulatory role in extreme heat in occupational settings.

A number of local health departments have produced their own extreme heat guidance directed at community residents and town employees. West Haven produced extreme heat education material for their residents and sent e-mails to town employees so that they could better assist the public with extreme heat questions. The West Haven Local Health Department specifically targeted their outreach efforts to local daycares and senior centers in order to prepare some of the populations most vulnerable to extreme heat. The Meriden Health Department used social networking websites to educate its residents on extreme heat preparedness, while the Quinnipiack Valley Health District offered cooling center fact sheets to the town administrators of member towns.

For more information about extreme heat preparedness, contact your local health department or visit the CT DPH website www.ct.gov/dph .

Research, Monitoring and Education

- **Educate other sectors of state government about public health climate change impacts and adaption**

The Connecticut Department of Public Health (CT DPH) should actively seek to educate other sectors of state government on public health adaptation so that these agencies can proactively identify adaptation opportunities within their own area of expertise and regulation. For example, the Department of Mental Health and Addiction Services (DMHAS) may want to develop strategies that include mental health concerns associated with the impacts and stressors of climate change. CT DPH could satisfy this adaptation strategy by holding an educational seminar or workshop for other state agencies. This adaptation strategy should be implemented within the short-term, before 2020, so that State agencies could immediately begin to examine their current and future planning initiatives.

- **Educate local health department staff on climate change impacts**

CT DPH took the opportunity of the CT DPH Commissioner's semi-annual meeting for local health department staff in 2011 to educate them on climate change projections, impacts and adaptation strategies. Climate change preparedness coordination and communication should be continued at subsequent meetings.

- **Develop educational materials concerning poor air quality**

Educational materials on public health problems, such as asthma, caused by poor air quality due to high amounts of ozone, , and strategies to mitigate these effects should be developed through a partnership of Local and State Public Health Departments. Strategies to avoid poor air quality ailments could be incorporated into existing sources of public health education, such as newsletters, but should also be included in new sources, such as social media, in order to target diverse audiences. Educational materials on poor air quality should be developed in the short-term, before 2020.

- **Continue to monitor health ailments caused by ozone non-attainment levels**

CT DPH currently monitors the public health threat caused by ozone non-attainment levels using the public health tracking system, which is made possible through federal support. CT DPH and other public health partners use the data from the tracking system to adequately respond to the public health threat caused by ozone non-attainment levels. The Public Health Workgroup considers the public health threat from ozone non-attainment to be significant and likely to increase, at least in the short-term, due to climate change. Therefore, the Public Health Workgroup recommends to its federal public health partners that Connecticut receive the support necessary to continue to monitor the public health threat caused by ozone non-attainment levels.

- **Assist local health departments with climate change adaptation**

Local health departments are essential partners in Connecticut's climate change adaptation planning because of their efforts to provide for their community's health needs. CT DPH should develop model public health climate change adaptation strategies for local health departments and provide education and training to build institutional capacity to implement these strategies and respond to public health impacts of climate change. Guidance should be provided to local health departments on how to deal with the impacts of climate change. Assisting local health departments with climate change adaptation should be developed as a mid-term strategy.

- **Incorporate climate change preparedness strategies into public health education**

The topic of climate change preparedness should be incorporated into existing public health education from grade school health education to any public health curriculum. Designing multi-audience lesson plans should be developed as a mid-term strategy.

- **Develop a database of morbidity and mortality caused by climate change**

CT DPH, local health departments and research institutions should collaborate to develop a database specific to the morbidity and mortality caused by climate change (e.g., incidences of heat exhaustion) in order to better assess the impact of climate change on public health. This data could then be used to identify public health priorities, prevention education and infrastructure needs related to climate change. Developing a climate change morbidity and mortality database should be developed as a mid-term strategy.

- **Intensify vector associated disease monitoring**

Vector associated disease monitoring is able to assess changing vector populations to determine the threat to public health and guide adaptation strategies. Vector associated disease monitoring should be increased in the later part of this century as changes in precipitation and temperature intensify. (See the "Adaptation Today" case study on vector associated disease monitoring below, for more information.)

- **Increase airborne pollen monitoring**

Warming temperatures will alter patterns of pollen production, which will increase incidences of allergies and asthma. More extensive monitoring of airborne pollen should be a long-term strategy.

Adaptation Today

Vector Monitoring is Imperative for Public Health Adaptation in Connecticut

Continuous monitoring of the impacts of climate change in Connecticut will be necessary for proper adaptation planning. The public health sector specifically relies on vector information from monitoring operations in order to respond to emerging disease threats. The Connecticut Agricultural Experiment Station (CAES) in New Haven currently monitors vector populations for the presence of known viruses and exotic diseases and vectors from outside the state.

The CAES mosquito surveillance program consists of 91 mosquito trap sites around the state, which are monitored from June to October. The program mostly monitors for the mosquitoes that transmit West Nile Virus (WNV), a usually mild disease that results in flu-like symptoms, and the more deadly, Eastern Equine Encephalitis (EEE), which results in inflammation of the brain, leading to headaches and in more severe cases, coma or death. The past two trapping season have illustrated the effect of changing precipitation patterns on mosquito vectors. In 2009, a wet summer, the mosquitoes that transmit EEE proliferated, while in 2010, a dry summer, the mosquitoes that transmit WNV proliferated.

Mosquitoes that transmit West Nile Virus are expected to continue to reproduce during dry summers because stagnant water in catch basins will serve to provide an environment for mosquito larvae to develop.
(Photo credit: Michael Thomas, CAES)

The CAES mosquito surveillance program also has found new species of mosquitoes that can transmit viruses and pathogens to humans. The Asian Rock Pool Mosquito (*Ochlerotatus japonicas*), a mosquito usually found in warmer locations, was recently found to overwinter in Connecticut. The Asian Rock Pool Mosquito is a very effective vector of WNV and scientists at CAES believe that it may proliferate with the projected increase in temperature. Another Connecticut exotic species, the Asian Tiger Mosquito (*Aedes albopictus*), has not been shown to overwinter, but is transported in tires each season from warmer locations. CAES scientists are monitoring to determine if projected warmer winters allow the Asian Tiger Mosquito, a vector of WNV, Yellow Fever and Dengue Fever, to overwinter and flourish in Connecticut.

Unlike mosquito vector populations, tick vector populations are more difficult to monitor because tick traps are not as effective. Therefore, the CAES tick vector monitoring program relies on ticks submitted by public health practitioners and individuals. The CAES tick vector

monitoring program is able to inform Connecticut public health officials about the threat from existing tick associated diseases, as well as identify new or proliferating diseases.

CAES scientists estimate that the Lone Star Tick (*Amblyomma americanum*), which is currently found in Connecticut, may proliferate as temperatures rise because it is most abundant in the warmer climates of the southern United States. The Lone Star Tick is the vector for *Ehrlichia chaffeensis*, the bacteria that causes human monocytic ehrlichiosis, which attacks white blood cells causing a severe, flu-like illness. CAES scientists are less certain of projections for the better-known Lyme disease, a disease caused by bacteria transmitted by the blacklegged, or deer tick (*Ixodes scapularis*). The white footed mouse is the winter reservoir for the Lyme bacteria, and warmer winters may allow the white footed mouse population to expand in Connecticut, providing more opportunity for the blacklegged tick to feed on an infected animal in the spring and pass the Lyme bacteria on to humans. However, the same warmer winter that may benefit the white footed-mouse population coupled with the increased food source, also may benefit its predators, which may help keep Lyme disease from increasing. Continuous monitoring of blacklegged ticks is recommended to determine the appropriate public health response.

It is unclear if the blacklegged, or deer tick, the vector for Lyme disease, will increase as a result of climate change. Continuous monitoring of blacklegged ticks is important to determine the appropriate public health response.
(Photo credit: Heidi Stuber, CAES)

See the CAES website (www.ct.gov/caes) for more information about tick and mosquito vector associated disease monitoring.

Policy, Legislation, Regulation and Funding

- **Develop legislation to allow regulatory agencies to respond to extreme heat conditions in occupational settings**

Currently, CT DPH and the Connecticut Occupational Safety and Health Administration (CT OSHA) cannot officially respond to extreme heat complaints in occupational settings. These regulatory agencies already receive a number of extreme heat complaints, and this number is expected to increase with climate change. Legislation should be developed to allow regulatory

agencies to evaluate and respond to extreme heat conditions in occupational settings. The need to address current extreme heat complaints already exists, so this recommendation should be implemented in the near-term.

- **Continue to support funding to provide for adequate updates to municipal sewage infrastructure**

Increased and more intense extreme precipitation events will stress current municipal sewage infrastructure and increase incidences of combined sewer overflows (CSOs) in Connecticut. These overflows can contaminate the State's water and aquaculture operations in Long Island Sound, which ultimately impacts public health. Continued funding to provide for adequate updates to municipal sewage infrastructure is needed to reduce this public health threat.

- **Support funding to provide for adequate updates to municipal water infrastructure**

Increased and more intense extreme precipitation events will stress current municipal water supply infrastructure and increase incidences of contaminations, water supply shortages and outages, and the need for regional interconnections which ultimately impacts public health. Funding to provide for adequate updates to municipal water supply infrastructure is needed to reduce this public health threat.

Implementation

Coordinated, iterative and transparent implementation of the adaptation strategies and plans identified in this report is an essential next step in preparing Connecticut for climate change.

While the strategies described within this report begin to establish a plan for the future, more remains to be done. Each workgroup identified the need for both continued monitoring of the impacts of climate change and an ongoing evaluation of the success of actions taken. In many cases, the workgroups identified a need for a finer level of detail such as localized inventories of what is at risk.

The many partners involved in the development of this strategy report should individually and collectively begin the work of implementing the identified strategies, continue to assess climate change impacts, and develop more specific action plans. State agencies must begin to integrate climate planning and preparedness into their existing planning processes, such as those listed in Appendix B, and municipalities must undertake the hard work of identifying critical areas at risk. Most importantly, new and on-going State and local government support will be critical to ensure success.

Demonstration Projects

As actions are implemented demonstration projects can be useful to define and test adaptation strategies and illustrate successes that can help garner support from state and local decision-makers and the public. The Adaptation Subcommittee developed the following criteria to help select demonstration project ideas:

- Addresses the impact(s) of at least one of the intersection areas;
- Demonstrates a level of urgency to undertake the project;
- Leverages or enhances existing and/or potential opportunities/projects;
- Facilitates an understanding of adaptation by the public;
- Promotes approaches and actions that are replicable and scalable;
- Provides a foundation for future work; and
- Demonstrates a government/private partnership.

Finally, to assure success across Connecticut additional outreach and education is needed to garner the necessary stakeholder support.

Committee

The Adaptation Subcommittee that developed this report is chaired by the Commissioner of CT DEEP and the Director of the Connecticut Chapter of The Nature Conservancy (CT TNC) and comprised of representatives from state and federal agencies, municipalities, academia and non-profits. The Subcommittee is further divided into four workgroups, agriculture, infrastructure,

natural resources and public health, which are lead by subject-matter experts. The committee's diversity and workgroup structure worked well for the adaptation strategies planning phase. However, the Adaptation Subcommittee's charge ends with this report.

Consideration should be given to establishing a similar standing panel or committee of state and local officials, and members from business, academia, non-profit organizations and the general public to continue to evaluate the success of state and local implementation efforts and provide ongoing guidance. Such a committee should retain the same subject-matter sub groups on agriculture, infrastructure, natural resources and public health. Two additional subgroups, one on research and monitoring, and another focused on municipal assistance and networking, should be considered as a part of any ongoing effort.

Conclusion

This report has laid a foundation to address Connecticut climate change vulnerabilities identified in the Adaptation Subcommittee's first report, *The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health*. Climate change adaptation planning must continue to be an iterative process in Connecticut. Ongoing, coordinated support of climate change adaptation at the regional, state and local level is necessary for Connecticut to prepare for the management challenges that impacts resulting from a changing climate pose to its communities and citizens.

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Appendix

Appendix A: Adaptation Menus

Appendix B: Identification of Appropriate Connecticut Planning Reports for Adaptation Strategy Inclusion

Appendix A:
Adaptation Menus for Agriculture, Infrastructure and Natural Resources

This appendix contains Adaptation Menus developed by the Agriculture, Infrastructure, Natural Resources and Public Health Workgroups. Adaptation Menus feature a list of specific adaptation strategies for planning areas within each interest area, as discussed by each workgroup.

Agriculture

General/ Applies to More than One Planning Area

- **Increased Management of Resources**
    - Implement agriculture management design and practices that minimize energy and water use (e.g., increase organic content of soil to hold more moisture, maximize natural ventilation of dairy barns through barn design).
    - Provide incentives for energy and water efficiency through technical assistance and grant programs.
    - Conserve/reduce water use/demand among all user groups.
        - In agriculture, may include greater irrigation efficiencies/seasonal changes in crop needs/varieties with greater drought tolerance.
        - Reduce water losses in distribution systems.
    - Increase storage of precipitation among all user groups.
        - Capture runoff from roofs, parking lots, etc. and store in ponds, cisterns and tanks for use in greenhouses and horticulture operations.
        - Promote infiltration for greater storage in soils to both reduce runoff and reduce irrigation demands by:
            - Tillage methods that reduce compaction and increase infiltration capacities of soils especially during spring/summer intense thunderstorm periods.
            - Landscape designs that direct runoff from impervious areas to vegetated areas for infiltration. Benefits include reduced flushing of nutrients and bacteria to lakes, streams and Long Island Sound (thereby benefiting shell fish operations), increased soil water for plant growth and reduced need for irrigation of vegetated areas. In addition, increasing infiltration will lead to greater percolation and ground water recharge for increased water availability.
            - Implementing techniques to reduce or ameliorate compaction from trafficked areas to promote greater infiltration capacity.
        - Investigate feasibility of ground water recharge of selected areas, e.g. alluvial floodplains, using high flows.
    - Water re-use including, but not limited to:
        - Reclaimed water for irrigation, cooling, etc.
        - Recycling and reuse of wash waters, cooling waters, tail waters and waste waters from processing, cleaning, and production practices within an operation, e.g. dairy barns, or other cleaning operations.

  - Increase soil organic matter and utilize surface cover through cover crops, mulches, crop rotations and tillage practices.
  - Increase the use of sustainable and organic growing methods and management practices.
  - Promote good soil/landscape management.
  - Utilize quality land/soil management practices (good drainage, no till agriculture to prevent erosion).
  - Increase crop diversity (including native crops).
  - Research benefits and funding opportunities for biochar as a soil amendment to promote improved plant growth, nutrient and soil moisture holding capacity, colonization of beneficial fungi, and reduction of disease from root-rotting fungi.
- **Land Use**
  - Consider the need for access to new lands for expansion of maple sugar operations in the near term, to buffer orchards and dairy farms, and to allow for land to grow new varieties of fruit trees and dairy support crops.
  - Continue preservation of prime and important farmland soils in order to secure ecosystem services these lands provide.
  - Continue to protect prime and important farmland soils close to population centers.
  - Encourage preservation of small, sustainable, diverse, community-supported farms in order to secure the ecosystem services these lands provide while educating the public about the importance of agriculture systems.
  - Encourage reuse of urban brownfields for agricultural use (such as community gardens), as appropriate.
  - Increase the amount of land in organic production systems and promote protection of these lands.
  - Identify and protect soil landscapes that are critical for groundwater recharge.
  - Reuse urban buildings for agriculture and promote vertical agriculture, e.g. green roofs, etc.
  - Analyze use of marginal agricultural lands to grow sustainable biomass and fuel such as switch grass and willow.
- **Infrastructure Changes**
  - Of high urgency requiring a high degree of financial resources, state agencies must work together to plan for infrastructure improvements to sewage treatment plants to minimize or halt combined sewer overflows.
  - Of high urgency requiring a high degree of financial resources, state agencies must work together to plan for the water needs of Connecticut agriculture.
  - Apply a filter for climate change adaptation to federal and state grant programs to select for projects that address, or are consistent with, climate change adaptation; additional funds will be needed to assist with infrastructure improvements, including but not limited to, maple syrup tapping equipment for efficiency in the near term, cooling technologies for dairy barns, post-harvest cooling methods for shellfish, irrigation and frost protection systems for orchards and warm weather crops, and greenhouse cooling technologies.

- Renovate or build new dairy barns to maximize passive ventilation and employ active cooling technologies where needed. More money will be needed in grants and education to assist with this.
- Increase filtration and pervious surface to handle stormwater runoff.
- Improve irrigation and water use efficiency for agricultural structures, processing, field crops, orchards and nursery/greenhouse industry.
- Utilize new hydrologic data for the designs and standards for all agricultural infrastructure and conservation practices.

- **Regulatory/Policy Changes**
  - Promote policies to reduce energy use, conserve water, and encourage sustainability.
  - Assess and amend regulations to allow for agriculture processing facilities for value added products, meat slaughter and processing, etc. so that Connecticut farmers can meet market demands for locally grown products and reduce waste of blemished fruit and vegetables.
  - Reduce export "complications."
  - Assess and amend regulations to decrease barriers and promote farm practices that address climate adaptation and sustainability, e.g. building codes for greenhouses, misting and irrigation systems, etc.
  - Increase supply of labor—federal government should extend visas to allow for the longer growing season.
  - Encourage local zoning regulations (e.g., concerning lights, noise) that enable agricultural workers to harvest during the cooler parts of the day (e.g.,. early morning).
  - Adopt supportive public policy that accelerates farmland protection, invests in farm viability, creates incentives for transition and adoption of new adaptation technologies, and fosters a sustainable food system (improve food for schools, etc.
  - Promote collaboration between the state departments of Agriculture, Environmental Protection and Public Health to facilitate changes needed in water use issues; water capture, storage and reuse must be addressed to allow for agriculture to access and control the water needed for production.
  - Include adoption of adaptation strategies in the ranking criteria for programs, grants, and loans.
  - Reduce producer risk in the transition to new crops/breeds, infrastructure and production management through: loan guarantees, cost share, farmer research groups, crop insurance, and new conservation practices.
  - Continue to redevelop the infrastructure needed to grow, process, store, market, sell, and eat local and regional foods.
  - Allow maximum flexibility in our policies, rules, regulations, standards, and funding; practicing a philosophy of adaptive management will allow agriculture to be the most successful.
  - Apply a filter for climate change adaptation to federal and state grant programs to select for projects that address, or are consistent with, climate change adaptation.
- **Education/Outreach/Technical Assistance**
  - Educate and train agricultural community and the general public on range of options and specific recommendations for climate change adaptation.

- via technical assistance to farmers/growers:
  - Fund more technical specialists in the UConn Cooperative Extension Systems to provide technical assistance to existing farmers to inform and train them in adopting/integrating new varieties, identifying and managing for emerging pests and pathogens, new soil/crop/water management practices, and transition to new farming methods.
  - Develop, promote, and provide training and funding to support agricultural management practices that help regenerate natural systems, focusing on soil and water, and help build resilience in our agricultural systems for adapting to climate change over the long term; practices include, but are not limited to: build soil organic matter, recharge water systems, and build diversity of plants and animals.
  - Educate farmers on the availability and utility of technologies for passive and active cooling measures in dairy barns, irrigation and other adaptive infrastructure.
  - Provide staff and funding for forestry technical assistance.
  - Support and expand opportunities to teach existing and new farmers on organic practices and organic production systems; tap into existing knowledge base at Cornell University.
  - Provide increased research, technology transfer, and technical assistance to develop and disseminate adaptation strategies to producers and service providers.
- via general education to consumers/public:
  - Provide staff and funding for outreach to communities to be generally supportive of agriculture and specifically supportive of climate adaptation strategies for farmers.
  - Continue and expand marketing and advertising to educate customers and general public on local produce types and availability and the benefits of buying locally.
  - Expand Farm to Fork type education.
  - Continue home economics education to teach students about produce and how to cook it.
  - Supply no-cook recipes, such as gazpacho, for consumers during hot weather.
  - Conduct outreach to increase farm market share and promote farm markets at train stations and other public venues.
  - Teach the benefits of eating locally produced produce (e.g., way to decrease carbon footprint) and serve farm products in local schools (e.g., support and expand Farm to School program).
  - Public institutions, including but not limited to state-funded schools and agencies, should teach by example and use practices of buying/eating locally grown produce and agricultural products and developing curriculum and educational materials about the connections between food, nutrition, and agriculture.
- via outreach to farm stakeholders:

        - Create a framework for continued dialogue with the agricultural community to engage stakeholders in creating a shared vision for building resilience and sustainability in Connecticut's agricultural system.
        - Incorporate climate change adaptation and resilient agricultural systems into any public policy, funding programs, and outreach at all levels (public and private sectors).
        - Conduct poll to evaluate CT farmers' baseline knowledge of climate change projections, anticipated risk to commodities, and potential adaptation strategies and then gear educational efforts based on results.
        - Provide outreach, education and networking opportunities needed for both existing and new farmers.
        - Encourage the development of agriculture processing facilities so that farmers can take advantage of the longer growing season, far-away markets and benefit from hail-damaged and excess fruit not picked by consumers during pick-your-own times.
        - Expand federal and state funding of grants for educational and marketing improvements to assist farmers and commodity advocacy organizations.
        - Inform pick-your-own operations of need to plant easy-to-pick varieties and shade trees in the fields for labor and customer relief in hot weather.
    - via educational institutions:
        - Supply better farming education and inspiration to future farmers through agriculture science and technology centers, including how to deal with the challenges of climate change.
        - Expand course opportunities at CT community colleges on topics relevant to farming and marketing.
        - Focus farming education in CT colleges and universities more on appropriate management strategies and production of crops that are important in Connecticut (e.g., tobacco) and can thrive under changing climate conditions.
        - Develop strong curriculum and training programs in our CT colleges and universities that will prepare students for the changes that will be required to build a food production and agricultural system that is resilient to changes in climate and is regenerative (i.e., rebuilds the natural system).
        - Make more affordable in-state tuition for college agricultural programs.
- **Research and Technology**
    - Increase funding for research on climate change and agriculture (current funding too low due to a lack of political expectation and government funding). Research should be married with practice to break down the political barrier.
    - Research and phase in new varieties and breeds of plants and animals (as well as farming practices) that are better adapted to climate change.
    - Research what is used in southern states to deal with higher temperatures and study what best could be applied to Connecticut, with consideration given to the interconnections between climate impacts and changes in the ecosystem (e.g., water availability, types and prevalence of pests, etc).
    - Identify state-of-the-art technology that would have applicability to farmers in Connecticut adapting to climate change.

- Determine emerging pests and pathogens that will become a problem in light of climate change.
- Develop management practices and plans to combat existing and emerging pests and pathogens.
- Determine best soil management practices under climate changes.
- Research how to get more young farmers interested in farming in CT.
- Research how to grow the local agricultural economy.
- Research the economic impact of the local food system, including how to increase consumer purchasing of local agricultural products.
- Promote regional cooperation between the CT Department of Agriculture, academic institutions, such as Cornell University and University of Vermont, and the U.S. Department of Agriculture to help the flow of information and technical assistance and access to research and technology to Connecticut farmers.

Nursery, Greenhouse and Sod

- Greenhouse production
  - Consider and support opportunity to grow field crops, displaced by climate change, in greenhouses.
- Outside production (trees, shrubs, non-vegetable herbaceous plants)
  - Conduct more research and monitoring will be needed to overcome the impact of climate change on outside nursery production.
  - Phase-out water-intensive plants and replace them with drought-tolerant plants in nurseries, which will help growers, as well as consumers, adapt to less summer precipitation.
  - Increase irrigation ponds and water capture techniques to accommodate and capture precipitation when it is abundant in order to compensate for the lack of summer precipitation.
- Sod
  - Grow new varieties of sod that are pest and fungal resistant..
  - Construct drainage infrastructure on sod farms.

Dairy

- Animal husbandry
  - Raise heat-resistant breeds.
  - Implement cooling technologies that maximize energy efficiency and the use of renewable energy.
  - Renovate barns for optimal cooling, using non-energy intensive systems (e.g.,. barns designed to maximize natural ventilation). Renovate or build new dairy barns to maximize passive ventilation and employ active cooling technologies where needed.
- Feed production
  - Be flexible, and where appropriate, conduct more intense crop management.
  - Plant heat resistant/drought tolerant forage species.

  - Increase acreage in corn, or use other crops, to compensate for the carbon dioxide-induced decrease in corn yield, and explore alternatives to corn feed (e.g. grass-fed livestock).
  - Manage for better erosion control to combat greater winter precipitation.

Poultry

- Egg and Meat Production
  - Explore multiple options for raising poultry under high temperature scenarios, such as small-scale open pasture or grass-fed poultry management, low-energy climate-controlled environments, etc

Fruit Orchards

- Apple and pear production
  - Grow hardy varieties, such as the Bosc pear.
- Peach, nectarine and plum production
- Cherry Production

Small Fruits

- Berry Production
  - Grow berries in a modified greenhouse approach or high tunnels (more labor and cost but will avoid hail damage, bugs and fungus).
  - Use drip irrigation.
  - Phase out cooler weather blueberries by 2080.
- Grape Production
  - Increase drainage/irrigation.
  - Plant more grape vineyards (grapes are expected to do well under climate change projections).
  - Support increasing market for eating/table grapes to help fill the void from climate change impact to berries.

Produce

- Warm weather crops (e.g., tomatoes)
  - Educate consumers to encourage new warm weather crop buying habits, e.g. encourage consumers to buy alternative salad crops that can withstand projected increases in temperature such as purselane, which is currently considered a weed by some people.
  - Research impact threshold for warm weather produce.
  - Promote research on new varieties and methods, which may focus on methods and varieties grown in the southern United States.
- Cool weather crops (e.g., spinach)
  - Promote research on the best cool weather produce variety to grow with climate changes.

Forestry Production

- Maple syrup
    - Re-train maple syrup producers.
- Witch hazel
- Cut Christmas trees
    - Grow different varieties of Christmas trees such as Canaan fir, Eastern red cedar, Virginia pine and spruce instead of more northern species like the balsam fir.
    - Educate consumer on new Christmas tree varieties to adapt purchase preferences.
    - Expand research to support Christmas tree growers in Connecticut to assist and expand on that conducted by Connecticut Agricultural Experiment Station (CAES).
- Wood production (e.g., lumber, saw logs)
    - Educate consumer on benefits of less popular wood products, such as red maple.
    - Consider forestry equipment needs which may change, at a large cost, to accommodate climate change.
- Biofuel crops
    - Develop a Woody Biomass plan to plan for the opportunities in this industry.
    - Research the potential benefits and funding opportunities for biofuel & biochar industries.
    - Provide economic incentives for combining heat and power systems on farms (using waste heat to heat and cool buildings).

Aquaculture

- Shellfish
    - Promote research to develop disease resistant shellfish strains.
    - Increase use of land-based hatcheries if disease resistant strains and/or triploid animals are utilized.
    - Implement funding opportunities for infrastructure improvements necessary to adapt to post-harvest cooling requirements.
    - Increase research on husbandry adaptation to waters of reduced pH.
    - Change siting mechanisms to allow for increased use of cage culture.
    - Change sewage treatment plants to reduce runoff during severe rain events.
    - Increase education and outreach for growers and other industry personnel such as product transporters and restaurateurs as well as the consumer.
    - Consider growing some species of shellfish in different locations to compensate for the increase in temperature and hypoxia.
- Finfish
    - Re-circulate, filter, sterilize and cool water in hatcheries as funding may allow.
    - Grow more temperature tolerant finfish species; the mid-Atlantic hatcheries already are having success with temperature tolerant finfish species.

Non-Poultry Animal Livestock

- Animal husbandry (beef cows, sheep and goats, pigs and horses)
    - Adjust capital investments, management plans, and farm decisions recognizing climate change projections before 2010.
- Feed production

- Promote rotational grazing and best management practices to combat drought.
- Identify irrigation technologies and funding sources that maximize water and energy efficiency.
- Incorporate into management plans new crop species tolerant of hot/dry and cool/wet climate conditions and new technologies.

- Bees
  - Encourage pollinator diversity in open space habitats.
    - Manage open space habitats for a diversity of bee nesting sites.
      - Maintain open habitat such as open grasslands and powerline right-of-ways for ground-nesting bees.
      - Leave dead and downed trees for tree-nesting bees.
      - Encourage a diversity of native flowering herbaceous plants and shrubs, especially early and late-blooming plants, and 'bunch grasses' (for bumble bees) to provide pollen.
      - Conserve riparian buffers which protect bare ground surrounding rivers for ground-nesting bees that prefer bare ground with loose soil.
    - Educate open space managers about the importance of pollinators and land management techniques to encourage these pollinators.
  - Encourage pollinator diversity through farming techniques.
    - Encourage the organic agriculture practice of supporting biodiversity by growing a diversity of crops, rather than a monoculture, and preserving, rather than removing, vegetation in the margins.
    - Encourage ground-nesting bees, such as the squash bee through no till practices.
    - Employ integrated pest management (IPM) practices for pest management to reduce pesticide applications.
    - Apple producers should construct nest boxes in the orchard to encourage mason bees, an apple pollinator.
    - Educate farmers on the importance of the diversity of pollinators and farming techniques that encourage pollinators.
    - Encourage dairy farmers to plant more bee-beneficial, clover.
  - Encourage homeowners to maintain their property to support pollinator diversity.
    - Encourage informed backyard bee rearing of the European honeybee by homeowners that have attended beekeeping information sessions, such as those provided by the CT Beekeeping Association or the Back Yard Beekeepers Association.
    - Provide education to homeowners through informational talks, such as those offered by the Connecticut Agricultural Experiment Station, and print media on the importance of pollinator diversity, including information to distinguish wasps from bees and evaluate stinging risks. Pollinator education information also should include information to prevent pollinator pests, such as the carpenter bee.
    - Encourage homeowners to plant native plants, such as goldenrod, that are beneficial to pollinators.

- Encourage homeowner organic lawn care to reduce applications of pesticides that could affect pollinators.
- Encourage homeowners to better target invasive plant control herbicide applications through spot spray or cut and paint methods instead of broad-cast spraying which could kill pollinator-beneficial, native plants.

- Reduce stressors:
  - Allow beneficial bee "weeds" type plants to grow.
  - Plant pumpkins.

Infrastructure

The infrastructure climate change adaptation menu, or "menu," presented below is organized into the two broad categories of "Land" and "Water" introduced above. It is then divided among the seven planning areas that the Infrastructure Workgroup identified in the impact assessment phase of this strategy development. Of necessity, there is some redundancy in the strategy and many of the actions address most or all planning areas in virtually the same way. For example, the four priority action areas described in the report in the "Framework for Action" section can generically be applied to all types of infrastructure identified within the seven planning areas. However, it was determined that this redundancy would be useful to regulators, industry and the public as it will allow them to review the full suite of actions and recommendations relevant to their area of interest.

The menu focuses on climate change adaptation but, where Infrastructure Workgroup members felt that climate change mitigation activities were ancillary to the charge of the Infrastructure Workgroup, they were briefly identified in the menu. Mitigation is generally treated as a co-benefit, as there are often benefits related to infrastructure adaptation for mitigation, water and habitat quality, and resiliency that are outcomes of adaptation actions, and vice-versa. However, the division between adaptation and mitigation is not always distinct and mitigation activities should continue to be included in the adaptation strategy as important components of addressing climate change effects on infrastructure. For example, energy conservation, a greenhouse gas mitigation technique would contribute to infrastructure benefits if a new power plant is not needed along the shore, for example.

LAND

Energy (gas, electricity, oil) and Communications

- Several mitigation actions to save energy and planning actions to ensure ample supply of energy were proposed. While it might be argued that mitigation is adaptation if it reduces the footprint of infrastructure in Connecticut, regardless of mitigation merit, these do not necessarily contribute directly to an adaptive strategy constructed around the Framework for Action, but are listed here nonetheless:
    - Encourage towns to assess energy footprints
    - Encourage energy conservation
    - Construct alternative energy sources to reduce emissions, e.g. solar, wave energy, wind, etc.
    - Evaluate current system capacity, fuel sources and efficiencies
    - Update and expand electric grids
    - Update interstate transmission to facilitate import of energy from renewable resources
    - Use more wireless communication (even wireless relies on ground infrastructure)
    - Encourage use of hybrid, fuel efficient vehicles for energy (fuel) transportation
    - Encourage short seas shipping to reduce land transport infrastructure
    - Consider recirculating or closed-system cooling
- Similarly, a few planning actions were proposed to ensure ample supply of energy at the lowest cost. In general, these planning activities are already conducted by the industry, as

required by law, and substantively reported in the "Integrated Resource Plan for Connecticut". The resource plan also addresses many of the mitigation actions presented above. Suggestions included:
    - Look at current system capacity, fuel source and how to maximize output
    - Evaluate energy options, including purchasing from other facilities
    - Encourage local solution and alternative technologies to lessen demand
    - Assess communication emergency preparedness adequacy to respond to future extreme weather events
- Suggestions relevant to adaptation actions were relevant to the "Framework for Action", above and can be generically related to at least three points in the Framework.
    - Consider climate change adaptation for siting and design of new and redesigned/ reconstructed facilities
    - Protect existing coastal and flood prone infrastructure using methods that minimize adverse environmental impact
    - Assess vulnerability of electricity conduits and communication lines to water, salt intrusion, and more frequent and stronger storm events
    - Protect electric grid and communication infrastructure (towers, lines, etc.) in coastal and inland flood zones
    - Assess energy and communications infrastructure operations and maintenance plans with respect to changing climate conditions
    - For communications, emergency generators and fuel supplies are often in basements or ground level, and vulnerable to flooding – building codes may have to be revised to allow for positioning this infrastructure at higher levels
    - Evaluate options for underground energy and communications infrastructure, where appropriate, to protect from storms, including use of fiber optic materials for replacement
    - Avoid flood prone or erosion prone areas for infrastructure, especially if underground or underwater transmission and pipe lines are a preferred alternative
    - Where there is no feasible, less environmentally damaging alternative, armor or buffer coastal and riparian flood zones to protect infrastructure
    - Identify areas for possible advancement inland of energy infrastructure
    - Maintain and expand funds dedicated to environmental, energy efficiency and conservation, and renewable energy projects and services.
    - Connecticut Energy Stakeholders suggested legislation that prohibits the state, even during a period of severe financial hardship, from seizing, diverting, shifting, borrowing, transferring, suspending, or otherwise taking or interfering with revenues that are dedicated to environmental, energy efficiency and conservation, and renewable energy projects and services.

Facilities and Buildings

- New and Reconstructed
    - Work with FEMA on building relocation policy after destructive events
    - Perform detailed local vulnerability assessments for land use planning, development and infrastructure
    - Support community planning for consolidation, relocation and regionalization

  - Seek funds to assist in pilot studies that can be shared at the local level and developed in partnership with regional and local authorities
  - Develop vulnerability assessments for public properties, e.g., schools, government buildings, hospitals, parks
  - Improve building codes to account for more frequent and stronger storms
  - Modify zoning regulations and plans of Conservation and Development to minimize risks from development of coastal and inland flood zones
  - Consider statewide policies to support or ensure better land use in vulnerable areas (e.g., zoning, tax incentives)
  - Change property tax structure to provide incentives for setbacks, rolling easements, and covenants to preclude building and reconstruction in vulnerable areas
  - Consider tax and insurance rates for development that exacerbates risk that appropriately reflect risk and at least cover replacement costs.
- Existing Infrastructure
  - Review installation and operation of flooding infrastructure and tide gates to protect facilities and buildings without impacting natural resources
  - Where practicable, relocate infrastructure outside of coastal and inland flooding zones
  - Reinforce or re-engineer existing infrastructure using methods that minimize adverse environmental impact
  - Ensure adequate insurance for level of risk with the state Insurance Commission and insurance industry to address defined risk where it occurs
  - Provide support to vulnerable populations (i.e., environmental justice communities, the elderly and disabled) to ensure residence resilience to climate change, including incentives for relocation if re-engineering is not feasible
  - Where practicable, relocate cultural resources outside of coastal and inland flood zones; where relocation is infeasible, protect areas around cultural resources from coastal and inland flooding, as allowed by law, using methods that minimize adverse environmental impacts
- Programmatic and Environmental Ancillary Effects and Co-benefits
  - Work with Army Corps of Engineers on beneficial reuse of dredged materials for shoreline protection and beach nourishment
  - Decrease stormwater runoff, which improves water quality and quantity and reduces heat island effect, through low impact development (LID) and other green solutions that build resiliency against climate change
  - Modify buildings to reduce impact on, and vulnerability to climate change including passive cooling and rain water controls such as rain gardens
- Educate and engage officials, regulators and the public to implement adaptive practices that also build resiliency and meet other environmental, social and economic objectives

Solid Waste Management

- Several recommendations were made to reduce the amount of solid waste that might reduce the need for added solid waste infrastructure, but are largely mitigative in nature rather than adaptive. These include:

  - Support programs that reduce waste from production and packaging to final disposal and recycling practices for both commercial entities and the public
  - Reduce reliance on solid waste disposal capacity by attaining the 58% diversion rate set in the state's solid waste management plan
  - Improve solid waste collection and prevent putrefaction of waste during hot weather or extreme events by creating a network of composting facilities
- New and reconstructed infrastructure, including landfills and transfer stations, should be located in areas less vulnerable to climate change
- Existing Infrastructure
  - Review current design standards for landfills and resource recovery centers with respect to temperature and precipitation changes and investigate retrofitting to require improvements with permit renewals
  - Focus adaptive strategies on vulnerable infrastructure such as landfills in coastal areas
  - Reinforce earthen caps on landfills to protect against erosion and leaching of pollutants caused by increased precipitation
  - Evaluate and install, as needed, leachate collection systems for landfills with consideration for climate change impacts
  - Consider climate change risk and vulnerabilities in updates of the State Solid Waste and Debris Management Plans
  - Evaluate ability and need to armor or relocate transfer station and related solid waste infrastructure located within sea level rise or inland flooding areas
  - Devise alternative routes or collection locations to service those areas that will be isolated by flooding
  - Update aging solid waste infrastructure considering green practices that may be more resilient to climate change impacts, especially precipitation and stormwater effects

Transportation

- A few mitigation recommendations were made with respect to transportation. They were generally aimed at improving efficiency of transportation, particularly mass transportation, which also reduces greenhouse gas emissions:
  - Provide incentive with federal and state funding for regional transportation solutions and sustainability instead of replacing existing climate vulnerable systems
  - Encourage alternative transportation (e.g., telecommuting, carpooling and mass transit) to alleviate stress on roads
  - Develop high speed rail lines, e.g., from New Haven to Springfield, as alternatives to more vulnerable routes such as the shoreline rail route
- New and Reconstructed Infrastructure
  - Continue to work with DOT and towns on coastal and riverine areas and roads, bridge overpass clearance, train location, etc.
  - Standardize flood elevation criteria and improve design criteria unrelated to funding source

    - Investigate the impacts of developments on the whole watershed and downstream effects on transportation infrastructure to evaluate effects and determine design criteria, e.g., culvert and drainage system sizing
    - Update and modify current design standards to provide guidance on adapting to future climate trends and impacts
    - Build redundant airstrips outside of the most flood prone areas of vulnerable airports
- Existing infrastructure
    - Balance needs of natural resources and human safety for determining which transportation infrastructure to reconstruct or relocate
    - Evaluate performance standards and need to re-engineer such as elevating or armoring transportation infrastructure in flood-prone areas
    - Consider abandonment of roads and bridges when re-engineering would be too costly to adapt to climate change, or when better environmental and resiliency options or alternative routes exist
    - Raise and strengthen bulkheads in ports or move inland when sea level rises
    - Dredge to maintain port depth as necessary to address changes in rates or locations of sedimentation
    - Consider land transportation adaptation to service low-lying coastal port transportation needs so they will not become isolated with sea level rise
    - Elevate or relocate airports in areas vulnerable to sea level rise or flooding as determined from assessments of DOT and airport authorities
- Programmatic and Environmental Ancillary Effects and Co-Benefits
    - Encourage softer design with vegetated swales, for example, where appropriate
    - Consider the level of watershed development, and potential LID and green practices that may affect engineering designs and level of development from transportation infrastructure
    - Use watershed management best management practices (BMP) including "green street" approaches to reduce flooding and lessen impacts on transportation infrastructure while building resiliency
    - Install flood-retaining and capturing structures (e.g., walls) and encourage natural buffers (e.g., wetlands) around airports to build resiliency to climate change

WATER

Coastal Flood Control and Protection

- New and Reconstructed Infrastructure
    - Investigate the viability of rolling easements, rebuilding restrictions, zoning changes and overlays, setbacks, and other regulatory requirements related to siting and design that address climate change adaptation
    - Enforce and propose laws and policies for new development that ensure human health and safety, maximize environmental benefit and resiliency, and decrease economic risks associated with climate change
    - Provide incentives to relocate infrastructure, especially residences, outside of areas of high risk and vulnerability (e.g., FEMA Severe Repetitive Loss Program may apply)

    - Institute rebuilding restrictions when structures are damaged by sea level rise and coastal storms
    - Work with FEMA and federal, local and state governments on reducing incentives to rebuild in vulnerable areas
- Existing Infrastructure
    - Protect vulnerable shoreline areas, using methods proven effective and economically and socially appropriate, which may include seawalls, levees, bulkheads, jetties, groins, flood/tide gates, allowed by law. These methods should be used only if alternatives that would cause less adverse environmental impact are determined to be infeasible.
    - Consider removal of existing tidal restrictions that might improve wetland resilience. Ancillary impacts such as potential to increase flooding must be evaluated.
- Programmatic and Environmental Ancillary Effects and Co-Benefits
    - Encourage softer, more resilient solutions such as living shorelines (e.g., wetlands) to provide for increased natural shoreline buffering by building on natural resource capital and design to reduce risk
    - Identify advancement zone areas for coastal wetlands and recommend the purchase and management of those areas for future wetland advancement and buffering against storms and sea level rise
    - Encourage communities to perform vulnerability assessments to assist in proper development, location and design in low risk areas where LID practices might also be applied
    - Provide local communities with tools and support on wetland migration and buffering practices that may help to avoid use of hard armoring practices
    - Amend building codes to require naturally resilient development design features
    - Create or allow for tidal flood storage areas, e.g., as proposed in the Thames Estuary 2100 Environmental Report, with consideration of upstream flooding and effects on tidal salt marshes
- Public Engagement
    - Educate and provide resources for the public and local governments aimed towards a "no-net-loss" strategy of natural and resilient coastal features that protect against climate change impacts
    - Provide incentives and/or disincentives to encourage coastal risk mitigation on private properties
    - Work with communities and the public to include climate change adaptation considerations in their local planning documents including, Coastal Area Management Plans, Stormwater Management Plans, Hazard Mitigation Plans, and Plans of Conservation and Development with a focus on LID and green practices that build resiliency and protect public safety, the environment and the local economy

Dams and Levees

- New and Reconstructed Infrastructure

    - Evaluate where fortification of existing dams and levees is necessary to withstand increased flooding and extreme storm events within authorities of state and federal programs
    - Revisit storm frequency data to determine design storm (e.g., 100-year return event) adaptation requirements that can protect public safety and property adequately in accordance with social, political and economic standards
- Existing Infrastructure
    - Modify the design standard for new dams and levees to accommodate increases in flooding and extreme storm events, considering state's vulnerability assessment to set priorities
    - Remove unnecessary dams and coastal levees to allow for wetland advancement zones and natural buffers against increased precipitation and extreme events
    - Monitor design parameters of coastal levees to ensure that they maintain an adequate margin of safety (i.e., freeboard and other factors of safety) against design storms and standards
- Programmatic and Environmental Ancillary Effects and Co-Benefits
    - Streamflow requirements and standards should be met to maintain ecosystem integrity of flowing waters while providing for operation and maintenance of dams that protect against flooding and extreme events
- Public Engagement
    - Implement an education/outreach program to private dam owners to increase awareness of possible adaptations to climate change and meet other environmental needs such as streamflow standards

Regulated Stormwater Point Sources and Nonpoint Source Runoff

- New and Reconstructed Infrastructure
    - Update and develop statewide or watershed design guidelines that consider climate change impacts and design new stormwater infrastructure accordingly
    - Evaluate changes in nonpoint source runoff and pollution related to climate change effects and determine standards needed to decrease environmental and social risks
    - Where warranted as the only solution, increase stormwater storage and treatment infrastructure, especially in highly urbanized areas
    - Develop BMPs to increase retention and detention times and promote infiltration where stormwater treatment is minimal and contributes to flooding risks related to climate change
- Existing Infrastructure
    - Determine new levels of terrestrial stormwater and nonpoint source pollution (e.g., through comprehensive watershed-based planning) related to climate change and determine standards required to address quantity and quality issues
    - Update aging stormwater and nonpoint infrastructure with consideration to sizing and retrofitting LID techniques to accommodate climate change adaptation and minimize runoff and flooding damage
    - Include climate change into local emergency operation plans, state Hazard Mitigation Plans, and similar response programs
- Programmatic and Environmental Ancillary Effects and Co-Benefits

  - Promote and require LID practices to decrease storage and treatment requirements and mitigate effects of climate change that contribute to flooding during extreme events
  - Promote and require preservation of natural features that treat and infiltrate runoff such as buffers, wetlands and related landscape conditions
  - Remove or modify impediments to natural treatment and storage (e.g., impervious cover, culverts, dams) to accommodate LID techniques including natural buffers and wetlands
  - Local stormwater and nonpoint source authorities should emphasize wet ponds and BMPs that mimic natural features to reduce runoff by infiltration or detention in biologically active conditions and will reduce primary pollutants including organic matter and nutrients
- Public Engagement
  - Increase communication, collaboration and planning among watershed authorities and the public to decrease stormwater by promoting LID and green BMPs at both the institutional scale by local governments and on private properties by homeowners and industry

Wastewater – Sewage

- Collection, including pump stations and similar infrastructure:
  - Evaluate and improve emergency power provisions to assure uninterrupted pump station service during heavy storms with associated power outages
  - Evaluate and improve, where necessary, the capacity of pump stations that are subject to infiltration and inflow
  - Implement LID measures (e.g., Municipal Planning and Zoning Regulations) to reduce wastewater volume from increased infiltration and inflow (I/I), including combined sewer system areas, especially from illicit rainwater connections (e.g., roof leaders, sump pumps)
  - Rehabilitate sewer systems to minimize groundwater infiltration and inflow of stormwater and snowmelt into the sanitary sewer system
  - Review National Pollutant Discharge Elimination System (NPDES) permit limits and sewer design standards to identify potential changes under climate change conditions that might include higher maximum flows or alterations in pollutant treatment efficiency, e.g., nitrogen
- Public/Community Treatment Works
  - Consider climate change effects and adaptation in life cycle and asset planning for treatment plant reconstruction and operations and maintenance
  - Investigate protection strategies (e.g., berms, dikes) to protect treatment infrastructure after consideration of non-structural, less hardening alternatives and/or or relocation of infrastructure subject to sea level rise and inland flooding
  - Review FEMA's current policies that do not allow for relocation and work to modify policies
  - Install effluent pumping systems for those wastewater treatment plants affected by sea level rise including adequacy of emergency generator systems
  - Evaluate the need to extend seasonal effluent disinfection periods to accommodate a lengthened water recreation season

  - Consider climate change as a part of DEEP facility planning checklist for public/ community wastewater treatment plants financed through the Clean Water Fund
  - Implement wastewater reuse for non-potable uses, such as golf course irrigation, to decrease potable water treatment needs and address water shortages
  - Implement a training program for wastewater treatment facility operators to educate them on how to prepare for climate change, e.g., extreme storms, high temperatures
  - Educate municipal inland wetland commissions and water pollution control authorities about emergency permit requirements for temporary equipment needed to protect wastewater treatment facilities located near regulated inland or coastal wetlands
  - Develop and implement wastewater treatment plant protocols to protect wastewater plants and minimize loss of treatment efficiency at times of high flows
  - Incorporate climate resiliency or plan into wastewater treatment design manuals
  - Promote the use of the Supervisory Control and Data Acquisition (SCADA) systems and training to assist in the monitoring and operation of water treatment plants during climate changed conditions and extreme events
  - Incorporate climate change effects into Emergency Response Plans
  - Amend Clean Water Fund to add priority points for climate change adaptation practices
  - Amend NPDES requirements on bypass, emergency power, disinfection, reporting, etc. to meet climate change adjustments
  - Increase design flood protection levels for operation
- On-site (subsurface disposal) systems
  - Add a planning requirement for climate change to state and local facility planning checklists or permit approval for on-site wastewater treatment systems
  - Assess existing on-site systems for effects related to climate change and, where necessary, consider alternative on-site technologies or abandonment in favor of public/community wastewater treatment systems
  - Consider the potential higher groundwater levels in design standards for separation distances and other relevant standards

Water Supply

- Since water supply may be impacted by drought as well as increased precipitation and flooding, conservation and reuse measures should be considered to reduce demand on potable and irrigation water supplies, including private wells, as well as streamflow needs to accommodate healthy stream and river ecosystems
  - Consider wastewater reuse and appropriate uses of Class B waters for non-potable uses such as irrigation and industrial cooling.
  - Implement rate structures to accommodate long term system improvements and encourage conservation.
  - While the high cost may constrain progress, it is essential and urgent that state agencies work together to plan for infrastructure improvements to public water systems. Encourage continued and expanded use of irrigation improvements, including replacement of broadcast irrigation with drip irrigation and installation of more sophisticated sensors which include a rain shut-off feature

  - Encourage xeriscaping as a form of water conservation
  - Increase water recycling in industrial processes
  - Provide an incentive to encourage water conservation of public water supply
  - Increased involvement of Water Utilities Coordinating Committees to assist in developing regional and statewide solutions to water shortages and emergencies including strengthening coordination of regional water supplies to encourage water conservation.
  - Encourage towns to approve the Model Water Use Restriction Ordinance to implement conservation during periods of water shortage.
  - Closed-loop recycling and dry cooling should be encouraged over once-through cooling in electricity generating facilities in order to conserve water in balance with potential energy and greenhouse gas emission considerations
  - Encourage water conservation best management practices for snow making for ski destinations in Connecticut
- Surface Water Sources:
  - Consider wastewater reuse and appropriate uses of Class B waters for non-potable uses such as irrigation and industrial cooling
  - Consider and account for current water supply demands, margins of safety, and mitigative activities in watershed management programs and conservation that will help assure adequate water supplies both for humans and fish and wildlife consistent with any adoption of streamflow regulations
  - Increase water supply capacity and create interconnections and redundancies to provide backup water supplies consistent with relevant regulations on streamflow and diversion
  - Re-evaluate Drought Management Plans and Wide-Area Response Networks to respond to increased drought occurrences
  - Purchase land around water supplies to increase the surrounding conservation buffer area
  - Water supply plans pursuant to CGS section 25-32d should include climate change vulnerability analyses and risk assessments for surface supply, including future drinking water availability, competing needs and options for adaptation and mitigation
- Groundwater Sources:
  - Increase public water supply hook-ups for private wells subject to salt intrusion
  - Water supply plans pursuant to CGS section 25-32d should include climate change vulnerability analyses and risk assessments for ground water including future drinking water availability, competing needs and options for adaptation and mitigation
- Treatment of Potable Water Supplies:
  - Increase effluent quality of wastewater treatment to allow for water reuse for non-potable uses
  - Continue to implement CT's aquifer protection program to protect water supply quality
  - Implement watershed management practices that can help increase source water protection and quality, which will help diminish water supply treatment needs

  - Decrease pharmaceutical and other emerging toxic chemical concentration in water supply that might be further spread by climate change effects by strengthening federal rules, and educating homeowners about safer disposal practices
  - Implement a training program with American Water Works Association and others for water supply treatment facility operators to educate them on how to prepare for climate change, e.g., extreme storms, high temperatures
  - Incorporate climate resiliency or other green planning practices into waste supply treatment design manuals for water reuse to lessen demand on potable water
  - Promote the use of the SCADA systems and training to assist in the monitoring and operation of water treatment plants.
  - Amend the Drinking Water State Revolving Fund (DWSRF) to give priority to new water supply development and protection
- Distribution of Potable Water Supplies:
  - Update and repair antiquated and leaking distribution infrastructure
  - Assess the location of water supply distribution infrastructure along the coast, and determine if any of it should or can be relocated
  - Provide funding for asset management program for distribution system replacement and protection under DWSRF

Natural Resources

Habitat Specific Climate Adaptation Recommendations

The following are climate adaptation strategies that apply to specific Connecticut habitats that have been identified as most vulnerable to climate change. These strategies aim to conserve a representative array of Connecticut ecosystems and maintain ecosystem function in a climate changed future.

Coldwater Streams and Associated Riparian Zones

To increase the resilience of Cold Water Streams across the state, we will need to protect/enhance the existing resource through progressive streamflow regulations that ensure more natural river flows and balanced water withdrawals, restoration of degraded stream banks and riparian zones, removal of structural impediments to fish and wildlife like dams to improve connections, and expansion of protected areas through land acquisition.

Short-term Strategies

- **Identify, prioritize, and acquire riparian land and wetland properties adjacent to high priority coldwater resources.**
- **Re-establish connectivity and more natural flows along our rivers and streams by removing or modifying existing structural impediments, such as dams, and culverts.**
- **Adopt streamflow regulations that provide more natural flows in order to reduce stress on fish and wildlife caused by rising water temperatures and cumulative impacts of water withdrawals (surface and groundwater) on stream temperature.**
- **Prioritize restoration and management activities for critical coldwater streams including; revegetation of stream banks/riparian zones and stocking of resilient strains and species.**
- **Stock trout strains that are most likely to establish self-sustaining wild populations, and avoid stocking domestic trout where significant wild trout populations occur.**
- **Establish/maintain long-term monitoring of coldwater fish populations to accurately assess natural variation and likelihood of conservation success.**

Mid-term Strategies

- **Explore water rights options that protect fish and other aquatic resources to keep the water in the streams as a legitimate use.**
- **Diversify fish raised in CT DEEP hatcheries to include more temperature tolerant strains and species.**
- **Advance land use policy/regulations (riparian buffer zones, stormwater management BMPs and Low Impact Development) that reduce temperature impacts to coldwater streams.**
- **Identify and protect critical ground water source/recharge areas in watersheds across the state.**

Tidal Marsh

To increase the resilience of Tidal Marsh across the state, additional attention needs to be directed towards comprehensively assessing the extent of inland migration of this habitat through modeling of "advancement zones" using agreed upon sea level rise and storm scenarios/tool(s) and the reform or addition of land-use policies at the state and municipal level that afford a place for this resource and resulting reduction in vulnerability of communities along the coast of Connecticut.

Short-term Strategies

- **Identify, prioritize, and acquire "advancement zones" for upslope migration and establishment of tidal marsh.**
- **Adopt the most appropriate sea level rise modeling tool to enable the state and municipalities to better prepare and plan for coastal change.**
- **Indentify and promote innovative, cost-effective, environmentally-friendly, engineering alternatives for coastal protection.**
- **Support land use policy reform to enable upslope migration of tidal marsh that will reduce vulnerability of coastal communities and infrastructure.**
- **Evaluate new techniques for regulating new development or post-storm re-development as shorelines and coastal habitats advance inland.**

Mid-term Strategies

- **Conduct research and monitoring to determine the long-term validity of management techniques to enable upslope migration and in situ maintenance (e.g., dredge spoils).**

Long-term Strategies

- **Promote understanding of long-term viability of traditional and novel management techniques for migrating and in situ tidal marsh and dependent species.**
- **Increase clarification of mitigation co-benefit from tidal marsh management for ecosystem services such as carbon sequestration.**

Open Water Marine

Short-term Strategies

- **Promote and continue research monitoring of marine resources to document changes and inform resource management (i.e., CT DEEP Trawl Survey).**
- **Continue and accelerate watershed management practices and land acquisition strategies to reduce nutrient and pollutant loading (water quality conditions, manure technologies) to Long Island Sound.**

Mid-term Strategies

- **Focus research on reevaluating the projected future of diverse marine fisheries (i.e., other viable fisheries) and identify ways to diversify fisheries industry to maintain industry and cultural heritage.**

Beaches and Dunes

Short-term Strategies

- **Identify, prioritize, and acquire "advancement zones" for migration and establishment of beaches and dunes.**
- **Nourish coastal beaches in accordance with an informed state-wide sediment management plan that incorporates natural sediment processes.**
- **Indentify and promote cost-effective, environmentally-friendly, engineering alternatives for coastal protection.**
- **Promote the awareness of (including cost/benefits) and regulatory authority to require softer engineering alternatives for coastal areas (i.e., fiber logs, planting dunes, restoring marshes).**

Mid-term Strategies

- **Evaluate new techniques for regulating new development or post-storm re-development as shorelines and coastal habitats advance inland.**
- **Require native vegetation buffers and sand dune protection.**
- **Construct shoreline oyster reefs to provide settlement habitat for oyster larvae and to buffer the shoreline from erosive waves and storms.**
- **Conduct monitoring, restoration and management activities to support beach and dune obligate plants and wildlife via traditional and novel approaches (e.g., floating habitat for birds)**

Herbaceous Freshwater Wetlands

Short-term Strategies

- **Advance land use policies and tools (stormwater management BMPs and low impact development) that reduce runoff and stream temperature.**
- **Increase expertise at the municipal review level to ensure that infrastructure improvements (e.g., culverts) and development will not alter existing natural hydrology.**

Mid-term Strategies

- **Examine watershed management practices and land acquisition strategies to reduce nutrient and pollutant loading (e.g., water quality conditions, manure management).**
- **Protect from development land adjoining herbaceous freshwater wetlands and upstream infiltration buffers and manage water withdrawals/diversions to maintain characteristic connectivity and hydrology.**

Intertidal Flats and Shores

Short-term Strategies

- **Inventory key intertidal habitats for migratory shorebirds, nesting colonial waterbirds and other wildlife and assess vulnerability and adaptation strategies.**

Mid-term Strategies

- **Construct shoreline oyster reefs to provide settlement habitat for oyster larvae and to buffer the shoreline from erosive waves and storms.**

Long-term Strategies

- **Secure intertidal lands gained through rolling easements, severe repetitive loss and other disincentive programs to implement habitat restoration.**

Major Rivers and Associated Riparian Zones

Short-term Strategies

- **Re-establish connectivity and more natural flows along our rivers and streams by removing or modifying existing structural impediments, such as dams, and culverts.**
- **Advance land use policy/regulations (stormwater management BMPs and low impact development) that reduce temperature impacts throughout watersheds.**
- **Acquire easements in strategic locations to conserve lands that allow for increased resilience of riparian zones.**

Mid-term Strategies

- **Modify upstream flood control and water management infrastructure and the operation thereof to allow for regular flooding of floodplain forests where feasible.**
- **Incorporate data on aquatic communities and update Water Quality Standards as they relate to point source discharge of warm water effluent, as needed.**

Long-term Strategies

- **Promote opportunities for warmwater gamefish in rivers where populations of temperature intolerant species decline.**
- **Reduce thermal impacts associated with wastewater discharges.**

Forested Swamps

Short-term Strategies

- **Employ land use policy/regulations (stormwater management BMPs and Low Impact Development) that reduce thermal and runoff impacts.**

Mid-term Strategies

- **Increase municipal level review and oversight of infrastructure improvements (e.g., culverts) and development that has or will alter existing natural hydrology.**
- **Protect land adjoining forested swamps and upstream infiltration buffers and manage water withdrawals/diversions to maintain characteristic connectivity and hydrology.**
- **Establish hydrology monitoring stations within existing locations to inform management alternatives; future conversion to alternative habitats and habitat migration options.**

Subtidal Aquatic Beds

Short-term Strategies

- **Examine watershed management practices and land acquisition strategies to promote and improve water quality conditions in near shore, estuarine and freshwater areas that support or could support subtidal aquatic beds.**
- **Investigate options for restoring or enhancing subtidal aquatic beds to provide habitat and shoreline protection through wave dissipation.**
- **Continue monitoring distribution and conduct research to identify the likely impact of climate on subtidal aquatic beds to inform management and restoration allocations.**

Lakes, Ponds, Impoundments & Shorelines

Short-term Strategies

- **Promote comprehensive nutrient and runoff BMPs, regulations and policies (municipal and state) for lakes, pond, and impoundments to reduce eutrophication.**
- **Advance land use policy/regulations for vegetative shoreline buffers in developments adjoining lakes and ponds.**

Mid-term Strategies

- **Reduce nitrogen runoff through the use of alternative manure technologies (e.g., manure biodigester, composting).**

Upland Forest Complex

In order to increase the resilience of Upland Forests across the state, management and outreach practices that reduces the impact of exotic insect species, improves regeneration and diversity in age and forest species through controlled burns and harvest regimes, and promotes coordination amongst state and private landowners and foresters around sustainable best management plans will be paramount in the near-term. Specific strategies include:

Short-term Strategies

- **Promote habitat resilience by managing invasive species, in particular exotic insects including woolly adelgid, Asian longhorn beetle, emerald ash borer and gypsy moth.**
- **Investigate potential impacts due to range expansion of southern tree species (displacement and trophic structure alteration).**
- **Promote upland forest resilience by increasing the use of fire control techniques through controlled burns and selective regeneration projects (improves diversity in forest age and species composition). Include open patch habitat and closed canopy habitat within overall forest habitat.**
- **Manage deer population densities to allow for sufficient forest regeneration. Monitor seedling regeneration in the understory.**
- **Promote best management plans and regulations among private landowners and foresters to increase sustainable management for resilient forests.**
- **Encourage towns to adopt conservation subdivisions and zoning reform to increase forest block size and reduce edge effects.**

Mid-term Strategies

- **Incorporate the impacts of extreme events into forest management practices. Promote increased understanding of such events among land owners and professional foresters.**
- **Greatly enhance land protection resources and incentives for private landowners to retain carbon sequestration value of state's forests.**

Long-term Strategies

- **Promote principles of "smart growth" to also retain carbon sequestration values of forest and to better facilitate public transportation systems and energy transmission infrastructure, including wide scale distributed generation options for renewable energy.**
- **Increase community preparedness for the potential of more frequent and intense wildland fires.**

Appendix B:
Identification of Appropriate Connecticut Planning Reports for Adaptation Strategy Inclusion

- Connecticut Climate Action Plan (2005)
  - "This plan represents a major milestone in the drive to reduce greenhouse gas (GHG) emissions and achieve the regional goals set by the New England Governors/Eastern Canadian Premiers (NEG/ECP)." "The goal is to reduce greenhouse gas emissions to 1990 levels by the year 2010 and an additional 10% below that by the year 2020." The Climate Action Plan includes 55 recommendations, which are clustered into the following sectors:
    - Transportation and Land Use,
    - Residential, Commercial, Industrial,
    - Agriculture, Forestry, Waste,
    - Electricity Generation, and
    - Education.
  - Administered by the Governor's Steering Committee on Climate Change (GSC) http://www.ct.gov/deep/lib/deep/climatechange/ct_climate_change_action_plan_2005.pdf
  - Affects all Workgroups
- Connecticut Drought Management Plan
  - In production
  - Will be posted on http://www.drought.state.ct.us/mgmtplan.htm
  - Replaces Connecticut Drought Preparedness and Response Plan (2003)
    - "The purpose of this drought plan is to preserve essential water uses during a drought (water used to satisfy federal, state, and municipal public health and safety requirements, water used for firefighting, and water needed to maintain aquatic life forms), to recommend a framework for an integrated approach to the assessment of drought conditions, and to set forth drought action levels and the appropriate responses that should occur as drought conditions worsen."
    - Prepared by the Interagency Drought Workgroup and accepted by the Water Planning Council
    - http://www.drought.state.ct.us/drtwkpln.pdf
  - Affects all Workgroups
- Connecticut on the Move, Strategic Long-Term Transportation Plan, 2009-2035
  - "The statewide long-range transportation (LRP) is the federally recognized transportation plan for the State of Connecticut." "The actions in the plan are general (as opposed to project-specific or region-specific) so that they can remain relevant over time, even if unanticipated changes occur. The statewide LRP serves as a framework for preparing future, more project-specific transportation plans such as the Department's Master Transportation Plan and the State Transportation Improvement Program."

  - Administered by DOT http://www.ct.gov/dot/lib/dot/documents/dpolicy/lrp/2009lrp/lrp2009_final_document_june_2009.pdf
  - Affects all Workgroups
  - Master Transportation Plan
    - "Section 13b-15 of the Connecticut General Statutes requires the Commissioner of the Connecticut Department of Transportation (ConnDOT) to publish a master transportation plan (MTP). The purpose of the MTP is to provide the Governor, the Connecticut General Assembly, local elected officials, and other interested parties with an understanding of the projects and programs that ConnDOT is proposing to undertake. This document is updated every two years and submitted to the Governor on or before January 31 of each odd-numbered year."
    - Administered by DOT http://www.ct.gov/dot/lib/dot/documents/dpolicy/mtp/2009mtp.pdf
    - Affects all Workgroups
  - Statewide Transportation Improvement Program (STIP) 2010
    - "The Statewide Transportation Improvement Program (STIP) is a four – year financial document that lists all projects expected to be funded in those four years with Federal participation."
    - Administered by DOT http://www.ct.gov/dot/cwp/view.asp?a=3529&q=447186
    - Affects all Workgroups
- Conservation and Development Policies Plan for Connecticut 2005-2010
  - "The Plan serves as a statement of the development, resource management and public investment policies for the State. The Plan is used as a framework for evaluating plans and proposals submitted to OPM for review through mandated review processes."
  - Administered by OPM http://www.ct.gov/opm/cwp/view.asp?a=2990&q=383182
  - Legislation passed this session allows for the next plan update to be adopted by the General Assembly in the 2013 session.
  - Related Plans- Municipal Conservation and Development Plan Policies
  - Affects all Workgroups
- The Green Plan: Guiding Land Acquisition and Protection in Connecticut 2007-2012
  - "This document is intended as a strategic plan for land acquisition and protection for the State of Connecticut through 2012. As such, it sets forth general guidance for program managers, is a tool for those who want to work with the State in preserving land, and provides an overview for the public of Connecticut's land acquisition and protection program."
  - Administered by DEEP http://www.ct.gov/deep/lib/deep/open_space/green_plan.pdf
  - Affects all Workgroups
- Water Allocation Policy Planning: Critical Path (2002)
  - "This model identifies the critical components of a water allocation policy that integrates aspects of water resource planning and management necessary for a reasonable and well-balanced process for decision-making."

  - Administered by The Water Planning Council (WPC) http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325644&deepNav_GID=1654
  - Affects all Workgroups
- Planning for Agriculture: A Guide for Connecticut Municipalities
  - "This guide is designed to assist towns in developing plans for the future of agriculture."
  - Administered by American Farmland Trust and Connecticut Conference of Municipalities http://www.ctplanningforagriculture.com/guide/AFT_guide_web9-29.pdf
  - Primarily affects the Agriculture Workgroup
- Blue Ribbon Commission on Land Conservation: A Report to the Governors (2010)
  - "On September 15, 2009, in Saint John NB, the New England Governors called on their responsible Chief State Officers, in collaboration with appropriate partners and the Commission on Land Conservation (CLC), to develop five integrated initiatives to: Keep Farmlands in Farming, Keep Forests as Forests, Connect People to the Outdoors, Protect Wildlife Habitat, and Safeguard Coastal and Estuarine Lands."
  - Already includes a consideration of climate change impacts and adaptation.
  - Administered by the New England Governors' Conference, Inc.
  - Primarily affects the Agriculture and Natural Resources Workgroups
- Connecticut Statewide Airport System Plan (CSASP) 2006
  - "The purpose of this CSASP is to provide a comprehensive review of the current state aviation system, to support the continued operation and maintenance of Connecticut's airports, and to recommend modifications to the airport system to meet existing and projected aviation needs. This will ensure that Connecticut's airports continue to serve the state's residents and businesses in the most efficient and cost effective manner possible. The CSASP concentrates primarily on airports that are open to the public."
  - Administered by DOT http://www.ct.gov/dot/lib/dot/documents/dpolicy/table_contents.pdf
  - Primarily affects the Infrastructure Workgroup
- Connecticut State Rail Plan 2010-2014
  - "The Connecticut State Rail Plan is a document to be issued every five years that seeks approval of the Secretary USDOT for content and collaboration in the State rail planning policy process. The Plan shall set forth policy involving freight and passenger rail including commuter rail in the State, setting priorities and strategies to enhance rail service in the State that benefits the public, and to serve as the basis for Federal and State investments within the State."
  - Latest plan is being developed.
  - Administered by DOT http://www.ct.gov/dot/cwp/view.asp?a=1386&q=437648&PM=1
  - Primarily affects the Infrastructure Workgroup
- State Natural Disaster Plan 2009
  - "The Plan establishes the mission assignments of state agencies in responding to natural disasters of a severity and magnitude typical for Connecticut. The Plan describes the interaction of state government with local governments, private

response organizations (e.g., utilities, the American Red Cross) and the federal government in natural disaster situations."
    - Administered by DEMHS http://www.ct.gov/demhs/lib/demhs/emergmgmt/planningguides/2009_natural_disaster_plan.pdf
    - Primarily affects the Infrastructure Workgroup
    - State Disaster Debris Management Plan 2008 (Annex to the State Natural Disaster Plan)
        - "Establishes the framework for proper management of debris generated by a natural disaster, with the goal of facilitating prompt and efficient recovery that is cost effective, eligible for FEMA reimbursement, and protective of the environment."
        - Administered by DEEP http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/debris_management/final_ddmp_plan_september_2008_(pdf).pdf
        - Primarily affects the Infrastructure Workgroup
- State Solid Waste Management Plan (Amended December 2006)
    - "The Plan examines the state of solid waste management in Connecticut; establishes goals and objectives; identifies problems and barriers; and outlines strategies for achieving the goals. The Plan will serve as the basis for solid waste management planning and decision-making for a twenty year planning horizon."
    - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2718&q=325482&deepNav_GID=1639
    - Primarily affects the Infrastructure Workgroup
- Connecticut Recreational Trails Plan- Draft 2005
    - "This document is the draft version of the DEEP's policy for the development and use of statewide recreational trails."
    - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2707&q=323868&deepNav_GID=1642
    - Primarily affects the Natural Resources and Infrastructure Workgroups
- Connecticut Statewide Comprehensive Outdoor Recreation Plan (SCORP)
    - "The SCORP is a planning document which assesses both the demand for and the supply of outdoor recreational facilities statewide. The National Park Service officially approved Connecticut's new SCORP in September 2005. Using the data and insights obtained through the preparation of the SCORP, both the state and its municipalities will be able to more effectively provide and improve outdoor recreational opportunities for Connecticut's residents and visitors."
    - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2707&q=323864&deepNav_GID=1642
    - Primarily affects the Natural Resources and Infrastructure Workgroups
- Natural Hazards Mitigation Plan (NHMP) for 2007-2010'
    - "This Plan represents the State of Connecticut's efforts to approach mitigating the effects of natural disasters on a multi-hazard basis, and shifts from a disaster-response driven system to one based on effective hazard mitigation planning."
    - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325652&deepNav_GID=1654

  - An updated plan will be submitted to FEMA, shortly, for review.
  - Primarily affects the Infrastructure and Natural Resources Workgroups
- Public Drinking Water Security and Emergency Response Guide (2009)
  - "This handbook includes guidance information, references and resources that should be used in conjunction with your utility's existing emergency response plan for quickly and effectively responding to contamination incidents, even in situations where information may be limited or unavailable. "
  - Administered by DPH http://www.ct.gov/dph/lib/dph/drinking_water/pdf/Public_Drinking_Water_Security_Emergency_Response_Guide.pdf
  - Primarily affects the Infrastructure and Public Health Workgroups
- Connecticut's Comprehensive Wildlife Conservation Strategy (Approved by US FWS 2006)
  - "The DEEP Wildlife Division has developed a Comprehensive Wildlife Conservation Strategy (CWCS) for Connecticut. This will allow the Department and its partners to integrate the management of natural resources, build valuable partnerships, and support regional and national efforts to secure long-term funding for wildlife conservation. Connecticut's strategy identifies species of greatest conservation need and their affiliated habitats. The strategy also identifies the priority research needs and conservation actions needed to address problems facing these species and habitats."
  - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2723&q=325886&deepNav_GID=1719
  - Primarily affects the Natural Resources Workgroup
- The Connecticut Statewide Forest Resource Plan 2004-2013
  - "The Connecticut Statewide Forest Resource Plan is designed to serve as an overview for planning future activities within the forest community of Connecticut"
  - Administered by DEEP http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322794&deepNav_GID=1631
  - Primarily affects the Natural Resources Group
- Directory of Connecticut Public Health Plans (2009)
  - "Issued in November, 2009 (updated January, 2010), the Directory contains abstracts of 35 recent health improvement and strategic plans issued by the Connecticut Department of Public Health. Each abstract contains summary listings of goals, objectives, strategies, priorities, and/or recommendations from the plan, along with other key information. Plans are cross-referenced by subjects (Keyword Index) and population groups (Target Population Index), to identify areas of mutual interest and facilitate collaboration and consistency among public health programs and services to improve public health in Connecticut."
  - Administered by DPH http://www.ct.gov/dph/lib/dph/state_health_planning/dphplans/plan_directory_dph_012010.pdf
  - Primarily affects the Public Health Workgroup
- Healthy Connecticut 2010 Final Report

  - "Released on June 16, 2010, the Healthy Connecticut 2010 Final Report describes progress made during the past decade to improve the health of Connecticut residents and eliminate health disparities. The report contains summary information and annual tracking data for 33 objectives related to the 10 Leading Health Indicators described in Healthy People 2010, the nation's health agenda."
  - Administered by DPH http://www.ct.gov/dph/lib/dph/state_health_planning/healthy_people/hct2010_final_rep_jun2010.pdf
  - Primarily affects the Public Health Workgroup
- Public Health Emergency Response Plan (2005)
  - "The Connecticut Public Health Emergency Response Plan (CT PHERP) identifies the DPH response activities during a public health emergency. This plan supports the public health and medical care component, Emergency Support Function (ESF) #8, in existing state disaster and emergency plans."
  - Administered by DPH http://www.ct.gov/dph/lib/dph/php/bt/pdf/pherp_final_report.pdf
  - Primarily affects the Public Health Workgroup