Chapter 11
Adapting to Climate Change

The Earth is experiencing changes in climate that appear to be accelerating and permanent. Climate change is already affecting New York State's communities, economy,, and natural ecosystems, and these effects are expected to increase. Historical climate conditions are no longer a reliable guide to the future for planning within natural, social, or economic systems.

Adaptation refers to actions taken to prepare for climate change, to reduce adverse impacts, or to take advantage of new opportunities. Adaptation can take place at many levels—individual, community, organizational, and institutional. In many respects adaptation is simply better planning, incorporating the most current information about future climate change into routine decision making. Adaptive *capacity is* the ability of a system to adjust to climate stresses or to cope with their consequences. New York State already has substantial adaptive capacity, but also significant vulnerabilities. The overarching goal of the adaptation recommendations is to create a more climate-resilient New York State.

Our current understanding of how the Earth's climate system will change does not provide the level of accuracy and precision desired often by decision makers, so adaptation planning must include flexible responses. Flexible adaptation enables stakeholders to take actions and put strategies into place that can be adjusted over time as climate science matures and initial adaptation efforts yield valuable lessons.

New York's Climate Action Plan Adaptation Technical Work Group

The Adaptation Technical Work Group was charged with identifying measures to safeguard New Yorkers' public health, infrastructure, ecosystems, and environment from the impacts of climate change. The Technical Work Group was comprised of more than 25 individuals including representatives from State and local government, academia, utilities, environmental justice groups, non-governmental organizations, environmental groups, and the insurance industry. The group was co-chaired by NYSERDA and DEC, with facilitation provided by the Center for Climate Strategies.

The Technical Work Group used the work of the NYSERDA-sponsored project entitled, Integrated Assessment for Climate Change Adaptation Strategies in New York State, also known as "ClimAID," as a foundational resource for its work. The ClimAID project provided New York- specific climate projections and climate vulnerability analyses, and strategies to reduce the detrimental effects of climate change on the State's economy, ecology, and public health. The project team was led by researchers from Columbia University, Hunter College, and Cornell University, with additional partners including Rutgers University, the Mt. Sinai School of Medicine, and New York University. The draft ClimAID summary report is included as Appendix H. The full report will be available at www.nyserda.org/programs/Environment/EMEP/. Information from other ongoing initiatives also provided valuable input to the process, including New York's Sea Level Rise Task Force, The Nature Conservancy's *Rising Waters*, and New York City's *PlaNYC*.

The Adaptation Technical Work Group developed policy options around the following concepts:

- Reduce physical, social, or economic impact of climate change.
- Take advantage of new opportunities emerging from climate change.

To facilitate discussions, the Adaptation Technical Work Group members divided themselves into eight subgroups, each of which developed recommendations for review by the entire Technical Work Group. Each subgroup addressed one of eight sectors: agriculture, coastal zones, ecosystems, energy, public health, transportation, telecommunications and information infrastructure, and water resources.

The process to assess risks and vulnerabilities was based on the latest climate projections for New York State and built on the process used in the ClimAID project. While the ClimAID project focused primarily on producing adaptation strategies to reduce vulnerabilities and exploit opportunities, the Technical Work Group took the process one step further by generating policies and some mechanisms to implement the strategies in New York State. Technical Work Group members prioritized adaptation strategies according to climate-risk levels, vulnerability and exposure, cost effectiveness, distributional and equity concerns, and institutional capacity and capability. Other factors considered include regulatory, design, and engineering standards; legal structures; and insurance opportunities. An overview of each recommended strategy is included later in this chapter. More detailed descriptions of each recommendation are available at www.nyclimatechange.us.

New York is just beginning climate adaptation planning. This Adaptation Plan should be viewed as a living document and must be revisited on a regular basis to incorporate the latest scientific research and knowledge, including actual climate impacts and the effectiveness of the proposed strategies. Such periodic reassessment will permit development of flexible adaptation pathways and increasing adaptive capacity.

The Adaptation Planning Process[1]

While New York has a wide range of vulnerabilities to changing climate, it also has the potential to adapt to and take advantage of some of these changes. Some of the hazards associated with climate change include higher temperatures leading to greater incidence of decreased air quality, and heat stress caused by more frequent and intense heat waves; increased droughts and extreme rainfall affecting food production, natural ecosystems, and water resources; and sea level rise causing enhanced flooding in coastal areas.

Climate change poses challenges for decision makers because of the uncertainties inherent in climate projections and the complex linkages among climate change, physical and biological systems, and socioeconomic factors. Fortunately, there is already a large body of knowledge on climate change that will assist in developing strategies to reduce vulnerability and building adaptive response capacity.

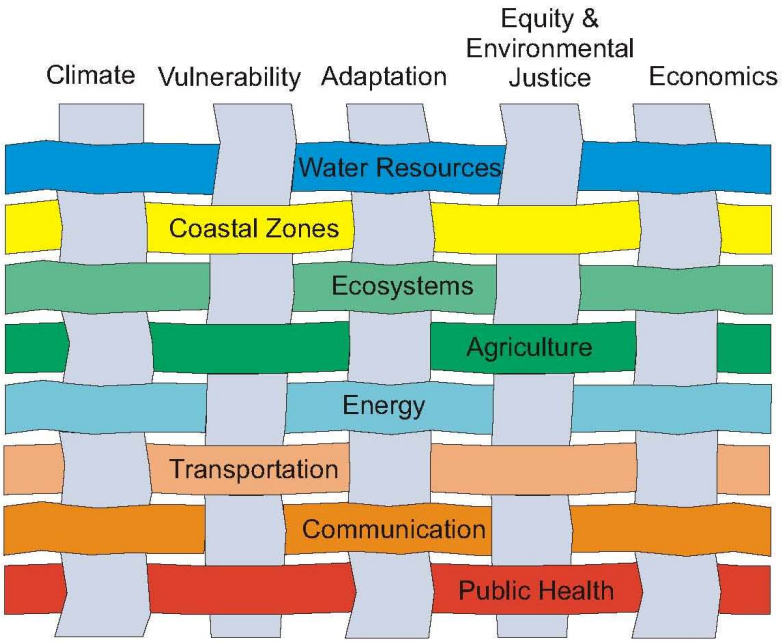
[1] Much of this discussion is based on the work of the ClimAID team.

A New York State climate change adaptation plan must consider a number of components:

- Understanding how the *climate* in New York State might change,
- Identifying potential *vulnerabilities* to a changing climate,
- Assessing *risk* levels of those vulnerabilities,
- Developing *adaptation strategies* that will help to minimize those risks,
- *Prioritizing* strategies, considering other adaptation tools, and developing an overall adaptation plan that is coordinated with greenhouse gas mitigation efforts.

Figure 11-1 from ClimAID illustrates five integrating themes across the eight sectors studied.

Figure 11-1. Relationship of Adaptation Sectors to Integrating Themes



The following elements were considered as part of the evaluation of adaptation strategies:

- Cost: What are the general costs of the proposed strategy, including human and other resources? This assessment can yield a rough measure of benefits and costs to the extent that the consequences are measured in economic terms, but there will be important non-economic consequences as well.
- Timing: The timing of implementation should be considered relative to the timing of impact; if the impact will occur in a time frame comparable to the time required for implementation, there is need for immediate consideration.
- Feasibility: How feasible is the strategy for implementation? Are there organizational, policy, legal, or engineering concerns; or expected technological changes that would affect feasibility?

- Efficacy: To what extent will the strategy, if successfully implemented, reduce the risk?
- Robustness: Is there the potential to install equipment or upgrade infrastructure that is resilient and designed to withstand a range of climate hazards? Are there opportunities for flexible adaptation pathways?
- Co-benefits: Will any strategies have effects on another stakeholder or sector? Is there potential for cost-sharing? Are there impacts on mitigation of greenhouse gases? Are there impacts on the environment or a vulnerable population?

Other important factors that must be taken into consideration include environmental justice, equity, social justice, sustainability, institutional context, and unique circumstances.

Indicators and Monitoring

The monitoring of climate change variables and other factors that might directly or indirectly influence risks and adaptation strategies is an important component of any adaptation plan. Monitoring of key indicators can help to initiate course corrections in adaptation policies and/or changes in timing of their implementation. Indicators must be devised and tracked over time to provide quantitative measures of climate change and its impacts, and the efficacy of adaptation strategies.

Summary

Climate hazards are likely to produce a range of impacts on the urban and rural fabric of New York State in the coming decades. Adaptation strategies described in this report can provide the basis for adaptation planning for decision makers who must work to reduce future impacts. These adaptation strategies will also produce benefits today, since they will help to lessen the impacts of current climate hazards. Some adaptation strategies also have the co-benefit of reducing greenhouse gasses.

Regular monitoring of climate and impacts indicators is critical. Indirect climate change impacts, including effects resulting from climate change impacts in other regions, must be considered as well. By continually evaluating this evolving information, New York State can best develop robust and flexible adaptation pathways that maximize climate and societal benefits while minimizing climate hazards and costs.

Adaptation Recommendations: Common Themes

Several common themes emerged from the sector-specific recommendations. Many of these common themes represent steps that must occur before other recommended actions could be implemented:

- Dissemination of climate change information to decision makers at all levels is critical to adaptation planning. Using academic and governmental resources New York State should develop the capacity to disseminate the best available climate projections, including associated uncertainties. These projections would be updated periodically and be the standard for decision making across the state. This capacity could be provided through State support of a Climate Science Institute— a collaborative effort of qualified academic institutions that could provide guidance on applications of climate projections.

- New York State should develop capacity to identify and monitor climate change indicators, including indicators of climate factor interactions, to provide necessary information to decision makers..
- New York State should develop a framework for describing, monitoring, assessing, and reporting progress on adaptation efforts within the state. An assessment of adaptation efforts by local governments, State agencies, and federal programs should be started to collect baseline information. This will help identify gaps in information, research, or tools needed for decision making and will help better prioritize next steps. Adaptation information should be shared and efforts coordinated among all levels of government.
- Support for research and development is necessary to develop new strategies and technological advances, and to provide the proper detail and confidence for recommended strategies.
- Emergency management capabilities across the state must be evaluated in light of climate projections to determine where these capabilities will be compromised. Emergency warning systems, access and availability of cooling centers, barriers to emergency evacuation, and the effects of power and communications outages must be assessed.
- Education and outreach at all levels are critical to the success of climate change adaptation efforts. Climate science should be incorporated in education curricula to bring the most current, science-based information to tomorrow's leaders. Targeted outreach to affected communities will also be necessary.
- Certain groups will be disproportionately affected by climate change; it is necessary to identify these groups and ensure their participation throughout adaptation planning processes. Climate change risks, vulnerabilities, and capacities to adapt are uneven across regions, sectors, households, individuals, and social groups. Equity concerns emerge because climate change impacts and adaptation policies can worsen existing inequalities and can also create new patterns of inequities. The impacts of climate change adaptation policies on different populations, areas and industries must be considered and addressed.
- Immediate action is needed. Current state investment decisions and policies as well as infrastructure siting and design decisions should be informed by climate projections to ensure necessary adaptive capacities the best use of state resources. Many recommendations focus on vulnerable populations that are already likely to experience adverse climate effects.

Many of the recommendations are based on existing state programs and policies. While specific opportunities for integration are not explicitly mentioned in these policy summaries, additional information on related efforts and potential implementation mechanisms will be available in the policy adoption descriptions at www.nyclimatechange.us.

Adaptation Recommendations

Summaries of the recommendations from the Adaptation Technical Work Group are listed below, by sector subgroups.[2] Detailed descriptions will be posted at www.nyclimatechange.us.

Agriculture

Vision Statement

Develop and adopt strategies and technological advances that recognize agriculture as a critical climate and resource dependent New York State industry that is inextricably linked to Earth's carbon and nitrogen cycles, and ensure that in 2050, the agricultural sector is not only viable, but thriving in a carbon-constrained economy, and is continually adapting to a changing climate.

Background

Agriculture is a significant component of the New York economy; it includes large wholesale grower-shippers selling products nationally and internationally, a substantial dairy industry, and thousands of small farm operations selling direct retail and providing communities throughout the state with local, fresh produce. Farmers will be on the front lines of coping with climate change, but the direct impacts on crops, livestock, and pests, and the costs of farmer adaptation will have cascading effects beyond the farm gate and throughout the New York economy. While climate change will create unprecedented challenges, there are likely to be new opportunities as well, such as developing markets for new crop options that may come with a longer growing season and warmer temperatures. Taking advantage of any opportunities and minimizing the adverse consequences of climate change will require new decision tools for strategic adaptation. Adaptation will not be cost- or risk-free, and inequities in availability of capital or information for strategic adaptation may become a concern for some sectors of the agricultural economy.

The agriculture sector in New York State encompasses more than 34,000 farms that occupy about one-quarter of the state's land area (more than 7.5 million acres) and contribute $4.5 billion annually to the state's economy. New York is the dominant agriculture state in the northeast and typically ranks within the top five in the United States for production of apples, grapes, fresh-market sweet corn, snap beans, cabbage, milk, cottage cheese, and several other commodities.

Climate Impacts

Warmer temperatures, a longer growing season, and increased atmospheric CO_2 could create opportunities for farmers with enough capital to take risks on expanding production of warmer temperature-adapted crops (e.g., European red wine grapes, peaches, tomato, watermelon), assuming a market for new crops can be developed. However, many of the high-value crops that

[2] Much of the text in the Background and Climate Impacts sections of each sector description has been drawn from the ClimAID report.

currently dominate the state's agriculture economy (e.g., apples, cabbage, potatoes) and the dairy industry benefit from the state's historically relatively cool climate. Some crops may have yield or quality losses associated with increased frequency of drought; increased summer high temperatures; increased risk of freeze injury as a result of more variable winters; and increased pressure from weeds, insects, disease, or other factors. Milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase, unless farmers adapt by increasing the cooling capacity of animal facilities.

The impacts from climate change will occur on top of non-climate stressors already affecting the sector. For example, as with many other businesses in New York and elsewhere, agriculture is sensitive to the volatile and rising costs of energy. Also, New York farmers are affected by often rapidly changing consumer preferences and demands of supermarket buyers; increasingly, farmers must consider global market forces and international competition as well as competition from neighboring states. As a final example, too much as well as too little rainfall is currently a recurrent problem for farmers in New York. Currently, summer precipitation is insufficient to fully meet the water needs of non-irrigated crops most years, while brief, intense rainfall events can have detrimental effects on crops. Climate change is likely to exacerbate these challenges.

Recommendation 1. Support research, development, and deployment of agricultural adaptation strategies that simultaneously manage on-farm GHG emissions and adaptation concerns.

The development of a coordinated statewide research, development, and deployment (R,D &D) program focused on agricultural adaptation strategies is necessary to ensure that New York State agriculture is positioned to respond to changing climatic conditions. This program could also identify research needs and opportunities that could be addressed by private industry. Research and development of the various adaptation practices and strategies should be disseminated to the agricultural community in a coordinated fashion. This effort will likely be a partnership among private and public entities, including universities.

Specific Actions

A. Support the introduction of existing varieties and the development of new varieties that can take full advantage of the beneficial effects of climate change.

Introduction of plant varietals that are adapted to extreme heat events and have increased drought tolerance and pest resistance will reduce climate-related vulnerabilities. Implementation should include the following:

- Development of varieties that are optimized for increasing levels of atmospheric CO_2;
- Introduction of new crop varietals from other regions into New York State;
- Development of crops with increased tolerance to climate stresses. These stresses include summer heat stress; and drought, frost/freeze and extreme precipitation events. These traits can be developed using conventional breeding, molecular-assisted breeding and genetic engineering.

Potential Cost

Low to moderate when compared to the cost of no action. Opportunity to encourage private/public partnerships in this effort (seed companies).

Timeframe for Implementation

Near term: Some research in progress. A more coordinated and focused approach would permit more efficient use of scarce resources.

B. Develop improved responses to extreme weather events (frost, freeze, heat, precipitation).

The ability of farmers to employ new and improved methods of protecting crops from extreme weather events would further reduce climate-related risks. These methods could include the following:

- Development of new pruning strategies;
- Shifting planting dates;
- Improving the efficiency of irrigation practices;
- Improving cover crop and mulching practices;
- Continued optimization of feed rations to reduce the effects of heat stress;
- Continued research on improving the cooling capacity and efficiency of new and existing livestock facilities.

Potential Cost

Relatively low when compared to the cost of no action.

Timeframe for Implementation

Near term: Many of these low-cost strategies have already had some level of research and represent low-cost/high-return strategies with a relatively low level of risk.

C. Develop improved responses to increased weed, disease and insect threats.

Providing agriculture, forestry, and communities with the tools to manage weed, disease, and insect threats in the most environmentally sound manner will require concerted and continued research efforts, which should include, at a minimum, the following:

- A primary focus on non-chemical control strategies for looming weed, disease, and insect threats;
- Development of target-specific chemical control methods with reduced environmental impacts;
- Continued research into species disruption effects of climate change specific to agricultural pest control;
- Development of pest-resistant plant varieties.

Potential Cost

Relatively low to moderate when compared to the cost of no action (i.e., no adaptation). The use of traditional means to manage new and increasing pressure from weed, disease and insect threats carries inherent environmental risks. Significant opportunities exist for private/public partnerships.

Timeframe for Implementation

Near term: Many of these low-cost strategies have already had some level of research and represent low-cost/high-return strategies with a relatively low level of risk.

D. Increase the accuracy of the existing real-time weather warning systems.

Improved delivery of state-of-the-art weather forecasts will be needed to inform growers of extreme events and to allow farmers to take appropriate measures to protect at-risk crops. Needs include the following:

- Development of sophisticated real-time weather monitoring and forecasting; current guidelines for many agricultural practices are based on outdated observations and the assumption of a stationary climate.
- Continued regional and climate science and modeling research to discern between normal climate variability and long-term climate shifts

Potential Cost

Low when compared to the cost of no action.

Timeframe for Implementation

Near term: Accurate weather forecasts in real time are critical to farmers making daily management decisions. Monitoring and forecasts also provide technical specialists and researchers with critical information related to the movement of weeds, diseases, and insects.

E. Support the development of decision-making tools to assist the agricultural community in adapting to climate change.

Tools may include methods for assessing the cost and benefits of crop diversification, shifting planting dates and/or locations, introduction of new varieties, changes in management strategies, and infrastructure changes. These tools will be crucial in determining the optimal time for adaptation investment. Needs include the following:

- Development of new economic decision tools for farmers that incorporate the best available science;
- Development of new decision tools for policy makers that integrate economic, environmental, and social equity impacts of agricultural adaptation efforts.

Potential Cost

Relatively low to moderate when compared to the cost of no action. Decision-making tools also help research and implementation dollars to be invested efficiently.

Timeframe for Implementation

Near term and requiring continual revisions to account for improving adaptation strategies.

F. Increase climate change impact education and outreach efforts to agricultural producers.

Inform agricultural producers of the impacts of climate change and enable the delivery of applied research and decision-making tools to the farm level. Ensure that adaptation strategies are integrated into farm management systems.

Potential Cost

Relatively low, especially when coupled with agricultural mitigation efforts as proposed in Climate Action Plan Mitigation Strategy AFW4, Integrated Farm Management Planning and Application.

Timeframe for Implementation

From 2010 -2013, build the technical capacity necessary to deliver this type of program, including pilot-programs. In 2013 roll out the statewide integrated program.

G. Ensure equity is incorporated into programs targeting agricultural adaptation.

In addition to regional variability in vulnerability related to the scale of impacts from climate change, there is also vulnerability due to the diversity of farm size in New York State. Small family farms with little capital to invest in on-farm adaptation strategies are most at risk and less able to take advantage of cost-related scale economies associated with such measures. Survival of many smaller farms will hinge on making good decisions regarding not only the type of adaptation measures to take but also the timing of the measures. The most vulnerable farmers will be those without access to training about the full range of strategies or those who lack adequate information to assess risk and uncertainty.

Potential Cost

Relatively low for development of decision-making tools and outreach and education efforts. Relatively low to moderate for cost-shared incentive programs.

Timeframe for Implementation

2010 -2013. Development of programs to address equity concerns. 2013. Statewide integrated program roll-out.

Impacts/Vulnerabilities Addressed

Some crops may have yield or quality losses associated with increased frequency of drought, increased summer high temperatures, increased risk of freeze injury as a result of more variable winters, and increased pressure from weeds, insects, disease, or other factors. Milk production per cow will decline in the region as temperatures and the frequency of summer heat stress increase unless farmers adapt by increasing the cooling capacity of animal facilities.

Environmental Justice Considerations

In New York State, there is a range of equity and environmental justice (EJ) issues at the intersection of climate change and agriculture. Particular agricultural sectors, regions, and crops will be most at risk from exposure to climate change and burdened by adaptation measures. Adaptation to climate change will put additional stresses on the fragile and economically important dairy industry in the region. Regional vulnerabilities include farmers on Long Island facing a disproportionate risk of crop damage from increasing storm frequency. Finally, certain crops have disproportionate vulnerabilities, such as perennials for which the cost and economic risk of changing crops as an adaptation strategy is sometimes much higher than for annual crops.

In addition to supply-side dimensions, climate change also may impact agricultural demand. Changes in climate both in New York State and in other regions may disrupt supply chains, leading to closing of retail centers and limiting consumer access to markets. Low-income farmers with insufficient information and training or without access to credit or infrastructure are particularly at risk when conditions demand immediate flexibility and require the ability to quickly line up alternative supply lines and retail locations.

Under such conditions, rural, resource-dependent communities may feel pressure to supplement incomes or diversify their business beyond agriculture but may lack the training or capital necessary to engage in such strategies. Decreasing yields and the high costs of adaptation may translate into significant downstream job losses and cascading economic effects across rural communities. Low-wage, temporary, seasonal, and/or migrant workers are particularly exposed to these shifts.

Examining equity in adaptation involves evaluating existing vulnerabilities, but it also requires evaluating the unintended outcomes, externalities (secondary consequences), and emergent processes of specific adaptation strategies. Successful adaptation by individual farmers or regions may create downstream inequities. As some farmers successfully adapt, other farmers may experience relative increases in inequality related to rural income and agricultural productivity. Certain industries (such as the grape and wine industries) also may consolidate in such ways that it becomes difficult for smaller businesses to enter the market. Increasing chemical inputs, such as fertilizers and pesticides, may create or exacerbate inequitable distributions of human health burdens, or negatively affect waterways, disproportionately impacting low-income or natural resource-dependent communities involved in hunting- and fishing-related revenue. Furthermore, degrading land and community health could drive down property values, exacerbating geographic inequities. Finally, increasing natural resource use, whether it is water for irrigation or energy for cooling, may result in increased utility costs and prices. These increases are felt most by low-income families who proportionally spend more on these basic goods than middle- and upper-income families.

Addressing and avoiding spillover effects in the implementation of adaptation measures require engaging local communities and agricultural managers in each stage of the planning process. This includes mechanisms for expressing and addressing property disputes and conflicting claims to resources, collaborative regional planning across sectors and communities, and training/retraining to provide information regarding strategies and best practices. In particular, adaptation strategies focused at regional or state scales have the capacity to marginalize local actors who are unable to capitalize on social or economic networks or access policymaking procedures.

More broadly, equity should be considered along every part and process of the agriculture food-supply chain. For example, climate stress on agriculture could impact the quality, accessibility, and affordability of local produce. This has implications for food security among low-income groups, communities with fragile connections to markets offering nutritional options, or those otherwise burdened by pre-existing poor nutrition.

Co-benefits and Unintended Consequences

Climate change may provide an incentive for farmers and consumers to take advantage of some opportunities that benefit both the farmer and the environment. Some of these opportunities may eventually be applicable to carbon-offset payments in emerging carbon-trading markets:

- Conserve energy and reduce greenhouse gas emissions (increases profit margin and minimizes contribution to climate change);
- Increase soil organic matter (improves soil health and productivity and, because organic matter is mostly carbon derived from CO_2 in the atmosphere via plant photosynthesis, reduces the amount of this greenhouse gas in the atmosphere);
- Improve nitrogen-use efficiency (synthetic nitrogen fertilizers are energy intensive to produce, transport and apply; and soil emissions of nitrous oxide increase with nitrogen fertilizer use);
- Enter the expanding market for renewable energy using marginal land for wind and solar energy, biomass fuels, and energy from anaerobic digestion of manure and food processing wastes ;
- Improve manure management (reduces nitrous oxide, methane and CO_2 emissions, and can be used as renewable energy source in manure digesters);
- Increase consumer support—from households to large institutional food services—of local "food shed" networks.

Adaptive actions taken to address specific climate change vulnerabilities may have additional effects beyond their primary intentions. In some cases adaptive actions may raise new problems, while in others it is possible to design actions with multiple co-benefits.

- Increased water use and increased chemical loads to the environment. Increases in water and chemical inputs will not only increase costs for the farmer but may also have society-wide impacts in cases where the water supply is limited, by increasing the reactive nitrogen and pesticide loads to the environment, and the risks to food safety, and by increasing human exposure to pesticides.

- Increased energy use and greenhouse gas emissions may be associated with some adaptation strategies. Examples include increased use of cooling fans in livestock facilities, more energy use to pump irrigation water as more farmers expand irrigation capacity or pump from deeper wells, and increased energy use associated with increased use of products that are energy intensive to manufacture, such as some fertilizers and pesticides.
- Changes in land use could result from changes in cropping systems and other farm adaptations. Harvesting of wooded areas for biofuel crops and increased diversion of corn acreage for biofuel markets are possible. Such effects can be averted with appropriate strategic planning, and efforts toward this end have been initiated in the *Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York State* (NYSERDA 2010). Land clearing for expansion of food or forage crop acreage may occur, particularly if other production regions of the country are more adversely affected by climate change than New York.
- Cascading negative effects on rural economies (see Environmental Justice Considerations above).

Recommendation 2. Incorporate anticipated increases in the incidence of weeds, diseases, and insect threats due to climate change in current detection, monitoring, and integrated pest management efforts.

An overall increase in the number of outbreaks of a wider variety of insects and pathogens is likely. Additionally, there are strong empirical reasons for expecting climate change and/or rising levels of CO_2 to benefit undesirable (noxious and invasive) weeds more than crops. New York State is fortunate to have existing statewide programs that target these specific threats while minimizing social, environmental, and economic costs. This policy recommendation has the dual purposes of initializing a comprehensive evaluation of existing programs to identify gaps; and leveraging existing state programs through expansion of outreach and education materials and curriculum, research and development of new management strategies, and enhanced coordination of monitoring, detection, and response efforts. Since many of these threats (specifically insects) have impacts beyond the farm that require similar responses, the Community Integrated Pest Management Program is included in the policy recommendations. (Note: Ecosystems Recommendation 1 discusses invasive species.)

Specific Actions

A. Conduct a formal evaluation of the capacity of existing federal, State, and local agriculture and forestry programs or systems focused on identifying and monitoring existing and emerging weed, disease, and insect threats as a response to a changing climate.

Federal, State, and an increasing number of local governments have programs focused on addressing the threats of weeds, disease, and insects in an economically and environmentally sound manner. An evaluation and gap analysis of these programs is necessary to address problems that may reduce the ability to adequately respond to these increasing threats in a cost-effective and proactive fashion.

Potential Cost

Cost of a review and evaluation should be relatively low.

Timeframe for Implementation

2010-2011. This recommendation should be implemented in the near term to ensure state resources are expended efficiently.

B. Develop coordinated protocols and multiple response tactics such as the development and deployment of pest-resistant plant varieties, regional coordination for early detection, and rapid-response approaches to emerging threats.

Existing State programs focused on agricultural and forestry threats are important mechanisms for ensuring the viability of these industries, which will increasingly face these threats under a changing climate. Integrated pest management programs are important mechanisms for communities to address infestation problems in housing, schools, recreational facilities, houses of worship, and other gathering places.

Potential Cost

For the past several years the Integrated Pest Management (IPM) program has been funded through a legislative appropriation of approximately $1 million annually for the agricultural IPM program and $400,000 for the community IPM program. Due to State budgetary constraints, funding for the 2010-2011 budget year was cut to $500,000 for agricultural IPM and $0 for community IPM. Historically, the IPM program has used the state IPM allocation to leverage $2-$3 million for New York State by obtaining grants from federal and private sources. With significantly reduced State funding, much of this leveraged funding will be lost. The New York State Cooperative Agricultural Pest Survey program has been funded exclusively through federal funds at $235,000 annually for the past several years. The public benefit of expanding these and similar programs is expected to significantly outweigh the cost of full programmatic funding.

Timeframe for Implementation

2010–2012. Restoration to historical funding levels should occur in the very near term as some programs that have experienced reduced levels of funding have had to cut staff and programs. 2012–2020: Expanded funding should occur in areas identified in the comprehensive review and evaluation of existing programs and be consistent with the timeline found in the Climate Action Plan Mitigation Strategy for IPM under AFW 4 1.2(e).

Impacts/Vulnerabilities Addressed

Resources being impacted include all agricultural crops and forests. The increase in weeds, disease, and insect pressure will result from several climatic factors including higher temperatures, increased frequency of intense precipitation, and increased CO_2.

Environmental Justice Considerations

Decreasing yields and the high costs of adaptation may translate into significant downstream job losses and cascading economic effects across rural communities. Low-wage, temporary, seasonal and/or migrant workers are particularly exposed to these shifts.

Co-benefits and Unintended Consequences

Early detection and rapid response to emerging or increasing weed, disease, and pest pressure while minimizing the use of chemicals to control these pressures will provide for reduced chemical loads to the environment. This will result in improved water and air quality, and improved public health. Employing a comprehensive and integrated approach to addressing these concerns will also decrease input costs for the farmer.

Recommendation 3. Evaluate and develop mechanisms to more effectively protect livestock from the effects of greater temperature variability and extremes.

The dairy industry in New York is likely to be affected by rising temperatures under climate change. These changes are expected to cause longer and more frequent episodes of heat stress for dairy cows, resulting in potential production losses and reduced calving rates. Mechanisms to protect dairy livestock from the projected temperature changes should be developed.

Specific Actions

A. Channel appropriate resources to continue research, development, and deployment of livestock protection measures and techniques such as climate-related modifications to feed management systems and approaches.

Short-term impacts of heat stress in dairy cows include decreases in feed intake and milk production; long-term effects include higher incidence of lameness and poorer reproductive performance. Modification of feed rations has proved to partially ameliorate heat stress effects in dairy cows.

Potential Cost

A comprehensive strategy of feed management that addresses multiple environmental concerns at the same time is a relatively low-cost approach under which multiple public benefits can be realized. The difficulty is assigning or accrediting benefits to individual funding sources, which are often based on single-resource objectives.

Timeframe for Implementation

Should be consistent with the timeline for Precision Feeding for Mitigation found under Climate Action Plan Mitigation Strategy AFW 4 1.3(f), which begins in 2013 and progressively ramps up to meet 2050 targets.

B. Support the increased installation of energy-efficient cooling systems and other structural or mechanical interventions.

Increasing the cooling capacity of existing livestock facilities is an obvious adaptation strategy to address heat stress in livestock but will bring with it increased expenditures in

energy costs. Opportunities to deploy energy-efficient systems and maximize on-farm generation of clean renewable energy to power these systems should be encouraged and supported.

Potential Cost

Cost of providing technical assistance will likely be relatively low. Costs of providing financial assistance to make structural and mechanical modifications will be relatively moderate to high. Costs to deploy renewable energy technologies will be relatively high. Multiple funding programs exist for the implementation of renewable energy technologies and the conduct of energy efficiency audits, as well as implementation of energy efficiency measures. Ability to use necessary structural and mechanical modifications as an eligible cost-share when coupled with renewable energy technologies to address heat stress in livestock as part of an adaptation strategy should be explored.

Timeframe for Implementation

Heat stress in livestock is already having a negative impact across New York State; there is also a high certainty that this will continue for the foreseeable future. Investments made now will be less expensive than in several decades. Many of these practices will require significant planning and design as well as capital. To ensure continued competitiveness and long-term viability of the New York State livestock (dairy) industry, these policy options should be pursued in the near term. Additionally, timelines for the complementary mitigation policies have been established with near-term and long-term goals.

Impacts/Vulnerabilities Addressed

The New York State Livestock Industry will likely experience production loss and reduction in calving rates due to heat stress. The ClimAID assessment concluded that negative economic impacts on the New York State dairy industry will be substantial unless dairies are able to adapt.

Environmental Justice Considerations

Vulnerability and capacity to adapt to climate change may vary substantially across different dairy regions in New York State due to differences in climate change exposure, regional cost structures, farm sizes, existing farm infrastructure, and overall productivity. Should climate change induced heat stress have a highly detrimental effect on dairy farming in the state overall, those regions with higher concentrations of dairy farms are likely to experience a more substantial economic disruption.

Differences in farm and herd size are also potentially significant factors in determining vulnerability and capacity to adapt to climate change. Comparison of small versus large farms throughout the state reveals significant differences in the costs, milk production per cow, capital efficiency, income, and profitability. All of these differences may affect the overall capacity of smaller farms to adapt to climate change, particularly if such adaptation requires significant new outlays of capital for the purchase and installation of cooling systems in dairy barns, as well as additional costs associated with energy for operating the equipment, and the installation of on-farm renewable energy generation.

Co-benefits and Unintended Consequences

- Contributing to the competitiveness and long-term viability of a significant, albeit currently struggling, sector of the upstate rural economy;
- Contributing to the size diversity of New York State livestock farms;
- Increasing the energy efficiency and renewable energy capacity of New York State, leading to greenhouse gas reductions.

Coastal Zones

Coastal Zones Adaptation Vision Statement

By 2050, all coastal waterfront communities, including those in the Hudson River estuary, and critical coastal resources and infrastructure, have prepared for and are protected from the changing climate.

Background

The U.S. Coastal Zone Management Act of 1972, as amended in 1996, defines the coastal zone as the land inward of the shoreline needed to control or manage uses that are likely to directly and significantly impact coastal waters or are likely to be "affected by or vulnerable to sea level rise." New York State considers coastal waters to extend three miles into the open ocean and up to the state lines of Connecticut and New Jersey along the shore. In this assessment, the coastal zone is considered to include the shoreline of New York State, including coastal wetland areas and inland areas adjacent to the shoreline that are likely to be affected by sea level rise and coastal storms. Also considered are the potential effects of climate change up the Hudson River to the Federal Dam at Troy and the influence rising ocean temperatures may have on migratory and sedentary fish and shellfish populations.

Coastal ecosystems include near-shore sub-tidal areas, the low-marsh intertidal zone, high-marsh, beaches, dunes, stream channels, rocky platforms, sea grass meadows, algal beds, and tidal flats. Even in a densely populated urban environment such as New York City, these coastal ecosystems provide numerous functions and values. Tidal marshes provide wildlife habitat, storm surge protection, wave attenuation, pollution absorption, and aesthetic appeal. More than 300 species of birds spend part of their life cycle in New York's coastal shores, feeding, resting, or nesting. Every May and June, thousands of horseshoe crabs come to spawn on the sandy beaches of Long Island, New York City, and Westchester County. Many bird species depend on the horseshoe crab eggs or other invertebrates of the tidal zone to replenish their fatty reserves and continue on migration routes along the Atlantic flyway.

Coastal marshes and wetlands are highly sensitive and must maintain a delicate balance as they are affected by rapid sea level rise, wave erosion, sediment deposition, and other forces; these important ecosystems provide wildlife habitat, protect coastlines against storms, and absorb pollution. New York State's coastal marshes are limited to the north and south shores of Long Island, New York City, Westchester County, and Hudson River. In the tidally influenced portion

of the Hudson River Estuary (up to the Troy Dam), the dominant ecological communities are freshwater and brackish tidal marshes, freshwater tidal swamps, tidal creeks, mud and sand flats, and freshwater sub-tidal aquatic beds. However, these are limited to north of the Tappan Zee Bridge, as there is little or no break in shoreline armoring (bulkheads and riprap) from Manhattan to the bridge.

The New York State coastline is comprised of a unique combination of glacial bluffs, pocket beaches, and extensive barrier island—bay systems. Long Island is particularly vulnerable to the effects of shoreline erosion since it is largely formed of sand and gravel deposits left by the retreating glaciers after the end of the last ice age around 20,000 years ago. The south shore of Long Island is a sandy environment consisting largely of barrier islands, spits, and back-barrier salt marshes that are very erodible and subject to inundation.

Climate Impacts

The coastal zone of the New York City metropolitan region faces both ongoing and future natural hazards of flooding, beach erosion, and sea level rise. The anticipated global sea level rise due to climate warming will have a significant impact on New York's coastal areas, in addition to other impacts like ocean circulation changes and higher water temperatures. The effects of global sea level rise will be amplified in New York State due to coastal subsidence caused by ongoing adjustments of the Earth's crust to the melting of the ice sheets that began 20,000 years ago.

New York's coastal zones are becoming more developed, increasing the consequences of flooding and coastal erosion. Sea level rise will greatly amplify current risks to coastal populations and will lead to permanent inundation of low-lying areas, more frequent flooding by storm surges, and increased beach erosion. Saltwater could reach farther up the Hudson River and estuaries, contaminating urban water supplies, while increased water depth could permit the tide and storm surges to propagate faster up the Hudson River to the Troy Dam, increasing flood risk far from the ocean coast.

Sea level rise may become the dominant stressor acting on vulnerable salt marshes. Loss of coastal wetlands reduces fish and shellfish populations. Higher water temperatures also affect these populations. Some marine species, such as lobsters, are moving north out of New York State, while other species, such as the blue claw crab, are increasing in the warmer waters.

High water levels, strong winds, and heavy precipitation resulting from strong coastal storms already cause billions of dollars in damages and disrupt transportation and power distribution systems. Barrier islands are being dramatically altered by strong coastal storms as ocean waters wash over dunes, create new inlets, and erode beaches. Warming ocean waters have the potential to produce stronger storms by increasing the source of energy for these storms.

Non-climate-related stresses will compound the effects of climate change. In the coastal region, most of these are associated with human consumption of natural resources and land-use practices. For example, coastal development, construction of organized drainage, and impervious surfaces has led to a reduction in groundwater recharge and degraded coastal water quality. The

interconnection among precipitation, land use, and local fish populations has also been documented, suggesting that increased urbanization may lead to a reduction in stream biodiversity. In addition to water-quality-related stresses, fish stocks and other marine ecosystems may be affected by harvesting practices, disease, normal population dynamics (increased predation), and recruitment processes. Over-development along the coast increases the demand for groundwater, which could lead to drawdown of the aquifer and increased saltwater intrusion. Coastal infrastructure inhibits natural migration of marine systems, including wetlands and barrier islands.

Impacts and Vulnerabilities Addressed for All Sea Coastal Recommendations

Sea level rise will progressively affect both human and natural systems, affecting water levels on the ocean and estuarine coastline including the Hudson Estuary to the Troy dam; shortening flood-recurrence intervals; increasing risk and geographic extent of coastal hazards such as storm-surge-related flooding, erosion, and groundwater intrusion. New York State needs the best available climate data to best plan for climate impacts. As outlined in the "Common Themes" section of this chapter, the provision of climate data and projections could be facilitated through state support of a Climate Science. The guidance that would be provided by this organization would be extremely helpful to decision makers in all sectors affected by climate change.

Recommendation 1. New York State should endorse a coordinated set of projections for sea level rise and associated changes in flood-recurrence intervals in all coastal areas, including the Hudson River to the Federal Dam at Troy, for use by State and local agencies and authorities for planning and decision-making purposes.

New York State should formally endorse projections for sea level rise and associated changes in flood-recurrence intervals in all coastal areas. It is necessary to factor this information into planning and decision making now to reduce risk to communities and infrastructure vulnerable to sea level rise and strong storms and to conserve coastal natural systems, where the greatest threat from sea level rise is the construction of protective barriers that will prevent them from naturally migrating inland in response to rising waters (see Recommendation #2). Columbia University, NASA/Goddard Institute for Space Studies has developed projections for sea level rise for the entire coastal area of New York State based on the findings and methodology of the Intergovernmental Panel on Climate Change (IPCC) and leading climatologists and glaciologists. These projections have been adopted by the New York State Sea Level Rise Task Force (SLRTF), New York City Panel on Climate Change (NPCC), and the NYSERDA Statewide Climate Impacts and Adaptation Assessment (ClimAID). However, projections should be regularly updated, modified, and refined.

Potential cost

There would be no direct cost to endorse the recently developed projections of the New York State Sea Level Rise Task Force, NYC Panel on Climate Change, and ClimAID. The cost of updating projections in the future may be minimal, since projections are expected to be based on existing global and regional models. The adoption of sea level rise projections offers the opportunity to change planning and decision making to reduce future impacts. Some coastal development opportunities may not be pursued as projections of vulnerability are factored into

permitting decisions. If no projections are adopted, New York State could incur significant long-term costs from flood damage and potentially damaging *ad hoc* responses to flood events. Funding will be needed to support the revision of statewide projections of climate change on a regular basis.

Timing of implementation

This recommendation should be implemented immediately. In New York State people and infrastructure are currently at very high risk of a powerful storm event in coastal areas. Coastal ecosystems are at greatest risk from human decisions to erect protective barriers in response to flood events. These risks are increasing over time due to sea level rise. The endorsement of sea level rise projections, followed by State policy, regulatory actions, and decision making changes, will support new planning and development processes in coastal areas aimed at reducing these risks.

Environmental Justice Considerations

Incorporation of projections of future conditions in State policies, planning, and decision making will make State spending more efficient by emphasizing appropriate development. Identification of area of greatest risk and the direction of resources to vulnerable communities within such areas would help reduce risk to those communities. Vulnerable communities will need assistance if they must relocate from high-risk areas, and there may be community objections to changes in State spending necessary to address sea level rise.

Co-benefits and Unintended Consequences

Adoption of sea level rise and storm-recurrence would provide the basis for a wide variety of State and local planning efforts. See recommendations 2-5.

Recommendation 2. Integrate sea level rise and flood-recurrence interval projections into all relevant agency programs and regulatory, permitting, planning, and funding decisions.

All State agencies should factor the projections of sea level rise and associated impacts from Recommendation 1 into relevant aspects of long-term planning, programming, permitting, regulating, and funding decisions. As necessary, the State should seek and/or provide technical guidance to make appropriate policy changes. Agencies should require or complete analyses of storm and sea level rise impacts over the design life of proposed projects in State permitting and funding decisions. Agencies should regularly update, modify, and refine guidance documents and plans based on current and new information on sea level rise. Local governments should also incorporate considerations of sea level rise into planning, zoning, and permitting decisions.

Potential cost

Although incorporation of sea level rise projections into agency decision-making *per se* would have minimal staff costs, resulting decisions could include costly capital outlays, reduction of some economic opportunities, and potential controversy. For example, denial of permits within a greater portion of the jurisdictional adjacent wetland area, may lead to legal challenges regarding private property rights. However, incorporation of these projections into agency decision making

can lead to better planning for future conditions, prevention of loss, and avoidance of the larger dramatic and potentially catastrophic costs of inaction.

Timing of implementation

Immediate action is necessary to respond to the causes and impacts of sea level rise and climate change. Given current agency cooperation on adaptation efforts, this recommendation could reasonably be implemented within two to five years. Delays in planning for current and increasing risks of sea level rise and coastal hazards will result in greater the risk to humans, infrastructure and ecosystems.

Environmental Justice Considerations

Incorporation of sea level rise projections in agency decisions would likely enhance protection of communities within areas of environmental justice concern. For example, sea level rise projections should be used to prioritize the analysis of potential toxic exposures in Significant Maritime and Industrial Areas (SMIA) and inform Waterfront Revitalization Programs (WRP). However, there is the potential for some decisions to affect such communities disproportionately, for example by resulting in decreased property values or reduced opportunities for economic development. Agency decisions must include clear evaluation and description of risk, robust public participation, and enhanced efforts for public involvement in areas of environmental justice concern. With increased regulatory protection against building in flood zones, a tradition of construction on cheaper land that historically is flooded may be prevented, saving state and community resources.

Co-benefits and Unintended Consequences

Specifics vary by program and type of decision, but co-benefits of accounting for sea level rise in regulatory decision making would generally include minimizing the extent of erosion and coastal flooding and inundation, thereby enhancing protection of critical natural habitats providing new opportunities for passive recreation; reducing the risk of disruption of important communication, transportation, and health services; improving land-use planning; reducing potential for forced relocation; and reducing expenditures for shoreline armoring and beach nourishment. Unintended consequences could include intensified land use outside the coastal zone, capital outlays for elevation and relocation, and political ramifications.

Recommendation 3. Identify and map areas of greatest current risk from coastal storms and greatest future risk from sea level rise and coastal storms in order to support risk reduction actions in those areas

New York State should take action immediately to define the most vulnerable coastal areas and revise standards for development and redevelopment to reduce risk in these areas, taking into account the progressive nature of sea level rise. Regulatory and planning programs to reduce risk will require identification, classification, and mapping of high-risk areas including the following:

- Areas at greatest risk from sea level rise;
- Areas at risk from storm surge with current sea levels;
- Areas at risk from storm surge with sea level rise.

In addition, criteria should be developed to identify areas that may be sites of dune, barrier island, and/or wetland migration in response to sea level rise. Maps of the coastal zone should be updated to include these areas. All of the above maps should be updated on a regular basis and the most up-to-date maps should always be used for official decision making.

The following information will be needed to fully assess vulnerability: localized projections of climate effects; projections of storm surge; environmental information such as high resolution elevation and bathymetry; spatial information for natural, built, and human resources; socio-economic data; and development models such as build-out scenarios.

This recommendation is consistent with and critical to the implementation of several recommendations of the New York State Sea Level Rise Task Force (SLRTF) and the ClimAID Statewide Climate Impacts and Adaptation Assessment.

Potential cost

The New York State Office of Cyber Security and Critical Infrastructure, in coordination with the NYSDEC and NYSERDA, is seeking to initiate a mapping mission to collect high resolution elevation data using light detection and ranging technology (LiDAR) on the coastal regions of New York State. High resolution contours of 1 foot are desired to be developed for all coastal areas of Long Island and the Hudson River estuary from its mouth at New York City, north to the Troy Dam. This effort would provide the resolution necessary to map communities and critical infrastructure at greatest risk of sea level rise in the near term (next 30-50 years), and to project the most likely path of inland tidal wetland migration in response to sea level rise. The total cost, including the development of maps, is estimated to be nearly $1 million. The combined costs of the development and update of storm surge projections, build-out scenarios, and tidal wetland migration areas could be significant but may benefit from federal support.

Timing of implementation

Recommendations for enhanced elevation mapping should be advanced immediately. At a minimum, digital base maps from the National Flood Insurance Program could be utilized as the basis for mapping projected flood plain inundation in 2050 and 2100. The technology exists to complete revised storm-surge projections and build-out scenarios, but funding is needed for research to identify coastal areas most suitable for tidal wetland migration. With adequate funding the extension of interactive mapping tools with high-resolution elevation data to enable visualization of future sea level rise and storm surge scenarios could take 2-5 years to develop.

Environmental Justice Considerations

Assessment of areas vulnerable to sea level rise could be used to identify program and planning needs to serve less affluent communities and to enable effective adaptation in those areas. Public investments could be used to support communities that have a lack of capacity to address the highest risks from coastal flooding. However, there is the potential for updated mapping products to result in decreased property values or reduced opportunities for economic development in areas that are highly vulnerable to flooding.

Co-benefits and Unintended Consequences

Identification of high-risk coastal areas would allow identification of priorities for capital investment funding to reduce risk, enhanced management planning for at-risk natural habitats, preservation of areas for public access and passive recreation, and the identification of risk to communication, transportation, and health services. Unintended consequences could include the development of land-use conflicts and the political ramifications of mapping high-risk areas coastal areas with high property values.

Recommendation 4. Reduce vulnerabilities in coastal areas at risk from sea level rise and storms (coastal risk management zone) and support increased reliance on non-structural measures and natural protective features to reduce impacts from coastal hazards.

Where appropriate, the preference for new development and re-development in the *coastal risk management zone* should be for projects or actions consistent with policies and programs that emphasize reliance on natural protective features and non-structural measures, such as elevation and relocation, to minimize negative impacts from coastal storms, erosion and sea level rise. Support should be provided to regional and/or local planning that aims to reduce risk from sea level rise and coastal hazards, to projects or actions identified in plans to conserve natural protective features and to secure opportunities for habitat migration in response to sea level rise, and to implement site-appropriate structural and non-structural measures to reduce risk of coastal hazards. Decision makers must be cognizant of the sensitive nature of land-use decisions and provide for local participation in decisions. Policies and programs must be consistent with the New York State Coastal Management Program Policies (Article 42) and Coastal Zone Management Act and should accomplish the following:

A. Development of Coastal Resilience Plans

Direct public investment, programs, and policies toward regional, county and/or local planning offices in coastal areas to support the development of long-term, regional-scale coastal resilience plans. Opportunities to develop partnerships at the federal level should also be pursued. Coastal resilience plans would be developed with the participation of the appropriate local governments and authorities. They should strive to reduce vulnerability in the *coastal risk management zone* through non-structural measures wherever possible; to identify areas of significant public investment, water dependent uses, and/or critical infrastructure that require structural protection because options for relocation, elevation, or employment of non-structural measures are not feasible; and to outline opportunities to reduce vulnerability during recovery and restoration following high-intensity coastal storms.

Potential Cost

State support is needed for the funding, guidance, and technical assistance necessary for the development of Coastal Resilience Plans and a policy shift toward a preference for non-structural solutions. Overall costs would be low, provided supporting recommendations on data acquisition and mapping are completed, compared to the costs of inaction.

B. Assistance in Funding Measures to Reduce Risk

Direct public investment, programs and policies to assist regional, county, and/or local planning offices in coastal areas to implement the risk-reduction measures outlined in approved coastal resilience plans.

Potential Cost

In the last five years, New York State spent more than $22.6 million in projects to protect public infrastructure, and commercial and residential property in high-risk coastal areas from erosion and flooding. Tens of millions of dollars are being allocated for coastal protection structures in the coming decades. Funding for these types of projects should be redirected over time to reduce vulnerability in coastal communities and support non-structural measures that will reduce long-term risk from coastal hazards with minimal ecosystem impact.

Timing of implementation

Modification of State coastal policies and programs to advocate and support preparation of coastal resilience plans should be proposed in the near term. Other planning supported by the State or involving State facilities or infrastructure should be coordinated with coastal resilience plans. Specific criteria that should be addressed in coastal resilience plans and the standards by which such plans would be evaluated for completeness should be identified. Plan preparation will take time and should be started as soon as possible. It will take a minimum of 2- 5 years for the first coastal resilience plans to be prepared after they are initiated. The completion of plans in all of the coastal areas of New York State would take several years depending on the commitment of funding.

Environmental Justice Considerations

Less affluent communities and individuals will have difficulty finding adequate resources to develop coastal resilience plans. Lower income community members in low-lying coastal areas may also have more at stake than, for example, second-home owners on the coast, and less time and resources to devote to participating in local planning efforts, and their needs may be overlooked if they don't have adequate representation. Assistance for developing plans, adapting public infrastructure and facilities, and addressing the needs of private low-income property owners is needed. Incentives should ensure participatory planning in low-income communities.

Co-benefits and Unintended Consequences

- Community planning for sea level rise will help identify critical development, infrastructure, and natural resource assets for risk management.
- Planning to reduce sea level rise impacts is more likely to secure natural resources than individual or uncoordinated actions in response to storm events as they occur. It is also possible that mapping of natural resources and systems will improve as a result of regional planning.
- Vacated lands could be converted to public-access points with broad community benefits.

- Allowing natural features to migrate and adjust to changing conditions via natural processes (breaching, washover, migration, etc.), unhindered by development improves their long-term survivability and flood-protection benefits to communities.

Recommendation 5. Develop a long-term interagency mechanism to regularly evaluate climate change science; set research priorities to foster adaptation; coordinate programming, regulatory, and funding actions; and assess progress in adapting to climate change and sea level rise

A permanent mechanism is needed to ensure interagency and multi-organizational coordination; to review projections of the anticipated impacts of climate change on a regular basis following the IPCC schedule (roughly every 5 years); to develop priorities for federal, State, and local research and policy and regulatory initiatives to respond to climate change; and to oversee progress in Council-recommended policy implementation, including the recommendations of the SLRTF and the ClimAID statewide impacts assessment. Prioritized recommendations for federal policy changes should also be developed since federal programs and policies often contribute indirectly to increasing or maintaining risk. Opportunities for regional coordination should also be investigated. The creation of a New York State Climate Science Institute would greatly assist these efforts.

With broad support at the executive level this recommendation could be highly effective at addressing state management of resources. Effective interagency communication would reduce duplication of efforts, allow expression of a broad range of perspectives on challenges, and a pool of resources and strategies to address them, and would provide a structure for policy adjustments, improving resiliency as new and better information becomes available.

Potential cost

Agencies will require staff to organize the interagency effort and advance these recommendations, develop products and disseminate information, and facilitate integration of new policies and programs into agency operations. Funding will be needed to monitor climate, impact, and adaptation indicators.

Timing of implementation

Action is needed immediately to advance agency coordination, initiate discussions with partner agencies, and establish information priorities. This recommendation could be implemented within 2 years.

Environmental Justice Considerations

Groups or communities with the least economic resources will be disproportionately affected by climate change because they are most likely to be living in more vulnerable areas and living in less durable homes, and have the least personal resources to enable them to adapt. The proposed interagency work group could offer a forum to discuss environmental justice issues and potential solutions, identify long-term funding so advocates for environmental justice can participate, and provide a venue for addressing related needs in state agency operations.

Co-benefits and Unintended Consequences

True interagency coordination on climate change would have an enormous benefit to regional and local governments. Regulated entities in the coastal zone must deal with an array of uncoordinated agency funding and regulatory programs that can confuse even the most seasoned of local officials. Consolidation of policy and regulatory priorities, funding programs, and technical assistance, and integration across agencies, could conserve both state and local resources and tax dollars. At a minimum, the interagency group offers an opportunity for State agencies to present unified information concerning climate change and sea level rise and a forum for two-way communication with communities and community groups on climate change adaptation needs. If climate change projections, and protective policies and regulations are not adopted to reduce vulnerability in high-risk coastal areas, New York State could incur significant long-term costs into the billions of dollars and increased risk to life and property.

Ecosystems

Vision Statement

Ecological systems will continue to sustain healthy, diverse, well-distributed and abundant populations of fish, wildlife, plants, and human communities that are adapted to survive and thrive in a world impacted by unprecedented and accelerating climate change.

Background

New York State covers an area of 54,077 square miles, including 47,047 square miles of land, 1,894 square miles of inland lakes and rivers, and 3,988 square miles of the Great Lakes. Variations in topography and in proximity to bodies of water cause large climatic variations and distinct ecological zones that support the complex web of biological diversity and provide important ecosystem services.

Valuable ecosystem services provided by New York's landscapes include harvested products (food, timber, biomass, and maple syrup), clean water and flood control, soil conservation and carbon sequestration, biodiversity support and genetic resources, recreation, and preservation of wild places and heritage sites. New York's ecosystems recharge groundwater supplies and reduce soil erosion by creating catchments that enhance rainwater infiltration into soils as opposed to allowing rapid runoff of storm water into streams. The healthy vegetation of landscapes helps to stabilize and conserve soils, and also sequesters carbon above ground in the standing biomass of trees and perennial plants and below ground in the form of roots and soil organic matter. The diverse flora and fauna supported by New York landscapes play a role in maintaining earth's biological heritage, and the complex interactions among species benefit society in many ways, such as natural control of insect pests and disease. Genetic diversity will be essential for the natural adaptation of ecosystems to environmental stresses such as high temperatures and drought that will be exacerbated by climate change. In addition, genetic diversity has potential economic value in the search for new pharmaceuticals or organisms or compounds with biotechnology applications.

Ecosystems, as defined here, encompass the plants, fish, wildlife, and resources of all natural and managed landscapes (e.g., forests, grasslands, aquatic systems) in New York State except those land areas designated as agricultural or urban. This sector includes timber and maple syrup industries, and tourism and recreation businesses conducted within natural and managed ecosystems. It also encompasses interior wetlands, waterways, and lakes as well as their associated freshwater fisheries and recreational fishing.

The impacts of climate change cannot be viewed in isolation, as other stressors are also affecting ecosystems and will affect vulnerability to climate change. While society and policymakers are likely to focus on ecosystem services, adaptation interventions by natural resource managers often will be implemented at the level of species, communities and habitats. As climate changes and the habitable zones of wild species continue to shift northward and/or up in elevation throughout the century, natural resource managers will face new challenges in maintaining ecosystem services and difficult decisions regarding change in species composition.

Climate Impacts

The initial impacts of climate change on species are already apparent, with documented accounts of changes in the seasonal timing of events like bud-break or flowering and species range shifts across the Northern Hemisphere. Within the northeastern United States, researchers have documented earlier bloom dates of woody perennials, earlier spring arrival of migratory birds, and other biological and ecological responses. Species and ecosystems are responding directly to climate drivers and indirectly to secondary effects, such as changes in timing and abundance of food supply, changes in habitat and increased pest, disease and invasive species pressure. Ultimately, biodiversity, net primary productivity, vegetation water use, and biogeochemical cycles could be affected by climate change. To date, however, there is no unequivocal evidence of climate change impacts on ecosystem services such as carbon sequestration or water storage and quality in New York State. The certainty in projecting climate change impacts diminishes as projections are scaled up from individual species and ecosystem structure to ecosystem function and services.

Within the next several decades New York State is likely to see widespread shifts in species composition in the state's forests and other natural landscapes, with the loss of spruce-fir forests, alpine tundra, and boreal plant communities. Warmer temperatures will favor the expansion of some invasive species into New York, such as the aggressive weed, kudzu, and the insect pest, hemlock woolly adelgid. Some habitat and food generalists (such as white-tailed deer) may also benefit. Additionally, higher levels of CO_2 tend to preferentially increase the growth rate of fast-growing species, which are often weeds and other invasive species. Both of these climate factors could also increase the productivity of some hardwood tree species, provided growth is not limited by other factors such as drought or nutrient deficiency.

Lakes, streams, inland wetlands, and associated aquatic species will be highly vulnerable to changes in the timing, supply, and intensity of rainfall and snowmelt, groundwater recharge, and duration of ice cover. Increasing water temperatures will negatively affect brook trout and other native coldwater fish.

Recommendation 1. Continue to support and maintain the Invasive Species Task Force, Invasive Species Council, Invasive Species Advisory Committee, and Partnerships for Regional Invasive Species Management (PRISMS) and support the implementation of the recommendations of the Invasive Species Task Force.

Invasive species pose a serious threat to the state's environment and economy, and these threats are exacerbated by the threat of climate change. Through the creation of the Invasive Species Task Force, New York State has taken proactive steps to address the spread of aquatic and terrestrial invasive pests and pathogens and to ensure state agencies, NGOs, businesses, and researchers are coordinated in their efforts to control this threat. In order for the state to be properly prepared to rapidly respond to emerging invasive species threats from a changing climate, investments must be made to implement the recommendations of the Invasive Species Task Force (ISTF).

The Invasive Species Council (ISC) has been established through legislation to continue the coordination of invasive species management across the state, enacting an important recommendation of the ISTF. In addition, the Invasive Species Advisory Committee has been formed and is helping to coordinate the broader efforts of outside partners and to provide important recommendations to the ISC. Both of these committees should be continued and supported to ensure that these important efforts continue. As these efforts progress, the state should ensure the federal government, neighboring states, municipal leaders, and NGOs are active participants in mitigation and response efforts. The continuation of the PRISM is an important way to achieve that coordination.

The ISC recently completed a final report on development of a regulatory system for non-native species that would prevent the importation and/or release of certain non-native species into the state and regulate the importation and sale of other invasive species. The recommended system would create the first official lists of invasive species for New York State. The recommendations in this report should be enacted, and an official regulatory system that would prevent future introductions of invasive species should be established.

As rapid response plans are developed and implemented to address emerging threats, these plans must include specific steps and funding to remediate the damage caused to the affected ecosystems. This will ensure that native ecosystems are healthy, productive, and resilient in the face of climate change. Also, all such invasive species response and management efforts must be coupled with a strong public outreach effort that educates and engages private landowners and the public on these restoration efforts.

Potential Cost

Aquatic and terrestrial invasive species cost the state and businesses millions of dollars to control and in lost productivity, and these costs will increase as climate change causes a wider distribution of invasive species. Although the continued operation of the Invasive Species Council and Invasive Species Advisory Council has minimal costs associated with it, the implementation of the recommendations could be quite costly. However, when the recommended actions are considered as preventative measures, and the costs of no action are included in the

cost determination, it is likely that the cost of prevention is much smaller that the impact of no action. A discussion of this is included in the ISTF report.

Timing of Implementation

Near-term, as the impact is currently being experienced and must be addressed. Since it is hard to predict exactly which invasive species on the horizon will impact New York's ecosystems, investing in the creation of a rapid response plan is critical to the capacity to address emerging invasives that may take 10-20 years to enter the state.

Environmental Justice Considerations

The spread of certain pests and pathogens, e.g., West Nile virus, is increasing and lower income communities may have fewer resources available for prompt and effective treatment. However, by proactively controlling invasive species, impacts to these communities can be reduced. There are opportunities to coordinate with adaptation recommendations from the public health sector.

Co-benefits and Unintended Consequences

By investing in the control of invasive species now, the state will realize improved agricultural health and output, improved public health, improved water quality, improved ecosystem resilience, and improved habitat value for species. However, these control measures may potentially increase costs of transportation of goods in the state and increase costs for certain recreational activities such as boating and fishing.

Recommendation 2. Ensure that New York State's ecosystems sustain healthy, diverse, well-distributed, and abundant populations of fish, wildlife, plants, and human communities that are adapted to survive and thrive in a world impacted by unprecedented and accelerating climate change.

Specific Actions

A. Support State agency efforts to incorporate an ecosystem-based management approach that factors ecosystem function, services, and biodiversity into decision making, including management plans, funding decisions, and policies.

Established as the result of the 2006 New York Ocean and Great Lakes Ecosystem Conservation Act (Act), the New York Ocean and Great Lakes Ecosystem Conservation Council (NYOGLECC) has a goal of integrating ecosystem-based management (EBM) and smart-growth principles into state programs that manage human activities affecting ocean and Great Lakes ecosystem health[3]. Much of New York State's response to climate change would benefit from an ecosystem-based management approach, as developed through the above initiative, and should be applied on a statewide basis.

[3] See Draft Summary Report of Agency Guidelines and Recommendations. http://nyoglecc.org/reports.html

Potential Cost

Continued NYOGLECC activities are being undertaken within existing agency operating budgets. Several council agencies are incorporating EBM principles into their respective organizational structures without significant additional cost or creation of new programs.

Timing of Implementation

EBM integration underway for State agency decision making has multiple timelines. Overall, NYOGLECC has advanced or completed priority recommendations on schedule according to its 2009 report. Continuation of this work is critical to developing additional momentum within the NYOGLECC member agencies as well as to the expansion of the concept to other agencies and broader regional entities and organizations.

Environmental Justice Considerations

An ecosystem-based management approach, by definition, includes the human component of the ecosystem as an integral part of the planning process. Environmental justice communities in New York State's coastal areas are particularly susceptible to many of the projected impacts of climate change, and an EBM approach will help to provide comprehensive solutions that target environmental and human needs. EJ communities must be involved with the planning and decision making from the start.

Co-benefits and Unintended Consequences

An EBM approach leads to greater efficiencies and effectiveness in the application of government funds to advance ecosystem goals and specific projects.

B. To enable ecosystems to better respond to changing climate conditions, incorporate adaptive-management principles, techniques, and approaches into New York's forest-management policies and programs.

The State of New York manages more than 775,000 acres of state forests recognized for sustainable management by the Forest Stewardship Council and the Sustainable Forest Initiative. The State holds conservation easements on an additional 700,000 acres, some of which is managed for timber production. On these lands the state should develop forest best management practices (BMPs) for adaptation to climate change and management for carbon sequestration. These BMPs could also be used by private forestland owners, who own the majority of the state's 18.5 million acres of forests.

Potential Cost

While funding for the research component of this recommendation would be substantial, little of the cost would fall on the State of New York. The benefits of the research would be applicable over the northeastern states that share common forest types; therefore, probable sources of funding would be those traditionally used by the academic research community (e.g., National Science Foundation, Environmental Protection Agency, U.S. Forest Service).

The Department of Environmental Conservation already manages 768,000 acres for timber production. Therefore, the costs of giving priority to management practices that maintain

the resiliency of forests stressed by climate change would be minimal. Rather, it requires a redirection of management objectives. Additional costs would be necessary in the demonstration component of this recommendation. This could be accomplished by adding four demonstration foresters to the DEC staff located across the state. An alternative approach would be to enhance Cornell University's Cooperative Extension Service by an equivalent amount. The estimated cost of this would be approximately $500,000 per year, including salary, travel, and operating expenses.

Timing of Implementation

The impact of changing forest practices is measured in decades, not years. Therefore, it is important to implement BMPs immediately to realize the carbon benefits of forest management that would occur by mid-century. The demonstration portion of this recommendation should begin in 2011 using the best information available on the influence of climate change on forests and on carbon storage and sequestration. At the same time, the demonstrators would be emphasizing the flexibility associated with adaptive management practices so that adjustments in forest management could be made as more research becomes available or as landowner objectives change.

Environmental Justice Considerations

There is little impact on environmental justice in the traditional use of the term. However, it is important to point out that average incomes in rural areas are, on average, lower than in urban areas.

Co-benefits and Unintended Consequences

Forests play an intriguing role in climate change in that the composition of forests are likely to change if there is significant climate change, while at the same time they can play a role in mitigating the impacts of climate change. A related issue is the potential for woody biomass as a substitute for fossil fuels as an energy source. The potential for solid fuels in the form of pellets, gasification as a source of heat and electricity, and liquid fuels such as ethanol is in its infancy but will likely grow. Thus, the combination of impacts of climate change on forest composition, the potential for improved carbon sequestration and storage, and the potential for forest products as a source of energy that may be more carbon neutral than fossil fuels is of high priority.

C. Protect and enhance the stability and function of stream, river, and aquatic coastal systems to accommodate changing climate conditions.

Safeguarding the integrity and increasing the resilience of stream, river, and aquatic coastal systems and associated wildlife corridors will greatly bolster the capacity of fish and wildlife to meet the many challenges of climate change. The following four inter-related strategies will address this goal:

- Maintaining and improving aquatic habitat connectivity by removing or mitigating man-made aquatic barriers including culverts, dams, and shoreline armoring;

- Increasing the protection for in-stream habitat features such as cold-water refugia, oxygen-rich riffles and runs, and natural shorelines with undercut banks and overhanging vegetation;
- Removing pollutants, including heat, from runoff entering water bodies;
- Maintaining hydrologic flows consistent with the needs of fish and wildlife and the functions of streams and rivers.

Shoreline corridors provide effective means of movement and dispersal of fish and wildlife. As such, they enable species to adjust their ranges in response to changing climate and environmental conditions. Much of the landscape is fragmented with human development, including subdivisions, roads, and commercial and industrial development. On the coast many shorelines are armored, preventing habitats like tidal wetlands from responding to sea level rise. This inhibits the ability of many species to adjust their ranges. However, New York has a rich and widely distributed network of streams and rivers. Providing shoreline buffers to coastal, stream, and river systems can provide the "transportation" system for fish and wildlife—both aquatic and terrestrial—to move on the landscape and establish new ranges in response to climate change.

Potential Cost

Protecting and restoring shoreline buffers will be a highly cost-effective strategy. Regulatory programs that protect existing buffers would require staffing. Although not inexpensive, these efforts are cost effective because they maintain existing habitats, offer a wide array of additional social and environmental benefits, and prevent other societal costs (e.g., addressing the effects of flooding along stream corridors). Incentive programs that pay to restore or protect shoreline buffers would vary in cost depending on the nature and magnitude of the restoration required.

Timing of Implementation

Adopting policies to protect and restore buffers should be undertaken immediately; it is a no-regrets action that has both short-term and long-term benefits. Buffers are already being restored in the state, so elevating this as a priority could result in very rapid implementation. This is a durable effort that could continue to restore additional buffers as future opportunities arise. Implementation of large-scale restoration programs would be a longer-term endeavor, with 86,000 miles of streams and rivers in the state, and 3000 miles of ocean and estuarine coastline, most of which have some degree of impact. It would be helpful to divide the state into priority watersheds and shoreline areas to concentrate initial attention and funding on the most critical areas.

Environmental Justice Considerations

This strategy would have positive impacts on all communities in the state, including EJ communities. Creating green space along shorelines and stream corridors improves the local environment and contributes positively to the quality of life in highly urbanized areas. Since the environmental justice community may have the least means to address the impacts of climate change, actions in environmental justice areas should be given high priority. Providing adequately sized road stream crossings such as bridges and culverts will

significantly decrease the frequency and severity of flooding at these key junctures, improving safety for the traveling public and residents alike. Conserving the natural processes of tidal wetlands, dunes, and barrier islands can also contribute to coastal flood protection from strong storms.

Co-benefits and Unintended Consequences

The co-benefits of protecting and restoring riparian buffers are numerous: improved flood protection, improved protection of transportation infrastructure and surface drinking waters, improved water quality, increased availability of important habitats, increased property values, reduced threats of erosion (including to agriculture lands), improved public health, decreased costs of drinking-water treatment, decreased costs of farming, improved recreation opportunities, and reduced liability insurance premiums. Conversely, by protecting additional land adjacent to streams, there will be a somewhat reduced availability of developable or farmable land with perhaps a corresponding decreased tax base for local communities, although this probably would be offset by the reduced cost of infrastructure maintenance and improved quality of life benefits.

Recommendation 3. Develop a research and monitoring plan to detect, record, and analyze changes in species, habitat composition, natural cycles, and fish and wildlife health, and effectively address current and future threats in changing climate conditions.

To effectively manage the natural resources of New York State, practitioners must understand the baseline condition of species, habitats, and population trends. Rapidly changing climate and associated changes in habitats and ecological community structure will likely increase fish and wildlife exposure to stressors (both existing and those caused by climate change), compromise their ability to adapt to stress, and affect the ability to detect harmful trends in fish and wildlife ecology and health. An increase in the capacity to identify key stressors is needed to inform management decisions and abate threats. Assessments of species' and habitats' climate vulnerabilities, including exposure sensitivity and adaptive capacity, should be used to prioritize conservation actions.

The information from baseline condition surveys, stressor identification, and vulnerability analyses will directly inform the development of a research and monitoring plan for New York. Such a plan should be based on explicit, predictive, and measurable objectives and indicators, and include monitoring protocols that can reliably detect signs of climate change impacts.

Potential Cost

Developing a research and monitoring plan will not be of extremely high cost and can most likely be done with current staff *if prioritized*. On the other hand, implementing the plan will have high start-up costs and will be fairly labor-intensive. This is a primary reason why most New York entities have not conducted whole-scale resource monitoring to date, though there are exceptions.

Inaction on this recommendation is far more costly to society and ecosystems in the long term than is implementation. Sound science forms the basis of effective adaptation strategies in

response to expected impacts from climate. In addition to the loss of ecosystem services gained directly and indirectly from nature, New York also stands to lose tens of millions of dollars annually from various grants and federal funding if it cannot demonstrate effectiveness of its conservation actions..

Timing of Implementation

The advent of climate change has increased the need for, and urgency of, developing and implementing a monitoring plan.

Environmental Justice Considerations

This recommendation would provide benefits across the state and all communities. Science-based projections of future conditions and vulnerabilities will assist in identifying communities most at risk, result in more efficient state spending and reduce long-term risk.

Co-benefits and Unintended Consequences

The research and monitoring detailed above will assist in incorporating adaptive-management principles into New York's natural resource management programs, protecting the stability and function of stream and river systems, developing and implementing an education and outreach strategy, and protecting and managing important migratory and dispersal corridors. To be effective, all of these activities must be based on sound science. This recommendation will also increase partnering efforts, maintain and leverage funding, help prioritize conservation actions, and maintain critical ecosystem services.

Conversely, by allocating staff time and dollars to research and monitoring, other management programs may be negatively affected in the short term. This will most likely be offset by greatly informing future management efforts to achieve the most cost-effective conservation actions.

Recommendation 4. Expand climate change education and outreach initiatives for students, landowners, and local governments. Include sound scientific information on the potential impacts of climate change on natural areas and ecosystem services.

Developing outreach and education mechanisms based upon up-to-date and reliable climate change data is a necessary component of the Climate Action Plan and the State's Climate Smart Community Program. Climate change education should be a component of general science curricula, and teachers across New York State and at all levels should be provided with reliable scientific information and have access to a suite of curriculum materials, including study lessons and student activity plans related to climate change.

On-the-ground and accessible demonstration sites reinforce climate education initiatives. The State should seek to secure funding and incentives for environmental educators to develop interpretive materials and assist schools in climate change education. Further, the State should encourage all agencies with programs related to education, resource management, and community planning to develop materials and displays that demonstrate the impacts associated with climate change and the role of each agency in the mitigation of these impacts.

Education and outreach to private landowners and land managers are critical to advancing on-the-ground climate-smart land management practices. State agencies involved in resource management should provide landowners and local governments with information on climate-smart BMPs related to planting climate resilient species, stochastic event planning, and optimizing wildlife habitat, managing riparian buffers, and controlling invasive species. Expanding and focusing current community technical assistance efforts to include standardized climate-smart BMPs is one way to expand education and outreach mechanisms to landowners and land managers across New York State.

Potential Cost

The costs of integrating climate education modules into general science curriculum standards are varied and long-term, and depend largely on the needed course materials relative to the level of training. The cost to New York State agencies to construct and implement climate demonstration sites and projects is immediate and short-term, but as learning sites for students and citizens would yield long-term benefits. The costs associated with expanding outreach to landowners and local communities may be offset substantially by effective coordination of non-governmental and state technical assistance initiatives.

Timing of Implementation

For New York State to successfully meet current and future challenges associated with climate change, education and outreach policy and mechanisms must be implemented immediately. Currently, there are successful efforts being undertaken across New York State; however, these initiatives must be expanded to adequately prepare New Yorkers for the myriad of impacts associated with climate change. Education and outreach to students, landowners, and local communities will require ongoing strategies, immediate implementation, and long-term resolve.

Environmental Justice Considerations

Education and outreach activities should be multi-lingual and multi-cultural, and include input from environmental justice communities as to the most effective means of communication.

Co-benefits and Unintended Consequences

The co-benefits associated with efficient education and outreach of students, landowners, and local communities are vast and varied. They include improved land management practices on private lands; expanded community energy efficiency, development, and planning initiatives; increased locally conserved lands; expanded green-technology workforce; clean-energy innovation; constituent support for environmental policies; increased wildlife habitat suitability as a result of changing land management practices; and increased wildlife habitat connectivity. Unintended consequences associated with pursuing dynamic goals include effort fragmentation resulting in inefficiency, complex delivery mechanisms that reduce effectiveness, and cross-effort redundancy. Progress metrics must be clearly established upon policy and mechanism implementation due to the ongoing nature and qualitative components inherent to many education and outreach initiatives.

Energy

Vision Statement

Ensure that the energy generation and delivery infrastructure throughout the state will prepare for, and adapt to, a changing climate by building system resilience, while providing the public with clean, safe, and reliable services.

Background

Energy is derived from a wide variety of fuel sources and technologies in New York State. Roughly 49 percent of the state's electricity is generated in-state using fossil fuels; nuclear power (30 percent) and renewables (21 percent) account for the balance. The generation mix varies widely in different parts of the state. The state's annual electricity load has increased by about 4.3 percent per year. New York City is by far the largest load zone in the state, responsible for approximately one-third of total annual electricity demand statewide

Thermal energy needs are satisfied in a variety of ways. New York State is home to more than a dozen district energy systems, which centrally generate steam, hot water, or cold water and distribute it to customers via a series of underground pipes. Natural gas and heating oil are the most commonly used sources of heating fuel in buildings around the state.

Reliable energy systems are critical to commerce and quality of life. New York State's electricity and gas supply and distribution systems are highly reliable, but weather-related stressors can damage equipment, disrupt fuel supply chains, reduce power plant output levels, or increase demand beyond the energy system's operational capacity.

Climate Impacts

Global climate change is expected to alter both average climate and the frequency and intensity of extreme weather events in New York State, affecting energy demand, system efficiency, and power supply potential. In certain cases, climate change may help New York's energy system function more smoothly, by eliminating weather-related supply chain problems through milder winter weather in some areas for example. However, climate change is more commonly predicted to adversely affect system operations, increase the difficulty of ensuring supply adequacy during peak demand periods, and exacerbate already-problematic conditions, such as the urban heat-island effect.

Impacts of climate change on energy demand are likely to be more significant than impacts on supply. Decreases in heating demand will primarily affect natural gas markets, while increases in cooling demand will affect electricity markets; such changes will vary regionally.

On the supply side, more frequent heat waves will cause an increase in the use of air conditioning, stressing power supplies and increasing peak demand loads. Increased air and water temperatures will affect the efficiency of power plants. Transformers and distribution lines for both electric and gas supply are vulnerable to extreme weather events, temperature, and

flooding. Coastal infrastructure in downstate areas is vulnerable to flooding as a result of sea level rise and severe storms.

Renewable generation may also be affected. Hydropower, located primarily in upstate areas, is vulnerable to drought and changes in precipitation patterns. The availability and reliability of solar power systems are vulnerable to changes in cloud cover, although this may be offset by advances in technology; wind power systems are similarly vulnerable to changes in wind speed and direction. The effect of climate change on biomass as an energy feedstock is unclear, though biomass availability depends to some degree on weather conditions during the growing season.

The indirect financial impacts of climate change may be greater than the direct impacts of climate change. These indirect impacts include those on investors or insurance companies linked to vulnerable energy system assets or on customers forced to grapple with changing energy prices resulting from changing climate conditions.

Recommendation 1. Ensure the accuracy of electric demand and peak demand forecasting for planning purposes and build resilience for meeting peak demand.

Currently, forecasts of long-term energy use and peak demand are based on historical use of electric and gas utilities. Forecasts do not currently reflect the energy requirements that would result from changes in temperature or greater occurrences of heat events anticipated in the future resulting from climate change.

Specific Actions

A. Incorporate best available projections of changes in seasonal average temperatures and increased frequency of extreme heat events in near- and long-term demand forecasting for electricity and natural gas.

Peak demand forecasts in particular should be revised to incorporate predicted higher seasonal average temperatures and increased frequency of extreme heat events. These climate impacts will likely result in increased energy use and/or increased reliance on demand response, energy storage, and other energy resources to meet peak demands.

B. Plan to meet regional demand growth and improved system resiliency through local implementation of demand response and energy efficiency measures, greater use of localized distributed generation, energy storage, other energy-supply technologies, and smart-grid technologies, beyond those efforts already underway and planned.

The current regulatory and planning frameworks should be made more flexible and adaptable to a rapidly changing climate and related adaptation and mitigation efforts and accommodate new and emerging technologies more quickly to meet emerging needs.

Impacts/Vulnerabilities Addressed

Higher seasonal average temperatures and greater frequency of heat events will contribute to transmission line sags and to increased energy demands, possibly resulting in additional stress on distribution transformers. Energy-demand forecasts are already implemented to ensure that

regional distribution capacity exceeds projected peak-load demand, thereby ensuring reliability of energy services. The regional load-planning process is an appropriate location for integrating temperature increases into demand forecasts, because problems with reliability will have disparate impacts based on where people live (e.g., urban heat islands). Furthermore, identification of energy efficiency and renewable distributed generation opportunities through this process can decrease the need to build additional distribution infrastructure. Planning for long-term increases in temperature will result in a more holistic approach to balancing the costs between distribution infrastructure and demand-reduction opportunities.

Energy demand will be impacted heterogeneously throughout the state. Some distribution systems will be impacted more than others, depending on regional characteristics. Rural areas could likely be impacted to a lesser extent than urban areas where there is a measurable heat-island effect.

Potential Cost

This recommendation calls for more effective planning and for incorporating projected temperature changes into demand forecast modeling. Doing so may add to the complexity of forecasting, but the increase in costs should be minimal. Identifying load conditions under high-temperature scenarios will facilitate more accurate cost/benefit comparisons between options for delivery infrastructure and for demand-reduction.

Timing of Implementation

Near-term: Incorporation of temperature increases into regional long-term load planning should begin at next opportunity (2-5 years).

Environmental Justice Considerations

There is concern over localized impacts of energy use and a desire to ensure that reductions in energy use result in localized emission reductions that improve regional air quality, including opportunities associated with peak-demand generation units. Better regional demand forecasting and planning can protect overburdened communities by accurately projecting future infrastructure requirements and identifying new sources of power or energy savings that reduce emissions for EJ neighborhoods by siting these facilities elsewhere, distributing the negative effects of power production, or reducing the need for operating those units presently located in or near affected communities, while maintaining electric system reliability.

Recommendation 2. Increase utilities' and energy providers' resiliency to climate-related impacts.

Climate models predict that higher ocean and atmospheric temperatures will contribute to the addition of energy to the global hydrologic cycle. As a result, it is predicted that New York State and the northeastern United States will experience more frequent and intense storm events. Higher wintertime temperatures may also contribute to more frequent ice storms. Electric outages that resulted from the March 2010 nor'easter storm in downstate New York demonstrated that heavy of precipitation coupled with high winds can be damaging to the electric transmission and distribution system. Many utilities in the southeastern United States operate in areas where high-energy storms occur. The exchange of risk-management criteria between

southeastern and northeastern utilities helps to establish the best management practices that maintain reliability at the lowest achievable cost and should continue.

Specific Actions

A. Ensure that best available projections concerning the frequency and severity of extreme storm events are incorporated into State and regional emergency response plans.

State and regional emergency response plans should continue to work with a spectrum of stakeholders including utilities, first responders, community organizations, and individual households to gather necessary information, share it effectively, and use it to continuously improve emergency preparedness.

B. As part of a statewide vulnerability assessment and planning effort, ensure that detailed statewide maps are available to assist in identifying areas and infrastructure at high risk from storm and flood damage.

Energy infrastructure includes electricity generation, transmission, substation, and distribution facilities; interstate natural gas pipelines, storage facilities, compressor stations, and local distribution systems; propane facilities; and transportation and storage systems for a wide range of petroleum products (including pipelines, large and small-scale storage tanks, barge and rail operations, and various transfer facilities). Development of inventories of this infrastructure and potential vulnerabilities to climate change is critical to prioritizing protection of existing facilities.

C. Work with organizations such as the Electric Power Research Institute (EPRI) and NYSEARCH (a voluntary sub-organization within the Northeast Gas Association) to survey and assess utility industry best practices for increasing resilience to climate change.

Development of effective protocols and procedures for considering climate change-related risks in decisions to locate, design, and build energy infrastructure, both to maintain the reliability of existing systems and to meet the future energy needs is important. To incorporate innovations and best practices in climate adaptation, the State energy- planning process should evaluate strategies and techniques employed by utilities, regulators, and independent power producers regionally, nationally, and internationally. This evaluation process would examine the appropriateness of strategies and techniques for particular regions in the state.

Impacts/Vulnerabilities Addressed

Outages on the electric distribution system during storm events can limit delivery of health care and emergency services, banking, commerce, and air conditioning, heating, communication, and transportation pathways. Currently, no central resource to identify areas of the state most likely to experience one or all of the possible impacts exists. Recommendation 2.B. calls for a centralized state mapping system to document the areas of high risks of weather-related damage to infrastructure. This information will inform utilities and the Public Service Commission (as well as other infrastructure-owning stakeholders) about which areas are most susceptible to

wind-tunnel effect, flooding, ice formation, erosion and other impacts from major storm events and which factors should be addressed in their infrastructure's risk assessments.

Differences in the manner in which infrastructure will be impacted by major storms across the state is a primary reason for identifying infrastructure risk through a central mapping program. Some distribution systems are more likely to be impacted by coastal storms from mid to late summer, whereas others are more likely to be impacted by severe snow and/or ice storms in the winter. Some utilities will also be susceptible to both types of storm events. Differences in regional characteristics will be a determining point for benchmarking.

Potential Cost

It is assumed that utilities and generators will upgrade their infrastructure to more resilient equipment as storms events become more frequent as a result of climate change. This set of recommendations seeks to minimize the cost of this process through analysis, climate forecasting, and benchmarking. Specifically, the cost of building resilience to climate change can be minimized or avoided if infrastructure is prioritized and triaged based on compelling long-term benefits and/or risk reduction (e.g., avoiding significant outages).

Timing of Implementation

Near to mid-term (10 years): Planning for and coordinating greater communication among emergency responders, utilities, and their customers, and independent power producers should proceed on an ongoing basis. Tracking infrastructure damage caused by storm-related incidents, initiating benchmarking between utilities, and developing best-management practices should be completed within the next 5-10 years.

Environmental Justice Considerations

During periods of storm activity, fuel and electric distribution can be compromised, as can communication pathways. Currently, utilities maintain records and prioritize restoration of services for individuals with home health care needs, emergency service providers, and hospitals. A significant or serious public health problem could arise if both electric power and communication networks are compromised at the same time. Leading up to and preceding large storm events, communicating with this at-risk population will be a critical and necessary public health concern. Communication efforts should be multi-lingual.

Public Health

Vision Statement

Begin planning now to protect and promote public health by reducing individual and community vulnerability to the potentially significant public health consequences of climate change.

Background

A diverse state, with populations spread unevenly over urban and rural service areas, New York is one of 26 states that rely primarily on a county-based system for public health service delivery. Local health departments operate under the authority of either the county legislature or local board of health. The result is a highly decentralized system with a non-uniform provision of core services. For example, local health departments provide environmental health services in 37 out of New York's 62 counties, while the State Department of Public Health provides service to the other areas. The New York State Public Health Council has identified this decentralization of public health service delivery as a key obstacle to efficient coordination of programming and data resources for climate-health preparedness. The Council has recommended regional, multi-county initiatives, which are proven models for more efficient and equitable distribution of expertise and services.

In an effort to improve health care provision, in 1996 New York State initiated a data and knowledge communication program linking a wide range of partners, including hospitals, local health departments, nursing homes, diagnostic centers, laboratories, insurance provider networks, and federal agencies. Current communication networks—Health Alert Network (state and city levels), the Health Provider Network, and the Health Information Network—are viewed as "both very helpful and very underutilized" by the Public Health Association of New York City. However, as a result of non-standardized data systems, the value of these networks across user groups is compromised. These would be appropriate organizations to target for climate-health educational outreach and to evaluate climate-health interventions.

Some current health conditions are considered potentially sensitive to the changing climate. Cardiovascular disease is the leading cause of death in the state and is made worse by extreme heat and poor air quality. Childhood asthma is an important current health challenge in many parts of New York State, especially in the five counties that comprise New York City, and is made worse by poor air quality. New York State has experienced the emergence of several vector-borne diseases (those spread by carriers such as mosquitoes and ticks) in the past few decades.

Climate Impacts

Climate change vulnerabilities in the public health sector are, to a large extent, those in which public health and environmental agencies are already engaged. However, climate change places an additional burden on public health agencies that are already burdened by low levels of staffing and funding. Climate-related risk factors include heat events, extreme storms, disruptions of water supply and quality, decreased air quality, changes in timing and intensity of pollen and mold seasons, and alterations in patterns of infectious disease vectors and organisms. Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change.

As a result of these climate risks, some climate-related health vulnerabilities have emerged. Heat-related illness and death are projected to increase, while cold-related death is projected to decrease. Increases in heat-related death are projected to outweigh reductions in cold-related death. Cardiovascular and respiratory-related illness and death will be affected by worsening air

quality, including more smog, wildfires, pollens, and molds. Allergy and asthma cases are projected to increase and become more severe.

Vector-borne diseases, such as those spread by mosquitoes and ticks (e.g., West Nile virus), may expand or their distribution patterns may change. Water- and food-borne diseases are likely to increase without adaptation intervention. Water supply, recreational water quality, and food production will be at increased risk due to increased temperatures and changing precipitation patterns.

More intense storms and flooding could lead to increased stress and mental health impacts, impaired ability to deliver public health and medical services, increased respiratory diseases such as asthma, and increased outbreaks of gastrointestinal diseases.

These vulnerabilities span a range from the relatively direct, data-rich, and well understood to more complex, multi-factorial systems for which both data and models are currently underdeveloped. Uncertainties pervade any effort to predict either direct or indirect health impacts of climate change. These uncertainties increase the importance of building resilience into the public health system to cope with inevitable surprises to come. Vulnerability assessments combined with a full accounting of uncertainties will help in prioritizing climate-health preparedness plans, informing communities on which actions should be taken first which information gaps are most critical to fill.

Recommendation 1. Improve or establish robust public health mechanisms to reduce the potential for heat-related morbidity and mortality in New York State.

Projections indicating that extreme heat events in New York State are likely to increase in frequency, intensity, and duration point to the need for mechanisms to reduce the potential for heat-related morbidity and mortality. These mechanisms include expanded outreach and education activities, assessment of the adequacy of existing heat warning systems and cooling center programs, working with utilities to address health needs associated with heat-related power outages, working with community-based organizations to provide assistance to vulnerable populations, and implementing a statewide plan to reduce the urban heat-island effect.

Specific Actions

A. Assess the adequacy of existing heat-warning systems and, as necessary, expand the capacity of existing cooling-center programs. For the latter, factors that should be considered include siting, potential transportation obstacles, effects of power outages or flooding, and other needs of vulnerable population/communities.

As heat-related climate events increase in frequency and severity, significant additional resources may be needed to prevent heat-related morbidity and mortality. A thorough assessment of existing systems and programs must be undertaken as soon as possible.

Potential Cost

State and local agencies will need additional staff resources to effectively implement this action. Other partners, such as academic researchers and community representatives, also may seek compensation for their efforts. Significant capital costs are likely to be associated with the siting of any additional cooling centers, relocating existing cooling centers, and with any necessary maintenance of cooling centers. Costs of staffing and operating some cooling centers and providing for public transportation to cooling centers also may be significant.

Timeframe for Implementation

New York State already uses systems to warn people about excessive heat. Therefore, while the recommended assessment of existing systems should begin in the near term, it has somewhat less urgency than some of the other recommended public health strategies and actions described in this section. Given the anticipated increase in the frequency and intensity of extreme heat events, work to begin expanding and enhancing cooling center programs should begin as soon as possible.

B. Enhance existing education and outreach activities, employing multilingual and culturally sensitive approaches and making use of appropriate media to increase awareness of the public health consequences of heat exposure and measures to avoid heat-related morbidity and mortality. Efforts should target particularly vulnerable populations.

Education and outreach may be the single most important way to reduce heat-related morbidity and mortality. To achieve effective awareness of heat-warning systems and use of cooling-center programs, efforts should be tailored to reach target audiences. Additionally, many vulnerable people lack personal mobility and may not be easily reachable via public-service announcements. Often they will be under physician care for chronic medical conditions; it may be effective to work with physicians and managed-care organizations to help get information to vulnerable patients, and to provide a communications link that those patients can use to call for help. Physicians and managed-care organizations might also be in the best position to identify those most vulnerable according to medical condition, language, and residential information (e.g., living on the top floor).

Potential Cost

One or more agencies should be provided with the necessary staffing resources to implement this action or be directed to reallocate existing resources. Additional costs will include those associated with publishing and distributing printed materials, purchasing space and time for commercial media message distribution (e.g., newspaper, radio, television) and social-networking media via the Internet, and necessary training (e.g., training of people to effectively deliver key messages).

Timeframe for Implementation

Implementation of this action should begin immediately upon adoption of a final Climate Action Plan, as heat-related illness and death are already a problem under current climate

conditions. Since outreach programs already exist, refinement or expansion of the efforts may be achieved relatively quickly.

C. Coordinate with utilities to develop an approach to address the public health needs resulting from power disruptions associated with extreme heat events.

A spectrum of stakeholders including state and local agencies, utilities, and community organizations must work together to identify the best ways to protect public health if heat events result in power disruptions. Local electricity generation resulting from demand response programs also can exacerbate poor air quality.

Potential Cost

It may be possible to accomplish initial planning efforts by redirecting existing resources. Possible costs associated with any necessary actions identified by the initial planning efforts are unknown at this time.

Timeframe for Implementation

Implementation of this action should begin as soon as possible.

D. Expand upon existing community-based volunteer networks and, as needed, establish additional networks to identify and assist vulnerable populations including senior citizens, people with impaired mobility, and people with limited English-language proficiency.

Volunteer efforts may be needed to augment outreach and education activities in order to better protect the most vulnerable populations in climate-related emergency situations. Volunteers would need climate change education and awareness training. Such networks could become part of existing community-based emergency preparedness activities.

Potential Cost

See 1-B above.

Timeframe for Implementation

See 1-B above.

E. Develop and implement a statewide "Green Cool-down Plan" to reduce the heat-island effect, with a particular focus on the most vulnerable communities.

Reflective building materials and green space can significantly reduce heat islands. Because communities with the least amount of green space often suffer most acutely from the heat-island effect, a plan to address and mitigate this phenomenon's negative impacts would be of significant benefit. The proposed statewide "Green Cool-down Plan" could build on existing programs and plans focused on creating open space and recreational

facilities, promoting urban forestry and agriculture, and employing green infrastructure practices. Augmenting building codes to maximize reflectivity of roofs, windows, and exterior walls in vulnerable urban neighborhoods should also be considered. These actions would contribute to both mitigation and adaptation efforts in the state.

Potential Cost

Initial costs of developing this plan should not be substantial as they probably would be limited to providing agencies and authorities with adequate staff resources and expertise (or redirecting existing resources) to develop an effective plan. Costs of implementing the plan could be substantial, but these costs probably would, to a greater or lesser extent, be balanced by the cost benefits achieved after implementation.

Timeframe for Implementation

Ideally, implementation would begin as soon as sufficient staff resources are available.

Impacts/Vulnerabilities Addressed

Climate change is likely to increase the frequency, intensity, and duration of extreme heat events in New York State. Extreme heat can directly cause an increase in heat-related morbidity and mortality, including increased risks for those with medical conditions such as cardiovascular disease, renal disease, emphysema, and others. Extreme heat also may lead to increased electricity demand, potentially resulting in short-term blackouts and brownouts, which can lead to other health effects. Weather conditions associated with extreme heat events often are associated with an overall decline in air quality.

All New Yorkers are vulnerable to the range of possible public health consequences associated with extreme heat events. However, certain sensitive populations are thought to be especially at risk for heat-related morbidity and mortality. The effects of extreme heat may be exacerbated in urban areas because of urban heat-island effects. Additionally, some people (e.g., in more rural, northern areas) may less readily acclimatize to heat and may be more sensitive to extreme heat events.

Environmental Justice Considerations

Research indicates that while the health consequences of climate change may affect all sectors of society, low-income people and people of color are likely to experience the greatest harm. These same populations often have limited transportation choices, as well, restricting their capacity to move to cooler areas or cooling centers. The California Climate Adaptation Strategy identifies factors that could contribute to health inequities related to people's exposure to extreme heat:

- **Chronic illness co-morbidity:** Some low-income and minority communities may have a higher prevalence of chronic illnesses that place individuals at greater risk of heat-related illness. Especially vulnerable are people who are receiving treatments at home that require electricity to operate and those who may have no means of transport to a medical clinic or facility.

- **Exposure to urban heat-island effect:** Low-income individuals and people of color are often concentrated in urban areas subject to the heat-island effect.
- **Access to air-conditioning:** Low-income individuals are less likely to have air conditioning. Differences in air conditioning prevalence have been shown to exacerbate racial differences in mortality due to heat effects
- **Occupation:** Some workers (e.g., agricultural and construction workers, road crews) are especially at risk of heat illness due to the combination of outdoor work in hot weather and jobs demanding physical exertion.
- **Fear of crime:** People in some communities (e.g., low income communities) may be reluctant to open doors and windows for ventilation during heat waves for fear of crime.

Co-benefits and Unintended Consequences

Public access to cooling centers and other air-conditioned spaces during extreme heat events can help to reduce people's exposure to outdoor air pollutants such as ozone, reducing the risk of air pollution-related health effects. Implementing a statewide "green cool down" plan to reduce urban heat-island effect can potentially reduce energy use, resulting in reductions in greenhouse gas emissions. This also can reduce energy costs. Increases in the amount of urban green space (e.g., through urban forestry or the creation of additional urban park space) also can contribute to healthier lifestyles if people take advantage of such spaces for exercise and recreation.

Recommendation 2. Educate, empower, and engage all New Yorkers to foster a better understanding of the public health consequences of climate change and take actions to reduce or eliminate those consequences.

The success of public health adaptation strategies will require that all New Yorkers, from policy makers and government officials to the general public, have access to information about the health consequences of climate change and the importance of allocating resources to reduce or eliminate those consequences.

Specific Actions

A. Raise the awareness of policy makers, State and local government officials, community leaders, businesses, institutions, health-care providers, and the general public about the public health significance and related costs of climate change.

Statewide awareness of the public health consequences of climate change is essential to the success of climate change adaptation.

Potential Cost

Initially, the costs associated with implementation will be those for adequate staff resources to develop the education and outreach program. Since this will be an ongoing campaign, those costs will be ongoing. Additional costs will include those associated with publishing

and distributing printed materials, purchasing space and time for commercial media message distribution, social networking via the Internet, and training. Implementation costs should be compared to the costs of no action.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

B. Create effective outreach materials and mechanisms focused on vulnerable and/or hard-to-reach populations, identify key health and mental health-care providers for training and capacity building, and establish sustained community dialogues that communicate critical information.

The creation and dissemination of multilingual and multicultural outreach materials and the identification of outreach mechanisms will be more effective with input from key community stakeholders, including health care professionals, religious and civic leaders, and community-based organizations. Such community leaders are often best positioned to communicate the possible public health consequences of climate change and its impact on their particular town, city, or neighborhood.

Potential Cost

The costs of this action are a subset of the costs of 2-A, above.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

Impacts/Vulnerabilities Addressed

There is an immediate need to provide effective communication to improve understanding of climate change and advance a public sense of urgency. Individuals can then see the local impact climate change can have on their lives, from day-to-day to extreme weather events. Preparing and alerting the public of these events provides an opportunity for climate change communication.

Environmental Justice Considerations

Different cultures, languages and literacy levels pose challenges to any public health education and outreach effort. While these challenges may be present in any population or community, they all are likely to be present in environmental justice communities, which are likely to be among the communities at the greatest risk of climate-related public health consequences. Implementing this recommended strategy will require an awareness of these challenges and the incorporation of approaches (e.g., employing a multilingual approach that incorporates cultural differences) to overcome them. Collaboration with community leaders also can help to identify approaches to overcome communication challenges.

Co-benefits and Unintended Consequences

Public health and safety messages must be received, understood, and acted upon to be effective. Cultural, linguistic, and technological advances in health and safety communication mechanisms, strategies, and techniques may help to inform difficult-to-reach populations. Lessons learned in trying to inform people about ways to reduce the health impacts of climate change may help to improve all public health communication programs.

Recommendation 3. Assess and improve the capacity of existing public health preparedness, response, and recovery programs to respond to climate-related impacts and direct resources where needed.

A number of the potential health consequences of climate change are associated with events that may result in public health emergencies (e.g., floods, severe summer and winter storms, extended power outages). While New York currently has robust public health preparedness, response, and recovery programs, the capacity of those programs to handle the anticipated increase of extreme weather-related events must be evaluated and any necessary measures to enhance the capacity of the programs should be implemented.

Specific Actions

A. Assess and, as necessary, enhance the capacity of existing preparedness, response, and recovery programs.

Measures such as expanding capacity for coordination and communication, evaluating existing early warning systems and the logistical feasibility of evacuation plans, and enhancing overall preparedness of the public health response to the potential increase in severe climate-related events may require additional planning and resources.

Potential Cost

Initial costs of performing the necessary assessment(s) may be limited to staff resources needed (e.g., through redirection of existing staff resources). Costs for enhancing/expanding program capacity are unknown at this time.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

B. Determine how existing telecommunications technology and social networking systems can be better integrated into early warning and evacuation systems.

In the era of texting, Twitter, and Facebook, information of interest to an individual can be, and often is, communicated in real-time. These technologies have already proved to be

extraordinarily valuable in crisis situations and should be fully incorporated into the emergency management system.

Potential Cost

The costs of this action are a subset of the costs of 3-A, above.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

Impacts/Vulnerabilities Addressed

In terms of emergency management, the most vulnerable populations are those that are not able to prepare for, respond to, or recover from emergency events without significant support because of their social, physical, or mental status (e.g., people at hospitals, nursing homes, or that require oxygen therapy; disabled or homeless people).

Environmental Justice Considerations

The potential for climate change to affect people's health in communities that already experience inequitable environmental burdens is discussed elsewhere in this section.

Co-benefits and Unintended Consequences

Any climate-change-related enhancements to public health preparedness and emergency management programs in New York State will better prepare those programs for all public health emergencies.

Recommendation 4. Build community resilience and integrated public health capacity to reduce human health impacts of climate change.

The effects of climate change on natural systems and the built environment can result in a spectrum of adverse public health consequences. The health consequences can be reduced by implementing measures to enhance the ability of individuals and communities to recover from climate change impacts and measures to help facilitate an efficient, coordinated public health response to climate-related events. These measures include planning for climate change at the state and local levels, directing the resources necessary to increase the climate resilience of individuals and communities, and coordinating emergency preparedness planning with a range of local entities.

Specific Actions

A. Consider the possible public health-related impacts of climate change in planning, programs, policies, and regulations.

Currently state and local agencies often make planning, policy, and regulatory decisions without considering climate change and the corresponding public health implications. This can decrease community resilience and increase climate-related risks and impacts. Future planning should include community resiliency planning efforts already underway.

Potential Cost

Given the numerous entities to which this action would be applicable and the diversity of programs, policies, and regulations, the cost of this action is likely to be significant.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

B. Increase the resilience of communities by providing additional support for healthy-built environment concepts, such as smart growth and green infrastructure, and for local and urban agriculture initiatives that strengthen food security.

Healthy-built environment concepts will help attenuate flooding, reduce the urban heat-island effect, and reduce air pollution, all of which are likely to be exacerbated by climate change and affect public health. Additional resources (both state and federal) should be directed to adaptation strategies that also protect and improve human health as critical components of building community climate change resilience. Implementation of these concepts will also lead to improved human health overall, which will make individuals more able to cope with the effects of climate change, such as extreme heat events. These efforts can yield mitigation co-benefits as well by reducing greenhouse gas emissions.

Potential Cost

Additional staff resources or redirection of existing staff resources will be necessary for the planning and program design activities. Costs of implementing the plan(s) that would be developed could be substantial, but these costs likely would, to a greater or lesser extent, be balanced by the cost benefits achieved after implementation.

Timeframe for Implementation

Ultimate implementation of this action could occur over the longer term (e.g., 5-10 years), but planning activities could begin as soon as adequate staffing resources are available.

C. Require that emergency preparedness plans include coordination and communication among critical stakeholders such as community-based organizations, local businesses, local health departments, utilities, and local government leaders.

Coordination and communication with key stakeholders, including people who live and work in a community, are integral aspects of well-formulated emergency preparedness plans.

Potential Cost

The costs of this action are a subset of the costs of 3-A, above.

Timeframe for Implementation

Implementation of this action should begin as soon as adequate staffing resources are available.

Impacts/Vulnerabilities Addressed

Climate change impacts in multiple sectors can have indirect effects on public health. These effects can compound the more direct public health impacts of change in climate and weather patterns. Adequate integrated public health capacity and the resilience of communities will serve to reduce the consequences of climate change discussed throughout this document.

Environmental Justice Considerations

Some New York communities of color and low-income status already suffer from disparities in health outcomes and disproportionate burdens of environmental insults. These communities, especially in urban areas, typically have limited access to resources such as adequate health care, nutritious food, adequate housing, and safe neighborhoods (see the NYS 2009 Energy Plan Environmental Justice Brief). Furthermore, lower incomes can restrict opportunities to engage in health promoting behaviors. For these reasons, low income communities and communities of color are particularly vulnerable to the impacts of climate change on public health, essential resources, and infrastructure. These communities may lack the resilience necessary to effectively adapt to changing climate and recover from impacts to public health and resources.

The combination of limited access to essential resources (such as health care, clean air, and others), and elevated incidence or prevalence of some health outcomes, results in the vulnerability of many communities of color or low income. Solutions include ensuring equity in access to resources and reducing health disparities.

Co-benefits and Unintended Consequences

Community resilience and integrated public health capacity that are developed in an effort to promote adaptation to climate change can have many co-benefits. Communities that are prepared to absorb the stresses of climate change impacts with minimal public health consequences will also be best prepared to absorb shocks from natural disasters unrelated to climate change, as well as from terrorism, crime, and other threats. Since programs that bolster resilience to climate change also impart resistance to other threats, efforts can be carried out collaboratively with other preparedness and capacity-building programs and the program costs shared.

Recommendation 5. Evaluate and enhance, as necessary, the capacity of existing surveillance programs for vector-, food-, and water-borne diseases and disease-causing agents to monitor and respond to the anticipated climate change-related increase in such public health threats.

New York State currently has extensive and robust programs for detecting, preventing, and controlling vector-, water-, and food-borne diseases, and disease-causing agents. However, changes in temperature and precipitation are likely to cause changes in the distribution and numbers of disease-causing vectors and changes in the quality of water used for drinking, recreation, and food production. These changes may result in increases in the incidence of some diseases (e.g., Lyme disease, West Nile virus, eastern equine encephalitis, *Salmonella* food poisoning). New York should implement measures so that existing programs, at both the State and local levels, are adequately prepared for the possible increase in these kinds of diseases and disease-causing agents.

Specific Actions

A. Evaluate the capacity of existing programs, enhance surveillance of disease and disease-causing agents, and enhance the capacity of public health programs that control disease-causing agents.

New York State programs for the detection, prevention and control of vector-, water-, and food-borne diseases, and disease-causing agents are likely to require additional resources.

Potential Cost

Although uncertain, it may be possible to accomplish the evaluation of existing program capacity with limited additional staffing resources. The costs associated with any necessary program enhancements are unknown at this time but could be estimated as part of the evaluation of existing program capacity and would be offset to a degree by the avoided health impacts.

Timeframe for Implementation

Since New York State already has extensive and robust programs in this area, immediate implementation may not be necessary. If feasible, initial implementation of this action (i.e., the recommended program evaluation) should begin as soon as adequate staffing resources are available.

B. Provide necessary assistance to local governments.

Much of the burden of responding to extreme climate variability and climate change will fall upon local governments. Mechanisms for providing assistance to these entities will be essential.

Potential Cost

Costs of determining the kinds of assistance that may be needed for local governments are a subset of the costs of 5-A. Costs of actually providing any necessary assistance to local governments could be substantial but are unknown at this time.

Timeframe for Implementation

Same as for 5-A, above.

C. Expand analytical laboratory capacity to support essential environmental monitoring, disease surveillance, and outbreak investigation/control activities.

Adequate analytical laboratory capacity is a critical component in detecting and preventing vector-, water-, and food-borne diseases.

Potential Cost

Additional staffing may be needed to evaluate existing laboratory capacity. The cost of any possible expanded analytical laboratory capacity is unknown at this time.

Timeframe for Implementation

Same as for 5-A, above.

Impacts/Vulnerabilities Addressed

The interaction of climate, vector populations, and other factors in determining incidence of vector-borne illnesses remains complex and not adequately understood. Validated models to predict future vector-, water-, and food-borne disease incidents in New York under extreme climate variability and climate change scenarios are not available. Even qualitative assessments remain highly uncertain. This recommendation would help address these gaps.

Environmental Justice Considerations

People with compromised immune systems will be particularly vulnerable to the increase in infectious diseases resulting from climate change. In addition, people of color, people living in remote areas, and persons of low socioeconomic status are often medically underserved, and so are potentially more likely to delay treatment for infections.

Small communities with limited resources to direct toward water and wastewater infrastructure may have a relatively high risk for water-borne illness. Similarly, small communities that rely on surface water supplies may find those supplies threatened by increased chemical and microbial contamination resulting from the impacts of climate change.

Co-benefits and Unintended Consequences

Implementation of this recommendation may improve New York's capacity to prevent and control many vector-, water-, and food-borne diseases that are not related to climate change. For

example, microbiologists and epidemiologists that investigate food-borne *Salmonella* outbreaks resulting from climate change are also available to investigate outbreaks due to many other agents.

Implementation may also improve New York's capacity to respond to agents that may be deployed by bioterrorists. The U.S. CDC lists plague (*Yersinia pestis*), botulism (*Clostridium botulinum* toxin), and viral hemorrhagic fevers among its Category A (high-priority) bioterrorism agents. Category B (second-highest priority) bioterrorism agents include food safety threats (e.g., *Salmonella* species, *Escherichia coli* O157:H7, *Shigella*); viral encephalitis (alphaviruses [e.g., Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis]); and water safety threats (e.g., *Vibrio cholerae*, *Cryptosporidium parvum*). These potential bioterrorism agents are also vector-, water-, and/or food-borne disease agents.

Recommendation 6. Assess and prepare for the significant public health risks associated with hazards related to sea level rise.

Rising coastal waters and the associated potential increase in storm surges can cause widespread coastal flooding, which may result in a range of adverse public health and safety outcomes. The risks to be addressed include storm surges, flooding, poor indoor air quality, saltwater contamination of public water supplies, post-traumatic stress, increases in disease vectors, inundation-related contamination problems, impaired access to health care, and loss of food security.

The SLRTF has been assessing the anticipated effects of sea level rise and developing recommendations for state action to address them. This Climate Action Plan recommendation supports the implementation of the public health recommendation[4] developed by the Sea Level Rise Task Force. Additional information can be found in the Coastal Zones section of this chapter.

Potential Cost

Additional agency staff resources are likely to be needed to implement this action.

Timeframe for Implementation

Implementation should be initiated as soon as possible after New York State adopts the recommendations of the SLRTF. According to the draft SLRTF recommendation, full implementation may occur within two to five years.

Impacts/Vulnerabilities Addressed

Sea level rise itself and the associated potential increase in storm surges are likely to cause an increase in coastal flooding. Forecasted storm surges from coastal storms may result in population evacuations that will displace people from home and work, which can have a range of possible health consequences including lack of access to medications and routine or emergency

[4] http://www.dec.ny.gov/energy/45202.html

medical care. Health care facilities may be at risk of flooding and may require evacuation, relocation, or protection (e.g., by floodwall construction). The flooding that may occur has the potential to cause a range of adverse public health consequences.

Environmental Justice Considerations

As with all of the potential health consequences of climate change, sea level rise and its attendant consequences will likely have the greatest effect on some people who are members of ethnic and racial minorities and people who are poor. People in these groups may live in areas that are subject to severe flooding from coastal storms, yet these areas may be poorly prepared to avoid the consequences of flooding. Poor people may lack the resources and means to evacuate high-risk areas and many, if not most, will have limited options in securing temporary or permanent alternative housing. Any loss of community centers, senior centers, and public recreational facilities may have a greater effect on poor than on more affluent communities. Overall, most of the possible effects (e.g., contamination resulting from combined sewer overflows and releases of toxic materials, power outages, mold growth) probably will have greater consequences for the poor. Actions to adapt to sea level rise must, as a priority, address the public health issues that will be confronted by these most at-risk populations.

Co-benefits and Unintended Consequences

Measures to avoid the public health consequences of sea level rise may include the construction of new dwelling units, commercial space, and other structures away from flood-prone areas. New construction initiatives will present opportunities to create healthier built environments. Climate-smart building practices can increase the energy efficiency of buildings and lead to energy cost savings for building owners and occupants.

Recommendation 7. Conduct and support research on the public health consequences of climate change and their effective incorporation into adaptation strategies.

A New York State research plan on the public health aspects of climate change would enable a more thorough understanding of the possible consequences of climate change. The plan also would provide a foundation for assessing the effectiveness of adaptation strategies so that those strategies can be optimally designed and modified to reduce or eliminate the health consequences of climate change.

Specific Actions

A. Develop a research agenda that includes making use of health impact assessments, developing appropriate health indicators, and assessing the effectiveness of adaptation technologies.

Developing a coherent research agenda focused on climate-related public health impacts and issues will help shape public policy and facilitate more efficient and effective use of scarce public resources. This research, together with monitoring and surveillance efforts, could help to identify and refine strategies to reduce the impacts of climate change on

human health, reduce uncertainties about the possible impacts, and design effective adaptation strategies.

Potential Cost

It may be feasible to develop a research agenda by redirecting existing staff resources. New York State agency costs of performing any research may be partially offset by seeking grant funding.

Timeframe for Implementation

Immediate or even near-term implementation of this action is probably not essential, but if feasible, implementation should be initiated as soon as necessary resources are available.

B. Develop participatory methods to assess the effectiveness, accessibility, and quality of public health-related climate change adaptation programs.

To further strengthen and develop measures, policies, and programs focused on the public health dimension of climate change adaptation, New York State should develop and implement assessment methodologies and practices designed to fully engage a wide spectrum of stakeholders, especially those members of the public most at risk from particular climate change-related health impacts such as heat-related morbidity and mortality, post-emergency mental distress, and respiratory, cardiovascular, and other diseases.

Potential Cost

While it may be feasible to perform this activity by redirecting existing staff resources, some limited additional staffing may be required.

Timeframe for Implementation

Same as for 7-A, above.

Impacts/Vulnerabilities Addressed

Climate-related risk factors include heat events, extreme storms and storm surge events, disruptions of water supply and quality, decreased air quality, and alterations in patterns of infectious disease vectors and organisms. Demand for health services and the need for public health surveillance and monitoring will increase as climate continues to change. Climate change places an additional burden on public health agencies that are already burdened by low levels of staffing and funding.

Environmental Justice Considerations

Expanded research can improve the understanding of potential health impacts to traditionally underserved groups that are likely to be affected by climate change.

Co-benefits and Unintended Consequences

Research to advance public health adaptation to climate change would enable proactive measures and overall community public health and resilience. Developing methods to link and quantify relationships among climate change, changes in energy production and use, air pollution, and health outcomes would provide opportunities for improved public health protection and its associated societal benefits.

The costs of investing in public health research will be offset by reduced health care costs resulting from improved preparedness and adaptation (Ebi et al., 2009). Ebi et al., 2009 concluded: "(g)iven the real risks that climate change poses for U.S. populations, the National Institutes of Health, Centers for Disease Control and Prevention, U.S. Environmental Protection Agency, and other agencies need to have robust intramural and extramural programs with funding of >$200 million annually. Despite the risks, extramural federal funding of climate change and health research is estimated to be <$3 million per year."

Telecommunication and Information Infrastructure

Vision Statement

Prepare for, and adapt to, a changing climate by building increased resilience into the communications infrastructure via opportunities for system-level redundancy, diversity, risk management, and review.

Background

Telecommunications infrastructure is vital to New York State's economy and welfare; its capacity and reliability are essential to the effective functioning of global commerce and the state's economy and are especially vital during emergencies. The sector has important public functions, but it is largely privately operated. The rapid technological changes inherent in the sector mean that the planning horizons and life spans for much of its infrastructure are at best on the order of a decade. The sector is tightly coupled to the energy sector, with power outages affecting the reliability of communication services; many of its communication lines also are located on the same poles as power lines. Modern digital technologies, including communication services based on fiber optics, broadband, and the Internet, can be more vulnerable to power outages than traditional landline technology.

A focus of the communication infrastructure sector is how to ensure that the perpetual introduction of new technologies enhances the reliability and uninterrupted access to services, rather than degrading these services. Such a focus is essential both now and in the future, when the perils from climate change may increase.

Climate Impacts

Communication service delivery is vulnerable to hurricanes, lightning, ice, snow, wind storms, and other extreme weather events, some of which are projected to change in frequency and/or intensity. Communication lines and other infrastructure are vulnerable to the observed and projected increase in heavy precipitation events and resulting flooding and/or freezing rain. In coastal and near-coastal areas, sea level rise in combination with coastal storm surge flooding will be a considerable threat later this century. The delivery of communication services is sensitive to power outages, such as those resulting from the increased demand associated with heat waves, which are expected to increase with climate change.

Under current climate conditions and severe weather events, there are already serious vulnerabilities that in many instances prevent the telecommunications sector from delivering services to the public that are resilient to extreme events. If the sector could be made more resilient to the current climate, then the incremental threat from climate change is likely to be more manageable.

Recommendation 1. Agencies and authorities, including municipalities, with jurisdiction over communication infrastructure, should prepare detailed inventories of telecommunications facilities, networks, and corridors; prioritize critical infrastructure; and complete climate vulnerability assessments of critical infrastructure and corridors within their jurisdictions.

All agencies and authorities, including municipalities, with jurisdiction over communication infrastructure, should prepare inventories of existing and proposed critical infrastructure and infrastructure corridors to assess their vulnerability to the impacts of climate change. Inventories should encompass the wide variety of elements and technology included in New York State's telecommunications sector, including cable television, Internet, network services, telecommunications, and medical and emergency services. The inventory should identify the most critical systems and facilities.

The inventories should be used to conduct vulnerability assessments for critical infrastructure. These assessments should rely on State-accepted climate change projections and consider how these projections may impact each communication facility and component over time. Assessments should also include detailed financial and social impact analyses that account for interdependencies within the sector and between the communications and energy sector. This information should be incorporated into long-term planning, design, funding, and operation of communication infrastructure at the State and local levels.

Development of inventories and vulnerability assessments must be coordinated across jurisdictions to eliminate duplication of efforts and allow for prioritization of critical infrastructure at the State level. While the costs of these assessments and actions to reduce the vulnerabilities to communication infrastructure could be significant in the near term, they may be dwarfed by the potential costs related their failure as the result of a changing climate.

Specific Actions

A. Agencies and authorities with jurisdiction over telecommunications infrastructure in New York State should identify and inventory existing and proposed communication components, facilities, networks, and corridors; and prioritize infrastructure that is essential to support critical state and local functions such as emergency preparedness and response capabilities.

The purpose of these inventories is to identify all communications infrastructure and prioritize infrastructure that is vital to the health, safety, and welfare of the people in the state. The inventory process must be coordinated among responsible agencies to eliminate duplication of effort and allow for prioritization of infrastructure statewide. Prioritization of infrastructure should be based on critical movement of data volume, type and, number of users, and the ability to interconnect regions within both New York State and adjacent states. Information should be provided to all communication agencies to assist in inventory preparation.

Potential Cost

Estimates to prepare baseline inventories differ according to municipality or agency jurisdictional size, resources, and communication infrastructure.

Timeframe for Implementation

The dependency of the state and its residents on telecommunications infrastructure necessitates that an effort to inventory critical infrastructure should be undertaken in the near term.

B. Agencies and authorities should conduct vulnerability assessments using New York State-accepted climate change projections to assess the impact of projected climate change on priority communication infrastructure.

Vulnerability assessments should be conducted using state-accepted projections for climate change such as those developed through the NYSERDA-sponsored ClimAID project. Vulnerability assessments should include detailed financial and social impact analyses including interdependencies of facilities and communication infrastructure.

Potential Cost

Regionally downscaled climate projections have been developed as part of the ClimAID project. Statewide, this effort is broadly estimated to require a staff time effort in the several millions of dollars. Some cost will be associated with updating climate projections on a regular basis.

Timeframe for Implementation

The vulnerability assessments should be undertaken in the near term and build on the inventory. The vulnerability assessment should be updated on a periodic basis to incorporate revised climate projections.

Environmental Justice Considerations

Key community-level infrastructure may be at risk from the effects of climate change, which could especially affect underserved EJ communities. Accessibility is a critical concern when planning evacuation and emergency procedures. New York State should give special considerations to those communities dependant on landline communication due to lack of access to wireless technology. Future prioritization of adaptation strategies and funding should coordinate with local community resiliency plans and incorporate impacts to all communities, especially EJ communities.

Recommendation 2. Incorporate state endorsed climate change projections into all relevant planning, design, funding, and operational decision making within New York State's telecommunication and information infrastructure sector.

When facilities such as communication networks are designed, planners project data-transfer volume so that the design will be adequate for future needs. Similarly, projections are available for future climate conditions. Climate change poses structural as well as operational hazards to the state's communication infrastructure. The growth of the telecommunication networks and data-transfer volume and the variability of climate change result in highly dynamic conditions for the communication sector. The level of dynamism in the sector can be expected to increase in the future.

A coordinated interagency effort should begin now to develop and implement specific design policies to incorporate projected effects of climate change into the design of facilities as appropriate for their expected design life. In this way the risks to communication infrastructure and users, and the costs of premature replacement, may be reduced or avoided.

Specific Actions

A. State agencies responsible for the management of communication infrastructure should develop specific design and operational guidance based on climate change projections and incorporate it into communication projects and investments.

The projects being designed and built today will face significant climate-related changes in conditions during their design lives. A well-designed facility, built with provision for those anticipated future conditions, offers major savings over one that will quickly become obsolete and require replacement. Examples of specific actions include avoiding installation of fiber optic cables in areas that are at high risk of flooding or sea level rise, and ensuring that communication centers that are in zones at high risk of flooding and sea level rise are identified and their relocation opportunities evaluated.

Potential Cost

Tens of thousands of dollars in staff time to develop needed guidance and criteria based on state-accepted climate projections.

Timeframe for Implementation

A significant opportunity exists to incorporate the most recent regional projections for climate change based on the best available science into state agency decision-making processes.

B. Direct funding as available for adaptive changes to existing critical communication networks used for emergency preparedness and response that are at greatest risk from climate impacts.

There are critical communication networks that are a major component of emergency preparedness plans (evacuation networks) and emergency response plans (relief supply networks and access to recovery responders and equipment). If these networks are not changed to make them more resilient to future extreme weather events projected by climate change forecasts, emergency preparedness and response plans could be adversely impacted.

Potential Cost

No estimated cost for addressing this recommendation has been developed at this time. A realistic cost cannot be prepared until the potential impacts and adaptive changes have been identified.

Timeframe for Implementation

Near term (1-3 years): New York State is increasingly vulnerable to large storm events in coastal areas that can cause service disruptions and threaten public safety.

Environmental Justice Considerations

The specific impact on EJ communities is not known at this time. As the critical communication networks serve both EJ communities and non-EJ communities alike, it is anticipated that this recommendation will allow more resilient emergency evacuation networks and resilient response to weather-related emergencies to EJ communities.

C. Develop models, guidance, standards, and financial support where possible to help local governments implement adaptive measures for priority communication infrastructure.

New York State design standards and guidance currently provide the framework for design for county and municipal communication agencies across the state and for much private development as well. Local agencies do not have the resources to develop specific criteria of their own, and local standards and guidance are most often modeled on those of county or State entities.

Potential Cost

Tens of thousands of dollars in staff time to produce guidance for local officials.

Timeframe for Implementation

As soon as possible.

Environmental Justice Considerations

Specific impacts are not known at this time; however, increased resiliency of the communication sectors could positively affect all state residents.

Recommendation 3. Where feasible and cost effective, reduce vulnerability of telecommunication infrastructure to extreme weather events through efforts to increase redundancy, shift toward a more distributed network, and reduce the interdependency of communication infrastructure and between communication and energy infrastructure.

Specific Actions

A. Foster a shift toward a more distributed network of communication infrastructure, including expansion of wireless services.

This will ensure that critical operational elements will not be lost if a specific location is impacted by an extreme event (e.g., flooding). Grouping different types of critical infrastructure, such as ducts and wiring, in one location or facility can increase vulnerability. By increasing the geographic diversity of communication centers, there is less chance that multiple networks will fail at the same time. For example, redundant switching nodes could be developed in several locations to ensure system operation should one node go out of service. Diversity may also be increased by having communication services use fiber optic rings in the local loop or set up alternative switching when a central communications center fails.

Potential Cost

Significant investment in some areas. Incremental costs associated with planned capital investments for system upgrades.

Timeframe for Implementation

As soon as possible.

B. Planning for investments in communications infrastructure and for changes in operations should support, and be coordinated with, adaptation and operations of other sectors, particularly the energy sector (e.g., smart grid).

Potential Cost

Large-scale investment— in the many millions of dollars; may be integrated into capital investment cycle.

Timeframe for Implementation

Coordination activities should begin as soon as possible.

C. Ensure system redundancies for communications infrastructure, including communication towers, at high risk of flooding and high winds.

Potential Cost

Large-scale investment—can be integrated into capital investment cycle.

Timeframe for Implementation

As soon as feasible in coordination with capital investment cycles.

Environmental Justice Considerations

Siting of additional communication infrastructure should take into account EJ considerations.

Recommendation 4. Improve the dialogue on climate resiliency between state agencies and private telecommunications service providers and provide increased accountability for service disruptions

Specific Action

A. To provide increased accountability carriers and other communication service providers should be required to report compliance with the Federal Communications Commission's standards

A significant challenge of the privatized sector is that reports of service outages to federal and State regulators are not accessible to the public and are not uniformly mandatory across the different types of services. In addition, service provider networks are not required to report on their vulnerability to extreme events or the quality of their service. It is recommended that reliability, survivability, and diversity be promoted according to FCC's Network Reliability and Interoperability Councils. Better reporting could be achieved by requiring service providers to file regular reports with the Public Service Commission. It may be necessary to improve reporting mechanisms and other areas of dialogue in this industry to ensure resiliency of this sector.

Potential Cost

Many tens of thousands of dollars of personnel hours

Timeframe for Implementation

As soon as reasonable.

Environmental Justice Considerations

No immediate, identified issues.

Transportation

Vision Statement

Advance transportation and land-use choices that increase the resilience of the state's transportation system to climate change; address specific regional vulnerabilities and those in common, including known infrastructure deficiencies; and be consistent with the state's commitment to smart growth land use, recognizing that all decisions must seek to safeguard and improve the safety and mobility of people, and goods and services with regard to social equity.

Background

New York State is home to a 113,000-mile network of interstate and State highways, including 16,000 bridges, a 4,600-mile rail network, which includes the largest mass transit system in the U.S., some 500 public and private aviation facilities, more than 130 public transit operators, four port authorities, and numerous private ports. Transportation contributes about 10 percent of the state's economy—about $100 billion annually.

The highest concentration of transportation infrastructure is generally located in regions that are population centers and vital drivers of the global, national and, state economies. Threats to these dense metropolitan transportation systems (especially New York City) would have far-reaching impacts.

Ground transportation systems (roads and rails) in coastal population centers are often placed underground in tunnels very close to or below sea level. Since transportation is a networked system, delays, failures, and catastrophic failures in one system can affect other systems.

Transportation occurs by different modes: land, air, and water. On land, it can be divided into road, rail, and pipeline. The goods of transport are people and freight (the latter including raw materials, supplies, finished products, and waste). In urban concentrations, mass transit systems serve the commuting populations going to and from daily work, school, shopping, etc. In suburban and rural areas, largely private vehicular transportation on roads and highways dominates but also reaches the central business districts of cities. Long-distance and interstate traffic on the roads is complemented by railway, water, and air transport.

Climate Impacts

The impacts of climate change have significant consequences for the transportation sector. Over the next few decades, heat waves, heavy precipitation events, and windstorms are likely to dominate the causes for moderate, more frequent transportation problems such as flooded streets and delays in mass transit. By 2050 at the latest, sea level rise and storm surge will become more significant threats. By later this century, this threat will be so severe that major adaptations will have to be in place, not only in the coastal zone, but all the way to cities including Troy and Albany as sea level rise and storm surge propagate up the tide-controlled Hudson River. Low-lying transportation systems such as subways and tunnels, especially in coastal and near-coastal areas, are at particular risk of flooding as a result of sea level rise and heavy-precipitation events.

Materials used in transportation infrastructure, such as asphalt and train rails, are vulnerable to increased temperatures and frequency of extreme heat events. Air conditioning requirements in buses, trucks, and trains, and ventilation requirements for tunnels will increase. Runways will require lengthening in some locations since hotter air provides less lift, necessitating higher speeds for takeoff.

The Great Lakes may see a shorter season of winter ice cover, leading to a longer shipping season. However, reduced ice cover is also likely to mean an increase in lake effect snow events, which cause various transportation problems.

Air- and land-based transportation systems are vulnerable to ice and snowstorms, although requirements for salting and snow removal may decrease as snow tends to turn more often into rain. Freeze/thaw cycles that disturb roadbeds may increase as winter temperatures rise. New York State has the most days per year of freezing rain in the nation. This affects air and ground transportation directly, and indirectly through electric and communication outages.

Recommendation 1. Encourage all State, regional, and local transportation agencies and authorities, including municipalities with jurisdiction over transportation infrastructure, to prepare detailed inventories and climate vulnerability assessments of critical transportation infrastructure and corridors within their jurisdictions.

All State, regional, and local transportation agencies and authorities, including municipalities, with jurisdiction over transportation infrastructure should prepare inventories assessing the vulnerability of critical transportation infrastructure and corridors from the effects of climate change using best available, State-endorsed climate change projections. These vulnerability assessments should include a baseline inventory of all transportation infrastructure and consider how projected climate change would affect each facility. Inventories should include detailed financial and social impact analyses. While the costs of new assessments and reducing the vulnerabilities of the state's transportation systems could be significant in the near term, such costs are expected to be dwarfed by a failure to address the changing climate.

Specific Actions

A. Key transportation corridors, designated according to the critical movement of people and/or freight and their importance to intra- and interstate travel, should be provided to transportation agencies.

As a necessary step prior to preparing inventories, New York State should identify key transportation corridors (see also recommendations 5 and 6), including both highway and non-highway routes (examples of such routes are existing coastal evacuation routes). Designation of key corridors should be based on critical movement of both people and freight and the ability to interconnect regions within New York State and adjacent states. Information should be provided to all transportation agencies to assist in inventory preparation.

Potential Cost

Statewide, this effort may potentially cost $5-15 million. Included in this estimate are paid hours of staff currently in state or agency service and consultant staff.

Timeframe for Implementation

This effort is estimated to take 12-18 months and would occur concurrently with work under Recommendation 1.B.

B. New York State should endorse a coordinated set of climate change projections and provide these to State transportation agencies, regional and local planning agencies and authorities, local municipalities, and other transportation stakeholders such as privately owned railroads, airports and marine shipping operators.

To ensure consistency of these transportation inventories, New York State should endorse projections for climate change variables and impacts such as sea level rise, heat indices, precipitation rates, in particular rainfall intensities, and extreme-storm events.

Refinement of the model projections and regular updates should be conducted.

Potential Cost

The majority of the climate projection work is complete. Refinement of models and updates will be relatively low cost.

Timeframe for Implementation

This effort would be an ongoing exercise.

C. Integrate climate change into vulnerability assessments, which should include a baseline inventory of existing and proposed transportation infrastructure and analyses of potential financial and social impacts based on climate projections endorsed by New York State.

Using climate change projections and key corridor definitions, all State transportation agencies, regional and local planning agencies and authorities, and local municipalities should assess the vulnerability of all transportation infrastructure and corridors within their

jurisdiction from the effects of climate change, including consideration of how climate change projections would affect each facility in given timeframes. Inventories should include financial and social impact analyses. Each individual agency, authority, and municipality should consider all New York State identified key transportation corridors, including interdependencies of adjacent agencies facilities. This underscores the need for statewide agency collaboration and communication during the development of each inventory

Potential Cost

Estimates to prepare baseline vulnerability inventories differ depending on municipality/agency jurisdictional size, resources, and transportation infrastructure. Statewide, this effort is broadly estimated to cost up to $15 million dollars

Timeframe for Implementation

Baseline Vulnerability Inventories: This effort is estimated to take12-18 months and would occur following efforts under 1-A and 1-B.

D. To facilitate investment decisions evaluate which freight and passenger transport systems are most resilient to climate change.

New York State should determine which transportation modes, structures, and facilities are the most resilient to climate change using the inventory created under this recommendation and the long-term vision for transportation from Recommendation 4. Various metrics, such as dollar-value-risk per person served and tons of CO_2 per passenger miles traveled would be applied to projects so that they can be evaluated consistently across the state. Results of this effort would be used in recommending priorities for infrastructure investment. New York State should prioritize infrastructure investments that support the Climate Action Plan adaptation-planning processes and greenhouse gas reduction efforts.

Potential Cost

Estimates to accomplish the administrative planning associated with this task range from $1-$5 million. This estimate is garnered from similar state agency costs and is largely based on staff time and does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

This effort is estimated to take 12-18 months and would closely follow work completed under recommendations 1-A and B but would occur prior to work under Recommendation 6-B. Work under Recommendation 5 would be used in Recommendation 1-C.

Impacts/Vulnerabilities Addressed

Vulnerability assessments should take into account all potential climate change impacts on this sector. In particular, rising sea levels, more frequent and severe riverine flooding, higher temperatures, and generally increasing variability of weather should be considered.

Environmental Justice Considerations

Key community-level infrastructure may be at risk from the effects of climate change, which could especially affect underserved communities. New York State should give special considerations to those communities dependant on mass transit due to lack of access to cars. Accessibility is a critical problem when planning evacuation and emergency routes. Future prioritization of adaptation strategies and funding should coordinate with local community resiliency plans, and incorporate impacts to all communities, especially environmental justice communities.

Co-benefits and Unintended Consequences

Vulnerability inventories would help identify both existing and future infrastructure problems and needs, especially in areas where aging infrastructure may already be at risk even without future climate change. New York State can use these assessments in prioritization of capital dollars. Building resiliency and efficiency into the state's transportation system in order to better adapt to climate change will also dramatically reduce GHG emissions, having a significant effect on climate change mitigation. Costs could include intensified land uses in certain areas, capital outlays, and political ramifications.

Recommendation 2. Prioritize transportation infrastructure that is essential for emergency preparedness and response capabilities.

Protecting critical transportation routes, such as those that are a major component of emergency preparedness plans (evacuation routes) and emergency response plans (relief supply routes and access to recovery responders and equipment), from climate-related impacts should be a priority for New York State. If these routes are not altered or protected so that they are more climate resilient, emergency preparedness and response plans could be adversely impacted.

Specific Action

A. Direct funding, as available, for adaptive changes to critical transportation routes used for emergency preparedness and response that are at greatest risk from climate impacts.

New York State should direct funding for adaptive changes to critical transportation routes used for emergency preparedness and response that are at greatest risk from climate change impacts. There are critical transportation routes that are a major component of emergency-preparedness plans (evacuation routes) and emergency-response plans (relief supply routes and access to recovery responders and equipment). If these routes are not changed to make them more resilient to future extreme weather events projected by climate change forecasts, emergency preparedness and response plans could be adversely impacted by future weather events.

Potential Cost

No estimated cost for addressing this recommendation has been developed at this time. A realistic cost cannot be prepared until the potential impacts and adaptive changes have been identified.

Timeframe for Implementation

Near-term (1-3 years). New York State is increasingly vulnerable to climate change, especially large storm events in coastal areas.

Impacts/Vulnerabilities Addressed

Disruption of emergency preparedness plans and response due to climate change impacts on transportation facilities.

Environmental Justice Considerations

The specific impact on environmental justice communities is not known at this time. As the critical transportation routes serve both EJ communities and non-EJ communities alike, it is anticipated that this recommendation would allow more resilient emergency-evacuation routes and resilient response to weather-related emergencies in EJ communities.

Co-benefits and Unintended Consequences

This proposal would assist in reducing the backlog of maintenance work on key transportation routes.

Recommendation 3. Incorporate State-endorsed climate change projections into all relevant planning, design, and operational decision making within New York State's transportation sector.

When facilities such as highways are designed, planners project future traffic levels so that the design will be adequate for future needs. Similarly, projections are available for future climate conditions. Most significant of these for the transportation sector are rising sea levels and increased flooding due to increased runoff from increasingly intense storms and rainfall. Unlike traffic congestion, these changes pose structural as well as operational hazards to the state's infrastructure. Yet transportation agencies currently design their projects, not for anticipated future conditions, but for the conditions of the past, even though those conditions have undergone documented change and are predicted to continue to change in the future.

A coordinated interagency effort should begin now to develop and implement specific design policies to incorporate projected effects of climate change into the design of facilities as appropriate for their expected design life. Efforts should be made to reduce runoff from existing sources to offset projected increases. In this way the risks to infrastructure and users and the costs of premature replacement can be reduced or avoided.

Specific Actions

A. To the extent feasible, State transportation agencies should develop specific design criteria and operational guidance based on climate change projections, to be incorporated into current and future transportation projects and investments.

Transportation infrastructure projects such as highway and rail embankments, bridges and culverts, and yard facilities, typically have design lives of 50 years or more. In many cases, the expectation is that the life of the project will then be further extended by rehabilitation. The projects being designed and built today will face significant climate-related changes in conditions during their design lives. A well designed facility, built with provision for those anticipated future conditions, offers major savings over one that will quickly become obsolete and require replacement.

Potential Cost

Tens of thousands of dollars in staff time. This figure does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

As soon as possible, since some transportation infrastructure projects are currently being designed and, once constructed, will last for decades. Unless these projects account for future climate conditions, they may be at risk from future climate impacts.

B. Stormwater management techniques and approaches should be incorporated wherever possible into existing contributors and across all sectors— private, commercial, municipal, etc.

Greater stormwater runoff control is necessary to reduce pressures, especially on urban drainage systems. Stormwater is currently regulated for new projects, but contributions from existing, unmanaged sources will continue to increase unless those sources can be retrofitted to reduce runoff. This effort should include an assessment of opportunities to create or maintain open spaces with permeable surfaces, to lessen the degree that storm surges will sweep toxic substances inland.

Potential Cost

Incremental increase to large expenditure for retrofitting existing runoff sources, depending on how aggressive action is targeted.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

C. Develop models, guidance, standards, and financial support where possible to help local governments implement adaptive measures for priority transportation infrastructure.

New York State design standards and guidance currently provide the framework for design for county and municipal transportation agencies across the state and for much private development as well. Local agencies do not have the resources to develop specific criteria of their own.

Potential Cost

Tens of thousands of dollars in staff time. This figure does not include actual engineering implementation costs that cannot yet be estimated.

Timeframe for Implementation

Implementation should begin as soon as possible, when necessary staff resources are available.

Impacts/Vulnerabilities Addressed

Planning should take into account all impacts of climate change on this sector, in particular sea level rise, increasing rainfall and storm intensities, more frequent and severe flooding on rivers and streams.

Environmental Justice Considerations

Infrastructure improvements should take into consideration environmental justice issues and seek collaboration at the local level.

Co-benefits and Unintended Consequences

Undesirable consequences of designing for future increases in sea level, storm surge, and flood discharges may be environmental effects. Higher embankments have wider footprints and, in low-lying areas, may encroach more into wetlands. Regulatory agencies may be reluctant to issue permits for structures to accommodate future conditions. Culverts that are oversized for today's conditions may spread lower flows too thin for fish passage. Care to mitigate these problems as much as possible would be necessary.

Recommendation 4. The New York State Transportation Master Plan should consider and incorporate State-endorsed climate projections.

The Transportation Master Plan projects trends in usage of personal vehicles, non-vehicular travel, public transportation, and freight movement to 2030, and seeks to guide transportation planning and investment to meet those needs. It does address the need to reduce greenhouse gas emissions, thus helping to mitigate their effect on climate change, but it does not address the changes that will occur, even if all the mitigation goals are achieved. These changes will reshape demographic, economic, and travel trends by the end of the century and beyond. Planning for long-lived infrastructure must include those factors that will shape the needs and use of that infrastructure beyond the near term.

Specific Action

A. Policy direction for the siting, design, operation, and maintenance of key transportation infrastructure elements should include climate change projections for the entire proposed useful life of those elements.

The current Transportation Master Plan attempts to steer the course of transportation planning to meet the expected needs of the state to 2030. However, the effects of climate change are expected to increase over periods well in excess of this planning horizon. At the same time, the typical life cycles of many transportation infrastructure elements are also well in excess of a 20-year planning window. Efficient and effective transportation planning and resource allocation must consider the full life cycle of these elements.

Potential Cost

The decision to develop a long-range Transportation Master Plan will in itself have minimal cost. The implementation of such a plan is likely to involve major and continuing capital outlays. Relocation of major transportation facilities, or raising them above expected flood levels, will require a tremendous increase in funding, even while existing systems must be maintained as new ones are developed to replace them. Each project that is undertaken on vulnerable facilities without such planning is one that will suffer premature obsolescence and require more costly replacement or retrofitting as the effects of climate change are felt.

Timeframe for Implementation

The State should take immediate action to develop and implement long-range planning that incorporates the effects of climate change. The long life cycles of transportation infrastructure elements guarantee that they will be affected.

Impacts/Vulnerabilities Addressed

All climate-change impacts to this sector should be considered, in particular rising sea levels, more frequent and severe riverine flooding, higher temperatures, and generally increasing variability of weather.

Environmental Justice Considerations

EJ considerations and input from EJ communities should be included in siting and design efforts.

Co-benefits and Unintended Consequences

Adoption of a truly long-range Transportation Master Plan could spur economic development, as businesses see that preparations are being made for a long-term stable system to meet their transportation needs. A responsible transportation plan could influence development and land-use decisions that would reduce the overall vulnerability of the state to climate change. In the nearer term, the large capital outlays needed to develop this new transportation system may have a dampening effect on the state's economy and will certainly face significant political challenges.

Recommendation 5. Transportation investments in New York State must be consistent with smart growth/transit-oriented development principles.

"Sprawl" refers to dispersed, homogeneous, and automobile-dependent land use patterns. Current policies and planning practices did not intend to encourage sprawl but have contributed to dispersed developmental patterns in many areas of the state. These developments favor automobile use over walking and transit, resulting in limited travel options. Smart growth encourages more efficient land-use patterns and transit-oriented development, and intelligent land-use choices, such as not building critical infrastructure in a potentially vulnerable location.

Smart-growth principles discourage development of remote properties or large swaths of previously undeveloped land. Natural systems, such as wetlands, forests, and barrier islands, provide services such as flood protection, storm buffering, and water infiltration that would be prohibitively expensive to replicate with human-built systems. In addition, smart growth would encourage infill and transit-oriented developments. This type of growth and development would provide two adaptation benefits: preservation of natural systems that provide adaptation services and less infrastructure exposed to climate impacts. Increased travel options will provide transportation system redundancy that can be utilized if certain components of the transportation network were to fail due to weather extremes.

Transportation and land use must be planned together. The effective integration of transportation and smart growth helps ensure success in other climate adaptation and mitigation measures related to ecological corridors, agriculture and food security, watershed management, water access and distribution, etc.

Specific Actions

A. Infrastructure investments should be assessed for their ability to implement the Transportation and Land Use Technical Work Group long-term vision for transportation, reducing vulnerability to climate impacts while improving travel choices and transportation network efficiency.

New York State should develop strategic approaches to lower the severity of climate impacts and reduce system vulnerability to climate change impacts. State efforts to incorporate compact land-use patterns and transit-oriented development (TOD) into growth strategies and master plans should continue.

Where Recommendation 1D considers different types of infrastructure, this recommendation considers the location of that infrastructure.

Effective implementation of smart-growth policies would help focus climate change adaptation efforts on population centers and critical transportation routes, while helping to reduce future climate risk through intelligent and directed land use and transportation investments.

Increased travel options that result from compact development and better planning will provide choices and alternatives that can be used if certain components of the state's transportation network were to suffer damage or failure as a result of climate change impacts.

Potential Cost

The Governor's Smart Growth Cabinet should remain operational. Capital expenditures will be necessary to provide attractive incentives to local communities promoting smart growth.

Incorporating smart-growth/TOD principles into agency decision making and local planning efforts would have minimal direct costs. However, resulting decisions likely will necessitate higher implementation costs. It is critical to note that the costs resulting from no-action (i.e., business as usual) transportation and land-use planning would likely be much higher. Land-use patterns would continue to be unsustainable, the State would not be able to minimize critical points of failure and the transportation system would remain vulnerable to climate change.

Infrastructure investments are always costly, for both new infrastructure and existing infrastructure upgrades. Using the inventory developed under Recommendation 1, this recommendation aims to make spending more efficient in the long term in two primary ways:

- Directing funds away from new infrastructure with high climate risk and toward infrastructure with low climate risk and high adaptive capacity;
- Directing funds toward existing infrastructure that is deemed critical to adaptation capacity.

Timeframe for Implementation

This action should be implemented as soon as possible. Transportation, land-use, and planning decisions being made today will influence growth and development for the next several decades. New York State should start now to effect significant change in development patterns and transportation infrastructure in order to adequately adapt to climate change impacts.

B. Infrastructure investments should be designed and constructed to protect and preserve natural resources and ecosystems that provide essential climate-adaptation services or benefits in addition to meeting transportation needs.

Ecosystems provide critical and varied services, which are typically unrecognized and under-valued but must be preserved. Natural systems, such as wetlands, forests, and barrier beaches, provide services such as flood protection, storm buffering, and water infiltration that would be prohibitively expensive to replicate with human-built systems. Smart growth would discourage development of remote properties or large swaths of previously

undeveloped land, allowing natural systems to provide climate-adaptation services and reducing exposure of infrastructure to climate impacts.

Potential Cost

Municipalities may require additional staff or incur costs by hiring consultants to accomplish ecosystem evaluations. State agencies will require staff hours to provide guidance. Administrative planning costs, based on staff hours, are estimated to be under $1million statewide, annually.

Timeframe for Implementation

Transportation, land-use, and planning decisions being made today will influence growth and development for the next several decades. New York State should start as soon as possible to effect any significant change in development patterns and transportation infrastructure to adequately adapt to climate change impacts.

C. Incorporate redundancy and travel choices into the transportation system to adapt to climate change impacts that may affect certain components of the transportation network.

Serious and sustained financial choices and investments that increase investment in transit (or shared low-carbon and zero-carbon modes) and existing infrastructure are needed to build redundancy and provide travel choices in the transportation network. Planning and building for a greater emphasis on shared modes of transportation will build efficiency and resiliency into transportation systems, reducing vulnerability to climate change impacts.

Potential Cost

The cost of this action is not yet quantified and will depend on the specific policies employed. Costs may be in the form of tax incentives for developers or grants for local governments.

Timeframe for Implementation

New York State should start as soon as possible to effect any significant change in development patterns and transportation infrastructure to adequately adapt to climate change impacts.

Impacts/Vulnerabilities Addressed

Significant shifts in population and business may occur in response to the increase in flooding and coastal inundation, resulting in new or altered transportation needs. Any component of the transportation system that exists in close proximity to water or in low-lying areas will be vulnerable to damage or diminished function as a result of climate change.

Environmental Justice Considerations

Economically disadvantaged citizens need transportation choices and typically rely on public transportation. Implementing this recommendation and expanding transit options throughout the state would benefit these groups. It has been shown that coordinated and well-planned transit-oriented development typically improves economic conditions and raises property values. However desirable this may be, sensitivity to the risk of pricing out poorer residents that might no longer be able to afford to live in these communities is necessary.

Co-benefits and Unintended Consequences

Co-benefits and costs are similar to EJ considerations. Seniors will also benefit from having additional transportation choices. The most significant co-benefit of this recommendation is that inverting mode-split and building resiliency and efficiency into the transportation system will also dramatically reduce GHG emissions, having a significant effect on climate change mitigation. Costs could include intensified land uses in certain areas, capital outlays, and political ramifications.

Water Resources

Vision Statement

As water is vital to New York's economic and environmental future, the State must pursue actions that will maintain this rich resource in the face of climate change and increase resiliency to the effects of climate change.

Background

New York State has an abundance of water resources. Despite having only 0.3 percent of the world's population, the state is bordered by lakes containing almost two percent of the world's fresh surface water: Lake Erie; Lake Ontario, and Lake Champlain. Central New York is home to the Finger Lakes, which are the largest of the state's 8,000 lakes as well as some of the largest inland water bodies in the United States. The state has several high yielding groundwater aquifers, particularly those of Long Island. It has an average rainfall of almost 40 inches, which readily supplies numerous small municipal reservoirs as well as the extensive New York City reservoir system located in the Catskill Mountains and lower Hudson River Valley.

Water resources are managed by a diverse array of large and small agencies, governments, and institutions, with little statewide coordination. In 2000, New York State's 19 million residents consumed approximately 2,200 million gallons per day of fresh surface water and 890 million gallons per day of fresh groundwater for public water-supply, irrigation and industrial uses. Of this nearly 3,100 million gallons per day of consumption, only about 10 percent was for industrial and agricultural use. This water comes from a diverse range of sources, each with different levels of vulnerability to climate change.

New York State's water and wastewater treatment infrastructure is in dire need of repair and upgrade. A needs survey conducted by DEC in cooperation with the New York State

Environmental Facilities Corporation (EFC) and the U.S. Environmental Protection Agency (EPA) determined that $36 billion of water treatment improvements and $40 billion of wastewater treatment improvements are necessary in New York State. The anticipated added challenges associated with a changing climate will only exacerbate the situation.

Although New York is a water-rich state, it must continue to strengthen its capabilities to better understand and manage its water resources. This is especially true given the growing demand for water, including water for human consumption and energy production. As other parts of the country experience large changes in drought frequency and intensity, New York's water resources may become a defining economic asset resulting in the migration of people and businesses into the state. This may bring some economic benefits but will also present new challenges as pressure on water resources increases. This potential has been recognized in the Great Lakes-St. Lawrence River Basin Water Resources Compact. New York State's water budget should be assessed to better understand the availability, limitations, and allocations of water and how that budget intersects with economic development, population growth, and ecological health. This would also allow for better planning of water resources for competing uses, including agricultural, industrial, ecosystem, and human uses.

Climate Impacts

Although there are several water-quality concerns directly linked to average air temperatures, in general, hydrologic processes are dependent on multiple interacting climate factors. In addition to temperature, possible future changes in timing and quantity of snow, rainfall, and evaporation will all have impacts on the state's water resources.

Rising air temperatures intensify the water cycle by driving increased evaporation and precipitation. The resulting altered patterns of precipitation include more rain falling in heavy events, often with longer dry periods in between. Such changes can have a variety of effects on water resources.

- The frequency of heavy downpours has increased over the past 50 years. This trend is projected to continue, causing an increase in localized flash flooding in urban areas and hilly regions.

- Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains.

- Less frequent summer rainfall is expected to result in additional and possibly longer summer dry periods, affecting water supply systems with limited storage.

- Reduced summer flows on large rivers and lowered groundwater tables could lead to conflicts among competing water users.

- Increasing water temperatures in rivers and streams will affect aquatic heath and reduce the capacity of streams to assimilate effluent from wastewater treatment plants.

Because New York is already experiencing water-resource challenges, the recommendations provided here represent actions that will enhance New York's water resources legacy. The anticipated effects of climate change add urgency to implementing these recommendations; however, these actions would also serve to improve water resources in the state independent of climate change.

Recommendation 1. Enact into law Governor's Program Bill #51-Water Withdrawal Regulation (S.8280-A/A.11436-B) to authorize implementation of a comprehensive statewide water management program to better regulate the use and consumption of the state's water resources.

This legislation directs DEC to implement a statewide permitting program for significant water withdrawals; generally, systems with a capacity of equal to or greater than 100,000 gallons per day would be regulated. Currently, water uses are managed by a piecemeal regulatory scheme; on Long Island, groundwater withdrawals are subject to a DEC permit, and in the Delaware and Susquehanna river basins, water withdrawals are regulated by the applicable interstate river basin commission. Elsewhere, only public-water supplies are regulated. This legislation would provide a rational and more consistent statewide approach. This legislation would provide DEC with more comprehensive information on water uses across the state and allow DEC to better manage New York State's water resources, which will become increasingly important as water availability changes with a changing climate. Additionally, this legislation would allow DEC to meet one of its obligations under the Great Lakes-St. Lawrence River Basin Water Resources Compact. Under the Compact, DEC must implement a regulatory program for all water withdrawals in New York's portion of the Great Lakes Basin by December 2013. Without this new program, New York State would continue to lack the necessary data to fully understand the statewide level of water demand for water supply; commercial, industrial, and agricultural uses; and the state's ability to meet future demand in a changing climate.

Potential Cost

DEC staff would be required to promulgate regulations and manage the new permitting program.

Timing of Implementation

The statewide permitting program would be implemented upon adoption of regulations by DEC, which would require passage of the legislation.

Recommendation 2. Build greater resilience to projected climate change impacts into drinking-water and wastewater infrastructure systems.

New York State communities should prepare for increased frequency and intensity of flooding and short-term drought due to climate change. Infrastructure must be adaptable and designed to be resilient to a changing climate to avoid service disruption and costly damage, particularly to

drinking-water and wastewater infrastructure, which can have dramatic impacts to public health, ecosystems, and local economies. Real-time monitoring systems should be used to evaluate vulnerability of facilities and determine strategic upgrades and replacement of existing infrastructure. Planning and design standards for new and, where feasible, upgrades to existing water infrastructure should emphasize the use of smaller and more distributed systems that foster groundwater recharge, system redundancies for critical populations, and systems that are adaptable to and operable under a wide range of flood and drought conditions to reduce vulnerability of human and natural systems to the effects of climate change.

Specific Actions

A. The State and all other governmental bodies with jurisdiction over drinking and wastewater infrastructure should, as part of their asset management strategies, prepare detailed inventories of critical water infrastructure within their jurisdictions and conduct climate vulnerability assessments that consider changing climate conditions and potential climate impacts over the full intended service lives of the identified infrastructure.

Potential Cost

The costs of modifying planning and permitting processes to accommodate new risk assessment processes to evaluate infrastructure decisions are considerable. However, accurate information is required for planning, especially for new infrastructure projects that will cost many millions or even billions of dollars. The costs of no action could be enormous. Disruptions to critical infrastructure can cause the loss of essential services, public-health impacts, and hardship to local residents; compromise economic activity; and entail costly repair and reconstruction.

Timing of Implementation

Near-term. As potential impacts are determined and adaptation actions are prioritized, water managers can implement certain no-regrets actions; that is, climate change considerations can add momentum and potentially expedite initiatives that have already been identified as priorities. By factoring climate projections into infrastructure investment decision making now, better choices will be made regarding how to deal with aging infrastructure and how to make existing and new infrastructure climate resilient in the future. By wisely incorporating climate-change impacts into infrastructure decision making now, authorities can avoid costly adaptation efforts later.

Environmental Justice

Implementation of this strategy will increase the resiliency of critical infrastructure throughout New York State, providing a benefit to all. However, this strategy may have a particular environmental justice benefit by focusing attention on neglected infrastructure in vulnerable urban communities with more limited adaptive capacity. In addition, because many water-treatment facilities and other water infrastructure are located in EJ

communities, the proposed vulnerability assessments will identify particular problems and challenges before they become acute, thus helping to mitigate negative impacts on host communities.

Co-benefits and Unintended Consequences

By increasing the resiliency of infrastructure, service disruptions will be reduced, limiting the health consequences that may arise from disruption of critical services, e.g., wastewater treatment or public transportation. Through better design of wastewater treatment plants, release of untreated waste into water bodies due to infrastructure flooding can be reduced, eliminating a potential source of environmental pollution. A flexible system can maximize operational approaches to adaptation such as green infrastructure that can produce a spectrum of co-benefits, including air-quality improvements and energy savings. Such a system can also potentially result in the design and implementation of smaller, infrastructure improvements that have lower cost and impact, consume less energy, and reduce hydrological impacts, but still effectively meet needs. Co-benefits of infrastructure-capital upgrades could include additional features to increase water-supply storage or flood prevention.

B. Relevant State and local agencies should update permit and design standards for drinking-water and wastewater infrastructure to factor in projected climate impacts, particularly precipitation-related events such as more intense rainfall events, reduced winter snow cover, and increased frequency of short-term droughts.

Potential Cost

An update to the hydrologic data that inform infrastructure design standards (TP 40) is currently funded and underway; however, resources will have to be dedicated to appropriately integrate the updated data into agency design standards.

Timing of Implementation

Updated hydrologic data should be incorporated into design standards by relevant agencies immediately upon completion. The USDA Natural Resources Conservation Service has funded the Northeast Regional Climate Center to provide updates to current rainfall frequency estimates. An assessment of ongoing programs and activities would inform investment in additional data collection and research.

Environmental Justice

This action would provide greater protection to the most vulnerable communities by reducing flooding of critical infrastructure in low-lying areas and ensuring the sustained quality of drinking water.

Recommendation 3. Adopt statewide and region-wide comprehensive sustainable water-resources-management strategies that consider climate change to preserve water quality and water quantity for human and natural communities, and encourage watershed-wide collaboration.

The natural hydrologic cycle is shaped by and adapted to accommodate a wide range of hydrologic and hydraulic conditions while being resilient to damage. Where State polices can mimic the efficiency of natural processes they will enhance the state's ability to adapt to climate change. Storm-water, wastewater, and water-supply permit guidance should reflect this goal.

Sound watershed management is a key component of sustainable water policy. A comprehensive sustainable water-resources strategy would fully recognize groundwater and surface water as a single, integrated resource that is essential to the ecological integrity and economic vitality of the state. Watersheds do not function based on political boundaries, and impacts to water quality and quantity are cross-jurisdictional. Inter-municipal and inter-agency collaboration to manage water resources is essential. In addition, climate impacts to water resources and management strategies will vary across the state and region due to varying levels of urbanization and infrastructure investment, economic factors and planning priorities, and the water needs of natural systems. For this reason many water issues are best addressed on a watershed or sub-watershed level and regional and intermunicipal watershed plans are needed. Where watersheds cross state boundaries, region-wide approaches should be developed.

Planning at this scale should include the following:

- Regional water budgets to ensure that the quality and quantity of surface water and groundwater are conserved and protected, particularly for critical waters;
- Regional conservation of wetlands and critical fish and wildlife habitats;
- Identification of regionally important projects needed to adapt to impending impacts of climate change and sea level rise, including protection or management of water supply, water quality, living resources or aquatic resources;
- Climate impacts on the Great Lakes, resulting in changing lake conditions and lake levels and related water-management issues.

Specific Actions

A. All water-related permit programs and policies should minimize alterations and disruptions to the natural hydrologic cycle to the extent possible. Regulatory agencies should implement this recommendation at multiple scales, including site-level planning and construction, as well as more regional watershed scales.

Technical guidance and design standards should be created and incorporated in storm-water, wastewater, and water-supply permit guidance, and permit reviews and approvals. This guidance and design standards should strive to maximize the ability of infrastructure and to mimic the hydrologic cycle through the following:

- Couple water-supply withdrawals and wastewater infrastructure to limit water transfer between watersheds to ensure that used water is returned to its donor source, reducing infrastructure and energy costs, helping to meet the needs of aquatic life, and providing for renewal of ground and surface-water resources;
- Require the reuse of wastewater and gray water in new development;
- Develop and enforce a zero-runoff storm water policy for new construction and maximize infiltration of storm water onsite at existing developed sites;
- Provide stronger protection for the preservation of natural hydrologic pathways by minimizing land disturbance, avoiding sensitive areas (e.g., steep slopes, recharge areas sustaining groundwater dependent ecosystems, wetlands, and stream corridors), avoiding soil compaction, and reducing impervious surface area;
- Require the use of resilient (e.g., drought-tolerant) native tree cover and plantings, and the removal of invasive species where landscaping is done.

Potential Cost

Although revising policy to address the need to mimic natural hydrology wherever possible may have minimal financial impact on state agencies, it is a paradigm shift in thinking and may require considerable costs to local project sponsors to meet new requirements. Federal and state funding agencies involved with water projects, such as EFC, DEC, DOH and EPA should require these types of recommended actions.

Timing of Implementation

A phased implementation approach could be taken over the next decade to comprehensively weave these philosophies into water policy, funding, and programs.

Environmental Justice

Without careful planning, there is the potential for some decisions to affect such communities disproportionately, for example, by resulting in decreased property values or reduced opportunities for economic development. Agency decisions should include robust public participation, with enhanced efforts for public involvement in areas of environmental justice concern.

Co-benefits and Unintended Consequences

Co-benefits of minimizing disruption of the natural hydrologic cycle include improved water quality, integration of many environmental program goals, improved flood-water attenuation, improved groundwater recharge, protection of river corridors, improved in-stream health, and reduced stream sedimentation.

B. Create mechanisms to foster development and State approval of regional intermunicipal watershed-management plans that address expected climate change impacts and to protect and improve the quality, quantity, and ecological function of surface and groundwater resources, while balancing human health, safety, and socio-economic factors.

Watershed management plans should be developed at the watershed or sub-watershed level by regional, State, and local officials; they should be officially endorsed and adopted by local governments and approved by relevant State agencies. State funding for water infrastructure should be conditioned upon completion of intermunicipal watershed management plans. These plans should include vulnerability assessments to inform planning efforts that consider factors such as water availability, flooding, and water quality. Vulnerability assessments done on a more localized basis should incorporate projected regional impacts, which are critical for effective State-level planning and protection of New York State's water resources.

Local and regional watershed planning will also address knowledge and management gaps related to groundwater systems, such as the extent, quality, and quantity of groundwater systems, and the role of groundwater in supporting ecological systems as the climate changes. Rural residents rely primarily on groundwater for drinking water and other domestic use. Climate change has the potential to negatively affect groundwater recharge; new development should be limited in areas where groundwater resources are already stressed. While the protection of groundwater may be regulated for human uses, current measures do not consider groundwater requirements for the maintenance of ecosystem integrity. This consideration is necessary for the protection of ecosystems. Projections of future water availability, human use, and ecosystem requirements should be updated regularly as new climate and water-use information is developed.

Potential Cost

Research leading to the characterization of groundwater resources has traditionally been conducted by the USGS with resources to meet local match requirements provided by cooperating agencies. TEPA also provides grants to the National Rural Water Association for groundwater assessments for towns on a case by case basis. Additional state resources for mapping and assessment of groundwater sources could improve planning decisions and ensure sufficient drinking-water resources are available for new development. The preparation of watershed-management plans has been funded in part by the New York State Department of State under Title 11 of the Environmental Protection Fund Local Waterfront Revitalization; and DEC, with CWA Section 319 funding, and grants under the Hudson River Estuary Program. Technical assistance in the preparation of watershed management plans could be provided outside of the State grant-assistance context, albeit at a lesser level, with the need for geographic targeting by limited agency staff.

Timing of Implementation

The preparation of intermunicipal watershed-management plans is ongoing in New York State. Incorporation of climate change adaptation can begin immediately. The mechanism for formal state approval of intermunicipal watershed-management plans could be established within a year.

Environmental Justice

Water-quality testing occurs for public water supplies; however, the same scrutiny is not afforded to private water supplies, such as private wells. Watershed-management planning could focus on surface waters, groundwater, or both, including water for human uses (e.g., consumption and recreation that supports local economies), as well for sustaining water-dependent ecosystems. For those communities that have difficulty providing matching funds for State grants, a lesser local match may be needed to encourage participation in watershed-management planning.

Recommendation 4. Allow "room for rivers." Acknowledge the dynamic nature of rivers on the landscape and strive to reduce risk to critical infrastructure and human development as the risk of flooding increases with climate change.

While a patchwork of interrelated river-corridor, wetland, and floodplain programs exists at the federal, State, and local levels, no comprehensive river-corridor program exists. Agencies with jurisdiction over streams, rivers, and their channels, corridors and floodplains should create policies and regulatory approaches to protect the dynamic nature of river corridors and strive to reduce risk to communities through non-structural measures like land-use planning and the elevation and relocation of highly vulnerable structures.

Specific Actions

A. Coordinate with key federal and local stakeholders such as the Federal Emergency Management Agency (FEMA), U.S. Department of Agriculture, and county soil and water conservation districts to identify and map areas of greatest current risk from riverine flooding and erosion due to movement of rivers across the landscape.

Flood-mapping efforts must be modernized to be an effective tool in emergency planning. Flood maps should be completed and updated using climate change projections and flood studies and made electronically accessible to local governments. In partnership with federal agencies, multi-layered, geographic-information-system mapping should be used to identify, classify, and map high-risk areas. Critical data include high-resolution elevation and bathymetry; spatial information for natural, built, and human resources; socio-economic data; sites that, if flooded, could contribute to toxic contamination; and development models that include build-out scenarios. DEC's floodplain-management program currently has only indirect enforcement capability. Legislative reform is needed to ensure wise management of floodplains.

B. Work with federal agencies to reduce new development in areas at high risk of riverine flooding and undertake long-term managed relocation or elevation of existing structures in these areas. Restructure disaster-recovery policies to ensure that redevelopment efforts strive to reduce long-term risk.

New York should eliminate incentives for development in high-risk floodplain areas. Federal disaster-recovery policies should be reformed so that reconstruction of damaged homes and infrastructure incorporates current standards and knowledge of flood risks due

to climate change, rather than simply funding replacement-in-kind of damaged structures and systems.

Potential Cost

FEMA, in partnership with DEC, is mapping areas at greatest risk for riverine flooding in New York. However, the considerable costs (tens of millions of dollars) associated with conducting flood studies and collecting the high-resolution elevation data necessary to generate accurate maps statewide has left many areas of the state still without accurate maps. Additional resources to conduct flood studies and collect high-resolution elevation data using LiDAR (Light Detection and Ranging) technology would allow for complete and accurate mapping of areas at greatest risk. In the absence of resources to complete the mapping, in the near term incentives could be provided to local governments to regulate floodplains and to limit development along stream and river corridors at minimal cost. New York State could also institute a setback regulation for river and stream corridors through State law; however, the mapping effort described above would have to be completed at considerable cost to enable enforcement of this regulation.

As the risk of large flood events increases so does the cost of State response and assistance during and after flood events. It may soon become more cost effective to map and regulate areas at greatest risk of flooding to reduce vulnerability. Significant resources will also be needed to support elevation and/or relocation of structures in high-risk areas.

Timing of Implementation

Implementing a program to reduce the vulnerability of structures and facilities in areas at high risk of flooding should begin soon, as this effort would take many years of planning due to its complexity, the need for the creation of an advisory committee, and perhaps the eventual creation of a State law to reduce the vulnerability of structures, homes, and facilities to flooding.

Environmental Justice

Stricter management of floodplains can depress property values in areas no longer deemed developable. Any program to move people out of these regions or discourage development in floodplains would require adequate mechanism for compensation and reestablishment of households outside of the floodplain.

Co-benefits and Unintended Consequences

Enhanced protection of riparian corridors offers many co-benefits, integrating many DEC and environmental program goals, including enhancement of riparian areas as greenhouse gas sinks, providing upland wildlife habitat, protecting water quality, improving flood-water attenuation, increasing biodiversity, and enhancing public access and scenic beauty.

Recommendation 5. Incorporate water-related climate projections into State and local emergency-management planning.

Specific Actions

A. State emergency-management and local hazard-mitigation plans should incorporate the best available projections of climate-related impacts, such as increased frequency of extreme rainfall, coastal storms, temperature extremes, and short-term droughts.

Expected increases in the frequency of extreme climate events should be factored into emergency planning, response, and recovery capacity. Floods tend to be relatively localized. Droughts may affect the whole state at once, but their significance will vary depending on local resilience (e.g., some groundwater-fed water supplies and those supplied by the Great Lakes may not be as significantly affected). Mitigation will necessarily include improving infrastructure to optimize system redundancy and flexibility.

B. Establish appropriate legal mandates, secure stable funding, and develop guidance for participatory vulnerability assessments and adaptation-planning processes at the local and regional levels.

While climate change is global, its impacts will be felt on a local level. Flooding is expected to increase in many areas of the state; the location, extent, and severity of flooding may be very different from that currently experienced. Drought will also have locally and regionally disparate effects. Hundreds of communities within New York State will be affected by climate change; appropriate resources, including funding and guidance, are necessary for communities to plan for the mitigation of their particular risks.

Potential Cost

The development of State guidance for local governments to help them conduct vulnerability assessments that include the best available climate information should be of relatively low cost. Costs associated with assessments and planning will require staff time at the local level as well as some funding for coordination efforts at the local and regional levels, and guidance and tools should be designed to minimize these costs.

Timing of Implementation

Climate projections should be incorporated into emergency-response plans immediately. Vulnerability assessments and specific adaptation-planning efforts should begin following the development of guidance and tools for local assessments.

Environmental Justice

Some low-income communities and communities of color are particularly vulnerable to the impacts of climate change, and may lack the resilience necessary to effectively adapt to changing climate and recover from impacts. Implementing guidance and planning efforts, especially at the local level, will require the incorporation of approaches specific to the needs of these communities (e.g., employing a multilingual approach that incorporates cultural differences).